Journal of Energy and Power Engineering 11 (2017) 491-496
doi: 10.17265/1934-8975/2017.07.008

Electricity Sector Transitions in an after War Country: A Review of Afghanistan's Electricity

Mir Sayed Shah Danish[1], Najib Rahman Sabory[1], Sayed Mir Shah Danish[2], Tomonobu Senjyu[3], Gul Ahmad Ludin[3], Ahmad Samim Noorzad[3] and Atsushi Yona[3]

1. Department of Energy Engineering, Kabul University, Kabul 1004, Afghanistan

2. Department of Electrical Engineering, Technical Teachers Training Academy (TTTA), Kabul 1006, Afghanistan

3. Department of Electrical and Electronics Engineering, University of the Ryukyus, Okinawa 903-0213, Japan

Received: February 22, 2017 / Accepted: March 06, 2017 / Published: July 31, 2017

Abstract: Afghanistan electricity sector has experienced many ups and downs of transitions from 1893 to date. With the growing global interest in Afghanistan rehabilitation, this paper presents an over view of Afghanistan electricity sector which includes the historical development trends, power generation potential, sustainable energy exploitation, electricity policy transition and immature policies experiences, and the legacy of the war. The lack of access to the basic information about Afghanistan power sector was one of the serious concerns of international donors and investors. Still, this information somehow has been kept in official documents wrap up. In this collection, the Afghanistan's electricity sector is pictured as a reference for Afghanistan electricity. It can be opening toward primary sources of Afghanistan electricity sector of the lessons learned and asset for researchers interesting in this topic.

Key words: Afghanistan electricity, electricity sector development, Afghanistan renewable energy.

1. Introduction

Afghanistan is a country in the South Asia extremely endowed with natural resources. The first electricity station with a capacity of 40 lights was built in 1893 in the capital of Afghanistan (Kabul). Afterward more small power plants were built [1]. Due to more than three decades conflict from 1989 to 2001, not only electricity sector failed to develop but also its foundations and systems suffered heavy damage. Namely, installed capacity decreased from 737.7 MVA to 435 MVA and generation capacity from 454 MW to 240 MW, and completely demolition of 630 km transmission line [1]. The percentage of the population access to electricity in Afghanistan is among the lowest in the world [2]. A few years ago, 6% of Afghanistan population had access to electricity throughout the country [3]. The trends in electricity generation and consumption in Afghanistan flourished when relative security were dominant in the country. Currently, about 30% of the Afghan households have access to electricity. The connecting rate within the provinces differs in wide range from zero in the rural area to near 100% in urban regions [4]. The electric power energy consumption per capita is approximated to 117.2 kWh/year. This is notably small compared to the other less developed countries [5]. However, the percentage mentioned above of the population that has access to electricity, utilized electric power sporadically in the round-the-clock. Since the Tokyo Conference on reconstruction assistance to Afghanistan in 2002, Afghanistan passage has turned from more than two decades infrastructure-destruction to the last fifteen years of reconstruction. Since 2002, there has been an increasing interest of Afghanistan government, international donors (World Bank, the Asian Development Bank, Germany, India and the USA [6]), and private sectors to investment on electric

Corresponding author: Mir Sayed Shah Danish, Ph.D. fellow, assistance professor, research field: sustainable energy.

energy sector and it has been emphasizing as a key to economic reform and industrialization. Whereas, these intense interests and investments require primary investigation which is correlative with update and adequate information. According to USAID (October 1, 2005) [7], "Reliable information about the power sector in Afghanistan has been difficult to obtain. Additional information has been sketchy, anecdotal, piecemeal, and often conflicting. As a result, planning and evaluating investments have been difficult, as is communication with stakeholders." This paper represents the history of electricity in Afghanistan, focusing on the transition of electricity in different phases through various systems such as economical, geographical, and political. The fundamental purpose of this study is to authenticate and merge historical transitions and current status of Afghanistan electricity sector in one document.

The rest of the Chapter is organized as follows: in Section 2, a concise outlook of electricity sector transitions in Afghanistan is presented. Section 3 describes regulation, deregulation and brief introduction on establishing of Afghanistan global relationship. Then, Afghanistan's renewable energy potential and exploitation opportunities are defined in Section 4. Finally, Section 5 concludes the preference of the study.

2. History

In 1893, the first power generation with a capacity of 40 lights began operating in Kabul. Then smaller power stations were built namely, the 20 kW of thermal engine in ARG (presidential place garden) in 1911, the 19 kW engine in Jalalabad province in 1915, and the 15 kW engine in Paghman district in 1916. In 1920, the first hydropower station was built in Jabal Seraj; it started operating with 1,500 kW installed capacity in 1922 which was transmitted to Kabul [1].

In 1935 to 1951, Afghanistan was declared a new policy to promote private sector and industrialization to provide them with facilities of starting a business in Afghanistan. Accordingly, some power plants were built and developed to overcome the challenge of electricity shortage [8].

2.1 Electricity Generation

Hydropower is known as the most widely used type of renewable energy in Afghanistan. Hydropower plants have attracted particular attention due to water resources availability and environmental impact. Hydropower has been the most promising resource for electricity generation in Afghanistan [9]. A major part of power generation was concentrated in the central of Afghanistan because of the largeness of the crowd, the existence of industrial centers and living facilities. Water flow volume in the country varies, with higher flow in spring season averagely in April to August. After 1893, there was a growing tendency for electric power production and consumption. Numbers of electricity generation factories were built and utilized throughout the country. Naghlu hydroelectric power plant is one of the largest hydropower plants in Afghanistan. The dam construction was started in January 1960, and it was completed in 1968. This plant has four generating stations operating in Kabul with approximately 110 m height from foundation to crest, located below the confluence of the Kabul and Panjshir rivers, with an installed capacity of 100 MW [10, 11]. Due to last three decades of war, Naghlu hydroelectric power station was partially subjected to an enormous damage. In February 2013, the 3rd turbine of Naghlu power plant was reactivated to enhance the power-generating capacity by 25 MW, and rebuilding is continuing [12].

Jabal Seraj power plant is the oldest hydropower plant, construction began in 1916 on Salang River at an altitude of 1,600 m above the sea level, during the reign of Amir Habibullah Khan [8]. The MEW (Ministry of Energy and Water) reports indicate that 13 major hydropower plants are operating throughout the country [13]. These power plants are listed as following: Naghlu (237,486 MWh), Surobi with two

turbines in Kabul (171,047 MWh), Mahipar with two running turbines (110,801 MWh) located 40 km from the city of Kabul in East, Kajaki One and Kajaki Three (in South) have production of (193,446 MWh) and it feeds the around 50,000 families in Kandahar and Helmand provinces with 51 MW capacity [14], Darunta with three turbines (47,025 MWh) in Jalal Abad, Pul-e-Khomri (two) produces (27,049 MWh) in Baghlan, Grishk with two turbines (8,598 MWh) in Helmand, Asadabad (1,975 MWh) in Kunar, Charikar (1,856 MWh), Jabal-u-Saraj power plant was constructed to provide electricity for Kabul [15] (848 MWh), Ghurband (523 MWh) in Parwan, and Istalif (304 MWh) in Kabul [1, 16]. Totally, eight hydropower plants are fed from Kabul River and its tributaries make 80.4% of the whole country installed capacity. For the first time in 1986, directorate of new energy project started solar hot water system producing and installation, which was inaugurated in different governmental offices [1]. Estimates show that in Afghanistan solar radiation averages about 5.5-6.5 kWh per square meter per day with 300 sunny days a year [17].

2.2 Legacy of the War: Crisis Phase (1979-2001)

Afghanistan's power grid has been severely damaged by years of conflict and civil war, now less than 30% of the population has access to electricity [18]. However, in the electrified areas, demand exceeds the supply, where power outage remained a challenge for always. However, sustainable socio-economic growth is not possible without the development of a reliable electric power supply [4].

2.3 Development Trend: Current State (2001-2014)

The new government of Afghanistan in 2001 sharply focused on electricity sector development similar to other key infrastructure sectors. Its overall goal was to provide sustainable power supply, at affordable prices, and in an environmentally clean manner, for socio-economic growth, and to improve living standards with an economic growth rate of 9% per annum [19]. This percentage always had been in change and trends to increase as shown in Table 1.

The figure of the production and consumption of electricity in the country shows 2,664.6 million kWh/year consumption, whereas, the total power generation was 846.6 million kWh in 2011, and in 2012 this figure has increased to 885.8 million kWh, which is recompensed through electricity imports [20].

Statistics states a steady reconstruction of power plants in Afghanistan, in 2006, 26 power plants were operating. In 2011, this figure reached 37 operating power plants [19]. As the Afghan energy sector moves from primarily state-owned operations to a more private market-oriented service delivery, new institutional arrangements will be established [21]. Recently, DABS (Da Afghanistan Breshna Sherkat) is reported, more than 60% revenue collection and around 12% decrease in technical and commercial losses [22] through implementing of modernization policy. Despite it all, most rural areas have no access to reliable and modern forms of energy and instead rely on self-supplied energy sources, using wood, dung, other biomass, and kerosene for illumination [23].

Table 1 Historical development of Afghanistan power production and imports.

Year	MWh	% Share		
		Hydro	Thermal	Imports
2006	1,289,246	49.94	16.52	33.54
2007	1,574,880	47.96	13.39	38.65
2008	1,566,343	39.39	12.61	48.01
2009	2,082,573	40.08	4.47	55.45
2010	2,583,753	35.23	3.92	60.85
2011	3,086,113	25.95	1.26	72.79

3. Electricity Institutional Reform

3.1 Regulation and Deregulation

In 2006, the ICE (Inter-Ministerial Commission for Energy) was established to coordinate government policy in the context of energy, leverage donor resources and integrate sector planning [6]. Afterword, Afghanistan has involved toward globalization on 3rd of August, 2008, Afghanistan becomes a member of SARSO (South Asian Regional Standards Organization) [24, 25]. International treaties bring nations together to harness the benefits of cooperation on an equal footing [26].

3.2 Inefficient and Wasteful Use of Electricity

Underpriced electricity is used inefficiently. Appropriate cost recovery will provide incentives to cut down on this wasteful use. In 2005, it was reported almost 40% losses in Afghanistan's power networks [22] due to corrosion, wear equipment, lack of sound management, and lack of technical and technological facilities and maintenance. The recent years' attempts of Afghanistan government through reconstruction and upgrading the systems throughout the country decrease this percentage significantly. Reference to the DABS authorities' report, the loss level in power systems is less than 30% at present. Necessary procedures are proposed to prevent from organized and sophisticated inelegant techniques of electricity theft and losses. Upgrading the old metering system is continuing with the new digital system.

3.3 Privatization and Local Expertise

The Afghanistan's administration is taking steps toward to provide the basis for the transition of the electricity sector from public provision to the private sector. The role of private sector in energy is growing, and it is significant in Afghanistan. However, occasionally the sector is plagued by inefficiency and underinvestment [6]. For years, electricity supply was as a public service under government's control. As a limited liability company, DABS was incorporated on 4th May 2008 and changed its name from DABM (Da Afghanistan Breshna Moassassa) as the national power utility, to DABS [27].

4. Role of Renewable Energy for Afghanistan Electricity Sector

Worldwide greenhouse gas emissions are increased by 70 % between 1970 and 2004 due to heavy reliance on coal for electricity generation or oil for transportation, and still around 1.2 billion people lack access to electricity and around 2.8 billion people mainly in Afghanistan, and other developing countries of South Asia and Sub-Saharan Africa rely on traditional unclean biomass for cooking and home heating [29-33]. Afghanistan just like other developing countries is facing major energy challenges such as low rates of access to modern energy services, insecurity of its energy supply due to heavy reliance on imports, deforestation and health issues due to excessive use of firewood as a primary energy source and air pollution.

4.1 Solar Energy

Solar energy as an interminable source of electricity has a lion share potential in the world. So due to exhaustive attention that has attracted solar technologies in the recent decades, this section solely covers the solar resource and potential, technologies (especially, PV (photovoltaic) and solar thermal technologies) solar technologies deployment and applications in Afghanistan. Also, the real-life utilization of solar energy is considered along with an illustration of Afghanistan's solar power plants information.

Afghanistan is well endowed with renewable resources, but effective utilization and consumption of these resources still remain sparse. One of the common uses of PV system is supplying communication tower stations, rural and remote areas, where these demands are located far away from power

generation stations. Those technically and economically due to barriers are not feasible to be electrified or connect to the grid. As well, PV system also can be used as remote site electrification or as emergency power supply anywhere the electrification is needed.

Many residences and other structures are simply too far from the utility distribution network to establish a grid connection. Also, power is required at construction sites before the connection has been installed. PV systems are an attractive way to provide electricity in this area. Conventional generators or other renewable energy sources, such as wind or micro-hydroelectric generators, may be used in conjunction with the PV system to ensure uninterrupted power availability. Some examples of remote site electrification are for rural homes, visitor centers in parks, park ranger sites, vacation cabins, hunting lodges, remote farm workshops, village island electrification, clinics and remote research facilities, highway rest stops, public beach facilities, campgrounds, and military test areas.

According to the recent finding of the Afghanistan solar resource, Afghanistan receives on average about 5.3 kWh of solar radiation per square meter of horizontal surface on a clear day with a standard deviation of 0.42 kWh, corresponds to an average annual GHI (global horizontal irradiance) of 1,935 kWh/m^2 [28]. The Bamiyan's 1 MW solar plant is one of the largest solar plants in the country that supplies 2,500 homes around the Bamiyan province. Also, the Afghanistan's first grid-connected (grid-tied) solar power with a capacity of 3 kW as a test to evaluate the ability of grid for feeding solar power generated by individual users [29-33].

4.2 Wind and Biomass Energies

Wind power is one of the renewable energy sources, which has been widely developed in recent years. Wind power has many advantages such as no pollution, relatively low capital cost involved in the short gestation period. The first wind turbine for electricity generation was developed at the end of the 19th Century. Afghanistan's first wind form is built up in 2008 in Pangshir Valley with a capacity of 75 kW, which consists of ten turbines [29-33].

Based on NREL, theoretically, Afghanistan has the potential to produce about 1,408 MCM (million cubic meters) of biogas annually.

5. Conclusions

This paper reviews numbers of transition in electricity sector in the past, in Afghanistan. The finding indicates that the power sector in Afghanistan has been confronted of excess ups and downs before and during the postwar period. Due to existence problems in the country, not too much work has been done to electricity sector; production and consumption are remains in initial stages. However, Afghanistan is one of the countries rich in natural resources for electricity generation in the region countries. This study can be counted as an information asset for Afghanistan electricity sector.

Acknowledgments

This work is part of a research study financially supported by the Japan Society for the Promotion of Science (JSPS) and by the Faculty of Engineering, University of the Ryukyus under a RONPAKU Ph.D. fellowship (JSPS/OF/214090, 2016).

References

[1] Sabavon Gardizi, W. 2008. *Electricity in Afghanistan.* Kabul: Madina Printing Press.

[2] GFA and Da Afghanistan Breshna Sherkat (DABS). 2013. Press Releases on Afghanistan Electricity Development.

[3] Kabul: The World Bank. 2013. Quick Look at the Current Situation in Afghanistan.

[4] Kabul: Islamic Republic of Afghanistan, Ministry of Energy and Water (MEW). 2013. Technical Assistance Consultant's Report.

[5] Kabul: Ministry of Energy and Water (MEW). 1980. Afghanistan Master Plan.

[6] Kabul: Islamic Republic of Afghanistan. 2008. Energy Sector Strategy, Pillar 3, Infrastructure.

[7] Kabul: USAID. 2005. Electricity Planning Tool—A Comprehensive, Detailed and Integrated Electric System Model.

[8] Danish, S. 2012. *Technical Study Report on Afghanistan's Power Plants and Kabul's Substations and Central*. Kabul: Polytechnica Univ.

[9] Kabul: The World Bank. 2013. Afghanistan overview.

[10] Adamec, L. 2011. *Historical Dictionary of Afghanistan*. 2nd ed. Lanham, Md: Scarecrow Press.

[11] Kabul: DABS. 2013. Environmental and Social Management Framework for Afghanistan, Naghlu Hydropower Rehabilitation Project (NHRP).

[12] Kabul: Panoramio. 2015. Naghlu Hydropower Plant.

[13] Kabul: USAID. 2015. Information of Afghanistan Energy Sector.

[14] Kabul: Pajhwok. 2013. Baghlan Hydropower Dams Being Reconstructed.

[15] Adamec, L. 2005. *Historical Dictionary of Afghan Wars, Revolutions, and Insurgencies*. Lanham: Scarecrow Press.

[16] Zia, A. 2013. *Country Update, the World Bank Group in Afghanistan*. Kabul: The World Bank.

[17] Nadeem, M. 2011. "Energy Resources in Afghanistan and Measures to Improve for Sustainable Development." *J Sustainable Energy* 2 (January): 1-11.

[18] Danish, M., Yona, A., and Senjyu, T. 2014. "Explicit Recognition of Afghanistan's Power Distribution Networks Problems and Feasible Suggestions." In *Proceedings of TENCON IEEE Region 10 Conference*, Bangkok, Thailand. doi: 10.1109/TENCON.2014.7022402.

[19] Kabul: Ministry of Energy and Water (MEW). 2007. Power Sector Strategy for the Afghanistan National Development Strategy with Focus on Prioritization.

[20] Kabul: Census Central Office. 2012. Afghanistan Statistical Yearbook.

[21] Kabul: ANDC. 2009. First Annual Report, Making a Difference: Transition from Planning to Practice.

[22] Kabul: Islamic Republic of Afghanistan. 2015. Afghanistan's Electrification Information.

[23] Oskarsson, K. 2012. Sustainability of Energy Supplies in Afghanistan. Kabul: Civil Military Fusion Centre.

[24] Kabul: ANSA. 2011. Afghanistan National Standard Authority. Law Penetrance on National Standards, Step toward Development of This Organization.

[25] Kabul: ANSA. 2011. Report on 2nd year, 4th Issue.

[26] Brussels: Energy Charter Secretariat. 2007. Regional Electricity Cooperation in Central and Southern Asia, Opportunities for Increased Regional Trade and the Role of the Energy Charter Treaty.

[27] Kabul: DABS. 2015. Da Afghanistan Breshna Sherkat's Annual Report.

[28] Ershad, A. M., Brecha, R. J., and Hallinan, K. 2016. "Analysis of Solar Photovoltaic and Wind Power Potential in Afghanistan." *Renewable Energy* 85: 445-53.

[29] Adamec, L. 2011. *Historical Dictionary of Afghanistan.* 2nd ed. Lanham, Md: Scarecrow Press.

[30] Nadeem, M. 2011. "Energy Resources in Afghanistan and Measures to Improve for Sustainable Development." *J Sustainable Energy* 2: 1-11.

[31] Kabul: Islamic Republic of Afghanistan, Ministry of Energy and Water (MEW). 2013. Technical Assistance Consultant's Report.

[32] Sieminski, A. 2014. "International Energy Outlook." *Energy Information Administration (EIA)* 18.

[33] Kabul: Islamic Republic of Afghanistan. 2015. Afghanistan's Electrification Information.