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A KNOWLEDGE NOTE SERIES FOR THE ENERGY & EXTRACTIVES GLOBAL PRACTICE

2018/96

THE BOTTOM LINE

The vast energy efficiency potential in industry remains largely untapped, impairing global efforts to mitigate climate change. With the right steps, energy savings by 2035 could rise to 668 million metric tons of oil equivalent in OECD countries, and up to five times more in developing countries. Gains could be achieved through plant modernization, process improvements, and deployment of the best available technologies. Reducing energy demand improves energy security, opens infrastructure bottlenecks, and mitigates the environmental impacts of industrial energy production and use. It also makes factories more competitive.

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Energy Efficiency in Industry

Why does energy efficiency in industry matter?

Unless energy efficiency potential is harnessed, industrial emissions of CO_2 will soar, accelerating climate change

In 2015 industry accounted for 29 percent of global energy consumption and 36 percent of CO_2 emissions (www.iea.org/statistics). By 2050 population growth and economic development in developing countries are likely to increase demand for raw materials by 45 to 60 percent (relative to 2010). These in turn will increase energy demand in the industrial sector. In the meantime, the vast energy efficiency (EE) potential in the sector remains untapped, even as industrial productivity has improved dramatically over the past few decades. Unless the EE potential is realized, the Intergovernmental Panel on Climate Change estimates that industrial emissions of CO_2 will rise 50 to 150 percent by 2050, impairing global efforts to mitigate climate change.

If EE were widely adopted, energy savings by 2035 could rise to 668 million metric tons of oil equivalent (Mtoe) in developed (OECD) countries, increasing up to five times more, to 3,482 Mtoe, in developing countries (IEA 2012).[1] Such gains could be achieved through plant modernization, process improvements and optimization, and deployment of the best available technologies. Improvements in industrial EE are also good public policy and good business. EE makes factories more competitive, and reduced energy demand in turn improves energy security, reduces infrastructure bottlenecks, and mitigates the environmental impacts of industrial energy production and use.

Although most analyses of the potential of industrial EE have focused on upgrading energy-intensive industrial processes, most countries have the bulk of their manufacturing employment and GDP productivity in small and medium enterprises (SMEs). It is therefore here, in SMEs, where the best opportunities exist for optimization and investment. But industrial EE should go beyond upgrading existing factories. Although some countries have large industrial bases (for example, China, India, and Turkey) and others have a legacy of outmoded and inefficient plants (the former republics of the Soviet Union), many more countries have ambitions for new or substantial growth in industrialization (for example, Vietnam, Uzbekistan, and nations in Sub-Saharan Africa).

What are the main challenges to greater energy efficiency in industry?

Although efficiency improvements are good business practice, they do not happen on their own. Key systemic barriers include:

- **Low energy pricing**, which makes investments in EE less financially attractive, thereby encouraging overconsumption.
- **Lack of data**, both on energy use and baselines, as well as credible data on the performance of newer systems and technologies. Energy audits and energy management systems can provide such data, but the associated costs may be higher than factories are willing to spend, particularly before they know the benefits.

[1] For reference, the total final energy consumption of the United States is about 1,500 Mtoe.

Energy efficient production makes factories more competitive. Reduced energy demand in turn improves energy security, reduces infrastructure bottlenecks, and mitigates the environmental impacts of industrial energy production and use.

- **Production bias and low priority for cost savings.** Factory owners favor investments that expand production and avoid disruptions. Energy costs may not be known or may represent only a small portion of production costs. Although technical information, energy audits, and so on provide information, decision makers at the factory level may not understand such technical assessments.
- **Limited interest among financiers in financing EE.** Investors favor loans for production expansion and traditional asset-based financing, rather than cost-saving measures and cashflow-based loans. Prevailing short loan tenors, overcollateralization, inability to assess EE investments and their associated risks, and weak creditworthiness of some factories (including SMEs) all further hamper bank lending for EE improvements.

Barriers are classified in table 1.

How have countries addressed these challenges?

Governments have developed a range of policies, programs, and approaches to surmount these barriers

National governments play a crucial role in creating successful EE programs in industry. They enact policy frameworks and regulations, develop accountable institutions, and adopt broad-based market principles (for example, setting energy prices at cost-recovery levels). As recent experiences in both industrial and emerging economies show, national governments also have a catalytic role in market development. They can remove barriers to the knowledge, incentives, capacity, and finance needed to scale up industrial EE investments. Developed countries with large industrial production sectors, like

Table 1. Barriers to implementing energy efficiency projects in the industrial sector

	Industrial energy users	Energy service or technology providers	Financiers
Knowledge, capacity, and incentive barriers	• Excessive management focus on short-term benefits such as sales revenue and growth • Low energy efficiency benefits relative to other costs and priorities • High perceived risks of new technologies or systems • Lack of credible data and information needed for decision making • Inadequate technical and financial expertise • Poor access to energy-efficient technologies and relevant services	• Limited demand for energy efficiency services and technological innovations • New contractual mechanisms (for example, energy savings performance contracts) that may increase business risks • Limited technical, business, and risk-management skills • Poor communication with bankers	• Lack of information on energy-efficient technologies and their benefits • Lack of customized financial products and appraisal procedures • Lack of capacity for measurement and verification • Limited understanding and capacity among loan officers and risk managers
Financial barriers	• High up-front capital costs, usually for energy-intensive industries • High borrowing costs and limited access to financing, especially for SMEs • Expectation of a high return on investment (quick payback) • High project development and transaction costs relative to project size, particularly for SMEs	• High project-development costs • Limited access to financing and equity	• High transaction costs associated with small and widely dispersed energy efficiency projects • Competition for capital from other high-return, low-risk business opportunities • Financial risks associated with SMEs, including energy service companies

Source: World Bank (2016a).

Note: SMEs = small and medium enterprises.

A well-designed national industrial EE program has clear policy goals linked with measurable targets and a range of policy instruments to guide and encourage action, facilitate financing, and build the implementation capacity of market participants.

Japan and the Netherlands, have encouraged and at times mandated industries to reach significant EE goals and targets. Other countries, including Germany and Canada, have supported information sharing, networks, and in some cases incentive schemes to encourage industries to reduce energy waste. Spain implemented demand-side response for industry, driven by electricity price differences between peak and off-peak hours. In emerging economies that have achieved consistent and substantial improvements in industrial EE, like China and India, governments have made deliberate efforts to pursue market reforms and to pilot, demonstrate, and scale up policy interventions.

A well-designed national industrial EE program has clear policy goals linked with measurable targets and a range of policy instruments to guide and encourage action, facilitate financing, and build the implementation capacity of market participants. A portfolio of industrial EE policies and programs could include:

Ambitious, yet realistic national targets based on sound market and technical analyses, understanding market gaps, cost-effective investment opportunities, and available resources. Both China and the European Union provide examples. In China, targets for reducing energy intensity are set in each Five Year Plan. The 12th Five Year Plan targeted a 16 percent reduction by 2015, which was overachieved; for the 13th Five Year Plan the target is a 15 percent reduction by 2020. The European Union's 20-20-20 targets call for a 20 percent improvement in EE by 2020, as part of the EU's 2020 Climate and Energy Package.

Sector-specific programs and core policy instruments can contribute industrial inputs to help meet national EE targets. Typical program elements include regulations, information, and awareness-raising campaigns, in addition to financing and technical assistance. Examples include China's 10,000 Enterprise Program (based on mandatory energy savings agreements), India's Perform-Achieve-Trade scheme (a market-based mechanism for trading certificates of industrial energy savings), and Denmark's voluntary agreements with some 300 industries, in place from 1996 to 2013.

Supplementary policies and implementation-support systems are important. Examples include requirements and support for enterprise energy managers, energy audits, and energy management; facilitation of commercial bank financing; support for energy-performance contracting, case studies, and implementation guides; standardized templates for project investments; and support for training and information dissemination.

Governments have a range of specific policy instruments at their disposal:

- Minimum energy performance standards for energy-consuming equipment (for example, boilers and electric motors)
- Voluntary or mandatory energy savings agreements with large energy users (when a third party can verify savings with "white certificates," these can be bought by large energy users that are unable to meet targets)
- Tax incentives, for example, for the installation of efficient equipment
- Elimination of import duties on efficient technologies and bans on inefficient technologies
- Incentive grants tied to verified energy savings
- Special assistance to SMEs (for example, grants or in-kind assistance for energy audits and project development)
- Assistance in establishing energy-management systems.

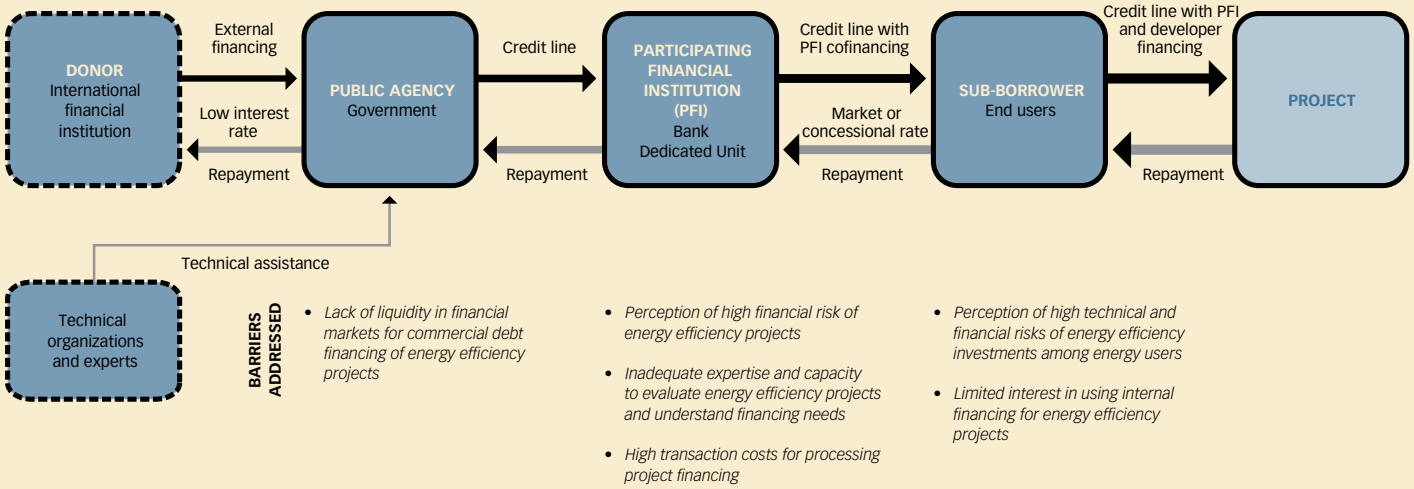
In addition to imposing policies and regulations, governments can inform and raise awareness about industrial EE. These campaigns can cite sector-specific case studies and provide information about technical needs and finance, subsector benchmarking, and mandatory reporting. "Fame and shame" programs can identify high and low performers.

Governments can also help with the development of alternative delivery mechanisms, such as energy service companies (ESCOs), utility demand-side management (DSM) programs, and commercial lending. ESCOs can be fostered through special equity/financing windows for contracting in industry. Utility mandates for industrial EE programs are useful when they include on-bill financing. Programs to train local banks to appraise EE projects are another way for governments to support industrial energy efficiency. Typical financing mechanisms for industrial EE include credit lines (box 1), special lending programs, incentive schemes, credit guarantees, ESCOs, and leasing.

"Fame and shame" programs can identify high and low performers.

Box 1. Credit lines for industrial EE

Credit lines are a standard financing mechanism for industrial EE. They also support bank lending, whereby factories access working capital and investment loans. Because the institutional setup of credit lines relies on banks and other financial institutions, no new mechanisms have to be established. As with all delivery mechanisms, however, credit lines have limitations. In developed financial markets—where the regulatory framework is strong and financial institutions have well-established project appraisal procedures, strong management commitment to pursue an EE lending business, and professional and technical expertise—implementation of the credit line may be more straightforward. In less-developed markets—where banking regulations are more restrictive and financial institutions' capacity to manage EE projects is less developed—a credit line's effectiveness may be more limited, and project-appraisal procedures may restrict the pool of borrowers for the credit line. But in some cases, as with the World Bank China Energy Efficiency Financing Project (see table 3), credit lines have been instrumental in helping energy service companies access financing for their projects, which can further facilitate industrial EE investments. The typical design of an EE credit line is depicted below:



Sources: World Bank (2014); World Bank (2016b).

Note: Thickness of arrow represents relative magnitude of financial flows to depict leveraging. Public agencies may offer credit lines without the aid of external donors (dashed border).

What has the World Bank done to help?

The World Bank's portfolio of industrial EE investments is paying off, but constraints remain

The World Bank uses a variety of instruments to support industrial EE financing in client countries, most often through credit lines and guarantee schemes (table 2). Over the past decade, the World Bank has developed multiple, large industrial EE programs in China and Turkey in addition to single operation projects in Brazil, Colombia, India, Jamaica, Tunisia, Vietnam, Ukraine, and Uzbekistan.

The World Bank has supported industrial EE and competitiveness programs for public enterprises as well as large, medium, and small private enterprises. It has supported a number of countries through technical assistance. The current portfolio of industrial EE projects (table 3) is estimated at about $1.53 billion in World Bank financing, with total investments reaching $24.6 billion, including funds from financial institutions and cofinancing from counterparts and subborrowers.

Table 4 includes results reported from some recently closed operations. Although results vary and are difficult to aggregate, they

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Table 2. World Bank program models for industrial EE

Program instruments	Credit lines, loan guarantees, mezzanine funds
Description	Lending to one or more local banks to support portfolios of smaller EE investments in public/private enterprises
Implementing agencies	Development banks, public and commercial banks, guarantee companies
Success factors	• Sound market analyses to identify eligible and viable target markets • Strong, stable demand built through multiple channels and technical intermediation • Appropriate financial products, standardized to lower transaction costs • Committed banking partners with internal capacity raised as needed through technical assistance

Source: World Bank (2016c).

Table 3. World Bank industrial EE projects (ongoing)

Country	Project	Total project cost (US$ million) [WB financing]	Description/model/target market	Approval date/ closing date
Brazil	Financial Instruments for Brazil Energy Efficient Cities	$1,324.0 [IBRD: $200.0; CTF: $20.0]	Unlock private financing by reducing credit risk and enhancing technical quality of street lighting and industrial EE projects	Jun 29, 2018/Dec 31, 2033
China	Shandong Energy Efficiency	$317.1 [IBRD: $150.0]	Support for financial leasing and energy performance contracting of EE investments in selected industrial enterprises	Jun 9, 2011/Dec 31, 2018
China	Innovative Financing for Air Pollution Control in Jing-Jin-Ji	$1,000.0 [IBRD: $500.0]	Program-for-results supporting replacement of inefficient equipment, processes, and technologies in industry	Mar 22, 2016/June 30, 2022
China	Developing Market Based Energy Efficiency	$17.8 [GEF: $17.8]	Improve results measurement and verification system; develop market-based mechanisms for EE	Mar 16, 2017/Apr 30, 2022
Colombia	Clean Energy Development	$1,015.0 [IBRD: $41.0; CTF: $40.0]	Increase nonconventional renewable energy and energy savings in industrial sector through mobilization of private investment	Jul 16, 2018/Jun 30, 2024
India	Financing Energy Efficiency at MSMEs (including Additional Financing)	$87.8 [GEF: $16.5]	Increase demand for EE investments in MSMEs and build their capacity to access commercial finance	May 27, 2010/May 4, 2019
India	Partial Risk Sharing Facility in Energy Efficiency	$133.0 [CTF: $25.0; GEF: $18.0]	Partial risk-sharing facility to finance EE investments in SMEs and municipal street lighting	Feb 25, 2015/Apr 1, 2022
Turkey	SME Energy Efficiency	$233.64 [IBRD: $201; GEF: $3.64]	Scaleup of commercial on-lending to EE in SMEs	Mar 27, 2013/Sep 30, 2019
Uzbekistan	EE Facility for Industrial Enterprises (Additional Financing)	$332.5 [IBRD: $200.0]	Line of credit to increase EE and competitiveness of industrial enterprises	Jan 30, 2018/Jan 31, 2023
Vietnam	Energy Efficiency Financing	$158.0 [IBRD: $100.0; IDA: $1.70]	Line of credit with cofinancing from participating financial institutions to finance industrial EE	Apr 14, 2017/Jul 31, 2022

Source: Author's compilation.

Note: IBRD = International Bank for Reconstruction and Development; CTF = Clean Technology Fund; GEF = Global Environment Facility; IDA = International Development Association.

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show substantial energy savings. Increasing the industrial EE portfolio has been constrained, however, by governments unwilling to use their limited sovereign guarantee for private financing, which they see as space best occupied by commercial banks. These constraints are compounded by local banking partners unwilling to lend for EE. Industrial owners, similarly, are reluctant to invest. But as more countries complete reforms of their energy sector and pricing, and as new taxes are introduced to better reflect the externalities of energy use and industrial production, governments will want to increase their commitment to climate actions. By the same token, industry will have to reduce energy use to remain competitive.

Table 4. Results from some recently closed World Bank industrial EE projects

Project name [implementation period]	Total project cost (US$ million) [WB financing]	Description	Reported results
China Energy Efficiency Financing II and III (Additional Financing) [June 2010–December 2016]	$752.5 [IBRD: $145.5]	Line of credit to finance industrial EE	Lifetime energy savings of 33,374,000 MWh Lifetime carbon savings of 10,559,000 tons of CO_2eq
China Energy Efficiency Promotion in Industry [May 2011–June 2016]	$24.1 [GEF: $3.8]	Capacity building for energy managers and policy support	Lifetime energy savings of 6,391,000 MWh Lifetime carbon savings of tons of 1,963,000 CO_2eq Facilitated 17 EE investments through demonstration projects and training programs
Tunisia Energy Efficiency [June 2009–January 2016]	$40.0 [IBRD: $40.0]	Line of credit to finance industrial EE and cogeneration	Lifetime energy savings of 1,019,137 MWh Lifetime carbon savings of 280,840 tons of CO_2eq
Turkey Private Sector Renewable Energy and Energy Efficiency [May 2009–December 2016	$3,100.0 [IBRD: $500.0; CTF: $100.0]	Line of credit to finance RE and industrial EE	Lifetime energy savings: 2,600 Tcal Lifetime carbon savings of 1,468,000 tons of CO_2eq
Ukraine Energy Efficiency [May 2010–March 2017]	$200.0 [IBRD: $200.0]	Line of credit to finance industrial EE	Lifetime energy savings of 115,817,000 MWh Lifetime carbon savings of 8,561,000 tons of CO_2eq
Uzbekistan Energy Efficiency Facility for Industrial Enterprises [June 2010–January 2018]	$178.3 [IDA: $108.7]	Line of credit to finance industrial EE	Lifetime energy savings of 5,379,000 MWh Lifetime carbon savings of 8,748,000 tons of CO_2eq Leveraged about $70 million in EE investments
Vietnam Clean Production and Energy Efficiency [July 2011-June 2017]	$4.2 [GEF: $2.4]	Develop EE action plans for key industrial sectors and develop energy service providers	Lifetime energy savings of 5,462,611 MWh Lifetime carbon savings of 2,282,530 tons of CO_2eq

Source: Author's compilation.

Note: IBRD = International Bank for Reconstruction and Development; CTF = Clean Technology Fund; GEF = Global Environment Facility; IDA = International Development Association.

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What lessons have been learned?

Implementing EE in the industry sector hinges on overcoming information barriers, addressing incentives and capacity gaps, and enabling access to finance

Lessons from recently implemented projects suggest that the success of an industrial EE project depends on the following factors:

- **Strong policy frameworks.** A sound policy framework is critical for developing a national-scale program. Broad programs provide the mandates, incentives, tools, and other mechanisms to help financing programs reach their lending goals.
- **Comprehensive market assessments.** A holistic market assessment is a precondition for early identification of a pipeline of projects to be financed. Market assessments do best when they identify geographical areas, energy-intensive subsectors, and appropriate technologies.
- **Building strong demand.** Once the market is identified, projects need to be designed in a way that builds demand for the product or program using multiple channels and technical intermediation. Marketing of EE, particularly to SMEs, requires intensive technical assistance to build knowledge, acceptance, and trust. Flexible program design is also important to allow pipelines to adjust to changing market conditions.
- **Standardization and aggregation.** EE loans tend to be small, particularly for SMEs. So transaction costs must be managed with appropriate financial products and standardization. These costs can also be lowered with aggregation mechanisms, ESCOs, or clustering that is geographically based and industry-specific.
- **Selection of capable banking partners.** Trusted and committed local banking partners are crucial. Industrial enterprises will be dealing with these financial companies on a day-to-day basis. Technical assistance to commercial banks needs to be incorporated into the project design so that EE lending can be scaled up over time without international assistance.
- **Monitoring and evaluation.** Robust monitoring and evaluation plans should be set up at the outset, including a timeline for reviews of the project. In addition to tracking project performance, M&E permits early detection of possible problems. Additionally, good data make for better communication about the project's performance and impact, helping to raise awareness about the benefits of EE.

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The internal World Bank briefing note on which this Live Wire is based was prepared in July 2016 and reviewed by Gevorg Sargsyan, Jas Singh, and Martina Bosi.

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