PROJECT INFORMATION DOCUMENT (PID)
CONCEPT STAGE

Report No.: PIDC14033

Project Name	Geothermal Exploratory Drilling Project (P152039)
Region	EUROPE AND CENTRAL ASIA
Country	Armenia
Sector(s)	Other Renewable Energy (100%)
Theme(s)	Infrastructure services for private sector development (90%), Climate change (10%)
Lending Instrument	Investment Project Financing
Project ID	P152039
Borrower(s)	MINISTRY OF FINANCE AND ECONOMY
Implementing Agency	Renewable Resources and Energy Efficiency Fund
Environmental Category	B-Partial Assessment
Date PID Prepared/ Updated	14-Dec-2014
Date PID Approved/ Disclosed	15-Jan-2015
Estimated Date of Appraisal Completion	06-Mar-2015
Estimated Date of Board Approval	31-Mar-2015
Concept Review Decision	Track II - The review did authorize the preparation to continue

I. Introduction and Context

Country Context

Economic indicators show that Gross Domestic Product (GDP) growth slowed from 7.2 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.

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 percent 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 percent for this

category.

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, little changed from 2009. 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. In 2013, rural and urban incidence of poverty was similar at about 32 percent.

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. Over the 2007-09 period, 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.

Sectoral and Institutional Context

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 established.

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 currently faced by the power sector are: (a) emerging power supply gap; (b) threatened power supply reliability; (c) increasingly unaffordable electricity tariffs; and (d) deteriorating governance.

Supply Adequacy:
The power system will need around 500 MW of new gas-fired generation capacity as soon as possible to: (a) stop buying power from old (>45 years) and inefficient (30% conversion efficiency) gas-fired Hrazdan Thermal Power Plant (TPP), which has the highest generation tariff in the system; and (b) 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 (e.g. Shnogh HPP, Loriberd HPP, and Karkar geothermal if the exploratory drilling confirms availability of adequate temperature resource).

The supply gap can be reduced through improvements in tariff structure to promote 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. AMD 8/kWh), which creates perverse incentives for consumers and promotes economically inefficient electricity consumption.

Supply Reliability:
The average interruption frequency per line for 110 and 220 kV lines on the balance sheet of High Voltage Electric Networks (HVEN) is 2.5 times higher than for comparator well-performing utilities.

Affordability:
In 2013-2014, the average electricity tariff for residential customers increased by 40% and the gas tariff increased by 19%. Those increases were estimated to have increased poverty by 3%. Moreover, bottom 20% of population (in terms of income) cannot afford adequate amount of energy for basic needs. The situation is expected to deteriorate further as much needed investments in the sector are made.

Governance:
The deterioration in governance was manifested through: (a) Inconsistent application of cost-recovery tariff methodology. This has resulted in under-spending on maintenance, significant increase of liabilities for the privately-owned distribution company and all state-owned companies (HVEN, Yerevan TPP, and ANPP), and reduced investments in improvement of power supply reliability and reduction of losses; (b) Large short-term borrowing by the state-owned companies for non-core business activities (financing of salaries of a large dysfunctional synthetic rubber plant); and (c) Deterioration in transparency and public disclosure of information as evidenced by a recent privatization transaction, and tariff review decisions.

The World Bank is supporting the Government to address the above challenges through a combination of analytical support and investment lending. Specifically:

(a) The Bank will help the Government to prepare a viable plan to construct a new 450-500 MW CCGT unit with involvement of the private sector. The Bank is also helping the Government to implement the proposed geothermal exploratory drilling project at Karkar site as well as kick-start development of utility-scale solar PV in the country. Both projects are included in the Scaling-up Renewable Energy Program (SREP) Investment Plan for Armenia, which was prepared by the Government with the joint support from World Bank Group (World Bank, IFC), ADB, and EBRD. The SREP Investment Plan of the Government was approved by the SREP sub-committee on June 2014.

(b) The Bank’s ongoing investment projects (Electricity Supply Reliability and its Additional Financing) are targeting replacement of 250 km of power transmission lines (80% of the total line length requiring rehab) and three substations (out of the total three requiring urgent rehab and without secured financing).

(c) The Bank is providing a comprehensive advisory support to the Government on options to mitigate the impact of the energy price increase on the poor, including subsidy delivery mechanisms, improvement of the targeting under the existing social assistance program.

(d) The Bank has initiated preparation of the financial rehabilitation plan for state-owned power

sector companies to provide advice to the Government on restructuring of the existing liabilities, which originated due to non-core business activities not serviced through the tariff.

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.

The Government has taken steps to support the development of indigenous renewable energy resources, including establishment of feed-in tariffs for small hydropower plants (SHPPs) by the Public Services Regulatory Commission (PSRC), mandatory 15-year off-take by the distribution company of the electricity generated by the small renewable energy plants, streamlining of licensing requirements and procedures. As a result, the share of electricity generated by SHPPs increased from less than 1% in 2004 to 9% 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.

The SREP Investment Plan identified geothermal power, utility-scale solar PV, and geothermal and solar heating as priority areas for support and future scale-up. With the support from SREP, The Government plans to construct 30-40 MW of utility-scale solar PV projects with subsidized capital cost from SREP. The total potential for geothermal power is currently estimated to be at least 150 MW. Of the known areas, the Karkar field has been assessed to have the highest potential, possibly around 30 MW, which is 8% of the new capacity required by the Government by 2021. Surface exploration has been completed 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.

Relationship to CAS

The 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 create through selective energy sector investments.

II. Proposed Development Objective(s)

Proposed Development Objective(s) (From PCN)

The proposed Project Development Objective is to confirm whether the Karkar geothermal site contains commercially exploitable geothermal resources suitable for power generation.

Key Results (From PCN)

PDO Level Indicators

Indicator One (Custom): The Government’s decision whether to construct or not to construct a geothermal power plant at the Karkar site.

Presented below are also some Intermediate Results Indicators:

Intermediate Result Indicator 1 (Custom): One or two slim exploratory wells drilled to the depth of

1,000 meters.

Intermediate Result Indicator 2 (Custom): One or two intermediate production wells or full production wells drilled to the depth of up to 1,800 meters if the results of the drilling of slim wells warrantee such drilling.

Intermediate Result Indicator 3 (Custom): The power generation potential of the Karkar site estimated if the geothermal resource is confirmed.

Intermediate Result Indicator 4 (Custom): The concept for financial structuring of geothermal power plant approved by the Government if construction is economically and financially viable.

III. Preliminary Description

Concept Description

Concept Description
The project will achieve the development objective through implementation of the following two components: (1) Exploratory drilling and construction of related infrastructure; and (2) Technical assistance for assessing the technical parametersof the geothermal resource.

Component 1: Exploratory drilling and construction of related infrastructure.

This component will finance:

(a) Construction of access road, water supply infrastructure and the rig pad. 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; and (c) preparation of the rig pads where the rig, and the associated equipment will be placed.

(b) Drilling of test wells. This will include drilling of one or two slim wells followed by intermediate or production-size wells. In order to minimize the costs if downside risk materializes (i.e. low temperature resource is found), 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. 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.

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 well and about half of the production-size well; and (b) 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.

If the results from the first slim well are inconclusive, then it is preferable to drill a second slim well. Depending on the information obtained from the first or second slim well, the following scenarios may result:

- Scenario 1: If the results from the first or second slim well show that reservoir temperature

is below 110o C, the project would stop (given that such low temperatures are not expected to be suitable for commercial power generation) and the SREP funds would be reallocated to other priority technologies identified in the SREP Investment Plan.

- Scenario 2: If the results from the first or second slim well show that the reservoir temperature is in the 110-200o 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 two production size wells would be drilled. The choice between full size or 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 200o, 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 two production-size wells, same as under Scenario 2 above.

Component 2: Technical assistance for assessing the technical parameters of the geothermal resource.

This component will finance:

(a) Well logging and mud logging. 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.

(b) Estimation of the power generation technology and potential through flow testing, chemical sampling and analysis: This will include an assessment of: (a) the possible power output of the well, the ratio between brine and steam, and (b) enthalpy. It will also include sampling of the br ine to analyze the resource as well as estimation of possible problems during power production, such as scaling and/or corrosion. This will assist in deciding what kind of power conversion techniques should be used, and estimate the power generation potential for a potential geothermal power plant.

(c) Assessment of the economic and financial viability of the potential geothermal power plant. This will include estimate of the economic and financial viability of a geothermal power plant based on the technical parameters of the geothermal resource as estimated under (b). Such analyses will also include assessment of the end-user electricity tariff impacts of the potential geothermal power plant.

(d) Drilling supervision and implementation support consultant: This will include support to R2E2 Fund in implementation and supervision of the drilling operation and review of the results and findings of well logging, mud logging, flow testing, and chemical analyses of cuttings.

(e) Transaction advisory services. This will include support to the Government to structure a transaction to involve private sector in construction and operation of a geothermal power plant.

This project will also finance the incremental operating costs of the R2E2 Fund associated with project implementation.

Implementation timeline
The project will be designed as a 3.5-year operation in order to ensure that all the necessary activities can be completed given the limitations on site accessibility caused by weather conditions (the site is only accessible from May to early October). However, the project may be completed in one year if the drilling of the two slim wells suggests that the resource is a low-temperature and not suitable for power generation.

IV. Safeguard Policies that might apply

Safeguard Policies Triggered by the Project	Yes	No	TBD
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	

V. Financing (in USD Million)

Total Project Cost:	10.68	Total Bank Financing:	0.00
Financing Gap:	0.00		

Financing Source	Amount
Borrower	2.13
Strategic Climate Fund Grant	8.55
Total	10.68

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