THE ENERGY IN AFGHANISTAN AS OF THE YEAR 2019

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Abstract

Afghanistan is a land-locked country with mountainous terrain that helps the country sustain the various climates they have. This in-turn provides for accumulation of sufficient water resources to enable the country not only to provide for its own energy needs but also be a supplier to the neighboring countries.

Of the many goals, the primer for the Energy sector is provisions of sufficient electricity through affordable and sustainable supplies. Sector plans envisages a comprehensive program of sequenced priority investment in power supply chain. Development experience from around the world confirms reliable power to be an essential ingredient to the economic growth and public welfare of any nation. As per the estimations, it is believed that the investments on Energy will support Afghanistan's growth at a rate of about 10% and per the government's broader goal of reducing poverty by 3% per annum and doing so in a cost-effective manner.

The current master plan under work envisions Afghanistan both as a major producer of clean energy and as a transit hub where a ring of transmission line around the major parts of the country will assist in transmission of this energy to other than those in Afghanistan. It is worth mentioning that Afghanistan has immense potential in all categories of non-conventional energy sources and as such can support the off grid locations with ample supply of renewable energy.

Mining sector as is on the boom in the country also has some potential for provisions of energy productivity, with this said, the Haji Gak Mine if explored has plans to include almost 50% of the coal-generated energy to the national grid. Although not an amount that can alleviate the energy problems, it sure can provide to immediate energy needs of the locals living around those areas.

Direct thermal Energy generation has also been studied and the proposal put forward a number of estimates for the energy that can be generated off the Sheberghan Gas fields. Among them one proposes thermally generate energy from the gas field for the whole lifetime of availability.

Finally, the imported energy which will be bulk of the energy consumption for the years to come will be a substitute for the country's need, this will be the case until the infrastructure is ample enough to provide for the needs of the country and then the final plan for these imported energies to be transmitted to neighboring countries. One such plan under work is the CASA 1000 project which will extend transmission lines till parts of Jalalabad and transiting the energy to Pakistan on a pay per use basis.

Introduction:

Afghanistan is a major country in the central Asian region and its ability to become a bridge between south and central Asia is critical to any form of development and inter-regional collaboration particularly in the energy sector. History has not been kind to Afghanistan, and it is a less developed country with poor governance and weak institutions. However, today there are opportunities to overcome the legacy of the past and seizure the vicious circle of economic regressions and political violence into enhanced political stability and economic development. Afghanistan has sufficient energy resources to provide reliable electricity to its people and industries.

Based on MEW estimates it has about 318 GW of renewable energy production capacity. Along with renewables there are significant hydrocarbons and coal resources. But despite the possession of these resources the country has remained underdeveloped with a low electrification rate of only around 30–38%. The deteriorating security conditions remain the main impediment to all the development incentives including the energy sector. The energy sector has technical, financial and institutional constraints. In addition, the trans-boundary water management issue remains a key obstacle for hydropower potential utilization.

Almost all rivers of Afghanistan are shared with neighbor countries and except with Iran there is no transboundary water sharing agreements with other recipient countries. This has hindered hydropower utilization of Afghanistan. Furthermore, considering weak financial institution of Afghanistan it is a distant possibility for Afghanistan to finance the hydropower projects by its own. Therefore, water sharing disputes resolution with neighboring countries should be the first priority for Afghan government to attract global financial institutions investments.

Cooperation grows from communal interests, and south and central Asia are united in the common benefits that both regions will get from energy trade and eventually regional prosperity. Afghanistan is well placed in adjacent proximity to the major hydropower and gas producer states which are desperate to diversify and reach central Asian markets. The country could become a hub of energy transit between the energy deficit south Asia and the energy surplus central Asia.

Cheap and reliable electricity plays a key role in the country's industrialization. It improves the economy, employment, welfare, and the living condition of communities. Sadly, despite having abundant energy resources, only 30–38% of households have access to electricity. Nevertheless, the electricity is currently among the basic needs of humans. Several industries have been closed due to unavailability of electricity (Glasse, 2013; Watson, 2011). This added on unemployment, poverty and further nurtured the

instability. Afghanistan indigenous resources have remained untapped and very little focus has been given to internal electricity production. The government from last 14 years has mainly focused on import

power from neighboring countries. And currently around 80% of Afghanistan electrical energy comes from import resources (ADB, 2015). This has caused a heavy economic burden on Afghan society and economy. Furthermore, almost every year the electricity tariffs

have been progressively increased. Furthermore, trans-boundary water management remained as a major challenge for Afghanistan energy and agriculture sectors. Afghanistan is sharing four major rivers with neighbors which have huge hydropower generation capacity (23,000 MW) but due to lack of regionally cooperative water usage frameworks for transboundary water management the utilization of

this energy potential has remained hugely untapped. It seems that there is a gap between the true realization of Afghanistan energy potential and the current policy making in the sector. The constant investment on import power has been questioned by many experts.

Energy socio economic impacts on Afghanistan:

Electrical energy is the backbone of socio-economic growth. Electricity plays an essential role in an economy, for both consumption and production of services and goods. Electricity is important for scientific and technological developments which are vital motives for the improvement of living standards across the globe (Apergis and Payne, 2011). Electricity infrastructures have emerged as key prospects in the growth of Afghanistan as industrialization and economy are closely linked with energy access (Bochkarev, 2014). The global demand for electricity is increasing driven by immense growth of population, countries industrialization, widespread urbanization, and living standards improvement

incentives (Yoo and Lee, 2010). Shoaib and Ariaratnam (2016) have studied social and economic impacts of Community centered Renewable Energy (CRE) schemes on Afghanistan communities and towns. The study has found that CRE projects had positive social impact and were able to provide sustainable energy to the rural communities. While they had modest impacts on economic growth as these projects had limitation in terms of magnitude, job creation and businesses improvement. Yoo and Lee (2010) have linked electricity with the improvement of living condition, economic growth, and poverty eradication. Energy has become one of the main need of life and a strong foundation of modern economy. In addition, Sadiqi et al. (2012) analyzed hybrid stand-alone power system for Afghanistan rural areas. The study has found that renewable energy (micro-hydropower, wind, and solar) based hybrid stand-alone power systems are highly cost effective and appropriate for rural areas than diesel power generation in Afghanistan. The study encouraged investment in rural communities and suggested that a combination of solar, wind and micro-hydropower will provide investment suitability and return.

Afghanistan is a mountainous country and most rural communities are inhibited along different rivers flows with having wind and solar potential so to utilize all these three energy sources a hybrid standalone power system can be a reliable and profitable solution for rural community's electrification (Sadiqi et al., 2012). Some researches insist on Afghanistan indigenous energy production (Bochkarev, 2014; Harsch and Smith, 2012) as the country possesses renewable and hydrocarbon energy resources which can be supported by import energy from energy rich countries located at Afghanistan neighborhoods
(Turkmenistan, Tajikistan and etc.). They recommended the development of holistic energy policies both on national and regional level for the transformation of Afghan energy sector and to facilitate regional energy transit plans. Furthermore and Rogers (2010) have linked the security of the countries with the security of natural resources in the 21 century. The developing countries, local communities and global economy rely to a huge extent on the availability of energy, potable water, minerals, arable land and other resources both renewable and nonrenewable to meet the demand of population growth in the world. Yet these resources availability is facing complications. Meanwhile, Apergis and Payne (2011) examined the causal relation between economic progress and electricity consumption for 88 countries under four World Bank income classification index (high income, upper middle income, low income and lower middle income) in 1990 to 2006 period. The result shows unidirectional causality in low income

countries (which includes Afghanistan) between the consumption of electricity and economic growth. This suggests that it is likely that energy preservation policies which decrease electricity consumption might have an adversative influence on economic growth. Halkos and Tzeremes (2014) analyzed the connection between Gross Domestic Product (GDP) levels and electrical energy consumption from renewable energy resources in 36 countries. The finding revealed a direct connection between renewable energy consumption and GDP improvement for most of the countries.

Meanwhile for developing economies the relationship was nonlinear, in some countries it tends toward ''M'' shape. This is because of the instable market the industries are in. While, the continuity of energy availability will most likely make the GDP progress smoother. places. Keating (2015) mentioned that resolving the conflicts over resource needs the understanding of wide collection of skills which include:

- Knowledge of resource governance and natural resources
- Understanding of political economy and local history
- Understanding of precedents
- State role awareness
- Ability to build trust
- Complex process management

Energy details

As a consequence of more than two decades of war and insurgency, Afghanistan's energy sector is struggling with technical, fiscal and governance deficits. The country continues to face energy insecurity due to sub-optimal development and management of its vast available resources. The sector remains institutionally fragemented and centralized, and lacks interated energy planning to address the country's short, medium and long term energy needs. Afghanistan's per capita energy consumption is dismally low at less than 1 million btu/ capita compared to Pakistan's 12, India's 14, China's 35, Indonesia's 22 and the US's 340 btu/ capita(btu=British thermal unit and is a measure of energy consumption). The government's abilitiy to prepare marked oriented strategic approaches that could optimize indigenous and other electricity and energy resources is constrained. Limited attention has been given to addressing commercial aspects of attracting private investment in the sector so greater emphasize has to be put on developing a strategy for private sector participation; the Govermnet needs to provide coordinated leadership and requires donor assistance in this regard.

In order to asses the power generation situation the current available information and the future development plans were assessed. Based on the available information is can be said that efforts as made to develop the generation capacity within the country and also to have imports from the nerighboring countries. Though the situation of energy secutiry needs to be addressed but given the situation on the ground this is as realistic as it can get.

In terms of hydro power the key source that contribute to the power supply of Kabul is the Naghlu, Mahipur and Surobi. Naghlu has four 25 MW units. One unit in Naghlu is under rehabilitation while the rest are available for generation. Surobi power plant has been refurbished recently that with two 11 MW units. The Mahipur Plant has three 22 MW units and wa currently refurbished providing full capacity.

In addition to above power plants two new power plants are proposed in vicinity of Kabul region. One of the plants namely Surubi II is on the Kabul river and has a proposed capacity of 180 MW. The other plant namely Baghdara with a capacity of 280 MW is proposed to be constructed on Panjshir River. Surobi II is a run of river plant, while Baghdara is a seasonal reservoir storage power plant. These two plants according to previous studies by consultants appear to be technically feasible. Some of the information available also suggests that two other Hydro plants, Kajakil of 52 MW and Salma of 44 MW are also planned to be commissioned soon. However, the status regarding the implementation of these plants is not clear.

As regards to thermal power plants, the Kabul North West Thermal Power Plant contributes to the supply of power to the Kabul region. Its installed capacity is about 58 MW. However, according to the current available information only units 3 and 4 are available so significantly curtailing its generation capacity. Also, a 104 MW diesel power plant has been commissioned recently.

One of key other projects under consideration is the 400 MW Aynak Thermal coal-fired power plant. Out of 400 MW, it is envisaged that 200 MW would be supplied to power grid, while rest of the power would be utilized for the copper mine, starting in 2014-15.

Small quantities of gas reserves have been reported in the Sheberghan area sufficient for a 100 MW plant. The plant has been planned and would be used to provide for the needs of northern areas. Below table summerises the energy scene in the country from 2006 till 2011.

Yeay	2006	2007	2008	2009	2010	2011
Hydro [GWh}	644	755	617	835	910	801
Thermal[GWh]	213	211	197	93	101	39
Imports[GWh]	432	609	752	1155	1572	2246
Total[GWh]	1289	1575	1566	2083	2583	3086

Brief of power imports from the many countries has been given and also a mention of the power purchase agreements has also been put forward. Below is detailed accounts of each category of energy and the other factors pertaining there in to.

Hydro power

Hydro power is the most reliable and cheapest energy source known to mankind. Afghanistan has historically been investing on many energy plants in locations where potential for such works existed.

It should be noted that some of the projects identified for hydropower generation will be located on a trans-boundary river system and, if constructed, will affect water resources in downstream neighboring countries. In the course of developing an inventory of the water resources of the country in general, the Government is also in the process of cataloguing its trans-boundary water resources. This inventory will help in the design of appropriate water usage mechanisms within the country, but also with the neighboring countries that share some of the water resources. It will facilitate coordination and negotiation of transboundary water resources utilization, the joint construction of dams for hydropower and irrigation purposes, and also implementation of measures for conservation of the water resources in a manner that will benefit all participating states. Water resources shall be shared in a sustainable and equitable manner so that all can benefit without any stakeholder facing shortcomings. Afghanistan participates in regional discussions on trans-boundary water issues, and is committed to follow international regulations and best practices on water resources development and utilization in trans-boundary rivers. However, for the bigscale hydropower projects to be implemented there would be a need for intensified and closer coordination and negotiation of trans-boundary water resources issues.

Overall situation

Local generation in Afghanistan is dominated by hydro power plants. The following is all about the existing plants in the country.

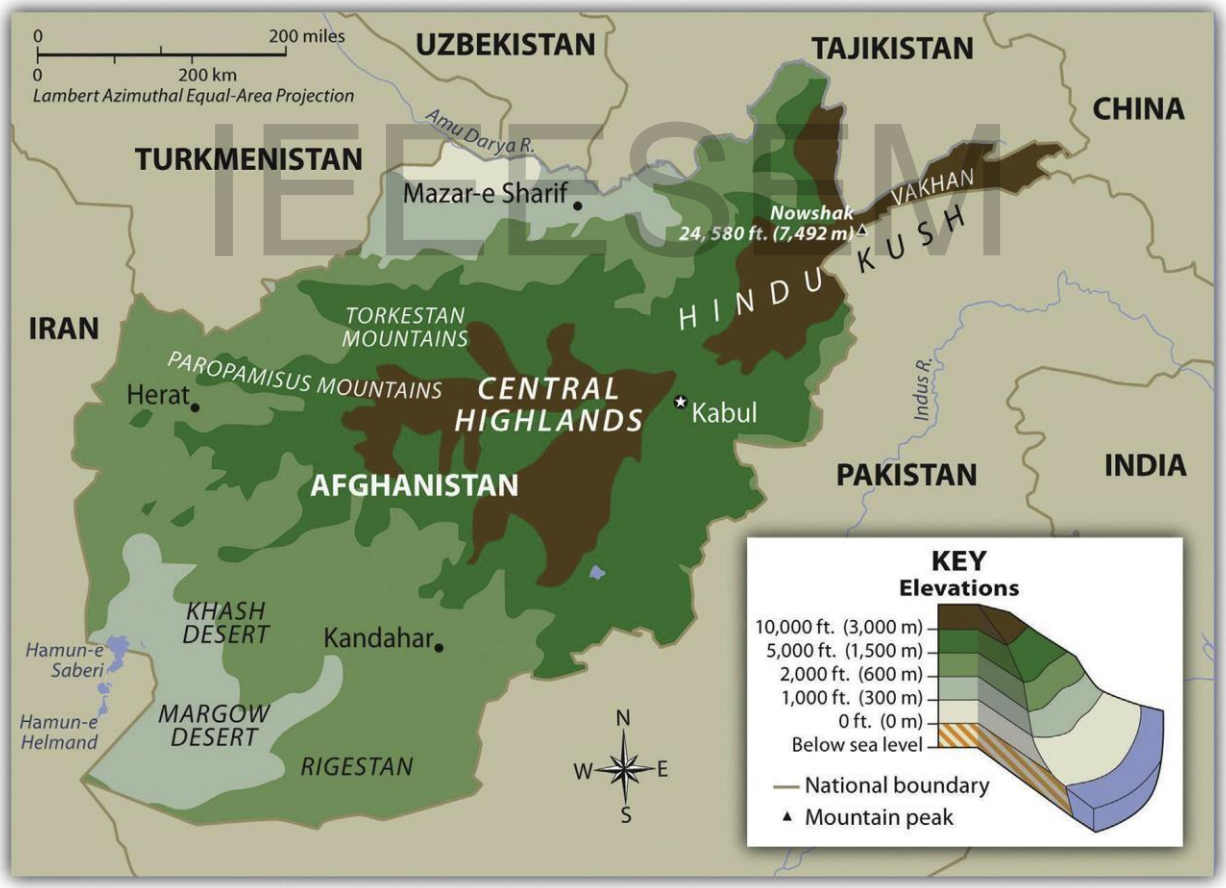
Naghlu HPP: is located on the Kabul river in the eastern region of Afghanistan. It was commissioned in 1967. The equipment is Russian. It has a reservoir dammed up by a concrete gravity wall. Due to the small reservoir capacity and high inflow, reservoir operation is limited, so operation is comparable with run of the river plants. The head is 64 m and installed capacity is 4x25 MW.

Sarobi HPP: Sarobi Hydropower Plant is located on the Kabul River in the eastern region of Afghanistan. It was commissioned in 1957. The original equipment is German. It is operated as a run of river plant. The installed capacity is 2x11 MW.

All units were rehabilitated recently taking into account that the lifetime of the electromechanical equipment is estimated to be about 25 years and costs for rehabilitation are approximately 30% of the construction costs of a new plant, rehabilitation costs will be approximately 25 million US$ based on construction costs of 84 million. The start of next rehabilitation is assumed to be in 2032.

Mahipar HPP: Mahipar Hydro power Plant is located on the Kabul River in the easterne region of Afghanistan. It was commissioned in 1967. It is operated as a run of river plant. The installed capacity is 3x22 MW.

All units were rehabilitated recently. Considering lifetime of the electro-mechanical equipment to be about 25 years and the costs for rehabilitation to be around 30% of the construction consts of a new plant, so rehabilitation costs will be approximately 80 million US dollars, based on construction cost of about 260 million US $. Next rehabilitation is planned for 2032.



Darunta HPP: Darunta Hydro power plant is located on the Kabul River in the eastern region of Afghanistan. It was commissioned in 1964. The installed capacity is 3x3.85 MW.

It is expected that all units will be rehabilitated by autumn 2012. The lifetime of the electro mechanical equipment is estimated to be 25 years. Rehabilitation may cost 14 million USD and is planned for 2035.

Assadabad HPP: This HPP is located on the Kunar River in the eastern region of Afghanistan. It was commissioned in 1983. The original instlled capacity is 2x0.35MW.

Charikar HPP: Charikar Hydropower plant is located on Ghorband river in the northern region of Afghanistan. It was commissioned in 1973. The original installed capacity is 3x0.8 MW.

Jabul HPP: Jabul Hydro power plant is located on the salang river in the northern region of Afghanistan. It was commissioned in 1920. The original installed capacity is 2x0.5+2x0.7 MW. (2 turbines of 0.5 MW capacity and 2 turbines of 0.7 MW capacity)

Ghorband HPP: Ghorband Hydropower plant is located on the Ghorband river in the northern region of Afghanistan. It was commissioned in 1975. The original installed capacity is 3x0.1 MW.

Kajaki I and III HPP: Kajaki HPPs are located on the Helmand River in the southern region of Afghansitan it was commissioned in 1975. The original equipment is American and the installed capacity is 2x16.5 MW. All units were rehabilitated recently.

Grishk HPP: Grishk HPP is located on the Helmand River in the southern region of Afghanistan. It was commissioned in 1957. The original installed capacity is 2x1.2 MW.

Pul-e-Chumri I & II HPP: These are located on the Kunduz River in the northern region of Afghanistan. It was commissioned in 1962. The original equipment is Russian. The installed capacity is 3x1.6+ 3x3.5 MW. Plants need rehabilitation.

Plans:

For the plan a list of most worthwhile projects is drawn in this conclusion. Effort was made to obtain the individual feasibility study for each of the projects but due to certain issues it was not possible. The following is based on the available resources and the best knowledge of the author.

No	Projects	River	Province	Capacity [MW]	Comm. Date	Annual Energy [GWh]	Est. Cost[$m}
1	Baghdara	Pajshir	Kapisa/Parwan	210	2021	968	600
2	Susrobi 2	Kabul	Lghman	180	2021	891	700
3	Kunar A	Kunar	Kunar	789	2022	4772	2000
4	Kajaki	Helmand	Helmand	100	2021	493	300
5	Kukcha	Kukcha	Badakhshan	445	2022	2238	1400
6	Gulbahar	Panjshir	Panjshir	120	2021	594	500
7	Capar	Pankshir	Panjshir	116	2021	574	450
8	Kama	Kunar	Nangrahar	45	2021	223	180
9	Kama B	Kunar	Kunar	300	2021	1485	600
10	Kajaki Extension	Helmand	Helmand	18.5	2015	91	90
11	Olambagh	Helmand	Uruzgan	90	2021	444	400
12	Kilagai		Baghlan	60	2021	297	250
13	Salma	Hari rud	Heart	40	2020	197	200
14	Upper Amu	Amu Daria		1000	2023	4955	25000
15	Dashtijum	Pyanj		4000	2023	19819	8000

Baghdara HPP: The project is located on the Panjshir River east of Baghdara village northeast of Kabul. The source of this river is the vicinity of Anjuman pass in the north eastern part of the country. The river first flows southwest before joining ghorband river and turning east where it enters a large cultivated flood plain. Then it eneters a long gorge, turns south and finally discharges into the Naghlu reservoir.

The project's potential reservoir and its associated structures are located along gorge of Panjshir river. The installed capacity is 210 MW and the average annual energy production is 967 GWh.

Surobi 2 HPP: this project is located downstream of the Surobi 1 HPP, so uses its discharge. The plan is with an installed capacity of 180 MW and average annual energy production of 890 GWh, is at an elevation of 970 meters above sea level and discharges through an 18.9 km tunnel to a tailrace at 770 Meteres above sea level.

Baghdara HPP is also located upstream of the Surobi 2 project and has a reservoir of 800Million Meter cubes capacity, so the Baghdara reservoir will influence operation of Surobi 2 HPP. In the Master plan it was suggested that a further feasibility, environmental impact studies and socio economic studies be conducted just to be on the safer side.

Kunar A Hydropower Plant: The Kunar A hydropower project is located on the Kunar River about 7 KM of Asmar and has a regulation reservoir with an active storage capacity of 1.0 million meter cubes. The dam is earth fill construction and the length of the diversion tunnel is 1050 M.

With regard to capacity, it was found that there are some inconsistencies, the power sector master plan estimates the capacity at 368 MW while in other documents it is estimated at 789 MW.

For the main investment opportunities in Afghanistan, it was stated that the hydro power potential of the Kunar River basin is 300 MW in the first stage and 900 MW in the second stage. The total cost of the project is about US$ 1.8 billion. IF this project finds financing it will take an estimated 5 years to complete and all provinces of Afghanistan will benefit, not just Kunar. The feasibility study for this project was already completed in 2008.

Kajaki Addition 2 Hydro power plant: This project has a regulation resereoir with a storage capacity of 1.7 m M3. The dam is of the rockfill type and was constructed in 1952 for irrigation purposes. The dam height is 98 m. the project aims to increase the active storage capacity from 1.7 to 2.7 million meter cubes. The project also proposes installation of a second power house to generate 100 MW. The annual energy production rate is 492 GWh.

The dam is over 60 years old, so the reservoir capacity must have been reduced due to sedimentation, so it is advisable to know its current capacity.

Kukcha HPP: Along the Kukcha River in the north-east provinces of Badakhshan and Takhar, a potential of over 1500 MW of hydro power is expected but studies and further information are available only for small power plants. The power plant mentioned in the Ministry of energy documents with an installed capacity of 445 MW could not be verified against other sources. However it is assumed that the potential along Kukcha River could be developed to this level and preparation of a feasibility study for the 445 MW power plant is required. Regarding annual average energy production, 2238 GWh could be expected for the 445 MW power plant along the Kukcha.

Gulbahar HPP: The Hydro power plant is located on the panjshir River approximately 1.5 Km upstream of Gulbahar city. It has a regulation reservoir with a capacity of 0.76 million Meter cubes with multi purpose water use for irrigation and electricity generation. The capacity of the plan is estimated to be

120 MW with an annual energy production of 593 GWh. Further feasibility studies are proposed for this plant.

Capar HPP : This plant is located on the panjshir river, down stream of Baghdara HPP, utilizing the head between the tail waters of baghdara and the head pond of Naghlu reservoir. The installed capacity is 116 MW with an average annual energy production of 574 GWh. Further feasibility studies are recommended for this project as Baghdara reservoir is used for seasonal regulations and it influences Capar HPP.

Kama HPP: This project is located on the Kunar River immedicately upstream of its confluence with Kabul River. The Kama dam has a regulation reservoir for multipurpose water use for irrigation and power generation.

The installed capacity is 45 MW, with three units the average annual energy production is 222GWh. Multi purpose reservoir operation should be investigated in the feasibility study as the water is being used both for power generation and irrigation purposes.

Kunar B HPP: This project is located on the Kunar River about 22 Km upstream of Asmar. IT has a regulation reservoir with a storage capacity of 7.0 Million Meter Cubes and 105 M high earth fill dam. There are some inconsistencies in regards to the amount of power generated some put it as 165 MW and others as 300 MW.

Kajaki Extension Hydropower plant: The Kajaki dam and hydropower plant is located on the Helmand River, 95 Km northwest of Kandahar city. The dam was completed in 1952 and was built for irrigation purposes. The first stage of the Hydro power component was completed in 1975 with installation of 2x16.5 MW with provision made for a third unit of 18.5 MW at a later stage.

The new installed capacity is 45 MW with an average annual energy production of 91 GWh.

Olambagh HPP: The project is located on the Helmand River in Kandahar Province near Olambagh village, whish is about 75 km Upstream of Kajaki. The project location is upstream of the Kajaki Hydropower project.

The project has a reservoir with an active storage capacity of 1.194 million meter cubes. It has a rockfill dam with a height of 38 m. The installed capacity is 90 MW and the average annual energy production is 443 GWh.

Kilagai HPP: Kilagai HPP is an irrigation and power supply project. Its cost is about US$ 350m and it benefits people in BAghlan province. The feasibility study has already been completed. The project will have an energy supply capacity of 60 MW.

Salma HPP: The salma project site is located on the Hari Rod River in Heart province. The salma project was planned to provide irrigation benefits in the Hari Rod basin. Once completed the Hydropower plant would generate 40MW in addition to providing irrigation for 75000Ha of farmland. Average annual energy generation is 197 GWh.

Upper Amu HPP: This project is located on the transboundry pyanj River. The project has an installed capacity of 1000M and annual energy production rate of 4954 GWh. The estimated cost of the project is US$ 3 billion.

Dashtijum HPP: The Dashtijum HPP is located on the pyanj River at a distance of around 280 KM south east of the Tajik Capital. The River forms the border. The project layout envisages a large rockfill dam with short connecting tunnelrs through the right rock flanks of the mountains to the surface power house. The project is of a capacity of 4000 MW.

Economic aspects

The major advantage of the Hydropower is that there is no underlying cost of fuel and for plants larger than 10 MW the cost of hydro power is 3-5 US cents. Of course as the plant size increases the cost of the plant also reduces there by reducing the per KW price. Plus after the sale of electricity has paid for the construction of the dams and the plant, it is free energy from that point onwards.

If compared to thermally generated energy there is not doubt that HPP will be the cheapest and most favorable. With this said, Hydropower has the advantage of many aspects. One can be that it provides infrastructural support for the agricultural settings which is the driving force behind any country's economic growth and as per the list of the new proposed power plants, almost all have such provisions to provide for the irrigation of many thousands of Hectares of land.

From the import point of view, power imported costs 7.5 cents from Uzbekistan 3 cents from Turkmenistan 2 cents for KWh from Tajikstan and 3 cents from Iran. This has been almost the least prices that could be negotiated and when we say this and evaluate we might come to point where to say that these are a bit cheaper than the above estimated cost for locally generated energy. But to say, the power imported are no firm energies with PPA's having a deadline and an estimated date of expiry. For example the CASA 1000 Project proposes that the rate of export of Tajikistan is 1.5 c per KWh this is for the reason that this is surplus energy and it is not firm and seasonally not needed in the host country while the potential for use of the same exists in Pakistan so why not sell it off. The basic economic concept of demand and supply is applied and so we get the pricing tags that we have now. For instance, if Afghan Hydro power projects are developed ,by 2030, we would have a surplus of more than 7000 MW to be exported to other regions and be a supplier of energy rather than an importer and in doing so earn greater potential for the economic prosperity of the country.

Pro and Cons

There are many factors associated to the energy and to hydropower and in case of Afghanistan the question of security arises without doubt. From the experience of author working with Ministry of energy and Ministry of finance I can say that plans when put forward never gets proper nods from all stakeholders. For the years 2013 and 2012 the yearly plan of ministry of energy were drafter by the author and came to almost 50% reduction by ministry of finance due to funding gaps.

This is a very realistic way of evaluating the situation. For many consultants find it hard to work in volatile areas due to security concerns and the allocated resources are carried forward year after year with no luck of the resources ever being committed. This comes with another side of the bargain that at times many of the projects were abandoned and staff at ministry of energy and ministry of finance were left crippled as how to solve the situation.

To say the least, the plans for projects put forward are the most realistic of them all and hoping that there are resources to invest in them and above all there are consultants who will without doubt commit to working in harsh environments, there is a glimmer of hope these plans will be enacted. Solar Energy

Besides wind, electricity generation using solar systems is most promising renewable energy source in Afghanistan.

Overall situation

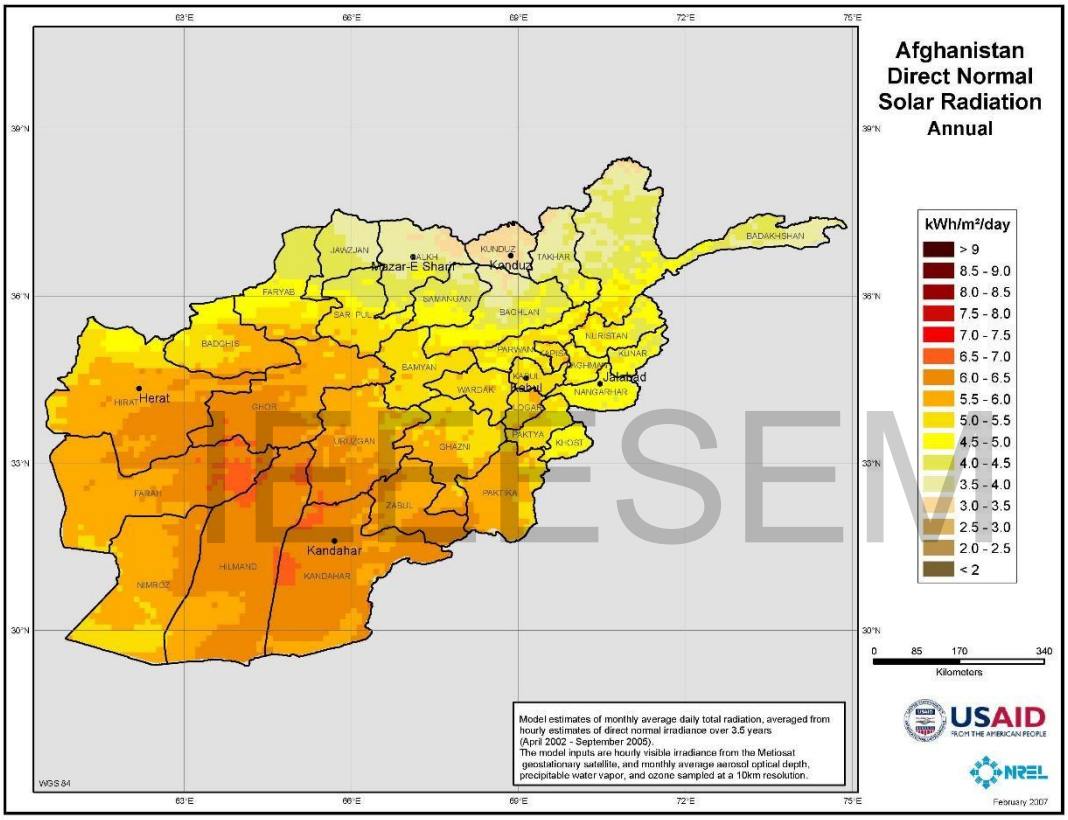
The country, in most parts enjoys 12 months of sunshine and so has the potential to be used to generate surplus of solar energy. Currently apart from very certain locations that utlise solar panels to power households, grid level solar energy extraction is non existent. A reference of 6 MW of solar energy was made in the preamble part of the paper. It is believed that is from the estimation of the many decentralized system in existence and is sourced to the database at Ministry of Energy and water. Although the Ministry claims the under usage capacity is almost double, 6 MW is still taken as the overall capacity.

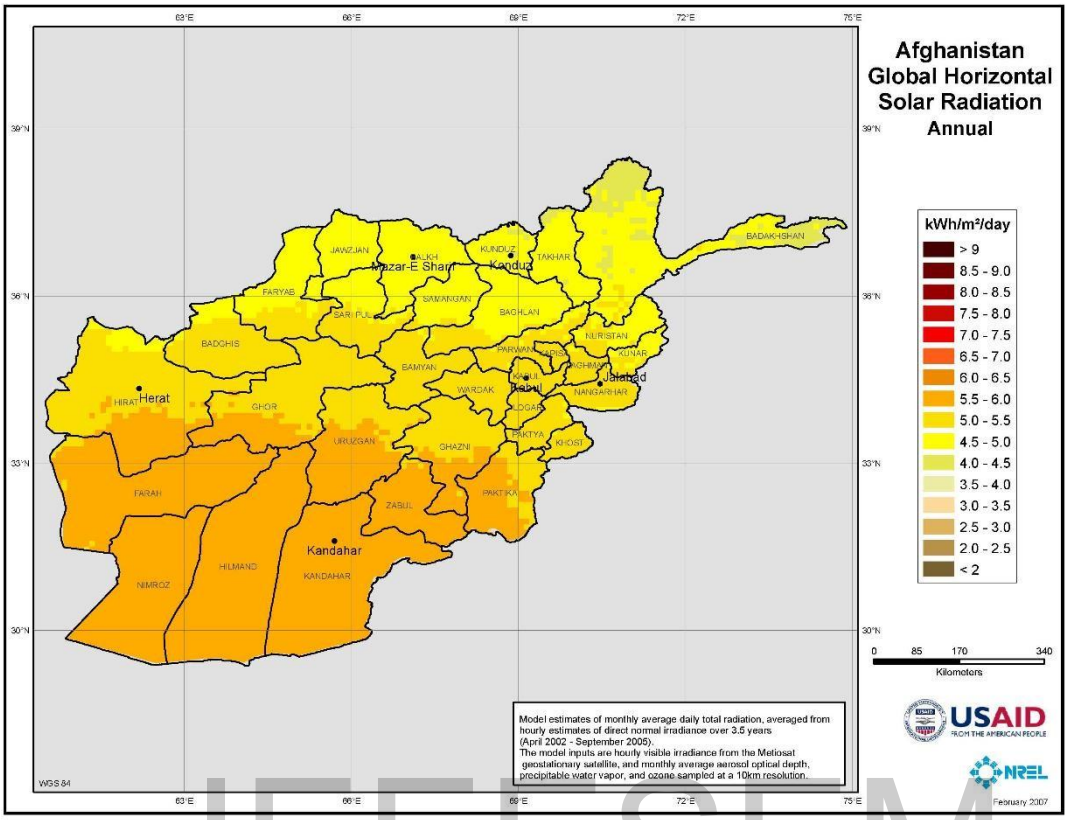
To elaborate on that, the rural energy scene has been picking up with many stockholders involved. Starting with flagship programs of the Ministry of Rural Rehabilitation and development that would hand over solar panels to locals in remote areas in provinces. Solar panels seemed the only feasible and maintainable source of energy generation to many. An estimation of how much of the population use solar panels as the only source of energy generation is not known but a realistic account would be that many use them. And this can be taken from how the solar panel market has been booming.

Apart from the use with decentralized systems there has been a number of grid level solar installations in the country. One such system is in the Bamyan province that was completed by New Zealand PRT and the capacity of which was not made available at time of writing. But to mention the least, there are such disaggregated small locations in existence that only provide for lightning purposes due to their limited capacity. One reason to this is that the technology required to make available the commercial scale power to costumers, and also the cost of such installations.

It was also proposed that the Government should work to support the provisions of locally manufactured photo voltaic so as to reduce the costs for installations of such systems in the country. But due to limitation on the technical side, that was not even a remote possibility. To make it simple, the potential of solar power exists throut the country and given such circumstances, cost of panels put forward the only limitation that hinders implementation of such systems.

In the figures provided in the next page, the annual amount of solar radiation that hits the ground surface in Afghanistan is given. From the data it could be concluded that immense potential exists for solar energy especially in southern provinces but installing such systems to provide for commercial electricity would be a technologically advanced step taken and it should be done from the renewable energy department within ministry of energy.





Plans

There doesn't exist a master plan that envisages the amount of Solar energy that is being produced or what are in the pipeline for production. Realistic estimation put it to be a secondary as there exist great potential of Hydro power and since funding for that is not available the much costly Solar Energy plans are always taken with less importance.

According to the renewable energy department much work is planned and since shortcoming in funding is there the plans cannot come into action.

Work on decentralized systems, on the other hand, is being carried out by many organizations that seek to work towards rural electrification where there is no possibility of transmission through the national grid. In such locations Small Solar systems are installed and they too provide for the lighting purposes and further usage with such a capacity is not warranted.

The Master plan puts forward 10 smaller decentralized solar power plants likely located in remote areas which can only be connected to a national grid with huge and impractical financial investment.

In light to carry on coherent work the MoEW renewable energy department has been focusing on grid level plans and as mentioned earlier these too are sidelined due to funding issues.

Economic aspects

Afghanistan is currently lagging behind in terms of technology so as to be able to implement these technologies to gird level installations. If in the near future the Government wishes to take full advantage of the solar potential in the country they would in the first place look for a very high procurement and installation cost. Given the life time of the solar equipment currently available in the market and the limited capacity of Afghan users who are willing to pay only a limited amount for the Per KWh energy they consume; solar energy would be unfeasible when compared to Imported Energy or Hydro power.

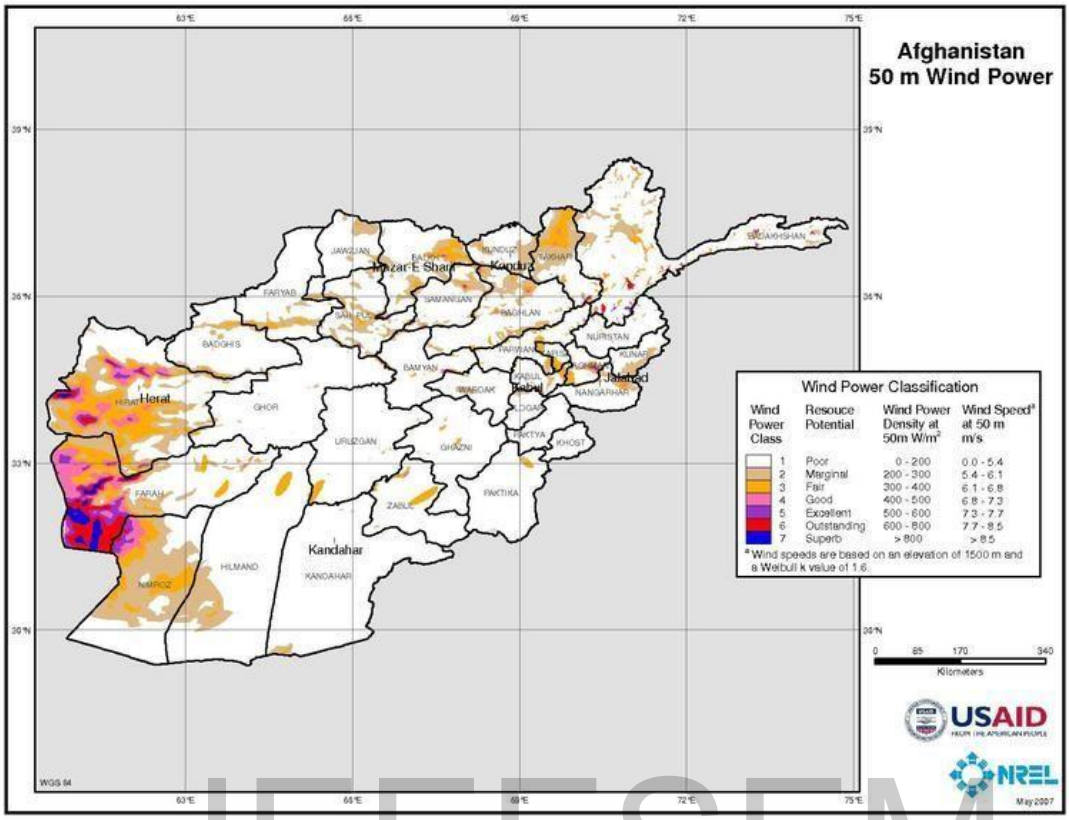
For large scale plants and if they are connected to grid the per KWh cost of Energy generated through solar could be taken at $ 15 cents. This is the estimate if a state of the art methodology is used and panels are acquired through reasonable means. In comparison to 3-5 $ cents per KWh of Hydro power and imports it sure is hefty but it has the advantage of security. Plus the energy from solar panels are not going to exhaust. So these two points are what gives the solar energy the edge.

Pro and Cons

Much of the pro and cons of solar energy was explicitly explained in the paragraphs above. Technological needs, cost, feasibility in comparison to hydro power and imports as well the funding issues and costs were detailed. The only addition that can be made here would be that Solar energy is free, available under all conditions is renewable and only the panels cost.

Wind Energy

Wind is one of the most abundant forces on this planet, many factors goes into producing it but for now all we need to know is that the dense colored areas in the map shown below actually has the potential to be used as wind energy production hubs.



Current Situation

A brief about the wind energy situation in the country is given in the preamble part of the paper. As portrayed in the map above the locations in western Afghanistan having a wind speed of more than 6.5 M/s can be utilized for such operation. The Energy sector master plan states that currently there isn't any wind turbine in operation but small scale systems in Panjshir province has been used. The capacity of those are not known. Although if utilized the wind farms may have enormous potential, the energy form has been untouched due to the funding and technological constraints.

Future Plans

There are plans for implementation of wind energy in conjunction of solar plants in remote areas to provided for lightening and agricultural purposes but due to the technological limitation and the costs associated it has not been taken into serious consideration. The data in the energy sector master plan shows work towards five wind parks with a capacity of 8 MW each that could power remote areas that are disconnected from the national grid. The data is based on wind parks consisting 10 Enercon E48 wind turbines with a rated power of 800KW each.

Decentralized units with comparable small capacities can be applied to existing diesel generation assets to substitute diesel. These hybrid solutions are promising options to supply electricity for rural electrification or for small grids.

Economic Aspects

Hefty financial investment is the major reason why these systems could never be installed in Afghanistan. One further drawback to solar energy, the energy generation is not continuous which requires that it either be connected to some stable source to make it possible to provide for steady state energy generation. Small scale decentralized systems are in plans and future use of this technologies will only be possible if the investment return is positive and these actually are applicable in the domain in question.

Pro and cons

Although not much can be said different about wind energy compared to solar, it still remains to be a technologically advanced form of energy. In saying so it could be accepted that the costs for wind energy is one of the main barriers to its implementation. There exists a vast untapped potential in western parts of Afghanistan and if explored could produce thousands of MW of free electricity but this will remain a dream in the neat future as grid level energy generation is in pilot phase and any future use can be determined from the success inferred from these implementations.

Thermal Energy

In current situation of Afghanistan and given that Afghanistan has good sources of hydrocarbons and that many areas are located far from reach of national grid, thermal energy remains the only reliable option. During the years of the war thermal energy was the only source known to many in the country. 2001 onwards the the country saw a sudden increase in use for thermally generated electricity and in many parts of the country in remained so and is still that way. Examples of such locations were given in the introduction part of the paper.

Under the current heading a situational analysis of how much known energy is being generated from Thermal sources, include an analysis of its economics, plans for future and brief about the positive and negative aspects of such.

Current Situation

Although the amount of thermal generated energy could be acuurately measured due to the decentralized use, the major systems in operation will be detailed in this section. The table below will elaborate on such a standing:

Site	Type	Capacity MW	Grid Segment
NW Kabul GT#	Turbine	21.8	Kabul
NW Kabul	Turbine	23.0	Kabul
Tarakhel	Engine	105.0	Kabul
Nangrahar	Engine	2.7	Kabul
Aybak	Engine	1.8	Off grid
Taleqan	Engine	1.4	Off grid
Ghazni	Engine	1.7	Off grid
Kandahar KTA50	Engine	11.9	Kandahar
Kandahar ~ exp	Engine	12.0	Kandahar
Kandahar Qsk60	Engine	8.8	Kandahar

Kandahar USACE	Engine	20.0	Kandahar
Khost	Engine	1.1	Off grid
Helmand	Engine	3.8	Kandahar
Musa qala	Engine	.9	Off grid
Paktiya	Engine	1.8	Off grid
Qalat	Engine	2.6	Off grid
Trin kot	Engine	0.9	Off grid.

All the existing thermal power plants are fired by imported diesel fuel. Nearly all comes from reciprocating engines with exception of Kabul NE power plant, which consists of two diesel fired gas turbines. The main dis advantage of thee systems is the cost for fuel that has to be imported at international prices.

Future Plans

To obtain affordable thermal power Afghanistan has to exploit potential of natural gas, coal and oil.

The sheberghan gas field provides opportunity to supply fuel for a power plant but a 200 MW gas fired power plant cannot be installed at the present rate of gas production. New well has to be drilled. Although there is enough gas discovered and un discovered in northern Part of the county, the wells to extract this gas has not yet been installed.

There is potential for developing gas fields and produce electricity from gas for heart as well. However, this potential and the feasibility of recovery of gas at an economic cost would have to be geologically verified.

On another note, there exists some 73 million tons of coal reserves in the country which also could be used for many of the coal fired energy generation. There are two interesting locations for such operation namely the AYNAK and HAJI GAK. The proposed capacity for AYNAK is 400 MW of which half will be fed into the grid and rest will be utilized the mine by the contracting company. HAJI GAK has been planned

for a capacity of 800 MW and this also will feed same amount of electricity to the grid as Aynak power plant.

Further, small diesel power plants, comprising gensets ranging from 50 KW to a few MW, have the advantage of straightforward operation and easy maintenance but need diesel fuel, which must be imported to Afghanistan from IRAN, the Central Asian Republics or Pakistan at international market prices. Given the fuel efficiency of genset is 35% the resulting electricity price is 40$/ MWh considering the cost of the fuel only. Peak power and emergency power could be further uses of expensive diesel generated power.

Economic Aspects

When there is question of economic applicability of thermal energy, it has come up to be costly in comparison to hydro power. As mentioned that the fuel used in many of the thermal plants are imported, the government has to pay hefty prices which cannot be re deemed from customers; causing a deficit in functioning. Since this is enough of a cause that limits the use of thermal energy, in areas where there is no possibility of any other form electricity; thermal electricity has been welcomed. This has only provided solutions to the ones that can afford such a luxury.

Further, it has been proposed by many of the geological surveys that there is locked potential for use of thermal energy on a commercialized scale. The locations were proposed in the previous sections and if they are explored, for the time of operation of the plants it could be a viable option for energy generation. At least it could help propel the energy market in localities those plants are installed and given the scale as well that the fuel is indigenous it can provide for competitive and affordable energy option.

Exploration of the tapped resources will take time and given the security situation large scale work is seen as a remote possibility which given the costs associated will even further put back the planned energy generation from the thermal sources.

Pro and Cons

From the above analysis it is easily concluded that Thermal power has its own usages and at times it is unavoidable. To say the least, usage of fuels to generate electricity to replace other forms if available is technically and economically unfeasible. Costs play a major role in make above statement much plausible and since at locations there is no other possibility one has to opt for thermal power.

The pros of Thermal power seem to be much reliant of easy availibity of fuel and other equipment needed. Not much of technological needs are associated with it and more on energy generated is reliable unlike some renewable technologies.

It is also worth putting here that initial investment needed is also much lower compared to other forms of energy and small scale generator sets are widely available.

Larger scale thermal plants have the positive aspect of the fuel being available in ample quantities and those sites has been discussed with detail in previous sections. If the government wishes to utilize these locations for energy generation the energy will be cheaper and could provide for the remote grid islands for which possibility of extension from hydro power is not yet an option. This will add value to the sector's cohesiveness and at the same time give a cost leadership when considering energy imports as a substitute.

Elaborating on the negative aspects of the power plants, it is always evident that it is a non renewable source and in terms of energy conservation resources are wasted on electricity generation while they could be used for other means. But given the situation at hand use of the above mentioned thermal sources is the only option as there are no immediate greener uses planned for it.

Environment will always be a concern when use of thermal energy is the topic. This will be a very significant aspect if Afghanistan was to follow a green trend but for th time being since the focus is more on providing energy for lighting purposes the author of this paper sees it justified to pave the way ahead for thermal power

Conclusion:

Given that in the future Earth will be dominated with an increase in population, it is therefore suggested that the next generation of Energy solutions should be opted when the above all options has been utilized. By means of the above option one can deduce that there exists sufficient technological support on the ground to absorb all the renewable options to its maximum capacity.

Given the author's vision to entertain Afghanistan as an Energy Transit hub, it is therefore suggested that nuclear options be considered in effect of immediately.

Although the author cannot recommend an operational system due to ethical issues, the author will strive to either implement one of the latest reactor designs implemented in the US, India, and France or

come up with an some new design that can be intellectual property of the institution under whose auspices it is developed and will be for sole use in Afghanistan.

On sidelines of the Nuclear option, Geothermal Energy can be utilized where the perquisites exist. The author while working with ERDA has proposed ample programmed plans that can be used for Wind, Solar and Geothermal Energy.

Energy being the sole driver of economy in any country, it is suggested that the implementation of the technologies be fast tracked so as to mitigate the problems associated with the economic lag. And in due course it is humbly requested from the international community to put ample resources in place so as this paper can be implemented in a fast forward basis.