Renewable Energy in Armenia

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Danish Energy Management in close consultations with main stakeholder and local experts in Armenia has prepared the Renewable Energy Roadmap for Armenia and its related technical studies which were funded by the Renewable Resources and Energy Efficiency Fund (R2E2) of Armenia under World Bank GEF Grant. This paper is a summary of the findings and conclusions of the studies and the roadmap.

Background

Renewable energy development has been slow in the past but its application throughout the world is accelerating. Policies to stimulate a faster deployment of clean energy technologies are necessary which in turn will create a level playing field by addressing market barriers, creating transparent pricing structures, and facilitating access to infrastructure financing. Because the renewable energy industry is not yet at the same level of development as the more traditional energy industries, it needs a more favorable regulatory environment in the near-term for its development, survival, and transformation to a mainstream energy resource.

Some renewable energy technologies are close to becoming commercial such as hydro, biomass, and wind and should be the first to be deployed on a massive scale. While other renewable energy technologies exhibit promising potential, they are less mature and require long-term vision, government encouragement, and favorable regulations to flourish.

According to the main results of the Armenian Renewable Energy Roadmap project, the contribution of the renewable electricity in Armenia can increase by fivefold in 2020 in comparison to the 2010 energy production from renewable energy. In 2010 renewable energy production generated 310 GWh, and it is forecasted to generate 740 GWh in 2015 and 1500 GWh in 2020. It is important to emphasize that the achievement of targets is much more dependent on politically implemented measures than on technical capabilities.

To date, several countries including United States and all 27 member states of European Union have implemented effective support policies for renewable energy development which have resulted in the acceleration of renewable energy technology deployments in recent years. Various regulations and incentives are used by different countries such as U.S. and European countries to promote the investment and use of energy from renewable sources. Some of these incentives and tools for promoting renewable energy are Tax Incentives, favorable Feed-in Tariffs, Rebate Programs, Net Metering, Renewable Portfolio Standards, and Time-of-Use Rates.

However, there still exists a large potential for improvement of policy design in most countries and considerable realizable potential across all renewable energy technologies. If effective policies were adopted in many more countries, this potential could be exploited more rapidly and to a much larger extent.

Current Energy Status in Armenia

Armenia does not have any fossil fuel or coal reserves; therefore, it is entirely dependent on the imported fuel for transportation, electricity generation, and heat production. While surrounded by countries that possess significant hydrocarbon reserves, Armenia's fossil fuel reserves are limited to a small number of lignite or brown coal mines located in the vicinity of Gumri and Spitak. Oil drilling results have shown that while some oil reserves exist, they are located too deep to be economically viable for extraction.

Armenia has overcome the energy crisis of the 90's and has built a viable energy system. However, compared to the year 1988, which was the peak of economic output of the Republic of Armenia, energy consumption lags far behind 1988. The generation capacity in 1988 was over 3.5 GW (gigawatts), but the energy use in 2010 was on average below 1.2 GW. This can be explained

by the fact that industry in Armenia has yet to recover fully from the economic decline that started with the collapse of the USSR.

A number of thermal power plants have been closed and one of the two reactors at the Metsamor Nuclear Power Plant has been shut down. Today, power generated from the Hrazdan-Yerevan and Vorotan Hydro Power Plant cascades remain as important a power sources as it was during the energy crisis of the early 90s. At present, electricity generation depends mostly on imported nuclear fuel and natural gas; however, hydropower is still responsible for approximately 1/3 of total power generation. Almost half of the electricity generation capacity and all small hydro power plants (100 MW installed, 9% of current operational capacity) are privately owned. The Armenian government is planning to decommission Metsamor Nuclear Power Plant between 2017 and 2021. There is a plan to build a replacement nuclear power plant with capacity of 1000 MW, which is planned to become operational no later than 2021.

The current cost of the electricity generation is relatively low due to the utilization of fully depreciated infrastructure, but the entire electric power generation and distribution system needs modernization, upgrade, or replacement. Similarly, upgrading the power distribution systems in terms of the power lines, controls, and management will be needed. One of the main requirements in this process is consideration of the social aspect, which means the prices of power should increase in proportion with the rise of the standard of living.

Thermal energy generation capacity has also changed substantially during the last two decades. During the Soviet era, there were no air conditioning systems installed in most of the residential or commercial buildings except for a very limited number of window units and the district heating systems, powered by heavy oil (mazut) and natural gas were the main heating source. After the collapse of the USSR most of the urban centralized heating systems were dismantled. Now a large portion of the population, approximately 1/3, has installed individual natural gas powered heating systems and the use of air conditioning has increased noticeably.

The major changes in transportation are related mostly to the slow but steady increase in living standards in Armenia, which in turn has increased the number of privately owned cars. Increases in the use of natural gas as an alternative to gasoline has increased the proportion of natural gas powered vehicles to approximately 50% of the total vehicle fleet. This trend is continuing but it has leveled off. Presently there are only few hybrid or electric vehicles in Armenia.

Currently Armenia can meet only 35% of the total current demand for energy with its domestic resources. The following is 2010 energy fuel source mix in Armenia by end use application:

- Electricity — uranium for the nuclear power plant (44%), imported natural gas and mazut for dual-fuelled thermal plants (29%), large hydro (24%), small hydro (3)
- Heating — imported natural gas (60%), electricity (20%), firewood and animal waste (20%)
- Transportation — imported gasoline (estimated 50%), imported compressed natural gas (estimated 50%)

Energy Independence

Renewable energy resources offer benefits because not only can they reduce pollution, but they also add an economically stable source of energy to the mix of electricity generation sources in Armenia. Depending only on imported fuel for energy production makes the country vulnerable to volatile prices and interruptions to the fuel supply. Since most renewable energy sources do not depend on fuel markets, they are not subject to price fluctuations resulting from increased demand, decreased supply, or manipulation of the market. Because fuel supplies are local, renewable resources are not subject to control or supply interruptions from outside the region or country. The nation's fossil fuel dependence also has serious implications for national security.

While there are compelling energy security arguments to increase the amount of renewable energy in the Armenian energy mix, unfortunately significant barriers inhibit private sector driven growth in the sector.

Any addition to the energy independence of Armenia has high direct social, industrial, and political value in addition to the psychological benefits. Such benefits tend to be rather difficult to assess in a monetary way. However, a potential approach could be based on the results of the analysis which indicates that a 1% increase in use of renewable energy is equivalent to 3.65 days of independent supply in the event of total energy blackout.

Governmental Agencies and Laws

The main body for all energy policy matters and issues in Armenia resides with the Ministry of Energy and Natural Resources which is responsible for overseeing and managing all aspects of the energy sector.

The main quasi-governmental organization that is heavily involved in renewable energy research and financing is the Renewable Resources and Energy Efficiency Fund (R2E2) of Armenia. This organization is mainly funded by the World Bank and Global Environmental Facility (GEF).

Development of various renewable energy sources and of industries associated with each of them is slow. Most of the time, on a cost basis they cannot compete with traditional energy sources, with the exception of small hydro power plants. Therefore, favorable laws and policies are necessary to stimulate the deployment of clean energy technologies. In general, laws and regulations of the Armenia are adequately addressing issues related to renewable energy. However, a more favorable regulatory environment is needed for the large-scale development of renewable energy resources in Armenia.

The two major laws related to the renewable energy are “Energy Law” of 1997 and “Law on Energy Saving and Renewable Energy” or 2004. These two laws adequately address issues related to the governing and developing of the renewable energy resources of Armenia. There are also several other laws, decrees, and government resolutions that further clarify and provide guidance for specific issues and situations.

The general energy-related issues in Armenia are regulated by the Energy Law and specific issues related to renewable energy are regulated by the Law on Energy Saving and Renewable Energy. The main purpose of the Law on Energy Saving and Renewable Energy is to define the principles of the state policy on development of the energy saving and renewable energy. The idea is to strengthen the economic situation and energy independence of Armenia by increasing the level of indigenous renewable energy production. These laws define the main principles of state policy in the energy sector, which are:

- Effective use of local energy reserves and alternative sources of energy as well as application of economic and legal mechanisms for that purpose;
- Ensure the energy independence and security of Armenia;
- Create new industries and organize new services, implement targeted national programs and apply new technologies in order to promote the development of renewable energy and energy saving;
- Promote energy-efficient and energy-saving technologies;
- Reduce environmental impacts.

According to the law, private electricity developers must sell all electricity generated to the grid operator and they are prohibited from selling directly to potential customers.

Renewable Energy Options

As a country possessing no fossil fuel resources, Armenia could utilize different sources of renewable energy available in the country. These sources include large and small hydropower plants, abundant sunshine, and a number of mountain passes with high average wind speeds.

Potential of renewable energy technologies in Armenia can be categorized under three groupings:

- Producing electric power: small hydro, wind farms, and photovoltaics (solar panels).
- Producing heat: solar thermal, biomass, biogas, and the use of heat pumps.
- Producing fuel for transportation: bio-ethanol and hydrogen.

The findings of a comprehensive review of renewable energy potential in Armenia have ranked small hydro power plants and solar hot water heaters as the most advanced renewable energy and the most economical for Armenia in the short to medium-term, followed by grid connected wind farms and the use of heat pumps. Photovoltaics, geothermal power, and bio-fuels, especially bio-ethanol from cellulosic feedstocks, are ranked as more costly in today's prices and are not expected to be commercially viable in the short to medium-term, but may play a more important role in the longer term. Biomass for both heat and electricity production for the short term can be considered, under several conditions, including re-planting of harvested trees and bio-fuels using fractionation process. In addition, hydrogen could be a possible fuel for transportation in the longer term. Finally, although not strictly a renewable resource, municipal solid waste in landfills is a practical source for generating methane for power production.

Electrical Cars – When the new nuclear power plant is become operational, there will be more than 2000 GWhs electrical power excess, especially during night time hours when internal demand is low and there will be less possibility of exporting electricity to the neighboring countries. However, if large numbers of electrical vehicles are introduced in Armenia for private and public use, the excess nighttime electricity can be used for charging them. The excess night time electric power would be sufficient for charging approximately number of vehicles equaling to one third of the total number of vehicles in use in 2010. Using electric vehicle could also help reducing costly fuel imports, leveling the electricity load of the new nuclear power plant, and reducing greenhouse gas levels.

Funding sources are readily available for the construction of new run-of-the river small hydro power generation systems or renovating existing systems. The main limitation is the availability of promising sites within reasonable proximity to good roads and transmission line access where more small hydro power generation systems can be constructed. Cost of installing electric power lines for renewable energy facilities at remote locations to get connected to the grid can be prohibitive from the perspective of overall commercial reliability. It is estimated that in 2020 small hydro power installed capacity will grow to be about 215 MW from the 100 MW level that existed in 2010.

According to a U.S. Department of Energy study, theoretically Armenia has 5,000 MW wind energy capacity. However, this does not mean that if there is capacity then it is equal to economically feasible electricity generation. Most of the areas with high wind are not easily accessible for heavy machinery that is needed for the installation of the wind turbines.

Utility-scale wind farms are still not commercially viable under the existing government established electricity purchasing tariff structure from the perspective of attracting private capital investment without either additional fiscal incentives or subsidies. The attractiveness of these investments would grow in all probability as lighter weight turbines exhibit increased efficiencies and the cost of the turbines decreases over time. However, the main technical barrier is the difficulty in transporting large turbines (1.5 to 3 MW) and composite blades (up to 52 meters in length) from a port of entry to the selected site in a landlocked, mountainous country like Armenia. Therefore, not

more than 300 MW of wind-generated capacity in 2020 would be a realistic number, using turbines that do not exceed 1.5 MW per unit. As of early 2011, only 2.6 MW of wind power was operative in the Lori region.

The economic viability of using photovoltaic solar panels for power production in Armenia is more complicated. The most cost-effective approach is currently to import solar cells and to assemble them into modules in Armenia. The second alternative is the development of an industrial base in Armenia for manufacturing silicon-based solar cells in the country, using its abundant quartzite deposits. This alternative is expected to require an investment of approximately $300 million. Presently there are only few small pilot type solar panel installations in Armenia.

Bio-ethanol production is essential for Armenia in order to move in the direction of greater energy security of supply in the motor transport sector and to offset potential future increases in the cost of imported gasoline and compressed natural gas. One hundred percent of motor transport fuels are imported. Even a 5% blend of bio-ethanol with gasoline will replace approximately 14,000 tons of expensive imported fuel per year. However, the cost of production of bio-ethanol using indigenous non-food feedstocks, such as Jerusalem artichoke or animal corn feed, is presently above the wholesale cost of gasoline, which means that voluntary blending of bio-ethanol and gasoline is unfeasible unless mandated by the government.

Recent explorations and test drilling conducted in Armenia have identified a maximum geothermal resource potential of only 75 MW. The economic viability for geothermal power in Armenia seems marginal, from both the perspective of cost (mostly for drilling and field development) and the total potential power output.

Although municipal waste is not strictly a renewable source, it is indigenous to the country and its disposal is a monumental nuisance and very costly. The average annual generation of municipal solid waste in Armenia today is estimated to be 1600 metric tons/day. The traditional disposal of municipal waste is in engineered landfills or else in mass burn incineration both of which generate serious environmental problems. Land for disposal is becoming increasingly scarce in urban areas and incineration emits toxic gases unless expensive sorting techniques are employed. The more recent and beneficial use has been to generate methane gas through anaerobic digestion, and then using the biogas to generate electric power. Typically 30 tons of municipal waste could generate 24 MW of electrical power.

The Lusakert Biogas plant in Northern Armenia is the first and only industrial sized, state-of-the-art biogas facility in Armenia based on organic waste from poultry. T2-26 Several years ago USAID had financed construction of approximately 40 small biogas units in the villages throughout Armenia, but most of these units are not operational because villagers much prefer to use the old style way of dried manure for heating and cooking, instead of using these units to generate biogas.

Environmental Benefits and Impacts

Renewable energy generation would have mainly positive, long-term environmental effects as it reduces the need for power generation based on fossil fuels, thereby reducing Greenhouse Gas (GHG) emissions. Renewable technologies can also reduce water consumption, thermal pollution, waste, noise, and adverse land-use impacts. Of course, renewable energy also has environmental impacts during construction and operation. Construction impacts are normally temporary and no worse than other industrial projects.

Approximately 2/3 of current power generation in Armenia is based on nuclear and hydro power which in turn lowers the per capita GHG emissions for Armenia. While still the reduction of the GHG emissions are among targets to pursue, the energy independence and reducing the cost of energy generation are of higher importance.

The main potential problems associated with small hydro power plant projects could be their impact on migrating fish stock if proper fish bypasses are not installed or proper precautionary

measures are not implemented to avoid fish being sucked into the turbines. There is also the possibility of an adverse impact to wildlife if the required minimum water flow is not maintained in the river downstream of the plant.

The main impacts resulting from the operation of wind farms are low frequency noise and visual pollution of the landscape. There is also a possibility of birds colliding with turbine blades; therefore, avoiding bird migration paths for wind turbine farms would minimize this impact.

Bio-fuel production results in virtually no net carbon emissions during a complete life cycle if forests are not destroyed to make land available for planting feedstock. Even though gasoline that is mixed with bio-ethanol has less CO_2, the blend produces higher nitrogen oxide than gasoline, which is the main component of air pollution that causes smog. Depending on the feedstock, the leftover by-products could be useful as fertilizer, fuel for operating processing plants, or become waste.

Possible impacts from solar electrical panels and solar water heaters could be the visual impact of reflected light. Burning fire wood crates air emissions and small particle matters that could be harmful to human health and there could be an impact to the eco system due to the unsustainable rates of harvesting biomass.

Entities in the Field of Renewable Energy

There are a handful of institutes, laboratories, and centers in Armenia that are involved in the field of renewable energy research and development. These organizations are either part of a government ministry, Armenian National Academy of Sciences, or a major university.

Several private companies are also involved in the field of hydro, solar, and wind power generation. Majority of these companies are engineering and consulting firms that are mainly providing engineering design and feasibility studies for small hydro power plants.

There are a few small companies that assemble stand alone solar water heaters or hybrid units that work in conjunction with central heating units of apartment buildings or social and educational institutions. There are several solar photovoltaic systems installed in Armenia, but they should be considered as demonstration projects rather than commercial scale operations. One of the mobile phone providers has started installing new cell tower units at remote locations that are powered by a solar photovoltaic system.

Because the small hydro power industry is the most developed renewable energy source in Armenia, presently a union of such small hydro power plant companies exists. As of early 2011 there were approximately 150 small hydro power plants in Armenia.

Job Creation

Use of renewable energy will not only keep hard currency in Armenia, but also create significant benefits through economic development. Use of renewable energy technologies creates jobs using local resources in the form of a new, "green," high-tech industry with an important export potential. Banks and construction firms will also benefit from development of renewable energy industries.

Biomass production is relatively labor intensive, which is one of the reasons it is slightly more expensive than fossil fuels. Growing, harvesting, and transporting biomass fuels all require local labor, as does maintaining the equipment, which contribute to the high cost of bio fuel. However, this means that jobs will be created in areas with a depressed agricultural economy.

Conclusions

The Renewable Energy Roadmap for Armenia has outlined the potential for the renewable energy in Armenia based on available facts and scientific analyses. The Roadmap addresses solar, wind, hydro, biomass, bio ethanol, and geothermal.

Even though Armenia has sufficient sunny days, residential and small scale solar electricity generation is still not an economically viable choice for Armenia due to the cost. However, using solar energy for water and space heating can be a viable option for Armenia. Theoretically Armenia has large capacity for wind energy generation but most of these areas are not easily accessible and they are not next to major roads and transmission lines; therefore, the capital costs can be high and would require major investments for installing wind farms.

Results of recently conducted tests have determined that geothermal resources are limited to only 75 MW in Armenia. Using the entire agricultural residue for biomass combined with specially planted trees, will make it possible to run only one of the five generators in Hrazdan thermal power plant units for approximately 10 to 11 months a year. Armenia can produce bio-ethanol from home grown plants equal to 5 to 8 percent of its gasoline usage. Armenian government is seriously considering starting producing bio-ethanol from home grown plants.

Hydro power from Sevan-Hrazdan and Vorotan Hydro Power Plant cascades plus more than 150 small hydro power plants are only indigenous renewable energy generating sources of Armenia. But use of that Sevan-Hrazdan system has been curtailed substantially to save Lake Sevan by raising its water level. Electricity is produced only by the water that is needed to be released for the agricultural use. Presently there is a large effort in Armenia to use mini hydro plants on the small rivers and streams for generating electricity which are the only reasonable renewable energy source for Armenia in the near future.

Armenia is surrounded by countries that have oil and natural gas resources (Azerbaijan and Iran); therefore, Armenia needs to counter balance this situation because it has no sizable natural resources. Considering that electricity is the oil of the future; Armenian government has decided to become a major electricity exporter. Given the fact that Iran, Turkey, Georgia, and Azerbaijan have large deficit of energy production (at least for now), such a decision is a prudent one. Exporting electricity will generate resources that will help the country grow and invest in its infrastructure. Becoming a major electricity exporter is the only way for Armenia to provide a geopolitical energy counterbalance to Azerbaijan and protect itself from unexpected interruptions of energy supply from neighboring countries.

Armenian government has embarked on an ambitious plan to build a new nuclear power plant to assure that Armenia will have electrical supply that is needed for its development and prosperity as well as enough electricity to become a major electricity exporter. After endless negotiations and efforts, recently there have been some noticeable successes in ensuring partners and possible financing for the project.

Renewable energy may not be the major source of energy development in Armenia but it should be an important component of it. As a result of dropping prices of various renewable energy technologies, in the near future renewable energy production cost could be competitive with more traditional sources. Developing all feasible and economically viable renewable energy resources will create a stable domestic power generation capabilities, which in turn could be a major component of Armenia’s national security.

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Wind turbines in Lori Marz

Solar panels on roof of AUA

Bio gas plant in Lousagerd farm