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FYR MACEDONIA

green growth

COUNTRY ASSESSMENT

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THE WORLD BANK GROUP

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abbreviations and acronyms

AquaCrop	crop water productivity model
BAU	business-as-usual scenario including the impact of a changing climate
BAU_0	business-as-usual scenario without the impact of a changing climate
bcm	billion cubic meters of natural gas
CHP	combined heat and power
CLIRUN	CLImate and water RUNoff model
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
DSGE	Dynamic Stochastic General Equilibrium
EC	European Commission
ECA region	countries of Eastern Europe and Central Asia: Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Estonia, Georgia, Hungary, Kazakhstan, Kosovo, Kyrgyz Republic, Latvia, Lithuania, FYR Macedonia, Moldova, Montenegro, Poland, Romania, Russian Federation, Serbia, Slovak Republic, Slovenia, Tajikistan, Turkey, Turkmenistan, Ukraine, and Uzbekistan
EPI	Columbia-Yale Environmental Performance Index
ESMAP	Energy Sector Management Assistance Program, World Bank
EU	European Union
Eurostat	the statistical office of the European Union
FDI	foreign direct investment
GCMs	Global Circulation Models
GDP	gross domestic product
GGKP	Green Growth Knowledge Platform
GHGs	greenhouse gases
GW	gigawatt (1000 megawatts)
GWh	gigawatt hour
ha	hectares
IEA	International Energy Agency
LEZ	Low Emissions Zone (urban)
MAC	marginal abatement cost
MOMA	Macroeconomic Options of Mitigation and Adaptation model
$MtCO_2e$	millions of metric tons of carbon dioxide equivalent
MWh	megawatt hours
NO_x	mono-nitrogen oxides
NPV	net present value
O&M	operations and maintenance
OECD	Organization for Economic Cooperation and Development
PM	atmospheric particulate matter
PM_{10}	atmospheric particulate matter smaller than 10 microns
$PM_{2.5}$	atmospheric particulate matter smaller than 2.5 microns
PSD	participatory scenario development
R&D	research and development
SIDA	Swedish International Development Cooperation Agency
Solar PV	Solar photovoltaic power
TCO_2e	metric tons of carbon dioxide equivalent
TREMOVE	EU TRaffic and Emissions MOtor VEhicle model (approximate)
UMC	upper middle income countries
UNFCCC	United Nations Framework Convention on Climate Change
US$	United States dollars
UTMS	urban traffic management system
VAT	value-added tax
WEAP	Water Evaluation And Planning model

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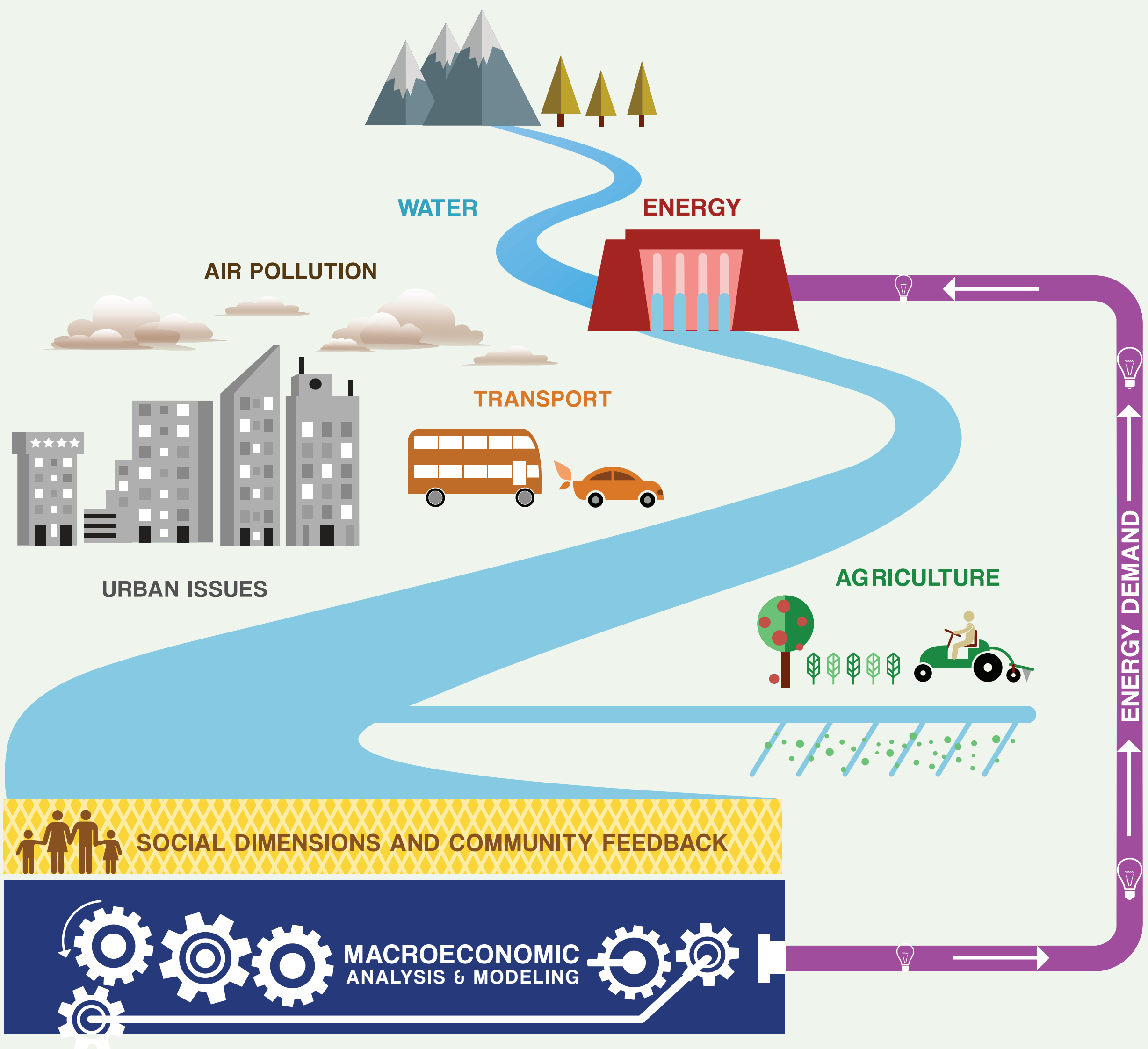
Sustainable development is not an abstract concept – it is the roadmap for responsible acts at national level. Climate Change imposes the necessity of ecologically innovative approaches to support economic development.

President Gjorge Ivanov
Copenhagen Summit, December 2009

executive summary



This green growth country assessment for FYR Macedonia aims to define the outlines of a green growth path and the initial steps along that path. According to the World Bank's recent flagship report, green growth is "growth that is efficient in its use of natural resources, clean in that it minimizes pollution and environmental impacts, and resilient in that it accounts for natural hazards and the role of environmental management and natural capital in preventing physical disasters."[1] While most countries might agree that such growth is a worthy goal, determining what a green growth path might mean for a particular country is a significant challenge. Green growth can be defined more precisely, as economic growth with more sustainable use of natural resources (minerals, water and clean air, and biodiversity), with proper consideration of mitigation of greenhouse gas emissions; with attention to adaptation to a changing climate; and with more focus on innovation and green jobs to enhance benefits flowing from the technological innovation and new industries spurred by a shift to green growth. This report takes a practical approach to identifying specific challenges and opportunities FYR Macedonia faces in building its green growth future and to present them in a form useful for decision makers. The report will address mitigation, adaptation, and the most immediately challenging resource sustainability issue—clean air.

1. World Bank. 2012. Inclusive Green Growth: The Pathway to Sustainable Development. Washington, DC: World Bank, p. 2.

FYR Macedonia, like many countries, is already moving in a green direction. The Macedonian economy continues to evolve, with ongoing programs of structural reforms to improve growth and competitiveness and with growing alignment with Europe. The country's momentum towards Europe is already requiring it to focus more on environmental issues. This report summarizes analytic work undertaken in sectors and on issues selected as critical for defining and understanding the green growth path of the country, with an emphasis on climate action. Chapters of the report start with an overview of the relevant challenges to green growth of climate adaptation and mitigation, and then set out the methodology applied, the findings that emerged, and consequent recommendations. The nine sectors and issues that constitute the components of the Green Growth Country Assessment are represented in the opening graphic in this summary.

The findings and recommendations that emerge from this country green growth assessment can be summarized. In the short-run, the country needs to address the many inefficiencies that keep it off its best possible growth path by pursuing reforms and investments to improve the overall performance of key sectors. These baseline actions will create conditions for the implementation of green growth policies and investments and need to be taken before (or in coordination as) the country makes green investments. Many of the baseline actions recommended in this assessment are already included in the country's economic plans or are required for full European Union (EU) membership. Many of them require limited investment and can be implemented with a small effort, constituting part of a list of 'no regret' interventions. Policymakers need, at the same time, to keep the long-term in mind, both the likely impact of a changing climate on water, agriculture, and infrastructure and the growing obligations to mitigate greenhouse gas emissions. This consideration is particularly important for decisions on long-lived infrastructure such as power supply or urban public infrastructure. A further set of no-regrets actions, such as energy efficiency or water conservation, that promote greener growth as well as efficiency should be adopted regardless of uncertainty about future climate. Perhaps most importantly, the underlying analysis supporting policy decisions needs continual updating using the tools and models developed under this Program and elsewhere to reevaluate any big moves that trade off short-term growth and long-term sustainability.

Critical actions and key advice that emerge from this country assessment stress the need to maintain momentum on sector reforms to foster overall economic growth while greening the growth path. The main elements of a green growth path reach across sectors, with a particular emphasis on water (and the closely-linked agriculture sector) to address adaptation challenges in a changing climate and on energy and transport to address greenhouse gas mitigation challenges.

- Competition for **water** between agriculture (especially as the climate warms and dries), the power sector (for hydropower, a critical element in a lower emissions electricity system, and for thermal cooling), and industrial and municipal uses will pose difficult tradeoffs for Macedonian policymakers by 2020 unless efficiency in both demand and supply is bolstered. The growing scarcity of water can be addressed, first of all, by reducing inefficiencies through pricing and regulation of groundwater and through rehabilitation and maintenance of existing infrastructure. Growing seasonal scarcity can be managed through investment in more storage (for irrigation and for hydropower), while overall shortages in future decades can be addressed through encouragement of water conservation.

- An evolution in **agriculture** towards larger, more competitive, export-oriented farms will raise overall sector incomes while heightening resilience to a changing climate. Investment in basin-scale irrigation and drainage infrastructure (as noted above) will be critical to help water supply meet water demand. Even ambitious adaptation investments in agriculture are estimated to deliver benefits through 2050 that exceed costs four-fold. At the same time, land consolidation, switching to high value crops, and farmer education campaigns, along with other efficiency improvements, will raise agricultural incomes and compensate for scarcer water.

- A greener **energy** sector needs to aim at increased supply security, reduced greenhouse gas emissions, and increased sector efficiency. More generation is needed to avoid blackouts and expensive imports. A cleaner sector demands replacing lignite and oil with gas and renewables in the supply mix over the medium to long run and modernizing existing lignite plants in the short run. Big investments are needed in new gas generation and infrastructure; renewable energy, including hydropower with water storage and wind; expansion of the transmission network; and replacement of outdated equipment in existing facilities. At the same time, aggressive energy efficiency measures will help contain the need for new generation. Most important will be equipment replacement in industry, building retrofitting and introduction of new construction standards, higher efficiency household appliances, modern stoves for residential heating (as a short term measure), and improved heating, cooling and lighting in the non-residential sector.

- A balance between better **transport** services to support growth and a more environmentally sustainable sector will require both infrastructure and new policies. Car ownership and driving distances are projected to increase steeply in the future, and so will emissions, unless measures are taken to improve vehicle fuel efficiency and reduce driving while encouraging public transport. Investment in transport infrastructure, especially in rail and public transport, is overdue, and projected increase in severe weather events will push capital and operations and maintenance (O&M) costs up. Measures in the transport sector should be implemented as packages, taking into account that they are interconnected: e.g., pricing policies to reduce personal car use should be accompanied by increased availability of public transport. Benefits outside of the transport sector should be considered in assessing options, including local air pollution reduction, decreased congestion and decline of traffic-related deaths and injuries.

- **Urban areas,** especially the capital city of Skopje, lead economically, contribute in a similarly outsized fashion to pollution and emissions, and hold the potential to lead FYR Macedonia toward a greener growth path. In recent years, urban sprawl, mainly driven by growth in the number of single family houses that use wood for heating and private cars for commuting, has pushed up the energy intensity of urban life as well as the cost of delivering infrastructure services to a less-dense community. Deterioration of local service delivery including public transportation, water and wastewater services, and solid waste collection and disposal have also pushed Macedonian cities farther away from a green path. First steps to more sustainable cities would include expansion of energy efficiency programs to reduce significantly demand for energy and, therefore, emissions from fuel combustion. In public transportation, investments are needed to increase availability and quality of services. Rehabilitation of water and wastewater networks and increased utility efficiency are recommended to improve the quality of water supply and reduce utility subsidies. Establishment of integrated regional waste management systems and usage of modern equipment and proper landfills in the solid waste sector is essential to reduce emissions and pollution from solid waste.

- Weather patterns affect the reliability and quality of **infrastructure** services, and climate change is exacerbating these effects. Uncertainty about future climate compounds the challenge of making wise choices on infrastructure that is often long-lived and expensive. Planners need to decide whether to build infrastructure to be more resilient today or wait to see what happens and spend more on maintenance and rehabilitation (or replacement) later. Since it would be unaffordable to build all infrastructure today to be resilient to all possible climate futures, *ex ante* adaptation should only be pursued where it makes financial sense. For FYR Macedonia, the top priorities for infrastructure adaptation over the next decade include urban drainage systems, health and education facilities and municipal buildings.

- **Air pollution** in the country is among the highest in Europe, and any green growth path that considers human health must address its reduction, which will provide large local co-benefits to Macedonians. Most of the particulate matter pollution comes from the largest industrial facilities and can be abated by installing modern pollution abatement equipment. A switch from lignite to natural gas in the energy sector will help to significantly reduce air pollution from electricity generation. Pollution from road paving can be addressed by better equipment for asphalt mixing, while exhaust from the country's old and polluting vehicles needs to be addressed through transport policies. Another large and unusual source of air pollution is the widespread use of wood for heat in urban areas by households which can be reduced in the near-term by replacing old inefficient stoves with modern ones. Building a system of policy incentives for industrial, commercial, and household compliance with existing air quality regulations will be essential to achieve green objectives.

- **Participation** of the population in the design of green growth strategies is critical for the success of their implementation. A participatory process can help to increase awareness about climate change, to refine the policies and investments chosen by government to those most efficient and least costly to society, and encourage communities to build resilience and flexibility to prepare for a greener future.

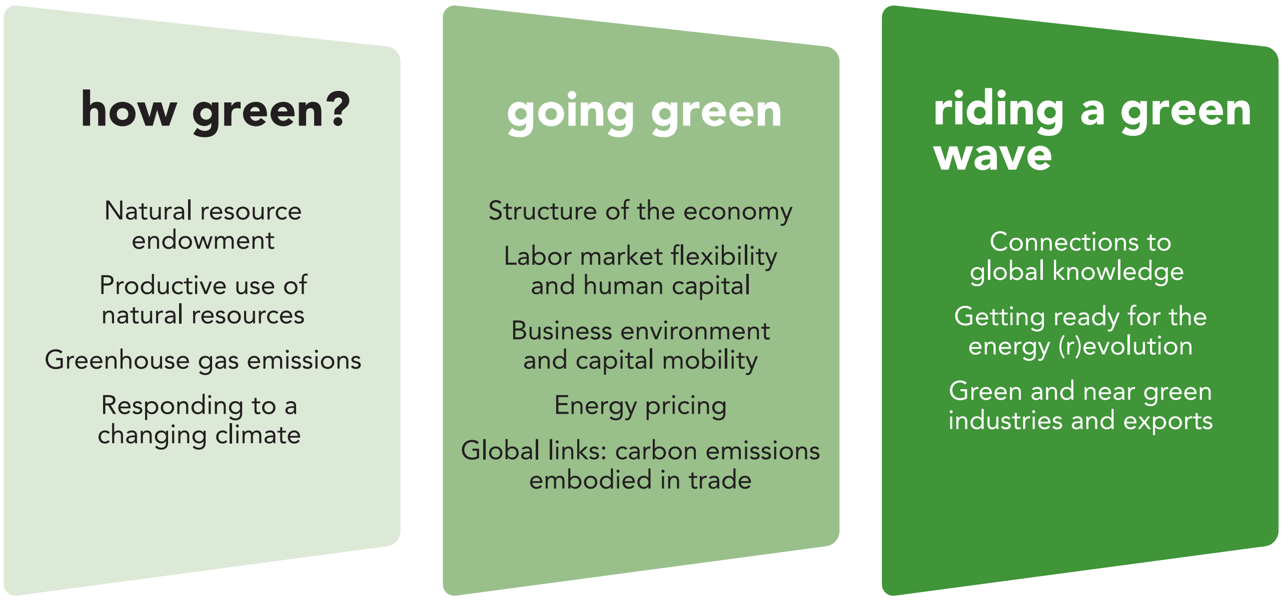
- Carefully-chosen public investments and policies can ease the path to a more resilient and climate-friendly economy without sacrificing long-term growth. An **economy-wide macroeconomic assessment** estimates the impact on growth and employment of packages of actions on green growth across sectors and provides advice on priorities for public investment. Climate investments pose costs upfront but provide benefits both now and later. Adaptation interventions (which protect tomorrow's output from climate damage) are found to be less costly to growth and employment in the short-term than mitigation measures (which reduce greenhouse gas emissions) once sector results are integrated into a general equilibrium model. Under a 'green' climate action scenario, moderate adaptation measures in agriculture and water and incremental expenses in the climate-proofing of physical infrastructure barely put a dent in output, while moderate mitigation measures would require the mobilization of resources constituting about one percent of annual GDP. More ambitious climate action, under a 'super-green' scenario, would require water sector investments that reach one percent of GDP by 2015 while mitigation investments require two percent of GDP by 2020. Green climate action would together generate short-term losses to national income of more than two percent if financing is mobilized domestically, while super-green action induces even bigger losses. However, both moderate and ambitious climate action promise a medium- to long-term boost in the level of GDP—reaching 1.5 to 2 percent by 2050.

CHALLENGES FOR GREENER GROWTH

How green is FYR Macedonia? A good place to start in understanding what greener growth might mean for the Macedonian economy is to understand how the country compares on various relevant dimensions. The scheme below (Summary Figure A) helps to categorize aspects of FYR Macedonia's economy that ease or obstruct the way to green growth. Firstly, has the country made any progress in decoupling economic growth and natural resource use, including greenhouse gas emissions?[2] Is the country preparing for the impacts of a changing climate? Secondly, is the Macedonian economy flexible enough to succeed in the transition towards green growth? Is it efficient and adaptable? Thirdly, how can FYR Macedonia be ready for a surge of innovation and be competitive in new and growing green industries? Better environmental stewardship is already well-defined as part of readiness for European Union membership, while the innovation and green jobs agenda, while intriguing, does not yet offer much beyond standard advice on openness and flexibility. Thus, this report focuses primarily on the challenges of mitigation and adaptation.

2. Emitting greenhouse gas emissions can be considered equivalent to using up the natural resource of the atmosphere as a carbon sink.

SUMMARY FIGURE A. A framework for green growth benchmarking



Benchmarking. FYR Macedonia falls short on air quality, productivity of natural resources it uses (especially scarce water), and the emissions intensity of production compared to other countries, while it is at the same time vulnerable to a changing climate and not well prepared for a greener world. The Green Growth At-A-Glance benchmarking exercise maps FYR Macedonia against comparator countries and country groups using available quantitative indicators that reach across the key aspects of greening to identify critical issues for further analysis. Firstly, FYR Macedonia's natural resource endowment is close to the EU average in most aspects, but air quality is among the worst. Resource usage is less sustainable over the long term, and natural resources are less productive, with water withdrawals that have created moderate water stress. Greenhouse gas emissions are high, driven by heavy use of lignite and high energy intensity of GDP. The country has high exposure to climate change among European countries and among middle-income countries globally. Its sensitivity to climate change (the likelihood of economic damages) is somewhat high because of low quality infrastructure and dependence on agriculture, while its capacity to adapt is limited by institutional weaknesses, high inequality and a relatively low income (Summary Figure B).[3] Secondly, FYR Macedonia's economy is not sufficiently flexible to benefit easily from going green. The country's supportive business environment cannot make up for poorly functioning labor markets, and global links are not yet strong enough to facilitate technology transfer. Lastly, FYR Macedonia's connections to global knowledge and readiness for an innovation revolution are insufficient to benefit from green technological change.

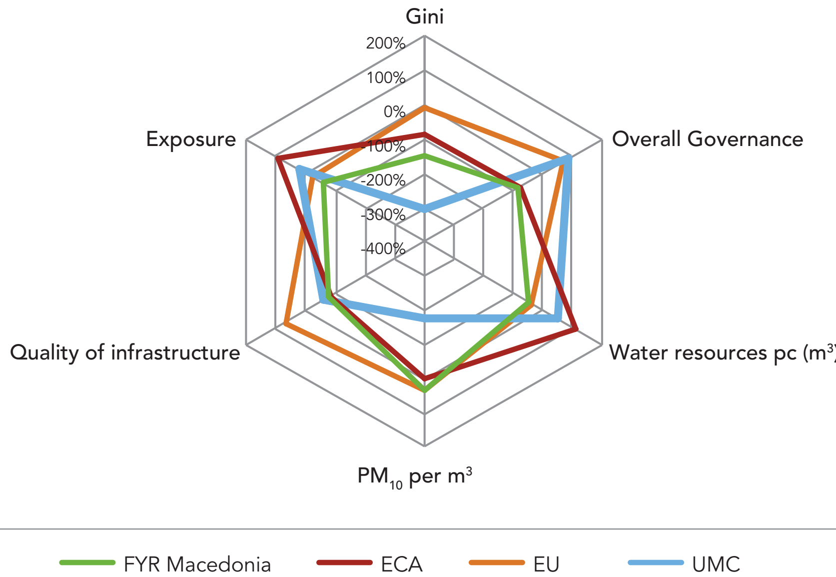
Climate damages. Projected climate change will affect FYR Macedonia's economy, mainly via a direct shock to agriculture and associated spillovers on other sectors in the economy, and to a lesser extent due to losses caused by extreme weather events. The effect of climate change on FYR Macedonia's water supply is estimated to be large and widespread, occurring as early as 2020 in most places in the country, but with larger reductions in mean annual volume of water through 2050 in rivers as temperature increases and rainfall declines. Changes in rainfall amounts as well as their temporal and spatial patterns will tend to reduce water availability across consuming sectors—agriculture, hydropower, thermoelectric cooling, and industrial and municipal demand—especially at times of peak demand. Growing water shortages will dampen crop yields and agricultural incomes. At the same time, as the country becomes drier and hotter, the risk of floods will diminish, but the risk of wildfires will increase.

Sector challenges. The overuse of natural resources and the persistent need for improved sector investments and policies compound the challenge of 'going green.' Drawing on the sector analysis of this assessment, it is clear that inefficient use of limited resources has resulted in water stress, energy insecurity, an energy demand-supply gap, soil fertility problems, dangerous levels of air pollution, and high emissions intensity of energy, industry and transport. These inefficiencies in FYR

3. Vulnerability to climate change can be thought of in three components: exposure, sensitivity and adaptive capacity, each of which can be measured approximately using indicators. The physical impacts of a changing climate, the impact of those physical changes on a country's people and economy, and the country's ability to react will vary.

SUMMARY FIGURE B. **FYR Macedonia is vulnerable to a changing climate**

Exposure, sensitivity and capacity to adapt to climate change, 2009-2010



Note: UMC is upper middle income countries.
Source: Staff calculations based on World Bank databases: Development Data Platform, Poverty and Inequality database, and Worldwide Governance indicators.

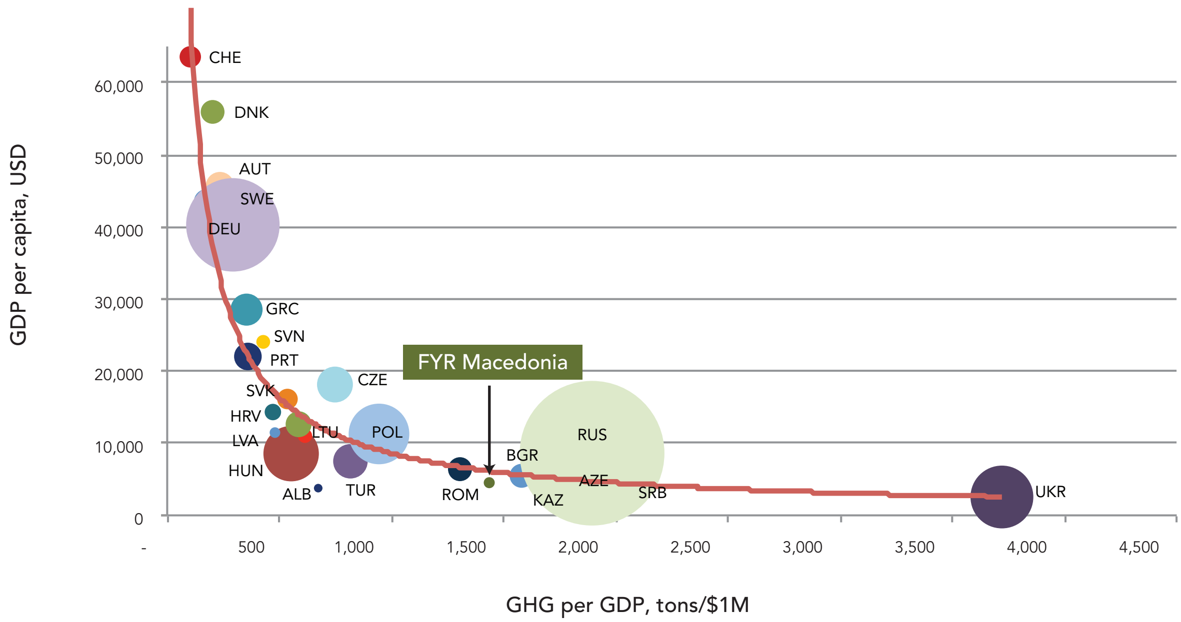
Macedonia's economy include outdated, poorly maintained assets across sectors; high supply losses in the water and power sectors; low service quality; inefficient pricing; and under-collection of payments, among other issues. The inefficiency of FYR Macedonia's economy creates a significant degree of gridlock for green growth (as well as a drag on 'plain' growth). It exacerbates the unsustainable use of natural resources, because an inefficient economy requires more water, energy, and other natural resource inputs per unit of output. An inefficient economy produces high and increasing emissions and blocks climate change adaptation efforts (Summary Figure C). Inefficiencies consume financial resources that could otherwise be used to enhance technological innovation and green jobs, which could better position the country for 'riding the green wave.'

More efficient use of FYR Macedonia's somewhat scarce natural resource assets is necessary, both to support economic growth in future decades as well as to allow a greener and more resilient path. This concern pertains especially to water and agriculture, energy, transport, urban planning, and the control of air pollution. In the water sector, FYR Macedonia is already experiencing moderate water stress. Water consumers–irrigation, municipal and industrial users, and the power sector–are facing seasonal water shortages. The consequences include agricultural yields below those in similar countries; poor quality water for municipal and industrial users, as well as insufficient quantity to thermal generation plants for cooling; and a low capacity factor of hydropower generation. A hotter, drier climate will damage infrastructure, including in transport, imposing costs on users and on the public budget. Climate-driven constraints on hydropower, in turn, limit options for a cleaner energy sector, with more supply—and more dependable supply—but fewer greenhouse gas emissions. The bounds for economical mitigation in FYR Macedonia's energy sector push responsibility for mitigation onto the transport sector, the next highest emitter. Urban public transport, in particular, needs boosting, since the trend towards sprawling development and fast-rising personal mobility portend sharply-rising emissions, in future decades. Local co-benefits such as reduced air pollution, currently taking a large toll on health, could justify and motivate otherwise expensive urban improvements. Across all these challenges lies the common thread of public policy and public investments, where choices supportive of a greener growth path will prove pivotal.

- In the **water** sector, assets are not performing as expected, and the system of irrigation is outdated. The cumulative required maintenance and needed rehabilitation of water sector infrastructure total almost four percent of GDP. Water prices are set below costs, driving up sector financial losses and further delaying overdue investment. Agriculture, mining, and industry, in an attempt to avoid economic losses

SUMMARY FIGURE C. **The Macedonian economy has high emissions intensity, although it produces limited total emissions due to its size**

Emissions intensity (Greenhouse Gases, GHG, per unit GDP), per capita GDP, and total emissions, 2005



Note: Total emissions Include CO_2, methane, HFC, NOx, PFC and SF6; total in the economy (from all sectors). Bubble size reflects total emissions, in Mt CO_2e/year.
Source: World Bank, Development Data Platform.

due to irregular supply from water utilities, have turned to widespread and unsustainable use of groundwater. Starting from a situation of moderate water stress, FYR Macedonia faces a drier and hotter climate in the future, with water supply shortages likely for all water-consuming sectors unless adaptation actions are undertaken.

- **Agriculture** is a major employer, with almost one-third of the labor force by some estimates, but it is also the economic sector most directly harmed by a changing climate. Both water scarcity and water demand for irrigation are predicted to rise. Irrigation is already insufficient and poorly designed for today's small farms. Many farms depend on local wells and unsustainable extracted groundwater, which is neither regulated nor priced. Soil fertility problems will worsen with a changing climate, especially erosion. Small and fragmented farms and inadequate land markets limit agricultural productivity, while government subsidy programs are poorly designed to achieve their stated objectives.

- In the **energy sector**, indigenous fossil fuel resources are limited to lignite, and the remaining lignite will be fully exploited within the next 30-45 years.[4] At the same time, the energy sector heavily depends on domestic lignite. With too little investment in generation from other potential sources,[5] and limited energy choices, FYR Macedonia faces deteriorating security of supply. Electricity demand has exceeded supply for a decade and the gap has been filled with power imports at a price well above domestic costs. In addition, the lignite-based energy sector–with lignite constituting 50 percent of primary energy— is very emissions-intensive and responsible for some 70 percent of the overall carbon dioxide equivalent (CO_2e) emissions[6] in the country (Summary Figure D). Imported oil further adds to the emissions intensity of energy while gas imports are negligible and constitute only 2 percent of primary energy. Predominant use of outdated devices and processes to utilize energy causes the inefficiencies in the sector. In addition, power sector tariff reform has been underway over the last decade, but electricity prices do not yet reflect the cost of supply. Gas sector liberalization is planned but overdue. Artificially high prices, an outcome of the modest levels of off-take, have so far limited demand for gas and delayed the partial replacement of lignite and oil with cheaper gas in the primary energy mix. The result is that the ratio of greenhouse gas emissions to GDP is five times higher than the EU average.

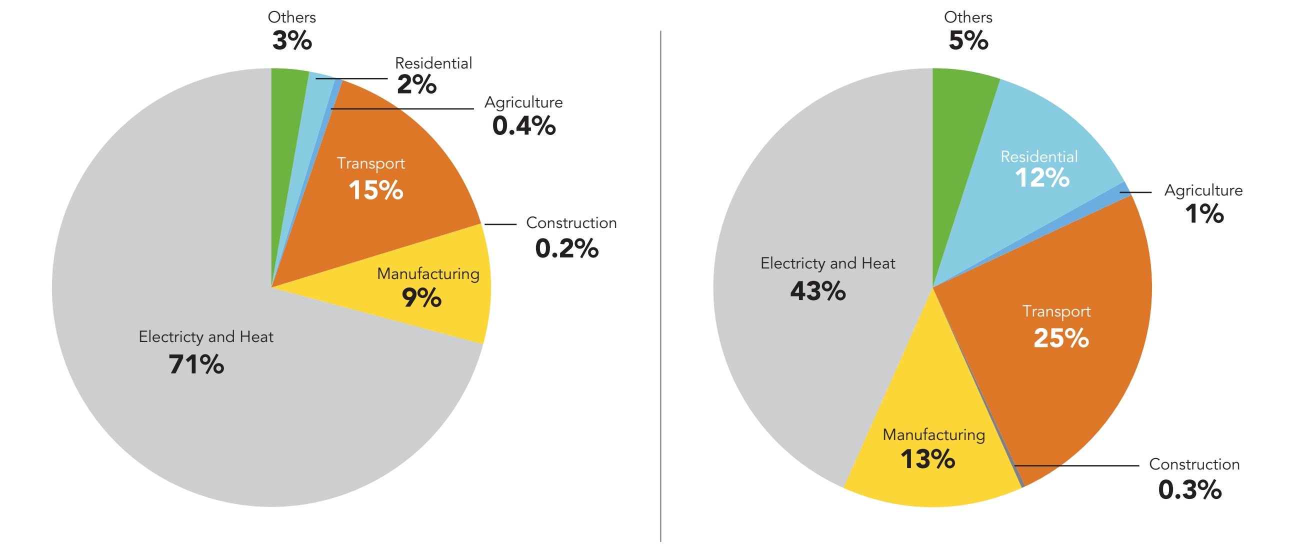
4. Assuming a 3 percent growth rate of lignite production, a rate consistent with the Government strategy.

5. The options considered are: domestic hydro, wind, solar, geothermal, biomass and biogas, as well as imported gas. See more detail in the next sections of the Report Summary and in Chapter 6 on energy.

6. Carbon dioxide equivalent or CO_2e is a standard unit to express emissions or concentrations of other greenhouse gases reflecting their global warming potential compared to CO_2.

SUMMARY FIGURE D. **Macedonian energy sector is the top emitter**

CO_2e emissions for FYR Macedonia and the EU, shares, 2009



Notes: Energy sector refers to electricity and heat production and energy sector own use; transport sector includes all transport activity regardless of the economic sector; residential refers to emissions from fuel combustion in households; "Other" includes commercial/institutional activities, fishing and emissions not specified elsewhere.
Source: Staff calculations using the International Energy Agency (IEA) database.

- In the **transport** sector, the poor condition of roads and rail infrastructure, an old vehicle fleet, and the lack of public transportation prevent the sector from providing efficient and appropriate services to the rest of the economy. Transport is emissions-intensive compared with other countries in the region. Its contribution to global warming and local air pollution significantly exceeds the technically unavoidable level. The sector is the second highest emitter in FYR Macedonia, following the energy sector; it produces about 15 percent of total greenhouse gas emissions. A high and growing share of road transport and the prevalence of old vehicles are the main factors in high sector emissions. The same factors render the sector vulnerable to climate change, abetted by low infrastructure quality.

- In the **urban sector**, inefficient use of land is reflected in urban sprawl, which leads to excessive use of energy, pushes up the cost of infrastructure services and spurs further growth of personal car ownership, which in turn exacerbates emissions. Urban development also suffers from interruptions of water supply, lack of wastewater treatment and irregular solid waste collection, interruptions of the power supply, and a dearth of public transportation.

- Vulnerability of **infrastructure** to weather is rising significantly because of climate change, including risks to power plants and transmission lines, telephone lines, roads, rail, airports, ports, water/sewer infrastructure, hospitals, health facilities, school buildings, municipal infrastructure, and urban storm water drainage. Strategies need to be developed to maintain infrastructure services into the future by applying either: (i) an adaptive strategy under which new infrastructure is built tougher, but more expensively; or (ii) a reactive strategy to wait for climate damage to occur and then fix or replace the infrastructure. The adaptation strategy involves high up-front investment but lower costs during the planned life of the asset. The reactive strategy requires higher costs later to maintain, rehabilitate or replace damaged infrastructure before the end of its economic life. The choice between the adaptive and reactive strategies is complicated by two considerations: a wide range of projections of the future climate and the long life of infrastructure assets, most of which cannot be easily upgraded.

- Driven by larger cities, mainly Skopje, the **air pollution** level in the country is one of the highest in Europe, resulting in the fifth highest air pollution-related death rate in Europe. A main culprit is the widespread use of wood for winter heating by urban households.

METHODOLOGY AND MAIN FINDINGS

Methodology

The analysis completed for this report responded to the challenges identified in the initial stages of sector assessments, and many different models and tools were used. Summary Table A (at the end of this Summary) presents the main characteristics of the analytic approach for each sector or issue. Analysis in each sector used available tools judged appropriate to the objectives, which included modeling (for macroeconomic analysis and setting the baseline for all analyses, and in the energy sector, transport sector, water sector, agriculture, and infrastructure); data collection and a decision-making tool (the urban sector), exposure-response functions (for air pollution analysis), and participatory tools (for social inclusion). While objectives were similar, the methodologies were customized as needed. Summary Table B summarizes the modeling scenarios. Modeling involved formulating three scenarios—Business as Usual, Green and Super Green—and using them to estimate the benefits of Green Growth, as is briefly explained in Summary Box A. A number of innovative elements across sectors were integrated in the analytic methodology, and critical new data was collected.

Water modelling linked sectors critical in adaptation and mitigation and allowed the assessment of water as a constraint to growth, assessing the impact of a changing climate on competing uses of water. A series of models were applied, starting from Global Circulation Models, to water planning, water run-off, and an agricultural yield model. The impact of green (adaptation) policies and investments on the water sector and the two main water consuming sectors– agriculture and power– was evaluated; and an optimal set of adaptation investments was linked to the macroeconomic modeling. The modeling outcomes provided new knowledge due to innovations in the way the modeling tools were interlinked and the detailed findings generated. As a result, the outcomes reflected not only the impact of runoff and irrigation water demand on water storage, hydropower potential and water availability, as did previous studies utilizing the same models, but also the reverse impact of the unmet irrigation demand on crop yields in irrigated areas. Further, water modeling included hydropower as a water-consuming sector, which was an innovative approach allowing for an estimate of an interconnection between hydropower and irrigation water consumption and, in particular, the negative impact of increased hydro production and newly deployed hydro plants on agricultural yields. In addition, the water analysis generated detailed data for sixteen water basins, using climate projections from global models and hydro-meteorological data for FYR Macedonia, as opposed to the previously available data for five basins, allowing for better and more practical policy recommendations.

In the energy sector, the main objectives were to find the optimal mix for power supply in FYR Macedonia by ensuring minimum cost of supply while reducing emissions, as well as to find demand-side energy saving solutions. Demand-side modeling estimated the potential reduction in energy demand as a result of energy efficiency improvements, applying an energy demand model, EFFECT ((Energy Forecasting Framework and Emissions Consensus Tool, developed by the World Bank). Supply-side modeling via a MARKAL energy supply model (developed by the IEA), provided power supply generation mixes to meet the new demand at minimum cost while reducing GHG emissions. A Marginal Abatement Cost (MAC) curve presents a standard summary of each of the proposed energy efficiency measures and supply technologies with marginal net cost per unit of abatement and the related abatement potential. The optimal mitigation investments were linked to the macroeconomic modeling. Substantial data collection, including a new household survey, created the country's first energy efficiency database.

In the transport sector, the impact of green policies and investments on transport demand and resulting emissions, as well as cost effectiveness of the proposed investments and policies, were assessed using transport sector models, the European Commission's TREMOVE (economic TRansport and EMissions model) and TRANSTOOLs (TOOLS for TRansport Forecasting ANd Scenario testing). Also, the EFFECT tool was first extended to include the railway sector, and new data was collected through a passenger vehicle survey (adding to the new energy efficiency database). Then, the tool was applied to assess green policy interventions and their potential impact on road and rail travel demand, on fleet composition, and on the level of emissions. The optimal mitigation investments were linked to the macroeconomic modeling. Modeling was complemented by vulnerability analysis which evaluated the transport sector's climate change sensitivities and climate change related increase in costs.

In the urban sector, the objective of the analysis was to prioritize the most urgent issues of urban development that need to be addressed in the context of green growth. The analysis was designed to assess the impact of urban policies and investments. The Tool for Rapid Assessment of City Energy (TRACE, developed by the World Bank) was used for in-depth city-level analysis of Skopje: assessing potential energy and cost savings from implementing cross-sectoral energy efficiency measures and for prioritizing policies and investments across sectors. The analysis included the following municipal service areas: urban transport, municipal buildings, water and wastewater, power and heat, street lighting, and solid waste management. The urban sector data collection tool also collected new data useful for sector strategic planning for a number of Macedonian cities. Rapid assessments were conducted in some other Macedonian cities and helped to propose relevant actions and prioritize them.

The infrastructure analysis developed a framework for decision-making about long-lived infrastructure assets despite uncertainty about future climate conditions. The methodology combined cost-benefit analysis under uncertainty, climate-informed decision analysis, and robust decision-making. The analysis applies a cost-benefit approach over a range of climate scenarios to identify robust options and then identifying a subset of options likely to yield satisfactory results under a range of climate outcomes. These adaptation assessments were linked into the macroeconomic modeling.

The air pollution analysis was designed to estimate the health impacts of air pollution in FYR Macedonia and the cost of these impacts to society using standard tools. It used exposure-response functions that quantify the relationship between the exposure to particulate matter and mortality/morbidity, to aggregate the impact of pollution on public health.

Social participation was considered by applying Participatory Scenario Development (PSD) methodology, which the government can use as one of the instruments of green growth decision-making. Participatory methodology aimed at improving government decision-making on green growth policies and implementation was tested. Pilot participatory scenario development workshops were held with local and regional stakeholders who discussed major challenges related to climate change and environment and policy options for a green transition.

The innovative aspect of the macroeconomic modeling was the integration of both mitigation and adaptation investments into an economy-wide model to assess the impact on growth, employment, and fiscal balances of climate action in water, agriculture, infrastructure, energy, and transport. This modeling brings together much of the sector analysis into a common framework to assess the net impact on growth and employment of packages of actions on green growth across sectors as well as assessing public investment options. Putting the sectors together provides the government with a potentially powerful tool to consider which public investments will have the highest returns over time, including investments to counter climate change and investments to reduce greenhouse gas emissions. Macroeconomic modeling developed a dynamic general equilibrium model with detailed sectors to simulate green scenarios against the baseline. The Macroeconomic Options of Mitigation and Adaptation model (MOMA model) captures the complex linkages between climate mitigation and adaptation policies and macroeconomic performance. This large-scale dynamic stochastic general equilibrium model integrates detailed engineering options for mitigating greenhouse gases and for adaptation. The options were analyzed by the MOMA model, not only in a 'bottom-up' manner (for agriculture and water, energy and transport) but also econometrically in a 'top-down' manner (for facilities of physical infrastructure). Mitigation and adaptation options were integrated into the model to allow analysis of the growth, employment, and fiscal implications of different combinations of green growth actions. Advice on public investment priorities emerges from the assessment.

SUMMARY BOX A. Green scenarios: a basic explanation

Scenario analysis is used to evaluate the impact of mitigation and/or adaptation actions in five overlapping sectors—water, agriculture, energy, transport, and infrastructure—which are then integrated into the macroeconomic or economy-wide analysis. Two policy scenarios—**Green** and **Super Green**—were formulated in a bottom-up fashion based on the specifics of each sector as part of the sector analysis. These scenarios are compared to **Business-as-Usual** (BAU) or the baseline scenario, a development path for the economy to 2050, which assumes sectoral inefficiencies are addressed and includes the main projected impacts of climate damages. The Green and Super Green scenarios involve government policies and investments to address greenhouse gas emissions mitigation and adaptation to climate damages. The Green scenarios in each sector constitute a package of ambitious but practical actions to reduce emissions and counter climate change. The Super Green scenarios are very ambitious and more expensive packages, generally requiring more aggressive implementation of Green measures or wider coverage of such measures. See Summary Table B for the main policy and investment elements of the green and super green scenarios.

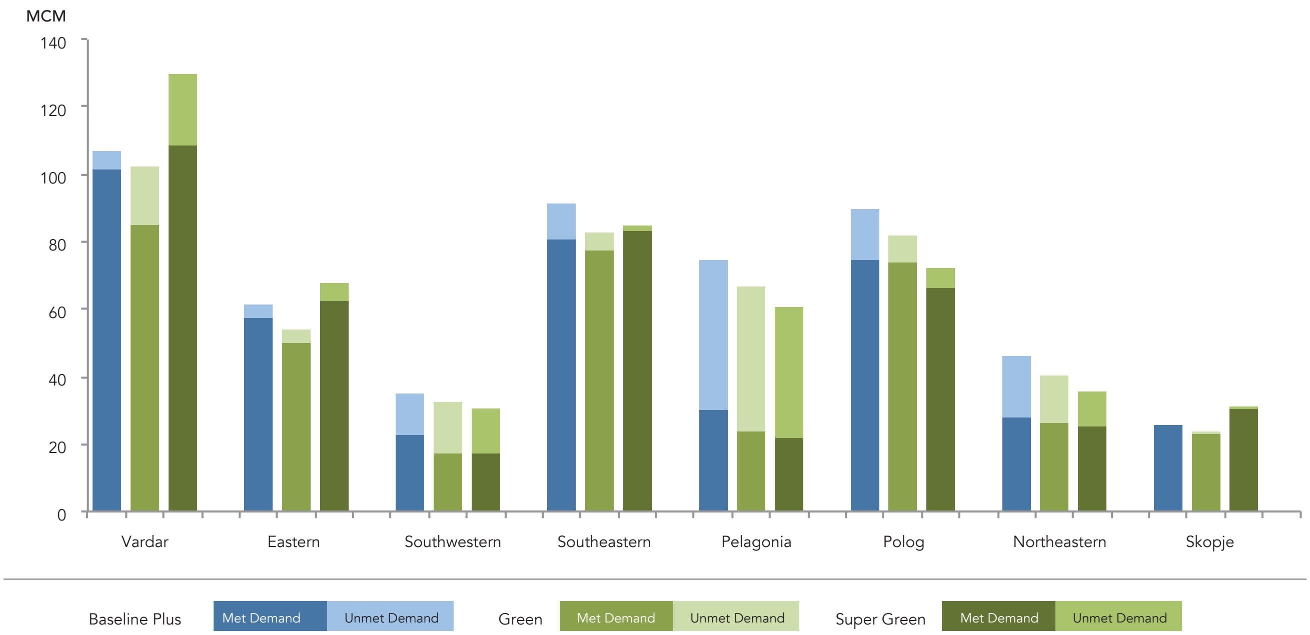
Main findings

Baseline scenario. The baseline scenario that has been generated as part of this assessment forms an essential starting point for the green growth analysis. It is a hypothetical path envisaging what would happen to FYR Macedonia until 2050 under current and expected policies and considering the impact on the economy of a changing climate. The business-as-usual (BAU) scenario reflects a broad consensus that income per capita in FYR Macedonia will catch up gradually towards European Union levels, growing at an annual average rate of 3.4 percent between 2012 and 2050. However, such a path assumes a gradual improvement in policies and performance over the long-term. At the same time, projected climate change will affect FYR Macedonia's economy, mainly via a direct shock to agriculture and associated spillovers on other sectors in the economy. These losses are projected to increase in absolute value, but they will decrease as a share of GDP because of the shrinking role of agriculture over the next four decades. Due to climate damage, the level of GDP in 2050 is estimated at around 0.6 percent lower than otherwise. It is critical to keep in mind that, for the baseline scenario to 2050 to materialize, *key sectoral inefficiencies will need to be addressed,* including dilapidated infrastructure, high supply losses, inefficient pricing of services and low quality of service provision.

Water. Water shortages will worsen into the future; and, despite action on adaptation, gaps between supply and demand will persist, especially for some basins. The overall demand-supply gap in the water sector must be managed through green actions in all water-using sectors, with a big emphasis on improving efficiency and strengthening conservation. Green action can constrain irrigation water demand only modestly but with high variance across basins. In irrigation, green (adaptation) investments will reduce water demand by implementing basin-scale irrigation improvements and drainage infrastructure upgrades, replacing and rehabilitating broken-down assets of the current irrigation infrastructure and creating a new irrigation system, adequate for a modern system of farming. Summary Figure E shows the variation across the country in unmet irrigation water demand under different policy scenarios. For the country as a whole, the package of Green adaptation measures reduces irrigation water demand by about nine percent for the next 40 years while the Super Green scenario has an impact of only five percent or so because of new irrigation in certain basins (in the Vardar, Skopje, and Eastern regions). Despite adaptation measures, a changing climate will affect the availability of cooling water for some thermoelectric power plants, and the expansion of hydropower that will help clean up the energy sector will not be possible without coordinated water-saving measures across sectors. An ambitious Super Green program of adaptation action can reduce total unmet water demand by more than half by 2050.

SUMMARY FIGURE E. Green actions help reduce demand-supply gaps for irrigation water

Met and unmet demand for irrigation water, by planning region, in MCM, 2050



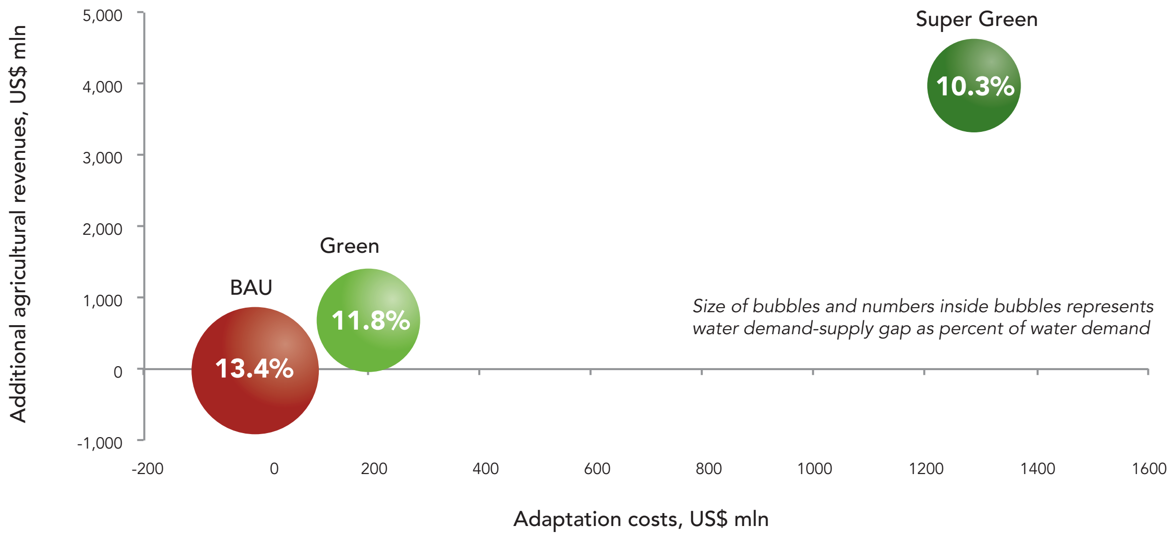
Notes: MCM is millions of cubic meters. The light shading is unmet irrigation demand while the dark is met demand.
Source: Agriculture sector technical paper and presentations.

Agriculture. **Climate change will pose tough challenges for agriculture which will require resolution of today's obstacles as well good choices on adaptation.** Although the economic importance of agriculture is likely to wane in coming decades, as overall growth pushes the Macedonian economy to look more like Europe, actions to contain irrigation demand while improving irrigation and overall sector efficiency and resiliency will be critical. The importance of irrigation water for the agriculture sector in largely arid FYR Macedonia cannot be overstated: climate change presents a risk of increased aridity and water shortages, particularly in the agricultural growing season, for most areas of the country. The water and agriculture modeling finds that adaptation expenditures are good investments. Significant adaptation effort under a Super Green scenario, with annual investment of about US$148 million in irrigation, drainage, improved crop varieties, and better agronomic practices yields benefits through 2050 that outweigh costs more than four-fold while closing the water demand-supply gap by almost one-quarter. Under both a more modest Green package of adaptation actions and the more ambitious Super Green package, crop yields and agricultural revenues rise, while with no action, incomes from agriculture would decrease by 17 percent by 2050 because of the impact of higher temperatures and reduced water availability. (Summary Figure F.)

Energy. **Aggressive energy efficiency measures will be critical to contain demand while investments in gas supply and renewables are important to clean up supply.** While demand-side actions are a critical short-term solution due to their lower cost and shorter implementation period, longer-term and investment-intensive supply-side measures provide the biggest gains in bridging the supply-demand gap and providing abatement. The outcomes of modeling show that the combination of the Super Green scenario's demand-side measures and the Green scenario's supply side measures is best in meeting jointly the strategic objective of supply security and the financial objective of minimizing abatement costs and is, therefore, recommended. By investing €800 million in Super Green demand measures, the required generation capacity can be reduced by 600MW and annual GHG emissions by 1.6 million metric tons by 2050. Under the Green supply scenario, the structure of supply by fuel will be very different from both the actual in 2009 and that projected for 2050 under BAU. It will be based on gas, which would constitute 83 percent of total supply, and have no lignite. The rest of the fuel mix will be hydro generation (15 percent) and other renewable sources (2 percent). This mix would significantly lower GHG emissions. Total GHG emissions in 2050 under the Green Supply scenario would amount to 4.2 $MtCO_2e$, down from 9.1 in the BAU scenario. (Summary Figure G.)

SUMMARY FIGURE F. **Adaptation efforts in green scenarios lead to increased revenue and improved irrigation efficiency**

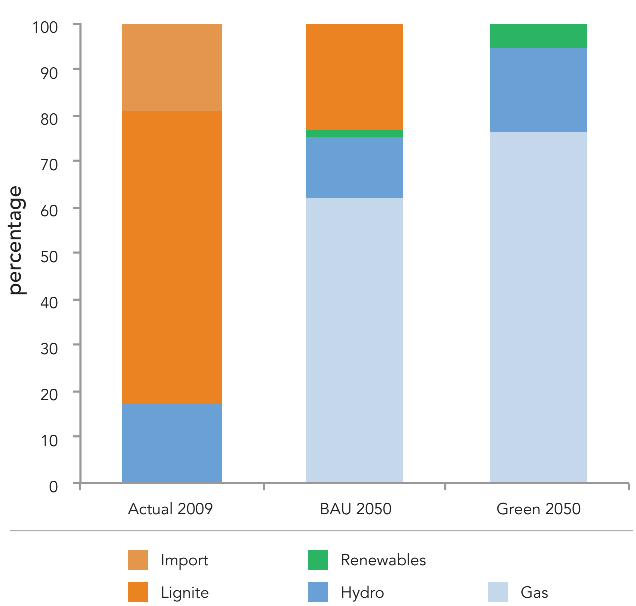
Impact of adaptation scenarios on agriculture, 2011-50



Notes: Costs are the present value over 2011 to 2050 of the flow of required additional expenditures (investment and O&M) compared to BAU. Revenues are the present value over 2011 to 2050 of the flow of the incremental sector revenues. Water demand-supply gap is the difference between water demand and supply (deficit), presented as percentage of demand.
Source: Staff calculations based on water and agriculture sector modelling outcomes

SUMMARY FIGURE G. **Energy: development of gas supply will help to replace lignite and oil with gas**

Power generation mix, actual in 2009 and by scenario in 2050



Source: Staff calculations based on energy sector supply-side modeling outcomes.

The energy sector Marginal Abatement Cost (MAC) curve ranks GHG mitigation measures from both demand and supply from least to most expensive. The curve uses two characteristics of the green scenarios and technologies within proposed new supply capacity: the unit cost of abatement (present value[7] of net investment cost[8] per unit of abated carbon (CO_2e)) and abatement potential ($MtCO_2e$) of each proposed green measure for 2010-2050. **Among all supply side technologies that are included in additional generation capacity in the green scenarios, the most cost efficient ones are new gas capacity, new hydro capacity and new nuclear capacity**—those with low net unit cost of abatement and high abatement potential.[9] Both demand scenarios, Green and Super Green, are very efficient–they have a negative net unit cost of abatement and high abatement potential (Summary Figure H).

Transport. Green policies such as vehicle fuel efficiency measures and investment in railways significantly reduce the rate of emissions growth; however, the level of emissions level compared with 2010 (Summary Figure I). Modeling outcomes show that the main drivers of emissions are the

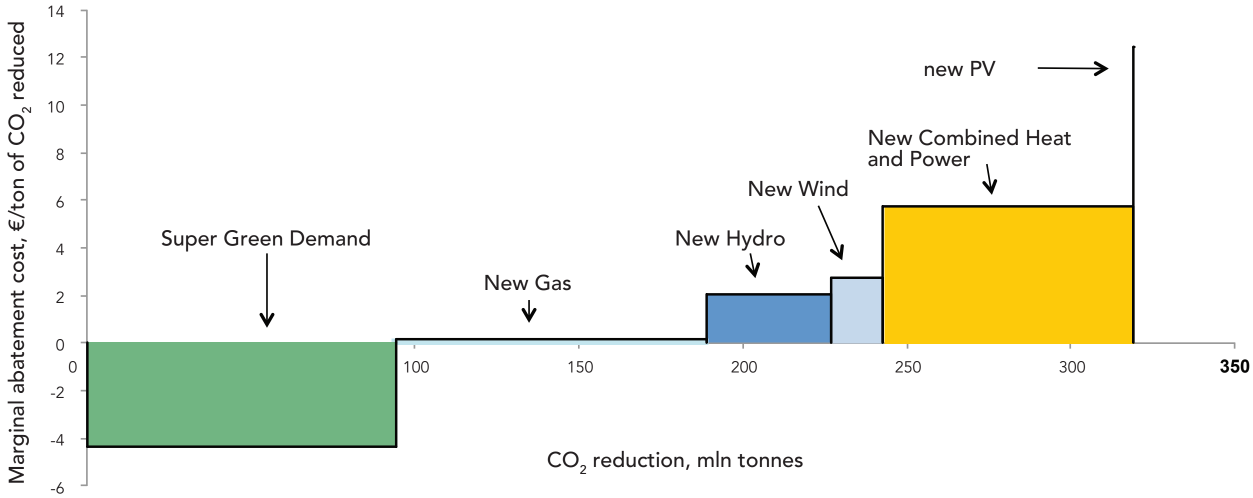
7. Capital and operational costs net of revenue discounted to 2010 at 6% rate.

8. In the transport sector analysis, policies were included in addition to proposed investments. This approach is not traditional and was used because in the FYR Macedonia transport reform, the emphasis in the road segment of the sector is on policy incentives.

9. Nuclear power is a technically available option that warranted consideration in the analysis.

SUMMARY FIGURE H. Energy: new gas and energy efficiency measures provide most cost efficient abatement

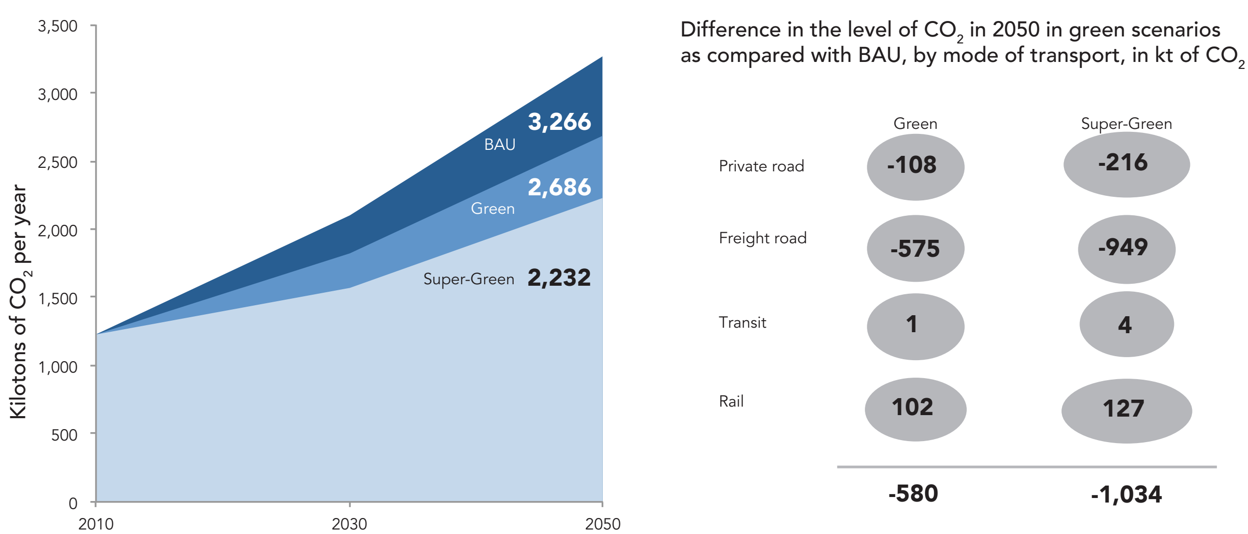
Marginal abatement cost (MAC) curve for supply technologies and energy efficiency (demand) measures, cumulative 2012-2050



Source: Staff calculations based on energy sector modeling outcomes.

SUMMARY FIGURE I. Transport: green policies limit emission growth, but do not achieve an absolute reduction of emissions

Projected land transport emission levels by scenario, in kilotons of CO_2e per year, and emission reduction in green scenarios in 2050 as % of BAU emissions



Source: Transport sector modelling outcomes, Transport sector technical paper.

old vehicle **fleet**, increasing private ownership of vehicles, low availability of public transportation, and a high road transport share. **The Fuel Efficiency package delivers the highest benefits and is most cost efficient**. It consists of policy options that create incentives to use less fuel, either by using fuel-efficient technologies/driving mode, or by driving less, and includes such measures as a pricing signal (adjusting the fuel price and/or tax), encouraging purchase of fuel-efficient vehicles, eco-driving information campaigns and training, and use of vehicle trains.[10] **The Rail Investment package provides the next highest benefits after the Fuel Efficiency package.** This policy option is aimed mainly at increasing the availability of both freight and passenger rail service, together with increased energy efficiency of rail. Rail investment will result in significant co-benefits including reduced congestion, increased road safety, and lowered air pollution levels. **The Urban Development package** is characterized by mutual complementarity of its policies. Many of the Urban Development policies support each other and are not as beneficial individually as they are together. Measures include parking management improvements (Skopje), behavior change and travel planning, investment in urban and inter-urban transit, and land use planning and regulation. A simple **vulnerability analysis** concludes that the main concern regarding transport sector sensitivity to climate change is related to the projected increase in temperatures and precipitation, which will push costs up.

Urban. Urban sprawl increases per capita emissions and drives up the cost of public service delivery. FYR Macedonia's cities, especially Skopje, are sprawling and losing density. Urban sprawl leads to increased emissions and problems with public service delivery pushing their cost up and their quality down. The main source of increased urban emissions is a growing number of urban single family houses that use wood for heating and cooking. Problems with service delivery are related to a larger city territory, which means that such networks as transportation, water and sanitation, solid waste collection, roads, street lighting and other infrastructure need to be expanded in areas with lower population density and therefore higher per household service cost. Buildings insulation and increased energy efficiency of street lighting could help reduce emissions significantly. Street lighting energy efficiency improvements also have considerable cost savings potential. Emissions from urban transport are driven by an increase in private car ownership and old vehicle fleet in both private and public segments. Public transport is old and emission intensive, but the first steps to improve the situation have been made. Limited wastewater treatment has become a major source of water pollution. GHG emissions from waste have been increasing in the transition years due to rising waste quantities and inappropriate disposal practices. Municipal water supply in FYR Macedonia suffers from high technical losses and low revenue collection.

Air pollution. Particulate matter (PM) in the air is responsible for over 1350 deaths in FYR Macedonia annually and thousands of lost work days, with economic costs equivalent to 3.2 percent of GDP. Most of PM pollution is generated by five economic activities in a few largest industrial facilities, as well as in the road sector and in the household sector. The economic activities with highest particulate emission concentration are ferroalloy production, electricity and heat production, energy combustion in the non-ferrous metals industry, road paving and wood combustion by households. Emissions are concentrated in particular production facilities and three large industrial emitters are responsible for 92 percent of emissions from large emitters: Jugohrom Ferroalloys near Tetovo (metallurgy), REK Oslomej, and Bitola (energy). PM pollution can be reduced by 80-90 percent using available technologies in the industry and the road sector and by government programs supporting usage of modern fuel-efficient stoves in the household sector. Pollution can also be geographically targeted, as almost half of the health impact occurs in Skopje and several local production zones. Also, at least one-third of PM emissions may come from transboundary sources, and regional agreements are needed to control them. Lowering PM_{10} and $PM_{2.5}$ to EU limit values would result in avoiding over 800 deaths and thousands of days in lost productivity, representing a health cost savings of €151 million per year. (Summary Figure J).

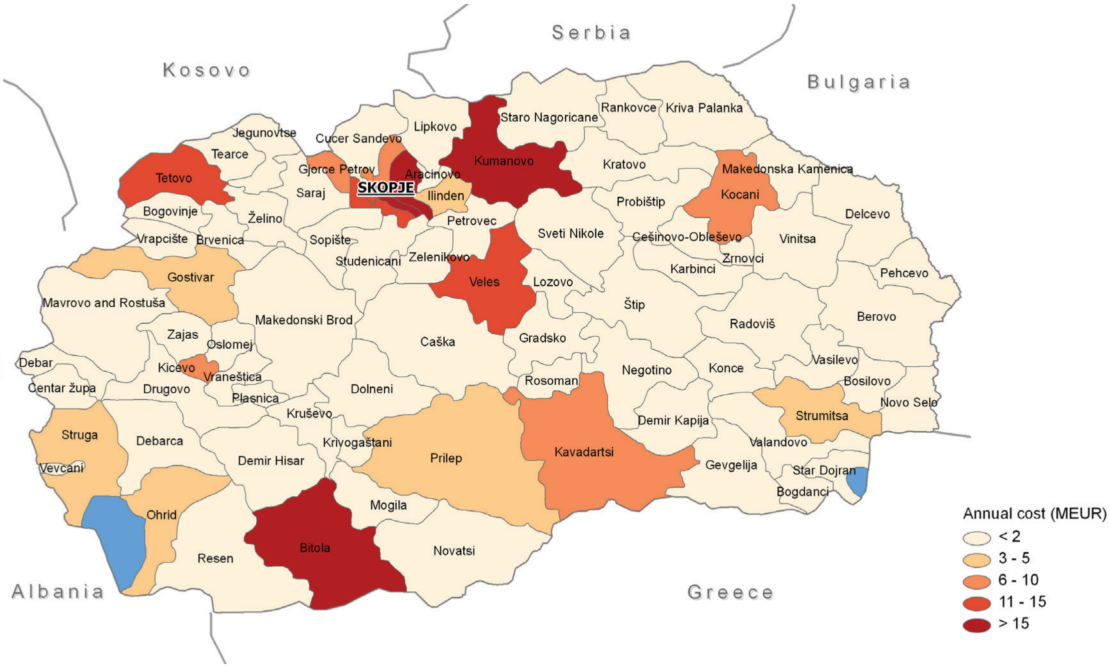
Social participation. The piloting of the Participatory Scenario Development (PSD) approach demonstrated its usefulness for participatory decision making. If used as a part of green growth strategy design, PSD will increase the sustainability of green growth measures by providing a tool for stakeholder consultations early on in the process and by increasing awareness about climate change. The PSD workshop discussions provided information about the level of awareness of the green growth concept; the potential impact on vulnerable groups including farmers and socially-disadvantaged groups such as the unemployed, disabled, elderly, children, rural women and farmers, and the need for social protection strategies; the potential impact on employment and the need for programs aimed at creating new skills and knowledge to adapt to new conditions; and the requirements for local capacity for planning and implementing green growth strategies.

Macroeconomic modeling. Mitigation measures enabling 40 to 70 percent reduction in emissions by 2030 costs about one

10. Vehicle trains are groups (platoons) of vehicles electronically connected together with a single manually-driven lead vehicle. This technology is new and currently undergoing trial, it is assumed available only starting in 2020. Each vehicle taking part is very conservatively assumed to achieve a 10 percent reduction in fuel use.

SUMMARY FIGURE J. Air pollution: Skopje, Bitola, Kumanovo, Tetovo, and Veles suffer the worst health impact

Economic cost of PM air pollution, € million

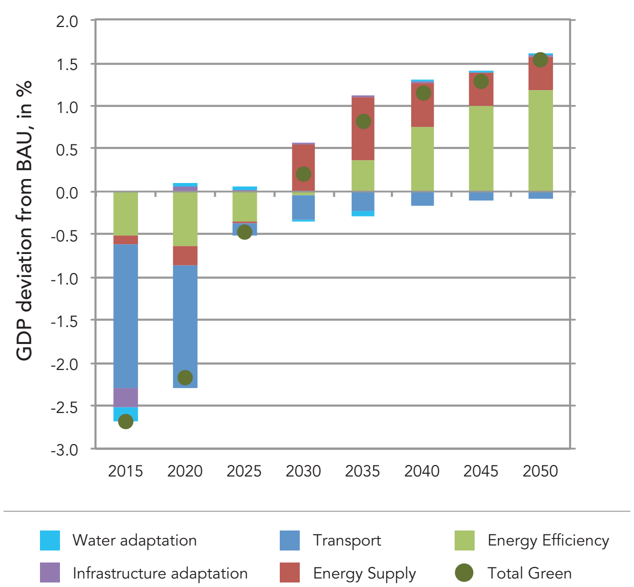


Source: Air pollution technical paper.

to two percent of GDP in incremental investment costs while adaptation measures in the water and agriculture sectors are profitable even at a high discount rate. The Green and Super Green scenarios, derived from the sector analyses, reflect ambitious and very ambitious climate action. The mitigation measures, mainly in energy, enable impressive 40 percent and 70 percent reductions in GHG emissions starting in the early 2030s, in the Green and Super Green scenarios respectively, measured relative to BAU (the business-as-usual scenario including the impact of a changing climate). A precautionary set of adaptation measures were selected in water and agriculture based on financial assessments (including benefit-cost ratios and NPVs) and in infrastructure based on positive rates of return. Implementation of the Green package of policies and investments will dampen GDP by 2.7 percent in the short-term but boost GDP by 1.5 percent of GDP by 2050 (Summary Figure K), while Super Green implementation will undercut GDP by almost seven percent in the short-term, but increase it by 1.3 percent by 2050. The ('bottom-up') estimates of costs of adaptation in the water sector were revealed to be of much higher magnitude than the ('top-down') costs of protecting infrastructure facilities; while for mitigation actions, the model finds that energy efficiency measures are most promising from a long-term growth perspective. The interventions proposed for transport seem to be prohibitively costly, but there is an

SUMMARY FIGURE K. Implementation of green packages of measures will dampen GDP in the short term, but then boost it

Macroeconomic modeling: decomposition of GDP impact of Green scenario



Source: Staff calculations based on macroeconomic modeling outcomes, Macroeconomic technical paper.

important caveat in this interpretation as local benefits of a modernized transport infrastructure were omitted. In the Super Green package, the economic effects are of similar pattern but of a higher magnitude.

Recommendations

The recommendations include both baseline sectoral reforms that should be implemented regardless of the green growth agenda as well as green actions needed to move the country to a greener growth path. The baseline reforms and investments would aim at improving the overall performance of key sectors and would constitute conditions for the effective implementation of green growth policies and investments. The baseline actions need to be taken before the country invests in greener growth. For example, baseline actions such as energy efficiency or water conservation should be adopted regardless of uncertainty about future climate. The next step would be to focus on green actions, including the necessity to adapt to a hotter drier climate and the obligations to mitigate greenhouse gas emissions. Adaptation actions form the core green agenda in sectors such as agriculture, water and physical infrastructure, while mitigation is critical in the energy and transport sectors.

Water. Top benefits in adaptation action will come from packaging together the green investments and policies identified in the analysis, thus enhancing their individual benefits. The growing scarcity of water can be addressed, first of all, by reducing inefficiencies through pricing and regulation of groundwater and through rehabilitation and maintenance of existing infrastructure. Growing seasonal scarcity can be managed through investment in more storage (for irrigation and for hydropower), while overall shortages in future decades can be addressed through encouragement of water conservation. Implementing measures aimed at municipal and industrial water conservation are also essential.

Agriculture. A more competitive, export-oriented agriculture sector in future decades will be possible only if adequate policies and investments are implemented and if adaptation measures are taken. In irrigation, adaptation investments in drainage infrastructure for irrigated areas will improve crop yields. Improved wheat varieties are another key modest adaptation measure. Under a stronger adaptation effort (the super green adaptation scenario), a package of expanded irrigation in some basins plus improved drainage infrastructure would provide major investment gains. In addition to investment in irrigation, other measures would bring important benefits, including: improved farm practices, greenhouse production, improved soil management, improved pasture management, land consolidation and land market improvements, and organic agriculture. Increased capacity of research and extension systems, incentives to adopt environmentally friendly practices, monitoring programs for soil, water, groundwater and biodiversity, improved hydro-meteorological capacity, and crop insurance would complement the key investments in adaptation.

Energy. The combination of ambitious (Green) supply and very ambitious (Super Green) demand measures delivers the best results in 2050, balancing security of supply, overall cost, unit investment costs, and unit cost of abatement. As part of the Green supply scenario, aggressive development of gas supply is recommended such that gas completely replaces lignite once the existing lignite plants reach the end of their economic life. This shift implies construction of new gas generation plants, of a new cross-border gas pipe line, of new transmission and distribution lines, and of new gas supply infrastructure. In addition, new hydropower and wind plants would be constructed. The key enabling policies on the supply side include developing a regional strategy and implementation plan for gas supply, addressing potential private investors' concerns about investing in hydropower, and ensuring that incentive schemes deliver renewables in the most cost-effective manner.[11] On the demand side, standard energy efficiency measures that have proved to be cost-efficient in other countries should be implemented as quickly and broadly as possible. Key elements of a successful energy efficiency strategy are strengthened institutional capability to design and implement energy efficiency programs; available low-cost capital for capital intensive, long-payback measures such as building retrofits; and utilities involved as intermediaries between the government and customers in energy efficiency programs.

Transport. Based on the outcomes of the analysis, two action plans were developed: a mitigation action plan aimed at reducing transport sector emissions and a climate adaptation plan. The proposed mitigation action plan recommends the following actions as bearing the greatest benefits: pricing signal, encouraging purchase of fuel efficient vehicles, rail investment, parking management (Skopje), investment in urban and inter-urban transit, and behavior change. **The main areas of concern coincide with the top drivers of emissions. Many of them should be addressed using policy incentives.** These include an old vehicle fleet and increasing private ownership of vehicles. They should be dealt with using such behavioral incentives as regulations, taxes, fees and pricing aimed at encouraging replacement of old vehicles with the ones that are newer and more fuel efficient (at a faster pace than current turnover) and at achieving reduction in driving time per vehicle, as well as in

11. The current level of feed-in-tariffs is extremely high, reaching up to 10 times the price currently paid by households for power.

driving in the city centers. **Investment is needed to address other emission drivers within the proposed action plan to reduce emissions.** In particular, this relates to recommended rail infrastructure and service development, which would provide a lower-emission alternative to road transport, both passenger and freight. Investment is also needed to revive public transport in Skopje, a clear alternative to private road transport, which can be developed faster and at a much lower cost than rail. Yet another investment recommended would help with the re-design of the city centers and improvements in sector management (parking management, urban traffic management systems). **A climate change adaptation plan's** measures mostly relate to the implementation of existing standards on local roads and improvement of road surface. Further improvements, using new pavement materials and implementation of new standards, may be required in order to adapt to future changes in climate.

Urban. **Recommended priority areas for intervention** include investment in public transportation and in water and wastewater networks rehabilitation, establishment of integrated regional waste management systems and expansion of energy efficiency programs. In **urban planning**, it would be important to develop integrated urban plans and provide incentives to make city centers more livable. This would decrease urban sprawl. Local authorities can influence dwelling patterns through investment decisions and urban planning that provide incentives for citizens and businesses to stay in the core city. This will require integrated planning across departments in city administration and better enforcement of existing planning regulations: building permits, parking zones, and business licenses. In the **public transport sector**, it is necessary to improve coverage and quality of public transport and invest in non-motorized transport modes. **Energy efficiency** improvement programs need to go beyond Skopje and other pilot cities. Investing in **water network rehabilitation and metering** would help reduce losses and increase cost recovery. In the **wastewater sector**, access to available grant funding to invest in wastewater treatment infrastructure is needed. In the **solid waste sector**, it would be beneficial to accelerate establishing integrated regional waste management systems.

Infrastructure. The infrastructure assets included in the analysis formed two groups: those where the **adaptation strategy** will be most beneficial and those where **reactive** strategy will be best. Adaptation is preferred for urban drainage systems, health and educational facilities and municipal buildings. In these sectors, design standards and O&M practices should be modified based on anticipated climate change. The reactive approach is better for roads, power, telecoms, water and sewer networks, and non-road transport, where enhanced maintenance and upgrades will be used to respond to future weather stresses. Monitoring weather outcomes and updating climate projections using the data collected will be an essential element of any set of adaptation policies. Assessment of the optimal choices for adaptation in infrastructure assets must also be updated regularly.

Air Pollution. **Reduction of pollution from ferroalloys and non-ferrous metal production is a priority,** since it constitutes a large share of overall pollution. Air pollution can be reduced using modern equipment. For example, in the biggest polluter Jugohrom Ferroalloy's, emissions could be reduced by up to 80 percent through such measures as low energy scrubbers, sealed furnaces and enclosed product transfer (e.g., conveyor) systems. In the **energy sector,** the major heat and energy suppliers need to undertake new investments to reduce emissions from existing sources and switching to natural gas. Emissions from public electricity and heat production could be reduced up to 80 percent through the installation of pollution abatement equipment and fuel switching. The primary fuel source in FYR Macedonia is high emission lignite. In addition, outdated plant equipment exacerbates the problem. In the **road sector**, installation of dust collectors and fabric filters in asphalt mixing plants is essential to reduce emissions. Many of these technological solutions can reduce emissions by over 90 percent. In the **household sector,** new modern stoves should be used to replace the currently inefficient ones. Some run on fuel such as concentrated wood pellets, can reach 80-90 percent efficiency and are associated with lower emissions of carbon monoxide, volatile organic compounds (VOCs), particulate matter and other hazardous air pollutants.

Social participation. **The piloted Participatory Scenario Development approach proved to be a valuable tool for participatory decision making. PSD should be used from early on and at all stages of the decision-making process in order to ensure full inclusion of stakeholder input into the country's Green Growth strategy and to maximize the level of population awareness of green growth measures.** Workshop outcomes should be analyzed, taking into account the location where they took place, representation of various social groups (by education, age, gender, income, professional affiliation) in each workshop, and the timing of the workshop in relation to major events that are relevant to the topics of workshop discussion. Then, the outcomes could be used at the local, as well as central, level and interpreted with better insight. The outcomes could be compared across the workshops to conclude which opinions are typical for the country and which could be representative for certain social groups and locations. The temporary impact of major events and their discussion in mass media could be separated from stable public opinion.

Macroeconomic modeling. Public investment choices on green actions can be guided by the findings produced by macroeconomic modeling. Adaptation interventions are less costly, and so more easily afforded than mitigation measures, both on the investments needed and the expected economic impacts. Within adaptation measures, public investments to prevent losses in agricultural production are significantly higher than those for maintenance of various infrastructure services. The investments in infrastructure resilience can be interpreted as a type of insurance against the risk that a changing climate will derail the country's growth in future decades by disrupting infrastructure services. From the viewpoint of cost efficiency and economic performance, the government's approach to mitigation should be equally selective and should focus first on energy efficiency. While foreign financing would counter the short-run costs to FYR Macedonia from green policies and investments, given the uncertainty of access to non-debt financing, including the availability of EU funds, domestic savings options are the most likely funding source over the near term. This fiscal constraint makes prioritization of public investments, including green investments, even more important since even the green scenario's relatively modest financing needs would constitute one-quarter to one-fifth of the annual public investment budget. Lastly, this assessment is not cast in stone. Many sources of uncertainty and several methodological issues remain in applying an economy-wide model such as MOMA, in conjunction with sector analytic approaches, to key green growth policy questions. Government commitment to ongoing and ever-improving in-country analyses to provide up-to-date assessments for their policy decisions will be essential. Technical assistance in building such tools with a working group drawn from across government and local institutions enables the government to apply such models to a variety of policy questions in the future.

Although the analysis synthesized in this report focuses on a greener development path for FYR Macedonia to 2050, more immediate advice for the government is also provided. The main focus of this green growth country assessment has been to lay out a long-term development path for FYR Macedonia that is greener and includes climate action. By developing a set of tools and models across eight sectors and issues, tied together with macroeconomic modelling, useful advice on priorities and sequencing could be generated for policymakers. As a first phase in focusing the many recommendations of this Program on the most needed actions in the next few years, Summary Table C divides actions recommended on the basis of both modeling and non-modeling analysis into two groups: 'no-regrets' actions and full-scale green growth actions. No-regrets actions combine two types of interventions. First, they include policies and investments essential for FYR Macedonia to realize the growth path set out in the baseline scenario, which moves the country forward on a convergence path towards Europe.[12] Second, they include recommended green actions that have relatively low costs and relatively low implementation barriers. Full-scale green actions include the remainder of green actions recommended based on the outcomes of Green and Super Green scenario modeling and sector analysis. The databases developed under the Program, especially the energy efficiency database, provide a strong starting point for additional analysis and monitoring.

Decisions being made today will amplify or diminish FYR Macedonia's opportunities to shift successfully to a greener growth path. The country needs to conserve relatively-scarce natural resources while supporting growth along a resilient path. Although greening is a long-term agenda, requiring a horizon that reaches out forty years or more, decisions on long-lived public investments and policies that shape the type and location of long-lived private investments as well as establishing directions for the economy will determine how green FYR Macedonia can be tomorrow. Assessing options on mitigation and adaptation is a critical first phase, hopefully quickly followed by a commitment to action. Continuing the benchmarking of the economy's greenness can then serve to monitor how the country is doing in the international context as well as contribute to tracking the impact of a green growth strategy. The longer term agenda needs to aim at preparing the Macedonian economy to thrive in a greening world. FYR Macedonia should aim not merely to attain the labor market flexibility and strong human capital, the efficient business environment and mature financial markets, to survive 'going green'. Rather, the country should aim at enhancing connections to global knowledge, fostering local technological innovation, and building green jobs, to better position the country for 'riding the green wave.'

12. The list is not exhaustive. Other challenges and imbalances that must be addressed include: inefficient industry, which uses outdated, energy-intensive and high-emissions equipment; substandard infrastructure in the water, agriculture, energy, transport, and urban sectors; high unemployment and somewhat inflexible labor markets; a low manufacturing export share; outdated telecommunications assets and low access to broadband; and insufficient research and development expenditures.

SUMMARY TABLE A. Methodologies for the Green Growth Country Assessment

SECTOR OR ISSUE	OBJECTIVE	ANALYTIC FRAMEWORK	
		MODELS USED AND MODELING FRAMEWORK	MODELING OUTCOMES
Water and Agriculture	Adaptation options: To assess the impact of a changing climate on competing uses of water, especially by the agriculture and power sectors.	**Global Circulation Models (GCMs), Water Evaluation And Planning (WEAP) model, a water run-off model (CLIRUN) and an agricultural yield model (AquaCrop). Investment options were linked to the macroeconomic model (MOMA).** 1. **GCMs** produced climate projections, which were used as inputs in **CLIRUN** to estimate streamflow runoff and in **AquaCrop** to estimate crop yield and irrigation water demand. 2. Runoff and irrigation demand estimates from **CLIRUN** and **AquaCrop** were used as inputs in the **WEAP** tool, where water storage, hydropower potential, and water availability were modeled. 3. To refine the **AquaCrop** estimates of crop yield in irrigated areas, the unmet demand for irrigation water from **WEAP**, together with statistical data on irrigated crop sensitivity to water availability, was fed back into **Aquacrop**. 4. Finally, the **WEAP** hydropower generation and **AquaCrop** crop yield results are analyzed to produce estimates of their economic implications: projected revenue from crop production and hydropower and NPV of investments in these sectors.	Intermediate outcomes: • Climate projections • Water runoff • Irrigation water demand • Crop yield • Water availability • Hydropower potential • Water storage Main outcomes: • Projected revenues from crop production and hydropower generation • NPV of investments Financial evaluation of infrastructure investment options for water and agriculture: • Net present value of the cash flow of benefits and costs
Energy	Mitigation options:[a] To find optimal solutions for power supply mix to cover demand at a minimum cost while reducing emissions and emission intensity of the power sector and industry. Included potential reduction in power demand as a result of energy efficiency measures in industry, household, and non-residential sectors.	**Demand-side modeling (EFFECT), supply-side modeling (MARKAL) and Marginal Abatement Cost (MAC) analysis, with links to the macroeconomic model (MOMA).** The **MOMA model** projected basic economic indicators which drive energy demand: GDP, energy sector value-added, and energy prices. They were used as inputs in **EFFECT** to produce energy demand projections for power and non-electric energy. To meet power demand projections, **MARKAL** found a least-cost mix of power sources— lignite, oil, gas, hydropower, solar, wind and nuclear—while accounting for constraints such as resources (hydro, nuclear, lignite), technology, user constraints and a cap on GHG emissions. **Marginal abatement cost (MAC) analysis** evaluated the effectiveness of each of the proposed abatement measures by measuring its marginal net cost (present value of net cost per unit of CO_2e abatement) and the related abatement potential.	**Reduction in energy demand and associated GHG emissions** as a result of energy efficiency measures, as well as required investments, for three sectors: residential buildings, public and commercial buildings, and industrial. **Optimal solution for electricity supply mix** at the minimum possible cost, given that the volume of power supplied should be sufficient to meet the level of demand projected from the demand-side analysis and GHG reduction target should be met. Energy efficiency database created. New household and vehicle surveys conducted.
Transport	Mitigation and adaptation options: To assess impact of green actions on land transport demand and emissions. To estimate the cost of proposed green investments and emissions reduction, and evaluate transport sector vulnerability to climate change.	**TREMOVE (economic TRansport and EMissions model), TRANSTOOLs (TOOLS for TRansport Forecasting ANd Scenario testing), EFFECT (Energy Forecasting Framework and Emissions Consensus Tool). Investment options were linked to the macroeconomic model (MOMA).** 1. **TREMOVE** and **TRANSTOOLs** models evaluated the impact of various transport and environmental policies on the transport sector outcomes. 2. The World Bank's **EFFECT** model assessed green policy interventions and their potential impact on road travel demand and on road transport fleet composition and performance, including fuel consumption and emissions. The outputs comprise forecast levels of vehicle ownership, travel and emissions by vehicle category for the period from 2010 to 2050. Modeling was complemented by vulnerability analysis aimed at assessing transport sector's climate change sensitivities and resulting increase in requires investment and maintenance costs.	Outcomes in EFFECT: • Road travel demand and road transport fleet composition and performance (fuel consumption and emissions) as a result of green policy implementation. Outcomes in TREMOVE: • Sectoral indicators (vehicle population and age, vehicle-kilometer traveled, ton-kilometer transported, volume of rail travel). Sectoral outcomes used to project the level of fuel consumption and emissions including CO_2, NO_X, and PM_{10}.[b]

a. Consistent with constraints on hydropower that emerged from water modeling.
b. NO_x is a generic term for mono-nitrogen oxides, in particular, NO_2. NO_2 forms quickly from emissions from cars, trucks and buses, power plants, and off-road equipment. In addition to contributing to the formation of ground-level ozone, and fine particle pollution, NO_2 is linked with a number of adverse effects on the respiratory system. NOx are distinct from nitrous oxide (N_2O), a greenhouse gas emitted from agricultural lands. PM_{10} is atmospheric particulate matter smaller than 10 microns.

SECTOR OR ISSUE	OBJECTIVE	ANALYTIC FRAMEWORK	
		MODELS USED AND MODELING FRAMEWORK	MODELING OUTCOMES
Macroeconomic Modeling and Construction of a Baseline Scenario	To capture complex linkages between mitigation and adaptation policies and economic performance; and to set out a detailed economic baseline scenario.	The **Macroeconomic Options of Mitigation and Adaptation model (MOMA model),** a dynamic stochastic general equilibrium model, was developed and applied to simulate green scenarios. Mitigation and adaptation options were integrated into the model. The components of the Green and Super green scenarios came from sector analyses. Incorporated mitigation actions from energy and transport; adaptation actions from water, agriculture, and the infrastructure analysis. **MOMA** and **GCMs** downscaled to country level used to estimate impact on macroeconomic variables of climate change.	Growth, employment, fiscal, and investment impacts of mitigation and adaptation actions, as well as impact on sectoral structure. Serves as the reference scenario for other sector and macroeconomic analysis.
Urban	To assess the impact of urban green policies and investments under two green growth scenarios.	Tool for Rapid Assessment of City Energy (TRACE) 1. **General urban sector review**. A scoping paper reviewed urban policies, strategies and pertinent legislation; identified existing data sources; and provided a preliminary overview of key urban trends. 2. An in-depth city level analysis of Skopje using the **Tool for Rapid Assessment of City Energy (TRACE)** for data collection and benchmarking. TRACE was used as a decision-making tool for assessing potential energy and cost savings from implementing cross-sectoral energy efficiency measures in Skopie and for using the outcomes to plan the city's green growth in a systematic way, prioritizing policies and investments across sectors. The analysis focuses on six municipal service areas: urban transport, municipal buildings, water and wastewater, power and heat, street lighting, and solid waste management. 3. To complement TRACE's analysis of Skopje, **rapid assessments** were conducted in selected additional Macedonian cities.	
Infrastructure	Adaptation options: To assess infrastructure adaptation investment choices despite uncertainty about future climate conditions.	Decision-making framework for infrastructure planning, combining cost-benefit analysis under uncertainty, climate informed decision analysis, and robust decision-making. 1. **Defining the baseline infrastructure needs** for all asset types for each five-year period from 2015 to 2050 based on the country's level of development and current climate conditions. 2. **Estimating the costs for each infrastructure category under adaptive and reactive strategies** using stressor-response (or dose-response) functions between the climate stresses and the costs, with planning horizon of up to 40 years, and outcomes of climate modeling (17 climate scenarios up to 2090 based on separate **GCM** runs). 3. **Filtering out infrastructure categories** for which adaptation is cost effective. 4. **Defining a robust adaptation strategy.** When adaptation is cost effective, a robust adaptation strategy, i.e., a strategy optimal for a wide range of climate outcomes, was defined. Standard economic models of decisions subject to uncertainty were used. Robust adaptation strategies were identified using systematic evaluation of all possible combinations of planning scenarios, planning horizons, and climate outcomes. The objective was to minimize the risk of making particularly costly mistakes and, at the same time, perform reasonably well for a range of climate outcomes.	
Air Pollution	Local co-benefits of mitigation: To estimate the health impacts of air pollution.	**The health impact of air pollution was estimated using exposure-response functions that capture the relationship between a pollutant's concentration and the health response of an individual.** Data on air pollutants was combined with estimation of the exposed population. Physical health impacts—mortality, morbidity, and DALYs (disability-adjusted life years)—were calculated using exposure-response functions and then the health impact was monetized using three approaches to valuation.	
Social Participation	Pilot Participatory Scenario Development (PSD) approach was aimed at testing a suitable participatory approach to green growth decision making.	**PSD workshops involved discussions with the population of two scenarios of development: Business as Usual and Green Growth.** Each workshop consisted of four steps: (i) facilitators inform participants about climate change and green growth and describe two scenarios of development—business-as-usual and green growth; (ii) participants discuss the social impact of climate change and green growth under two scenarios; (iii) participants identify adaptation and mitigation solutions; (iv) participants discuss feasibility of the proposed solutions. **PSD is a process of stakeholder discussions of policy issues** and is used to identify the effects of alternative responses to challenges; to determine how different groups of stakeholders view the range of possible policy and management options; and to identify appropriate public policies and investment support necessary to facilitate effective action. The pilot social module explored possible solutions to mitigate negative effects in dialogue with major stakeholders at regional level.	

SUMMARY TABLE B. **Green scenarios developed for modelling**

Summary of policies and investments used for analysis

SECTORS	GREEN SCENARIO	SUPER GREEN SCENARIO
Water and Agriculture Modelling	Combination of water conservation, investment in sector assets and re-positioning of agriculture: 1. Improved water management and conservation in response to today's moderate stress on water resources, which increases with climate change; 2. Improvement in basin scale irrigation efficiency in all basins to 75% 3. New basin scale storage as laid out in plans 4. Improvement of drainage infrastructure in all currently irrigated areas 5. Improvement in wheat varieties (irrigated and rainfed)	Expanded Green scenario: 1. All Green interventions; 2. Improvement in basin scale irrigation efficiency in all basins to 100% 3. Improvement of drainage infrastructure in currently irrigated and rainfed areas 4. Improvement in varieties for wheat, maize, and apples (irrigated and rainfed) 5. Optimization of timing of water and fertilizer application for all crops in all basins 6. Irrigation expanded by 50% in basins with sufficient water; low-value rainfed production converted to irrigated maize, apples, and/or tomatoes
Energy Supply and Demand Modelling	Combination of demand side (improved energy efficiency) and supply side (optimized power generation mix) measures: 1. **Supply-side measures** include significantly increased usage of gas and construction of a new gas pipeline, reduced usage of lignite and oil, moderate hydropower development and renewable energy development 2. **Demand side measures** include full implementation of all available energy efficiency interventions in household, commercial, public and industrial sectors	Expanded Green scenario: 1. All Green interventions 2. More aggressive gas strategy, more investments in wind and solar 3. Replace some lignite and gas with new nuclear plant 4. Tighter schedule of energy efficiency implementation
Transport Modelling	A mix of investments in infrastructure, policies creating behavioral incentives, and management improvements: 1. **Investments in infrastructure:** in rail infrastructure and services and rail energy efficiency, in urban and inter-urban transit, in walking and cycling infrastructure, in vehicle train technology for road freight 2. **Behavioral incentives:** fuel prices increase, fuel tax introduction, policies to increase carpooling and reduce travel time, policies to increase demand for fuel efficient vehicles, eco driving; pedestrian zones, limited parking, freight restrictions 3. **Management improvements**: parking management; urban traffic management systems	Expanded Green scenario: 1. Higher investment level 2. Tighter implementation schedule
Macroeconomic Modeling	Ambitious climate action on mitigation and adaptation. 1. **Mitigation** measures to achieve a 40 percent reduction in GHG emissions from energy supply and energy efficiency; transport 2. **Adaptation** measures (precautionary) from agriculture, water, and physical infrastructure across sectors	Very ambitious climate action on mitigation and adaptation. 1. **Mitigation** measures to achieve an almost 70 percent reduction in GHG emissions from energy supply and energy efficiency; transport 2. **Adaptation** measures (proactive) from agriculture, water, and physical infrastructure across sectors

SUMMARY TABLE C. **Recommended actions by sector**

Detailed policies, investments, institutions

'NO REGRETS' ACTIONS (urgent measures to sustain growth and low-cost green measures with positive short-term returns)	FULL-SCALE GREEN ACTIONS (more ambitious and more costly greening measures from both the Green and Super Green scenarios)
WATER AND AGRICULTURE	
Policies: • Design policies for municipal and industrial water conservation to reduce water demand and eliminate waste (metering) • Design policies to address unregistered wells – create national groundwater register – reestablish national groundwater monitoring network – create groundwater permit/tariff system • Increase efficiency of the Water Economies (utility) including first steps toward cost recovery tariffs and control over ground water usage (metering, better collection) • Optimize water user fees in agriculture • Improve municipal and industrial water system efficiency and address water losses • Agriculture: first set of measures toward land consolidation and land market improvement • Design policies to address soil management of arable land Investments: • Improve basin scale irrigation efficiency targeting high value crops • Rehabilitate water supply assets Institutional strengthening and knowledge sharing: • Agriculture: organize educational campaigns and experience-sharing among farmers, such as precision farming, soil management, pasture management, greenhouses	Policies: • Apply municipal/industrial water conservation policies • Further control over groundwater usage (wells) • Agriculture: continue land consolidation and land market improvement • Convert low-value rainfed production to irrigated maize, apples, or tomatoes • Optimize timing of water and fertilizer application for all crops in all basins • Apply policies to address soil management of arable land Investments: • Improve basin scale irrigation efficiency through better design and more efficient infrastructure (remove, rehabilitate, or expand) • Expand irrigation to all crops that need to be irrigated in all areas with sufficient water • Improve drainage infrastructure in all irrigated and rainfed areas • Construct basin scale storage • Improve wheat, apple and maize varieties (irrigated and rainfed) • Build the planned hydropower plants as part of energy strategy Institutional strengthening and knowledge sharing: • Agriculture: continue educational campaigns and experience-sharing among farmers
ENERGY	
Policies: • Adopt the National Plan for Energy Efficiency in Public Buildings • Develop a regional strategy and implementation plan for gas supply • Address potential private investors' concerns about investing in hydropower • Design and apply incentive schemes for renewables • Achieve cost recovery pricing in power and gas • Set up a sustainable financing mechanism for energy efficiency measures • Make low-cost capital available for energy efficiency investments (e.g., building retrofits) Investments: • Energy efficiency – increase efficiency of HH appliances – improve efficiency in heating, cooling and lighting in non-residential sector – replace inefficient equipment in the industry – roll-out LEDs for street lighting across the country Institutional strengthening and knowledge sharing: • Strengthen the institutional capability to design and implement energy efficiency programs • Build and maintain energy consumption data • Implement energy efficiency training programs for professionals (architects, building contractors, energy auditors) • Organize consumer information campaigns regarding energy efficiency measures	Policies: • Design and implement policies to address transmission and distribution losses • Apply a regional strategy and implementation plan for gas supply • Establish new construction standards to reduce demand for heating • Establish commercial building standards for new construction Investments: • Invest in new gas plants (replacing lignite plants) • Construct new hydropower plants • Invest in wind plants and solar PV panels • Expand natural gas infrastructure • Household sector: apply more efficient lighting, introduce higher energy efficiency standards for refrigerators and water heaters, retrofit buildings • Non-residential sector: more efficient lighting, building retrofit • Industry: introduce energy-efficient technologies, including optimizing existing energy supply systems and technology replacement when new production capacity is added Institutional strengthening and knowledge sharing: • Continued efforts

'NO REGRETS' ACTIONS (urgent measures to sustain growth and low-cost green measures with positive short-term returns)	FULL-SCALE GREEN ACTIONS (more ambitious and more costly greening measures from both the Green and Super Green scenarios)
TRANSPORT	
Policies: • Road sector – design incentives to improve fuel efficiency of vehicles and reduce car usage (prices, taxes, regulations) – apply emission standards for all road transport – design and apply policies to reduce vehicle occupancy and the number of trips • Urban sector: design and implement improved regulated and paid parking • Rail: design and apply passenger information system and e-ticketing, electronic freight billing and tracking of shipments system Investments: • Invest in improved road infrastructure • Road sector: design investment plans for public transportation (buses, trams) • Urban sector: create investment plans for city center re-design including walking/cycling zones and for reducing city congestion (parking restrictions and charges, pedestrian zones, cycling zones, freight restrictions) • Rail: design a program for rail sector development and rail track and infrastructure investment Institutional strengthening and knowledge sharing: • Road sector: design and implement awareness campaigns and driver training aimed at driving style (smooth acceleration and deceleration, no idling), observed speed limits, tire pressure checks, timely vehicle maintenance • Road and rail: improve transport sector adaptation information and data – create a database of extreme weather events – conduct damage calculations (Agency for State Roads) – create a database costing infrastructure damages by weather events	Policies: • Road sector – apply fuel tax – apply policies for improved fuel efficiency of vehicles and reduced car usage (prices, taxes, regulations) – apply passenger car scrappage scheme • Urban sector – expand regulated and paid parking and increase parking charges – implement improved ticketing system and fares – integrate smart cards • Rail – apply competitive fares (against car use costs) and freight access charges – change to electricity recharge mechanism to incentivize operators adopting energy efficient behaviors Investments: • Road sector: invest in public transportation (buses, trams) • Urban sector • build tram infrastructure in Skopje • invest in walking and cycling infrastructure • invest in freight consolidation centers • Rail – start construction of the track and infrastructure along Pan-European corridor VIII – invest in stations, rail yards and depots – rolling stock investment – regenerative braking (rolling stock and infrastructure investment) Institutional strengthening and knowledge sharing: • Road sector: conduct awareness campaigns and driver training; • Rail: conduct driver energy efficiency training – on-board energy use metering and software – driver training
URBAN	
Policies: • Design integrated urban plans – create incentives to make urban center more livable – design and implement improved regulated and paid parking • Design and implement water conservation policies • Improve operational efficiency of water utilities • Meter water supply • Accelerate establishing integrated regional waste management systems Investments: • Create investment plans for city center re-design including walking/cycling zones and for reducing city congestion – parking restrictions and charges – pedestrian zones – cycling zones – freight restrictions • Invest in/find financing for public transport, water supply networks and wastewater sector • Access available grant funding for wastewater treatment infrastructure • Invest in/find financing for parking, traffic management, and walking and cycling infrastructure • Invest in/design financing for energy efficiency improvements Institutional strengthening and knowledge sharing: • Awareness campaigns regarding energy efficiency, water conservation, trash recycling • Promotion of public transportation, biking and walking, driver training	Policies: • Expand regulated and paid parking and increase parking charges • Implement improved ticketing system and fares • Integrate smart cards Investments: • Build tram infrastructure in Skopje • Invest in walking and cycling infrastructure • Invest in freight consolidation centers • Invest in public transportation. Institutional strengthening and knowledge sharing: • Continued actions

<table>
<tr><th>‘NO REGRETS’ ACTIONS
(urgent measures to sustain growth and low-cost green measures with positive short-term returns)</th><th>FULL-SCALE GREEN ACTIONS
(more ambitious and more costly greening measures from both the Green and Super Green scenarios)</th></tr>
<tr><td colspan="2">SOCIAL</td></tr>
<tr><td colspan="2">Capacity development:
Provide for stakeholder involvement in the design of any green growth strategy and related sectoral planning</td></tr>
<tr><td>INFRASTRUCTURE</td><td></td></tr>
<tr><td>Policies:
• Design new (modified) standards and operations and maintenance practices for urban drainage systems, health and educational facilities, and municipal buildings
Investments:
• Invest in urban drainage systems, health and educational facilities, and municipal buildings
Institutional strengthening and knowledge sharing:
• Continuously revise and improve monitoring of the weather outcomes and update climate projections on this basis
• Regularly update the assessment of the optimal choices for adaptation in infrastructure assets</td><td>Policies:
• Design financing to support upgrades and maintenance for roads, power, telecoms, water and sewer networks, and non-road transport
• Investments:
• For roads, power, telecoms, water and sewer networks, and non-road transport: enhanced maintenance and upgrades to respond to current weather stresses
Institutional strengthening and knowledge sharing:
• Continued efforts</td></tr>
<tr><td>AIR POLLUTION</td><td></td></tr>
<tr><td>Policies:
• Design and implement policies to create incentives for industry, energy, and road sectors to invest in pollution reduction, primarily in:
• modern equipment in ferroalloys and non-ferrous metal production
• pollution abatement equipment and fuel switching in the heat and power production
• dust collectors and fabric filters in asphalt mixing plants
• Include PM in air emission programs and in health impact estimates for urban, energy and transport planning
Investments:
• Design and implement low cost financing mechanism/find grants to the household sector to replace inefficient stoves and for energy efficiency improvements
• Design and implement low cost financing mechanism for enterprises for improved environmental management
Institutional strengthening and knowledge sharing:
• Continue financial support to air quality monitoring (MEPP)
• Develop capacity in the area of health impact monitoring (MEPP)
• Conduct health impact assessments on a regular basis (Institute of Public Health)</td><td>Policies:
• Continue including PM in air emission programs and in health impact estimates for urban, energy and transport planning
Investments:
• Invest in modern equipment in ferroalloys and non-ferrous metal production
• pollution abatement equipment and fuel switching in the heat and power production
• dust collectors and fabric filters in asphalt mixing plants
• Replace inefficient stoves and implement energy efficiency improvements
Institutional strengthening and knowledge sharing:
• Continued actions</td></tr>
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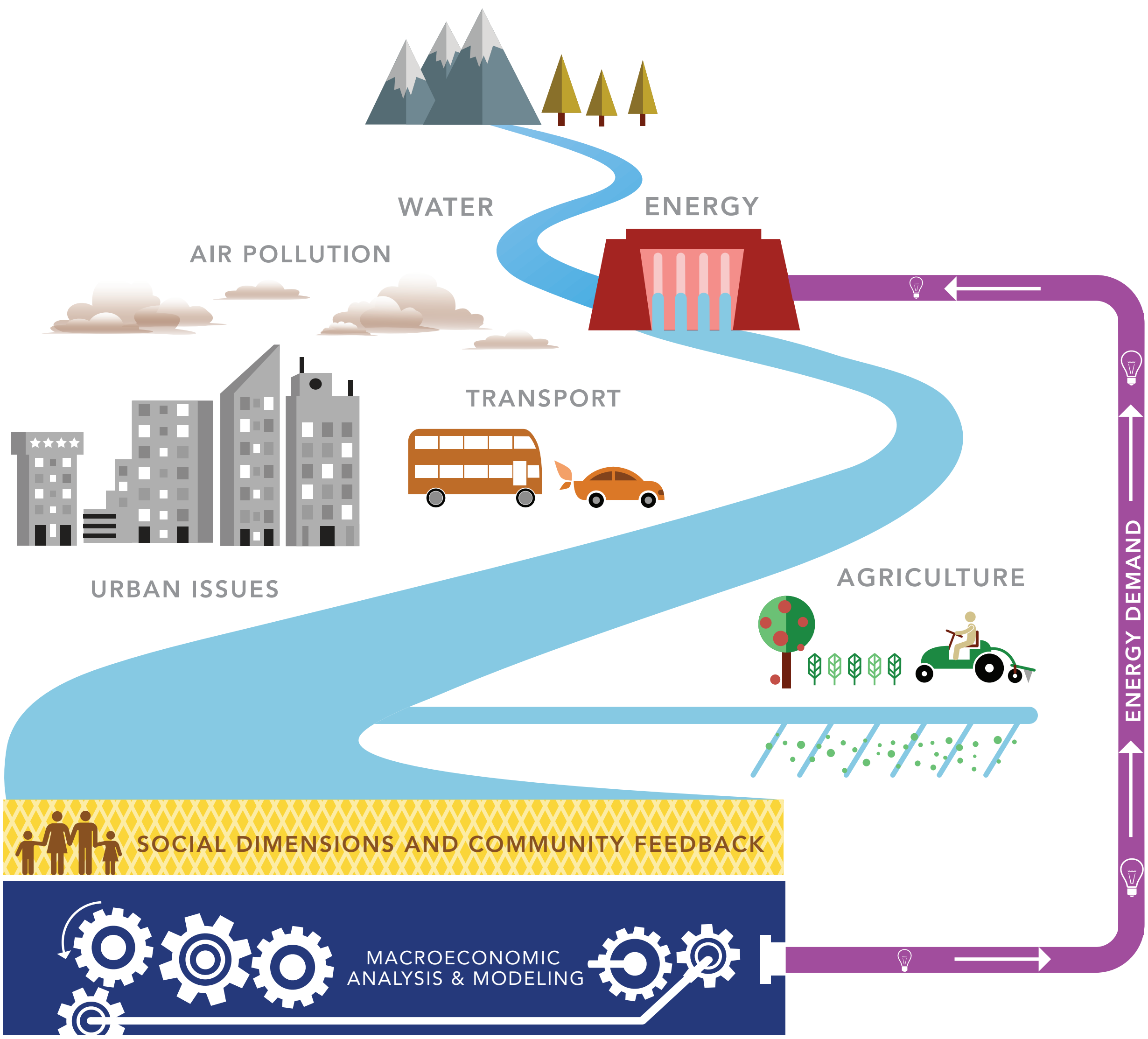

WATER
ENERGY
AIR POLLUTION
TRANSPORT
URBAN ISSUES
AGRICULTURE
ENERGY DEMAND
SOCIAL DIMENSIONS AND COMMUNITY FEEDBACK
MACROECONOMIC
ANALYSIS & MODELING

introduction

This report takes a practical approach to identifying specific challenges and opportunities FYR Macedonia faces in building its green growth future, presenting them in a form useful for decision makers. In particular, it defines green growth in concrete terms, as economic growth with more sustainable use of natural resources (minerals, water and clean air, and biodiversity), with proper consideration of mitigation of greenhouse gas emissions; with attention to adaptation to a changing climate; and with more focus on innovation and green jobs to enhance benefits flowing from the technological innovation and new industries spurred by a shift to green growth. This green growth country assessment for FYR Macedonia aims to define the outlines of a green growth path and the initial steps along it.

FYR Macedonia, like many countries, is already moving in a green direction. The Macedonian economy continues to evolve, with ongoing programs of structural reforms to improve growth and competitiveness and with growing alignment with Europe. Environmental and sustainability issues are gradually rising in importance in the public policy debate, although, as in most countries, more so during times of stable growth. The country's momentum towards Europe is already requiring it to focus more on environmental issues, including climate action.

This synthesis report summarizes analytic work undertaken specifically under the Green Growth and Climate Change Program in sectors and on issues selected as critical for defining and understanding the green growth path of FYR Macedonia. The report starts with an overview of the main green growth challenges in the country, mapping FYR Macedonia against the EU, the Eastern Europe and Central Asia (ECA)[13] region, and upper middle income countries (UMC)[14] using selected indicators from the Green Growth benchmarking analysis developed by the study team (Chapter 1). **Then, the next two chapters lay out baseline projections to generate a 'business-as-usual' scenario, the starting point for the subsequent analysis of green growth issues**. Chapter 2 describes a 'zero-baseline,' which provides macroeconomic projections as well as projections for greenhouse gas (GHG) emissions[15] for the period up to 2050. The zero-baseline considers past economic trends as well as current policies and developmental plans but does not include the impact of a changing climate on the economy. Chapter 3 describes the final baseline scenario (Business-as-Usual or BAU scenario), which incorporates an estimate of climate change damages, creating a more realistic possible growth path for the economy to 2050.

13. ECA is the East Europe and Central Asia region and includes the following twenty-eight countries: Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Estonia, Georgia, Hungary, Kazakhstan, Kyrgyz Republic, Latvia, Lithuania, FYR Macedonia, Moldova, Montenegro, Poland, Romania, Russian Federation, Serbia, Slovak Republic, Slovenia, Tajikistan, Turkey, Turkmenistan, Ukraine, and Uzbekistan.

14. Using the World Bank classification of countries by income.

15. A greenhouse gas absorbs and emits radiation within the thermal infrared range. This process is the fundamental cause of the greenhouse effect. The primary greenhouse gases in the Earth's atmosphere are water vapor, carbon dioxide, methane, nitrous oxide, and ozone. See Wikipedia or any of numerous sources for further explanation.

The central part of the report further examines green growth issues specific to FYR Macedonia and, starting from the BAU scenario, generates Green and Super Green scenarios for each. (See Box 1.1 for more on scenarios). Sectoral outcomes under the two green growth scenarios are assessed by comparing them with the baseline scenario. This analysis is conducted for the following sectors: the water sector (Chapter 4), the agriculture sector (Chapter 5), the energy sector (Chapter 6), and the transport sector (Chapter 7). **The following report chapters present cross-sectoral green growth issues, which by necessity take issue-specific approaches:** urban green growth challenges (Chapter 8), adaptation in infrastructure in the face of climate damages (Chapter 9), air pollution as a health issue critical for FYR Macedonia, and the inclusion of stakeholders in green growth reforms (Chapter 11).

The report concludes with a macroeconomic analysis based on modeling that generates economy-wide outcomes building on the sectoral analyses of water, energy, transport, and agriculture. Putting the sectors together allows consideration of the impact of green growth actions (investments and policies) in each sector on other sectors and on overall economic growth and employment and provides the government with a tool able to compare the impact of public investments across sectors.

Chapters of the report have a standard structure. Each starts with a chapter summary, followed by an overview of the relevant challenges to green growth and a description of sectoral issues critical for greener growth. Then, the methodology is laid out, and the main findings summarized. Finally, conclusions and recommendations are introduced. Despite the identical structure of the chapters, the underlying analytic work varies. Background technical papers are available with greater detail for each of the chapters.

Analytic work undertaken for each sector or topic of this country assessment differs depending on sector specifics, green growth objectives in particular sectors in FYR Macedonia, and analytic tools available. Therefore, the analysis has varying objectives, methodological frameworks, analytic tools including modeling, and types of findings and recommendations.

- In the water, transport and energy sectors and in the macroeconomic analysis (Chapter 4, Chapter 6, Chapter 7 and Chapter 12), the analysis is based on modeling and includes an interlinked set of models that evaluate the impact of green investments and policies on sector and macroeconomic outcomes. As a result, the main findings in these sectors reflect proposed investments and explain their rationale, while the recommendations describe optimal investment strategies.
- In agriculture (Chapter 5), the analysis combines modeling outcomes[16] with relevant sector analysis from outside this assessment, and the findings and recommendations are also a combination of quantitative and qualitative analysis.
- Urban analysis (Chapter 8) examines cross-sectoral urban issues in several municipal sectors: water and wastewater, energy, transport, waste collection and disposal. It utilizes the Tool for Rapid Assessment of City Energy (TRACE) for data collection and benchmarking, which provides a structured way to collect and analyze data and to identify areas of greatest potential efficiency gains. As a result, the findings propose focus areas for municipal policy decision-making and recommend priority areas for interventions across the municipal sectors.
- Adaptation choices for infrastructure (Chapter 9) involve an alternative approach to climate uncertainty and assessed the choices to be made when investing in long-lived infrastructure assets in the context of climate change. The recommendations provided are related to the timing of infrastructure replacement and refurbishing and are based on the cost of various available options.

BOX 1.1. Green Scenarios: a basic explanation

Scenario analysis is used to evaluate the impact of mitigation and adaptation actions in five overlapping sectors—energy, transport, water, agriculture, and infrastructure—which are then combined in the macroeconomic or economy-wide analysis. Two policy scenarios—**Green** and **Super Green**—were formulated in a bottom-up fashion based on the specifics of each sector as part of the sector analysis. These scenarios are compared to **Business-as-Usual** (BAU) or baseline scenario, a development path for the economy to 2050, including the main projected impacts of climate damages. The Green and Super Green scenarios involve government policies and investments to address greenhouse gas emissions mitigation and adaptation to climate damages. The Green scenarios in each sector constitute a package of ambitious but practical actions to reduce emissions and counter climate change. The Super Green scenarios are very ambitious and more expensive packages, generally requiring more aggressive implementation of Green measures or wider coverage of such measures.

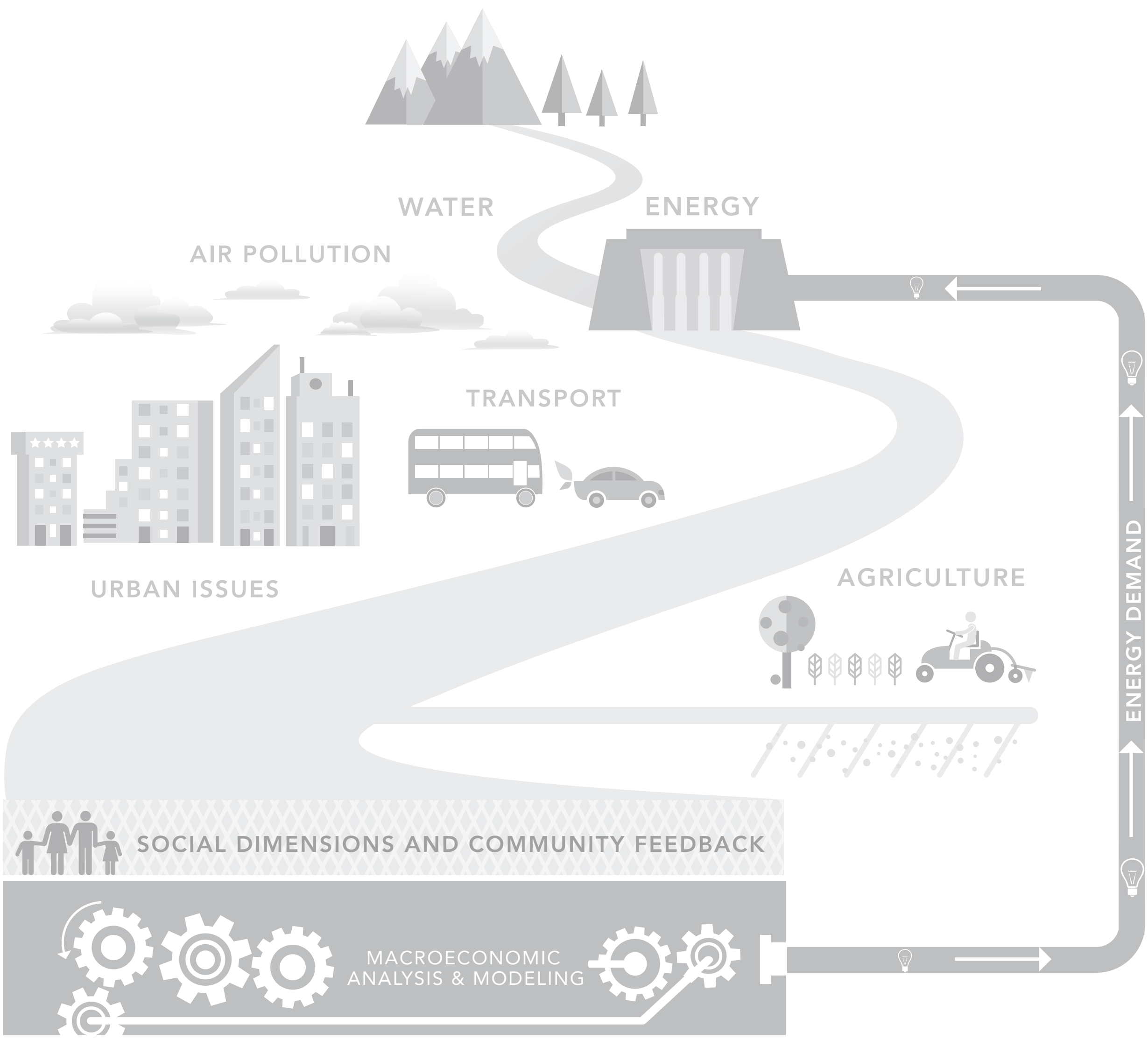
16. The water and agriculture sectors are modeled jointly.

- The air pollution analysis (Chapter 10) was designed to estimate the cost of the health impact of air pollution, both a typical target of greening efforts and a co-benefit of many mitigation efforts. The findings also identify economic activities and geographic areas with the highest reduction potential from targeted actions.

- The social inclusion analysis (Chapter 11) proposes a participatory instrument that would help policymakers to make green growth design and implementation socially inclusive and reports on its successful piloting as part of this assessment.

- The macroeconomic analysis (Chapter 12) used a dynamic computable general equilibrium model constructed for the Macedonian economy that captures the complex linkages between climate mitigation and adaptation policies and macroeconomic performance in an innovative manner.

Summaries of the methodologies used for each sector and cross-cutting issue and of the main policies and investments that constitute the Green and Super Green scenarios for the assessment are available as concluding tables in the Report Summary.


WATER
ENERGY
AIR POLLUTION
TRANSPORT
URBAN ISSUES
AGRICULTURE
ENERGY DEMAND
SOCIAL DIMENSIONS AND COMMUNITY FEEDBACK
MACROECONOMIC
ANALYSIS & MODELING

CHAPTER 1

What is Green Growth, and How Green is FYR Macedonia? A Benchmarking Exercise

CHAPTER SUMMARY

Using a broad set of indicators of green growth, FYR Macedonia is compared to international and regional benchmarks to provide an initial portrait of the country's status, prospects, and challenges with respect to green growth. Green growth is growth in economic output that preserves the ability of natural assets to provide the resources and services on which human welfare depends.[17] Green growth starts with a traditional concern about sustainable use of natural resources, including minerals, water and clean air, and biodiversity, and then adds consideration of mitigation of greenhouse gas emissions, attention to adaptation to a changing climate, and more focus on innovation and green jobs. For any individual country, the nature of a greener growth path will depend on endowments and history, which position countries quite differently with respect to current 'greenness' and potential greening of their growth paths. A framework to define a list of questions key to understanding how FYR Macedonia or any country compares in an international context is constructed with three aspects — "how green?", "going green," and "riding a green wave," and used to guide a benchmarking exercise in which FYR Macedonia is mapped against comparator countries and country groups using a dataset of more than 100 indicators for 69 countries for 1990 to 2009. This benchmarking exercise aims to define, "What is green growth, and how green is FYR Macedonia?"

A selection of key indicators constitutes Green Growth At-A-Glance to illustrate the main messages from the benchmarking exercise. Firstly, FYR Macedonia's natural resource endowment is close to the EU average in most aspects, but air quality is among the worst in the EU. Resource usage is less sustainable over the long term than in the EU, and natural resources are less productive, with somewhat high levels of mineral extraction, water withdrawals that have created moderate water stress, and low productivity of agricultural land. Greenhouse gas emissions are high, driven by heavy use of lignite and high energy intensity of GDP. The country has high exposure to climate change among European countries and among middle-income countries globally. Its sensitivity to climate change (the likelihood of economic damages) is somewhat high because of low quality infrastructure and dependence on agriculture, while its capacity to adapt is limited by institutional weaknesses. Secondly, FYR Macedonia's economy is not sufficiently flexible to benefit easily from going green. The country's supportive business environment cannot make up for poorly functioning labor markets, and global links are not yet strong enough to facilitate technology transfer. Lastly, FYR Macedonia's connections to global knowledge and readiness for an innovation revolution are insufficient to benefit from green technological change.

This benchmarking exercise not only identified key issues for further analysis but also could serve as a tool for monitoring progress under a green growth program. As the Macedonian

17. Green Growth Knowledge Platform website. Developed in partnership between the Global Green Growth Institute, the OECD, UNEP, and the World Bank: www.ggkp.org.

government considers implementation of a green growth program, policymakers need to think when drawing down natural capital in the interest of economic growth is a wise tradeoff and when it is not. Certainly, more investment in maintaining and upgrading natural assets seems warranted; substantial investments are needed, especially in the energy sector to advance mitigation of greenhouse gases; and government needs to manage actively the likely impacts of a changing climate on agriculture. To cope with a greening world, greater flexibility of the economy, strengthened connections to global knowledge, and more effective support of innovation should be fostered through policies and investments. In addition to these key elements of a green growth strategy, the government should consider the development of a results framework populated by a combination of internationally-comparable and locally-developed indicators to support effective implementation. With a growth path already shaped by the requirements of EU accession, this first glance at green growth for FYR Macedonia seems to indicate much complementarity between the short term and the long term, with relatively little conflict between policies and structural reforms that will lead to more vibrant as well as more sustainable growth.

CHALLENGES FOR GREENER GROWTH

Overview

According to the World Bank's recent flagship report, green growth is "growth that is efficient in its use of natural resources, clean in that it minimizes pollution and environmental impacts, and resilient in that it accounts for natural hazards and the role of environmental management and natural capital in preventing physical disasters."[18] Further, the report explains that, "Inclusive green growth is not a new paradigm. Rather, it aims to operationalize sustainable development by reconciling developing countries' urgent need for rapid growth and poverty alleviation with the need to avoid irreversible and costly environmental damage." [19] While most countries might agree that such growth is a worthy goal, determining what a green growth path might mean for a particular country is a significant challenge. This green growth country assessment for FYR Macedonia aims to define the outlines of that path and the initial steps along it.

18. World Bank. 2012. Inclusive Green Growth: The Pathway to Sustainable Development. Washington, DC: World Bank, p. 2.

19. Ibid. This definition is consistent with those set out by the OECD and UNEP, and the approaches of the three institutions are being brought together under the Green Growth Knowledge Platform, along with a fourth partner, the Global Green Growth Institute. The Platform, launched in Mexico City in January 2011, is a global network of researchers and development experts that seeks to identify and address major knowledge gaps in green growth theory and practice. Through widespread consultation and world-class research, the GGKP hopes to provide practitioners and policymakers with better tools to foster economic growth and implement sustainable development (www.ggkp.org).

Green growth starts with a traditional concern about sustainable use of natural resources. The efficient exhaustion of nonrenewable resources such as energy and mineral deposits and the sustainable use of renewable resources such as forests and fisheries, water and clean air have been considered part of a sustainable growth agenda for decades. Natural resources are necessary to economic activity, providing raw materials and environmental services essential for production to continue. Some components of natural resources have become of greater concern in recent years, among them freshwater resources affected by overexploitation, pollution, and climate change; and biodiversity under threat from habitat alteration and pollution.

Mitigation of greenhouse gas emissions is a critical additional component of environmental sustainability, with rising prominence and particularly difficult challenges for countries. The growing imbalance of greenhouse gases (or 'carbon') in the atmosphere is a clear example of the breeching of planetary boundaries and of a global public good. As such, individual countries can reap only local co-benefits such as reduced suspended particulates in the air if fossil fuel burning is reduced. Since the bulk of the benefits do not accrue to an individual country, a decision to move to low carbon generally must be motivated by other considerations, including access to carbon finance and other external funding, in response to regional standards and requirements such as those of the European Union, or driven by a decision to lead on global issues and prepare for an eventual global agreement.

Adaptation to a changing climate must also be part of a country's sustainable growth path. Regardless of future greenhouse gas emissions, climate is already changing, with more extreme weather events, rising sea levels, and overall warming. Some countries, sectors, and populations will be strongly affected, although with major impacts in most places not materializing for some decades. For many countries, it makes sense to consider how adaptation needs can be incorporated into decisions about long-lived infrastructure such as new hydropower plants. More generally, countries that will face significant impacts need to factor such shifts—in frequency of droughts, in crop yields, in coastal and riverbank flooding—into thinking about sustainable and greener development paths.

The newest element of the green growth agenda is the strong emphasis on innovation and green jobs. This dimension of green growth proposes that a shift towards greener growth will spur technological innovation, especially in the energy sector, and promote the emergence of new industries. Innovation can help decouple growth from natural resource depletion and greenhouse gas emissions by shifting out global production possibilities and allowing more production with

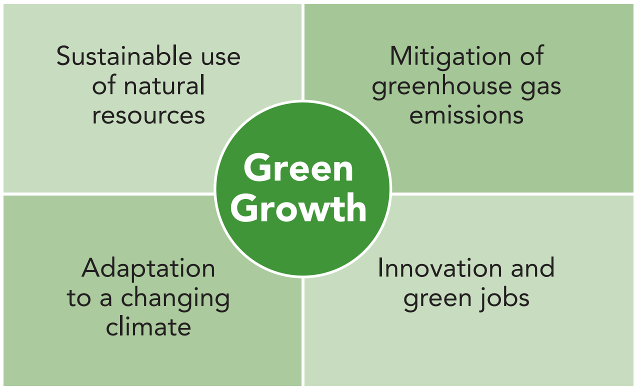
fewer and more environmentally-friendly inputs. Environmental considerations don't necessarily constrain growth, but, to the contrary, a dynamic technical change towards low carbon and low pollution technologies could drive growth and generate jobs at all skill levels.[20] (Figure 1.1)

Where Should Countries Start?

A greener growth path must address these four aspects and balance greening with growth of output and incomes, but the details of a country's path will depend on country-specific conditions and policy choices. Each country starts with a set of endowments, natural and man-made. While some aspects of any country's current condition are driven by recent policy choices, much derives from exogenous characteristics such as geography or endowments of fossil fuels, hydropower potential, or forests; and the myriad of distant policy decisions that drove national development to where it is today. These characteristics position countries quite differently with respect to the current 'greenness' and potential greening of their growth paths. In considering the complex task of assessing green growth at the country level, the starting point is fundamental to the costs and tradeoffs the country faces in choosing a greener path forward.

One holistic approach to sustainability is national wealth accounting and the measurement of natural capital, which aims to capture a good part of the green challenges to orthodox growth measurement. Part of the determination of an optimal green growth path for a country involves proper valuation of environmental costs and benefits, an approach which has been part of the sustainability agenda for many years. Recent international agreement to support wealth accounting or green national accounts is moving this effort into the mainstream. A correct costing of depreciation of natural resources such as mineral deposits and of externalities such as air and water pollution will take countries who adopt such an approach a good distance to maximizing a greener type of GDP. However, some elements of greenness are not easily costed, among them greenhouse gas emissions, biodiversity and the non-income benefits (or happiness) that comes from living in a country with a healthy and well-protected natural environment.

FIGURE 1.1. Elements of environmental sustainability that together constitute green growth



A simpler starting point in such assessment is benchmarking against comparator countries—using indicators that measure various dimensions of green growth. This quick mapping can help identify challenging areas, as well as easy wins. It can create a balanced portrait of a country's green issues, and, as set out below, it can have an analytic rather than monitoring objective.

20. Such an argument is consistent with mainstream economic thinking if there is close substitutability between clean and dirty technologies. In that case, temporary government subsidies or other supportive policies can push the economy towards a clean solution, causing the sector with clean technology to become large enough to be self-sustaining. In such a situation, the shift to greener technologies will support growth rather than limiting it. See Aghion, Philippe, Daron Acemoglu, Leonardo Bursztyn and David Hemous. 2011. "The Environment and Directed Technical Change." Growth and Sustainability Policies for Europe (GRASP) project of the European Commission (EC). Working Paper 21. Brussels: EC. See also the quick overview in Jamus Lim. May 23, 2010. "Environmentally-Friendly Growth Without the Pain." Prospects for Development. Washington, DC: World Bank, http://blogs.worldbank.org/prospects/environmentally-friendly-growth-without-the-pain#1.

METHODOLOGY AND MAIN FINDINGS

Methodology

The scheme below (Figure 1.2) helps to define a list of questions key to understanding how FYR Macedonia or any country compares in an international context. Firstly, how important are natural resources to current growth, and how productively has the country made use of them? Is pollution a major problem? Has FYR Macedonia made any progress in decoupling economic growth and greenhouse gas emissions? Is the country preparing for the impacts of a changing climate? Secondly, is FYR Macedonia's economy flexible enough to succeed in the transition towards green growth? Is FYR Macedonia's economy well-diversified and ready to reap emerging opportunities? What will be FYR Macedonia's greatest challenges in greening its economy, and what will be its biggest payoffs from 'going green'? Thirdly, how can FYR Macedonia be ready for a surge of innovation and be competitive in new and growing green industries? These three aspects of measuring 'green-ness' capture a country's status, prospects, and challenges with respect to the four elements in Figure 1.1.

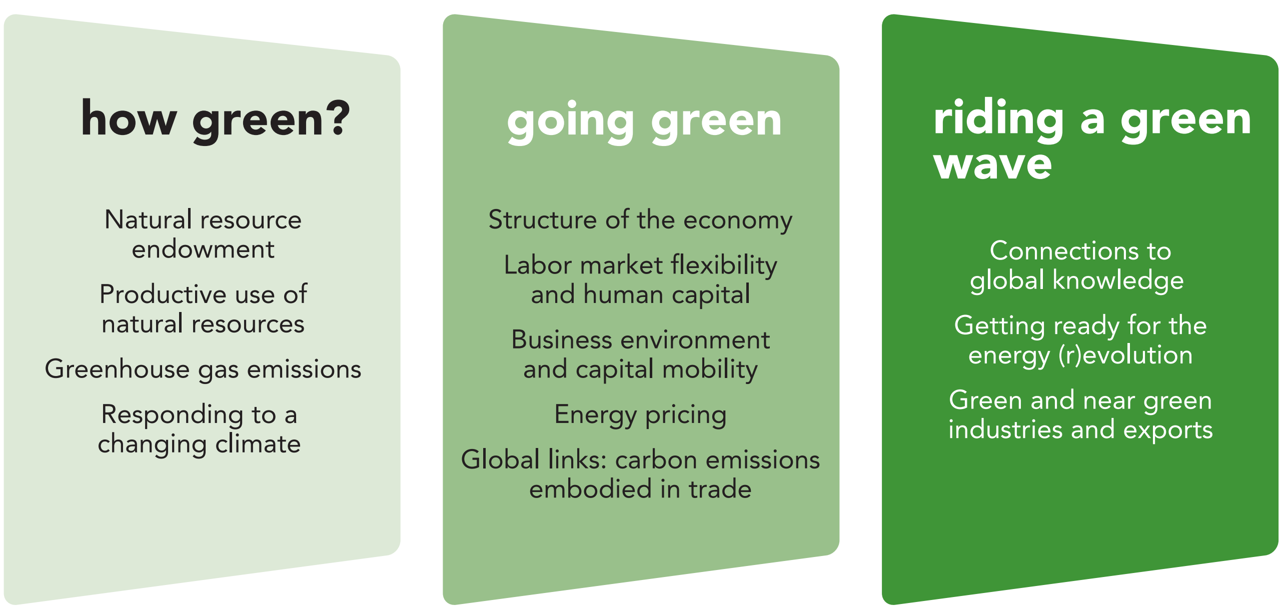
FYR Macedonia was benchmarked against comparator countries using a specially-constructed database. Information on more than 100 indicators across 69 countries for 1990 to 2009 was collected.[21] FYR Macedonia was compared to a subset of these countries selected based on economic, social and policy criteria and also against three country groups: the European Union (EU), the ECA region, and all upper middle income countries (UMC).[22] Acknowledging that attempting to measure green growth is not a new effort, the design of the database draws on lessons from recent OECD and Environmental Performance Index (EPI) publications.[23] Data is derived from a variety of sources, including the World Bank's Development Data Platform. The selection of relevant indicators balanced data availability and reliability. Some indicators are proxies or correlated variables such as using life expectancy to capture environmental health impacts. Unfortunately, there are important areas of environmental performance where reliable, internationally comparable data is missing, e.g., waste production and management, toxic substance concentrations, and water and soil quality.

21. All European Union, OECD, and other Eastern Europe and Central Asia countries are included as well as ten other large countries to allow for more balanced regional representation.

22. For more detailed analysis and comparisons to selected comparator countries, see the Benchmarking technical paper. The ECA region is the Eastern Europe and Central Asia region and includes the following thirty countries: Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Estonia, Georgia, Hungary, Kazakhstan, Kosovo, Kyrgyz Republic, Latvia, Lithuania, FYR Macedonia, Moldova, Montenegro, Poland, Romania, Russian Federation, Serbia, Slovak Republic, Slovenia, Tajikistan, Turkey, Turkmenistan, Ukraine, and Uzbekistan.

23. One of the best known approaches to country environmental performance is the Columbia-Yale Environmental Performance Index. For the newly-emerging area of green growth, the OECD, the EU, and the UN have pioneered work on indicators, and the World Bank's new Green Growth Knowledge Platform, a joint effort with OECD, UNEP, and the Global Green Growth Institute, will focus on further development and harmonization of indicators of green growth.

FIGURE 1.2. A framework for green growth benchmarking



Main findings

While wealth accounting with natural capital incorporated is conceptually appealing, as noted above, in practice this approach does not produce sufficient insights on green growth for FYR Macedonia. Wealth accounting aims to inform the sustainability of a country's GDP, in particular through calculation of the adjusted net savings rate[24] to allow a judgment as to whether total wealth is increasing or decreasing. FYR Macedonia's adjusted net savings ratio has fluctuated over the last 15 years, from -1.6 percent of GNI to 10.5 percent (See Figure 1.3). Strongly positive net national savings in recent years has been somewhat offset by higher mineral depletion, which rose from an annual average of -0.3 percent of GNI during 1996-2005 to -4.0 percent during 2006-2010. A smaller factor depressing savings is fuel (lignite) depletion, which increased from an annual average of -0.4 percent during 1996-2005 to -0.8 during 2006-2010. As for the richest countries globally, FYR Macedonia's total wealth is dominated by intangible (human and social) capital rather than natural capital. Thus, other approaches are needed to generate useful insights into the nature of FYR Macedonia's green growth issues and challenges.

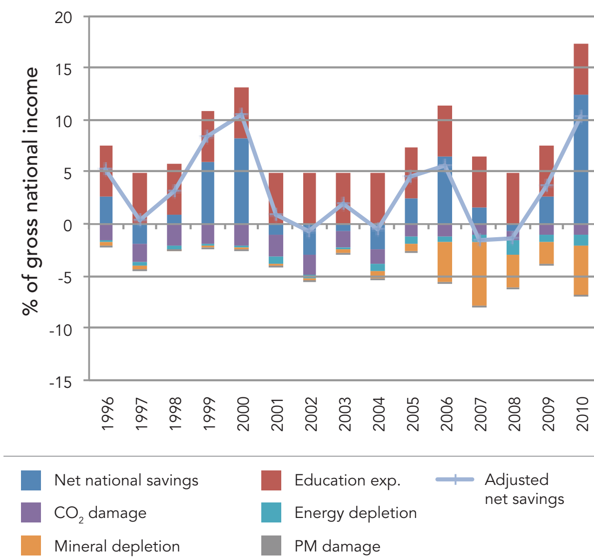
The figures and text below constitute an approach to Green Growth At-A-Glance. Each of the three blocks of the benchmarking framework is addressed in turn. A selection of key indicators is presented to illustrate the main messages from the full benchmarking exercise. Note that the data were rescaled using a normalization formula[25] to adjust indicators measured in different units and make them comparable to each other. Each indicator in the charts is measured in percentage difference from the sample mean for all 69 countries, weighted by its sample standard deviation. Note that zero in the charts below is the sample mean for each indicator. In addition, the data were adjusted by assigning a positive or a negative sign depending on the interpretation of the indicator: when higher values of the indicator reflected a desirable outcome, the sign was made positive (e.g., cereal yield); when higher values mean a worse outcome (e.g., unemployment), the sign is negative. As a result, the higher the indicator value in the charts, the better the outcome with respect to green growth.

24. Adjusted net savings equals gross savings minus consumption of fixed capital, plus education expenditures, minus energy depletion, mineral depletion, net forest depletion, and particulate emissions and carbon dioxide damage. For detailed methodology see: World Bank. 2011. The Changing Wealth of Nations: Measuring Sustainable Development in the New Millennium. Washington, DC: World Bank.

25. The normalization formula is (x-μ)/σ, where x is a value of the indicator, μ is the mean of all values of an indicator across all 69 countries, and σ is the standard deviation, and measures the difference between each indicator value and the sample mean per unit of the sample's standard deviation. The outcome is negative when the raw score is below the mean, positive when above.

FIGURE 1.3. **Mineral extractions are drawing down total wealth**

Adjusted net savings



Source: Staff calculations based on World Bank Development Data Platform.

PART 1: HOW GREEN IS FYR MACEDONIA? ENVIRONMENTAL PERFORMANCE AND THE GREEN ASSET BASE

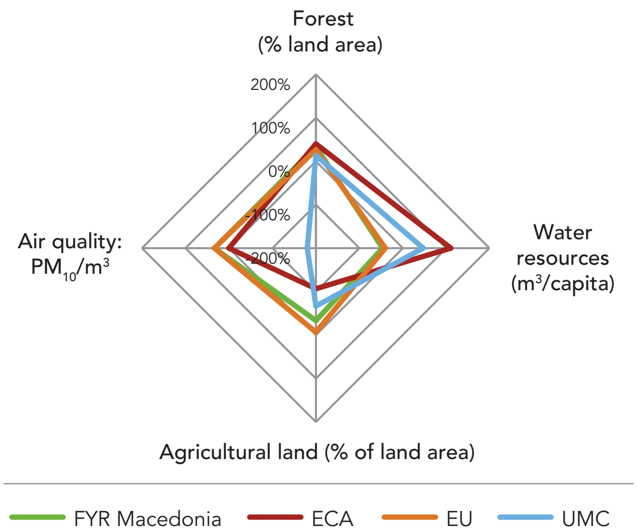
A country's natural resources are vital as productive inputs into economic processes or as conditions for production, as well as providing direct utility. Like other forms of capital, this natural capital requires investment, maintenance and good management in order to be productive and contribute to rising output and welfare. Environmental degradation, on the other hand, is costly to welfare and eventually to growth; while counteracting degradation can raise the long-run growth rate. Countries start with differing endowments of land (forests and agricultural land), water, clean air,[26] energy and minerals, and ecosystems, and they use these resources with differing degrees of sustainability of exploitation and productivity. Greenhouse gas emissions are considered here (as use of the natural resource of the atmosphere as a carbon sink) as is the country's stance towards adapting to a changing climate (important to sustainability of growth).

FYR Macedonia's natural resource endowment is close to the EU average in most aspects: land (including forest, agricultural land, mineral deposits and terrestrial ecosystems), water (water resources per capita, surface and ground water), and ecosystems. Air quality is among the worst in the EU, especially when adjusted to account for where people live (see Figure 1.4).

26. Clean air is not strictly an endowment but rather an outcome linked to past and current policy choices (as well as other factors such as industrial structure and geography).

FIGURE 1.4. **Air pollution worse than EU average**

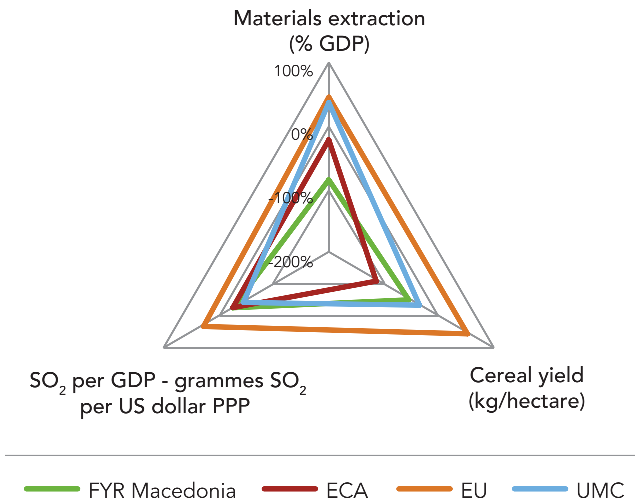
Natural assets: land, water, air, energy and minerals, ecosystems, 2009-2010



Source: Staff calculations based on World Bank Development Data Platform.

FIGURE 1.5. **Natural resources are less productive than in the EU**

The productive use of natural assets: land, water, air, energy and minerals, ecosystems, 2009-2010



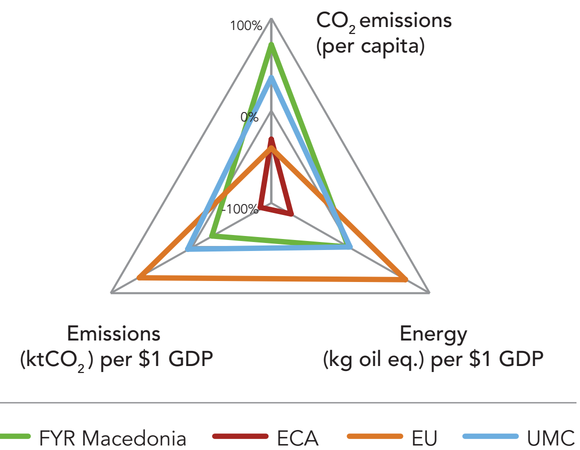
Source: Staff calculations based on World Bank Development Data Platform.

Further, **resource usage is less sustainable** over the long term than in the EU. The level of materials extraction (minerals) is somewhat high: as a percent of GDP, it is more than double the EU average although slightly below the ECA regional average (see Figure 1.5). In addition, FYR Macedonia has low efficiency of freshwater resource usage (or, phrased differently, the somewhat high level of water withdrawals creates moderate water stress), low agricultural productivity including low cereal yield, a high level of SO_2 pollution compared to output (almost 3 times above the EU and close to the ECA region's average level), and insufficient ecosystem protection. *The issue of unsustainable resource usage in FYR Macedonia is addressed in the following chapters of this report: Energy, Water, Agriculture, Urban, and Air Pollution.*

FYR Macedonia is not ready for a changing climate. The country has high **exposure** to climate change, worse than averages for any of the three comparator groups and in the top quintile within ECA countries (see Figure 1.8). With negative impacts already in evidence for its agriculture, water and hydropower sectors and with projected increased temperatures and reduced (and more variable) precipitation, the damages will increase unless resilience is improved. At the same time, FYR Macedonia's **sensitivity** to climate change is somewhat high, due to the relatively low quality of infrastructure, the importance of agriculture in today's output and employment (the sector expected to be hit hardest), and high existing levels of air pollution (indicating already damaged health). Low infrastructure quality is not only a problem for today's economy but also will tend to amplify climate damages into the future. Last, FYR Macedonia's **adaptive capacity** is somewhat low, driven by high inequality (Gini coefficient), limited political stability, somewhat weak governance and voice and accountability scores, and relatively low GDP per capita. (See Box 1.2 for definitions.) *FYR Macedonia's vulnerability to a changing climate is addressed in the following chapters: Transport, Urban, Agriculture, Air Pollution, and Social Aspects.*

FIGURE 1.6. **Production is creating high levels of greenhouse gas emissions**

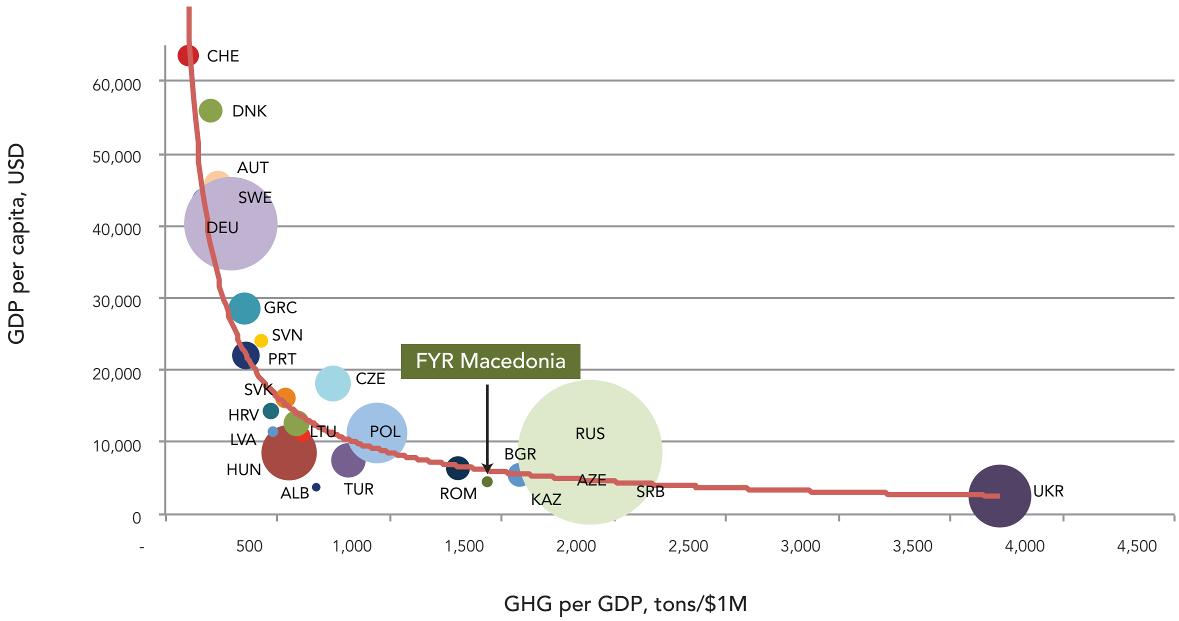
Indicators of greenhouse gas emissions and energy use, 2009-2010



Source: Staff calculations based on IEA database.

FIGURE 1.7. **The Macedonian economy has high emissions intensity, although it produces limited total emissions due to its size**

Emissions intensity (Greenhouse Gases, GHG, per unit GDP), per capita GDP, and total emissions, 2005



Note: Total emissions Include CO_2, methane, HFC, NOx, PFC and SF6; total in the economy (from all sectors). Bubble size reflects total emissions, in Mt CO_2e/year.
Source: World Bank, Development Data Platform.

BOX 1.2. Measuring Vulnerability to Climate Change[a]

Vulnerability to climate change can be thought of in three components: exposure, sensitivity and adaptive capacity, each of which can be measured approximately using indicators. The physical impacts of a changing climate will vary by country. The impact of those physical changes on a country's people and economy will vary. And the country's ability to react will vary.

Exposure is the strength of future climate change relative to today's natural variability for a country. It is measured here as an index based on annual and seasonal temperature and precipitation.[b]

Sensitivity to climate change is measured based on indicators likely to increase the impact of climate shocks. These include the level of water stress (renewable water resources per capita), the extent of air pollution (PM_{10}); the importance of agriculture in the economy (share of employment and value added); the exposure of the power sector to climatic risks (share of electricity generated by hydroelectric plants); the exposure of network infrastructure to climate change including extreme events (logistics index or index of overall quality of transport infrastructure); and the share of population under 5 (a measure of demographic/social flexibility of the society).

Adaptive capacity aims to capture a country's ability to react effectively. This capacity is a function of organizational skills, access to and ability to use information, and access to financing. In this analysis, three types of adaptation capacity are included: social adaptive capacity measured by the Gini coefficient (income inequality indicator), economic adaptive capacity measured by GDP per capita, and institutional adaptive capacity reflected in governance indicators.

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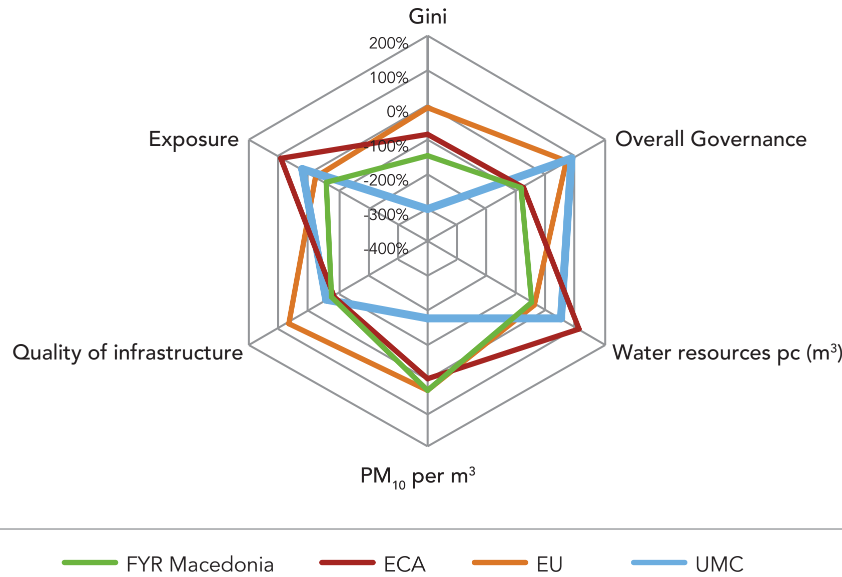
a. The definitions and many of the indicators used here replicate those proposed in Marianne Fay, Rachel Block, Tim Carrington, and Jane Ebinger, eds. (2009) Adapting to Climate Change in Eastern Europe and Central Asia. Washington, DC: World Bank.

b. Based on data used in Baettig, Michele B., Martin Wild, and Dieter M. Imboden. 2007. "A Climate Change Index: Where Climate Change May Be Most Prominent in the 21st Century." Geophysical Research Letters, Vol. 34, Issue 1. Washington, DC: American Geophysical Union.

FIGURE 1.8. **FYR Macedonia is vulnerable to a changing climate**

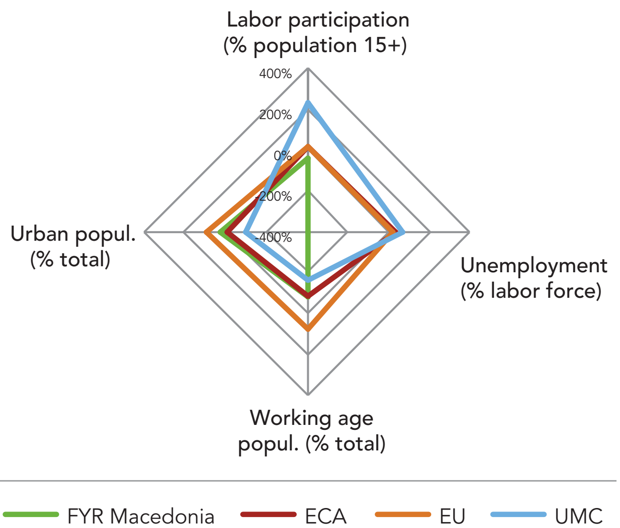
Exposure and sensitivity to climate change and capacity to adapt (selected indicators), 2009-2010



Source: Staff calculations based on World Bank databases: Development Data Platform, Poverty and Inequality database, and Worldwide Governance indicators.

FIGURE 1.9. **FYR Macedonia's supportive business environment cannot make up for poorly functioning labor markets**

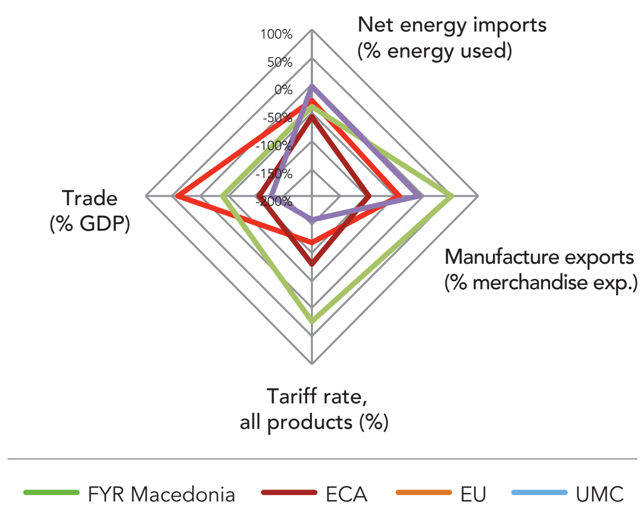
Labor market flexibility and human capital, 2009-2010



Source: Staff calculations based on the World Bank Development Data Platform.

FIGURE 1.10. **Global links are not yet strong enough**

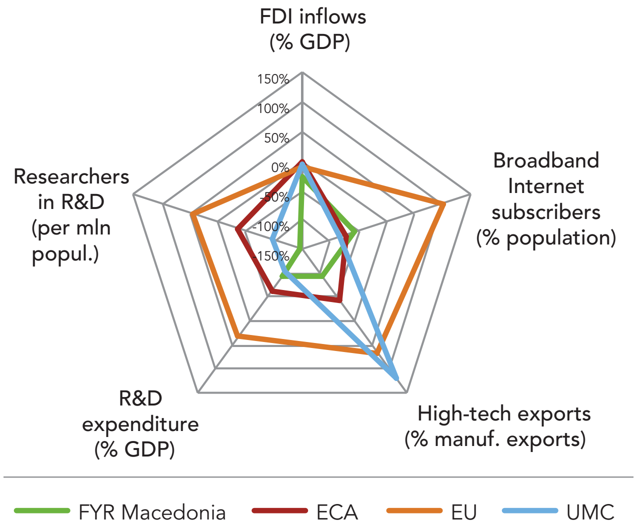
Trade and openness, 2009-2010



Source: Staff calculations based on the World Bank Development Data Platform.

FIGURE 1.11. **FYR Macedonia is not ready for a wave of innovation**

Global connections, innovation readiness, and green industry, 2009-2010 (for FDI inflows: 2006-2010)



Source: Staff calculations based on the World Bank Development Data Platform.

PART 2: GOING GREEN: FLEXIBILITY OF THE ECONOMY

Transition to a greener economy can be thought of as an economic shock, where higher benefits and lower adjustment costs will be closely related to flexibility and availability of human capital and the nature of global links. As for a trade shock, the greening of the world will change relative prices.[27] The same basic conditions that support economic growth would also support the shift to greener growth: a flexible labor market, human capital adequate for a modern economy, and a supportive business environment and sufficient capital mobility to ease firms' entry and exit. Efficient labor market regulation and strong human capital are critical for the green growth transition as labor resources should be easily reallocated to more dynamic sectors; and urban concentration facilitates that mobility. Business regulation defines the private sector capacity to create jobs in response to changing prices and markets while other supporting indicators are a current focus on manufacturing rather than agriculture (which tends to respond slowly) and energy pricing that covers costs (as a first step towards reducing energy sector emissions). Lastly, global links need to be strong. Openness to trade facilitates new technology transfer and replacement of more obsolete capital stock.[28]

27. The parallels between trade shocks and greening of growth are also proposed in a recent paper: Porto, Guido. 2012. "The Cost of Adjustment to Green Growth Policies: Lessons from Trade Adjustment Costs." World Bank Policy Research Working Paper 6237. Washington, DC: World Bank.

28. Openness to trade and the nature of trade are important for a variety of reasons. Greater openness (such as lower tariff rates) allows for easier technology transfer and adoption, often embedded in capital equipment. A focus on manufactures exports makes such transfer more likely. Trade allows for outsourcing of pollution—carbon leakage or trading. Greater dependence on imported fuels and minerals reduces the ability of the economy to adjust quickly and with modest cost to higher fuel prices.

FYR Macedonia's economy is not sufficiently flexible to benefit easily from going green. The country had some of the strictest employment protection legislation in the ECA region (as of 2008), and unemployment is the highest in Europe at 34 percent of the labor force. Labor force participation is low, as is tertiary school enrollment. The business regulatory environment is evaluated as well above average, and the overall level of investment is one of the highest. The trade channel should be important for FYR Macedonia in benefiting from global green growth agenda. However, the country's share of manufactures exports is at the low end of the sample range for the EU and the ECA region, while tariff barriers to trade remain high, well above the ECA regional average. Last, FYR Macedonia is dependent on imports of energy, although less so than most of the countries in the sample. *Flexibility of the Macedonian economy as it relates to green growth is discussed in the following chapters: Macroeconomics, Water, Agriculture, Energy, Transport, Urban, Air Pollution, and Social Aspects.*

PART 3: RIDING A GREEN WAVE: INNOVATION

Might greener growth be faster growth that creates more jobs? If so, it will be due to frontier innovations that shift out global production possibilities. The scope of opportunity for any particular country will depend on how fast the world as a whole goes green and whether that country has access to global knowledge coupled with the ability of its firms to understand, adapt and use that knowledge. Some countries offer best practice examples of achieving green growth objectives through innovation (see Good Practice Box 1). The energy sector is likely to be at the heart of both frontier and catch-up innovations which adapt new technologies to local settings. Openness to international trade and foreign direct investment (FDI) are among the key factors correlated with innovation. Many green technologies are embodied in imported capital goods, machinery and equipment. Foreign trade opens the gate for technological advances as new technologies embedded in imports help modernize the existing capital stock, while new markets offer scale economies from export expansion. Access to modern communication means is another significant factor of innovation. Finally, country's capacity to absorb knowledge, reflected in such characteristics as research and development (R&D) expenditures, the percentage of researchers in the population and patent applications, is a critical component of its innovation potential.

FYR Macedonia's connections to global knowledge and readiness for an innovation revolution are insufficient, by these indicators. Although the foreign trade-to-GDP ratio in FYR Macedonia increased from around 62 percent in the early 1990s to around 100 percent by 2010, the country remains less open than such economies as Hungary, Slovakia, the Czech Republic, Slovenia, Lithuania and Bulgaria. In recent years, FYR Macedonia attracted FDI of about 2 percent of GDP, which is close to the sample average but far below the level needed to achieve investment-driven accelerated growth today or strong global links into the future. While FYR Macedonia's potential in the energy sector and in the broader green economy is significant, FYR Macedonia will need to craft appropriate policies to take advantage of these opportunities. For access to modern communication, FYR Macedonia lags behind neighboring countries: its broadband subscription level (subscribers per 100 people) is 2.5 times below that of the EU. FYR Macedonia also needs to enhance its knowledge absorption capacity: currently it lags behind countries like Denmark and Switzerland by a factor greater than 10 in the indicator of researchers per million of population; it has a very low level of R&D expenditures—the lowest level of patent applications by population in Europe (among countries with available data). *These issues, while important, reach beyond the scope of this report.*

RECOMMENDATIONS

This benchmarking exercise identified a selected set of issues within the broad green growth agenda on which FYR Macedonia should focus as it considers how to move onto a greener growth path. Mapping FYR Macedonia against comparator countries and country group aggregates allows policymakers to consider the country's relative standing on the three aspects of measuring 'green-ness': (i) How green? (ii) Going green, and (iii) Riding a green wave. Benchmarking is, of course, only a starting point, making use of existing data to highlight in a quick fashion the key aspects for a particular country that merit more serious analysis and consideration. Further, a country pursuing green growth might find occasional benchmarking of value to measure relative progress. It would likely be most useful if supplemented with a locally-designed results framework, populated with local detailed data. In some instances, it may be necessary to develop and collect new and better data to enhance monitoring. With this benchmarking exercise as evidence, the Macedonian government might consider the use of these and similar indicators, and the development of a results framework populated by indicators, to support the implementation of its National Strategy for Sustainable Development.[29]

FYR Macedonia faces numerous challenges in building its green growth path. One complicated area is **unsustainable use of resources**. The Macedonian economy suffers from decades of unsustainable usage of resources including moderate water stress created by high water withdrawals, low agricultural productivity including low cereal yield, a high level of pollution, insufficient ecosystem protection, and, more recently, rather high rates of metal extraction.

29. FYR Macedonia's National Strategy for Sustainable Development (NSSD), adopted by the Government in 2010, pulled together analysis across 11 sectors and six themes to provide an integrated strategy aimed at economic growth, environmental stewardship, and social progress, a combination that now is often called 'green growth'. The strategy declares that social, economic and environmental goals should be complementary and interdependent throughout the development process, a concept lying at the heart of the concept of sustainable development. It aims to provide an effective framework on how to plan and implement sustainable development, offering an overall umbrella for policies and strategies across various sectors. Submitted to the EU as part of candidacy requirements, the NSSD recommended that the government develop an integrated policymaking approach and combat a lack of awareness on sustainable development issues. The new analysis synthesized in this report will be used to revise the NSSD and generate a prioritized action plan for implementation.

GOOD PRACTICE BOX 1.

Achieving green growth objectives through innovation and R&D policies in Norway

The Norwegian green growth strategy aspires to achieve green objectives through innovation and sees innovation as a process of building a creative society, which puts human wellbeing and sustainability at the center.[a] Three areas of innovation are prioritized—entrepreneurship, business growth and innovative environment building—and six sectors are targeted: energy and environment, oil and gas, healthcare, agriculture, marine, maritime and tourism.

In line with the strategy, a new environmental technology scheme supporting enterprises which conduct pilot research was launched with funding of US$ 80 million. More research funds are now allocated to the development of environmental technology. A Strategy Council for Environmental Technology was set up and a national strategy for environmental technology prepared.[b] The users of the new technologies are involved in the development of innovation programs, increasing the program quality and leading to strong and continued stakeholder support. Also, the Norwegian Research Council's new strategy for innovation for 2011-2014 was adopted. It emphasizes public sector innovation and innovation through procurement and focuses on competitive Norwegian sectors, such as energy, marine, and maritime.

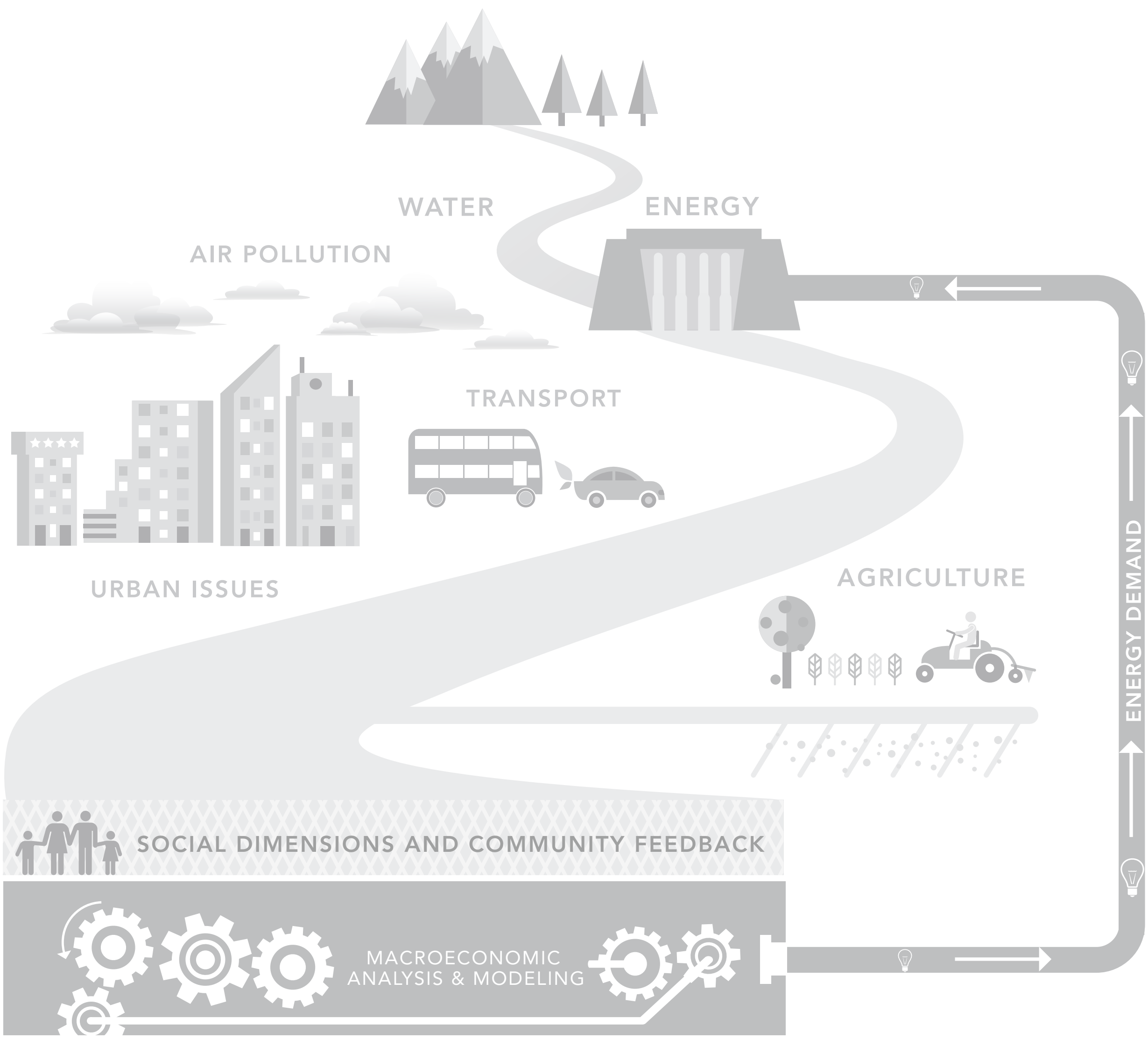
Source: Background information from the Green Growth Best Practice Initiative, Green Growth Best Practice Assessment Report 2013. Seoul: GGBP.

a. See the 2008 white paper on Innovative and Sustainable Norway by the Norwegian Ministry of Trade and Industry.

b. Towards a New Innovation Policy for Green Growth and Welfare in Nordic Region. 2012. Oslo, Norway: Nordic Innovation. Available at http://www.nordicinnovation.org/Global/_Publications/Reports/2012/2012_02%20Towards%20a%20new%20innovation%20policy%20for%20green%20growth%20and%20welfare%20in%20the%20Nordic%20Region.pdf, accessed on 10 July 2013.

Policymakers need to consider when drawing down natural capital in the interest of economic growth is a wise tradeoff and when it is not. More investment in maintaining and upgrading natural assets seems warranted from the benchmarking exercise. Another area of concern is the **high emission intensity** of the Macedonian economy. To break this pattern, substantial investments are needed, with the most significant capital expenses likely to be in gas transport and distribution; energy sector and large industry modernisation; and construction of new electricity generation facilities, mainly hydro and renewable energy. Policy reforms are also critical to achieve reduced emissions in the energy, industrial, transport and household sectors. FYR Macedonia also needs to **improve its climate change adaptive capacity and reduce its sensitivity to climate change**. Many of the improvements needed will arise naturally as part of rising incomes, but the government does need to manage actively the likely impacts on agriculture, especially because of the large number of households still dependent on agricultural earnings. The impact of a changing climate should provide additional impetus to the government to modernize agriculture, improve infrastructure, and invest in skills.

Rigidity of the economy will prove an obstacle to green growth. It will be important for the success of any green growth plans to implement a set of structural reforms, consistent with the government's short-term growth agenda, to address the remaining rigidities of the Macedonian economy—creating a truly flexible labor market, enhancing openness to trade, and continuing to strengthen the business environment, and improving infrastructure and logistics. A last challenge, and perhaps the most difficult, is in increasing **connections to global knowledge and support of innovation,** to bridge the gap with other European countries in access to modern communications and in support of scientific research. While the list of challenges seems long, FYR Macedonia also benefits from advantages. The tradeoffs between high, traditionally-measured economic growth and a broader definition of long term welfare are not severe in the case of FYR Macedonia; rather, there is much complementarity between the short term and the long term. The country continues to implement policy and structural reforms that will lead to more vibrant as well as more sustainable growth. Its location in the middle of Europe in itself provides substantial economic opportunities, and its aspirations to membership in the EU both limit its policy choices and align them with greener paths.


WATER
ENERGY
AIR POLLUTION
TRANSPORT
URBAN ISSUES
AGRICULTURE
ENERGY DEMAND
SOCIAL DIMENSIONS AND COMMUNITY FEEDBACK
MACROECONOMIC
ANALYSIS & MODELING

Where is FYR Macedonia Heading? A Baseline Scenario for Economic Development to 2050

CHAPTER SUMMARY

The baseline or business-as-usual (BAU0) scenario in the absence of climate change serves as a starting point for comparisons of economic outcomes before and after policy actions or investments. It is a hypothetical path envisaging what would happen to FYR Macedonia until 2050 under current policies and without considering the impact on the economy of a changing climate. The BAU scenario proposed here reflects a broad consensus that income per capita in FYR Macedonia will catch up gradually to European Union levels, growing at an annual average rate of 3.4 percent between 2012 and 2050. The baseline scenario to 2050 developed here initiates an answer to the question, "Where is FYR Macedonia heading?"

Total factor productivity gains are expected to be the main growth driver. Structural change in the Macedonian economy will be reflected in a gradual shift from primary sectors such as agriculture and industry towards services, although FYR Macedonia is to retain more specialization in these sectors in comparison to the average experience in the EU. Shifts in output towards less energy and emissions-intensive sectors and rising efficiency within sectors will together drive energy and greenhouse gas emission intensities in FYR Macedonia towards EU levels. While the BAU scenario incorporates current information and agreed assumptions, updating will be necessary if further analysis is to be undertaken at a future date. This baseline is also incomplete because it fails to consider the damages to economic activity likely from a changing climate into the future.

CHALLENGES FOR GREENER GROWTH

Overview

A baseline scenario serves as a benchmark for comparisons of economic outcomes before and after policy actions or investments, but it is a purely hypothetical path that envisages what would happen in the case of no policy change or 'business-as-usual' (see Box 2.1 describing baseline scenario as compared with green scenarios). In the academic literature, business-as-usual projections are often based on extrapolation of historical trends or adoption of steady-state GDP growth. A steady-state baseline, in which all physical quantities grow at an exogenous uniform rate while relative prices remain unchanged, would have the virtue of providing a transparent reference path for the evaluation of policy options. However, such a path is unrealistic, especially over a long time period, limiting the usefulness of the model results to policymakers, who need more realistic comparisons. For example, when a country decides on a target for mitigating greenhouse gases, the target is generally defined against a base year, as a certain percent reduction compared to that year. But such a definition provides little indication of the degree of challenge involved in meeting the target. What matters is the size of the reduction compared to the level of emissions in the target year, which lies in the future. This expected level is a matter for projections, determined by assumptions about the growth rate of emissions in the absence of additional policy—the business-as-usual emissions baseline. Faster expected growth translates to faster rising emissions, and the higher is the future emission level in the absence of climate policy, the more stringent are the effective reduction targets and, thus, the costs of abatement.

Does the Past Provide a Good Roadmap for the Future?

FYR Macedonia's historical trends are important inputs into the construction of the baseline scenario, and the recent disturbances in longer term trends due to the global crisis make this exercise complicated. FYR Macedonia's steady growth during the pre-crisis period of 2004-2008 was followed by a mild recession in 2009. Then the gradual recovery to near 3 percent during 2010 and 2011 became increasingly threatened by the worsening Euro zone outlook. Southern Europe suffered most from this downturn, and FYR Macedonia's 2012 GDP growth was pushed below 0.5 percent. Without the last two years, the average growth rate in FYR Macedonia in the 2000s would reach 3.2 percent on average. However, due to improved business climate efforts to attract investment, the medium-term growth outlook for FYR Macedonia is relatively positive, with growth projected to rebound in 2013-2014 and reach 3.5 percent in 2015. Also, from a broader, global perspective and considering the experience of fast growing middle-income economies in East Asia and selected African countries, FYR Macedonia can be seen to possess significant reserves that could speed up GDP growth. Similar to other countries moving towards EU membership in the past, FYR Macedonia may well reap substantial benefits from ever-closer economic integration with Europe (See Figure 2.1).

Economic convergence is a reality for the European Union. Although there is no agreement over whether economic convergence of nations holds overall, the European Union has demonstrably fostered strong convergence among its members and also, to some extent, on candidate countries. The 'catch-up' hypothesis is driven by the assumption that productivity growth rates vary inversely with productivity levels. Then it follows that the convergence process stems from lower initial income levels, higher returns on capital, and substantial potential to improve labor participation and productivity, while the country benefits from a diffusion of global technological progress. Over a long forecasting period, such as the 40-year horizon used in this analysis, convergence is a convincing and practical approach to predicting what any individual economy might look like in the distant future.

BOX 2.1. Baseline scenario as a benchmark for analyzing the impact of green interventions

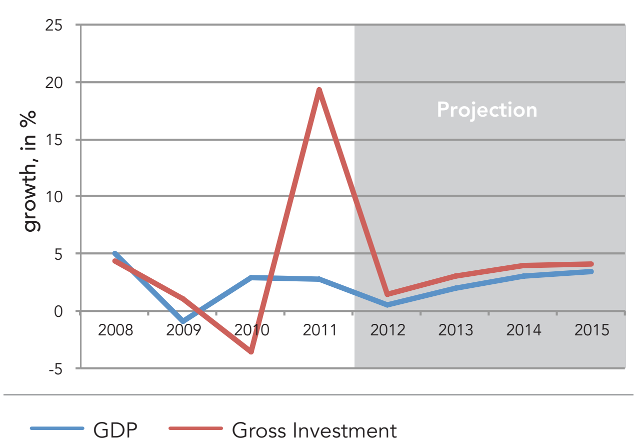
Scenario analysis is used to evaluate the impact of mitigation and/or adaptation actions in five overlapping sectors—water, agriculture, energy, transport, and infrastructure—which are then integrated into the macroeconomic or economy-wide analysis. Two initial scenarios and then two policy scenarios are constructed for the analysis.

Green scenarios. Two green policy and investment scenarios—'Green' and 'Super Green'—are formulated in a bottom-up fashion based on the specifics of each sector, as part of the sector analysis. For each sector, the Green and Super Green scenarios involve government policies and investments to address greenhouse gas emissions mitigation and adaptation to climate damages. They constitute a package of ambitious but practical actions to abate emissions and counter climate change. The Super Green scenarios are very ambitious and more expensive packages, generally requiring more aggressive implementation of green measures or wider coverage of such measures. The sector scenarios are then combined into economy-wide green scenarios.

Business as Usual (BAU) scenarios (see Chapters 2 and 3). The policy (green) scenarios are compared to BAU, a baseline scenario, which extrapolates current economic development trends for FYR Macedonia to 2050 and also accounts for climate change projections. Sometimes called a 'no policy change' scenario, the BAU scenario is built as an extrapolation of current economic trends without considering climate damages (the BAU0 scenario). Even under BAU, however, key sectoral inefficiencies must be addressed to allow the economy to reach a consensus growth path. Then the scenario is adjusted for climate change to create the final BAU scenario.

FIGURE 2.1. Recent turbulence makes projections more difficult

Macedonian growth path



Source: Staff calculations.

What should FYR Macedonia do to catch up with the European Union?

A set of essential reforms is needed for FYR Macedonia to catch up with EU countries over time, and the baseline scenario assumes progress. Across sectors, the largest productivity gains that are implicitly included in the baseline will come from tackling three major problems of the Macedonian economy: (i) outdated and broken down assets that need to be refurbished or replaced; (ii) some prices below cost recovery level; and (iii) an insufficient legal and institutional framework. All these reforms will require policy support, and some will require substantial investments. Their full implementation is a long-term task.

Essential sectoral assets are run down, leading to lowered productivity. Assets have outlived their lifespan and have not been maintained properly since for decades. In agriculture, this relates to irrigation systems, which do not provide adequate coverage of the irrigation needs and are dilapidated. At the same time, irrigation is essential for expanding production of high-value crops, which is the core objective of the sector reform. In the water sector, the supply systems are broken down, causing unreliable water supply and water losses. This creates economic losses throughout the economy, affecting productivity of all water-consuming sectors including the household sector. Low quality roads and railways cause problems with connectivity, negatively affect safety of transportation, and, as a result, impose additional cost on the economy. This is exacerbated by a growing prevalence of old fuel inefficient personal vehicles, which adds to the safety problem and increases the cost of transportation. In the telecommunications, outdated assets negatively affect both present and future competitiveness of the country in the increasingly technology-based global economy.

Pricing key inputs below cost recovery level means high level of subsidization, both implicit and explicit, which is burdensome for the public sector and discourages private investment. Water tariffs do not cover the cost of water supply, with resulting negative net revenue of the water utilities. While a good tariff methodology has been approved as a law, it is yet to be applied. Gas sector liberalization has been delayed, and gas pricing is inefficient, leading to lowered demand for gas, which could be a major component in the future Macedonian fuel mix, reducing the prices of energy. Electricity prices in the industrial and commercial sectors reached cost recovery, but the process of power tariff increases in the household sector, after significant progress during 2008-2012, has stalled. District heating prices are also below their cost recovery level.

A poor legal and institutional framework is yet another problem that must be overcome to reach EU levels of productivity. In the water sector, lack of control over groundwater has led to its unsustainable usage, free of charge, by agriculture, mining and industry. In agriculture, farm fragmentation and inadequate land markets have encouraged unproductive land use. In addition, unregulated and careless farm practices has led to soil fertility problems, such as erosion, soil-born pests and diseases, and soil pollution by fertilizers, seriously affecting agricultural productivity. In transport, public transportation is almost non-existent, including in cities, exacerbating over-use of private vehicles.

FYR Macedonia is a relatively small and open economy; hence, productivity improvements and projected further declines in energy and carbon intensities will be byproducts of trade and international technology spillovers. Those spillovers will occur automatically through new investment, because most capital machines and equipment are imported; and even if not new, they will be newer and more efficient than the existing Macedonian capital stock. Assuming a five percent depreciation rate of existing capital, the total capital stock in FYR Macedonia would be replaced in about 20 years, and this process will repeat during the next 20 years. Therefore, the energy and carbon intensity of the economy will improve via the trade channel, which will provide technological spillovers via embedded technical progress. Thus, innovation in the EU—its main trading partner—or elsewhere in the world will spread to FYR Macedonia.

As will be outlined in each of the sectoral chapters below, FYR Macedonia will achieve increased employment, boost its long-term economic growth, and make progress toward the EU requirements for the country's accession to Europe if the problems described above are tackled. FYR Macedonia has already committed to specific plans and a schedule of actions in energy, renewable energy, competition, and the environment by ratifying the Energy Community Treaty for South East Europe in 2006. Actions in other areas will be added to this list of commitments as the country moves closer to European Union membership.

METHODOLOGY AND MAIN FINDINGS

Methodology

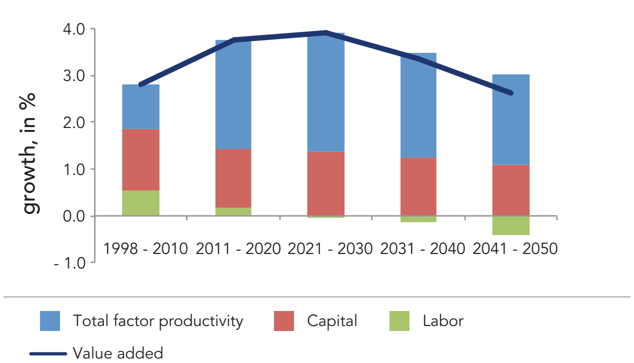
The baseline scenario for FYR Macedonia 2050 reflects a broad consensus that income per capita in FYR Macedonia will catch up gradually to EU levels, growing at an annual average rate of 3.4 percent during 2012-2050. Future economic trends in FYR Macedonia are expected to follow broadly the trends observed in countries that in the past had comparable income per capita levels to FYR Macedonia today. These trends include a shift from primary sectors such as agriculture and industry towards services, quickly rising labor supply and labor productivity in the near term, moderating over the long-term; sustained total factor productivity growth, and a strong contribution from capital.

Total factor productivity gains are expected to be the main growth driver in FYR Macedonia through 2050. The projected growth trajectory is consistent with long-term total factor productivity (TFP) growth rates of about 2.3 percent in FYR Macedonia and 1.5 percent in the EU. The latter assumption reflects a reduced growth potential due to the recent crisis. Smaller positive contributions to growth are to stem from capital accumulation during the projection period. A positive contribution from labor is expected only in the 2010s and 2020s, when increases in the employment rate from its current extremely low level (of 39 percent in 2010) outweigh the negative effects of an aging population. In the following two decades, the contribution of labor will become negative, while over the same time period, both GDP and TFP growth rates begin to moderate. (See Figure 2.2).

The baseline scenario through 2050 was estimated econometrically, based on continuation of the trends and convergence processes observed in the EU and FYR Macedonia in the recent past. The business-as-usual scenario (before consideration of climate change, the BAU_0 scenario) assumes that FYR Macedonia will continue to converge towards the economic structure of the average EU country in line with the path experienced by EU members in the recent past. Using data for EU countries and FYR Macedonia during 1996-2006, panel regressions estimated the pace of convergence across 11 sectors for value-added share, energy intensity, and emission intensity. Long-term growth trends for the 27 EU countries were estimated based on the same

FIGURE 2.2. **Productivity growth and capital investment will be the major sources of long-run growth**

Value-added decomposition, annual growth in %



Source: Macroeconomic technical paper.

data. Then projections of the key variables for the EU27 and FYR Macedonia through 2050 were generated based on the growth trends for the EU adjusted by the convergence rates for each sector. Once the convergence process is completed, i.e., the country reaches the average EU level, it continues to grow at the average, trend rate.

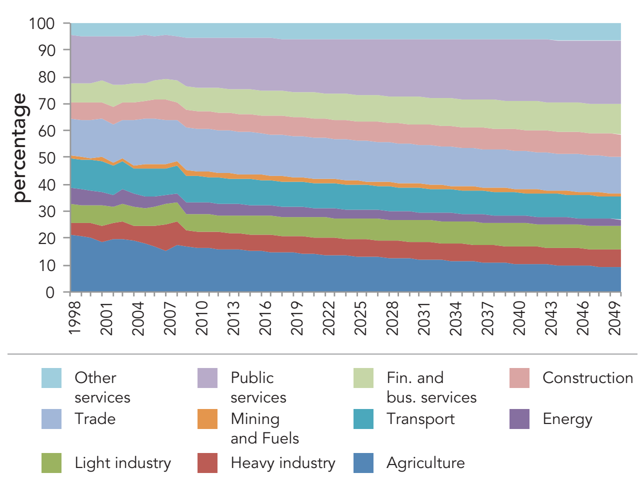
Main findings

The structure of output will gradually shift from primary sectors such as agriculture and industry towards services by 2050. This pattern derives from the general growth pattern observed in more advanced EU countries in the past and other high-income countries outside Europe over recent decades as incomes were rising. The sector projections were generated based on historical data as a starting point and adjusted by the projected convergence rates for each sector, calculated using regression techniques, as noted above. Following experts' judgment, a few modifications were introduced to the sectoral pattern—given that the regression sample was from the pre-crisis period, the share of finance and business services was kept stable rather than increasing to the very high levels observed in the EU pre-crisis. (See Figure 2.3).

Despite moving towards the economic structure of the EU, agriculture and industry will continue to have a higher share in the Macedonian economy than in the EU today, and this will be reflected in employment. The share of agriculture and agro-industry in value-added is projected to decline from 17 percent in 2010 to about 10 percent in 2050, a level three times higher than the average in the EU. At the same time, the share

FIGURE 2.3. **Structural shift from agriculture towards services will continue, but agriculture share in total output will remain relatively high**

Structure of value-added by sector



Source: Macroeconomic technical paper.

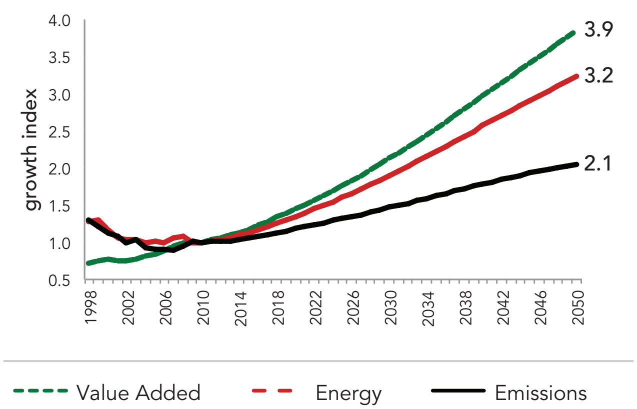
of light and heavy industry is to increase from 13 percent to 16 percent over the next four decades, reflecting the country's comparative advantage in these sectors. Finally, the shares of construction, public, financial, and other services will rise gradually. These trends in value-added, together with changes in labor productivity, will be reflected in the sectors' shares of employment. Employment shares in agriculture, industries, and energy are projected to decline, while there will be a higher share of employment in services and construction.

Energy and GHG emission intensities in FYR Macedonia will also converge towards EU levels. Sectors vary in their energy and carbon intensities (defined as the ratio of energy consumption or GHG emissions to value-added in a given sector). A unit of output produced by heavy industry usually requires more energy (and, hence, more emissions) than a unit of output in services. The energy and emissions intensity projections for FYR Macedonia in 2050 are fairly conservative and assume gradual improvements in energy and carbon intensity levels over time. The efficiency gains will be slower in the years ahead as compared to those FYR Macedonia experienced in the past decade. The picture depicted by future energy and carbon intensity portrays a partial decoupling of energy and GHG emissions from GDP growth, as emissions grow but more slowly than output. (See Figure 2.4).

The projected energy and carbon efficiency improvements over the next 40 years will be largely channeled through imports of investment goods (with embedded new technologies). With robust economic growth through 2050, value-added in FYR Macedonia is to increase by a factor of 4, energy use by a factor of 3, and emissions by a factor of 2, all relative to 2010. As a small open economy, FYR Macedonia will benefit from the new technologies developed elsewhere, even without adopting state-of-the-art technologies, since any new vintage of capital is usually more energy efficient than the previous one.

FIGURE 2.4. **Energy and emissions will be partly decoupled from GDP growth**

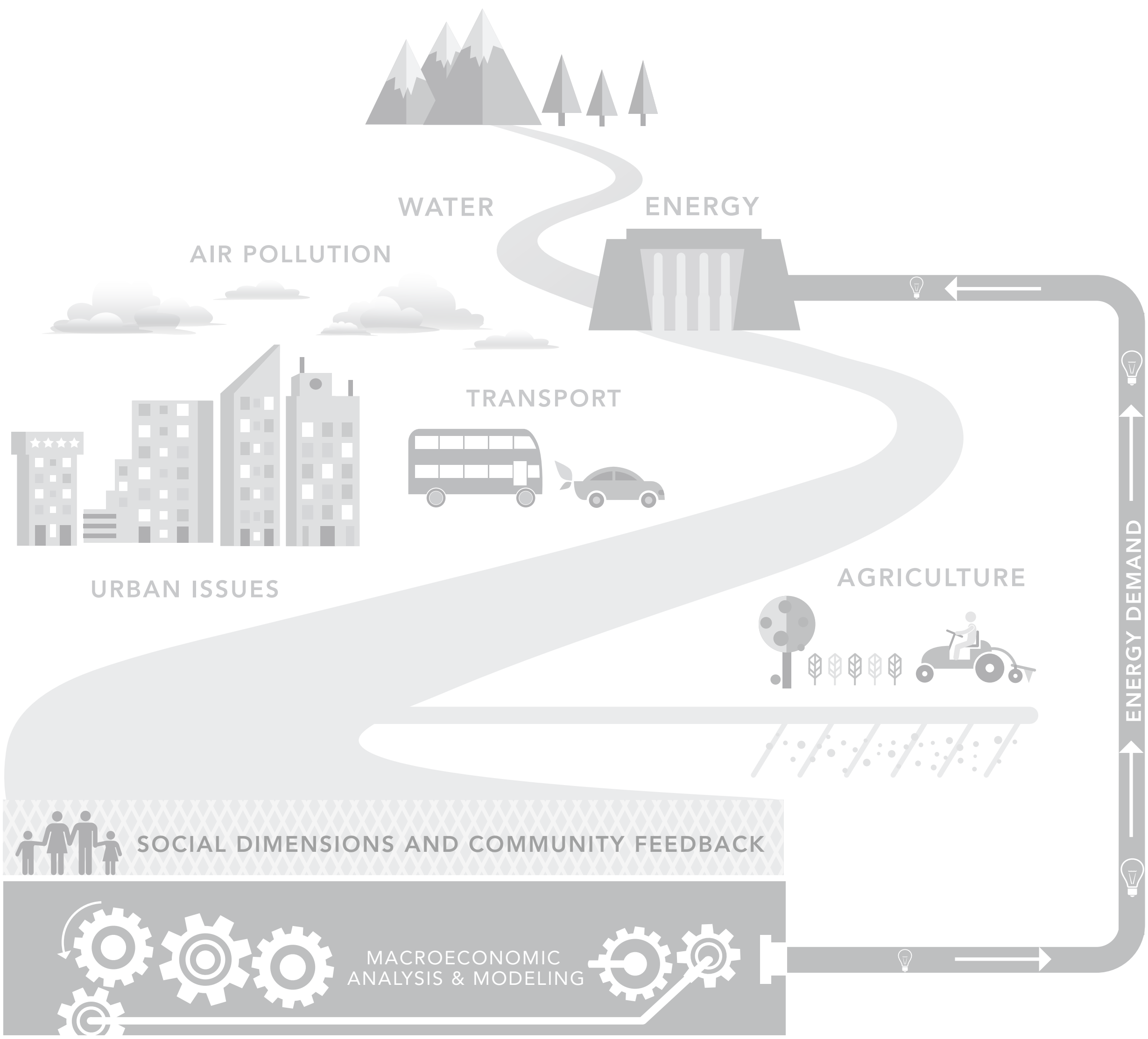
Value-added, energy consumption, and GHG emissions, Year 2010=1



Source: Macroeconomic technical paper.

RECOMMENDATIONS

A business-as-usual scenario is the foundation of any analysis of alternative policy and investment paths. Since the baseline is so critical to analytic results, it is particularly important that the method of construction is transparent, that assumptions such as future world energy prices are frequently reassessed, and that alternative baselines are explored. The scenario needs to be updated whenever its assumptions have become stale or whenever policymakers or analysts change their views about the likely path forward for the economy in the absence of any policy change. Importantly, the BAU_0 scenario is not an accurate forecast of the future until the likely impact of a changing climate on economic assets and activity is incorporated. (See the next chapter).


WATER
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ANALYSIS & MODELING

How Will a Changing Climate Affect FYR Macedonia's Future? A Climate-Sensitive Baseline

CHAPTER SUMMARY

a more complete business-as-usual (BAU) scenario starts from the BAU0 scenario set out in Chapter 2 and aims to capture the main elements of the impact of projected climate change on FYR Macedonia's economy to 2050.[30] A baseline that ignored climate damages over the next 40 years would be inaccurate. The climate-sensitive BAU scenario sets the appropriate baseline against which to assess adaptation measures to recover from those damages and addresses the important question, "How will a changing climate affect FYR Macedonia's future?"

Projected climate change will affect FYR Macedonia's economy mainly from a direct shock in agriculture and associated spillovers on other sectors in the economy, and to a lesser extent due to losses caused by extreme events. Growing water shortages will dampen crop yields and agricultural incomes. These losses are projected to increase in absolute value, but they will decrease as a ratio to GDP because of the shrinking role of agriculture over the next four decades. As the country becomes drier and hotter, the risk of floods will diminish but the risk of wildfires will increase. Due to climate damage, the level of GDP in 2050 is estimated at around 0.6 percent below the BAU scenario level.

The BAU scenario improves the baseline by bringing it closer to the likely evolution of the Macedonian economy in the absence of policy change. However, in addition to the uncertainty of a simple baseline, the incorporation of some main avenues for climate damage into the scenario compounds the complexity of the forecast and greatly raises the degree of uncertainty surrounding the scenario.

CHALLENGES FOR GREENER GROWTH

Overview

A changing climate is expected to impose damages on economies. Those damages can come from extreme weather events: floods and storm surge, heat waves and wildfires, and sea level rise; and related events such as the spread of disease. The damage can come from reductions in productivity driven by, for example, growing water scarcity. The damage can be directly to people, to their houses and possessions, or to infrastructure and capital. Estimates of global costs to world GDP in 2050 related to a changing climate generally do not exceed 2 percent. The impact of a changing climate on the Balkan Peninsula, for which little analysis has been undertaken to date, can be expected to resemble that for the Mediterranean region, where economic losses by the 2080s are projected at not more than 1.5 percent of GDP.[31]

30. See Box A and Box 2.1 describing modeling scenarios in this study.

31. See macroeconomic modelling technical papers for a review of global estimates.

While GDP losses due to climate change have not before been quantified at the national level for FYR Macedonia, the country's latitude and geography would argue that rising temperatures and less rainfall accompanied by more extreme weather are most likely to dominate the climate future. Scarcer water and hotter summers could well put agriculture, a major employer and important economic sector in today's FYR Macedonia, at risk and might also have direct health impacts. More variable weather would increase damages to infrastructure and people from weather extremes such as floods, droughts and wildfires.

The business-as-usual scenario derived in Chapter 2 is not an accurate baseline for FYR Macedonia's future growth because it ignores the impact of a changing climate on economic performance. Although incorporating climate change into growth scenarios is a challenging task with no agreed methodology, the failure to do so would make it difficult to consider the positive impacts of adaptation policies and investments, a key part of a greener growth path. Those investments are meant to recover some of the lost output and employment caused by climate damage.

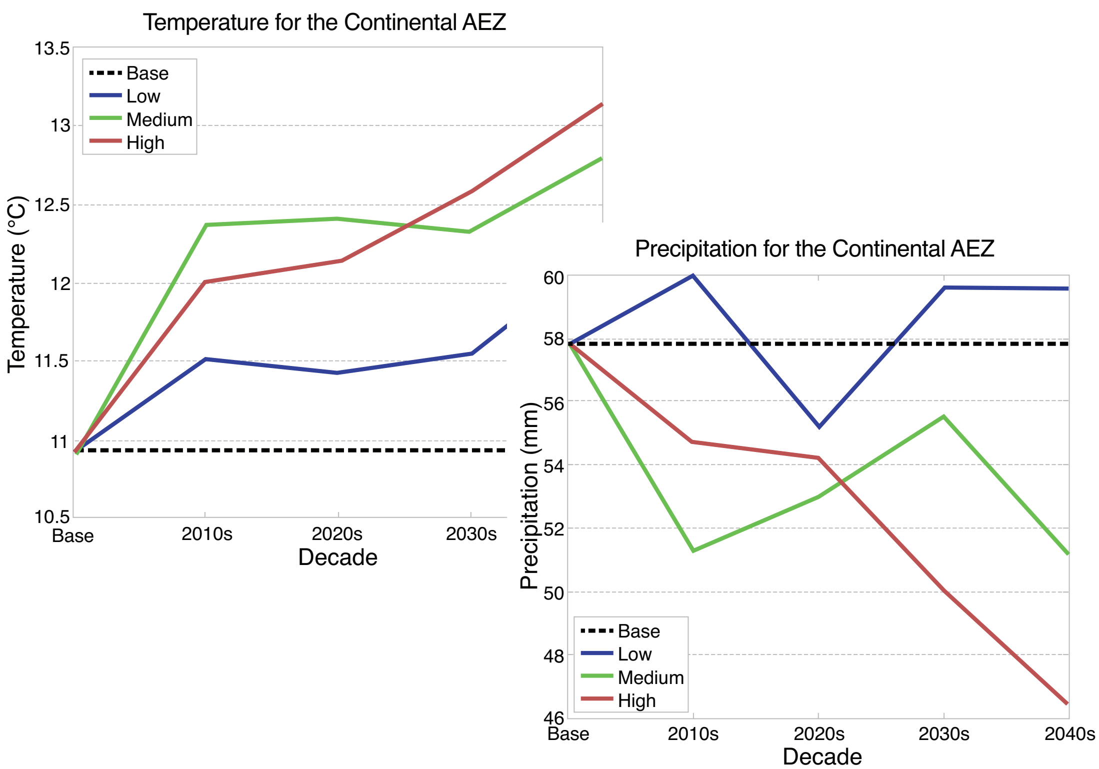
METHODOLOGY AND MAIN FINDINGS

Methodology

Future climate scenarios were developed, showing rising temperatures and falling precipitation. Climate baselines were developed using climate data for each of FYR Macedonia's 16 river basins, derived from monthly historical temperature and precipitation observations from the country's 22 meteorological stations for 1961 to 2000. The baselines were combined with projections of changes in temperature and precipitation obtained from Global Circulation Models (GCMs) to create daily and monthly time series of future climate from 2011 to 2050. Three climate scenarios are used--low impact, medium impact, and high impact--based on the most positive, the median, and most negative changes in the climate moisture index (a measure of aridity) from the baseline to 2050 across 56 available combinations of GCMs and scenarios employed by the Intergovernmental Panel on Climate Change (IPCC) (See Figure 3.1).

FIGURE 3.1. A hotter and drier future is likely

Three scenarios for future temperature and precipitation through 2050



Source: Water sector technical paper; Agriculture sector technical paper.

Two kinds of losses from a changing climate were considered—from extreme weather events and from agriculture. To estimate the impact of the changing climate on FYR Macedonia's economy, a production function approach proved to be helpful. With that framework in mind, extreme weather events can be seen as harming mainly physical capital–the stock of buildings and machinery required for production. On the other hand, there are losses in agriculture that directly harm crops and production in that sector. Consequently, the flow of GDP in the agriculture sector should be adjusted by expected losses. **Agricultural losses** were assessed using a linked series of models. The climate projections from the GCMs were used to estimate runoff, crop yields, and irrigation demand and other sector demand for water, including hydropower. The outcomes of this set of models—revenue from crop production and hydropower—were then translated into impacts on GDP. (See Chapter 4). Future **losses from extreme weather events** for FYR Macedonia were approximated using data for the Balkans and Mediterranean countries as well as global data from the EM-DAT database.[32] For flood loss calculations, a log-normal distribution was assumed with an expectation is about 0.88 percent of GDP loss per flood, while for wildfires, the Generalized Extreme Value distribution was used, assuming an average cost of wildfires of 0.26 percent of GDP. Wildfires are correlated with the annual maximum of consecutive dry days. Based on the assumption that wildfires occur if the annual maximum number of consecutive dry days exceeds 40, the probability of losses will increase significantly in the next few decades.

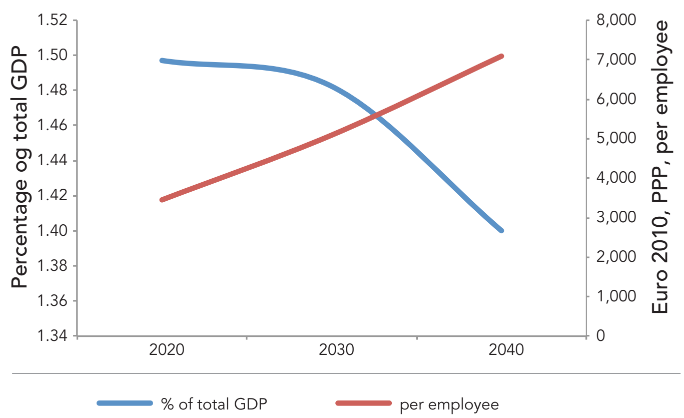
Main findings

Climate change is likely to exert its major impact on FYR Macedonia's economy via water supply, through changes in rainfall amounts as well as temporal and spatial patterns. Temperature changes are also important in determining the available water supply for the country, because higher temperatures cause higher levels of evaporation in natural lakes and man-made reservoirs. Climate change also affects water demand in the agricultural, municipal, and thermoelectric sectors. Crop irrigation requirements are affected by both temperature and precipitation, as water demand is directly linked to both crop yield and to evapotranspiration. Climate also affects the timing of water demands. Recent warming has led to the presence of higher spring temperatures. As a result, Macedonian crops now some years begin to demand water in April instead of May, and irrigation water demand peaks in June instead of July – further, much water demands are sustained through August. Continued warming will exacerbate these changes. Municipal demands for water increase during the hotter months, for drinking, bathing, cleaning, and for support of gardens and lawns. In the thermoelectric sector, where water is used for cooling, higher water temperatures in rivers can reduce its efficiency as a medium for heat dispersion.

Losses in agriculture will result mainly from the projected water deficit. Once translated into water flows, the predicted changes in climate from Figure 3.1 are forecast to depress annual runoff by 18 percent against the baseline by 2050. Competing demands for water were assessed across growing municipal and industrial water use, irrigation demands, hydropower demands, and environmental flows. Unmet demands create sector losses, which can be translated into changes in GDP and employment. Note that while the absolute values of agriculture losses per employee continue to rise through 2040, those losses constitute a declining share of GDP (as agriculture occupies a shrinking share of total output) (Figure 3.2).[33]

FIGURE 3.2. **While agriculture losses per employee rise, those losses constitute a declining share of GDP, as agriculture occupies a shrinking share of total output.**

Agriculture losses as a percentage of GDP and per employee



Source: Water sector model outputs and staff calculations.

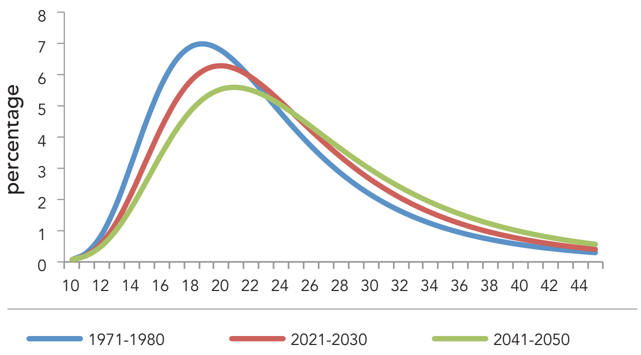
The type of extreme weather event for which FYR Macedonia is at greatest risk will shift from floods to heat wave and wildfires. Distribution analysis of annual temperature and precipitation suggests that FYR Macedonia will be drier and hotter (Figure 3.3). Based on this projection, floods will occur less frequently and heat waves and wildfires more frequently than they do now. Climate models anticipate a substantial shift in annual maxima of number of consecutive dry days, which is strongly correlated with wildfires. That shift is so important that it implies the expected losses from wildfires will almost equal losses from floods by 2050.

32. An Emergency Events Database maintained by WHO's Collaborating Centre for Research on the Epidemiology of Disasters (CRED).

33. See Chapter 4 on water.

FIGURE 3.3. **FYR Macedonia is projected to become drier and hotter**

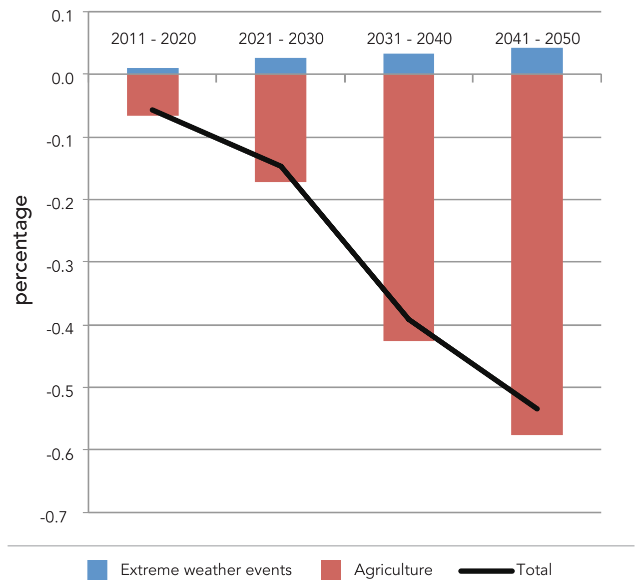
Generalized extreme value distribution shift of maximum annual number of consecutive dry days (with precipitation of less than 0.5 mm)



Source: Macroeconomic technical paper.

FIGURE 3.4. **Projected climate change, including extreme weather, leads to a 0.6 percent drop in GDP.**

Difference in GDP and extreme weather events between BAU and BAU$_0$



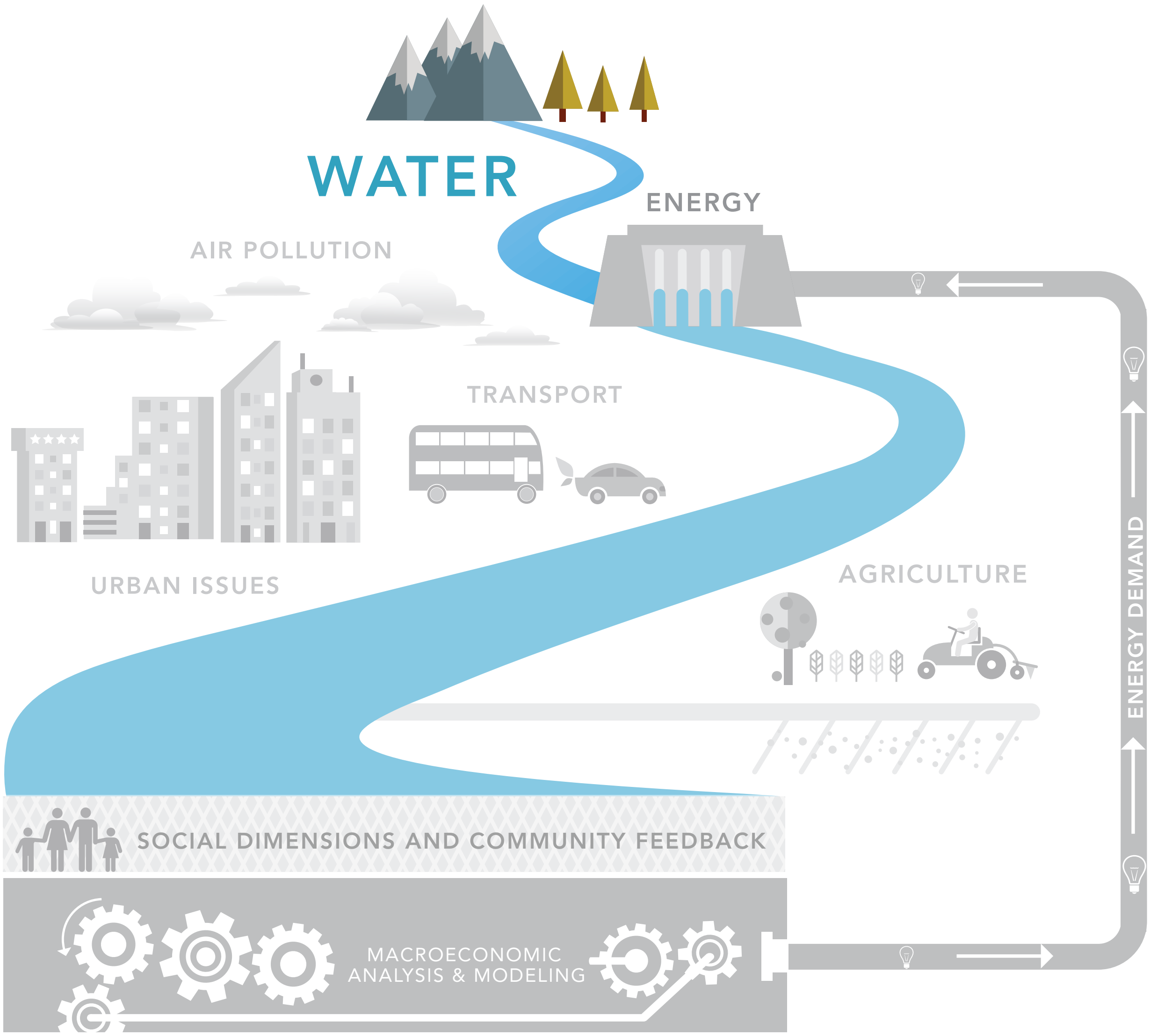
Notes: BAU is the business-as-usual scenario including the impact of a changing climate. BAU0 is the business-as-usual scenario without the impact of a changing climate.
Source: Macroeconomic technical paper.

In the BAU scenario, the level of GDP in 2050 is estimated at around 0.6 percent below the BAU$_0$ scenario, while the loss in physical capital reaches about 0.2 percent relative to the partial baseline derived in the previous chapter. The rising cost of wildfires is more than offset by the milder and less frequent floods in the future, resulting in less physical capital being destroyed and adding slightly to GDP. At the same time, more frequent and severe droughts lead to significant losses in agriculture. (See Figure 3.4).

RECOMMENDATIONS

These results suggest that over the next few decades, protection against droughts and wildfires will be of growing importance. Farmers will be more likely to suffer severe losses of crops due to droughts. Although the Macedonian economy will grow, and thus losses will be less perceptible for the average inhabitant, they will touch farmers more and more intensively. As farmers are the poorest group of society, more attention should be devoted to designing policies and programs that might protect them from significant loss of income resulting from the severe droughts that will occur more frequently in the future. (See Chapter 5). Furthermore, in coming years, more attention will need to be paid to the protection of people and capital against wildfires.

The BAU scenario improves the baseline by bringing it closer to the likely evolution of the Macedonian economy in the absence of policy change. However, in addition to the uncertainty of a simple baseline, the incorporation of some main avenues for climate damage into the scenario compounds the complexity of the forecast and greatly raises the degree of uncertainty surrounding the scenario. The GCMs involve much uncertainty, both around future emissions levels and the impact of emissions concentrations on climate as well as the downscaling to a particular country. Data on the distribution of losses from extreme events—in particular, floods and wildfires in the Balkans—is limited. Policymakers will need to have confidence in the BAU scenario if it is to be used for policy analysis, and sensitivity analysis and updating would be wise measures if the scenario is to be maintained for a long period.



WATER
ENERGY
AIR POLLUTION
TRANSPORT
URBAN ISSUES
AGRICULTURE
ENERGY DEMAND
SOCIAL DIMENSIONS AND COMMUNITY FEEDBACK
MACROECONOMIC
ANALYSIS & MODELING

CHAPTER 4

Will Water Shortages Constrain Growth?

CHAPTER SUMMARY

a well-functioning water sector in FYR Macedonia is essential for the economy, especially for the agriculture sector, but projected climate change will deepen water scarcity. Current water withdrawal levels create moderate stress on limited national water resources, with climate change exacerbating scarcity. Water sector assets, including irrigation infrastructure, are old, unreliable, and dilapidated; and seasonal water shortages reduce productivity of all water-consuming sectors. The accumulated backlog of maintenance and rehabilitation of water sector infrastructure now totals almost four percent of GDP. Agriculture, mining, and industry, in an attempt to avoid economic losses due to irregular supply from water utilities, have turned to widespread and unsustainable use of groundwater. These challenges raise the important question, "Will water shortages constrain growth?"

The analysis is aimed at evaluating green (adaptation) policies and investments in the water sector and two main water-consuming sectors: agriculture and power.[34] Several interlinked models are used in the analysis: Global Circulation Models (GCMs), Water Evaluation And Planning (WEAP) model, a water run-off model (CLIRUN) and an agricultural yield model (AquaCrop). Two green (adaptation) scenarios are compared to the business-as-usual scenario. The Green scenario presumes policies and investments consistent with EU membership requirements, including more hydropower to meet mitigation obligations, investments in storage, water conservation, upgrading of irrigation and drainage, and improved crop varieties. The Super Green scenario includes more ambitious adaptation measures including substantial new irrigation infrastructure. The analysis finds that water supply shortages are likely for all water-consuming sectors unless adaptation Is undertaken. Competition for water between agriculture (especially as the climate warms and dries), the power sector (for hydropower, a critical element in a lower emissions electricity system, and for thermal cooling), and industrial and municipal uses will pose difficult tradeoffs for Macedonian policymakers by 2020 unless efficiency in both demand and supply is bolstered.

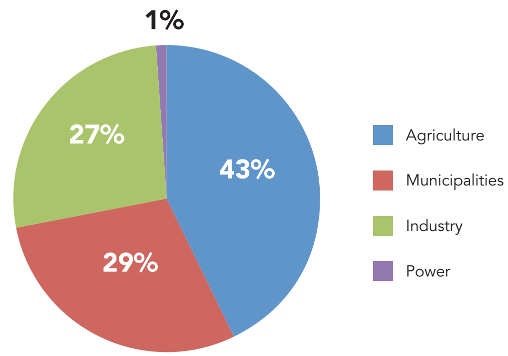
Water shortages will worsen into the future; and, despite action on adaptation, gaps between supply and demand will persist, especially for some basins. The overall demand-supply gap in the water sector must be managed through green actions in all water-using sectors, with a big emphasis on improving efficiency and strengthening conservation. Green action can constrain irrigation water demand only modestly but with high variance across basins. In irrigation, green (adaptation) investments will reduce water demand by implementing basin-scale irrigation improvements and drainage infrastructure upgrades, replacing and rehabilitating broken-down assets of the current irrigation infrastructure and creating a new irrigation system, adequate for a modern system of farming. Despite adaptation measures, a changing

34. The same modeling was used for the agriculture sector analysis, and Chapter 5 provides more detailed outcomes for agriculture. See also Chapter 6 on the power sector, which provides complementary analysis.

climate will affect the availability of cooling water for some thermoelectric power plants, and the expansion of hydropower that will help clean up the energy sector will not be possible without coordinated water-saving measures across sectors. An ambitious Super Green program of adaptation action can reduce unmet water demand by half by 2050. Implementing measures aimed at municipal and industrial water conservation are critical. The top benefits will come from packaging together the investments and policies described above, thus enhancing their individual benefits. The growing scarcity of water can be addressed, first of all, by reducing inefficiencies through pricing and regulation of groundwater and through rehabilitation and maintenance of existing infrastructure. Growing seasonal scarcity can be managed through investment in more storage (for irrigation and for hydropower), while overall shortages in future decades can be addressed through encouragement of water conservation.

FIGURE 4.1. **Agriculture is the top water consuming sector**

Total annual freshwater withdrawals in FYR Macedonia, shares by sector



Source: Agriculture sector technical paper.

CHALLENGES FOR GREENER GROWTH

Overview

With hot dry summers and somewhat limited water, FYR Macedonia needs a water sector[35] that can sustain agriculture but also provide resources to industry and the power sector and drinking water for municipalities.[36] Irrigation is critical for agriculture, especially since its high value-added segments are mainly in irrigation-intensive crops.[37] At the same time, most irrigation water is currently used for the production of rice, a very water-intensive crop with low value per area of land and very low value per unit of irrigation water consumed. Irrigation water demand is high and makes agriculture the top water consuming sector in FYR Macedonia with 43 percent of total freshwater withdrawals. It is followed by the municipal water demand, accounting for 29 percent of water withdrawals, and then by industry consuming 27 percent of the total amount of water used, in particular, mining, metallurgy, chemicals, and textiles). The remaining one percent is attributed to cooling for the thermal power sector (Figure 4.1). In addition to these water-using sectors of the economy, FYR Macedonia's mountainous landscape has long supported hydropower generation, which remains an important source for electric power, providing 20 percent of electricity generation.[38] Also, water ecology requires a level of flow defined by existing environmental norms for ecosystem maintenance.

Current water withdrawal levels create moderate water stress, and a relatively low level of national water resources increases the need for adaptation measures in the water sector. Annual freshwater withdrawals as a percentage of total internal water resources–16.1 percent–places FYR Macedonia in the category of countries with moderate water stress, indicating that improvements in water supply and demand management, as well as investments in sectoral assets, might be required.[39] FYR Macedonia's level of freshwater withdrawals is also high for the region, at 40 percent above the comparator average (Figure 4.2). This pattern is driven by the relatively low level of overall water resources per capita in FYR Macedonia.

Many water sector assets are old, unreliable, and dilapidated, and the system of irrigation outdated. Most damaging for the economy is the condition of irrigation assets since irrigation is key to today's agricultural production as well as to expanded production of high-value crops, which are considered to be FYR Macedonia's comparative advantage. Since the 1980s, irrigated area in the country has shrunk, and the majority of irrigation infrastructure has been abandoned. Currently, only one-quarter of land suitable for irrigation is actually irrigated,[40] and much of that depends on local groundwater wells for supplemental water.[41] Much of the existing irrigation infrastructure consists of pipes and canals that are often not operational, located too far from current agricultural fields, and use outdated equipment, such as standpipes designed for mid-20th century agriculture.

35. The water sector is defined here to include water-related impacts on agriculture (especially irrigation, but also water use efficiency and drainage), energy (mainly hydropower), and municipal and industrial water supply.

36. Problems with municipal water supply are discussed in Chapter 8 on urban issues.

37. More information about irrigation can be found in Chapter 5 on agriculture.

38. More information about hydropower can be found in the Energy chapter.

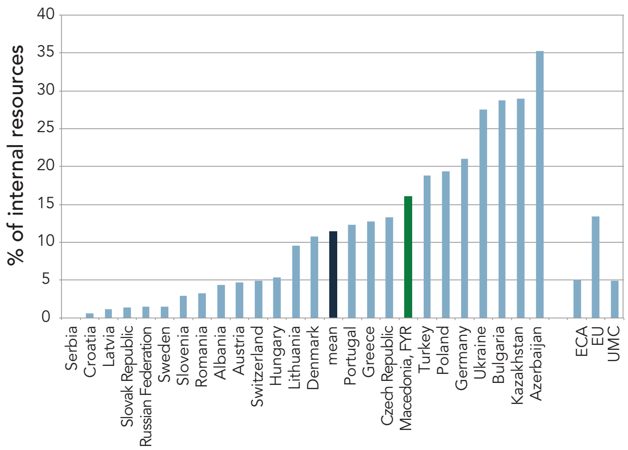
39. This indicator is significantly affected by the size of the country's water resources; therefore the data are more indicative for countries that are at the either end of the scale of total resources: scarcity or abundance, while FYR Macedonia is in the middle of the range.

40. 162,500 ha have or had infrastructure for irrigation. But only 127,000 ha are considered suitable for irrigation, and 33,000 ha are irrigated. See World Bank (2011).

41. Data on groundwater wells is very sparse. Estimates suggest that up to half of irrigated areas rely on groundwater sources (local wells).

FIGURE 4.2. **Water withdrawal level creates moderate water stress**

Annual freshwater withdrawals, % of resources, by country, 2009



Note: Unweighted averages for ECA, EU, and UMC
Source: World Bank Development Data Platform

The lag of required cumulative maintenance and rehabilitation of water sector infrastructure equals about US$186 million or 3.8 percent of GDP. The government has not been able to finance water infrastructure rehabilitation since the early 1990s. Water utilities lack resources to do it either, as water tariffs do not cover the cost of water supply, leaving the utilities with negative net revenue. **The total financing gap of the water utilities is US$18.6 million per year or 0.4 percent of GDP.** However, the water utilities are being reformed, and the new utilities, the Water Economies, perform better than their predecessors, the Water Management Agencies (WMAs). The Law on Water Economies provides for many needed reforms including a good tariff methodology. However, there is still a long way to go. While water tariffs need to be restructured to recover cost and eliminate cross-subsidization in the long run, government subsidies are a necessity in the short run.

The irregular supply from water utilities has pushed users in agriculture, mining and industry towards extensive use of groundwater. An unknown number of wells have been drilled across the country in recent years, and many users, including large-scale agricultural and industrial concerns, rely on unregistered wells dug for own use. Consumption of groundwater resources is unmeasured, and groundwater wells are not regulated. The size of the groundwater aquifer resources has not been estimated, but it is known that in some locations, water tables are falling, signaling that the groundwater aquifers will be used up if this practice continues. To resolve this problem, aquifer appraisal needs to be conducted, a groundwater well national register put in place, a national groundwater monitoring network reestablished, and a groundwater permit and tariff system created.[42]

42. Although data is incomplete, it is estimated that groundwater wells supply about 20 percent of total municipal and industrial water supply. In some areas of the country, it is estimated that half of irrigation comes from groundwater.

Dealing with Sector Inefficiency in the Context of Green Growth[43]

Climate change is projected to exacerbate water supply shortages, placing water and water-consuming sectors at the heart of vulnerability to climate change. Future weather is expected to reduce supply and increases demand for water. Water shortage is already an issue in the southeast of the country, the area where desertification has already started (the Krivolak Semi-desert) and also in the northeast. Irrigation across the southeast is suspended regularly. Municipal water supply in the cities of Negotino, Kavadarci and Radovis in the southeast, as well as in Kumanovo in the northeast is often cut due to shortages. Water resources are currently abundant in some regions, but the dual effects of climate change on supply and demand has the potential to cause water shortages even in previous surplus regions. For example, it is likely that Strumica and Gevgelija in the southeast will start experiencing seasonal cuts within the next decade. (See Chapter 3 for a discussion of climate damages.)

Climate change raises water demand from agriculture, from the municipalities, and for thermoelectric cooling. Crop irrigation requirements are affected by both temperature and precipitation, as water demand is directly linked to both crop yield and to evapotranspiration. Climate also affects the timing of water demands. Recent warming has led to the presence of higher spring temperatures. As a result Macedonian crops now some years begin to demand water in April instead of May, and irrigation water demand peaks in June instead of July – further, much water demands are sustained through August. Continued warming will exacerbate these changes. Municipal demands for water increase during the hotter months, for drinking, bathing, cleaning, and for support of gardens and lawns. In the thermoelectric sector, where water is used for cooling, higher water temperatures in rivers can reduce its efficiency as a medium for heat dispersion.

Hydropower plays a special role in the greening of growth in FYR Macedonia, providing a key clean energy source to mitigate greenhouse gases while facing constraints from water scarcity driven by climate change. Increased hydropower capacity will mean reduction of emissions from lignite and diesel generation plants. However, sufficient water flows must be maintained for hydropower electricity generation plants to produce planned levels of power. This intersection of mitigation and adaptation, and the interactions between the water sector and the key water-consuming sectors and actors—agriculture, power, industry, and municipalities and households—creates complexity in assessing a green development path.

43. See World Bank. 2011. Water Security in South-east FYR Macedonia through Strengthening of Water Economies. Country analysis. Washington, DC: World Bank.

Achieving higher water use efficiency is one of the key factors in a green growth strategy. Adaptation measures in the water sector, starting with policies, investments, and institution building to improve sector efficiencies and conserve water supply, will be the backbone of green (adaptation) scenarios for the country. The problems to resolve include dilapidated infrastructure and limited financing for its rehabilitation and modernization, inconsistent water supply, and financial and operational inefficiency of utilities. All this is a threat to economic productivity in the agriculture, power and industrial sectors as well as to households in water-scarce regions. More efficient water usage will result in lower pressure on already stressed water resources. Improved irrigation and municipal and industrial water infrastructure, in combination with more efficient water utilities, will mean reduced/controlled demand for water and water sector subsidies.

Transboundary flow arrangements are also a critical determinant of water availability in FYR Macedonia, since the Vardar River flows into Greece. Although there are no existing formal transboundary water agreements with Greece, the flow of water to Greece does represent an important aspect of international cooperation between the two countries.

METHODOLOGY AND MAIN FINDINGS[44]

Methodology

The objective of the analysis was to assess the impact of 'green' (adaptation) policies and investments on sectoral outcomes in the water sector and two main water consuming sectors–agriculture and power— and to provide financial evaluation of the proposed infrastructure investment options for water and agriculture. The impact of green policies and investments was evaluated by comparing two green (adaptation) scenarios to the outcomes in the baseline or Business as Usual (BAU) scenario. Note that the BAU scenario already includes how climate change will affect water availability and irrigation water demand (See Chapter 3). Table 4.1 provides details on the policies and investments included in each scenario, Water sector outcomes were measured using indicators of annual water availability and the water demand-supply gap in agriculture (irrigation), in the combined demand from municipalities and the industrial sector, and in the energy sector (thermoelectric cooling demand). Agriculture sector outcomes were measured by crop yields in irrigated areas and related revenues. Hydropower production outcomes were estimated by the indicators of annual generation of hydropower and related revenues.

44. The analytic work presented here builds on prior World Bank-supported work, in particular the "Macedonian Response to Climate Change for Agriculture", which was part of a regional study of climate change and adaptation in agriculture: World Bank. 2012. Reducing the Vulnerability of FYR Macedonia's Agricultural Systems to Climate Change: Impact Assessment and Adaptation Options. Washington, DC: World Bank.

The following models were used for the analysis: the Global Circulation Models (GCMs), the Water Evaluation And Planning (WEAP) model, a water run-off model (CLIRUN) and an agricultural yield model (AquaCrop). The models were implemented in the following sequence (Figure 4.3):

- **Step 1.** The Global Circulation Models of future climate produced climate projections as a function of initial conditions and projected quantities of greenhouse gases emitted.
- **Step 2.** Climate projections from GCMs were used as inputs in the CLIRUN model to estimate streamflow runoff[45] and also in the AquaCrop model to estimate crop yield and irrigation demand.
- **Step 3**. The runoff and irrigation water demand estimates from CLIRIN and AquaCrop, along with other hydrologic system inputs and non-irrigation water demand estimates, were incorporated into the WEAP tool, where water storage, hydropower potential, and water availability were modeled.
- **Step 4.** To refine the AquaCrop estimates of crop yield in irrigated areas (see (2) above) by adjusting it to water availability modeled in WEAP (see (3) above), the unmet demand for irrigation water from WEAP, together with statistical data on irrigated crop sensitivity to water availability[46], was fed back into Aquacrop.[47]
- **Step 5.** Finally, the WEAP hydropower generation and AquaCrop crop yield results were analyzed to produce estimates of their economic implications.[48] The main outcomes at this step were projected revenue from crop production and hydropower and net present value (NPV) of investment in these sectors.

In addition to modeling, analysis involved evaluation of infrastructure investment options for water and agriculture. It was designed to provide ranking, based on financial assessment, of several water and agriculture sector investments used in modeling[49]. The financial assessment calculated the benefit-cost ratio; the net present value of the cash flow of benefits and costs; the internal rate of return; and the payback period. Costs included both capital and annual operating and maintenance costs. Benefits were calculated as direct financial

45. Streamflow runoff is the flow of water in streams, rivers, and other channels.

46. Data from Food and Agricultural Organization (FAO).

47. Details of this approach are provided in the prior work (World Bank. 2012. Reducing the Vulnerability of FYR Macedonia's Agricultural Systems to Climate Change: Impact Assessment and Adaptation Options. Washington, DC: World Bank).

48. Ibid.

49. In almost all cases, benefits and costs are assessed for each option assuming other options are not employed. It is assumed climate change will progress as anticipated for the medium climate change scenario.

TABLE 4.1. **Green policy and investment action in water, by scenario**

SCENARIOS TO 2050	SCENARIO DESCRIPTION	POLICY/INVESTMENT ACTIONS
Business as Usual Scenario (no adaptation)	Policies gradually align with regional norms and no new infrastructure investments unless already planned. • Impact of climate change on demand for irrigation and municipal water; • Impact on water supply for water consuming sectors (irrigation, hydropower, thermal cooling for power generation, and municipal and industrial).	• All current and planned thermal and nuclear plant deployment/retirement; • All current and funded or in construction future hydropower plants and associated storage; • Current reservoir construction ; • Irrigation capacity, use, and efficiency at current levels. • No increase in irrigation water demand.
Green Scenario (modest adaptation effort)	Adaptation/mitigation in water and water-consuming sectors consistent with EU membership requirements: • Hydropower investments reflected in Macedonian energy sector strategy; • Planned investments in storage; • Municipal and industrial water conservation; • Upgrade of irrigation and drainage; • Improvement in crop varieties.	Annual investment of around US$11 million for the following measures in all basins: • Full build-out of planned hydropower plants; • New basin scale storage as laid out in plans; • Municipal and industrial water conservation; • Improvement in basin scale irrigation efficiency in all basins to 75%; • Improvement of drainage infrastructure in all currently irrigated areas; • Improvement in wheat varieties (irrigated and rainfed).
Super Green Scenario (ambitious adaptation effort)	Maximizes greening potential by expanding Green scenario: • All investments in Green scenario • plus: • Additional investment in water use efficiency; • Cancellation of plans for a Macedonian nuclear power plant; • Additional adaptation investments in water and agriculture sectors.	Annual investment of around US$148 million for the following measures: All investments in Green scenario, plus: • Further municipal/industrial water conservation; • Improvement in basin scale irrigation; • Cancellation of plans for nuclear plant; • Improvement of drainage infrastructure in currently irrigated and rainfed areas; • Improvement in varieties for wheat, maize, and apples (irrigated and rainfed); • Optimization of timing of water and fertilizer application for all crops in all basins; • Expand irrigation by 50% in basins with sufficient water; convert low-value rainfed production to irrigated maize, apples, and/or tomatoes.

Note: See Table 5.1 for policy and investment actions in agriculture, and Box A and Box 2.1 describing modeling scenarios in this study overall.

flows that result from the investment. Evaluated investment options were related to water-use efficiency by municipalities and in the industrial sector and in irrigation; construction and rehabilitation of irrigation infrastructure and optimization of its usage; agricultural drainage infrastructure; improvement of crop varieties; and construction of hydropower plants and non-hydropower reservoirs.[50] These investment options were then incorporated into the economy-wide modelling in Chapter 12.

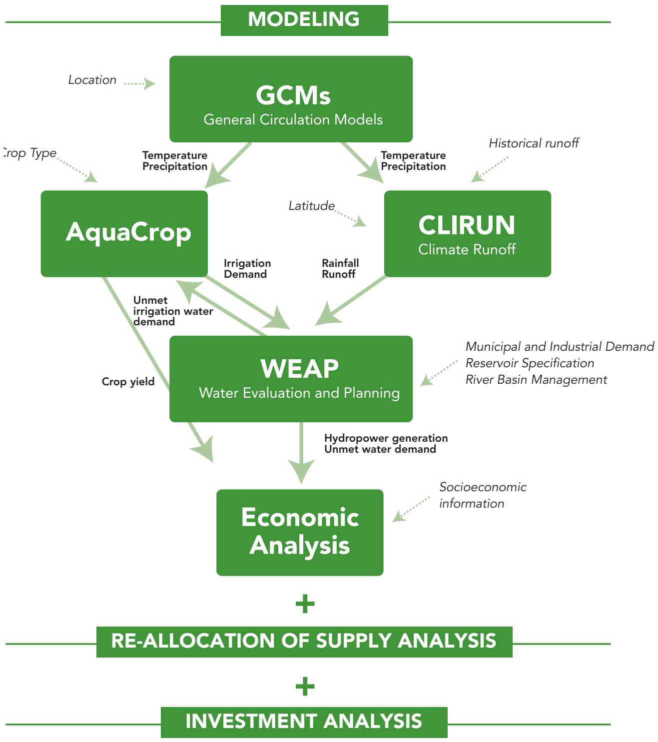
The analysis was designed to answer several questions and provided an innovative approach to capturing the links between the water, agriculture, and power sectors. (i) What are potential adaptive responses by farmers to climate change and the resulting marginal impact on agricultural production and incomes? (ii) What is the potential impact of climate change and green investments on power generation? (iii) What are the trade-offs between alternative prioritization of water use by (irrigation, energy, municipalities and industry)? (iv) What are the options of investing in irrigation and hydropower infrastructure and the resulting impact on agriculture and energy production?

50. See the water and agriculture papers under Technical Reports in the Reference section for details on calculation of benefits and costs and data sources.

Main findings

Climate change will undercut water availability while raising demand, triggering likely water shortages in all water-consuming sectors, even thermoelectric cooling. Predicted changes in climate will reduce annual runoff in almost all basins. In 2020 and 2030, runoff will be almost 10 percent below 2010 levels and near 20 percent below by 2050. Pelagonia and the Southwest face the largest supply-demand gaps for irrigation water in 2050 (see Figure 4.4). Only the Lower Vardar and Dojran basins show increases in runoff for some scenarios. A striking result of this analysis is the prediction of shortages even in water for thermoelectric cooling. Although in general, unmet thermoelectric water demands are modest, at the Bitola plant, the gap reaches 22 percent in the baseline scenario.

FIGURE 4.3. Analytic Framework for Water Sector



Source: Water sector technical paper.

Green policies and investments can help manage water demand for irrigation.[51] Investments in storage and upgrading of drainage increase irrigation efficiency, pushing water demand down, while expanded irrigation has the opposite effect and increases demand. The combined outcome is a reduction in irrigation water demand as compared with the BAU scenario for both the Green and Super Green scenarios for all three time points: 2020, 2030 and 2050. The Green scenario reduces irrigation water demand by about nine percent for the next 40 years. The Super Green scenario cuts irrigation water demand by about six percent in 2020, near three percent in 2030, and over three percent in 2050. In select basins (Greater Skopje, Middle Vardar, Middle and Lower Bregalnica, Middle and Lower Crna, Lower Vardar, and Debar), water demand increases in the Super Green scenario, reflecting new irrigation in those basins. (Figure 4.4).

51. Here and throughout the Findings section, the underlying assumption is that the demand sectors are prioritized as follows: first, municipal and industrial; second, environmental; third, thermoelectric cooling; fourth, agricultural irrigation; and last, hydropower. Sensitivity analysis was also used, which evaluated supply reallocation among users with an alternative prioritization giving the fifth priority to agriculture and the fourth to hydropower. The outcomes demonstrated that while water availability for municipal and industrial use, as well as for thermoelectric generation were not affected by this change in sectoral prioritization, agriculture experienced significantly worsened water shortages and, as a result, a substantial decrease in yields.

Green action can reduce the overall water demand-supply gap. Excess demand for water from all sectors combined will be significantly lowered as a result of green investments and policies such as storage and drainage, municipal and industrial conservation, and efficiency measures in agriculture. The gap reduction in the Green scenario as compared with BAU equals 28 percent in 2020 and 46 percent in both 2030 and 2050. In the Super Green scenario, the demand-supply gap is reduced from the BAU level by about one-third in 2020, and over half in both 2030 and 2050. Green action affects the water demand-supply gap in each of municipalities and industry, agriculture (irrigation), and thermal power (cooling). differently (Figure 4.5)

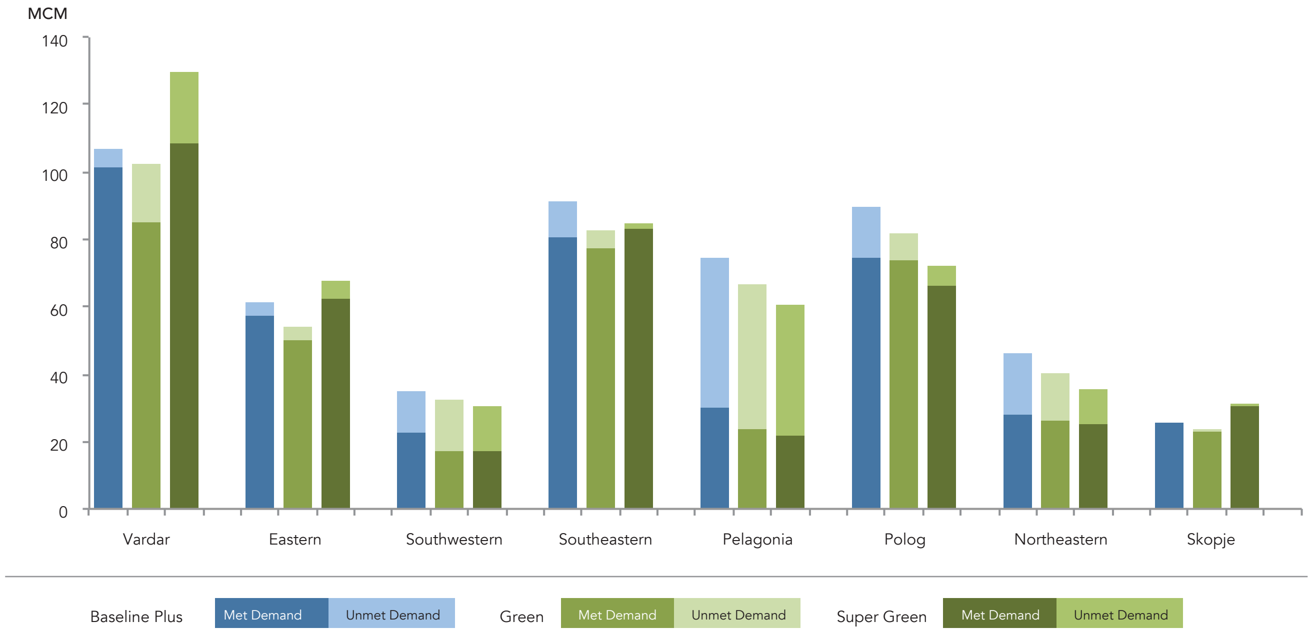
- **In the municipalities and industry, the water demand-supply gap is modest and drops significantly due to adaptation action in both green scenarios in all future decades.** The reduction is about half in 2020 in both green scenarios; about 90 percent in 2030; and over 80 percent in 2050. The size of the gap is small, however, at only three to six percent of total municipal and industrial demand, although it differs significantly across basins. In Pelagonija/Upper Crna, the gap is the highest, largely because of the upstream reservoir, at 38 percent even in the Super Green scenario in 2020 and then, moderating somewhat as a result of water conservation, stands at a still high at 24 percent gap in 2050.

- **In irrigation, the impact of green investment on water demand is small overall, but varies significantly by basin.** The water demand-supply gap is reduced over the next four decades in the Super Green scenario (by about 10 percent in both 2020 and 2030 and by 16 percent in 2050) while the gap grows in the Green scenario (holding steady through 2020, 12 percent larger in 2030, and then unchanged through 2050. The size of the irrigation water demand-supply gap varies from zero to about 80 percent across basins. In some basins, a high gap is explained by additional new hydropower plants upstream of these basins (Ohrid-Struga and Prespa). Across the three policy scenarios in 2050, irrigation water demand-supply gaps are greater than 40 percent of total irrigation demand in the Pelagonija/Upper Crna, Dojran, Prespa, and Ohrid-Struga basins.

- **In thermal power,** water **shortages are persistent for some plants, despite adaptation measures.** With competing municipal and industrial demands, only a percentage of water demands for the thermoelectric facilities can be met, even with strategic reservoir management. The water demand-supply gap in 2020 is about 90 percent higher in both green scenarios and then drops significantly for 2030

FIGURE 4.4. **Green actions help reduce demand-supply gaps for irrigation water**

Met and unmet demand for irrigation water, by planning region, in MCM, 2050

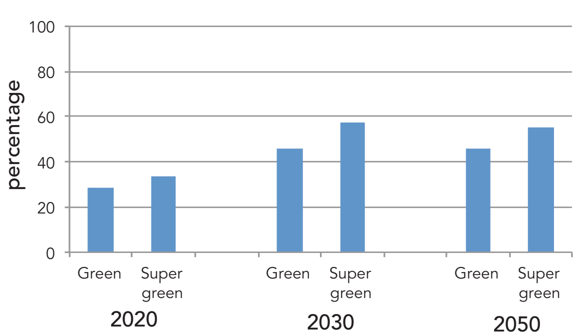


Notes: MCM is millions of cubic meters. The light shading is unmet irrigation demand while the dark is met demand.
Source: Agriculture sector technical paper and presentations.

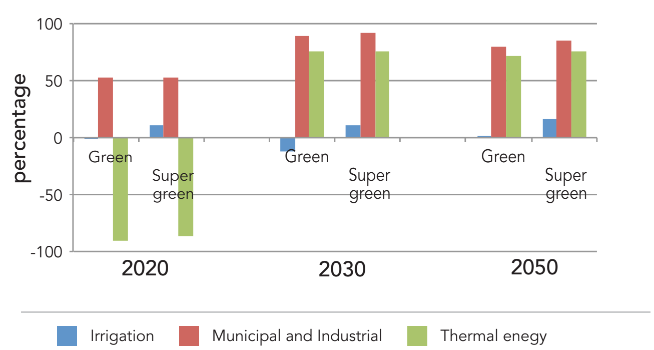
FIGURE 4.5. **Green investments lead to increased water sector efficiency**

Water supply-demand gap reduction in Green and Super Green scenarios as % of gap reduction in BAU scenario

A. OVERALL



B. BY COMPONENT



Source: Water and agriculture sector modeling outputs.

and 2050. The gap ranges from zero percent to 44 percent across the power plants. High gap levels are explained by specific plant conditions: for example, Bitola plant has the biggest gap, at 44 percent in both green scenarios in 2020, because it draws water from the Strezevo Reservoir, which has very low summer inflows.

Hydropower generation can more than triple by 2050, but only with the right adaptation actions.[52] Implementing both new additions to hydropower capacity and water-saving measures in other sectors, as in the green scenarios, adds significantly to hydropower production. As planned facilities are built to meet European Union obligations on mitigation and renewables, overall hydropower production more than doubles by 2030 and more than triples by 2050 in both the Green and Super Green scenarios. The most significant increases in hydropower production occur at the Cebren, Gradec, and Veles facilities. For existing facilities, however, hydropower production is expected to either decline or remain relatively stable, across both green scenarios and over time. The exception is the Globochina station which increases production in 2020 and reduces it thereafter. For current hydropower facilities, firm flow[53] generally declines or experiences only modest gains, both over time and across both green scenarios. St. Petka represents a notable exception from this trend, experiencing significant production growth between 2020 and 2030. In 2050, production is lower than in 2030 but still much higher than in 2020. These gains can only be accomplished if measures in all sectors are implemented in jointly, due to the competition for water resources. The effect of green action is most dramatic in 2050, because without these green actions, hydropower could decline by more than 25 percent. Clearly, the benefits of a green growth investment program are substantial.

As a result of green investments, revenue from crop production and hydropower sales increase, while the NPV of investments is positive. In **agriculture,** in all instances, green investments push up sector revenues. The revenue from crop production increases in the Green scenario in all three time periods by 16 percent and in the Super Green by almost 100 percent for each time period. Under the Super Green scenario, agricultural revenues increase more dramatically due to a broader set of investments made. Overall NPV values for FYR Macedonia under the Green and Super Green scenarios are positive at US$449 million and US$2.65 billion, respectively. However, owing to the irrigation water demand gap, several basins have negative NPV values in both green scenarios. In **hydropower,** in both green scenarios, revenues increase dramatically: in 2020, by 86 percent; in 2030, by 153 percent; and in 2050, by 290 percent[54]. This is a result of new hydropower plants' construction. Generally, NPVs are positive across projects, although Lukovo Pole, Chebren, and Galishte have negative NPVs. (Figure 4.6)

Financial assessment of proposed green investment options identified a set with the highest projected net benefit.[55] Optimizing agronomic inputs, installing drainage systems, expanding irrigation systems, improving municipal and industrial system efficiency, and improving basin-level irrigation system efficiency are part of the set. These options

52. Hydropower modeling is also presented in Chapter 6 on energy. The energy sector analysis applies different models than the analysis of the water sector, but the general outcomes for hydropower are similar.

53. Firm flow is defined as the flow available at least 95 percent of the time (in this case, 95 percent of the time during the period).

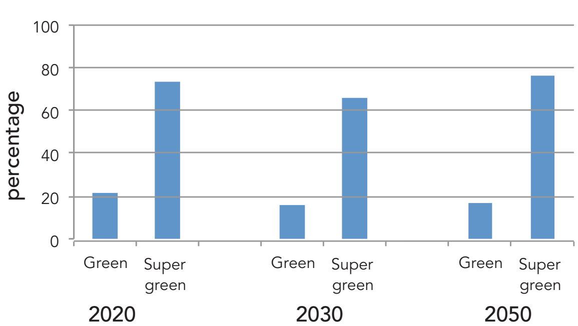
54. There is no difference between the Green and Super Green scenarios because they share the same construction schedule for the 16 planned facilities.

55. As mentioned above, in almost all cases, benefits and costs are assessed for each option assuming other options are not employed.

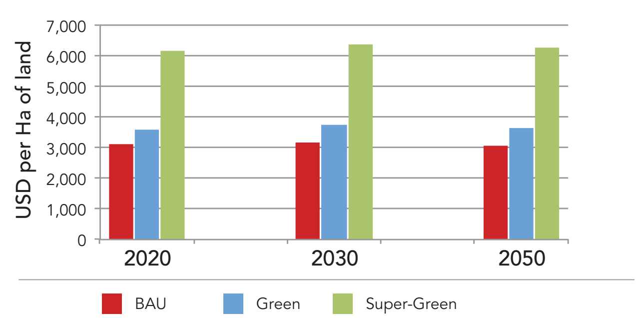
FIGURE 4.6. Green investments lead to increased efficiency in agriculture

Percentage increase in Green and Super Green scenarios as compared with BAU

A. INCREASED IRRIGATED CROP YIELDS



B. INCREASED UNIT REVENUE FROM SALE OF CROPS



Source: Water and agriculture sector modeling outputs.

have positive projected NPVs, benefit-cost ratios above 1 (benefits higher than costs), positive (in many cases, high) internal rates of return (IRR) and average payback periods under eight years both at the national level and in all basins (Table 4.2). Some other investment options are expected to have negative net benefits at the country level (negative NPV and below 1 benefit-cost ratio) and, at the same time, varying financial outcomes 1 at the facility/basin level, with some facilities/basins providing high levels of net benefits. These options include building hydropower facilities and enhancing apple crop varieties. Other options such as drip irrigation have negative net benefits across the board. Basin level details of these options are presented in Table 4.3.

The greatest green investment potential exists for optimizing agronomic inputs, including fertilizer inputs, with

TABLE 4.2. Financial assessment summary for proposed investment options

INVESTMENT		TOTAL NPV (MILLIONS)	AVERAGE BC RATIO	FRACTION BC RATIOS > 1	AVERAGE PAYBACK PERIOD (YEARS)
Optimize agronomic inputs		$848.70	3.86	14 / 16	
Drainage systems	Irrigated lands	$380.68	21.24	14 / 16	0.4
	All lands	$704.66	11.25	14 / 16	0.9
Expanding irrigation systems		$153.48	3.26	14 / 16	8.0
M&I system efficiency		$34.80	2.26	15 / 16	4.3
Basin-level irrigation efficiency		$26.83	2.62	16 / 16	3.6
Hydropower facilities		($73.79)	1.12	13 / 16	11.2
Non-hydropower reservoirs		Not evaluated			
Enhance crop varieties	Wheat	($13.96)	0.64	1 / 16	6.0
	Maize	$40.98	2.41	14 / 16	0.9
	Apple	($0.34)	0.94	6 / 16	4.6
Drip irrigation systems to optimize timing of water application		($178.40)	0.54	0 / 16	14.0

Notes: $ are US dollars. BC ration is benefit-cost ratio.

TABLE 4.3. Investment options with varying facility/basin level financial assessment outcomes

HYDROPOWER FACILITIES	**Pros:** Most of planned facilities (13 out of 16) provide positive projected outcomes: • positive net benefits, • payback periods between 8 and 14 years, • Internal rates of return 6-13 percent, • most facilities may provide particularly high pay-off. **Cons:** Three of the facilities have negative projected financial outcomes and, as a result, the overall NPV of this investment option is negative: • significantly negative projected NPV (ranging between -US$29.7 million and -US$196 million), benefit-cost ratio below 1 and internal rate of return either negative or very low (0.1%) in three planned facilities: Lukovo Pole, Galishte, and Chebren. • Negative financial projections are due to water stress: Lukovo Pole has competing demands from Skopje, and Chebren and Galishte are already experiencing water demand gaps.[a]
DRIP IRRIGATION SYSTEMS TO OPTIMIZE TIMING OF WATER APPLICATION	**Pros:** Prior studies show that this option is beneficial for some crops including irrigated maize.[b] **Cons:** • universally negative NPV values across basins, ranging from -US$350,000 to -US$35 million; • benefit-cost ratios below 1, ranging from 0.1 to 0.9; • these negative outcomes are due to high capital and O&M costs of drip irrigation systems.

a. Analysis of the Lukovo Pole project might underestimate its benefits due to incomplete attribution of incremental gains from hydropower production from other plants. Construction cost for this project reflects a new reservoir and a small hydropower plant. The incremental hydropower attributable to the site, therefore, is from the small HPP. However, while the benefits of the project include enhanced capacity and efficiency of the existing HPPs in the system, they are not included in this analysis.

b. This was not part of the current analysis. However, it is one of the outcomes of: World Bank. 2012. Reducing the Vulnerability of FYR Macedonia's Agricultural Systems to Climate Change: Impact Assessment and Adaptation Options. Washington, DC: World Bank.

the pay-off in significantly increased crop yields. Financial assessment ranked this option among the best. (Table 4.2). The investment would focus on expanding high-quality extension services, as well as on ensuring that sufficient quantities of fertilizers are available to farmers, the latter involving fertilizer subsidization. The highest benefit of this investment would be with high-value added crops such as fruits and vegetables. Currently, basins which focus on high value crops and will, therefore, benefit the most from this investment are Middle and Lower Bregalnica, Pcinja, Strumica, Greater Skopje, and Pelagonija/Upper Crna, as well as in parts of the main Vardar basin.

Drainage infrastructure investments also have a high potential and bring higher crop yields. This investment has the highest benefit-cost ratio and the second-highest NPV and the second lowest payback period among proposed investment options. Its NPV is below that of the agronomic input optimization investment option due to higher initial capital and annual maintenance costs as compared to extension services[56]. The basins with highest benefit/cost ratio from this investment are the Middle and Lower Bregalnica, Polog/Upper Vardar, and Strumica basins.

56. Financial assessment of the drainage infrastructure investment option is based on a relatively crude assessment of current soil types and drainage capacity – these high capital cost investments should require more careful examination at a project level before moving forward.

RECOMMENDATIONS

Expanded irrigation will bring major gains, but those gains depend critically on coincident investments in multi-sector water-use efficiency and in prior or simultaneous resolution of institutional issues in the agriculture sector. All water-using sectors, including agriculture, industry and municipalities, and hydro and thermal power, need to invest in water-saving technologies and improve demand management. Rehabilitation of irrigation systems and expansion in those basins where water shortages are not binding, along with drainage investments, will be key but must be accompanied by improved functioning (including cost recovery) of the Water Economies as well as demonstrated capacity of basin authorities and other institutions that regulate water, starting with pricing and oversight of groundwater. Complementary policies in agriculture include better soil management, land consolidation, and enhanced relevance and effectiveness of agricultural extension to improve and modernize farm practices. (See Chapter 5). An example of water sector regulatory reform that includes a strong institutional capacity building component is presented in Good Practice Box 2.

Hydropower investments are a critical element in a greener growth path for FYR Macedonia, but they must be accompanied by the right adaptation actions. Net benefits

GOOD PRACTICE BOX 2. Institutional capacity building to increase efficiency of tariff reform in the water and wastewater sector in the Danube Basin

The experience of the Danube Basin provides evidence on the importance of institutional capacity building for the success of technically complicated and politically challenging economic reforms. In this case, the implementation of cost recovery water and wastewater tariffs and effluent charges needed to be supported by improved understanding of the use of economic instruments by stakeholders, achieved through technical training and institution building.

Regulation of tariffs set by water operators is critical for successful cost recovery policy and for the overall reform of the water and wastewater sector. However, such reform is both technically complicated and politically challenging, thus requiring reliable stakeholder support. To achieve stakeholder ownership of the reform program in the Danube Region, an extensive capacity building project is being implemented: regulators and water providers are receiving training on the economics of water sector reform.

This effort is supported by the Danube Region Water Supply and Wastewater Sector Capacity Building Project, financed by the World Bank and under implementation in 11 countries. The objective of the project is to improve institutional capacity while developing regulatory and policy instruments. In the past, large capital investments in sectoral assets were not consistently matched with required institutional support. A new approach embraces the legal, regulatory, institutional, financial, organizational and managerial dimensions of the reform. Reforming utility management, better targeting subsidies to low income groups, restructuring tariffs, professionalizing staff, and improving cost recovery are all the ingredients for sustainable water and wastewater service provision. Also, training covers such topics as establishing management systems that motivate service quality improvements, usage of more efficient technologies, and increasing operational efficiency.

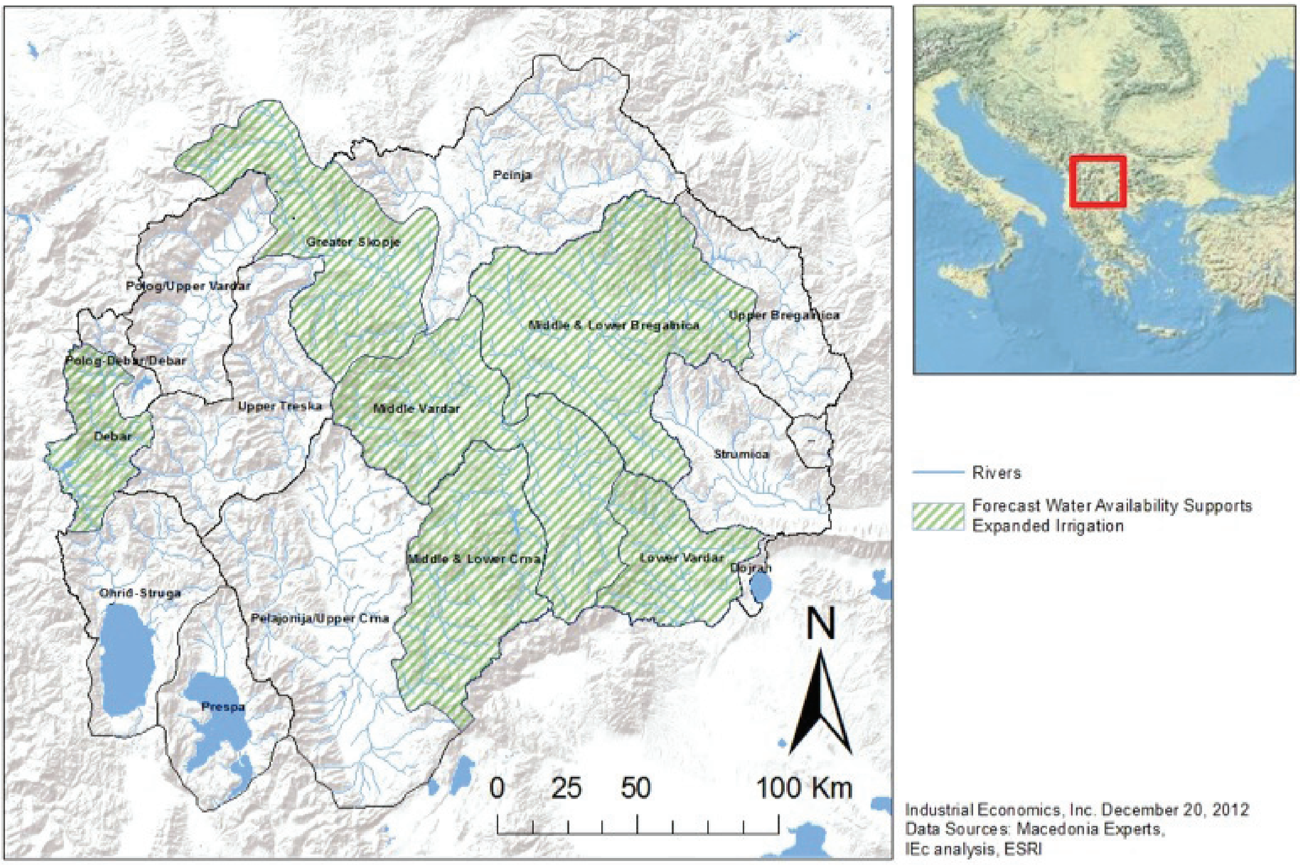
Sources: Background information from the Green Growth Best Practice Initiative, Green Growth Best Practice Assessment Report 2013. Seoul: GGBP. World Bank, Danube Region Water Supply and Wastewater Sector Capacity Building Project.

from hydropower facilities are lower than those from other investment options, with only a marginally attractive return. However, hydropower electricity generation is beneficial for green growth as it provides renewable power and can be used to replace lignite which currently dominates the power mix, driving the high emissions intensity of the power sector. The energy sector analysis (Chapter 6) recommends new hydropower development, and the Green energy supply scenario, which is recommended for implementation, increases the volume of hydropower by 130 percent from 2010 to 2050, while keeping the share of hydro generation in total at the same level of 20 percent. However, it is also noted in Chapter 6 that hydropower sites in FYR Macedonia have low capacity, and, thus, costs are higher than average costs of hydro production globally. Hydropower can deliver important benefits, but competition for water resources must be addressed.

Top benefits will come from packaging together beneficial investments, and in particular, an irrigation package would provide major investment gains. The package would consist of all four proposed irrigation sector investments: construction of new or rehabilitation of existing irrigation capacity, improvement of basin-scale irrigation water efficiency, improvement of agricultural drainage infrastructure, and drip irrigation systems to optimize timing of water application. Further, improvement of municipal and industrial water use efficiency would be also important to support the package. This package would be primarily applicable to six basins (Greater Skopje, Middle Vardar, Middle and Lower Bregalnica, Middle and Lower Crna, Lower Vardar, and Debar) that could support additional irrigation in the future, as they are projected to have sufficient runoff (Figure 4.7).

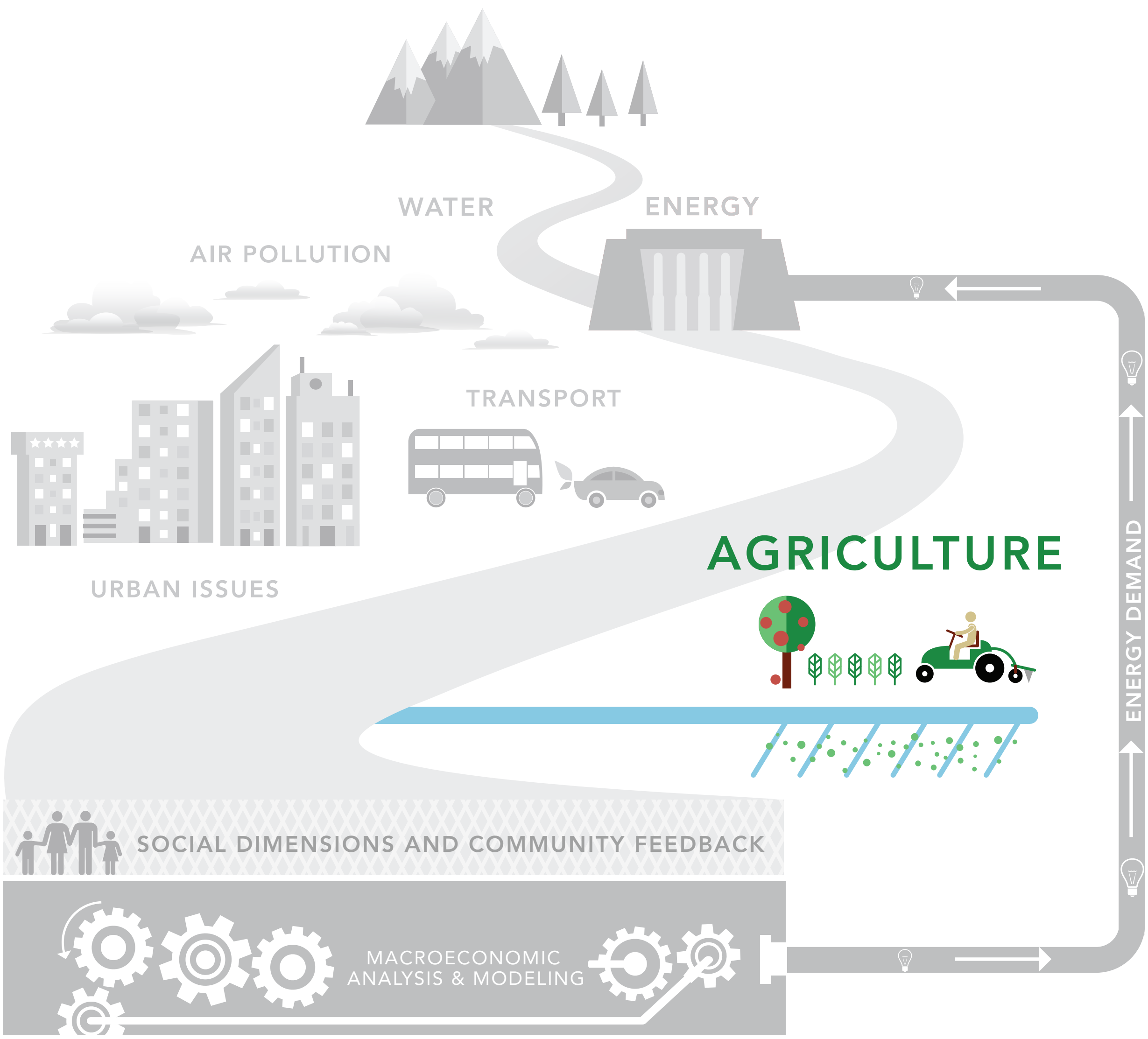
Water shortages will worsen into the future, and, despite action on adaptation, gaps between supply and demand will persist, especially for some basins. Conservation and efficiency measures need to be at the center of a green strategy for the water sector. These challenges will vary significantly across the country. The reality of trade-offs between sectors in providing access to limited water resources needs to be recognized more directly by policymakers. For example, the analysis here indicates that there will be shortages of cooling water in the future for the Bitola and Bitola 4 power plants, and also modest shortages at Mariova and Negotino II (if Negotino II is built). Water availability needs to be considered carefully in the decision to locate thermoelectric power plants. Water scarcity and how to respond need to be addressed as part of urban planning in drier parts of the country such as Strumitsa. (See Chapter 8). Zoning for new industrial concerns with water-intensive production should consider the suitability of local water resources.

FIGURE 4.7. Areas projected to have sufficient water availability to support expanded irrigation



Source: Water sector technical paper.

The overall demand-supply gap in the water sector must be managed through green actions in all water-using sectors, with a big emphasis on improving efficiency and strengthening conservation. Clear positive investments across all basins include expanding irrigation systems, installing drainage systems, optimizing agronomic inputs, and improving municipal and industrial and basin-level irrigation system efficiency. The Green scenario assessed above includes a set of core measures consistent with EU membership requirements that address water sector challenges: hydropower investments, some new water storage, municipal and industrial water conservation measures, and upgrading of irrigation and drainage infrastructure as well as improvement in crop varieties in agriculture. Together, these measures are estimated to reduce irrigation water demand by less than 10 percent, but the overall water demand-supply gap is reduced by almost half. The Super Green scenario contains more ambitious adaptation actions, and new irrigation causes water demand to rise, but the overall water gap is reduced by more than half during the next four decades.


WATER
ENERGY
AIR POLLUTION
TRANSPORT
URBAN ISSUES
AGRICULTURE
ENERGY DEMAND
SOCIAL DIMENSIONS AND COMMUNITY FEEDBACK
MACROECONOMIC
ANALYSIS & MODELING

CHAPTER 5

Can Agriculture Flourish in a Changing Climate?

CHAPTER SUMMARY

Agriculture is a key sector that needs to be transformed to achieve greener growth in FYR Macedonia. The country's reliance on agriculture is a major component of its vulnerability to climate change, which will compound current sector inefficiencies. Agriculture and agro-processing may employ almost one-third of the labor force, once informality estimates are included. The country is already experiencing moderate water stress, and climate change is pushing up water demand in agriculture, worsening the 'adaptation deficit'. Irrigation is already insufficient and poorly designed for today's small farms. Agriculture, as well as mining and industry, are trying to avoid economic losses due to irregular supply from water utilities and have turned to an unsustainable use of groundwater. Soil fertility problems will worsen, especially erosion. Small and fragmented farms and inadequate land markets limit agricultural productivity, while government subsidy programs are poorly designed to achieve their stated objectives. Can agriculture flourish in a changing climate?

The objective of the analysis was to assess the impact of green (adaptation) policies and investments on agriculture outcomes through joint modeling of water, agriculture, and the power sector; and to provide financial evaluation of the proposed infrastructure investment options for water and agriculture. Several interlinked models are used in the analysis:[57] Global Circulation Models (GCMs), Water Evaluation And Planning (WEAP) model, a water run-off model (CLIRUN) and an agricultural yield model (AquaCrop). The modeling finds that adaptation expenditures are good investments. Significant adaptation effort, with annual investment of about US$148 million in irrigation, drainage, improved crop varieties, and better agronomic practices yields benefits through 2050 that outweigh costs more than four-fold while closing the water demand-supply gap by almost one-quarter.

A more competitive, export-oriented agriculture sector in future decades will be possible only if adequate policies and investments are implemented and if adaptation measures are taken. In irrigation, adaptation investments in drainage infrastructure for irrigated areas will improve crop yields. Improved wheat varieties are another key modest adaptation measure. Under a stronger adaptation effort (the super green adaptation scenario), a package of expanded irrigation in some basins plus improved drainage infrastructure would provide major investment gains. In addition to investment in irrigation, other measures would bring important benefits, including: improved farm practices, greenhouse production, improved soil management, improved pasture management, land consolidation and land market improvements, and organic agriculture. Increased capacity of research and extension systems, incentives to adopt environmentally friendly practices, monitoring programs for soil, water, groundwater and biodiversity, improved hydro-meteorological capacity, and crop insurance would complement the key investments in adaptation.

57. The same modeling was used for the water sector analysis (Chapter 4). This chapter presents more detailed outcomes for agriculture than those described in the Chapter 4.

CHALLENGES FOR GREENER GROWTH

Overview

Agriculture is one of the sectors that need to be transformed to achieve green growth in FYR Macedonia. While agriculture is not a major source of FYR Macedonia's overall GHG emissions, the country's reliance on agriculture is a major component of its vulnerability to climate change, which will compound current sector inefficiencies. Official statistics[58] show that agriculture is a currently a major contributor to national output in FYR Macedonia. Agricultural value-added constitutes 11.1 percent of total value-added, placing FYR Macedonia well above the ECA region average of 8.9 percent. When agro-processing is included, the contribution to GDP increases to 16 percent.[59] Exports of agricultural products constitute 15 percent of the country's merchandise exports. The share of employment in agriculture is 19.7 percent, slightly below the ECA region average of 22 percent. (Figure 5.1).

The significance of agriculture for FYR Macedonia is underestimated by official statistics, which do not capture the entire sector, as a substantial part of it is informal, both in terms of employment and transactions. Almost half of all agricultural workers are not recorded as employed in the sector as they are members of agricultural households[60]. Using official statistics, a revised estimate of rural employment, both formal and informal, is 34 percent of the total[61]. This number stayed stable over the last two decades, which is not the case in many neighboring countries (see Figure 5.1)[62].

The importance of agriculture for FYR Macedonia is also reflected in the country's structure of natural capital, which is dominated by crop and pasture land. While the overall structure of wealth in FYR Macedonia is similar to the majority of European countries—most of total wealth (for FYR Macedonia , 83 percent) is intangible capital (human and social) with the remainder being produced and natural capital—the structure of natural capital is very different from most of Europe. In FYR Macedonia, crop and pasture land provide 88 percent of total natural capital, and forests and protected areas add another 12 percent. This structure of natural wealth differs significantly from that of economies in which agriculture is no longer economically important, where the share of crop and pastures is limited, or from energy-rich countries such as Russia, where natural capital is dominated by energy.

58. Source of data: World Bank, Development Data Platform. Data for 2011 or, when mentioned, the latest year available prior to 2011.

59. Sutton, William R., Peter Whitford, Emanuela Montanari Stephens, Suzette Pedroso Galinato, Bonnie Nevel, Beata Plonka, and Ebru Karamete. 2008. Integrating Environment into Agriculture and Forestry: Progress and Prospects in Eastern Europe and Central Asia. Washington, DC: World Bank.

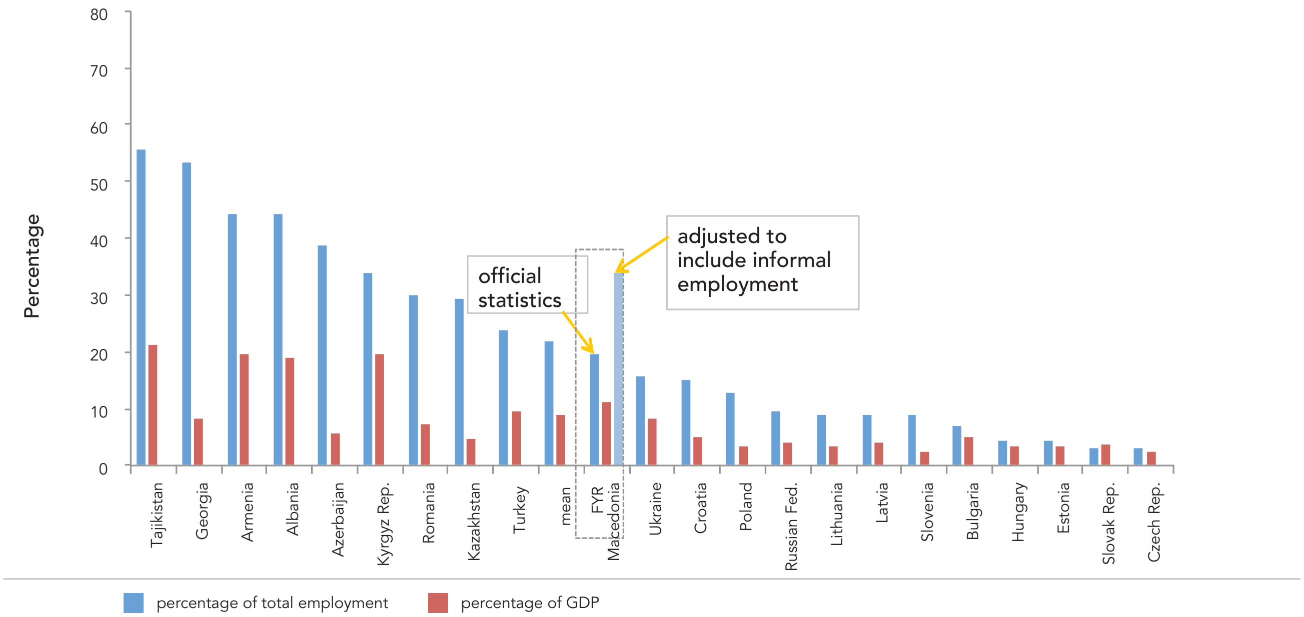
60. World Bank. 2005. FYR of Macedonia Poverty Assessment for 2002–2003. Washington, DC: World Bank.

61. Rural employment is estimated using the share of rural population and age distribution of the population. Rural population is reported in official statistics at 41 percent of the total. Population 15 and older constitutes 83 percent of the total in the country and is higher in rural areas. Considering the informality of FYR Macedonian agriculture, it is assumed (i) working age for rural areas at 15 years and above and (ii) 100% employment rate. The resulting estimate for rural employment rate is 34% (=41%*83%). This is a conservative estimate—the actual number can be higher because rural population is older than urban, while the national age distribution is applied in the calculations.

62. Since this number is a derivative of the share of working rural population, it has probably stayed stable over the last two decades, as the share of rural population varied little, from 40 to 42 percent, during the period 1990-2011.

FIGURE 5.1. **Agriculture is important for economic output and employment in FYR Macedonia and underlies the country's vulnerability to climate change**

Agricultural value added and agricultural employment, 2011 or latest available year



Source: Staff calculations using World Bank Development Data Platform.

Agricultural productivity has been increasing in the last 15 years. Annual growth of agricultural value added has averaged 2.6 percent in the past decade – slightly higher than in the ECA region. Value added per worker has been steadily increasing with the annual average growth of 6.0 percent in the period 1995-2010. This was happening mainly because agriculture is moving toward high value added crops such as fruits, vegetables, and livestock. Total crop area declined by about 13 percent from 2000 to 2008. At the same time, fruit crop areas increased by 8 percent.

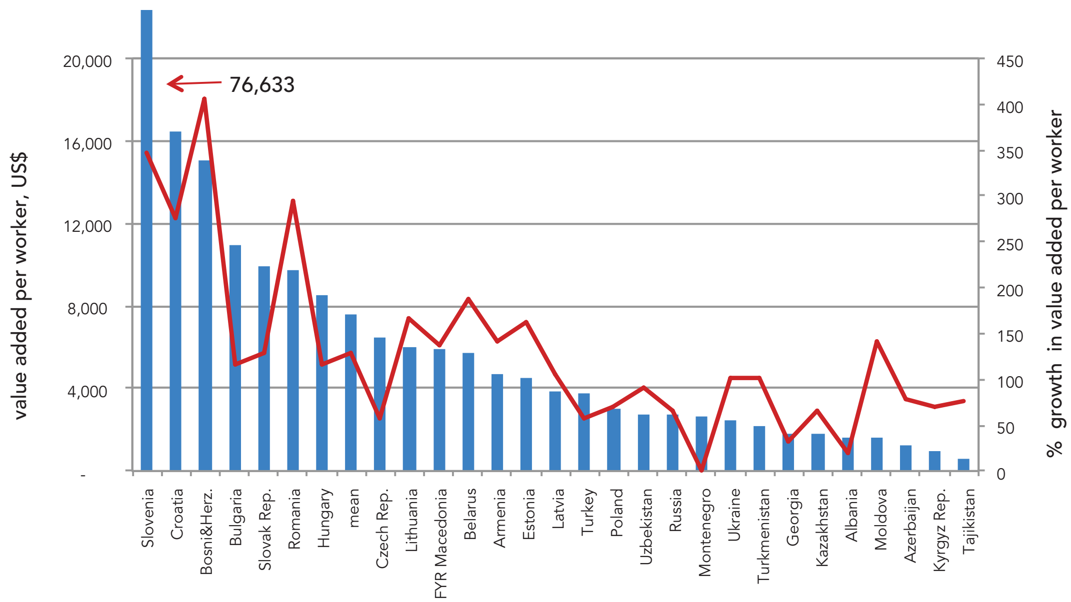
Benchmarking shows that FYR Macedonia's performance with respect to agricultural productivity is higher than in most ECA countries: FYR Macedonia is considerably above the regional median and close to the regional mean in agricultural value added per worker. FYR Macedonia also has been performing well according to the growth in this indicator, which exceeds regional median growth and almost equals the regional mean in the period 1995-2010 (Figure 5.2). Considering informality of Macedonian agriculture, however, official data might be overestimating agricultural productivity, and the country's position in the regional ranking could be lower once informality is accounted.

Small and fragmented farms and inadequate land markets limit agricultural productivity, while government subsidy programs are poorly designed to achieve their stated objectives. Average farm size (including all types of agricultural land) is 5.3 ha; and, on average, a farm is fragmented into 6 non-contiguous plots, each less than one hectare. Average arable land plots are even smaller, averaging 1.7 ha per farm, according to the 2007 agricultural census. In practice, some non-transparent land uses (such as unregistered leasing) may moderate this problem, but it remains the fact that most farms are too small. While some small farmers can be competitive depending on the type of production, most small farms cannot achieve production economies of scale nor obtain the quantity needed to reach the most profitable markets. Government expenditures on agriculture aim at the objective of increasing the productivity of agriculture to make it competitive in European and Middle Eastern markets, where demand for agricultural imports is expected to be strong,[63] and agricultural spending grew 44-fold during 2006 and 2012 and is planned to be further increased, by 14 percent in 2012-2015 (Figure 5.3). However, the structure of FYR Macedonia's agricultural subsidy program encourages preservation of small farms since farmers receive direct subsidy payments even for farms of 0.5 ha, creating an incentive for smallholders to hold onto their property even if unused.

63. Demand from Middle Eastern countries is expected to increase in coming decades as severe impacts of climate change sharply reduce local production.

FIGURE 5.2. **Agricultural productivity has been increasing**

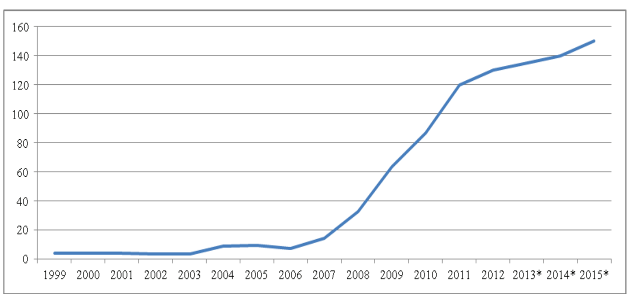
Agricultural value added per worker, 2010, and its growth 1995-2010



Source: Staff calculations using World Bank Development Data Platform.

FIGURE 5.3. **Government expenditures on agriculture grew 44-fold during 2006 to 2012**

Past and planned government support to agriculture, € millions



Source: Agriculture sector technical paper.

Dealing with Sector Inefficiency in the Context of Green Growth

Agricultural output and incomes could be much higher in future decades if climate change adaptation measures are undertaken. Given the proximity to lucrative EU markets, and the potential opening of new markets in Northern Africa, demand for FYR Macedonia's agricultural production can be high. Agricultural growth, however, is constrained by sectoral inefficiencies, which will be exacerbated by climate change in the future if no adaptation actions are taken. According to a recent World Bank report[64], FYR Macedonia's agricultural systems are poorly adapted to current climate, reflecting an 'adaptation deficit.' A key finding of that report is that many of the high-priority measures for adapting to future climate can also provide benefits in the short term and increase sector efficiency.

FYR Macedonia's vulnerability to climate change is high, in part due to the high share of agriculture in today's economy, but also due to limited water availability, sectoral structure and inefficiencies of the sector. The shares of both agriculture in GDP and agricultural employment in total employment are high, and these are important elements in considering

64. Sutton, William R., Jitendra P. Srivastava, and James E. Neumann. 2013. Looking Beyond the Horizon: How Climate Change Impacts and Adaptation Responses Will Reshape Agriculture in Eastern Europe and Central Asia. Directions in Development: Agriculture and Rural Development. Washington, DC: World Bank.

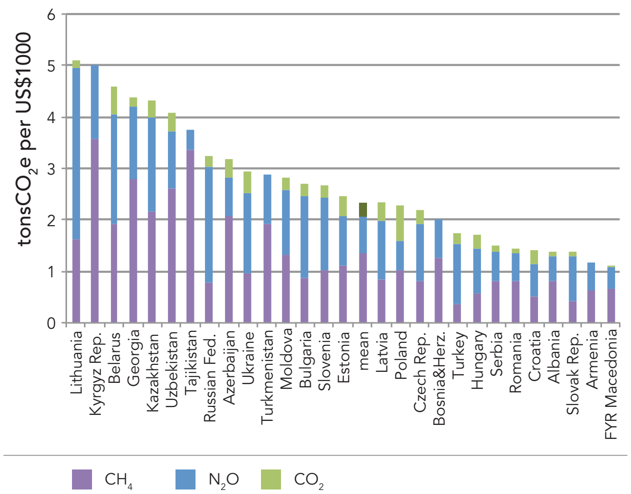
vulnerability to climate change.[65] Climate projections forecast that climate change in FYR Macedonia will mean a rise in temperatures, in the variability of precipitation, and in the intensity of the rainfall. The latter will mean increased run-off and soil erosion and reduced water availability. The risk for Macedonian agriculture is exacerbated by the fact that arable land is limited – at 0.2 ha per person, just half of the ECA region average.

In contrast, agriculture contributes very little to overall emissions in FYR Macedonia and is not emissions intensive. The sector does not produce high level of emissions mainly due to its structure (type of crops which do not require nitrogen fertilizers, type of soil, and a relatively low share of livestock). Its contribution to national GHG emissions is very low, at 0.4 percent of the total. The emissions intensity of agriculture ($MtCO_2e$ per US$ of agricultural value-added) is also very low, both overall and by major components—methane (CH_4), nitrous oxide (N_2O), [66] and carbon dioxide (CO_2). Benchmarking places FYR Macedonia at the very end of ranking in the ECA region and shows that intensity of all three major components of agricultural emissions combined is the lowest in the region. Breaking down overall agricultural emissions by component, FYR Macedonia keeps its place in the ranking (lowest intensity among comparator countries) in N_2O and CO_2 emissions, while moving to the fifth place from the bottom in methane emissions. (Figure 5.4)

Water availability is a critical issue for agriculture, with inadequate irrigation already limiting productivity, and climate change expected to exacerbate the problem.[67] The country is already experiencing moderate water stress, and climate change is pushing up water demand in agriculture. The rising frequency of water shortages is undermining the dependability of irrigation and, consequently, pushing down crop yields. Despite the insufficient irrigation, agriculture, according to formal statistics, is currently the largest user of water in FYR Macedonia accounting for 43 percent of total water withdrawals. Irrigation is critical to achieve expansion of production of high-value crops, for which FYR Macedonia has a comparative advantage. However, the Macedonian irrigation system is highly inefficient: assets are old and not operational, the location of pipes and canals is inadequate considering the current location of farms, and the system is designed to serve large-scale farms, while today's agriculture is based on small

FIGURE 5.4. **Macedonian agriculture is not emissions intensive**

Agricultural emissions as % of agricultural value-added



Notes: CH4 is methane. N2O is nitrous oxide. CO_2 is carbon dioxide. TCO_2e per US$1000 is metric tons of carbon dioxide equivalent per thousand US dollars of agricultural value-added.
Source: Staff calculations using World Bank Development Data Platform.

farms. As a result, only 20 percent of the available irrigation infrastructure is actually used and farmers invest in their own independent irrigation systems, usually based on wells. These individual schemes are rarely registered, and the groundwater is often used without being paid for, which leads to overuse. Sustainability of this system is questionable[68].

Soil fertility problems seriously affect agricultural productivity, and this situation will worsen with climate change. The issues include erosion, soil born pests and diseases, soil pollution by fertilizers and pesticides and to a lesser extend salinization and water logging. According to FAO, about 52 percent of the country is subject to soil erosion[69], a much larger share than the average in the ECA region. Currently an estimated 1.7 million cubic meters of soil are lost annually due to erosion[70]. Erosion primarily affects topsoil, where most of the organic matter and nutrients are concentrated. In addition to causing yield reduction, it also produces large amounts of sediment, which pollutes waterways and negatively affects the functioning of reservoirs and irrigation and drainage infrastructure. Soil

65. See Chapter 3 on Benchmarking for a more complete discussion of vulnerability. In addition to the share of agriculture, FYR Macedonia's vulnerability to climate change is driven by a relatively high (as compared to ECA countries) exposure (see definition in the previous footnote), relatively low GDP per capita, relatively high inequality, relatively high political instability, relatively low quality of governance, and relatively low quality of infrastructure.

66. Nitrous oxide (N_2O), which is emitted from agricultural lands, is distinct from NOx, a generic term for mono-nitrogen oxides, in particular NO_2 (nitrogen dioxide).

67. See more information regarding water availability in the Water chapter.

68. Recent legislation requires water abstraction to be formally reported. Incentives to formalize informal land leasing have also been put in place. With growing demand for irrigation at farm level and formalization of abstraction permits, investments in selective irrigation rehabilitation should become economically more viable.

69. Food and Agriculture Organization (FAO). Land and Water Development Division. 2005. National Soil Degradation Maps, FYR Macedonia. ftp://ftp.fao.org/agl/agll/docs/wsr.pdf

70. The annual loss of soil represents annual average loss of cultivable soil layer of 20 mm thickness on an area of 8,500 ha. Source: European Commission (EC). 2005. Agri-Environmental Programme for Implementation of IPARD Measure 201: Preparation for Implementation of Actions Relating to the Environment and the Countryside. Brussels: EC.

erosion will worsen with climate change, as a result of projected more intense precipitation combined with higher top temperatures unless adaptation actions are taken. Adaptation measures would include regulating land use, land consolidation, improved farming practices, using greenhouses and organic farming, and improved soil and pasture management (see Good Practice Box 3 on Kazakhstan's experience with agriculture adaptation measures which improved yields).

GOOD PRACTICE BOX 3.

Climate-smart investment in agriculture in Kazakhstan

The Kazakhstan experience demonstrates how green investments in agriculture can lead to improved productivity combined with environmental benefits. The country adapted an innovative 'no-till' technology which increases yields, reduces soil erosion, improves soil fertility, saves fuel, and captures carbon.

The strong winds of the steppes of northern Kazakhstan tend to blow away the snow in winter, making soil moisture in the spring a vexing issue for farmers. This problem has been exacerbated by a recent increase in the frequency and magnitude of extreme weather events. With support from the government and international organizations, an innovative conservation-agriculture no-till technology has been successfully applied as part of climate change adaptation. In 2012, this technology was used on 1.85 million hectares or 10 percent of all Kazakh farmland. The new technology leaves the stubble of the previous year's crop standing in the field to trap the snow. This technique allow for greater soil moisture when the weather warms. Farmers also chop and spread the old crop residues on the fields at sowing time in the spring.

In 2012, the adoption of no-till technology in Kazakhstan resulted in 0.7 million tons of additional wheat harvest, enough to feed 5 million people for a year. The new method is increasing yields by 30 to 40 percent, cutting cultivation costs, and reducing soil erosion. No-till requires investments in machinery and herbicides of $250-300 per hectare, but the investment pays back in just a few years. No-till is also capturing carbon, as healthy organic matter, in the soil, contributing to climate mitigation. In Kazakhstan, the shift in methods sequesters 1.3 million additional tons of carbon dioxide a year, which is the equivalent of taking 270,000 cars off the road.

Source: World Bank. 2013. "No-Till: A Climate Smart Agriculture Solution for Kazakhstan." Agricultural Competitiveness Project. Projects and Operations. World Bank website: http://www.worldbank.org/en/results/2013/08/08/no-till-climate-smart-agriculture-solution-for-kazakhstan

METHODOLOGY AND MAIN FINDINGS

Methodology

The objective of the analysis was to assess the impact of green (adaptation) policies and investments on sectoral outcomes in agriculture through joint modeling of water, agriculture, and the power sector; and to provide financial evaluation of the proposed infrastructure investment options for water and agriculture. [71] The models used are Global Circulation Models (GCMs), the Water Evaluation And Planning (WEAP) model, a climate runoff (CLIRUN) model and an agricultural yield model (AquaCrop). The models forecasted yields and prices of the crops that account for more than 50 percent of FYR Macedonia's total agricultural production: corn, rice, industrial crops (tobacco), vegetables (tomatoes), apples, grapes, pastures, wheat, and alfalfa. AquaCrop (Figure 5.5) was used to model crop yields and irrigation demand. Last, the Water Evaluation and Planning System (WEAP) model was applied, using the inputs from CLIRUN to analyze potential basin-level shortages in water available to agriculture. Any estimated water shortage from the WEAP model was fed back to the biophysical step to estimate the net effect of the shortage on irrigated crop yields.[72](See Chapter 4 for more details).

Modeling[73] started with a Business-as-Usual (BAU) scenario for agriculture through 2050. This baseline scenario assumes that the economy of today would evolve over the next 40 years according to the pattern of West European countries. (Chapters 2 and 3). While policies would gradually align with regional norms, no significant new infrastructure investments would be made in agriculture beyond those already funded and/or under construction. The BAU scenario incorporates the expected impact of climate change on the demand for irrigation water and the impact of climate on water supply for all demand sectors (irrigation, hydropower, thermal cooling for electric power production, and municipal and industrial uses). [74] Agriculture is projected to grow at an annual rate of two to three percent until the mid-2040s and then at 1 percent to the end of the 2040s. Since the rest of the economy is projected to grow

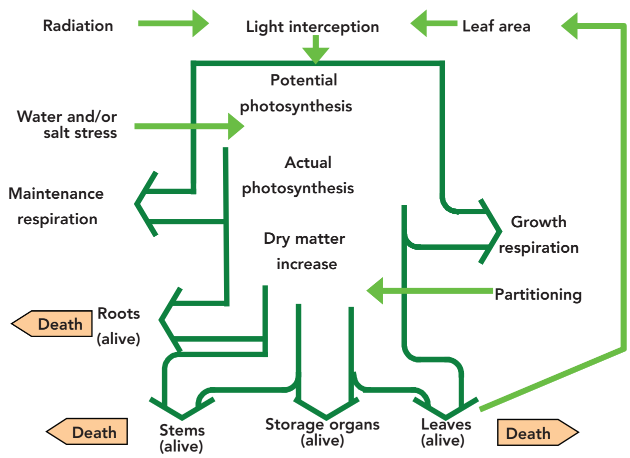
71. As mentioned above, modeling was done jointly for the water and agriculture sectors. A more detailed description of modeling is presented in Chapter 4 on water.

72. As outlined in Chapter 4, there are two basins in FYR Macedonia for which future agriculture water shortages are forecast. There should be sufficient irrigation water in other basins under climate change scenarios.

73. Modeling was done jointly for the water and agriculture sectors. While the general approach is described in Chapter 4 on water, specific agriculture sector issues are presented here in more detail.

74. The current Strategic Plan for Agriculture and Rural Development, while acknowledging the importance of irrigation for improving agricultural productivity, supports only general measures for increasing irrigation water access and infrastructure rehabilitation or re-construction.

FIGURE 5.5. **AQUACROP model**



Source: Agriculture sector technical paper.

faster than agriculture, the relative weight of the sector will contract from the current 16 percent to 9 percent in 2050.[75] As a consequence of agricultural labor absorption by other sectors, agricultural employment will contract from the current 20 percent to 13 percent in 2050 (a level similar to Greece today). This is a normal path in most countries, and it is not expected that FYR Macedonia will significantly deviate from such a pattern, but achievement of this path will require improvements in technology used in the sector, key structural reforms, and implementation of planned investments. Once today's obstacles are addressed, the level of technology will increase, together with the size of land plots; agriculture will gradually become less labor intensive, while the value of its products will improve.

Since water and agriculture were jointly modelled, the two green scenarios for agriculture are identical to those for water. (See Chapter 4 and Table 4.1 on joint water modelling scenarios). The Green scenario assumes that modest adaptation measures are taken across agriculture and water-using sectors with an annual investment cost of around UD$11 million. This scenario is based on policy actions required for EU membership (see Box 5.1 with EU cross-compliance requirements). It implies the following high benefit-cost measures: improved drainage infrastructure in all currently irrigated areas and usage of improved wheat varieties for all irrigated and rainfed wheat.[76] The Super Green scenario, by comparison, assumes significant adaptation effort and that, in addition to the measures of the Green scenario, new measures and investments are implemented, for a total annual cost of US$148 million. These investments would include: improving drainage infrastructure in all current irrigated and rainfed areas, resulting in yield increases for all crops; use of improved varieties for wheat, maize, and apples (irrigated and rainfed); optimization of agronomic practices (including timing of water and fertilizer application) for all crops in all parts of the country; and expansion of irrigation by 50 percent in each basin of the country that has sufficient water in the Super Green scenario.

BOX 5.1. **EU cross-compliance requirements for agriculture**

Good Agricultural and Environmental Conditions:

1. Protect soils through appropriate measures (minimum soil cover and land management)
2. Maintain soil organic matter levels through appropriate practices (standards for crop rotation where applicable and arable stubble management)
3. Maintain soil structure through appropriate measures (appropriate machinery use)
4. Ensure a minimum level of maintenance and avoid the deterioration of habitats (livestock stocking rates and/or appropriate regimes, protection of permanent pasture, retention of landscape features, avoid the encroachment of unwanted vegetation)

Statutory Management Requirements:

1. Conservation of Wild Birds
2. Protection of Groundwater against Pollution
3. Protection of the Environment and Soil when Sewage Sludge is used in agriculture
4. Protection of Waters against Pollution caused by Nitrates
5. Conservation of Natural Habitats and of Wild Flora and Fauna

6/7/8. Identification and Registration of Animals

9. Authorization, Placing on the Market, use and Control of Plant Protection Products
10. Prohibition on the use in of certain substances for livestock farming
11. Food law requirements and procedures in matters of food safety

12/13/14/15. Rules for the prevention, control and eradication of certain animal diseases

16/17/18. Rules concerning the protection of animals kept for farming purposes

75. Including agriculture and agro-processing.

76. These measures were agreed by major agricultural stakeholders to be the highest priority measures to undertake.

TABLE 5.1. Green policy and investment actions in agriculture, by scenario

SCENARIO	ADAPTATION POLICIES AND INVESTMENTS
Business as Usual Scenario (no adaptation)	• Maintaining current investments in adaptation as constant
Green Scenario (modest adaptation effort)	**Annual investment of around US$11 million including the following measures in all basins:** • Improve drainage infrastructure in all currently irrigated areas, results in yield increases for all irrigated crops • Improve wheat varieties (irrigated and rainfed)
Super Green Scenario (ambitious adaptation effort)	**Annual investment of around US$148 million including the following measures:** • Expand irrigation by 50% in each basin that has sufficient water in the Green scenario • Improve drainage infrastructure in all rainfed areas, causing yield increases for all crops • Improve varieties for wheat, maize, and apples (irrigated and rainfed) • Optimize agronomic practices (including timing of water and fertilizer application) for all crops in all basins

Note: See Table 4.1 for policy and investment actions in water, and Box A and Box 2.1 describing modeling scenarios in this study overall.

Main findings[77]

The modeling outcomes show that the significant adaptation effort of the Super Green scenario would outweigh costs even more than the modest adaptation effort of the Green scenario. In particular, over the period from 2011 to 2050, a moderate adaptation expenditure of US$199 million (Green scenario, total discounted additional investment and O&M) would bring additional revenue of US$674 above that of BAU, while a significant adaptation expenditure of US$1,287 million (Super Green scenario) would result in much higher additional revenue of US$3,984 above BAU's level.[78] In both cases, benefits outweigh costs by more than 4 times: 4.1 times with the Green scenario's modest effort and 4.5 times with the Super Green scenario's significant effort. Also, green adaptation measures, especially those aimed at water demand reduction, help close the water demand-supply gap: the gap is reduced by 12 percent in the Green scenario and by 23 percent in the Super Green scenario. (Figure 5.6).

The models also estimate that if no adaptation effort is undertaken, total agricultural revenue will decrease by 17 percent by 2050 as the combined effect of positive and negative factors. The negative factors are the impact of higher temperatures on rainfed crops, evapo-transpiration, and decreased availability of water for irrigation. The positive factors are related to the potential for yield increases for some rainfed crops[79] and for all crops in some areas of the country[80] due to higher temperatures during key stages of crop growth and a longer growing season. However, this assumes improved irrigation and investments to increase water efficiency and to optimize water use

Cross-sector considerations. Agriculture critically depends on other sectors. The importance of irrigation water for the agriculture sector in largely arid FYR Macedonia cannot be overstated: climate change presents a risk of increased aridity and water shortages, particularly in the agricultural growing season, for most areas of the country. Changes in water supply and water demand, water-use efficiency, and return flow volumes in non-agricultural sectors that use water

77. Calculations of the present value of future revenues and costs were made using a 5-percent discount rate, consistent with recent analysis by the World Bank (see: World Bank. 2010. Economics of adaptation to climate change: social synthesis report. Washington, DC: World Bank.). Future prices were not adjusted according to the International Food Policy Research Institute (IFPRI) global price change forecast, which forecasts an increase of relative prices for food products. Such adjustments would significantly increase the benefits produced by investments in food producing activities such as agriculture.

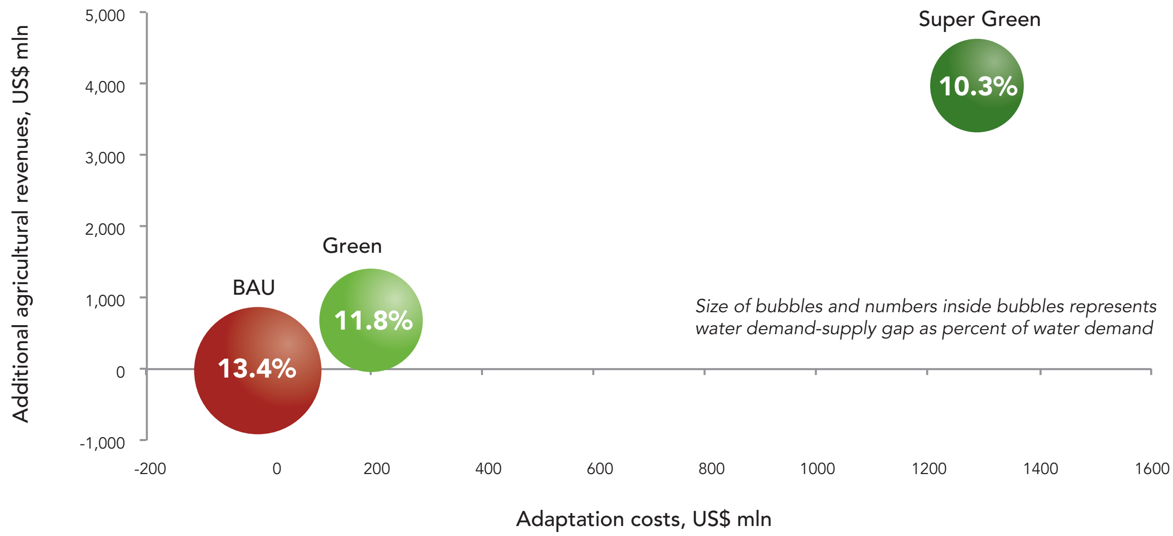
78. Present value of incremental (additional to level in BAU) revenues and incremental total (capital and O&M) costs for the period 2011-2050, discounted at 5 percent.

79. Irrigated crops: wheat, alfalfa, apples, maize, and vegetables.

80. Alpine AEZ.

FIGURE 5.6. Adaptation efforts in green scenarios lead to increased revenue and improved irrigation efficiency.

Impact of adaptation scenarios on agriculture, 2011-50



Notes: Costs are the present value over 2011 to 2050 of the flow of required additional expenditures (investment and O&M) compared to BAU. Revenues are the present value over 2011 to 2050 of the flow of the incremental sector revenues. Water demand-supply gap is the difference between water demand and supply (deficit), presented as percentage of demand.
Source: Staff calculations based on water and agriculture sector modelling outcomes

affect the volume of water available for agriculture. The timing of non-agricultural water demands is also important—municipalities and industry, hydro generation and thermal generation.[81,82] Also, interconnections between agriculture and energy provide opportunities for green energy projects that improve living standards and quality of life in rural areas (see Good Practice Box 4 on China's experience with eco-farming projects).

RECOMMENDATIONS

A more competitive, export-oriented agriculture sector in future decades will be possible only if adequate policies and investments are implemented and if adaptation measures are taken. In order to address the climate change challenge, while also remediating current sector inefficiencies, several areas of interventions are critical. These include irrigation improvements, improved management of arable land, improved pasture management, land consolidation and land market improvement, and development of organic agriculture. Since overall water demand is expected to grow even while water supply becomes scarcer, all water-using sectors— agriculture,

81. Thermal generation utilizes water for cooling.

82. See Chapter 4 (Water), Chapter 6 (Energy) and Chapter 8 (Urban).

GOOD PRACTICE BOX 4.

Eco-farming goes together with improved living standards in China

The innovative Hubei Eco-Farming Biogas Project in China combines the benefits of reduced GHG emissions, improved indoor air quality, and increased living standards.

In Hubei Province, China, 33,000 households in eight counties participated in the Clean Development Mechanism biogas digester program. The project reduces carbon emissions by installing and operating biogas digesters that recover methane from livestock manure. The biogas is then used by households for heating and cooking, replacing high-emissions coal. The project also helps the households make other improvements including an upgrade of the toilet, the pig pen, the kitchen, and installation of a gas burner.

The use of biogas digesters by households has led to a reduction of 59,000 TCO_2e in emissions annually. This translates into revenues of US$8.3 million to the participating farmers from selling Certified Emission Reduction (CER) credits. It also improved indoor air quality, reducing the incidence of respiratory diseases and eye ailments caused by the burning of coal and fuel wood.

Source: Baeumler, Alex, Ede Ijjasz-Vasquez, Shomik Mehndiratta, editors. 2012. Sustainable Low-Carbon City Development in China, Directions in Development, Countries and Regions. Washington, DC: World Bank.

industry and municipalities, hydro and thermal power—need to invest in water-saving technologies and improve demand management. Even with these precautions, not all basins will have sufficient water for all sectors, and some prioritization will be required.

- **Irrigation improvements.** Irrigation systems should be rehabilitated and expanded in those basins where water shortages are not binding. As noted in Chapter 4, an irrigation package including drainage would provide major investment gains. Investments in irrigation need to target water efficiency rather than simply increased irrigated area. To optimize water use, rehabilitation should be targeted to areas with the highest benefits from irrigation, in particular, those with high value crops (horticulture, orchards, and vineyards). The option to work with micro-catchments and more locally-based irrigation systems rather than full large scale system rehabilitation should be also considered. Other approaches to increase water efficiency include optimization of water fees, beneficiaries' co-financing requirements and private options for micro catchments. Improved functioning (including cost recovery) of the Water Economies will be necessary as well as demonstrated capacity of basin authorities and other institutions that regulate water.

- **Improved soil management of arable land**. Global experience shows that farmers on good soils are less affected by climate change. Reduced soil disturbance, proper management of crop residues, crop rotation, reduce soil erosion and cultivation costs, improve water efficiency, and increase crop intensity and productivity. Other adaptation technologies include: avoiding burning of crop residues, smoke curtains to address late spring and early fall frosts, and hail protection nets for orchards or vineyards.

- **Improved pasture management**. Improved pasture management could reduce soil erosion while improving productivity.

- **Land consolidation and land market improvement**. Modern land consolidation can make agriculture and rural economies more productive, competitive, risk-tolerant, and environmentally sustainable. Small and fragmented land plots often lack access to roads and/or irrigation canals. The land consolidation process organizes land plots around access roads and irrigation canals.

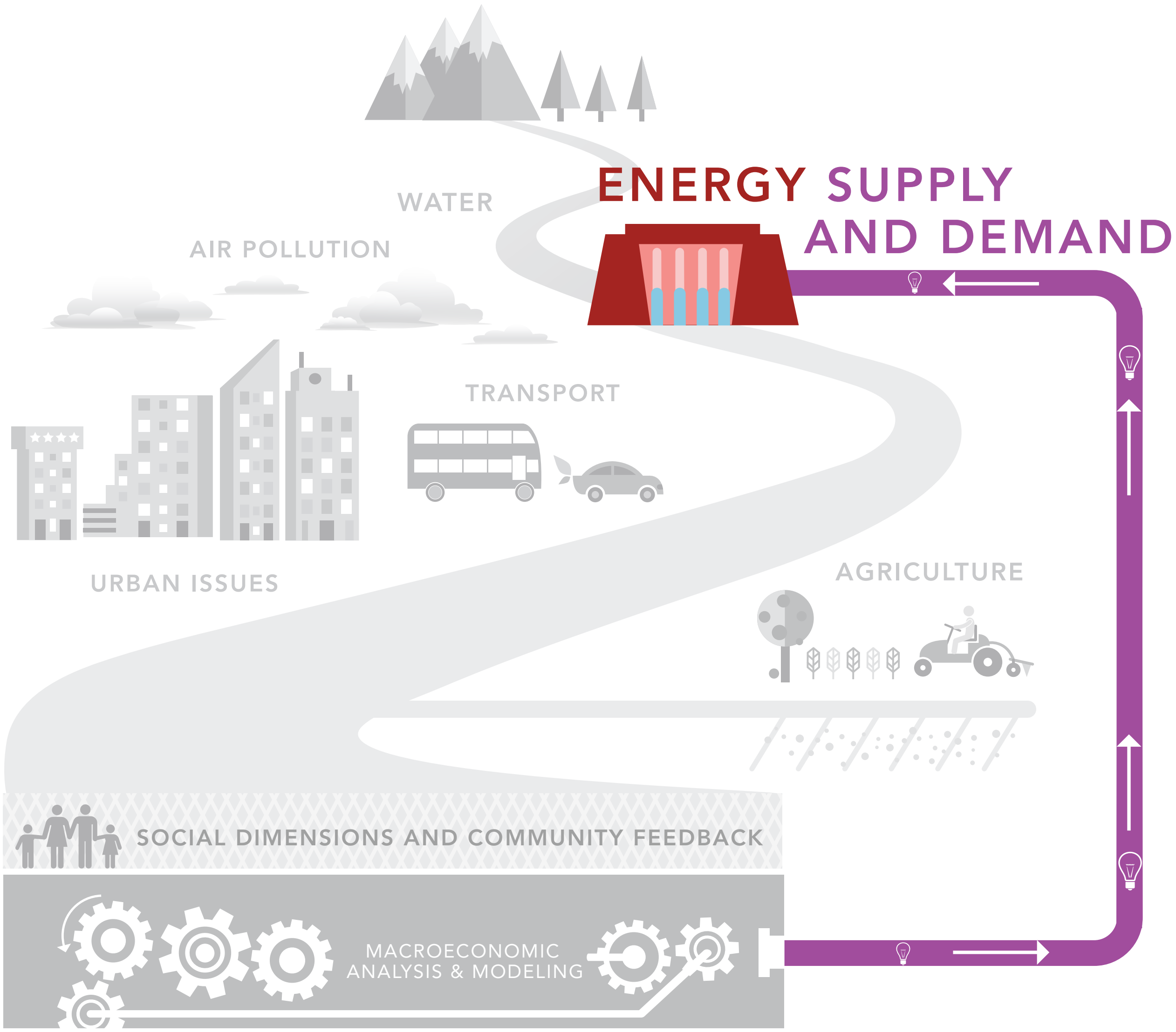
- **Improved farm practices**, in particular, precision farming based on observing and responding to intra-field variations—including locating precise positions in a field using the Global Positioning System (GPS)—can significantly reduce the amount of nutrient and other crop inputs while boosting yields. More generally, enhanced relevance and effectiveness of agricultural extension is needed.

- **Greenhouses** help reduce impact of climate on agriculture while adding value. On the negative side, agricultural production in greenhouses often requires a significant level of inputs, including pesticides, which need to be carefully managed.

- Finally, **organic agriculture** can help in reducing the environmental impact of agriculture while contributing to growth and employment generation, even though it is not an adaptation practice.

Policy and institutional strengthening is critical to support the recommended interventions. Capacity of the research and extension systems should be upgraded to be able to address adaptation challenge, especially the capacity to test feasibility of adaptive technologies. Systematic agri-environmental monitoring programs for soil, surface, groundwater and biodiversity are critical for sustainable agriculture. Improved hydro-meteorological capacity would be necessary to track better the changes in climate. With increasing climatic risks to crops, crop insurance, particularly for droughts, needs to be available and accessible to farmers. To motivate farmers to adopt good agricultural practices, a system of incentives should be created and supported by information campaigns, and any agricultural subsidy program should support water-efficient choices of crops.

Long-term challenges and opportunities are many. A last, long-term challenge for the agriculture sector will be to remain competitive when availability of cheap labor decreases and food safety and quality requirements tighten. On the other hand, climate change is expected to provide opportunities in addition to challenges, as demand for agricultural goods may increase, in particular from Middle Eastern countries, whose own production potential is expected to suffer due to climate change.



ENERGY SUPPLY
AND DEMAND
WATER
AIR POLLUTION
TRANSPORT
URBAN ISSUES
AGRICULTURE
SOCIAL DIMENSIONS AND COMMUNITY FEEDBACK
MACROECONOMIC
ANALYSIS & MODELING

CHAPTER 6

How Can the Energy Sector Be Transformed, and What Can Energy Efficiency Contribute?

CHAPTER SUMMARY

The main objectives of a green growth strategy in the energy sector are achieving demand-supply balance and supply security, lowering emissions intensity, and increasing efficiency of the sector. In the power sector in FYR Macedonia during the last decade, demand has outpaced domestic supply, sometimes significantly. Power pricing, as well as operational inefficiencies (collection and T&D, transmission and distribution, losses) have also been critical issues. Significant progress has been achieved on tariff reform, but household tariffs for power and tariffs for district heating still need to be adjusted to achieve cost recovery. Gas sector liberalization has been delayed, but the government plans to achieve efficient pricing of gas, leading to increased demand for gas and partial replacement of lignite and oil with gas in the primary energy mix. A particularly challenging issue is the very high emissions intensity of the Macedonian economy: the ratio of greenhouse gas (GHG) emissions to GDP is 5 times higher than the EU average, mainly due to the prevalence of lignite in the energy mix and a negligible share of gas, but also due to outdated equipment. How can the energy sector be transformed, and what can energy efficiency contribute?

The main objectives of the analysis are to find best solutions for the Macedonian power supply mix that would cover demand at a minimum cost while reducing emissions and the emission intensity of the power sector and industry, as well as to find demand-side energy-saving solutions. Demand-side modeling estimates the potential reduction in energy demand as a result of energy efficiency measures implementation under two green (mitigation) scenarios[83]. Supply-side modeling outcomes provide a minimum cost solution for the power generation mix while meeting expected EU requirements for mitigation (21 percent reduction by 2020 compared to 2005) and taking into consideration technology and other resource constraints. Marginal abatement cost (MAC) curve analysis evaluates the effectiveness of each of the proposed energy efficiency measures and supply technologies by measuring marginal net unit costs (the present value of net cost per unit of CO_2e abatement) and the related abatement potential of each measure. Three interlinked models are used for the analysis: the macroeconomic model, the energy demand model EFFECT and the energy supply model MARKAL.

The outcomes of modeling show that the combination of the Super Green scenario's demand-side measures and the Green scenario's supply side measures is best in meeting jointly the strategic objective of supply security and the financial objective of minimizing abatement costs and is therefore recommended. While demand-side actions are a critical short-term solution considering their lower cost and shorter implementation period, longer-term and investment-intensive supply-side measures provide the biggest gains in bridging supply-demand gap and abatement. These measures should include aggressive development of gas supply, such that gas completely replaces lignite and oil. This shift implies construction of new gas generation plants, of a

83. See Box A and Box 2.1 describing modeling scenarios in this study.

new cross-border gas pipe line, and of new gas distribution infrastructure. In addition, new hydro and wind plants should be constructed. On the demand side, standard energy efficiency measures that have proved to be cost efficient in other countries should be implemented as quickly and broadly as possible to support the maximum achievable reduction in demand. Strengthening the institutional capability to design and implement energy efficiency programs is a key element of a successful energy efficiency strategy for FYR Macedonia. Making low cost capital available for demand-side energy efficiency investments is essential for capital intensive, long-payback energy saving measures such as building retrofit.

CHALLENGES FOR GREENER GROWTH

Overview

Energy sector transformation is critical for green growth in FYR Macedonia. The main objectives are achieving demand-supply balance and supply security, lowering emission intensity, which makes energy sector the top contributor to the country's total GHG emissions, and increasing efficiency of the sector including efficient cost of services and increased quality of service provision. Importance of these objectives places energy sector at the very top of the green growth agenda. The major current tasks include Western Balkan countries' energy market integration, investment in energy infrastructure and energy efficiency improvements, supported by institutional and policy reforms. These tasks correspond to the goals of the 2005 Energy Community Treaty, which aims at converging energy policy of the Western Balkan countries (Albania, Bosnia and Herzegovina, Croatia, FYR Macedonia, Moldova, Montenegro, Serbia and Kosovo) with that of the EU. The main obligations of the countries-parties to the Treaty are full unbundling of the energy companies, establishment of regulatory framework, liberalization of the energy markets including allowing consumers to choose suppliers, and cost recovery pricing of the end-user energy products. All of the above are essential conditions for private sector participation in generation and obtaining financing for investments in cross-border power transmission and gas pipelines, as well as in the construction and refurbishment of the generation plants and the networks.

FYR Macedonia has already made progress toward meeting these obligations. The new regulatory framework is set to achieve full liberalization of the energy market by January 1, 2015. An independent regulator Energy Regulatory Commission was established in 2002, with the mandate to issue energy licenses and regulate energy prices including power tariffs. The Energy Agency was created in 2005 to implement energy policy, while the energy policy design and energy sector management are in the hands of the Department of Energy within the Ministry of Economy. The most important issues to be addressed, as reflected in the FYR Macedonia's Energy Strategy[84], are in the power and gas segments of the energy sector.

Reform in the power sector is most advanced. Power sector restructuring started in 2004 with the vertical unbundling of the Electric Power Company of FYR Macedonia (ESM) into three legally separate entities – generation, transmission, and distribution and supply. Currently, tariffs for transmission, as well as distribution and public supply are regulated, while generation and wholesale supply to qualified consumers (large industrial users) are not regulated and are set by the market[85]. Generation is fully state owned and the Electric Power Plants FYR Macedonia (ELEM) operates two major thermal power plants, Bitola and Oslomej, comprising approximately 55 percent of the total installed capacity, and seven hydropower plants with 35 percent the total installed capacity. The government is planning to sell 49 percent of ELEM's assets to a private investor, starting the deal in 2013[86]. Transmission is also fully state-owned and operated by Macedonian Electrotransmission System Operator (MEPSO). Distribution and supply is privatized and operated by a private joint stock company EVN FYR Macedonia (90 percent owned by EVN Austria, 10 percent by MEPSO).

The biggest issues in the power sector are supply-demand balance, import dependence and operational efficiency of the sector, which includes efficient pricing. During the last decade, **demand has exceeded domestic supply**, and the gap has been filled with imported power. Over the period from 2000 to 2009, electricity demand rose by 18 percent,[87] while domestic supply decreased by 3 percent and power imports averaged at as much as 20 percent of demand, peaking at even higher 32 percent in 2008 (Figure 6.1). The average annual cost of the power import in 2003-09 was €95 million, peaking at €235 million or 3.6 percent of GDP in 2008, thus adding substantially to the country's current account deficit.[88] **Energy import dependence[89] is 45 percent**, which is close to the

84. Ministry of Economy, FYR Macedonia. 2010. Strategy for Energy Development in the Republic of Macedonia until 2030. Skopje.

85. Market prices will be eventually applied to a wider range of consumers. At the next step of this process, on July 1, 2013, middle sized companies will be qualified to pay market prices.

86. Previous attempts to attract private investment in hydro generation, namely, in two large plants Chebren and Galishte, were not successful. However, a new tender for this deal has been recently announced.

87. Annual average 1.9 percent in 2000-2009; the 12 percent drop from 2008 to 2009 is explained by the collapse of electricity-intensive exports from heavy industry.

88. Tieman, Alexander F. 2011. "The Electricity Sector in FYR Macedonia." IMF Working Paper WMP/11/30. Washington, DC: IMF.

89. Net imports as percent of total primary energy supply.

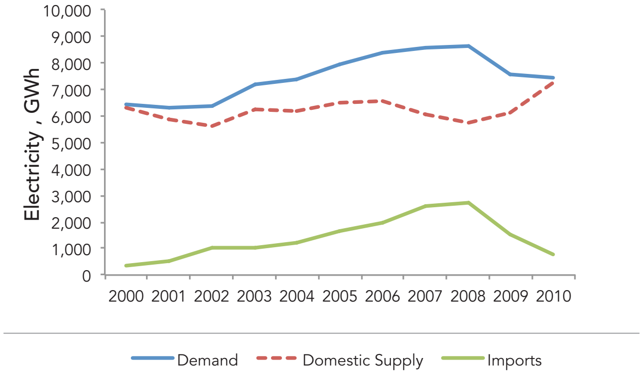
OECD average of 44 percent. All crude oil and oil products are imported and constitute 12 percent of total imports making it the country's largest single import item.[90] Also, all natural gas is imported. Starting in 2000, FYR Macedonia has been importing electricity.

Power pricing, as well as operational inefficiencies (collection and T&D losses) have also been critical issues. Significant progress has been achieved with tariff reform and industrial tariffs have reached cost recovery. However, household tariffs, while there have been increases in the previous years, are still below cost recovery level. Since distribution was privatized, operational inefficiencies were substantially reduced. The latest available analysis of the tariff subsidy estimated it at 0.7 percent of GDP for 2010[91]. It also estimated T&D losses and collection losses[92] at additional 0.8 percent of GDP for 2009. Tariff subsidy reduced significantly from 2008-09, when it amounted to 3.8 percent of GDP and 2.3 percent of GDP respectively. Also, after distribution was privatized in 2006, supply inefficiencies – T&D losses and under-collection – were reduced. However, the problem with subsidization has been exacerbated, following the 2008 crisis, by a decrease in the share of large industrial users, the only customers paying non-subsidized tariffs. Their share of consumption decreased from 25 percent in 2005-08 to 17 percent in 2009, resulting in higher average cost-tariff gap. Also, after two household tariff increases in 2012 (a 7.8 percent increase in January and a 9.8 percent increase in August), subsequent increases were delayed and household tariffs are still below their cost recovery level[93].

Another critical issue is power sector cost efficiency, which can be increased through continuing power and gas sector liberalization and increase in the gas share in the generation mix. Gas sector liberalization has been delayed, but the Government plans to address it and achieve efficient pricing of gas, increased demand for gas and partial replacement of lignite and oil with gas in FYR Macedonia's primary energy mix, which would support the objectives of the energy sector transformation including energy security, emission intensity reduction and efficient costs of services. In the current market situation, both the supply of gas and demand for gas are constrained. First, there is an ownership dispute regarding the currently operating gas pipeline, which delivers Russian gas through the border with Bulgaria. The dispute relates to the joint-stock venture between the Government of FYR Macedonia and Makpetrol[94]. As a result of the dispute, the gas pipeline to Skopje is operating at 12 percent of its capacity. Second, demand for gas is constrained by high prices for imported gas[95], which are based on the long-term oil-indexed gas contracts and exceed gas prices in the EU, making power more attractive as an energy source for all customers, including exporting industry and households, an inefficient outcome in terms of both market costs and emission intensity. Resolving the dispute and achieving market-based gas pricing will drive demand for gas up. At the same time, a sufficient infrastructure for gas supply will be required to support this outcome.

FIGURE 6.1. **Demand exceeds supply and the gap is filled with imported power**

Electricity demand, supply and imports 2000-2010



Source: Alexander F. Tieman, The Electricity Sector in FYR Macedonia , IMF Working Paper WP/11/30, IMF, Washington DC, 2011

Both a cross-border gas transportation system designed to ensure supply security and a gas distribution network within the country will be needed. The existing cross-border pipeline is transporting Russian gas to FYR Macedonia across the border with Bulgaria and has capacity to deliver 0.8 bcm per year, with a possibility to be upgraded to 1.2 bcm per year, enough to provide gas for more than 800 MW of base-load power generation capacity, approximately half of the total generation capacity today. Construction of additional pipeline(s) is under consideration; this involves delivery of Russian and Algerian gas via new routes. A recently-built

90. International Energy Administration (IEA). 2008. Energy in the Western Balkans. The Path to Reform and Reconstruction. Prepared in Cooperation with United Nations Development Program. Paris: Organization of Economic Cooperation and Development / IEA.

91. Tieman, Alexander F. 2011. "The Electricity Sector in FYR Macedonia." IMF Working Paper WP/11/30. Washington, DC: IMF.

92. Not recorded in ELEM's accounts.

93. Tariff analysis subsidy source: Tieman, Alexander F. 2011. "The Electricity Sector in FYR Macedonia." IMF Working Paper WP/11/30. Washington, DC: IMF. Note that this subsidy is implicit: it is recorded in state-owned ELEM's accounts as a loss and is cross-subsidized with profits from other activities. The estimate of this full implicit subsidy is based on a regional market price of €63 per MWh (ELEM's average weighted import price in 2009), while the price at which ELEM supplies tariff customers is equivalent to some €30 per MWh. In addition, calculating the implicit subsidy takes account of the average transmission price of €4 per MWh, which is included in the import price of €63 per MWh but should not be included when calculating the opportunity costs, as this revenue would not accrue to the generator.

94. Makpetrol is licensed to sell gas to industrial customers, while the joint venture operates the pipeline.

95. FYR Macedonia has no indigenous gas resources; all gas has to be imported.

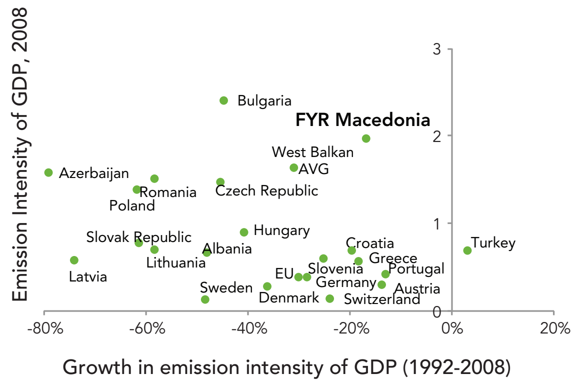
Skopje Combined Heat and Power (CHP) plant would then likely become a least-cost source of heat supply in Skopje during the winter and provide power at competitive prices in the summer. To deliver gas for heating to customers, investment in a gas distribution network will be needed. It is not yet clear whether the least cost option would be to create a network to deliver gas to CHP plants for district heating or directly to customers. A Government study evaluating costs of these alternative options is about to be started in five Macedonian cities. Most efficient use of resources and increased energy security would be provided by regional integration of gas supply and the Energy Community is exploring a possibility for developing it.[96]

A most challenging issue is a very high emissions-intensity of the Macedonian economy: the ratio of GHG emissions to GDP is 5 times higher than the EU average and 1.5 times higher than the ECA regional average (Figure 6.2).[97] The main reason is the structure of Macedonian energy consumption dominated by lignite and oil that together constitute more than three-fourths of the total. As a result, the energy sector accounts for 71 percent of total GHG emissions in the country (Figure 6.3) and is highly emission intensive mainly due to its heavy reliance on fossil fuels. Additional factors of high emission intensity of the Macedonian economy include energy-intensive industry; aged assets with low energy efficiency across the economic sectors, including power sector; the district heating sector based on high-emission heavy fuel oil; a recent trend, driven by increased power tariffs and low quality of power supply, of the household sector's high and increasing usage of wood and inefficient[98] stoves for heating; inefficient heat pumps for cooling; and poor building insulation in households, municipalities, and the commercial and industrial sectors.

The structure of Macedonian energy consumption differs from the majority of the EU and non-European OECD countries in two respects: Macedonian consumption is characterized by

FIGURE 6.2. **Macedonian economy has high emissions-intensity compared with European countries**

Emissions intensity of GDP in 2008 and its growth, 1992-2008



Source: Staff calculations using the IEA database.

prevalence of lignite and a negligible share of gas. In countries such as Denmark, Germany, Britain, Italy, Canada and the USA, the share of natural gas in total primary energy consumption ranges from 20 percent to 40 percent, and the share of lignite from 8 percent to 22 percent. In FYR Macedonia, the economy relies heavily on domestic lignite, which is the dominant energy source, accounting for half of total primary energy consumption and 60 percent of electricity generation. Hydropower and other renewables account for four percent of primary energy consumption and 19 percent of electricity generation[99]. The first wind generation plants are being constructed currently, and a limited solar photovoltaic capacity is functioning. Biomass (fuel wood, agricultural and municipal residues and wastes) accounts for seven percent of primary energy consumption, but it is almost entirely fuel wood, which is widely used by households for heating and cooking (see Box 6.1). The structure of Macedonian primary energy consumption has remained more or less the same for the last decade. (Figure 6.4).

96. However, recent ideas of creating a West Balkans' Natural Gas Ring, a gas transmission pipeline linking Albania, Bosnia-Herzegovina, Croatia, Kosovo, FYR Macedonia, Montenegro, and Serbia, originally suggested by Turkey's Botas and Greece's DEPA in 2003, have not been implemented in view of Greek and Turkish participation in the Nabucco and/or ITGI project (See http://www.transconflict.com/2010/09/re-linking-the-western-balkans-the-energy-dimension-309).

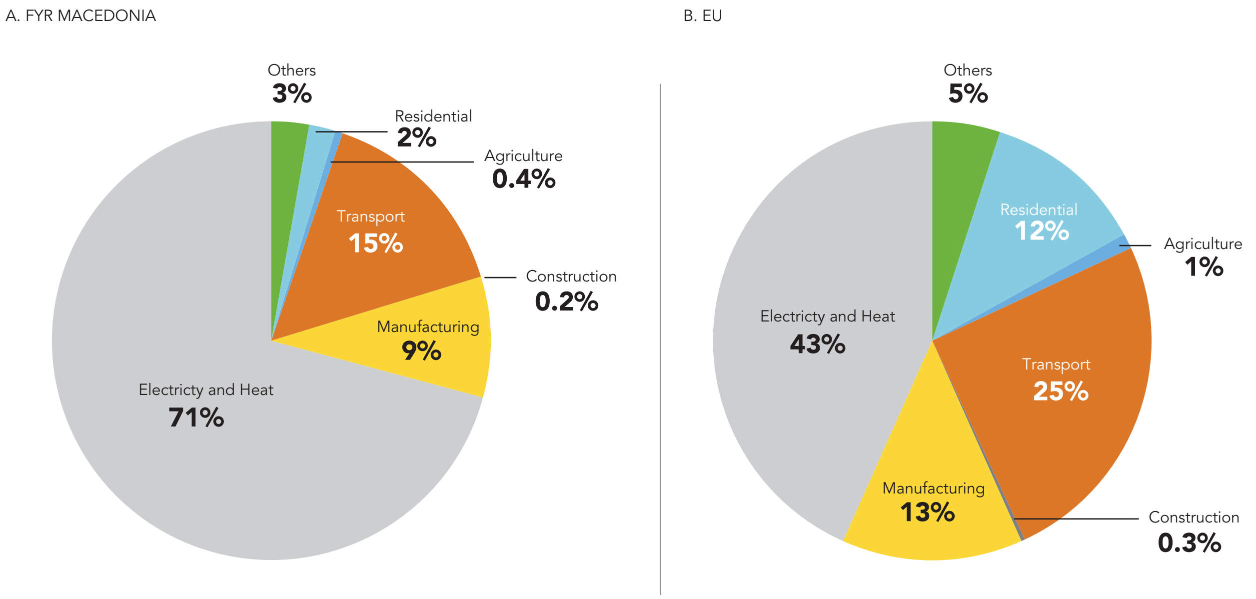
97. Very similar outcomes are presented in the following source: International Energy Administration (IEA). 2008. Energy in the Western Balkans. The Path to Reform and Reconstruction. Prepared in Cooperation with United Nations Development Program. Paris: Organization of Economic Cooperation and Development / IEA. According to this source, energy intensity in FYR Macedonia is 0.71 tons of oil equivalent per unit of GDP (1000's of 2000 $), more than three times the average for OECD Europe (2005 data). In 2005, FYR Macedonia produced 0.64 kg CO_2e per unit of GDP (1000's of 2000 GDP), almost three times higher than the world average and more than five times the average for OECD Europe.

98. Typically with 22 percent efficiency. See International Energy Administration (IEA). 2008. Energy in the Western Balkans. The Path to Reform and Reconstruction. Prepared in cooperation with United Nations Development Program. Paris: Organization of Economic Cooperation and Development / IEA.

99. Source: IEA database

FIGURE 6.3. Macedonian energy sector is the top emitter

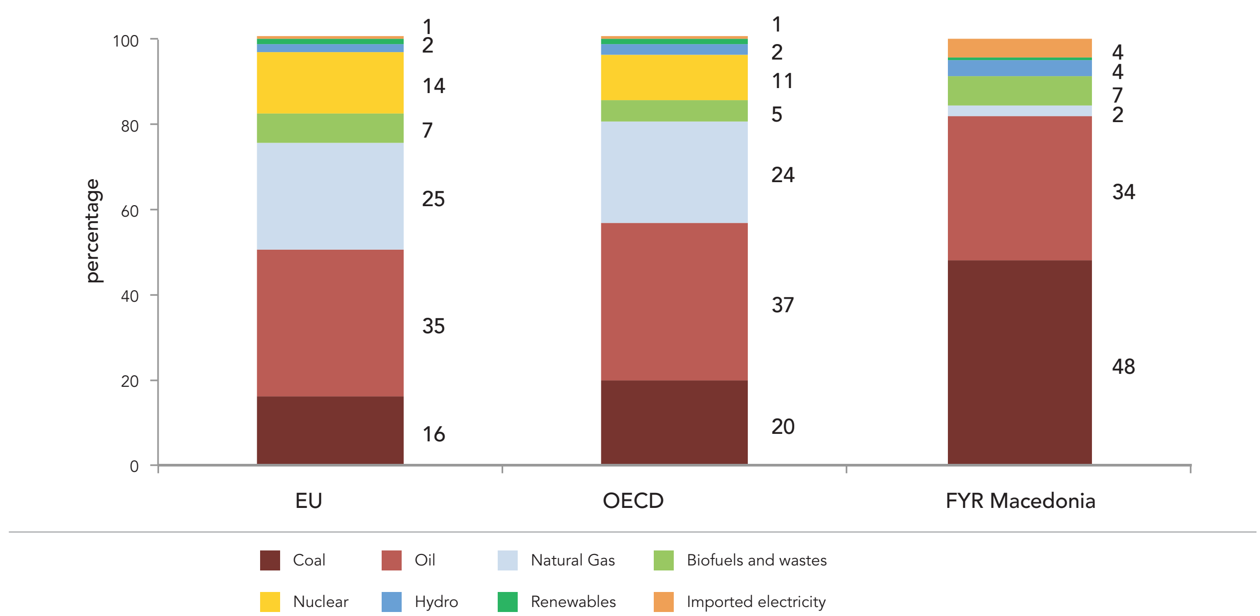
CO_2e emissions for FYR Macedonia and the EU, shares, 2009



Notes: Energy sector refers to electricity and heat production and energy sector own use; transport sector includes all transport activity regardless of the economic sector; residential refers to emissions from fuel combustion in households; "Other" includes commercial/institutional activities, fishing and emissions not specified elsewhere.
Source: Staff calculations using the International Energy Agency (IEA) database.

FIGURE 6.4. Macedonian economy relies heavily on lignite and has almost no gas in primary energy

Primary energy by fuel, FYR Macedonia and comparators, 2009



Source: Staff calculations using data from the National Statistical Office.

BOX 6.1. Fuel wood use in FYR Macedonia

A surprisingly high and rising reliance on wood for heating drives up FYR Macedonia's emission intensity and generates excessive local air pollution. Household wood burning generates about eight percent of the country's GHG emissions and about the same share of total particulate matter pollution according to official statistics. About 70 percent of energy used for heating comes from biomass or fuel wood. Most importantly, it is the widespread use of inefficient wood stoves[a] that undermines what could otherwise be a climate-friendly use of renewables. Instead, the increasing usage of biomass should be seen as an indication of energy poverty, reflecting household inability to afford modern heating sources, such as gas, district heating or electricity; as well as a lack of access to gas.

Biomass use in FYR Macedonia is higher than most of Europe (Box Figure 6.1) **and has been rising in recent years**. Three-quarters of the population use wood for heating on a daily basis. Particularly surprising, even in urban areas, nearly 60 percent of households rely on biomass for heating (compared to 95 percent of rural households). Within Europe, only Montenegro, Bosnia and Herzegovina, and Kosovo approach Macedonian levels of biomass use. The upward trend for heating and cooking with biomass in FYR Macedonia has accelerated in recent years, rising by an average 6 percent during 2005-2010 after a much lower average 3 percent annual growth during 1991-2005.

The numbers above underestimate the problem by 25 to 30 percent because of widespread illegal logging. The use of illegal fuel wood (in excess of regulated levels and cut without appropriate licensing) is prevalent throughout the country.[b] While the overall forested area in FYR Macedonia has remained relatively stable, at about 37 percent of the territory, illegal logging is a significant and growing threat to forest resources, taking a large proportion of the growing stock each year. 85 percent of wood harvested legally is for fuel while illegally harvested wood is presumed to be used entirely for fuel. Forest fires have also had deleterious impacts on FYR Macedonia's forests, affecting nearly 100,000 ha over the last 10 years (out of about 950,000 ha of total forest), while climate change has exacerbated the threat of insect and disease damage.

The drivers of escalating biomass use in FYR Macedonia are the rising price and low quality supply of district heating, higher electricity tariffs, and the underdeveloped gas supply network. Poor building insulation aggravates the problem: residential energy consumption for heating is two to three times higher than in Western Europe. The very low efficiency of most (50-85 percent) of wood stoves, at around 22 percent, renders the economic choice of wood into a high-polluting option. Modern masonry or down-burning stoves or pellet boilers could achieve efficiencies of 60 to 80 percent. Further, since wood is mostly used in detached houses, urban sprawl, a dominant characteristic of FYR Macedonia's urban development over the past two decades, is another factor.

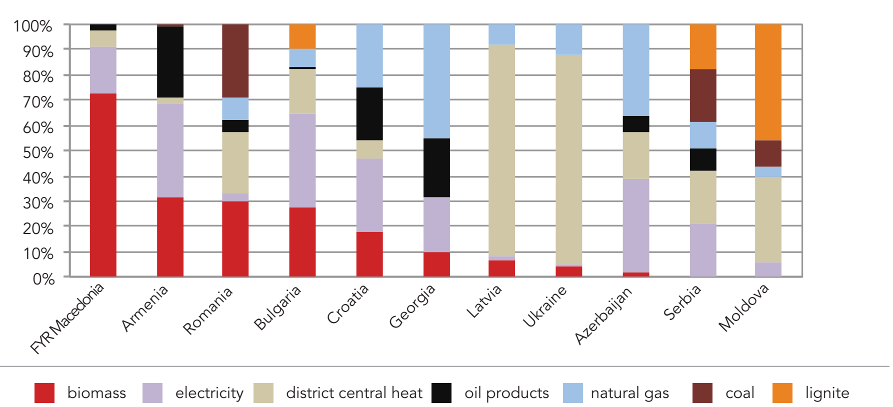
Only 10 percent of households are currently connected to district heating. Increasing prices (partly due to rising world oil prices, but also system inefficiencies), building-level metering, and poor supply quality are all factors. Widespread disconnections in recent years followed implementation of consumption metering at the building level. At that time, many households in poorly insulated buildings, as well as in buildings with low connection rates, opted for disconnection and switched to electric and biomass heating.

Combined electric and biomass heating is a typical pattern in FYR Macedonia. Macedonians use a much larger share of electricity for heating than in a typical European country. On the average, households use 57 percent of electricity for heating, 25 percent for home appliances, 11 percent for heating water, and only 7 percent for lighting. Still, because of the recent years' increase in electricity tariffs and the growing unreliability of supply, consumers combine use of electricity and biomass and have been increasing the share of the latter. In the winter, when fuel wood prices increase and supply is short, consumers turn to electric heaters, contributing to overload of the electricity network.

Reduction of biomass consumption by households can significantly cut GHG emissions and air pollution. Modeling conducted for this study showed that most of the potential household energy savings, and therefore emission reduction of 68-69 percent lies in biomass.[c] A combination of expanded gas supply networks, improved central heating supply, and programs aimed at stove replacement would be needed to reduce emissions

BOX FIGURE 6.1. Wood is the dominant fuel for Macedonian heating

Final heat consumption by energy source, 2007



Source: United States Agency for International Development (USAID). 2007. Alliance to save energy. Municipal network for energy efficiency. Regional urban heating policy assessment, Part 1.

from biomass combustion. Stove replacement could be a first-tier solution, as it can be implemented faster and with a lower budget than the more permanent centralized heating options. Inefficient stoves should be replaced by modern ones that run on fuel such as concentrated wood pellets, can reach 80-90 percent efficiency, and are associated with lower emissions of carbon monoxide, volatile organic compounds, particulate matter and other hazardous air pollutants.

Sources used:

Ministry of Economy, FYR Macedonia. 2010. Strategy for Energy Development in the Republic of Macedonia until 2030. Skopje.

Ministry of Environment and Physical Planning, FYR Macedonia. 2012. FYR Macedonia's Informative Inventory Report (IIR) 2010. Submission under the United Nations Economic Commission for Europe (UNECE) Convention on Long-range Transboundary Air Pollution. Skopje: UNECE.

International Energy Administration (IEA). 2008. Energy in the Western Balkans. The Path to Reform and Reconstruction. Prepared in Cooperation with United Nations Development Program. Paris: Organization of Economic Cooperation and Development / IEA.

European Commission (EC). 2011. Biomass Consumption Survey for Energy Purposes in the Energy Community, FYR Macedonia. Centre for Renewable Energy Sources and Savings. EC.

Stojilovska, Ana and Sonja Zuber. 2013. Energy poverty in FYR Macedonia. European Union (EU) Policy Brief. October 2013. Produced by Konrad Adenauer Stiftung and Analytica Think Tank, FYR Macedonia. EU.

US Forest Service, International Programs, FYR Macedonia. http://www.fs.fed.us/global/globe/europe/macedonia.htm.

a. 61% of the households that reported biomass consumption use biomass for cooking. Very few, approximately 6 percent, of households use biomass for water heating.
b. Ministry of Economy, FYR Macedonia. 2010. Strategy for Energy Development in the Republic of Macedonia until 2030. Skopje.
c. Other sources of energy included in the calculations were district heating, LPG, gas/diesel, and lignite.

METHODOLOGY AND MAIN FINDINGS

Methodology

The main objective of the analysis was to find best solutions for Macedonian power supply mix that would cover demand at a minimum cost while reducing power sector overall emissions and emission intensity of both the power sector and the industry. Another objective was to estimate potential reduction in the demand for power as a result of implementation of energy efficiency measures in household, industry and non-residential sectors. The cost of the proposed power sector green investments per unit of emission reduction wase evaluated. The analysis was done in three steps: demand-side modeling, supply-side modeling and Marginal Abatement Cost (MAC) analysis. Green policy measures were evaluated using three-scenario modeling (see description of the scenarios including policy measures in Table 6.1): the outcomes of Green and Super Green scenarios were compared with the outcomes of the Business as Usual (BAU) scenario.

Demand-side modeling was used to estimate reduction in energy demand as a result of energy efficiency green measures implementation in two Green scenarios. It also evaluated the level of investment needed to implement the proposed green measures. Modeling was done for three sectors - residential, non-residential (public and commercial) and industrial – and the outcomes were then added up to calculate electricity sector total. **Supply-side modeling provided best solution for electricity supply mix** at the minimum possible cost and considering that the volume of power supplied should be sufficient to meet the level of demand projected in the demand-side analysis and the GHG emission reduction target should be met. **MAC curve analysis evaluated the effectiveness of each of the proposed abatement measures** by measuring its marginal net cost (present value of net cost per unit of CO_2e abatement) and the related abatement potential.

Modeling was performed using three policy scenarios: the Business as Usual (BAU) scenario, the Green scenario and the Super Green scenario[100]. BAU scenario is based on the characteristics of the Macedonian national energy system - existing power technology stock, domestic power resource availability and import options, and existing policies, – as well as on the power sector development plans reflected in the FYR Macedonia Energy Strategy (2010).[101] [102] However,

100. See Box A and Box 2.1 describing modeling scenarios in this study.

101. Ministry of Economy, FYR Macedonia. 2010. Strategy for Energy Development in the Republic of Macedonia until 2030. Skopje.

102. In fact, this analysis uses the same supply-side model as the Macedonian Energy Strategy (MARKAL model, see description in this section below). However, this modeling uses more recent base year data (2009) than the Strategy (2006).

BAU differs from the FYR Macedonia Energy Strategy in two aspects. First, the Energy Strategy assumes imports of lignite for power generation, while BAU does not consider lignite imports, as they are no longer justified based on the currently expected increase in the price of lignite mining (see Section 1) and on the higher than previously anticipated and considered in the Energy Strategy investment cost of lignite power plants. Second, the BAU scenario does not consider hydro and wind power plants, except those that are already under construction. The reasons for limiting new hydro capacity in BAU include higher than previously projected cost of hydropower due to low capacity factor of FYR Macedonia's hydro plants, pushed further down by climate change[103], which, when combined with high up-front investment requirements and long-term nature of hydro power construction, becomes incompatible with the urgency of the FYR Macedonia supply-demand balance need and BAU's limited financial resources.[104] (Box 6.1)

Energy efficiency improvements assumed in the BAU scenario are also consistent with the FYR Macedonia Energy Strategy and driven by the country's current economic development objectives. BAU assumes that households and businesses move into new buildings or houses, retrofit the old ones and replace electric appliances at the rate corresponding to the projected rate of economic growth and considering current regulations. BAU also assumes that industries replace equipment and implement energy efficiency measures at the rate consistent with the projected rate of growth in industrial value added. BAU assumes no expansion plans for district heating companies and no new natural gas distribution lines and therefore no increase in usage of natural gas and district heating by households, businesses and small and medium industrial users.

The Green and Super Green scenarios include policy measures and investments aimed at reducing energy demand as compared with the BAU level at the lowest possible cost while lowering the GHG emissions as required by the EU policies. This is achieved by switching from solid and petroleum-based fuels to natural gas and deploying renewable power. In particular, retiring lignite plants are replaced by gas plants and new hydropower and wind capacity is added above the BAU level. Super Green scenario also considers adding solar photovoltaic and nuclear capacity.[105] As a result, in both Green scenarios, 20 percent of supplied power comes from renewable sources by 2020, consistent with the EU requirements. The Green and Super Green Scenarios also assume that energy efficiency measures are taken more aggressively than in BAU. These measures combine building retrofit, investments in new technology, and policy incentives aimed at containing energy demand (see details in Table 6.1).

Three interlinked models were used for the analysis: the macroeconomic model, the energy demand model EFFECT and the energy supply model MARKAL. **The models were implemented in the following sequence (Figure 6.5):**

- **Step 1. The Macroeconomic model** produced projections for basic macro indicators, which are considered the key factors of energy demand: GDP, energy sector value added, and energy prices. These projections were used as input in the micro model EFFECT, which projects energy demand.

103. Climate change has a negative impact on river runoff.

104. Hydropower development is also modeled in Chapter 4 on water. While the modeling framework in the water sector analysis differs, the outcomes are similar.

105. Nuclear power is included in the Super Green scenario because the Macedonian Government's Strategy for Energy Development includes the construction of a 1000 MW nuclear power plant in the future, sometime after 2020. Nuclear power is a technically available option that warranted consideration in the analysis.

BOX 6.2. Modeling parameters, constraints and assumptions for the baseline scenario*

Key modeling parameters, projected using macroeconomic modeling and data from the UN, Eurostat and the World Bank, include: 4.5 percent average annual GDP growth, 2.8 percent average annual energy sector growth, and 4.2 percent annual average household income growth (2010-2035); fuel prices; existing generation plants plus new generation plant options; expanded international trade; and increased tourism.

Key constraints and assumptions for the supply side energy optimization model include:

- New wind plant capacity is limited to plants already under construction and does not exceed 150 MW in 2050;
- New solar photovoltaic capacity is limited to 40 MW;
- Imported power price is 4.5-11 € cents/kWh;
- Capacity of new large hydro plants is limited to those already under construction;
- Retiring lignite plants are replaced by new lignite and gas plants;
- Committed gas combined-heat-and-power plants are built.

Key assumptions for demand side modeling include increased efficiency of household appliances; improved efficiency in heating, cooling and lighting in non-residential sector; and equipment replacement in industry.

Note: Green scenarios have the same modeling parameters as in the business-as-usual (BAU) or baseline scenario; change in constraints and assumptions from BAU is related to the shift in the fuel mix away from solid and petroleum-based fuels to natural gas, hydro generation, wind, and solar photovoltaic; they also have more aggressive energy efficiency strategy than in BAU.

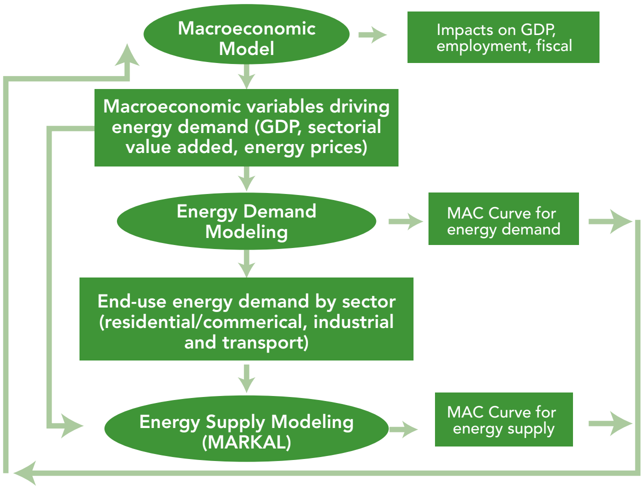
- **Step 2. The World Bank's EFFECT model (Energy Forecasting Framework and Emissions Consensus Tool)** (see Box 6.2) used macroeconomic projections from Step 1, together with other input data, to project energy demand for four sectors—household, non-residential, industrial, and transport—over the period from 2010 to 2035. The results were then extrapolated to 2050. For each sector, demand was projected by subsector and type of usage. The projections were made separately for power and non-electric energy. The projections for transport sector are presented in the transport chapter of this report.

Some of the data needed as input into EFFECT were not present in the available sources and a household survey was conducted to collect the data on ownership and energy consumption of household appliances, as well as consumption of cooking fuels such as biomass, LPG and kerosene. The survey was conducted by specialists at the Ss Cyril and Methodius University in Skopje. The sample, representative of economic regions of the country and of socio-economic groups of the population, included 754 households.

TABLE 6.1. Green policy/investment action in energy, by scenario

SCENARIO	SCENARIO DESIGN *(see Box 6.1 for modelling parameters)*	POLICIES/INVESTMENTS
Business as Usual (BAU): no change in planned policies	**Supply side:** Increased share of gas in the energy mix, slightly reduced share of lignite and low profile hydro generation development. Differs from FYR Macedonia's energy strategy on two aspects: no lignite imports or aggressive hydro development. **Demand side:** Full implementation of all energy efficiency interventions: household, commercial, public and industrial sectors.	**Supply-side investments/policies:** • Investment in new gas CHP and hydro plants; • Investment in a new gas pipeline and in reinforcement of the existing one; **Energy efficiency:** increased efficiency of household appliances; improved efficiency in heating, cooling and lighting in non-residential sector; equipment replacement in the industry. • Household sector: lighting, refrigeration, water/space heating account for 83% of household electric use and will be targeted. This would include substitution of CFL/LED lights for incandescent bulbs; new refrigeration units; improved water heaters; building insulation. • Non-residential sector: building insulation, efficient lighting; • Industrial sector: equipment replacement; • Establishing minimum efficiency standards for new units Space heating improvements through insulation. Air conditioning: choice of higher efficiency options; • Tackling T&D losses.
Green: green policies/ investment plan	**Supply side:** • More aggressive gas, hydro and wind deployment than in BAU; fuel mix shifts further away from solid and petroleum based fuels (lignite and oil) to natural gas; • More aggressive energy efficiency strategy than in BAU.	**Supply-side investments/policies:** • More aggressive new natural gas plant investment (replacing lignite plants) than in BAU; • More hydroplant investment than in BAU, commissioned in 2012-22; • More wind plants than in BAU, 2.5 times higher capacity; • Investment in natural gas pipeline almost double of the BAU level. **Energy efficiency**: • Household sector: more efficient lighting than in BAU, introduction of higher energy efficiency standards for refrigerators and water heaters than in BAU, retrofitting 50% of households with wall and roof insulation, new construction standards to reduce demand for heating; • Non-residential sector: more efficient lighting, retrofitting of 50% of buildings with wall and roof insulation, establishment of commercial building standards for new construction; • Industry: introduction of more energy-efficient technologies including optimization of the existing energy supply systems and technology replacement when new production capacity is added.
Super-green: extended green policies/ investment plan	The Super Green Scenario is a more aggressive version of the Green Scenario, both on the supply and demand side. In addition to renewable energy in the Green scenario, it assumes solar PV. It also includes deployment of a nuclear plant.	**Supply-side investments/policies:** • More gas plants than in Green; • More hydro than in Green, commissioned after 2025; • More wind than in Green; • More solar PV than in Green: solar PV constitutes 0.06% of total power generation in 2012 to 0.3% in 2050; • Nuclear plant 1000MW, introduced after 2030; • Additional investment in new gas pipeline as compared with Green; • More significant energy efficiency measures than in Green.

FIGURE 6.5. Methodological Framework for the Energy Sector Analysis



Source: Energy supply technical paper.

BOX 6.3. EFFECT (Energy Forecasting Framework and Emissions Consensus Tool)

EFFECT was developed by the World Bank and is an Excel-based modeling tool used to forecast cross-sectoral greenhouse gas (GHG) emissions for a country under a range of development scenarios. It covers sectors that contribute significantly to emissions including road transport, power, industry, household and non-residential sectors. It is an 'open' tool with all inputs and formulas visible (or 'open') to the users. It is also open to the public because its usage does not require specialized knowledge and anybody proficient with Excel can utilize it. EFFECT is a bottom-up engineering tool and is very data extensive: it is based on very detailed engineering data, such as energy usage by household appliance and by unit of industrial equipment, or structure of car ownership by vehicle model and age. The data are collected using available statistics, industry data (e.g., sales of new cars by model), expert opinions (e.g., when designing a set of assumptions for projections) and consumer surveys. Consumer surveys are used when data are not available otherwise, for example, to collect data on the model and make structure of vehicle park for vehicles that were bought as used. The model is available at http://esmap.org/esmap/EFFECT.

- **Step 3.** To meet power demand projected at Step 2, **MARKAL, an IEA energy supply model** (see Box 6.3), found the best mix of various power sources—including lignite, oil, gas, hydropower, solar, wind and nuclear—while accounting for several constraints such as resources, technology, user constraints and a cap on GHG emissions. The optimization was aimed at finding the least cost power mix solution. The model produces projections for the power mix and corresponding emissions for the period from 2010 to 2050. Analysis at this step was limited to power and did not include non-electric energy.

Main findings

The combination of the Super Green scenario's demand side measures and the Green scenario's supply side measures is optimal in meeting jointly the strategic objective of supply security and the financial objective of minimizing abatement costs. These cost concerns include limiting both the investment costs of lowering GHG emissions consistent with EU requirements for member countries (21 percent reduction by year 2020 as compared with 2005) but also limiting the unit cost of abatement. While demand-side actions are a critical short-term solution considering their lower cost and shorter implementation period, longer-term and investment-intensive supply-side measures provide the biggest gains in bridging supply-demand gap and abatement.

Demand Side Green Measures. The overall conclusion of the demand-side modeling is that the demand-side Super Green scenario, which has full-scale energy efficiency measures, is preferable to the Green demand scenario, with more modest energy efficiency actions, because the Super Green scenario better supports supply security and because the unit cost of abatement is negative.[106] Given current policies, the supply-demand gap in the power sector will increase in the coming years. Half of power generation capacity is scheduled to close in the next 15 years while power demand is projected to increase by 30 percent. Moreover, other Western Balkan countries are experiencing the same problems, and FYR Macedonia will not be able to continue covering its supply-demand gap from regional imports. Energy efficiency measures can reduce demand for power as well as non-electric energy. Demand-side modeling provided estimates for reduction in demand for power and non-electric energy as a result of energy efficiency measures in the Green and Super Green scenarios over the period 2010-2035.[107] The set of Super Green demand measures provide higher benefits than the Green demand measures. By investing €800m in Super Green demand measures, the

106. Energy efficiency is also part of the discussion in Chapter 8 on urban issues.

107. Energy efficiency measures considered in the analysis are described in detail in Table 6.1. To summarize, they include equipment replacement in industry, building retrofitting and introduction of new construction standards, increased efficiency of household appliances, usage of more efficient stoves by households, and improved efficiency in heating, cooling and lighting in the non-residential sector.

BOX 6.4. MARKAL (MARKet ALlocation) model*

MARKAL is a family of models used for the analysis of energy/environment policy and planning including design of carbon mitigation strategies. Typical questions MARKAL answers include the following:

- How to reach carbon dioxide reduction?
- What is the effect of market-based instruments?
- How to model technology dynamics and the impact of R&D?

MARKAL is a data-driven, energy system optimization model combining 'bottom-up' engineering and 'top-down' macroeconomic approaches. The user inputs the structure of the energy system to be modeled, including resource supplies, energy conversion technologies, end use demands, and the technologies used to satisfy these demands. The user must also provide data to characterize each of the technologies and resources used, including fixed and variable costs, technology availability and performance, and pollutant emissions. MARKAL then calculates, using linear and mixed-integer linear programming techniques, the least cost set of technologies over time to satisfy the specified demands, subject to various user-defined constraints. Outputs of the model include a determination of the technological mix at intervals into the future, estimates of total system cost, energy demand (by type and quantity), estimates of criteria and GHG emissions, and estimates of energy commodity prices.

The first MARKAL model was developed in the late 1970s at Brookhaven National Lab in response to the oil crisis. In 1978, the International Energy Agency adopted MARKAL and created the Energy Technology and Systems Analysis Program (ETSAP) to oversee its development. Over time, under the IEA/ETSAP oversight, the model evolved from a simple optimization bottom-up framework to a family of sophisticated models with many applications. MARKAL models are used in approximately 40 countries.

**Sources:*
US EPA: http://www.epa.gov/nrmrl/appcd/climate_change/markal.htm
IEA-ETSAP: http://www.iea-etsap.org/web/Markal.asp
Ad J. Seebregts et al., Energy/Environmental Modeling with the MARKAL Family of Models: http://www.gerad.ca/fichierspdf/rx01039.pdf

required generation capacity can be reduced by 600MW and annual GHG emissions by 1.6 million metric tons by 2050.

Electric energy savings. **If energy efficiency measures are implemented, overall power demand will be noticeably reduced.** In 2035, demand in the Green scenario is 15 percent lower than in BAU and in the Super Green, 22 percent below baseline. The high industrial savings (46 percent and 41 percent of totals in the Green and Super Green scenarios respectively, see Table 6.2) are a result of significant investment in equipment replacement and building retrofit, made possible by the ongoing expansion of the sector. Households also save substantial amounts of energy: 36 percent of the total in the Green scenario and 40 percent in the Super Green scenario). (Table 6.2).

Household sector power demand reduction is achieved mainly through increased efficiency of lighting, electric space heating, refrigeration and electric water heating, which jointly account for 92 percent of total power saved during 2010-2035. **In the non-residential sector**, most power saving comes from private offices and retail buildings. Less significant non-residential power saving comes from restaurants, hotels, other buildings, and government offices. **Power demand reduction in the industrial sector** comes mostly from the group of largest

TABLE 6.2. Households and industry contribute most to power demand reductions under both scenarios

Reduction in electricity demand in 2035 and cumulative savings, 2010-35, by scenario

	DEMAND REDUCTION IN 2035, % OF BAU DEMAND	CUMULATIVE DEMAND REDUCTION, 2010-35, % OF TOTAL
Green	**15**	**100**
Households	12	36
Non-resident.	15	18
Industrial	18	46
Super Green	**22**	**100**
Households	21	40
Non-resident.	19	18
Industrial	25	41

Source: Energy demand technical paper.

industries known as the "Big Four" and comprising iron and steel, cement, ore extraction, and food/beverages/tobacco. Jointly, they reduced total current industrial use of power by 13 to 18 percent during 2010-2035. Within this group, the iron and steel industry generated more power savings than the rest of the "Big Four" industries combined: 62 percent in the Green scenario and 65 percent in the Super Green scenario during 2010-2035.

Non-electric energy savings. **Approximately two-thirds of the energy savings achieved during 2010-2035 in both green scenarios are in non-electric energy, with the remaining third in power.** Because industry is the dominant user of non-electric energy and because of the sector's high projected rate of growth, allowing for investment in new and more energy efficient technology, industry is responsible for more than half of the total non-electric energy demand reductions—66 percent in the Green scenario and 57 percent in the Super Green scenario In the Green scenario, industry also achieves the highest overall reduction of energy use, equaling 23 percent, while in the Super Green scenario, it is the non-residential sector that leads (with 38 percent total energy savings), driven by a high volume of projected new construction. New construction standards provide much greater energy savings compared to the alternative, which is building retrofitting. By comparison, the household sector is projected to have a high volume of retrofitting and less new construction, which means fewer chances to reduce energy loss by applying stricter new construction standards. (Table 6.3.)

Which fuels are used less after energy efficiency measures are implemented? Households burn less wood, which accounts for almost 70 percent of total non-electric energy savings in the household sector during 2010-2035. They substitute cleaner fuels and use more efficient heating and cooking appliances. In addition, they use less district heating and gas/diesel, which adds 10-12 percent to the overall energy savings. These three energy sources–wood, gas/diesel and district heating—account for 97 percent of total non-electric energy savings in the Green scenario and 93 percent in the Super Green scenario. The non-residential sector uses less heating oil, which constitutes 57 percent of the overall savings achieved during 2010-2035 in both scenarios. This sector also reduces consumption of gas and wood. Industry substitutes natural gas for petroleum-based and solid fuels.[108]

Supply Side Green Measures. The main conclusion from the supply-side modeling is that the Green supply scenario brings the highest benefits in terms of supply security, investment costs, and unit cost of abatement. The main

108. The need for measures to reduce solid and oil-based fuel consumption in large industry is also discussed in Chapter 9 on air pollution because large industries are top polluters, significantly contributing to the particulate matter air pollution which is most damaging to human health.

TABLE 6.3. **Industry contributes most to non-electric energy demand reductions under both scenarios**

Reduction in non-electric energy demand in 2035 and cumulative savings, 2010-2035, by scenario

	DEMAND REDUCTION IN 2035, % OF BAU DEMAND	CUMULATIVE DEMAND REDUCTION, 2010-35, % OF TOTAL
Green	**22**	**100**
Households	12	14
Non-residential	31	20
Industrial	23	66
Super Green	**33**	**100**
Households	33	25
Non-residential	38	17
Industrial	32	57

Source: Energy demand technical paper.

measures include gas regional integration and greater use of renewable domestic resources– primarily hydropower, but also wind, solar and biomass—which would, in turn, reduce GHG emissions at a lower per unit cost than the Super Green scenario. The supply side modeling included as a modeling input a strategic objective to increase the share of gas in the energy mix, replacing lignite and oil sources, as well as moderate hydro generation development. Lignite-based production in green scenarios is phased out by 2030 due to two main reasons. In addition to the high level of emissions from lignite combustion, Macedonian domestic lignite is becoming more expensive: its potential is limited[109] and the cost of production is increasing,[110] as surface mines with cheap lignite production become exhausted, leaving only more expensive underground mining in the future. Rising lignite prices are making other energy sources such as gas and hydro price competitive. Moreover, EU standards will eventually require lower emission intensity of newly constructed lignite-fired power plants, which will translate into higher average unit capital costs of production and therefore higher average unit costs of lignite-based power. The need for carbon allowances

109. Macedonian lignite reserves (proven and exploitable lignite) are limited to 332 million metric tons and, given the current share of lignite in energy consumption, will be exhausted within approximately 30 years; FYR Macedonia n 300 million metric tons of additional resources (proven but currently unexploitable or unproven but possible lignite) will add 15 years to this estimate thus extending the availability of lignite to 45 years. Source: Staff calculations using 3 percent growth rate in lignite annual production and data from 2 sources: German Federal Institute for Geosciences and Natural Reserves (BGR) and World Energy Council:
http://www.bgr.bund.de/EN/Themen/Energie/Downloads/annual_report_2011_en.pdf?__blob=publicationFile&v=2
http://www.worldenergy.org/documents/ser_2010_report_1.pdf

110. Production cost of lignite will increase with time, as surface mines are depleted and replaced with cavity lignite excavation.

once FYR Macedonia joins the European Union's Emissions Trading Scheme is yet another factor increasing the costs of lignite-based generation. As a result, gas is already nearly price competitive with lignite.

Supply-side modeling produced best power supply generation mixes for the Green and Super Green scenarios. These minimum cost solutions aimed to achieve GHG emission reduction consistent with the EU requirements for member states (21 percent reduction by 2020 compared with 2005), taking into consideration technology and other resource constraints (Box 6.1). The generation mix included natural gas, hydropower, wind, solar, and nuclear sources of power. As compared to the baseline, natural gas is developed more aggressively in the green scenarios, with **natural gas** power plants replacing some of the lignite fired power plants included in BAU. **Hydropower** is also developed more aggressively in the green scenarios, but note that policy measures to attract investment would be needed since FYR Macedonia's hydropower sites do not have an attractive profile for the private sector due to low capacity factors. Green supply scenarios also include aggressive implementation of wind power. By 2050, **wind power** capacity under Green supply scenario would be 2.5 times higher than in BAU. Although controversial, **nuclear power** is an option considered in the Super Green supply scenario for analytic purposes,[111] with a 1000 MW nuclear power plant proposed for introduction after 2030.

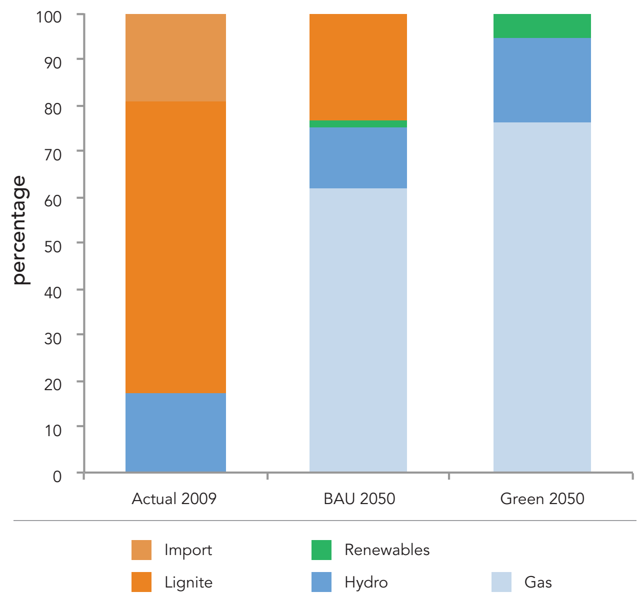
Under the Green supply scenario, total installed capacity in 2050 would be 2.6 gigawatts (GW), and electricity supply would be 14 terrawatt hours,[112] fully covering demand if the proposed energy efficiency measures under the Green or Super Green demand scenarios are implemented. The structure of supply by fuel will be very different from both the actual in 2009 and that projected for 2050 under BAU. It will be based on gas, which would constitute 76 percent of total supply, and have no lignite. The rest of the fuel mix will be hydro generation (19 percent) and other renewable sources (5 percent) (Figure 6.6). This mix would significantly lower GHG emissions. Total GHG emissions in 2050 under the Green Supply scenario would amount to 4.2 $MtCO_2e$,[113] down from 9.1 in the BAU scenario.

The total investment cost of the Green supply scenario is much lower than that of the Super Green supply scenario. Considering that the installed capacity in both scenarios is the same, it means that the unit cost of investment (€ per GW) is much lower in the Green scenario (Table 6.4). Unit abatement cost in the Green scenario is also lower than in the Super Green scenario, because gas, the dominant component of Green supply, has a lower marginal cost per unit of abatement than nuclear energy (see Figure 6.7), which replaces more than 50 percent of gas in the supply mix of the Super Green scenario as compared with the Green scenario. Under the Green supply scenario, total investment costs (present value) would be €9.2 billion (Table 6.4), consisting of the €8.4 billion in supply side costs and €0.8 billion in demand side costs. The supply side investments include construction of new gas plants, a new gas cross-border pipeline, new transmission and distribution lines, extended gas supply infrastructure, and additional hydro and wind plants. By comparison, the Super Green scenario requires total investment (present value) of €9.8 billion, of which €9.0 billion are the supply side costs and €0.8 billion are the demand side costs. The higher cost of the Super Green supply measures is mainly due to the cost of the nuclear generation plant which is part of this scenario, but not of the Green scenario.

The total investment cost of the Green supply scenario is below the cost of the BAU supply scenario, while the emissions are substantially reduced. This is due to cheaper gas plants replacing lignite capacity, which allows for additional

FIGURE 6.6. **Greening power supply mix means moving away from lignite and oil to gas**

Power generation mix, actual and by scenario in 2050



Source: Staff calculations based on energy sector supply-side modeling outcomes.

111. See footnote 121 above.

112. One terawatt hour is equal to a sustained power of approximately 114 megawatts for a period of one year.

113. From this point on, all Green supply modeling outcomes assume that the previously recommended Super Green demand measures have been implemented.

TABLE 6.4: **Combined supply and demand scenario characteristics**

	Total investment supply and demand cost (€ billions)	GHG emissions, 2050 ($MtCO_2e$)	Installed capacity, 2050 (GW)	Cost per unit of installed capacity (€ /GW)
Business-as-Usual	9.7	9.1	3.2	3.0
Green supply-Super Green demand	9.2	4.2	2.6	3.5
Super Green supply-Super Green demand	9.8	1.6	2.6	3.8

Source: Staff calculations based on energy demand and supply modeling outcomes.

expensive wind and hydro to be included in the mix and for the cost associated with extending the gas supply infrastructure. The cost of new transmission and distribution lines is broadly in line with that of the BAU supply scenario because the amount of additional renewables resources remains low (in the order of 50-100 megawatts to 2050), and because it is assumed that the new gas plants will be built at the location of the new lignite plants in the BAU supply scenario. **The cost of the Super Green scenario is much higher than the cost of the Green scenario due to the construction of a nuclear plant,** but emission reduction is much more noticeable. However, **implementing mitigation measures would reduce emissions in both Green and Super Green scenarios significantly as compared to BAU:** in year 2050 in the Green scenario, total emissions amount to 4.2 $MtCO_2e$ and in the Super Green scenario – to 1.6 $MtCO_2e$, while BAU is projected to produce a much higher emission level of 9.1 $MtCO_2$ in year 2050 (Table 6.4). In the Green supply scenario, emission reduction against BAU is driven by new gas replacing new lignite power production and by new hydro, wind and PV solar generation. In the Super Green scenario, emission reduction is driven by nuclear replacing lignite and/or gas.

The energy sector Marginal Abatement Cost (MAC) curve (Figure 6.7) displays two characteristics of the **recommended Super Green Demand–Green Supply** scenario measures: the marginal unit cost of abatement achieved cumulatively during 2010-50 (present value of net marginal cost[114] per unit of abated carbon (CO_2e)) and abatement potential ($MtCO_2e$) for 2010-2050. Abatement potential for each measure corresponds to the width of the bar representing the measure. Marginal unit cost of abatement for each measure is reflected in the height of the bar. The total width of the MAC curve is the sum of abatement potential of all measures implemented individually (if options were implemented together, they would have a smaller impact as some of them target the same emissions). Measures with a negative unit cost result in net revenues for the public sector (Figure 6.7).

Among all supply side technologies that are included in additional generation capacity in the green scenarios, the most cost efficient ones are new gas capacity, new hydro capacity and new nuclear capacity—those with low net unit cost of abatement, as reflected in the height of the corresponding bars, and high abatement potential, as reflected in the width of the bars. Both demand scenarios, Green and Super Green, are very efficient–they have a negative net unit cost of abatement and high abatement potential.

RECOMMENDATIONS

The combination of Green supply and Super Green demand measures delivers the optimum results in 2050 considering security of supply, overall cost, unit investment costs and unit cost of abatement. As part of the Green supply scenario, aggressive development of gas supply and a significant increase of it in the generation mix are recommended such that gas completely replaces lignite and oil. This shift implies construction of new gas generation plants, of a new cross-border gas pipe line, of new transmission and distribution lines and of new gas supply infrastructure. In addition, new hydro and wind plants would be constructed.

On the demand side, standard energy efficiency measures that have proved to be cost efficient in other countries should be implemented as quickly and broadly as possible.[115] This action will support the maximum possible reduction in demand, an important measure considering the current demand-supply gap and the policy objective of secure supply. Economic incentives, capacity building, and knowledge dissemination are critical for the success of this task across customer groups: industrial, non-residential, and households (see Good Practice Box 5 on Vietnam's experience with energy efficiency knowledge dissemination in manufacturing).

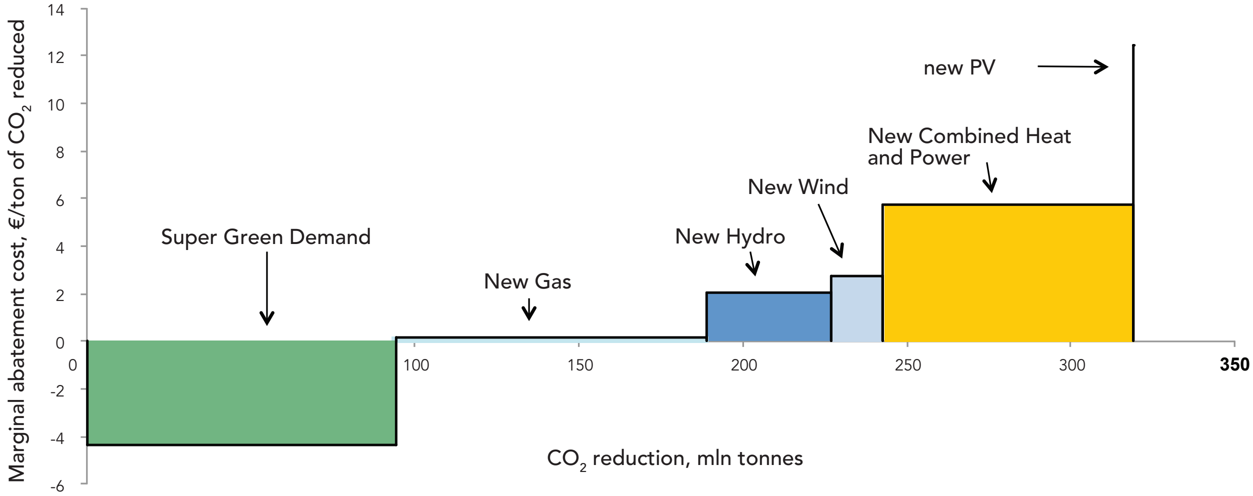
Strengthening the institutional capability to design and implement energy efficiency programs is a key element of a successful energy efficiency strategy for FYR Macedonia. A lead agency or ministry department must have sufficient budget to attract high quality professional expertise. Capability to build and maintain energy consumption data is also crucial. Similarly, developing energy efficiency training programs for

114. In the transport sector analysis, policies were included in addition to proposed investments. This approach is not traditional and was used because in FYR Macedonia transport reform, the emphasis in the road segment of the sector is on policy incentives.

115. As noted above, energy efficiency measures considered in the analysis are described in detail in Table 6.1.

FIGURE 6.7. **New gas and energy efficiency measures provide most cost efficient abatement**

Marginal abatement cost (MAC) curve for supply technologies and energy efficiency (demand) measures, cumulative 2010-2050



Note: This chart presents cumulative abatement potential of the period 2010-50, while the data in Table 6.4 and in the related text refers to year 2050 only.
Source: Staff calculations based on energy sector modeling outcomes.

GOOD PRACTICE BOX 5.

Green growth in manufacturing through green knowledge dissemination in Vietnam

The Vietnam Clean Production Center has become a leading organization in disseminating clean production knowledge among manufacturers in the region.

Since its establishment in 1998, the Center has been assisting companies in identifying problems that affect their environmental and economic performance and in finding solutions, including innovative approaches that would lead to emissions reduction combined with increased revenue and employment. Initially, the Center focused on cleaner production, but now its expertise has expanded to include sustainable product innovation, corporate social responsibility, financial engineering (via a Green Credit Line scheme financed by the Swiss Government), and implementation of Multilateral Environmental Agreements. The Center regularly conducts capacity building workshops and conferences around the region.

To date, the Center has successfully assisted more than 500 manufacturing enterprises in Viet Nam, Lao PDR and Cambodia. Examples of the Center's achievements include two clean production projects implemented in 2012 that cut emissions by 1,462 tons of CO_2 and reduced wastewater by 37,660 m^3. The Center has helped smaller enterprises engage in new markets, including those related to sustainable goods and services, and introduced them to sustainable public procurement regulations, eco-labels, and green global value chains. The Center has become the reference institution for green knowledge dissemination, and its clean production model has been replicated in 50 countries through South-South technical exchange.

Source: United Nations Environment Program (UNEP). 2013. Building inclusive green economies – Success stories from South-South Cooperation. New York: United Nations.

professionals (architects, building contractors, and energy auditors) as well as raising consumer awareness through information campaigns will be critical.

Making low-cost capital available for demand-side energy efficiency investments is essential for investments in capital intensive, long-payback energy saving measures such as building retrofits. Involving utilities as intermediaries between the government and the customers in energy efficiency programs proved to be a successful approach, since in many countries, utilities find that investing in customers' energy efficiency is financially beneficial for them (see Good Practice Box 6 describing Mexico's experience with financing schemes and Brazil's experience with utilities' involvement in residential energy efficiency projects).

The key enabling policies on the supply side include developing a regional strategy and implementation plan for physical gas supply, addressing potential private investors' concerns about investing in hydropower, and ensuring that incentive schemes deliver renewables in the most cost-effective manner. A plan for the development of national gas infrastructure should be prepared and implemented.

Incentives are necessary to attract investment in renewables. However, the current level of feed-in-tariffs is extremely high, reaching 10 times the electricity price paid by households for some technologies. Alternative approaches could be more economically attractive.

GOOD PRACTICE BOX 6. Financing energy efficiency programs in Mexico and Brazil

USING FINANCING SCHEMES TO REPLACE INEFFICIENT HOME APPLIANCES IN MEXICO

Mexico's Special Climate Change Program aims at reducing annual greenhouse gas emissions by more than 40 percent by 2030 without sacrificing economic development. The strategy encompasses a sweeping transformation of domestic home appliance markets to increase energy efficiency and offset the projected 4.8 percent annual increase in electricity demand. Some 1.7 million aging refrigerators and air conditioners are being replaced by the project with modern, energy-efficient models. The Program is supported by the Clean Technology Fund (CTF).

To phase out inefficient appliances, CTF concessional financing will support a credit line for low-interest consumer loans, complementing a World Bank loan that will support a rebate program. The financing scheme will be offered through some of the country's largest retail markets. In addition, local manufacturers and distributors will be receiving financial support to shift to the new technologies. Already, public awareness campaigns are alerting consumers to the advantages of an energy-efficient lifestyle. To ensure a seamless transition, the government is setting up recycling facilities for old lighting systems, disposal centers for out-of-date refrigerators and air-conditioning units, and local testing facilities for new appliances.

SUCCESS OF ENERGY EFFICIENCY PROGRAMS WITH UTILITIES AS INTERMEDIARIES IN BRAZIL

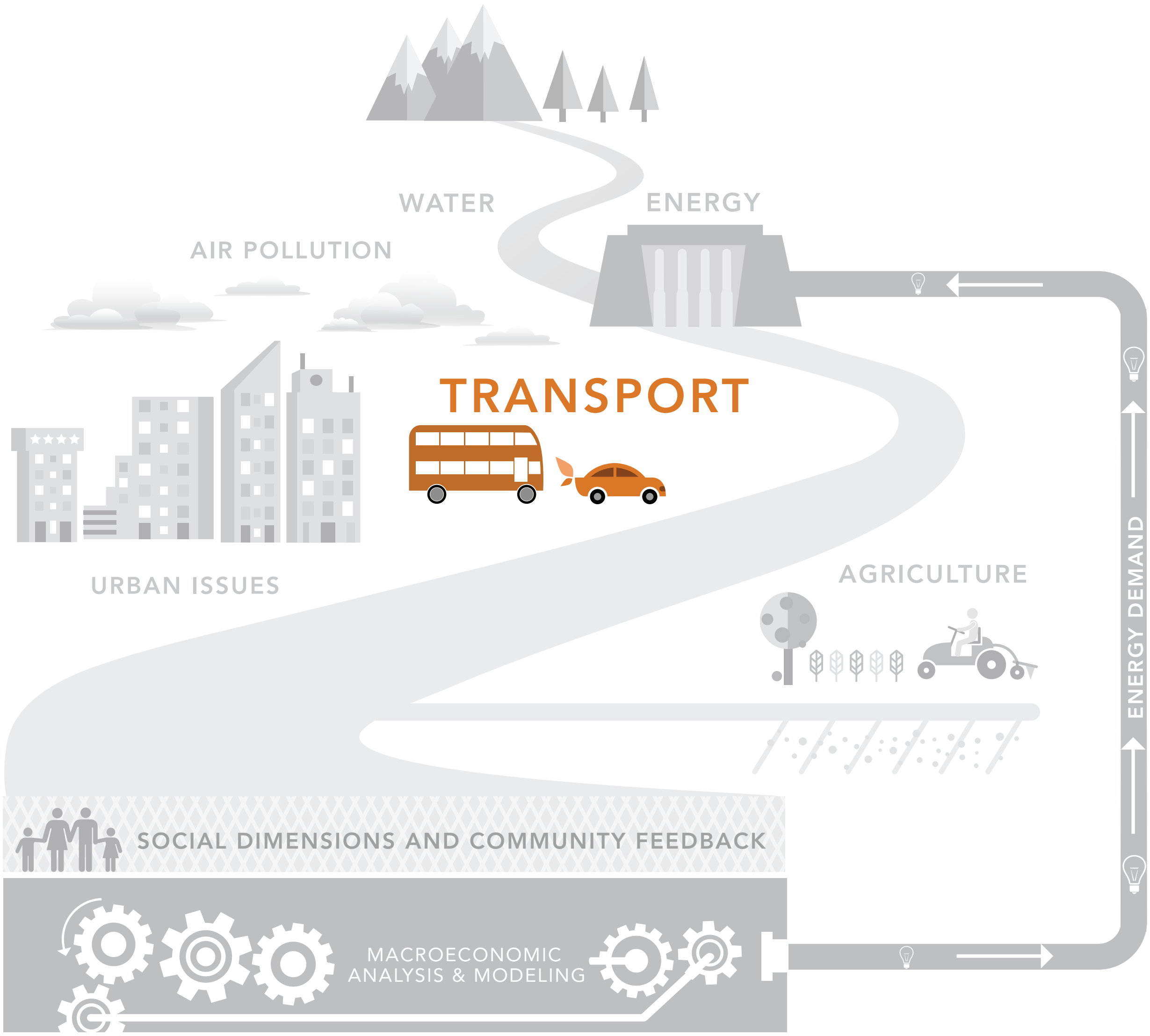
The Brazilian experience shows how energy efficiency programs with utilities acting as intermediaries between the government and household customers can achieve the government's energy efficiency targets through creating economies of scale. These programs benefit utility customers the most, especially poor households, who would not be able to incur the needed energy efficiency expenses on their own.

In 2005, the Brazilian government established an energy efficiency program that requires utilities to invest 0.5 percent of their annual revenues in improving customers' energy efficiency. Fifty percent of the investment should benefit low-income households. Eligibility for the program is determined by consumption levels, connection type, and enrollment in other social assistance schemes. The utilities are in charge of designing and implementing the energy efficiency projects but are also allowed to subcontract energy service companies. The projects that target low-income households include mostly the following: replacing old, inefficient refrigerators; installing compact fluorescent light bulbs; replacing inefficient electric water heaters with more efficient electric or solar ones; informing households about efficient use of electricity. Investments are either covered by the utilities or shared by the utilities and the households. In the latter case, utilities offer financing schemes.

Between 2005 and 2007, over 5 million compact fluorescent light bulbs and 60,000 efficient refrigerators were installed under the program. Because refrigerators and lighting account for 90 percent of the electricity consumption of low-income households in Brazil, the program achieved significant reductions in energy consumption. According to field assessments, electricity consumption of refrigerators and lighting on average was reduced by approximately 70 percent and 23 percent, respectively. As a result, peak demand for power was decreased by 15–20 percent.

Sources: Climate Investment Funds website. "Mexico Gives Green Light to Energy Efficiency." Highlights form the CIF Portfolio. Accessed on November 26, 2013: https://www.climateinvestmentfunds.org/cif/node/3361

Deichmann, Uwe and Fan Zhang. 2013. Growing Green: The Economic Benefits of Climate Action. Washington, DC: World Bank.


WATER
ENERGY
AIR POLLUTION
TRANSPORT
URBAN ISSUES
AGRICULTURE
ENERGY DEMAND
SOCIAL DIMENSIONS AND COMMUNITY FEEDBACK
MACROECONOMIC
ANALYSIS & MODELING

CHAPTER 7

How Can Transport Support Sustainable Growth?

CHAPTER SUMMARY

The transport sector provides critical services to the rest of the Macedonian economy but faces special challenges in a landlocked country framed by mountain ranges. Transport infrastructure to foreign markets is focused into a small number of corridors, and transit traffic, already significant, is increasing. The transport sector is the second highest emitter in FYR Macedonia, producing 14.5 percent of total greenhouse gas (GHG) emissions, following the energy sector. The transport sector is also emissions-intensive compared with other countries in the region: its contribution to global warming and local air pollution significantly exceeds technically unavoidable levels. A high and growing share of road transport and the prevalence of old vehicles are the main factors driving high transport sector emissions, while vulnerability to climate change is heightened by the low quality of infrastructure and the vehicle fleet. How can transport support sustainable growth?

The analysis summarized in this chapter assesses the impact of green policies and investments on transport demand and the resulting emissions, as well as the cost effectiveness of the proposed investments and policies, using modeling. In particular, the EC's TREMOVE (economic TRansport and EMissions model), EC's TRANSTOOLs (TOOLS for TRansport Forecasting ANd Scenario testing) and the World Bank's EFFECT (Energy Forecasting Framework and Emissions Consensus Tool) were applied.

The findings provide evidence that green policies can significantly reduce the rate of emissions growth; however, emission levels will continue to rise compared with 2010 due to increasing demand for transportation. Vulnerability analysis concludes that the main concern regarding transport sector sensitivity to climate change is related to projected increases in temperatures and extremes of precipitation, which will push transport costs up. The recommended mitigation plan includes measures that deliver the highest abatement level—pricing signals, rail investment and encouraging purchase of fuel efficient vehicles—as well as measures characterized by a relatively high level of abatement in combination with low costs—land use planning and regulation, parking management (in Skopje), and behavior change. Investment is needed in rail infrastructure, in public transportation (in Skopje), and in urban development, including parking management and re-design of city centers to provide walking and cycling infrastructure. A conservative and practical plan for climate change adaptation focuses mostly on better implementation of existing standards for local roads and improvement of road surfaces.

CHALLENGES FOR GREENER GROWTH

Overview

Transport connections play a pivotal role in supporting FYR Macedonia's economic growth, particularly due to its landlocked location and an already significant yet increasing transit traffic. The country's exports depend on two trans-European corridors passing through its territory and providing links to the markets in Western Europe.[117] In the past 20 years, significant investments have been made in rehabilitation and maintenance of the corridors. At the same time, less attention has been paid to other sectoral issues. This situation is changing and the government is starting to address a wider set of sector reforms. In the last revision of the National Transport Strategy (2007-2017), the government included measures to support a modal shift from road to rail, stimulate greater public transport usage in urban areas and promote alternatively fuelled vehicles.[118]

The Macedonian transport sector is emissions-intensive and, considering continuing growth in vehicle ownership and road travel, is expected to be increasingly polluting, unless transport policies change. The transport sector in FYR Macedonia has higher emissions-intensity than in other countries in the region; and, therefore, its contribution to global warming and local air pollution exceeds the technically unavoidable level. Within the country, the transport sector is the second highest emitter, producing almost 15 percent of total GHG emissions, following the energy sector, which contributes about 70 percent.[119] The share of transport sector emissions has stayed relatively stable over the past two decades,[120] while overall emissions have grown. Current trends of increasing car ownership and road travel are projected to continue, and FYR Macedonia is likely to reach on-land personal mobility of 9,000 passenger-kilometers per capita–about 13 times its current level–when GDP per capita reaches US$ 7,000[121] (Figure 7.1, Figure 7.2). This will mean significantly higher emissions, unless transport policies change, addressing the main emission drivers— growth in road transportation, expansion of the personal vehicle park, the old age of vehicles, and low availability of public transportation.

High and growing road transport share is a major factor of transport sector emissions in FYR Macedonia. In the transport sector globally, key sources of emissions derive from road transport. At the same time, East European and Central European countries have been experiencing a steep increase in the share of road transport in the last decade, both in passenger and freight segments of the sector, and FYR Macedonia is no exception. Among the new EU member

117. Corridor X (Munich-Ljubljana-Zagreb-Belgrade-Skopje-Thessaloniki-Athens) and Corridor VIII (Port of Durresh-Tirana-Skopje-Sofia-Port of Burgas).

118. Ministry of Transport and Communications, FYR Macedonia. 2007. FYR Macedonia National Transport Strategy 2007-2017. Skopje.

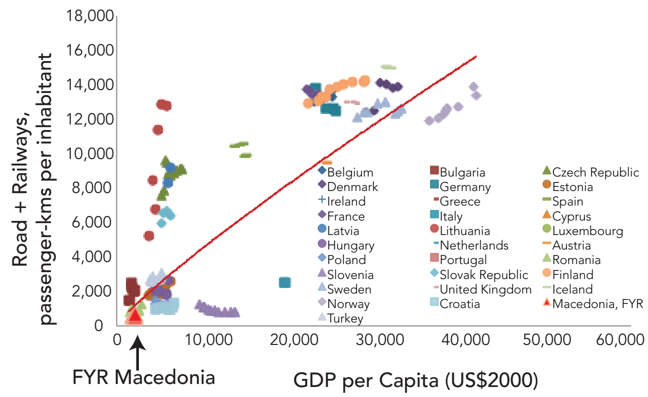
119. Source: IEA, 2009; transport sector includes all transport activity regardless of the economic sector.

120. The current share of transport sector emissions is not very different from that of the previous years. According to the FYR Macedonia national GHG inventory, the transport sector had a stable contribution to total GHG emissions, in the range of 10.6 to 13.4 percent from 1990 to 2002. Source: FYR Macedonia's Second National Communication under the UNFCCC, 2008, page 75: http://unfccc.int/resource/docs/natc/macnc2.pdf

121. Staff calculations

FIGURE 7.1. **Mobility in FYR Macedonia will rise sharply with economic growth, and so will emissions**

Kilometers travelled per capita, 1995-2008, multiple data points for each country, and income per capita



Source: Staff calculations based on FYR Macedonia's road and rail transport development vectors from the Eurostat and the World Bank's Development Data Platform data.

countries, the share of road traffic in total freight traffic rose from 55 percent to 71 percent between 2000 and 2008. The same was happening in the passenger segment in the new EU member countries: vehicle passenger trips, measured in km, increased from 68 percent of total passenger trips in 2000 to 77 percent in 2008 and, as a result, rail carried only 7.5 percent of passengers in 2008. In FYR Macedonia, the share of road transport in the sector is even higher than in the EU's new member states and growing: rail carried only 2.3 percent of passengers in 2008, down from 3.5 percent in 2000[122]. This trend is echoed by FYR Macedonia's freight segment, where road transport accounted for 84.3 percent of passenger-kilometers in 2010.

Other drivers of sectoral emissions are prevalence of old vehicles, dominant and increasing private vehicle usage, and low availability of public transportation. FYR Macedonia's car, road freight and rail fleets are old: in 2012, the average age of the road fleet was 14 years and of the rail traction fleet 37 years. As a consequence, it has high emission intensity, for example, half of the sampled trucks do not meet Euro 1 standards[123]. Passenger transport is dominated by private cars, public transportation decreased significantly, thus pushing up the level of emissions. Private cars accounted for 76.2 percent of passenger-kilometers in 2010. Given that car ownership is still low when compared to EU 27 average and is projected to

122. This is significantly less than the EU-15 average, which is 7.5 percent of passengers carried by rail in 2008.

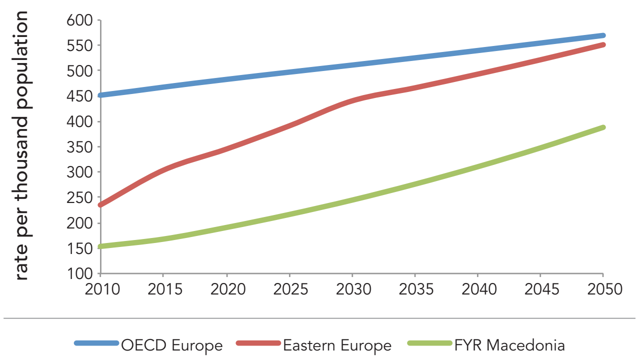
123. World Bank transport survey conducted in FYR Macedonia, February-March 2012.

rise, this factor will continue to exacerbate emission problem unless policies change.

In addition to being emissions-intensive, transport sector in FYR Macedonia is also vulnerable to climate change due to low infrastructure quality and an old vehicle fleet. A significant part of the transport infrastructure has outlived its planned 20-year life span, and benchmarking analysis places FYR Macedonia among the bottom one-third of comparator countries in ranking based on Logistics Performance Index.[124] With already low quality, transport infrastructure will be more easily damaged by extreme weather. In addition, old vehicles are less capable of tolerating extreme weather events and increased climatic variability. (Figure 7.3)

FIGURE 7.2. Growth in car ownership—a major emissions driver—is promising to increase with income

Passenger car ownership per population, projections: 2010-2050



Source: United Nations Economic Commission for Europe (UNECE). 2013. Transport database: http://www.unece.org/trans/main/wp6/wp6.html

Dealing with Sector Inefficiency in the Context of Green Growth

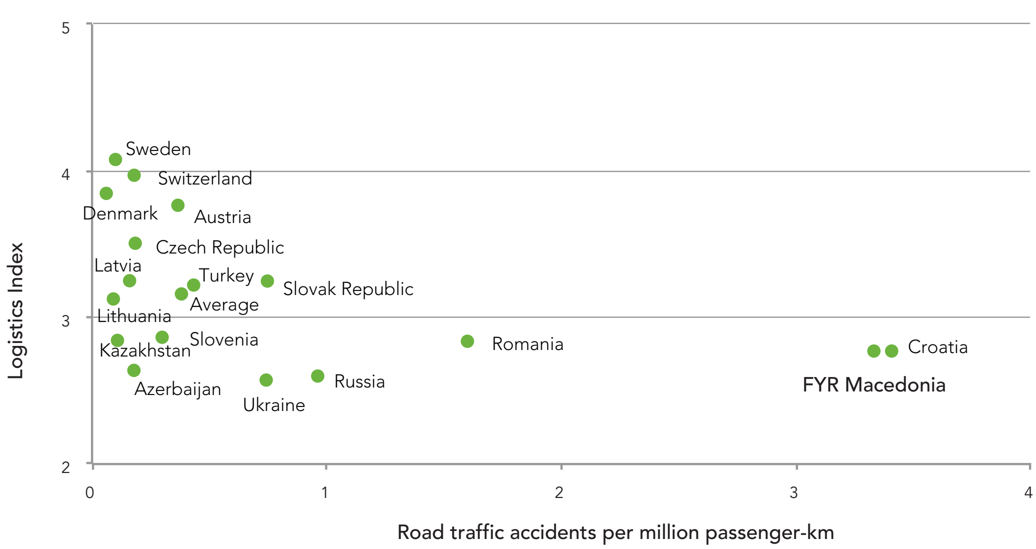
Lowering emission intensity of the future transport sector growth represents a key challenge and will require departure from 'business as usual' policies in the transport sector.[125] Mitigation policies need to support growth and provide local co-benefits and enhanced efficiency of the transport system, in addition to reducing emissions. For FYR Macedonia as an EU candidate country, the policies also need to follow the EU's transport policy, as well as the climate and energy package, the latter setting specific targets for reducing GHG emissions. For transport, excluding air transport, GHG emissions need to be cut by 10 percent as compared with the 2005 levels through reduced emission intensity of the vehicle fleet and increased transport efficiency. Fuel efficiency of new cars and vans need

124. Logistics Performance Index is a combination of: (i) outcomes of a worldwide survey of global freight forwarders and express carriers reflecting logistics "friendliness" of the countries where they work (conducted every 2 years) and (ii) quantitative data on performance of key components of the logistics chain by country. The Index combines the following dimensions: customs (efficiency of clearance process); quality of ports, roads, railroads, information networks; ease of organizing international shipments; quality of logistics services; quality of tracking systems, timeliness of shipments. (Source: World Bank Development Data Platform)

125. Organization of Economic Cooperation and Development / International Transport Forum (OECD/ITF). 2008. Greenhouse Gas Reduction Strategies in the Transport Sector, Preliminary Report. Paris: OECD/ITF.

FIGURE 7.3. Poor quality of roads translates into high level of accidents

Logistics performance index (2010) versus road accidents per kilometers travelled (latest year available, 2005-2011)



Source: World Bank Development Data Platform and Economic Commission for Europe (UNECE) Transport Database, 2013 to be improved, alongside the long standing Euro standards which apply to cars, vans and Heavy Duty Vehicles (HDVs).[126] Policies regarding the types of fuel used and fuel taxation need to be assessed and reconsidered (see Good Practice Box 1 on the benefits of a fuel switch in public transportation in Los Angeles). Investment in transport infrastructure is overdue. While this presents a challenge, it is also an opportunity to climate proof transport infrastructure by including adaptation measures to account for increased flooding and precipitation, higher variation in temperature, and extreme weather events.

A specific challenge is related to pricing policies. At present, pricing does not cover the full cost of transport, including investments, let along the cost of negative externalities. Current investments are heavily focused on enhancing road capacity. Pricing needs to be restructured to cover full costs and to provide for all required investments and climate change mitigation. Changing current pricing would require the adoption of the "user pays" principle, when all costs are covered by end-user prices including the costs of congestion, accidents, infrastructure wear and tear, noise and air pollution, and GHG emissions. The EU is involved in the review of the New European Driving Cycle (NEDC) to develop a test cycle, which reflects real life vehicle emissions more closely. As the large majority of vehicles in use in FYR Macedonia are designed to be compliant with EU requirements at the time of production (to be sold on the EU market), these regulations are already supporting an improvement in fuel efficiency for new vehicles purchased in the country. Research work has also been undertaken on potential improvements to HDV fuel efficiency.

126. See in: European Commission climate action website: http://ec.europa.eu/clima/policies/transport/vehicles/cars/index_en.htm

A rapid development of the road transport sector in East Europe comes at a cost of sector inefficiency and increased emissions, but the same set of actions will be needed to resolve both problems, and investment and policies addressing emissions will produce increased sector efficiency as a co-benefit, resulting in cost savings. Specifics of the transport sector development are such that the set of policy actions and investments that is needed to tackle sector inefficiencies significantly overlaps with actions needed to contain growth of the transport sector emissions. In other words, quoting a recent publication, which discusses transport sector policies aimed at reducing GHG emissions and applicable to ECA countries, "climate friendly transport policies" would "provide a menu of policy options to improve the functioning of the transport sector in the ECA region, while addressing the externalities generated by the sector"[127]. Thus, reduction of transport sector emissions will effectively have a co-benefit of increased sectoral efficiency. When co-benefits of the sector efficiency are considered, the costs of greening the transport sector, often viewed as being too high, becomes very reasonable. Sectoral co-benefits can, in fact, be potentially much higher than the benefits in terms of reduced emissions and air and noise pollution (see Box 7.1).

Inefficiencies resulting from the transition of the road transport sector in Eastern Europe can be grouped in the following four types: pricing inefficiencies, fuel inefficient technology, and those that come with spontaneous transition of the urban form. Pricing inefficiencies can be addressed using such pricing instruments as fuel and road

127. Monsalve, C. 2013. Controlling Greenhouse Gas Emissions Generated by the Transport Sector in ECA: Policy Options; World Bank, Washington, DC.

GOOD PRACTICE BOX 7.

Reducing emissions while lowering fuel costs through fuel-switching in Los Angeles, USA

Los Angeles, USA provides an informative case of a successful green project in public transportation. The city completed the transition from diesel to gas in public buses in 2011, reducing the impact of transport on climate and on local air pollution.

Los Angeles has long been one of America's most smog-plagued cities. However, the city is making efforts to improve the situation. The Los Angeles County Metropolitan Transportation Authority purchased its first clean compressed natural gas (CNG) bus in 1995 and retired its last diesel bus in 2011. Today the Los Angeles metropolitan area has the largest fleet of CNG buses in the US—approximately 2,200 buses. The Los Angeles buses cover approximately 1.5 billion miles annually, and it has been estimated that, as of 2011, the CNG buses have collectively driven more than one billion miles.

Fuel-switching helped reduce emissions while lowering fuel costs. Since the conversion to CNG buses, the daily release of particulate matter from the bus fleet has decreased by 80 percent, and greenhouse gas emissions have fallen by approximately 300,000 pounds. In addition, 10 to 20 percent of operational costs are being saved on fuel alone.

Los Angeles residents are noticing the difference. Regular riders note that before the switch to CNG, bus exhaust was visible and the noise from the buses was louder. They say that Los Angeles has become cleaner as a result of the switch.

Source: America's Natural Gas Alliance, http://thinkaboutit.org/transportation/#.Uo7QuGT5kQs

BOX 7.1. External costs of road transport[a]

A recent publication by Proost and Van Dender[b] presented the estimates for the main five external costs of the transport sector (Table X). The estimates of the cost of damages from emissions and air and noise pollution, which adds up to US$ 0.46 (at the high end of the estimate range), are dwarfed by those from main sectoral inefficiencies - traffic congestion and accident risk, - which amount to US$ 0.28 (Table X). These costs exceed typical fuel taxes.

Climate change mitigation offers considerable co-benefits in terms of reduced sectoral inefficiencies, especially congestion, and vice versa. For example, in Istanbul, as its population increased by 3.3 percent per year, average motorized travel times increased from 41 minutes in 1996 to 49 minutes in 2007, and estimated CO_2 emissions jumped from 7 million to 9 million tons (Gerçek and Demir 2008). Another example is Washington, DC, the most congested metro area in the United States (2011). Its approximately 2.6 million commuters each spent an average of 73 hours annually in traffic jams in 2010, each burning an extra 37 gallons (140 liters) of gasoline. In total, this wastes 95 million gallons (360 million liters) and adds 840,000 tons of CO_2 to the already significant emissions from the region's road transport. The extra gasoline and wasted time cost the regional economy US$3.8 billion or about US$1,495 per commuter per year.

BOX TABLE 7.1. Five main external costs of transport sector emissions

EXTERNALITY	COST: US CENTS PER MILE, 2005 PRICES
Congestion	4.2-35.7
Air pollution from fuel combustion and exaust	1.1-14.8
Traffic safety: high traffic density increases accident risk	1.1-10.5
Noise	0.1-9.5
Climate change: GHG emissions from fossil fuel use	0.3-3.7

Source: Proost, Stef, and Kurt Van Dender. 2011. "What Long-Term Road Transport Future? Trends and Policy Options." Review of Environmental Economics and Policy 5 (1): 44–65. Oxford: Oxford University Press. Based on several European and US sources presented in: Small, Kenneth, Kurt Van Dender. 2007. "Long-run trends in transport demand, fuel price elasticities, and implications of the oil outlook for transport policy." Joint Transport Research Center Discussion Paper 2007-16. Paris: Organization of Economic Cooperation and Development / International Transport Forum.

a. Deichmann, Uwe and Fan Zhang. 2013. Growing Green: The Economic Benefits of Climate Action. Washington, DC: World Bank.
b. Proost, Stef, and Kurt Van Dender. 2011. "What Long-Term Road Transport Future? Trends and Policy Options." Review of Environmental Economics and Policy 5 (1): 44–65. Oxford: Oxford University Press.

pricing (including toll roads and high occupancy (HOV) lanes), urban congestion pricing, vehicle registration fees, parking policy and other measures. Fuel pricing is the most effective policy instrument in reducing travel time and creating incentives for switching to fuel efficient vehicles. **Inefficiencies resulting from the usage of the fuel inefficient technology and deficient parts can be reduced through regulation.** In particular, introduction of vehicle emission standards would create incentives to buy newer and more fuel efficient cars, including vehicles that run on electricity (hybrid and plug-in), on natural gas (compressed or liquefied), or on biofuels, and maintain existing vehicles. **Inefficiencies resulting from a deficient urban form are most notorious in the transition countries[128].** In Skopje, unplanned urban sprawl resulted in deterioration of services including public transportation and services requiring transportation (e.g., health, education and social services), while increased personal vehicle ownership and travel time lead to traffic congestion[129]. These problems can be addresses with public transportation designed in response to a changed urban shape, land use policies limiting urban sprawl, city center re-design to promote walking and cycling and discourage driving, and transport management systems reducing congestion and smoothing traffic flows.

In addition to addressing the inefficiencies of the road transport sector, a modal shift from road to a much less emission intensive rail transportation could be beneficial, as it would help contain road transportation demand and therefore emissions, while also resulting in a co-benefit of reduced road congestion. For example, to transport 100 tons of freight from Basel (Switzerland) to the port of Rotterdam (Netherlands) 4.7 tons of CO_2 emissions are generated by road, 2.4 tons by inland waterways, and 0.6 tons by rail. A recent independent study commissioned for the US Federal Railroad Administration found that on average rail was four times more fuel efficient than trucks, reducing GHG emissions by 75 percent.[130]

128. One of the extreme examples is the congestion levels in Moscow, where the number of vehicles has risen since 1990 from 400,000 to 4 million while the transportation system did not change sufficiently and where the mayor publicly announced the fight against congestion to be his major task as the city administrator (see in: Carolina Monsalve. 2013. "Controlling Greenhouse Gas Emissions Generated by the Transport Sector in ECA: Policy Options." Transport Papers. Washington, DC: World Bank.).

129. See a detailed discussion of it in Chapter 8 describing the urban issues.

130. Monsalve, Carolina. 2013. "Controlling Greenhouse Gas Emissions Generated by the Transport Sector in ECA: Policy Options." Transport Papers. Washington, DC: World Bank.

METHODOLOGY AND MAIN FINDINGS

Methodology

The objective of the analysis was to assess the impact of "green" policies and investments on transport demand and resulting emissions, estimate cost of the proposed green investments per unit of related emission reduction and evaluate transport sector vulnerability to climate change. The impact of green policies was assessed by comparing the outcomes of Green and Super Green scenarios against the Business as Usual (BAU) scenario (see scenario description in Table 7.1). The outcomes were measured using sectoral indicators, such as vehicle population and age, vehicle sales, vehicle scrappage, vehicle-kilometer traveled, passenger-kilometer traveled, ton-kilometer transported, and volume of rail travel. Sectoral outcomes helped project the level of fuel consumption and emissions including CO_2, NO_X, and PM_{10}.[131]

Modeling included policies and investments that would address inefficiencies discussed above and the rail sector investment. In particular, a wide range of urban development policies was modeled to understand how the **issues resulting from deficient urban development** could be dealt with. These policies include parking management in Skopje, investment in urban and inter-urban transit, investment in walking and cycling infrastructure, land use planning and regulation (including pedestrian zones, limited parking, provision of public transport), urban access freight restrictions and consolidation centers, urban traffic management systems, and congestion charge in Skopje. Several policies encouraging improvement in **vehicle fuel efficiency** were modeled as well: encouraging the purchase of fuel efficient vehicles, pricing policy (taxation of fuel), behavior change and travel planning (including information campaigns, policies to reduce vehicle occupancy and the number of trips), eco-driving information campaigns, and investment in vehicle train technology. A modal shift from road to rail was modeled as a rail infrastructure investment option. Proposed policies and investments included in green scenarios for each policy option are provided in Table 7.1.

The following models were used for the analysis and implemented in the sequence shown below (Figure 7.4): the European Commission's (EC) TREMOVE (economic TRansport and EMissions model), the EC's TRANSTOOLs (TOOLS for TRansport Forecasting ANd Scenario testing), the World Bank's EFFECT (Energy Forecasting Framework and Emissions Consensus Tool) and its MacCurve tool.

131. CO_2 is carbon dioxide. NOx is a generic term for mono-nitrogen oxides, in particular, NO_2. NO_2 forms quickly from emissions from cars, trucks and buses, power plants, and off-road equipment. In addition to contributing to the formation of ground-level ozone, and fine particle pollution, NO_2 is linked with a number of adverse effects on the respiratory system. NO_x are distinct from nitrous oxide (N_2O), a greenhouse gas emitted from agricultural lands. PM_{10} is atmospheric particulate matter smaller than 10 microns.

TABLE 7.1. Green policy actions in transport

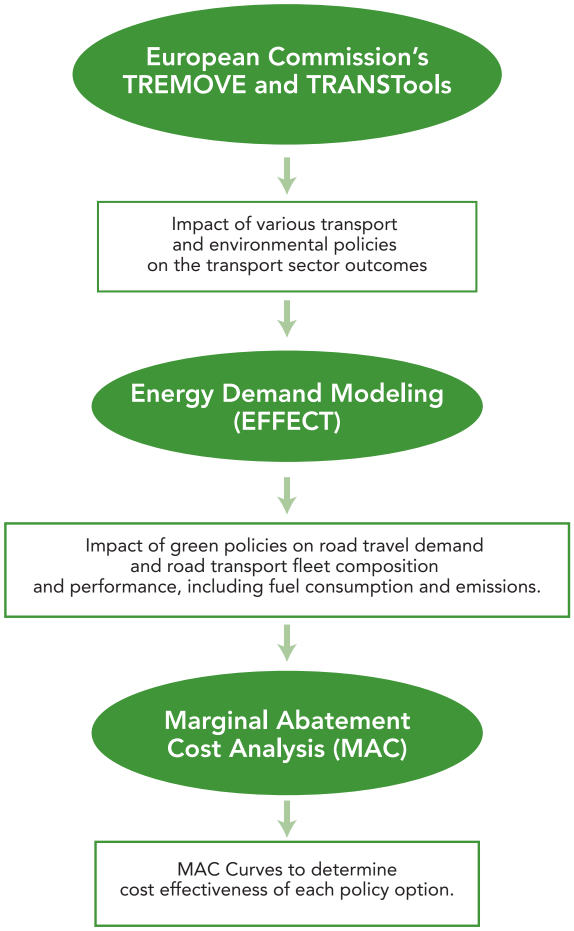
	POLICIES	POLICY ACTIONS AND INVESTMENTS EVALUATED IN MODELING, BY SCENARIO	
		Green scenario: Assumes compliance with EU requirements by 2020 and includes other proposed green policies and investments.	**Super Green scenario:** Assumes stricter policy actions or tighter schedules as compared with Green scenario.
FUEL EFFICIENCY	Pricing signal (fuel price)	• fuel tax starting in 2013; • 20% increase in fuel prices relative to BAU by 2020, to average EU level of US$2/litre.	• 60% increase in fuel prices relative to BAU by 2020, to top EU level of US$2.5/liter.
FUEL EFFICIENCY	Encouraging purchase of fuel efficient vehicles	• passenger car requirements: used imported vehicles should meet Euro 4 standard starting in 2015; • passenger car scrappage scheme targets 60,000 cars between 2012 and 2015: replacement of Euro 2 standard (or lower) vehicles with new or used vehicles at Euro 4 or 5 standard and with a maximum emissions rate of 140g CO_2/km; • public sector fleet : Clean Vehicle Directive[a]; • buses below Euro 4 standard should be renewed to Euro 5 standard by 2025; • taxis: all Skopje taxis should meet Euro 4 standard by 2020.	• passenger car requirements: used imported vehicles should meet Euro 5 standards in 2015; • passenger car scrappage scheme: same as in Green but targets 120,000 cars over the same time; • public sector fleet: same as in Green, plus introduction of electric vehicles to the fleet; • buses: same as Green plus 10% of national bus kilometers (all within Skopje) would be covered by electric bus by 2025; • taxis should meet Euro 5 standard by 2020; 5% of taxi fleet would be electric by 2020.
FUEL EFFICIENCY	Eco-driving information campaign and training	• awareness campaign and driver training, 2013 2015: aimed at driving style (smooth acceleration and deceleration, no idling), observed speed limits, tire pressure checks, timely vehicle maintenance); • campaigns repeated every 3 years.	Same as in Green, but more intensive campaigns.
FUEL EFFICIENCY	Vehicle trains	Not implemented	Implementation starts in 2020 on the key road corridor, with 5% of HGVs and 2% of cars taking part in 2020 and 10% and 5% respectively taking part in 2050.
RAIL INVESTMENT	Investment in rail infrastructure and services and rail energy efficiency	• track and infrastructure investment along Pan-European corridor VIII; • investment in stations, rail yards and depots; • competitive fares (against car use costs) and freight access charges; • improved service quality ; • passenger information system and e-ticketing, electronic freight billing and tracking of shipments; • rolling stock investment and improved management; • regenerative braking (rolling stock and infrastructure investment); • driver energy efficiency (on-board energy use metering and software, driver training); • changes to electricity recharge mechanism to incentivize operators adopting energy efficient behaviors.	Same as Green, but more intensive strategy.

a. The Clean Vehicle Directive is a European Union initiative ("The Directive on the Promotion of Clean and Energy Efficient Road Transport Vehicles"). Its objective is increased usage of environmentally-friendly vehicles. It requires that energy and environmental impacts of road vehicle operation over their lifetime are taken into account in all purchases of such vehicles. See: http://ec.europa.eu/transport/themes/urban/vehicles/directive/

URBAN DEVELOPMENT			
	Parking management improvements (Skopje)	• step 1: expansion of regulated and paid parking: all 6000 existing spaces in central Skopje charged at current rates (100 denars per day); • step 2: a 50% increase in parking charges in the center of Skopje (corrected for inflation) in 2030.	Same as in Green, except stricter: • 50% increase in parking charges in the center effective in 2013, and a 100% increase above current charges in 2030 (corrected for inflation).
	Behavior change and travel planning	Information campaigns, policies to reduce vehicle occupancy and the number of trips.	Same, but more stringent measures.
	Investment in urban and inter-urban transit	• building tram infrastructure in Skopje: tram line 1 opens in 2015-2020; • improved ticketing system and fares levels: integration and smart cards, 2012-2015; • urban bus: urban traffic management system (UTMS), improvements to vehicles and routing: reduction of travel time, increased occupancy, 2015-2019.	• tram: same as in Green, plus implementation of three additional tram lines in Skopje by 2020; • ticketing and fares: same as in Green, plus fares subsidization with a 10% decrease in fares for all users; • urban bus: same as in Green.
	Land use planning and regulation	• pedestrian zones; • limited parking; • provision of public transport.	Same as in Green, but more stringent measures.
	Investment in walking and cycling infrastructure	• Options include: • additional pedestrian streets; • removal of cars parked on pavements; • improved crossing facilities; • additional cycling facilities (extensive network of cycle paths and lanes, cycle parking facilities); • walking and cycling information and campaigns; • use of regulations and agreements with developers and employers to improve facilities and promote walking and cycling.	Same as in Green, but more stringent measures.
	Urban access freight restrictions and consolidation centers	• one Low Emissions Zone (LEZ) and one consolidation center in Skopje, with use encouraged through regulation and/or pricing signals. Each LEZ would require the HGVs entering it to meet Euro 4 standards from 2015, Euro 5 from 2020 and Euro 6 from 2030.	• same as in Green, but expanded: one LEZ and three consolidation centers in Skopje, plus one LEZ and one consolidation center in each of the locations: Bitola, Kumanovo and Tetovo.
	Urban traffic management systems (UTMS)	• ongoing UTMS upgrade, due in Skopje in 2013; • traffic regulation and enforcement: investment is limited to Skopje in 2013-14; then investment every 5 years up to 2045 for upgrades.	• same as in Green, but coverage is expanded to include Bitola, Kumanovo and Tetovo.
	Congestion charge (Skopje)	• Not implemented	• Implementation starts in 2020. Options considered: • cordon/zone charging: a charge is applied when vehicles cross a defined cordon line; • area licensing: charges are applied when vehicles drive within a defined area.

Note: Vehicle trains are groups (platoons) of vehicles electronically connected together with a single manually-driven lead vehicle. This technology is new and currently undergoing trial, it is assumed available only starting in 2020. Each vehicle taking part is very conservatively assumed to achieve a 10 percent reduction in fuel use.

FIGURE 7.4. **Methodological framework for transport sector**



Source: Transport sector technical paper

- **Step 1. European Commission's TREMOVE and TRANSTOOLs** (Box 7.2): transport sector top-down modeling aimed at evaluating the impact of various transport and environmental policies on the transport sector outcomes. The models used were the EC's TREMOVE (economic TRansport and EMissions model) and TRANSTOOLs (TOOLS for TRansport Forecasting ANd Scenario testing) models. They have been used in a number of recent forecasting studies of carbon impact of transport, including TEN-Connect[132] TRANSVisions 2009[133] and iTren 2030.[134]

132. Report on Scenario, Traffic Forecast and Analysis of Traffic on the TEN-T, 2009: http://www.tetraplan.com/cases/ten-connect.aspx

133. Petersen, Morten S., Carlo Sessa, Riccardo Enei, Andreu Ulied, Efrain Larrea, Oriol Obisco, Paul M. Timms, Christian O. Hansen. 2009. TRANSvisions: Report on Transport Scenarios with a 20 and 40 Year Horizon. Final report. Copenhagen: European Commission, Directorate General for Transport and Energy (EU DG TREN).

134. Integrated Energy and Transport Baseline to 2030, 2009: http://ec.europa.eu/research/transport/projects/items/__itren_2030__en.htm

Because none of the existing transport sector models included FYR Macedonia , the modeling outcomes for countries with characteristics similar to FYR Macedonia (for instance, in terms of fuel prices, trading patterns and socio demographic changes), adjusted using key economic indicators such as GDP/capita, population size and type of settlement (metropolitan, urban or rural), were used for FYR Macedonia. The countries selected to provide proxy estimates for FYR Macedonia were main East European countries: Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, and Slovakia. The output of macro modeling was used as one of the inputs to the bottom-up engineering model, EFFECT.

- **Step 2. The World Bank's EFFECT model** (Box 7.3)**: bottom-up modeling to assess green policy interventions and their potential impact on transportation demand and emissions**. EFFECT was used to project energy demand for four sectors – transport, household, non-residential and industrial – over the period from 2010 to 2035. The results were then extrapolated to year 2050. For each sector, demand was projected by subsector and type of usage. The projections were made separately for power and non-electric energy. The projections for sectors other than transport are presented in the energy chapter of this report. The road transport module of EFFECT was utilized to estimate the impact of green policies on road travel demand and road transport fleet composition and performance, including fuel consumption and emissions. The inputs included macro variables such as GDP, population, urbanization, household expenditure and other household characteristics, forecasted for period 2010-2050, and actual current sectoral data for such as car ownership and fleet composition. The outputs comprise forecast levels of vehicle ownership, travel and emissions (including CO_2, NO_X and PM_{10}), by vehicle category (including mini, small, medium, large/luxury cars, sports utility vehicles, goods and passenger light commercial vehicles, heavy goods vehicles, and buses and coaches) and year in the period from 2010 to 2050.

Some of the sector indicators essential for EFFECT modeling were not available from the existing sources and a survey was conducted to collect the missing data. The survey collected data on vehicle usage, ownership, and the number of privately imported vehicles. One of the main objectives was to define mortality curves per vehicle type for FYR Macedonia. The survey was implemented by Ipsos Strategic Pulse. It was administered in gas & fuel stations and covered 3116 vehicles. The sample was representative of types of vehicles and of different areas

BOX 7.2. European Commission's TREMOVE and TRANSTOOLS models (economic TRansport and EMissions model and TOOLS for TRansport Forecasting ANd Scenario testing)

TREMOVE*: estimates impact of transport and environment policies on transport sector characteristics including emissions. The policies included in the analysis are road pricing, public transport pricing, emission standards, and subsidies for cleaner cars. The output indicators are transport demand, modal shift, vehicle stock renewal, scrappage decisions, as well as GHG emissions, air pollutants and welfare. It models passenger and freight transport, as well as inland urban and interurban transport modes: road, rail, water, and air transportation. It covers 1995-2030 and includes 31 countries: EU-27 plus Croatia, Norway, Switzerland and Turkey**.

TRANSTOOLS***: estimates impact of transport and environmental policies, as well as transport infrastructure characteristics, on transport sector performance. Output indicators include transport activity (traffic volumes, modal shares, congestion points, accessibility indicators, level of service), economic activity (impact on GDP, employment, welfare, government budget, and production costs average transport costs) and energy and environment (fuel consumption; emissions, noise and accidents). Transtools models passenger (car, rail, air) and freight (truck, rail, inland water, sea shipping) transport and includes 55 countries.***

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*Additional information available at http://www.tremove.org, http://www.tmleuven.be/methode/tremove/home.htm

**Source: http://ec.europa.eu/environment/air/pollutants/models/tremove.htm

***Developed in projects funded by the European Commission Joint Research Centre's Institute for Prospective Technological Studies (IPTS) and DG TREN

****Sources: http://energy.jrc.ec.europa.eu/transtools/, http://www.ec-gis.org/Workshops/inspire_2008/presentations/11_3_Bamps.pdf

of the country. It included Skopje and the surrounding rural areas, Northwest and Kumanovo (areas with good roads), Southwest (areas with fair roads) and East/Central region (mainly rural areas with lower quality roads).

Modeling was complemented by vulnerability analysis aimed at assessing transport sector's climate change sensitivities. An assessment of climate change vulnerability was conducted in addition to modeling. Vulnerability is a function of three variables: sensitivity of infrastructure and services to weather and climate, exposure to climate change, and adaptive capacity or ability to respond to climate events (physically, financially and organizationally). Vulnerability analysis involved the following steps:

BOX 7.3. World Bank's EFFECT

EFFECT (Energy Forecasting Framework and Emissions Consensus Tool) was developed by the World Bank and is an Excel-based modeling tool used to forecast cross-sectoral greenhouse gas (GHG) emissions for a country under a range of development scenarios. It covers sectors that contribute significantly to emissions including road transport, power, industry, household and non-residential sectors. It is an "open" tool with all inputs and formulas visible (or "open") to the users. It is also "open" to the public because its usage does not require specialized knowledge and anybody proficient with Excel can utilize it. EFFECT is a bottom-up modeling tool and is very data extensive: it is based on very detailed data, such as energy usage by household appliance and by unit of industrial equipment, and structure of car ownership by vehicle model and age. The data are collected using available statistics, industry data (e.g., sales of new cars by model), expert opinions (e.g., when designing a set of assumptions for projections) and consumer surveys. Consumer surveys are used when data are not available otherwise, for example, to collect data on the model and make structure of vehicle park for vehicles bought as used. The model is available at http://esmap.org/esmap/EFFECT.

- **Step 1. Assessment of sensitivity of road and rail infrastructure assets and services to climate change**: estimation of the marginal cost of increased exposure due to the following change in climate:
  - cold weather: shorter winters, less days with temperatures below freezing;
  - hot weather: more hot, heat waves and extremes, maximum temperatures increase;
  - wet weather: rainfall declines, except in winter; rainfall heavier, snow-melt quicker and earlier.
- **Step 2. Evaluation of adaptation measures and their prioritization, design of an adaptation Action Plan, design of adaptation guidelines, for use in future risk assessments.** Implementation of the plan, with associated monitoring and evaluation, should reduce existing and future vulnerability of land transport assets and services to weather-related risks.

Main findings

Emissions are estimated to grow significantly under the BAU scenario. Land transport GHG emissions increase by over 70 percent between 2010 and 2030 and more than double (165 percent growth) between 2010 and 2050. Within the land transport sector, GHG emissions from road freight grow the most, by 400 percent during 2010-2050, due to an increasing share of road freight in land transport, which reaches 65 percent in 2050. This change is mainly driven by significant GDP growth. Figure 7.5 presents main outcomes of modeling for the two green scenarios as compared with the baseline.

Green policies limit projected emission growth as compared with the baseline projections. Overall land transport CO_2 emissions increase is only 50 percent during 2010-2030 and 120 percent during 2010-2050. These increases are below the ones observed in BAU. They are reduced by 14 percent from the BAU level in 2030 and by 18 percent in 2050. The highest reduction as compared with BAU is in road freight. Transit (public transport except rail) and rail emissions increase due to significant additional rail freight and some other services. The highest GHG reduction as compared with BAU among policy options, assuming each one of them is implemented independently, is from the implementation of pricing policies, investment in rail and promotion of fuel efficient vehicles.

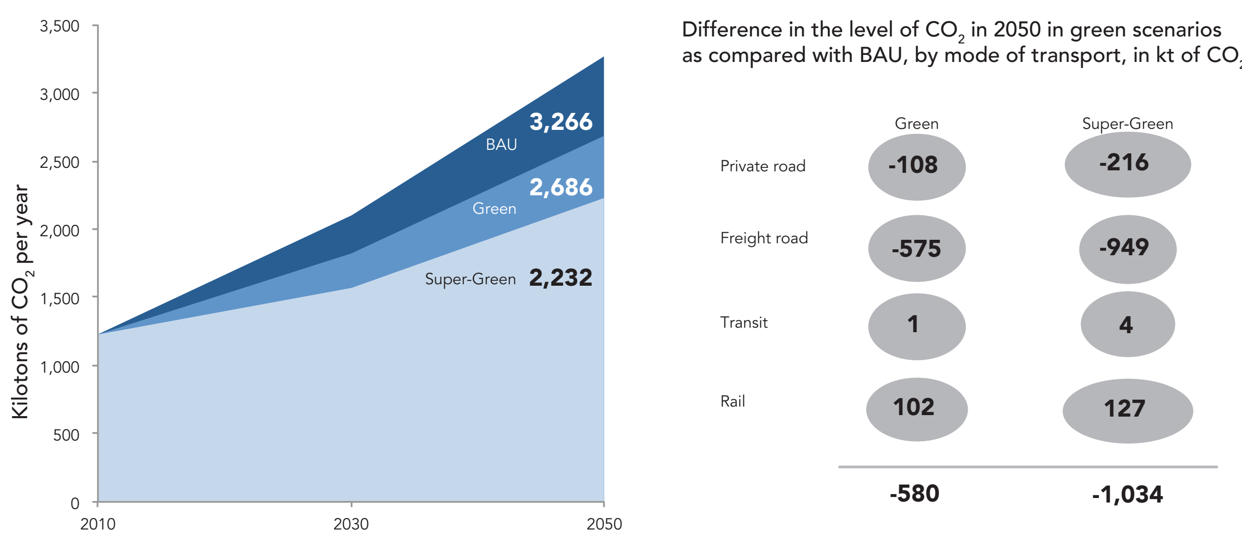
Super Green policies push projected emission growth further down as compared with BAU although still don't achieve an absolute reduction in emissions relative to 2010. Overall land transport GHG emissions increase by 30 percent during 2010-2030 and by 80 percent during 2010-2050. As compared with BAU, Super Green policies reduce emissions by 25 percent in 2030 and by 32 percent in 2050. The largest reduction as compared with BAU is in road freight. Transit and rail emissions grow due to increase in rail freight. The same policy options as in the Green scenario bring the highest GHG reduction as compared with BAU: pricing signal, investment in rail and promotion of fuel efficient vehicles.

Implementation of a complete set of the options modeled in the Green scenario delivers modest abatement while the Super Green scenario triples that abatement. Green scenario options total 12.5 $MtCO_2e$ in reduced transport emissions, while a full Super Green scenario's set of options provides abatement of 24.9 $MtCO_2e$. Table 7.2 presents modeling outcomes in absolute terms (cost, abatement level and unit abatement cost) by scenario, policy package and policy option. The cost effectiveness of each scenario (unit abatement cost) appears high but other factors need to be considered:[135] €41.1 per TCO_2e in the Green scenario and €60.9 per TCO_2e in the Super Green scenario. These characteristics differ by policy package and by policy option within packages. It is important to note the set of green actions needed

135. As previously discussed, specifics of the transport sector mitigation are such that the set of green actions needed for mitigation significantly overlaps with the set of sectoral reforms required to increase sector efficiency, and, therefore, the green objectives of reducing the transport sector emissions will have a co-benefit of increased sectoral efficiency.

FIGURE 7.5. **Green policies limit emissions growth, but do not achieve an absolute reduction**

Projected land transport emission levels by scenario, in kilotons of CO_2e per year, and emission reduction in green scenarios, 2050, as % of BAU emissions



Source: Transport sector modelling outcomes, Transport sector technical paper.

for transport mitigation significantly overlaps with the set of sectoral reforms required to increase sector efficiency, and, therefore, the green objectives of reducing the transport sector emissions will have a co-benefit of increased sectoral efficiency.

The Fuel Efficiency package delivers the highest benefits. This package generates 80 percent of the total Green abatement and 68 percent of the total Super Green abatement. This package also has the best outcomes in terms of cost efficiency: €18.3 per TCO_2e in the Green scenario and €26.7 per TCO_2e in the Super Green scenario. The package consists of policy options that create incentives to use less fuel, either by using fuel efficient technologies/driving mode, or by driving less. The package is not designed as a set of options that are complementary to each other; each of the options in the package is self-standing. Modeling outcomes for individual policy options in this package are as follows:

- **Pricing signal (modeled as increased fuel price).** This policy option can include a number of instruments: fuel taxes, vehicle registration fees and taxes at point of purchase, charges associated with usage of roads, or a fixed road fee for a time period. (see Good Practice Box 2 with an example of a successful pricing policy, which increased the price of higher emissions cars and reduced the price of lower emission cars in France). In this study, the pricing signal policy option was modeled through a fuel tax, the most effective of these instruments (see details in Table 7.1). A fuel tax increases the price of fuel, creating incentives to reduce travel and to use fuel-efficient cars (smaller cars or those with better emission standards), thus reducing demand for fuel for road transport and road transport emissions. The outcomes of modeling show that the pricing signal option is one of the two most beneficial options (together with rail investment), judged by both the resulting abatement and the unit abatement cost: it reduces emissions by 3.7 $MtCO_2e$ in the Green scenario and by 11.2 $MtCO_2e$ in the Super Green scenario, while the unit cost of abatement is €8.4 per TCO_2e in the Green scenario and €24.9 per TCO_2e in the Super Green scenario. This option is essential for transport sector policy, because price incentives provide the most impact directly and because many other measures deliver better results if built on them.

- **Encouraging purchase of fuel efficient vehicles.** This policy option can include the following instruments: point-of-purchase taxes related to fuel efficiency of vehicles, stricter vehicle import regulations, scrappage schemes, low emission standards for public sector vehicles and taxis, and information and marketing regarding fuel efficiency of vehicles. Instruments modeled comprised the following: regulations to improve freight fleet efficiency, regulations requiring higher standards for car imports, scrappage scheme for passenger cars, Clean Vehicle Directive[136] for public sector fleet, and new regulation for buses and taxis (see Table 7.1 for details). Increased fuel efficiency of vehicles reduces demand for fuel and therefore lowers emissions. Modeling outcomes show that this policy option will result in the third best abatement level among all policy options: 2.5 $MtCO_2e$ in the Green scenario and 4.8 $MtCO_2e$ in the Super Green scenario. The option is cost efficient and requires €31 per TCO_2e in the Green scenario and €30 per TCO_2e in the Super Green scenario. This option is consistent with the EU requirements to transport.

- **Eco-driving information campaign and training**. This option was modeled to include training and information campaign, mainly for freight operators and bus drivers, regarding driving speed and driving style, removal of roof racks, timely vehicle maintenance, and tire pressure checks. The emission reduction is achieved through changed driving habits and purchase of smaller cars. While this measure delivers limited abatement, it is cost efficient and has an important co-benefit of road safety.

- **Vehicle trains** are a new technology, still in the testing stage. This technology would be implemented only in the Super Green scenario starting in 2020 and would affect a limited share of traffic. Therefore, the modeling shows a very small level of abatement from the implementation of this option. This option has significant co-benefits in reduced freight costs, increased road safety and reduced congestion. It will have a greater impact when the technology is more widespread.

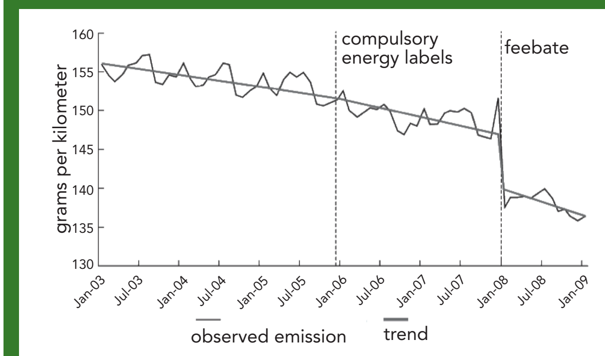
- **The Rail Investment package provides second highest benefits after the fuel efficiency package:** it delivers abatement of 3.9 $MtCO_2e$ in the Green scenario and of 5.0 $MtCO_2e$ in the Super Green scenario. The cost efficiency of the package is good for a transport sector intervention: €65 per TCO_2e in the Green scenario and €98.2 per TCO_2e in the Super Green scenario. This policy option is aimed mainly at increasing the availability of both freight and passenger rail service, together with increased energy efficiency of rail. Rail investment will result in significant co-benefits including reduced congestion, increased road safety, and lowered air pollution level.

136. As previously described, the Clean Vehicle Directive is a European Union initiative aimed at increased usage of environmentally-friendly vehicles and internalization in vehicle price of environmental impacts of road vehicle operation over their lifetime: http://ec.europa.eu/transport/themes/urban/vehicles/directive/

GOOD PRACTICE BOX 8.

Reducing transport emissions through a price mechanism in France

French experience demonstrates how pricing policies help reduce emissions through modifications in consumer behavior. During 2003 to 2009, the average emissions of new cars in France decreased, dropping precipitously in 2008 after the government introduced a "feebate," which increased the price of high-energy and reduced the price of low-energy-consuming cars. This led to a 20 percent decrease in the average CO_2 emissions of new cars, of which 34 percent is related to the type of cars on the market and 46 percent to price effects (gasoline prices and "feebate"). The biggest preference changes occurred among young people and rich people.



Source: World Bank. 2012. Inclusive Green Growth: The Pathway to Sustainable Development. Washington, DC: World Bank.

The Urban Development package is characterized by mutual complementarity of its policies. Many of the Urban Development policies support each other and are not as beneficial individually as they are in the package. For example, investing in the re-design of the downtown areas into low traffic ones with walking-only streets should be combined with well-developed parking and public transportation. Behavior change effort is complementary to investments and policy incentives, such as land use planning, investment in urban and interurban transit, and parking management. Individually, some policies in the Urban Development package have very high unit abatement cost, but this outcome should not be regarded as a reason to abandon them: they are part of the package and deliver interlinked value within the package. Urban transport policies are only one, albeit significant, part of the overall bigger urban package, which also includes mutually complementary interventions in the energy sector, water and wastewater sectors, and solid waste sector.

The combination of the first six measures in the Urban package (Table 7.2) – parking management (Skopje), behavior change, investment in urban and inter-urban transit, land use planning and regulation, investment in walking and cycling infrastructure, and urban access freight restrictions and consolidation centers[137]— **will deliver abatement of 1.7 $MtCO_2e$ in the Green scenario and 2.6 $MtCO_2e$ in the Super Green scenario and provide significant co-benefits of enhanced business development in the city centers and therefore improved standards of living, as well as improved urban quality of life and road safety.** Particular options have the following features:

- The **parking management option** will aim at providing adequate parking supply, management, pricing and information, as well as parking enforcement. Modeling of this option involves better (limited in the city center) parking supply, and improved management, as well as increased parking pricing. As a result, demand for travel in the city will be reduced and emissions lowered.

- **Behavior change** is a low cost option designed to enhance the impact of the other measures in the package. It was modeled through information campaigns leading to reduced demand for trips and a mode switch from cars to public transport and walking and cycling.

- **Investment in urban and interurban transit** can include investment in bus and tram services, in bus rapid transit, in better ticketing systems, and subsidized public fares. This option was modeled as investment in a tram network, in interurban bus service and in an efficient ticketing system with increased fares. The outcome of this investment is a transportation mode switch, away from cars and toward public transport.

- **Land use planning and regulation** is a set of measures limiting and reversing urban sprawl. It includes various regulations aimed at permitting only planned urban development, with the priority building construction as a fill-in in existing city areas, and with new developments permitted only if public transportation and city infrastructure are provided. This option is modeled through its impact on the demand for travel.

- **Investment in walking in cycling infrastructure** can involve construction of cycling facilities, pedestrian streets, improved crossing, and information campaigns regarding walking and cycling. The modeling focused on development of walking and cycling infrastructure resulting in a mode switch from driving to walking and cycling.

137. Consolidation or transshipment centers are facilities at an intermediate shipment destination, from which goods are transferred to their next or final destination, often using different vehicles.

- **Urban access freight restrictions and consolidation centers** can have different designs, with restrictions based on emissions levels from vehicle operation, weight and size of vehicles, loading factors, or time of day. The option was modeled using EU emission standards-based restrictions and involved construction of consolidation centers. This intervention will reduce demand for heavy duty vehicle travel within the cities. (Heavy vehicles are already prohibited from Skopje in summer).

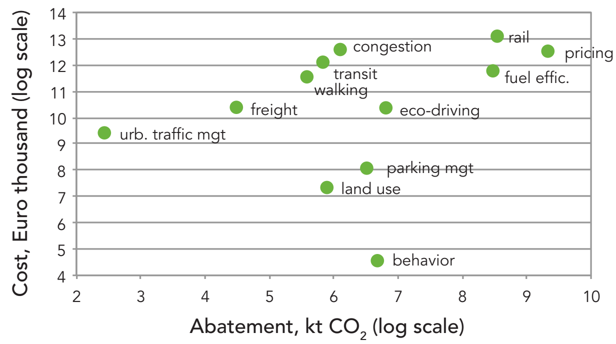
Other options in the Urban Development package – urban traffic management systems (UTMS) (Skopje) and congestion charge (Skopje) **- would also add value in terms of abatement (Table 7.2), as well as co-benefits, such as reduced traffic and increased safety.** However, modeling showed limits to their implementation. UTMS allow for better use of existing city infrastructure, optimized speed and therefore safety and reduced emissions. The option was modeled through an upgrade of the existing UTMS. This option has high cost and limited benefits as compared with other interventions. Congestion charge was modeled through a charge applied when vehicles cross a border to the city center. It would apply in the Super Green scenario only and have a limited applicability due to a complicated implementation.

While the previous paragraphs describe modeling outcomes in terms of abatement level and unit abatement cost, it is also important to consider the overall cost of the policy options, especially from the point of view of financing and budget impact. Figure 7.6 shows the relationship between the total cost of the policy options included in modeling (see Box 7.4 for details on the calculation of costs) and the achieved abatement level, based on the data presented in Table 7.2. It provides a good illustration of no or little direct relationship between investment level and emission reduction outcome by policy option. This seemingly perplexing conclusion is driven by the importance of policy complementarity and co-benefits, discussed above. The figure also illustrates the high abatement level delivered by certain policy options— a pricing signal, rail investment and encouraging purchase of fuel efficient vehicles—as well as a relatively high level of abatement in combination with low cost of such measures as land use planning and regulation, parking management (in Skopje), and behavior change by households.

Analysis of transport sector sensitivity to climate change concluded that the main concern in this area is related to projected increase in temperatures and precipitation, which will push the costs up. Vulnerability analysis found that road sector is highly sensitive to projected hot and wet weather: high temperatures, rain and flooding will damage pavement and cause road closures, traffic delays, and accidents, thus

FIGURE 7.6. **Cost of Super Green policies (NPV, 2012-2050) is not directly related to the resulting abatement**

Cost of interventions (NPV, 2012-2050) and projected land transport emission level by policy, in kilotons of CO_2e per year (log scale), and emission (log scale)



Source: Staff calculations based on transport sector modeling outcomes.

requiring increased maintenance and investment expenses. Drainage infrastructure will be affected by capacity exceedance and erosion caused by rain and flooding. Embankments and cuttings remain highly vulnerable to subsidence (exacerbated by poor drainage) and river erosion. For rail, future vulnerability to cold and hot weather is the main concern. Rail tracks will be more vulnerable to buckling. In hot weather, the risk of fire is the main concern. In wet weather, bridges, tracks, and the substructure are likely to become more vulnerable due to the increased likelihood of floods and landslides.

RECOMMENDATIONS

The proposed mitigation action plan recommends a set of actions on the basis of estimated benefits. This plan includes implementation of a pricing signal, encouraging purchase of fuel efficient vehicles, rail investment, parking management (Skopje), investment in urban and inter-urban transit, and behavior change. The main areas of concern coincide with the top drivers of emissions, and many of them—such as the old vehicle fleet and increasing private ownership of vehicles—should be addressed using policy or behavioral incentives such as regulations, taxes, fees and pricing aimed at encouraging replacement of old vehicles with newer and more fuel efficient ones (at a faster pace than current turnover) and at achieving reduction in driving time per vehicle, as well as reducing driving in the city centers. In particular, the recommended pricing signal option would include increased fuel taxes, vehicle registration fees and sales taxes, vehicle/infrastructure charge/tax for a fixed period (vignette), as well as charges for using roads (tolls).

TABLE 7.2. **Main outcomes of modeling: abatement level, implementation cost and unit cost of abatement, by scenario, policy package and individual policy option.**

POLICY PACKAGES AND INDIVIDUAL POLICY OPTIONS		GREEN			SUPER GREEN		
		Abatement, kt CO_2	Cost, 2012-50, NPV, € thousand	Unit abatement cost, €/ TCO_2e	Abatement, kt CO_2	Cost, 2012-50, NPV, € thousand	Unit abatement cost, €/ TCO_2e
Package 1: FUEL EFFICIENCY							
1	Pricing signal (fuel price)	3,728	31,196	8.4	11,180	278,521	24.9
2	Encouraging purchase of fuel efficient vehicles	2,487	77,169	31.0	4,750	142,733	30.0
3	Eco-driving information campaign and training	602	16,244	27.0	894	30,324	33.9
4	Vehicle trains	Not applied	--	--	67	52	0.8
SUBTOTAL: FUEL EFFICIENCY		6,817	124,609	18.3	16,891	451,630	26.7
Package 2: RAIL INVESTMENT							
5	Investment in rail infrastructure and services and rail energy efficiency	3,917	256,026	65.0	4,958	486,733	98.2
Package 3: URBAN DEVELOPMENT							
6	Parking management (Skopje)	632	1,679	2.7	671	3,358	5.0
7	Behavior change	431	57	0.1	796	107	0.1
8	Investment in urban and inter-urban transit	311	74,092	238.1	346	180,140	520.1
9	Land use planning and regulation	211	1,506	7.1	421	1,506	3.6
10	Investment in walking & cycling infrastructure	113	29,122	256.9	259	103,085	398.0
11	Urban access freight restrictions & consolidation centers	13	16,831	1,318.7	88	33,569	380.3
12	Urban traffic management systems (Skopje)	9	7,727	893.3	12	11,409	990.6
13	Congestion charge (Skopje)	--	--	--	490	246,149	502.4
SUBTOTAL: URBAN DEVELOPMENT		1,719	131,013	76.2	3,084	579,324	187.9
TOTAL		**12,453**	**511,648**	**41.1**	**24,933**	**1,517,686**	**60.9**

Other measures would involve changes in regulations applied to second-hand vehicles to discourage imports of old polluting vehicles, incentives to purchase fuel efficient vehicles, e.g., through taxation and scrappage schemes. Capacity building and training would be important to support options such as parking management improvement.

Investment is needed to address other emission drivers within the proposed action plan to reduce emissions. In particular, this relates to recommended rail infrastructure and service development, which would provide a lower-emission alternative to road transport, both passenger and freight. Investment is also needed to revive public transport in Skopje, a clear alternative to private road transport, which can be developed faster and at a much lower cost than rail. Yet another investment recommended would help with the re-design of the city centers and improvements in sector management (parking management, urban traffic management systems).

The climate change adaptation plan's measures mostly relate to better implementation of existing standards on local roads and improvement of road surface. Further improvements, using new pavement materials and implementation of new standards, may be required in order to adapt to future changes in climate. (See Chapter 9 on how policymakers can choose adaptation more efficiently for infrastructure assets).

The institutional side of adaptation reform is critical. Actions in this area should start with collaboration between transport stakeholders, such as Government ministries and departments, the Agency for State Roads, the rail sector, the City of Skopje, municipalities, bus operators and parking

BOX 7.4. Sources and assumptions for implementation cost estimates[a]

Costs of the implementation of the policy options to the public sector are calculated, for most of the options, based on international experience. For example, parking management option costs are based on evidence from the Paris 'bollard' scheme, corrected for population size; scrappage scheme costs (part of the option encouraging purchase of fuel efficient cars) are derived from evidence reported by the European Commission,[b] congestion charge costs are drawn from experience in Stockholm[c], eco-driving cost assumptions are obtained from experience in the Netherlands,[d] while cycling infrastructure costs are gained from London cycling budgets. For some of the options, the cost estimates are based on existing assessments made for Skopie: for the UTMS policy option, costs include the amount of existing loans provided for the purpose of this intervention; in the case of tram network development (within the option of urban and inter-urban transit), the concession study conducted for the proposed tram line is utilized; and in the case of rail investment, costs were provided by Macedonian Railways Transport JSC Skopje, the public rail company.

The approach to estimating the costs of the pricing signal option differs. It is based on calculation of the deadweight loss or "Harberger triangle" from the introduction of fuel tax. In the calculations, it is assumed that supply is perfectly elastic and that fuel price elasticity of demand equals 0.11.[e] The level of demand and price before the introduction of the fuel tax are from EU databases. The price after the tax is introduced is calculated according to the Green and Super Green scenario modeling (20 percent increase in the Green scenario and 65 percent increase in the Super Green scenario). Then the after-tax quantity demanded is calculated using these inputs and the standard formula:

$$e=d(Q)/d(P)$$, where

e is the price elasticity of demand, and d(P) and d(Q) are, correspondingly, price and quantity differentials before and after tax introduction. Next, the deadweight loss is calculated as one-half of the multiple of the quantity and price differential.

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a. Kodransky, M., G. Hermann: Europe's Parking U-turn: from Accommodation to Regulation, 2011

b. Assessment of the Effectiveness of Scrapping Schemes for Vehicles Economic, Environmental and Safety Impacts, European Commission, March 2010.

c. Carl Hamilton: Revisiting the Cost of the Stockholm Congestion Charging System, Center for Transport Studies , Royal Institute of Technology, Stockholm, 2010.

d. ECODRIVEN Campaign Catalogue for European Eco-driving and Traffic Safety Campaigns.

e. Transport sector EFFECT model.

management organizations. More complicated but also necessary actions in this area should aim at creating clear governance structures and contractual arrangements, as well as increasing administrative and technical capacity to support strategy development and project implementation.

A behavior change program within adaptation measures would involve an eco-driving information campaign and driver training, specifically for drivers with traffic offenses, for public sector and high mileage drivers (such as drivers of vans, taxis, and buses); and demonstration projects targeting main transport generators in urban areas that could be linked to projects in public transportation development and in walking and cycling infrastructure development.

There is an urgent need for improved transport sector adaptation information and data. Information and data limitations make FYR Macedonia lag behind best practice in other countries in climate change adaptation. There is no database of extreme weather events, the Agency for State Roads does not conduct damage calculations, nor has it a database quantifying or costing infrastructure damages by weather events.


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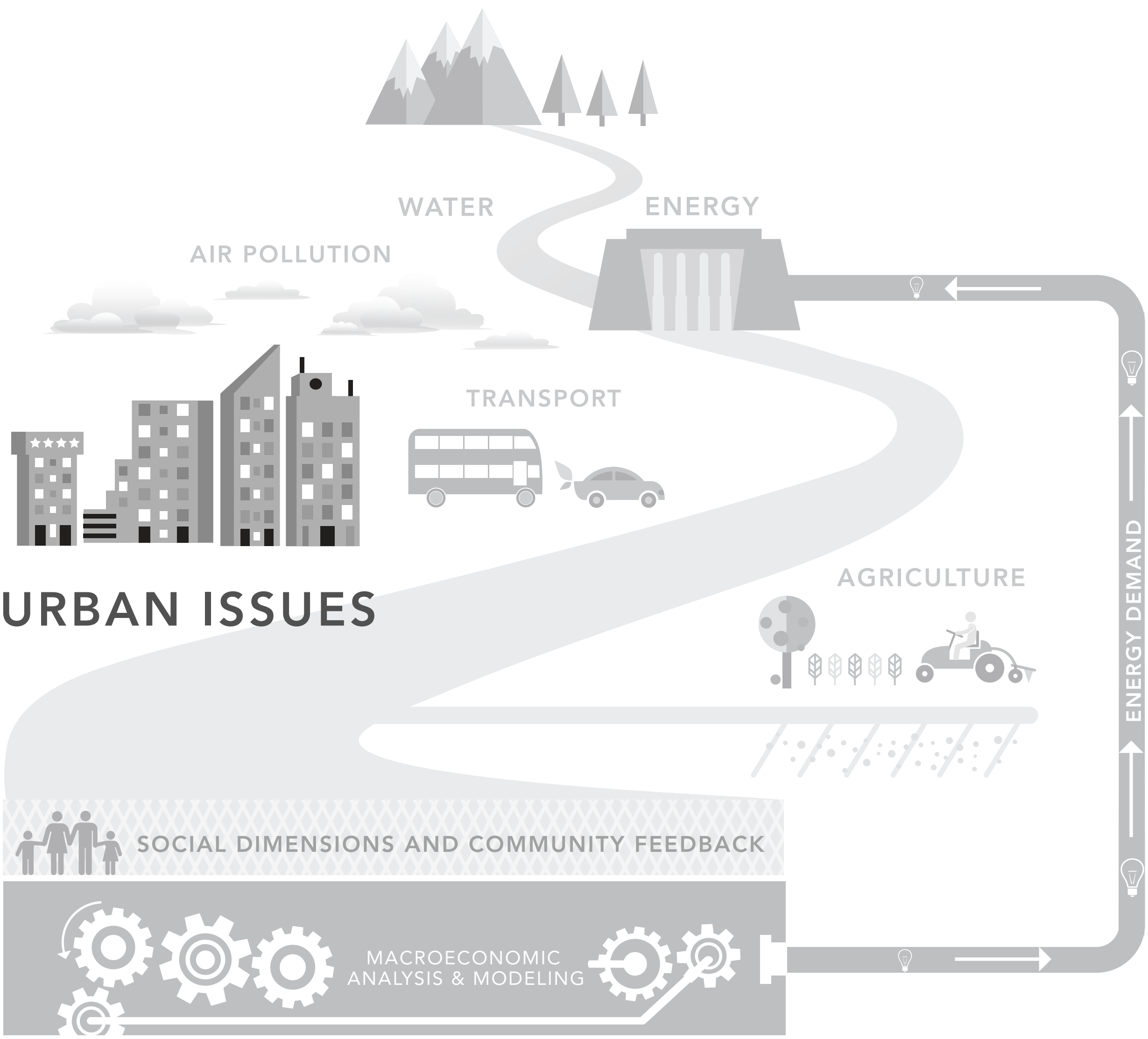
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ENERGY DEMAND
SOCIAL DIMENSIONS AND COMMUNITY FEEDBACK
MACROECONOMIC
ANALYSIS & MODELING

CHAPTER 8

Can Urban Areas Lead on Greening?

CHAPTER SUMMARY

FYR Macedonia's urban areas have a leading role in the overall economy, with most people and most economic assets; thus, green growth needs strong roots in cities and towns. More than two-thirds of the country's population resides in cities, and rural-to-urban migration is rising. Skopje alone generates some 60 percent of national GDP and an estimated comparable share in greenhouse gas emissions. Cities and municipalities are responsible, moreover, for the provision of key public services. Greener growth in urban areas would mean improved public service provision; increased efficiency and lowered emissions; reduced water losses; proper treatment of wastewater; collection, separation and processing of solid waste using modern equipment and improved landfills; well-organized public transport; and modern health and education services that are consistent with the needs of a competitive economy.

The analysis presented in this chapter is aimed at defining issues of urban development that are most important to address in the context of green growth. The methodology was designed to assess the impact of urban policies and investments and included a review of urban policies, strategies and pertinent legislation; an in-depth city level analysis of Skopje using the Tool for Rapid Assessment of City Energy (TRACE); and rapid assessments of selected additional Macedonian cities. TRACE was used as a tool for assessing potential energy and cost savings from energy efficiency measures in Skopie and prioritization of policies and investments across sectors. The TRACE analysis was conducted for six municipal service areas: urban transport, municipal buildings, water and wastewater, power and heat, street lighting, and solid waste management.

The findings show that cities have a high potential to achieve improved growth coupled with reduced emissions. Urban sprawl induces increased per capita emissions, mainly driven by growth in the number of single family houses that use wood for heating and private cars for commuting. Better building insulation[138] and increased energy efficiency of street lighting could help reduce emissions significantly and should be prioritized by the municipalities. Emissions from urban transport are driven by an increase in private car ownership and an old vehicle fleet; therefore, focus on public transport systems is essential.[139] Rising air and water pollution from wastewater and solid waste from run-down sector assets as well as unacceptable waste collection and disposal practices constitute another set of municipal challenges. Lastly, municipal water supply suffers from high technical losses and low revenue collection, leading

138. Building insulation is one of the main energy efficiency measures recommended in Chapter 6 on energy on the basis of modeling.

139. A detailed discussion of the emission intensity of transport as it relates to growth in private car ownership and increased number and length of car trips in FYR Macedonia is discussed in Chapter 7 on transport.

to subsidization of the sector.[140] Recommended priority areas for intervention include investment in public transport and in water and wastewater networks rehabilitation, establishment of integrated regional waste management systems, and expansion of energy efficiency programs.

CHALLENGES FOR GREENER GROWTH

Overview

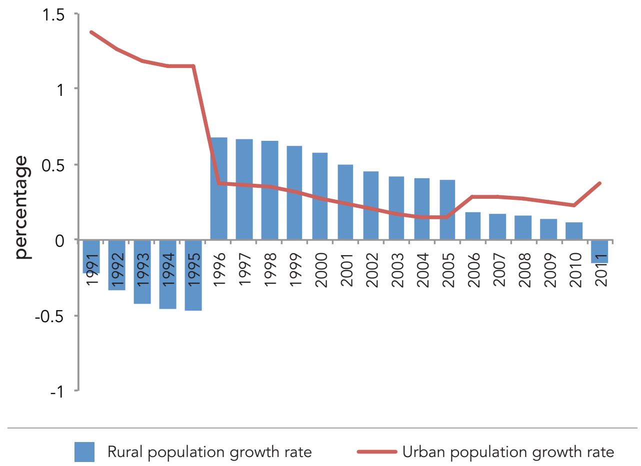
FYR Macedonia is an urbanized country with 68 percent of its population residing in cities. The five biggest cities alone–Skopje, Kumanovo, Bitola, Tetovo and Prilep–are home to 40 percent of the population. A relatively recent trend, observed during the last six to seven years, is an increasing rate of migration from rural areas of the country to the cities. As a result, during 2006 to 2011, the urban population grew by 1.7 percent, while the rural population increased by 0.6 percent. In 2010-11, urban population growth equaled 0.4 percent, while rural population fell by 0.2 percent. FYR Macedonia is now as urbanized as Italy and Austria and more urbanized than countries like Portugal, Greece, Finland, or Ireland. (Figure 8.1).

Cities produce most of FYR Macedonia's wealth and drive economic growth. Wealth in FYR Macedonia is disproportionately concentrated in the capital city. In 2009, Skopje generated almost 60 percent of the country's GDP.[141] It has a quarter of the country's population (not counting nearby cities, towns, and villages which form the Skopje agglomeration or 'big Skopje'), and current trends suggest that Skopje will continue to grow disproportionately.

Macedonian cities play an increasing role in public service provision and investments. Municipalities are responsible for provision of key public services, such as water supply and sanitation, solid waste management, and public transport, but also for critical social services such as primary and secondary education and basic health care. Local governments have the responsibility to prepare urban plans to guide development in their jurisdictions and allocate funds for capital investments. In 2011, Macedonian cities and municipalities invested more than €116 million in public infrastructure, equivalent to 40.5 percent of total public capital expenditure or 1.5 percent of the national Gross Domestic Product (GDP), up from 0.95 percent in 2008. The increase of local government revenues has been even more dramatic: revenues rose from 0.88 percent of GDP in 1999 to 5.65 percent in 2011[142]. Urban municipalities and

FIGURE 8.1. **FYR Macedonia's urban population has recently been growing faster than rural population**

Rural and urban population growth, annual



Source: World Bank Development Data Platform.

the City of Skopje account for the largest share of both local revenues and capital expenditure.

Cities are responsible for most of the country's emissions.[143] FYR Macedonia's economy is emissions intensive, and most of the emissions – 95 percent - come from energy, transport and manufacturing and are related to urban activities.[144] A major part of emissions is from the energy sector and constitutes 71.2 percent of total. The transport sector contributes 14.7 percent to overall emissions, while manufacturing adds 9.3 percent. At the same time, agriculture/forestry contribute only 0.4 percent to the overall level, and residential emissions (produced mostly by rural households and urban ones living in single family houses[145]) equal only 1.6 percent of the total.[146]

At the same time, cities in FYR Macedonia will benefit from implementing green growth policies. As will be outlined in the following, Macedonian cities may reduce costs from energy and resource consumption, increase employment and contribute to long-term economic growth, and improve citizen's quality of life. Infrastructure and service quality upgrading helps improving productivity and attracts skilled people. Growth in knowledge, service and other green industries located in cities can help address the country's endemic unemployment issue; and as one of the most energy intensive economies

140. Chapter 4's water sector analysis includes a discussion of the municipal water demand gap, which is exacerbated by the dilapidated condition of water supply infrastructure.

141. State Statistical Office of the Republic of FYR Macedonia.

142. World Bank. 2013. Western Balkans Municipal Finance Review. Forthcoming.

143. Source of data in this paragraph: IEA database.

144. A major part of emissions is from the energy sector and constitutes 71.2 percent of total. Transport sector contributes 14.7 percent to the overall emissions, while manufacturing adds 9.3 percent. Energy sector refers to electricity and heat production and energy sector own use. Transport sector includes all transport activity regardless of the economic sector

145. Residential refers to emissions from fuel combustion in households.

146. IEA database. See details in chapters on Energy and Agriculture.

in Europe, FYR Macedonia has enormous savings potential for cities, including in public service provision. Investments in upgrading FYR Macedonia's municipal infrastructure will support 'greener growth', but also help making progress in meeting the requirements of FYR Macedonia's accession to the European Union (EU). FYR Macedonia has already ratified the EC Treaty for South East Europe in 2006, agreeing to a schedule for the implementation of the in the fields of energy, competition, environment, and renewable energy. To catch up with EU income levels while improving environmental sustainability, FYR Macedonia needs to unleash the full potential of its cities through well targeted urban policies, regulations, and investments. Experience shows that urban green interventions are most effective when implemented as a package of various measures, combining investments with regulations, financial incentives, pricing measures, consumer awareness and capacity building (see Good Practice Box 9).

Critical Urban Issues in the Context of Green Growth

Two main areas of focus in the context of urban green growth in FYR Macedonia are the way urban form is taking shape and how key local services are being delivered. Both have a direct influence on the efficiency and environmental impacts of cities.

Urban form is a determining factor for the use of land and energy in cities, and the cost of infrastructure and municipal services. Denser cities use less energy and generate lower emissions per capita (Figure 8.2) as compared to cities with higher rates of urban sprawl. They also provide access to services at lower cost. Generally, cities with a dense urban mass tend to have lower energy intensities and fewer emissions than sprawling cities (see Figures 8.2-8.3). A compact city promotes energy efficiency in different ways. An apartment in multi-story building has a lower footprint than a single detached home, as heating and cooling are shared between apartments. Also, apartments tend to have a smaller area that needs to be heated, cooled, lighted, and otherwise powered. Services are provided at lower cost. It is easier and more cost-efficient to provide a public transportation system in a city with higher densities. Public transport networks in dense cities are generally easier to maintain as they cover a smaller area, require less energy inputs, and have a higher ridership. Solid waste management systems require smaller transport times in compact cities than in sprawling cities, and waste can be collected in a more efficient way from apartment buildings than from individual homes. Water and sewage systems are more compact in denser cities, which means that networks are easier to maintain, demand for energy to pump water in and wastewater out of the system is lower, and incidences of

GOOD PRACTICE BOX 9. Eco-cities allow ecological and economic progress to go hand-in-hand through integrated urban planning and management in Singapore

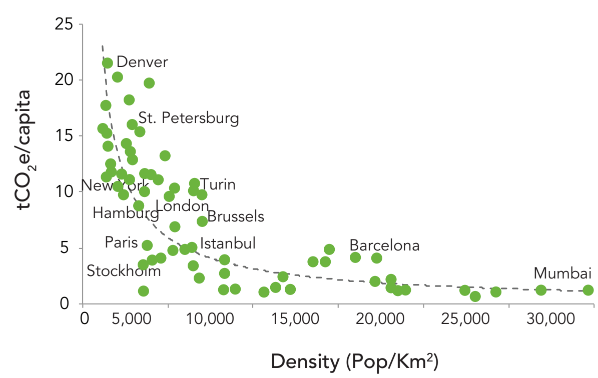
In many ways, Singapore is the prototype of effective urban environmental policy. Its clean and green image has even been a critical marketing tool in attracting foreign investment. The Singaporean Government is very successful in using a comprehensive mix of regulations and standards, financial incentives and pricing systems, consumer education and awareness, and capacity building.

The Green Plan 2012 was launched at the World Summit on Sustainable Development in Johannesburg in 2002 and has been reviewed and upgraded at 3-year intervals. Singapore has also been effective in applying a rigorous approach to developing tailored and coordinated solutions for each environmental goal. The Inter-Ministerial Commission on Sustainable Development launched the Sustainable Singapore Blueprint in 2009, setting out ambitious and specific targets for energy efficiency, water consumption, local air pollution, use of public transportation, water catchment areas, and green certification of buildings.

Background information from the Green Growth Best Practice Initiative, Green Growth Best Practice Assessment Report 2013. Seoul: GGBP.

FIGURE 8.2. Denser cities account for fewer GHG emissions per capita

GHG emissions per capita and density of population, global comparison



Source: World Bank Development Data Platform and Citymayors.com leaks are less frequent. Denser cities have fewer streets that need to be lit, so expenses on public lighting sector are lower.

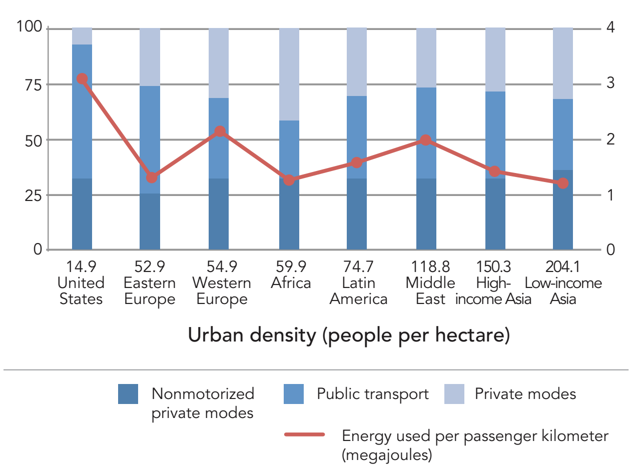
FYR Macedonia's cities are sprawling out and losing density. Macedonian cities' urban mass is growing at a faster rate than the city population. The number of new dwellings added annually is higher than actual population growth, and more than four times higher than the growth in the number of households (see Figure 8.4). A majority of new dwellings is represented by detached houses with four rooms or more, built on the outskirts of cities. This pattern is typical for transition countries: during transition, many cities expanded despite stagnating or even decreasing population, driven by the unmet demand for housing from the centrally planned systems. Available housing stock was mostly in apartments in multi-story buildings in overbuilt cities, while demand for single family housing was unsatisfied, and available land was usually on the city outskirts. As a result, most cities in transition countries have witnessed a process of de-densification of city centers, as people move out of crowded apartments to new dwellings, in many cases single detached houses in the city outskirts.

Municipal service provision in FYR Macedonia requires improvement. The most challenging problem is the dilapidated condition of the municipal assets. Management of public services is another area of concern. This involves such sectors as urban water and wastewater, urban public transportation, urban solid waste collection, and municipal buildings. Municipal water supply and wastewater services are characterized by unreliable service provision, high level of system losses, subsidization and low revenue collection. Wastewater treatment is almost non-existent leading to high level of water pollution. Water and wastewater assets are in a deteriorated condition. Solid waste collection rates are low, especially outside of Skopje, and recycling rates are the lowest in the region. Emissions from solid waste are among the highest in Europe. Energy efficiency of buildings can be improved and the municipalities can lead this transition. Street lighting efficiency can also be improved. Urban transport infrastructure has been declining and the quality and availability of public transportation has been decreasing. All these urban sectors require significant investment to bring urban services to a level compatible with that of the EU.

Today's investment decisions in Macedonian cities and municipalities will define their development path for the future, determining operational performance, energy intensity and emissions for decades to come. A careful assessment and weighing of different available options and between conflicting priorities across sectors is required to optimize public resource use for green growth in cities. This requires long-term, integrated planning across multiple sectors and stakeholders which has to be based on reliable and comparable information of the current situation to make informed decisions. The analysis done under the FYR Macedonia Green Growth urban sector work provides a first step in that direction.

FIGURE 8.3: **Urban form influences service delivery patterns and energy intensity**

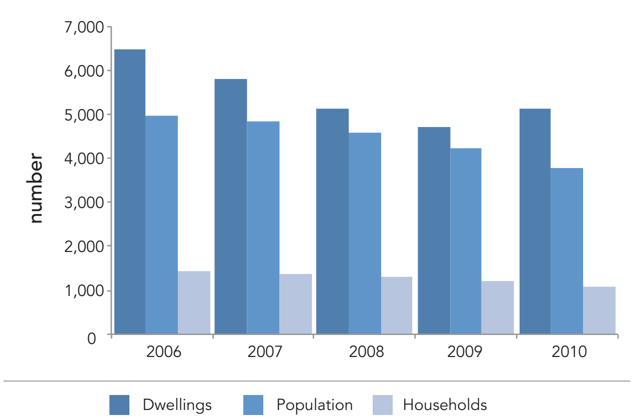
Urban density, transportation mode, and energy intensity of passenger transport, 2010



Source: World Bank Development Data Platform.

FIGURE 8.4: **Houses in FYR Macedonia are growing much faster than households**

Annual increase in number of dwellings, population, and number of households, 2006-10



Source: Statistical Yearbook of the Republic of FYR Macedonia, 2011.

METHODOLOGY AND MAIN FINDINGS

Methodology

The objective of the urban sector analysis was to assess the impact of urban policies and investments under different green growth scenarios in FYR Macedonia. Cities are complex, multi-sector and multi-stakeholder systems. To build a diagnostic that adequately assesses and tracks green performance in such systems, a staged approach from a general urban sector review to a simple multi-city indicator performance review and an in-depth single city-level analysis was applied. **The analysis was done using the following sequence:**

- **Step 1. General urban sector review.** A scoping paper was developed to summarize the current state of urban sector knowledge. The scoping paper reviewed urban policies, strategies and pertinent legislation; identified existing data sources; and provided a preliminary overview of key urban trends in FYR Macedonia, e.g. demographic shifts, growth dynamics in a spatial context, land and housing development patterns, and performance of municipal public services.

- **Step 2. An in-depth city level analysis was conducted in Skopje using the Tool for Rapid Assessment of City Energy (TRACE)** (see Box 8.1) for data collection and benchmarking. Although TRACE has a focus on energy efficiency, the scope of the city-level analysis goes well beyond that and includes urban transport, municipal buildings, street lighting, water and waste water, power and heating, and solid waste. Data on a number of indicators related to energy consumption within these six sectors were collected using TRACE. The tool provided a structured way to collect and analyze data. In addition, the same data were collected from other cities in the country to allow for benchmarking of performance and to identify areas of greatest potential efficiency gains. TRACE provided initial pointers and recommendation for implementing improvements.

BOX 8.1. The Tool for Rapid Assessment of City Energy (TRACE)[a]

TRACE is a decision-support tool developed by ESMAP (Energy Sector Management Assistance Program, World Bank) and designed to help cities quickly identify under-performing sectors, evaluate improvement and cost-saving potential, and prioritize sectors and actions for energy efficiency intervention. It covers six municipal sectors: passenger transport, municipal buildings, water and waste water, public lighting, solid waste, and power and heat.

TRACE is designed with the intention to involve city decision makers in the deployment process. It starts with benchmark data collection, goes through an on-location assessment involving experts and decision makers, and ends with a final report to city authorities with recommendations of energy efficiency interventions tailored to the city's individual context.

TRACE consists of three modules: an **energy benchmarking** module which compares key performance indicators (KPIs) among peer cities, a **sector prioritization** module which identifies sectors that offer the greatest potential with respect to energy-cost savings, and an **intervention selection** module which functions like a "playbook" of tried-and-tested energy efficiency measures and helps select locally appropriate energy efficiency interventions.

TRACE was initially field-tested with positive results in Quezon City, Philippines. The tool has since been deployed in thirteen other cities. In Turkey, TRACE helped define the Sustainable Cities pillar in Turkey's US$4.5 Billion Country Partnership Strategy with the World Bank for the years 2012-2015. In Indonesia, the World Bank used TRACE to create city-level case studies, the results of which are being used to create Sustainable Urban Energy Program guidelines for cities across the region. In Georgia, TRACE contributed to the development of the Georgia Municipal Development fund where a third generation of the fund will consider using the sustainable cities framework. TRACE is expected to be deployed in cities in Africa, Latin America and the Middle East in 2013. As new cities use TRACE, additional city benchmark data will be added to the tool, as well as more case studies, making it even more effective in the years ahead.

[a] ESMAP: http://esmap.org/TRACE

TRACE was used as a decision making tool for assessing potential energy and cost savings from implementing cross-sectoral energy efficiency measures in Skopie and to use the outcomes to plan the city's green growth in a systematic way, prioritizing policies and investments across sectors. The analysis had three objectives: (i) to assess potential energy and cost savings; (ii) to help local authorities and policy makers to think about cities in an integrated way; and (iii) to guide 'green' city planning. The analysis focuses on six municipal service areas that are typically under the responsibility of cities: urban transport, municipal buildings, water and wastewater, power and heat, street lighting, and solid waste management. Indicators used in the analysis included both energy and non-energy measures, the latter providing recommendations beyond energy savings. The findings were assessed using a benchmarking process that compared Skopje with other cities included in the international TRACE database and helped prioritize possible interventions. For comparison purposes, cities were selected based on the level of development, climate, and population.

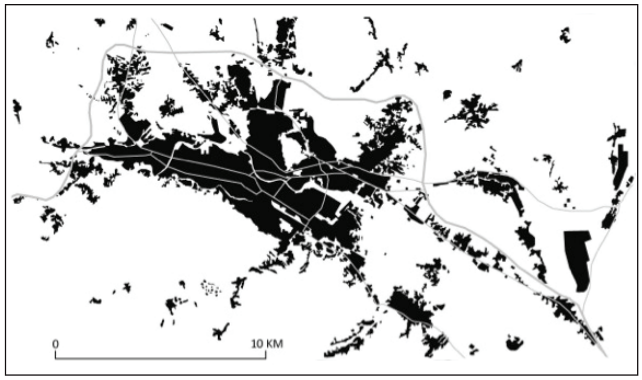
- **Step 3. To complement TRACe's analysis of Skopje, rapid assessments were conducted in selected additional Macedonian cities** using indicators from various tools, including TRACE and International Benchmarking Network for Water and Sanitation Utilities (IBNet). The objective was to make selected in-country comparisons and to prioritize proposed green growth policy actions outside of Skopje.

Main findings

Urban sprawl increases per capita emissions and drives up the cost of public service delivery. FYR Macedonia's cities are sprawling out and loosing density. This relates to most of cities, but more so to Skopje (Figure 8.5), which is now five times as large as the second largest city Kumanovo. Urban sprawl leads to increased emissions and problems with public service delivery pushing their cost up and their quality down. The main source of increased urban emissions is a growing number of urban single family houses that use dirty fuels for heating and cooking, which is not usually an option in apartment buildings. Problems with service delivery are related to a larger city territory, which means that such networks as transportation, water and sanitation, solid waste collection, roads, street lighting and other infrastructure need to be expanded in areas with lower population density and therefore higher per household service cost.

Buildings insolation and increased energy efficiency of street lighting could help reduce emissions significantly. Energy consumption and emissions from public buildings can be significantly reduced using thermal insulation. Globally, buildings are responsible for up to 40 percent of primary energy use and 30 percent of global GHG emissions[147]. In FYR Macedonia, residential, commercial and public buildings combined account for over 40 percent of total energy consumption and 6 percent of electricity and heat consumption. This makes them the top energy consumer in the country and therefore the top emitter. Most of the energy in buildings is used for heating (67 percent), followed by lighting and electrical appliances (15 percent)[148]. Cost savings can be mainly achieved from thermal insulation, fuel switching and increased efficiency of heating and cooking appliances[149]. Local authorities in FYR Macedonia have already started taking measures to address building energy efficiency, primarily in

FIGURE 8.5. **Skopje is sprawling outwards**



Source: Urban sector paper.

Skopje, and the thermal performance of municipal buildings has significantly improved.

Street lighting energy efficiency improvements has cost savings potential. Although public street lighting accounts for only 1.42 percent of total electricity consumption in FYR Macedonia, it translates into expenses significant for municipal budgets. The efficiency of street lighting is low because the bulbs currently used produce little light and a lot of heat. In 2007, 86 percent of all street lamps had energy inefficient mercury vapor light bulbs[150]. Modern sodium lamps have a lifetime period three times higher than that of mercury vapor bulbs and generate more than double their light output. Bulb replacement therefore can significantly increase street lighting efficiency. Many cities in FYR Macedonia started bulb replacement programs. In 2008-09, Skopje replaced 60-70 percent of street lights on the main streets. Bogdanci, a small town in the south of FYR Macedonia, saved 47 percent of the electricity bill as a result of street light bulb replacement: using a loan, the city replaced 520 inefficient lights and extended the street lighting system. In addition, maintenance costs were reduced by 78.4 percent.

Emissions from urban transport are driven by an increase in private car ownership and old vehicle fleet in both private and public segments. [151] Transport is the second largest emitter in FYR Macedonia, following energy sector. The share of transport emissions in total stayed stable over the last 20 years, while the level of emissions has increased significantly. The primary reason for growth in transport sector emissions in the increase in private car ownership: a growing number of passenger cars and a growing number of car trips. This trend was paralleled with the cities' sprawling, intensifying it and being exacerbated by it. With decreasing density, public

147. United Nations Environment Program (UNEP). 2009. Buildings and Climate Change. Summary for Decision Makers. Paris: UNEP.

148. European Commission's Energy Efficiency Plan: http://ec.europa.eu/energy/efficiency/action_plan/action_plan_en.htm

149. See more information in the Energy chapter.

150. Energy Charter Protocol on Energy Efficiency and Related Environmental Aspects (PEEREA). 2007. In-depth Review of Energy Efficiency Policies and Programmes. Brussels: Energy Charter Secretariat

151. See more information in the Transport chapter.

transportation networks become less economical and have to reduce coverage, leaving even more urban residents without public transport and leading to even higher rate of private transportation. Between 2006 and 2010, the number of public transit lines fell by 25 percent, their total length dropped by 42 percent, the number of public transport vehicles and seating capacity decreased by 16 percent, and urban public transport ridership shrank by 100 million people from a peak of 164 million in 1988 to 64 million in 2010 (Table 8.1, Figures 8.6-8.7).

Public transport is old and emissions-intensive, but first steps to improve the situation have been made.[152] Buses represent the only public transport available in FYR Macedonia, and out of 494 urban public transport buses, 459 are in Skopje (2010). The bus fleet is very old. From 2001 to 2007, there were almost no efforts to renew it and the decrease in quality of service was dramatic. Private bus operators were allowed to in 1994, and the competition decreased demand for public transportation. In 2011, Skopje procured 200 new double-decker buses. As a result, ridership has increased substantially with the introduction of the new buses. In 2011, Skopje public buses carried 10 percent more passengers than in 2010. In parallel, Skopje together with the Public Transport Enterprise started an initiative aimed at converting part of the old vehicle fleet from diesel to natural gas.

Increased air and water pollution from wastewater and solid waste caused by the run down sector assets and unacceptable waste collection and disposal practices, as well as insufficient management capacity lead to increased emissions. Limited wastewater treatment has become a major source of water pollution. Although countrywide 80 percent of the population has access to wastewater collection, only 5 percent of the sewage is currently being treated. Most of the wastewater is being discharged directly into rivers and lakes. For example, Skopje does not have a functioning wastewater system. All of the wastewater is discharged into the Vardar virtually untreated. Local authorities indicate that the Vardar River enters Skopje with Category II level pollution and leaves the city with higher pollution, at Category III or even IV.

GHG emissions from waste have been increasing in the transition years due to rising waste quantities and inappropriate disposal practices. GHG emissions from solid waste in FYR Macedonia are almost double the EU average. Although FYR Macedonia generates less waste per capita than most of European countries, the share of emissions from waste is estimated at almost 6 percent, compared to around 3 percent globally. The high share of emissions from waste is a result of waste disposal in landfills without a treatment (occurs with most of waste), widespread wild dumps and waste burning in backyards. In Skopje, only 87 percent of generated waste is collected. Landfills usually don't comply with minimum disposal standards: the 'Drisla' landfill, which serves the Skopje region, is the only one complying with these standards. All other municipal landfills dispose of waste openly, without minimum engineering standards to meet basic environmental criteria, let alone methane gas capture. Frequently, hazardous waste, including medical and animal waste, is disposed of together with regular waste, which causes serious risks to public health. (Figure 8.8)

152. Transport sector modeling included policy options related to public transportation, see Chapter 7.

TABLE 8.1. Urban transport network and equipment declines

Main urban public transport indicators

	2006	2007	2008	2009	2010
Number of Lines	195	167	148	136	145
Length of Lines, Km	4,109	4,073	3,417	2,096	2,394
Number of Vehicles	773	722	670	651	650
Seating and Standing Capacity	87,846	82,522	77,163	74,775	74,178
Average Number of Vehicles	435	380	408	355	494
Passengers Carried (in '000)	66,687	61,147	64,378	65,151	64,120

Source: Statistical Yearbook of the Republic of FYR Macedonia , 2011

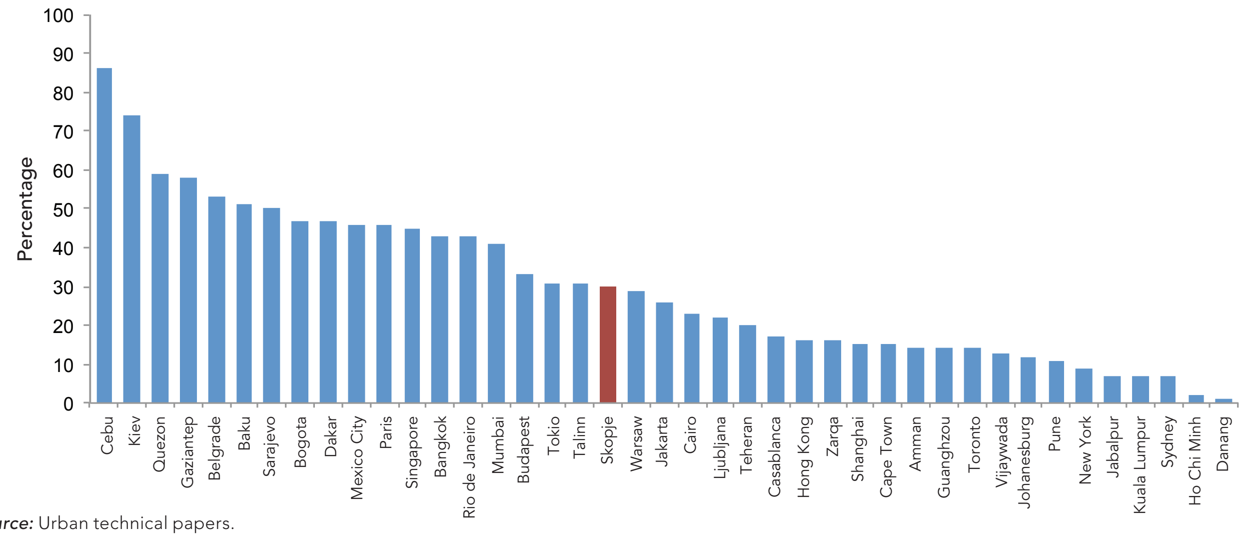
Waste collection coverage and recycling rates remain low, particularly in rural areas. In 2008, only 60-70 percent of the urban population was covered by regular municipal solid waste collection services. In some rural areas, collection coverage is as low as 10 percent. As a result, solid waste is disposed of in wild dumps. The recycling industry is small and dominated by the informal sector. Only a few cities including Skopje started introducing separate collection systems for recyclables. Still, Skopje's recycling rate of 1.5 percent ranks among the lowest in the region (2008).

The existing waste management system is atomized and mostly inefficient. Upgrading it to reach the EU standards will require most of the existing landfills to be closed. Only a few of the existing sites could be economically rehabilitated to meet the EU sanitary disposal standards. In addition, the system is inefficient due to high market fragmentation, which prevents it from achieving economies of scale. Municipalities operate a vast number of small dumps, with 45 municipal landfills covering only 15,000 people per landfill[153], many of them close to each other, servicing municipalities within a

153. According to the National Waste Management Plan 2008-14

FIGURE 8.6. Share of public transportation in Skopje is below average

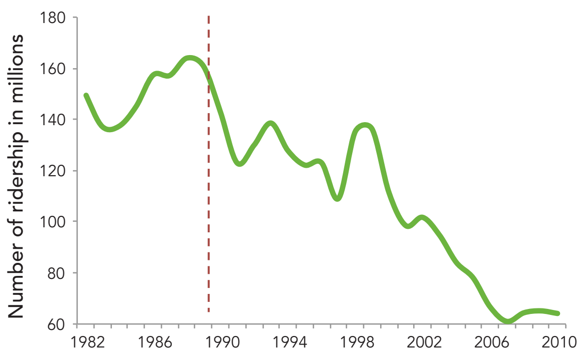
Share of public transportation, global comparison



Source: Urban technical papers.

FIGURE 8.7. Urban public transport ridership in FYR Macedonia has been declining

Ridership



Source: Statistical Yearbook of the Republic of FYR Macedonia, 2011.

radius of no more than 10-30 km. Outdated collection equipment is often fuel inefficient and adds to high operating cost and to emissions.

Municipal water supply in FYR Macedonia suffers from high technical losses and low revenue collection. The networks are old, mostly built before the 1990s and some constructed more than 100 years ago, they are in dire need of rehabilitation. This causes significant water losses ranging between 40 and 80 percent in Macedonian cities[154]. Skopje has one of the highest levels of water loss in the region equaling 61 percent. Cities in FYR Macedonia had higher water system losses and collected fewer revenues compared to other cities in the ECA region (Figure 8.9). Two main causes have led to high losses:

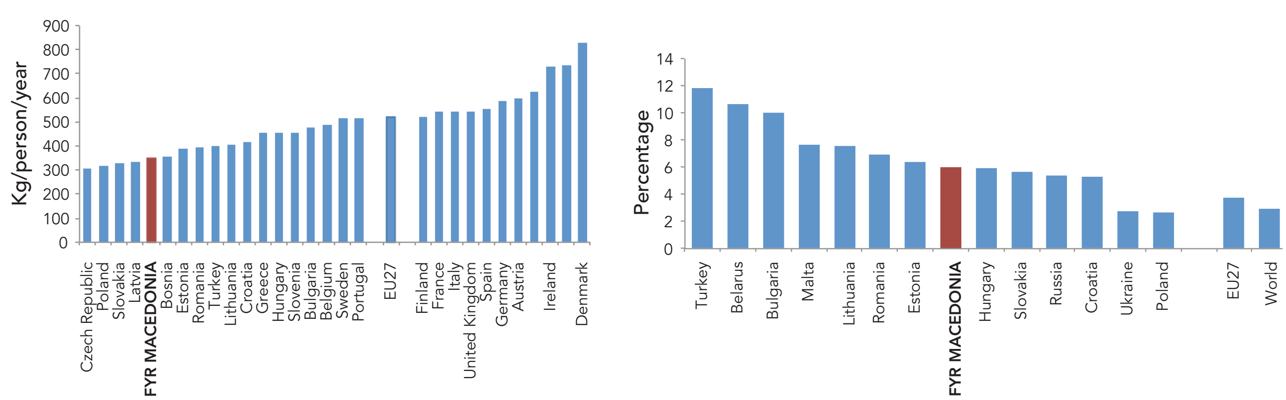
154. World Bank, International Benchmarking Network for Water and Sanitation (IBNet): www.ib-net.org/

FIGURE 8.8. FYR Macedonia generates less waste than other EU countries

Waste generated and percentage of GHG emissions from waste

A. WASTE GENERATED

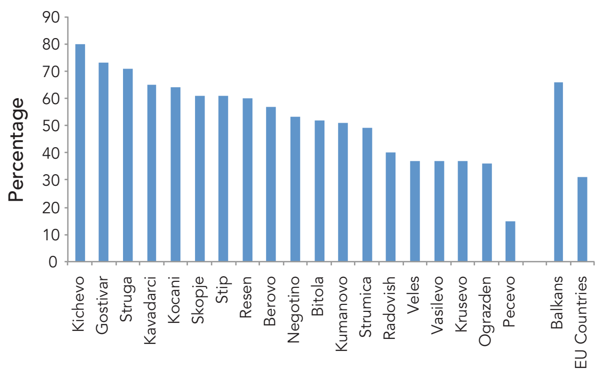
B. GHG EMISSION FROM WASTE



Source: Statistical Yearbook of the Republic of Macedonia, 2011.

FIGURE 8.9. **The level of non-revenue water in FYR Macedonia is high comparable to cities in the region**

Percentage of non-revenue water: Macedonian cities and regional averages



Source: World Bank IBNet.

relatively old network infrastructure and poor metering, the latter accounting for an estimated 20 percent of losses.

RECOMMENDATIONS

The following actions would address urban sprawl and urban service deterioration, the main problems in urban development in FYR Macedonia, and help to reduce urban emissions: urban planning, public transportation improvements, energy efficiency measures, water network rehabilitation and metering of water supply, wastewater infrastructure rehabilitation, and creation of regional waste management systems.

Urban planning: developing integrated urban plans and providing incentives to make city centers more livable will decrease urban sprawl. Local authorities can influence dwelling patterns through investment decisions and urban planning that provide incentives for citizens and businesses to stay in the core city. This will require integrated planning across departments in city administration and better enforcement of existing planning regulations: building permits, parking zones, and business licenses.

Public transport sector: improve coverage and quality of public transport and invest in non-motorized transport modes. The recent positive trend of increasing public ridership numbers should be continued in Skopje and expanded to other cities in FYR Macedonia. In parallel, cites may consider extending pedestrian and bicycle infrastructure. Potential cost savings from extending non-motorized transport modes and implementing parking and traffic restraint measures in Skopje are estimated at US$7.0 million; while cost savings of US$4.1 million are expected from upgrading public transport infrastructure.

Energy efficiency: expand energy efficiency improvement programs beyond Skopje and other pilot cities. In Skopje, potential cost savings from energy efficiency improvements in municipal buildings and public street lighting are estimated at US$1.4 million. However, despite strong financial incentives, replication of existing experience across the country is yet to start. Municipalities need to require better dissemination of pilot experience and information about available funding sources and financial instruments.

Water sector: investing in water network rehabilitation and metering to reduce losses and increase cost recovery. Network rehabilitation should have priority over network extensions. Also, technical water losses should be reduced. Municipalities need to address low cost recovery caused by a combination of operational inefficiencies, low tariffs and low revenue collection. Municipalities should request utilities to draft and adopt operational performance improvement plans, achieve 100 percent water metering and upgrade meters to ensure proper functioning. Local authorities need to implement tariff increases and reduce untargeted subsidies, which led to over-consumption of water and financial melt-down of utilities.

Wastewater sector: access available grant funding to invest in wastewater treatment infrastructure. Financing to improve wastewater treatment is available from the European Commission Instrument for Pre-Accession (IPA) and International Financial Institutions. Municipalities should use these resources and require technical assistance from central government to facilitate access to capital investment funds.

Solid waste sector: accelerate establishing integrated regional waste management systems. Annual GHG emissions could be reduced by more than 160,000 tons per year by installing methane capture and flaring devices at existing landfills. However, given the cost of integrated solid waste management, municipalities need to cooperate at the regional level to benefit from economies of scale. Although FYR Macedonia has assigned six waste management regions to implement regional waste management plans, progress on the ground has been very slow. More targeted support and assistance from the central level is required. Also, municipalities should extend waste collection coverage to 100 percent of the population, including in rural areas, upgrade waste collection equipment and start implementing waste separation schemes. International experience in improving landfills and establishing recycling and waste separation and processing practices could be replicated (see, for example, the experience of Japan and Turkey).

GOOD PRACTICE BOX 10.

Waste management in Japan and Turkey

IMPROVED WASTE MANAGEMENT IN YOKOHAMA, JAPAN

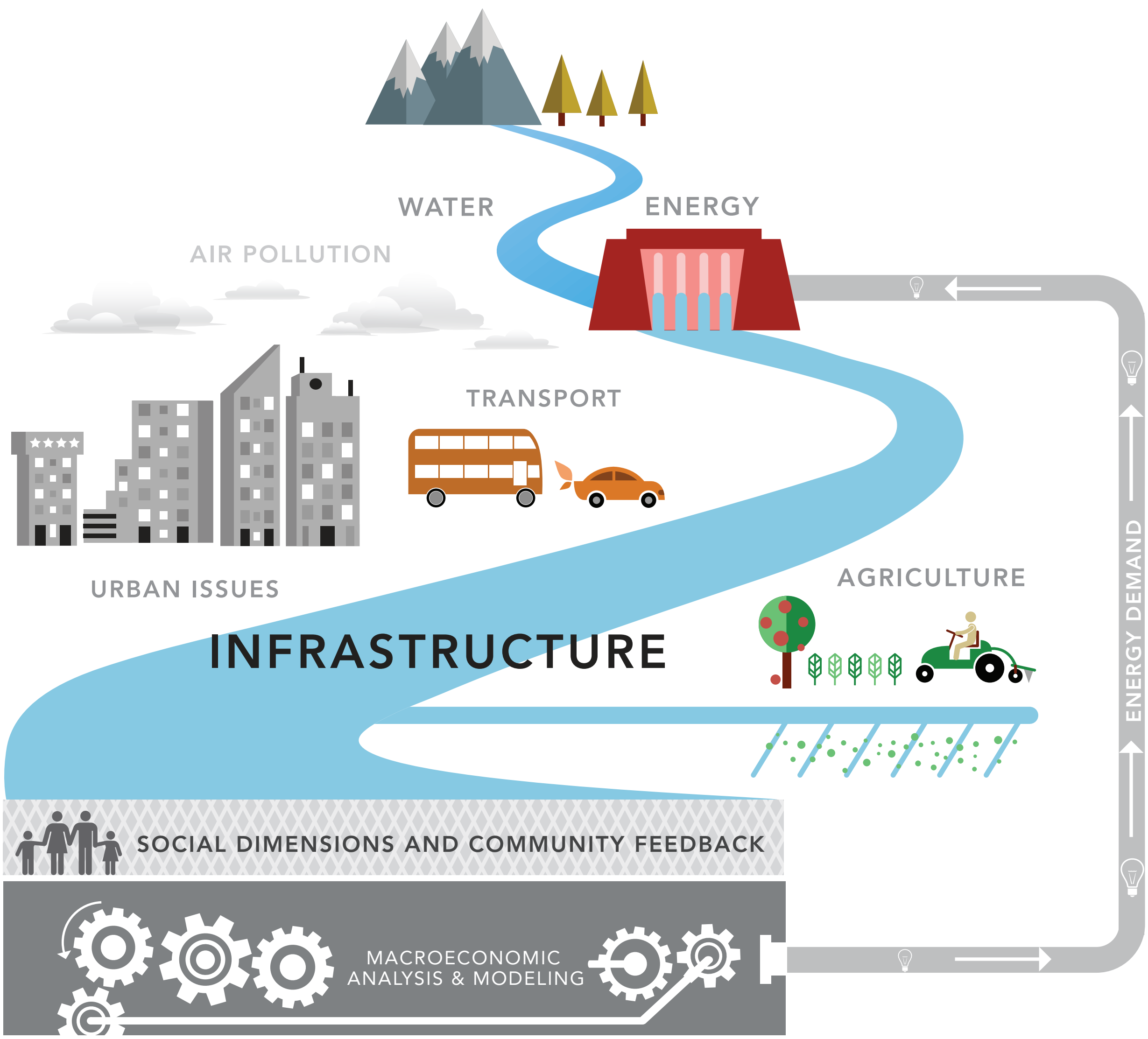
In Yokohama, Japan, improved waste management has generated ecological as well as economic surpluses. During a period when population grew by 170,000, Japan's second largest city managed to reduce solid waste by 38.7 percent. Urban planners integrated waste management with stakeholder engagement to pursue the goals of reducing waste and increasing recycling. When the city doubled its trash categories to 10, it handed residents a 27-page booklet with detailed instructions on how to sort their trash. The significant waste reduction allowed Yokohama to save US$1.1 billion in capital costs and US$6 million annual operation and maintenance costs.

CONVERTING HAZARDOUS LANDFILLS INTO A RECYCLING FACILITY IN TURKEY

Turkey's success with landfill rehabilitation is an example of an innovative project that produced combined economic, environmental, and health benefits: it reduced methane and carbon dioxide emissions, eliminated health hazards from improperly disposed waste, created a new renewable energy generation facility that utilizes waste, increased local employment and improved quality of life in the area surrounding the landfill.

The horrible smell from the decomposing waste at the Mamak landfill along the highway has long been an assault to visitors coming from the airport into the capital city of Ankara in Turkey. The residues caused serious environmental and health problems. With financing from the World Bank through the Industrial Development Bank of Turkey, the landfill was converted into a garbage-recycling station that creates heat and energy for local greenhouses. A bio-digester at the facility treats organic waste and produces biogas, which is then used to generate power and heat in a power plant with 14.6 MW of capacity – enough to power 31,000 households in Turkey. Recyclable waste such as glass and plastics are processed and sold. What remains is less than 10 percent of the incoming waste mass, which is placed back in the landfill, covered with soil and reforested. The excess heat produced by power generation and waste processing is fed to a greenhouse where tomatoes are grown. Heat will also be provided to a new café on the site.

Source: World Bank. 2010. Lights Out? The Outlook for Energy in Eastern Europe and the Former Soviet Union. Washington, DC: World Bank.


WATER
ENERGY
AIR POLLUTION
TRANSPORT
URBAN ISSUES
AGRICULTURE
INFRASTRUCTURE
ENERGY DEMAND
SOCIAL DIMENSIONS AND COMMUNITY FEEDBACK
MACROECONOMIC
ANALYSIS & MODELING

CHAPTER 9

Should Infrastructure Be Built Differently to Be Climate Resilient?

CHAPTER SUMMARY

Building physical infrastructure[155] resilient to future climate change is an important component of green growth. However, climate change projections are typically not taken into account in planning infrastructure investment and maintenance, and there is no agreed practice of how to do it. It is clear that there are two alternative approaches: (i) ***an adaptive strategy***: building more resilient infrastructure in anticipation of climate change as projected and (ii) ***a reactive strategy***: maintaining existing design standards and managing the impacts of climate change once they are realized. The adaptive strategy involves high up-front investment balanced by lower costs during the life of the asset. The reactive strategy involves the risk of a costly replacement of the infrastructure before the end of its economic life. The choice between the adaptive and reactive strategies is complicated by two considerations: a wide range of projections of the future climate and a long life of the infrastructure assets, most of which cannot be easily upgraded. The question is how to include climate change projections in infrastructure planning bearing in mind all these considerations. Should infrastructure be built differently to be climate resilient?

This chapter develops a framework for decision-making when planning for the development of infrastructure assets in the context of climate change. The methodology combines cost-benefit analysis under uncertainty, climate-informed decision analysis, and robust decision-making. Relationships reflecting the sensitivity of the infrastructure service costs to climate conditions are an essential element of the model. The analysis applies a cost-benefit approach over a range of climate scenarios to identify robust options. Rather than using a cost-benefit approach to select optimal infrastructure development and investment plans based upon specific assumptions about key parameters, the focus is on identifying a subset of infrastructure development and investment plans that are likely to yield satisfactory results under a range of climate outcomes.

It is recommended that FYR Macedonia apply the adaptive approach to some assets and the reactive approach to other assets. The priorities for adaptation include urban drainage systems, health and educational facilities, and municipal buildings. For these infrastructure assets, design standards and operations and maintenance practices should be modified based on projected climate conditions ten to twenty years from the date of construction. In contrast, the best option for roads is to follow a reactive strategy and to plan enhanced maintenance and upgrades to respond to weather stresses. For other sectors including power, telecoms, water and sewer

155. All types of infrastructure are included in the analysis: electricity-generating capacity, fixed telephone lines, roads, rail, airports, ports, water and wastewater treatment facilities, transmission and distribution lines, water/sewer infrastructure, hospitals, health facilities, school buildings, municipal infrastructure, urban storm water drainage, dwellings of durable materials, and others.

networks, and non-road transport, costs and benefits of adaptation are small, and the reactive strategy will be sufficient. Finally, monitoring weather outcomes and updating climate projections using the data collected is essential. Assessment of the optimal choices for infrastructure planning must also be updated regularly using the latest climate projections.

CHALLENGES FOR GREENER GROWTH

Overview

Building physical infrastructure resilient to future climate change is an important component of green growth. Climate-resilient infrastructure reduces shocks to the economy and society from increasingly severe weather, which is characteristic for a changing climate. Countries with infrastructure that can sustain weather shocks have much lower costs of the after-shock recovery and are able to implement actions needed for the recovery in a timely fashion. This relates not only to the economic aftermath of such shocks, but also to human outcomes, such as a reduced death and injury toll. The importance of weather resilient and high quality infrastructure makes it one of the main indicators of a country's sensitivity to climate change.[156]

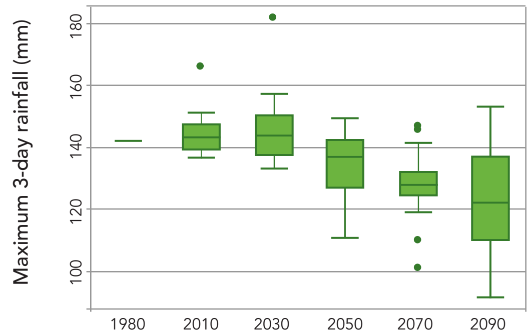
Climate change projections need to be taken into account in planning infrastructure investment and maintenance. However, currently the level of the infrastructure resilience is engineered based on the past weather experience, typically using the weather patterns of the preceding 40 years, without considering projected climate change. Since the weather and climate conditions of the past are no longer a good guide to the future, they no longer constitute a good basis for infrastructure engineering decision-making. If current practices are not changed, higher summer temperatures, more intense precipitation, flooding or water shortages, and more severe freeze-thaw cycles will drive up the costs of infrastructure maintenance and require that infrastructure be replaced before the end of its economic life. However, despite a clear need in including climate change projections in infrastructure planning, there is no agreed practice on how to do it.

Development of a new practice of including climate change projections in infrastructure planning is complicated by two considerations: uncertainty about future climate patterns (a wide range of projections of the future climate) and the long life of infrastructure assets, most of which cannot be easily upgraded.

156. An index of sensitivity to climate change is described in Box 1.1. Measuring Vulnerability to Climate Change.

FIGURE 9.1. Impact of climate change on weather patterns is uncertain

Distribution of maximum 3-day rainfall for FYR Macedonia for 17 climate scenarios from 2010 to 2090



Source: Infrastructure technical paper.

Uncertainty about future climate patterns means that planners do not know to what conditions they should adapt. Current climate models agree that global mean surface temperatures will increase under the business-as-usual scenario, but disagree about the extent to which temperatures will increase, globally or at particular locations. Similarly, though there is relative agreement that climate change will increase the intensity of precipitation events, and the frequency and intensity of extreme weather events, there is little agreement among the models on such issues as whether total rainfall will increase or decrease in particular regions or the extent of increase in frequency of extreme events. This creates difficulties in accounting for climate change in infrastructure planning. For example, a key factor in designing roads to cope with flooding is the amount of short-term rainfall intensity. At the same time, there is a large variation in projections of rainfall intensity, as shown in Table 9.1. The median value for the maximum three-day rainfall (shown by the solid line in the boxes) increases up to 2030 and thereafter decreases. At the same time, the full range of the distribution increases over time. Should the planner build roads to cope with the median value, the maximum value or the minimum value?

Most of the infrastructure assets are long-lived and cannot be upgraded easily. For some types of infrastructure, the cost of adapting upfront will be lower than the cost of doing nothing and relying on O&M or early upgrade to cope with climate impacts for the same climate outcome. While in the case of roads, it is neither difficult nor expensive to upgrade the specification of pavements to cope with higher temperatures or to install additional culverts to cope with higher precipitation as a part of intermittent maintenance or upgrading operations, it will be much more difficult to raise bridges or divert the route of roads to accommodate more extreme flooding or to increase the size of underground sewers to handle higher water flow (Table 9.1 provides economic life data for different infrastructure assets). Difficulty in upgrading some infrastructure assets will bias the decision in favor of building infrastructure differently. (See Good Practice Box 11 on how flexibility of project design in the Thames Estuary 2100 project in London reduces the risk of financial loss in the future).

GOOD PRACTICE BOX 11. The UK's Thames Estuary 2100 Project

The Thames Estuary 2100 Project (TE2100) in London is an integral part of the city's flood risk management strategy that has reduced the uncertainty of the planning process, such that decisions made today are more resilient to changes in future climate. In 1980, the Thames barrier was opened for construction to guard Central London against storm surges until 2030. However, the protection system might need interim modifications, given that the central risk components – the frequency and intensity of storm surges – are expected to increase with climate change.

Flexibility is essential for infrastructure investment adaptation projects, since they are often large-scale, costly and irreversible, while at the same time based on decisions made in light of uncertain climate risk projections. Investment costs under certain scenarios in TE2100 can reach £9 billion. Therefore, TE2100 adopted a 'route-map decision analysis' (or a 'decision pathways approach') to sequence packages of adaptation options over a broad range of possible climate scenarios by 2100. Initial packages are 'no-regrets' measures that suit almost all scenarios and allow resources for adjustments in the future, when risk is better understood. Examples include early warning systems and construction of walls with larger foundations so that they can be raised rather than replaced. Packages at later stages include more irreversible measures such as building a new barrage as opposed to upgrading the existing one. Construction in each package is to be triggered when water levels cross a pre-determined threshold, budgeting for lead time needed for implementation. The flexibility to examine whether and when the system needs to be modified can increase the overall costs, and therefore economic analysis (net present value of investments and environmental impact) will be applied.

Encouraged by the example set by the UK's Environment Agency, similar route-maps are also being proposed in New York City and the Netherlands as part of their climate change adaptation strategies.

Source: Reeder, Tim and Nicola Ranger. 2011. "How do you adapt in an uncertain world? Lessons from the Thames Estuary 2100 project." World Resources Report 2010-2011: Decision Making in a Changing Climate. Washington, DC: World Resources Institute.

TABLE 9.1. Infrastructure assets are long-lived

Commonly assumed economic life of selected infrastructure assets

LIFE (YEARS)	INFRASTRUCTURE ASSETS
10	Unpaved roads
20	Airports
40	Generating plants, fixed telephone lines, ports, water & wastewater treatment, electricity networks, water networks, health, education & social infrastructure
50	Paved roads, railway track
60	Sewer networks, housing

Source: Infrastructure technical paper.

METHODOLOGY AND MAIN FINDINGS

Methodology

This chapter develops a framework for decision making when planning for the development of long-lived infrastructure assets in a context of uncertainty about future climate conditions. The decision making framework considers two basic alternative approaches: (i) **adaptive strategy**: creating new infrastructure construction standards in anticipation of climate change as projected and (ii) **reactive strategy**: maintaining existing design standards and managing the impacts of climate change once they are realized. Adaptive strategy involves high up-front investment and lower costs during the life of the asset. Reactive strategy involves a risk of a costly replacement of the infrastructure before the end of its economic life. The choice between these two approaches should be based on comparing the cost of building stronger infrastructure (adaptive strategy) and the cost of more frequent maintenance or partial reconstruction. The decision making framework is applied to a range of infrastructure types: transport (roads and rail), electricity, water and sanitation, communications, urban drainage, urban housing, and health and education facilities.

The framework uses a combination of methods – cost-benefit analysis (CBA) under uncertainty, climate informed decision analysis (CIDA) and robust decision making (RDM). Relationships reflecting the sensitivity of the costs of providing infrastructure services to climate conditions are an essential element of the model. The analysis applies a cost-benefit approach (CBA) over a range of climate scenarios to identify robust options. Rather than using CBA to select optimal plans based upon specific assumptions about key parameters including climate projections, the focus is on identifying a subset of options that are likely to yield satisfactory cost-benefit results under a range of climate outcomes. The framework is applied to decisions made at the beginning of each five-year period from 2015 to 2050. It involves four broad steps:

- **Step 1 is defining the baseline infrastructure needs for all asset types** for each five-year period from 2015 to 2050. The baseline infrastructure needs are defined under the assumption that the past climate conditions will continue into the future and there will be no necessity to cope with the future climate change. The baseline is calculated on the basis of such indicators as GDP per capita, population, and climatic conditions. The approach taken is to assume that there is sufficient infrastructure and that it is built to the right design standard such that there is no adaptation deficit. This assumption holds for the entirety of the investment profile so that in the future too investments are made to cope with weather variability present at the time of the investment.

- **Step 2 is estimating the costs[157] for each infrastructure category under adaptive and reactive strategies.** Costs of the adaptive strategy are defined as the present value of the sum of the baseline cost of the project (the costs to be incurred under the assumption that future climate conditions will be identical to the historic climate), incremental capital costs of the adaptive strategy due to the prospect of climate change, and O&M costs that must be incurred annually. Costs of the reactive strategy are defined as the present value of the sum of the baseline cost of the project, annual O&M costs, and costs of upgrade or early replacement of the asset. O&M costs under the reactive strategy will be higher than O&M costs under the adaptive strategy for the same climate event.

  The main factors of the costs in both strategies are the impact of climate events on the infrastructure, the planning horizon, and the nature of the climate uncertainty. To measure the impact of these factors, certain functions are used and decisions made:

  - *Stressor-response functions.* For each infrastructure category a set of dose-response relationships between the relevant climate stresses and the costs are specified using detailed evidence collected by engineers from experience around the world[158]. These dose-response relationships capture the change in costs as materials and designs are altered to maintain the quality of the infrastructure services in the face of climate change. For example, more expensive binders have to be used in the pavement layer of roads if they are exposed to higher temperatures; more culverts may have to be installed to minimize the risk of flooding and the damage caused by standing water.

  - *Planning horizon.* How far ahead should a planner look when taking account of climate change in designing new infrastructure? Should the planning horizon be the same for all climate scenarios? The economic life of the assets considered in the study ranges from 10 to 60 years (see Table 9.1 for details). Building assets that are capable of withstanding weather stresses that they may only encounter at the very end of their life is likely to be an unnecessarily expensive strategy. For pragmatic reasons, therefore, the maximum planning horizon examined in this study is 40 years, so one option for assets built in 2045 is to construct them so that they are capable of withstanding the weather stresses to which they may be exposed in 2085. The minimum planning horizon is zero years. The analysis also examines planning horizons of 10, 20 and 30 years in order to assess whether the most economic planning horizon varies across types of infrastructure or over time.

  - *Climate uncertainty.* Finally, it is important to estimate the costs across a wide range of climate projections. There is no one 'correct' future climate projection. Different climate projections are based on structural models that are conceptually different and should be treated as being equally likely. It would be wrong to rely on probability-weighted combinations of different projections or to rely on the average of all projections. The analysis carried out in preparing this chapter examined 17 climate scenarios up to 2090 that are based on separate Global Circulation Models (GCMs) runs using the A2 SRES scenario for emissions of CO_2 and other greenhouse gases.[159] The projections for the key climate variables – monthly average, minimum and maximum temperatures plus precipitation – for each GCM are constructed by calculating average differences for

157. The cost analysis is limited to non-extreme weather events and does not include catastrophic failures linked to climate events–bridges falling down, roads being washed away, buildings being destroyed by wind or storm surges. This is done for two reasons. First, this allows to simplify the analysis and to avoid the necessity of specifying a damage function associated with every climate event. Second, it is hard to estimate the shift in the distribution of extreme events that is caused by climate change because these events are too rare for drawing statistically reliable conclusions on the basis of existing observations.

158. The dose-response relationships used in this study reflect the economic and engineering choices made by a wide pool of experts based upon their collective knowledge.

159. It is possible to obtain a larger set of 26 or more GCM projections on a consistent basis for a specific SRES scenario, but the suite used here is smaller because not all of the projections provide values for maximum and minimum temperatures, which are important for examining the impact of climate change on infrastructure. Additionally, the analysis in this paper does not explore the implications of uncertainty surrounding climate projections from a given GCM. GCMs are usually stochastic and therefore repeated runs of these models generate a distribution of future climate projections. When reference is made to the projections generated by a GCM, that is, to a climate scenario, this usually refers to the mean or median projections of interest.

2026-35 (2030), 2046-55 (2050) and 2086-95 (2090) for 1° grid squares with respect to the average of runs for the same GCM over the period 1960-99. These differences were added to the mean values of historical climate variables, obtained from the CRU historic dataset,[160] for the same time period and interpolated to generate projections for each time period. Since the costs of adaptation are affected by changes in humidity as well as extreme values (represented by the 99th percentile) of both temperature and precipitation, statistical models based upon historical data have been used to estimate the changes in weather variables that are not generated directly by the GCMs.

- **Step 3 is filtering out infrastructure categories for which adaptation is cost effective**. As an initial filter in considering whether upfront adaptation is justified, planners should look at whether it is cost-effective to adapt under perfect foresight. The motivation for this step is that if ex-ante adaptation cannot be justified when the decision maker has complete information about future climate outcomes, then it will not be justified when allowance is made for the effects of uncertainty about future climate scenarios. If the planner knows with certainty what climate pattern will evolve, then there is no risk that the initial investment in adaptation will be redundant. This step allows the planner to identify the types of infrastructure for which there is a prima facie case that adaptation is cost-effective.

- **Step 4 is defining a robust adaptation strategy.** For all infrastructure categories where adaptation is cost effective, a robust adaptation strategy, that is, a strategy that is optimal for a wide range of climate outcomes, needs to be defined. The key idea is to focus on the expected cost of the errors associated with each option. The analysis makes use of standard economic models of decisions subject to uncertainty**.** The identification of a robust adaptation strategy relies upon a systematic evaluation of all possible combinations of planning scenarios, planning horizons, and climate outcomes. The objective is to identify a set of planning assumptions that minimize the risk of making particularly costly mistakes and, at the same time, perform reasonably well for a range of climate outcomes.

Table 9.2 provides an illustration of an adaptation cost matrix across a range of climate scenarios covering the entire range of the adaptation costs. Note that the net adaptation costs (the difference between the final two rows in the table) is positive for the MIROC and the NCAR scenarios, but not for the other three scenarios. This suggests that adaptation may be cost effective for the former two scenarios and the planner needs to identify a robust adaptation strategy. The matrix also shows that if the country is not risk averse, the best planning scenario would be a scenario with one of the lowest expected adaptation cost: Reactive, MIROC or NCAR. If the country is highly risk averse, then it would wish to minimize the worst outcome given the choice of the scenarios. In that case it should focus on the column marked "Max" and the best scenario would be the MIROC scenario. For less risk averse planners, the analysis to identify a robust strategy must also include a measure of the variability of the distribution of adaptation costs over climate outcomes and the planner would want to identify a strategy that has a low mean and low variation. The reactive and the CSIRO scenario have a high variation in outcomes, whereas the UKMO has the lowest variation but a high mean. The UKMO outcome is consistently among the worst climate scenarios for all of the planning scenarios. The MIROC and the NCAR scenarios, on the other hand, have the lowest average costs and the lowest variability. Although there are small differences between them, there is no strong reason to prefer one over the other, so either of them may be considered robust.

The adaptation cost matrix can provide the starting point for a variety of other analyses. For example, the calculation of the expected adaptation costs under uncertainty can be adjusted if planners believe that some climate scenarios are more likely than others for the country. The choice of a planning horizon can be incorporated into the analysis by allowing selection over combinations of climate scenarios and the planning horizon, so that the MIROC option becomes MIROC with horizons of 10, 20, 30 or 40 years and so on.

Main findings

To provide an indication of the magnitude of the costs required for upfront adaptation, Table 9.3 shows estimates of the costs of adaptation under perfect foresight averaged over all climate scenarios for FYR Macedonia and other countries in the region. For FYR Macedonia, the average costs of adaptation are 0.5 percent of the baseline infrastructure expenditures. This is significantly below t**he sample average cost of adaptation of 1.4 percent of baseline expenditures and even below the sample average of 1 percent after the outliers—**Greece and Montenegro—are excluded.

Table 9.4 shows how **the average adaptation costs as a percentage of baseline expenditures are distributed across different infrastructure categories by country**. Though average costs of adaptation across all climate scenarios and all infrastructure types are below 0.5 percent of baseline expenditures on infrastructure, **adaptation costs are significantly higher in the roads and other transport sectors.** The average cost of adaptation for

160. The CRU historic dataset refers to series of historic weather data for 0.5o grid squares compiled by the Climate Research Unit at the University of East Anglia (in cooperation with the UK Met Office).

TABLE 9.2. **Cost matrix for all infrastructure for five selected adaptation scenarios, FYR Macedonia, 2031-35**

(US$ million per year at 2005 prices)

	CLIMATE OUTCOME SCENARIOS:					EQUAL PROBABILITIES		
Planning scenarios:	BCCR	CSIRO	MIROC	NCAR	UKMO	MEAN	MAX	SD
BCCR BCM20	34	33	46	41	55	42	55	9
CSIRO MK30	39	34	78	56	75	56	78	20
MIROC 32	39	35	35	35	45	38	45	4
NCAR CCSM30	37	34	37	34	47	38	47	5
UKMO HADCM3	55	54	54	54	59	55	59	2
Comparison under perfect foresight								
REACTIVE	29	10	59	42	52	38		
ADAPTATION	34	34	35	34	59	39		

Notes: Discount rate of 5% and 20-year planning horizon.
Source: Infrastructure background paper.

TABLE 9.3. **Adaptation costs for most countries are below 2 percent of baseline expenditures**

Average cost of adaptation for all infrastructure assets by country for 2011-50

COUNTRY	US$ MILLION PER YEAR	AVERAGE AS % OF BASELINE	AVERAGE AS % OF AGGREGATE GDP
Albania	30	0.7%	0.07%
Bulgaria	110	0.7%	0.08%
Bosnia	43	0.9%	0.09%
Greece	1,033	3.4%	0.30%
Croatia	166	1.8%	0.15%
Kosovo	15	0.7%	0.06%
FYR Macedonia	18	0.5%	0.05%
Montenegro	35	2.9%	0.33%
Romania	656	1.6%	0.16%
Serbia	76	0.6%	0.06%
Slovenia	126	1.5%	0.18%

Notes: Averaged over all climate scenarios; values at 2010 international prices with no discounting; planning horizon = 20 years.
Source: Infrastructure background paper.

roads is 2.4 percent of baseline expenditure in FYR Macedonia and this is low as compared to other countries in the region. Using more expensive pavement binders to cope with higher pavement temperatures as well as building and maintaining unpaved roads to cope with changes in the levels and monthly precipitation patterns of rainfall lead to a significant increase in costs of building roads relative to the baseline. These costs affect other transport infrastructure—railways, ports and airports—as well. For other sectors, adaptation costs are one percent or less of baseline expenditures in FYR Macedonia and most countries in the region.

How should FYR Macedonia build its infrastructure differently to be resilient to climate change? The low cost of upfront adaptation for some categories of infrastructure means that the risks of upfront adaptation are also relatively low: incurring additional costs amounting to 1% of baseline expenditures to adapt to uncertain climate scenarios will not impose a significant economic burden. However, there is rather more at stake in the choice between upfront and reactive adaptation, when the costs of upfront adaptation are larger or when they vary substantially across alternative climate scenarios.

In order to assess whether the adaptive strategy is better than the reactive strategy, the time profiles of the expected capital and O&M costs associated with climate change under the alternative strategies are constructed and the discount rate applied to convert future costs to present values. The net benefit of upfront adaptation is calculated as the present value of adaptation costs under the reactive strategy minus the present value of adaptation costs with upfront adaptation. As an initial filter, the average net benefits are calculated on the assumption of perfect foresight for each climate scenario and then averaged over climate scenarios.

Figure 9.2 shows that, with perfect foresight, **upfront adaptation generates positive net benefits for some, but not all sectors in FYR Macedonia**. Consistently positive net benefits are observed in social sector (health and schools)

TABLE 9.4. Adaptation costs vary considerably by sector

Average cost of adaptation by sector as% of baseline expenditures

COUNTRY	POWER & PHONES	WATER & SEWERS	ROADS	OTHER TRANSPORT	HEALTH & SCHOOLS	URBAN	HOUSING
Albania	0.6%	0.2%	7.1%	3.7%	0.9%	1.1%	0.0%
Bulgaria	0.6%	0.4%	3.2%	2.9%	1.0%	1.1%	0.0%
Bosnia	0.6%	0.3%	8.5%	5.4%	1.0%	1.2%	0.0%
Greece	0.8%	0.5%	22.6%	2.4%	2.1%	2.3%	2.0%
Croatia	0.6%	0.3%	25.2%	5.3%	1.0%	1.1%	0.0%
Kosovo	0.6%	0.3%	21.4%	2.9%	0.9%	1.1%	0.0%
FYR Macedonia	0.5%	0.3%	2.4%	2.4%	0.9%	1.0%	0.0%
Montenegro	0.6%	0.3%	22.3%	4.2%	0.9%	1.0%	0.0%
Romania	0.6%	0.3%	13.3%	4.5%	1.0%	1.1%	0.0%
Serbia	0.6%	0.3%	4.0%	3.8%	1.0%	1.1%	0.0%
Slovenia	0.7%	0.3%	10.6%	4.6%	1.1%	1.2%	0.0%

Notes: Averaged over all climate scenarios; planning horizon = 20 years.
Source: Infrastructure background paper.

and in urban infrastructure. In these sectors the net benefits increase markedly over time, rising from a total of about US$7 million in 2011-2015 to US$41 million by 2046-2050. However, the total net benefits are less than $20 million for periods before 2031-35, so that delay in adopting a strategy of upfront adaptation does not involve a large loss of welfare. The net benefits are small (between (-2) and 2 percent) for three categories: power & telecoms, water and sewage networks, and non-road transport. The net benefits of upfront adaptation are consistently negative for the roads sector. The high costs of upfront adaptation in this sector mean that the alternative strategy of waiting for the impacts of climate change to be realized and then either investing in O&M or road upgrading is a better option.

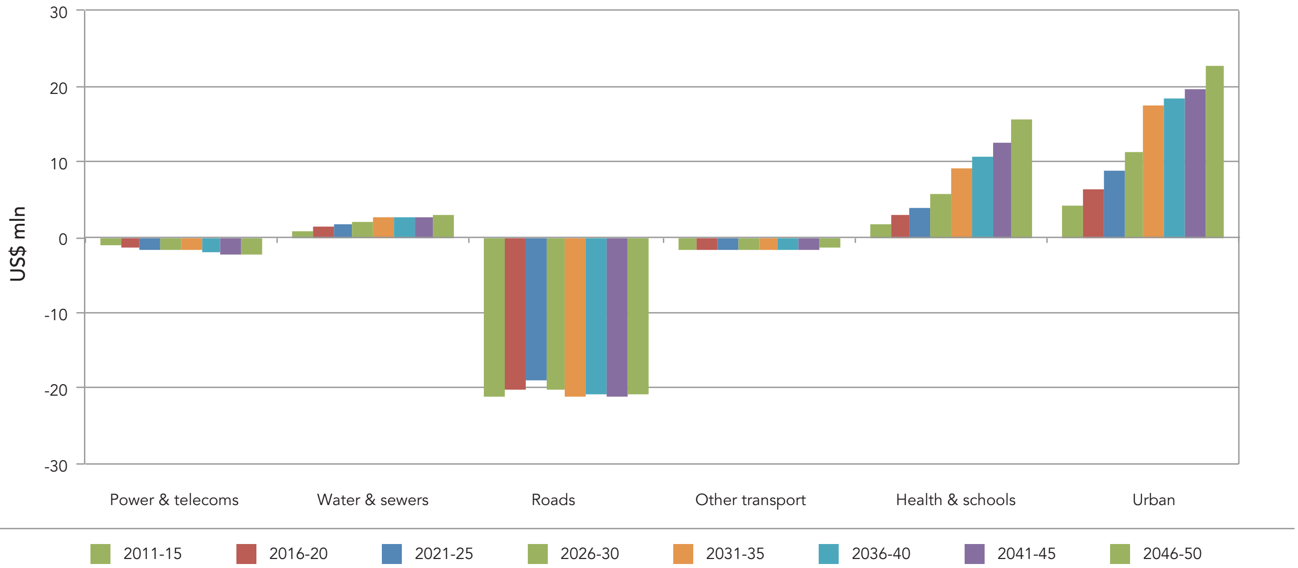
There are two other features of the analysis, which should be noted. First, the analysis suggests that it is rarely cost-effective for the planner to use a planning horizon that looks beyond 20 years from the time at which the infrastructure is being built. Even with perfect foresight about the climate scenario, upfront investment to reduce potential O&M costs due to climate change that will arise 30 or more years in the future is rarely cost efficient. Second, the standard deviations of the net benefits of upfront adaptation across climate scenarios is more than 50% of the averages for the social and urban infrastructure categories up to 2026-30. This means that **the variation in costs and net benefits across climate scenarios is substantial and therefore identifying the climate scenario that best represents the changes in climate stresses in these sectors is a significant issue.**

Having concluded that it may be cost-effective for FYR Macedonia to adapt its investments in social and urban infrastructure, the next question to answer is: what constitutes a robust adaptation strategy, which would take account of the uncertainty of the climate scenarios? **For a risk-neutral planner a robust adaptation strategy is one that yields the lowest adaptation costs over all climate scenarios.** With a high level of risk aversion, however, the best strategies are those that minimize the maximum cost of adaptation under all climate outcomes. In the case of FYR Macedonia, the results indicate that even for a very risk averse planner it is rarely worth adopting a planning horizon of more than 10 years and never one longer than 20 years. A short planning horizon reduces the potential variation between the climate scenarios with respect to the differences between climate projections in the weather stresses to which social and urban infrastructure will be exposed. This eases the task of identifying a robust set of planning assumptions.

On the assumption that the country is risk neutral, which is a reasonable assumption given the relatively low costs of adaptation, the differences between decisions based upon the optimal planning scenario and the average of all climate scenarios are quite small—no more than 0.1 percent of the baseline expenditure. Further, the risk of making a bad decision is limited since the difference between the best and worst scenarios amounts to 0.2 to 0.4 percent of baseline expenditure. As a consequence, it would make sense for FYR Macedonia to rely upon an average of all climate scenarios when planning adaptation since the benefits of identifying optimal strategies for each sector and time period will be limited. This implies that reliance upon the average climate scenario as the basis for planning adaptation is a robust choice for the next 20 years.

FIGURE 9.2. Adaptation is cost-effective for FYR Macedonia in some but not all sectors, and its value rises over time for many sectors

Net present value of adaptation for different types of infrastructure



Notes: Averaged over all climate scenarios; discount rate = 5%.
Source: Infrastructure technical paper.

RECOMMENDATIONS

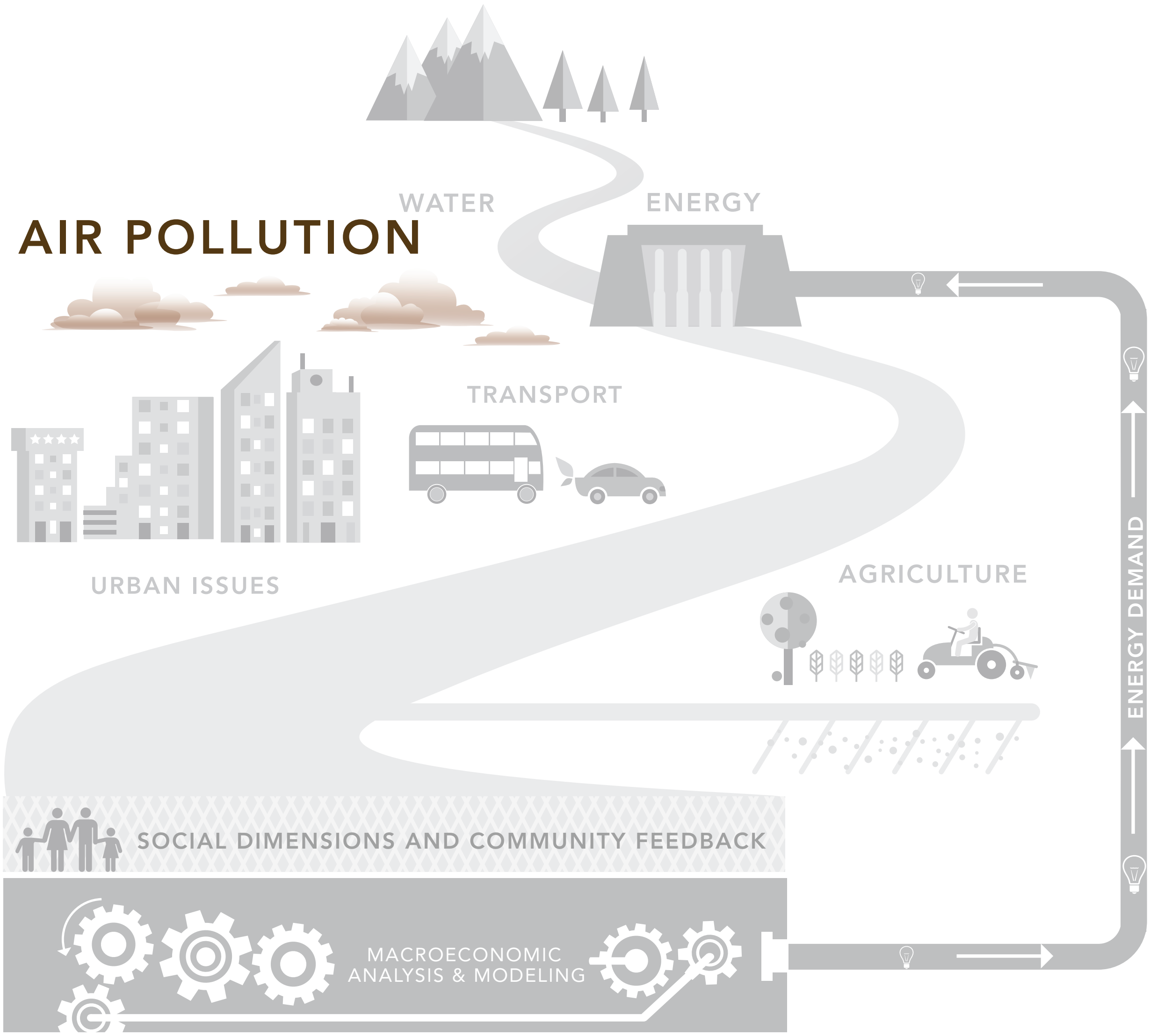
FYR Macedonia should build its infrastructure differently to be resilient to climate change. Projected changes in climate patterns will affect the reliability and quality of infrastructure services. Temperature increases will cause roads to degrade, and intense rainfall events will lead urban drainage systems to overflow, for example, affecting connectivity and economic activity. To minimize the economic impacts and manage these risks, FYR Macedonia should take account of future climate condition when designing new infrastructure or replacing existing assets.

Overall adaptation costs are very modest at 0.05 percent of GDP annually for the next 40 years. Although the net benefits of adapting vary depending on climate scenarios and time periods (with higher benefits for investments made further in the future), the incremental costs are very small in relation to the substantial cost of meeting the country's future infrastructure requirements. All infrastructure assets—roads and rail, electricity, water and sanitation, communications, urban drainage, urban housing, and health and education facilities—could be adapted to maintain service levels as the climate changes for an additional cost of US$18 million per year or about 0.5 percent of infrastructure investment costs.

The priorities for adaptation in the current decade include urban drainage systems, health and educational facilities and municipal buildings. The net benefits of adaptation for urban and social infrastructure increase over time. For these infrastructure assets, design standards and O&M practices should be modified so as to look ahead to projected climate conditions either 10 or 20 years ahead of the date of construction. In contrast, the best option for roads is to follow a reactive strategy of "wait, monitor, and act," in which adaptation takes the form of enhanced maintenance and upgrades to respond to current weather stresses. For other sectors including power, telecoms, water and sewer networks, and non-road transport both the costs and benefits of adaptation are small, so that the reactive strategy will be sufficient for the next two decades.

Finally, resources to monitor weather outcomes and to update climate projections using the data collected are an essential element of any set of adaptation policies. Projections of future climate are being improved and revised continuously. Assessment of the optimal choices for adaptation in infrastructure assets must also be updated regularly.

AIR POLLUTION



CHAPTER 10

Can Co-benefits such as Cleaner Air Arise from Greening?

CHAPTER SUMMARY

FYR Macedonia's air pollution is one of the highest in Europe and any green growth path that takes into consideration human health would include its reduction[161]. The objective of the analysis in this chapter is to estimate the health impacts of air pollution in FYR Macedonia and the cost of these impacts to the society.

Using the exposure-response functions that quantify the relationship between the exposure to particulate matter and mortality/morbidity, the analysis provides an aggregated measure of the impact of pollution on public health. The aggregated measure – DAYLY (disability-adjusted life years) - weighs illnesses by severity assigning the highest weight of 1 to mortality. Next, the analysis estimates the cost of the health impact to the society using three approaches: adjusted Human Capital approach, Value of a Statistical Life, and Cost of illness.

The findings show that particulate matter (PM) is responsible for over 1350 deaths in FYR Macedonia annually and thousands of lost work days, representing an economic cost of €253 million annually or 3.2 percent of GDP. Lowering PM_{10} and PM2.5 to EU limit values would result in avoiding over 800 deaths and many lost work days, representing a health cost savings of €151 million per year. Most of PM pollution is generated by five economic activities in a few largest industrial facilities, as well as in the road sector and the household sector. It can be reduced by 80-90 percent using available technologies in the industry and the road sectors and by government programs supporting usage of modern fuel efficient stoves in the household sector. Pollution can also be geographically targeted, as over 45 percent of the health impact occurs in Skopje and a few several local production zones. Also, at least one-third of PM emissions are estimated to come from transboundary sources, and regional agreements are needed to control them.

161. Particulate air pollution is one of the indicators of a society's sensitivity to climate change and is part of the index of climate change vulnerability. The higher the particulate matter (PM) air pollution levels, the more vulnerable the country is to climate change impact (Chapter 1, Benchmarking).

CHALLENGES FOR GREENER GROWTH

Overview

FYR Macedonia's air pollution (see definitions in Box 10.1) is one of the highest in Europe, and any growth path that values health would include its reduction. Particulate matter is responsible for over 1350 deaths in FYR Macedonia annually and thousands of lost work days–representing a loss equivalent to 3.2 percent of GDP. FYR Macedonia ranks highest in its population's exposure to particulate matter in the air and fifth in annual deaths due to small particulate (PM_{10}) air pollution in Europe, and even with reduced industrial activity due to the economic crisis little changed by 2011 (Figure 10.1, Figure 10.2)[162].

162. European Environment Agency (EEA). 2009. Spatial Assessment of PM10 and Ozone Concentrations in Europe (2005). EEA Technical report No 1/2009. Copenhagen: EEA.

BOX 10.1. PM_{10} and $PM_{2.5}$: definitions and their health impact

Air pollution is most often measured using particulate matter (PM). PM is made up of tiny particles (a fraction of the thickness of a human hair) in the air and is linked to various respiratory diseases and premature death. The health impacts of particulate air pollution are calculated using ambient (background) concentrations of PM_{10} or $PM_{2.5}$. PM_{10} stands for Particulate Matter of less than 10 micrometers (10μm) in diameter. These particles have the greatest potential for reaching the furthest parts of the lungs. $PM_{2.5}$ stands for Particulate Matter of less than 2.5 μm, which is covered by the PM_{10} heading. It is believed that $PM_{2.5}$ is responsible for much of the health effects attributable to PM_{10}.

Particles may arise from a wide variety of sources, natural or man-made. Natural sources include sea spray, pollens, fungal spores or soil particles. Man-made particles mainly result from combustion processes, working with soil or rocks, industrial processes or friction of road surfaces by motor vehicles. Generally, there are six major sources of PM_{10}: airborne road dust and soil, vehicle exhausts, secondary particles, coal combustion, incineration and the metals industry, road salt and marine aerosols.

According to the WHO (2005), the following are attributed to short-term PM exposure: respiratory and cardiovascular hospital admissions, emergency department visits, and primary care visits; use of respiratory and cardiovascular medications; days of restricted activities; work and school absenteeism; acute symptoms (wheezing, coughing, phlegm production, respiratory infections); physiological changes (such as lung function); and even death. Effects attributed to long-term exposure include mortality due to cardiovascular and respiratory disease; chronic respiratory disease incidence and prevalence (asthma, chronic obstructive pulmonary disease (COPD), and chronic pathological changes); lung cancer; chronic cardiovascular disease; and intrauterine growth restriction (for example, low birth weight at term).

PM is one of the most significant pollutants associated with short- and long-term respiratory disease and death. The relationship between particulate matter and health has been investigated in literature[a] including several studies in FYR Macedonia.[b] A recent study in Skopje found that an increase of PM_{10} by 10 μg/m^3 above the daily maximum permitted level (50 μg/m^3) was associated with a 12% increase in cardiovascular disease.[c] Analyses of monthly morbidity reports produced by the Institute of Public Health show that both preschoolers (under 6 years of age) and schoolchildren (aged between 7 and 14 years) living in polluted cities, such as Skopje and Veles, are two to three times more likely to have respiratory diseases (excluding influenza and pneumonia) than children living in less polluted villages. The difference is higher in the winter, when heating and climatic factors (including temperature inversion) contribute to an increase in air pollutants.

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a. Ostro, Bart. 1994. "Estimating the Health Effects of Air Pollution: A Method with an Application to Jakarta." World Bank Policy Research Working Paper 130. Washington, DC: World Bank; Ostro, Bart. 2004. "Outdoor Air Pollution: Assessing the Environmental Burden of Disease at National and Local Levels." Environmental Burden of Disease Series, No. 5. Geneva: World Health Organization (WHO); Pope, C.A., R.T. Burnett, M.J. Thun, E.E. Calle, D. Krewski, K. Ito, and G.D. Thurston. 2002. "Lung Cancer, Cardiopulmonary Mortality, and Long-term Exposure to Fine Particulate Air Pollution." Journal of the American Medical Association (JAMA) 287: 1132-1141. JAMA online.

b. Kochubovski, M. and V. Kendrovski. 2012. "Monitoring of the Ambient Air Quality (PM10) in Skopje and Evaluation of the Health Effects in 2010." Journal of Environmental Protection and Ecology 13(2): 789-796. Thessaloniki, Greece: Balkan Environmental Association; Kochubovski, M., J. Janevski, M. Dimovska, P. Simjanoski, and V. Ristova. 2008. "Monitoring of the Ambient Air Quality in Skopje and Veles and Evaluation of the Health Effects in 1990-2006." Journal of Environmental Protection and Ecology 9(4): 743-752. Thessaloniki, Greece: Balkan Environmental Association.

c. Kochubovski, M. and V. Kendrovski. 2012. "Monitoring of the Ambient Air Quality (PM10) in Skopje and Evaluation of the Health Effects in 2010." Journal of Environmental Protection and Ecology 13(2): 789-796. Thessaloniki, Greece: Balkan Environmental Association.

FYR Macedonia has recognized the seriousness of this issue by creating pollution inventory and air quality monitoring systems. Through its air quality monitoring network, the Ministry of Environment and Physical Planning (MEPP) can now gauge the level of air quality in major urban and industrialized centers. The MEPP also developed air pollution monitoring methods – based on EU experience – of sources and assembled this information in its Cadastre of Polluters and Pollutants to track major contributors and meet the reporting requirements of the Convention on Long-Range Transboundary Air Pollution (CLRTAP). In addition, many of the EU air quality Directives have been transposed and integrated into various laws on ambient air quality and the environment.[163] Based on this regulatory and informational foundation, FYR Macedonia should focus on actions to reduce emissions: identify major polluters and formulate policy in reducing air pollution.

163. For a summary of what has been implemented, see Ministry of Environment and Physical Planning, FYR Macedonia. 2012. National Plan for the Protection of Ambient Air. Skopje.

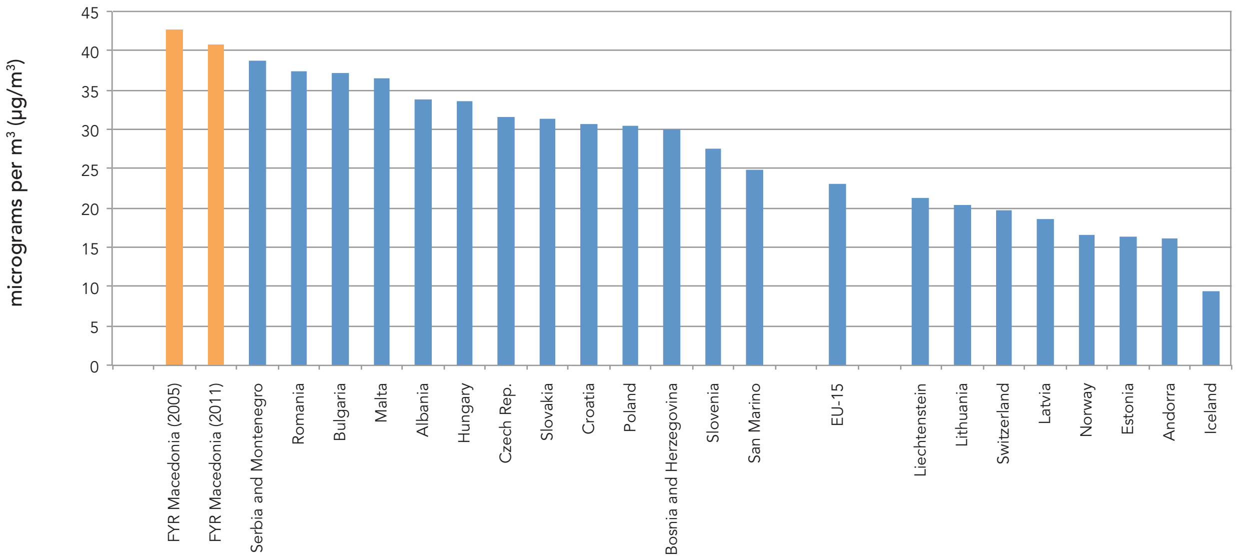
METHODOLOGY AND MAIN FINDINGS

Methodology

The objective of this analysis was to estimate the health impacts of air pollution in FYR Macedonia and the cost of these impacts to the society. The analytical framework is presented in Figure 10.3. The analysis used the air quality information collected through FYR Macedonia's monitoring systems, health data from the Ministry of Health and the

FIGURE 10.1. FYR Macedonia's population has the highest exposure to particulate matter air pollution

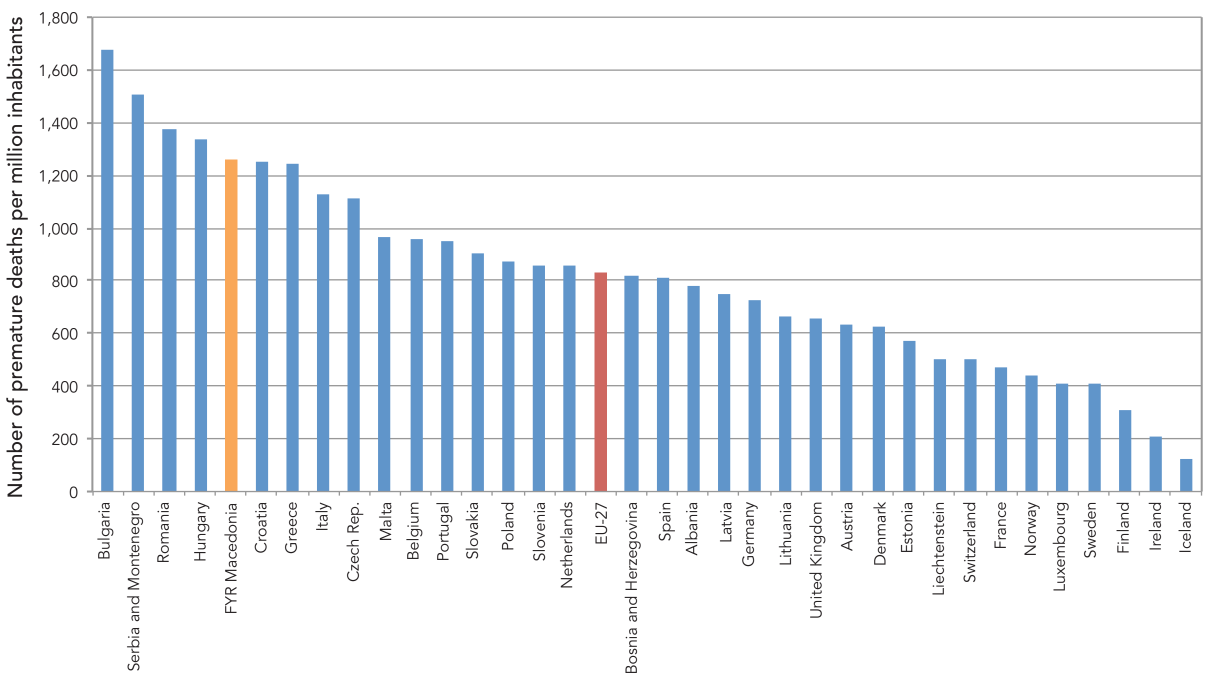
Population-weighted PM_{10} concentration, 2005 (for FYR Macedonia: 2005 and 2011)



Source: European Environment Agency (EEA). 2009. Spatial Assessment of PM10 and Ozone Concentrations in Europe (2005). EEA Technical Report No. 1/2009. Copenhagen: EEA.

FIGURE 10.2. FYR Macedonia has fifth largest death rate in Europe due to particulate matter air pollution

Premature deaths attributable to PM_{10} exposure, 2005



Source: European Environment Agency (EEA). 2009. Spatial Assessment of PM10 and Ozone Concentrations in Europe (2005). EEA Technical Report No. 1/2009. Copenhagen: EEA.

Institute of Public Health, and demographic data from the FYR Macedonia State Statistical Office. To calculate the impact of air pollution on health, exposure-response functions that capture the relationship between a pollutant's concentration and the health response of an individual were applied. **The calculations were conducted following a sequence of steps:**

- **Step 1. Collection of monitored data on air pollutants**. A network of 17 Automatic Monitoring Stations of the Ministry of Environmental Protection was used to collect the air pollutant data. The data included levels of SO_2, NO_2, CO, PM_{10}, $PM_{2.5}$, ozone, benzene, toluene, ethyl benzene, and BTX.

- **Step 2. Estimation of exposed population**. Demographic data including age distribution of the population to reflect higher vulnerability of children under 5 years of age and people over 65 was used.

- **Step 3. Exposure-response functions** are based on epidemiological statistical research. They quantify the relationship between exposure to $PM_{10}/PM_{2.5}$ and mortality/morbidity. The mortality functions represent statistical relationships between exposure to pollutants and the risk of three types of causes of death: cardiopulmonary, lung cancer, and ALRI in children under five. Mortality functions were used from Ostro[164] and morbidity coefficients were applied from Ostro[165] and Abbey et al.[166].

- **Step 4. Calculation of physical health impacts: mortality, morbidity, DALYs**. Using the ambient concentration data and demographic data for FYR Macedonia in the exposure-response functions, mortality and morbidity rates are calculated and combined into one measurement – DALY (disability-adjusted life years). The DALY method weighs illnesses by severity: more severe illnesses have higher weights, while mortality has the highest weight of 1. Weights from Larsen (2004) were utilized.

- **Step 5. Monetizing the health impact.** Valuation used three approaches: the adjusted Human Capital approach (HCA), Value of a Statistical Life (VSL), and The Cost of Illness (COI). The HCA estimates the indirect cost of productivity loss through the value of the individual's future earnings. The VSL measures the willingness to pay to avoid death using actual behavior and the tradeoff between risk and money. The COI estimates the direct treatment costs of doctor visits, hospitalization, and restricted activity days. Mortality was valued using HCA as a lower bound and the VSL as the upper bound. For morbidity, COI was used as a lower bound and a doubled COI as a higher bound.

- **Step 6. Data were matched at the municipal level and associated with information from the air quality stations**. For each municipality, population and health data were associated with air quality from nearest station data. Municipalities classified as 'rural' were associated with the rural station in Lazaropole, near Debar, unless an actual station existed in the municipality. In a few instances, municipalities were classified as rural but contained industrial activities. However, a local monitoring station was present in each case.

Main findings

Particulate matter concentrations violate annual EU standards for air quality. Observations from the monitoring network suggest that particulate matter is one of the most serious concerns in the country. PM_{10} significantly exceeds the EU annual standard of 40µg/m^3 (Figure 10.4). PM_{10} has been on the decline since 2005 reaching its minimum in the aftermath of the economic crisis. However, 2011 and 2012 readings suggest it is on the rise again, driven by recovering economic activity.

Over 90 percent of particulate emissions (PM) are generated by five economic activities and 92 percent in largest industrial facilities.[167] They can be reduced by 80-90 percent using available technologies. The economic activities with highest PM emission concentration are ferroalloy production, electricity and heat production, energy combustion in the non-ferrous metals industry, road paving and wood combustion by households (Figure 10.5). Emissions are concentrated in particular production facilities and three large industrial emitters are responsible for 92 percent of emissions from large emitters: Jugohrom Ferroalloys near Tetovo (metallurgy), REK Oslomej, and Bitola (energy). The largest emitter, Jugohrom Ferroalloys has smelting processes that produce ferrosilicon (iron and silicon) which is used by the steel industry to enhance product performance. REK Bitola has three large lignite-fired turbines installed in the early to late 1980s.

Particulate matter pollution could be reduced by up to 80 percent in the ferroalloys and energy sectors and by 90 percent in road paving activities and among wood-burning

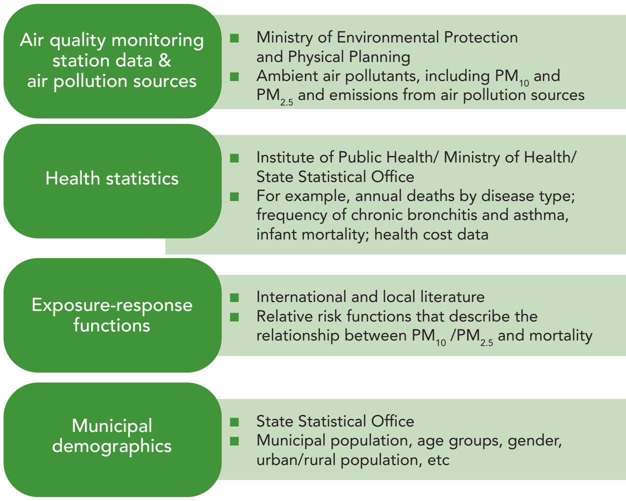
164. Ostro, Bart. 2004. "Outdoor Air Pollution: Assessing the Environmental Burden of Disease at National and Local Levels." Environmental Burden of Disease Series, No. 5. Geneva: World Health Organization (WHO).

165. Ostro, Bart. 1994. "Estimating the Health Effects of Air Pollution: A Method with an Application to Jakarta." World Bank Policy Research Working Paper 130. Washington, DC: World Bank.

166. Abbey, D. et al. 1995. Long-Term Ambient Concentrations of Particulates and Oxidants and Development of Chronic Disease in a Cohort of Nonsmoking California Residents. Inhalation Toxicology, Vol 7: 19-34. London: Informa.

167. Energy sector modeling (Chapter 6) notes that large industries are the worst emitters after the energy sector and concludes that GHG emission reduction efforts should address the issue of emission-intensive processes and equipment in large industries.

FIGURE 10.3. Analytic framework



Source: Air pollution technical paper.

households by using simple technologies: adoption of dust collection and scrubbing technologies in the energy sector; usage of dust collectors in road pavement processes; and replacement of inefficient wood stoves, increasingly used for heating in response to tariff increases, in the household sector.

Over 45 percent of the health impact occurs in Skopje and several local production zones. Insufficient air circulation in Skopje during the winter months exacerbates the health impact of PM air pollution. Outside Skopje, specifically-sited industrial production is the major contributor to local air quality: energy production in the municipality of Bitola, metallurgical works in Kavadarci and Tetovo and oil refining in Miladinovci. (Figure 10.6)

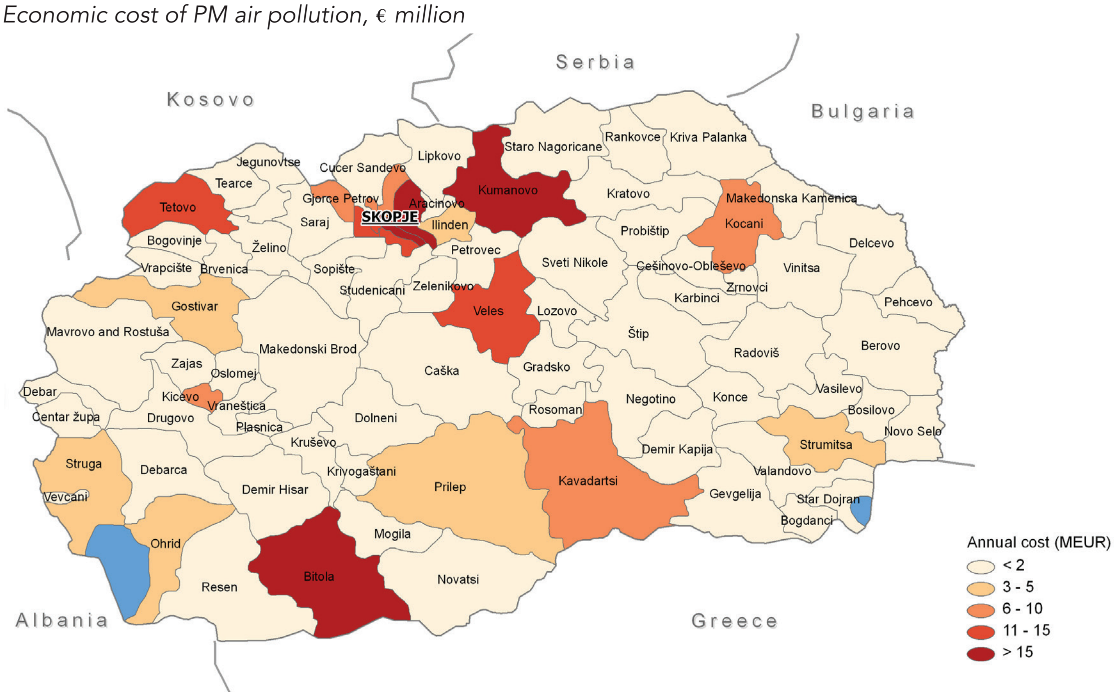
Up to 30-80 percent of particulate matter may come from transboundary sources – and FYR Macedonia's compliance with EU standards may only be realized with a regional agreement. Several studies have shown that depending on the location and season, emissions from neighboring countries can contribute between 30 and 80 percent of air quality conditions in FYR Macedonia.[168] Therefore, local interventions need to be combined with regional agreements. FYR Macedonia needs to undertake studies to determine how much of the air pollution is from local or regional sources.

Particulate matter pollution is responsible for approximately 1350 deaths annually with thousands of lost productive work-days – representing an economic cost of €253 million annually or 3.2 percent of GDP. Premature deaths occur from cardiopulmonary disease and lung cancer. In 2011, the level of particulate matter pollution was primarily responsible for 485 new cases of chronic bronchitis, 770 hospital admissions,

168. Klein, Heiko, Michael Gauss, Agnes Nyiri and Birthe Marie Steensen. 2011. 2012. Transboundary Air Pollution by Main Pollutants (S, N, O_3) and PM: The Former Yugoslav Republic of Macedonia. Data Note. Norwegian Meteorological Institute. Oslo: European Monitoring and Evaluation Programme (EMEP).

FIGURE 10.6. Health impacts are highest in municipalities of Skopje, Bitola, Kumanovo, Tetovo, Veles

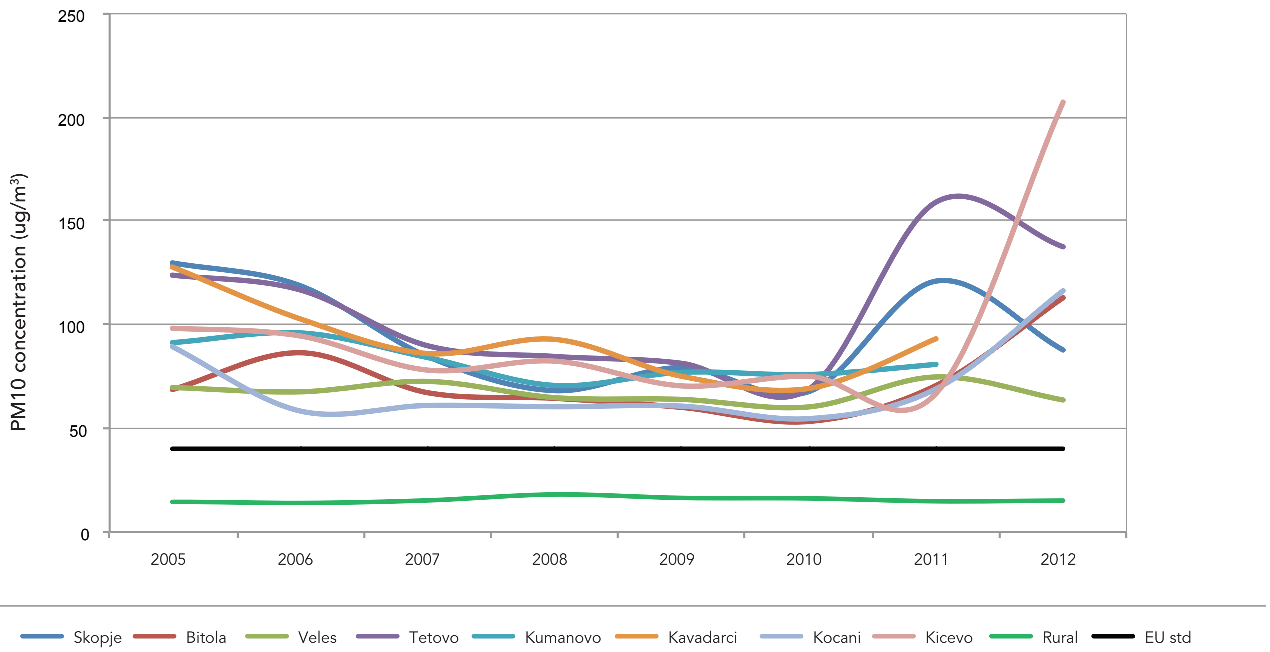
Economic cost of PM air pollution, € million



Source: Air pollution technical paper.

FIGURE 10.4. **Air pollution has been above EU standards for years**

Annual average PM_{10} concentration by monitoring station



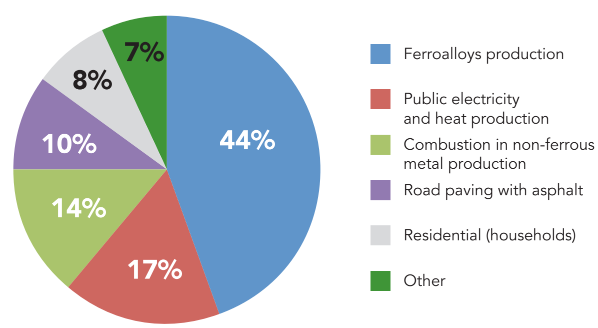
Source: Ministry of Environment and Physical Planning, FYR Macedonia. 2012. Macedonia's Informative Inventory Report (IIR) 2010. Submission under the United Nations Economic Commission for Europe (UNECE) Convention on Long-range Transboundary Air Pollution. Skopje: UNECE.

and 15,200 emergency visits. Converting it into DALYs[169,] these health effects represent an annual economic cost of €253 million or 3.2 percent of GDP[170.] These estimates are consistent with other recent studies including one in Kosovo.[171] (See Table 10.1)

Lowering PM_{10} and $PM_{2.5}$ to EU limit values would result in avoiding over 800 deaths and thousands of days in lost productivity, representing a health cost savings of €151 million per year. If greening interventions were undertaken in the sectors identified above and this lowered current particulate matter concentrations to EU limit values,[172] the number of deaths and disabilities would be substantially lower. A reduction of even 1 μg/m³ in ambient PM_{10} or $PM_{2.5}$ would imply savings of €34 million per year in reduced health costs or 0.4 percent of GDP (see Table 10.2). If FYR Macedonia were to comply with EU standards, the savings would be €151 million per year or 1.9 percent of GDP.

FIGURE 10.5. **Over 90 percent of PM emissions are from metallurgy, electricity and heat production, asphalt mixing in road paving and household wood burning.**

Sources of PM emissions, 2003-2010



Source: Compiled from: Ministry of Environment and Physical Planning, FYR Macedonia. 2012. Macedonia's Informative Inventory Report (IIR) 2010. Submission under the United Nations Economic Commission for Europe (UNECE) Convention on Long-range Transboundary Air Pollution. Skopje: UNECE.

169. More precisely, disability-adjusted life years is the sum of years of potential life lost due to premature mortality and the years of productive life lost due to disability.

170. Note that premature death accounts for over 90 percent of the total health cost since the loss of life is a loss of total income.

171. World Bank. 2012. Kosovo Country Environmental Analysis: Cost Assessment of Environmental Degradation, Institutional Review, and Public Environmental Expenditure Review, Washington, DC.

172. That is PM_{10} = 40 μg/m³ and $PM_{2.5}$ = 20 μg/m³.

TABLE 10.1. Annual deaths and disabilities in FYR Macedonia due to air pollution cost over €253 million

Number of annual cases, DALYs per year and economic cost in million Euros, 2011

HEALTH IMPACT	ANNUAL CASES[A]	TOTAL DALYS PER YEAR	ANNUAL ECONOMIC COST (€ MILLION)
Cardiopulmonary & lung cancer mortality ($PM_{2.5}$)	1,351	10,809	232.0
Acute lower respiratory infections mortality (PM_{10})	1	17	0.1
Chronic bronchitis (PM_{10})	485	1,066	3.0
Hospital admissions (PM_{10})	770	12	0.4
Emergency room visits (PM_{10})	15,200	68	0.9
Restricted activity days (PM_{10})	3,213,000	964	8.6
Lower respiratory illness in children (PM_{10})	22,400	146	1.5
Respiratory symptoms (PM_{10})	10,197,000	765	6.8
	Total	**13,847**	**253.3**

Notes:
a. Mid-point estimates using a baseline for PM_{10} = 15 μg/m^3 and $PM_{2.5}$ = 7.5 μg/m^3 See Ostro, B. (2004), Outdoor Air Pollution - Assessing the Environmental Burden of Disease at National and Local Levels. Environmental Burden of Disease, Series, No. 5. Geneva: WHO.

Source: Air pollution technical paper, staff calculations.

TABLE 10.2. Potential health savings from reduction in PM_{10} and $PM_{2.5}$ can equal 2 percent of GDP if EU limit values were reached, €million and % GDP

LEVEL OF REDUCTION IN AMBIENT PM_{10} AND $PM_{2.5}$ (MG/M^3) [A]	ANNUAL HEALTH SAVINGS (€ MILLION)	SAVINGS AS % OF GDP (2011)	FINAL AIR POLLUTION IMPACT AS % OF GDP (TOTAL IMPACT MINUS SAVINGS)
0	0.0	0.0	3.2
1	34.1	0.4	2.8
5	98.9	1.3	2.0
10	133.6	1.7	1.5
15	161.5	2.0	1.2
20	184.9	2.3	0.9
EU standards met [b]	151.5	1.9	1.3

Source: Air pollution technical paper, staff calculations.
a – Example reductions were equally applied to both PM_{10} and $PM_{2.5}$ and at the same time.
b – PM_{10} = 40 μg/m^3 and $PM_{2.5}$ = 20 μg/m^3

TABLE 10.3. **Skopje and its municipalities represent half of the health burden from air**

Annual cost, € million, % share, and % GDP

MUNICIPALITY	ANNUAL COST (€ MILLION)	% TOTAL	CUM %
Skopje[a]	113.4	44.8	44.8
Bitola	21.5	8.5	53.2
Kumanovo	20.4	8.0	61.3
Tetovo	13.0	5.1	66.4
Veles	12.2	4.8	71.2
Kavadarci	8.5	3.4	74.6
Kočani	8.0	3.2	77.7
Kičevo	6.6	2.6	80.3
Prilep	3.6	1.4	81.8
Ohrid	3.0	1.2	82.9
Gostivar	2.8	1.1	84.1
Ilinden	2.7	1.1	85.1
Strumica	2.5	1.0	86.1
Struga	2.3	0.9	87.0
Aračinovo	1.9	0.8	87.8

Source: Air pollution technical paper, staff calculations.
a – Skopje includes the municipalities of Centar, Gazi Baba, Aerodrom, Čair, Kisela Voda, Butel, Šuto Orizari, Karpoš, Gjorče Petrov and Saraj.

Across FYR Macedonia's 80 municipalities, 15 represent 88 percent of the total health burden of air pollution with nearly half in Skopje. The municipalities of Skopje are small, densely populated and urbanized. When combined with the poor atmospheric conditions in December–air pollution becomes a serious concern. The distribution of this burden is reflected in Table 10.3 where Skopje (and its municipalities) constitutes 45 percent of the total health cost. Other more industrialized areas such as Bitola, Kumanovo, Tetovo, Veles and Kavadarci also rank high. International examples show that addressing urban pollution as a whole, including all types of pollution sources, brings highest benefits (See Good Practice Box 12).

GOOD PRACTICE BOX 12.

Improving air quality in Vienna and Mexico City

Under current EU law, local authorities are required to reduce air pollution and to comply with air quality limit values for several pollutants. Vienna has, therefore, adopted a modal shift to public transport, which includes metro, tram and bus lines. The fleet consists of over 500 tramcars and 500 buses and has been optimized and extended over the years. The city's bus fleet operates fully with liquefied petroleum gas engines, mostly equipped with additional filter systems. The current focus is on the U1 and U2 metro lines as well as the new main station. The city also plans to continue the expansion of 'park and ride' spaces, which stand at 30,000 currently.

Mexico City has also made determined efforts to reduce vehicle emissions, which represent the greatest source of pollution in a city that the United Nations declared to be the most polluted urban area in the world in 1992. About 1,000 deaths and 35,000 hospitalizations per year were estimated to be caused by the dangerous air quality. Similar to Skopje, thermal inversions held a blanket of dirty air over Mexico City, especially in the winter months. Yet the city has many practical lessons to offer to other fast-growing cities in the world today. The presence of lead in the air has dropped by 90 percent since 1990. Particulate matter has been cut by 70 percent. Carbon monoxide and other pollutants also have been drastically reduced. The improvement can be attributed to the multi-pronged approach and determined efforts of the city:

- Industrial and power sectors: Refineries and factories were closed or relocated; fuel oil was replaced with natural gas;
- Public transport: the low-emissions Metrobus, hybrid buses and suburban train system will be expanded to replace hundreds of thousands of vehicles;
- Auto emissions: Under the "One Day without a Car" (or "Hoy No Circula") program, older and soot-emitting cars are kept off the road for one day a week. Older cars that do not meet emissions standards are further subject to an environmental contingency program, which bans them from city roads on days when measured pollution levels are high. Furthermore, Mexico-based auto manufacturers are required to put catalytic converters on car engines, and all diesel vehicles are required to be retrofitted with a filter that is equivalent of a catalytic converter.

Sources: European Environmental Bureau and Friends of the Earth Germany website. The City Ranking Project of Soot-Free-For-the-Climate. Accessed on November 26, 2013: http://sootfreecities.eu/city O'Connor, Anne-Marie. 2010. "Mexico City drastically reduced air pollutants since 1990s." Washington Post, April 1, 2010.

RECOMMENDATIONS

The analysis conducted for this chapter identified main sources of air pollution and actions targeted at reducing pollution from these sources should be prioritized. These actions include using modern equipment in ferroalloys and non-ferrous metal production, installation of pollution abatement equipment and fuel switching in the heat and power production, installation of dust collectors and fabric filters in asphalt mixing plants, and usage of new modern stoves in the household sector. In addition, regulations related to air pollution should be significantly improved.

Actions in Priority Sectors. **Reduction of pollution from ferroalloys and non-ferrous metal production is a priority, since it constitutes a large share of overall pollution. They can be reduced using modern equipment.** For example, in the biggest polluter Jugohrom Ferroalloy's, emissions could be reduced by up to 80 percent through such measures as low energy scrubbers, sealed furnaces and enclosed product transfer (e.g., conveyor) systems.

In the energy sector, in response to the new EU directives[173] regulating particulate emissions entering into force in 2016, the major heat and energy suppliers need to undertake new investments to reduce emissions from existing sources and switching to natural gas. Emissions from public electricity and heat production could be reduced up to 80 percent through the installation of pollution abatement equipment and fuel switching. The primary fuel source in FYR Macedonia is high emission lignite. In addition, outdated plant equipment exacerbates the problem.

In the road sector, installation of dust collectors and fabric filters in asphalt mixing plants is essential to reduce emissions. The most significant source of emissions in the road sector is from batch mix plants where asphalt is made. Aggregate dust, VOCs and a fine aerosol of liquids are also emitted from the conveying, classifying and mixing equipment. Vented emissions from these areas may be controlled by equipment ranging from dry mechanical collectors to scrubbers and fabric collectors. Many of these technological solutions can reduce emissions by over 90 percent[174].

In the household sector, new modern stoves should be used to replace the currently utilized inefficient ones. They run on fuel such as concentrated wood pellets, can reach 80-90 percent efficiency and are associated with lower emissions

173. 2001/80/EC

174. European Monitoring and Evaluation Programme/European Environment Agency (EMEP/EEA). 2009. Emission Inventory Guidebook 2009: Technical Guidance to Prepare National Emission Inventories. Copenhagen: EMEP/EEA.

of carbon monoxide, volatile organic compounds (VOCs), particulate matter and other hazardous air pollutants. These stoves Investment costs could be subsidized through government programs aimed at emission reduction.

Actions at the Policy Level. The programs to reduce air emissions in FYR Macedonia need to include particulate matter. Currently existing programs[175] focus on sulfur oxides, mono-nitrogen oxides, ammonia, and volatile organic compounds and not on particulate matter.

The process of obtaining environmental permits should be shortened. Industrial facilities are obliged to introduce measures to reduce emissions in all environmental media (by way of obtaining an Integrated Pollution Prevention and Control (IPPC) permit[176], introducing Best Available Techniques (BAT), efficient use of resources, use of better quality fuels and renewable energy sources, introducing filters and installing systems for pollution reduction). However, given the time it takes for the enterprises to invest in environmental protection, the lack of expertise in BAT implementation and the length of time to issue a permit (e.g. up to one year) - the status of issuance is becoming a concern.

To help speed up environmental protection investments, FYR Macedonia should explore the use of economic instruments to incentivize emission reductions. In particular, in cooperation with the financial sector, the Government may offer forms of financing that could be made available to enterprises with well-developed plans for improved environmental management. At a household level, similar incentives could be offered to improve energy efficiency. Government revenues generated from the implementation of the 'polluter pays' principle (from companies that pay fines or penalties due to their non-compliance with a standard) could help finance these environmental investment activities.

175. The most recent ones are: (1) Ministry of Environment and Physical Planning, FYR Macedonia. 2012. National Programme for Gradual Reduction of Emissions of Certain Pollutants at the Level of the Republic of Macedonia. Skopje. And (2) Ministry of Environment and Physical Planning, FYR Macedonia. 2012. National Plan for the Protection of Ambient Air. Skopje.

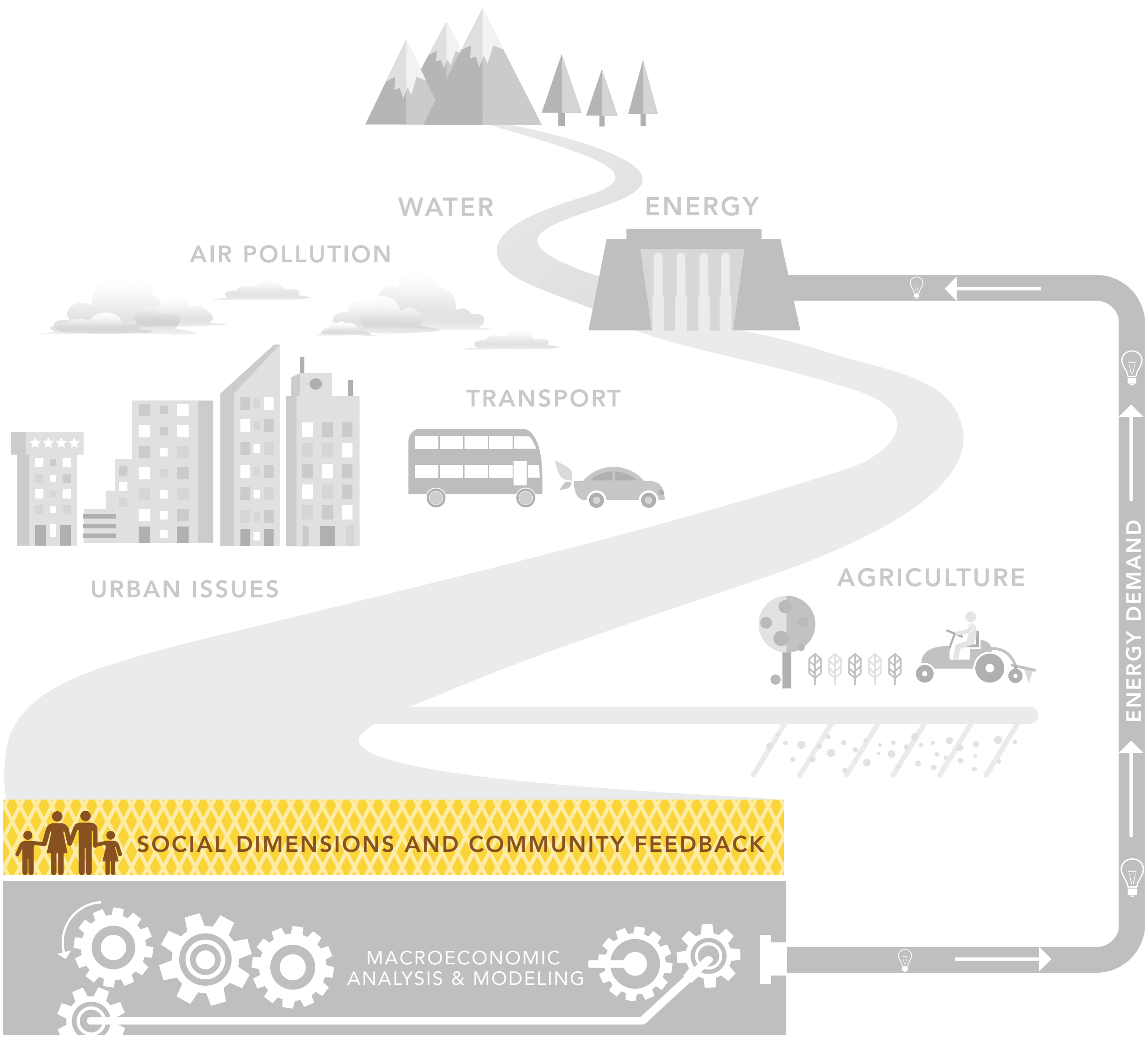
176. In 2010, the IPPC Directive was replaced by the Industrial Emissions Directive (IED) (2010/75/EU).

The Government should continue financial support to maintain and expand the air quality monitoring abilities of the MEPP and strengthen capacity in new areas – such as source attribution studies. FYR Macedonia has progressed in the development of monitoring and evaluation systems for air quality.

At the policy and strategic level, health impacts should factor into urban, energy and transport planning[177]. Spatial planning that limits urban sprawl and lessens the burden on transport and roads would help curb pollution. More accessible public transport that gets more cars off the road would achieve the same objective. Cleaner energy sector mix would also mean reduced pollution.

In the public health sector, there is a need to undertake more health impact assessments and support greater technical and human capacity on environment/health linkages at the Institute of Public Health. Further research on the linkages between environmental quality and public health is necessary in providing evidence that certain economic activities are impacting the population. Specific health assessments in the areas of air quality should become part of regular monitoring by the Institute of Public Health and other health-related organizations. The first step would be to build capacities in these institutions (e.g. epidemiology) and then to plan strategic studies that would tackle some of the largest gaps in FYR Macedonia's knowledge (e.g. studies on the impact of particulate matter pollution). This would enable practitioners to base results from FYR Macedonia's population – and not rely as much on international studies to back up their expert judgment.

177. See chapters: Energy, Transport and Urban



WATER
ENERGY
AIR POLLUTION
TRANSPORT
URBAN ISSUES
AGRICULTURE
ENERGY DEMAND
SOCIAL DIMENSIONS AND COMMUNITY FEEDBACK
MACROECONOMIC
ANALYSIS & MODELING

CHAPTER 11

How Should Social Dimensions Be Addressed?

CHAPTER SUMMARY

Socially-inclusive green growth would take into account the characteristics as well as the perceptions of various social groups to maximize inclusion of all parts of the society into a greener economy. Participation of the population in the design of green growth strategies will help to increase awareness about climate change and to build resilience and flexibility at the community level to adopt green growth measures. FYR Macedonia is characterized by wide social disparities, a situation that makes the objective of social inclusion especially challenging but also especially important. Inequality complicates green growth policy design and implementation, while social inclusion can help ameliorate these complications. How should social dimensions be addressed?

This chapter describes the outcomes of a pilot application of a participatory methodology aimed at making green growth design and implementation socially inclusive. This methodology— Participatory Scenario Development (PSD)[178] – is proposed to the Government as an important and useful tool for green growth decision making. The pilot PSD was aimed at developing and testing a suitable participatory approach to green growth decision making in FYR Macedonia. The workshops with local and regional stakeholders discussed major challenges of green growth and potential development scenarios and policy options for a green transition.

The pilot provided evidence that the PSD approach is a valuable tool for participatory decision making. The workshop discussions provided information about the level of awareness of the concept of green growth; the potential impact on vulnerable groups including farmers and socially disadvantaged groups and the need for strengthened social safety nets; the potential impact on employment and the need for programs aimed at creating new skills and knowledge to adapt to new conditions; and the need for improved local capacity for planning and implementing green growth strategies.

CHALLENGES FOR GREENER GROWTH

Overview

Participation of the population in the design of green growth strategies is critical for the success of their implementation. A participatory process helps to increase awareness about climate change and to build resilience and flexibility to adopt green growth measures. Social inclusion in the context of green policy design and implementation will help support equitable outcomes, improved governance, better decision making and efficient institutional development. Green policies, when implemented, will impact various social groups

178. Participatory scenario development (PSD) is a method of social assessment applied to test potential reaction of different stakeholder groups to a set of policy options in order to identify those that would win public support. PSD was developed by the World Bank (see Bizikova, Livia, Samantha Boardley, and Simon Mead. 2010. "Participatory Scenario Development Approaches for Identifying Pro-Poor Adaptation Options." Development and Climate Change. World Bank Discussion Paper 18. Washington, DC: World Bank.).

in different ways and it is important to anticipate the impact to make sure that all parts of the society benefit from green growth in an equitable way and the vulnerable groups are protected in the process of economic restructuring. Also, it is important to understand perceptions and verbal behavior of the population in respect to green growth policies and use it in policy design and implementation. This would include design of the regionally specific policies, mass media actions, and information campaigns. In addition, FYR Macedonia has significant differences in economic, social and cultural characteristics by region and urban-rural location. These differences need to be reflected in the Macedonian green growth strategy. Socially inclusive policies will help take these differences into account. Participatory approaches have proved efficient in many countries, making a difference in green policy implementation (see Good Practice Box 13 for an example from India).

This chapter describes the outcomes of a pilot application of a methodology aimed at making green growth design and implementation socially inclusive. This methodology - Participatory Scenario Development (PSD)[179] – is proposed to the Government to be used as one of the instruments of green growth decision making. The pilot was designed[180] to test the suitability of the PSD approach for discussing green growth challenges and policy options with a large number of stakeholders in order to understand which groups are affected by climate change and green growth measures, how they perceive these the changes, what actions they are willing to take to adapt their living and working situation to the changing conditions, and what actions they expect from local and national government.

Challenges of Social Inclusion in the Context of Green Growth

Socially inclusive green growth would consider objective characteristics and perceptions of various social groups while designing green policies, with the objective to maximize benefits to all parts of the society from green economy. Social groups differ with respect to income and employment, knowledge and skills, age and gender, urban-rural location and other characteristics. The challenge of designing a socially inclusive green growth strategy is in understanding and incorporating in a green growth strategy relevant views and behavioral reactions of all these diverse groups.

179. Ibid.

180. The pilot PSD in FYR Macedonia was developed for the Green Growth study by a project team of the Agricultural Economics Research Institute (LEI), part of Wageningen University and Research Centre in the Netherlands, in close cooperation with its Macedonian partner Terra-Consulting and NGO's in FYR Macedonia.

GOOD PRACTICE BOX 13. Participatory approach helps to link global environmental solutions with local development in India

Participatory methods prove efficient when local specifics need to be taken into account in the design of the country-wide or region-wide programs. Such methods are also useful instruments to strengthen support for reforms among citizens and to maximize reform benefits across the population.

In Andra Pradesh, the government faced a difficult task of designing an effective state-wide adaptation strategy to reduce the impacts of increasing drought on agriculture. The challenge was that the effects of the drought differed across the state due to variations in local climatic and land characteristics, access to markets, and irrigation water availability. Participatory methods helped tailor interventions to local differences. The pilot Andhra Pradesh Drought Adaptation Initiative selected communities that were representative of different challenges (e.g., little irrigated land, common property, depleted topsoil) and conducted participatory consultations with community members to identify vulnerabilities and devise ways of addressing them. A set of matrices classifying drivers of vulnerability, climate change impact, and potential responses was created and analyzed. The matrices were used to determine interventions optimal for each community. The findings were then used in the state level strategy, and it was decided that this project will be scaled up to a larger area.

Source: World Bank. 2011. Social Resilience and Climate Change: Operational Toolkit. Washington, DC: World Bank.

FYR Macedonia is characterized by wide social disparities, the situation that makes the objective of social inclusion especially challenging and also more important than in equitable societies because inequity complicates green growth policy design, while social inclusion can help reduce these complications. Disparities in FYR Macedonia include a Gini coefficient[181] that is the highest in Europe, equaling 44 percent,[182] and which has been steadily increasing from the level of 28 percent in 1998; the second highest in Europe (after Kosovo) level of unemployment at 35 percent[183] and 54 percent among young people[184], 3.8 times above the EU level;[185] large gaps in incomes and quality of life between

181. The Gini coefficient is one of the indicators of a society's adaptive capacity for climate change and part of the climate change vulnerability index. The higher the inequality (and Gini), the lower the adaptive capacity and the more vulnerable the country is to climate change impact (see the Benchmarking analysis in Chapter 1).

182. Social sector technical paper.

183. Ibid.

184. Ibid.

185. See also the discussion of unemployment in the Macroeconomic chapter (Chapter 12).

urban and rural communities,[186] significant ethnic inequality, regional inequalities, and other disparities. Twenty-seven percent of the households in the country live below poverty line[187] and per capita GDP is one of the lowest in Europe at $5,058. (Figure 11.1, Figure 11.2, Table 11.1).

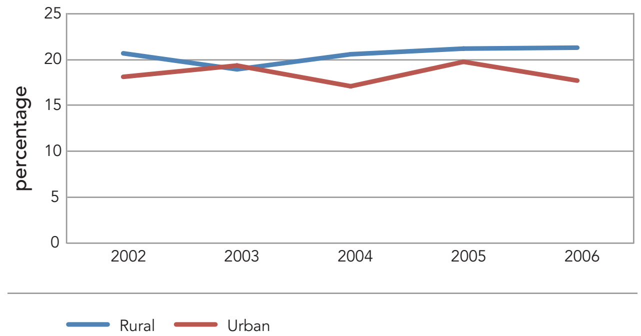
Creating employment is crucial for green growth to be socially inclusive. High unemployment rates cause many Macedonians to emigrate and seek jobs abroad, emigration rates are particularly high in the rural areas in the Northeast, Vardar and South-Western regions. Ongoing efforts to make agriculture more sustainable may create new jobs, but in order to reduce unemployment, incentives must be created for employers to hire more workers. Possible institutional

186. These issues are also mentioned in the Agriculture chapter (Chapter 5) and in the Urban chapter (Chapter 8).

187. Social sector technical paper.

FIGURE 11.1. The gap in living standards between urban and rural regions increases

Population below poverty line



Source: Social sector technical paper.

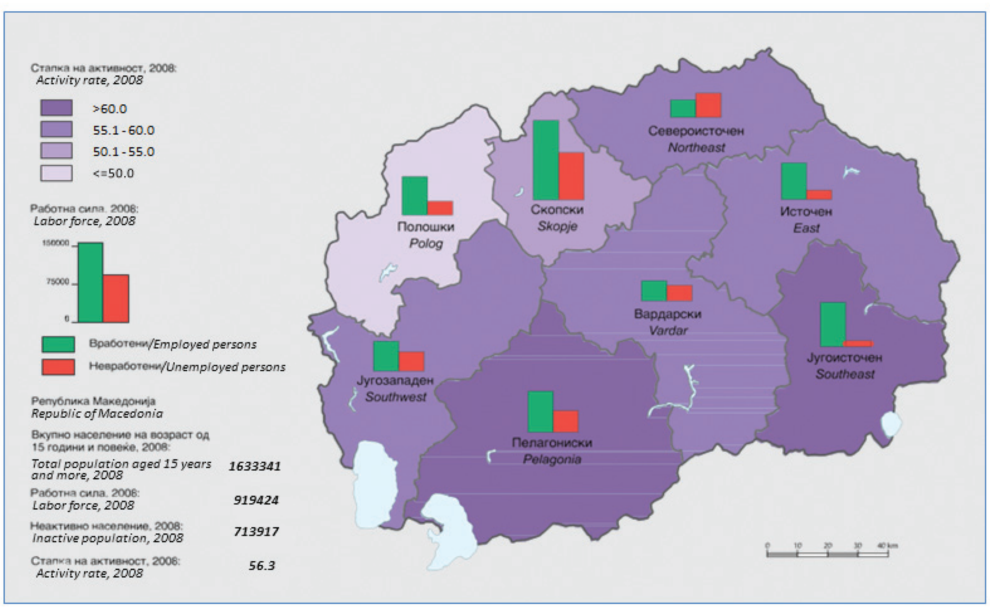
TABLE 11.1. Employment opportunities in some regions are scarce

Participation and unemployment rate by region, 2008

Working population (15 years and older)	FYR Macedonia	Vardar	East	South-west	South-east	Pelagonia	Polog	North-east	Skopje
Number of persons	1,633,341	122,138	152,504	176,191	141,859	195,363	234,365	137,773	473,148
Participation rate	56.3	57.9	59.2	55.5	70.5	63.6	43.9	59.5	53.1
Unemployment rate	33.8	43.6	20.0	39.3	11.7	34.5	26.4	58.0	37.3

FIGURE 11.2. Regional differences in employment are high

Population in labor force and unemployed, persons, 2008



Source: Social sector technical paper.

barriers in the labor market, such as closed-shop conditions, should be removed.

A transition towards a green economy requires an educated society capable to acquire new competences and skills. The educational attainment in FYR Macedonia have improved in recent years: among 18-24 year olds, the percentage of school drop-outs at the level up to junior secondary school decreased from 31 percent in 2000 to 20 percent in 2008.[188] This level is comparable with the EU average, which is 15 percent. The quality of education requires improvement. However, with a share of GDP at 3 percent, the expenditure on public education in FYR Macedonia is low.

Green growth presents specific challenges for urban areas. FYR Macedonia is a highly urbanized country, with 68 percent of the population living in cities, with strong urban growth, especially in Skopje which already has more than a quarter of the total population and is growing at over 3 percent per year. Urbanization largely takes place in the form of unplanned urban sprawl, which necessarily increases the costs of infrastructure services, such as water, electricity, transportation, sewage and waste disposal. Skopje has most of urban development issues due to the high and unplanned growth.

188. State Statistical Office, Republic of FYR Macedonia (2010). Regions of the Republic of FYR Macedonia, 2009.

METHODOLOGY AND MAIN FINDINGS

Methodology

The pilot Participatory Scenario Development (PSD) approach[189] was aimed at developing and testing a suitable participatory approach to green growth decision making in FYR Macedonia. The workshops with local and regional stakeholders discussed major challenges of green growth and potential development scenarios and policy options for a green transition. Representatives of different local and regional organizations and social groups including municipal governments, public organizations, private trade and industry representatives, business associations, social and cultural organizations, research and (inter)national developmental organizations, participated in the workshops. The participants expressed their opinions about two scenarios of FYR Macedonia's Green Growth development: Business as Usual and Green Growth, the last one following the EU 2020 policies. The scenarios are hypothetical and represent different pathways for the future, with different policy objectives and

189. Participatory scenario development (PSD) is a method of social assessment applied to test potential reaction of different stakeholder groups to a set of policy options in order to identify those that would win public support. PSD was developed by the World Bank (see Bizikova, Livia, Samantha Boardley, and Simon Mead. 2010. "Participatory Scenario Development Approaches for Identifying Pro-Poor Adaptation Options." Development and Climate Change. World Bank Discussion Paper 18. Washington, DC: World Bank.).

measures useful as starting points for the discussions in the workshops and illustrating the green growth policies to the participants in the workshops (see Box 11.1).

The project team organized four PSD workshops. The PSD workshops took place in August and September 2012 in Probistip, Ilinden and Gostivar (see locations in Figure 11.3). The national concluding workshop was held in Skopje in November 2012. The workshop duration was up to six hours. The sequence of activities and methods were adapted to the topics of the respective workshops (overview of topics is presented in Table 11.2). The workshops consisted of four successive steps:

- **Step 1. Informing the participants of climate change and green growth.** The project team presented the major aspects of climate change and green growth to the participants at hand of two distinctive scenarios, which are explained below. The differences between the two scenarios were illustrated by graphs, timelines and impact chains.

- **Step 2. Determining the (social) impact of climate change and green growth.** The scenarios, explained at national level, were further explored by the participants for the impact on their region, drawing timelines for possible social, economic and environmental developments under different assumptions and mind mapping for identifying the social groups that will be affected by these developments. This part of the workshop consisted of one or two sessions in which the participants worked together in groups of about six people, followed by a plenary feedback session.

- **Step 3. Exploring solutions for negative effects of climate change and green growth measures**. After a plenary feedback session to prioritize the negative effects of climate change and green growth measures for specific groups in the region, the participants returned working in small groups to identify possible solutions. Brainstorming and mind mapping were tools used in this session.

- **Step 4. Assessing feasibility of proposed options and recommendations**. In a plenary meeting, after preparation in working groups, the participants discussed the feasibility of the various options proposed to improve the situation in the region. Ranking methods were used to prioritize the identified problems and proposed solutions.

BOX 11.1. Summary of scenarios used at the PSD workshops

A. BUSINESS-AS-USUAL SCENARIO

In the business-as-usual scenario, a development path is assumed in which no new (significant) green growth policies and measures are undertaken and no adaptation measures on climate change. In summary, this scenario includes the following developments:

- The current development of sectors is linearly extended to the future;
- The expected exogenous challenges, such as climate change, energy demand, and demography are included;
- No new policies are assumed or included, only those presently in force;
- Investments for renewal or replacement in the energy, construction and transport sector are based on conventional technology only;
- No specific green investments are foreseen.
- Accession to the EU, with additional policy demands to FYR Macedonia is not anticipated.

B. GREEN GROWTH SCENARIO

The concept of green growth aims at long-term economic development without aggravating climate change, environmental degradation and unsustainable use of natural resources. The green growth strategy is aiming at adaptation to a changing climate, reducing GHG emissions and other pollution, promoting efficient use of natural resources and preserving biodiversity, and at the same time promoting green innovation and jobs, i.e. processing agro-raw material for biofuels, pharmaceutics, textile and new biomedical material.

The Green scenario assumes that FYR Macedonia will enter the European Union and will implement the EU green growth strategy as described in the Europe 2020 strategy. The priorities of this strategy are:

- Smart growth: improving the performance in education, research and innovation, and digital society.
- Sustainable growth: building a more competitive low-carbon economy, protecting the environment, developing new green technologies and production methods, improving the business environment and helping consumers to make well-informed decisions.
- Inclusive growth: developing a high-employment economy, ensuring economic, social and territorial cohesion, creating more and better jobs and modernizing labor markets and welfare systems.

The Green Growth scenario involves major investments in a 'cleaner' economy. These investments are not made quantitative in the social module but only described in qualitative terms.

TABLE 11.2. **Overview of the major environmental, economic and social dimensions by sector/theme**

Topics of the workshops

DIMENSIONS / SECTORS	ENVIRONMENTAL DIMENSIONS	ECONOMIC DIMENSIONS	SOCIAL DIMENSIONS
AGRICULTURE	Inefficient water use Erosion Decreasing yields Soil & water pollution Decreasing biodiversity GHG emissions	Many small farms Fragmented farms Lagging investments (incl. irrigation systems) Inefficient land use Low income Hidden unemployment	Age structure Poverty Health problems Social/ethnic tensions
ENERGY	GHG emissions Air pollution Landscape destruction through open-pit mining	Outdated power plants Inefficient use of resources Energy prices not market driven	Dependence on subsidies
TRANSPORT	Air pollution GHG emissions	Declining public transport Increasing private transport (cars)	Declining access to transport Increasing isolation of low income groups Health problems
URBAN ISSUES	Water scarcity Lack of wastewater treatment Inefficient sanitation services Urban sprawl	High cost of solid waste management High cost of infrastructure	Health problems Social /ethnic tensions

One of the methods was scoring the possible solutions on a combined cost and complexity scale, as presented in Figure 11.4. The priority problems and solutions were integrated into recommendations for short and medium term for the government at different levels. The workshops were prepared by the project team and a number of facilitators trained to provide support to the working groups.

Main findings

The pilot demonstrated that the PSD approach is a valuable tool for participatory decision making. If used as a part of green growth strategy design, PSD will increase the sustainability of the green growth measures by providing a tool for stakeholder consultations early on in the process and by increasing awareness about climate change.

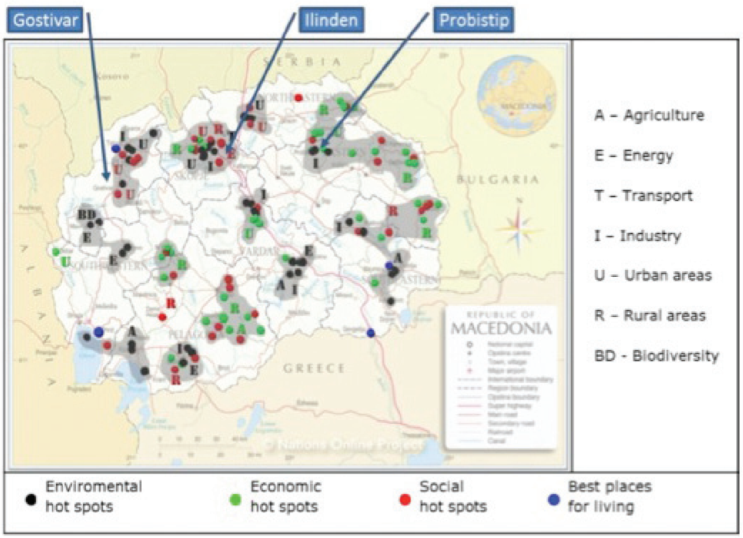
The outcomes of the workshop discussions show what type of findings the PSD approach provides. The pilot outcomes cannot be used to make conclusions regarding the perceptions of the population of the green growth issues because the pilot, being used to test the methodology, did not involve a wide enough representation of the Macedonian population and therefore the outcomes are not representative for the entire country or any part of it.

The workshop discussions provided information about the level of awareness of the green growth concept; the potential impact on the vulnerable groups including farmers and socially disadvantaged groups such as the unemployed, disabled, elderly, children, rural women and farmers, and the need in social protection strategies; the potential impact on employment and the need in programs aimed at creating new skills and knowledge to adapt to new conditions; and the requirements to local capacity for planning and implementing green growth strategies.

The participants in the workshops identified a long list of possible inclusive green growth measures and ranked them on a two-dimensional scale of complexity and costs. This approach can be used in the PSD workshop discussions in the future. In Figure 11.4, a selection of green growth measures is presented in a four-quadrant cost-complexity diagram where the easiest and cheapest set of measures can be started immediately, such as walking and cycling instead of taking the car, turning off the light, recycling of waste, and rational use of water. The second set of measures is easy to implement, but they require investments. These include thermal isolation of buildings, installation of solar energy panels and drip irrigation systems. The third set of measures is hard to implement and expensive. Examples are solar and wind power plants, electric

FIGURE 11.3. **FYR Macedonia is a country with major environmental, economic and social problems**

Hot spots identified during the inception workshop and the location of the PSD workshops



Source: Social sector technical paper.

FIGURE 11.4. **Examples of green growth measures, divided in categories of complexity and costs of implementation by workshop participants**

EASY TO IMPLEMENT		HARD TO IMPLEMENT
Most expensive, need for financial support		
Innovation in green technology Utilization of solar renewable energy sources Thermal insulation of buildings Irrigation and drainage systems in agriculture Increasing the service level of public transport Early retirement schemes to provide jobs for young people	Hybrid/electric vehicles (private/public) Hydro and geothermal power plants New water reservoirs Sewage water treatment plants Gas-fuelled heating systems Public-private partnerships in public services and green industry	
Vocational training in new technologies Education and training of farmers Awareness raising campaigns on climate change, environment and green growth, incl. energy saving and waste recycling	Revision of education system Changing legislation Law enforcement	
Less expensive, no need for financial support		

transport, waste collecting and recycling facilities, and waste dumpsites. The fourth set includes most complex and time consuming ones: revision of the education system, new and adapted legislation and law enforcement, are required, which is, in most cases, complex and time consuming.

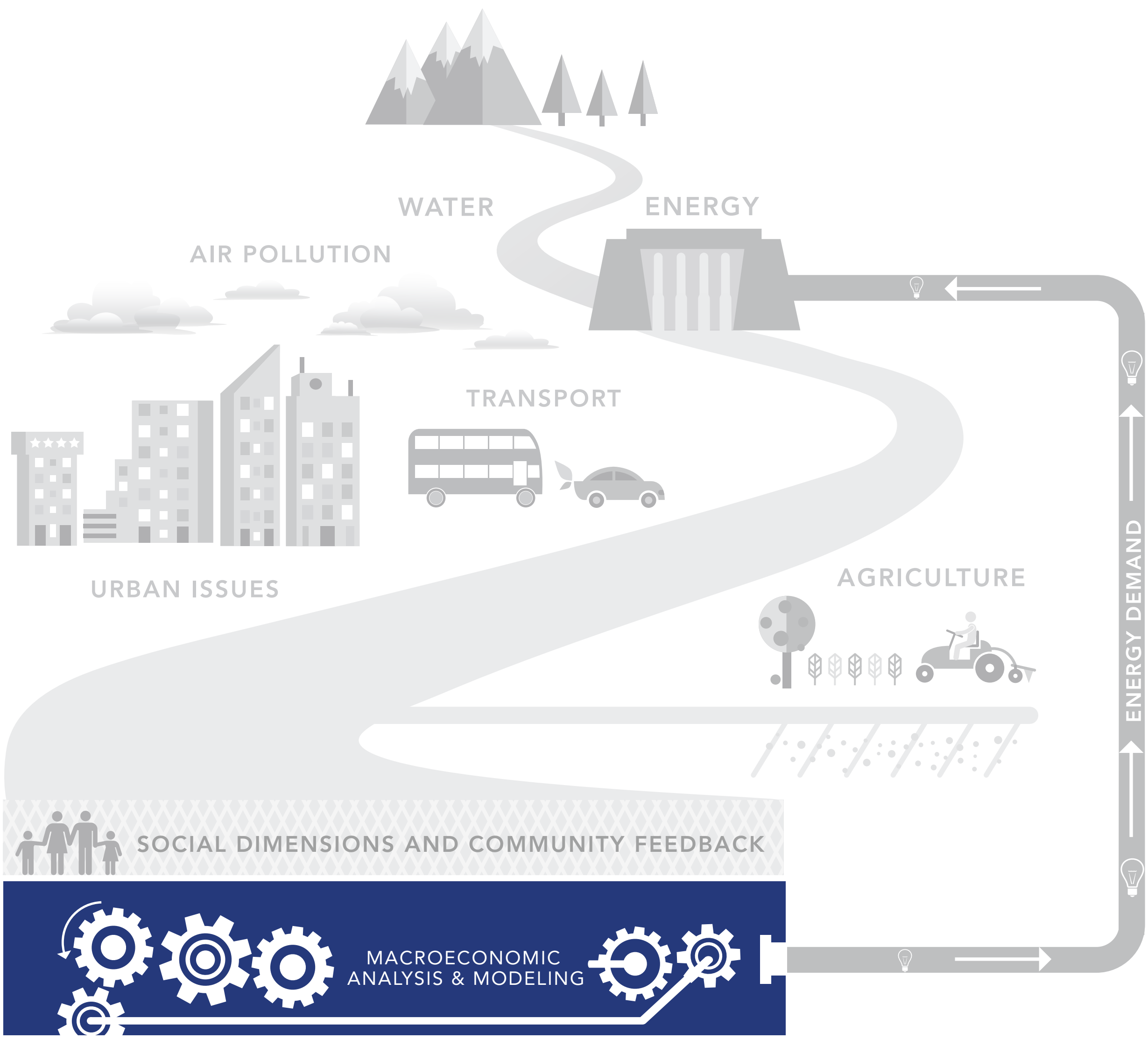
RECOMMENDATIONS

The piloted Participatory Scenario Development approach proved to be a valuable tool for participatory decision making. It can provide information about the level of awareness and understanding of the concept of green growth; the potential impact on vulnerable groups; the potential impact on employment and the need for programs aimed at creating new skills and knowledge to adapt to new conditions; new insights into how to strengthen social safety nets; and the need for improved local capacity for planning and implementing green growth strategies.

PSD should be used from early-on and at all stages of the decision making process in order to ensure full inclusion of the stakeholder input into the Green Growth strategy and to maximize the level of population awareness of the Green Growth measures.

The outcomes of Green Growth PSD workshops can be used not only to support the design of the Green Growth strategy, but also **for informing general decision making in all sectors included in the workshop discussions**, such as water, agriculture, energy, transport, and urban. They can also provide relevant information for the social sectors, in particular, for education and social protection. To use the workshop discussions to the full benefit of the sectors, sector representatives should be consulted during the preparation of the workshop discussion instruments and be encouraged to add questions or topics of importance to their work. This approach would also increase incentives for the government stakeholders to be fully involved in the Green Growth strategy design.

Workshop outcomes should be analyzed taking into account the location where they took place, representation of various social groups (by education, age, gender, income, professional affiliation), in each workshop and the timing of the workshop in relation to major events that are relevant to the topics of workshop discussion. Then, the outcomes could be used at the local, as well as central level, and interpreted with a better insight. The outcomes could be compared across the workshops to conclude which opinions are typical for the country and which could be representative for certain social groups and locations. The temporary impact of major events and their discussion in mass media could be separated from stable public opinion.


WATER
ENERGY
AIR POLLUTION
TRANSPORT
URBAN ISSUES
AGRICULTURE
ENERGY DEMAND
SOCIAL DIMENSIONS AND COMMUNITY FEEDBACK
MACROECONOMIC
ANALYSIS & MODELING

CHAPTER 12

How Can Public Investment Choices Support Greener Growth?

CHAPTER SUMMARY

The macroeconomic model constitutes a backbone for the harmonization of the sectoral work in a consistent and rigorous manner, and the economy-wide analysis builds directly on the sectoral analyses of water, agriculture, infrastructure, energy, and transport. The modeling assesses the impact on growth and employment of packages of actions on green growth across sectors and calculates the impact of actions in any one sector on all the others. While there is some body of experience with linking mitigation measures to a macroeconomic model, a useful approach to adaptation actions has been more elusive. Putting the sectors together provides the government with a potentially powerful tool to consider which public investments will have the highest returns over time, including investments to counter climate change and investments to reduce greenhouse gas emissions. This modelling analysis aims to inform policymakers on the question, "How can public investment choices support greener growth?"

The Macroeconomic Options of Mitigation and Adaptation model (MOMA model) is a dynamic stochastic general equilibrium model and captures the complex linkages between climate mitigation and adaptation policies and macroeconomic performance in an innovative manner. This large-scale model builds on the advances generated under the World Bank's low carbon growth country study for Poland[190] to integrate detailed engineering options for mitigating greenhouse gases. Adaptation measures were analyzed by the MOMA model, not only in this 'bottom-up' manner (for agriculture and water) but also econometrically in a 'top-down' manner (for facilities of physical infrastructure). The Green and Super Green scenarios, derived from the sector analyses, reflect ambitious and very ambitious climate action. The mitigation measures, mainly in energy, enable impressive 40 percent and 70 percent reductions in greenhouse gas (GHG) emissions starting in the early 2030s, in the Green and Super Green scenarios respectively, measured relative to the business-as-usual scenario (including the impact of a changing climate). Implementation of the Green package of policies and investments will dampen GDP by 2.7 percent in the short-term, but boost GDP by 1.5 percent of GDP by 2050, while Super Green implementation will undercut GDP by almost seven percent in the short-term. The ('bottom-up') estimates of costs of adaptation in the water sector were revealed to be of much higher magnitude than the ('top-down') costs of protecting infrastructure facilities; while for mitigation actions, the model finds that energy efficiency measures are most promising from a long-term growth perspective. The interventions proposed for transport seem to be prohibitively costly, but there is an important caveat in this interpretation as local benefits of a modernized transport infrastructure were omitted. In the Super Green package, the economic effects are of similar pattern but of a higher magnitude.

190. Jorgensen, Erika, and Leszek Kasek (2011), Transition to a Low-Emissions Economy in Poland. A Low Carbon Growth Country Study. Washington, DC: World Bank.

Public investment choices on green actions can be guided by the findings produced by macroeconomic modeling. Adaptation interventions are less costly, and so more easily afforded than mitigation measures, both on the investments needed and the expected economic impacts. Within adaptation measures, public investments to prevent losses in agricultural production are significantly higher than those for maintenance of various infrastructure services. The investments in infrastructure resilience can be interpreted as a type of insurance against the risk that a changing climate will derail the country's growth in future decades by disrupting infrastructure services. From the viewpoint of cost efficiency and economic performance, the government's approach to mitigation should be equally selective and should focus first on energy efficiency. While foreign financing would counter the short-run costs to FYR Macedonia from green policies and investments, given the uncertainty of access to non-debt financing, including the availability of EU funds, domestic savings options are the most likely funding source over the near term. This fiscal constraint makes prioritization of public investments, including green investments, even more important since even the green scenario's relatively modest financing needs would constitute one-quarter to one-fifth of the annual public investment budget. Lastly, this assessment is not cast in stone. Many sources of uncertainty and several methodological issues remain in applying an economy-wide model such as MOMA, in conjunction with sector analytic approaches, to key green growth policy questions. Government must make a commitment to ongoing and ever-improving in-country analyses to provide up-to-date assessments for their policy decisions. Technical assistance in building such tools with a working group drawn from across government and local institutions enables the government to apply these models and their successors to a variety of policy questions in the future.

CHALLENGES FOR GREENER GROWTH

The preceding chapters have set out findings and recommendations across eight sectors and topics, but that presentation does not constitute a unified analysis. Each sector chapter has provided recommendations on climate actions—to support mitigation of greenhouse gas (GHG) emissions or adaptation to a changing climate—and greening. Governments cannot simply aggregate sector level recommendations and requests for spending. Limited resources need to be allocated, and so sector assessments need to be integrated to some degree, and recommendations prioritized. One approach to such integration is economy-wide analysis that aims to link up with the sectoral analyses.

At the macroeconomic or economy-wide level, modeling can provide integration across sectors. General equilibrium models set up a coherent economy-wide framework and allow economic decision-making to be the outcome of decentralized optimization by producers and consumers.

They simulate the functioning of a market economy, including markets for commodities, for labor, and for capital. They provide a detailed look at how changes in economic conditions are mediated through prices and markets while assuring that all economy-wide constraints are respected. They also enable quantitative examination of how shocks or policies move through the economy and influence its performance and structure. Dynamic processes can be captured, which is important if the time horizon of the modeling is long (such as the 40 year horizon used here).

Putting the sectors together will provide the government with a potentially powerful tool to consider which public investments will have the highest returns over time, including investments to counter climate change and investments to reduce greenhouse gas emissions. Formal links to the detailed sector analysis, or iterative interactions, will enhance the consistency of the sector analysis and strengthen the insights that emerge from the macroeconomic analysis. The macroeconomic modeling needs to provide a basic economic framework to each of the sectors as a starting point: overall growth, inputs, and prices; while the sector analysis confirms the consistency of sectoral details in the economy-wide baseline scenario. The integration of sector findings into the macroeconomic model then allows richer insights about the alternative scenarios. However, the method of integration is not clear-cut. The modeling approaches developed for the World Bank's low carbon growth country study for Poland[191] allowed for inclusion of mitigation investment options into the model, thus feeding the 'bottom-up' analysis of sectors directly into a general equilibrium framework.

METHODOLOGY AND MAIN FINDINGS

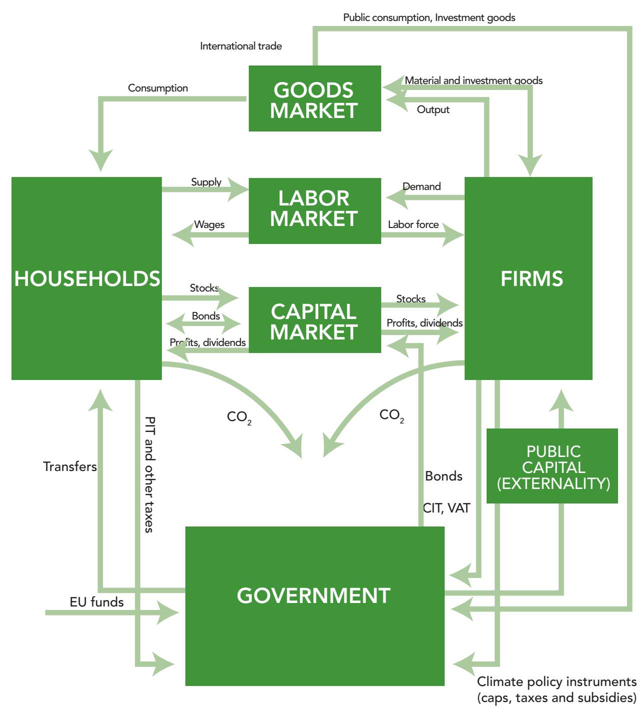
Methodology

The Macroeconomic Options of Mitigation and Adaptation model (MOMA model) is a DSGE-type of model and captures complex links between economic sectors and policy instruments. It is a simulation model and generates conditional forecasts of future economic development depending on various policy choices. The MOMA model is a large-scale, dynamic, stochastic, general equilibrium (DSGE) model. It is dynamic in that it captures the path of an economy, not just an end point, providing insight into the transition process that occurs following an economic shock. It is stochastic, including random shocks to the economy, such as technology changes, changes in relative prices, or new government policies. Finally, it is general equilibrium and covers the economy as a whole, reflecting intersectoral linkages. The model was calibrated directly on Macedonian macroeconomic data for 2008 and includes 12 sectors: agriculture (including food industry), light industry, heavy industry, energy and heat production, lignite mining, gas and oil refining, construction, transport, finance and business services, trade, public services, and other services. The MOMA model is in line with mainstream contemporary macroeconomics: neoclassical in spirit (microeconomic principles, optimization by producers and consumers), but combines elements of Real Business Cycle (flexible prices, business cycle due to technological change) and New Keynesian theories (prices set in monopolistic competition, market frictions and other imperfections). (Figure 12.1).

The MOMA model captures the linkages between climate mitigation and adaptation policies and macroeconomic performance in an innovative manner. GHG emissions are a byproduct of intermediate goods consumption by producers, sector by sector, and final consumption of households. Emissions from both sources are associated with the consumption of fossil fuels. The MOMA model builds on the advances generated under the Poland low carbon study, but

FIGURE 12.1. Three markets and three agents

Basic layout of the Macroeconomic Options of Mitigation and Adaptation (MOMA) model



Source: Macroeconomic technical paper.

191. Jorgensen, Erika, and Leszek Kasek (2011), Transition to a Low-Emissions Economy in Poland. A Low Carbon Growth Country Study. Washington, DC: World Bank.

it has several new features: a more detailed representation of international trade at the sectoral level; a semi-endogenous growth mechanism based on productive R&D spending; and a flexible mechanism of capital vintages (although not implemented fully due to data scarcity). This treatment of capital, nevertheless, enables modeling of the endogenous responses of enterprises and households to economic shocks and also to technological innovations arising in energy and emissions efficiency and in resilience (to climate change) of new investment goods. The model incorporated mitigation actions related to energy supply, energy efficiency, and transport and adaptation measures related to agriculture, water, and infrastructure.

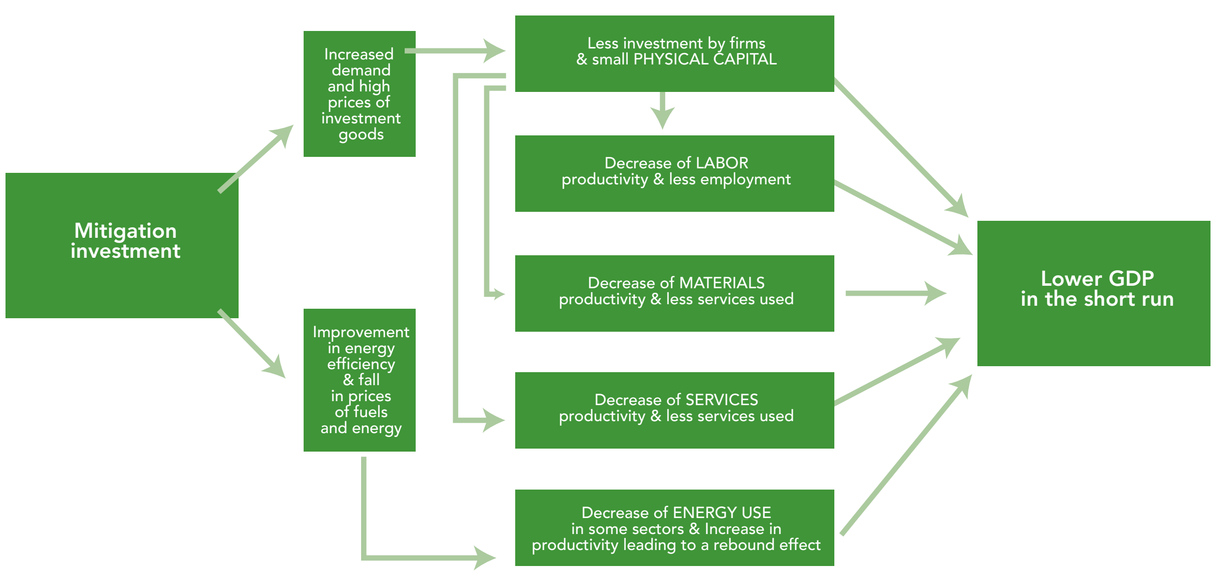
Microeconomic mechanisms in the model allow integration of mitigation and adaptation policies, albeit in simplified form. Climate action measures, whether mitigation or adaptation, can be characterized as requiring investment upfront and providing benefits later: for mitigation options, reduced operations and maintenance (O&M); for adaptation options, averted losses. The initial costs tend to depress GDP, as higher relative prices of capital goods suppress investment. Neither savings on fuel nor reduced climate damage can outweigh these costs in the short-run. Over time, however, the economy benefits either from more emissions-efficient or more resilient capital. Figure 12.2 presents a simple exposition of the short-run impact of a mitigation investment. (See also Figure 12.3).

Adaptation measures were analyzed not only in this 'bottom-up' manner (for agriculture and water), but also econometrically in a 'top-down' manner (for facilities of physical infrastructure). The protection of physical infrastructure against changing precipitation or rising temperatures is a different kind of adaptation than, for example, expanding irrigation to reduce losses in agriculture. The question for policymakers is whether to invest in strengthening (adapting) infrastructure today—building it differently—to make it resilient enough to maintain the level of infrastructure services despite the future stresses of extreme weather. An econometric estimation of infrastructure needs resulting from changes in climate conditions was carried out for the following sectors: power and telecommunications, water and sewers, roads, other transport, health and schools, urban, and housing. (See Chapter 9). These interventions have varying implementation timelines, ranging from just a few years (for power and water) to decades (for transport infrastructure). (Figure 12.3).

A critical complementary activity to the MOMA model development was technical assistance to build economy-wide modeling capacity in FYR Macedonia. A gradual, systematic, and highly-interactive learning approach was applied, with a combination of tailored learning and distance learning utilizing both World Bank technical staff and international experts with a group of technical staff from the public administration and academia. A dynamic Computable General Equilibrium model for FYR Macedonia has been developed, with an interactive user-friendly interface, and is available for future assessments and updates. Technical assistance in building such tools enables the government to apply such models to a variety of policy questions in the future.

FIGURE 12.2. Short-run impact of mitigation investment on GDP

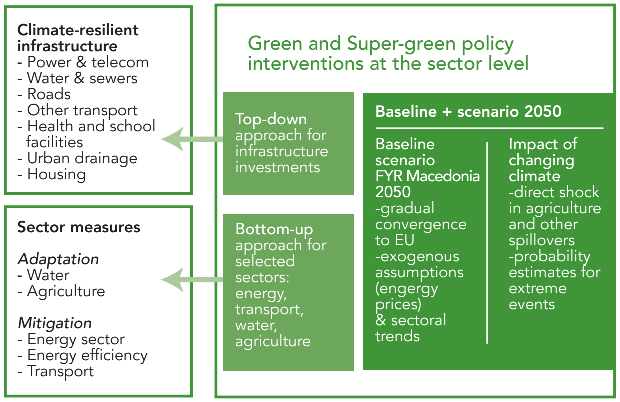
Main pathways for a policy shock



Source: Macroeconomic technical paper

FIGURE 12.3. Modeling macroeconomic impact of 'green' policy interventions in sectors

Diagram of links to mitigation and adaptation measures



Source: World Bank staff.

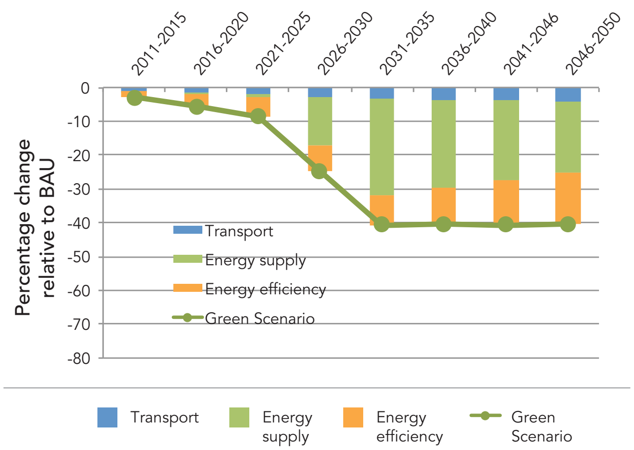
Main Findings

The Green and Super Green scenarios reflect ambitious and very ambitious climate action on the mitigation and adaptation front. Mitigation measures are drawn from energy supply and energy efficiency and transport, while adaptation measures derive from the agriculture and water sectors. The package of actions that are defined as the Green scenario contains mitigation actions to achieve a 40 percent reduction in GHG emissions. A precautionary set of adaptation measures were selected in water and agriculture based on financial assessments (including benefit-cost ratios and NPVs) and in infrastructure based on positive rates of return. The Super Green scenario has mitigation actions to achieve an almost 70 percent reduction in GHG emissions plus a set of proactive adaptation actions. These scenarios differ from each other in terms of associated investment costs, avoided economic losses, and abated GHG emissions. Projected incremental investment costs in the Green scenario are well below one percent of GDP equivalent, while in the Super Green scenario they approach two percent of GDP. The MOMA model compares the Green and Super Green scenarios to the BAU scenario—the business-as-usual scenario including the impact of a changing climate. (Chapter 3). (See Table B for a summary of policies and investments in the green scenarios).

The mitigation measures, mainly in energy, enable an impressive 40 percent and 70 percent reductions in GHG emissions starting in the early 2030s, in the Green and Super Green scenarios respectively, measured relative to BAU. The major reduction in emissions is to be achieved through energy supply and energy efficiency measures, while transport's contribution is relatively minor. Also, the most substantial change occurs between 2026 and 2035, when an existing lignite-fired power plant is to be decommissioned and replaced by a new power plant, powered by a modern but still lignite-fired plant in the baseline scenario, and replaced by a natural gas plant in the Green scenario and a nuclear plant in the Super Green scenario. (Figures 12.4 and 12.5).

FIGURE 12.4. GHG emissions fall by 40 percent

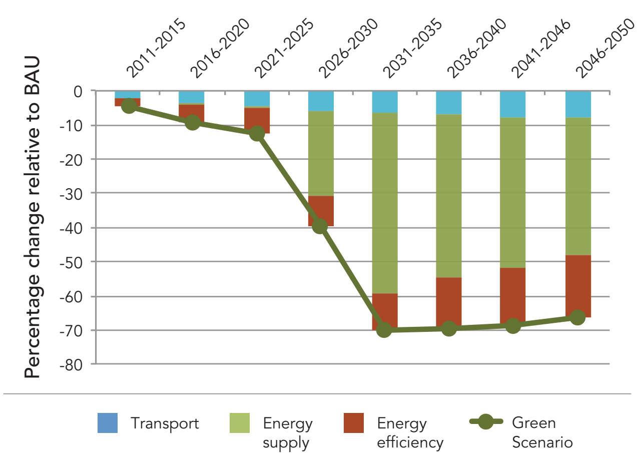
Projected GHG emissions by 2050 in Green scenario



Source: Macroeconomic model output.

FIGURE 12.5. GHG emissions fall by 70 percent

Projected GHG emissions by 2050 in Super Green scenario



Source: Macroeconomic technical paper.

Projected incremental investment costs in the Green scenario are well below one percent of GDP equivalent while, in the Super Green scenario, they exceed two percent of GDP in the later years of the current decade. It might be surprising that capital costs for energy supply turn negative after 2025 in the Green scenario and between 2021 and 2025 in the Super Green scenario, but this result stems from the lower capacity that needs to be installed in comparison to the BAU scenario due to sizable energy efficiency interventions on the demand side in the current and next decades. The baseline for the energy sector was defined in a bottom-up manner in the MARKAL model. (Chapter 6). For transport, the major cost driver is the modernized transport infrastructure that is to be developed (in both scenarios) in the current decade. (Figures 12.6 and 12.7).

On the operations and maintenance side, savings result from energy efficiency improvements (lighting and heating) and modernized energy plants, while transport generates additional costs. The incremental O&M benefits are much higher in the Super Green scenario, and by 2050, they reach 0.8 percent of GDP for energy supply (especially due to savings on fuel costs) and 0.5 percent of GDP for energy efficiency measures. Given the existing gaps, a big potential for savings is available in the current decade. Note that for transport, the operational benefits stemming from a modernized infrastructure might be underestimated as the cost estimates are focused on emissions abatement and do not take into account other benefits such as safer roads and fewer fatalities, time saved from reduced traffic congestion, or less air pollution.

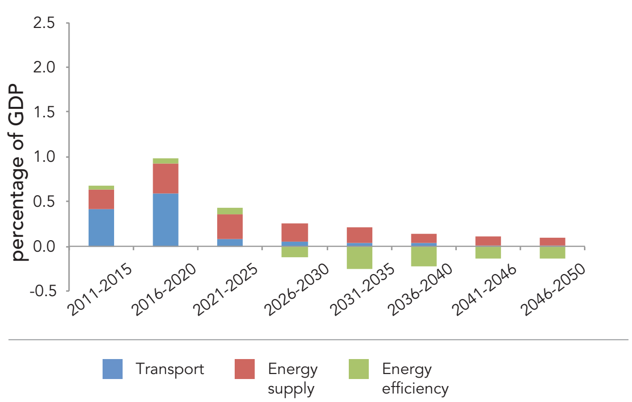
Implementation of the Green package of policies and investments will dampen GDP by 2.7 percent in the short-term but boost GDP by 1.5 percent of GDP by 2050, while Super Green implementation will undercut GDP by almost seven percent in the short-term. The macroeconomic impact of the Green and Super Green policy packages are neutral or positive in the long-run, but at a cost of short-term GDP losses.[192] With the savings rate determined by the optimal decisions of households, the large-scale investment program in 'green' sectors absorbs limited resources from the rest of the economy and leads to slower growth. By 2020, the level of real GDP falls by about 2 percent below the baseline while by 2050, it rebounds to 1.5 percent above the BAU path. To the extent that some upfront costs are funded externally (as tested in the "FDI or foreign grants financing closure" of the model, which would include any EU structural funds available to finance green policies and investments),[193] then the negative temporary effects on GDP are offset because of the positive impact of external financing on domestic aggregate demand. The

192. As an alternative to GDP, consumption or welfare changes could be presented, but because they are strongly correlated with GDP, the differences are not significant. In the MOMA model, welfare is defined as a function of discounted consumption and leisure. Local pollutants are not modeled, because of a lack of geographical dimension in this analysis, so the model cannot demonstrated the co-benefits of climate action, other than a more efficient use of (cleaner) energy or a more diversified economy.

193. Fiscal closure is the variable in the model that satisfies the government budget constraint. To meet the government budget constraint, a change in taxes or expenditures is required to cover the fiscal losses or gains resulting from the policy change. Six fiscal closures are used in which these categories of spending or taxes are adjusted: social transfers, public consumption, FDI and foreign grants (which would include any EU structural funds available to finance green policies and investments) and three tax closures: personal income tax, corporate income tax, and value-added tax.

FIGURE 12.6. **Green mitigation requires investments of 1% of GDP**

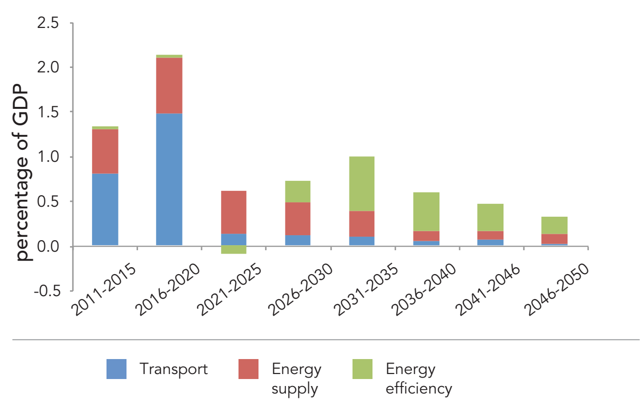
Incremental investment in mitigation measures in Green scenario, deviation from BAU as % of GDP



Source: Macroeconomic technical paper.

FIGURE 12.7. **Super green mitigation requires investments of 2% of GDP**

Incremental investment in mitigation measures in Super Green scenario, deviation from BAU as % of GDP



Source: Macroeconomic technical paper.

short-term loss in real GDP can be reduced to a marginal level in this case. Over the long-term, the economy benefits from improved resource efficiency and modernized infrastructure. The impact on employment is noticeably smaller than the impact on GDP, but the pattern is similar. (Tables 12.1 and 12.2).

The short-term impact on GDP differs across climate action measures. Among mitigation measures, those aimed at increasing energy efficiency have stronger positive effects driven by savings on energy. Less energy use means more resources available for other sectors. Lower energy demand translates into a decrease in energy commodity prices, which stimulates other sectors to expand output over time. Transport measures constitute a drag on real GDP over the whole period as they require not only higher initial expenditures on the transport infrastructure than in the baseline, but also higher outlays on its maintenance. This observation has to be treated with caution since the sectoral transport estimates, while focused on costs of emissions abatement, did not take into account other benefits of a modernized transport infrastructure such as less congestion, fewer traffic accidents, and cleaner air. Therefore, the negative impact of transport on GDP is likely overestimated in the MOMA model. Adaptation measures are aimed at preventing future losses resulting from climate change; they have rather limited economic impact but pay back faster than mitigation measures. In the short run, the effects of adaptation interventions are similar to those of mitigation measures, but they start to bring benefits to the economy soon after their introduction through the expected value of avoided losses. Also, in contrast to mitigation measures, their O&M costs are small. Since adaptation activities cost much less than mitigation projects, their macroeconomic impact is also smaller—by at least one to two orders of magnitude. (Figure 12.8).

The decomposition of GDP impact in the Super Green scenario is similar to the Green scenario, but its magnitude is bigger. More ambitious climate action delivers a significant shift towards a low-emissions economy (due to the addition of nuclear power to the generation mix), and a more resilient economy (especially for agriculture). In this scenario, even substantive external financing, e.g. from EU funds, cannot completely compensate for GDP losses, although the losses from transport seem to be again overestimated. (Figure 12.9).

The estimates of costs of adaptation in the water sector are of much higher magnitude than costs of protecting infrastructure facilities. While incremental investments in the water

TABLE 12.1. Economic impact of the Green scenario (deviation from BAU, in %)

	2015	2020	2025	2030	2035	2040	2045	2050
	Closure: VAT							
GDP	-2.7	-2.2	-0.5	0.2	0.8	1.2	1.3	1.5
Employment	-1.0	-1.1	-0.5	-0.2	0.0	0.2	0.3	0.4
	Closure: FDI or foreign grants							
GDP	-0.3	-0.3	-0.2	0.5	0.9	1.0	1.0	1.1
Employment	-0.4	-0.5	-0.4	-0.2	0.0	0.2	0.2	0.3

Source: Macroeconomic technical paper, MOMA model simulations.

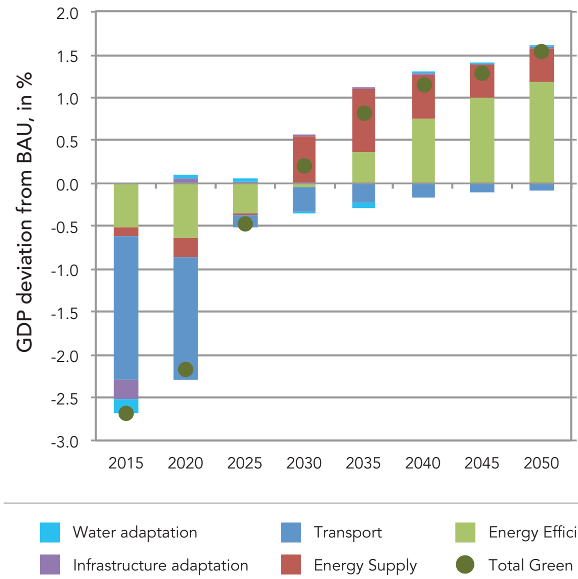
TABLE 12.2. Economic impact of the Super Green scenario (deviation from BAU, in %)

	2015	2020	2025	2030	2035	2040	2045	2050
	Closure: VAT							
GDP	-6.9	-3.7	-0.1	-2.3	-2.4	0.1	0.6	1.3
Employment	-2.9	-1.7	-0.2	-1.1	-1.5	-0.1	0.1	0.4
	Closure: FDI or foreign grants							
GDP	-1.6	0.2	0.1	-1.1	-1.2	0.5	0.8	1.1
Employment	-1.6	-0.4	-0.3	-0.9	-1.2	-0.1	0.1	0.3

Source: Macroeconomic technical paper, MOMA model simulations.

FIGURE 12.8. Impact on GDP differs across climate action measures

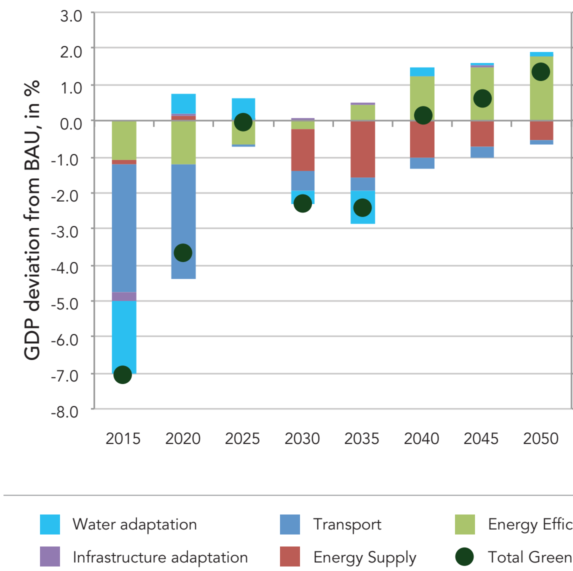
Decomposition of GDP impact of Green scenario, VAT closure



Source: Staff calculations based on macroeconomic modeling outcomes, Macroeconomic technical paper.

FIGURE 12.9. Decomposition of GDP impact in the Super Green scenario is similar to the Green scenario, but its magnitude is bigger

Decomposition of GDP impact of Super Green scenario, VAT closure



Source: Macroeconomic technical paper, World Bank staff calculations.

sector in the Super Green scenario reach one percent of GDP by 2015, the measures to protect infrastructure would cost less than 0.1 percent of GDP. However, patterns of investment and O&M costs are similar– investments incur upfront costs, and benefits emerge later. Also, the benefits increase in the long run if measured in absolute values but tend to decline over time if measured as a percentage of the country's rising future GDP. Aging adaptation capital also requires higher expenses for repairs and maintenance.

Adaptation measures in the water and agriculture sectors are profitable even at high discount rates (10 percent), while profitability of adaptation in infrastructure largely depends on the choice of discount rate. By 2050, the ratio of net benefits from adaptation in agriculture and the required investment ranges between 1.2 and 1.3 in the Green and between 1.4 and 1.8 in the Super Green scenario. In the case of infrastructure measures, the discount rate of 5 percent indicates a break-even point between investment cost today and discounted benefits. For a rate below 5 percent, the investments are profitable; otherwise, discounted benefits are lower than the cost of the investment.

RECOMMENDATIONS

Public investment choices on green actions can be guided by the findings produced by macroeconomic modeling. Adaptation interventions are less costly than mitigation measures from the macroeconomic perspective, calculated either as the value of associated investment needs or in terms of expected economic impacts. Moderate adaptation measures in agriculture or incremental expenses in the climate-proofing of physical infrastructure would amount to the equivalent of around 0.1 percent of annual GDP, while Green mitigation measures would require the mobilization of resources constituting about 1 percent of annual GDP. Given the current economic situation and tight public budgets, this difference is not trivial. Should the authorities decide on more ambitious climate action, the investment costs of Super Green adaptation would approach 1 percent of GDP, while Super Green mitigation would require the equivalent of around 2 percent of GDP. The effects of the proposed adaptation measures on GDP and employment are marginally negative or almost neutral from a short-term perspective, reaching a slightly positive level in the medium term (5 years from the investment phase). Moderate or ambitious mitigation action would also promise a medium- to long-term boost in GDP level up to

1.5 to 2 percent by 2050, but the short-term GDP loss would exceed 2 percent were financing to be mobilized domestically.

On adaptation, public investment requirements aimed at preventing losses in agricultural production due to changing climate patterns are significantly higher than investment requirements focusing on the maintenance of infrastructure services across different sectors. Aggressive action averting potential losses in agricultural production and farmers' incomes through the modernization of irrigation and other facilities would require investments as high as the equivalent of 1 percent of annual GDP. According to the water sector analysis, the monetary benefits of such interventions are higher than costs and are not sensitive to the assumed discount rate. This means that investing in modernized irrigation and more resilient crops pays off even at relatively high (above 5 percent) discount rates. By comparison, making power, road or urban infrastructure more climate-resilient is aimed at preventing disturbances in FYR Macedonia's future economic development. This can be interpreted as a type of insurance against the risk that a changing climate will derail the country's growth and income convergence towards Europe in future decades. Following the patterns in other countries in the past, this will require more investment in physical infrastructure and improvements in its quality. The low price of this insurance, at the equivalent of 0.1 percent of annual GDP; makes it seem a price worth paying to prevent potential climate damage over the next decades. On the other hand, the price for even more resilient infrastructure largely depends on the authorities' time preference. If they attach a higher value to costs and benefits emerging over the medium- to long term rather than the short term, then they will be willing to invest in this insurance. In technical terms, time preferences are reflected in the assumed discount rate. With a discount rate below 5 percent, investments in climate change-resilient infrastructure bring more benefits that costs. However, if less value is attached to costs and benefits in the future (and the discount rate is higher than 5 percent), these investments will prove inefficient. Naturally, there are significant differences in the costs and benefits associated with investments in various types of infrastructure. Additional funds devoted to the climate resilience of health and education facilities, urban drainage systems, and municipal buildings are more efficient than spending on roads, other transport, and power and telecoms facilities.

From the viewpoint of cost efficiency and economic performance, the government's approach to mitigation should be selective with respect to different sectors and should focus first on energy efficiency. Improved energy efficiency can be tapped into before deciding to build new low- or zero-carbon power plants or trying to implement impressive developments in the transport sector through upgraded rail infrastructure, urban and inter-city transit or traffic management systems similar to those operational in richer countries. Green and Super Green energy efficiency measures would reduce medium-term GDP by 0.5 or 1 percent relative to the baseline respectively, but by 2050, GDP would reach a level 1 percent and almost 2 percent respectively above the baseline path. Investments in green energy supply (mainly gas-fired plants) induce effects on GDP and employment similar to energy efficiency measures (an affordable drag on GDP in the short term and benefits in the longer term). By comparison, ambitious green measures in energy supply or mitigation for transport are more difficult objectives for the Macedonian government to achieve. GDP losses under the Super Green scenario in energy supply (due to the construction of a nuclear power plant), or transport investments in both scenarios, lead to persistent and significant GDP losses (up to 3 percent of GDP). However, these estimates are based on the assumption that this costly transition in power and transport relies exclusively on domestic savings and the fiscal space created either by higher taxes or reduced public expenditure (which are suitably conservative assumptions).

The source of finance for green transformation investments is important for macroeconomic results. Domestic savings options are the most likely funding source over the near term. Given the reality of fiscal constraints, prioritization of public investments, including green investments, becomes even more important since even the green scenario's relatively modest financing needs would constitute one-quarter to one-fifth of the annual public investment budget. Unsurprisingly, a reliance on external non-debt creating sources such as private FDI or EU accession or structural funds yields the best outcomes for the domestic economy. Access to the latter is dependent on the political agenda, of course, and cannot be predicted in this sort of model; but the impact of such financing, if it were to become available, can be simulated. Financing the Macedonian green transformation from EU funds would provide the exceptional possibility of raising aggregate demand without creating a public debt burden or requiring some part of current savings to be discarded. This conclusion supports the government's efforts to attract foreign investors and strengthen the environment for doing business in FYR Macedonia—it's good for growth, and it's good for green growth.

Mitigation measures also provoke different economic repercussions across sectors and the adjustment is mainly borne by the energy-intensive and trade-exposed sectors. These sectors play an important role in such a small and open economy. The estimated value-added patterns in the energy-intensive sectors, such as power and heavy industry, demonstrate higher declines in output and employment than in the rest of the economy through 2050. Therefore, the government needs to be prepared to monitor the cross-sectoral effects of the green transition and consider measures aimed at facilitating the reallocation of labor and capital from one sector to another.

Government must make a commitment to ongoing and ever-improving in-country analyses to provide up-to-date assessments for their policy decisions. Many sources of uncertainty and several methodological issues remain in applying an economy-wide model such as MOMA, in conjunction with sector analytic approaches, to key green growth policy questions. Some of the key uncertainties and issues follow. First, technical progress creates an enormous source of uncertainty over the 40-year horizon. Technological breakthroughs could substantially decrease the costs of climate action. Secondly, global developments—on natural resource prices and on global economic growth—will drive local costs and benefits but are almost impossible to predict. Third, projections of the global climate models vary considerably–more pessimistic climate developments translate into higher economic losses in the future and larger benefits of adapting. Fourth, 'adaptive capacity' determines how well countries cope with a changing climate, but a precise definition that would allow this factor to be integrated into analysis is lacking. Fifth, there is a lack of distinction between the costs of climate change and the costs of natural disasters that occur within current climate conditions. Sixth and finally, the discount rate is critical. If the discount rate is high, reflecting less concern about the future on the part of citizens and government, then both future benefits and future costs will be heavily discounted, and fewer green actions will have positive net present values. For progress against these challenges to full understanding of a green growth path, analytic work needs to continue in future years. Technical assistance to a working group drawn from across government and local institutions has enabled the government to apply these models to a variety of policy questions in the future, even as data, tools, and models are improved. The comprehensive analysis of this report, and the acquisition of tools to apply into the future, should give confidence to Macedonian policymakers considering green investments and policies that a future that is both wealthier and greener is achievable.

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European Commission's climate action:

http://ec.europa.eu/clima/policies/transport/vehicles/cars/index_en.htm

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Green Growth Knowledge Platform website, developed in partnership between the Global Green Growth Institute, the OECD, UNEP, and the World Bank.

http://www.ggkp.org;

http://www.oecd.org/greengrowth/greengrowthknowledgeplatform.htm; http://gggi.org/activities/research/green-growth-knowledge-platform/; http://sustainabledevelopment.un.org/index.php?menu=1447.

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South East European Forum on Climate Change Adaptation:

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World Bank's EFFECT:

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This Green Growth Country Assessment for FYR Macedonia defines a green growth path to 2050, focusing on climate action. While addressing today's economic challenges, policymakers need to keep the long-term in mind, both the likely impact of a changing climate on water, agriculture, and infrastructure and growing obligations to mitigate greenhouse gas emissions, especially from energy and transport. These considerations are particularly important for decisions on long-lived infrastructure such as power supply, irrigation, or urban streets, water distribution, and sewers.

Innovative modeling of water, as a constraint on growth as the climate becomes warmer and drier, quantified the tough tradeoffs that will be needed to balance competing demands from agriculture, the power sector, and municipalities and industry. A greener energy sector demands aggressive energy efficiency measures while bolstering supply security and reducing greenhouse gas emissions. Sizable investments are needed in rail and public transport to support growth and reduce emissions. Growing energy intensity in urban areas, driven by sprawling development of single family houses using wood for heating and private cars for commuting, must be reversed. Any green growth path must also address the country's harmful air pollution, the reduction of which will provide large local benefits to Macedonians' health.

Carefully-chosen public investments and policies can ease the path to a more resilient and climate-friendly economy without sacrificing long-term growth. An economy-wide macroeconomic assessment found that climate investments pose costs upfront but provide benefits both now and later. Even if financed entirely domestically, the impact on GDP growth of a package of green actions on adaptation (which protects tomorrow's output from climate damage) and mitigation (which nearly halves greenhouse gas emissions) is modestly negative at first and becomes a boost to growth within 15 years. On the benefit side, policymakers will have taken a significant step towards creating a greener, more sustainable economy for generations to come. Such comprehensive analysis should give confidence to policymakers considering green investments and policies.

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