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The World Bank

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Report No: 68254-DJ

PROJECT APPRAISAL DOCUMENT
ON A
PROPOSED IDA CREDIT
IN THE AMOUNT OF SDR4 MILLION
(US$6 MILLION EQUIVALENT)

AND
A PROPOSED GRANT FROM THE
GLOBAL ENVIRONMENT FACILITY TRUST FUND
IN THE AMOUNT OF US$6.04 MILLION

AND
A PROPOSED GRANT FROM ESMAP IN THE AMOUNT OF US$1.10 MILLION
TO THE
REPUBLIC OF DJIBOUTI
FOR A
GEOTHERMAL POWER GENERATION PROJECT

May 14, 2013

CURRENCY EQUIVALENTS
(Exchange Rate Effective February 28, 2013)

Currency Unit =
SDR 1 = US$1.51
US$1 = SDR 0.66

FISCAL YEAR
January 1 – December 31

Abbreviations and Acronyms

ADF	African Development Funds
AFD	French Development Agency *(Agence Française de Développement)*
AfDB	African Development Bank
AFFI	Arab Financing Facility for Infrastructure
ARGeo	Africa Rift Geothermal Facility
CAS	Country Assistance Strategy
CBA	Common Bank Account
CCC	Construction, Connections and Conditioning
CPS	Country Partnership Strategy
CERD	Djibouti Center for Studies and Research *(Centre d'Etudes et de Recherches de Djibouti)*
DA	Designated Account
DSC	Drilling Service Company
EDD	Djibouti Electricity Company *(Electricité de Djibouti)*
EHS	Environment, Health and Safety
EPC	Engineer, Procure, Construct
ESS	Environmental Safeguards Specialist
ESIA	Environmental and Social Impact Assessment
ESIAF	Environmental and Social Impact Assessment Framework
ESMF	Environmental and Social Management Framework
ESMP	Environmental and Social Management Plan
ESMAP	Energy Sector Management Assistance Program
EU-Africa ITF	European Union Africa Infrastructure Trust Fund
FCFP	Free Cash Flow to Project
FCFE	Free Cash Flow to Equity
FDI	Foreign Direct Investments
GCC	Geothermal Consulting Company
GDP	Gross Domestic Product
GEF	Global Environment Facility
GGDP	Global Geothermal Development Plan
GoDj	Government of Djibouti
GWh	Gigawatt Hour
HFO	Heavy Fuel Oil
IC	Individual Consultant
ICB	International Competitive Bidding
IDA	International Development Association
IFC	International Finance Corporation
IPP	Independent Power Producer
IRR	Internal Rate of Return

IT	Information and Telecommunication
JGE	Junior Geothermal Expert
Km	Kilometer
kVA	Kilovolt Ampere
kWh	Kilowatt Hours
LCB	Local Competitive Bidding
MENA	Middle East and North Africa
MOE	Ministry of Energy, Water, and Natural Resources
MOF	Ministry of Finance
MW	Megawatts
NCB	National Competitive Bidding
NPV	Net Present Value
OFID	OPEC Fund for International Development
O&M	Operation & Maintenance
OP / BP	Operational Policy / Bank Policy
ORAF	Operational Risk Assessment Framework
PB	Parsons Brinkerhoff Power
PCN	Project Concept Note
PDO	Project Development Objectives
PEFA	Public Expenditure and Financial Accountability
PMU	Project Management Unit
PPA	Power Purchase Agreement
PPIAF	Public-Private Infrastructure Advisory Facility
PPP	Public Private Partnership
QCBS	Quality and Cost-Based Selection
Re	Required Return on Equity
REI	Reykjavik Energy International
ROE	Return on Equity
SG	Secretary General
SGE	Senior Geothermal Expert
SDR	Special Drawing Rights
SEFA	Sustainable Energy Fund for Africa
SMEs	Small Medium-Size Enterprises
SOE	Statement of Expenditures
SREP	Scaling Up Renewable Energy Program
SSS	Social Safeguards Specialist
SW	Staff-Week
TA	Transaction Advisor
TTL	Task Team Leader
US	United States of America
WB	World Bank
WACC	Weighted Average Cost of Capital

Regional Vice President:	Inger Andersen
Country Director:	Hartwig Schafer
Sector Director:	Junaid Kamal Ahmad
Sector Manager:	Charles Joseph Cormier
Task Team Leader:	Ilhem Salamon

REPUBLIC OF DJIBOUTI
Geothermal Power Generation Project

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PAD DATA SHEET

Djibouti

DJ Geothermal Power Generation Project (P127143)

PROJECT APPRAISAL DOCUMENT

MIDDLE EAST AND NORTH AFRICA

MNSEG

Report No.: PAD227

Basic Information			
Project ID P127143	Lending Instrument Specific Investment Loan	EA Category B - Partial Assessment	Team Leader Ilhem Salamon
Project Implementation Start Date 05-Jun-2013		Project Implementation End Date 01-Jul-2018	
Expected Effectiveness Date 01-Jul-2014		Expected Closing Date 31-Dec-2018	
Joint IFC No			GEF Focal Area Climate change
Sector Manager Charles Joseph Cormier	Sector Director Junaid Kamal Ahmad	Country Director Hartwig Schafer	Regional Vice President Inger Andersen

Borrower: Republic of Djibouti			
Responsible Agency: Ministry of Energy			
Contact:	Djama A. Guelleh	Title:	Directeur General
Telephone No.:	25321355368	Email:	Djama-ag2a@edd.dj

Project Financing Data(in USD Million)					
[ ]	Loan	[X]	Grant	[ ]	Other
[X]	Credit	[ ]	Guarantee		

Total Project Cost:	31.23	Total Bank Financing:	6.00
Total Cofinancing:		Financing Gap:	0.00

Financing Source	**Amount**
BORROWER/RECIPIENT	0.50
International Development Association (IDA)	6.00
Global Environment Facility (GEF)	6.04
African Development Bank	2.34
African Development Fund	5.00
Energy Sector Management Assistance Program	1.10
FRANCE French Agency for Development	3.25
OPEC FUND	7.00
Total	31.23

Expected Disbursements (in USD Million)

Fiscal Year	2013	2014	2015	2016	2017	2018	2019	0000	0000
Annual	0.00	0.12	2.94	2.94	0.00	0.00	0.00	0.00	0.00
Cumulative	0.00	0.12	3.06	6.00	6.00	6.00	6.00	0.00	0.00

Proposed Development Objective(s)

The Project Development Objective is to assist the Recipient in assessing the commercial viability of the geothermal resource in Fiale Caldera within the Lake Assal region.

Proposed Global Environmental Objective(s)

Same as PDO

Components

Component Name	**Cost (USD Millions)**
Component 1 - Drilling Program	27.80
Component 2 - Technical Assistance for the Drilling Program	1.80
Component 3 - Program Management	1.60

Institutional Data				
Sector Board				
Energy and Mining				
Sectors / Climate Change				
Sector (Maximum 5 and total % must equal 100)				
Major Sector	Sector	%	Adaptation Co-benefits %	Mitigation Co-benefits %
Energy and mining	Other Renewable Energy	100		
Total		100		

☑ I certify that there is no Adaptation and Mitigation Climate Change Co-benefits information applicable to this project.

Themes		
Theme (Maximum 5 and total % must equal 100)		
Major theme	Theme	%
Environment and natural resources management	Climate change	100
Total		100

Compliance		
Policy		
Does the project depart from the CAS in content or in other significant respects?	Yes[ ]	No[X]
[redacted]		
Does the project require any waivers of Bank policies?	Yes[ ]	No[X]
Have these been approved by Bank management?	Yes[ ]	No[ ]
Is approval for any policy waiver sought from the Board?	Yes[ ]	No[X]
Does the project meet the Regional criteria for readiness for implementation?	Yes[X]	No[ ]

Safeguard Policies Triggered by the Project	**Yes**	**No**
Environmental Assessment OP/BP 4.01	**X**	
Natural Habitats OP/BP 4.04	**X**	
Forests OP/BP 4.36		**X**
Pest Management OP 4.09		**X**
Physical Cultural Resources OP/BP 4.11		**X**
Indigenous Peoples OP/BP 4.10		**X**
Involuntary Resettlement OP/BP 4.12		**X**
Safety of Dams OP/BP 4.37		**X**
Projects on International Waterways OP/BP 7.50		**X**
Projects in Disputed Areas OP/BP 7.60		**X**

Legal Covenants

Name	**Recurrent**	**Due Date**	**Frequency**
Update of Project Operation Manual (POM)		3 months after effectiveness	

Description of Covenant
The POM has been updated in a manner satisfactory to the Association.

Name	**Recurrent**	**Due Date**	**Frequency**
Recruitment of fiduciary staff		3 months after effectiveness	

Description of Covenant
Recruitment of an internationally recruited PMU director, an accountant, a procurement specialist, an environmental safeguards specialist, and a social safeguard specialist.

Conditions

Name	**Type**
Execution and delivery of Joint Co-financiers' Grant Agreements	Effectiveness

Description of Condition
The Co-financing Agreements have been executed and delivered and all conditions precedent to their effectiveness or to the right of the Recipient to make withdrawals under them have been fulfilled.

Name	**Type**

Execution of the Memorandum of Understanding (MoU)	Effectiveness
Description of Condition The MoU has been executed and delivered and all conditions precedent to its effectiveness have been fulfilled.	
Execution of the Subsidiary Agreement	Effectiveness
Description of Condition The Subsidiary Agreement has been executed on behalf of the Recipient and the Project Implementing Entity.	

Team Composition

Bank Staff

Name	Title	Specialization	Unit
Ilhem Salamon	Senior Energy Economist	Task Team Leader	MNSEG
Hassine Hedda	Finance Officer	Finance Officer	CTRLA
Victor B. Loksha	Senior Energy Economist	Financial Analysis	SEGES
Wassim Turki	Consultant	Financial Management	MNAFM
Mark M. Moseley	Lead Counsel	Lead Counsel	LEGPS
Hayat Taleb Al-Harazi	Program Officer	Financial Analysis	MNARS
Salim Benouniche	Lead Procurement Specialist	Procurement	MNAPC
Ben J. Mescher	Consultant	Geothermal Expert	LCSEG
Ruxandra Costache	Counsel	Country Lawyer	LEGAM
Mark M. Njore	Program Assistant	Program Assistant	MNSSD
Fatou Fall	Social Development Specialist	Social Safeguards	MNSSO
Rock Jabbour	Financial Management Analyst	Financial Management Analyst	MNAFM
Brian Roy White	Consultant	Geothermal Drilling Consultant	EASIS
Walid Dhouibi	Procurement Specialist	Procurement	MNAPC
Andrew Michael Losos	Environmental Specialist	Environmantal Safeguards	MNSEN
Yassine Cherkaoui	Consultant	Financial Analysis	MNSEG

Non Bank Staff

Name	Title	Office Phone	City
Robert Bacon	Consultant		Washington, DC

Locations

Country	First Administrative Division	Location	Planned	Actual	Comments
Djibouti	Region de Tadjourah	Region de Tadjourah	X	X	Fiale Caldera in the Lac Assal region, 80 Km away from the city of Djibouti

I. STRATEGIC CONTEXT

A. Country Context

1. The Republic of Djibouti aspires to leverage its strategic location between the Red Sea and the Gulf of Aden to become a maritime and international business hub for East Africa. The country, which had a population of about 905,564 and a growth rate of about 1.9 percent in 2011, is poorly endowed with natural resources and has limited arable land, rainfall, and water. Furthermore, its manufacturing sector is weak and its agriculture sector is virtually non-existent. Djibouti has little industry and depends heavily on foreign assistance to help support its balance of payments to finance development projects and to meet its food requirements. With less than 1,000 km^2 of arable land (0.04 percent of 23,200 km^2) and an average annual rainfall of 5.1 inches, the country has a chronic food deficit and is totally dependent on imports to meet its food needs. As a result, Djibouti is highly sensitive to external shocks such as spikes in food and fuel prices and natural disasters such as floods and droughts.

2. Djibouti has an economy of services based essentially on the commercial activities of its harbor. Landlocked Ethiopia, which has a population of 75 million, is the primary user of Djibouti's port and currently generates 85 percent of the trade that transits through its container terminal.

3. Djibouti is classified in the low-middle income bracket with a GDP per capita in Power Purchase Parity terms of US$2,290 in 2009. The unemployment rate is approximately 60 percent and close to 42 percent of the country's population lives below the absolute poverty line of US$2 per day. Djibouti is almost a city-state, with two thirds of its population living in Djibouti city. The third of the population not formally residing in the capital consists mainly of shantytown dwellers, who rely on the informal sector for their living, and poor pastoral and nomadic people, who sparsely occupy the rest of the land. The presence in the country of a large number of refugees fleeing conflicts in neighboring countries exacerbates poverty and increases the pressure on already strained national social services.

4. Since 2005, Djibouti has experienced a fiscal expansion and a surge in Foreign Direct Investments (FDI) that have helped transform the economy and generate a rapid average yearly growth of 5.2 percent. The port has benefited from investments that have contributed to a marked increase in activity. The creation of the Djibouti Free Zone in 2004 for instance has enabled the import, storage, transformation and re-export of goods without being subject to tariff or non-tariff barriers. In addition, a public-private partnership (PPP) involving Dubai Port World led to a significant increase in investment, efficiency, activity and revenues of Djibouti's port, airport and customs. It also resulted in the construction of a new container terminal that helped significantly expand the port's capacity. Gulf investments in the small East African country also included tourism, a sector which benefited from the recent building of a five star hotel that provided a welcome boost to business.

5. Despite progress on infrastructure development, Djibouti's high growth did not significantly reduce poverty or unemployment. Economic activity has been largely confined to the free trade zone and port, and positive spillovers to the rest of the economy have been minimal. Thus far, the development of domestic companies and benefits of foreign investments have been hampered by high production costs stemming from high energy costs. A survey of Small and Medium Enterprises (SMEs) conducted in 2008 for a World Bank study revealed that the lack of reliable, secure and low-cost energy supply was considered by

more than half of the interviewees as the single most important constraint to doing business in Djibouti. Even though the tariffs offered by Electricité de Djibouti (EDD) are high, the utility has operated under a heavy financial burden and the Government has had to regularly provide the energy utility with budgetary support.

B. Sectoral and Institutional Context

6. *Institutional framework of the electricity sector.* Djibouti's electricity sector is regulated by the Ministry of Energy, Water, and Natural Resources (MoE). In this capacity, the MoE oversees the state-owned and operated utility, Electricité de Djibouti (EDD), which has a monopoly on the generation, transmission, and distribution of electricity. The status and duties of EDD are defined in decree no. 83-071/PWEDD of February 2, 1983. The decree states that the State of Djibouti is ultimately responsible for EDD's obligations vis-à-vis third parties and suppliers. The decree also specifies that the electricity distributed by EDD can either be produced by the utility or by facilities owned by third parties.

7. *Electricity tariffs.* Electricity tariffs are high and average US$0.32/kWh, mainly as a result of increased oil prices and technical and non-technical inefficiencies. EDD's 2012 tariffs range from a social price of US$0.153/kWh (life-line tariff) to US$0.426/kWh paid by construction sites. Shops and government buildings are charged US$0.397/kWh for electricity. The electricity tariffs offered by EDD are defined by a decree of the Council of Ministers.

8. *Electricity demand.* In Djibouti, only around 50% of the population has access to electricity, as the demand is constrained by high tariffs, high connection costs and an electricity grid that covers only Djibouti City and its outskirts. Hourly load data from 2009 shows that the national grid demand ranges between a low of 15 MW in winter to a high of 63 MW in summer. Fifty-four percent of the demand stemming from Djibouti City comes from large consumers. Recently, population growth (estimated at 1.9% per year since 2005) and urbanization of the country have led to a rising demand for electricity. The Ethiopian interconnection completed in 2011 has helped meet part of the increased demand. Work done by Parsons Brinckerhoff (PB Power) for the feasibility study of the electricity interconnection with Ethiopia foresees a 5.2 percent yearly increase in electricity demand from now until 2025. The forecasts of PB Power are more conservative than those of EDD as the utility also considers the additional demand that will be induced by large projects currently planned in Djibouti.

9. *Electricity supply.* Electricity supply consists of EDD's thermal capacities and hydroelectricity imports from Ethiopia. EDD relies primarily on ageing generation capacity running on expensive imported fuel oil to produce base load electricity. The utility has 18 generating units running on Heavy Fuel Oil (HFO) in Boulaos and Marabout. One 15 MW generator is less than 5 years old (2007), fourteen generators equivalent to 78 MW are between 5 and 15 years old and the remaining capacity is 20 years and older. Due to unreliability of older generators, EDD's effective generation capacity is limited to 57 MW out of the 119 MW installed.

10. *Energy imports from Ethiopia.* Since 2011, a new interconnector between Addis Ababa, Ethiopia and Djibouti City provides the country with low cost energy supply when the resource is available. Under the terms of the Power Purchase Agreement (PPA), 180 to 300 GWh are to be sold to Djibouti annually. The PPA, which excludes energy sales during Ethiopia's dry season's peak hours, represents 22.35 to 37.24 MW of continuous generation.

The supply of electricity is limited by hydrological conditions and the availability of excess energy: the hydro-based generation of Ethiopia is in excess of its demand during the wet season which happens to correlate with Djibouti's high demand summer months. Correspondingly, Djibouti's low demand in winter correlates with Ethiopia's dry season, a period during which daily peaks require thermal generation.

11. The energy supply from Ethiopia however is not provided under a firm capacity agreement, meaning that energy is not necessarily available when needed most by Djibouti. A firm capacity agreement with Ethiopia would create a better level of security of supply. However, only installed capacity in the country truly ensures security of supply. In negotiating firm capacity with Ethiopia, Djibouti will also have to consider that the cost of excess energy and/or firm capacity will continue to rise as Ethiopia continues to open new markets through additional transmission interconnections. If Djibouti were to entirely rely on Ethiopian capacity without an installed base of efficient, reliable capacity, it would expose itself to potential future price increases, which would be no different from the current situation where its reliance on the international oil market has exposed it to the risk of price hikes.

12. *Least cost option for future electricity supply.* In 2009, the Bank commissioned a Least Cost Electricity Master Plan for Djibouti[1] to determine the best option to bridge the growing gap between electricity demand and supply. According to this Master Plan, "the difference in cost between the fossil fuel fired generation in Djibouti and the hydroelectric generation in Ethiopia is so large that Djibouti is likely to import most if not all the energy that is available. This situation would continue until Djibouti installs some form of low-cost generation utilizing indigenous resources, most probably geothermal […]". The proposed project aims to support the development of the least cost geothermal base load capacity using indigenous resources.[2]

C. Higher Level Objectives to which the Project Contributes

13. The World Bank Group's FY09-12 Country Assistance Strategy specifically states that "the World Bank will support the Government of Djibouti's (GoDj) efforts to strengthen the business environment, with a focus on reducing constraints and costs to private sector development, especially in the power, telecommunications and financial sectors". A new Country Partnership Strategy is currently under preparation and incorporates the geothermal power generation project. The strategy builds on the results of 'A New Growth Model for Djibouti', a study undertaken by the Bank that underlines that electricity is considered by the majority of companies in Djibouti as the main impediment to private sector development and economic diversification. Hence, the proposed project also responds to these findings. Given that high electricity prices and electricity unreliability are widely considered as major impediments to business development in Djibouti, the electricity cost reduction potentially achieved through the project is likely to play a key role in bolstering the business environment and the private sector in the country, which is in line with the pillar, "accelerating sustainable growth," in the Bank's MENA Regional Strategy.

[1] Parsons Brinckerhoff (2009) *"Least Cost Electricity Master Plan Djibouti"*

[2] Unlike wind and solar, geothermal provides base load capacity instead of energy alone.

14. In addition, the project is central to GoDj's response strategy to climate change. Djibouti's climate change program is based on the principles of the United Nations Framework Convention on Climate Change and on the guidelines set out in the country's program for economic and social development over the period 2001-2010. Among others, it includes the following goals: (i) to mitigate the effect of greenhouse gas emissions, bearing in mind that emissions in Djibouti account for only 0.045 percent of global emissions and that the country is in fact a greenhouse gas sink; and (ii) to develop and implement adaptation measures to enable the country to cope with the negative effects of climate change on the natural environment.

II. PROJECT DEVELOPMENT OBJECTIVES

A. PDO

15. The Project Development Objective is to assist the Recipient in assessing the commercial viability of the geothermal resource in Fiale Caldera within the Lake Assal region. Achieving this objective could lead to unlocking Djibouti's geothermal potential – something that would help reduce domestic electricity generation costs, increase the country's energy security of supply and foster private sector participation in the energy sector.

B. Project Beneficiaries

16. The direct beneficiaries of the project will be the Government of Djibouti, whose budget will benefit from significant savings to be reallocated to alternative use. In addition, staff from *Electricité de Djibouti* (EDD), the Ministry of Energy, Water, and Natural Resources (MoE), the Ministry of Finance (MoF), and the Djibouti Center for Studies and Research *(Centre d'Etudes et de Recherches* de Djibouti - CERD) will benefit from hands-on capacity building training and related activities. Project beneficiaries will also include women through the provision of these training activities. Public funding by donors on concessional terms for the high risk exploration phase should allow the GoDj to attract private sector power producers, who are expected to offer a lower cost of kWh than if the private sector had undertaken the high risk exploration phase themselves. This of course assumes that the publically funded drilling results show that geothermal resources are commercially viable (see Annex 8). Furthermore, the analysis of system generation cost savings associated with the geothermal power generation project (see Annex 9) indicates that the replacement of the thermal facilities with geothermal generation capacity will save the Government approximately US$57 million per year. This amount is significant since it is equivalent to more than ten percent of Djibouti's national annual budget. In addition, the project is designed in a manner which enables CERD staff, the project management unit and other involved GoDj institutional staff to directly benefit from capacity building in the design and management of a geothermal drilling program.

17. Indirect project beneficiaries include the private sector and the people of Djibouti. The development of geothermal electricity is expected to reduce electricity tariffs significantly, something that would lessen the cost burden on private sector development and encourage economic diversification. Moreover, the population would also benefit from the reduction in CO_2 emissions that would result from the replacement of thermal capacity by geothermal generation.

C. PDO Level Results Indicators

18. The Global Environmental Objective will be measured using the following indicator:

- Greenhouse gas emissions avoided

19. The Project Development Objective will be measured using the following indicators:

- Develop a fully-fledged power generation feasibility study
- Publish periodic updates of project implementation
- Geothermal well test protocol developed and in place
- Well test results independently reviewed and certified

III. PROJECT DESCRIPTION

A. Project Components

20. The proposed project supports an exploratory well drilling program financed by multiple donors. The drilling program will follow a pre-approved test protocol and yield certified results. Provided that the geothermal resource is proven to be commercially viable for large-scale power generation, a follow on project will be undertaken to competitively offer the geothermal resource to the international Independent Power Producer (IPP) market. In the event that the resource is confirmed for large scale power generation, the follow on project will finance the recruitment of a Transaction Advisor that will develop a prequalification process pursuant to Bank procurement rules that will be intended to result in a Public Private Partnership under which an IPP will develop, operate and maintain a power plant under a long term power purchase agreement. In the event that the resource is confirmed for commercial power generation but at a level below that which attracts international IPP attention, other means by which a viable power project can be developed will be considered.

21. The proposed project includes three components that are briefly summarized below. Co-financing arrangements are presented in Table 1 and a detailed description of the full project, its components and its contracting structure, is provided in Annex 2:

- **Component 1: Drilling Program (US$ 27.18 million, of which US$ 6 million IDA, US$ 6.04 GEF and US$ 1.1 ESMAP) –** This component includes the provision of works, goods and consultants' services for: (i) civil engineering preparatory works necessary for the execution of the drilling program (financed by AfDB); and (ii) execution of the drilling program as designed by the geothermal consulting company (jointly co-financed by GEF, IDA and OFID); (iii) steel material needed during the execution of the drilling program; (financed by AFD) and (iv) for the inspection and testing of reservoir flow rates (financed by ESMAP).
- **Component 2: Technical Assistance for the Drilling Program (US$ 1.8 million) –** This component comprises the provision of goods and consultants' services to: (i) design the drilling program and well test protocol; (ii) execute the well test protocol and ensure third party certification of the results of the drilling program; and (iii) preparation of a technical feasibility study for the geothermal power plant provided that the geothermal resource is suitable for power generation. The component will be financed by AfDB through one of the Trust Funds under its management.
- **Component 3: Project Management (US$ 1.6 million) –** This component involves the provision of goods, consultants' services, including audit and training,

and operational costs for the purposes of project management and implementation, including monitoring and evaluation. It will be jointly co-financed by GoDj and AfDB.

B. Project Financing

Lending Instrument

22. The proposed lending instrument is an IDA credit under "blend terms" with a maturity of 25 years, grace period of 5 years, a 1.25 percent interest charge (plus 0.75 percent service charge), and principal repayable at 3.3 percent per annum for years 6-15 and 6.7 percent per annum for years 16-25.

23. GEF and ESMAP are providing their contribution in the form of grants. If all our wells drilled are successful, the equivalent of the GEF and ESMAP contributions will have to be paid back to the Government of Djibouti by the IPP selected to develop the geothermal power plant. The funds will serve to accrue a fund dedicated to the development of renewable energy in Djibouti. In the event that one or more wells is a failure however, the IPP will not have to reimburse the funds to the Government of Djibouti.

Project Cost and Financing

24. The project is estimated to cost a total of US$31.23 million. Of this amount, the World Bank will finance US$6 million. The Global Environment Facility (GEF) will provide US$6.04 million[3]of which US$6.04 million will directly support the total project cost, while US$0.6 million will cover the agency's fee. The OPEC Fund for International Development (OFID) will fund US$7 million. The African Development Bank (AfDB) will fund US$5 million through the African Development Fund and EUR 1.8 million through one of the trust funds it manages. *Agence Française de Développement* (AFD) will fund EUR 2.5 million. Energy Sector Management Assistance Program (ESMAP) will fund US$1.1 million[4] through the Africa Renewable Energy Access II program budget as part of the newly created Global Geothermal Plan. Finally, the GoDj will make an in kind contribution of US$0.5 million.

25. OFID and GEF will provide joint co-financing to IDA, while AfDB, AFD, ESMAP and GoDj will provide parallel co-financing. IDA will administer GEF and ESMAP funds and it will enter into a Memorandum of Understanding with OFID to ensure compliance with World Bank policies, procedures and guidelines. AfDB will administer the African Development Fund and a trust fund.

26. As shown in table 2:

- AfDB will finance, through the African Development Fund and the trust fund under its management, the contracts that will be implemented during the first two

[3] The GEF and ESMAP are providing their contribution in the form of a grant. If all of four wells drilled are successful, GEF and ESMAP funds have to be reflowed by the IPP selected to develop the power plant to the Government of Djibouti to accrue a fund dedicated to the development of renewable in Djibouti. If one of the wells fails, the funds do not have to be reimbursed by the IPP. The precise modalities following which GEF and ESMAP grants would be reflowed to the IPP will be specified during the project implementation.

[4] See footnote 3.

years of the project: components 2 and 3 and the civil works contract which is the first contract to be implemented under component 1;

- AFD will finance the multiple contracts related to steel based materials (Group 1 contracts);
- GEF, IDA and OFID will finance the drilling service company contracts (which include Group 3 specialty contracts)
- ESMAP will finance inspection and testing contracts (Group 2 contracts).
- GoDj will finance the operational costs of the Project Management Unit (PMU).

27. It is important to underline that AFD, ESMAP, GEF, IDA and OFID will only start disbursing eleven months after the project starts, as the first contracts will be entirely financed by AfDB.

28. Table 1 summarizes the breakdown of project cost by component and sources of funding:

Table 1: Breakdown of project cost by component and source of funding

In $ (USD)	AfDB	AFD	ESMAP	AfDB Trust Funds	GoDj	GEF	OFID	IDA	Total
Component 1: Drilling Program	3,729,000	2,727,590	923,184	-	-	5,069,121	5,874,809	5,035,550	23,359,254
Contingency	737,800	522,410	176,816	-	-	970,879	1,125,191	964,450	4,497,546
Component 1: Total	**4,466,800**	**3,250,000**	**1,100,000**	**-**	**-**	**6,040,000**	**7,000,000**	**6,000,000**	**27,856,800**
Component 2: Technical Assistance				1,591,100					1,591,100
Contingency	-	-	-	173,900	-	-	-	-	173,900
Component 2: Total	**-**	**-**	**-**	**1,765,000**	**-**	**-**	**-**	**-**	**1,765,000**
Component 3: Project Management Unit	462,000	-	-	500,000	450,000	-	-	-	1,412,000
Contingency	71,200	-	-	75,000	50,000	-	-	-	196,200
Component 3: Total	**533,200**	**-**	**-**	**575,000**	**500,000**	**-**	**-**	**-**	**1,608,200**
Total Project Cost	**4,191,000**	**2,727,590**	**923,184**	**2,091,100**	**450,000**	**5,069,121**	**5,874,809**	**5,035,550**	**26,362,354**
Total Contingency	**809,000**	**522,410**	**176,816**	**248,900**	**50,000**	**970,879**	**1,125,191**	**964,450**	**4,867,646**
Grand Total	**5,000,000**	**3,250,000**	**1,100,000**	**2,340,000**	**500,000**	**6,040,000**	**7,000,000**	**6,000,000**	**31,230,000**

Table 2: Breakdown of project components by source of funding (percent)

	AfDB	AFD	ESMAP	AfDB Trust Fund	GoDj	GEF	OFID	IDA	Total
Component 1: Drilling Program									
Civil Works Contract	100%								**100%**
Drilling Service Company Contract (including Group 3 Contracts)						32%	36%	32%	**100%**
Group 1 Contracts: Steel Based Materials		100%							**100%**
Group 2 Contracts: Inspection & Testing			100%						**100%**
Component 2: Technical Assistance for Drilling Program									
Geothermal Consulting Company				100%					**100%**
Component 3: Project Management									
PMU Director				100%					**100%**
Operational Cost					100%				**100%**
PMU Costs	100%								**100%**

C. Lessons Learned and Reflected in the Project Design

29. The previous geothermal drilling programs performed in the Lake Assal region did not include a program development phase that clearly targeted geothermal wells linked to a test protocol to which results are certified in order to provide assurance to investors that testing was properly performed. In addition, there was no clear and approved basis upon which the commercial development of geothermal power generation would proceed based on the test results. Without a fully developed project in which key technical and procedural parameters were accepted and approved by all donors, the project was susceptible to primary philosophical changes after field operations were mobilized. Based on these lessons, the project has been designed to incorporate a well test protocol that delineates the specific tests to be run, the standards to which the testing must conform and the methods that will be used to gather test data. To assure accurate test results upon which an IPP can rely, the final test data will be certified by an independent testing company or experts in the geothermal field to have been gathered in compliance with the approved protocol. To assure that macro program changes do not occur after drilling begins, a well-qualified Geothermal Consulting Company will be engaged that will be responsible for development of the well test protocol and the well drilling and targeting plan. The drilling plan will benefit from data gathered from past drillings as well as from the extensive geologic testing that REI performed during their 2010 attempt to develop a geothermal project by drilling the Fiale Caldera. It should be noted that REI has agreed to provide this data for use in this project.

30. Once drilling operations are mobilized, costs are incurred for labor and equipment regardless of whether or not drilling is progressing. In the case of the previous drilling projects, the disappointing results of the first wells prompted a decision by the Project Manager to completely reconfigure the program design and move the drilling rig to a location not previously considered. The resulting macro change in program design created delays that negatively impacted the project budget. With this impact came a lack of definition concerning drilling costs to be expended as project milestones were met. The end result was found in the exhaustion of the drilling budget without a clear quantification of the viability of the geothermal resource. In this project, the GCC will develop a comprehensive drilling plan that will focus on the Fiale Caldera as the specific geologic formation that will be drilled after which the drilling plan will be accepted by the donors. While every exploratory drilling program undergoes certain managed variations based on results of field operations, the basis of the project design will not allow for macro field based changes like that experienced when the drilling targets were moved to a different geologic formation.

31. Without a pre-defined and approved well test protocol that the donors could rely upon to set the stage for commercial power development, the donors found themselves at odds. Significant delays can result from disagreements between parties and, in some instances, these disagreements threaten the viability of projects.

32. This project has been developed for the specific purpose of technically quantifying the Lake Assal, and more specifically, the Fiale Caldera geothermal fluids for commercial power generation. The proposed project will finish with the preparation of a feasibility study that will analyze the well test data and access the viability of the geothermal fluids for commercial generation. The project has been carefully designed to assure accurate testing that can be relied upon by IPPs that are capable of bringing geothermal power expertise and private funding to develop and install cost effective power generation. To that end, an international

call for tender will be prepared to invite IPPs to bid on the geothermal resource through the offering of a long term electric tariff.

33. Under all conditions, geothermal resource development starts with the risk of loss that is associated with an exploratory drilling program. With the high, front loaded cost of exploratory drilling, private equity is generally unwilling to invest unless the resource has been proven either in the field to be drilled or within the geologic formation. When private equity commits to the risk of exploratory drilling, the commitment comes with high returns on equity (ROEs) and government guarantees that can result in a significant undervaluing of the resource conveyed to the IPP when the drilling is successful. Due to the high risk of exploratory drilling, equity (in lieu of loans) is the only viable means available to the IPP to finance verification of the resource. As many as five years can elapse between the initial exploratory drillings and the first revenue derived from commercial power plant operations. This "equity / time" equation results in a compounding effect that occurs as the equity investment in drilling accrues at an ROE commensurate with exploratory risk (i.e. equal to or greater than 25%). The result is generally a tripling of the equity investment before operating revenue is realized. This equation ends with tariff rates significantly higher than those realized when the risk of verifying the resource is removed from the responsibility of the IPP. As a result of shifting exploratory risk to the public sector, the remaining IPP risk more closely reflects that of a traditional carbon based power project in which IPP risk is associated with the Engineering Procurement and Construction (EPC) and operations of the power block; all of which are considered to be within the reasonable control of the IPP. History has shown that the initial exploratory drillings that launch geothermal power programs generally depend on public sector support in one form or another. Given the ever increasing market price of carbon based fuels and their resulting footprints, there is a renewed focus on the clean reliable electric generation capacity that geothermal provides. This is best characterized by the recently created Global Geothermal Development Plan (GGDP) by ESMAP. Through the GGDP, geothermal exploratory risk is mitigated through funding techniques like those used in the project in order to bring a catalyst to the development of global geothermal power generation. It must be noted that this project is the first project for which ESMAP has approved GGDP funding.

Table 3 below highlights the shortcomings and lessons learned from previous projects.

Shortcomings of previous projects	Lessons incorporated in current project design
At a technical level	
Limited knowledge of the geology	Good knowledge of the geology, based on decades of exploration, including the latest 2010 REI pre-feasibility study.
Drilling of slim-hole wells using vertical drilling techniques	Drilling of production-sized wells using deviated drilling techniques that penetrate the multiple, permeable vertical fractures found in the Fiale Caldera region. This will maximize the chances of high geothermal fluid production.
The drilling program was not clearly focused on a single geologic formation which made it susceptible to macro field based changes that drained the project budget without obtaining bankable test results	The drilling program methods, drilling targets and testing protocol are carefully predefined and targets are specifically set on a single geologic formation that has been identified as the area with the greatest potential to yield positive results.
The lack of geological knowledge led previous attempts to reach reservoirs that contained fluids with very high levels of salinity, and the technology at the time did not allow for the use of these fluids for power generation.	Improvements in technology have made it possible to use geothermal fluids for power generation that contain high salinity. At the same time, the Fiale Caldera region has been targeted due to its geology which promises lower salinity than that experienced in the closed reservoirs

Shortcomings of previous projects	Lessons incorporated in current project design
	tapped by the previous drilling programs.
Issues at donors' level	
Project design allowed donors to make critical technical decisions along the way (radical changes in well targeting, decisions to stop or continue the drilling program, definition of condition of success etc.)	All key parameters of the program have been pre-defined (number of wells, location, drilling techniques etc.), all remaining technical decisions are to be taken by the expert Geothermal Consulting Company with specific consideration of attaining accurate test data within the defined project budget.

IV. IMPLEMENTATION

A. Institutional and Implementation Arrangements

34. The project management unit will be anchored within EDD. The company has a demonstrated capacity of managing projects financed by donors, including AfDB, IDA, and OFID. While the technical oversight of the project will be provided by EDD, the financial oversight will be provided by both EDD and the Ministry of Finance. A Steering Committee consisting of the Secretary General of the Government, a representative of the Ministry of Energy, the Secretary General of the Ministry of Finance and the Director of CERD (Centre d'Etudes et de Recherché de Djibouti) as stated in Decree Number 2012-257/PRE has been established to resolve issues that may arise during the design and implementation of the drilling program.

35. EDD has undertaken several projects supported by donors funds, such as the Power Access and Diversification projects financed by the World Bank and the Ethiopia interconnection project financed by the African Development Bank. As a result, the utility has developed the fiduciary and safeguards capacities needed to undertake the geothermal power generation project. Additional staff will be hired to handle all fiduciary and safeguards aspects of the Geothermal Power Generation Program. For cost effectiveness reason however, this staff will be recruited once the geothermal project is effective. Until then, all operations will be handled using the fiduciary capacities of EDD, including the recruitment of the geothermal power generation project's director, accountant, procurement specialist, safeguard specialists, as well as the procurement of the consulting services needed to update the project execution manual and purchase the additional license for the accounting software.

36. The Geothermal Power Generation Project Director (Director) will supervise the Geothermal Power Generation Project Team (Team) and be in charge of the project's administrative and fiduciary aspects. The Director will work in seamless coordination with the GCC Project Manager who will have control and authority over the technical parameters of the drilling program. Through this seamless coordination, a complete project management and control structure will be formed.

37. The Director will report to the Head of EDD, who will have authority over project recommendations that deviate from the accepted project design. The Director will provide timely updates on project execution to the Head of EDD who will take charge of the project's public relations, coordinate with Government and technical Authorities, keep the Steering Committee appraised on project progress and ensure the timely support of the International Scientific Advisory Committee when needed. The Director will benefit from the support of a senior geothermal expert (SGE) already working for EDD, as well as a junior geothermal expert (JGE) seconded by the Ministry of Energy, in charge of natural Resources, who will be the project focal point for safeguards. The Director will also be in charge of ensuring adequate capacity building and knowledge transfer towards the JGE and any other local geothermal

experts identified by the Head of EDD. In addition, as is the case with most projects in Djibouti, an experienced accountant will be hired for the financial management and reporting aspects of the project, and a specialist will be hired to support the Director in executing procurement aspects of the project, following World Bank guidelines for all contracts co-financed by IDA. Finally, two safeguards specialists, one social, one environmental, will be hired to support the work of the Team and a secretary will provide administrative help.

38. A Geothermal Consulting Company (GCC) will be engaged to develop and implement the technical design and oversight of the exploratory drilling program by; (i) performing any necessary geologic studies not already prepared; (ii) developing a detailed drilling plan and well targeting analysis; (iii) developing a well test protocol; (iv) preparing the technical component of all contractor TORs; and (v) providing technical management of field based drilling operations. Based on drilling and well test results, the GCC will prepare a technical feasibility study concerning the viability of the geothermal resource for power generation.

39. To ensure best results, the Head of EDD can call upon the resources of an international scientific advisory committee, the Regional Center created by the Scaling Up Renewable Energy Program in Low Income Countries (SREP), to review the well drilling program, the targeting analysis and the well test protocol prepared by the GCC, on a case by case basis.

40. A Drilling Service Company (DSC) will be engaged under a "semi integrated" drilling contract through which the DSC will be responsible for the physical drilling operations under the direct technical management of the GCC. The semi integrated contracting approach will provide for DSC responsibility being taken for specialty subcontracts that are directly associated with the rotation of the drill. Steel material and testing contracts will be engaged directly by the PMU to allow for coordination of long lead time steel materials and to eliminate conflicts of interest associated with well testing being performed by the DSC.

41. The Project's Operations Manual will be updated within 3 months following project effectiveness. The updated POM will outline implementation arrangements, project costs and parallel/co-financing arrangements, disbursement, financial management and procurement arrangements, internal controls, etc. It will be used by all donors co-financing the project.

B. Results Monitoring and Evaluation

42. The project will be monitored and evaluated on the basis of the parameters and targets set out in the results framework provided in Annex 1. The Bank and other donors will carry out at least semi-annual supervision missions during which project progress, outputs and work plan updates will be reviewed. Moreover, the Team will be required to submit comprehensive progress reports on implementation aspects semi-annually that would include reporting on procurement, financial management, and environmental aspects among others.

43. A monitoring and evaluation specialist will participate in implementation support missions to ensure a proper follow up on the Result Framework, track relevant information required to provide periodic updates on lessons learnt from project design and implementation and prepare a "lessons learnt" section that can be disclosed as part of the Implementation Support Review.

C. Sustainability

44. *Government ownership of the project.* The Government of Djibouti has been attempting to develop the geothermal project over the past 40 years. Djiboutian authorities

have shown a continued interest and commitment towards the exploitation of geothermal resources for power generation.

45. *Resilient project design.* The project design incorporates key elements to ensure technical, financial, environmental and social sustainability:

- At the technical level, sustainability will be ensured through the assessment of the quality and quantity of the geothermal resource in Fiale Caldera, which will in turn enable the optimization of the steam gathering system and power plant size in order to maximize the return on investment.
- At the financing structure level, sustainability will be ensured through a funding level that is high and conservative enough to provide the project with the flexibility required to support risks inherently associated with a drilling and resource geothermal resource confirmation program.
- Appropriate measures to mitigate the environmental and social impact associated with the proposed project have been developed in the Environmental and Social Impact Assessment Framework, with support from an international consultant.

D. Coordination between Donors

46. The World Bank and OFID will sign a Memorandum of Understanding with the GoDj to ensure that the project will follow World Bank policies, procedures and guidelines in terms of safeguards and procurement. Moreover, all co-financiers will conduct a yearly joint implementation support mission. Finally, a single Project Operation Manual has been developed and will be used by all donors to guide the implementation of the project by the Team.

V. KEY RISKS AND MITIGATION MEASURES

A. Risk Ratings Summary Table

Risk Category	**Rating**
Stakeholder Risk	H
Implementing Agency Risk	
-Capacity	H
-Governance	M
Project Risk	
-Design	M
-Social and Environmental	M
-Program and Donor	H
- Delivery Monitoring and Sustainability	M
Other	
- Institutional and Regulatory	M
- Third party Claims	M
Overall Implementation Risk	H

B. Overall Risk Rating Explanation

47. The overall risk at implementation is High. A detailed description of project risks is provided in the Operational Risk Assessment Framework (ORAF) in Annex 4. Below is a

summary of the predominant project risks and mitigation measures associated with the Geothermal Power Generation Project: drilling and testing, and lack of implementation capacity.

Stakeholder Risk

48. *Drilling/Testing Risk:* Stakeholders are concerned whether or not the geothermal resource, which is proven to exist, is of sufficient quantity and quality for large-scale power generation. This risk is mitigated through comprehensive geologic testing and independent engineering reviews, developed in the context of previous attempts to finance the project over the last 40 years, which estimate chances of success of the exploration phase at 80 percent based on existing geological data and past drilling programs.

49. Risk is further reduced through agreement reached with Reykjavik Energy International (REI), which allows for the use of all geologic testing and information developed by REI and its subcontractors to the GCC. REI, which is a public Icelandic geothermal firm, conducted extensive geological investigation starting 2008 in Lake Assal, before the global financial crisis hit Iceland and put an end to the company's project in Djibouti. Following negotiations with REI, the ownership of investigations' results was transferred to the Government of Djibouti. These results will enable the GCC to have a solid scientific platform on which it can develop the well targeting and drilling program (see Annex 2 for more details).

50. The salinity of the geothermal resource proved to be an issue 25 years ago during previous exploration attempts as, at the time, there was no technology available to handle this type of fluid. Since then, experience gained developing geothermal resources with high salinity in the Salton Sea region of California as well as in a number of other regions, including Japan and Iceland, led to the conclusion that geothermal wells drilled in the Lake Assal area could be successfully exploited. A high salinity rate requires specific techniques that are more costly but available and the use of one of the operators that have previous experience with handling this type of fluids. In addition to technological advances, this risk is being mitigated by targeting the Fiale Caldera area for which the geology indicates an open reservoir in which the geothermal fluids are being refreshed with sea water. Acid fluids may require special materials in the future or alternative resources. The current back-up resource for either acid fluids or scaling fluids is the shallow resource intercepted by all wells to date, which has a temperature adequate for binary cycle generation.

Implementing Agency Risk

51. *Capacity Risk:* Due to the complexity of the project, an internationally experienced Director will be engaged to handle all project implementation activities. Moreover, the Director will report to and operate under the leadership of the Head of EDD who has a successful record in implementing energy projects and who has an excellent understanding of Djibouti's geothermal resource. The Team will also benefit from the experience and capacity of the staff of EDD. Finally, the Team will include an accountant and a procurement specialist recruited to align fiduciary practices with donors' rules, as well as a social safeguard specialist and an environment safeguard specialist to ensure satisfactory implementation of World Bank safeguards rules. All relevant staff will benefit from thorough training in fiduciary and safeguards management. To ensure transparency, a segregated designated account will be

opened in the commercial bank in terms acceptable to the World Bank, to track project expenditures. In addition, an external (fiduciary) auditor with qualification and experience satisfactory to the World Bank will conduct annual audit of the project's financial statements and a safeguard auditor will carry out an annual audit of safeguards compliance.

Project Risk

52. *Donor coordination risk:* At project level, the predominant risk pertains to the fact that the project is financed by multiple donors, which requires a high level of coordination. To ensure that there are no implementation delays due to donor coordination issues (e.g. procurement and technical challenges), most contracts will be financed under a joint co-financing, with a set of smaller contracts financed under parallel financing. The risk however remains high as the entire project's contracts are interdependent: any delay in a contract is likely to delay the project as a whole.

VI. APPRAISAL SUMMARY

A. Economic Analysis

53. **Economic benefit of the project.** The criterion for measuring the net economic benefit of the project was defined as the expected reduction in the net present value of the cost of the generation expansion plan, to meet expected power demand, made possible by the introduction of 50MW of geothermal plant, allowing for the costs of the Geothermal Power Generation Project. The expected net present value of the cost associated with undertaking the drilling program was measured by the following criterion: (*the probability of a successful project times the net present value of the cost of the expansion plan including geothermal plus the probability of an unsuccessful project times the net present value of the expansion plan without geothermal) plus the cost of the drilling project.* This expression was compared to the net present value of the expansion plan if the drilling project were not undertaken.

54. **Conditions for a well to be considered successful.** A well would be considered as a success if it were assessed as being able to support at least a sustained 4 MW of electrical energy, with acceptable fluids for ongoing operation. Earlier studies have assessed the probability of a success for the first well, given existing geophysical evidence, at 0.80 which is typical of a brownfield success ratio, while the present project is still a greenfield development for which a probability of 0.7 may be more appropriate. For the present analysis a range of values from 0.75 down to 0.35 were analyzed. Probabilities of well success were considered to be independent of the well sequence.

55. **Conditions for the drilling program to be considered successful.** For the program as a whole to be considered successful, a criterion of at least two of the wells out of four being successful was used in order to provide an evaluation of the potential benefits from possible geothermal generation investment. If the program was deemed to be a success this was equivalent to assuming that the private sector would definitely come forward, on the basis of the test results, to finance a geothermal power station of 50MW.

56. **Expected net economic benefits of drilling program.** Table 4 presents the expected net economic benefits that would occur for a range of well success probabilities. The breakeven well success probability was 0.2. Sensitivity analysis for higher and lower demand

growth of power demand scenarios was carried out and the results indicate that under both scenarios the net expected values of the project were positive and not very different from that of the base case.

Table 4: Expected net economic benefit of drilling exploration project

Case number	Well probability for independent trials	Probability of project success	Reduction in expected net present value of cost of follow-up plan (US$ million)
1	0.75	0.95	70
2	0.65	0.87	63
3	0.55	0.76	53
4	0.45	0.61	39
5	0.35	0.44	24
High power growth	0.75	0.95	76
Low power growth	0.75	0.95	41

B. Financial Analysis

57. The proposed World Bank supported project is a US$31.2 million investment of multilateral donor funds to finance the exploration phase of a geothermal power generation project. From a financial analysis perspective, the purpose of this project is to finance the riskiest part of the geothermal power generation project – exploration – with concessionary funds in order to ascertain the commercial viability of the resource of the Fiale Caldera in the Lake Assal area and provide incentives for an IPP to develop a 50 MW geothermal power plant that could markedly reduce the cost of the electricity produced in Djibouti.

58. The scope of the financial analysis includes both the exploration phase and the full scale development phase to assess the conditions under which the geothermal resource is commercially viable. While the full scale field development (including production and reinjection well drilling) and the power plant construction and commissioning phases of the geothermal project are chronologically beyond the scope of the immediate World Bank supported project, they are an integral part of this analysis. The assumptions about the costs and finances required during these phases are key to assessing the value of the exploratory phase investments and the tariff that is required for cost recovery by an IPP. The analysis thus focuses in particular on the appropriate off-take price/tariff level for the power produced by the prospective 50MW plant to be built by an IPP entering the project as an equity investor.

59. The assumptions retained for the financial analysis are chosen conservatively. The financing package for the US$31.2 million investment would combine grants (US$11.09 million), soft loans (US$13 million)[5] and conditional grant contribution from GEF (US$6 million) and ESMAP (US$1.1 million)[6]. The additional main assumptions used in modeling the commercial viability of the geothermal power generation project are as follows:

- *Exploratory drilling implementation time frame:* 3 years, with the bulk of the US$31.2 million investment costs incurred in Year 2 (2014, US$25.8 million). By the end of

[5] The terms of the OFID soft loan (US$7 million) are: interest rate of 2.75% and a 15-year amortization of principal, following a 5-year grace period. The terms of the IDA Credits (US$6 million) are a maturity of 25 years, a grace period of 5 years, a 1.25 percent interest charge (plus 0.75 percent service charge), and principal repayable at 3.3 percent per annum for years 6-15 and 6.7 percent per annum for years 16-25.

[6] The GEF contribution is a grant to the Republic of Djibouti, with the condition that the Government offers the proceeds as a loan to the geothermal resource developer if the exploratory drillings are successful. If all of four wells drilled are successful, the GEF funds have to be reflowed by the IPP selected to develop the power plant to the Government of Djibouti to support a fund dedicated to the development of renewable energy projects in Djibouti. If any one of the four wells fails, the funds do not have to be reimbursed by the IPP.

Year 3, four wells are drilled and definitive conclusions about commercial viability of the resource are made. The financial model assumes that commercial viability of the resource is largely confirmed by the end of 2014. The IPP is selected in 2015 and starts its project in 2016.

- *Capital expenditures for geothermal field development:* US$181 million for a 50 MW plant (i.e., US$3.62 million per MW installed). The total cost includes expenditures for the first three years of exploration.
- *Capital structure of the IPP:* the base case assumes a 70:30 debt-equity ratio. The interest on the debt portion is assumed to be 6% per annum in real terms, the term of the loan 15 years, the repayment of principal is deferred until the start of project operation, and interest during construction is capitalized. In the main scenario (base case), the IPP takes over the Government's obligation to repay the US$7 million OFID loan, the US$6 million IDA credit, and the conditional obligation to repay grants from GEF and ESMAP.
- *Required rate of return on equity (Re)* was modeled using a range from 15% to 25%, with the main case for the prospective IPP project being 20%.
- *Geothermal plant capacity factor:* a 90% capacity factor is assumed for the 50 MW plant. Annual production would thus amount to 394.2GWh.
- *Operation and Maintenance costs:* O&M costs, including periodic drilling of make-up wells, are assumed at US$9,172,500/year. This is a very high-end estimate of geothermal O&M, owing to the high salinity levels in Lake Assal.
- *Depreciation of capital assets:* the main case assumes depreciation of power plant and related infrastructure assets over 20 years of operation using the straight line method. An alternative calculation based on 30 years of operation is available for comparison.
- *Initial working capital:* US$5.4 million, for net current assets including accounts receivable and inventory for geothermal power plant operation.
- *Taxes:* 10-year tax holiday granted by the Government of Djibouti, with a corporate income tax of 25% applying in subsequent years.

60. **The results of the financial analysis show that the power generation project with concessionary financing of the exploration phase could allow for the prospective IPP to break even at an electricity tariff ranging from <u>US$ 8.75 cents/kWh to US$ 9.10 cents/kWh</u>.** This assumes that the geothermal resource is confirmed and the IPP tender is concluded by the end of year 2015 to start the full scale geothermal field development in 2016 upon completion of the exploratory phase under the current project.

61. Summary results including other levels of electricity tariff are presented in the table below.

Table 5: Internal Rates of Return and Net Present Values resulting from different electricity tariff levels

						IPP Break Even
Tariff charged by IPP, US$ cents/kWh	**8.00**	**9.00**	**10.00**	**11.00**	**12.00**	**9.10**
Project IRR (based on FCFP)	7.6%	9.3%	10.9%	12.3%	13.7%	
Project NPV, US$ (based on FCFP discounted by WACC)	(18,798,294)	(2,220,989)	14,233,117	30,565,859	46,779,040	
Return on equity (based on FCFE)	14.8%	19.6%	24.0%	28.0%	31.7%	20.0%
Equity NPV, US$ (based on FCFE) at Re = 20%	(11,458,678)	(1,017,362)	9,423,953	19,865,269	30,306,585	0

Note: FCFP = Free Cash Flow to the Project; FCFE = Free Cash Flow to Equity (see Annex 8 for details of methodology).

62. The results confirm that concessionary financing of the exploration phase markedly reduces the required tariff for geothermal electricity generation. Indeed, a hypothetical investor entering the project in 2012, before the exploration phase and without grant financing, would require a tariff of US$13-14 cents/kWh rather than the US$9.1 cents/kWh shown above. The lower tariff in the proposed concessionary financing scenario is the result of a combination of three factors: (i) the reduction of the investment cost of the IPP project by the amount of exploration costs including the drilling of four initial wells; (ii) the removal of uncertainty about the resource and the resulting reduction in the required rate of return; and (iii) the reduction in the length of the lead time between the first capital investments and the first revenues from selling electricity.

63. The prospective IPP would require a 20% return on equity in the scenario yielding the break-even tariff indicated above. However, the required rate of return on equity (Re) is market driven and depends on several factors including the general perception of the business climate in Djibouti, the quality of the legal and regulatory PPP framework, as well as project-specific factors such as the residual resource risk involved in further development of the geothermal field. All of these factors would contribute to the determination of the required rate of return and ultimately the tariff specified in the Power Purchase Agreement (PPA) with the IPP. In addition, the commitment of the IPP to take over the debt obligations resulting from the prior phase cannot be considered certain at this stage. This is especially true for the conditional obligations resulting from the GEF and ESMAP contributions. A number of different scenarios are possible as a result, with the most salient ones summarized in the table below.

Table 6: IPP break-even tariff (US cent/kWh) depending on the Re and the need for IPP to take over prior debt and contingent debt obligations

Concessionary funding of exploration phase	IPP Re	IPP repays IDA	IPP repays OFID	IPP repays GEF	IPP repays ESMAP	Tariff – US cents/ kWh
No	25%	NA	NA	NA	NA	13.84
Yes	25%	Yes	Yes	Yes	Yes	10.25
Yes	25%	No	No	No	No	9.90
Yes	**20%**	**Yes**	**Yes**	**Yes**	**Yes**	**9.10**
Yes	**20%**	**No**	**No**	**No**	**No**	**8.75**
Yes	15%	Yes	Yes	Yes	Yes	8.05
Yes	15%	No	No	No	No	7.70

64. Further details of the financial analysis, as well as additional sensitivity tests on the various categories of costs and several other variables, are available in Annex 8 of the PAD.

C. Technical

Project Description

65. The Geothermal Power Generation Project aims at developing cost effective, environmentally green geothermal power generation on the Assal Rift. If successful, the program would help reduce domestic electricity generation costs, increase the country's energy security of supply and foster private sector participation in the energy sector. The project detailed in this project document will ascertain the technical and financial feasibility of large scale geothermal power generation in Fiale Caldera.

66. The Geothermal Power Generation Project maximizes technical and financial feasibility by testing both the intermediate and deep geothermal reservoirs. The intermediate reservoir has been encountered between the depth of 240 and 600 meters by each of the six deep exploratory wells that have been drilled in the Assal Rift. The intermediate reservoir fluid temperatures range between 140ºC and 190ºC that are suitable to drive a binary cycle power plant.

67. Binary power plants extract energy from low temperature geothermal fluids (93ºC to 180ºC) by pumping the fluid through a heat exchanger which in turn, transfers the heat energy into a refrigerant. The cooled geothermal fluid is pumped back to the geothermal reservoir while the heated refrigerant changes state from liquid to vapor. The absorbed energy is then extracted by passing the refrigerant vapor though a turbine which drives an electric generator. The remaining energy in the refrigerant vapor is then extracted through a cooling tower which changes the refrigerant back to its liquid state. The liquid refrigerant is then pumped back to the heat exchanger where it is reheated to create a continuous Organic Rankine Cycle.

68. Binary power plants are well suited for modularization in the size range of 1 to 103 megawatts. They also provide the additional benefit of maintaining the geothermal brine in a liquid state while being pumped through the binary plant heat exchangers. By maintaining the liquid state, scaling that occurs when geothermal brine vaporizes into steam may be controlled.

69. After drilling and testing the intermediate reservoir, the exploratory well will be cased past the intermediate reservoir test point. The drill string will then be deviated (i.e. start of directional drilling technique) and drilling will continue to the deep geothermal reservoir target (~2,500 m deep). The deep geothermal resource tapped by existing exploratory wells range in temperature between 230ºC and 350ºC, though testing is required to see if there is permeability at these temperatures or if fluids are suitable for use. These temperatures and the geothermal fluid flows previously tested are suitable for power generation using Flash plant technology. Unlike binary plants where the heat energy of the geothermal fluid is transferred to a refrigerant, flash plant technology uses steam directly from the geothermal reservoir to drive the turbine after it is separated from the brine. Although the management of the geothermal fluid becomes more technically challenging with a flash plant, the plant can process significant amounts of high temperature fluids to generate comparatively high power outputs (i.e. 20 to 60 MW typical flash plant size range).

70. A technical feasibility study of both the intermediate and deep geothermal reservoirs will conclude the Geothermal Power Generation Project. This technical feasibility study will

provide all the technical input required to undertake the transaction advisory activities to be undertaken in a follow on project.

Building on lessons learnt from previous projects

71. It is important to note that in 1987, the World Bank through IDA in participation with the Government of Italy, the African Development Bank, UNDP, the GoDj (ISERST & USAID Grant) and the OPEC Fund executed the exploratory drilling of Assal wells 3 through 6. The geothermal well production criteria (i.e. number of productive wells) necessary for the participants to engage a second project for the development and construction of a geothermal plant was met. The World Bank Geothermal Development Project, Credit 2055-DJI was put in place for the development and construction of the power plant inclusive of supporting activities. Disbursement was delayed when the participants were not in agreement concerning the need for additional quantification of the geothermal reservoir.

72. This proposed project has incorporated lessons learnt from the previous exploratory projects. Specifically, the project has been structured to assure that the wells are carefully targeted and drilled, and that the proper testing is performed under an approved test protocol that will assure bankable reservoir data. With successful data, a subsequent project will be developed under which the geothermal reservoir will be competitively offered to the international IPP market. This follow on project is intended to result in a Public Private Partnership under which the IPP will perform production drilling, develop, construct, operate and maintain the power plant under a long term power purchase agreement.

73. Since the canceled 1987 development project, geothermal power plant technology (i.e. both binary and flash cycle) has advanced giving more viability to the use of geothermal fluids like those encountered in the Assal Rift. In addition, more advanced and complete geologic field testing has been performed across the Assal Rift to better understand the geology which will serve to improve exploratory drilling success.

74. Geo-scientific information has been gathered over the last 36 years. Included in this 36 year span of geo-scientific information is the geologic testing and studies performed by REI between 2008 and 2010 while working to develop a power plant in the Lake Assal region. REI has agreed to provide this comprehensive information which identifies the Fiale Caldera as the target of highest potential for an exploratory drilling program. The Geothermal Consulting Company may recommend some infill studies but the best quantification of the resource will be achieved by performing the Geothermal Power Generation Project.

D. Financial Management

75. An evaluation of the financial management capacities of the Team was conducted as part of the preparation for the project through a series of meetings held with the MoE, the MoF, the Director of External Financing of the MoF, the SGE and the JGE.

76. The Team that will be managing the geothermal project will be newly created and will hence have limited experience with World Bank or other Donors operations. As a result, financial management risks are high, and significant training and supervision will be needed to properly mitigate the following risks:

- *Team capacities:* The Geothermal Power Generation Project will benefit from the fiduciary support of EDD staff. EDD has undertaken several projects with international donors and has satisfactory FM capacity. In addition, an experienced accountant will be hired to provide financial management support to the Project

Director. The terms of reference for this position have already been developed and the experienced accountant will be recruited and on board on a full time basis within three (3) months after effectiveness. The timeline of recruitment is presented as a dated covenant. The Bank FM team will ensure that the accountant has the proper training on all Bank FM procedures and guidelines.

- *Fiduciary Management capacities:* the Geothermal Power Generation Project will utilize the accounting software used by EDD for its donor funded projects and which was deemed acceptable to the Bank. The PMU will acquire an additional license for the Geothermal Project per se. The additional part will be independent from the World Bank Power Access Project and will have its own accounting and reporting mechanism. The PMU will ensure to have the additional part fully operational and able to capture transactions and generate the required financial reports within three (3) months after effectiveness. The timeline is presented as a dated covenant. The PMU will update the Financial Management part of the Project Operational Manual used for the Power Access and Diversification Project no later than 3 months after the effectiveness of the project and this timeline is presented as a dated covenant. The updated POM will clearly detail the FM functions and procedures of the project. The Team has already developed terms of reference for the recruitment of consultants who will be in charge of developing the administrative and financial procedures manual.
- *Disbursement:* The proceeds of the IDA Credit, and the GEF and ESMAP grants will be disbursed in accordance with the traditional disbursement procedures of the Bank and will be used to finance project activities through the disbursement procedures currently used: i.e. Direct Payment, Advances, Reimbursement and Special Commitment. Replenishment and Reimbursement Withdrawal Applications will be accompanied by Statement of Expenditures (SOEs) in accordance with the procedures described in the Disbursement Letter and the Bank's "Disbursement Guidelines". The details of these arrangements are described in the Disbursement Letter.

E. Procurement

77. The PMU will be set up within EDD. It will be in charge of all transactions related to the contracts financed by the project. EDD, as the agency responsible for implementing project activities, is subject to the rules and regulations that fall under the Public Procurement Code of the GoDj. Above 5,000,000 FDJ (equivalent to US$ 28,500), all procurement decisions (bid opening, evaluation report, contract award, etc.) are subject to a prior review by the Higher Procurement Commission (Commission Nationale des Marchés Publics-CNMP). Overall, the new Djiboutian procurement manual of procedures for goods, works and employment of consultants is broadly in line with the World Bank's procedures and the country has, since May 2010, adequate standard bidding documents and request for proposals broadly similar to those of the World Bank.

78. The PMU has some knowledge of Procurement Guidelines and Procedures of Donors as it is involved in the implementation of World Bank and African Development Bank projects such as the Power Access and Diversification Project and the Ethiopia Interconnection Project.

79. Procurement for the proposed project will be carried out in accordance with the World Bank "Guidelines: Procurement of Goods, Works, and Non-consulting services under IBRD loans and IDA credits & grants by World Bank borrowers" dated January 2011 ("Procurement

Guidelines”), and "Guidelines: Selection and Employment of Consultants under IBRD Loans and IDA Credits and Grants by World Bank Borrowers” dated January 2011(“Consultant Guidelines”), and the provisions stipulated in the Credit Agreement. The PMU’s capacity should therefore be significantly strengthened in order to be able to provide the necessary management preparation of documents and oversight of procedures in compliance with the World Bank’s procurement and consultants’ guidelines. The SGE and the JGE that have been recently assigned to the Team are technical experts with no prior fiduciary experience. As a result, procurement risks are considered high and there is an acknowledged need to recruit a procurement expert, experienced with IDA’s and AfDB Procurement and Consultants Guidelines

F. Social (including safeguards)

80. OP 4.12 is not triggered as the implementation of the project will not involve any involuntary land taking leading to involuntary displacement of communities and/or loss of income sources, habitat and other resources.

81. The proposed project location, in particular, the proposed drilling sites and its surroundings are on state owned land. Attribution of these lands is decided by administrative authorities. These areas are mostly covered by airborne volcanic material or lake sediments with extreme climate conditions, lack of water and scarcity of green areas not conducive to a permanent living habitat. There will not be involuntary acquisition of land for purposes of implementing project activities.

82. An Environmental and Social Impact Assessment Framework (ESIAF) has been prepared by the counterpart. The ESIAF indicates that the project area, in particular the drilling site, is an unpopulated area with very limited local use. The closest identified communities are between 5 and 7 km away; there will not be any displacement of people for the purpose of implementing project activities. In terms of potential economic impacts, a transhumance route crosses part of the selected project area as well as a tourist pathway. Though both are not used on a continuous basis, initial mitigation measures have been proposed in the ESIAF so as to maintain both the route and the pathway functional to the extent possible during project implementation. However, in order to anticipate any potential impact from a potential partial closure of the transhumance corridor, the more detailed Environmental and Social Impact Assessment (ESIA) to be prepared will seek to (a) document the magnitude of usage of the transhumance corridor. (i.e. estimated number of animals/heads crossing the route, frequency of passage) in order to (b) assess any potential impact on users’ livelihoods. Consultation was held during the preparation of the ESIAF with a broad range of relevant stakeholders including local communities. Women were adequately represented during the consultation. The feedback provided during these meetings has been incorporated into the ESIAF. Minutes of the meetings with local representatives is included as an annex to the ESIAF, along with a list of participants.

83. In terms of institutional arrangements, the Team does not have experience with World Bank’s social safeguard policies. Though OP 4.12 is not triggered, preliminary capacity building on OP 4.12 has been provided to the designated SGE and the JGE in order to present the context, objectives and procedures of the policy. A copy of OP 4.12 has been made available to both staff.

84. The ESIAF was disclosed in Djibouti on December 1, 2012 and at the World Bank Infoshop on that same day, December 1, 2012.

G. Environment (including Safeguards)

85. The project triggers the World Bank Environmental Assessment Policy (OP 4.01) and is classified as Category B. It is not expected to have large-scale or irreversible negative impacts on the environment, but the exact nature of any impacts cannot be determined until the detailed design of the drilling program is known.

86. As a result of this residual uncertainty, the Team has completed an environmental and social impact assessment framework (ESIAF) detailing the process to be followed to manage the risks associated with the project. The ESIAF provides a blueprint for the preparation of a future, detailed Environmental and Social Impact Assessment (ESIA). That ESIA, once produced, will spell out the potential impacts of the drilling program and outline the management measures required to effectively address them in a comprehensive environmental and social management plan (ESMP). The ESIAF also describes the appropriate institutional arrangements towards implementing the measures proposed and the capacity building required that will be implemented through the project budget.

87. *Project impacts.* The exploration activities of the proposed operation include the construction of access roads and the operation of a quarry, the installation of drill pads and drilling rigs, the erection of temporary accommodations, the provision of seawater supply, the use of drilling fluids and associated cuttings, the testing phase (including geothermal fluid discharge), the management of solid waste and the power generation for exploratory drilling. The potential environmental implications of exploration are the following: surface disturbances (construction of new access routes and drilling pad), noise, fluid withdrawal, thermal pollution, chemical pollution (particularly if surface waters used for potable water abstraction are located close to the drill site) and degradation of ecological habitat. The ESIAF includes analysis of all of these potential impacts.

88. The safeguard policy on natural habitats (OP 4.04) is also triggered by this project, due to the proximity of the drilling sites to two bodies of water: Lac Assal, a protected area under Djiboutian law, to the northwest and the potentially sensitive ecosystems of Golfe du Goubhet to the southeast. The ESIAF contains provision to protect both of these habitats by prescribing measures which will manage the risk of discharge of untreated geothermal fluids or drilling fluids into either the water bodies themselves or into the water table connected to them. More precise measures will be specified in the ESIA when it is prepared. The project is not expected to negatively impact natural habitats once the appropriate mitigation measures are implemented.

89. *Mitigation measures.* An Environmental and Social Management Framework (ESMF) has been prepared and is included in the ESIAF of the proposed drilling operation. Analogously to the ESIAF, the ESMF outlines the elements that the final Environmental and Social Management Plan (ESMP) must contain in order to manage the risks inherent in the project, and prescribes certain constraints on the range of possible mitigating actions that shall be considered for inclusion in the ESMP. The Environment, Health and Safety (EHS) Audit Consultant will provide an independent monitoring of the implementation of the ESMP during implementation of the project.

90. *Public Consultation and Feedback:* Consultative meetings were held during the preparation of the ESIAF with a broad cross-section of Djiboutian stakeholders, from government ministries and agencies through academic institutions to the local populations themselves. These meetings sought the feedback of stakeholders on the project's proposed

approach to environmental risk assessment and management, and the comments received have been incorporated into the final design of the ESIAF and ESMF. The minutes of the meeting with local representatives is included as an annex to the ESIAF, along with a list of participants.

Annex 1: Results Framework and Monitoring

Country: Djibouti

Project Name: DJ Geothermal Power Generation Project (P127143)

Results Framework

Project Development Objectives

PDO Statement

The project development objective is to assist the Recipient in assessing the commercial viability of the geothermal resource in Fiale Caldera within the Lake Assal region.

Project Development Objective Indicators

Indicator Name	Core	Unit of Measure	Baseline	Cumulative Target Values					Frequency	Data Source/ Methodology	Responsibility for Data Collection
				YR1	YR2	YR3	YR4	End Target			
Greenhouse Gas Emissions avoided	☐		0.00					390358.00	At the end of the project	World Bank/GEF	World Bank/GEF
Develop a fully-fledged power generation feasibility study	☐	Text	No study has been done.		Well tests results certified and technical feasibility study ready		Well tests results certified and technical feasibility study ready	Study complete	Yearly	PMU	PMU/World Bank
Publish periodic updates of project implementation	☐	Text	None	Well test protocol published	Initial test results published	Complete test results published	Complete feasibility study published	All periodic updates published	Yearly	PMU	PMU/World Bank
Geothermal well test protocol developed and in place	☐	Yes/No	No	No	Yes	Yes	Yes	Yes	Once	PMU	PMU/World Bank
Well test results independently	☐	Yes/No	No	No	No	No	No	Yes	Once	Independent third party	PMU

reviewed and certified										verification	

Intermediate Results Indicators

Indicator Name	Core	Unit of Measure	Baseline	Cumulative Target Values					Frequency	Data Source/ Methodology	Responsibility for Data Collection
				YR1	YR2	YR3	YR4	End Target			
Access to the site is constructed	☐	Yes/No	No	Yes	Yes	Yes	Yes	Yes	Once	PMU	PMU/World Bank
Number of wells drilled	☐	Number	0.00	0.00	2.00	4.00	4.00	4.00	Yearly	Drilling Service Company	PMU/Geothermal Consulting Company
Joint missions by donors	☐	Number	0.00	1.00	2.00	3.00	4.00	4.00	4	Donors	World Bank

Annex 1: Results Framework and Monitoring

Project Name: DJ Geothermal Power Generation Project (P127143)

Results Framework

Project Development Objective Indicators

Indicator Name	Description (indicator definition etc.)
Greenhouse gas emissions avoided	If the first four wells are successful, the probability of constructing more generation capacity increases significantly due to the successful drilling and learning processes of the first phase. If 50MW generation capacity is installed and becomes operational, this project is expected to directly offset total CO_2e emissions of about 11,710,750 tons over a 30 year life cycle
Develop a fully-fledged power generation feasibility study	Development of a power generation technical and financial feasibility study that includes a recommendation to either proceed or not with a follow-on project.
Publish periodic updates of project implementation	Publish the test protocol drilling program, test results, and other relevant information.
Geothermal well test protocol developed and in place	Geothermal well test protocol undertaken
Well test results independently reviewed and certified	Well test results certified

Intermediate Results Indicators

Indicator Name	Description (indicator definition etc.)
Access to the site is constructed	Preparatory civil works completed ahead of drilling commencement
Number of wells drilled	Drill 4 full-size production wells.
Joint missions by donors	Joint missions undertaken to improve donor coordination

Core Results Indicators

None of the Core Sector Indicators are applicable to the project.

Annex 2: Detailed Project Description

I. Geothermal Power Generation Project

91. The project development objective is to assist the Recipient in assessing the commercial viability of the geothermal resource in Fiale Caldera wihtin the Lake Assal region. Achieving this objective could lead to unlocking Djibouti's geothermal potential – something that would help reduce domestic electricity generation costs, increase the country's energy security of supply and foster private sector participation in the energy sector.

92. The drilling component of the project will be developed in the Fiale caldera area. The drilling will include four full size production wells of 9 5/8 inch diameter production casing, with an average well depth of around 2,500 meters and using deviated and aerated techniques. The rationale for these key assumptions is developed hereinafter.

A. Fiale Caldera Drilling Area Focus

93. The Lava Lake is a geologic manifestation of magma flow located within the Fiale Caldera. Based on interpretations of studies performed by BRGM in 1979 and in 1983 using Audio-magnetotelluric (AMT) Gravimetric and other methods and by ORKUSTOFNUN in 1988 using Electro Magnetic (EM) methods of subsurface investigative measurement, an "upflow" was demonstrated in the Lava Lake area based on a supposed hydrostatic pressure level higher than sea level in the absence of high resistivity at depth. The top of the conductor body delineates the groundwater flow gradient toward Lake Assal from the Goubhet sea water. The Goubhet sea water follows the form of the heavy body identified by gravimetry (CFG 1993). The analysis of the difference between the resistant layer and the heavy body altitudes establishes the location of heavy and conductor bodies in the zone of Fiale, which configuration could suggest a geothermal reservoir.

94. Additional seismicity studies (CERD-IPGP; Hirn et al., 1988) using seismic reflection and PSV methods observed that seismicity is exclusively concentrated in the Lava Lake area between 2,500 and 3,000 m depth. This activity would be explained by the interaction between the top of the magmatic chamber area and water circulation. In essence, the correlation of the geologic surface studies performed starting in 1973 (Assal 1 drilling) through the 1988 CERD-IPGP study has led to the conclusion that water flow through low resistivity conductors between the Goubhet seawater and Lake Assal in combination with a magmatic chamber existing at 2,500 to 3,000m under Lava Lake provides the geologic characteristics which point to the potential of a productive geothermal reservoir.

95. As part of the REI pre-feasibility study, that REI has agreed to provide for use in this project, Iceland GeoSurvey (ISOR) performed an additional geophysical survey applying shallow subsurface testing with transient electromagnetics (TEM) and deep subsurface testing using magnetotelluric (MT) resistivity methods. The survey was performed by creating a grid that stretched across the Assal Rift in the area between Lake Assal and the Goubhet Sea. Readings were taken at grid intersection points. As a result of the geophysical studies in combination with existing data, ISOR has concluded that there are three geothermal sectors located within the studied area. The first sector overlays the area in which Assal wells 1, 2, 3 and 6 were drilled during the 1975 and 1987 drilling programs. This sector was proven to be productive based on geothermal fluid flows from Assal 1, 3 and 6. The Assal 3 well was the subject of the 1990 Virkir-Orkint scaling study during which the well was flowed at a

production rate equivalent to 10 MW of electricity if the scaling problem could be managed without power loss.

96. ISOR concluded that the reservoir is effectively a “sealed off” system that would require a comprehensive re-injection system to maintain geothermal fluid flow for power generation applications. This corresponds with the Virkir-Orkint study that identified this first geothermal sector to have a low permeability factor, high salinity fluids and relatively small reservoir size based on flow testing. The second sector located to the north-northwest of the first sector consists of a large low resistivity anomaly. This area has not been studied through exploratory drilling and therefore its potential is unknown. Given the lack of information concerning this sector, it does not suggest a high enough potential to become the focus of a production focused exploratory drilling program. By the same token, REI/ISOR did not rule out this sector as having development potential for the expansion for an existing power generation program started in the Fiale Caldera area.

97. The third geothermal sector encompasses the Fiale Caldera and its central geologic manifestation, Lava Lake. The ISOR study essentially confirms the findings of the earlier subsurface studies, which conclude the presence of a magmatic heat source and the anticipated recharging of a geothermal reservoir by seawater that traverses the rift through permeable conductors connecting the Goubhet Sea to Lake Assal. ISOR’s study further confirms the presence of cross faulting characteristics that suggest geothermal fluid presence and recharge capacity. In addition, surface manifestations including the presence of significant amounts of magma deposits and active fumaroles tend to support ISOR’s conclusion concerning the presence of a geothermal reservoir.

98. Exploratory well Assal 5 was drilled in the Fiale area in 1982. Although the well was not productive, its well logs show that the temperature did not climb continuously higher with depth but instead inverted as the drill went deeper until ending with a 350 degree Celsius temperature at 2,000m. ISOR identifies this phenomenon as temperature changes occurring as the well bore passes through hot and cold formations thus indicating the existence of permeable channels that flow fresh seawater to a deep geothermal reservoir. The 350 degree C bottom hole temperature indicates a significant heat source that is expected to provide support of long-term geothermal fluid extraction. Fresh seawater flow in the presence of significant cross faulting is expected to; (i) help maintain geothermal reservoir pressure in counterbalance with steam extraction for power generation; and, (ii) result in geothermal fluid salinity levels below those identified in the less permeable Assal 3 geothermal sector.

99. It is also noted in the ISOR study that the presence of hot and cold flow channels can present a challenge in well targeting in that the well must be far enough away from the cold water channel but close enough to benefit from the recharging of the geothermal reservoir. Similar flow channels and geologic characteristics have been identified in Iceland and have not shown to be a constraint in geothermal steam production. Based on conclusions of geophysical studies performed in the Assal Rift area dating back to 1975, inclusive of the studies performed by ISOR through REI, the GoDj and WB have concluded that the Fiale Caldera area provides the best potential for drilling success and will therefore be the focus area of this project.

B. Value of Using Full Size Production Wells

100. During the project development phase, consideration was given to the value attained by the use of three different production casing well diameters. The three sizes can be characterized as slim hole (~3 ½" diameter production casing), mid-size wells with alloy casing to minimize scaling deposits (~7" diameter) and full size production wells (~9 5/8" diameter).

101. Slim hole wells could be drilled at a significantly reduced cost compared to the cost of a mid-size or full size production wells. This is a result of using a much smaller, easily mobilized drilling rig along with a proportional cost reduction in well casing, drilling mud and other drilling commodity costs. Although the geothermal fluid chemistry of the Fiale Caldera area is anticipated to be less difficult to manage than that encountered in the Assal 3 geothermal sector, the well scaling experienced on Assal 3 could not be ignored. Slim hole drilling was rejected on the basis of potential scaling that would quickly plug the smaller diameter casing. In addition, the objective of this project includes assessment of the geothermal reservoir, which will include flowing the exploratory well for a planned 90 days period. The flow rates supported by the small diameter wells would not support such an assessment.

102. Although seven-inch wells with high alloy production casing would be capable of testing temperature, fluid chemistry and reservoir flow characteristics, it is anticipated that these wells would not provide sufficient flow for use as power plant production wells. As such, the only anticipated value of the seven inch exploratory wells after resource testing would be for use as possible geothermal fluid re-injection sites; however, well targeting based on optimizing reservoir testing would not result in the best location for fluid re-injection.

103. To enhance project value, the stakeholders weighed the increased cost of approximately US$6.5 million to drill four full size production wells in lieu of the seven inch mid-size wells. In the event of drilling success and proven reservoir viability, the four full size production wells would effectively reduce the cost of a power generation production drilling program by approximately US$3.5 to $5 million per successful well (typical geothermal well cost when executing a multiple well drilling program). In consideration of increasing the project cost by US$6.5 million in return for a potential US$16 million reduction in cost of a future production drilling program, the stakeholders chose to use full size exploratory production wells.

C. Consideration of Vertical versus Deviated Drilling Techniques

104. The Fiale Caldera is surrounded by a steep, 20 to 30 meter high, 1.5 km diameter rim which surrounds Lava Lake. It is connected to two adjacent, smaller calderas all of which are believed to be fed by the same magmatic heat source at depth. All three calderas are cut by a dense network of east/west to north/west striking open fissures and small normal faults. Fluids in a geothermal formation move through permeable formations and when formations are impermeable (i.e. dense rock), the fluids move through fractures and faults. As a rule, fracture-controlled permeability is better than formation permeability. To maximize drilling success, the well needs to be drilled through as many fracture zones as possible. Directional drilling achieves this objective while vertical drilling techniques do not.

105. In addition to the practicality of improving success ratios, Lava Lake is an environmental anomaly that must be protected. Prime geothermal drilling targets represented by significant cross faulting under Lava Lake were rightfully targeted under the REI exploratory drilling program from outside the edge of the caldera. It is likely that these areas

will again be targeted in the final design prepared by the GCC under this project. The only means by which drilling targets under Lava Lake can be accessed without sitting directly above the target is through deviated drilling techniques.

D. Drilling Program Parameters to be Incorporated in GCC Design

106. The GCC will confirm and as necessary, modify the following drilling parameters after which it will develop a detailed drilling program design. The project budget for the Geothermal Power Generation Project is based on drilling four full size production wells in the Fiale Caldera area using deviated, aerated drilling techniques. The DSC will perform the physical drilling tasks under the direct supervision of the GCC.

107. The first objective in drilling each of the four exploratory wells will be to tap and test the intermediate (or shallow) reservoir. The intermediate reservoir is known to exist after being encountered at depths between 240 and 600 meters by all six wells that have been drilled in the Lake Assal area (ENEL, 1990; Jalludin 1992). Intermediate reservoir temperatures recorded during previous exploratory drilling programs ranged between 140 and 190 degree Celsius. These temperatures are within the range of consideration for use in commercial power generation using binary power plant equipment.

> Binary Power Plants extract the energy from lower temperature geothermal fluids by passing it through a heat exchanger that in turn vaporizes a refrigerant. The energy absorbed by the refrigerant through its change from a liquid to vapor state is then extracted by passing the refrigerant though a turbine which drives an electric generator. The remaining vapor present in the refrigerant is then condensed back into its liquid state and pumped to the heat exchanger to create a continuous cycle.

108. After testing the intermediate reservoir pursuant to the requirements of the approved protocol (anticipated tests include temperature, fluid chemistry, pressure and injectivity), drilling will continue to the point at which the drill string will be deviated. Deviated drilling will then continue to the targeted deep geothermal reservoir (~2,000 to 2,500 m). In the event that it is later decided that the shallow reservoir will be used for power generation, a casing perforation gun or similar device can be used to perforate the casing in order to use the well for shallow reservoir production.

109. Deep reservoir testing pursuant to the approved well test protocol will include temperature, pressure, fluid chemistry, flow testing and transient tests. A 90-day continuous flow test is anticipated in order to quantify the reservoir capacity and steady state flow characteristics for use in power generation using flash plant technology. Consideration will be given to core sampling to better define reservoir structure and geology.

110. Depending on the scaling potential of the Fiale Caldera geothermal fluid, consideration will be given to the further testing of increased well head pressures (i.e. 20 barg) and chemical inhibitors to control scaling pursuant to the recommendations of the 1990 Virkir-Orkint scaling study.

> Depending on heat in the fluid and temperatures, Flash Plants either utilize dry steam produced directly by the geothermal reservoir (these situations are rare worldwide) or steam that is generated by passing high temperature geothermal fluids through a separator vessel which separates the steam phase from the liquid phase using centrifugal force to generate dry steam. The steam energy is extracted by passing it through a conventional steam turbine that drives an electric generator.

II. Project Design to Meet Development Objectives

111. The project, which is financed by multiple donors, has been broken down into 3 primary components. Each component consists of contracts that segment technical and managerial responsibilities necessary to execute the project. The primary responsibilities and authorities are vested in the Director as it pertains to the financial / procurement aspects of the project while the GCC is responsible for overall technical management. By segmenting technical and procurement responsibility and defining the scalar authority through which these responsibilities interface, lessons learned from the difficulties encountered in the 1987 drilling program can be avoided and the Project Development Objective can be attained.

III. Three Primary Project Components to be Financed:

112. The proposed project includes three components that are briefly summarized below. The co-financing arrangements are presented in section III of the Project Appraisal Document.

- **Component 1: Drilling Program –** This component includes the provision of works, goods and consultants' services for: (i) civil engineering preparatory works necessary for the execution of the drilling program (financed by AfDB); and (ii) execution of the drilling program as designed by the geothermal consulting company (jointly co-financed by GEF, IDA and OFID); (iii) steel material needed during the execution of the drilling program; (financed by AFD) and (iv) for the inspection and testing of reservoir flow rates (financed by ESMAP).
- **Component 2: Technical Assistance for the Drilling Program –** This component comprises the provision of goods and consultants' services to: (i) design the drilling program and well test protocol; (ii) execute the well test protocol and ensure third party certification of the results of the drilling program; and (iii) preparation of a technical feasibility study for the geothermal power plant provided that the geothermal resource is suitable for power generation. The component will be financed by AfDB through one of the Trust Funds under its management.
- **Component 3: Project Management –** This component involves the provision of goods, consultants' services, including audit and training, and operational costs for the purposes of project management and implementation, including monitoring and evaluation. It will be jointly co-financed by GoDj and AfDB.

Component 1: Exploratory Drilling Contracts

Civil /Infrastructure Contract (financed by AfDB through ADF)

113. Prior to mobilizing the drilling rig and related heavy equipment in Lake Assal, certain preparatory work must be performed. Among other work identified during development of the final design of the drilling program, the Civil / Infrastructure contract will include; i) strengthening roadways and crossing between the port of Djibouti and the drill sites to support the weight of the heavy, oversized drilling equipment, ii) install roadbeds in the "off road" area to provide access to the drill sites, iii) prepare drill pads and pour concrete cellars, iv) prepare water pumping sites, v) and general living infrastructure as necessary for accommodation of operations.

114. In order to accomplish this work, the Civil / Infrastructure contract will be mobilized prior to mobilization of the Drilling Service Company (DSC) contract which will be responsible for supply of the heavy drilling equipment. The Civil / Infrastructure work will be

contracted by the PMU. The Director will benefit from the support of the GCC for management of all technical aspects of the contract.

Drilling Service Company (DSC) and Group 3 "Drilling Operations" (financed by GEF, IDA and OFID)

115. The DSC will be a reputable geothermal drilling company with sufficient financial capacity and geothermal drilling experience in high temperature fields. The DSC will be responsible for the execution of the drilling program designed by the GCC, including the performance of field-based operations and drilling activities pursuant to the requirements of the approved drilling program. The DSC will operate under the technical management of the GCC with procurement and contract administration being managed by the Director. The DSC contract will include the Group 3 "Drilling Operations" specialty contracts to form a single semi-integrated DSC contract.

Group 1 "Steel Materials" and Group 2 "Testing" (financed by AFD and ESMAP respectively)

116. The Group 1 "Steel Materials" are generally long lead time items. As such, these material supply contracts will be procured on a unit price basis early in the program through international competitive bidding. The Group 2 "Testing" contracts will be time based service contracts procured through international competitive bidding.

Component 2: Technical Assistance for the Drilling Program

Geothermal Consulting Company (GCC) (financed by AfDB through a TF)

117. The GCC will be a reputable geothermal consulting company with sufficient financial capacity and strong technical experience. The GCC's primary responsibilities will include: (i) field testing and assessment in the Fiale caldera area[7] as necessary to supplement existing information and structure a comprehensive exploratory drilling and testing program and well targeting analysis. With REI's agreement to provide all geologic test data and studies performed on behalf of its pursuit of an IPP power plant from 2008 through 2010, the supplemental studies to be performed by the GCC are anticipated to be minimal; (ii) designing an exploratory drilling program and the required well test protocol; (iii) will prepare the ESIA and any update needed to the ESMP; (iv) preparing all technical inputs needed for the DSC, Civil / Infrastructure and Group 1 & 2 specialty contract tendering process which will be managed by the Director in collaboration with the GCC; (v) on-site technical management of the Civil / Infrastructure contract as well as the overall drilling program; (vi) management and coordination of the onsite well testing performed by the Group 2 "Testing" contractors and certification of test results for compliance with the test protocol; (vii) developing a power generation feasibility study using well test results; (viii) compilation of certified test results for inclusion in an IPP tender document; and (ix) preparation of all technical inputs to documents required for competitive tendering of the geothermal power plant and steam field development (if justified by the feasibility study). The GCC will work in seamless coordination with the Director and will be his backup in his absence.

Component 3: Project Management

[7] A caldera is a large crater formed by volcanic explosion or by collapse of a volcanic cone.

(co-financed by AfDB through ADF and a TF, and GoDj)

118. The Team will consist of a Director, a SGE already working for EDD, a JGE seconded from the Ministry of Energy, in Charge of Natural Resources, an accountant, a procurement specialist, an environmental specialist, a social safeguard specialist and a secretary. Their tasks and responsibilities are described under the project institutional implementation arrangements in annex 3.

IV. Tentative Project Schedule

119. The tentative schedule of the Geothermal Power Generation Project has been prepared based on a typical 220 workdays per year and accounts for 10 days of holidays. It notes that drilling is a 24/7 operation without breaks until program completion. The numbers of days referenced in the schedule are workdays, not calendar days. The schedule starts with the staffing and training of the Geothermal Power Generation Project Team and ends with the completion of the technical feasibility study, assessing the commercial viability of the geothermal resource in Fiale Caldera. The total project duration is 33 months and does not take into consideration potential delays. Given the complexity of the multi-donor financing of the project, an additional 15 months is added to the implementation schedule as a buffer, bringing the total project duration to 48 months. The project has been broken down into five phases that overlap.[8]

120. <u>Phase I: Staffing and Training of the Team (55 days).</u> Project execution will start with the proper staffing and training of the Team once the project is effective. The ToRs for the recruitment of the Director, the Accountant, the Procurement Specialist, the Social Safeguards Specialist, the Environmental Safeguards Specialist and the Secretary are all available. Likewise, the ToRs for the update of the project execution manual have been prepared and cleared during appraisal while the required accounting software is available. Phase I should thus be completed no later than 55 days after project effectiveness, provided that the procurement of goods (new license for accounting software) and services (Team) is done using advanced procurement procedures. The fiduciary and safeguard training of Team take another week. Finally, the preparation of the project execution manual will be updated and ready for project effectiveness.

121. <u>Phase II: Engage Exploratory Geothermal Consulting Company (105 days).</u> The Director will prepare all bidding documents needed for the competitive recruitment of the GCC under AfDB guidelines (TORs, REOI, RFP) and lead the evaluation committee in charge of awarding the contract. To this end, the Director will benefit from the support of EDD’s fiduciary staff. Phase II is completed with the engagement of the GCC.

122. <u>Phase III: Exploratory Drilling Program Development (160 days).</u> Phase III starts with the GCC Desk Study that will be used to confirm and as necessary, modify the drilling program parameters upon which the Geothermal Power Generation Project is based. The Desk Study will also identify the specific field-testing and geophysical surface studies if necessary that must be performed in the Fiale Caldera area in order to best target the four full-size production wells. Careful attention to well targeting is particularly important given the proximity of hot and cold water flows that are believed to feed the geothermal reservoir in the

[8] Once enough data has been collected, follow up project will be put together to fund the hiring of a Transaction Advisor that will help develop the call for tender for an IPP.

Fiale Caldera. This phase also includes the development and approval of the well test protocol as well as the completion of the ESIA.

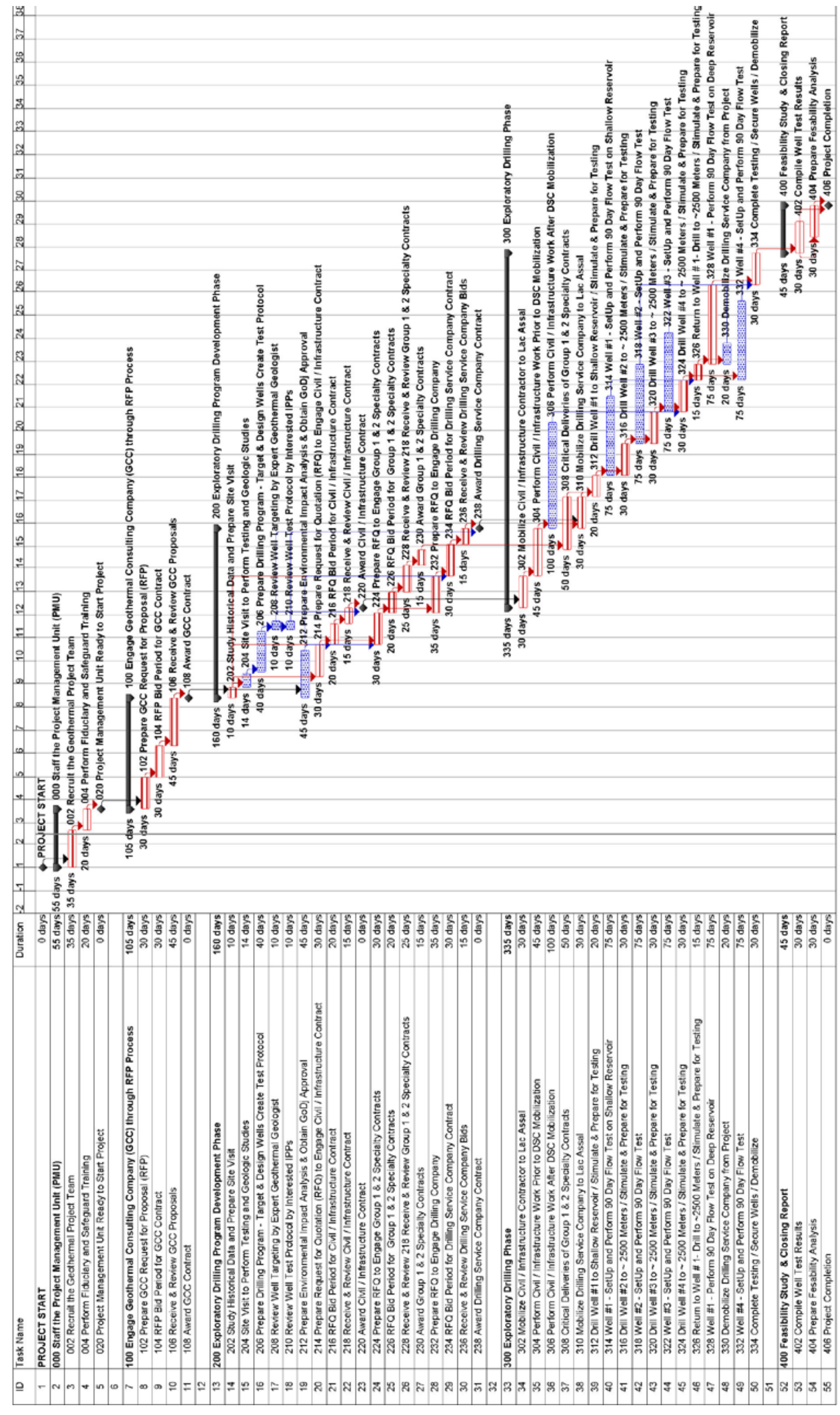
123. During this phase, the GCC will provide technical support to the Director who will perform the procurement of the Civil / Infrastructure contract which will be mobilized to prepare roads for heavy haul vehicles, construct drilling pads and seawater pumping systems to supply drilling water. The GCC will also provide all technical support to the Director to procure the DSC contract and manage the competitive bidding process in conformance with WB procurement guidelines. This phase is complete upon award of the DSC contract.

124. Phase IV: Exploratory Drilling (335 days). Phase IV starts with the mobilization of the DSC to the Fiale Caldera drilling site. This phase includes the field operations necessary to perform the drilling program and test the wells pursuant to the test protocol. The phase is complete after the wells are fully tested, secured, and the drilling operations are demobilized.

125. Phase V: Feasibility Study Based on Well Test Results (45 days). This phase includes the GCC's compilation and analysis of well test results and completion of the Power Generation Feasibility Study. The feasibility study will address the technical aspects of the use of geothermal fluids for large-scale power generation. It will be used as an input for the full-fledged feasibility study that will be performed by the TA under a follow up project, and into the ESIA for the station and steamfield development that will be prepared by the IPP developer.

126. The Critical Path Method Project schedule is available in the next page.

Figure 4: Critical Path Method Project Schedule

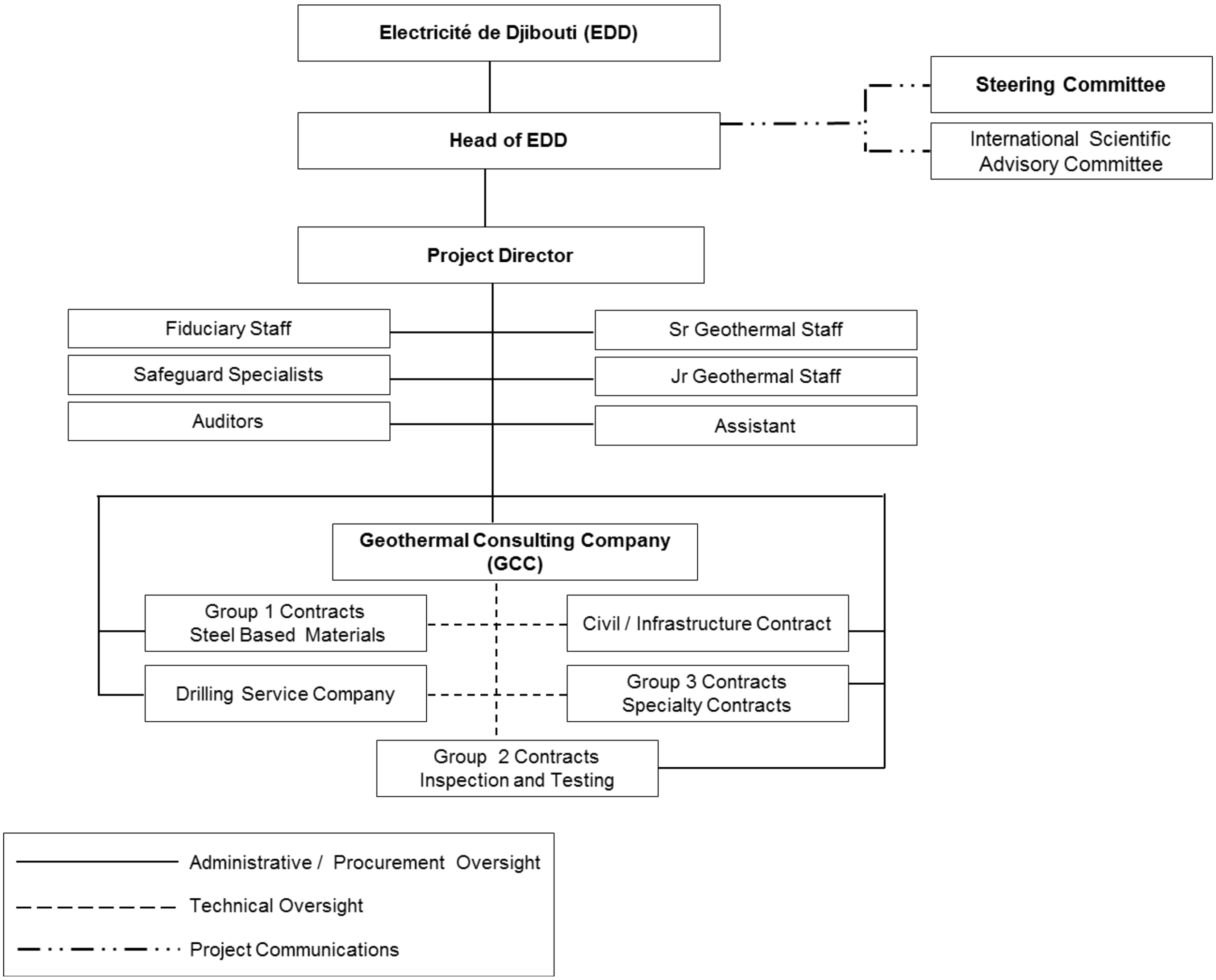


Annex 3: Implementation Arrangements

I. Project Institutional and Implementation Arrangements

A. Structure and oversight of the Geothermal Project Team

Figure 5: Structure and Oversight of the Geothermal Project Team



B. Institutional arrangements:

Project Team: oversight and reporting

127. The project will be anchored within EDD. The Geothermal Project Team will be headed by a Director, who will report directly to the Head of EDD. The project administrative and technical oversight of the project will be provided by EDD only, while the financial oversight will be provided by both EDD and the Ministry of Finance. The Director will prepare a monthly (or more often as requested) report to the Head of EDD who will deliver it to a Steering Committee consisting of the Secretary General of the Government, a representative of the Ministry of Energy, the Secretary General of the Ministry of Finance and the Director of CERD (Centre d'Etudes et de Recherches de Djibouti) as stated in Decree

Number 2012-257/PRE. Official meetings of the Steering Committee shall be held no less than four times per year or as requested by the President of Djibouti or the Head of EDD.

128. The Head of EDD will be able to call on the resources and capacity of the Steering Committee to assist in solving issues that arise during the project design and implementation phase. The Director in cooperation with the GCC Project Manager will convene regular meetings attended by the following personnel to discuss, coordinate and resolve project issues.

- Director
- GCC Project Manager
- Drilling Service Company Project Manager
- CERD Representative
- Other Contractor Representatives and/or Team members as identified by the Director or Head of EDD.

129. The Director will prepare and provide progress reports in time frames and formats specified by the Donors' Task Team Leaders (TTL) that will include details concerning project execution, procurement, financial management and social and environmental safeguards.

PMU: administrative and technical management

130. The Director will supervise the local team that will include a SGE already working for EDD and a JGE seconded from the Minister of Energy in Charge of natural Resources, an accountant, a procurement specialist, an environmental specialist, a social safeguard specialist and a secretary.

131. The Director will also be in charge of the procurement and contract administration of the following contracts:

- The Financial Auditor;
- The Safeguards Auditor;
- The Geothermal Consulting Company (GCC);
- The Drilling Service Company (DSC).
- The Civil / Infrastructure Contractor; and
- Other Specialty Group Contracts.

132. Technical management of the project will be provided by the GCC who will work cooperatively with the Director to provide seamless technical and administrative management of the project.

Geothermal Power Generation Project Team: tasks and responsibilities

133. <u>The Director:</u> the Director will provide executive management of the Team while also providing management control over procurement and contract administrative requirements for the Geothermal Power Generation Program in Djibouti. The Director will deliver capacity in the form of effective contract development, negotiation, administration and project budget control. The role of the Director will also include supervising the project budget, providing

administrative control over the project contracts signed directly with the Project Team and fulfilling traditional fiduciary project management responsibilities. The Director will be the only Team member entitled to manage project budget; however, the Director will not have contract signing authority. Signing authority will be held by the Head of EDD and the Director of External Financing of the Ministry of Economy and Finance in Charge of Industry. The Head of EDD will second the Director as it pertains to project technical decisions and financial decisions normally within the purview of the Director.

134. The Senior Geothermal Expert (SGE): the SGE will support the work of the Director during the execution of the project as it pertains to direction of local staff and management of local project affairs. The SGE will help coordinate with local authorities, government officials, and technical authorities.

135. The Junior Geothermal Expert (JGE): the JGE will second the SGE during the execution of the project. The JGE will be the focal point for Environmental and Social Safeguards. As such, the JGE will supervise the social and environmental safeguard specialists that will be hired to provide support to the Team. Last, the JGE will assist the Director in preparing procurement documents.

136. The Accountant: the Accountant will be in charge of the financial management and reporting aspects of the project, following World Bank guidelines. The accountant will report directly to the Director.

137. The Procurement Specialist: the Procurement Specialist will provide support to the Director for the procurement of all contracts, supplies and materials pursuant to World Bank and AfDB guidelines. The Procurement Specialist will report directly to the Director.

138. The Environmental Safeguards Specialist (ESS): The ESS will be responsible for ensuring that all environmental mitigation measures including occupational health and safety practices are mainstreamed into the project design, applied, monitored and reported in accordance with the provisions of the ESIA, and for making bi-annual reports on safeguards compliance to the World Bank through the JGE. The ESS will prepare and deliver to the JGE and Director safeguard on conformance reports and recommendations for mitigation. Enforcement action shall be carried out as approved by the Director in consultation with the JGE and safeguard specialist.

139. The Social Safeguards Specialist (SSS): The SSS will be responsible for ensuring that all social impact mitigation measures are mainstreamed into the project design, applied, monitored and supervised in accordance with the provisions of the ESIA, and for making bi-annual reports on safeguards compliance to the World Bank through the JGE. The SSS will also be responsible for interfacing with the local population to put in place safeguards and to log and track grievances (each grievance will be given an identification number and followed through by recording details and timing for their resolution and closing out).

140. The Secretary: the Secretary will provide administrative help to the Director and the Team.

PMU: technical consultants.

141. The Geothermal Consultant Company (GCC): The GCC's will have technical responsibility and authority over the project. The Head of EDD will second the Director as it pertains to project technical decisions and financial decisions normally within the purview of the Director. The primary responsibilities of the GCC will include: (i) field testing and

assessment in the Fiale caldera area to supplement existing information and structure a comprehensive exploratory drilling program and well targeting analysis; (ii) designing an exploratory drilling program and the required well test protocol; (iii) preparing all technical inputs needed for the Drilling Services Company's tendering process managed by the Director; (iv) on site management of the drilling program, including compliance with safeguards policies; (v) on site well testing and certification of test results for compliance with the test protocol; (vi) providing the Transaction Advisor with all technical inputs required for the development of a technical power generation feasibility study using well test results; (vii) compilation of certified test results for inclusion in an IPP tender document; and preparation of all technical documents required for competently tendering the geothermal power plant and steamfield (if justified by the feasibility study).

142. To ensure best results, the Director, through the Head of EDD can call upon the resources of an international scientific advisory committee, the Regional Center created by the Scaling Up Renewable Energy Program in Low Income Countries (SREP), to review the well drilling program, the targeting analysis and the well test protocol prepared by the GCC.

143. <u>Description of the Transaction Advisor (TA) as a part of a follow-on project not Financed by this project:</u> In the event that the geothermal resource is confirmed, a reputable advisory consortium led by an investment bank or a financial consulting company, with support from a law firm and an accounting firm, will be hired under a follow on project with support from donors to conduct a financial feasibility study to prepare for the tendering of a geothermal power plant following World Bank directives. The TA will determine the financial impact of the geothermal power plant on EDD's finances and the utility's capacity to engage into a Power Purchase Agreement. Based on well testing results and the technical feasibility study prepared by the GCC, the TA will determine whether the project is financially viable. If this proves to be the case, the TA will draft a Power Purchase Agreement and an Implementation Agreement for EDD and the IPP. Finally, the TA will be in charge of competitively tendering the development of a geothermal power plant.

II. Financial Management, Disbursements and Procurement

A. Financial Management

144. The Bank's experience in Djibouti and the Public Expenditure and Financial Accountability (PEFA) review in 2011 indicate that the Public Financial Management System is governed by an elaborate legal and regulatory framework. However, it still has many weaknesses. As a result, it is considered average. The main weaknesses are related to the budget preparation process, the implementation of a Framework Medium Term Expenditure, procurement management, the state accounting, the internal audit, and the external audit.

145. The project will be implemented in Djibouti according to the procedures of the World Bank and other Donors.

146. **Administration arrangements.** The project will be carried out by a Team, which will be under the authority of EDD and the MoF. The Team will be in charge of planning, executing, monitoring and evaluating the project activities.

147. The Director will operate under the technical oversight of EDD and the financial oversight of the MoF. The Team will report periodically to a Steering Committee and will be able to call on the resources and capacity of the Steering Committee to solve issues that arise

during the project implementation phase. The Team will handle the project management of the project including the financial management and accounting.

148. The Team will be responsible for the project bookkeeping. As such, it will produce annual Project Financial Statements (PFS) as well as quarterly Interim Unaudited Financial Reports (IFR) within 45 days of the end of each calendar quarter. The Team will be responsible for maintaining acceptable financial management system throughout the life of the project.

149. The Director will supervise the experienced accountant.

150. **Financial Management Risk Assessment and Mitigation measures.** The risks below have been identified:

i. Team capacities: The Geothermal Power Generation Project will benefit from the fiduciary support of the staff of EDD. EDD staff has satisfactory financial management experience as the utility has undertaken several donor funded projects in the past, including the World Bank Power Access and Diversification Project and the African Development Bank Ethiopia Interconnection project. In addition, the PMU will hire an experienced and qualified accountant that will handle the financial management aspects of the Geothermal Power Generation Project. The Terms of References of the Experienced Accountant have been developed and are acceptable to the Bank.

ii. The new Team will acquire an additional license to be able to use the accounting software of the Power Access and Diversification Project and will to be able to use it. The Team should acquire this license to allow the administration of the project financial data and the extraction of the required financial reporting.

iii. The Team does not have extensive experience in Bank FM procedures. The Bank will provide the necessary training on all FM procedures and guidelines and will be closely following on the FM performance of the project in coordination with the Director and the experienced accountant. The project will update the FM procedures manual used by the Power Access and Diversification Project in EDD which is part of the operational manual. The updated FM manual will detail all financial and accounting aspects of the project.

151. The overall financial management risk is deemed to be high at this stage.

152. The PMU should comply with the recommendations listed in the action plan in order to establish and maintain an acceptable financial management system. The main recommendations are: (i) Update and implement the Power Access and Diversification Project's Financial Procedures Manual; (ii) Hire an Experienced Accountant for the Geothermal Power Generation Project within three months after effectiveness; and (iii) Acquire a license to use the PMU's accounting software and have the accounting software fully operational within three months after the effectiveness. The timeline requested is added as a dated covenant.

153. **Budgeting.** The Team will prepare an annual budget for the financial commitments. The overall budget includes contributions from other donor-financed projects managed by the Team. The budget will specify each component and the financing source.

154. **Project accounting system.** The transactions will be registered in the accounting system by the financial accountant. The project's experienced accountant is responsible for preparing the IFRs before their transmission to the Director for approval. Periodical reconciliation between accounting statements and IFRs is also done by the experienced accountant. The project financial statements will include: (i) all sources and uses of project funds including payments made and expenses incurred. All transactions related to the project will be entered into the accrual accounting system which will allow the extraction of the required reports; and (ii) project transactions and activities will be distinguished from other activities undertaken by the Team.

155. IFRs summarizing the commitments, receipts, and expenditures made under the project should be produced by the system every quarter using the templates agreed on. The Team will send these reports no later than 45 days after the end of each quarter.

156. **Internal Control.** The Geothermal Power Generation Project will be implemented by a dedicated Team. Since the Team has limited experience with Bank and Donors FM procedures, the FM procedures manual used by the Power Access and Diversification project at EDD will be updated. This Manual should clearly define all FM procedures and guidelines. This manual of procedure will be subjected to the approval of the Bank and other donors. The Team should also be equipped with accounting software for the project bookkeeping, and financial reporting. Payments of eligible expenses will be done based on instructions signed by the MOF (Direction of External Financing - DEF) and EDD, and according to the Disbursement Letter and Bank disbursement guidelines.

157. **Project reporting.** The project financial reporting will include Interim Unaudited Financial Reports (IFR) and yearly Project Financial Statements.

- IFR should include data on the financial situation of the project as a whole including the other donors' component and financing. These reports should include: (a) a statement of funding sources and uses for the period covered and a cumulative figures, including a statement of the Bank project account balances; (b) a statement of use of funds by component and by expenditure category; (c) a reconciliation statement for the DAs and CBA; and (d) a budget analysis statement indicating forecasts and discrepancies relative to the actual budget. The accountant should produce the IFRs every quarter and submit them to the director for review and approval. The director then submits them to the head of EDD for review and submission to the World Bank within 45 days from the end of each quarter.
- PFS should be produced annually. The PFS should include (a) a cash flow statement; (b) a closing statement of financial position; (c) a statement of ongoing commitments; and (d) an analysis of payments and withdrawals from the grant account.
- IFR and PFS should be extracted by the experienced accountant from the accounting system, submit them to the Director for approval who will then submit them to the head of EDD for his review, approval and submission to the external auditor.

158. **Audits of the project financial statements.** An annual external audit will cover all aspects of the project and all uses of funds. It will also cover the financial transactions, internal control and financial management systems, as well as a comprehensive review of statements of expenditures (SOEs). An external auditor acceptable to the Bank will be appointed according to Term of References cleared by the World Bank and should conduct

the audit in accordance with international auditing standards suitable to the Bank. The auditor should produce: (i) an annual audit report including his opinion on the project's annual financial statements; (ii) a management letter on the project internal controls; and (iii) a limited review opinion on the IFRs. The annual reports should be submitted to the World Bank within six months from the closure of each fiscal year and the limited review opinion should be submitted to the World Bank with the IFRs.

159. **Flow of funds.** Payment will be authorized by signature of the Ministry Of Finance. Advances from financier's grants accounts co-financing certain components will be transferred to a Common Bank Account (CBA) to be used for the project expenditures while respecting percentage financed by each donor. The Ministry will appoint a person authorized to sign the payment requests. Payment requests will be signed and sent by EDD to the MOF, which should verify the supporting documents and the eligibility of the expenses in light of procedures and official agreements with the Bank and will then proceed with the signature of the payment instruction. The Team will file the original supporting documents

160. **e–Disbursement.** The World Bank has introduced the e-Disbursement for all its supported projects in Djibouti. Under e-Disbursement, all transactions will be conducted and associated supporting documents scanned and transmitted on line through the Bank's Client Connection system. e-Disbursement will considerably speed up disbursements and facilitate project implementation. It is mandatory for all World Bank financed projects starting January, 2013. The e-Disbursement functionality would (i) expedite World Bank processing of disbursement requests; (i) prevent common mistakes in filling out Withdrawal Applications - WAs (Form 2380); and (iii) reduce the time and cost of sending paper WAs and supporting documentation to the Bank. The e-Disbursement would not require any changes to the project current internal procedures and controls for preparing and submitting WAs.

161. **Summary of actions to be implemented.** Project implementation support actions are summarized below:

Actions	Deadline
Use fiduciary capacities of the power Access and Diversification Project until the new Team is fully staffed and operational	On-going
Update and implement an Administrative and Financial Procedures Manual for the PMU acceptable for the World Bank	Three months after Effectiveness
Hire an Experienced Accountant for the Geothermal Power Generation Project Team	Three months after Effectiveness
Acquire a license for the accounting software	Three months after Effectiveness

162. The frequency and scope of World Bank supervisory missions will be adapted to the needs of this project and will be delivered both at central and regional levels. Supervisory frequency will be half-yearly, though this may be increased if needed.

B. Disbursement

163. The proceeds of the IDA Credit and the GEF and ESMAP grants would be disbursed in accordance with the traditional disbursement procedures of the Bank and will be used to finance project activities through the disbursement procedures currently used: i.e. Direct Payment, Advances, Reimbursement and Special Commitment. Replenishment and Reimbursement Withdrawal Applications will be accompanied by Statement of Expenditures (SOEs) in accordance with the procedures described in the Disbursement Letter and the Bank's "Disbursement Guidelines". Interim Unaudited Financial Reports and Annual Financial Statements will be used as a financial reporting mechanism and not for

disbursement purposes. The minimum application size for direct payment and reimbursement will be the equivalent of 20% of the Advance ceiling amount. The Bank will honor eligible expenditures completed, services rendered and delivered by the project closing date. A four months' grace period will be granted to allow for the payment of any eligible expenditure incurred before the Loan Closing Date. The details of these arrangements will be described in the Disbursement Letter. The categories of eligible expenditures that will be financed out of the proceeds the IDA Credit and the GEF and ESMAP grants are as follows:

Category	IDA Allocation in US$	GEF Allocation in GEF	ESMAP in US$	% Of Financing Inclusive of Taxes
Goods, Works, non-consulting services, and consultant' services under Part A (ii) of the project	6,000,000	6,040,000		32%
Goods, non-consulting services, and consultant' services under Part A (iv) of the project			1,100,000	100%

164. **Designated Account (DA).** The Geothermal Power Generation Project Team will open a segregated Designated Account for each Financier (IDA, GEF and ESMAP) at the Central Bank of Djibouti in US Dollars to cover Financier' shares of eligible project expenditures. The Ceiling of the Designated Accounts would be 10% of the Credit and Grant's amount. The Team will be responsible for submitting monthly replenishment applications with appropriate supporting documentation.

165. **Sub-account.** The project will also maintain a bank account in local currency (Franc de Djibouti), provided it is within the agreed ceiling. Transfers from the USD account to the Sub-Account will only be made after the expenditure has been incurred and payments are to be made. In essence, as much as possible, the Sub-Account at the national level would have a zero balance. Payments from the sub-account can be replenished as disbursements occur and proper supporting documents are filed. The Borrower/ Recipient is responsible for bearing all risks associated with foreign exchange fluctuations when making transfers from the Designated Account which is denominated in US Dollars to the sub-account denominated in Franc de Djibouti. At the end of the project, any unused balances in the sub-account should be deposited to the related Designated Account, including any balance in Franc de Djibouti which should be converted to US Dollars.

166. **A manual of disbursement documenting the disbursement mechanism and its steps is part of the Project Operations Manual that will be updated.**

167. **Statement of expenditures (SOEs).** Necessary supporting documents will be sent to the Bank in connection with contracts that are above the SOE threshold, except for expenditures under Contracts with an estimated value of: (a) US$ 100,000 or less for works and goods; (b) US$ 100,000 or less for Consulting Firms; (d) US$ 50,000 or less for Individual Consultants, as well as incremental operating costs and training, which will be claimed on the basis of SOEs. The documentation supporting expenditures will be retained at respective Project Implementation Unit and will be readily accessible for review by the external auditors and periods Bank supervision missions. Interim Unaudited Financial Reports and Annual Financial Statements will be used as a financial reporting mechanism and not for disbursement purposes.

C. Procurement

168. Procurement for the proposed project will be carried out in accordance with the World Bank "Guidelines: Procurement of Goods, Works, and Non-consulting services under IBRD loans and IDA credits & grants by World Bank borrowers" dated January 2011 ("Procurement Guidelines"), and "Guidelines: Selection and Employment of Consultants under IBRD Loans and IDA Credits and Grants by World Bank Borrowers" dated January 2011("Consultant Guidelines"), and the provisions stipulated in the Credit Agreement. National Competitive Bidding (NCB) will be carried out with procedures acceptable to the Bank. Overall, the new Djiboutian Procurement Manual of Procedures for goods, works and employment of consultants is in line with the Bank's procedures and the country has, since May 2010, adequate standard bidding documents and request for proposals similar to the Bank's ones.

169. **Project Management.** A Geothermal Power Generation Project Team will be added to the PMU already anchored within EDD. The PMU will have dedicated team for each project under operation. However, until the Geothermal Power Generation Project Team is fully staffed, the Power Access and Diversification team will be used to carry on the geothermal project execution. Once the new team is fully staffed and operational, it will be responsible for the overall supervision and coordination of the Geothermal Power Generation Project. The new Team will be headed by a director and supported by the relevant technical services inside of EDD for bidding documents preparation. The Team will be the interlocutor to the World Bank during the supervision and appraisal missions.

170. **Procurement of Non-consulting Services.** The main non-consulting services to be financed for the project will cover: (1) the selection of a Drilling Service Company (DSC) which will perform the drilling program prepared by the GCC and (2) the well testing services. The two (2) contracts will be procured through an international competitive bidding (ICB) and the Bank's Standard Bidding documents for the procurement of non-consultant services shall be used.

171. **Assessment of PMU capacity to execute the project procurement activities.** The PMU's capacity to execute procurement activities in the framework of this project has been assessed and the report will be filed in the Procurement Risk Assessment Management System (P-RAMS). The PMU's capacity to oversee the procurement management has been judged weak. However, this capacity could be improved provided that the recommended actions are taken before project's effectiveness. The risk has been rated as **High**. The **frequency** of procurement supervision including PPR/Audit will be **every 6 months**.

172. The Action Plan is summarized below:

Analysis of Procurement Capacity	Issues/Risks	Mitigation Measures
1. Organization.	The PMU is not committed to this responsibility and the tasks that it entails.	Make the implementation arrangements including coordination and reporting responsibilities clear in the Project Operation Manual.
2. Facilities, Support Capacity and Staffing/Professional Experience.	There are some doubts about the full availability of the other staff and capacity to produce adequate procurement documentation in a timely manner.	Hire a procurement specialist who will provide support to the Director for the procurement of all contracts, supplies and materials pursuant to World Bank guidelines. The Procurement Specialist will report directly to the Director.

Analysis of Procurement Capacity	Issues/Risks	Mitigation Measures
3. Record Keeping and Filing System.	Capacity to cope with the project volume of transactions and insufficient space for records keeping	Provide the PMU with: (i) sufficient space in furnished offices, (ii) instructions and (iii) training to ensure that project specific files are kept for all procurement and related transactions and recorded contract by contract in an adequate manner.
4. Procurement Planning.	Procurement Plans would not be updated peridocally.	The PMU shall update procurement plans throughout the duration of the project at least annually by including contracts previously awarded and to be procured in the next 12 (twelve) months.
5. Monitoring/Control Systems.	Procedures used are not fully compliant with the Bank ones and cumbersome/slow prior review by the Commission Nationale des Marchés Publics (CNMP)	(i) Have a procurement section in the Operations Manual, describing in a clear manner the adequate procedures to follow for the implementation of the project, and (ii) expedite the prior review by CNMP
6. Capacity to meet Bank's Reporting Requirements.	Report not provided in a timely manner and in adequate format.	Confirm that the Director is the person/staff responsible for the reporting as well as to define clearly the content of the report and the contribution of the components managers.

173. The methods to be used for the procurement under this project, and the estimated amounts for each method, as well as the prior review thresholds are set in Table A below.

Prior review and Procurement Method Thresholds

Prior Review Thresholds (in USD)		
Procurement Type	**High Risk Implementing Agency Prior Review Thresholds**	**Comments**
Works, Turnkey and S&I of Plant and Equipment	0.1 million	And 1st contract regardless of the amount
Goods	0.05 million	And 1st contract regardless of the amount
IT Systems and Non-consulting Services	0.05 million	And 1st contract regardless of the amount
Consulting Firms	0.05 million	And 1st contract regardless of the amount
Individual Consultants	0.025 million	And 1st contract regardless of the amount

Procurement Method Thresholds (in USD)						
Djibouti	**Goods/Non-consulting Services**			**Works**		
	ICB	***NCB***	***Shopping***	***ICB***	***NCB***	***Shopping***
	> 150,000	≤ 150,000	≤ 40,000	> 1 million	≤ 1 million	≤ 200,000

174. **Procurement Planning.** The Project Operation Manual of the PMU will be prepared and will include the description of applicable procurement procedures. A detailed procurement plan (dated Aptil 12, 2013) for the first 18 months of all activities planned under the Geothermal Power Generation Project has been prepared.

175. **Works/Goods/Non-consulting services.** One ICB contract is expected for the selection of the Drilling Service Company. The Bank's standard ICB for Non-Consulting Services shall be used.

III. Environmental and Social (including safeguards)

176. This project is not expected to have any large-scale or irreversible negative impacts on the natural environment, provided appropriate risk management measures are put in place. However, the overall goal of testing the potential for large-scale geothermal power generation is one which has the potential to greatly improve the environmental footprint of Djibouti by giving access to a substantial and reliable source of renewable energy in a country almost totally dependent on fossil fuel imports for electricity supply. This will have positive effects on local air quality as well as on climate change mitigation efforts.

177. At the time of appraisal, it is known that there is the potential for some negative impact on the environment from the exploratory activities planned under this project, but the exact nature of any impacts cannot be determined until the detailed design of the drilling program is known. As a result of this residual uncertainty, the Team has completed an Environmental and Social Impact Assessment Framework (ESIAF) detailing the process to be followed to manage the risks associated with the project. The ESIAF was disclosed in Djibouti on December 1, 2012, and in the World Bank Infoshop on that same day.

178. This project proposes physical activities and works that will have some effect on the natural environment, and therefore is subject to OP 4.01, Environmental Assessment, which is the authority governing the preparation and application of the ESIAF and its successor documents as described below.

179. The safeguard policy on natural habitats (OP 4.04) is also triggered by this project, due to the proximity of the drilling sites to two bodies of water: Lac Assal, a protected area under Djiboutian law, to the northwest and the potentially sensitive ecosystems of Golfe du Goubhet to the southeast. The ESIAF contains provision to protect both of these habitats by prescribing measures which will manage the risk of discharge of untreated geothermal fluids or drilling fluids into either the water bodies themselves or into the water table connected to them. More precise measures will be specified in the ESIA when it is prepared. The project is not expected to negatively impact natural habitats once the appropriate mitigation measures are implemented.

180. No other safeguard policies are expected to apply to this project.

181. The ESIAF contains foundational research and constrained sets of options for risk management approaches that will help shape the future environmental and social management of the project, which will be codified in a future document, the environmental and social impact assessment (ESIA). The preparation of the ESIA, which will contain a detailed environmental and social management plan (ESMP), will be the responsibility of the drilling company selected to execute the drilling program designed by the GCC. As such, all bidders for the drilling contract will be required to submit an ESIA as part of their bid package, and the quality of ESIA submissions will be graded as part of the bid evaluation process. In addition, the services of the GCC will be retained to help in monitoring the drilling company's adherence to the final ESIA.

182. The objective of the ESIAF is to: (i) describe the relevant legal and regulatory context of the project; (ii) the current state of the environment in the project area and surroundings; (iii) identify the potential environmental and social impacts, both positive and negative as appropriate, of the exploratory drilling activity, as far as they may be determined at this early stage with certain important information still outstanding; (iv) alternative options considered; and (v) establish the procedure and parameters for the preparation of the detailed ESIA and its associated ESMP.

183. The ESIAF provides indications on which data should be recorded, the consultation process to be carried out, and the instructions for the ESMP will include the definition of potential mitigation, monitoring, and institutional measures to be applied during the implementation of the project in order to offset or reduce adverse environmental and social impacts. It details the institutional arrangements as well as the capacity- strengthening measures needed to ensure proper follow-up of the ESIAF. If needed, the ESIAF can be updated from time to time, in agreement with the World Bank.

184. The exploration activities of the proposed operation include the construction of access roads and the operation of a quarry, the installation of drill pads and drilling rigs, the erection of temporary accommodations, the provision of seawater supply, the use of drilling fluids and associated cuttings, the testing phase (including geothermal fluid discharge), the management of solid waste and the power generation for exploratory drilling. The potential environmental implications of exploration are the following: surface disturbances (construction of new access routes and drilling pad), noise, fluid withdrawal, thermal pollution, chemical pollution (particularly if surface waters used for potable water abstraction are located close to the drill site) and degradation of ecological habitat. The ESIAF includes analysis of all of these potential impacts.

185. The drilling company will have direct responsibility for implementation of the ESMP, including all Environment, Health and Safety measures during the drilling phase. Adequate budget, staff and material support will be provided to the drilling company's environmental and social safeguards coordinator to assist him/her to implement this mandate. The drilling company's Safeguards Coordinator will have experience coordinating and implementing Environmental Health and Safety (EHS) policies during drilling operations and will, inter alia, prepare a monthly Health, Safety and Environment report

186. The Geothermal Power Generation project Team will include two dedicated safeguards staff: an Environmental and a Social Safeguards Specialists. These Safeguards Specialists will be responsible for ensuring that all environment and social impact mitigation measures including occupational health and safety guidelines are mainstreamed into the project design; monitored and supervised in accordance with the provisions of the ESIA, and for making bi-annual reports on safeguards compliance to the World Bank. The Social Safeguards Specialist will also be responsible for logging and tracking grievances (each grievance will be given an identification number and followed through by recording details and timing for their resolution and closing out).

187. The Team's environmental and social safeguard Specialists will be assisted by an Environmental Health and Safety (EHS) Audit Consultant to be hired by the Team. The EHS Audit Consultant will provide an independent monitoring of the implementation of the environmental and social management plan. The ESIA will describe the complete institutional arrangement and will include the terms of reference of the EHS Audit Consultant. The ESIA will be attached to the bidding documents and contracts financed by the proposed operation.

188. If the proposed operation identifies a promising geothermal resource, a transaction advisor (TA) will be recruited to tender the development phase of the project. The latter will prepare the terms of reference for the ESIA, which will be developed in line with World Bank rules, before the construction of the geothermal power plant.

189. **Social Safeguards:** OP 4.12 is not triggered as the implementation of the project will not involve any involuntary land taking leading to involuntary displacement of communities and/or loss of income sources, habitat and other resources. Further relevant information is provided below.

190. The project area, including the drilling sites is on state owned land. However, though land belongs to the state and administrative authorities attribute it, its management and usage in rural areas, in particular that of transhumance routes have always associated customary authorities and rural communities. The Environmental and Social Impact Assessment

Framework (ESIAF) indicates the customary passage and communal grazing attributed to communities.

191. The ESIAF has established that the project area is an uninhabited area with very limited local use. Traditionally, the Assal Zone is not known as a permanent living habitat, because of the extreme climate conditions, of the lack of water and the scarcity of green areas. This area used to be a temporary transit zone for herders transiting north –south or vice versa between the dry and wet seasons .There are no basic services and infrastructures in the project area and its surroundings.

192. The ESIAF distinguishes further between an extended project area and the drilling sites. There are no inhabitants in the proposed drilling sites. In the extended project area, there are about 298 households, respectively in three villages, at a distance of 5 km minimum of the drilling sites: Daba le Gahar (76 households, at 5km), Carrefour and Laïta (222 households at about 6 and 7 km). Some other 248 households of semi –nomadic tradition have been identified also in the extended project area, but none closer than 5 km of the drilling sites. There will not be any displacement of communities for the purpose of implementing project activities.

193. The proposed drilling area is crossed in part by (1) a transhumance route used by herders at least twice a year, sometimes three to four times[9] (on an approximate length of 2-3 km and width of 5 m to one km) and more recently by (2) a tourist pathway going to the « Lava lake » and the « Ardoukoba Volcano ». The ESIAF has identified relevantly a potential economic impact, for the limited time frame of the project, on this transhumance route and the tourist pathway. However, the ESIAF has indicated that the selection of the drilling sites must be done in a diligent manner so as to not block the access of communities to resources and to not cause loss of revenues. Hence, mitigation measures have been proposed to maintain both the transhumance route and the tourist pathway functional during project implementation though slight deviations or modifications might occur. The ESIA that will be prepared more in detail will seek to measure the magnitude of usage of the corridor, should a partial closure occur during project implementation hence impact on livelihood of users of the corridor.

194. Communities, relevant local and administrative entities have been consulted on the proposed project, its potential impacts and the socio-economic development priorities and constraints of the area. Before project implementation, a detailed plan of project sites and related activities will be posted and communities will be consulted again as well as administrative authorities.

[9] The ESIAF indicates that breeding in the Tadjoura area is both for household consumption and commercial usage. However, the exact number of livestock transiting and the frequency of their passage could not be specified because of frequent variations depending on the quantity of rains in the regions of origin and of destination.

Annex 4: Operational Risk Assessment Framework (ORAF)

Operational Risk Assessment Framework (ORAF)

Djibouti: DJ Geothermal Power Generation Project (P127143)

<table>
<tr><td colspan="7">Project Stakeholder Risks</td></tr>
<tr><td>Stakeholder Risk</td><td>Rating</td><td colspan="5">High</td></tr>
<tr><td rowspan="3">Description:

Stakeholders are concerned whether or not the geothermal resource, which is proven to exist, is of sufficient quantity and quality for large-scale power generation. A factor affecting the quality of the geothermal resource and its commercial viability is its level of salinity. Assal 1 drilled in 1975 produced excessively high brine super saturated geothermal resource with dissolved solids that ended up plugging the well. Another concern could be fluid acidity given proximity of magma.</td><td colspan="6">Risk Management:

This risk is mitigated through comprehensive geologic testing and independent engineering reviews, developed in the context of previous attempts to finance the project, which estimate chances of success of the exploration phase at 80 percent based on existing geological data and past drilling programs. Regarding the salinity issue, while there was no available proven technology to handle this type of fluid back in the 70s, experience gained developing geothermal resources with high salinity in the Salton Sea region of California as well as in a number of other regions, including Japan and Iceland, led to the belief that geothermal wells drilled in the Lake Assal area could be successfully exploited. A high salinity rate requires specific techniques that are more costly but available and the use of one of the operators that have previous experience with handling this type of fluids. In addition to technological advancements this risk is being mitigated by targeting the Fiale Caldera area for which the geology indicates an open reservoir in which the geothermal fluids are being refreshed with sea water. Acid fluids may require special materials in the future or alternative resources. The current back-up resource for either acid fluids or scaling fluids is the shallow resource intercepted by all wells to date, which has a temperature adequate for binary cycle generation.</td></tr>
<tr><td>Resp:</td><td>Status:</td><td>Stage:</td><td>Recurrent:</td><td>Due Date:</td><td>Frequency:</td></tr>
<tr><td>Both</td><td>In Progress</td><td>Both</td><td>☐</td><td></td><td></td></tr>
<tr><td colspan="7">Implementing Agency (IA) Risks (including Fiduciary Risks)</td></tr>
<tr><td>Capacity</td><td>Rating</td><td colspan="5">High</td></tr>
<tr><td>Description:

The lack of capacity is an issue in Djibouti and constitutes a substantial risk that needs proper mitigation measures. This is all the more important in the case of this project since it will be operating with a newly created Project Team with no experience in donors operations.</td><td colspan="6">Risk Management:

Due to the complexity of the project, an internationally experienced Director will be brought on board to handle all project implementation activities. Moreover, the Director will report directly to the Head of EDD, who has a record of successful experience in energy project implementation and an excellent understand of Djibouti's geothermal resource. The new Team will benefit from the recruitment of a dedicated accountant to align fiduciary practices with donors' standards. All the Team will benefit from thorough training in fiduciary and safeguard management. To ensure transparency, a segregated designated account will be opened in the Central bank in terms acceptable to the World Bank, to track project expenditures. In addition, an external auditor with qualification and experience satisfactory to the World Bank will conduct annual audit of the</td></tr>
</table>

project's financial statements.

Resp:	Status:	Stage:	Recurrent:	Due Date:	Frequency:
Both	In Progress	Implementation	☐		

Governance	**Rating**	**Moderate**

Description:

Any disruption of the Team in implementing the project would have a negative impact, e.g. suspension of staff salaries, change in key staff, etc. The severity of the impact would depend on the nature and length of the disruption.

Risk Management:

All instrumental members of the Team will be financed by donors. The Team will therefore have the resources necessary to function properly.

Resp:	Status:	Stage:	Recurrent:	Due Date:	Frequency:
Both	Not Yet Due	Implementation	☑		Yearly

Risk Management:

This risk will be mitigated by the recruitment of an external auditor acceptable to IDA and other donors' regular supervision missions including Financial Management staff.

Resp:	Status:	Stage:	Recurrent:	Due Date:	Frequency:
Both	In Progress	Implementation	☐		

Project Risks

Design	**Rating**	**Moderate**

Description:

Successful completion of the project is dependent on accurately compiling the results of well test data to provide information necessary for IPPs to confidently propose geothermal electric tariff pricing.

Risk Management:

To mitigate the risk of compiling inaccurate or superfluous test data results, the GCC will prepare a well test protocol as part of the drilling program and will have to certify the results obtained following this protocol.

Resp:	Status:	Stage:	Recurrent:	Due Date:	Frequency:
Client	Not Yet Due	Implementation	☐		

Social and Environmental	**Rating**	**Moderate**

Description:

The proposed operation will include building access roads and drill pads, water supply arrangements and drilling of four deep geothermal exploration wells. Drilling of the wells will be followed by a testing period of approximately three months per well in order to evaluate the characteristics and geothermal potential of the reservoir. In case the results from the proposed operation are negative, the drill pads will be reshaped to blend in

Risk Management:

The project will be located 80 km away from Djibouti city, near the Assal Lake. More specifically, the project will take place north of the Lava Lake. This area is wild and desert-like, mostly covered by airborne volcanic material or lake sediments. An Environmental and Social Impact Assessment Framework (ESIAF) has been prepared by the Team, based on terms of reference cleared by the World Bank. The impacts of the proposed project are expected to be insignificant or moderately negative on the physical and biological environment if appropriate mitigation measures are properly implemented.

<table>
<tr><td rowspan="4">with the landscape and all wellheads be minimized.</td><td colspan="6">The potential use of land and the potential human presence around the project sites have been documented in the ESIAF. The implementation of the project should not necessitate an involuntary acquisition of land leading to impacts such as involuntary displacement of people and/or loss of access to or of assets, revenues, and habitat. The project area and drill sites are on state owned land.</td></tr>
<tr><td>Resp:
Client</td><td>Status:
Completed</td><td>Stage:
Preparation</td><td>Recurrent:
☐</td><td>Due Date:
01-Dec-2012</td><td>Frequency:</td></tr>
<tr><td colspan="6">Risk Management:
At the time of the official assessment of the project, neither the technology that will be used for various aspects of the drilling program nor the location of the drillings were known and it was not possible to ascertain them precisely before finalizing the detailed drilling program. Therefore the exact nature of potential impacts could not be determined and the mitigation measures not precisely described. Because of this uncertainty, an Environmental and Social Impact Assessment Framework (ESIAF) was prepared. The ESIAF will serve as a foundation for the preparation of an Environmental and Social Impact Assessment (ESIA), which will contain a detailed environmental and social management plan (ESMP). The preparation of the ESIA will be the responsibility of the drilling services company (DSC) selected to execute the drilling program designed by the geothermal consulting company (GCC). As such, all bidders for the drilling contract will be required to submit an ESIA as part of their bid package, and the quality of ESIA submissions will be graded as part of the bid evaluation process. In addition, the services of the GCC will be retained to help in monitoring the drilling company's adherence to the final ESIA.</td></tr>
<tr><td>Resp:
Client</td><td>Status:
Not Yet Due</td><td>Stage:</td><td>Recurrent:
☐</td><td>Due Date:
31-Dec-2013</td><td>Frequency:</td></tr>
<tr><td>Program and Donor</td><td>Rating</td><td colspan="5">High</td></tr>
<tr><td rowspan="2">Description:
The project is jointly financed by GEF, OFID, AfDB and AFD and therefore comes with a significant coordination risk at implementation.</td><td colspan="6">Risk Management:
The largest contracts to be awarded under this project will be based on co-financed funds and will therefore be handled by the Bank. Other smaller contracts have been allocated under parallel financing.</td></tr>
<tr><td>Resp:
Client</td><td>Status:
In Progress</td><td>Stage:
Preparation</td><td>Recurrent:
☑</td><td>Due Date:</td><td>Frequency:</td></tr>
<tr><td>Delivery Monitoring and Sustainability</td><td>Rating</td><td colspan="5">Moderate</td></tr>
<tr><td>Description:
Possible implementation delays due to procurement or technical challenges.</td><td colspan="6">Risk Management:
The PMU will be staffed with international professionals that have significant experience in developing similar projects. Moreover, the PMU will benefit from the assistance of a high level</td></tr>
</table>

	steering committee that comprises representatives from the line ministries and that has the capacity to help solve issues likely to arise.					
	Resp:	**Status:**	**Stage:**	**Recurrent:**	**Due Date:**	**Frequency:**
	Client	Not Yet Due	Both	☐		
Other (Optional)	**Rating**	**Moderate**				
Description: In the event that the well test data and feasibility study demonstrate the technical viability of the project, institutional and regulatory risks still remain. There is no regulatory framework for PPPs under current government laws and regulations.	**Risk Management:** To mitigate this risk, the Government of Djibouti requested PPIAF support to develop a legal and regulatory framework to foster IPPs' appetite to enter the market. PPIAF responded favorably to this request that is now being executed by a consultant working under World Bank supervision. Moreover, donors' involvement in the following phase of the project will be exclusively focused on ensuring the implementation of the above-mentioned regulatory framework.					
	Resp:	**Status:**	**Stage:**	**Recurrent:**	**Due Date:**	**Frequency:**
	Client	Not Yet Due	Implementation	☐		
Other (Optional)	**Rating**	**Moderate**				
Description: Risk of Third Party Legal Claims: The GoDj has signed a number of Memoranda of Understanding (MoUs) and similar agreements with various third parties in regard to the development of the country's geothermal resources. These include the 2008 agreements signed with REI, which have now been terminated. The risk is that the parties to these MoUs may assert legal claims which would interfere with the implementation of the project -- or the subsequent development of a power generation plant -- in accordance with World Bank procurement and safeguard rules.	**Risk Management:** During appraisal, the World Bank obtained a legal opinion from the GoDj setting out the purpose and status of all MoUs signed by the GoDj in regard to geothermal resource development.					
	Resp:	**Status:**	**Stage:**	**Recurrent:**	**Due Date:**	**Frequency:**
	Client	Completed	Preparation	☐		
Overall Risk						
Overall Implementation Risk:	**Rating**	**High**				
Risk Description: The Geothermal Power Generation Project is a high-risk high reward project due to the fact that it finances primarily exploration with a probability of success of 80%. Nevertheless, the World Bank has not financed pure exploration in over the past two decades.						

Annex 5: Implementation Support Plan

A. Strategy and Approach for Implementation Support

195. The strategy for implementation support has been developed based on the design of the project and its risk profile. It aims at providing the Geothermal Power Generation Project Team with the technical support needed to ensure safeguards and fiduciary compliance with World Bank guidelines as well as to carry out all risk mitigation measures defined in the ORAF during project preparation. More specifically, the strategy includes the following pillars.

- **Technical:** the World Bank supervision team will work in close collaboration with the Team and its international consultants to ensure that the design and execution of the drilling program and the test protocol meet industry and international standards. Monthly conference calls including the World Bank team, the Geothermal Power Generation Project Team, the Project Manager of the GCC, cognizant representatives from relevant contractors will take place to identify issues at the strategic and Team level and help resolve them. The project team shall not interfere with the technical day to day decisions of the contractors of the project under any circumstances
- **Environmental and Social Safeguards:** the World Bank team will ensure quality supervision of the environmental and social management plan defined by the environmental and social impact assessment of the project.
- **Procurement:** the World Bank team will provide sufficient support to the Team to ensure timely review, evaluation and submission of key bidding documents. Support will also include necessary training and workshop provided to the Team staff in charge of procurement prior to the beginning of project implementation. In addition, a drilling consultant will be part of the implementation support process and will help ensure a rapid clearance process of project contract procurement documents by providing a technical support to the project team.
- **Financial Management:** Supervision of project financial management will be performed applying a risk based approach. The supervision will review project financial management systems including but not limited to accounting, reporting and internal control.
- **Coordination with donors:** A Memorandum of Understanding between IDA and OFID will ensure that all IDA co-financed operations are undertaken in line with World Bank fiduciary and safeguards rules. A yearly joint implementation support mission that includes all donors will take place. Finally, the PMU will update the Operations Manual to include all implementation arrangements needed for the Geothermal Power Generation Project, such as project costs and parallel/co-financing arrangements, disbursement, financial management and procurement arrangements, internal controls, etc. The Operations Manual will be used by all donors co-financing or parallel financing the project.
- **Information sharing:** A monitoring and evaluation specialist will ensure follow up on the Result Framework, track relevant information required to provide periodic updates on lessons learnt from project design and implementation and

prepare a “lessons learnt” section that can be disclosed as part of the part of the Implementation Support Review.

B. Implementation Support Plan

196. To successfully implement the Geothermal Power Generation Plan, the task team consists of experts of all subject matters relevant to the project (geothermal, environmental, social, procurement, financial, economics). Formal supervision and field visits will be carried out at least twice a year

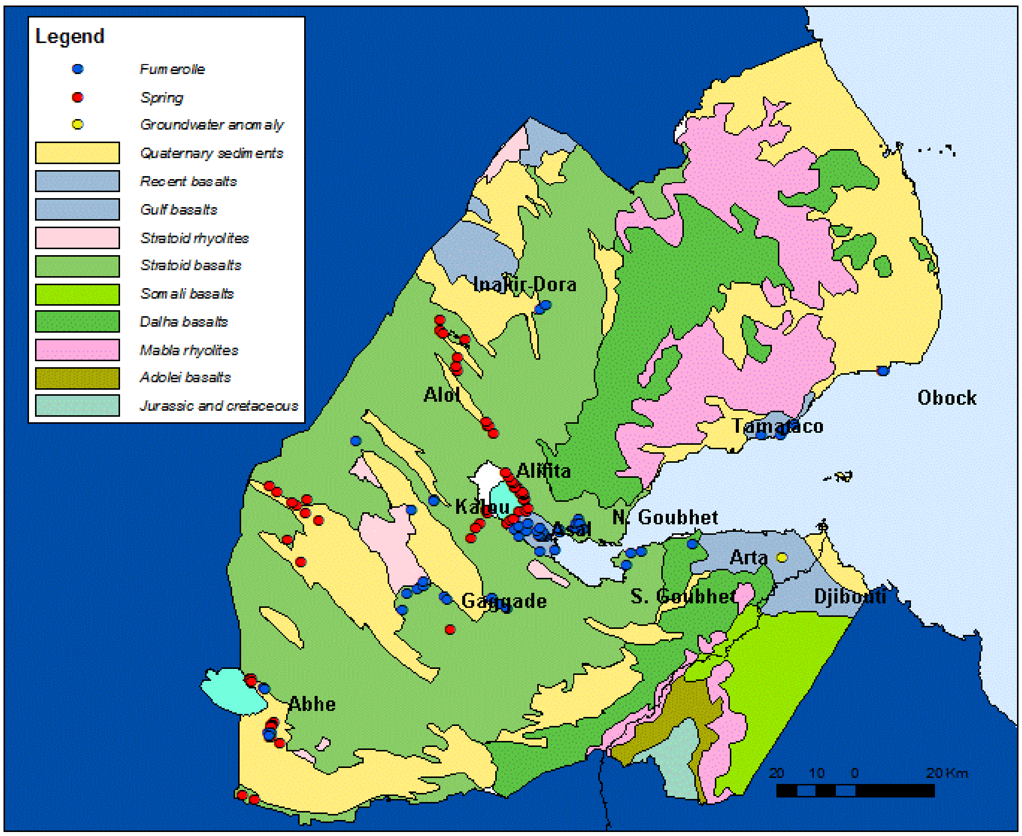
Skills required	Number of Staff Weeks (SWs)	Number of Trips	Comments
Task Team Leader	12 SWs Annually	Field Visits as Required	
Geothermal Specialist	16 SWs Annually	Field Visits as Required	
Financial Management Specialist	3 SWs Annually	Minimum of 2 Trips Annually Field Visits as Required	
Monitoring & Evaluation Specialist	6 SWs Annually	Minimum of 2 Trips Annually	
Procurement Specialist	6 SWs the first year 3 SWs annually the following years	Minimum of 2 Trips Annually Field Visits as Required	
Social Safeguards Specialist	1.5 SWs Annually	Minimum of 2 Trips Annually Field Visits as Required	
Environmental Safeguards Specialist	3 SWs Annually	Minimum of 2 Trips Annually Field Visits as Required	
Counsel	2 SWs Annually (on the last year)		

Annex 6: Assal Rift Exploratory Drilling History and Lessons Learned

I. Geological Context

197. The Republic of Djibouti is located within the Afar Depression; a geologic triple junction structure formed by the intersection of the Red Sea, the Gulf of Aden and the East African rifts. Volcanic and tectonic activity at this intersection has been occurring for 30 million years. The Assal rift, which includes the exploratory drilling focus of this Geothermal Power Generation Project, is the westward-emerged portion of the Gulf of Aden rift in Djibouti.

Figure 1: Geological Map of Djibouti



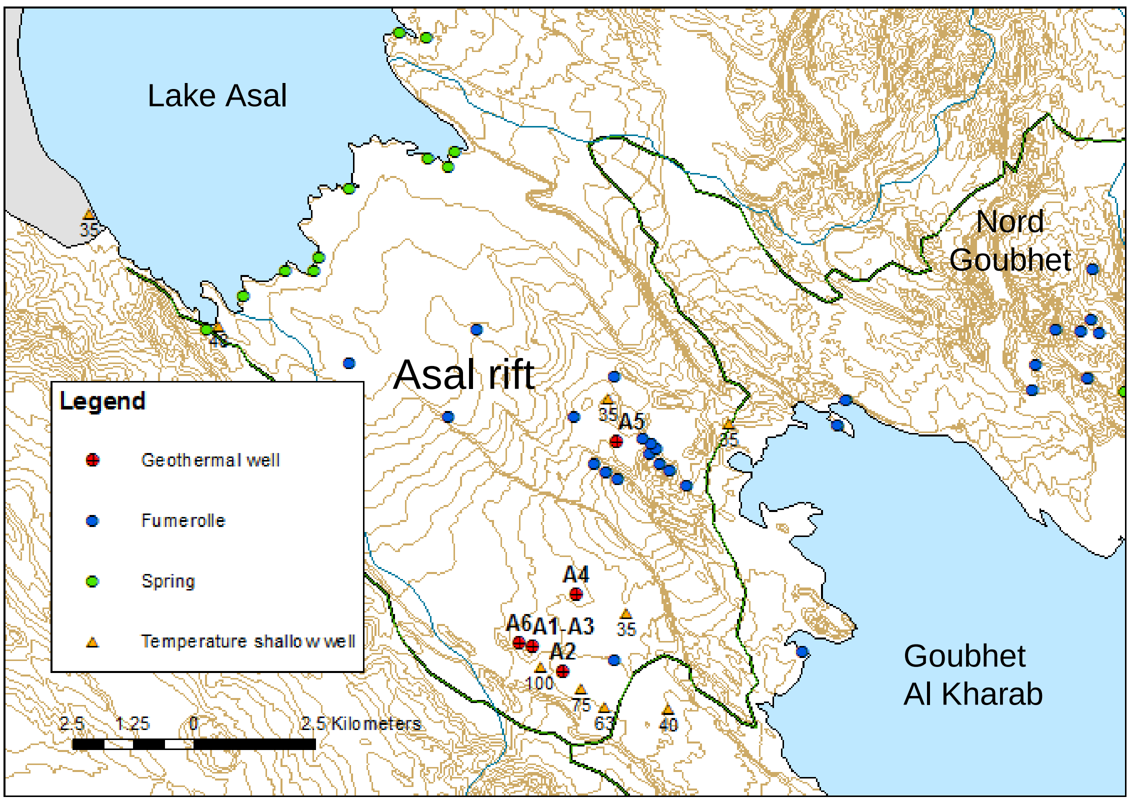
198. The map presented above describes the geology of Djibouti and the main geothermal prospects. Approximately twelve geothermal provinces have been identified in Djibouti based on locations of surface hydrothermal manifestations. All of the surface manifestations are fracture controlled and occur within the recent volcanic and sedimentary rocks or at the intersection point of recent and old formations.

199. As a result of the GoDj's commitment to continuing development of renewable geothermal energy, priority was given to the prospects of Nord-Goubhet and Lake Abhé in addition to the Assal site. Nord-Goubhet is located immediately east of the Assal rift zone. It was selected as a result of surface studies that have been performed at the site (including a gravimetric survey) and due to the ease of site accessibility that supports commercial development potential. The Lake Abhé site is located in Southwest Djibouti. Consideration was given to Lake Abhé based on the geologic importance of the surface hydrothermal

manifestations and the low salinity of the hot springs. The CERD has recently completed a pre-feasibility surface study for Nord-Goubhet. A similar pre-feasibility surface study is currently being performed at Lake Abhé and should be finalized in 2013. The geologic features of Nord-Goubhet and Lake Abhé in combination with the surface studies performed to date show these sites to be promising prospects for further geothermal study in the form of exploratory drilling.

200. Although the geologic features and surface studies performed to date indicate that Nord-Goubhet and Lake Abhé represent promising geothermal prospects, there has been no exploratory drilling or definitive confirmation of a geothermal resource suitable for power generation in these areas. Unlike Abhé and Goubhet, geologic research and testing over the last 36 years in combination with two exploratory drilling programs in the Lake Assal rift area have proven a significant geothermal resource.

Figure 2: Main Geothermal Prospects in Djibouti



201. Exploratory drilling previously performed at the Assal site has confirmed the existence of both a shallow and deep geothermal reservoir. The shallow reservoir has a medium enthalpy characteristic with geothermal fluid salinity close to that of sea water (~35 to 40 g/l). The high enthalpy deep reservoir tapped by Assal wells 1, 2, 3 & 6 was identified as a “sealed reservoir” with limited recharge capacity, thus accounting for the high salinity (~130 g/l) encountered in these drillings. A high scaling potential was also recognized when wellhead pressures were held below 18 barg.

202. The Assal geophysical data taken in the Fiale zone in combination with exploratory drilling results of the Assal 5 well (inverted temperature profile) have revealed a geothermal

conceptual model that includes a reservoir that is recharged by constant seawater flow. As a result of this model, the Geothermal Power Generation Project has been focused on drilling the Fiale zone where salinity is expected to be significantly reduced from that of the previously encountered, sealed reservoir. In addition, the project will utilize deviated drilling techniques that will penetrate multiple vertical fractures in the axial part of the Assal rift in order to improve geothermal fluid productivity rates.

203. With this improved geothermal model resulting from recent shallow subsurface testing using time electromagnetics (TEM) and deep subsurface testing using magnetotelluric (MT) methods, it is now believed that Djibouti's Lake Assal geothermal resource can be successfully exploited for use in generating electric power using either flash plant (high enthalpy deep reservoir) or binary power plant (medium enthalpy shallow reservoir) technologies.

204. The Geothermal Power Generation Project has been developed based on international best practices and the lessons learnt from geothermal exploratory drilling already undertaken in the Assal rift in Djibouti.

II. Assal Rift Exploratory Drilling History

A. 1975: Geothermal Wells - Assal 1 & 2.

205. Two deep wells (~1000 m) were drilled by the French Bureau for Geological and Mining Research (*Bureau de Recherche Géologique et Minière – BRGM*) in 1975 and encountered bottom hole temperatures between 230 and 260 degrees Celsius. These wells were not fully tested for power generation potential due to budget constraints. Well testing was later performed by BRGM in 1981 with UNDP funding. Assal 2 was non-producing while Assal 1 produced excessively high brine supersaturated with dissolved solids (saline fluid 130g/l with sodium chloride type fluid with the presence of silica, and sulfides). Brine production ultimately resulted in plugging the well. In spite of the difficulty posed by handling the fluids, experience gained in developing geothermal resources with high salinity in the Salton Sea region of California, USA led to the belief that geothermal wells drilled in the Lake Assal area could be used for power generation.

B. 1987: Geothermal Wells - Assal 3 through 6

206. The World Bank through IDA in participation with the Government of Italy, AfDB, UNDP, the GoDj and OFID jointly financed an exploratory drilling program focused on the Hanle / Gaggade area in western Djibouti[10]. After drilling two wells that did not provide sufficient results, the drilling rig was moved to the Lake Assal area after which Assal wells 3 through 6 were drilled.

207. **Geothermal Well - Assal 3:** Assal 3 was sited within a few meters of Assal 1 to assure hitting the same reservoir. The drilling encountered a very strong source of 264 degree Celsius for which the drilling crew was unprepared. As a result, the drill pipe was cut with a portion of it being left in the well. In spite of this obstruction in the hole, it was determined that the well was capable of producing more than 100 tons per hour of steam and hot water with a total content of dissolved solids of about 180,000 ppm. In terms of total enthalpy, the

[10] World Bank Geothermal Exploration Project - Credit 1488-DJI

well was classed as the largest in Africa at the time capable of producing 10 MW if the scaling problem could be managed without power loss.

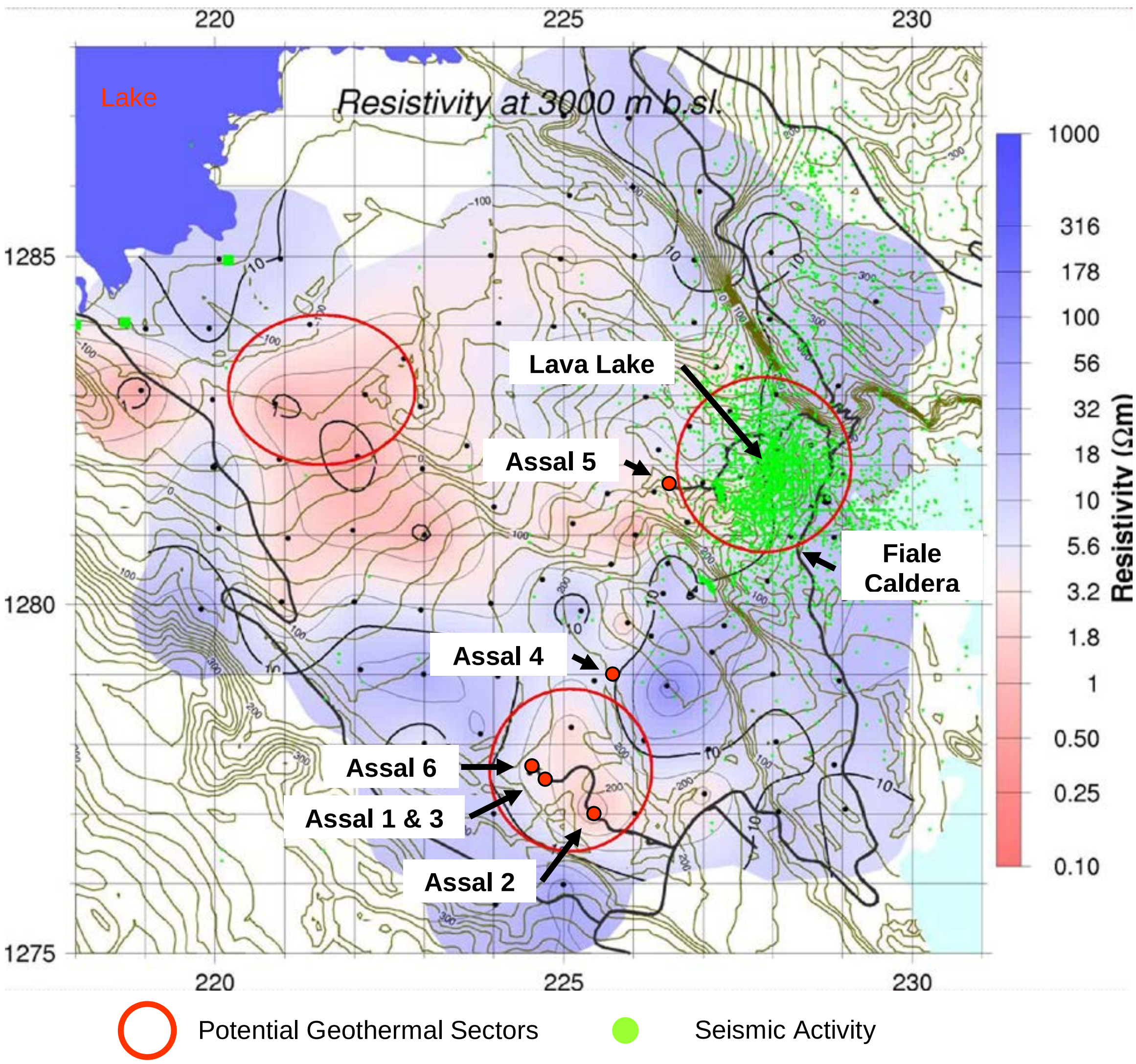
208. **Geothermal Well - Assal 4:**Assal 4 was sited approximately 1.4 km from Assal 3 and was drilled to 2,013 meters. Bottom hole temperatures were in the range of 340 degree Celsius. The well did not encounter a high production zone similar to Assal 3. A permeable zone was encountered near total depth resulting in a total loss of circulation. Although the World Bank and Aquater (supervisory firm) recommended continuation of the drilling after the permeable zone was penetrated, the decision was taken to stop the Assal 4 drilling after a colored, acidic fluid was collected at depth. In September of 1988 a test was made at Assal 4 using coiled tubing. Temperature was not reported as a result of the test instruments being lost when the well blew out and then caved in. Despite the coiled tube breaking, the test indicated the presence of a source of very hot water and dry steam probably entering the hole by way of the lost circulation zone that was penetrated just before abandonment. Indications prior to the loss of instrumentation suggested that Assal 4 could have been made into a producing well if different considerations had been given during the drilling process.

209. **Geothermal Well - Assal 5:** Assal 5 was located 5 km north of Assal 3 on the edge of the Fiale caldera. Project funds were near exhaustion when starting Assal 5 so the Project Manager attempted to save money by drilling quickly without testing or taking measurements at interesting zones. As a result of cost saving measures and in contradiction to the supervisory firm's recommendations, testing at the shallow (500m) high temperature (180 degrees Celsius) zone was not performed. The hot shallow zone was underlain by a relatively thick cold zone before temperatures increased to reach 350 degrees Celsius at 2000m depth. While it is assumed that the cold layer precluded commercial production at depth, there should also be some fundamental data on the permeability of this well.

210. **Geothermal Well - Assal 6:** Assal 6 was located approximately 240 meters northwest of Assal 3 and drilled to a total depth of 1,761 meters. By unnecessarily expending 1258 meters of 9 5/8 inch casing on Assal 5, there was insufficient casing available for Assal 6. As a result, certain drilled zones caused problems when they should not have. Assal 6 encountered a zone very similar to Assal 3 with large volumes of hot water. Test results showed flow rate over 100 ton/hour of steam and hot water. Assal 6 confirmed the indication of a reservoir; however, it was predicted that the well would not be useable due to a change in the casing which lines the well giving a very peculiar hole geometry and a technically inferior result.

211. The "Geothermal Exploration Project - Credit 1488-DJI Agreement" required the successful drilling of one additional steam producing well besides Assal 1 (1975 French program) and Assal 3 in order to justify proceeding with a follow-up geothermal development project. In order to obtain this result, Assal 6 was drilled with GoDj funds after the IDA funds had been exhausted with the drilling of Assal 5. The declaration of Assal 6 as a steam producer provided the necessary justification to proceed with a follow-up project to develop the Assal geothermal field.

Figure 3: Geothermal Sectors and Location of Assal Exploratory Wells



C. 1989: Multi-donor Geothermal Power Plant Development Project[11]

212. The Geothermal Development Project Credit 2055-DJI was subsequently prepared. It was meant at ensuring both exploration and production of the geothermal resource through the installation of a geothermal power generation plant. The project also included the design and installation of desalination plant and a transmission line connecting the production site to Djibouti City.

213. IDA funds were subsequently approved after which the World Bank found itself at odds with the other program participants concerning project scope and risk. Effectiveness was

[11] Geothermal Development Project, World Bank Credit 2055-DJI

delayed by over a year when; (i) the Italian grant was not made effective[12], (ii) the final results of the scaling study were delayed, and most importantly, (iii) the participants could not agree on risk parameters leading to fundamental program design differences. In November of 1992, IDA informed the GoDj that it would not extend the December 31, 1992 closing date of the credit. The Geothermal Development Project, Credit 2055-DJI was subsequently canceled. In addition to the fundamental differences between the participants, by early 1992, civil unrest in the northern part of Djibouti had made the project area inaccessible. According to the Implementation Completion and Results Report, "clearly what [was] to blame [was] not the geothermal energy itself but the inappropriate methodology adopted [for project design]".

D. 1990: Virkir-Orkint Consulting Group Ltd. Scaling Study

214. The delayed scaling study referenced above was ultimately produced in August of 1990. The study entitled "Djibouti Geothermal Scaling and Corrosion Study Final Report" was prepared by the Virkir-Orkint Consulting Group Ltd. of Reykjavik, Iceland. The main objective of the study was to assess the effect and avoidance of scaling and corrosion and to appraise the response of the Assal reservoir to utilization. The study included 28 weeks of fieldwork during which Assal 3 was continuously discharged for a total of 93 days. It was found that the scaling rate increased by six times at wellhead pressures below 16 barg, when compared to scaling characteristics at pressures between 18 and 20 barg. Corrosiveness of the geothermal steam was not considered to be severe. The findings of the Virkir-Orkint study indicate that the use of inhibitor chemicals to control scaling while holding wellhead pressures above 18 barg. is promising in terms of controlling scaling of power generation production wells. In regard to the viability of the reservoir in which Assal 3 and 6 are drilled, it was concluded that the reservoir was small in size and that low porosity and a relatively small drainage area would provide only limited capacity. The low permeability factor in combination with high salinity (indicating stagnant fluids) suggests that the reservoir is a "sealed off" system that would not recharge fast enough to provide commercial power generation without significant expenditure for a fluid re-injection system. These facts were taken into account by Reykjavik Energy Invest and again by the Geothermal Power Generation Project leading to the targeting of the Fiale Caldera area in lieu of the reservoir system in which Assal 3 and 6 are drilled.

215. The primary recommendations of the Virkir-Orkint study were that (i) extensive field testing should be performed to obtain more accurate data for estimating the actual size and capacity of the reservoir, and that (ii) a laboratory study of potential inhibitor chemicals should be carried out, and based on its outcome, field tests should be initiated which include down hole injection of selected inhibitors. The results of the scaling study indicate that the Lake Assal geothermal fluid can be technically managed for use in power generation. It must be noted that the recommendation of extensive field testing to obtain accurate reservoir size and capacity data is the basis upon which the Geothermal Power Generation Project has been developed. The requirement of testing "accuracy" has been designed into the project through the use of an approved test protocol and certification of test results to be in conformance with the protocol.

[12] The Government of Italy was the primary donor for this project, with a contribution of US$22 million out of a total of US$38.04 million. World Bank contribution was of US$9.02 million and OPEC/UNDP contributed US$1.4 million. The remaining amount was financed by the GoDj.

E. 2007: Reykjavik Energy Invest Proposed Geothermal Project

216. In 2007, the President of Iceland offered support to the President of Djibouti to develop Djibouti's geothermal resource and the offer was accepted. The pledged support took the form of a proposal by Reykjavik Energy Invest (REI) to take total project risk (including exploration risk) as an IPP Developer and recoup investment and associated return through a 20-year electric tariff.

217. The parties signed legally binding Project and Power Purchase Heads of Agreement (PA and PPA) as well as an exclusive license for geothermal utilization in the Assal Rift. Before the deal was consummated, the financial crisis in Iceland impacted REI's ability to fulfill its project obligations. REI subsequently partnered with Contour Global and the IFC (the "REI Consortium" or "Consortium") to try and amend the PA and PPA and proposed a 13 cents/kWh tariff price that was rejected by the GoDj. The proposal was rejected based on the observation that 40% of the tariff reflected a cost of interests that was significantly higher than what was originally planned. Following this rejection, REI was reported to be working with Sithe Global, an alternate IPP, with the stated intention of proposing a lower tariff price structure. No alternate tariff pricing was received by the GoDj from REI/Sithe Global since then.

218. To support its tariff offer, the Consortium performed a geothermal Desk Study to develop a picture of the site's environmental setting including geology, hydrogeology and hydrology among others using previous research, reports and exploratory drilling results from the earlier Assal drilling programs. The Desk Study was followed by a Pre-feasibility Study during which the Consortium performed a surface exploration study based on several decades of geothermal exploration in Djibouti. In cooperation with the GoDj, this work resulted in the preparation of a directional drilling program that focuses on the Fiale Caldera area.

219. The Consortium's proposal was officially rejected in 2010 as it was significantly different from the original deal. The development of Djibouti's geothermal potential once again came to a standstill. In order to move the development of its geothermal resource forward, the GoDj requested IDA support. In October 2012, REI and the Government of Iceland agreed to provide all of the herein referenced test data and studies previously performed by REI and its subcontractors while in pursuit of an IPP based power plant in the Lake Assal region. This information will serve to reduce both the cost and the risk of this exploratory drilling project.

III. Lessons Learned which Guide Project Design

Insufficient project design and lack of donor coordination have hampered geothermal development in Djibouti since the 1970s.

220. There have been many attempts to develop the geothermal resource in Djibouti over the past 40 years. Most of these endeavors involved multiple donors given that Donor allocations for Djibouti are insufficient to fully cover the cost of a geothermal exploration program. As a result, a strong coordination between donors is a must which can only result through a thorough project design which is effectively communicated between the Donors. A review of the Assal Rift exploration history shows that this was not the case in Djibouti when the projects fell short of definitively quantifying the geothermal resource resulting in Donor disagreements concerning the next steps (i.e. installation of commercial generation). In 1993, a World Bank Implementation Completion and Results Report stated indeed that "clearly,

what is to blame is not the geothermal energy itself, but the inappropriate methodology [used during project design]".

221. The current project builds on the lessons learned from previous attempts at developing geothermal generation in Djibouti. All key components of the project have been defined by international experts and discussed thoroughly between the donors and the Government. The proposed project has been simplified through the statement of the definitive goal of quantifying the viability (i.e. temperatures, chemistry, quality and quantity) of the Lack Assal geothermal fluid for use in commercial power generation. The project is now focused on the Fiale Caldera which promises water recharge from the sea which is expected to mitigate the risk of geochemistry constraints to power generation like that imposed by the sealed reservoir tapped during earlier drillings. Unlike the previous drilling programs in which finding and quantifying the resource was secondary to justifying the installation of a small power plant, this project is focused on the accurate quantification of the fluids in order to attract qualified IPPs to develop and build cost effective power generation. As such, this project provides for a carefully structured and controlled drilling and testing program with an end result of assuring accurate resource data that is certified pursuant to the well test protocol.

Project design proposed as a result of lessons learned.

222. Based on field test data, the stakeholders have concluded that the Fiale (or Lava Lake) caldera is the location most likely to provide the best geothermal drilling results. The Fiale caldera is connected to two adjacent, smaller calderas all of which are believed to be fed by the same magmatic heat source at depth. All three calderas are cut by a dense network of east/west to north/west striking open fissures and small normal faults. Based on water flow characteristics of the region, it is anticipated that the Fiale will provide geothermal fluids that will be less saline than those encountered in past drillings.

223. Given the geologic conditions of the Fiale caldera, it has been concluded that vertical drilling techniques used in the previous drilling program will reduce the probability of drilling success. Instead, this project uses deviated (or directional) drilling techniques to increase the probability of success through the ability to penetrate multiple vertical fault zones that are known to exist in the caldera. In addition to improving probability, deviated drilling provides a more environmentally sensitive approach to the Fiale caldera region when directional wells can be drilled from outside the rim of the caldera.

224. To obtain value from the exploratory wells after testing is complete, the stakeholders weighed the cost of drilling four full size production wells (i.e. 9 5/8 inch production casing) in lieu of the seven-inch exploratory wells (roughly US$5 million differential) that can only be used for testing. In the event of drilling success and proven reservoir viability, the four full size production wells would effectively reduce the cost of a power generation production drilling program by approximately US$3.5 to US$5 million per successful well (typical geothermal well cost in multiple well drilling program). We anticipate that this production drilling capital cost reduction would in turn reduce the electric tariff price proposed by a future IPP. As such, the project has been designed to include the drilling of four full sized production wells.

225. In addition to exploitation of the deep geothermal reservoir using dry or flash steam power plant technology, the stakeholders recognize the potential value of the lower temperature shallow reservoir that is known to exist in the Assal Rift area of which the Fiale Caldera is a part. Regional experience indicates that the lower temperature shallow reservoir

may be used to heat a binary fluid such as butane that is vaporized, directed to a turbine generator and then condensed in an air or water cooled heat exchanger (binary cycle geothermal power plant). Although the drilling program is premised on a deep drill design (~2,500 meters), program design includes stopping the drill at the shallow reservoir to perform testing in support of binary plant viability. Consideration of binary cycle generation using the shallow reservoir increases the probability of success in the event that the deep reservoir does not prove out.

Annex 7: Economic Analysis

A. Overview.

226. The purpose of the project is to increase the level of technical information about the potential for a successful geothermal power station to be constructed in the future and to prepare necessary documentation to enable this. The economic value of the project was assessed by calculating the expected reduction in the net present value of the costs of the electricity generation expansion plan that would be made possible by the inclusion of a 50MW geothermal power station following a successful drilling program. The difference in the net present value of the costs of expansion plans without, and with the drilling program and possible geothermal station, was weighted by the probability that the drilling program would identify an adequate source of geothermal supply, and this difference was then compared to the cost of undertaking the exploratory drilling program.

227. **Key assumptions for costs of exploration program.** The project cost is US$31 million and this will finance the construction of four production type wells and production of documentation to enable development.

228. **Key assumptions for the evaluation of the probability of constructing a geothermal power station:**

- **Number of wells to be drilled.** The project plans to drill four wells that can serve for production if viable quantities and qualities of geothermal resources are identified. The wells will be drilled in sequence (rather than simultaneously) in order to learn from the earlier results and so maximize the chances that subsequent wells will be successful. It was assumed that all four wells would be drilled, irrespective of the outcomes on the earlier trials.
- **Conditions for a well to be considered successful.** In accordance with previous analysis of the geothermal potential in Djibouti, a well would be considered as a success if it were assessed as being able to support at least a sustained 4 MW of electrical energy. The ability to supply this amount of electricity depends on the temperature and volume of the resource, while other characteristics such as salinity or acidity can also affect the feasibility of using any resource discovered.
- **Conditions for the drilling program to be considered successful.** For the program as a whole to be considered successful, a criterion of at least two wells out of four being successful was used in order to provide an evaluation of the potential benefits from possible geothermal generation investment. Sensitivity analysis using a more stringent condition (three out of four successes) was also carried out. If the program is deemed to be a success this is equivalent to assuming that the private sector shows interest in provision of an IPP, on the basis of the test results, to finance a geothermal power station of 50MW. Finding a definite availability of a smaller resource would in practice permit a smaller geothermal station to be developed that would reduce the net cost of the development of the geothermal power plant, but by a smaller amount.
- **The probability of a successful first well**. Earlier studies have assessed the probability of success for the first well, given existing geophysical evidence, at 0.80. For the present study that is still a greenfield development a probability of 0.7 would be a normal success ratio. For the present analysis a range of values from 0.75 down to 0.35 was analyzed. Some evidence lends support to the probability of a well success

being substantial, even if not as high as 0.80. The study by Sanyal and Morrow[13] found that the mean success rate of a sample of 2,528 wells in 52 fields in 14 countries was 68%.

- **The probability of success of subsequent wells**. Two alternatives for the probabilities of successes of the second, third, and fourth wells were considered. The first case (independent probabilities) assumed that no learning about where to drill takes place so that the probabilities of success for these three wells were also assumed to be the same as that of the first well (0.75 – 0.35). The second case (dependent probabilities) would assume that learning does take place, so that following a first success the probability of a success for the second well would be greater than that of the first well and the probabilities of third and fourth successes would be higher still etc. Without more detailed geophysical information there was no way to quantify this possibility[14].
- **The probability of success of the drilling program.** From the individual well probabilities the probability of at least two (three) successes in four trials was calculated using the standard binomial probability distribution formula.

229. **Key assumptions for evaluating the net present value of the costs of alternative generation expansion programs**

- **Source of calculations.** The net present values for the least cost generation expansion plan were based on those calculated in the study undertaken by Parsons Brinckerhoff (PB) in 2009, as a report to the World Bank.
- **Electricity demand forecast**. A sales forecast by category of user was used, based on actual data, regression analysis, and assumptions about the growth of the Djibouti economy. Forecast growth rates for GDP were taken from the Country Economic Memorandum, and for the base case scenario were assumed to be at 3.5% until 2015 and then to slowly decline to 3% by the end of the period. In addition it was assumed that the sales forecasts, based on a detailed sector build-up, were adjusted by energy losses. These included a steady but slow reduction of the estimated 15% technical losses until a value of 12% was reached in 2024, and a sharper decline in non-technical losses from 8% in 2011 to 1% by 2015. These assumptions formed the basis of the estimated demand for power sent out. Generation sent out was estimated to rise from 325 GWh in 2008 to1236 GWh in 2035, while maximum demand was estimated to increase from 57 MW in 2008 to 218MW in 2035.
- **Existing generation and operating philosophy**. The existing power system consists entirely of thermal stations using heavy fuel oil or diesel. An interconnector from Ethiopia was completed in 2011 and this will be able to supply a limited amount of energy at all times except the peak dry season in Ethiopia. The PPA allows for between 180 and 300 GWh of supply from this source that, being lower cost than domestic generation, will be utilized whenever available. The operating objective for

[13]*Success and the Learning Curve Effect in Geothermal Well Drilling—a Worldwide Survey*.Sanyal, S. and J. Morrow 2012.Proceedings of the Thirty-Seventh Workshop in Geothermal Reservoir Engineering. Stanford, California.

[14]Modeling Dependence Among Geologic Risks in Sequential Exploration Decisions. Bickel, E., J. Smith, and J. Meyer. 2008. *Society of Petroleum Engineers: Reservoir Evaluation & Engineering*, 11 (2), 352-361.

the Djiboutian power system is to minimize the amount it spends on fuel, O&M costs, and capacity costs, subject to maintaining full capacity to meet its own demand at all times. In other words, the objective is to maximize the fuel cost savings from using the interconnector whilst keeping capacity costs as low as possible. The volume of imports impacts the nature and costs of the expansion plan.

- **The least cost expansion plan**. The least cost expansion plan was constructed for a number of scenarios. The basic scenario assumed that no geothermal plant was feasible, so that all new plant was thermal, and that there were zero imports from Ethiopia. This was varied by allowing for 180 GWh or 700 GWh of imports. A second group of scenarios assumed that 60MW of geothermal power was available, and that either zero or 700 GWh of imports were available. The lower variable cost of geothermal than of the best thermal alternatives ensured that it entered the expansion plan. World oil prices were assumed to rise steadily from 2009 until 2020 (reaching US$119 a barrel) and more slowly thereafter, reaching $130 by 2035. The long run marginal cost of the system was estimated to be $0.20 per kWh as of 2009. Current oil prices suggest that the cost may be as high as $0.25 per kWh. The discount rate for the expansion plan was taken to be 10% indicating that investment could be attractive to the power sector while not allowing excessive profits. All costs were stated in constant 2008 US$.
- **The no project scenario.** If the project were not to go forward it was assumed that Djibouti would follow the least cost generation expansion without geothermal. That is, without further geophysical information, investors for geothermal plants would not come forward. Further, any deviation from this plan, such as the construction of a large oil-fired plant as is being currently considered, would raise the cost of the no project scenario.
- **The successful drilling scenario**. If the criterion for a successful project, as defined above, is satisfied, then it was assumed that a developer for a 50MW geothermal project would come forward and that expansion would take place according to the plan including geothermal. An adjustment was made to scale the net present values of the expansion plan to 50MW geothermal rather than 60MW, as assumed in the expansion plan, by using a linear interpolation between expansion with no geothermal, and expansion with 60MW of geothermal. If the exploration project were undertaken, a probability was attached to overall success, depending on the probabilities for individual well successes indicated above.
- **The unsuccessful drilling scenario.** If the criterion for success is not satisfied, then it was assumed that no geothermal generation would occur and that generation expansion would take place according to the “no project scenario”. The unsuccessful drilling scenario was assigned the complementary probability to the successful drilling scenario.

B. Methodology.

230. **Economic benefit of the project.** The criterion for measuring the net economic benefit of the project was defined as the expected reduction in the net present value of the cost of the generation expansion plan made possible by the introduction of 50MW of geothermal plant allowing for the costs of the exploratory drilling program. The costs of the follow up project included all fuel, other O&M costs, and capital costs including costs of drilling

enough wells to supply a 50MW geothermal plant. The expected net present value of the net cost associated with undertaking the drilling program was measured by the following criterion: *(The probability of a successful project times the net present value of the cost of the expansion plan including geothermal plus the probability of an unsuccessful project times the net present value of the expansion plan without geothermal) plus the cost of the drilling project).*This expression was compared to the net present value of the expansion plan if the drilling project were not undertaken. If the criterion was smaller than the net present value of the cost of generation expansion in the absence of the project then the project would result in a positive economic benefit from the reduction in the expected net present value of the cost of the generation expansion program required to meet forecasted growth in electricity demand. The rationale for comparing the costs of alternative expansion plans is that both deliver the same output and hence economic value to users. The benefits come from the difference in costs that accrue to the economy either through reduced power sector subsidies, or increased utility net receipts. Other benefits of introducing a geothermal plant, such as a reduction in greenhouse gas emissions, or an increase in energy security through increased fuel diversity, were not included. The use of the expected values of the successful and non-successful outcomes, and the project cost, as the sole inputs into the evaluation criterion, implies that risk neutrality was assumed. If risk aversion were important then the project, which includes a degree of uncertainty, would need to offset this by an increased margin of net expected cost reduction that would depend on the degree of risk aversion.

231. **Probabilities of well successes—independent probabilities.** Assuming a probability of success of 0.75 for the first well, the probability of a failure was 0.25. For the subsequent wells the probabilities of success and failure were kept constant. A range of values for well success ranging from 0.35 to 0.75 were used for sensitivity analysis.

232. **Probability of project success**. The probabilities of project success were built up from the well success values, and the criterion for project success. The probability of at least two successes out of four trials was the sum of the probabilities of two, three, and four successes. The first of these, for example, could occur in six different combinations (first and second, first and third, etc.) each of which was the product of two well success probabilities (0.75) and two well failure probabilities (0.25), giving an overall value of 0.21 for the probability of exactly two successes. Adding the values for three successes (0.42) and four successes (0.31) gave a probability of 0.95 of observing at least two successes if the probability of each well success were 0.75.

233. **Adjustment to 2008 values.** All the values used in the expansion plan to calculate net present values are in 2008 constant US$ discounted at a 10% rate to that year, while the costs of the exploratory drilling project were in current dollars (as of 2012).Two adjustments were used to produce values on a common metric. The estimated project cost of 31 million was adjusted to take account of the 4.65% US inflation that took place between 2008 and 2012. The net present value of this cost to be incurred in 2012 was seen from the standpoint of 2008, using a discount rate of 10%. This value was used for the comparison of the net present values of the costs of the alternative expansion plans.

234. **The treatment of drilling costs.** The expansion plan, allowing for geothermal, included the associated drilling costs for this volume of production based on well output of 3.35 MW per well indicating that about 15 production wells might be needed. The number of wells required and the associated drilling costs estimated did not include any offset from the successful production wells if identified in the exploration drilling project. These could range

between two and four wells and would help to reduce the total costs of the geothermal expansion plan. Without an adjustment for the expected number of successful wells the net present value of the costs of the with-project scenario was overstated, and hence the net economic value of the exploratory drilling project was understated.

C. Results

235. **Net present value of the costs of alternative expansion plans.** Table 1 provides net present values of the least cost expansion plans as calculated for a number of scenarios did not cover all the cases required in the current assessment. The latter were derived by linear interpolation.

Table 1: Net present values for alternative generation expansion plans

Scenario number	Imports assumed via interconnector	Geothermal plant	Net present value of cost of expansion plan (US$ million)
1	None	None	1084
2	Up to180 GWh	None	930
3	Up to 700 GWh	None	622
4	None	60 MW	906
5	Up to180 GWh	60 MW	821*
6	Up to 700 GWh	60 MW	575
7	None	50 MW	936*
8	Up to180 GWh	50 MW	839*
9	Up to 700 GWh	50 MW	583*

* indicates linear interpolation from PB data.

236. The scenarios that corresponded most closely to the ones required for the economic analysis of the drilling project were scenario 2 (no geothermal and 180 GWh imports) and scenario 8 (50 MW geothermal and 180 GWh imports).

237. **Probabilities of project success.** Table 2 provides the overall probabilities of project success calculated according to the principles explained above. If it assumed that at least two successes out of four trials would be sufficient to ensure private sector involvement in a geothermal power station then, with prior probabilities of individual well success as low as 0.35, the prior assessment of project success was nearly 50 percent. Even if a stricter criterion of at least three well successes is used, the prior probability of project success is over 50 percent for a well probability of 0.65.

Table 2: Probabilities of project success based of drilling four exploratory wells

Case number	Well probabilities (independent case)	Success criterion - number of successful wells	Probability of project success
1	0.75	At least 2	0.95
2	0.65	At least 2	0.87
3	0.55	At least 2	0.76
4	0.45	At least 2	0.61
5	0.35	At least 2	0.44
6	0.75	At least 3	0.73
7	0.65	At least 3	0.56
8	0.55	At least 3	0.39
9	0.45	At least 3	0.24
10	0.35	At least 3	0.12

238. **Expected net benefit of project.** Combining values from generation expansion scenarios 2 and 8 with the probability of project success and the cost of the drilling project,

yielded the with-project expected net present value of the costs of the expansion plan. This was compared to the net present value of the cost of the without-project expansion plan. The latter less the former was the measure of the expected economic benefit that would be obtained if the drilling project were undertaken. Table 3 provides the values of the economic value of the project under different assumptions. When the success criterion was taken as requiring at least two successful wells, then the project would make a substantial positive net benefit for the economy over a wide range of well probabilities. Only at a project probability as low as 0.18 would there be zero economic benefit, and this corresponded to a well probability of 0.2. When the criterion of project success was assumed to be three well successes out of four, net economic benefits were substantially smaller at the same well success probabilities, and the breakeven project success probability corresponded to a well success probability of 0.4.

Table 3: Expected net economic benefit of drilling exploration project

Case number	Well probability for independent trials	Success criterion – number of successful wells	Reduction in expected net present value of cost of expansion plan (US$ million)
1	0.75	At least 2	70
2	0.65	At least 2	63
3	0.55	At least 2	53
4	0.45	At least 2	39
5	0.35	At least 2	24
6	0.75	At least 3	50
7	0.65	At least 3	35
8	0.55	At least 3	19
9	0.45	At least 3	6
10	0.35	At least 3	-5

239. **Sensitivity analysis—oil prices and the discount rate.** Sensitivity analysis was included above for variations in the prior probability of a well success, and for the number of well successes that would be required for the private sector to be willing to finance a geothermal power station. Because the geothermal station was the only viable alternative to diesel and heavy fuel oil, a crucial assumption in the PB estimation of net present values was the path of the oil price. In fact oil prices are currently already at a level (around $100 a barrel) that the expansion plan assumed would be reached only by 2015. The higher the oil price, the greater the benefits would be from introducing geothermal. An oil price path 25% lower than their base case (only reaching $90 a barrel by 2020) was also considered and even in this case geothermal would enter the least cost expansion program, although insufficient information was available to determine whether the reduction in cost would be sufficient to pay for the costs of the exploratory drilling program.

240. **Sensitivity analysis—demand growth.** More extensive sensitivity analysis of the expansion plan was carried out for higher and lower demand growth scenarios. In the high case, reflecting stronger GDP growth, generation sent out was assumed to reach 1396 GWh by 2035 (1260 GWh in the base case), while in the low case generation sent out was assumed to reach 919 GWh by 2035. The same expansion plan scenarios were evaluated for these two cases and the net economic benefits of the project were calculated for the base case well probabilities (0.75) and project success criterion (at least two successful wells). The results shown in Table 4 indicate that under both high growth and low growth scenarios the net expected value of the project is positive for these parameter values, and that the results are not very different from the base case.

Table 4: Expected net economic benefit of drilling exploration project under high and low demand growth assumptions

Growth scenario	Geothermal station	Net present value of cost of expansion plan (US$ million)	Reduction in expected net present value of cost of expansion plan (US$ million)
High	None	984	76
High	50 MW	887*	
Base case	None	930	70
Base case	50 MW	839*	
Low	None	658	41
Low	50 MW	598*	

Source: Parsons Brinkerhoff 2009. * indicates linear interpolation from PB data.

241. **Sensitivity analysis—well productivity.** The criterion for well success chosen for analysis was the ability to produce at least 4 MW of electric power. The PB study used a lower value (3.35 MW) with a larger number of wells required to achieve a given total geothermal output. The actual production of a successful well could in fact be substantially higher than 4 MW, and this would affect the costs of the expansion plan including generation from geothermal. The greater the well productivity the fewer the number of wells that would need to be drilled, and hence the net present value of the cost of the with-geothermal expansion plan would be reduced leading to a larger net economic benefit for the drilling project.

Annex 8: Financial Analysis

Introduction

242. **The proposed World Bank supported project is a US$ 31.2 million investment of multilateral donor funds to finance the exploration phase of a geothermal power generation program.** The financing of the project combines grants totaling US$11.09 million, soft loans amounting to US$13.00 million, a US$6.04 million conditional grant from the GEF as detailed later in this Annex, and US$ 1.1 million from ESMAP with conditions similar to those of the GEF. From a financial analysis perspective, the purpose of this project is to finance the riskiest part of the geothermal power generation program – exploration – with concessionary funds in order to ascertain the commercial viability of the resource of the Lake Assal area and provide incentives for an independent power producer (IPP) to develop a utility scale geothermal power plant that could markedly reduce the cost of the electricity produced in Djibouti. The plant capacity of 50 MW is envisaged in the main case, although possible smaller sizes have also been considered in the sensitivity cases.

243. **The scope of the financial analysis includes both the exploration phase and the full scale development phases to assess the conditions under which the geothermal resource is commercially viable**. While the full scale field development (including production and reinjection well drilling) and the power plant construction and commissioning phases of the geothermal project are chronologically beyond the scope of the immediate World Bank supported project, they are an integral part of this analysis. The assumptions about the costs and finances required during these phases are key to assessing the value of the exploratory phase investments and the tariff that is required for cost recovery by an IPP. The analysis thus focuses in particular on the appropriate off-take price/ tariff level for the power produced by the prospective 50MW plant to be built by an IPP entering the project as an equity investor.

Methodology of the financial analysis

244. **The financial analysis of the prospective 50 MW geothermal project is based on a customized cash flow model built in Excel.** The model calculates the internal rate of return (IRR) on the project and its net present value (NPV), as well as the rate of return on equity investment and its respective NPV. The dollar amounts are given in real terms (constant dollars of 2012).[15]The NPV on the project and its respective IRR take the perspective of all investors, including the suppliers of debt (lenders). The cash flow used in this part of the calculation is based on the concept known in project finance as free cash flow, sometimes defined more specifically as the free cash flow to the firm (FCFF). In this appraisal, the "firm" is the IPP project, so the cash flow is denoted as FCFP. The formula to determine the project NPV is:

$$\mathrm{NPV}_{\mathrm{proj}} = \sum_{t=0}^{n} \frac{\mathrm{FCFP}_t}{(1+\mathrm{WACC})^t}$$

- where:

[15]To convert the results into nominal terms, escalation factors would need to be introduced for all cost items as well as for the tariff.

- $FCFP_t$ is the free cash flow to the project in year t in the project life of n years; and the
- WACC is the weighted average cost of capital. WACC is found by the formula WACC = interest rate of the debt x (1 – corporate income tax rate) x proportion of debt in the project capital + (required rate of return on equity x proportion of equity in the project capital). When grants are included, they reduce the amount of capital to be covered by debt and equity.

245. The NPV of the cash flow to equity and the respective rate of return take the perspective of equity investors only, which is the perspective of the IPP in this case. The cash flow used in this calculation is based on the concept of free cash flow to equity (FCFE). The formula to determine the equity NPV is:

$$\mathrm{NPV}_{\mathrm{equity}} = \sum_{t=0}^{n} \frac{\mathrm{FCFE}_t}{(1+R_e)^t}$$

- where:

- $FCFE_t$ is the free cash flow to equity in year t in the project life of n years; and
- Re is the required return on equity, sometimes also called the hurdle rate of return on equity. Re is a measure of the cost of equity capital. Discounting by Re (rather than by WACC) is consistent with the fact that the annual interest and principal payments for the debt are already made and the entire remaining cash flow belongs to the equity investors. The latter generally require a higher return from this cash flow to compensate for the higher risk associated with being the last in line to receive the payoff.

<u>Assumptions of the financial analysis</u>

Exploratory drilling implementation time frame:

246. The exploratory drilling project and the tendering of the steam field and geothermal power development is implemented over the course of three years, with the bulk of the costs incurred in Year 2 (2014) as shown in the table below. The exploratory drillings would be mostly completed by the end of Year 2, and the preparation of the IPP tender can start during Year 3 provided that the drilling results to-date are positive. By the end of Year 3, all four production type exploratory wells are drilled and the necessary information about the resource potential is obtained. If the positive results are confirmed, the Government proceeds with the selection of the IPP to complete the geothermal field development and build the proposed plant.

Project investments under the current project:

Investments M US$	**2013 *(Year 1)***	**2014 *(Year 2)***	**2015 *(Year 3)***
Preparation	US$2.94 M	-	-
Exploratory Drilling	-	US$25.83 M	-
Feasibility Studies and IPP tender	-	-	US$2.46 M
Total Exploration Costs 2013-2015		**US$31.2 M**	

Financing package of the geothermal exploration:

247. Project funds are assumed to include US$11.09 million in grants from AfDB, EU-Africa ITF/SEFA and AFD, co-financed by US$ 0.5 million from the Government of Djibouti.[16] IDA and OFID would provide concessional debt in the amount of US$ 6.0 million and US$ 7.0 million, respectively[17,18]. Finally, conditional grants in the amount of US$6.04 million and US$ 1.1 million are provided by the GEF and ESMAP, respectively. It is further assumed that the OFID and IDA debt liability as well as the contingent liabilities created by the GEF and ESMAP amounts may have to be absorbed by the incoming IPP. In the case of the GEF and ESMAP funds, the repayment of the grant is contingent on the success of the exploration phase: if all the wells drilled are successful, the equivalent of the GEF and ESMAP contribution has to be paid back by the IPP to the Government of Djibouti for reinvestment in renewable energy projects (condition of the PPA)[19]. In the event the resource is not commercially viable, neither the GEF nor ESMAP equivalent contributions will have to be repaid.

Capital expenditures for geothermal field development:

248. The total capital expenditures for the 50 MW geothermal power generation program, including those of the first three years of exploration, are about US$181 million, or $3.62 million per MW installed. This estimate allows for the costs of drilling about 16-20 wells, building the power plant and associated infrastructure including a steam gathering system, a cooling system, a transformer substation at the plant site, and the cost of connection to the power grid[20]. The IPP investment program is expected to take four years. This is believed to be a realistic time frame for completing the envisaged program of capital investments. In fact, some reduction in the time required is possible as plant construction may commence before all wells are drilled. Nevertheless, the possibility of delays in completing the drilling program has been analyzed in the sensitivity cases, while the cost profile for the main case is shown in the following table:

Investment cost profile assumption for the IPP project (base case):

Investments	**2016** *(Year 4)*	**2017** *(Year 5)*	**2018** *(Year 6)*	**2019** *(Year 7)*
Complete Drilling	US$31.6 M	US$31.6 M	-	-

[16] The amount of US$11.09 million is inclusive of the Government's proposed contribution of US$0.5 million, even though the Government's contribution will be in kind.

[17] The terms of the IDA Credits are a maturity of 25 years, a grace period of 5 years, a 1.25 percent interest charge (plus 0.75 percent service charge), and principal repayable at 3.3 percent per annum for years 6-15 and 6.7 percent per annum for years 16-25.

[18] The terms of the OFID soft loan are: interest rate of 2.75% and a 15-year repayment term following a 5-year grace period.

[19] The financial analysis assumes the following terms of the repayment of the equivalent of the GEF and ESMAP grants: a maturity of 25 years, a grace period of 5 years, a 1.25 percent interest charge (plus 0.75 percent service charge), and principal repayable at 3.3 percent per annum for years 6-15 and 6.7 percent per annum for years 16-25.

[20] This refers to the connection to a power line that is yet to be built by the Government of Djibouti. The line (about 50 km long) would connect the proposed geothermal plant site to the now built and operating interconnector transmission line to Ethiopia. The estimated cost of US$181 million does not include the cost of building the 50-km power line as it would not be part of the costs borne by the IPP that would affect the tariff.

Power Plant Construction, Connections and Commissioning (CCC)	-	-	US$43.4 M	US$43.4 M
Total IPP Project Costs			**US$150.0 M**	

Capital structure of the IPP project:

249. The base case for the capital structure of the IPP investment project (net of working capital) assumes a 70:30 debt-equity ratio[21]. Since this ratio may ultimately be affected by the availability of debt on suitable terms and by the equity investor preferences for using leverage, other possible debt-equity ratios are considered in the sensitivity cases. The interest on the debt portion is assumed to be 6% per annum in real terms, and the term of the loan in the main case is 15 years. The repayment of principal is deferred until the start of project operation, and interest during construction is capitalized.

Geothermal plant capacity factor, operation and maintenance costs:

250. Once built and commissioned, the 50 MW geothermal power plant is assumed to operate with a capacity factor of 90%, thus producing 394.2GWh annually. The costs of operation and maintenance (in US$ million per year) are assumed as follows:

<u>Operation and maintenance cost estimates for the IPP project</u>

Operation and Maintenance Costs	**Costs**
Steam Field O&M including periodic drilling of make-up wells	US$5.8 M
Power Plant O&M excluding fixed labor costs	US$1.9 M
Fixed labor costs	US$1.5 M
Total O&M costs	**US$9.2 M**

Depreciation of infrastructure, initial working capital and taxes:

251. In the main case, the geothermal plant and associated infrastructure are depreciated over 20 years of operation using the straight line method. Longer periods of operation and longer depreciation periods have been tested in sensitivity cases. The extra years of revenue generation improve the financial results, while longer depreciation periods make them slightly less attractive when the foregone tax benefits of accelerated depreciation are considered. The positive net impact is small since the revenues generated during those extra years are heavily discounted[22]. Overall, the period of 20 years is retained for the main case, to stay on the conservative side of the analysis.

252. The initial working capital requirement is estimated at $5.4 million. This figure includes a 45-day allowance for accounts receivable net of a 30-day allowance for accounts

[21] The initial working capital requirement of the IPP project is assumed to be entirely financed by IPP equity.

[22] In the main case, twenty years of plant operation following seven years to develop the resource and build the plant and associated infrastructure brings the total time horizon for this project analysis to 27 years, from 2012 (Year 0) to 2039. The extension of the plant operation period beyond this horizon, while technically plausible, has relatively little impact on the financial modeling results since the revenues coming after 2039 are heavily discounted.

payable, an inventory of spare parts estimated at 1% of the total power plant costs, and a 30-day allowance for O&M costs[23].

253. A tax holiday is assumed to be granted by the Government of Djibouti for the first 10 years of project operation, with a corporate income tax of 25% applying in subsequent years.

IPP Required Return on Equity:

254. **The rate of return on equity (Re) required by the IPP retained for the main scenario is 20%**, assuming positive results from exploratory drillings. This is a 5% reduction due to an equivalent reduction in the risk premium relative to the case of a hypothetical equity investor entering the project today, without waiting for grant support for exploratory drillings. Such an equity investor would require a return of at least 25% according to recent research in the industry[24]. In fact, it cannot be excluded that a similar rate of return might still be required by equity investors in Djibouti even with successful completion of exploratory drillings. This is possible because the project will still face substantial risks including the geological risk in bringing the geothermal field to the target capacity of 50 MW, as well as commercial and regulatory risks in all phases. On the other hand, the cost of equity capital is subject to market forces too, and the possibility of its downward movement should not be ruled out. Several sets of sensitivity cases with Re = 15%, 20% (main case), and 25%, have thus been explored for most of the key dependent variables in this financial analysis.

Results of the financial analysis

255. **The results of the financial analysis show that the power generation program with concessionary financing of the exploration phase could yield an electricity tariff ranging from US$8.75 cents/kWh to US$9.10 cents/kWh.** In the main scenario, the geothermal resource is confirmed and an IPP tender is completed by the end of 2015 to start the geothermal field development in 2016, after the end of the exploratory phase. Prospective IPPs in this scenario require a 20% return on equity and find the project attractive if the Power Purchase Agreement (PPA) with the Government of Djibouti sets a flat tariff at about US$8.75 cents/kWh or higher. Indeed:

- In a conservative base-case scenario, the breakeven tariff for the selected IPP is US$9.1 cents/kWh. In this scenario, all four exploratory wells are assumed to be successful and the equivalent of the GEF and ESMAP contributions has to be repaid by the selected IPP to the GoDj. Furthermore, the scenario also assumes that both the loans by OFID and IDA have to be repaid by the selected IPP.
- In a less conservative base-case scenario, the breakeven tariff for the selected IPP is US$8.75 cents/kWh. This scenario assumes that the IPP does not have to pay back any of the concessionary financing of the exploration phase.

256. In the subsequent sections including sensitivity cases, the relatively more conservative scenario with the breakeven tariff at US$9.10 cents/kWh is retained as the reference case. The

[23] The return of working capital at completion of the geothermal plant operations has not been explicitly modeled. The inclusion of the heavily discounted terminal year cash flows, such as working capital recovery and salvage value of the equipment, would improve the estimated financial results to a very small extent.

[24]Bloomberg New Energy Finance. Geothermal Financing Strategies: Pricing the Risk. Research Note. August 18, 2011.

following table summarizes the main results of the analysis corresponding to different levels of electricity tariffs.

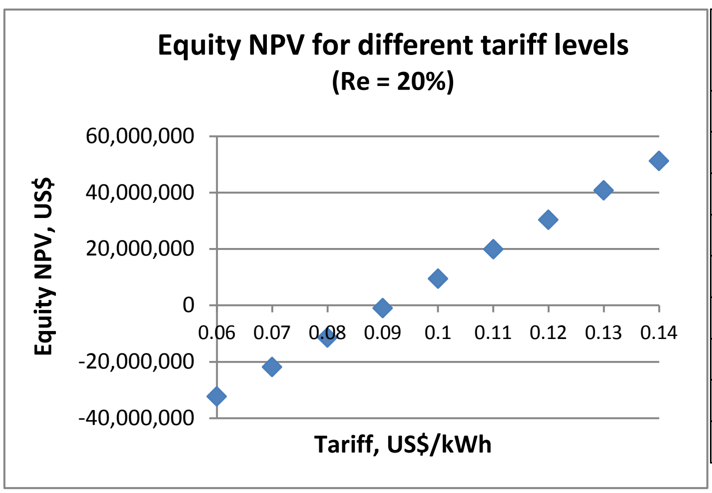
Internal Rates of Return and Net Present Values resulting from different electricity tariff levels

						IPP Break Even
Tariff charged by IPP, US$ cents/kWh	**8.00**	**9.00**	**10.00**	**11.00**	**12.00**	**9.10**
Project IRR (based on FCFP)	7.6%	9.3%	10.9%	12.3%	13.7%	
Project NPV, US$ (based on FCFP discounted by WACC)	(18,798,294)	(2,220,989)	14,233,117	30,565,859	46,779,040	
Return on equity (based on FCFE)	14.8%	19.6%	24.0%	28.0%	31.7%	20.0%
Equity NPV, US$ (based on FCFE) at Re = 20%	(11,458,678)	(1,017,362)	9,423,953	19,865,269	30,306,585	0

Note: FCFP = Free Cash Flow to the Project; FCFE = Free Cash Flow to Equity.

257. It is worth noting that the NPV results for the project as a whole are based on project cash flows discounted at a weighted average cost of capital (WACC), while the cash flows for the equity investor are discounted by the required return on equity Re. At the same time, the calculation for the project as a whole assumes that the relatively expensive equity capital is not involved until completion of the exploratory drillings. In this way, the perspective of the current project supported by the Bank is clearly distinguished from that of the IPP equity investor entering several years later.

258. Equity NPV as a function of tariff level is graphed below:



Tariff, US$/kWh	Equity NPV, US$ (based on FCFE)
0.06	-32,341,310
0.07	-21,899,994
0.08	-11,458,678
0.09	-1,017,362
0.10	9,423,953
0.11	19,865,269
0.12	30,306,585
0.13	40,747,901
0.14	51,189,217

Benchmarking of the results of the financial analysis

259. **The financial analysis shows that, without concessionary financing of exploration, the tariff of geothermal electricity would be 4-5 cents higher than the US$9.1 cents/kWh foreseen for the project under assessment.** Indeed, the IFC previously attempted to undertake a geothermal power generation program in Djibouti with the Icelandic firm REI, but the project did not go through. The IFC/REI financial model assumed that construction (including test drillings) would take 5 years instead of the 7 years envisaged by the project

under assessment. At the same time, it assumed that the exploratory drilling phase would be financed on a commercial basis, with a capital structure of about 60% equity at a required return of 25% per annum and 40% debt with an interest rate of at least 9% per annum[25.] The result of the IFC/REI financial model was a tariff of US$13 cents/kWh[26], a level that has been deemed excessive by the Government of Djibouti.

260. **The concessionary financing of the exploration phase thus markedly reduces the required tariff for geothermal electricity generation.** The lower tariff reached through concessionary financing of exploration results from a combination of three factors:

(i) The reduction of the investment cost of the IPP project by the amount of exploration costs including the drilling of initial four wells;

(ii) The removal of uncertainty about the resource and the resulting reduction of the required rate of return; and

(iii) The reduction in the length of the lead time between the first capital investments and the first revenues from selling electricity.

<u>Sensitivity testing of the results of the financial analysis</u>

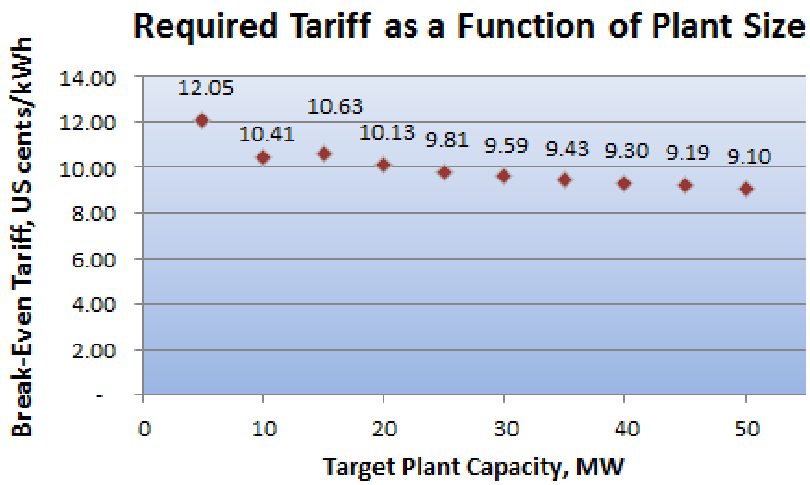
261. Sensitivity cases have been developed to test a number of key variables influencing financial results, including: (a) the size of the proposed geothermal power plant; (b) the length of the power plant's operational life and the depreciation period; (c) delayed start of revenue generation due to a longer-than-expected production drilling phase; (d) investment and O&M cost overruns; and (e) capital structure of the project and the cost of capital from various sources.

262. The optimal plant size from the power system perspective is discussed in Annexes 7 and 9, both pointing to 50 MW as being an appropriate choice for the main case. The financial analysis confirms that, in the absence of geological, environmental, or other non-economic constraints, a 50 MW plant requires a lower tariff for the IPP than any smaller plant size due to economies of scale. Plant sizes that add only a few extra MW to the production capacity already available from the four exploratory wells are at a particular disadvantage. The specific factors driving up the tariff for a smaller plant include the need to remobilize (and demobilize) the drilling rig equipment. This one-off cost is largely fixed, and it is more efficient to spread it over a larger number of units of output (gigawatt-hours of electricity) by increasing the plant size. The figure below demonstrates this point graphically[27].

[25] The debt interest rate would have been even higher if the contribution of a 15% subordinate loan is considered in the IFC/REI model.

[26] When applying similar assumptions about the capital structure and the timing of the equity investor's entry, the model presented in this annex yields a tariff of US$13.84 cents/kWh, similar to the result of the IFC/REI model. The 0.84 cent's difference is primarily explained by the shorter lead time to project completion assumed in the IFC/REI model.

[27] The lowest tariff for the smaller plant sizes corresponds to the number of megawatts available from the four wells drilled under the exploration project, in which case no additional production drilling is required. The tariff for a 12 MW plant (e.g., assuming that three wells produce 4 MW each, and one well is dry, possibly suitable for reinjection only) is US$ 10.12 cent/kWh, still making 12 MW an inferior choice relative to larger plant sizes. It should be noted that in the case of a dry well the GEF and ESMAP contingent loans may be forgiven, in which case the entire curve shown in the graph will shift down by some fraction of a cent.



263. The impact of extending the plant operation period from 20 years to 30 years can be assessed by comparing the table immediately below with the similar table presented earlier. As can be seen, while the financial results improve noticeably from the overall project perspective (i.e., from the perspective of all suppliers of capital including lenders), the results from the IPP equity perspective and the impact on the tariff change relatively little. The break-even tariff for the IPP changes from 9.1 to 9.0 US cents/kWh[28].

						IPP Break Even
Tariff charged by IPP, US$ cents/kWh	**8.00**	**9.00**	**10.00**	**11.00**	**12.00**	**9.00**
Project IRR (based on FCFP)	8.6%	10.2%	11.6%	13.0%	14.3%	
Project NPV, US$ (based on FCFP discounted by WACC)	(10,471,758)	8,182,610	26,836,979	45,491,347	64,145,715	
Return on equity (based on FCFE)	15.6%	20.0%	24.3%	28.4%	32.2%	20.0%
Equity NPV, US$ (based on FCFE) at Re = 20%	(10,906,186)	3,482	10,913,150	21,822,818	32,732,487	0

264. To test the degree of a negative impact from a longer than expected project development period, calculations have also been run for scenarios where the IPP takes longer than expected to complete the required drillings for a 50 MW plant. The 1-year delay scenario revealed that the required tariff would have to increase from US$ 9.10 cents/kWh in the reference case to US$ 9.26 cents/kWh. A 2-year delay brings the required tariff to 9.45 cents/kWh. Thus, the impact of delay by one or two years is relatively minor. This is in part because the investment cost profile of the IPP project has an increase in the power plant construction years relative to the drilling years. Moving the cost of financing those larger

[28] The unequal impact of extending the project horizon on the results from the project versus equity perspective is mostly due to heavier discounting of the additional years' cash flows in the case of the equity perspective (FCFE is discounted by Re that is higher than WACC).

investments to later years partially compensates for the delayed revenues. A delay by more than 2 years was considered unlikely and not modeled[29].

265. *Cost overruns*. The reference case investment cost estimates in this analysis conform closely with the previous study by IFC/REI. They are on the high side of estimates from some other recognized studies (Sanyal 2004[30], ESMAP 2012a)[31] and come close to the medium estimate from the recently published Geothermal Handbook (ESMAP 2012b) for a 50 MW geothermal power project[32]. However, costs actually incurred may substantially deviate from targets as geothermal projects face a number of risks – most notably, those related to resource productivity and extraction conditions. Sensitivity analysis of investment cost overruns is thus an important part of this appraisal and, as expected, it shows that financial results are quite sensitive to investment cost overruns. Should a cost overrun occur, the expected NPV for the equity investment may turn negative, calling for an upward revision of the tariff. For example, the table below indicates that an investment cost overrun by 40% would call for a tariff between 11 and 12 cents / kWh to achieve a positive NPV.

Equity NPV (US$) as a function of investment cost overrun and levelized tariff

Investment cost overrun ratio →	**1.0**	**1.1**	**1.2**	**1.3**	**1.4**	**1.5**
Tariff, US$ cent/kWh ↓						
8.00	(11,458,678)	(18,109,131)	(24,759,584)	(31,410,037)	(38,060,489)	(44,710,942)
9.00	(1,017,362)	(7,667,815)	(14,318,268)	(20,968,721)	(27,619,174)	(34,269,626)
9.10	0	(6,650,453)	(13,300,906)	(19,951,358)	(26,601,811)	(33,252,264)
10.00	9,423,953	2,773,501	(3,876,952)	(10,527,405)	(17,177,858)	(23,828,311)
11.00	19,865,269	13,214,816	6,564,364	(86,089)	(6,736,542)	(13,386,995)
12.00	30,306,585	23,656,132	17,005,679	10,355,227	3,704,774	(2,945,679)

266. To approach the same issue from a different perspective, the impact of cost overruns has also been assessed with respect to their impact on the IPP's expected return on equity (ROE) while holding the tariff constant[33]. For better appreciation of the role of various contributing factors, the costs are divided into three categories: (a) investment costs during the drilling phase, (b) investment costs during the plant construction connection and

[29] The reference scenario of a combined 4-year timeline for drilling and power plant construction already includes some degree of conservatism since time overlap is likely between the two major phases - i.e., plant construction can start before all wells are drilled.

[30] Cost of Geothermal Power and Factors that Affect It. Subir K. Sanyal. Proceedings, Twenty-Ninth Workshop on Geothermal Reservoir Engineering Stanford University, Stanford, California, January 26-28, 2004.

[31]Model for Electricity Technology Assessment (META).Completed in July 2012 by Chubu Electric Power Company & Economic Consulting Associates Ltd under study financed by World Bank/ESMAP.

[32] Geothermal Handbook: Planning and Financing Power Generation. ESMAP Technical Report 002/12.

[33] Expected rate of return on equity (expected ROE) is distinct from the required rate of return on equity (Re). The former is an output of a model that measures the expected performance of the project based on the parameters that determine the free cash flow to equity. ROE is basically the IRR for this cash flow. Re, on the other hand, is the discount rate representing the cost of equity capital. When expected ROE is equal to or greater than Re, the project is considered attractive for the equity investor (i.e., it has a positive NPV from the equity investor's perspective).

commissioning phase, and (c) O&M costs. The results are illustrated graphically at the end of this Annex. In summary, the simulations show that a 50% investment cost overrun during the drilling phase reduces the expected ROE from 20% to about 14%, while a 40% saving on drilling costs increases it to 26.6%. Cost overrun during the power plant construction and connection phase has a slightly greater impact on the ROE. The sensitivity testing of O&M cost shows that a 50% overrun on O&M reduces the expected ROE from 20% to about 14%, while a 40% cost saving increases it to about 24%.

267. Additional insights on the impact of possible cost overruns are found by considering them in combination with various levels of the cost of capital: the required rate of return on equity in particular. The upside potential for Re is a market risk that the buyer of privately financed geothermal power has to face. If the market were to price equity higher than the base-case 20%, then the tariff would need to be higher for the IPP to receive an adequate pay-off on the investment. If the capital expenditures for the project were to exceed the target at the same time, the tariff would need to be even higher. The table below shows that, in extreme cases, an unfavorable combination of the two factors can lead to required tariff levels approaching or even exceeding 13 US cent/kWh, a level previously deemed excessive as noted earlier. The reference value of 9.1 US cent/kWh, however, should be regarded as the most likely one assuming Re upon completion of the exploratory drillings is at 20% as envisaged. Finally, cost saving (under run) scenarios, under which the required tariff levels would be below those shown in the table, are also possible.

<u>IPP break-even tariff (US cent/kWh) as a function of investment cost overrun and cost of equity (Re)</u>

Investment cost overrun ratio →	**1.0**	**1.1**	**1.2**	**1.3**	**1.4**	**1.5**
Re ↓						
25%	10.2	11.0	11.7	12.5	13.2	14.0
20%	9.1	9.7	10.4	11.0	11.6	12.3
15%	8.0	8.6	9.1	9.7	10.2	10.7

268. Sensitivity scenarios have also been constructed for the assumed share of equity in the IPP project's capital structure, which is 70% debt and 30% equity in the main case. The replacement of debt capital with equity can happen for various reasons, including market environment and the preferences of the developer and its shareholders. The capital structure may also change throughout the project. For example, the IPP may initially not be able to mobilize debt on suitable terms. In a 4-year investment program of the IPP, financing the first year with 100% equity and the second year with 40% equity would bring the average equity ratio to 0.5, i.e., 50% debt. As shown in the table below, the corresponding tariff level is then 10.4 US cent/kWh, assuming Re at 20%. In extreme cases of complete (or near complete) replacement of debt with equity, the impact on the required tariff can be severe.

<u>IPP break-even tariff (US cent/kWh) as a function of equity ratio and cost of equity (Re)</u>

Average equity ratio →	**0.3**	**0.4**	**0.5**	**0.6**	**…**	**1.0**
Re ↓						
25%	10.2	11.2	12.2	13.1		16.9
20%	9.1	9.7	10.4	11.0		13.5
15%	8.0	8.4	8.8	9.2		10.6

<u>Note</u>: The equity ratio of 0.3 corresponds to a debt-to-equity ratio of 70:30. The cost of debt is assumed at 6% real interest rate.

Sensitivity of the electricity tariff to the Required Return on Equity and the IPP debt liability:

269. As previously shown, the level of tariff required by the IPP is sensitive to the assumed cost of equity capital, Re. In addition, the different financing options related to the OFID and IDA Credits as well as the GEF and ESMAP conditional funding also have an impact on the tariff required for the IPP to break even. Specifically, the results on the tariff depend on whether or not the IPP is required to assume the debt and contingent debt liabilities incurred by the Government of Djibouti during the exploratory drilling phase. The following table shows the impact of these key assumptions on the electricity tariff.

<u>IPP break-even tariff (US cent/kWh) depending on the Re and the need for IPP to take over prior debt and contingent debt obligations</u>

Concessionary funding of exploration phase	IPP Re	IPP repays IDA	IPP repays OFID	IPP repays GEF	IPP repays ESMAP	Tariff – US cents/ kWh
No	25%	NA	NA	NA	NA	13.84
Yes	25%	Yes	Yes	Yes	Yes	10.25
Yes	25%	No	No	No	No	9.90
Yes	**20%**	**Yes**	**Yes**	**Yes**	**Yes**	**9.10**
Yes	20%	No	No	No	No	8.75
Yes	15%	Yes	Yes	Yes	Yes	8.05
Yes	15%	No	No	No	No	7.70

<u>Monte Carlo Simulation</u>

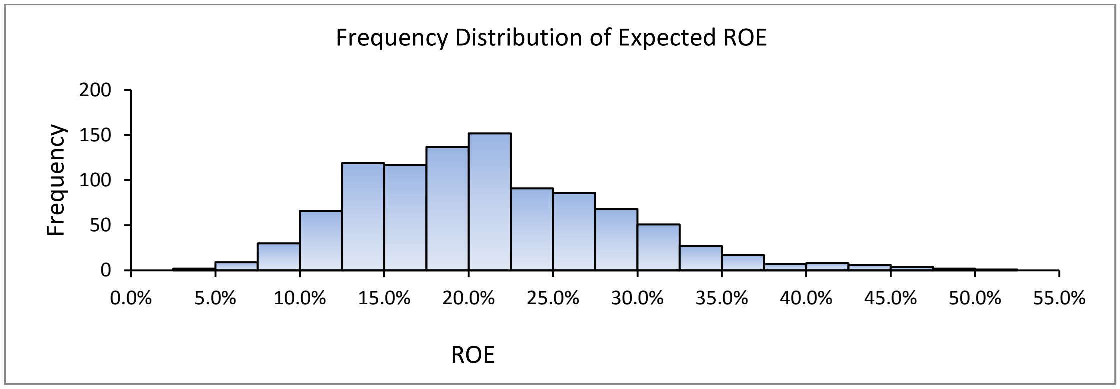
270. Monte Carlo simulations were conducted to test the collective impact on the financial results from random variation in the project costs. Three independent variables were included in the simulations: (a) capital costs during the drilling phase, (b) capital costs during the power plant construction phase, and (c) O&M costs. For each of these three variables, a normal distribution function and a standard deviation of 30% of the mean were assumed. The tariff was set at 9.1 cents/kWh as assumed in the main case. The dependent variables in the analysis were the expected ROE and the Equity NPV.

271. For the ROE, the resulting mean estimate is very close to the 20% target, but other levels of ROE are possible with varying degrees of probability. In the simulation depicted below, the ROE can go as high as 45% or more, or can fall to levels as low as 5% or less. However, the probability of such extreme levels of ROE is quite low. In 1000 trials underlying the distribution depicted below, there is only about a 5% chance that the ROE would be less than 10.4%. This corresponds to 95% confidence that at least this level of return on equity will be achieved by the IPP at this tariff level, and substantially higher levels of return are likely.

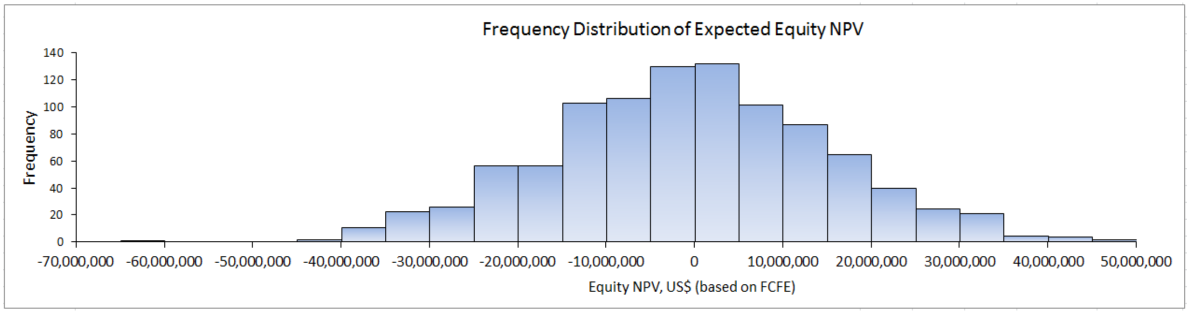
272. Similarly, Monte Carlo simulations for the equity NPV indicate that this value can go as high as US$45 million or more, or can fall to levels as low as -US$40million or less. The probability of the equity investment losing US$30 million from its initial value is calculated to be about 3.7%. On the high side, there is a similar probability of gaining a comparable

amount of positive NPV[34]. It should be kept in mind that any amount of NPV above zero is essentially a surplus return over and above the required rate of return on equity. The equity investors' risk tolerance and investment strategy will ultimately guide their decision to invest in the project, while the Government can help establish the contractual framework to ensure that the investor's risks are adequately rewarded.

Monte Carlo Simulation for ROE



Monte Carlo Simulation for Equity NPV



Note: For the input parameters (costs), normal distribution and a standard deviation of 30% of the mean are assumed.

273. The Monte Carlo simulation for Equity NPV allows making additional inferences about the probability of higher than expected tariff levels due to cost overruns[35]. For example, the probability of having to set the tariff atUS$12 cents/kWh due to cost overruns might be less than 3.5%[36].Higher tariffs are even much less likely to be required – e.g., the probability of requiring a tariff of US$13 cents/kWh or more would be a fraction of a percent.

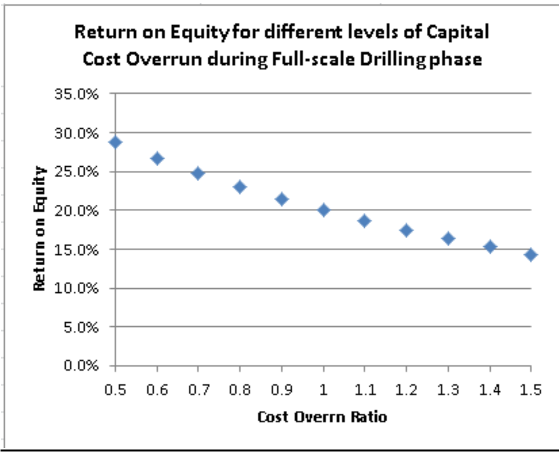
[34] According to a random run of 1000 trials by the Monte Carlo simulation model, the standard deviation of the equity NPV from its expected value is $15.9 million, with the mean value being reasonably close to zero.

[35]The structure of the financial model utilized in this analysis did not allow directly running Monte Carlo simulations for the required tariff as the dependent variable.

[36]The probability of having to set the tariff at US$12 cents/kWh should be close to the probability of a negative equity NPV of US$30.3 million based on the respective value in the first column of the earlier table in the *Cost Overruns* section. The probability of that level of loss on the NPV due to cost overruns is less than 3.45% according to the Monte Carlo simulation for the NPV.

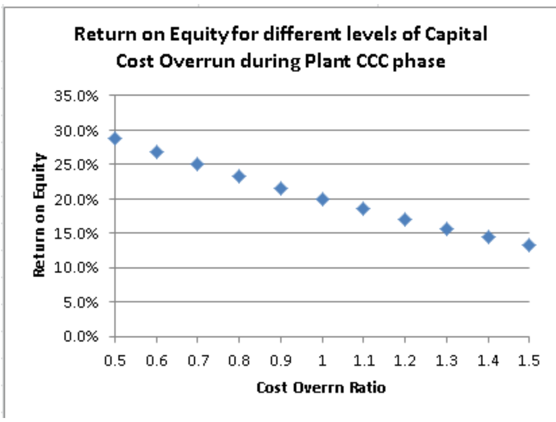
274. Finally, as mentioned previously, an additional set of graphs was produced showing how cost overruns (or under-runs) could affect the ROE if the tariff is held constant at the expected break-even value of US$ 9.1 cents/kWh:

<u>Impact of drilling cost overrun on expected ROE (at Tariff = 9.1 US$ cent/kWh)</u>



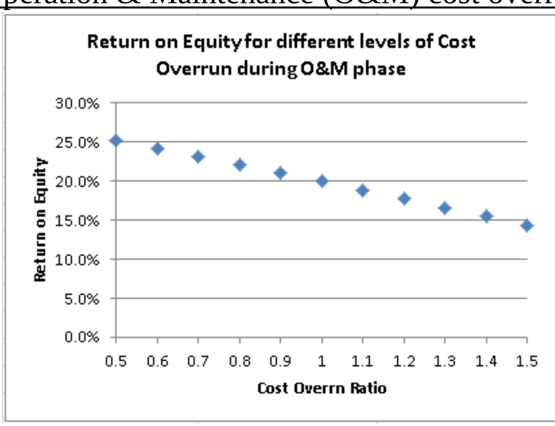
Cost overrun ratio during full scale drilling	ROE (based on FCFE)
0.5	28.8%
0.6	26.6%
0.7	24.7%
0.8	23.0%
0.9	21.4%
1.0	20.0%
1.1	18.7%
1.2	17.5%
1.3	16.4%
1.4	15.3%
1.5	14.3%

<u>Impact of Construction, Connections and Commissioning (CCC) cost overrun on expected ROE</u>



Cost overrun ratio during Plant CCC	ROE (based on FCFE)
0.5	28.9%
0.6	26.9%
0.7	25.0%
0.8	23.3%
0.9	21.6%
1.0	20.0%
1.1	18.5%
1.2	17.1%
1.3	15.8%
1.4	14.5%
1.5	13.3%

<u>Impact of Operation & Maintenance (O&M) cost overrun on expected ROE</u>



Cost overrun ratio during O&M	ROE (based on FCFE)
0.5	25.2%
0.6	24.2%
0.7	23.2%
0.8	22.1%
0.9	21.1%
1.0	20.0%
1.1	18.9%
1.2	17.8%
1.3	16.6%
1.4	15.5%
1.5	14.3%

Annex 9: Optimal Size of the Geothermal Plant and Associated System Generation Cost Savings

275. This analysis has been prepared to provide an understanding of relative generation costs when comparing oil fired reciprocating engine technology with geothermal power generation. System generation cost savings are calculated for Djibouti based on the project design outlined in this Project Appraisal Document. The advantages of the transmission interconnection between Ethiopia and Djibouti are considered.

Djibouti's Existing Reciprocating Engine Generator Plants

276. Djibouti's domestic power generation is currently supplied by reciprocating engine generators that burn either heavy fuel oil or light distillate fuel oil. In year 2009, Djibouti's electrical demand ranged from a 20 MW (15 MW in para 8) minimum to a 70 MW maximum hourly demand that is dependent on the time of day and day of the season. Until 2011, Djibouti's power grid had not been interconnected with any other country power grid.

277. Relatively speaking, Djibouti's electric demand is small. For purposes of comparison, a large factory in a developed western country could experience electrical demands exceeding 35 MWs or half of Djibouti's peak demand. Given Djibouti's electric load profile, connected generation equipment must have the capability to increase and decrease output on an instantaneous basis to meet large load swings. Reciprocating engine generator technology is best suited for this type of service.

278. Engine generators of the vintage owned by Djibouti have a heat rate in the range of 11,000 BTU/kWh[37] which includes consideration for parasitic loads. A gallon of fuel oil of the type burned in this equipment has a heat content of approximately 135,000 BTU/Gal (Low Heating Value). Using these figures, the engines can generate approximately 12.27 kWh per gallon of fuel burned. When a gallon of fuel oil costs US$2.80, the resulting fuel cost to generate is US$0.23/kWh. With an additional US$0.02/kWh considered for direct engine generator operation and maintenance (O&M), the generation cost becomes US$0.25/kWh[38].

279. Using actual 2009 electric data and escalating it at 5.1% per year, EDD would need to generate 492,443,000 kWhs of electricity in 2016. At US$0.25/kWh, the year 2016 system generation cost would be US$123,110,750.

Comparison of Engine Generator Versus Geothermal Generation Cost

280. For the purposes of this analysis, we are assuming that the capital cost associated with the existing engine generator equipment has been fully amortized and therefore does not enter into the US$0.25/kWh cost of generation (consists of fuel cost and direct O&M). It must be understood that any refurbishment of the existing engine generator plants or construction of a new engine generator plant will increase the true cost of generation by amounts equal to servicing and retiring capital debt over the life of the plant[39]. To compare the stated engine generation cost of US$0.25/kWh (cost of fuel plus O&M without consideration of capital

[37]It is anticipated that new technology engine generators would have improved efficiencies of approximately 15% when compared to Djibouti's existing generators.

[38]This cost equation does not consider utility G&A, transmission and distribution costs.

[39]It is also anticipated that there would be improvements in engine efficiency and a reduction in O&M costs after refurbishment or new construction.

cost) to an equivalent geothermal generation cost, the capital cost of the geothermal plant would need to be set aside resulting in a generation cost of approximately US$0.03/kWh (typical geothermal O&M cost).

System Generation Cost Savings with the Geothermal Power Generation Project

281. The Geothermal Power Generation Project is based on using public funds (grants and soft loans) to perform the exploratory drilling necessary to validate the geothermal resource. This validation would be performed through a predefined testing protocol after which an international tender offer would be used to attract Independent Power Producers (IPP) that would engineer, procure and construct a geothermal power plant in the form of a Public Private Partnership (PPP). The PPP would recoup its capital investment and associated profit under a predefined tariff structure that we anticipate will have a 90% take or pay requirement.

282. In the last two years, an IPP developer approached the GoDj with a levelized tariff offer of US$0.13/kWh over a 25 year life of their proposed geothermal plant. Given the developer's stated Return on Investment and "at risk" exploratory drilling program, the GoDj recognized that a significant reduction from $0.13/kWh could logically be realized through competitive bidding as outlined under the Geothermal Power Generation Project. Depending on the quality of the geothermal resource, it is anticipated that a competitively bid geothermal tariff could range between US$0.08/kWh and US$0.11/kWh. It must be noted that this cost per kWh *includes* the geothermal plant O&M as well as debt service and IPP profit.

283. A geothermal electric plant receives a constant flow of steam energy from the earth that cannot simply be adjusted to change the output of the electric generator. Changes in flow from a well can bring in rock debris which can clog the well and surface equipment, or through thermal cycling could damage well casing or its bonding with cement. As such, a geothermal plant is a base load power plant that cannot meet instantaneous changes in the system electrical demand in the same way as that of an engine generator, unless the steam was simply vented to atmosphere in order to reduce power output. Such an approach to control of power output would be wasteful of the resource while increasing the cost of plant equipment. To respond to instantaneous load changes, and to properly balance electric load flow across the grid, the geothermal plant will need to operate synchronously with a complement of engine generation to meet technical requirements. Given the differential operating costs, system operation will be financially optimized at that point in time when enough engine generation (and no more) is on the line to meet the system technical needs.

284. To simulate an optimized geothermal / engine generator operation, a model was created that allows for no less than 10% of the hourly demand to be met with engine generators. Using the projected year 2016 hourly demand data, the financial model was iterated through various rated capacities of the geothermal plant until the optimum plant size was found to be 56 MW. The 56 MW optimum sizing case was then run to identify the anticipated savings based on the following parameters.

- *Reciprocating engine generation cost: US$0.25/kWh* (no consideration of capital cost)
- Reciprocating engine generators adjusted to generate at least 10% of demand to maintain stability of electric grid
- *Geothermal tariff price $0.091/kWh* (50 MW financial analysis base case)
- Geothermal electric tariff 90% (of rated capacity) take or pay provision

Optimized Case - 56 MW Geothermal Power Plant Capacity	
Year 2016 Cost of System Generation with Reciprocating Engine Generators Only:	$ 123,110,873
Year 2016 Cost of System Generation with 56 MW Geothermal Plant Operating Synchronously with Engine Generators:	$ 65,752,583
Year 2016 Savings with Geothermal Plant	**$ 57,358,290**
Average Generation Cost per kWh	**$ 0.1299**

In consideration of the possibility that; i) the amount of geothermal fluid found is insufficient to supply 56 MWs of power generation, or; ii) it is decided to ramp up geothermal generation in 20 MW increments, a second analysis was run. The 20 MW analyses used the same load growth and reciprocating engine generation cost assumptions as outlined above. The geothermal generation capacity was then incremented to 20 MWs and the geothermal tariff cost was increased from $0.091 to $0.098 to account for losses in economy of scale. The following results were obtained:

Incremental Case - 20 MW Geothermal Power Plant Capacity	
Year 2016 Cost of System Generation with Reciprocating Engine Generators Only:	$ 123,110,873
Year 2016 Cost of System Generation with 20 MW Geothermal Plant Operating Synchronously with Engine Generators:	$ 98,039,678
Year 2016 Savings with Geothermal Plant	**$ 25,071,195**
Average Generation Cost per kWh	**$ 0.1991**

Effect of Transmission Interconnect with Ethiopia

285. The “Interconnector” Power Purchase Agreement (PPA) provides an avenue for Djibouti to sell base load geothermal power to Ethiopia during the dry season when Ethiopia’s hydro generation is curtailed and thermal generation must be used to meet dry season power demands. Ethiopia’s dry season corresponds to Djibouti’s low demand winter season thus creating a potential market for Djibouti’s geothermal power when referenced against Ethiopia’s thermal

286. In addition, the Interconnector provides Djibouti with the future option of fully exploiting the potential upside of discovering a large geothermal resource by building generation in excess of its own needs (i.e. > 50 MW). This additional flexibility puts Djibouti in the position of deriving income through export of excess geothermal power wheeled through Ethiopia to other foreign markets interconnected to the Ethiopian grid generation.

Annex 10: Procurement Plan

Procurement Plan– Works &Goods and Non-Consulting Services financed by the Geothermal Power Generation Project

Financiers	**Description**	**Cat.**	**Method**	**Est. Amts (US$)**	**Prior/Post Review**	**Plan vs. Actual**	**Bidding Doc.**	**Bid Evaluation Report**			**Contract Amt. (US$)**	**Contract Signature**	**Contract Completion**
							Launching of Bidding Process	Submission deadline and Bid Opening	Evaluation Rpt to the Bank	Bank No-Objection			
IDA/GEF /OFID	Drilling service company	NCS	ICB (with PQ)	15,729,800	Prior	Plan	1/5/14	3/5/14	4/5/14	4/25/14		7/5/14	3/6/15
						Revised							
						Actual							
AfDB (ADF)	Civil Contract	Works	ICB	3,644,250	Prior	Plan	10/1/13	11/15/13	12/15/13	12/31/14		3/22/14	*7/3/15*
						Revised							
						Actual							
ESMAP	Testing, Sampling & Coring During Drilling + Well Testing Services	NCS	ICB	941,132	Prior	Plan	10/7/13	1/7/14	3/7/14	3/22/14		6/7/14	*7/3/15*
						Revised							
						Actual							
AFD	Steel Casing Materials+ Steel Wellhead Assembly (Supply and Install)	Goods	ICB	1,946,283	Prior	Plan	10/7/13	1/7/14	3/7/14	3/22/14		6/7/14	*2/6/15*
						Revised							
						Actual							
AFD	Other Well Equipment, Liner Hangers	Goods	NCB	123,738	Prior	Plan	10/7/13	1/7/14	3/7/14	4/7/14		6/7/14	*2/6/15*
						Revised							
						Actual							
AFD	Bits, Stabilizers, reamers & Hole Openers	Goods	ICB	886,248	Prior	Plan	10/7/13	1/7/14	3/7/14	4/7/14		6/7/14	*2/6/15*
						Revised							
						Actual							
AfDB (ADF)	Accounting Software	Goods	Shopping	30,000	post	Plan	12/1/12	1/2/13	NA	NA		*2/1/13*	*2/28/13 Assumes training time*
						Revised							
						Actual							

Procurement Plan – Consulting Services financed by Geothermal Power Generation Project

Financiers	Description	Selection Method	Cost Estimate (US$)	Contract Type	Prior/Post Review by Bank	Plan vs. Actual	Launching of Selection Process	Submission Deadline and Public Technical Proposals Opening	Contract Amount US$	Contract Signature	Contract Completion	Comments
AfDB (TF)	Director	IC	**500,000**	TIME-BASED	Prior	Plan	1/15/13	3/1/13		4/15/13	9/4/15	Advanced procurement foreseen, contract will be signed for project effectiveness
						Revised						
						Actual						
AfDB (TF)	Geothermal Consulting Company	QCBS	**1,591,100**	LUMP-SUM/ TIME-BASED	Prior	Plan	5/1/13	9/1/13		11/15/13	9/4/15	
						Revised						
						Actual						
AfDB (ADF)	Accountant	IC	**90,000**	TIME-BASED	Prior	Plan	12/1/12	12/15/12		12/30/12	7/3/15	Advanced procurement foreseen, contract will be signed for project negotiation
						Revised						
						Actual						
AfDB (ADF)	Procurement Specialist	IC	**90,000**	TIME-BASED	Prior	Plan	12/1/12	12/15/12		12/30/12	7/3/15	Same as above
						Revised						
						Actual						
AfDB (ADF)	Social Safeguard Specialist	IC	**60,000**	TIME-BASED	Prior	Plan	1/15/13	3/1/13		4/15/13	7/3/15	Advanced procurement foreseen, contract will be signed for project effectiveness
						Revised						
						Actual						
AfDB (ADF)	Environmental Safeguards Specialist	IC	**60,000**	TIME-BASED	Prior	Plan	1/15/13	3/1/13		4/15/13	7/3/15	Advanced procurement foreseen, contract will be signed for project effectiveness
						Revised						
						Actual						
AfDB (ADF)	EHS Auditor	CQS	**80,000**	LUMP-SUM	Prior	Plan	4/15/13	6/15/13		8/15/13	7/3/15	
						Revised						
						Actual						
AfDB (ADF)	Auditor	CQS	**80,000**	LUMP-SUM	Prior	Plan	4/15/13	6/15/13		8/15/13	7/3/15	
						Revised						
						Actual						
AfDB (ADF)	Fully Fledged Project Execution Manual	IC	**52,000**	LUMP-SUM	Prior	Plan	12/1/12	12/15/12		12/30/12	5/31/13	Advanced procurement foreseen, contract will be signed for project negotiation
						Revised						
						Actual						

Annex 11: Djibouti Geothermal Generation Project - Green-House Gas Accounting

Introduction

287. The MENA Region is preparing a geothermal power project in Djibouti, partially funded by the GEF. The project objective is to assess commercial viability of the geothermal resource in Fiale Caldera (located in the Lac Assal region).This could lead to potentially unlocking Djibouti's geothermal potential which would help reduce domestic electricity generation costs, increase the country's energy security of supply and foster private sector participation in the energy sector. The project is also a central element of the Government of Djibouti's response strategy to climate change, demonstrated by reductions in GHG emissions[40]. This is the main objective of the GEF support to the project.

288. The project involves drilling four geothermal production wells. If the drilling is deemed a success, these wells will yield an initial generation capacity of 16MW. The Project Appraisal Document (PAD) also notes that the potential resources in the project site can yield 50MW of geothermal generation capacity in the long-term (including the 16MW capacity from the first four wells)[41].

289. This note presents an assessment of GHG emissions savings from the project when compared with the emissions growth in the baseline scenario (without the project intervention).

Methodology

290. The environmental benefits of this project are demonstrated by the net reduction in emissions as a result of project intervention as follows. Notably, the project emissions are compared to baseline emissions: emissions that would occur from the same level of electricity that the project will deliver, if there was no project intervention.

Project emissions – Baseline Emissions = Net Emissions (Reduction)

Baseline Determination

291. If the geothermal capacity generation is not constructed, it can be assumed that the same level of electricity will instead be supplied by the existing power generation mix in Djibouti, which is noted in the PAD as follows.

Djibouti Power Generation Mix

(i) 18 oil-fired generation units, only one of which is less than 5 years old, totaling 119 MW of installed capacity.

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[40]As per Bank OP 10.04: the project's global externalities - normally identified in the Bank's sector work or in the environmental assessment work are considered in the economic analysis - when (a) payments related to the project are made under an international agreement; or (b) projects or project components are financed by the Global Environmental Facility (GEF). As this project is partially financed by GEF, the assessment of GHG should ideally have been covered in the project economic analysis.

[41] Earlier studies have assessed the probability of a success for the first well, given existing geophysical evidence, at 80%, which is typical of a brownfield success ratio, while the present project is still a greenfield development for which a probability of 70% may be more appropriate.

- Only 57 MW is effective generation capacity due to the unreliability of the older thermal generators.

(ii) A power purchase agreement (PPA) with Ethiopia to import between 22.35 to 37.24 MW of continuous generation annually, mostly in the form of hydroelectricity.

- PPA excludes energy sales during Ethiopia's dry season's peak hours, forcing Djibouti to increase reliance on thermal generation.

292. Based on the effective thermal generation capacity and electricity imports, the national grid emission factor for Djibouti was calculated to be 0.73tCO2/MWh.42 For the baseline calculation; this figure is used as the rate of GHG emissions for the equivalent amount of generation the proposed geothermal units would have delivered.

Inputs and Assumptions

293. Sources of emissions considered in this analysis are operational emissions that occur in the generation process, and "one-off" emissions that occur in constructing the generation units. This "one-off" category considers emissions from materials manufacturing, component manufacturing (including electricity used during manufacturing), transportation from the manufacturing facility to the construction site, and on-site construction.

294. The following inputs and assumptions are used in the GHG accounting calculations:

(i) **Drilling:** Drilling emissions are considered to be negligible. Unless intense land clearing or bitumen extraction is involved, drilling emissions tend to be relatively small. Drilling emissions only occur at the outset of production or sporadically during field life and are typically less than five percent of the yearly generation emissions.[43]

(ii) **Generation "One-Off" Emissions:** If the drilling phase is deemed successful, four geothermal generation units will be constructed, yielding 16 MW of generation capacity. The "one-off" emission factor for constructing geothermal generation units has been calculated to be 2,229 kgCO_2e/kW of capacity constructed.[44]

(iii) **Operational Emissions:** With a 90% capacity factor for the generation units, the first four wells generate 126,144 MWh per year. This electricity generation will produce 7,689,788 tons of methane steam emissions per year. The average mass fraction of carbon dioxide in the produced steam was calculated to be 0.001299%.[45]

(iv) **Lifecycle:** The geothermal generation units are assumed to have a 30 year lifecycle.

(v) **Subsequent Generation Capacity:** If the first four wells are successful, the probability of constructing more generation capacity increases significantly due to the successful drilling and learning processes of the first phase

[42] ACM0002: Tool to calculate the emission factor for an electricity system – Version 01.1. UNFCCC. 29 July 2008.

[43] CDC-DOGGR. Annual Report of the State Oil & Gas Supervisor. Technical report, California Department of Conservation, Department of Oil, Gas and Geothermal Resources (and predecessor organizations), 1915-2011.

[44] Hiroki Hondo, Life cycle GHG emission analysis of power generation systems: Japanese case, Energy, Volume 30, Issues 11–12, August–September 2005, Pages 2042-2056, ISSN 0360-5442, 10.1016/j.energy.2004.07.020.

[45] ACM0002: Consolidated methodology for grid-connected electricity generation from renewable sources – Version 11. UNFCCC.12 February 2010.

(vi). Without more detailed geophysical information, however, there is no way to quantify this probability at this point in the project.[46]

295. The total anticipated generation capacity for the project site is 50 MW (16 MW from the first phase, plus an additional 34 MW of geothermal generation capacity if the first phase of the project is successful). The potential emissions savings for this 50MW capacity are included in the calculations.

Key Findings and Results

296. All figures are displayed as tons of CO_2e produced over the life of the project equipment, as the GEF framework stipulates.

Phase 1 Success – 16 MW Capacity

Category	Emissions
Drilling Emissions	negligible
"One-Off" Emissions	35,657
Generation Emissions	305,483
Total Project Emissions	**341,140**
Baseline Emissions	4,143,831
Net Emissions	**(3,802,691)**

297. If the drilling phase is successful and the four wells produce 16 MW of geothermal generate capacity, this project is expected to directly offset total CO_2e emissions of about 3,802,691tons over a 30 year life cycle.

Additional 34 MW Capacity

Category	Emissions
Generation Emissions	649,150
"One-Off" Emissions	75,771
Total Project Emissions	**724,922**
Baseline Emissions	8,632,980
Net Emissions	**(7,908,058)**

298. If an additional 34MW of capacity is installed, this will directly offset total CO_2e emissions of about 7,908,058 tons over a 30 year life cycle.

Aggregate Emissions

299. Based on this analysis, if 50MW generation capacity is installed and becomes operational, this project is expected to directly offset total CO_2e emissions of about 11,710,750 tons over a 30 year life cycle.

[46] Modeling Dependence Among Geologic Risks in Sequential Exploration Decisions. Bickel, E., J. Smith, and J. Meyer. 2008. *Society of Petroleum Engineers: Reservoir Evaluation & Engineering*, 11 (2), 352-361.