

Document of
The World Bank

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Report No: PAD1243

INTERNATIONAL BANK FOR RECONSTRUCTION AND DEVELOPMENT

PROJECT APPRAISAL DOCUMENT

ON A

PROPOSED GRANT

IN THE AMOUNT OF US\$8.55 MILLION

TO THE

REPUBLIC OF ARMENIA

FOR A

GEOHERMAL EXPLORATORY DRILLING PROJECT (GEDP)

JANUARY 9, 2015

Energy & Extractives
EUROPE AND CENTRAL ASIA

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CURRENCY EQUIVALENTS

(Exchange Rate Effective January 9, 2015)

Currency Unit	=	AMD
480	=	US\$1
US\$1.5	=	SDR 1

FISCAL YEAR

January 1 – December 31

ABBREVIATIONS AND ACRONYMS

ADB	Asian Development Bank	IP	Investment Plan
AMD	Armenian Dram	kV	Kilovolt
BOT	Board of Trustees	kWh	Kilowatt-hour
CCGT	Combined Cycle Gas Turbine		
CPS	Country Partnership Strategy	LEC	Levelized Energy Cost
DA	Designated Account	MENR	Ministry of Energy and Natural Resources
DSC	Drilling Service Company	MDBs	Multilateral Development Banks
DSCR	Debt Service Coverage Ratio	MOF	Ministry of Finance
EBRD	European Bank for Reconstruction and Development	NGO	Non-Government Organization
EMP	Environmental Management Plan	NPV	Net Present Value
ESIA	Environmental and Social Impact Assessment	ORC	Organic Rankine Cycle
FM	Financial Management	PP	Procurement Plan
FMM	Financial Management Manual	PPP	Public Private Partnership
GEDP	Geothermal Exploratory Drilling Project	PSOD	Private Sector Operations Department
GEF	Global Environmental Facility	PV	Photovoltaic
GHG	Greenhouse Gas	R2E2	Renewable Energy and Energy Efficiency Fund
GRM	Grievance Redress Mechanism	RAP	Resettlement Action Plan
GWh	Gigawatt-hour	RPF	Resettlement Policy Framework
HPP	Hydropower Plant	SOE	Statement of Expenditures
IBRD	International Bank for Reconstruction and Development	SREP	Scaling-up Renewable Energy Program
IDA	International Development Association	TSSC	Technical Supervision and Support Consultant
IFC	International Finance Corporation	TTL	Task Team Leader
IFR	Interim Financial Report	US\$	United States Dollars
		WACC	Weighted Average Cost of Capital

Regional Vice President:	Laura Tuck
Country Director:	Henry Kerali
Senior Global Practice Director:	Anita George
Practice Manager:	Ranjit Lamech
Task Team Leader:	Artur Kochnakyan
Co-Task Team Leader:	Almudena Mateos Merino

ARMENIA
Geothermal Exploratory Drilling Project

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PAD DATA SHEET

Armenia

Geothermal Exploratory Drilling Project (P152039)

PROJECT APPRAISAL DOCUMENT

EUROPE AND CENTRAL ASIA

0000009058

Report No.: PAD1243

Basic Information			
Project ID P152039	EA Category B - Partial Assessment	Team Leader Artur Kochnakyan	
Lending Instrument Investment Project Financing	Fragile and/or Capacity Constraints []		
	Financial Intermediaries []		
	Series of Projects []		
Project Implementation Start Date 15-May-2015	Project Implementation End Date 30-Apr-2019		
Expected Effectiveness Date 10-May-2015	Expected Closing Date 31-May-2019		
Joint IFC No			
Practice Manager/Manager Ranjit Lamech	Senior Global Practice Director Anita George	Country Director Henry Kerali	Regional Vice President Laura Tuck
Approval Authority			
Approval Authority Regional Vice President (RVP)			

Borrower: MINISTRY OF FINANCE AND ECONOMY									
Responsible Agency: Renewable Resources and Energy Efficiency Fund									
Contact:		Ms. Tamara Babayan			Title: Director				
Telephone No.:		+37410-58-80-11			Email: director@r2e2.am				
Project Financing Data(in USD Million)									
<input type="checkbox"/> Loan		<input type="checkbox"/> IDA Grant			<input type="checkbox"/> Guarantee				
<input type="checkbox"/> Credit		<input checked="" type="checkbox"/> Grant			<input type="checkbox"/> Other				
Total Project Cost:		10.69			Total Bank Financing:		0.00		
Financing Gap:		0.00							
Financing Source									
								Amount	
Recipient								2.13	
Strategic Climate Fund Grant								8.55	
Total								10.68	
Expected Disbursements (in USD Million)									
Fiscal Year	2015	2016	2017	2018					
Annual	1.5	5.0	1.2	0.85					
Cumulative	1.5	6.5	7.7	8.55					
Institutional Data									
Practice Area / Cross Cutting Solution Area									
Energy & Extractives									
Cross Cutting Areas									
<input checked="" type="checkbox"/> Climate Change									
<input type="checkbox"/> Fragile, Conflict & Violence									
<input type="checkbox"/> Gender									
<input type="checkbox"/> Jobs									
<input checked="" type="checkbox"/> Public Private Partnership									
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	%
Financial and private sector development	Infrastructure services for private sector development	90
Environment and natural resources management	Climate change	10
Total		100

Proposed Development Objective(s)

The proposed project development objective is to confirm whether the geothermal resource at Karkar site is suitable for power generation and, if confirmed, to involve the private sector in development of a geothermal power plant.

Components

Component Name	Cost (USD Millions)
Exploratory drilling and construction of related infrastructure	9,210,000
Technical assistance for assessment of the geothermal resource potential and technical supervision	1,470,000

Systematic Operations Risk- Rating Tool (SORT)

Risk Category	Rating
1. Political and Governance	Low
2. Macroeconomic	Moderate
3. Sector Strategies and Policies	Low
4. Technical Design of Project or Program	Substantial

5. Institutional Capacity for Implementation and Sustainability	Moderate
6. Fiduciary	Substantial
7. Environment and Social	Low
8. Stakeholders	Low
OVERALL	Substantial

Compliance

Policy

Does the project depart from the CAS in content or in other significant respects?	Yes []	No [x]
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

Description of Covenant

Conditions			
Source Of Fund	Name	Type	
Description of Condition			
Team Composition			
Bank Staff			
Name	Title	Specialization	Unit
Almudena Mateos Merino	Energy Specialist	Co-Team Leader	GEEES
Armine Aydinyan	Consultant	Procurement	ECCAR
Artur Kochnakyan	Senior Energy Economist	Team Lead	GEEDR
Darejan Kapanadze	Senior Environmental Specialist	Senior Environmental Specialist	GENDR
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Garik Sergeyan	Sr Financial Management Specialist	Financial Management	GGODR
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Hiwote Tadesse	Operations Analyst	Operational Support	
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Irina Tevosyan	Program Assistant	Logistical and Operational Support in Country Office	ECCAR
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Rocio Mariela Malpica Valera	Senior Counsel	Senior Counsel	LEGLE

Sarah G. Michael	Senior Social Development Specialist	Senior Social Development Specialist	GSURR
Thrainn Fridriksson	Energy Specialist	Geothermal	GEEES
Vipasha Bansal	Consultant	Legal	LEGLE
Wendy E. Hughes	Lead Energy Economist	Peer-reviewer	GEEES

Non Bank Staff

Name	Title	City
Gordon Bloomquist	Geothermal expert – Peer reviewer	
Jack Mozingo	Environmental Safeguard Consultant	

I. STRATEGIC CONTEXT

A. Country Context

1. The Gross Domestic Product (GDP) growth slowed from 7.2 percent in 2012 to 3.5 percent in 2013, and is likely to settle at about 2.6 percent in 2014 as a whole. Growth of agriculture remained strong, mainly because of expanding livestock production. However, metallic mining output declined, and the construction sector also continued to decline. The bright spot remains the service sector, where the highest contributors to growth were the financial sector, telecommunications, and real estate.

2. Inflation had picked up significantly by mid-2013 largely due to gas and electricity price increases. However, twelve-month inflation slowed to less than 1 percent in August of 2014, below the lower bound of the central bank's 2.5-5.5% target range. The slowdown was mainly driven by deflation of food products. Prices of non-food products remained broadly stable during the first eight months of the year, and the 12-month price index increased by only 1.1% for this category.

3. Despite the economic recovery, poverty incidence continues to be higher since the 2009 economic crisis. In 2013, 32 percent of Armenians were living in poverty, a small change from 2009. In contrast, 27.6 percent of Armenians were considered poor in 2008. In 2013, rural and urban incidence of poverty was similar at about 32 percent. About 34 percent of female headed households were considered poor in 2012.

4. The slow poverty reduction pace is related to the slack in the labor market created by the decline of the construction sector. Employment and earnings, more than pensions or safety nets, are important for staying out of poverty. In 2007-09, construction was the largest contributor to growth and employment creation. Over this same period, consumption growth of the bottom 40 percent of the distribution—an indicator of shared prosperity—outpaced consumption growth experienced by the population overall (4.3 percent vs. 3.5 percent). The 2009 crisis undid the gains delivered by construction-driven growth and eroded the gains in consumption. The subsequent recovery between 2010 and 2012 and changed sectoral composition of employment led to positive consumption growth albeit from a lower base than in the pre-crisis period, and some poverty reduction. Overall, the recovery has benefited individuals across the distribution: on average, between 2007 and 2012, consumption of the bottom 40 percent grew at 1.4 percent per year while consumption of the overall population registered an annual growth of 1.6 percent. The crisis has left the income distribution slightly more unequal than in 2007, and the poor have not benefited as much from the economic recovery.

B. Sectoral and Institutional Context

5. During the first phase of reforms in 1990s and early 2000s the power sector achieved some remarkable results. The collection of electricity bills reached 100 percent of sales. A competent and independent regulatory agency for the sector was established. The regulatory framework has been adequate and overall conducive to private investments. The explicit and implicit subsidies were eliminated.

6. However, currently the power sector faces a number of major challenges that need to be addressed as part of the second phase of reforms. The key challenges are: (a) supply adequacy; (b) supply reliability; (c) affordability of energy tariffs; (d) financial viability of state-owned power companies; and (e) transparency.

7. Supply Adequacy: The power system will need around 500 MW of new gas-fired generation capacity as soon as possible to preclude emergence of supply capacity gap by 2020. To ensure sufficient long-term supply the Government will also need to develop a number of renewable energy projects, which are estimated to be part of the least-cost supply plan.

8. Improvement of tariff structure can also contribute to reducing the need for new generation capacity through promotion of more efficient energy consumption. Specifically, the existing electricity tariff structure does not reflect the large difference between the costs of supply during winter and summer months (AMD 28/kWh vs. AMD8/kWh), which creates perverse incentives for consumers and promotes economically inefficient electricity consumption.

9. Supply Reliability: The average interruption frequency per line for 110 and 220 kV overhead transmission lines (OTLs) on the balance sheet of High Voltage Electric Networks (HVEN) is 2.5 times higher than for comparator well-performing utilities. The average age of substations is around 35 years and 14 out of 16 substations have not undergone any major rehabilitation or upgrade. According to the findings from Armenia Power Sector Policy Note (2014), the substation of Yerevan Thermal Power Centre (YTPC) and Ashnak substation have the highest rehabilitation priority.

10. Affordability: In 2013-2014, the average electricity tariff for residential customers increased by 40 percent and the gas tariff increased by 19 percent. After the increase, the share of energy expenses in the total expenses of an average household reached 10 percent, a level considered to be energy poverty. The poor suffered the most from the electricity and gas tariff increase, which increased the share of energy expenses in their disposable income to 13.6 percent considering the gas life-line tariff introduced by the Government in 2011.¹ The energy tariff increase also led to fuel substitutions (e.g. gas with wood or manure) and to energy deprivation among the poor households with resulting negative environmental and health implications. The affordability of electricity is expected to deteriorate further as much needed investments in the sector are made.

11. Financial viability of state-owned power companies: The financial standing of state-owned power companies deteriorated since 2011 due to:

(i) *The Government intervention in tariff filings of state-owned power companies*. The Government intervened in setting revenue requirements and associated tariffs for some of the state-owned companies to limit the impact of increasing costs on end-user tariffs. Specifically, the Government, as the owner, agreed to eliminate or reduce some of the allowed expenses, such O&M, depreciation and return on assets. Moreover, the O&M expenses of the sector companies in real terms reduced by 40 percent in 2009-2013 given that no adjustment for inflation was made when approving the tariffs. This has resulted in

¹ Families registered in PFBP with poverty score above zero paid a reduced tariff of AMD100/m³ for first 300 m³ of consumption

under-spending on maintenance and reduced investments in improvement of power supply reliability and efficiency.

- (ii) *Large short-term borrowings by the state-owned companies for non-core business activities* (financing of salaries of other distressed enterprises). These companies have accumulated AMD24 billions (US\$50 million) of payables² (27 percent of their total revenue), of which AMD3.5 billion (US\$7.4 million) is expensive, short-term commercial debt (9-12 percent annual interest). The companies have increasing difficulty servicing this debt, which is not covered in their tariffs.

12. Transparency: The transparency of the sector has deteriorated since 2011. This has manifested through reduced public disclosure of information related to energy sector issues and challenges.

13. The Government has taken steps to support the development of indigenous renewable energy resources, including establishment of feed-in tariffs for small hydropower plants by the Public Services Regulatory Commission, mandatory 15-year off-take by the distribution company of the electricity generated by the small renewable energy plants, and streamlining of licensing requirements and procedures. As a result, the share of electricity generated by SHPPs increased from less than 1 percent in 2004 to 9 percent in 2013. The Government remains committed to further increase the share of the renewable energy in the generation mix by promoting development of renewable energy technologies, which have large potential for scale-up and limited impact on end-user tariffs.

14. Armenia has an adequate regulatory regime for development of renewable energy, including licensing and permitting procedures. There is an independent and competent energy sector regulator. The key stakeholders have sufficient capacity to coordinate and make decisions related to development of the geothermal plant in case the resource is confirmed. There is no PPP framework in the country, however, the Law on Energy and other legislation allow for privately owned generation. The involvement of the private investors/developers would be contractual and custom-tailored for the needs of the project. The financial structuring decisions would be made at a later stage if the resource is confirmed.

15. The Government is committed to develop the country's geothermal resources as they can become an affordable source of base-load electricity that is generated from indigenous resources, therefore contributing to the country's energy security. The total potential for geothermal power in Armenia is currently estimated to be at least 150 MW. Of the known areas, the Karkar field was assessed to be the most promising site. Development of the Karkar geothermal site is one of the projects included in the Scaling-up Renewable Energy Program (SREP) Investment Plan (IP) developed by the Government with support from development partners³ and approved by the SREP Sub-committee on June 26, 2014. The SREP IP identified geothermal power, utility-scale solar PV, and solar heating as priority areas for support and future scale-up.

² Excluding the intra-sectoral debts to each other. Source: Bank team estimates.

³ WBG, ADB, and EBRD.

16. The selection of the Karkar site for exploratory drilling is based on comprehensive field investigation works completed for two prospective sites, which were deemed the most promising by the local and international geothermal experts. The field investigation works at the above two sites were supported under the GEF financed GeoFund 2: Armenia Geothermal Project completed in 2012. The field investigation works included: (a) field scouting; (b) magneto-telluric sounding (MT) study; (c) independent interpretation of results of MT study; (d) three-dimensional (3D) MT study, and (e) independent interpretation of the results of 3D MT study. All of the above surface exploration at the Karkar site was conducted according to international standards and exploratory drilling is now needed in order to confirm whether the field contains adequate resources that can be exploited for electricity generation.

17. The ultimate objective of the Government is to construct a geothermal power plant at Karkar site if the resource is confirmed. Since private investors are not willing to assume the resource risk associated with exploratory drilling, the Government will use SREP resources for Stage 1 of the Karkar geothermal project to: (a) carry out the exploratory drilling to confirm the resource; and (b) if the resource is confirmed, assess the feasibility of a geothermal power plant at Karkar and support involvement of private sector in construction of a geothermal power plant.

18. The Stage 2 of the Karkar geothermal project is the construction of a geothermal power plant if the results from Stage 1 confirm the suitability of resource for power generation. The early-stage analyses suggested that a 28 MW geothermal power plant could potentially be constructed at Karkar geothermal site with total estimated cost of US\$106 million. The potential geothermal power plant with estimated cost of US\$106 million could be developed with a mix of public and private capital as suggested by the below indicative financial plan of the Government.

Table 1: Indicative financing plan for geothermal power project

	Government	MDBs	Private sector (equity)	Commercial/private arms of MDBs	TOTAL
Construction cost	6	30	35	35	106

19. Therefore, SREP support for exploratory drilling can catalyze additional financing from public and private sources and serve to demonstrate the feasibility of geothermal power in Armenia if adequate resources are confirmed. The first successful project can also build domestic capacity in the development of additional geothermal resources at Armenia’s other prospective geothermal sites. It will also strengthen the investor confidence that geothermal is a viable and profitable investment opportunity in Armenia.

20. The proposed project is consistent with the strategic energy sector objectives of the Government. Specifically, the Concept of National Energy Security (2013), the Armenian Development Strategy for 2014-2025 (March 2014), and the Law on Renewable Energy and Energy Efficiency (2008) prioritize increased use of indigenous renewable resources to ensure supply adequacy and improve energy security. If adequate resource temperature and other technical parameters required for electricity generation (at competitive cost) are confirmed under the proposed project, the Government will be in a position to seek additional financing from public and private sources in order to proceed with construction of the geothermal power plant.

Such plant would help the Government to meet the forecast electricity demand and improve the energy security and energy independence of the country.

21. The proposed project will leverage the World Bank's current engagement in the energy sector in Armenia (see Box 1) to help the Government to address the challenge of supply adequacy.

Box 1: World Bank Group Engagement in the Energy Sector in Armenia

The WBG is engaged in the energy sector through investment financing operations, policy dialogue, and analytical activities.

Preparation of the Financial Recovery Plan. The World Bank is now preparing a financial recovery plan for state-owned power sector companies to advise the Government on restructuring of the existing liabilities of those companies, which originated due to non-core business activities not serviced through the tariffs.

Armenia Power Sector Policy Note. The note analyzed the challenges facing the power sector and outlined the potential solutions to inform the Government policy thinking.

US\$39 million Electricity Supply Reliability Project (ESRP): The ESRP is financing replacement of around 230 km section of the power transmission backbone from Hrazdan Thermal Power Plant to Shinuhayr substation.

US\$40 million Additional Financing to Electricity Supply Reliability Project (ESRP AF): The ESRP AF is financing rehabilitation of Haghtanak, Charentsavan-3, and Vanadzor-1 substations.

US\$51 million Electricity Transmission Network Improvement Project (ETNIP): The project is financing rehabilitation of two critical substations important for reliable evacuation of power from the Nuclear Power Plant and Yerevan Thermal Power Plant.

US\$10.6 million Energy Efficiency Project (including GEF grant of US\$1.8 million): The project is financing energy efficiency retrofits in public and social facilities, including but not limited to state and regional government bodies, schools, kindergartens, hospitals, theaters.

Analytical and Advisory Support for Mitigating Energy Tariff Increase on the Poor: The World Bank has also been providing analytical support to the Government to assess the impact of gas and electricity tariff increases in 2013-2014 on the poor and inform the Government thinking by identifying the subsidization options for mitigating the impacts and assessing their fiscal costs.

US\$15 million Sustainable Energy Finance Project of IFC. The project supports establishment of a sustainable market for energy efficiency and renewable energy investments. For energy efficiency, IFC project primarily supports financial institutions to develop energy efficiency lending and awareness raising on sustainable energy finance.

C. Higher Level Objectives to which the Project Contributes

22. Inadequate power supply in the long-term and low energy security due to dependence on imported gas with long-term volatile prices may constrain economic growth and job creation. The proposed project is consistent with the current Country Partnership Strategy (October 9, 2013) for Armenia since it is centered on the Engagement Area 1.3 of the CPS (Improved access, quality, and sustainability of key infrastructure) to eliminate constraints to competitiveness and job creation through selective energy sector investments.

23. The proposed project will not directly impact the Government's higher level objectives of economic growth and job creation, but will reduce the risk of constructing a geothermal power plant, which would contribute to ensuring power supply adequacy and, thus, contribute to reducing the impending power supply gap in the country and improving energy security.

24. Moreover, the project will also contribute to the Bank's twin objectives of reducing poverty and promoting shared prosperity. Specifically, low-cost electricity from a potential geothermal plant can help keep the electricity affordable for the poor. If adequate geothermal resources are confirmed, then construction of a geothermal power plant will reduce the need for expensive gas-based thermal generation. This could help reduce the rate of expected increase of electricity tariffs (given large investment needs in the sector) and, thereby, help reduce the impact of the electricity tariffs on the poor.

II. PROJECT DEVELOPMENT OBJECTIVES

A. PDO

25. The proposed project development objective is to confirm whether the geothermal resource at Karkar site is suitable for power generation and, if confirmed, to involve the private sector in development of a geothermal power plant.

B. Project Beneficiaries

26. The main project beneficiary is the Government. The project will allow the Government to assess whether Karkar holds adequate geothermal resources for power generation and, if so, increase the possibility of attracting private investment for construction of the power plant.

C. PDO Level Results Indicators

27. The PDO level result indicators are:

Indicator 1 (Custom): Evidence provided to the Government for its decision whether to construct or not to construct a geothermal power plant at the Karkar geothermal site.

Indicator 2 (Custom): If geothermal resource is confirmed, power plant development is competitively awarded to qualified private developer(s).

Indicator 3 (Custom): Percent of registered project related grievances responded to within stipulated service standards for response times.

III. PROJECT DESCRIPTION

A. Project Components

28. The proposed project consists of two components: (1) Exploratory drilling and construction of related infrastructure; and (2) Technical assistance for assessment of the geothermal resource potential and technical supervision.

29. **Component 1: Exploratory drilling and construction of related infrastructure (US\$9,212,500, including US\$7,370,000 SREP grant).** This component will finance:

30. **Sub-component 1.1: Construction of access road, water supply infrastructure and rig pads (US\$812,500, including US\$650,000 SREP grant).** This will include construction of: (a) a gravel road with sufficient length and width to allow for safe transportation of equipment and other materials to the site; (b) infrastructure to supply the water from the nearby springs or the river to ensure a continuous water supply required for the drilling operation if drilling of production-size wells is warranted; and (c) preparation of the rig pads where the rig, and the associated equipment will be placed, if drilling of production-size wells is warranted.

31. Drilling of slim wells does not require preparation of the rig pad and water supply infrastructure given that truck-mounted rigs are used and drilling of slim wells is not water-intensive process.

32. **Sub-component 1.2: Drilling of exploratory wells (US\$8,400,000, including US\$6,720,000 SREP grant).** This will include drilling of one or two slim wells followed by one or two production-size wells if results from drilling of slim well(s) warrant drilling of production-size wells. The coordinates of the two slim wells were determined through field investigations works (see Annex 2 for details). The production-size wells will be drilled at the same location as the slim wells and the final coordinates will be determined after the drilling of the slim wells is completed and if results justify the drilling of production-size wells.

33. **Component 2: Technical assistance for assessment of the geothermal resource potential and technical supervision (US\$1,475,000, including US\$1,180,000 SREP grant).** This component will finance:

34. **Sub-component 2.1: Well logging and mud logging (US\$300,000 SREP grant).** This will include analyses of the cuttings from the borehole, well temperature and pressure measurements and gathering of essential data (such as drilling progress, changes in flow line temperatures, etc.), both as the drilling progresses and at the end of each drilling stage.

35. **Sub-component 2.2: Feasibility study for a geothermal power plant (US\$375,000, including US\$300,000 SREP grant).** This will include: (a) assessment of the possible power output of the wells, the ratio between brine and steam; (b) assessment of enthalpy; (c) sampling of the brine to decide the type of power conversion techniques to be used and the type of the plant to be constructed, and estimate the power generation potential for a potential geothermal power plant; (d) assessment of the economic and financial viability of the potential plant; (e)

legal gap analyses of the institutional and regulatory framework for construction and operation of a geothermal power plant; and (f) preparation of conceptual/preliminary design of transmission lines and a substation, and other infrastructure required for connection of the potential power plant to the grid.

36. Sub-component 2.3: Technical supervision and support consultant (US\$375,000, including US\$300,000 SREP grant). This will include support to the R2E2 Fund in technical supervision of the drilling operation; review of the results and findings of well logging, mud logging, flow testing, and chemical analyses of cuttings; and other technical advice and support.

37. Sub-component 2.4: Transaction advisory (US\$250,000, including US\$200,000 SREP grant). This will include provision of transaction advisory services to the Government in order to structure and complete a PPP transaction involving the private sector in construction and operation of the geothermal power plant if resources are confirmed. If needed, the Government will seek additional funding from SREP, Public Private Infrastructure Advisory Facility (PPIAF), Energy Sector Management Assistance Program (ESMAP), and other sources to complement the SREP financing for transaction advisory services.

38. Sub-component 2.5: Project audit and operating costs (US\$100,000, including US\$80,000 SREP grant). This will include: (a) incremental operating costs of the R2E2 Fund related to implementation of the project; and (b) project audits.

39. The project was designed as a 4-years operation in order to ensure that all the necessary activities can be completed given the limitations on site accessibility caused by weather conditions and also given the time needed to complete the PPP transaction for the power plant. The “window of opportunity” for accessing the site is generally from mid-May to mid-September, so at least two seasons would be needed to complete the drilling project. However, the project may be completed in one year if the drilling of the slim well(s) suggests that the resource is a low-temperature.

B. Project Financing

40. The proposed project will be financed by a US\$8.55 million grant from the SREP, one of the Strategic Climate Funds of the Clean Investment Funds. The SREP allocation for this project was endorsed by the SREP Sub-Committee in June 2014, including a US\$0.3 million Project Preparation Grant.

41. If the results of the drilling suggest that the geothermal resource at Karkar site is not suitable for power generation, the project would be closed and the remaining grant resources, after the approval by the SREP Sub-committee, would be reallocated to other priority projects identified in the SREP IP.

C. Project Cost and Financing

42. The project will be financed with US\$8.55 million SREP grant provided to the Republic of Armenia. The Ministry of Finance will provide the grant proceeds to the implementing entity of

the project, the Renewable Resources and Energy Efficiency Fund (R2E2 Fund), under a Subsidiary Agreement.

Table 1: Breakdown of project components and financing plan (in US\$ million)

Project Components	Project cost	SREP grant	% Financing
1. Exploratory drilling and construction of related infrastructure	9.21	7.37	80%
2. Technical assistance for assessment of the geothermal resource potential and technical supervision	1.47	1.18	80%
Total Costs	10.68	8.55	80%
Total Project Costs			
Front-End Fees	-	-	-
Total Financing Required	10.68	8.55	80%

IV. IMPLEMENTATION

A. Institutional and Implementation Arrangements

43. The R2E2 Fund will implement the project since it has acceptable capacity and experience in implementing Bank financed projects. The R2E2 Fund is a non-profit organization established by the Government in 2005 with the mandate to promote the development of renewable energy and energy efficiency markets in Armenia and to facilitate investments in these sectors. The implementation of the project as well as overall R2E2 Fund operations will be supervised by the Board of Trustees (BOT), consisting of representatives of government agencies, NGOs, and the private sector, thus, ensuring required professional expertise. The BOT is chaired by the Minister of Energy and Natural Resources.

44. Given the technical complexity of the project, the R2E2 Fund will set-up a project implementation structure that provides the necessary technical, coordination and project management skills that are required to execute an on-time and cost-effective drilling operation. This will include hiring a technical supervision and support consultant (a geothermal consulting company) to perform technical management of the geothermal drilling operation and provide technical advice to the R2E2 Fund throughout project implementation.

45. The R2E2 Fund will need to strengthen its procurement capacity given the complex contractual nature of the project. The R2E2 Fund will improve its procurement capacity by hiring specialists with local and international experience. The latter will also be responsible for training the R2E2 Fund's procurement staff during project implementation. The staff should also participate in the procurement trainings organized by the Bank locally, regionally or internationally. The R2E2 Fund also will be responsible for the implementation of the financial management (FM) function of the project, including planning and budgeting, accounting, financial reporting, external auditing, funds flow, and internal controls. Overall there are no

significant weaknesses identified at the R2E2 Fund, which will update its Financial Management Manual (FMM) before the project implementation starts to reflect the activities of the project

B. Results Monitoring and Evaluation

46. The R2E2 Fund will be responsible for monitoring and reporting on project implementation progress. The required data will be furnished by the reports generated by the implementation support consultant based on the data to be regularly provided by the drilling contractors, mud logging, well logging and chemical sampling analyses consultants. No data or information will be acquired from publicly available or other external sources given the very specialized nature of the project.

C. Sustainability

47. There is a strong commitment from the Government for the project, which was confirmed during preparation and approval process of the SREP IP and during project preparation. The Government is committed to developing the potential power plant at the Karkar site after the suitability of the resource for commercial power generation is confirmed.

V. KEY RISKS

A. Overall Risk Rating and Explanation of Key Risks

48. The overall risk of the project is rated as Substantial due to substantial technical and fiduciary risks, and moderate risks associated with the operating environment and institutional capacity for implementation.

- a. The technical risk is “Substantial.” Geothermal drilling projects are technically complex and require a very specific set of skills, both during the design and implementation stages. Given the limited geothermal expertise in Armenia, the project will provide technical assistance in order to ensure that the design of the drilling program is finalized according to international best practice and that the drilling operations are appropriately supervised on-site. Having the adequate technical capacity on site in order to make quick decisions in case issues such as circulation losses, lost-in-hole equipment or others that are encountered during drilling will be essential in order to limit their impact on the project schedule and costs. In addition, adopting an integrated drilling approach (one single company providing all the drilling-related services to the R2E2 Fund) will reduce the number of contracts that the implementing agency will need to manage directly, reducing the risk of on-site difficulties and delays, as well as of costs over-runs, and facilitating the monitoring of processes.
- b. The fiduciary risk is “Substantial.” Procurement of geothermal drilling programs is a very specific activity that will require very specialized procurement expertise in similar projects. The R2E2 Fund does not currently have sufficient in-house capacity to carry out such complex procurement and will require the support of experts with international experience during project implementation. In addition, and given that the overall procurement environment in Armenia remains “high risk” as decision have become politicized, special attention will be needed to prevent interference in procurement processes from politically-linked special interest groups which could affect transparency and cause delays in project implementation.

Systematic Operations Risk- Rating Tool (SORT)	
Risk Category	Rating
1. Political and Governance	Low
2. Macroeconomic	Moderate
3. Sector Strategies and Policies	Low
4. Technical Design of Project or Program	Substantial
5. Institutional Capacity for Implementation and Sustainability	Moderate
6. Fiduciary	Substantial
7. Environment and Social	Low
8. Stakeholders	Low
OVERALL	Substantial

VI. APPRAISAL SUMMARY

A. Economic and Financial Analysis

49. This section contains description of the rationale for public financing of the project; summary of the value added of the Bank's support; economic analysis of the project; and financial analysis of the project.

50. Rationale for public sector financing: Most of the international geothermal development experience shows that the upstream phases of development inevitably rely strongly on public sector investment, with private developers entering the project at more mature phases (i.e. when resource risk has been significantly reduced).

51. Unlike other renewable energy technologies, such as wind, solar, and hydro, it is not possible to validate the geothermal resource with sufficient confidence for commercial development without performing exploratory drillings at depth to assess specific geologic conditions in the field. After completing surface exploration, a conceptual model of the geothermal field is developed, which needs to be validated with the results of exploration drilling. The combination of relatively high capital requirements (typical costs for drilling are in the range of US\$2 to US\$5 million per well), high uncertainty of this phase, and time taken to complete this resource validation phase, about 3 years, deter commercial investors.

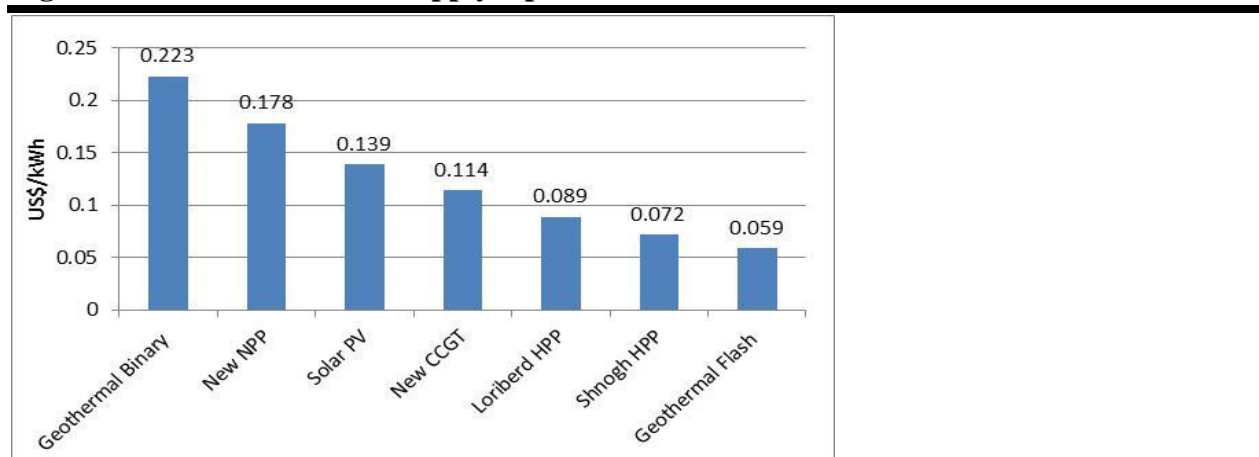
52. Value added of the Bank's support: The Bank has a long history of supporting geothermal development. Over US\$2.2 billion in financing provided by the Bank has led to total project investments of more than US\$5.5 billion in these endeavors. Although the Bank financing for geothermal, as well as that of other donors, has historically focused on the downstream phases of project development (i.e. construction of power plants and associated infrastructure), ongoing engagements in Kenya, Ethiopia and Djibouti put the Bank at the forefront of support for the riskier exploratory and production drilling stages. The leading role played by the World Bank in the country's sector dialogue, and the access to a wide network of geothermal experts built

through the Global Geothermal Development Plan make the World Bank a very strong partner to the Government for further exploration and subsequent development of its geothermal potential.

53. Assumptions: The economic analysis of the potential geothermal power plant was conducted for two different geothermal plant concepts assuming the possible lowest and highest temperatures. Specifically, the economic analysis was conducted for the flash cycle plant with expected resource temperature of 250°C and binary plant (Organic Rankine Cycle, ORC) with expected resource temperature of 130°C. It is important to note that the resource temperatures and related enthalpies presented here are the expected lower and upper bounds. See Annex 5 for detailed assumptions.

54. Economic Analyses: The economic analysis suggests that the potential geothermal power plant at the Karkar site is one of the least-cost supply options available for Armenia if a geothermal resource with a temperature of around 250°C exists at the site. The LEC of the potential flash cycle geothermal power plant is estimated at US\$0.060/kWh, which is below the estimated economic LEC of all new supply options available to Armenia. On the other hand, if the exploratory drilling suggests that the resource temperature is low and only binary plant would be feasible, then it will be have significantly higher LEC compared to other supply options.

Figure 1: LECs of Potential Supply Options for Armenia



Source: Bank team estimate

55. Financial analyses. The financial analysis of the potential geothermal power plant was conducted for the same two power plant concepts as in the economic analyses – Flash cycle and ORC. The financial viability of a potential power plant was estimated by estimating the minimum tariff, required to make the potential plant financially viable, with the estimated minimum tariffs for other generation options. The US\$0.08/kWh tariff required by the Flash cycle plant is the lowest compared to other supply options available to Armenia. The ORC plant is estimated to require a tariff of US\$0.25/kWh, which significantly above the required tariff for other supply options.

B. Technical

56. The project will use two-phase drilling strategy. First, one or two slim wells will be drilled to a depth of about 1,000 m in order to assess the temperature of the low resistivity layer. One or

two production-size wells will be drilled subsequently if the results from slim wells suggest that drilling of production-size wells is warranted.

57. It is common to encounter difficulties during the mechanical process of drilling of exploratory wells, the most common being: (i) unstable formations can collapse on the drill string and can trap the string inside the borehole, which can cause loss of hole, loss of tools, and may require re-drilling parts of the borehole; (ii) loss of circulation of drilling fluids into the formation may cause difficulties in clearing the cuttings from the hole, and the cuttings may accumulate in the borehole and trap the drill string; and (iii) sticking due to differential pressure may impede progress and cause loss of hole, materials, and tools. Most of these risks can however be mitigated by proper well design.

58. The key difficulty lies in the fact that before drilling, the developer does not have detailed a priori knowledge of the lithology, stratigraphy, and permeability of the formations required to correctly design a well and select techniques and materials. This knowledge is acquired only after drilling the first wells. Information gained by drilling first with a slim well is very valuable, especially in early stages of a project, even if the coring rig does not reach the same depths as the production wells. The information acquired is subsequently used to design a larger diameter well, thus avoiding and mitigating the higher risk of drilling problems and/or failure.

59. In addition, small coring rigs used for slim wells drill at a much lower cost than large rigs. For this reason, if a difficult formation is encountered with a small rig, the problem of getting through it is less costly than the same problem encountered with a large rig. Moreover, the mobilization/demobilization costs for a small rig are also typically a fraction of the cost to move a large rig, and the civil works required for a small rig are much smaller.

60. For the reasons above, drilling one (or two) slim wells will be the most inexpensive way of obtaining information not only about temperature and pressure of the geothermal resource, but also about the lithological, stratigraphic, and mechanical stability information required to plan larger diameter wells if warranted by the temperatures and permeability discovered.

C. Financial Management

61. The R2E2 Fund has adequate FM arrangements in place for the project implementation. In particular: (i) the R2E2 Fund's FM/accounting staff has significant experience in implementing Bank-financed projects; (ii) the audits of the active Bank-financed project implemented by the R2E2 Fund revealed no major issues, and (iii) the IFRs on the active project were always received on time and in general found to be acceptable to the Bank.

62. The project will produce a full set of semi-annual interim un-audited financial reports (IFRs) to be submitted to the Bank within 45 days of the end of each calendar semester, from the first disbursement and throughout the project life.

63. The FM/accounting staff of the R2E2 Fund is well aware of the Bank's disbursement procedures. The R2E2 Fund will establish and manage a Designated Account (DA) specifically for this project in the State Treasury (which is under the MOF), maintained by Central Bank of Armenia, which is holding almost all DAs for ongoing World Bank financed projects in

Armenia. No issues are expected with the government counterpart funding as the level and timeliness of the government counterpart funding under the Armenian portfolio (including the ongoing project) is adequate for a number of years. Both the Bank and counterpart funding will be managed by the R2E2 Fund.

64. The audit of the entity (the R2E2 Fund) and the project will be conducted (i) by independent private auditors acceptable to the Bank, on terms of reference (TOR) acceptable to the Bank and procured by the R2E2 Fund, and (ii) according to the International Standards on Auditing (ISA) issued by the International Auditing and Assurance Standards Board of the International Federation of Accountants (IFAC).

65. The annual audits of the entity and the project financial statements will be provided to the Bank within six months since the end of each fiscal year; and for the project also at the project closing. If the period from the date of effectiveness of the project to the end of the Recipient's fiscal year is no more than six months, the first audit report may cover financial statements for the period from effectiveness to the end of the second fiscal year. The Recipient has agreed to disclose the audit reports for the project and the entity within one month of their receipt from the auditors and acceptance by the Bank, by posting the reports on its (www.r2e2.am) web site. Following the Bank's formal receipt of these reports from the Recipient, the Bank will make them publicly available according to World Bank Policy on Access to Information. The cost of the audit will be financed from the proceeds of the project.

D. Procurement

66. The Country Procurement Assessment Review (CPAR) updated in 2009, as indicated in the previous section, concluded that the public procurement environment in Armenia is in the medium to high risk category. The procurement risk for Armenia, based on country's public procurement legislation, practices and overall procurement environment is rated as "Substantial" and is expected to remain unchanged for this project. Procurement will be carried out by the R2E2 Fund, which has prior experience with World Bank projects. The R2E2 Fund's procurement capacity, however, has shown weaknesses over the last year. Currently, the R2E2 Fund has a full-time procurement specialist and a part-time procurement consultant. However, the R2E2 Fund's procurement capacity needs to be enhanced. The procurement risk for the project is rated as "Substantial" given that: (i) the R2E2 Fund's current procurement capacity is not sufficient; (ii) the quality of procurement documents, including TORs and technical requirements prepared by the R2E2 Fund, needs to be improved, and (iii) the R2E2 Fund staff is not familiar with the specific procurement circumstances and procedures stipulated for the procurement packages under the project.

67. A preliminary Procurement Plan (PP) covering the first 18 months of project implementation has been prepared by the R2E2 Fund. A final PP, agreed by the Bank, will be prepared by project appraisal and agreed with the Bank. The final version of the Procurement Plan will be disclosed (without cost estimates) and posted on the Bank's website and www.procurement.am. More details are provided in Annex 6.

E. Social (including Safeguards)

68. The social impact of this project is expected to be positive. The project will enable to assess whether Karkar holds adequate geothermal resources for power generation and, if so, provide consumers with additional electricity generation resources, and thereby protect them from price fluctuation that is associated with possible increases of price of fuel imported for power generation. This could help minimize the effect of such price fluctuations on domestic electricity tariffs and, thereby, help keep electricity service affordable for consumers. The project also has potential to create short-term jobs during the construction of the civil works and the implementation of the drilling program. If the existence of geothermal resources is confirmed, additional short-term and long-term jobs would be created during the development and operations of a geothermal plant. Given the remote location of the Karkar site, the project could help reduce rural unemployment in the surrounding areas.

69. The Karkar exploration site is accessed via lands owned by the three local villages. The project is not expected to affect any privately owned lands, but construction activities may take place on some of the community lands owned by the villages. These lands are used for pasture, and local authorities do not expect the geothermal exploration activities to interfere with any pasture activities. Since the precise construction plans will not be known until detailed designs are finalized, a Resettlement Policy Framework (RPF) has been prepared by the R2E2 Fund in lieu of a Resettlement Action Plan (RAP). The RAPs will be prepared as needed by the R2E2 Fund, subject to review and approval by the Bank. The RAP preparation and implementation will involve in-depth public consultations with all interested stakeholders and affected people.

70. The project will promote gender-sensitive consultation mechanisms at all stages. A grievance redress mechanism (GRM), managed by HVEN, will also be in place to support citizen engagement with the project. The GRM will supplement the resettlement-specific GRM under the project and will allow all project affected people and other interested stakeholders to submit complaints, suggestions, or questions related to the project.

F. Environment (including Safeguards)

71. Safeguards Category B is proposed for the project. Although the project site is in the area with poor vegetation and modest wildlife, is remote from human settlements, and does not carry any natural resources currently used by communities or businesses, the planned works still carry moderate environmental and social risks. Therefore, the project triggers OP/BP 4.01 and is classified as environmental Category B. Potential adverse environmental impacts to be examined through the Environmental and Social Impact Assessment (ESIA) are related to the extraction of water from natural sources available nearby and its delivery to the project site, generation of excess material from drilling and other earth works, generation of waste water and possibly some small amount of hazardous waste (i.e. solid materials used and discarded while drilling, toxic materials injected during the drilling and contained in the extracted samples, and those mixed with waste water generated while drilling and/or exhausted with emissions). Likelihood and exact nature of these potential has been studied during ESIA and mitigation measures have been provided in the environmental mitigation and monitoring plan.

Annex 1: Results Framework and Monitoring
REPUBLIC OF ARMENIA: Geothermal Exploratory Drilling Project

Project Development Objectives										
PDO Statement										
The proposed project development objective is to confirm whether the geothermal resource at Karkar site is suitable for power generation and, if confirmed, to involve the private sector in development of a geothermal power plant.										
These results are at		Project Level								
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	End Target			
Indicator One: Evidence provided to the Government for its decision whether to construct or not to construct a geothermal power plant at the Karkar geothermal site (Yes/No)	<input type="checkbox"/>	Text	No	No	No	Yes	Yes	Semi-annual	Feasibility study	R2E2 Fund
Indicator Two: If geothermal resource is confirmed, power plant development is competitively awarded to qualified private developer(s) (Yes/No)	<input type="checkbox"/>	Text	No	No	No	No	Yes	Semi-annual	Concluded agreements with qualified investor	R2E2 Fund
Indicator Three: Percent of registered project related grievances responded to within stipulated service standards for response times ⁴	<input type="checkbox"/>	Percent	n/a	100%	100%	100%	100%	Semi-annual	GRM reports of R2E2 Fund	R2E2 Fund

⁴ 15 days for general complaints and 30 days for complex complaints.

Intermediate Results Indicators										
Indicator Name	Core	Unit of Measure	Baseline	Cumulative Target Values				Frequency	Data Source/ Methodology	Responsibility for Data Collection
				YR1	YR2	YR3	End Target			
Intermediate Result Indicator One: One or two slim exploratory wells drilled to a depth of around 1,000 meters (Yes/No)	<input type="checkbox"/>	Text	No	Yes	Yes	Yes	Yes	Semi-annual	Project progress reports of the R2E2 Fund	R2E2 Fund
Intermediate Result Indicator Two: One or two production-size wells drilled to a depth of around 1,800 meters if the results of the drilling of slim wells warrant such drilling (Yes/No)	<input type="checkbox"/>	Text	No	No	Yes	Yes	Yes	Semi-annual	Project progress reports of the R2E2 Fund	R2E2 Fund
Intermediate Result Indicator Three: Feasibility study for a potential power plant completed (Yes/No)	<input type="checkbox"/>	Text	No	No	No	Yes	Yes	Semi-annual	Project progress reports of the R2E2 Fund	R2E2 Fund
Intermediate Result Indicator Four: Tendering for private sector involvement in construction of a geothermal power plant completed if results from the feasibility study confirm the technical and economic/financial viability of such a plant (Yes/No)	<input type="checkbox"/>	Text	No	No	No	No	Yes	Semi-annual	Project progress reports of the R2E2 Fund	R2E2 Fund
Intermediate Result Indicator Five: R2E2 Fund publishing reports on GRM (disaggregated by gender) and how the issues were resolved	<input type="checkbox"/>	Text	None	Semi-annual report on GRM, including responses and resolution of issues	Semi-annual report on GRM, including responses and resolution of issues	Semi-annual report on GRM, including responses and resolution of issues	Semi-annual report on GRM, including responses and resolution of issues	Semi-annual	GRM reports of R2E2 Fund	R2E2 Fund

Annex 2: Detailed Project Description

REPUBLIC OF ARMENIA: Geothermal Exploratory Drilling Project

1. Armenia is located in a zone of high tectonic activity and recent volcanism. Several preliminary assessments carried out in the 1990s and 2000s, both with donor support and by the Ministry of Energy and Natural Resources (MENR), confirmed the existence of geothermal resources in various parts of the country and identified potential areas where resources could be suitable for power generation. The most promising sites identified were Karkar, Jermaghbyur, Grizor, and some other sites with combined potential power output of 150 MW. However, none of these assessments included comprehensive surface exploration works in any of those areas.

2. The Geofund 2: Armenia Geothermal Project, approved in 2009, provided financing to carry out comprehensive field investigation studies for the most promising geothermal sites, Gridzor⁵ and Karkar,⁶ in order to assess the feasibility of exploratory drilling at the site with the highest potential. Studies included geological field scouting, magneto-telluric (MT) sounding surveys for both sites and interpretation of their results, and 3D MT survey and interpretation of its results for the Karkar site, which was deemed to have the highest geothermal potential.

3. The 3D MT modeling identified the existence of a 600 m thick conductive zone lying South/South West – North/North East at a depth of around 500-1000 m below the surface and indicated that two different conceptual models (or a combination of the two) might exist for the Karkar site. Model A assumes that the low resistivity is not present in the geothermal zones of interest, which would mean that the reservoir only holds moderately warm waters (less than 100°C). Model B assumes that the low resistivity may be present in geothermal zones of interest, providing for a localized high-temperature source of heat (i.e. some of the layers could hold water above 250°C). Determining whether the Karkar field holds low or high temperatures will thus require drilling exploratory wells in the fissure zone located in the western part of the basin in order to determine the nature of the low resistivity structure.

72. Additional surface exploration was carried out by ISOR and GEORISK in August 2014 to provide a more accurate recommendation on the location of the exploratory wells. This included soil gas diffusing measurements⁷ and a GeoRadar study⁸. Reconciliation of the data from these two studies resulted in the following coordinates for the slim wells to be drilled at the Karkar site (39°46'54"N, 45°57'37"E for well B1 and 39°47'3"N; 45°56'50"E for well B2). The production-size wells will be drilled at the same location as the slim wells and the final coordinates will be determined after the drilling of the slim wells is completed and if results justify the drilling of production-size wells.

⁵ Located on the Gegham mountain plateau in the South Eastern part of Armenia.

⁶ Located on the Syunik plateau in the South Eastern part of Armenia.

⁷ The soil gas diffusion method aims mainly at trying to identify the faults that are most likely to be active, which are the ones that may act as a channel for hydrothermal brine towards the surface.

⁸ The GeoRadar technique (ground penetrating radar) is a method that uses radar pulsing (radio waves) to detect shallow subsurface structures. This technique may be able to detect faults and fractures as well as horizontal layering (structures).

4. The proposed project consists of two components: (1) Exploratory drilling and construction of related infrastructure; and (2) Technical assistance for assessment of the geothermal resource potential and technical supervision.

5. **Component 1: Exploratory drilling and construction of related infrastructure (US\$9,212,500, including US\$7,370,000 SREP grant).** This component will finance:

6. **Sub-component 1.1: Construction of access road, water supply infrastructure and rig pads (US\$812,500, including US\$650,000 SREP grant).** This will include construction of: (a) a gravel road with sufficient length and width to allow for safe transportation of equipment and other materials to the site; (b) infrastructure to supply the water from the nearby springs or the river to ensure a continuous water supply required for the drilling operation if drilling of production-size wells is warranted; and (c) preparation of the rig pads where the rig, and the associated equipment will be placed, if drilling of production-size wells is warranted.

7. Drilling of slim wells does not require preparation of the rig pad and water supply infrastructure given that truck-mounted rigs are used and drilling of slim wells is not water-intensive process.

8. **Sub-component 1.2: Drilling of exploratory wells (US\$8,400,000, including US\$6,720,000 SREP grant).** This will include drilling of one or two slim wells followed by one or two production-size wells if results from drilling of slim well(s) warrant drilling of production-size wells.

9. It may be possible to flow test the slim well(s) with airlift and get some indications on flow capacity and brine, besides temperature measurements. The project will first finance drilling of one or two slim wells (with diameter of 3 ½ inches) to a depth of 1,000 meters in order to confirm the nature of the low resistivity layer located at 500-1,000 m and to measure the temperature just below it (phase 1). This would be followed by intermediate (with diameter of 6 1/8 inches) or full-size production wells (with diameter of 8 ½ inches) to a depth of about 1,800 meters in order to reach into the resource and test its temperature and flow and directly estimate its potential for power generation (phase 2). The decision about whether to drill intermediate or full-size production size wells will only be made after phase 1 has been completed and will depend both on the information obtained from the slim well(s) as well as on the remaining budget..

10. This approach is based on the following reasons: (a) the cost of a slim well is estimated to be 40 percent lower than the cost of an intermediate-size production well and about 50 percent lower than the cost full-size production well, so the costs would be minimized if the downside risk materializes (i.e. low temperature resource is found); (b) the geological information gathered from slim wells is very useful to reduce the risk of encountering costly mechanical problems when drilling production-size wells; (c) drilling of a slim well is not a water-intensive process and does not require construction of lengthy and costly water supply infrastructure required for drilling of production size wells; and (d) the potential environmental and social impacts of drilling only slim wells are likely to be of lower magnitude.

11. Depending on the information obtained from the first slim well, a decision to drill a second one may be made. Based on the results from the slim well(s), the following scenarios are illustrative of the possible outcomes of the exploratory drilling activities:

- Scenario 1: If the results from the first or second slim well show that reservoir temperature is below 110°C, the project would stop (given that such low temperatures are not expected to be suitable for commercial power generation) and the remaining project funds will be cancelled and returned to SREP.
- Scenario 2: If the results from the first or second slim well show that the reservoir temperature is in the 110-200°C range, then the Government will decide whether it would like to build a binary geothermal power plant (which is the only option for such temperatures) considering energy costs of such a plant. If the Government decides to pursue construction of such a binary power plant, then one or two production wells would be drilled. The choice between full-size and intermediate-size production wells will depend on the remaining budget available under the project after drilling of slim wells.
- Scenario 3: If the results from the first slim well show that the reservoir temperature is above 200°C, then the Government will initiate construction of flash cycle power plant (which will most likely be among the lowest cost power supply options available to the Government). Thus, the Government will proceed to drill one or two production-size wells, same as under Scenario 2 above.

12. **Component 2: Technical assistance for assessment of the geothermal resource potential and technical supervision (US\$1,475,000, including US\$1,180,000 SREP grant).** This component will finance: This component will finance:

13. **Sub-component 2.1: Well logging and mud logging (US\$375,000, including US\$300,000 SREP grant).** This will include analyses of the cuttings from the borehole, hole temperature and pressure measurements and gathering of essential data (such as drilling progress, changes in flow line temperatures, etc.), both as the drilling progresses and at the end of each drilling stage.

14. **Sub-component 2.2: Feasibility study for a geothermal power plant (US\$375,000, including US\$300,000 SREP grant).** This will include: (a) assessment of the possible power output of the well, the ratio between brine and steam; (b) assessment of enthalpy; (c) sampling of the brine to decide the type of power conversion techniques to be used and the type of the plant to be constructed, and estimate the power generation potential for a potential geothermal power plant; (d) assessment of the economic and financial viability of the potential plant; (e) legal gap analyses of the institutional and regulatory framework for construction and operation of a geothermal power plant; and (f) preparation of conceptual/preliminary design of transmission lines and a substation, and other transmission infrastructure required for connection of the potential power plant to the grid.

15. **Sub-component 2.3: Technical supervision and support consultant (US\$375,000, including US\$300,000 SREP grant).** This will include support to the R2E2 Fund in technical supervision of the drilling operation; review of the results and findings of well logging, mud logging, flow testing, and chemical analyses of cuttings; and other technical advice and support.

16. **Sub-component 2.4: Transaction advisory (US\$250,000, including US\$200,000).** This will include provision of transaction advisory services to the Government in order to structure and complete PPP transaction involving the private sector in construction and operation of the geothermal power plant if resources are confirmed. The transaction advisory services will support financial structuring of the transaction; marketing of the project among potential investors; preparation of the tender documents for involvement of private operator; drafting of legal documents; negotiations with developers; and financial close.

17. **Sub-component 2.5: Operating costs (US\$100,000, including US\$80,000) and project audit.** This will include: (a) incremental operating costs such as salaries of staff members, except for those who are civil servants; office supplies; minor office equipment; field trips; consuming materials; utilities; operation and maintenance costs, mass media and printing costs; in-country and international travel costs; communication costs, reasonable banking charges and other costs directly associated with the project implementation, based on the annual budgets and acceptable to the Bank; and (b) project audits.

18. The project has been designed as a 5-year operation in order to ensure that all the necessary activities can be completed given the limitations on site accessibility caused by weather conditions and also given the time needed to complete the PPP transaction for the power plant. The “window of opportunity” for accessing the site is generally from mid-May to mid-September, so at least two seasons would be needed to complete the drilling project. However, the project may be completed in one year if the drilling of the slim well(s) suggests that the resource is a low-temperature.

Figure 2.1: Simplified project implementation timeline

	05/15	07/15	08/15	09/15	01/16	09/16	10/16	11/16	07/17	01/19	04/20
Road construction is completed											
Drilling of the first slim well is completed											
Drilling of the second slim well (if required) is completed											
↓											
If results from slim well(s) are promising											
↓											
Construction of water supply infrastructure is completed											
Procurement of a drilling contractor for production-size wells is completed											
Drilling of production-size well(s) is completed											
Cooling of the well(s)											
Feasibility study is completed											
Bidding for power plant construction and											

	05/15	07/15	08/15	09/15	01/16	09/16	10/16	11/16	07/17	01/19	04/20
operation is completed											
Financial close											

Annex 3: Implementation Arrangements

REPUBLIC OF ARMENIA: Geothermal Exploratory Drilling Project

Project Institutional and Implementation Arrangements

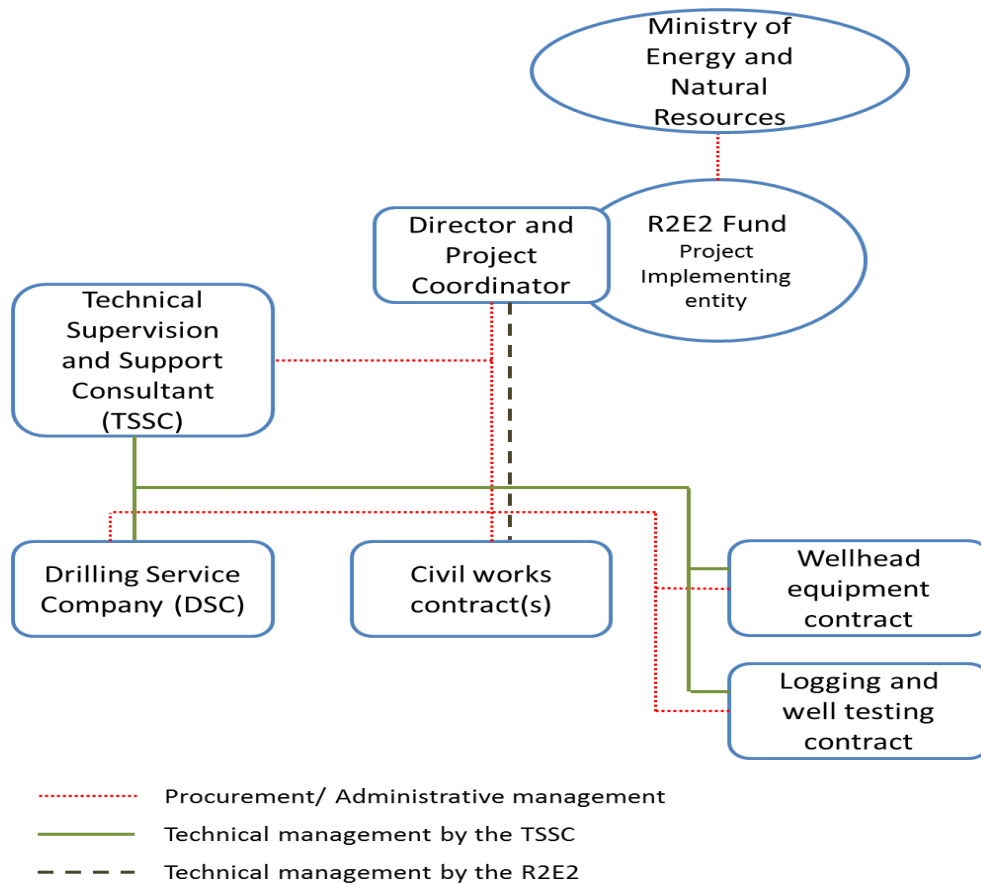
19. The R2E2 Fund is a non-profit organization established by the Government in 2005 with the mandate to promote the development of renewable energy and energy efficiency markets in Armenia and to facilitate investments in these sectors. The implementation of the project as well as overall operations of the R2E2 Fund will be supervised by the Board of Trustees (BOT), consisting of representatives of the government agencies, NGOs, and the private sector, thus, ensuring required professional expertise. The BOT is chaired by the Minister of Energy and Natural Resources.

20. The R2E2 Fund has experience with World Bank projects. It is currently implementing the GEF Energy Efficiency Project, and has implemented a number of other Bank-financed projects (Urban Heating Project, Renewable Energy Project, and the Geofund 2: Armenia Geothermal Project).

21. Geothermal exploratory drilling projects are complex to implement given the large number of separate highly specialized consultant services as well as works and supply contracts that must be procured and managed on a flexible and time sensitive way. Given the lack of relevant expertise in Armenia, the R2E2 Fund will hire an implementation support consultant (specializing in geothermal drilling projects) to provide the necessary technical, coordination and project management support that is required to execute a timely and cost-effective drilling operation.

22. For developers without the required relevant experience, such as the R2E2 Fund, the use of integrated drilling services is recommended. Under this approach, equipment and, even in some cases, materials that are directly related to the drilling are integrated in one single contract under the responsibility of a Drilling Service Company (DSC). This simplifies project management since the number of contracts is reduced from about 8-10 in the traditional approach to only 3-4 contracts. The project implementation and reporting structure is depicted in the figure below.

Figure 3.1: Project implementation structure



23. The responsibilities of the R2E2 Fund and the Technical Supervision and Support Consultant are presented below:

24. R2E2 Fund: The role of the R2E2 Fund will be to coordinate and maintain effective project management, procurement, contract negotiation, contract administration and project budget oversight and control.

25. Technical Supervision and Support Consultant: The R2E2 Fund will select a technical supervision and support consultant (TSSC) to perform the technical management of the physical drilling operations. The TSSC would assume the role traditionally played by the client's geothermal technical team by providing overall program coordination and technical management of the drilling operations. The TSSC will help to manage the Drilling Service Company (DSC) and the two additional contracts, i.e. the well testing and logging contract and the completion wellhead equipment contract.

26. The TSSC will have only a consulting role with no scope for material or equipment supply. In addition, the TSSC will not be responsible for contract procurement or the administration of

contracts inclusive of invoice approval for the various contractors. These procurement and administrative tasks would be performed by the R2E2 Fund. However, the TSSC will be responsible for the technical aspects of the procurement process for the DCS and the additional specialty contracts and would provide the direct technical management of the contracts that are entered directly by the R2E2. This would include development of the TORs after which the TSSC would take a lead role in the technical evaluation of the proposals for various drilling related highly specialized consultant services.

27. The TSSC would be responsible for on-site drilling supervision and would have the authority to make decisions on any technical issues on behalf of the R2E2 Fund, including but not limited to introducing changes in the drilling program, requesting operational changes and modifying procedures during the execution of the work.⁹ It is then essential that the drilling supervisor(s) on site¹⁰ is fully authorized to make quick decisions as drilling progresses in order to prevent costly delays in the project. Moreover, all communication channels must be well defined and clearly mapped out at the beginning of the project in order to ensure that the R2E2 Fund and TSSC can perform their technical obligations respectively in a coordinated manner.

Financial Management, Disbursements and Procurement

Financial Management

28. The R2E2 Fund has adequate FM arrangements in place for the project implementation. In particular: (i) the R2E2 Fund's FM/accounting staff has significant experience in implementing Bank-financed projects; (ii) the audits of the active Bank-financed project implemented by the R2E2 Fund revealed no major issues, and (iii) the IFRs on the active project were always received on time and in general found to be acceptable to the Bank.

29. The overall FM risk for the project before and after mitigation measures is assessed as Moderate.

30. The R2E2 Fund is capable of preparing relevant budgets. The annual budget is based on procurement plan. The director, the financial manager and the procurement specialist are involved in the preparation of the annual budget. The budget is prepared in such detail, which is necessary for monitoring of the project. It is classified by categories, components and sub-components, and sources of funds. The director, the financial manager, and the procurement specialist are involved in the preparation of the annual budget. The final plans and budgets are submitted to the MOF for approval. When the budget is approved by the MOF, it is submitted to the Management Board for approval. The R2E2 Fund agrees all variations from the budget with the Bank and the Government in advance, and then makes changes in the annual budget. The

⁹ Specific responsibilities of the drilling supervisor would also include, among others: monitoring that rig up, drilling, and well completion are carried out according to the contract; certifying all materials and equipment used in the drilling activities, certifying book keeping for drilling materials, conducting daily operations meetings with the drilling contractor; approving all the contractor's reports; and approving any deviation from the drilling program.

¹⁰ The drilling supervisor on site needs to have wide experience on geothermal drilling activities, with emphasis on drilling in high temperature geothermal systems. He will need to be accessible 24 hours at the drilling location.

budgeted amounts are incorporated into IFRs. The IFRs also indicated the detailed variances between planned and actual expenditures.

31. There is adequate FM/accounting staffing in place at the R2E2 Fund. The R2E2 Fund utilizes 1C accounting software, used by a number of PIU in Armenia and found to be adequate. For the project accounting and reporting accrual basis is applied, and for the entity accounting and reporting IFRS is applied. The current chart of accounts for the ongoing project will be adapted to be used for the project as well. The accounting policies and procedures are properly documented in the Fund's FMM which will be updated to reflect the activities of the project.

32. The R2E2 Fund has overall acceptable and well documented internal control system in place, and the R2E2 Fund will update its FMM to include the activities of the project. There is a proper segregation of duties between the staff.

33. The project management-oriented IFRs will be used for the project monitoring and supervision. The R2E2 Fund has significant experience in IFR preparation, and the IFRs of active project were always received on time and in general found to be acceptable to the Bank.

34. The format of the IFRs has been confirmed during assessment and includes: (i) Project Sources and Uses of Funds, (ii) Uses of Funds by Project Activity, (iii) Designated Account Statements, (iv) A Statement of the Financial Position, and (v) SOE Withdrawal Schedule.

35. The R2E2 Fund will be producing a full set of IFRs every calendar semester throughout the life of the project. These financial reports will be submitted to the Bank within 45 days of the end of each calendar semester.

36. The R2E2 Fund's current auditing arrangements are satisfactory to the Bank (there are no pending audits for the projects implemented by the R2E2 Fund, and no major issues were mentioned in the latest audit of the active project implemented by the R2E2 Fund), and it has thus been agreed that similar audit arrangements will be adopted for the project, to cover the project financial statements. The audit of the entity (the R2E2 Fund) and the project will be conducted (i) by independent private auditors acceptable to the Bank, on terms of reference (TOR) acceptable to the Bank and procured by the R2E2 Fund, and (ii) according to the International Standards on Auditing (ISA) issued by the International Auditing and Assurance Standards Board of the International Federation of Accountants (IFAC).

37. The annual audits of the entity and the project financial statements will be provided to the Bank within six months since the end of each fiscal year; and for the project also at the project closing. If the period from the date of effectiveness of the project to the end of the Recipient's fiscal year is no more than six months, the first audit report may cover financial statements for the period from effectiveness to the end of the second fiscal year. The Recipient has agreed to disclose the audit reports for the project and the entity within one month of their receipt from the auditors and acceptance by the Bank, by posting the reports on its (www.r2e2.am) web site. Following the Bank's formal receipt of these reports from the Recipient, the Bank will make them publicly available according to World Bank Policy on Access to Information. The cost of the audit will be financed from the proceeds of the project.

Disbursements

38. The FM/accounting staff of the R2E2 Fund is well aware of the Bank’s disbursement procedures. The R2E2 Fund will establish and manage a Designated Account (DA) specifically for this Project in the State Treasury (which is under the MOF), maintained by Central Bank of Armenia, which is holding almost all DAs for ongoing World Bank financed projects in Armenia.

39. The project funds will flow from the Bank, either: (i) via the DA to be maintained in the Treasury, which will be replenished on the basis of SOEs or full documentation; or (ii) on the basis of direct payment withdrawal applications and/or special commitments, received from the R2E2 Fund. The government funding will be made via the Treasury through regular budget allocation procedures initiated by the implementing agency in accordance with standard Treasury and Budget execution regulations. No issues are expected with the government counterpart funding as the level and timeliness of the government counterpart funding under the Armenian portfolio (including the ongoing project, w) is adequate for a number of years. Both the Bank and counterpart funding will be managed by the R2E2 Fund.

40. Withdrawal applications documenting funds utilized from the DA will be sent to the Bank at least every three months. The following disbursement methods may be used under the project: Reimbursement, Advance, Direct payment and Special Commitment. The DA ceiling is proposed to be established at US\$800,000, which will be finalized and reflected in the Disbursement Letter. Detailed instructions on withdrawal of credit proceeds are provided in the Disbursement Letter.

Procurement

41. The project risk for procurement is rated as “Substantial.” The procurement assessment concluded that the R2E2 Fund currently does not have adequate experience and capacity for the successful implementation of the project. The risks have been identified taking into account the circumstances outlined in Section VI (D) in the main text. The procurement related risks are summarized in the table below:

Description of Risk	Rating of Risk	Mitigation Measures	Rating of Residual Risk
The current procurement capacity of the R2E2 Fund is not sufficient	Substantial	The R2E2 Fund procurement staff should participate in all the procurement trainings/workshop organizing by the Bank locally, regionally or internationally.	Moderate
The R2E2 Fund does not currently have sufficient in-house capacity to carry out such complex procurement as required by the project	Substantial	The R2E2 Fund would hire procurement consultants with international and local experience for project implementations	Moderate

Being in a multi-stakeholder environment, the possible interferences and pressures from different groups could result in implementation delays	Moderate	Ensure that: (i) project implementation is protected from the interferences and pressures of special interest groups to avoid delays; (ii) that decision making is transparent and based on disclosed evaluation criteria in bidding documents and proposal documents.	Low
Low quality of the procurement/selection documents prepared by the R2E2 Fund	Substantial	The Fund will make additional efforts to improve the quality of the technical components in procurement documents, including TORs for consulting services.	Moderate

42. Procurement for the project will be carried out in accordance with the World Bank's "Guidelines: Procurement of Goods, Works and Non-consulting Services Under IBRD Loans and IDA Credits and Grants" dated January 2011 and revised as of July, 2014 (Procurement Guidelines); and "Guidelines: Selection and Employment of Consultants Under IBRD Loans and IDA Credits and Grants by World Bank Borrowers" dated January 2011 and revised as of July 2014 (Consultant Guidelines) and the provisions stipulated in the Legal Agreement (LA) and POM. The World Bank Guidelines on Preventing and Combating Fraud and Corruption in Projects Financed by IBRD Loans and IDA Credit and Grants dated October 15, 2006 and revised on January 2011, would also apply. The implementation arrangements will be described in the Operational Manual (OM) for the project that will be prepared by the R2E2 Fund and submitted for the Bank's review and approval. The various items to be procured under the project and the different expenditure categories are described below.

General Procurement Notice

43. A General Procurement Notice (GPN) will be published on **XXXX, 2015 in UNDB** on-line and in its printed version. Specific Procurement Notices (SPN) will be published for all Procurement and Consulting contracts as per Guidelines, as the corresponding bidding documents and RFPs become ready and available.

Thresholds for Procurement Methods

44. Goods: Goods and equipment estimated to cost US\$1,000,000 or more would be procured through International Competitive Bidding (ICB). Goods estimated to cost less than US\$1,000,000 and equivalent or more than US\$100,000 may be procured through National Competitive Bidding (NCB). Readily available off-the-shelf goods estimated to cost less than US\$100,000 each may be procured through Shopping (SH) on the basis of at least three written quotations obtained from qualified suppliers. The World Bank sample for Invitation to Quotes shall be used. Direct Contracting method for goods consistent with justifications per Procurement Guidelines will be subject to the World Bank prior review.

45. Works: Works estimated to cost US\$5,000,000 and more would be procured through ICB. Works estimated to cost less than US\$5,000,000 and equivalent or more than US\$200,000 may be procured through NCB. Contracts estimated to cost less than US\$200,000 each may be

procured through Shopping (SH) procedures on the basis of at least three written quotations obtained from qualified contractors. Direct Contracting method for works consistent with justifications per Procurement Guidelines will be subject to the World Bank prior review.

National Competitive Bidding of the Borrower may be used for procurement of goods, works and non-consulting services for the Project, provided that the following provisions are complied with:

- (i) entities in which the Republic of Armenia owns a majority shareholding shall not be invited to participate in tenders for the Government unless they are and can be shown to be legally and financially autonomous and operate under commercial law;
- (ii) post-qualification criteria shall only pertain to past contract performance, financial, managerial and technical capabilities of bidders;
- (iii) joint venture partners shall be jointly and severally liable for their obligations;
- (iv) estimated contract prices shall not be advertised;
- (v) no bids shall be rejected at the bid opening;
- (vi) no bids shall be rejected solely because they exceed the estimated price. Bids can be cancelled and new bids invited, only if the conditions of clause 2.61-2.64 of the Procurement Guidelines and clause 2.33-2.34 of Consultant Guidelines are met;
- (vii) all bid evaluation criteria shall be quantifiable in monetary terms or expressed as a pass/fail criteria; and
- (viii) advance Bank's approval is required for any modifications in the contract scope/conditions during implementation.

46. Consultant Services and Training: Consultancy services to be provided by consulting firms would be procured through Quality and Cost Based Selection (QCBS) method. Other methods such as Consultant Qualification based method (CQBS), Fixed Budget Selection (FBS), Quality Based Selection (QBS), and Least Cost Selection (LCS) shall be made available through legal agreement. Individual Consultants (IC) will be selected in accordance with Section V of the Consultancy Guidelines. Single/Sole Source Selection method for firms and individuals consistent with justifications per Consultant Guidelines will be subject to the World Bank prior review. For assignments estimated to cost US\$300,000 and less, the shortlist may be comprised only of national firms according to the paragraph 2.7 of the Consultant Guidelines. However, if foreign firms express interest, they shall be considered.

47. Operating expenditures: Operating expenditures are not subject to the Procurement and Consultant Guidelines. The procurement under this category may follow the national procedures. Nevertheless, in case of selection/appointment of the managerial and key staff of the R2E2 Fund, the Recipient shall provide the Bank team with the TOR and the qualification assessment report of the selected candidates for review and comments/opinion, prior to offering the contracts to the preferred candidates. Operating cost will not include salaries of civil servants.

Post Review Ratio

48. Contracts not subject to Bank's prior review will be post reviewed by Bank's supervision missions and/or during regular post-reviews by PAS on sampling basis, i.e. 1 out of every 5 contracts. Post review ratio is 20 percent. Procurement supervision mission would be carried out by the Bank to include: (a) review of procurement plan; (b) physical inspection of goods; consultant's reports (outputs); and (c) site visits of works contracts. There would be one supervision mission every year to carry out post review of procurement actions.

Filing and records keeping

49. The R2E2 Fund will be in charge of filling and record keeping. The R2E2 Fund has experience in this activity from other WB-financed projects.

Anti-Corruption Measures

50. The Recipient shall ensure that the project, including procurement, is carried out in compliance with the current version of the Bank's Anti-Corruption Guidelines.

51. All bidding documents, including contracts, used under the project shall include the latest version of the provisions on fraud and corruption.

52. All members of the evaluation committees shall sign a disclaimer on absence of conflict of interest and confidentiality for each evaluation process.

Procurement Plan

53. For each contract to be financed under the project, the various procurement or consultant selection methods, the estimated costs, prior review requirements, and time frame have been agreed between the Recipient and the Bank and presented in the Procurement Plan (Annex 6). The procurement plan discloses also the prior review thresholds.

54. The TORs of consulting assignments (individual and firm) and technical specifications of procurement packages are subject to prior review of the TTL. All cancellation of selection process and/or re-invitation shall be subject to Bank's prior review. All the contracts where cost estimate was below the Bank's prior review threshold are subject to prior review if the financial offer of the selected firm exceeds such threshold at the proposal evaluation stage. Irrespective of the thresholds, the selection of all consultants (firm and individuals) hired for legal work or for procurement activities as well as the individual hired for long-term technical assistance or advisory services for duration of the project (or most of it) are subject to prior review.

55. The Procurement Plan will be updated at least semiannually or as required to reflect the actual project implementation needs and improvements in institutional capacity. The Procurement Plan its updates or modifications, shall be subject to the Bank's prior review and no objection before implementation. The final version of the Procurement Plan will be disclosed (without of cost estimation) and posted on the Bank's external website in accordance with

paragraph 1.18 of Procurement Guidelines and paragraph 1.25 of the Consultants Guidelines and on free accessed website www.procurement.am.

Environmental and Social (including safeguards)

56. Environmental: Safeguards Category B is proposed for the project. Although the project site is in the area with poor vegetation and modest wildlife, is remote from human settlements, and does not carry any natural resources currently used by communities or businesses, the planned works still carry moderate environmental and social risks. Therefore, the project triggers OP/BP 4.01 and is classified as environmental Category B. Potential adverse environmental impacts to be examined through the ESIA are related to the extraction of water from natural sources available nearby and its delivery to the project site, generation of excess material from drilling and other earth works, generation of waste water and possibly some small amount of hazardous waste (i.e. solid materials used and discarded while drilling, toxic materials injected during the drilling and contained in the extracted samples, and those mixed with waste water generated while drilling and/or exhausted with emissions). Likelihood and exact nature of these potential risks will be studied during ESIA and mitigation measures will be provided in the environmental mitigation and monitoring plans.

57. Social: The social impact of this project is expected to be positive. The project will enable to assess whether Karkar holds adequate geothermal resources for power generation and, if so, provide consumers with additional electricity generation resources, and thereby protect them from price fluctuation that is associated with possible natural gas and uranium price increases. This could help minimize the effect of such price fluctuations on domestic electricity tariffs and, thereby, help keep electricity service affordable for consumers. The project also has potential to create short term jobs during the construction of the civil works and the implementation of the drilling program. If the existence of geothermal resources will be confirmed, additional short-term and long-term jobs would be created during the development and operations of a geothermal plant. Given the remote location of the Karkar site, the project could help reduce rural unemployment in the surrounding areas.

58. The nearest villages to the Karkar exploration site are Tsghuk, Sarnakunk, and Spandaryan, all located on Highway M2. The combined population of these villages is of <1,500 people. Their residents own almost 4,500 sheep, and more than 3,000 bovine cattle. The project is not expected to affect any private lands, but construction activities may take place on some of the community lands owned by the villages. These lands are used for pasture, and local authorities do not expect the geothermal exploration activities to interfere with any pasture activities. In fact, local authorities are highly interested in the improvement of the access road to the Karkar site, as an improved road will help local communities to transit shepherds and cattle. In addition, the road will enable people to access more easily a hot spring that is located in the highlands and that is known for its medical benefits.

59. Since the precise construction plans will not be known until detailed designs are finalized, a Resettlement Policy Framework has been prepared by the R2E2 Fund in lieu of a Resettlement Action Plan. RAPs will be prepared as needed by the R2E2 Fund, subject to review and approval by the Bank. RAP preparation and implementation will involve in-depth public consultations with all interested stakeholders and affected people

60. The project will support widespread stakeholder information-sharing and consultation before commencement of civil works as well as during preparation of project ESIA, EMP, RPF and RAPs (if required). Project activities and potential risks will be communicated in a transparent manner. The project will promote gender-sensitive consultation mechanisms at all stages.

61. The GRM will be operated by R2E2 Fund and will supplement the resettlement-specific GRM to allow project affected people and other interested stakeholders to submit all types of complaints, suggestions, or questions related to the project. R2E2 Fund will be responsible for widely advertising the availability of the GRM (on public billboards, in the vicinity of construction sites, in its offices, etc.), and it will accept complaints submitted via regular mail, email, phone, or as part of in-person meetings. All complaints will be registered by R2E2 Fund and a tracking registration number will be assigned to each complainant. Regular complaints will be addressed within 15 days, and complex complaints that require further inquiry will be addressed within 30 days (the complainant will be notified accordingly in such a case). In case that the complaint cannot be resolved by R2E2 Fund, they will be responsible for registering it, conveying to the relevant authority, and notifying the complainant accordingly. All responses will be provided to complainants in a written form. The implementation of the GRM will be monitored as part of Key Indicator #3 on the percent of registered project related grievances responded to within stipulated service standards for response times.

Monitoring & Evaluation

62. The R2E2 Fund will be responsible for monitoring and evaluation of project progress. The R2E2 Fund will monitor and evaluate the progress towards achievement of the development objective and the intermediate result indicators reflected in Annex 1, which were defined to match the phased project approach. The R2E2 Fund will be sending quarterly project progress reports to the Bank based on the regular reports by the Drilling Contractor and the consultants on: (a) drilling parameters; (b) drilling and/or coring logs, mud logs, and wire line logs; (3) casing and cementing programs, including detailed well drawings; (4) results of all well tests (production, injection, and interference), including logs; (5) results of all geochemical sampling, analyses and calculation of geo-thermometers, scaling, corrosion potential, etc.; and (6) any other relevant drilling records. In order to ensure that the R2E2 Fund has adequate capacity to reliably monitor and evaluate this critical information, the R2E2 Fund will rely on the expertise of the TSSC to be hired under the project.

Annex 4: Implementation Support Plan
REPUBLIC OF ARMENIA: Geothermal Exploratory Drilling Project

Strategy and Approach for Implementation Support

63. The strategy for implementation support (IS) has been developed based on the nature of the project and its risk profile. It aims to make IS to the client more flexible, efficient and focused on preventing risks and efficiently addressing implementation challenges.

Implementation Support Plan

64. The Bank team members will be based at headquarters and in the Armenia and regional country offices to ensure timeline, efficient and effective implementation support to the client. Formal implementation support missions and field visits will be carried out twice a year.

65. Technical. The geothermal specialist on the Bank team will provide the required assistance, advice and guidance to the R2E2 Fund on various technical aspects of geothermal drilling operation. The Bank's and R2E2 Fund staff will conduct site visits during site preparation, drilling and well testing activities.

66. Procurement. The procurement team will provide timely support to the R2E2 Fund in order to improve its capacity and contract management efficiency, as well as a part of its project implementation support and supervision missions.

67. Financial Management. As part of its Project implementation support and supervision missions, the Bank will conduct risk-based financial management implementation support and supervision within a year from the Project effectiveness, and then at appropriate intervals. During the Project implementation, the Bank will supervise the Project's financial management arrangements in the following ways: (a) review the Project's semi-annual IFRs as well as the entity's and the Project's annual audited financial statements and auditor's management letters and remedial actions recommended in the auditor's management letters; and (b) during the Bank's on-site missions, review the following key areas (i) Project accounting and internal control systems; (ii) budgeting and financial planning arrangements; (iii) disbursement arrangements and financial flows, including counterpart funds, as applicable; and (iv) any incidences of corrupt practices involving Project resources. As required, a Bank-accredited Financial Management Specialist will participate in the implementation support process.

68. Environmental and social safeguards: The environmental and social specialists will closely supervise implementation of the ESIA, RPF and RAP (if required) of the project. The environmental and social specialist will conduct field visits on annual basis to monitor implementation of safeguards policies.

Time	Focus	Skills Needed	Resource Estimate (staff weeks (SW))
First twelve months	Task management	Sr. Energy Economist / Energy specialist	5 SWs
	Technical review of the bidding documents and general support with technical aspects of drilling operation	Geothermal expert	8 SWs
	Procurement review of the bidding documents	Procurement specialist	6 SWs
	Financial management	Sr. Financial management specialist	1 SWs
	Environmental supervision	Sr. Environmental specialist	2 SWs
	Social supervision	Social safeguards specialist	1 SW
12-54 months	Task management	Sr. Energy Economist / Energy specialist	16 SWs
	Guidance and implementation support on technical issues	Geothermal expert	16 SWs
	Review of procurement documents, and procurement guidance	Procurement specialist	10 SWs
	Financial management and disbursements	Financial management specialist	6 SWs
	Environmental supervision	Environmental specialist	4 SWs
	Social supervision	Social development specialist	2 SWs

73. The staff skill mix and focus in terms of implementation support is summarized in the tables below.

Skills Mix Required

Skills Needed	Number of Staff Weeks	Number of Trips	Comments
Task management	21	Field trips as required	Country office based
Geothermal expert	24	3-4	Headquarters based
Procurement specialist	16	Field trips as required	Country office based
Sr. Financial management specialist	7	Field trips as required	County office based
Environmental specialist	6	4	Georgia office based
Social specialist	3	3	Headquarters based

Annex 5: Economic and Financial Analysis
REPUBLIC OF ARMENIA: Geothermal Exploratory Drilling Project

74. This section contains description of the rationale for public financing of the project; summary of the value added of the Bank's support; economic analysis of the project; and financial analysis of the project.

75. **Rationale for public sector financing:** Most of the international geothermal development experience shows that the upstream phases (resource confirmation) of development inevitably rely strongly on public sector investment, with private developers entering the project at more mature phases (i.e. when resource risk has been significantly reduced).

76. Unlike other renewable energy technologies, such as wind, solar, and hydro, it is not possible to validate the geothermal resource with sufficient confidence for commercial development without performing exploratory drillings at depth to assess specific geologic conditions in the field. After completing surface exploration, a conceptual model of the geothermal field is developed, which needs to be validated with the results of exploration drilling. The combination of relatively high capital requirements (typical costs for drilling are in the range of US\$2-US\$5 million per well), high uncertainty of this phase, and time taken to complete this resource validation phase, about 3 years, deter commercial investors.

77. Therefore, by using grant resources from SREP, the Government can help reduce the risk of developing the site for the private sector. If a geothermal resource exists at the site, this support can assist in making geothermal power a financially attractive investment for private investors and an affordable source of electricity for Armenia's grid.

78. The support can also serve to demonstrate the feasibility of geothermal power in Armenia. A first successful project can build domestic capacity in the development of additional geothermal resources in the country's other prospective geothermal sites. It will also build investor confidence that geothermal is a viable and profitable investment opportunity in Armenia.

79. **Value added of the Bank's support:** The Bank has a long history of supporting geothermal development. Over US\$2.2 billion in financing provided by the Bank has led to total project investments of more than US\$5.5 billion in these endeavors. Although the Bank financing for geothermal, as well as that of other donors, has historically focused on the downstream phases of project development (i.e. construction of power plants and associated infrastructure), ongoing engagements in Kenya, Ethiopia and Djibouti put the Bank at the forefront of support for the riskier exploratory and production drilling stages. The leading role played by the World Bank in the country's sector dialogue, and the access to a wide network of geothermal experts built through the Global Geothermal Development Plan make the World Bank a very strong partner to the Government for further exploration and subsequent development of its geothermal potential.

80. **Economic analyses of the potential geothermal power plant:** The economic analysis of the potential geothermal power plant was conducted to determine whether it is part of the least economic cost supply plan for Armenia.

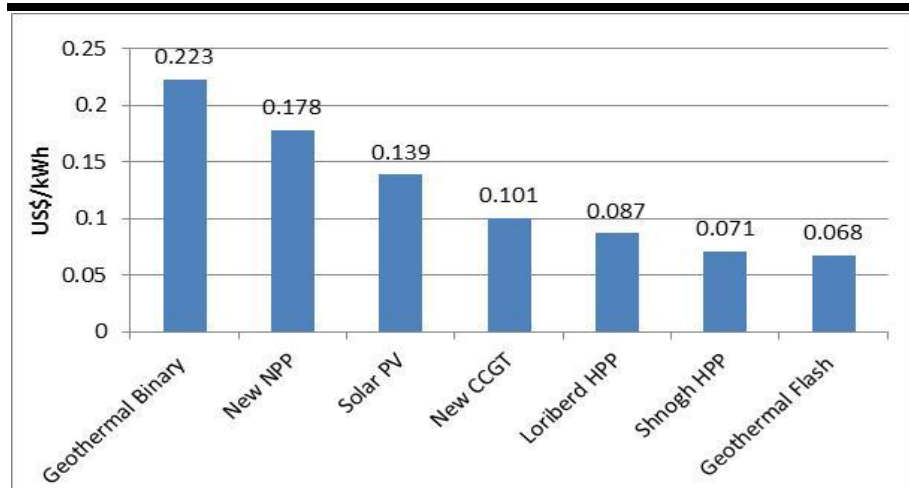
81. The economic analysis of the potential geothermal power plant was conducted for two different geothermal plant concepts assuming the possible lowest and highest temperatures. Specifically, the economic analysis was conducted for the flash cycle plant with expected resource temperature of 250°C and ORC with expected resource temperature of 130°C. It is important to note that the resource temperatures and related enthalpies presented here are the expected lower and upper bounds.

82. Estimates of resource temperature and other parameters at the site were made based on interpretations of previous studies and investigation of the potential geothermal resource at the site. The economic cost estimates were derived based on known or inferred relationships between costs and technical characteristics of geothermal projects. These include the economic cost of externalities, such as social cost of carbon. Economic analysis excludes taxes and duties. These costs must be paid by project developers but are not costs to the economy as a whole, as they simply represent a transfer or resources within the same economy.

83. The capital cost per kW of installed capacity includes the cost of surveying, production wells, plant construction, equipment and transport costs, engineering, and physical contingency. Detailed assumptions are presented in the Table 1 below.

84. Results of economic analysis: The economic analysis suggests that the potential geothermal power plant at the Karkar site should be part of the least-cost supply plan for Armenia if a geothermal resource with a temperature of 250°C exists at the site (allowing for flash cycle technology to be used). The LEC of the potential flash cycle plant at this temperature is estimate at US\$0.06/kWh, which is below the estimated economic LEC of most of the new supply options available to Armenia. On the other hand, if the exploratory drilling suggests that the resource temperature is low (130°C) and only binary plant would be feasible, then the potential plant will have significantly higher LEC compared to other supply options. Figure 5.1 compares the LEC of each of the other supply options to those of the conceptual plant in each scenario.

Figure 5.1: LECs of Potential Supply Options for Armenia



Source: Bank team estimate

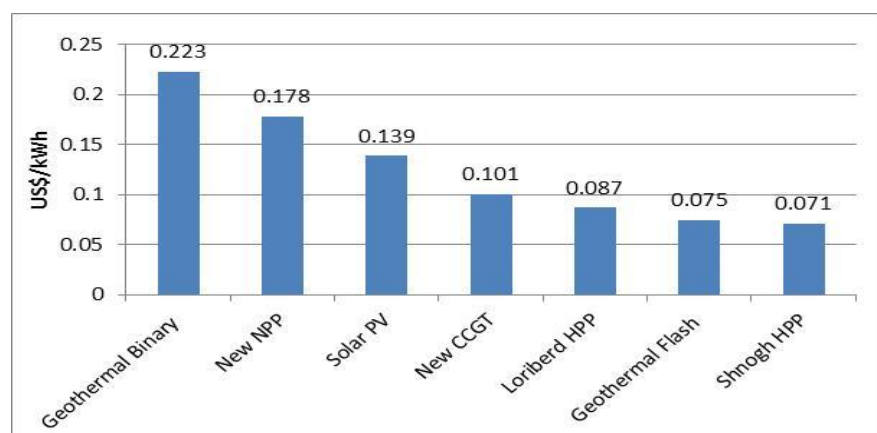
85. Sensitivity analyses: Sensitivity analysis was conducted to determine whether geothermal flash cycle plant remains one of the least-cost supply options in Armenia depending on the

changes of main evaluation variables affecting the LEC of geothermal and the LECs of other options. Sensitivity analysis covers the following cases:

- a. 20 percent lower forecast border price of Russian natural gas with the expected base-case values for all other variables.
- b. 20 percent higher investment cost for the geothermal power plant.

86. The results of the sensitivity analyses suggest that flash cycle geothermal power plant remains the least-cost supply option even in the case of 20% capital cost over-run for the power plant and 20% lower-than-estimated gas prices that Armenia will be paying for imported gas.

Figure 5.2: Results of Sensitivity Analyses of Potential Supply Options for Armenia



Source: Bank team estimate

87. **Financial analyses of the potential geothermal power plant.** The financial analysis of the potential geothermal power plant was conducted for the same two power plant concepts as in the economic analyses – Flash cycle and ORC. The financial viability of a potential power plant was estimated by estimating the minimum tariff, required to make the potential plant financially viable, with the estimated minimum tariffs for other generation options.

88. The financial costs are the cost of a project from the perspective of investors. Financial costs include applicable taxes and duties as well as financing costs. Construction costs are allocated over the life of the project according to a depreciation schedule. Costs and revenues are discounted to present value terms using a discount rate that is equal to the weighted average cost of debt and equity (the weighted average cost of capital).

89. The financing costs included the interest during construction (IDC), debt service and equity shareholder dividends. IDC is treated as an additional capital cost calculated as the monthly interest on construction loan disbursements over the duration of the construction period. Debt service consists of principal and interest payments over the course of the loan period, which is assumed to be 20 years in every scenario. Cost of capital assumptions are presented in Table 5.2.¹¹ Shareholder dividends are calculated in scenarios where it is assumed that private investors

¹¹ The capital structure for the purposes of financial analysis is different from the indicative financing plan of the Government as presented in the SREP Investment Plan. Such different assumption was required to ensure meaningful comparison with other power supply options.

take an equity stake in the project. Dividends are assumed to be disbursed after all tax and debt service obligations are satisfied.

Table 5.1: Cost of Capital Assumptions under PPP project

	Commercial Financing
Debt percentage	70%
Equity percentage	30%
Cost of debt	10%
Debt repayment term	20 years
Cost of equity	16%
Weighted Average Cost of Capital (WACC)	11.8%

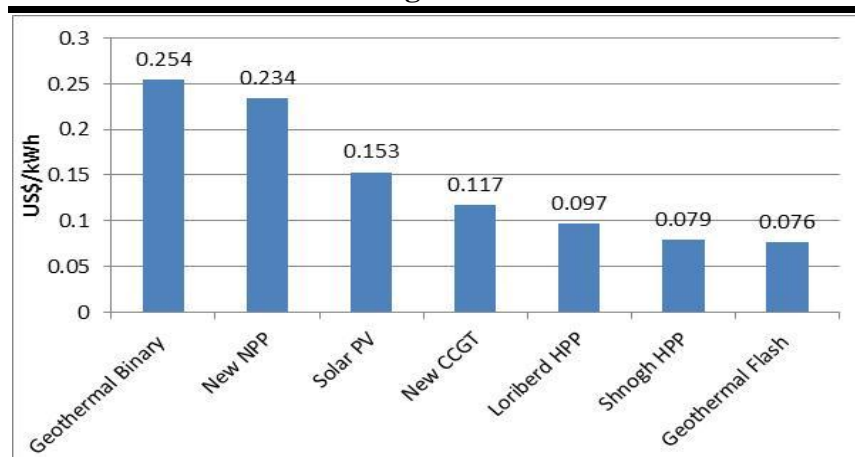
90. In order to make the project financially viable, the minimum tariff should ensure the below financial viability criteria are met:

Table 5.2: Summary of Financial Viability Metrics

Metric	Minimum Criteria for Financial Viability
NPV	Positive
FIRR	Greater than the WACC
Debt service coverage ratio (DSCR)	At least 1.5 average over project life
Equity IRR (when applicable) (EIRR)	At least equal to desired equity return

91. Results of financial analysis: The US\$0.08/kWh tariff required by the Flash cycle plant is the lowest compared to other supply options available to Armenia. The ORC plant is estimated to require a tariff of US\$0.25/kWh, which significantly above the required tariff for other supply options.

Figure 5.3: Minimum Tariffs Required for Financial Viability of Potential Supply Options Under Commercial Financing



Source: Bank team estimate

Table 5.3: Plant-specific Assumptions Underlying the Economic Analyses

		Flash cycle	ORC	CCGT	New NPP	Solar PV	Wind	Shnogh HPP	Loriberd HPP	Data Source
Installed capacity	MW	28.5	28.5	1,100	1,100	70	100	75	66	Bank team
Service life	years	30	30	30	50	20	20	70	70	Bank team
Capital cost	US\$/kW	3,720	12,000	1,100	5,500	2,000	2,200	1,780	1,800	Bank team
Capacity factor	%	94%	84%	85%	55% ¹²	20%	27%	30%	23%	Bank team
Fixed O&M cost	US\$/kW/yr	70	203	14	68	30	50	25	25	Bank team
Variable O&M cost	US\$/kWh	-	-	0.0025	0.00012	-	-	-	-	Bank team
Real plant gate price of natural gas	US\$/tcm	-	-	See Table 2	-	-	-	-	-	Bank team
Real price of nuclear fuel	US\$/mmbtu	-	-	-	7	-	-	-	-	Bank team
Transmission infrastructure cost	MUS\$	3.2	3.2	-	-	-	-	-	-	Bank team
Construction period	Years	4	4	3	8	1	1	5	5	Bank team

Table 5.4: General Assumptions Underlying Economic Analysis

Assumptions		2015	2016	2017	2018	2019	2023	2027	2031	2035	2039	2043	2047	Data Source
Average annual forecast AMD/US\$ exchange rate	AMD/US\$	480	480	480	480	480	480	480	480	480	480	480	480	Bank team
Average annual forecast US\$ CPI	\$	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	Bank team
Average annual forecast AMD CPI	%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	Bank team
Real border price of Russian gas	US\$/m3	0.187	0.194	0.203	0.211	0.220	0.258	0.291	0.315	0.339	0.362	0.386	0.409	Bank team
Plant gate price of natural gas	AMD/m3	117	122	127	133	138	163	185	204	226	250	277	308	Bank team
Plant gate price of natural gas	US\$/m3	0.244	0.255	0.265	0.277	0.288	0.339	0.386	0.425	0.471	0.521	0.578	0.641	Bank team
Annual change in the plant gate price of natural gas	US\$/m3	1.0%	4.2%	4.2%	4.2%	4.2%	4.1%	2.4%	2.6%	2.6%	2.6%	2.6%	2.6%	Bank team
Social cost of carbon	US\$/mt	30.0	30.9	31.9	32.9	33.9	39.0	44.9	51.3	57.0	63.3	69.2	75.2	Bank team ¹³

¹² Given the possible overcapacity of the new NPP under the forecast demand until 2030.

¹³ Based on Guidance note on social value of carbon. The World Bank. 15 July 2014.

Annex 6: Scaling-Up Renewable Energy in Low Income Countries Program
REPUBLIC OF ARMENIA: Geothermal Exploratory Drilling Project

Table 6.1: Results Framework¹⁴

Indicator	SREP Leveraged Project¹⁵	Transformational Scale-Up¹⁶
Annual electricity output from RE as a result of SREP interventions (GWh)	224	1,183
Financing leveraged through SREP funding [US\$ million]	- SREP: US\$8.55 - Government: US\$8.60 - Other donors and private investors: US\$100.0 ¹⁷ (debt/equity ratio for private investors: 70:30)	- SREP: US\$8.55 - Government: US\$8.60 - Other donors and private investors: US\$526.31 ¹⁸ (debt/equity ratio for private investors: 70:30)
SREP leverage ratio	1:13	1:63
Co-benefits		
Tons of GHG emissions reduced or avoided ¹⁹ -Tons per year [tCO _{2eq} /yr]	166,000	892,000
-Tons over lifetime of the project [tCO _{2eq}]	5,256,000	28,159,000

¹⁴ **Clarification Note:** The scope of the GEDP project will be limited to the confirmation of whether geothermal resources at the Karkar site are suitable for power generation. SREP funding will be solely applied to exploratory drilling and associated infrastructure and consultancies. Hence, the output of the project is not electricity generation. If adequate resources are confirmed, the data will be used to prepare the feasibility study for a power plant, which is expected to be financed through a PPP arrangement.

¹⁵ The results presented in this column have been produced implying causality and attribution between the activities proposed for funding under the GEDP project and the potential generation of electricity at Karkar. The figures illustrates the possible results from financing an operating a 28.5 MW flash plant. A load factor of 94% was assumed.

¹⁶ The results presented in this column correspond to the development of 150 MW, which is the combined potential of the most promising sites identified by the preliminary assessments carried out in the 1990s and 2000s. However, it is important to keep in mind that none of those assessments included comprehensive surface exploration works, so these figures should be considered as a very rough approximation of the potential that could be unlocked by the development of the first geothermal plant in Armenia.

¹⁷ Assuming total capital cost of US\$106 million, which includes associated infrastructure (e.g. transmission, access road, etc.)

¹⁸ Assuming the construction of four additional geothermal plants of similar characteristics to the SREP leveraged project.

¹⁹ Using SREP proxy-based method (emission equivalent based on diesel-generated electricity: 793.7 tCO_{2eq} per GWh) and assuming (i) zero emissions from geothermal generation for the low case (i.e. 6 MW binary plant), (ii) discounting 5 percent of calculated emission reductions for the high case (i.e. 28 MW flash plant), and (iii) 30 year plant lifetime.

Indicator	SREP Leveraged Project ¹⁵	Transformational Scale-Up ¹⁶
Other co-benefits	<ul style="list-style-type: none"> • Increased penetration of renewable energy in Armenia’s energy mix, therefore diversifying from a gas and nuclear dominated mix for increased energy security; • Creation of employment opportunities (direct/ indirect) derived from civil works, geothermal drilling operation, and power plant development and maintenance; • Promotion of low-carbon development pathway; • Creation of knowledge and experience in geothermal development. 	

A. Introduction

Country and Sector Context

92. Armenia experienced strong economic growth in 2002-2008, but was severely affected by the global financial crisis. Real GDP grew, on average, 12.2 percent annually from 2002 to 2008, but declined 14.1 percent in 2009. Armenia has experienced moderate growth since 2009, but, despite annual increases, growth rates have not recovered to pre-crisis levels. Economic growth slowed from 7.2 percent in 2012 to 3.5 percent in 2013, and is likely to settle at about 2.6 percent in 2014 as a whole. Despite the economic recovery, poverty incidence continues to be higher since the 2009 economic crisis. In 2013, 32 percent of Armenians were living in poverty. Although the poverty rate has been continuously decreasing since 2010, it is still at a higher level than 2008, when it stood at 27.6 percent in 2008.

93. During the first phase of reforms in 1990s and early 2000s the power sector achieved some remarkable results. The collection of electricity bills reached 100 percent of sales. The regulatory framework was stable and overall conducive to private investments. The explicit and implicit subsidies were eliminated. A competent and independent regulatory agency for the sector was also established. However, the power sector currently faces a number of major challenges that need to be addressed as part of the second phase of reforms. The key challenges currently faced by the power sector are: (a) supply adequacy; (b) supply reliability; (c) affordability of energy tariffs; (d) financial viability of state-owned power companies; and (e) transparency (see Section I in the main text for additional details).

94. Given the challenges of impending power supply adequacy and energy security, the Government prioritizes development of indigenous renewable energy resource as reflected in the several strategic documents of the Government, including the Concept of National Energy Security (November 2013). The Government targets to increase the share of small renewable energy based power generation in the supply mix from the current level of 9% to 20% by 2020.

Armenia’s SREP Investment Plan

95. The SREP Investment Plan for Armenia was endorsed by the SREP Sub-Committee in June 2014. Under this Plan, the Government will utilize US\$40 million of SREP financing to

scale-up geothermal power, utility-scale solar PV, and geothermal and solar heating. The criteria used to select these technologies included potential for scale-up, cost-effectiveness, and immaturity of the market.

Table 6.2: SREP Investment Plan for Armenia

SREP Project	SREP	Government	MDBs	Private sector	Total
Geothermal Power	9.0 ²⁰	8.6	30.0	70.0	117.6
Development of Utility-Scale Solar PV	28.0	7.5	30.0	63.5	129.0
Development of Geothermal Heat Pumps and Solar Thermal	3.0	-	-	9.0	12.0
GRAND TOTAL	40.0	16.1	60.0	142.5	258.6

B. Project description

96. The Government is committed to develop the country’s geothermal resources as they can become an affordable source of base-load electricity that is generated from indigenous resources, therefore contributing to the country’s energy security. Since private investors are not willing to assume the resource risk associated with exploratory drilling, the Government will use SREP resources to carry out the riskier drilling stages of its first geothermal power project. SREP support can thus catalyze additional financing from public and private sources and serve to demonstrate the feasibility of geothermal power in Armenia if adequate resources are confirmed through exploration drilling. A first successful project can build domestic capacity in the development of additional geothermal resources at Armenia’s other prospective geothermal sites. It will also build investor confidence that geothermal is a viable and profitable investment opportunity in Armenia.

97. The initial phase of Armenia’s first geothermal power project will consist of two components, designed to support the Government in confirming whether the Karkar geothermal site has resources good enough for commercial power generation. These components are (1) Exploratory drilling and construction of related infrastructure; and (2) Technical assistance for assessment of the geothermal resource potential and technical supervision. Component 1 will finance: (i) construction of access road, water supply infrastructure and rig pads and (ii) drilling of exploratory wells, starting with one or two slim wells to confirm the temperature of the low resistivity layer located at 500-1,000 m depth, followed by one or two intermediate or full size production wells to a depth of 1,800 m if results from drilling the slim wells are promising. Component 2 will finance technical assistance activities with the following main objectives: (i) assessing the technical parameters of the geothermal resource and ensuring sound technical management of the operation, (ii) elaboration of a full feasibility study for the geothermal power plant, (iii) drilling supervision and implementation support consultant; and (ii) transaction advisory services to the Government to structure and complete PPP transaction involving the private sector in construction and operation of the geothermal power plant if resources are confirmed.

²⁰ US\$8.55 million is available for the proposed exploratory drilling project given the project preparation grant of US\$300,000 and US\$150,000 World Bank share of support to the Government for SREP IP preparation.

C. Assessment of Proposed Project with SREP Investment Criteria

98. Increased generation capacity. As indicated before, the scope of this project will be limited to the confirmation of whether geothermal resources at the Karkar site are suitable for power generation. SREP funding will be solely applied to exploratory drilling and associated infrastructure and consultancies. Hence, the output of the project is not capacity construction or electricity generation. If adequate resources are confirmed a geothermal power plant is expected to be built. The capacity of the plant will depend on the nature of the geothermal resources found. The potential geothermal power plant is expected to have an installed capacity of 28.5 MW flash plant (about 224 GWh of annual generation).

99. Low emission development. If adequate geothermal resources are confirmed through the proposed Project and a geothermal power plant is subsequently built, this would result in increased penetration of renewable energy in Armenia's energy mix. In addition, the support can also serve to demonstrate the feasibility of geothermal power in Armenia. A first successful project can build domestic capacity in the development of additional geothermal resources in Armenia's other prospective geothermal sites. It will also build investor confidence that geothermal is a viable and profitable investment opportunity in Armenia. The application of the proxy-based method agreed for the SREP program would help get a sense about the emission saving capacity of the proposed project vis-à-vis other projects either funded from SREP or other sources. Applying the proxy-based method to estimate emissions of CO₂ equivalent based on diesel generated electricity (793.7 tCO₂eq per GWh), the proposed project could help avoid between 166,000 tCO₂eq on an annual basis and 5,256,000 MtCO₂eq over the lifetime of the project, hereby estimated at 30 years.

100. Affordability and competitiveness of renewable sources. The economic analysis suggests that the potential geothermal power plant at the Karkar site should be part of the least-cost supply plan for Armenia if a geothermal resource with a temperature of 250°C exists at the site (allowing for flash cycle technology to be used). The LEC of the potential flash cycle plant at this temperature is estimate at US\$0.06/kWh, which is below the estimated economic LEC of most of the new supply options available to Armenia (see Annex 5 for details). Thus, construction of the power plant will reduce the increase in overall end-user tariffs and improve affordability of electricity. Specifically, the average end-user electricity tariffs increased by 40% in 2013-2014 due to increasing gas prices and other costs. Together with increase in gas tariffs, the share of energy expenditures of average households reached 10%, a level considered to be energy poverty. Therefore, if resource temperature at Karkar supports development of flash cycle power plant, it will help reduce the anticipated increase in electricity tariffs given that the country needs 500 MW of new generation capacity by 2021.

101. Productive use of energy. The electricity generated by the potential geothermal power plant would feed into the grid and serve residential, industrial and commercial consumers, ultimately having a positive impact on the economy by: (a) supporting the social and primary economic activities of household; and (b) economic activities of non-residential users.

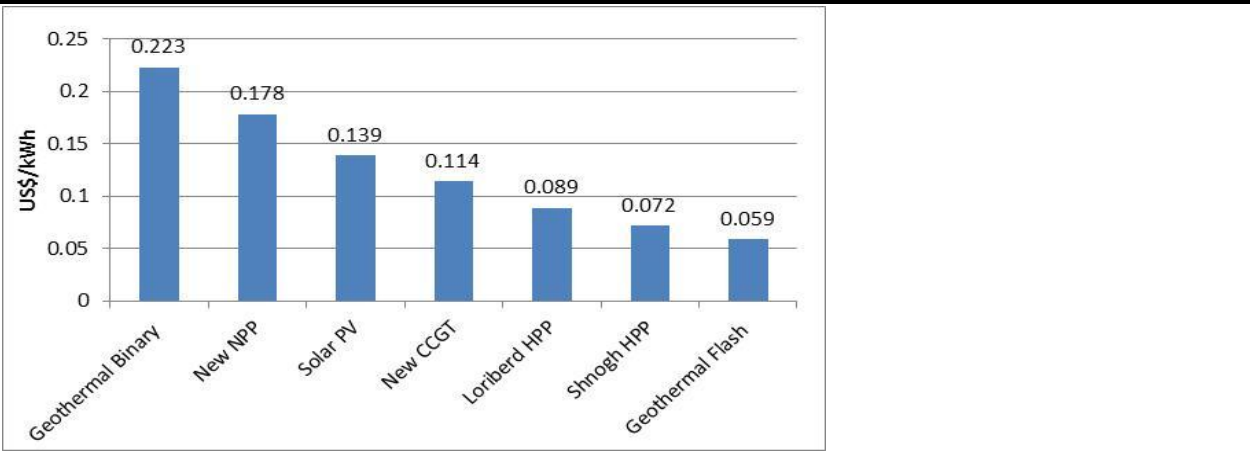
102. Economic, social and environmental development impact. The project is expected to have a positive impact on the local economy through the creation of temporary jobs during construction

and permanent jobs during operation, as well as by attracting additional investments. This can have positive impact on local communities. In addition, at the national level, the development of geothermal power would reduce the dependence on energy imports, especially natural gas, also reducing the impacts of price fluctuations in electricity tariffs and affordability. Besides job creation, the project will also have a positive impact on the local community thanks to the access road to be constructed to the site, which will enable easier transit by shepherds and cattle that depend on the surrounding meadows for their livelihoods. Regarding environmental benefits, a geothermal power plant has the potential to reduce greenhouse gas as well as local particulate matter emissions from gas-fired power generation. Although the majority of Armenia’s energy generation is from nuclear and hydropower sources, there is still the potential to reduce greenhouse gas emissions from Armenia’s operating natural gas-fired power plants by offsetting their generation with energy from a geothermal power plant.

Economic and financial viability

103. Economic analysis of the potential geothermal power plant was conducted to determine whether it is part of the least economic cost supply plan for Armenia. The economic analysis suggests that the potential geothermal power plant at the Karkar site is one of the least-cost supply options available for Armenia if a geothermal resource with a temperature of around 250°C exists at the site. The LEC of the potential flash cycle geothermal power plant is estimated at US\$0.060/kWh, which is below the estimated economic LEC of all new supply options available to Armenia. On the other hand, if the exploratory drilling suggests that the resource temperature is low and only binary plant would be feasible, then it will be have significantly higher LEC compared to other supply options (see Annex 5 for details).

Figure 6.3: LECs of Potential Supply Options for Armenia



Source: Bank team estimate

104. Financial analyses. The financial analysis of the potential geothermal power plant was conducted for the same two power plant concepts as in the economic analyses – Flash cycle and ORC. The financial viability of a potential power plant was estimated by estimating the minimum tariff, required to make the potential plant financially viable, with the estimated minimum tariffs for other generation options. The US\$0.08/kWh tariff required by the Flash cycle plant is the lowest compared to other supply options available to Armenia. The ORC plant

is estimated to require a tariff of US\$0.25/kWh, which significantly above the required tariff for other supply options (see Annex 5 for details).

Leveraging of additional resources

105. If the resource is confirmed, the potential geothermal power plant with estimated cost of US\$106 million will be developed with a mix of public and private capital. Specifically, the Government may attract concessional loans from MDBs to finance some of the capital costs of developing the steam field and the geothermal power plant as a way of making it more attractive to private investors. The Government may also finance transmission lines, or other infrastructure required at the site. The Government contributions may also include the land and co-financing of taxes. The remaining capital will be raised in the form of equity and debt from the private arms of MDBs and the commercial lenders/investors. The initial financing structure for the potential geothermal power plant is presented in the table below. Specifically, the leverage of the US\$8.55 million exploratory drilling project is estimated at 1:13.

Table 6.4: Indicative financing plan for geothermal power project

	Government	MDBs	Private sector (equity)	Commercial/private arms of MDBs	TOTAL
Investments in geothermal plant	6	30	35	35	106

Gender

106. During the project construction phase, including drilling, the workers camp will have to be provisioned with food services that will most likely be provided by local business run by women. During the operation phase, contractual agreements could include set asides for women to make up a certain percentage of local staff.

Co-benefits of geothermal development

107. As stated above, if adequate geothermal resources are confirmed through the proposed Project and a geothermal power plant is subsequently built, this would result in increased penetration of renewable energy in Armenia’s energy mix, therefore diversifying from a gas dominated mix, for increased energy security.

108. Additional co-benefits will include: (i) Creation of 500 person-month of temporary employment opportunities (direct/indirect) during power plant development, including drilling; and 20 person-month of permanent jobs during operation of the power plant; (ii) promotion of a low-carbon development pathway; creation of knowledge and experience in geothermal development.

D. Monitoring and Evaluation

109. The Project Implementation Unit, the R2E2 Fund, will be responsible for monitoring and evaluation of project progress. The R2E2 Fund will monitor and evaluate the project development objective and the intermediate result indicators reflected in Annex 1, which were defined to match the phased project approach. In order to ensure that the R2E2 Fund has adequate capacity to reliably monitor and evaluate this critical information, the R2E2 Fund will rely on the expertise of the Geothermal Consulting Company to be hired under the project. If geothermal resources are proven and a geothermal plant is built, R2E2 Fund will continue to be responsible for monitoring the indicators for the SREP leveraged project.

E. Implementation Readiness

110. Given the challenges of impending power supply adequacy and energy security, the Government prioritizes development of indigenous renewable energy resource as reflected in the several strategic documents of the Government, including the Concept of National Energy Security (November 2013). The Government targets to increase the share of small renewable energy based power generation in the supply mix from the current level of 9% to 20% by 2020 and is committed to promoting development of renewable energy technologies which have large potential for scale-up and limited impact on end-user tariffs.

111. Armenia has an adequate regulatory regime for development of renewable energy, including licensing and permitting procedures. There is an independent and competent energy sector regulatory. The key stakeholders have sufficient capacity to coordinate and make decisions related to development of the geothermal plant in case the resource is confirmed. There is no PPP framework in the country, however, the Law on Energy and other legislation allow for privately owned generation. The involvement of the private investors/developers for the construction of a geothermal power plant would be contractual and custom-tailored for the needs of the project. The financial structuring decisions would be made at a later stage if the resource is confirmed.

112. In terms of project readiness, surface exploration at Karkar were completed according to international standards and drilling targets for confirmation of the resource were identified. With financing from SREP Project Preparation Grant, the R2E2 Fund is preparing the environmental and social assessment, the design of the civil works, and the bidding documents for drilling the slim holes. Preliminary designs for the production-size wells, including the drilling program, were also prepared. It is thus expected that the proposed project will be ready for implementation by the time of the World Bank approval.

F. SREP Additionality

113. Most of the international geothermal development experience shows that the upstream phases of development inevitably rely strongly on public sector investment, with private developers entering the project at more mature phases (i.e. when resource risk has been significantly reduced).

114. Unlike other renewable energy technologies, such as wind, solar, and hydro, it is not possible to validate the geothermal resource with sufficient confidence for commercial development without performing exploratory drillings at depth to assess specific geologic

conditions in the field. After completing surface exploration, a conceptual model of the geothermal field is developed, which needs to be validated with the results of exploration drilling. The combination of relatively high capital requirements (typical costs for drilling are in the range of US\$2 to US\$5 million per well), high uncertainty of this phase, and time taken to complete this resource validation phase, about 3 years, deter commercial investors.

115. Therefore, by using grant resources from SREP, the Government can help reduce the risk of developing the site for the private sector. If a geothermal resource exists at the site, this support can assist in making geothermal power a financially attractive investment for private investors and an affordable source of electricity for Armenia's grid. No other government, donor or private resources are willing to support exploratory drilling in Armenia.

Annex 7: Procurement Plan

REPUBLIC OF ARMENIA: Geothermal Exploratory Drilling Project

I. General

1. **Project information:**

- a. Project Name: Geothermal Exploratory Drilling Project
- b. Project ID – P152039
- c. Implementing Agency: R2E2 Fund

2. **Bank’s approval Date of the procurement Plan:** [will be indicated]

3. **Date of General Procurement Notice:** [will be indicated]

4. **Period covered by this procurement plan:** 18 months

5. The TOR of consulting assignments (individual and firm) and technical specifications of packages are subject of prior agreement with the TTL. All cancellation of selection process and/or re-invitation shall be subject to Bank’s prior review. All the contracts whose cost estimation was below the Bank’s prior review threshold are subject to prior review if the financial offer of the selected firm exceeds such threshold at the proposals evaluation stage. Irrespective of the thresholds the selection of all consultants (firm and individuals) hired for legal work or for procurement activities as well as the individual hired for long-term technical assistance or advisory services for duration of the project (or most of it) are subject to prior review. In case of a slice and package arrangement, the prior review threshold is determined based on the aggregate value of individual contracts to be awarded under such arrangement.

II. Goods and Works and Non-consulting services

1. **Prior Review Threshold:** Procurement Decisions subject to Prior Review by the Bank as stated in Appendix 1 to the Guidelines for Procurement:

	Procurement Method	Prior Review Threshold	Procurement Method Threshold	Comment
1.	ICB (Works)	All contracts	≥US\$5.0 mil	
2.	ICB (Goods)	All contracts	≥US\$ 1.0 mil	
3.	NCB (Works)	First contract and all the contracts with estimation above US\$ 3.0 mil.	<US\$5.0 mil.	
4.	NCB (Goods)	First contract and all the contracts with estimation above US\$ 0.5 mil.	<US\$ 1.0 mil.	
5.	Shopping (Works)	First contract	<US\$200,000	
6.	Shopping (Goods)	First contract	<US\$100,000	
7.	Direct Contracts (Goods and Works)	All contracts.		

All negotiations with lowest bidder, cancellation of procurement or selection process and/or rebidding shall be subject to prior review.

2. **Pre-qualification.** – N/A
3. **Reference to (if any) Project Operational/Procurement Manual:** Operational Manual for the project to be developed by R2E2 Fund and be approved by the Bank.
4. **Any Other Special Procurement Arrangements:** N/A
5. **Procurement Packages with Methods and Time Schedule**

Ref. No.	Contract (Description)	Est. Cost, US\$ (tax inclusive)	Est. Cost, US\$ (tax exclusive)	Proc. Method	Prequalf. (yes/no)	Dom. Prefer. (yes/no)	Review by Bank (Prior / Post)	Expect. Bid-Open. Date	Comments
GEDP-CW-1/2015	Construction of access road	625,000	500,000	NCB	No	No	Prior	March, 2015	
GEDP-CW-2/2015	Preparation of the rig and construction of water supply infrastructure	187,500	150,000	NCB	No	No	Prior	March, 2016	
GEDP-CW-3/2015	Drilling of two slim wells	4,200,000	3,360,000	ICB	No	No	Prior	April, 2015	
GEDP-CW-4/2016	Drilling of production-size well(s)	4,200,000	3,360,000	ICB	No	No	Prior	May, 2016	

ICB - International Competitive Bidding (in accordance with section 2 of the Guidelines);

NCB - National Competitive Bidding (in accordance with paragraph 3.3 – 3.4 of the Guidelines)

SH - Shopping (in accordance with paragraph 3.5 of the Guidelines);

DC - Direct Contracting (in accordance with paragraphs 3.7-3.8 of the Guidelines)

III. Selection of Consultants

1. **Prior Review Threshold:** Selection decisions subject to Prior Review by Bank as stated in Appendix 1 to the Guidelines Selection and Employment of Consultants:

	Selection Method	Prior Review Threshold	Comments
1.	Contracts with Firms	>US\$ 200,000 and all SS contracts	
2.	Contracts with Individual Consultants	>US\$ 50,000 and all SS contracts	

2. **Short list comprising entirely of national consultants:** Short list of consultants for services, estimated to cost less than \$300,000 equivalent per contract, may comprise entirely of national consultants in accordance with the provisions of paragraph 2.7 of the Consultant Guidelines.
3. **Any Other Special Selection Arrangements:** None

4. Consultancy Assignments with Selection Methods and Time Schedule

Ref. No.	Description of Assignment	Est. Cost US\$ (tax inclusive)	Est. Cost US\$ (tax exclusive)	Selection Method	Review by Bank (Prior / Post)	Expected Proposals Submission Date	Comments
GEDP-CS-1/2015	Well logging and mud logging for slim wells	250,000	200,000	QCBS	Prior	June, 2015	
GEDP-CS-2/2015	Well logging and mud logging for production size wells	125,000	100,000	QCBS	Prior	June, 2016	
GEDP-CS-3/2015	Feasibility Study	375,000	300,000	QCBS	Prior	Sep, 2016	
GEDP-CS-4/2015	Technical supervision and support consultant	375,000	300,000	QCBS	Prior	March, 2015	
GEDP-CS-5/2015	Transaction advisory	250,000	200,000	QCBS	Prior	December, 2017	
GEDP-CS-6/2015	Project audits	37,000	30,000	CQS	Post		
	Operating costs		50,000	SOE			

QCBS = Quality and Cost-based Selection (in accordance with paragraphs 2.1 - 2.35 of the Consultant's Guidelines)

FB-Selection under Fix Budget

QBS = Quality Based Selection (in accordance with paragraph 3.2 the Consultant's Guidelines)

LCS = Least-Cost Selection (in accordance with paragraph 3.6 of the Consultant's Guidelines)

CQ = Consultants Qualifications (in accordance with paragraph 3.7 of the Consultant's Guidelines)

SSS= Single source Selection (in accordance with paragraph s 3.8-3.11 of the Consultant's Guidelines)

IC = Individual Consultant (in accordance with section V of the Consultant's Guidelines)

SS-Soul Source Procedures for the Selection of IC

SOE= Statement of Expenditure

Annex 8: Map

REPUBLIC OF ARMENIA: Geothermal Exploratory Drilling Project

