



## The Existing Dynamics of Electric Grid Systems in the Province of Takhar, Afghanistan

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### Abstract:

The research paper investigates about the development of electric networks which states the amount of electricity that the people of Takhar currently use in Afghanistan, and expansion of Takhar's electrical networks. The electric networks have become a significant importance research area to the socio-economic development of the country. It is in a state of flux and development among difficulties in Takhar province, currently. The region still has a long way to go before attaining widespread and dependable electrification, even with the notable progress made in recent years toward expanding access to power and strengthening infrastructure. Takhar's electrical

grid is made up of both conventional and renewable energy sources, while it imports a significant amount of power from nearby nations. However, it has been determined that a crucial tactic for improving the province's energy security and sustainability is the incorporation of renewable energy sources, particularly hydroelectric and solar power. The research explores the present situation, difficulties, and potential futures of the province's electric networks. The main problem for using a mixed-methods methodology that combines qualitative interviews with important stakeholders including local utility providers, government officials (Ministry of Energy and Water, Da Afghanistan Brishna Shirkat (DABS)), and community members with quantitative data analysis. In order to overcome current obstacles and meet the region's electrical demands, this abstract emphasizes the dynamic character of the electric network growth in Takhar province and emphasizes the vital need for ongoing investment, innovation, and cooperation. Finally, the researcher found out the amount of renewable energy sources in Takhar, the amount of energy that Takhar can produce, the amount of electricity that the people of Takhar currently



use, and the amount of electricity that is needed by 2032 so that the people of Takhar Be self-sufficient in electricity.

**Keywords:** *Electric Networks, Electrification, Renewable Energy, Hydroelectric, Electrical Demands.*

## Introduction

Afghanistan is one of the least developed countries in the world with minimum access to electric power and Takhar province is a symbol of perseverance and progress, with the growth of electric networks promoting socioeconomic revival. The growth and development of Takhar's electric network are essential to accomplishing more general development objectives. Afghanistan's prosperity and progress have long been attributed to the availability of reasonably priced electricity (Sediq, & Naeem, 2007). The research explores the Takhar province power system, distribution transformers, the total electricity supplied at the moment (including national grid, PV, hydropower) and electricity demand. Takhar is one of the second – class provinces that has been located in northeast area of Afghanistan (Jablonski, & Masroor 2023). The total area of Takhar is 12457.8  $Km^2$  that constitutes 1.91% of the total land area of Afghanistan. Takhar is divided into 17 administrative units (Snezhko, et al., 2012). In the last census in Afghanistan in 2022/2023, the population of Takhar was 1133570 people. By this information we can calculate that averagely the density of Takhar population is about 91 people per kilometer square and the population growth is 1.84 during recent years. About 51% of the population in

this province are men and 49% are women (NSIA., 2021), as given in Table 1. Of the 1.13 million people living in the province of Takhar, little over 400 000 have access to energy facilities, and the vast majority of people live in rural areas without power. The problem with Takhar Province's electricity use is that it only imports 16 MW of power and lacks resources to produce its own electricity. As a result, the province's rural areas are unable to obtain import electricity. By taking a comprehensive approach, the purpose of this research is to provide insightful analysis and useful suggestions that will help development partners, stakeholders, and policymakers improve Takhar Province's electric network infrastructure and bolster the region's sustainable development while also enhancing the lives of its residents. It is a fact that increasing the availability of power for Takhar's rural populace is essential. Access to electricity is generally seen to have positive effects. These benefits include social welfare, income, education, and health improvements. Adequate energy is necessary for every industrialized civilization to have significant economic progress. Additionally, the potential to raise the local population's level of living by providing the tools for the growth of commercial and educational activities at night (Kim, & Jung, 2018).

**Table 1. The Population, Households and the Electricity Demand of Takhar in 2023**

Takhar province	Population (10 <sup>3</sup> )	Households	Electricity demand (MW)
Rural area	977.73	99161	99
Urban area	155.84	19005	38
Total	1133.57	118166	137

## Takhar Province Power System

There is only one imported power line supplying power for Takhar City (AEIC, 2019), that given in figure (1). Takhar Breshna has a 220/20KV

substation, which is a power transformer base with a power of 16MVA, which was built and put into operation in 2014 by an Indian company. The mentioned substation supplies

electricity to the surrounding areas of Taluqan city and a number of neighboring districts. It has

5 output feeders. The creating other substations is under plan in Rustaq and Chah Ab districts.

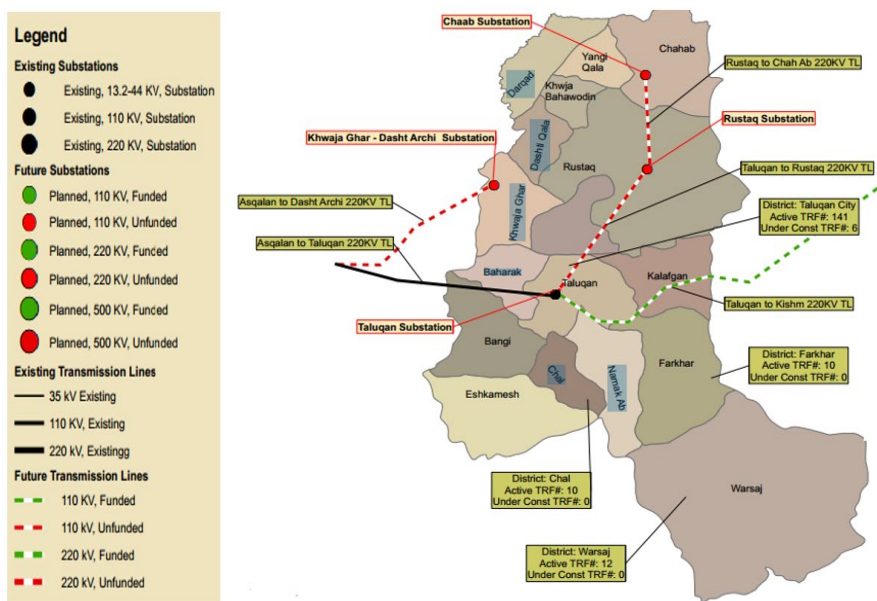


Figure 1. Takhar Province Power System Map

### Takhar Distribution Transformers

A transformer is a device that uses voltage and current changes to transmit energy from one circuit to another using the electromagnetic induction phenomena (Blodgett, 2014). This usage of electromagnetic energy has several

applications in the power sector through the use of Faraday's law of induction (Jacob, 2018). It is essential to every aspect of human existence, from the home to the workplace, regardless of the industrial revolution (Reddy, et al., 2020). The active distribution transformers of Takhar province given in Table (2), briefly.

Table 2. The Active Distribution Transformers of Takhar Province

No.	Location	Total power (KW)	Transformers
1	Taluqan town center	36745	176
2	Warsaj district	1753	13
3	Farkhar district	868	11
4	Chal district	1215	10
5	Hazarsamuch district	480	3
6	Baharak	9861	64
Total		50922	277

### Current Expansion of Takhar Electric Networks

The new substation Kunduz 2 with one-line feeder, has been expanded, the new substation 220/110/20 kV at Taluqan with one inter-bus transformer 50 MVA and one transformer 16

MVA has erected and the 220 kV line Kunduz 2 to Taluqan type 1x3x2xACSR300 with a length of about 66 km has constructed, as given in Table 3, and the current expansion of Takhar electric networks has remained like it was in 2013 and not been developed yet.

**Table 3. Capital Expenditure (CAPEX) for Power System in Takhar**

Plant	Type	No	Cost (M\$)
Expansion substation Kunduz 2	220KV	1	0.9
New substation Taluqan	220KV	2	6.0
New substation Taluqan	110KV	2	3.3
Interbus transformer Taluqan	220/110 KV	1	1.0
Transformer Taluqan	110/20 KV	16	0.3
220KV line Kunduz-Taluqan	1X3X2XACR300	1	18.5

### Renewable Energy Sources in Takhar Province

Generally, in Takhar province, there are 6 energy sources (national grid, solar energy, hydropower, wind energy, biomass energy and diesel energy). Takhar has enough sunny days (300 days) for producing solar energy and also has enough rivers for producing hydropower, the amount of renewable energy in Takhar province given in

Table 4 (Slimankhil, et al., 2020). By the end of 2024 these project (The capacity of Taluqan river is 10MW with cost of 26 million USD and the capacity of Qalay Mamay is 420MW with cost of 950 million USD) has been planned. Kokcha river has the capacity of 1927 MW, Amu river has 9110 MW capacity and the Panj river has the capacity of 9050 MW electricity (Sumber, et al., 2022).

**Table 4. Shows the Production Energy Capacity in Takhar Province**

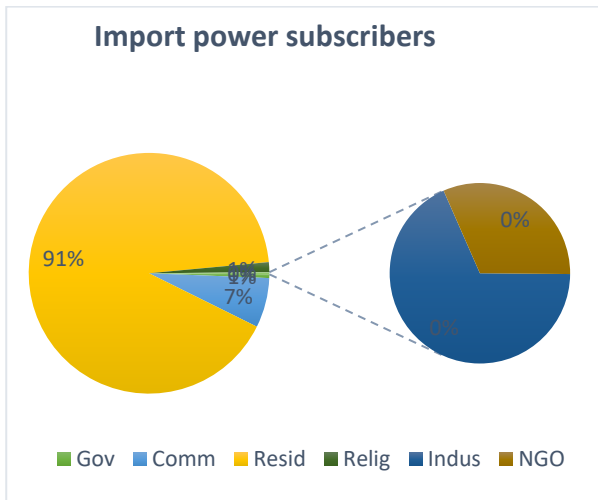
Renewable energy resource technical potential						
Solar (MW)	Wind (MW)	Hydro (MW) (river basin)	Biomass – Electrical energy production potential (MWh/year)			
			Municipal Waste	Solid	Animal Dang	Agriculture Waste
2543	1199	20137 (Panj – Amu)	29990		269732	1524344

### The Current Situation of National Grid in Takhar

There is only one substation in Takhar province that the imported electricity from Tajikistan to Kunduz has extended before. In 2013 DABS extended 220 KV double circuited transmission line from Kunduz new substation to Taluqan tepa-e-Ortaboz substation with total length of 65.68 km and at a cost of 32 million USD from Asian bank. other districts of this province supplied their electricity from small hydroelectric devices, solar energy systems and diesel generators. many of these systems were adapted through the NSP (National Solidarity Program). The capacity of this imported electricity is 16 MW and the other 16 MW is under plan up to next year. This 16 MW is not enough even for the center of Takhar, so the people use the electricity, intermittently. Currently the people of Taluqan, Baharak center

and Hazar Sumuch center (37795 subscribers) are using from imported electricity and the people of Farkhar and Warsaj (about 5000 subscribers) are using from hydropower, and the people of chal district (about 1300 subscribers) are using from PV and the rest of districts don't access to national grid, they use from small hydropower plants, solar energy and diesel generators are used in center of districts. The number of electricity subscribers in Takhar is 37795 subscribers (189 Government, 2526 Commercial, 34467 Residential, 509 Religious, 71 Registered industries and 33 NGOs) as given in figure 2.





**Figure 2. The Subscribers of National Grid in Takhar Province**

### The Current Situation of PV (Photovoltaic) Energy in Takhar

In Takhar province there are two solar power plants (SPP) that has been located in Chal district (Yeka Tut SPP with 200KW capacity as given in figure 3, Khanaqah SPP with 44KW capacity).



**Figure 3. Solar Panels of Yeka Tut Village of Chal District**

### Small Hydropower (SHP) and Smaller Hydropower

There are a large number of SHPs in Takhar that Approximately 88% of the units has implemented by the NSP or private programs and is used by local people or private individuals. A little over 12% of the units were erected as a result of private efforts. Under the energy program of the German Technical Cooperation (GTZ, now GIZ), one unit (a cross flow turbine with an installed capacity of 36 kW) was erected in the Khwaja Ghar district (Bhandari, R., et al., 2015). There are more than 175 (Table 5) SHPs that its total installed capacity is 4.4 megawatts and connects 14% of the total population of the province to electricity decentralized stations. Individual plants ranged in installed capacity from 4 to 152 kW. About 8% of these devices have a capacity of less than 10 kW and 8% of them have a capacity between 5 and 100 kW. Only two hydroelectric devices had a capacity higher than 100 kW. Most of these power plants (i.e. 129 power plants) are equipped with crossflow turbines. But there are also two Francis turbines and 27 Waterville turbines. About 55% of the surveyed power plants produce electricity for consumption purposes, and about 30% of them provide electricity for production use on a small scale. There were only two units producing energy continuously: One run by the community and the other by the commercial sector. They were both providing power for useful purposes as well (Bhandari, R., et al., 2015). The installed plants' investment costs varied widely, from less than \$1,000 to more over \$2,500 USD/kW. Other nations' MHP plants likewise have capacity prices in comparable higher ranges; for example, facilities with a 50kW capacity would cost around 2,500–3,000 USD/kW (Mainali, & Silveira, 2013).

A socio-economic survey has conducted to estimate the number of hydropower consumers as given in Table 6.

**Table 5. Summary of SHPs Built in Takhar Province**

The total number of surveyed small hydro plants	175
The total number of surveyed big hydro plants	2
Total installed capacity	4281KW
Inactive capacity	550KW
The average cost of installing the device (in 145 areas)	1213 USA\$/KW without big hydro plants
The total population who are connected to all power plants	154750

**Table 6. Result of Socio-Economic Survey about Hydropower in Takhar Province**

No.	Village	District	Power (KW)	Consumers	Investment in millions of USD
1	Baharak	Baharak	110	6790	0.715
2	Farkhar	Farkhar-1	350	9000	2.625
3	Farhang Gird	Farkhar-2	250	15200	1.775
4	Jari Khizan	Farkhar-3	475	15200	4.037
5	Saripul	Farkhar-4	350	15200	2.905
6	Dusat	Khaja Ghar	130	13000	1.750
7	Kuri Baqi	Namakab-1	500	14540	4.250
8	Deh Bala	Namakab-2	216	6070	1.568
9	Warsaj	Warsaj	500	19800	3.750
10	Yengi Qala	Yengi Qala	1000	30000	6.500
11	Chal	Chal	400	9950	3.400
Total			4281	154750	33.275

## The Current Situation of Diesel Energy in Takhar

Before the imported electricity (2014), the people of Takhar used diesel electricity with limited capacity in Taluqan. The 2010 energy cost for residential consumers was 66 ¢/kWh (USD 1 = ~ AFN 53, Afghani currency), with around 1.3% of the province's population residing in Taluqan receiving diesel electricity from DABS (Xe, 2013). Now, the people of district centers or some big villages that don't have access to national grid or hydropower, they are using diesel electricity by one or two big generators. For example, in Khwaja Ghar the district center, including the bazaar, has access to electricity using a small on-site hydroelectric plant (approximately 30KW). In Rustaq the people of the district center and shopkeepers in the bazaar use from the electricity of two private diesel generators. It is said that these two generators have a production capacity of 10 KW and 20KW, respectively. In Chah Ab diesel generators (private or owned by the local people) are the main source of electricity supply in this

district, whose production capacity is said to be between 20 KW and 30 KW. The center of district also has a diesel generator.

## Electricity Demand from 2023 up to 2032

Energy is now a crucial component of a nation's socioeconomic and even economic development (Ekonomou, 2010). It is not possible to employ a single universal technique for all kinds of energy demand forecasts. Therefore, a suitable approach needs to be identified for every demand profile. It is customary to use historical data of a specific demand profile (NSIA, 2022). Several characteristics define the process of forecasting power demand. There are differences in demand between day and night, as well as between weekday and weekend demand, but hourly demand is better than others (Porteiro, et al., 2010). Demand differs from other typical days in summer and winter on exceptionally hot and muggy summer days and severely windy and cold

winter days. For governments and private businesses alike, demand forecasting is essential to managing the supply and demand of energy (Ghalekhondabi, et al., 2017). There are three categories for electrical energy consumption: commercial (non-residential), industrial, and residential (Electricchoice.com, 2016). Energy demand mostly influences energy supply (Mauky, et al., 2015). According the calculation, there is the electricity demand in Takhar province up to 2032 in Table 7. The

consumption demand (137MW), the pure consumption demand (13620KW), the social and public consumption demand (5MW) calculated by the researcher that the total consumption demand in Takhar province is 155620KW in 2023. In this calculation the population growth is 1.84%, the annual commercial consumption is 10% and the annual social and public consumption is 3% (GIZ, 2012).

**Table 7. Total electricity demand in Takhar province (in Kilowatt)**

Year	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Consumption demand (10 <sup>3</sup> )	137	140	142	145	147	150	153	156	159	161
Pure consumption	13620	14982	16480	18128	19941	21935	24129	26541	29196	32115
Social and public consumption	5000	5150	5304	5464	5627	5796	5970	6149	6334	6524
Total consumption in the field	155620	160132	163784	168592	172568	177731	183099	188690	194530	199639

## Conclusion

An examination of the state of the electric networks in Afghanistan's Takhar Province reveals a terrain full of prospects and obstacles. Although there are many challenges to overcome, such as distant location, limited resources, and the requirement for infrastructure development and technological know-how, there are also obvious routes for advancement and sustainability. Takhar has 277 distribution transformers with 50922 KW capacity, almost all of them are active and in normal condition that they are enough for mentioned subscribers. Since 2013, Current expansion of Takhar electric networks has remained as it is and not been developed yet. There are 6 energy sources (national grid, off grid or solar energy, hydropower, wind energy, biomass energy and diesel energy) that there are 1847945 renewable energies (2543MW PV, 1199MW wind, 20137MW hydro, and 1824066 MWh/year biomass). There is only one substation in Takhar with 16MW capacity, in 2013 DABS extended 220 KV double circuited transmission line from Kunduz new substation to Taluqan tepa-e-Ortaboz substation with total length of 65.68 km

and at a cost of 32 m\$ from Asian bank. This 16 MW is not enough even for the center of Takhar, so the people use intermittently. Currently the people of Taluqan, Baharak center and Hazar Sumuch center (37795 subscribers) are using from imported electricity. There are 2 SPP that has been located in Chal district (Yeka Tut SPP with 200KW capacity and Khanaqah SPP with 44KW capacity) with about 1300 subscribers. There are a large number of SHPs that Approximately 88% of the units has implemented by the NSP or private. There are more than 175 (Table 5) SHPs that its total installed capacity is 4.4 megawatts and connects (154750 people) 14% of the total population of the province to electricity decentralized stations that total installed capacity is 4281KW that 550KW capacity are inactive. Now, the people of district centers or some big villages that don't have access to national grid or hydropower, are using diesel electricity by one or two big generators. Total electricity demand in 2023 is 155.62MW but according the calculation of demand forecasting it reaches to 200MW in 2032. The study emphasizes how crucial it is to keep funding the infrastructure of the electric network, with an emphasis on creative and

environmentally friendly fixes that are adapted to the local environment. To mobilize the required resources and knowledge, cooperation between foreign partners, the business sector, and local government agencies is essential. In addition, community involvement and capacity building are necessary to guarantee the electric network's long-term viability and upkeep. In conclusion, even if Takhar Province's electric network has many obstacles, there is a base upon which to construct a more dependable, reachable, and sustainable energy future. Takhar can facilitate better socioeconomic growth and a higher standard of living for its residents by tackling the existing constraints and seizing the chance for the integration of renewable energy. All parties involved in this project must work together with a common commitment to development and resilience.

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