

Armenia

Country Profile

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1. Overview of Electricity Supply

Armenia was formed in the early 1990s upon the breakup of the former Soviet Union. Armenia is bordered by Georgia to the north; Azerbaijan to the east; Turkey to the west; and Iran and Azerbaijan to the South. The economy experienced positive growth throughout the 1990's, despite setbacks associated with the formation of the independent state and the 6-year war with Azerbaijan.

Electricity is currently generated through thermal, hydroelectric, and nuclear resources, with no generation from appreciable renewable energy sources.

Urgently needed reform of the energy sector is now under way. The sector has required increasing levels of government support, and is suffering from severe underinvestment. Restructuring to upgrade the system, promote commercialization and increase competition is imperative. The priorities are to address system malfunctions and invest in maintenance of circuits and equipment as well as technology replacement.

In September 1998 the government approved a revised reform program for the energy sector, which includes efficiency improvement measures, debt workouts and tariff increases. After a rate increase in January 1999, tariffs now cover operating costs. Despite very good collection rates, high commercial and technical losses on otherwise billable consumption have affected planned investment and maintenance and the ability to import fuel. The energy sector recorded an estimated net loss of US\$ 62 million in 1999, equivalent to 3 per cent of GDP.

Armenia Country Summary Table

Demographical Information	
Population, millions (2003)	3.1
Land area, thousand Ha (2002)	2,980

Macroeconomic Information (2003)	
GDP, billion US\$	2.8
Real GDP growth rate, percent	13.94
Foreign direct investment (net), million US\$	121
Electricity sector	
Electricity tariff, US¢/kWh (2002)	4.3
Collection rate, percent (2002)	98
Load utilization factor, percent (2000)	NA
Electricity disposition, billion kWh (2003)	
Generation	4.95
Consumption	4.42
Exports	0.65
Imports	0.46
Generation capacity, million kWh (2003)	
Nuclear	0.4
Thermal	1.8
Hydro	1.2
Other renewables	0.0
Total	3.3
<i>Sources: European Bank for Reconstruction and Development, U.S. Energy Information Administration, Food and Agriculture Organization of the United Nations.</i>	

Armenia's electricity generation is primarily produced via the Metsamor Nuclear Plant. This plant has two units with a combined capacity of 815 MW. The plant was shut down in March of 1989 because of safety concerns, however, Unit 2 was restarted in 1995, while Unit 1 has been deemed unusable to operate and will not be restarted.

In addition to the nuclear plant, Armenia has 3 thermal plants with a total capacity of 1,756 MW. These plants are operating beyond their planned lifetime, which significantly limits plant efficiency. All fossil fuels must be imported into Armenia, thus these plants are continually low on fuel and are unable to operate near capacity.

Hydroelectricity provides a significant portion of Armenia's electricity, with 25 percent of generation in 2000. The current hydroelectric capacity is concentrated on the Hrazdan River.

The electric supply is currently not available to all regions on a regular basis, thus potential demand far outpaces supply. The Armenian and Iranian power grids are currently connected, thus allowing electric trade across the border. The interconnection of the power grids in Georgia and Turkmenistan to that in Iran is currently being investigated to increase regional trade and power supply stability.

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2. Energy Policy, Barriers and Incentives

On November 9, 2004 legislation was passed on the Law of the Republic of Armenia on Energy Saving and Renewable Energy. The purposes of the present Law shall be defining the principles of the state policy on development of the energy saving and renewable energy and the mechanisms of the enforcement of those aimed at:

- Strengthening the economic and energy independence of the Republic of Armenia;
- Increasing the economic and energy security; and energy systems safety level of the Republic of Armenia;
- Establishment and development of new industry infrastructure and organization of services promoting energy saving and renewable energy;
- Reduction of adverse techno-born impacts on the environment and human health.

The principles of state policy in the area of energy saving and renewable energy are:

- Increasing level of supply of indigenous renewable energy carriers to satisfy the energy demand of the economy;
- Implementation of energy saving, as well as development and enforcement of legal and economic mechanisms for the promotion of renewable energy;
- Ensuring high priority of efficient use of energy given the increasing volumes of imported and extracted energy resources;
- Ensuring increase of renewable energy resources usage as well as application and development of renewable energy new technologies aimed promoting that;
- Ensuring competitiveness of renewable energy resources and protection/enforcement of rights of businesses engaged in the area of renewable energy;
- Ensuring high priority of issues of environmental protection and efficient (economic) usage of natural resources while implementing measures/activities aimed at the development of the energy saving and renewable energy;
- Promotion of energy efficient production of electric and/or heat energy, including for autonomous energy producers;
- Promotion of integrated activities between the autonomous energy producers, using renewable energy resources, and the energy system aimed at the exchange of electric energy;
- Promotion of consumer choices and use of different energy carriers and energy efficiency technologies;
- Implementation of energy saving and renewable energy state (national) targeted programs.

Additional energy policy, barriers and incentives include:

- Wind- Armenian Energy Regulatory Commission has issued a tariff of 5 cents/kWh (excluding VAT) for the SolarEN project
- All energy – Difficult economic conditions

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3. Wind

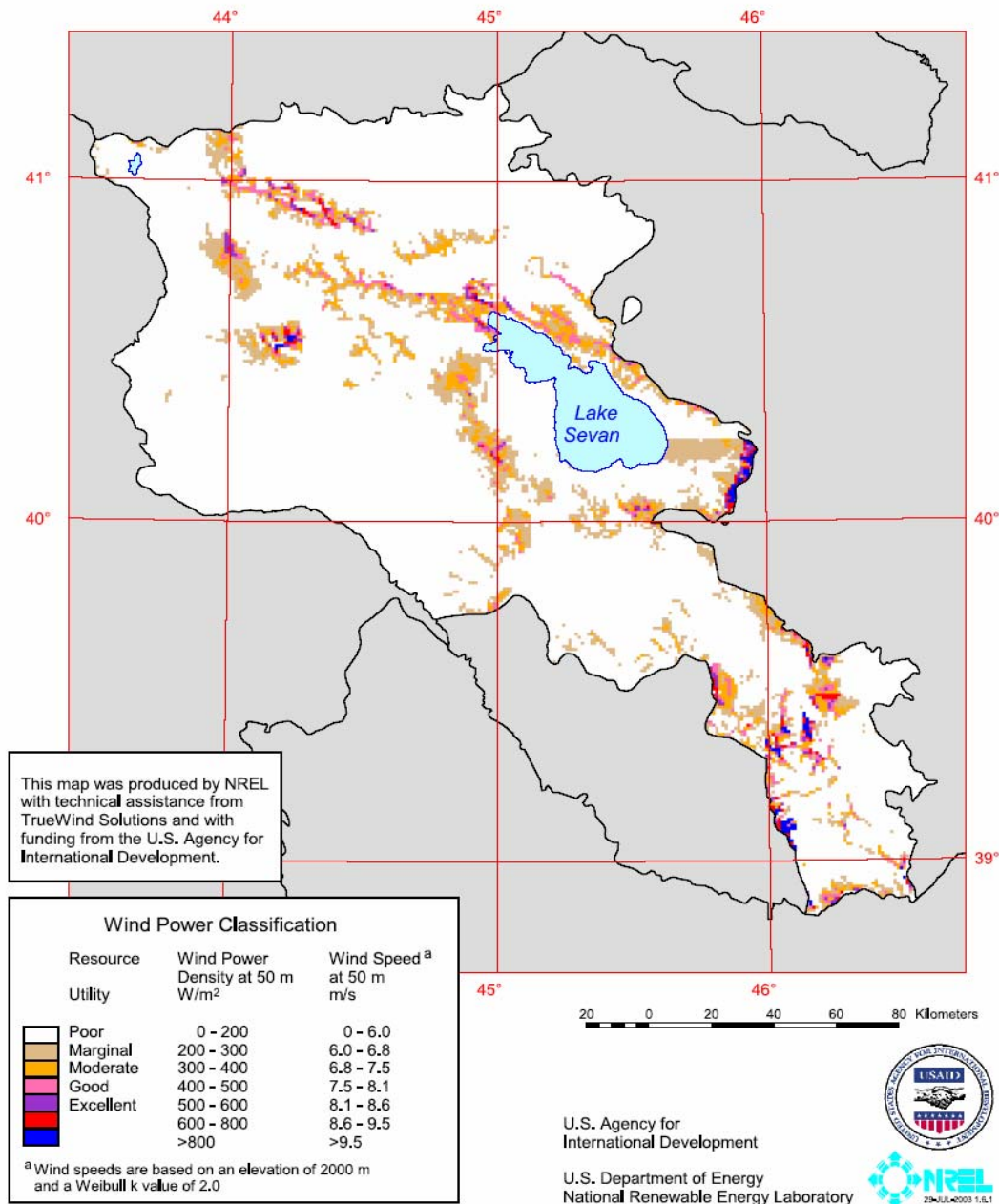
Armenia's best wind resource areas are generally located on top of the higher ridges and mountains or in wind corridors such as mountain passes. Armenia is located beneath the mid-latitude westerly jet stream, a high-speed ribbon of air several kilometers above sea level that circles the globe and also affects the wind resource in North America and Asia. The interaction of the jet stream and the major topographic features of Armenia is one of the factors that have a significant influence on the distribution of the wind resource. The jet stream also controls the progress of weather systems across Armenia and the Trans-Caucasus region. The pressure gradient between weather systems can have a major effect on the wind resource in areas subject to acceleration because of local terrain. The jet stream influence is greatest from October through March. In the warmer part of the year (April through September), the jet stream is considerably weaker, and differential heating caused by the elevation changes within Armenia and between locations to the north and east of the country controls the distribution of the wind resource. The differential heating among the plateaus, ridge tops, and low elevation areas produce regional and local temperature and pressure gradients that cause the wind to blow.

As a result of the regional and local winds, the wind resource distribution in Armenia during the warm season is quite disparate. Some locations have little wind resource and other locations, especially in some passes, have high wind resource. Overall, the combination of jet stream and regional heating influences produce a complex wind resource pattern in Armenia and it is highly recommended that measurements be made before any wind energy project is established.

Armenian law provides that purchasing of all the electrical energy from renewable energy sources is mandatory until the year 2016. The announced feed in tariff is 0.05 USD/kWh. There is currently 3 MW of wind energy capacity installed in Armenia.

Armenia has a fairly good potential for wind energy development. The most promising sites are (from north to south) Pushkin-Pass, Aragaz, Sevan Lake, Sisian-Pass, and Karakhach Pass. There are 3 MW of wind power installed currently in Armenia.

Armenia - Wind Resource Map



Armenia Wind Resource Map (Source: U.S. National Renewable Energy Lab)

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4. Biomass

Biomass energy has potential to provide significant power if utilized. Armenia has reasonable areas of land covered by forests and lands for agricultural industry, including farming of plants and animals. These sources can potentially produce residues which could be used as fuel for biomass combustion or gasification, as well as biogas production through anaerobic digestion. Forest residues such as slash from forest thinnings and waste wood from sawmills can provide a concentrated resource to be used as fuel for

energy production. Agricultural residues can provide a range of residues, including crop residues (corn stover, nutshells, fruit tree branches, etc.) and animal wastes.

To utilize biomass as an energy resource in Armenia would require significant analysis of the available residues. Given the amount of forestland, agriculture, and livestock, biomass fuels could prove to be valuable sources of energy.

Although biogas is not currently utilized as a modern energy resource in Armenia, an attempt has been made to attract foreign investment for the construction of a large biogas plant. If funding were available, it could be possible to construct a biogas plant within 12 to 15 years with a daily methane production of up to 100,000 m³.

In 1994 The Armenian Ministry of energy articulated a strategy to "Develop and demonstrate a set of improved farm scale biogas concepts". Under this program, The Armenian State Engineering University, the Armenian Agricultural Academy, and the Biological Institute assisted in the technical design and construction of a few digesters. However, given the reorganization at the farms and lack of technical and organizational support, these systems became non-operational over a short time. No meaningful data was therefore generated, however the interest to anaerobic digesters is strengthening by the privatization of agriculture and farm in Armenia. Family farms are increasingly incorporating strong commercial elements. One result is livestock concentration, a situation offering potentially larger quantities of available animal manures in a more localized region.

The table below shows the overall biomass resource data for Armenia.

Armenia Biomass Resource Data

Biomass resource type	Total production	Production density
Percent of total land area covered by		15%
Forests		24%
Shrublands, savanna, and grasslands		55%
Cropland and crop/natural vegetation mosaic		1%
Urban and built-up areas		0%
Sparse or barren vegetation; snow and ice		5%
Wetlands and water bodies		15%
Primary crop production, tonne	(avg. 1999–2001, tonne)	(tonne / 1000 Ha)
Total primary crops (rank among COO)	4,101,449 (23)	1,454 (14)
Top 10 primary crops		
Forage Products (misc)	2,513,333	891
Potatoes	356,072	126
Maize for Forage & Silage	233,833	83
Wheat	229,984	82
Tomatoes	156,301	55
Grapes	115,698	41
Vegetables Fresh (misc)	82,333	29
Cabbages	69,253	25
Watermelons	65,380	23
Barley	52,291	19
Animal units, number	(number)	(number / 1000 Ha)
Cattle	473,904	168
Poultry	3,722,000	1,320
Pigs	78,370	28

Equivalent animal units	542,472	192
Annual roundwood production	(1996–98, 000 m ³)	(m ³ / Ha)
Total	33	11.7
Fuel	33	11.7
Industrial	NA	NA
Wood-based panels	NA	NA
	(1996–98, 000 metric tons)	(metric tons / Ha)
Paper and paperboard	NA	NA
Recovered paper	NA	NA

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5. Solar

Armenia is rich in solar energy resources, the utilization of which will reduce the need for imports of other energy sources. The average annual solar radiation is approximately 1,720 kWh/m² compared to the average annual European solar radiation of 1,000 kWh/m². Over a quarter of the territory of the country has solar resources with an intensity of 1,850 kWh/m². Solar radiation in the Sevan basin is substantial at 2,800 hours.

In spite of very favorable climatic conditions and absence of own traditional energy resources, there is little use of solar energy in Armenia.

The solar energy resource potential is characterized by the data presented in the tables below for three areas, Yerevan (a capital), Sevan, Kochbek. The last one is located at Southwest of Republic at the height 2387 m over sea level.

Monthly and annual total solar radiation incident on horizontal surface, MJ/m²

	Yerevan	Sevan	Kochbek
Jan	200	281	311
Feb	267	357	392
Mar	417	518	537
Apr	540	545	573
May	720	666	654
Jun	821	768	764
Jul	858	825	817
Aug	754	743	743
Sep	594	580	589
Oct	428	435	445
Nov	251	285	299
Dec	171	234	272
Yearly	6021	6237	6396

Monthly and annual direct solar radiation incident on surface normal to sunlight beams, MJ/m²

	Yerevan	Sevan	Kochbek
Jan	178	387	391
Feb	243	386	384
Mar	364	441	408
Apr	450	442	409
May	667	565	534
Jun	826	734	749
Jul	861	774	848
Aug	810	775	804

Sep	740	704	743
Oct	534	587	616
Nov	312	440	461
Dec	175	373	373
Yearly	6160	6599	6720

The territory of Republic is very small and the climate is practically uniform throughout the country. The solar energy resource potential depends not on what part of the country the project is located, but more upon the height above sea level. It is evident from the tables that the solar energy resource potential increases at higher altitudes.

There is a potential for solar water-heating plants with total power 2-3 MW (thermal), and photovoltaic plants. The project "Autonomous solar power supply of national service of seismic protection and national meteorological service" with overall capacity up to 100 kW is now in the process of realization.

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6. Geothermal

Armenia is located in a zone with high tectonic activity and recent volcanic activity; however, the geothermal resources are not so rich and characterized by low-to-medium temperature thermal water. Currently thermal water is used only for swimming pools and in therapeutic baths. At this point only obsolete technologies are in use: spouting (free flow) well operation, direct use of geothermal water. Total installed heat capacity is less than 1 MWt. There is no national program promoting use of geothermal energy.

Armenia needs to carry out a careful analysis of available geological and geothermal data including the results of hydrodynamic investigations and testing of geothermal reservoirs in existing wells to reveal prospective areas in order to advance geothermal development. From reviewing published data, it appears technically possible to use the low-temperature thermal water with heat pumps in Martuni and Sisian.

The underground reservoirs containing the thermal water were formed both in the porous alluvial sedimentary rocks of intermountain basins and in fissured crystalline rocks. A narrow zone in the central part of Armenia (Sisian – Martuni – Sevan) is considered to have the best potential. The geothermal gradient here reaches 500 °C/km. The maximum measured temperature in the deeply occurring reservoirs is 1400 °C.

Geothermal reservoirs in porous rocks containing high-temperature thermal water were investigated in some places:

- inflows of thermal water with temperature of 110 °C were obtained in the upper cretaceous sediments in wells with a depth of 2.5 km (Bajandur, Dilidjan, Vanadzor);
- a temperature of thermal water of 100 °C was recorded at a depth of 2.6 km in the upper cretaceous sediments of Ararat basin (Razdan). It is projected that at a depth of 3.6 km the temperature might be up to 160 °C.

Considerable inflows of low-temperature thermal water were obtained in two regions:

- Martouni: prospecting wells with a depth of 1200 m investigated the reservoirs with the thermal water. Its temperature is 32-40 °C, mineralization 2-3 g/l, inflows- 2-50 l/s. The total thermal capacity is estimated as 8 MWt;
- Sisian: prospecting wells investigated the adjoining hydrothermal system, where the temperature of thermal water is 36-43 °C, its mineralization 4-6 g/l, the inflows 20-100 l/s. The total thermal capacity is estimated as 8 MWt.

The only definite opportunity for geothermal development in Armenia lies in creation of state-of-art heat supply systems with heat pumps. Any electricity production projects need high cost investigations with additional exploration drilling.

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7. *Hydroelectric*

The hydro potential of Armenia has been evaluated to be about 21.8 billion kWh/year, including 18.6 billion kWh from large and medium rivers and 3.2 billion kWh from small rivers. The economically feasible potential is about 3.3 to 3.5 billion kWh, with 1.5 billion kWh already utilized.

Considering that the electricity production has been about 6 billion kWh during the last few years, utilization of hydro potential would satisfy 50 per cent of the current demand and not only avoid an energy crisis but also contribute to the development of the economy and increase the stability of improvements.

Potential hydro resources of Armenia are rather scarce, but through concentration of hydro resources on the territory the potential is significant. The Razdan River, Lake Sevan, the Vorotan, Debed, Aras Rivers have the largest potential.

In estimation of total hydropower potential of Armenia, small hydro development was singled out. The largest small hydro potential is concentrated in the Northern part of Armenia (the Kura River basin), Central part (Lake Sevan basin) and in the south of the Republic (the Aras River basin). Further hydro development could be realized using potential of medium-size and small rivers.

There are small hydropower development programs in Armenia that include adding small HPPs to water management projects with already existing water retaining structures with the aim of utilizing waste releases. Additionally, construction of new small HPPs for power supply of users in remote areas of the power system.

Development of the energy sector is being implemented in accordance with "The Program of Development of the Energy Sector in Armenia until 2020", which was compiled by experts from Armenia and foreign companies with technical assistance from TASIC (EU), USAid, The World Bank and others.

The Government of Armenia is taking efforts in rehabilitating the power sector and has developed an investment program for power development up to the year of 2010.

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8. *Relevant Links*

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9. *References*

- Evaluation of renewable energy resources in Armenia. Draft Report on "Energy efficiency, demand side management and renewable energy resources program", USAID Task Order Out-LAG-1-816-98-00004-00, BIO ENERGY, January 2002.
- National Renewable Energy Laboratory (NREL), Elliott, D., Schwartz, M., Scott, G., Haymes, S., Heimiller, D., George, R., Wind Energy Resource Atlas of Armenia, July 2003

- Armenian Engineers and Scientists of America, Wood Energy Crops and Other Biomass to Electricity in Armenia
- Ghandilyan, A., M. Kalashyan and A Harutyunyan. 2000 "Biogas Production Technology Combined with Solar Water Heating System for Small-scale Farm". Presented at 1st World Conference on Biomass for Energy and Industry, Sevilla, Spain. June 5 – 9, 2000.
- European Bank for Reconstruction and Development, Transition Report 2004
- V.Afian. Autonomous solar power supply for National service of seismic protection. "Renewable Energy", 1998, no.4.
- United Nations Economic and Social Conditions for Asia and the Pacific, <http://www.unescap.org/esd/energy/information/electricpower/2001-2002/html/armenia.htm>
- Applied scientific reference book on climate of the USSR. Hydrometeoizdat, L., Issue 16, 1990.
- Internet site: [www.bpsolar.com/ContentDocuments/17/PV System Sizing Tools.zip](http://www.bpsolar.com/ContentDocuments/17/PV%20System%20Sizing%20Tools.zip)
- Evaluation of renewable energy resources in Armenia. Draft Report on "Energy efficiency, demand side management and renewable energy resources program", USAID Task Order. Out-LAG-1-816-98-00004-00, BIO ENERGY, January 2002.
- Ghandilyan, A., M. Kalashyan and A Harutyunyan. 2000 "Biogas Production Technology Combined with Solar Water Heating System for Small-scale Farm". Presented at 1st World Conference on Biomass for Energy and Industry, Sevilla, Spain. June 5 – 9, 2000.
- A Strategic Plan for the Development of European Geothermal Sector. Blue Book on Geothermal Resources, European Communities, 1999.
- M. Badalyan. Geothermal Features of Armenia: a Country Update. Proceedings World Geothermal Congress 2000, Tokyo, 2000.
- R. Henneberger, D. Cooksley and J. Hallberg. Geothermal Resources of Armenia, Proceedings World Geothermal Congress 2000, Tokyo, 2000.
- Power Resources of the USSR. Hydropower Resources. A.N.Voznesensky et al., 1967
- Small Hydropower, L.P.Michailov et al, 1989
- Magazine "Hydraulic Construction"№2-2002.

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10. Country Contacts

Contacts made in the preparation of this assessment are gratefully thanked for their contribution to this report. Contacts include: