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# Potential of Solar Energy in Afghanistan

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**ABSTRACT:** In Fact, Renewable energy resources are the key in to a sustainable economic, social, and environmental development all around the world specifically for Afghanistan. especially solar energy which has a significant role among the other renewable resources for electricity generation in the country. Though we have major sources inside the country for power production but unfortunately still we are dependent to our neighboring countries to meet our daily power consumption. this power imported is not suitable as well as its very costly. Recent three decades' war destroyed everything all around the country, almost 80 percent of our power production is imported from four countries (Turkmenistan, Iran, Tajikistan and Uzbekistan) Around 85 percent of total population uses biomass energy for heating and cooking, which furthermore of co2 emission and other toxic elements, is very harmful to our health due to having lots of problems.in this study we aim to assessment the total implementable power production from solar energy in Afghanistan where the Average solar irradiance is about 6.5 kWh/m2/day which is a suitable and proper area for developing the sustainable resources (RE) for power production.

**KEYWORDS:** Technical Potential, Solar Energyin Afghanistan

## I. INTRODUCTION

Afghanistan is a precipitous and landlocked country which is situated in South-Central Asia, North and west of Pakistan, east of Iran. It is located between Latitude 29°35′ and 38°40′ degrees north and longitude 60°31′ and 75°00′ east. The total land area is 652,864 km2 with parched and semiarid atmosphere and cold winters and hot summers. The total population is 31,627,506 out of 2014 with over 75% (27.5 million individuals) live in rural regions [1,2]

Access to electricity is a higher priority and furthermore the second need after the standard of law, for Afghanistan. A large portion of the foundations of the nation, explicitly its national lattice (existed power plants, substations, and transmission and distribution networks) were destroyed and wrecked during the most recent 30 years of common war and precariousness. Plus,

as vitality is the foundation of the national economy of every country and furthermore, expectation for everyday comforts of every country's residents is demonstrated by GDP of the country which is professed to be about 90% reliant on per capita energy consumption. Afghanistan with its $687 GDP per capita and 78.21 kWh power utilization per capita (195 kWh per annum) in 2014, positions among the lowest country on the world [3][4]

Here is some point or reasons that just 9% rural and 30% of the entire country's population power are: initially, most of the populace live in the rural region, and development of the current transmission system will be pricey. Secondly, regardless of whether the first is to be accomplished the significant (78%) of provided electricity in Afghanistan is the powerimports from neighboring countries which is professed to be very expensive and unaffordable for its residents particularly for the individuals who live in suburbia with the least income basically from agriculture and livestock. The main concern is the resource, generation of energy from fossil fuel based plants, because of disadvantages that they have, appears not applicable to the 21st century any longer. As NASAs Earth Observatory clarified that a Global Warming was the bizarrely fast expanding in Earths normal surface temperature over the previous century essentially because of the Greenhouse gases (GHGs) discharged as individuals copy non-renewable energy sources. In addition, as indicated by the world Health Organization(WHO), every year millions of people arepassing because of the air pollution in the world [4][5].

On the other side, as indicated by the Afghanistan power sector master plan(APSMP), the total power demand is estimated to arrive at 3500 MW excluding losses in 2032. [6]

According to the Afghan Rural Renewable Energy Strategy, 85% of primary energy demand in Afghanistan is met by traditional biomass mainly wood and waste, which is utilized for cooking and Heating purposes. [7]

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### 1.1 Afghan Energy System

Afghanistan is one of thelowest country in electricity utilization in the world —around 100 kilowatt hours (kWh) every year per capita utilization— furthermore only 30% of its population are connected to the grid. total peak demandin year 2014was 750 megawatts (MW), where the unsuppressed demand is evaluated at 2,500 MW. In 2014, practically 80% of electricity was provided by imported power, and demand was increasedby 25% in major cities. In spite of the fact that the reliability of the grid has improved significantly since 2002, load shedding is as yet normal and private generators fill the gap. To satisfy this demand Growth, Afghanistan plans to build up a blend of a domestic fossil fuel,renewable energy generation projects andhydropower, through public and private sector participation, complemented by diversified import solutions. [8]

[9] In AfghanistanThe total installed generation capacityis just around 520 MW, which is 254 MW (49%) from hydropower resources; while200 MW (39%) from thermal sources (furnace oil, diesel, and gas); and 65 MW (12%) from distributed generators. Table 1.1 Afghanistan power plants installed capacity [8,9] at this time, Afghanistan doesn't have any grid-scale of renewable energy resources. While with solar energy, wind and biomass resources potential, the country depends fundamentally on power imports, pursuit by hydropower, thermal plants and diesel generation. DABS (Da Afghanistan BreshnaSherkat) is the state-owned supplier of electricity in Afghanistan and has the ownership of generation, transmission and distributionservices, sale of the electricity and revenue collection with operation and maintenance inside the country.

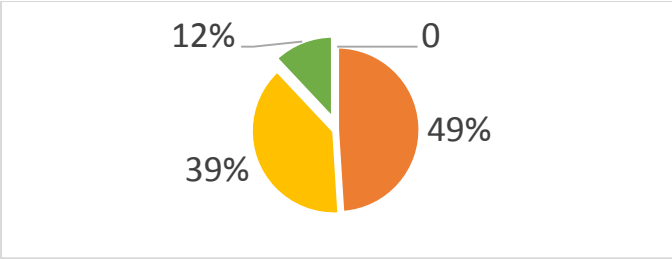


**Fig 1.1 Total Installed Generation Capacity**

### 1.2 Supply Demand Gap

There is a growing gap among supply and demand, but available forecasts of demand don't reflect the current reality in terms of both stalled economic growth and growing security concerns. Among 2010 and 2015, the number of family unit connection with the grid increased by 60 percent and the total connection was about 57 percent. Where household dominate the client base, representing approximately 93 percent of the all connections, while commercial clients indicate only under 7 percent and government agencies were less than 1%. [10] The latest and complete figure of electricity demand in Afghanistan was developed as part of the preparation of the Afghanistan Power Sector Master Plan (APSMP). Net demand was anticipated to increase from roughly 2,800 GWh in 2012 to 15,909 GWh in 2032, representing to a normal yearly development rate of 9.8 %. Peak demand was forecast to increment from roughly 600 MW at the outset of the forecast period (2012) to an anticipated 3,502 MW in (2032)–it means around 8.6 percent every year. It is this demand projection that the GoA is proposing to meet at least in part with renewable energy resources. [11] Figure 1.2 and Figure 1.3 show the Development of net electricity demand and development of peak load in Afghanistan respectively [6].

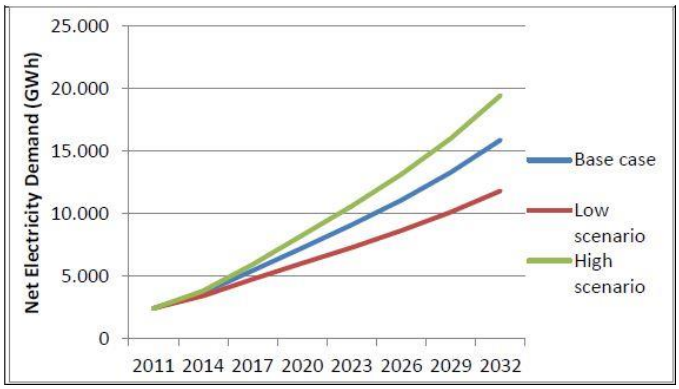


**Fig 1.2 Development of Net Electricity Demand inAfghanistan [6]**

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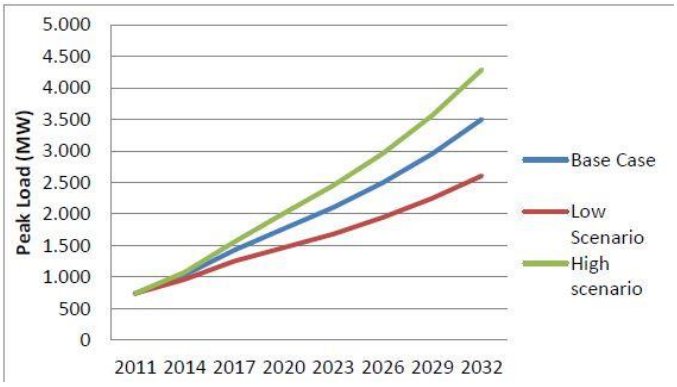


**Fig. 1.3 Development of Peak Load in Afghanistan [6]**

### 1.4 Status of Renewable Energy in South Asian countries:

#### 1.4.1 Solar Energy

As we know in the earth solar energy is the rudimentary type of energy. It has been surveyed that the solar energygetting by earth is right around 5000 times more prominent than the whole significant existing energy sources in the earth. Considering the cross-sectional region of the earth 127,400,000 m2 and the daily average solar irradiance 200 W/m2, it has been evaluated that the earth gets around 222,504,000 Terawatt hours (TWh) of solar energy per annum tantamount to 19,349,957 Mtoe [12] Figure 1.4 shows the everyday normal sunlight based irradiation(GHI) capability of South Asian nations.

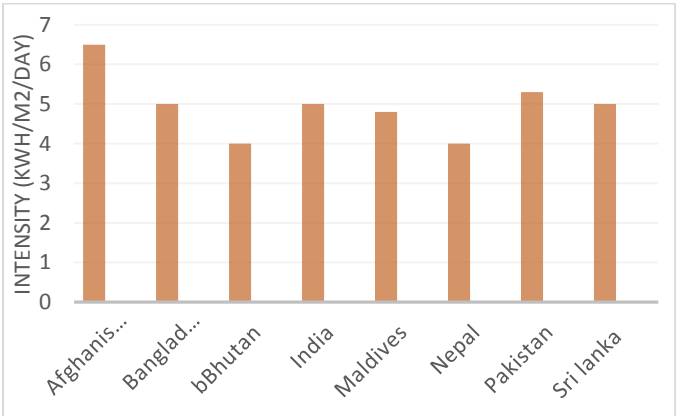


**Fig. 1.4Average Solar Power Potential OfSouth Asian Countries**

As we see among these countries Afghanistan has energy potential (GHI)of about 6.5 kWh/m2/day which is the highest solar energy potential.

#### 1.4.2 Hydropower Energy

world's total hydropower potential in year 2013 was around 1000 GW. Plus, power production potential was around 3750 TWh with an ascent of 4% over the previous year. Hydropower chip in, in globalprimary energy consumption is about 3.8%. on the other side, 16.4% of the global power is produced by hydro power energy [13]. in the South Asian territoryHydropower is one of the biggest energy capitals. India, and also its neighbors has enormous capacity to generate hydropower, and by sharing this hydropower they can minimize their energy demand. The governments of this area have an extraordinary chance to build up this project and strategy. Figure 1.5 demonstratethe capacity of hydropower inSouth Asian countries. Between these countries India is the greatest

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country in producing hydropower potentialwith a limit of 150 GW followed by Nepal of limit 80 GW.[14]

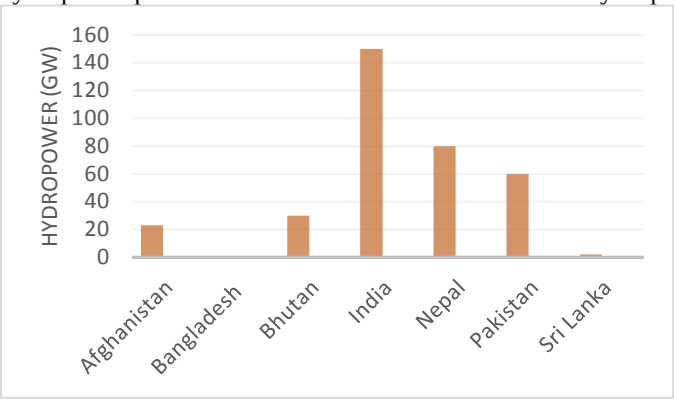


**Fig. 1.5 Potential of Hydropower Energy in South Asian Countries**

### 1.4.3 Wind Energy

Among south Asian countries Afghanistan has the greatest wind power generating country followed by Pakistan and India. Up until now, Bangladesh is the country in south Asian which has installedwind turbine with potential of 19.72 kW.

Overall wind power outputwas 35 GWin the year 2000 which expanded in year 2013 up to 318 GW. Figure 1.6 shows the capacity of wind power in South Asian countries.[14]

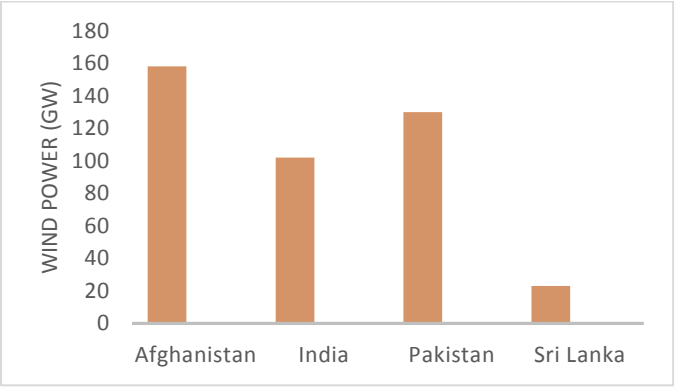


**Fig 1.6Potential of Wind in South Asian Countries**

### 1.4.4 Biomass Energy

between south Asian countries India is the greatest bioenergy generating country of absolute capability of 8764 Peta Jules (PJ).after India Pakistanhas a capability of 2245 and Bangladeshhas 1345 PJ biomass capacity. Figure 1.7demonstrated the biomass potential in south Asian [14]countries

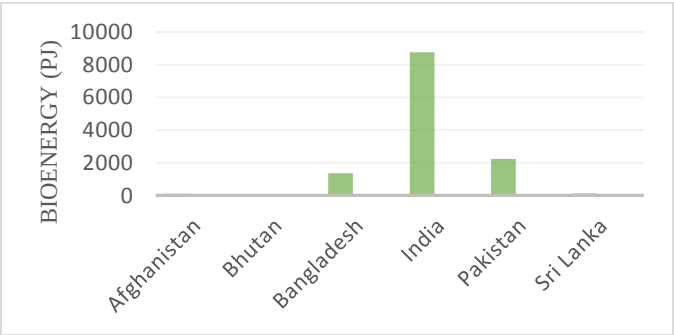


**Fig. 1.7Demonstrate The Biomass Potential in South Asian Countries**

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## Chapter II

### Literature Review

In [4] a study has been done in case of theoretical potential and utilization of solar, hydro power, wind, biomass and geothermal energy in Afghanistan. The paper concluded the total potential of renewable energy excluded geothermal energy, about 66000 GW with total feasible energy about 297 GW where the major portion dominates by solar energy. Due to that study the total feasible potential of energy all around the country is 66 times of the total demand of 2032[4]

**. M. A. Anwarzai** (2018), in this research, the executalecapacity of solar and wind technologies are studied. As the results, the total calculated implementable potential of an annual generation of solar PV and wind turbines would be; 342,521 GWh and 140,982 GWh respectively. Also about 6,000 GWh from Concentrating Solar Power (CSP). Less than 1% of this energy production can meet the load requirements in the country. [15]

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a study has been done on renewable energy resources in Iraqspecifically on solar energy which has potential to produces 1800 kWh/m2/year to 2390 kWh/m2/year and with almost 10 hours of sunshine per day. Which is a proper and suitable area for developing solar energy. The study concluded that solar power generation in Iraq is limited to simple applications, such as water heating for household use, lighting of streets, and for irrigation in agriculture. As well as study shown installing of CSPtechnology has been proven to be economically feasible. (16)

**Rezaei M, Chaharsooghi SK, Abbaszadeh P** (2016) Iran is also one of the developing countries which is the one of the greatest producer of oil and gas in the world that are used in diverse industrial section such electric power plants.. The government is trying to follow the energy sustainability in the Iran by development of renewable energy technology. The target is set to 20000 MW (10% of the required electricity) by 2025. Due to the various renewable energy policy challenges, the Iran's energy system looks far from sustainability

The total solar electricity generation in 2004 was 14020 KW. This rate has reached 67000 KW in 2010 [17]

## Chapter III

### 3.1 Methodology and data Input

Among various potential (Resource, Technical, Economic and Geographical) in this paper we are concentrating on Technical potential which is an Executable Resource particularly for Afghanistan.

Afghanistan with 300 sunshine days in a year and with average solar radiation (Global Horizontal Irradiance or GHI) is assessed at 6.5 kWh per m2 every day. Higher qualities win in the southern territories of Kandahar, Helmand, Farah and Herat areas. in any case, even in the northern regions, where irradiance midpoints just 4.5 kwh per m2 every day, power generation is technically feasible [15]

We havetwo main technical option for grid-level solar power plants; first concentrated solar power (CSP) and second solar photovoltaic (PV).CSP utilizes varieties of mirrors to center an enormous territory of daylight onto a small region, in this way making elevated levels of heat which is captured in a high-temperature Heat Transfer Fluid (HTF, for example, syntheticoil or molten salt. The warmed HTF is then used to make steam which drives ordinary steam turbines to produce electricity. The thermal energy in the CSP plant canas well be stored until electricity is needed. Solar PV panels change sunlight directly to electricity utilizing a layer or layers of semi-conductive material which discharge electrons when struck by light. Caught electrons make a progression of DC current which can then either be utilized to control DC machines, stored in batteries, or fed through an inverter to deliver AC current for use in different applications. . Table 3.1 shows the List of LULC Exclusion to describe the site suitability areas while Table 3.2 shows thelist of exclusion do define site suitability areas. [9] all the process in this paper like area suitability, data collection, list of inclusion and exclusion areas and other parameters are discussed and after collection of the data, data has been analyzed in RE-EXPLORER software which is under US NREL (United State National Renewable Energy Laboratory) for estimation of technical potential of solar energy in all 34 provinces that make up Afghanistan. A short description of what we done in following:

- Using Solar Atlas for determining the GHI of Areas.
- The site selection criteria development for solar farms installation.
- Introduction of CSP and PV technologies and demonstrate the executable power potential of solar energy.

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- Using of RE Data Explore Software for calculating of the total potential of solar energy around the country.

### 3.2 Selection of site for solar power plant

For the solar power plants site selection, the selection criteria are identified to consider the available and applicable environmental, technical and economic factors.However, till now there is no specific solar energy siting criteria or site selection decision procedure in Afghanistan. Constraints solar power plants implementation such as low resource, land use, topography, road access, social and environmental issues are examined, and the appropriate threshold are selected to define the possible solar power plants.

**Table 3.1 List of LULC Exclusion to define site suitability areas**

Land Use Land Cover ClassInclusion criteria

Rangeland (Grassland/forbs/low shrubs) Included

Irrigated: Intermittently Cultivated Excluded

Irrigated: Intensively Cultivated (1 Crop/year) Excluded

Rainfed Crops (Sloping areas) Excluded

Rock Outcrop / Bare Soil Included

Marshland permanently inundated Excluded

Fruit trees Excluded

Rainfed Crops (flat lying areas) Excluded

Settlements Excluded

Natural Forests (closed cover) Excluded

Natural Forests (open cover) Excluded

Irrigated: Intensively Cultivated (2 crop/year) Excluded

Degenerate Forest/High Shrubs Excluded

Water bodies Excluded

Permanent Snow Included

Marshland Seasonal Excluded

Vineyards Excluded

Sand Covered Areas Included

Sand Dunes Included

Pistachio Forest Excluded

Gardens Excluded

**Table 3.2 list of exclusion do define site suitability areas**

| Parameter | Inclusion Criteria for Solar | Unit |
|---|---|---|
| Lakes | Value >=500 | Distance in meter |
| River | Value >=500 | Distance in meter |
| Slope | Value <=10 | Slope in percentage |
| Elevation | Value <=4000 | Elevation in meter |
| Protected areas | Value >=500 | Distance in meter |
| Land use/Land Cover | Value >0 | Distance in meter |

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| | | |
|---|---|---|
| Airports | Value >=2000 | Distance in meter |
| Airfields | Value >100 | Distance in meter |
| Population | Value <=200 | Density/square km |
| Bedrock Landslide in slow Elevation | Value <=4 | Susceptibility (min 0- max 8) |
| Cover Material Landslide in Rapid Elevation | Value <=4 | Susceptibility (min 0 – max 8 |
| Earthquake | Value <=2 | Peak ground Acceleration (g) |
| Flash Flood | Value <=4 | Susceptibility (min 0- max 8) |
| Fluvial Flood | Value <= | Water depth in meter |
| Avalanche | Value <=3 | Impact Pressure in kPa |

**Table 3.3 shows the solar potential in each province**

| No | Provinces | Province solar land ($Km^2$) | Total irradiance ($kWh/m^2/day$) | potential (MW) |
|---|---|---|---|---|
| 1 | Badakhshan | 44,836 | 5 | 5309 |
| 2 | Badghis | 20,794 | 6.15 | 7876 |
| 3 | Baghlan | 18,255 | 5.05 | 1486 |
| 4 | Balkh | 16,186 | 4.3 | 3059 |
| 5 | Bamyan | 18,029 | 6.2 | 2815 |
| 6 | Daykundi | 17,501 | 6.55 | 1855 |
| 7 | Farah | 49,339 | 6.6 | 25236 |
| 8 | Faryab | 20,798 | 5.4 | 8484 |
| 9 | Ghazni | 22,460 | 6.2 | 14392 |
| 10 | Ghor | 36,657 | 6.9 | 12978 |
| 11 | Helmand | 58,305 | 6.85 | 28004 |
| 12 | Herat | 55,869 | 6.13 | 25636 |
| 13 | Jawzjan | 11,292 | 4.74 | 2187 |
| 14 | Kabul | 4,524 | 5.73 | 2845 |
| 15 | Kandahar | 54,845 | 6.8 | 48225 |
| 16 | Kapisa | 1,908 | 5.75 | 837 |
| 17 | Khost | 4,235 | 5.15 | 1290 |
| 18 | Kunar | 4,926 | 5.54 | 483 |
| 19 | Kundoz | 8,081 | 3.8 | 1560 |
| 20 | Laghman | 3,978 | 5.08 | 261 |

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| | | | | |
|---|---|---|---|---|
| 21 | Logar | 4,568 | 5.93 | 942 |
| 22 | Nangarhar | 7,641 | 5.3 | 2234 |
| 23 | Nimroz | 42,410 | 6.4 | 31605 |
| 24 | Nooristan | 9,267 | 5.75 | 146 |
| 25 | Paktia | 5,583 | 5.48 | 4581 |
| 26 | Paktika | 19,516 | 6.2 | 10106 |
| 27 | Panjshir | 3,772 | 5.95 | 411 |
| 28 | Parwan | 5,715 | 5.75 | 1159 |
| 29 | Samangan | 13,438 | 5.2 | 2780 |
| 30 | Sar-i-pul | 16,386 | 6.05 | 5046 |
| 31 | Takhar | 12,458 | 4.9 | 2812 |
| 32 | Urozgan | 11,474 | 6.83 | 6334 |
| 33 | Wardag | 10,348 | 6.05 | 1194 |
| 34 | Zabul | 17,472 | 6.5 | 14978 |
| **Total** | | **652,864** | **6.5** | **279146** |

## Chapter IV

### Discussion and Conclusion

This paper reviews the technicalpotential of solar energy in Afghanistan where there is more than 6.5 kwh/m2 per day GHI average, which is the second country after African countries

from the continuing discussion, it is concluded that the total potential of Solar energy is around 279,000 MW and with estimated about 13% of capacity factor for solar PV in Afghanistan [18] estimated total power production of almost 317 million MWh per year which is a huge resource for power production inside the country. by using only 1 percent of this resource we can overcome the energy crises in Afghanistan and stop importing of electricity from outside of the country.as well as this is an implementable and executable investigation of solar energy for electricity generation in country.

Study shows that the major potential of solar is often in south west and south east provinces such as (Helmand and Kandahar) and in west of Afghanistan especially in Herat, Farah and Nimroz provinces.Where there is located more than 40% of the total potential in this 5 provinces with having at least GHI of about 3.8 kWh/m2/day in minimum for Kunduz province in north east and maximum GHI is about 6.9 kWh/m2/day belong to Ghor province in west of Afghanistan.

The CSP technology is also one of the possible option for the power generation; they have an implementation in the South-West provinces where there is no abundant wind and hydro power potentials such as Ghazni, Paktika, Helmand, and Kandahar provinces. The launch of CSP technologies in the country can create demand for the direct use of thermal waters in the industry and food processing. Helmand and Kandahar cities are the best locations for the largescale, for example 100MW, CSP technologies installation and power production. [15]

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