

Research and Investigate of Renewable Energy in Afghanistan

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Abstract About 78% to 80% of power energy imported from neighboring countries in Afghanistan. Roughly 70% of the population don't have access to electricity, and 90% of those without electricity live in rural areas. reduction of energy resources, increasing use of fossil fuels and unrefined coal for home heating, cooking is a major problem in the world and even a serious challenge to environmental pollution specially for whom who lives in Afghanistan. In this research we have introduce new sources of energy, which is renewable energy, as an alternative to fossil energy. Nowadays, due to the gradual reduction of fossil energy sources and increase of air pollution and environmental damages has forced scientists to look for a sustainable and clean energy to be cheap and economically and be friendly with environment. This research shows that renewable energy is more appropriate compared to the fossil fuels in order to decrease air pollution and would be economically for people.

Keywords: energy, renewable energy, fossil fuels, geothermal energy, biomass energy

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1. Introduction

The energy crisis is a challenge in the world and scientists are looking to find and introduce access to cheap and clean energy sources. On the other hand, environmental pollution is a serious threat for the climate because most industrialized countries have using greenhouse gas emissions. In Afghanistan the most exploited renewable resources are hydroelectric, photovoltaic (PV) and wind [1]. Fortunately, there are plenty of sunny days and renewable energy sources in Afghanistan. In this article, research has been done on the use of renewable energy in Afghanistan how much has been used and what is the extent of renewable energy production capacity. Therefore, renewable energy sources include hydro energy, solar energy, wind energy, geothermal energy and biomass energy.

Due to the different climate in different parts of Afghanistan and despite the mountainous areas, the vast plains are favorable for the use of renewable energy, in this article, these points have been studied technically and it has been clarified that in which parts of Afghanistan the type of renewable energy is appropriate and has more efficiency until use its national and international facilities in future. Gradually, the dependence of energy on neighboring countries will decrease. The geography and climate of Afghanistan is favorable for renewable energy production, according to a study by the national renewable energy laboratory of the united states [2].

The Renewable Energy Roadmap for Afghanistan is developed to realize the vision and intent of the

Renewable Energy Policy (RENP) for Afghanistan that sets a target of deploying 4500 – 5000 MW of renewable energy (RE) capacity by 2032 and envisions a transition from donor grant-funded RE projects to a fully-private sector led industry by 2032 [3].

2. Renewable Energy Sources

There are many sources of renewable energy which have been using as energy for daily activity in Afghanistan.

2.1. Hydro Energy

People have been using water power since the beginning of civilization. Along with the burning wood for light and heating, water power was used as the main source for generating mechanical driving power [4]. Power generation in Afghanistan is mainly hydro based and this slightly increased in the past. Thermal generation has reduced in the recent years and the total local generation has remained constant in the range of 800 to 1000 GW-hrs [5]. Afghanistan, with its snow – capped mountains, some of which are always under snow, is source of watery rivers which flow into the neighboring countries through a long route with high valleys. The total potential in Afghanistan is **124500MW**, but it will also become an exporter of electricity. Research shows that the use of hydropower in Afghanistan is about **377MW** and the feasible capacity of hydropower generation is up to **23000MW** (large, medium and micro hydropower plants) [6].

Table 1. Active hydropower plants in Afghanistan [6]

No	Dam name	location	Capacity (million cubic meter)	Head (m)	Height (m)	Length (m)	Width (m)	No Of turbines	Current capacity (MW)
1	Asadabad	kunar						2	0.75
2	Chak wardak	wardak				4000		3	3.3
3	Charikar	Parwan		19		22000		3	2.4
4	Dahlah	Kandahr	314					1	11.5
5	Darunta	Nangarhar	40.5		22	140	18	3	11.55
6	Ghorband	Parwan		125	2	45	33	3	0.375
7	Grishk	Helmand						2	2.4
8	Istalif	Kabul	0.006			50	35	2	0.1
9	Jabalusseraj	Parwan						4	2.4
10	Kajaki Iand 3	Helmand	2800		100	270	2290	3	33
11	Mahipar	Kabul						3	66
12	Naghlu	Kabul	580	75	110	240	24	4	100
13	Pul-e-khomri 1	Baghlan	4				90	3	4.8
14	Pul-e-khomri 2	Baghlan				5500	20	3	10.5
15	Salma	Herat	633		37	550	550	3	42
16	Sarobi	Kabul	6.5		17		18	2	24
17	Other hydro power potential (HPP)								61.925
Total			4,378.006					44	377

Afghanistan annually has 75 to 80 billion cubic meters of surface water, of which only 25% to 30% of this water is used inside the Afghanistan for agriculture and energy production, and the remains without exploitation flow to the neighboring countries. The greatest source of energy in this country is hydroelectric power which provide about 50% of the its energy needs, about 10% comes from domestic hydroelectric power and 40% hydroelectric power imports from neighboring countries. Although, there are 17 hydropower in Afghanistan as shown in Table 1 so, most of electric power imported from its neighboring which is serious problem in energy sector in this country.

2.2. Solar Energy

The sun is the biggest source of energy in our lives. The sun gives off enormous amounts of heat and light in all directions. Scientists say it will continue to shine for billions of years in the future [7]. Sunlight energy is one of the energies that has enabled all living things to live on earth planet that comes from fusion energy in the sun that is obtained from joining of hydrogen atoms and converting to the helium atoms. Solar energy is one of the cleanest energies that has no destructive effect on the climate and decreased of the pollution. Sunlight is the largest source of energy in our planet, so that the energy radiated to the earth is 4.3×10^{20} joule in one hour. In developed countries, solar panels are equipped with thermal sensors and a dynamic system so the solar panels always rotate toward the sun according the rotation of the sun, like a sunflower that is always facing the sun.

Solar energy constitutes the major portion of renewable energy potential in Afghanistan [8]. A large part of the southern, western and northern regions of Afghanistan are deserts and barren plains, which usually have low rainfall and temperature in these areas reach up to 45 degrees Celsius during the summer. If we use even one percent of the mentioned areas, we will have **1036 MWh** of energy per year according to the statistics of the ministry of energy and water. The total feasible potential of solar energy is about **222GW** throughout the Afghanistan [8].

Table 2. Solar resources potential per each provinces [8]

N0	provinces	Province area Province area Km ²	Solar Solar radiation KWh/m ² /day	Total potential MW	Feasible potential MW
1	Badakhshan	44,836	5	3,736,325	3,736
2	Badghis	20,794	6.15	2,131,385	5328
3	Baghlan	18,255	5.05	1,536,479	1,536
4	Balkh	16,186	4.3	1,160,018	2,900
5	Bamyan	18,029	6.2	1,863,017	1,863
6	Daykundi	17,501	6.55	1,910,570	1,911
7	Farah	49,339	6.6	5,427,301	27,137
8	Faryab	20,798	5.4	1,871,784	4,679
9	Ghazni	22,460	6.2	2,320,867	5,802
10	Ghor	36,657	6.9	4,215,601	10,539
11	Helmand	58,305	6.85	6,656,499	33,282
12	Herat	55,869	6.13	5,707,898	28,539
13	Jawzjan	11,292	4.74	892,029	2,230
14	Kabul	4,524	5.73	432,032	432
15	Kandahar	54,845	6.8	6,215,710	31,079
16	Kapisa	1,908	5.75	182,850	183
17	Khost	4,235	5.15	363,530	364
18	Kunar	4,926	5.45	447,436	447
19	Kunduz	8,081	3.8	511,790	1,279
20	Laghman	3,978	5.08	336,796	842
21	Logar	4,568	5.93	451,471	451
22	Nangarhar	7,641	5.3	674,964	1,687
23	Nimroz	42,410	6.4	4,523,680	22,618
24	Nooristan	9,267	5.75	888,059	888
25	Paktia	5,583	5.48	509,932	510
26	Paktika	19,516	6.2	2,016,643	5,042
27	Panjshir	3,772	5.95	374,017	374
28	Parwan	5,715	5.75	547,697	548
29	Samangan	13,438	5.2	1,164,609	2,912
30	Sar – I - pul	16,386	6.05	1,652,215	4,131
31	Takhar	12,458	4.9	1,017,387	2,543
32	Urozgan	11,474	6.83	1,306,090	6,530
33	Wardak	10,348	6.05	1,043,454	1,043
34	Zabul	17,472	6.5	1,892,778	9,464
Total		652,866	6.5	65,982,913	222,652

Afghanistan is one of the sunny dry countries that has an average 300 sunny days (10 months) in a year with a capacity of 2400 to 3500 hours of sunshine with a temperature of 15 to 45 degrees Celsius. Each 10m² area of solar panel produces an average 1KW of energy and in areas where air pollution is low and solar panels are exposed to vertical light its effectiveness will increase. The optical properties of materials in solar panels is a deep and complex subject of study covering many aspects of the interaction of radiation with materials [9].

2.3. Wind Energy

Table 3. wind power potential per each province [8]

No	provinces	Provinces area (km ²)	Windy area (km ²)	Total potential (Mw)	Feasible potential (Mw)
1	Badakhshan	44,836	1,428	3,314	331
2	Badghis	20,794	410	762	191
3	Baghlan	18,255	1,064	2083	208
4	Balkh	16,186	1,689	3,145	786
5	Bamyan	18,029	100	240	24
6	Daykundi	17,501	-	-	-
7	Farah	49,339	19,270	61,353	30,677
8	Faryab	20,798	560	1,008	252
9	Ghazni	22,460	93	191	48
10	Ghor	36,657	160	336	84
11	Helmand	58,305	1,040	1872	936
12	Herat	55,869	14,694	36,947	18,473
13	Jawzjan	11,292	95	171	43
14	Kabul	4,524	230	414	41
15	Kandahar	54,845	130	234	117
16	Kapisa	1,908	450	810	81
17	Khost	4,235	-	-	-
18	Kunar	4,926	40	72	7
19	Kundoz	8,081	180	324	81
20	Laghman	3,978	460	1020	255
21	Logar	4,568	-	-	-
22	Nangarhar	7,641	300	582	146
23	Nimroz	42,410	10,130	21,450	10,725
24	Nooristan	9,267	90	-	-
25	Paktia	5,583	-	-	-
26	Paktika	19,516	220	396	99
27	Panjshir	3,772	80	180	18
28	Parwan	5,715	705	1269	127
29	Samangan	13,438	503	1,064	266
30	Sar-i-pul	16,386	385	729	182
31	Takhar	12,458	2,547	4,795	1,199
32	Urozgan	11,474	550	990	495
33	Wardak	10,348	80	180	18
34	Zabul	17,472	860	1,632	816
Total		652,866	58,543	147,563	66,726

Wind energy is one of the oldest sources of energy used by mankind [10]. Wind energy generated by temperature changes over the earth's surface has different velocities at different parts of the globe therefore, the wind speed the high levels of the atmosphere reaches more than 160km/h in Afghanistan. The first wind energy research device has been installed and put into operation in the white hotel area of Shakiban village, Zendajan district of Herat province. Afghanistan have thousands of narrow valleys,

mountains and hills from which wind energy can be obtained. Afghanistan's land can be divided into three main parts in terms of wind flow:

1) Badghis, Herat and Nimroz areas where the wind speed reaches up to 27m/s and in these areas strong wind turbines of 100kw and more should be used.

2) Areas with moderate wind currents, such as southern, eastern and central regions (Kandahar, Zabul, Urozgan, Bamyan, Daikundi, paktia and paktika) in which the wind speed is 9m/s and it is suitable to use wind turbines with power of (30 - 100)Kw.

3) Areas with weak wind currents such as the north, northeast and south (Balkh, Badakhshan, Takhar, Baghlan, Kundoz, Laghman and Jalalabad) where the wind speed in these areas reach up to 6m/s it is convenient to use from (1 - 30) Kw turbines.

In Afghanistan every 10m² areas has the capacity to produce 1Kw wind energy and the total capacity of wind energy production is up to **158Mw**, including about 25Mw wind energy in government and private sectors are used in provinces (Takhar, Bamyan, Herat, Kandahar, Kabul) which are mostly installed at low voltage and have recently been used from wind energy in some parts of northern provinces for irrigation. It is remarkable that about 3% of wind energy is used in our country. Afghanistan's feasible wind energy potential is about **63GW** [11].

2.4. Geothermal Energy

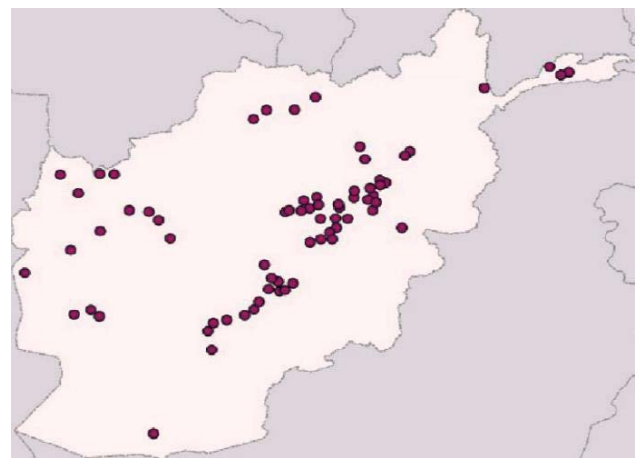


Figure 1. major locations of geothermal resources

Geothermal energy is the thermal energy stored in earth and it is underground heat. 99% of the earth is hotter than 1000°C and only 1% is colder than 100°C. The average temperature at the earth surface is 14°C [12]. In Afghanistan research about the use of geothermal heat was started in 1964 by Russian and Afghan geologists. Because there are mountainous and has old and new tectonics, the presence of such energy is abundant in Hindukush areas, especially central Hindukush and Herat province areas. One of the symptoms of these points is the emergence of hot springs and people use for treatment of skin diseases. This energy is produced by the heating of magma in the ground, solid plates of fractures and under the pressure of hydro carbonate. Afghanistan's hot water is composed of chloride bicarbonate, chloride, sulfide, sodium and a small number of elements such as Ge, Be, B,

Fe, Ag, Zn, Pb, Ba, Li, Rb, Sr and Sc.. The Afghanistan national development strategy (ANDS), which has been studied the countries energy development issues has concluded that investing in geothermal energy in Afghanistan and it is important and necessary for living. Natural resources not only contribute to its industrial and agricultural development, but also have a good outlook for investors and energy producers. Of course, the use of geothermal energy is about 0.1%, which is mainly used for bathing and washing in different parts of the Afghanistan [1]. There are some geothermal resources which shows in Figure 1.

2.5. Biomass Energy

Biomass energy is another source which use of biomass as an energy resource show that it is approximately 13% of all primary energy used [13]. Biomass is a fuel that is made from organic materials and is a renewable and

sustainable source of electrical and other forms of energy. There are types of biomass energy:

- 1) Forests and forests wastes
- 2) Agricultural, horticultural and food industry products and wastes
- 3) Animal waste
- 4) Municipal and industrial wastewater
- 5) Industrial wastewater
- 6) Municipal solid wastes

Potential of power production from biomass resources in Afghanistan indicates that amounts of crop residues are 3092MW, animal manures 841MW and municipal solid waste 94MW so the total current use of biomass energy become **4027MW** as shows in Table 4. The use of biomass energy accounts for a total of 15% Afghanistan's energy resources (mostly used for heating and cooking predominantly in villages) specially forests and animal waste in rural areas where they are the main fuel material for them. Afghanistan's feasible biomass energy potential is **20GW**.

Table 4. Biomass resource potential per each province [8]

No	provinces	Municipal solid waste (Tone/year)	Electricity production potential (MWh/year)	Animal manure (Tone/year)	Electricity production potential (MWh/year)	Crop Residue (Tone/year)	Electricity production potential (MWh/year)
1	Badakhshan	132086	29059	2407756	452658	143550	598604
2	Badghis	68897	15157	787318	148016	138570	577837
3	Baghlan	126100	27742	1579481	296943	345860	1442236
4	Balkh	181785	39993	1045096	196478	415330	1731926
5	Bamyan	62123	13667	761429	143149	68720	286562
6	Daykundi	64021	14085	1114886	209599	46620	194405
7	Farah	70430	15495	865514	162717	90030	375425
8	Faryab	138408	30450	971824	182703	323940	1350830
9	Ghazni	170645	37542	1212019	227860	322200	1343574
10	Ghor	95951	21109	1236102	232387	97470	406450
11	Herat	259880	57174	2258046	424513	415470	1732510
12	Helmand	128407	28250	2033377	382275	482920	2013776
13	Jawzjan	74767	16449	403238	75809	217440	906725
14	Kabul	576744	126833.6	367493	69089	111600	465372
15	Kandahar	168061	36973	2164179	406866	266440	1111055
16	Kapisa	61291	13484	911902	171438	106020	442103
17	Khost	79833	17563	1956218	367769	90290	376509
18	Kunar	62605	13773	1669748	313913	107680	449026
19	Kunduz	139255	30636	2066156	388437	446790	1863114
20	Laghman	61919	13622	1431920	269201	156870	654148
21	Logar	54473	11984	386770	72713	202020	842423
22	Nangarhar	209656	46124	3333441	626687	419610	1749774
23	Nimroz	22864	5030	252388	47449	71730	299114
24	Nooristan	20571	4526	832461	156503	22420	93491
25	Paktia	76650	16863	1263836	237601	147740	616076
26	Paktika	60415	13291	768982	144569	114090	475755
27	Pnjshir	21331	4693	197212	37076	44560	185815
28	Parwan	92214	20287	852559	160281	135580	565369
29	Samangan	53845	11846	282627	53134	99890	416541
30	Sar-i-pul	77672	17088	664815	124985	147900	616743
31	Takhar	136320	29990	1434745	269732	365550	1524344
32	Urozgan	48691	10712	847924	159410	140190	584592
33	Wardak	82870	18231	451688	84917	127030	529715
34	Zabul	42238	9292	374493	70405	62700	261459
subtotal		3723018	819013.6	39187643	7367282	6494820	27083398
Total energy production from biomass resources 35,269,694(MWh/year)							

Table 5. comparative potential resources

No	Type of energy	Total potential (MW)	Feasible potential (MW)	Current potential (MW)
1	Hydro	124500	23000	377
2	Solar	65982913	222652	1036
3	Wind	147563	66726	158
4	Biomass	35269694	20000	4027

According to discussed different renewable energy resources in Afghanistan in Table 5 there are comparative

potential resources which shows total energy capacity in Afghanistan.

Comparison of collected data shows that our Afghanistan has a high potential of renewable energy and we have used just 1.68% of this energy. The amount of geothermal energy consumption is so small that the percentage can be neglected and not much research has been done on the amount of geothermal energy because of the ongoing civil war. The comparative graph of renewable energy is shown in Figure 2.

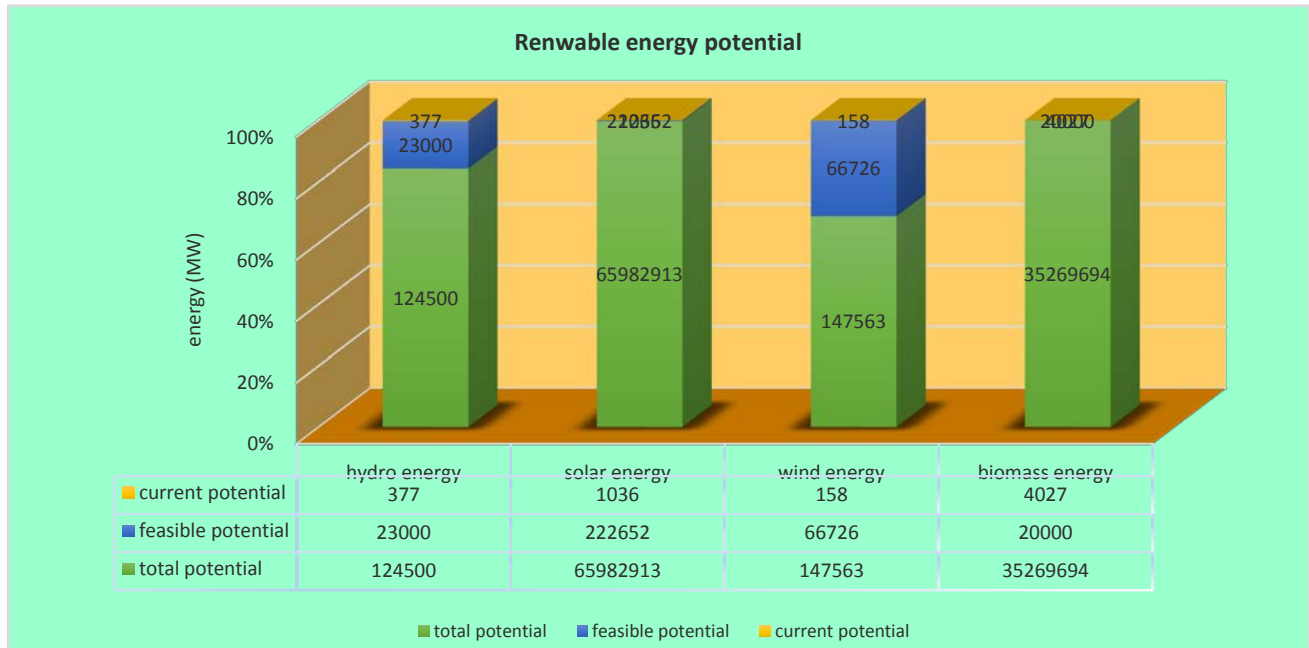


Figure 2. Comparative graph in renewable energy sources in Afghanistan

3. Conclusion

Afghanistan have high potential for producing renewable energy specially in solar and hydro energy, but civil war caused to prevent extensive research in this area. This article shows that the most use of renewable energy belongs to the biomass especially in rural areas. Solar energy, hydro energy and wind energy respectively could be effective for decreases air pollution in Afghanistan. There are more Renewable energy resources and suggest to develop it and use for heating and cooking instead of coal and wood in order to decreases air pollution in Afghanistan.

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