Case Study of Electrical Energy Requirement for Various Needs in a Desert Dwelling

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ABSTRACT

A case study of electrical energy requirement for various needs in a desert dwelling is carried out in order to explore an indigenous self-sustained electrical power generation process, which can provide means to produce electrical power, potable water and agricultural production. The objective of such study is to develop a self-sustainable and self-contained electrical energy system that can cater for energy needs for the people living in such remote areas. The study is carried out on a micro level but these results are stretchable to macro levels to accommodate a possible increase in the scale of energy consumption in the long run.

Key Words: **Needs Analysis, Self-Sustained Electrical Energy Supply System, Sustainable Development.**

1. INTRODUCTION

Energy is considered a prerequisite for the production of finished products such as food, potable water and electrical power. Therefore, necessary amount of energy should be provided to all the people living in all types of areas equally, especially in the isolated places.

However, adequate amounts of food and potable water are not available in the same volume in certain areas because of the lack of existence of sustainable electrical energy generation and supply system. As a result, their basic needs of water, food and domestic electrical energy and other needs such as entertainment and business and community development remain unsatisfied, which result in poor social and economic indicators such as poor diet, low levels of water consumption, poor socio-economic conditions, low agricultural productivity and a low human development index. Opportunities exist for meeting these needs by the utilisation of available renewable electrical energy utilisation in such areas [1].

However, information on required amounts of energy is required for understanding and establishing a robust energy supply system. With this objective, a case study on indigenous renewable energy powered electrical energy supply system is contemplated to meet their energy needs

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and to raise their quality of life to some extent. It is believed that solar energy possesses the required potential of utilisation for isolated and backward areas of Pakistan [2]. The process of socioeconomic and sociocultural development can be attained through the use of solar power generation and desalination processes in these backward areas [2-5].

Electrical energy is required for the pumping and treatment of contaminated water. In the absence of water treatment and desalination plants, unhygienic drinking water is consumed. The problems of clean drinking water can be resolved if sufficient the amounts of energy is available. The water shortage problem is a complicated one as its demand keeps up increasing with an increase in the local population [6-7].

The underground aquifer water is not usable for drinking needs due to contamination caused mainly because of high levels of salinity. Desalination of underground aquifer water is not currently possible because of lack of electrical power supply system [8]. Due to the absence of alternative electrical energy arrangements the water supply problem lingers on. Therefore, there is a dire need for exploration of an indigenous renewable energy powered systems in these underdeveloped areas.

The drinking water consumption quantities based on standard clinical drinking water amounts per person per day can be referred in the calculation of drinking and non-drinking water [9]. The water calculator includes indoor potable drinking water as well as water usage in the kitchen, bathrooms and toilets. The electrical energy consumption in the desalination and pumping process is in the range of 0.3 and 1kWh/m^3 of desalinated water [10].

The prospects of reverse osmosis desalination are also studied for their use in the treatment of contaminated water. The reverse osmosis process desalination process can obtain a 40% recovery rate, depending on the depth of the well and the salinity level of the raw water [11]. The potable water recovery ratio is taken as 40:60. This means that for each 1m^3 of brackish water used in the desalination process, 0.4m^3 of potable water can be obtained. These allowances are provided in the table on total electrical power consumption.

Besides drinking water, the prospects of availability and treatment of water required for the cultivation of crops is also evaluated, with the aim to utilise large areas of such lands for agricultural production. The bio-saline agriculture technology is used for economical utilization of desert land for agricultural purposes through an integrated approach, and National Bio saline Agriculture Programs is being launched to bring into use all such lands [12-13].

Water heaters, air coolers, lights, refrigerators, air-conditioners, vacuum cleaners, fan, motor, iron, computers and televisions etc. all require an electrical energy. In the event of the lack of adequate electrical these needs, however, cannot be met [14]. The entertainment needs of these communities also remain unsatisfied, as televisions, internet and computers also require electrical energy.

If the electrical energy needs of the people are not met by the conventional power generation systems such as thermal and hydro power plants, it is essential to look for alternative means of energy production; especially power generation systems which are self-sustainable.

2. METHODOLOGY

An analysis for estimation of electrical energy requirement for meeting basic amenities is attempted. The energy required per person per day for meeting needs

of electrical energy, potable water and food are estimated in the first stage. The energy requirement break-down for each of these is furnished precisely. These estimates are based on water, food and electrical power consumption quantities patterns in the rural areas of Pakistan. The statistical data pertaining to the amounts of consumption per person per day are originated by the use of available published literature and online calculation tools.

Water usage, electrical energy consumption calculators are used for the calculation of estimated amounts of water and electrical energy that could be consumed per person and dwelling per day. The total amounts of drinking, non-drinking and cultivation water along with electrical energy requirements are given in Tables 1-4 respectively.

3. RESULTS AND DISCUSSION

The amounts of potable water, domestic electrical energy consumption and food commodities that would be required per person and per day are calculated respectively. The total electrical energy requirements includes transmission and distribution network Transmission and distribution losses.

3.1 Total Electrical Energy Requirement

The total amounts of electrical energy equivalent to electrical energy requirement for supply of all potable water, electrical power and cultivation water are calculated. The break-down of total electrical energy is furnished in Table 1.The break-down of estimated amounts of potable water, domestic electrical energy consumption and food commodities that would be required per person and per day are provided in Tables 2-4.

3.2 Electrical Energy Requirement for Potable Water Supply

The amount of water required for drinking, non-drinking and cultivation of crops is calculated on basis of the agricultural crops consumption per person per day i.e. water consumed. The cultivation water calculations are based on the amounts of water that are consumed per 1000 kg of wheat, rice or pulses cultivation in Pakistan [13-15]. The break-down of the total drinking and non-drinking (cultivation) water per person per day water in a desert community is given in Table 2.

TABLE 1. BREAK DOWN OF TOTAL ELECTRICAL ENERGY PER PERSON PER DAY (kWH) REQUIRED TO CATER THE NEEDS OF PUMPING, BRACKISH WATER DESALINATION AND DOMESTIC POWER IN PAKISTAN [5-7]

Nature of Electrical Energy Consumption	Energy Required
Pumping Electrical energy requirement for pumping of underground aquifer water for drinking, non-drinking and cultivation per person per day(kWh)	0.387
Desalination for populationelectrical energy requirement for desalination of water for drinking and non-drinking per person per day(kWh)	0.095
Desalination wheatElectrical energy requirement for desalination of cultivation water for wheat perperson per day (kWh)	0.020
Desalination riceElectrical energy requirement for desalination of cultivation water for rice per person per day(kWh)	0.245
Desalination pulses Electrical energy requirement for desalination of cultivation water for pulses per person per day (kWh)	0.027
DomesticElectrical energy requirement for domestic use per person per day= (kWh)	1.35
Total electrical energy requirement for desalination of water for drinking, non-drinking, crops cultivation and domestic power per person per day(kWh)	2.12
Total with T&D lossesTotal electrical energy requirement for desalination of brackish water and domestic power use per person per day, allowing for 20% T&D losses (kWh)	2.54

3.3 Electrical Energy Requirement for Domestic Power Supply

In a bid to calculate the total electrical power need per day, the electrical energy for heating, lighting, washing cooling, vacuuming and cleaning per person per day are calculated in kWh. The electrical energy supply situation in backward areas is not according to the required demand [16]. The breakdown of domestic electrical energy consumption per person per day in desert community is shown in Table 3.

TABLE 2. BREAK DOWN OF SPECIFIC AMOUNTS OF WATER REQUIRED TO CATER FOR THE NEEDS OF DRINKING AND NON-DRINKING PER PERSON PER DAY (m^3) IN PAKISTAN [15]

Nature of Water Consumption	Water Required
Drinking water per person per day (m3)	0.002
Flushing water per person per day(m^3)	0.006
Brushing water per person per day(m^3)	0.006
Bath water per person per day(m^3)	0.040
Washing water per person per day(m^3)	0.010
Shaving water per person per day(m^3)	0.006
Dish clean water per person per day(m^3)	0.014
Cooking water per person per day(m^3)	0.011
Total drinking and non-drinking water consumption per person per day (m^3)	0.095

3.4 Electrical Energy Requirement for Food Supply

As mentioned earlier, due to the lack of availability of a water source, the production of crops such as wheat, rice and pulses are seriously affected. It is believed that if the agricultural water needs of the desert communities are met, these communities can become self-sufficient. In order to realise the practical implications of this approach, the quantities of consumption of agricultural commodities per person per day in a desert community are estimated. The total amount of consumption is estimated on the basis wheat, rice and pulses consumption per person per day. This is shown in Table 4.

TABLE 3. BREAK DOWN OF DOMESTIC ELECTRICAL ENERGY CONSUMPTION PER DWELLING AND PER PERSON (kWH) AND THE CALCULATION OF TOTAL DOMESTIC ELECTRICAL ENERGY CONSUMPTION (KWH) IN PAKISTAN [17]

Nature of Electrical Energy Consumption	Energy Required
Electrical energy consumption on water well pump per dwelling per day(kWh)	3
Electrical energy consumption on TV per dwelling per day (kWh)	0.6
Electrical energy consumption on lighting per dwelling per day(kWh)	0.33
Electrical energy consumption on ceiling fan per dwelling per day(kWh)	2.83
Total electrical energy consumption per dwelling per day(kWh)	6.76
Electrical energy consumption per person per day(kWh)	1.352

TABLE 4. BREAK DOWN OF WHEAT, RICE AND PULSES CONSUMPTION PER PERSON PER DAY (KG) AND THE CALCULATION OF TOTAL AMOUNTS OF WHEAT, RICE, PULSES PER DAY (KG) AND WATER REQUIRED FOR THE CULTIVATION OF THE WHEAT, RICE AND PULSES PER PERSON PER DAY (M^3) FOR DESERT DWELLING [12-14,16,18]

Crop Type	Crop consumption per head per day (kg)	Wheat seed/10^3 kg crop cultivation per day (kg)	Total crop quantity necessary per person per day (kg)	Crop cultivation water/10^3 kg crop cultivation (m^3)	Crop cultivation water allowing for water recovery ratio (60:40) (m^3)	Total crop cultivation water per person per day (m^3)
Wheat	0.32	29	0.412	$0.30x10^3$	$0.49x10^3$	0.020
Rice	0.042	27	0.0534	$2.66x10^3$	$4.59x10^3$	0.245
Pulses	0.0037	139	0.0042	$38.5x10^3$	$6.48x10^3$	0.027

4. CONCLUSION

The study reveals the importance of the availability/supply of the electrical energy for launching a process of sustainable development of such unprivileged communities and underdeveloped areas. It is believed that the availability of self-sustained electrical energy supply system could be capable of meeting their basic and entertainment needs and would improve to a considerable extent the socioeconomic conditions of these areas. The findings of the case study can be utilised for development of a self-contained indigenous solar powered electrical energy system for underdeveloped desert areas of Pakistan which are suffering due to an acute shortage of energy supply.

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