

Wind Resource Development Project for Armenia

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Abstract

Armenia has few proven reserves of natural energy and is dependent on long, unreliable transport lines for oil and gas. Preliminary studies indicate that the wind energy potential in Armenia is more than 500 megawatts (MW), assuming a reasonable fraction of 10% of the land area in the high-wind zones. Over the long term, the Armenian government intends to meet 8%–10% of its electric consumption needs by grid-connected wind turbines. The goals of this project are to enhance Armenia's energy security, mitigate the environmental damage of conventional sources of energy, reduce future carbon dioxide emissions, build an environmentally sound and sustainable model for economic development, and promote trade between the U.S. and Armenia. The project is being funded by the Cafesjian Family Foundation, a private foundation based in the United States in Naples, Florida, with the participation of Ecotrade, Inc. of Glendale, California. The National Renewable Energy Laboratory (NREL) is providing technical assistance.

As part of the wind energy development project, we conducted a preliminary wind-energy resource assessment for some regions in Armenia. This activity provided valuable information needed to facilitate the commercialization of wind farms in Armenia and to lay the groundwork for subsequent wind resource activities. This paper presents the wind resource monitoring results (1999–2000) for the candidate site. Our preliminary assessment identified areas with good-to-excellent wind resource potential.

Republic of Armenia

Armenia is a small, landlocked, mountainous country with few natural resources covering an area of 29,800 square kilometers (about the size of the state of Maryland). It is situated in the Caucasus Region, surrounded by Georgia, Azerbaijan, Iran, and Turkey. The population is around 3 million people. The capital city is Yerevan, which has a population of about 1.2 million people [1].

Economic Overview

Currency: Dram (\$1.00 U.S.=520 Dram)
Nominal GDP: \$1.9 billion (according to the U.S. Energy Information Administration)
Major trading partners: Russia, Turkmenistan, United States, and Europe

Major export products: Agricultural, machinery and transport equipment, light industrial products

Major import products: Fuel, foodstuffs

Energy Overview

Proven fossil fuel reserves: Coal (not commercialized)
Fossil fuel production: None
Oil consumption: 13,000 barrels per day
Crude oil refining capacity: None
Natural gas consumption: 46 billion cubic feet
Electric generation capacity: 3.0 gigawatts (GW)
Practical generation capacity: 1.2 GW
Electricity generation: 5.1 billion kilowatt-hours (kWh)
Major power plants: Metsamor nuclear plant (408 MW); Hrazdan oil/gas plant (1,110 MW); Yerevan heat/power plant (550 MW); Sevan-Hrazdan hydroelectric plant and smaller plants (925 MW)

The electricity balance forecast for Armenia is shown in Figure 1 [2].

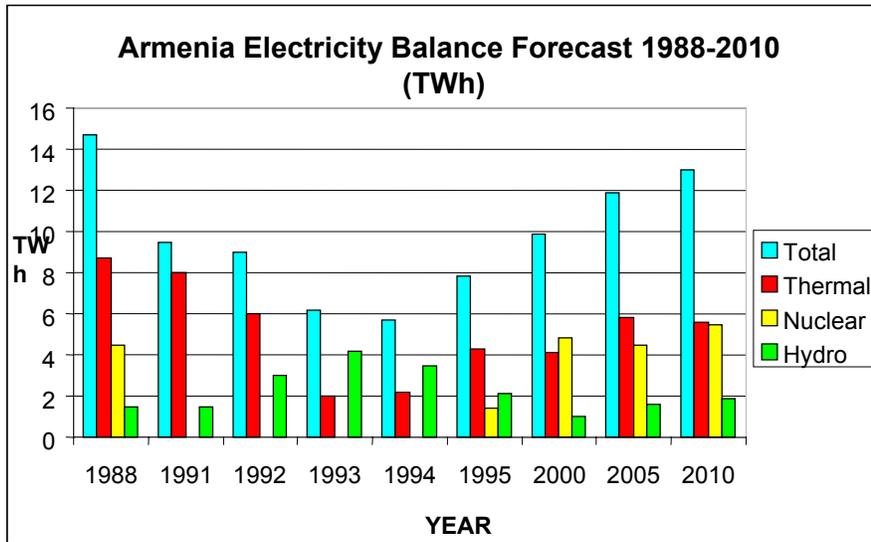


Figure 1. Electricity balance for Armenia

Environmental Overview

Major problems: The soil is polluted from toxic chemicals such as DDT; an energy blockade has led to deforestation; the Hrazdan river is polluted; draining Lake Sevan for hydropower threatens drinking water supplies; and the Metsamor nuclear and oil/gas burning power plants are reaching the end of their economic life cycles

Armenian Government Objectives

Over the next 15 years, Armenia's total investment needs in the power sector to rehabilitate and replace generation facilities is estimated at \$1.7 billion U.S. The Armenian government intends to meet 8%–10% of its long-term electric consumption needs by grid-connected wind turbines. The results of this project will establish a commercial track record for the development of independent power producer (IPP) projects using renewable energy sources in Armenia. IPP projects will be essential to attract private capital to fund the power sector's investment requirements.

Armenia's Wind Energy Potential

Preliminary studies indicate that the wind energy potential in Armenia is over 500 MW, assuming a reasonable fraction of 10% of land area in the high-wind zones.

The known areas of high wind potential (7 meters/second (m/s) and higher) are shown in Figure 2:

1. Arpi Lake area
2. Pushkin Pass area
3. Lake Sevan (north and east)
4. coastal areas
5. Zod area
6. Karakhach Pass area

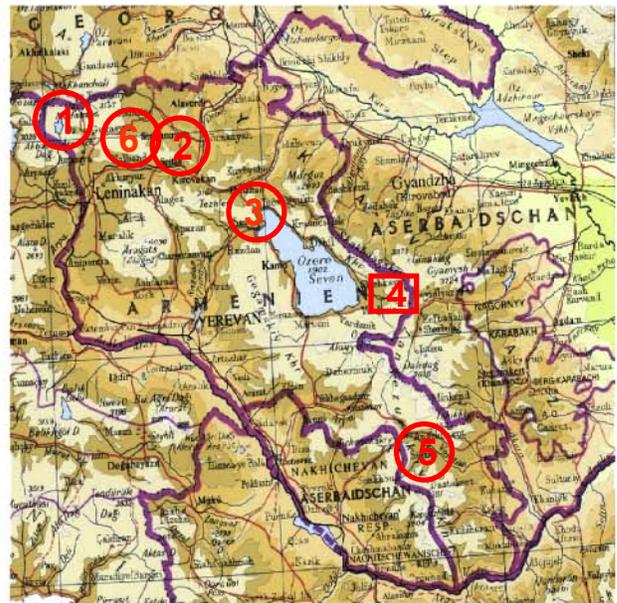


Figure 2: Known areas of high wind potential

Micrositing Study for Zod Region

Seven NRG wind-monitoring stations were installed during September–October 1999. A topographic map of the site with station locations is shown in Figure 3.

The list of NRG equipment used on the site:

- NRG-NOW System 40 m—2 sets (stations #2 and #7)
- NRG-NOW System 20 m—3 sets (stations #4, #5, and #6)
- NRG Wind Explorer 10m—2 sets (station #1 and #3)

Measurements started in September 1999

Averaging interval—10 min

Zod area elevation is 2,000–2,700 m above sea level.

Sites #3 and #4 (Figure 4) have the most favorable wind conditions based on six-month monitoring results. The six-month average wind speed is 8.4 m/s for Site #3 and 8.5 m/s for Site #4. The maximum recorded gust over a six-month period was 50.5 m/s.

The wind speed time series for Site #3 is shown in Figure 5. Figure 6 shows the monthly averages for Sites #3 and #4. The wind speed distribution frequency for Site #4 is shown in Figure 7.

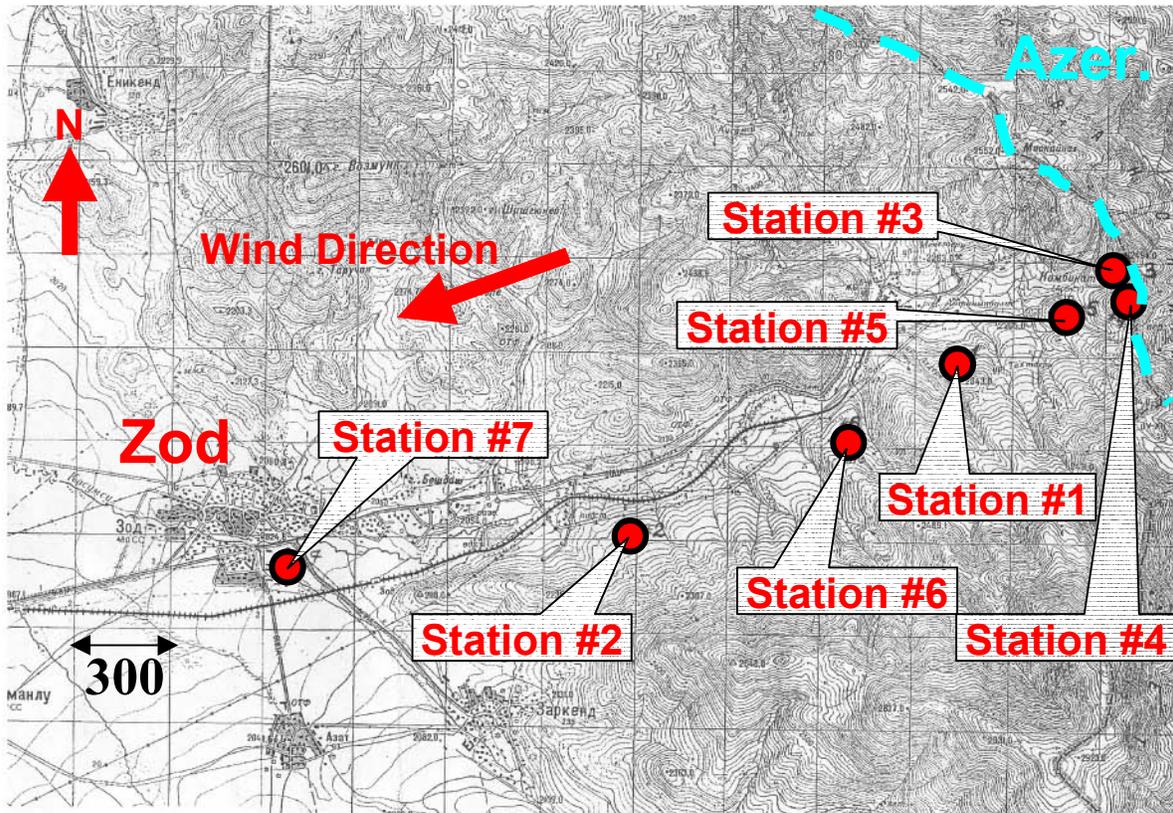


Figure 3: Zod area topographic map with station locations



Figure 4. Sites #3 and #4

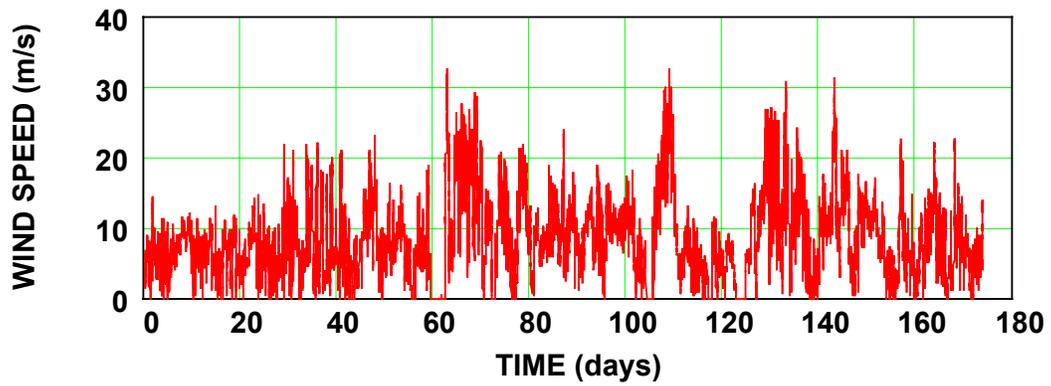


Figure 5. Wind speed time series for Site #3 (start date September 22, 2000)

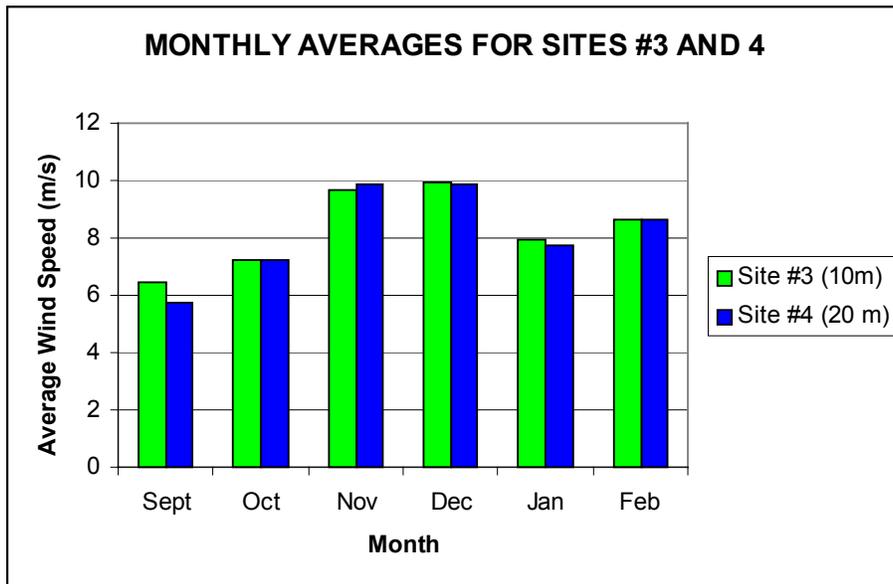


Figure 6. Monthly averages for Sites #3 and #4

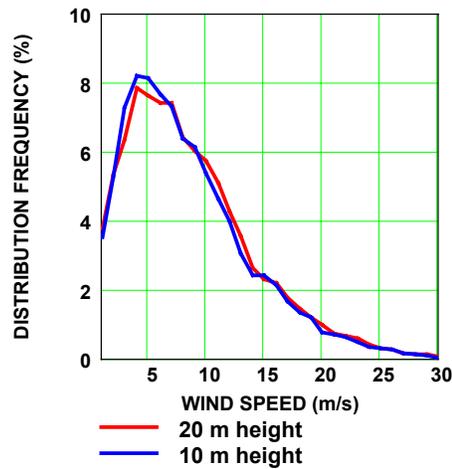


Figure 7. Wind speed distribution frequency for Site #4

Zod Region of Armenia as a Potential Site for Development of First Commercial Wind Farm in Armenia

- The wind resource data collected so far indicates the availability of a sufficient wind resource.
- The wind speeds are higher during the winter season. This will increase the value of the electrical power produced by the wind farm, because the peak electrical loads in Armenia occur during winter months.
- It is close to power transmission lines, major highways, and railroads.
- There are several energy-dependent industries in the region (gold mines, etc.).

Development of a Wind Resource Atlas for Armenia

A cooperative effort between NREL and the United States Agency for International Development (USAID) is being established to support the development of a Wind Resource Atlas for Armenia. NREL has committed to developing the annual average wind resource maps for utility applications using global terrain and climatic data sets, GIS technology, and meteorological and upper air historic data from Armenian weather stations. There will be four primary project activities:

- Collecting existing data and information;
- Processing and analyzing the data to characterize the wind resource;
- Developing the wind resource maps;
- Establishing wind monitoring stations in key wind resource areas.

Plans for 2000–2001

- Continue wind resource monitoring for Zod area
- Complete the data analysis based on one-year monitoring results

- Conduct economic analysis and feasibility study for developing a 10–20-MW grid-connected wind farm in the Zod area
- Develop an investment program
- Seek financing options from international financial institutions

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