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Energy Scenario of Afghanistan

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Abstract: This paper attempts to review Afghanistan energy scenario with focus on renewable energy sources, energy losses, tariff cost and imported energy from neighboring countries. The study found that the energy scenario in Afghanistan is facing numerous challenges. Afghanistan energy sector is still one of the least development sectors with almost 70% of country population has no access to the electricity. The study shows that though the country has abundant renewable energy sources but its reliance on imported power has increased to almost 80% of its power imported from neighboring countries paying huge cost per year. In rural areas, the level of electrification has not increased. Which necessitates the development of untapped renewable energy sources with specific focus on small hydro power which cost less than imported electricity and is considered, as ultimate solution for electrification of rural areas.
The existence of different energy isolated zones and lack of integrated tariff mechanism lead to significant variations in electricity tariff. Energy losses due to poor maintenance, huge overloading of transformers, unmetered supplies with wrong billing are some of the serious challenges discussed in this paper.

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I. INTRODUCTION

Energy is one of the most important factor in economic and social development of a nation. Still globally 1.06 billion people are without electricity and 2.8 billion are without clean cooking fuels [1]. It is projected that world energy generation has increased from 21.6 (2012) to 25.8 trillion kWh by 2020[2]. Long term global prospects continue to improve the generation from renewable energy sources. As of 2017, world renewable energy share consists of 1114 GW hydro power, 122 GW of bio power, and 402 GW solar PV [3], while the world installed wind capacity has increased from 467.23 (2016) to 513.94 GW (2017) [3].

Energy scenario of Afghanistan is unstable due to the country's damaged and fragmented energy Generation, Transmission and Distribution Infrastructures. As evident form much lower per capita energy consumption (140 kWh/capita/day) compared to global average larges consumption of 3060 kWh [4]. Fortunately, Afghanistan's top economic development priorities are demonstrated by Afghanistan National Development Strategy (ANDS) and Afghanistan Power Sector Master plan(APSMP) [5]. Over the past few years, Afghanistan's total installed capacity is 655 MW consisting of 333 MW hydro (including large hydro) with the capacity factor of 40% and 6 MW share of utility and private owned solar rooftop [3]. The balance is thermal (diesel and furnace oil) with high generation cost [6]. The rapidly expanding of consumption is met mainly by power imports. Grid 80% Power is imported from neighboring countries like Uzbekistan, Tajikistan, Iran and Turkmenistan [7]. At the present, large Afghan population, especially in rural areas, has no access to electricity, which is the key problem for improving economic status of its people [8]. Afghanistan power system is not synchronized with any of the four countries. Fortunately, Afghanistan is rich in renewable energy sources and can develop its own domestic electricity generation capacity from renewable energy sources [9]. The present paper is to reviews Afghanistan energy scenario with focus on renewable energy potential and its status, energy losses, energy trading with its neighboring countries, opportunities, challenges and solutions purposed.

II. STATUS OF RENEWABLE ENERGY IN AFGHANISTAN

In Afghanistan the renewable energy resources are underexploited, as evident from the past that significant energy demands are still met from traditional resources. Currently increasing access for energy demand is of high priority for the development of the country. Major efforts are underway to increase the access to reliable electricity as the government has the target to generate 5,000 MW from renewable energy by 2032, which is equivalent to supply 95% of the country's electricity demand [9]. At the present about 5100 Renewable energy Projects consisting of biomass, Solar, MHP and wind have been completed [10].

Table 1: HydroRenewable energy Projects

No.	Type of hydro Project	Capacity (KW)
1	Pico	< 1 kW
2	Micro	< 100 kW
3	Mini	< 1000 kW
4	Small	< 3000 kW

As shown in Table 1, Hydro projects up to 3 MW installed capacity, consisting of Pico, micro, mini and small hydro, treated as renewable energy projects [9]. By end of 2017 Afghanistan renewable installed capacity (aggregated to 55 MW) has touched around 339MW, including of 42.4 MW off grid renewable electricity [3].

Table 2: Status of off grid renewable Energy as for 2017

No.	**Source**	**Potential (MW)**
1	Hydro	37.99
2	Solar	4.33
3	Other	0.1
	Total	**42.4**

However, the off grid capacityas shown in Table 2 is not with record of power utility DABS installed by Ministry of Rural Rehabilitation and Development(MRRD) and private, and no revenues are added to DABS. Several privately owned DGs are operating in rural areas for lighting purposes are also not in the record of DABS.

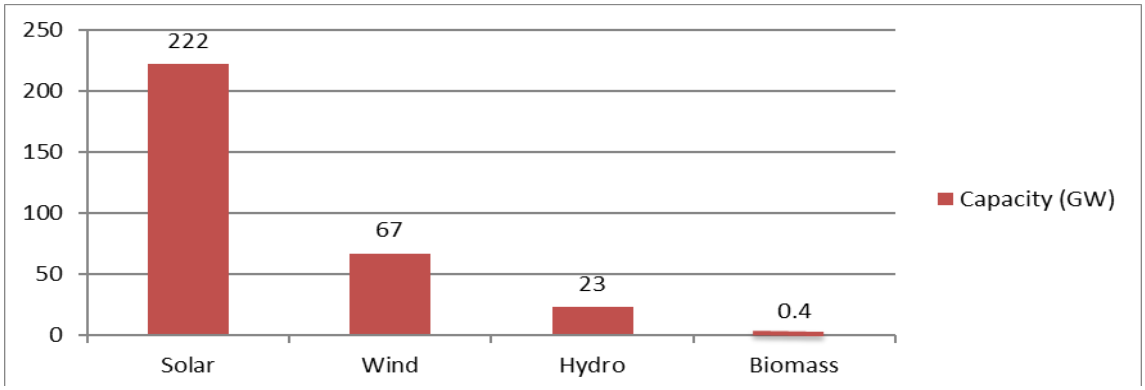

Figure 1: Potential of Renewable energy sources in Afghanistan

Fig 1 shows that the total untapped potential available is of solar (222 GW), Feasible wind (67GW), hydro (including large hydro) 23 GW and biomass resources 0.4 GW in the country [9].

The undiscovered hydro carbon resources in the Amu river and Afghan-Tajik basins is in the range of 3.5 to 35 TCF of gas, 0.4 to 3.6 billion barrels of oil and o.1 to 1.3 million barrels of natural gas liquids [11]. The undiscovered technical recoverable natural gas reserves in the country is estimated 444 BCM [11]. In 2014, about 97% Afghanistan oil needs were imported Due to lack of a gas pricing framework and insecurity inhibit private sector participation to develop own reserves [6].

Fortunately, currently a 200 MW gas fired power generation plant construction is undergoing in Sheberghan to design a roadmap for development of the gas fields in northern Afghanistan. 50 MW Gas Power plant is under plan in Mazar province, this will address the country's critical power shortage and minimize the import energy reliance.

2.1 Major Tapped and un Taped Hydro Power Potential

Hydropower plants in Afghanistan were built mostly between the 1950s and the mid-1970s, with major Power plants located in Kabul, Helmand Province and a number of others Power plants are being built in different parts of the country, mainly for irrigation purposes. Afghan-India friendship dam (Salma Dam) recently build with capacity of 42MW.

It is estimated that hydropower potential of Afghanistan is 23,000 MW, with majority of large dams based plants. As for 2017 total installed hydro energy capacity of Afghanistan is 333 MW which includes micro, small and large hydro power plants [3].

Table 3: Afghanistan Hydro Power Plants with likely year of operation based on optimized scenario [5]

Planned year of operation	Name of Power Plant	Installed Capacity (MW)	Status As of 2018
Expected soon	Salma	40	Commissioned on 2017
Expected soon	Kajaki Expansion	18.5	Commissioned on 2017
2024	Kunar B	300	Pre-feasibility study
2026	Kunar A	789	Feasibility study
2028	Kajaki Addition	100	Aggrement signed.
2029	Olambagh	90	feasibility study
2032	Baghdara	210	Pre-feasibility study

As shown (Table 3) feasibility study for most of these projects has conducted long back but due to many reasons still remain un operational [12]. the main challenges for implementation of hydro power plants are the unavailability of financial budget, trans-boundary water sharing agreement, lack of experts, and high of cost of construction. Hence for bringing large hydro power plants into operation transboundary water agreement with Pakistan is important because Afghanistan is hugely reliant on international donors' funds and donors are less likely invest on projects which have bilateral disputes [13]. Therefore, Development of micro and small hydro power plant in the country could be a good option which will helps to create a more diversified electricity system.

In addition, for long term sustainable development of energy sector integration of other renewable energy sources such as wind and solar with hydro power plants will have advantages to store hydro power potential in reservoir and used in peak periods [13].

2.2 Solar Energy Potential

Afghanistan is rich in solar energy with sunny 300 days a year with average solar radiation on horizontal surface of 5.3 KWh/m^2/day. The annual average Global Horizontal Irradiance (GHI) in Afghanistan is 1935 kWh /$m^2$and the average seasonal maximum and minimum solar irradiance are 7.84 and 2.38 kWh/m^2/day, respectively [14].

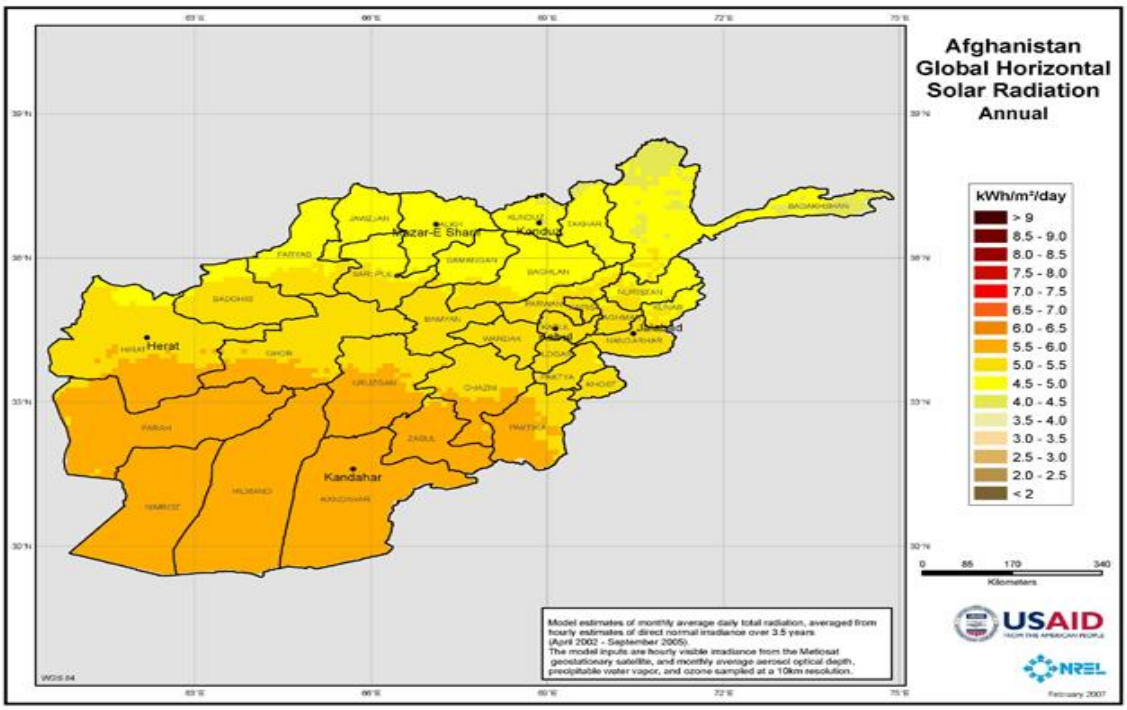

Figure 2: Afghanistan Global Horizontal Solar Radiation map [15].

The (Fig .2) gives solar radiation map of the country which indicates that the Provinces with the solar radiation of > 6 kWh/m²/day are Badghis, Bamian, Daikondi, Farah, Ghazni, Ghor, Herat, Hilmand, Kandahar, Nimruz, Paktika, Sari Pol, Uruzgan, Wardak and Zabul. Some provinces in the west and south have GHI summer peaks of about 9.0 kWh /m^2/day. Based upon preliminary estimates by the National Resource Energy Laboratory (NREL) of the United States, the total solar energy potential in the country is > 220 GW [15].

Another study estimated the annual generation solar energy potential of 146,982GWh, consisting of 140,982 from SPV and 6,000GWh from concentrating solar power (CSP) technologies [16].

The Major solar PV plants in the country are 100KW Syed karam, 244kW Chal PV plant, Bamyan 400 KW solar-diesel hybrid, Bamyan1.03MW Solar-DG hybrid plant and the largest solar-wind hybrid power plant in Herat Province with a capacity of 2 MW [17].

2. 3 Wind Energy Potential

Afghanistan has wind potential of about 158 GW. With 12% of the land area having class 3 or better wind regimes from 6.1 to 6.8 m/s wind speed [14, 18]. Seasonal dusty winds as high as 6.5–9 m/s with averages speed of 4 m/s (Table 2) are available in the West regions with over 120 windy days at speeds above >7 m/s at 50 m height [19].

Table 4: Afghanistan Estimated Wind Potential [18]

Wind Power Class	Wind Speed (m/s)	Wind Power (W/m^2)	Resource Potential	Land Area (Km^2)	Wind Power Potential (MW)
4	6.8-7.3	400-500	Good	15193	75970
5	7.3-7.7	500-600	Excellent	6633	33160
6	7.7-8.5	600-800	Outstanding	6615	33100
7	> 8.5	>800	Superb	3169	15800
	Total			**31610**	**158030**

Table 4 shows that 15.8 GW wind potential is available in superb area with wind speed > 8.5m/s, 33.2GW in outstanding wind zone with the mean wind speed of 8 m/s, 33.1 GW in excellent wind zone with the mean speed 7.5 m/s and about 76 GW in good wind zone with mean wind speed 7 m/s. Therefore, 31610 Km^2 (4.9%) area of the country has wind potential in good, Excellent, outstanding and superb range with a total 158GW of wind potential. The majority of the above wind speeds are in high capacity factor range of 28 with the annual energy production of 2418-3709 MWh/MW. Against the World typical capacity factor range of 20-35 with the annual energy production range of 1752-3066 MWh/MW [14]. Till now only two wind power projects are in operation in the country: one was built in Punisher Province in 2008 with a Capacity of 100 kW (wind/diesel hybrid project) consist of 10 turbines each with capacity of 10 kW. Another is solar wind hybrid project commissioned in 2017 in Herat province. Which is consist of 1.7 MW of solar PV and 300 KW of wind having 3 turbines each with a capacity of 100 KW [17].As expanding the grid in near future to cover isolated rural areas is difficult. Hence, for the village level rural electrification, wind and solar systems with diesel generator back-up hybrid system with the subsidize fair tariff are reasonable options.

2.4 Biomass Energy Potential

More than 85% of Afghanistan energy needs are met by traditional biomass (mainly Wood and dung) [20, 21]. The total 3.72 MT of municipal solid waste is annually produced that can generate 819 GWh of energy. The 39.2 MT of animal waste is produced annually can generate 1567 MCM of biogas that can be used to generate 7367 GWh of energy. Likewise, 6.5MT of crop residue produced annually can generate 27083 GWh of energy [22].In rural areas heating and cooking mostly based on wood and charcoal, but electricity energy is rarely used. Hence, village-scale biogas digestors fueled by animal waste are reported to have good potential, with biogas produced from animal waste, which is usually combusted for heat [20, 23].

2.5 Geo Thermal Potential

Afghanistan significant underground hot water having huge geothermal potential [24]. In Afghanistan, the geothermal energy potential is estimated as 3500MW about 70 sites were identified, where at each location, about 5-20MW capacity power plant can be built. However, at present there is no power production from geothermal energy in the country [21].

III. ENERGY SECTOR INSTITUTIONAL SETTINGS

Three main public organizations, (i) the Ministry of Energy and Water (MEW), (ii) Ministry of Rural Rehabilitation and Development (MRRD) and (iii) the state-owned power utility Da Afghanistan Breshna Sherkat(DABS) are involved in the development of Afghanistan's energy sector. In energy Sector the MEW is mainly responsible for all policies, planning, and the regulatory framework including development of renewable energy in the country. DABS deals with cost-effective, reliable, and safe electricity supply, purchase electricity from sources within and outside Afghanistan, collect the electricity consumption bills and operate & maintain all the power system. MRRD look after social and financial growth in rural areas, primarily in the non-farm sector and supplies of renewable energy electricity to rural population across the country. The recently created project Afghanistan Sustainable Energy for Rural Development (ASERD), is providing rural electricity services.

IV. ENERGY POLICIES

The following policies are discussed briefly:

4.1 Afghanistan Power Sector Master Plan (APSMP)

APSMP endorsed in 2013 covers energy demand forecasts based on three (Base, low and high) case scenario, identified power generation options and possible transmission expansions to meet growing future demand through grid-based supply as well as assessments of power purchase agreements. The APSMP power system expansion puts heavy focusses on large-scale hydropower system expansion as well as other renewable energy sources.

4.2 Power Services Regulation Act(PSR):

The Act passed in 2015 has the main objectives of supplying electricity from indigenous and import from other countries. Accordingly, improvement in quantity and quality of energy services, economic growth development and public welfare in the country is given top priority. The Act also provides the right of fair price, public access to electricity and a nondiscriminatory access of the electric energy service providers to the market [25].

4.3 Afghanistan Rural Renewable Energy Policy (ARREP)

ARREP was drafted in 2013 by MEW and MRRD to create better social, economic and environmental conditions for the citizens of Afghanistan in rural locations. The immediate main objective is to provide clean energy for lighting to rural consumers [26]. The policy also looks after financial and technical support for mini grid development, to provide livelihood opportunities through rural electrification. This policy also aims to electrify rural households through renewable energy off grid system.

4.4 Renewable Energy National Policy (RENP)

The RENP was framed in 2015. MEW is looking after the development and implementation of RENP in Afghanistan. Its goal is to set a framework for the development of renewable energy in the country. The RENP sets a target of deploying 4500 – 5000 MW of renewable energy capacity as of the total demand by 2032[9].

The policy will be implemented in two steps: 1 (2015 – 2020) to create and support an atmosphere and activities for the development and growth of the renewable energy sector particularly in the Public Private Partnership (PPP) mode and 2: (2021-2032) to deploy renewable energy in full commercialization mode [9]. The policy targets have focused mostly on electricity generation from renewable energy resources through techno-economically developed technologies in environmentally sustainable manner. The policy has limited focus on affordable and efficient cooking and heating devices operated either on renewable energy or traditional biomass the latter is being given priority [27]. MRRD has authorized to implement up to 1MW of renewable energy projects though DABS and MEW can do same. Afghanistan has a huge Renewable energy potential but is facing financial hardship to harness the potential.

Afghanistan has a huge Renewable energy potential but is facing financial hardship to harness the potential.However, Afghan government targets to generate 5000 MW from renewable energy by 2032 and so, for Sustainable energy the Governments and needs to develop suitable policies packages to allow easy access to finance by reducing the risks of investors. Trans-boundary water management, subsidizing national policy and strategy, Synchronization policy is required to develop unique grid system in the country. Though, there is no specific hydro power policy in Afghanistan to encourage the private sector investment and no approved support mechanism for PV development.

Table 5 provides the status of energy policies in renewable energy sector of Afghanistan [27, 28].

Table 5: Status of Energy Sector Policies

No.	Policies	Main elements	Status As of 2018
1	Private Investment Law	This drafted on 2005, with the objectives to Encourage and protect domestic and foreign private investment. AISA is the responsible institution.	Adopted
2	Afghanistan National Development Strategy (ANDS)	Drafted on 2008, to address the challenge of coordinating the efforts of numerous domestic agencies and their international partners who were participating in the development of the electricity sector [29]. MEW & MRRD are jointly responsible institutions.	Adopted
4	Rural Renewable Energy Policy	Drafted on 2014, the objective is Limited to off grid electrification of rural areas. MEW & MRRD are jointly responsible institutions.	draft
5	National Renewable Energy Policy	Drafted on 2015, focused mostly on electricity generation from renewable energy resources through techno-economically developed technologies in environmentally sustainable manner. MEW is responsible institution.	Adopted
6	Power Sector Master Plan	Drafted on 2013, Focus on Supply, demand, grid system, import energy and analysis of hydro power plants etc. MEW is responsible institution.	Adopted
7	National Renewable Energy Strategy	Drafted on 2015, Mainly focus RENP. establish ZRECs. Prepare regulatory scheme (RPO in Electricity Law, prepare standard PPAs). MEW is responsible institution.	Draft
8	Power Services Regulations Act	Drafted on 2015, Main objectives are to supply and expansion of electrical energy from local natural resources and imported energy. Provide public access to electricity in a fair price. MEW is responsible institution.	Approved
9	Feed-in-Tariff Policy	Drafted on 2015, focus on subsidy and financial support mechanisms and guidelines. MEW is responsible institution.	draft
10	Investment Policy	Drafted on 2015, mainly facilitating and attracting investment in the Afghan economy – strong links for private participation in the RET sector. MEW is responsible institution.	Final
11	National integrated Energy Policy	Drafted on 2016, Overall objective is to provide directions, regulate, oversee and monitor the energy sector. ensures energy access to all in Afghanistan in an economically viable, reliable, socially equitable and environmentally sustainable manner [29]. MEW is responsible institution.	Adopted
12	Law on Public Private Partnership (PPP)	Drafted on 2016, Regulating issues relevant to PPP on Basis of principles of transparency, open competition and effectiveness. The law also identifying opportunities for joint investment of public and private sectors. MoF is responsible institution.	Approved
13	Renewable Energy Roadmap	Drafted on 2017, with the objective to Set target of 5000 MW RE & developed fully Private by 2032, Increase Domestic supply, provide electricity to rural area MEW is responsible institution.	Adopted

V. IMPORT OF ELECTRICTY FROM NEIGHBORING COUNTRIES

Afghanistan's Domestic generation capacity has remained stagnant over the years. The rapidly increasing demand for electricity is being met by importing 80% of the Power from neighboring countries like Turkmenistan, Tajikistan, Iran, Uzbekistan, and Kyrgyzstan. It indicates that the country is investing far too

much on imported energyfrom neighboring countries and far too less on utilization and developmentof its own energy natural resources [13]. Total Energy supplied during 2015-16 was 4,773 GWh from the grid, of which 3,767 MW was imported with balance from Hydro (967) and thermal (39 GWh). Country's demand was much more than supply and the importedpower system also suffered by frequent interruptions [28].

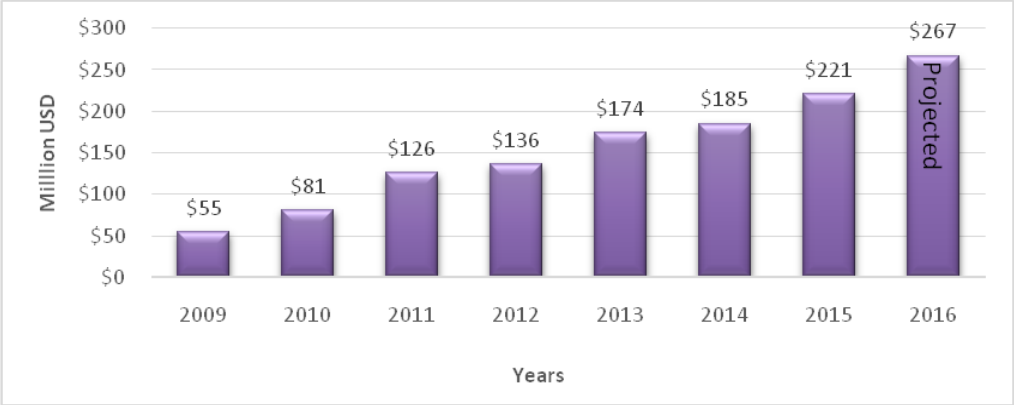

Figure 3: increased in paid amount in US$ for import energy from 2009 to 2016

Fig. 3 shows that from 2009 to 2016 Afghanistan relied on imported and the cost rise to 385% [30]. In this priced for imported power cost has increased from 221 (2015) to 267 million US$ (2016). However, the country has huge imported power with much untapped energy potential. This necessity the development of untapped renewable energy sources with specific focus on small hydro power plants which cost less than imported electricity from neighboring countries. Depending on imported will cause the government to increase the electricity prices. The imported power is also unstable power, due to insurgent action on 220 KV North west power system (NEPS) towers supplying electricity to Kabul leading to significant load shedding [28]. As a result, almost most parts of the capital are facing power cuts problem, thereby reducing the incomes of power utility.

VI. ELECTRICITY CONSUMPTION AND ITS TARIFF PRICES

Current household consumption varies from province to province. The residential consumption is comparatively higher in load center like Kabul (> 3000 kWh) and in Heart to (2600 kWh). However, in most provinces connected to a DABS system, average annual household consumption is lower to 178 kWh (2010) in Ghor Province [5]. The electricity tariff for Domestic and imported power are the cheapest tariff in country. The south provinces (Badghis, Urzgan, Ghazni and Farah) not connected with the imported power grid or domestic grid mostly use diesel generators giving power to residents at very high tariff (Fig.4).

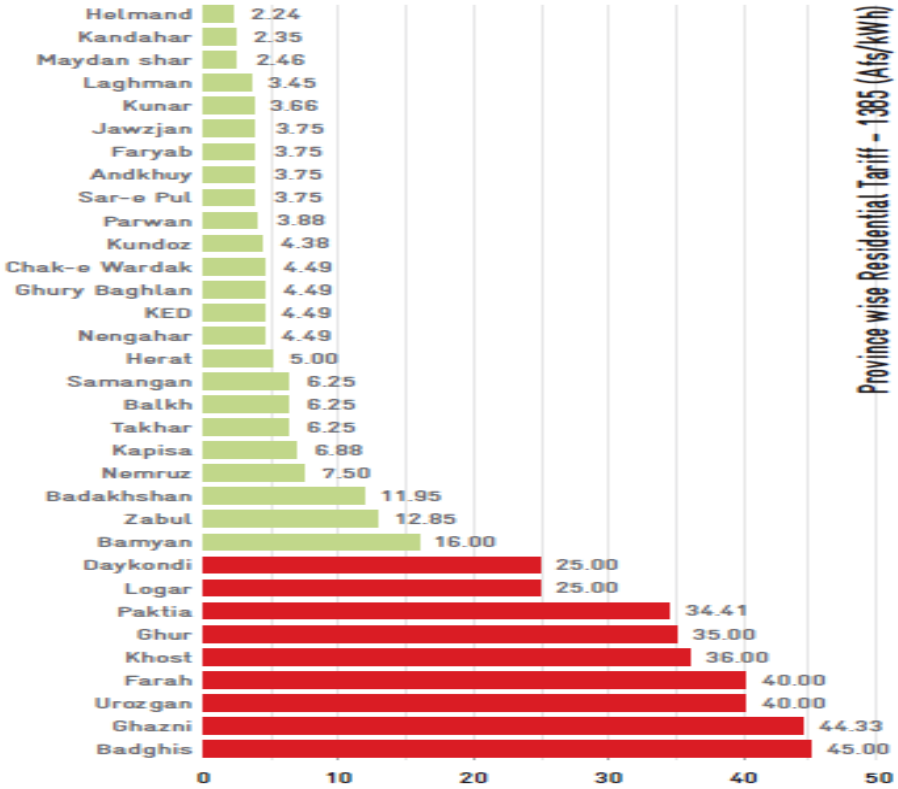

Figure 4: Tariff Prices in 34 Province of Afghanistan [31]

As indicated earlier about 80 % of the electricity in Afghanistan is imported with the current price 25% higher than in 2015 (paid in USD) [31]. Higher tariff for diesel generators depends on the fuel cost which is much higher compared to imported power (Import tariffs ranging from US$0.02/kWh from Turkmenistan to US$0.085 from Uzbekistan) [32].

VII. POWER LOSSES

Technical and commercial losses were extremely high in Afghanistan (above 50%) in 2010(Fig 5). Due to very aged energy system equipment, improper installation, overloading and mainly unmetered electricity supplies. Assuming 10% is an acceptable level of technical and commercial losses. Suppose average tariff cost of import power US $ 0.05 cent/kwh, only the import power (3767 GWh) losses will be around US $ 18.8 million in a year.Afghanistan energy Master Plan has targeted to reduce commercial losses to 13% in 2021 and 8% in 2032 [5].

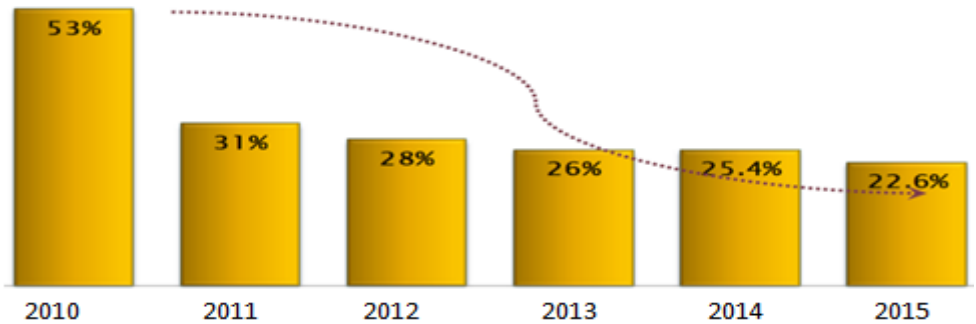

Figure 5: Afghanistan Energy Technical and commercial losses **[**22]

As per the Inter-mistrial commission for energy DABS mitigate the energy losses to 22.6%(2015) which is for more than the projected losses of 13% (2021) to achieve Power Sector Master Plan targets [22]. DABS is attempt to chalk out annual asset maintenance, bulk metering plan, and computerized maintenance management system to reduce system losses [33]. Furthermore, currently DABS is removing all analog energy

meters and putting smart energy meters so that split wireless keypad (CIU), can be needed to control the amount of consumed energy, and arrest the thefts.

VIII. CONCLUSION AND RECOMMENDATIONS

Development of energy sector is the priority of Afghan government. The policies have been formulated and adopted to improve domestic generation with focus on renewable energy with target of achieving 5000 MW of electricity from renewable energy by 2032.

Though Afghanistan has abundant renewable and non-renewable energy sources but currently facing the challenge of importing 80% of energy supplied from neighboring countries, and so country has different isolated grid with each of these countries.This necessity the development of untapped renewable energy sources which is cost less than imported electricity from neighboring countries.Following are therecommendations:

1. Country hydro power stations are not synchronized with the imported power in order to run on their maximum generating peak capacity. Asynchronous supplies limit the opportunities to interconnect, improve security of supplies and expand the power network in a rational way. Furthermore, this will cause huge load shedding which result serious power cuts. Hence, there is need for standard and unique grid system throughout the country on which the imported power from one system can transfer to the other system accordingly it can synchronize with country Demotic generation. Since, existing of different isolated system will reduce optimization of domestic power supply and generation,
2. Afghan government can reach its renewable energy targets if provide no or less tax on renewable energy equipment which almost all are imported. Furthermore,to encourage private sector investment in the energy sector its necessity forsubsidy allocation, easy provision of land facilities, structure regulatory authority, fair tariff setting mechanisms and the right and obligations of the government with respect to private sectors.
3. Same and fair tariff is the right of each Afghan citizens. Different source of energy causes different tariff system in the country. Areas which are connected with national grid electricity tariff is much cheaper than those which are not connected to the national grid.There is need to develop a unique tariff system in the country. For the time being the cost variation can reduce and balance with affordable price through subsides allocation to those who are suffering the high tariff cost.
4. Many institutions mainly MEW, MRRD and DABS are active in development of renewable energy sources sometimes lead to overlapping the scope between the institutions, this could affect donor support and also impacts potential investors to invest on energy sector. This is happened due to many reasons examples could be development of institutions specific policies, and poor working relationship between the institutions and lack of supervision unit for proper implementation of policies.
5. More Focus is needed for cross border energy agreements (transmission of energy from central to south Asia). Since the benefits could be purchasing its required power, wheeling charges, attracting the huge investment will definitely bring peace in the country and country transmission grid will also get developed, creating job opportunities. In order to avoid future conflict there is need for development of detail regional integrated energy policy and ensure security for smooth implementation of the projects.
6. As indicated in 2015 country had 22.6 % energy losses due to using analog energy meters, old energy infrastructures, technically unfeasible networks, incorrect billing, defective energy meters and mainly unmetered electricity supplies energy thefts result in high energy losses. This could be minimized by proper planning and utilization of energy (generation, transmission and distribution) systems. Replacing analog meters with electronic meters which are accurate and temper proof in all provinces.
7. As sees rely on imported power is getting increased and country is paying more than US$220 per year which is huge amount.Therefore, there is need for broader national energy plan to focus on generating of electricity from untapped domestic renewable energy resources.

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