SECTOR ASSESSMENT (SUMMARY): ENERGY[1]

Sector Road Map

1. Sector Performance, Problems, and Opportunities

1. **Sector performance.** Armenia has no proven reserves of oil or natural gas, and no oil refinery. It has some reserves of coal but no coal production. It imports refined oil products and natural gas from the Russian Federation and Europe (via Georgia) and a relatively small amount of natural gas from Iran. Imported natural gas and refined oil products account for more than two-thirds of total primary energy supply, with imports of natural gas from the Russian Federation making up about 80% of total energy imports.

2. The total installed generating capacity of Armenia's power system is 4,100 megawatts (MW), of which 74% (3,047 MW) is operating. The Metsamor nuclear power plant (NPP), thermal power plants, and hydropower plants account for almost all installed generating capacity.[2] The NPP and the hydropower plants provide baseload capacity, while the thermal power plants are used to meet winter peak demand and to serve baseload for several months when the NPP goes offline for maintenance. The thermal power plants burn imported natural gas, and uranium is imported from the Russian Federation to fuel the NPP.

3. Armenia produces enough electricity to meet domestic demand. It also trades electricity with neighboring countries, with exports of electricity exceeding its imports. Power generation comprises 31% nuclear, 28% hydropower, and 41% thermal power (using imported natural gas). In 2013, total electricity output was 7.70 billion kilowatt-hours (kWh). Exports of electricity amounted to 1.31 billion kWh, and imports 0.15 billion kWh. Armenia has a competitive advantage in electricity production because of its cheap generation resources and excess capacity, particularly during summer months.

4. Since 2000, the energy sector has undergone a series of reforms, which have significantly improved its performance. They involved unbundling the vertically integrated electricity subsector, and privatizing the entire power and gas distribution networks and most generating companies.[3]In addition, the Public Service Regulatory Commission—an autonomous agency responsible for regulating the electricity, gas, district heating, and telecommunication subsectors—was established in 2004. The commission plays an important role in developing the energy sector by licensing companies and setting tariffs and service quality standards in the electricity and gas subsectors.

5. **Problems and challenges.** The core energy sector problems are the low efficiency of energy resources utilization and the deteriorating and aging power infrastructure. The first manifestation of this problem is very limited utilization of Armenia's substantial renewable energy resources. In 2010, the total installed capacity of power plants producing electricity from renewable sources (namely, the small hydropower plants with capacity of less than 10 MW and the wind-power plant) was 104.6 MW, or only about 6% of total electricity output.[4] Armenia has roughly 3.6 terawatt-hours of hydropower potential, of which only around 2.5 terawatt-hours are currently exploited. The country's total renewable energy potential is estimated at more than 3,575 MW, which include more than 1,000 MW each of solar thermal power and photovoltaic, 300–500 MW of wind power, and 250–300 MW of small hydropower. The main reasons for the limited utilization of renewable energy are relatively high

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[1] This summary is based on Armenia Energy Sector Assessment (Supplementary Appendix), various technical assistance reports of the Asian Development Bank, and consultations with relevant government agencies and other stakeholders.

[2] Armenia has one wind-power plant, which accounts for less than 0.1% of the total installed generating capacity of the power system.

[3] The private sector now owns 57% of the total generating capacity of the power system.

[4] E. Karapoghosyan. 2011. *Armenian Energy Sector: Overview (*http://eneken.ieej.or.jp/data/3921.pdf).

investment costs of renewable energy technologies and limited availability of finance for renewable energy projects.

6. The second manifestation of the core problem is the low efficiency of thermal power plants, high operation and maintenance cost and low reliability of large hydropower plants, and relatively large electricity transmission and distribution losses.[5] The main reason is that many electricity generation, transmission and distribution assets are old and in poor condition. Roughly 70% of the installed equipment at hydropower plants has been in operation for more than 30 years, and 50% for more than 40 years.[6] The third manifestation of the core problem is that Armenia's potential for exporting electricity is not fully realized, even with the current state of the energy sector. Armenia can expand net exports of electricity and reduce the overall cost of electricity production by exporting (importing) more electricity during periods when more (less) water is available for generating hydroelectricity and demand for electricity is relatively low (high). One of the main obstacles to this is the limited interconnection of Armenia's electricity system with that of neighboring countries due in part to the poor condition of Armenia's power transmission infrastructure.

7. Another major problem in the energy sector (and in part a consequence of the sector's core problem) is Armenia's tenuous energy security. The country fully depends on imports of natural gas, refined oil products, and uranium to produce around two-thirds of electricity output. This renders the country vulnerable to fluctuations in world energy prices and to possible supply disruptions. To enhance its energy security, Armenia needs to diversify the energy supply mix in particular by expanding the use of renewable energy.

8. The Metsamor NPP is vital for Armenia's energy security. However, the plant is old and is to be retired in 2020.[7] Armenia needs to keep the plant safe and reliable, and prepare for its retirement to ensure an adequate supply of electricity. In 2009, the government approved a joint venture with the Russian Federation to build a new reactor (1,060 MW capacity) at the plant, but it has not yet secured funding for the project (estimated to cost the equivalent of about half of Armenia's current gross domestic product).

9. To attract more private investment into the energy sector, expand the use of renewable energy, and secure funding for the construction of the new nuclear reactor without jeopardizing the sustainability of public debt, Armenia will have to increase electricity tariffs substantially. This is likely to have a significant adverse impact on poverty, as poorer households tend to spend a larger proportion of their income on utilities than better-off households.[8] A formidable challenge for the government will be to increase social assistance to the poor and other vulnerable segments of the population to mitigate the adverse impact of tariff increases on poverty, while keeping the fiscal deficit under control.

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[5] Old combined-cycle turbines at Yerevan Thermoplant and Hrazdan Unit 5 have a 30% efficiency coefficient. In 2010, transmission and distribution losses amounted to 11.2% of total electricity output in Armenia. World Bank. World Development Indicators Database (http://data.worldbank.org/data-catalog/world-development-indicators, accessed 2 July 2013).

[6] The average age of power transmission assets is 45 years, distribution assets 32 years; nearly 90% of 220-kilovolt overhead lines require rehabilitation, and about 42% of low-voltage substations are in deficient technical condition. World Bank. 2011. *Charged Decisions: Difficult Choices in Armenia's Energy Sector*.

[7] The plant was constructed in the 1970s and has two reactors: units 1 and 2. Both reactors were shut down shortly after a strong earthquake in 1988. However, Unit 2 (408 MW capacity) was brought back into operation in 1997 because of the severe energy crisis in the country. The plant was to be retired in 2016, but the government recently extended the operating license for Unit 2 to 2020.

[8] In 2011, the share of expenditure on electricity in total household expenditure was 4% for non-poor households, 4.8% for poor households, and 6.1% for extremely poor households. National Statistical Service of Republic of Armenia, Foreign Financing Projects Management Center of the Ministry of Finance, and World Bank. 2012. *Social Snapshot and Poverty in Armenia: Statistical Analytical Report Based on the Results of the 2011 Integrated Living Conditions Survey of Households*. Yerevan.

10. **Opportunities.** The use of renewable energy can be expanded considerably; this would help Armenia increase the production and export of electricity, diversify the energy supply mix, enhance energy security, and retire the NPP without causing a supply disruption. Effective utilization of these renewable energy resources will require active private sector participation.

11. Furthermore, Armenia can increase the efficiency of electricity production, reduce electricity transmission and distribution losses, and improve the reliability of the power supply by rehabilitating, upgrading, or replacing decrepit electricity generation, transmission, and distribution assets. Armenia can also improve the interconnection of its power system with that of neighboring countries, and expand its cross-border trade in electricity.[9]

2. Government's Sector Strategy

12. The government sets out its energy sector strategy in the National Program on Renewable Energy and Energy Efficiency, approved in 2007, which underscores the importance of expanding the use of renewable energy and increasing energy efficiency. It calls for a broad range of energy-saving measures, including specific measures to be undertaken in individual sectors of the economy.[10]

13. The Armenia Development Strategy 2025, which articulates the government's long-term development vision, calls for maximum utilization of domestic energy resources (especially renewable energy resources), replacement of old power plants with obsolete technologies with new plants that use modern technologies, strengthening of power system safety and reliability, diversification of sources of energy supply, regional integration in the energy sector, development of the nuclear power subsector, and promotion of energy efficiency in all energy-consuming sectors.[11] The Government Program for 2013–2017, which is the government's medium-term action plan, identifies priorities for the energy sector as enhancing the country's energy security, improving the utilization of renewable energy resources (in particular through more efficient use of hydropower), promoting energy efficiency, modernizing the power system with new technology and equipment, improving the reliability of power supply, and constructing Armenia–Georgia and Armenia–Iran power transmission lines to expand cross-border trade in electricity.[12]

3. Sector Experience and Strategy of the Asian Development Bank

14. **Previous program.** The interim operational strategy, 2006–2009 for Armenia of the Asian Development Bank (ADB), identified the energy sector as one of the priority sectors for ADB intervention.[13] ADB involvement in the sector began only in 2012 when ADB approved a technical assistance grant for the preparation of a power transmission rehabilitation project.[14] In April 2013, ADB approved a nonsovereign loan ($25 million) for the Sevan–Hrazdan Cascade Hydropower System Rehabilitation Project.[15]

15. **Future public sector lending.** ADB will continue assisting Armenia in improving the utilization of energy resources. By doing so, ADB will help Armenia enhance its energy security and protect the natural environment. All energy projects will include appropriate greenhouse gas emission

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[9] Expanded cross-border trade in electricity would help Armenia fully utilize the capacity of the new nuclear reactor and ensure its stable and efficient operation if and when the reactor is built.
[10] Government of Armenia. 2007. *National Program on Renewable Energy and Energy Efficiency*. Yerevan.
[11] Government of Armenia. 2013. *Armenia Development Strategy 2025 (Draft)*. Yerevan.
[12] Government of Armenia. 2013. *Republic of Armenia Government Program*. Yerevan.
[13] ADB. 2006. *Economic Report and Interim Operational Strategy: Armenia, 2006–2009*. Manila.
[14] ADB. 2012. *Technical Assistance to Armenia for Preparing the Power Transmission Rehabilitation Project.* Manila.
[15] ADB. 2013. *Report and Recommendation of the President to the Board of Directors: Proposed Loan for the Sevan–Hrazdan Cascade Hydropower System Rehabilitation Project in Armenia*. Manila.

mitigation and accounting measures. Key areas for ADB operations are based on government sector priorities, and are aligned with ADB's Strategy 2020 and Energy Policy 2009. They include the following:

(i) **Rehabilitation of the power transmission network.** To help reduce electricity transmission and distribution losses, and improve power supply reliability, ADB will help rehabilitate the power transmission assets. Priority will be given to secondary towns and rural areas with poor services. The Power Transmission Enhancement Project will involve rehabilitating eight existing substations and expanding the supervisory control and data acquisition system.

(ii) **Rehabilitation of large hydropower generating assets.** To help increase the efficiency of use of scarce water resources in generating hydroelectricity and enhance the safety and reliability of large hydropower systems, ADB will help rehabilitate these systems. In particular, ADB will help—in collaboration with the European Bank for Reconstruction and Development—rehabilitate the Sevan–Hrazdan Cascade Hydropower System.

(iii) **Improvement of cross-border interconnection of power systems.** To help expand cross-border trade in electricity and utilize the generating capacity of the power system more efficiently, ADB will assist the country in improving the interconnection of its power system with Georgia. A feasibility study for the construction of high-voltage transmission facilities between Armenia and Georgia is currently ongoing. ADB will consider financing the project if it is found to be technically and financially viable.

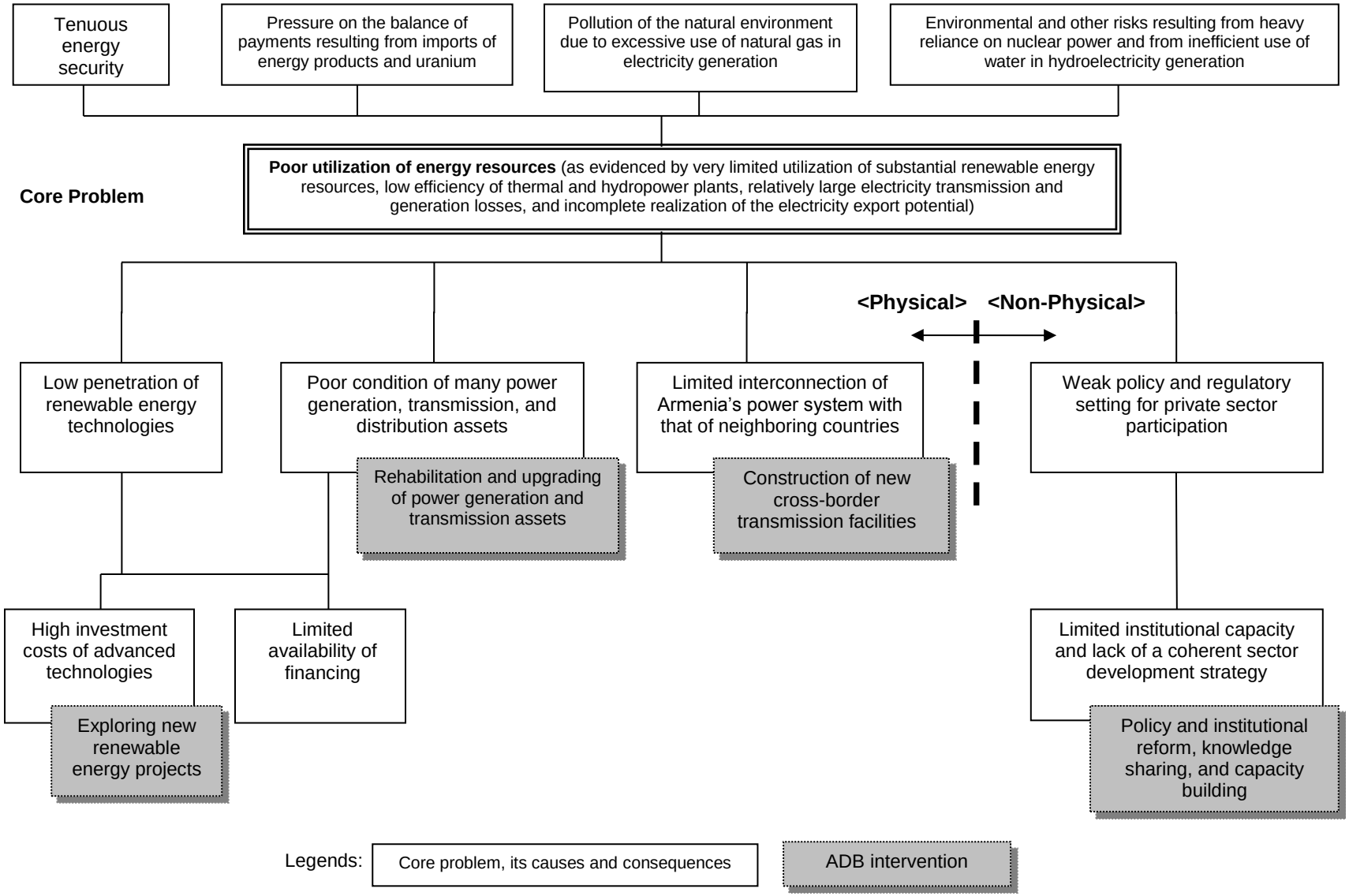
(iv) **Development of the renewable energy subsector.** To help improve the utilization of substantial renewable energy resources and diversify the energy supply mix, ADB will support—in cooperation with other development partners—the development of the renewable energy subsector. ADB is currently exploring potential financing opportunities within the framework of the Scaling-Up Renewable Energy Program.

16. **Knowledge products and services.** ADB's policy analysis and advisory services will support—in cooperation with other development partners, including the European Bank for Reconstruction and Development, KfW, and the World Bank—the government's institutional reforms aimed at creating a sound policy and regulatory environment for private sector participation in energy sector development, sector management, use of public–private partnerships and innovative financing tools, and cross-border power trade. ADB will help the government carry out legal, regulatory, and institutional reforms needed to ensure environmental sustainability of hydropower projects, and to facilitate private sector participation in the utilization of renewable energy to combat climate change and enhance the country's energy security.

17. To strengthen the policy environment in Armenia, ADB will focus policy dialogue on succession planning for the energy sector's aging assets, environmental and social safeguards in the energy sector, and creation of a strong regulatory environment for the use of renewable energy and for private sector participation.[16]

[16] Other potential topics for the knowledge products program, preliminarily proposed by the government, included harmonizing new and old power supply units (400 and 250 megawatt-hours) for their efficient parallel operation, reliability and maintenance of a relay system, energy efficiency in residential buildings, and a new inventory of wind energy (monitoring standards).

Problem Tree for the Energy Sector



Sector Results Framework (Energy Sector, 2014–2018)

Country Sector Outcomes		Country Sector Outputs		ADB Sector Operations	
Outcomes with ADB Contribution	**Indicators with Targets and Baselines**	**Outputs with ADB Contribution**	**Indicators with Incremental Targets**	**Planned and Ongoing ADB Interventions**	**Main Outputs Expected from ADB Interventions**
Increased and more efficient use of energy, including renewable energy Expanded cross-border energy trade	Per capita consumption of power increased to 2,500 kWh by 2018 (2013 baseline: 2,000 kWh) Annual CO_2 emissions (tCO_2 per year) decreased by 20,000 tons by 2018 (2008 baseline: 5.5 million tCO_2) Exports of electricity increased to 2.5 billion kWh by 2018 (2013 baseline: 1.3 billion kWh)	Energy infrastructure and systems (including renewable energy) expanded and improved	Available generation capacity increased to 4,000 MW by 2018 (2013 baseline: 3,000 MW) Annual electricity generation increased to 10,000 GWh by 2018 (2013 baseline: 6,300 GWh) Additional 600 km of 220 kV and above high-voltage power transmission line installed and rehabilitated by 2018 (2013 baseline: 0) Electricity generation from renewable energy increased to 2,900 GWh by 2018 (2011 baseline 2,500 GWh) Share of electricity generated from renewable energy in total electricity output increased to 36% by 2018 (2011 baseline: 20%)	**Planned key activity areas** Rehabilitation work and dams (18% of funds) Electrical power transmission (36% of funds) Renewable energy subsector development (46% of funds) **Pipeline projects with estimated amounts** Power Transmission Rehabilitation Project, ($67 million), Power Transmission Rehabilitation Project 2 ($30 million) Renewable Energy Project ($20 million) **Ongoing projects with approved amounts** Sevan–Hrazdan Cascade Hydropower System Rehabilitation Project ($25 million)	**Planned key activity areas** Renewable energy generation capacity increased to 1,400 MW **Pipeline projects** Eight 220 kV substations rehabilitated and national load dispatch and central control system upgraded **Ongoing projects** 44.7 MW of power generating capacity restored

ADB = Asian Development Bank, CO_2 = carbon dioxide, GWh = gigawatt-hour, km = kilometer, kWh = kilowatt-hour, kV = kilovolts, MW = megawatt, tCO2 = total carbon dioxide.

Source: Government of Armenia. 2013. *Armenia Development Strategy 2025* (Draft). Yerevan; Asian Development Bank analysis.