Sustainable Development with Renewable Energy in India and Pakistan

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Abstract- The development and massive use of renewable energy depends on two main factothe use of Reuse rs: progress of related technologies and dedicated incentive policies. Improvement of technology is highly dependent on the amount of founds dedicated to the related R&D. Long-term incentive policies that address favoring investment are also essential to achieve general progress and a widespread use of clean energies. However, the latter scenario is not always available and in some countries, and confusion emerges as stable incentive policies are lacking. In this paper we show a capital budgeting analysis of standard investments in renewable energy photovoltaic systems in two developing countries such as India and Pakistan. Standard profitability indicators, such as net present value, payback and internal rate of return, are applied to such investments. The production of electricity through solar energy is sustainable from both economical and ecological point of views. This can be an additional advantage for developing countries like India and Pakistan, as they have much of their electric network still under construction. Despite the lack of incentive policies, we show how the technology and the markets are nowadays enough mature to consider photovoltaic systems for electric energy production a profitable investment from an economic viewpoint.

Keywords: Capital budgeting, solar energy investments, cash flow diagram, net present value, internal rate of return, photovoltaic system

1. Introduction

Development all around the world entails an increasing demand of electricity, for developed countries around 1% and developing countries 5% yearly [1]. All countries have to make face to the depleting resources together with environmental damage linked to the use of traditional sources of energy like oil, coal or nuclear.

So, renewable energy sources in the latest decades have reached a prominence for developing countries as for developed countries. The formers are looking for inexhaustible source of energy, together with environmental concerns, profitability criteria, and energy dependent. But for developing countries, with areas and economics sectors looking for economic growth, renewable energy is a unique opportunity of progress, to secure supplies of energy that is involved in social and economic development.

Examples included in this paper are India and Pakistan; both are developing countries with growing population. According to world health organization the total population of India in the year 2012 was 1240,000,000 and its gross national income per capita $ 3,910. Pakistan total population in 2012 was 179,000,000 and gross national income per capita was $ 2,880 in 2012.

It is well know that energy is essential to socioeconomic development. The growing energy needs, have to take into account three features of the energy source: the cost, the environmental concern and supply. To avoid the mentioned questions renewable energy source has to be used. Among possibilities of renewable, solar has some advantages over wind or biomass, as it is one of the main recipient areas in energy investments right now, as well as solar has a great production potential: Earth receives about 100,000 TW of solar power at its surface in one hour, that is enough energy to supply humanity´s energy needs for a year. But it is no its main advantage of developing countries, because these countries have remote areas and villages where it is quite hard to be connected to the grid. This fact have been evidenced in differents countries and with differents analysis models [2]

Investments in renewable energy as sustainable business options can carry out further advantages such as economic stability, low interest rates, high energy prices, change in the cultural values, Kyoto objectives, etc. deserve to be analyzed carefully [3]. In addition the development of new and appropriate technologies, issues related to their financial and economic viability and financing of renewable energy systems are being given considerable importance. However, despite all the above the promotion of clean energy strongly depends on incentive policies, as is presently the case in countries were these technologies have been developed: USA, Great Britain, German and Spain, even though these incentives have not been the panacea to the energy problems [4]. Developing countries should follow the lead of these countries; because they have shown not only that solar energy is clean but also with an assumed risk-free return [5].

In this paper, we analyze the evolution of the advantages of PV installations in developing countries as India and Pakistan. We make a description of its socio-economical situation and through a capital budgeting analysis we study the profitability of photovoltaic (PV) installation in the market conditions. The main conclusion is that despite the high profitability of this investment, the main advantage is not the use of solar energy, but other favoring factors like environment protection and sustainability.

2. Advantages of solar energy for a developing country

The advantages of the use of solar energy are almost infinite if we compare with the scarce fossil fuel reserves. If we compare with nuclear, the advantages of solar energy are also infinite in regard to safety system. Modern society looks for a secure and accessible supply of energy and a sustainable source of energy; it is both economically and technically variable.

Also, the production of energy through solar has been proven as an efficient and easy to use system with the available PV technology. In addition, solar energy also presents advantages over other renewable energy sources as wind energy because solar is more abundant and more predictable than wind, mainly in our target zone in India and Pakistan. Solar is less vulnerable to changes in seasonal weather patterns than wind or hydropower. Other additional advantage for these developing countries with a large part of its population in rural areas is that solar energy can produce power at the point of demand, in both rural and urban areas [6].

Solar PV is an equally significant energy option in developing countries because of the cost of transmission lines and the difficulty in transport system, since electrification is one of the main infrastructure requirements for the overall rural development. So, PV can solve part of our environmental concerns and lack of elements of development [7].

PV may be used to supply power to remote communities in off-grid villages and resort in desert areas etc. The budgetary investment is low if we compare with to get grid in remote areas in India or Pakistan over the mountains. Even PV can be installed piecemeal, house-by-house and business-by-business in off grid areas without well-developed infrastructure. The public opinion accepts the use of solar energy and that is a sign of respect of environment and contributes to slow down the climate change.

The technology of thin film solar cell is one of the most technologies used because the potential for reducing production cost, the low material consumption and the profitability indicators that we obtain. This technology can be used for small or large power requirements. PV arrays can be fitted as a part of the building elements as roof or facades to diminish the landscape-environmental impact.

3. Background information of India and Pakistan

Pakistan consists of four major provinces namely, Khayber-pakhtunkhwa (kpk), Punjab, Sindh, and Baluchistan, in additional to Federal Administered Tribal Area (FATA), Gilgit- Baltistan and Azad Kashmir. These units respectively comprise 9.4%, 25.8%, 17.7%, 43.6%, 3.4%, 9.1%, and 1.5% of the total area of the country.

The total population of Pakistan in 2012 is 179 million people. The heavy population growth has resulted in increased demand for housing and electricity, the rural sector, which comprises 62% of the total population is depend on the use of non-commercial energy resources. The infrastructure of industry, agriculture, transport, roads and the construction of buildings need to be improved and requires a supply of energy to accelerate the development process.

According to the World Bank report of Pakistan in 2014[2] the population density in Pakistan was 225.19 and a population in largest city in it was 13,124,793 which are 20.43% of the total population of Pakistan. On the other hand the rural population was 109,363,831 which are nearby 63% of the total population. The urban population was found to be 64,229,551 (nearly 37 %). the rural and urban population growth was 1.14% and 2.94%, respectively with an over all population growth of 1.80%.

Potential of solar radiation in Pakistan more then 70% of the 0.8 million km^2 area of the country receives annual average solar radiation energy from 5 to 5.5 $kwh/m^2/day$. Five major cities of Pakistan like Quetta receive a yearly average of 21.65 MJ/m^2 of solar radiation per day, or approximately about 2,300-2,700 h per annum, with a maximum of 29.68 $MJ/m^2/day$ in the month of June. This corresponds to an annual average of 6 $KWh/m^2/day$ and a maximum of 8.25 $KWh/m^2/day$ solar resources. The annual average for Karachi, Multan, Peshawar and Lahore are 19.25 $MJ/m^2/day$, 18.7

[2] http://www.worldbank.org/pk

MJ/m^2/day, 18.36 MJ/m^2/day and 17.0 MJ/m^2/day, respectively [8].

The subcontinent of India lies in South Asia. The land of India is like a peninsula with three sides and surrounded by Arabian Sea in the South West. India lies between 8.4 and 37.6 north latitude and 68.7 and 97.3 east longitude. The total area of India is 3,287,590 km^2. India shares its political borders with Pakistan and Afghanistan on the West, Burma and Bangladesh in the East, China, Tibet, Nepal and Bhutan in the North. The nation is divided into four large natural regions. The greatest mountain zone, the Himalayas, along the northern border, the fertile, densely populated Ganges plains immediately to the South, the desert region in the North West in the Deccan plateau in the Centre in South. Most of the country lies in the tropics, and so stay warm throughout the year. The Himalayas shelter the country from cold north winds. The climate is subject to monsoon influence, hot and dry for eight months of the year, and raining heavily from June to September.

The population of the republic of India is estimated to be about 1.27 billion people in the 2013, which is an increase of about 2.3% from the last record of the population. According to World Bank report of 2014[3] the population density in India was 410.72 (people per sq.km) the rural and urban population was 838,995,448 and 382,160,870, which means 68.70% and 31.30% of the total population, respectively. Population in the largest city was 22,569,419 which are 5.91% of the total population. The rural and urban population growth (annual %) was found to be 6.65% and 2.45% respectively with an over all population growth of 1.28%.

About half of billion people belong to middle class. The demand of energy increase day by day in India energy is one of the most basic of human needs, and also there is a direct relationship between energy and population, increase in population so the demand of energy also increase. Per capita energy consumption in India is 3,629 kWh remains low as against the world average of 17,620 kwh. Annual capacity additions have not been able to keep up with demand. There are 580 million people lacking electricity in India. The network of electricity is technically within reach of 90% of the populations. Due to poverty only 43% of the population connected with electricity and the remaining are not able to afford the cost of connection, in the year 2013, per capita GDP was reported to be US$1219 with an annual growth rate 4.5% and annual inflation rate of 8.3%. India GDP is composed of agriculture -25% industry -30% and services - 45% main industry include textiles, chemicals, food processing, steel, transportation equipment, cement, mining, petroleum and machinery.

The renewable energy technologies are owed mostly to its noiselessness, non-toxic emission, and relatively simple operation and maintenance. Due to the increasing demand of energy renewable energy also use for different kind of application, such as lighting, heating, ventilation, and air – conditioning areas. India has an annual temperature ranging from 25º to 27.5º, its means that India has huge solar potential. India receives a solar energy equivalent of more then 5000 trillion kw/h per year; daily global solar radiation is around 5 kwh/m2/day with sunshine ranging between 2,300-3,200 h/year in most part of India [9].

4. Financial and economic analysis

Techno-economic analysis is used for project cost control, profitability analysis, planning, scheduling and optimization of operational research etc. In the case of PV systems, it is necessary to work out its economic viability so that the users of the technology may know its importance and can utilize the area under their command to their best advantage. An effective economic analysis can be made by the knowledge of cost analysis, using cash flow diagrams. First of all, we define Cash Flows as the difference between inflows and outflows of funds that occur in the company and they arise from investment; it is the primary indicator of business health [10]. For analysing the profitability of the inversion several Capital Budgeting Criteria have to be used. Payback (PB), Net Present Value (NPV) and Internal Rate of Return (IRR) are widely used to perform profitability analysis. Let us define these criteria [11].

The PB is the number of years necessary to exactly recover the initial investment or also called Capital Outlay, it is computed by summing the annual cash flow values and estimating the period through the relation. PB analysis provides an easy to apply and intuitive decision process. However, PB suffers many well-known deficiencies as an investment analysis tool with the most obvious being the inability to distinguish between short and long-lived investment.

The NPV is the difference between the value of incomes and the expenses from an investment, up to date at the investment time, thus the NPV provides an estimate of the net financial benefit provided to the organization if this investment is undertaken [12]. A positive NPV means a positive surplus indicating that the financial position of the investor will be improved by undertaking the project. Obviously, a negative NPV would indicate a financial loss.

$$NPV = -D + \sum_{j=0}^{n} \frac{CF_i}{(1+i)^j} \quad (1)$$

where D is the capital outlay, i is the interest rate, and n is the technology life.

Despite of the NPV is an easy to use, intuitive tool which also presents some limitations related to (i) the discount rate chosen for its estimation; with a very low value of interest rate, an alternative with benefits spread far into the future may unjustifiably appear more profitable that an alternative whose benefits are more quickly realized but is of a lower amount in undiscounted terms; (ii) the distinction between project with capital outlay and smaller cost, thus the NPV does not give any indication of the scale of efforts required to achieve the results.

[3] http://www.worldbank.org/in

The IRR is a discounted of investment worth and is used as an index of profitability for the appraisal of projects. The IRR is defined as the rate of interest that equates the NPV of a series of Cash Flow to zero. Mathematically the IRR satisfies the equation (2)

$$0 = -D + \sum_{j=0}^{n} \frac{CF_i}{(1 + IRR)^j} \quad (2)$$

IRR is widely accepted and used in the appraisal of projects because it is a indicator of the expected return of profitability of the project, the IRR is easily compared with the banking worth rates or the cost of the funds used to finance the project.

5. Description of the PV investment. Case of Study.

The development of new and appropriate technology entails its corresponding financial and economic viability. This area involves: project cost control, profitability analysis, analysis planning, etc. The main factors that affect to economic analysis are: capital outlay, tariff electricity, solar hours (production), annual maintenance cost, annual insurance cost, and life of the solar PV installation and salvage value.

To make clear the profitability variation of an investment in a photovoltaic power in this research we have applied the capital budgeting criteria to photovoltaic power plant of 1 MW peak, one in India in West Bengal area and other in Pakistan in Karachi's area. Fig. 1 shows a picture of 1 MW photovoltaic solar plant consisting of 4,000 polycristaline silicon modules of 250 Watts each.

The area occupied by a photovoltaic installation of 1 MW is approximately 7 Acres. Due to the different conditions of availability of land in India and Pakistan, it has not been taken into account this factor when analysing profitability, so after results, the land question should be precised.

The energy production of a PV system is the product of the peak power of the installation and the average of Equivalent Sun Hours (ESH), which has been taken as 1,500 h/year in both locations West Bengal and Pakistan. The energy production can be roughly estimated using this method. However, at present there are several softwares that allow making a precise assessment of the energy production. To evaluate the energy productions of a 1MW PV plant we have use PVGIS [9]. PVGIS is free software developed by the Eurpoean Union that uses climatic databases to takes into account climatic conditions as well as sun irradiation data of the location. The software is also able to evaluate the utilization factor of the PV installation by taking into account the losses due to reflexions, climatic conditions and performance of the electronic components of the facility. So, according to PVGIS, the electricy production per year for a 1MW PV plant located in West Bengal is estimated to be 1,825,000 kW·h and 1,459,500 kW·h for the same PV capacity located in Pakistan. These energy productions are for

Fig. 1. Appearance of a PV system with a power of 1 MW consisting of 4,000 modules of 250 W each.

the first year of operation of PV plants. In subsequent years the estimated energy production will be reduced by 0.5% annually due to the aging of the facility.

According to WBREDA (West Bengal Renewable Energy Development Agency[4]) the tariff applied for solar PV is 12.5 INR, and in Pakistan is 16.16 PKR. As we will analyse the PV plant in India and Pakistan the estimations are made with in Indian rupees (INR), which is a tariff for Pakistan of 9.86 INR. In the appraise of the tariff have been taking in account an inflation rate of 6.49 % yearly for India and 6.20% for Pakistan; obtained as an average of the last 15 years inflation rate in both countries. The lifetime later for the solar PV installation is estimated in 15 years, because the PV modules manufacturer guarantees an electricity production of PV modules higher than 80 % after 15 years.

The expenditures considered in the solar PV installations connected to the grid are insurance, maintenance and network access taxes. With the aim to include inflation these payments were conditioned to yearly incomes, and prevailing market conditions. With a conservative bent these charges are estimated to be around 9%, where 3% of income corresponds to maintenance, 3% of income for insurance and 3% of income for tax to network acces, both in India and Pakistan. The percentages of maintenance and insurance are typical values in Europe, while the tax to grid acces depends on the policy of every country. Here we consider that a tax of 3% would allow the dissemination of renewable energies and seems sufficient to ensure a correct conservation of the electric network.

To estimate the capital outlay prevailing market conditions have been used. for a solar PV power plant of polycrystalline silicon of 1 MW peak power, mode turnkey. Companies like Titan Energy Systems Ltd are engaged in the installation of solar plants with these characteristics. For West Bengal the capital outlay is 57,500,000.00 INR, and for Pakistan 95,000,000.00 PKR. Estimations for NPV are made in INR, then we have use an exchange rate between the Indian rupee and the Pakistan rupee of 1 INR=1.63 PKR.

The electricity prices in India and Pakistan are shown in Table 1. In both countries the prevalent legislation difference between domestic and non-domestic or commercial use. In India made a distinction on a consumption basis of three

[4] http://www.wbreda.org/

Table 1. Electricity prices in India and Pakistan

Electricity prices in India		**INR**
Domestic	Section 0-150	2.3
	Section 151-400	4.2
	Section 401-∞	4.4
Non Domestic Commercial	Section 0-150	4.5
	Section 151-400	4.7
	Section 401-∞	6.0
Average		**4.18**
Electricity prices in Pakistan		**PKR**
Domestic		18.00
Commercial		14.50
Average		**16.16**

intervals for both uses; so the electricity price for the lowest power consumption from 0 to 150 Kwh is 2.30 INR in domestic use, and the highest energy price is 6.00 INR when consumption exceeds 401 kWh for commercial use. As we cannot make distinction in the destination of power, we have use for the financial analysis the average of the electricity prices in India: 4.18 INR. For Pakistan the distinction in power electricity price depends only on the use, as well as in India, there are two types of consumption: domestic and commercial. We have used also the average of these fees to obtain the financial analysis.

In the case of India, at the time of investment (year 0) only the outflow of capital outlay takes place. After installation, production and sale of energy begins, as well as expenses.

The expected annual energy production in kWh in the PV plant for the first year is 1,825,000 kWh for India. The inflows obtained for this production are 7,642,664 INR, calculated at an electric tariff of 4.18 INR/kWh. After year 1, owing to inflation the inflows varies, and then both electrical tariff and expenditures increase. On the other hand, some drop in the energy production is also expected due to aging of the solar modules and other components of the facility. As mentioned before, expenses have been considered as 9% of incomes (insurance, taxes for access to the grid, and general maintenance, cleaning solar modules, etc.). For the first year the amount for outflows are 164,250 INR. The cash flow is the difference between inflows and outflows. In first year of operation the cash flow is 7,478,414 INR. Repeating the same procedure for the subsequent years of operation, the cash flow before taxes during the lifetime of the PV plant, which is estimated in 15 years. To obtain cash flow after taxes, we have estimated depreciation for the PV plant, under the under the assumption that depreciation is uniform throughout the lifetime of the installation; and after depreciation is taken of the cash flow, we apply the tax rate.

We have repeated the calculus for Pakistan, and the capital outlay is 57,985,522 INR when the PV system is installed. In year 1 the inflows are 14,391,972 INR for tariff fees of 9.86 INR. Taking into account the expenses mentioned before the outflows are 1,295,278 INR. After removing the uniform depreciation (6,333,333 INR), the cash flows after taxes (10,797,152 INR) is obtained. This process has been used to calculate the cash flows of the PV installation during the 15 years of expected lifetime of the facility in both locations India and Pakistan.

Although the cost of capital, according to Hail and Leuz [13] in India is around 14% and in Pakistan 19%, the NPV is obtained with discount rates from 0 to 30%.

Fig. 2 shows the NPV after tax for 1 MW PV solar plant working under the irradiation conditions and expected climatic data of Pakistan and India. The NPV is calculated using Equation (1) for several discount rates ranging from 0 to 30% and according to the electric tariffs mentioned previously. As expected, with low discount rates a positive value of NPV is obtained. For the Indian case, from discount rate up to 11.84% the NPV reaches positive values, which means that the PV installation provides net economic benefits to the investor. For higher discount rates the NPV is negative, which means that the PV plant would produce losses for investors, so in that condition the investment should not be implemented. In the case of Pakistan, up to discount rates of 21.83% the NPV is positive, producing net profits to the investor. After this discount rate the NPV is negative and, as in the Indian case, the investment should not be implemented.

The NPV is always positive, even for a greater cost of capital rates. That is extremely significant regarding economical and political point of views; because the PV system leads not only environmental benefits but also profits with an economic perspective. In market conditions and without grants the PV system can provide electricity at competitive prices.

The IRR for the investment is calculated according to Equation (2). Table 2 displays the value for IRR obtained for the before and after tax, using for the prevalent applied rate tax in companies' profits, for India 35% and for Pakistan 34%. Then, in order to obtain the net IRR, the capital cost must be removed. With the previsions of the cost of capital we obtain positive returns in both countries. The risk country for these investments should also be studied, mainly for foreigner inversors. We are already working in the assessment of risk country in the countries object of this work. Besides, other research can help to improve the decision maker for an investor if we evaluate this investment in other Asian countries [14].

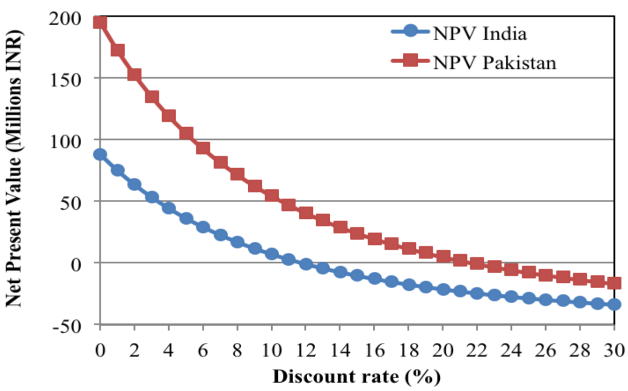

Fig. 2. Net Present Value (NPV) after tax for PV solar plants located in India and Pakistan, respectively

Table 2. Internal rate of return for a PV production plant in India and Pakistan.

Internal Rate of Return (IRR)		
India	Before Tax	15.83%
	After Tax	11.84%
Pakistan	Before Tax	27.36%
	After Tax	21.83%

As previously mentioned the Payback points out the time period that the potential investor lasts in recover the investment. For Pakistan is near five years and for India about seven years. Besides, as this type of investment does not require reposition of PV panels or any other additional investment, the PB is within a reasonable time. It is worth to notice that the raw material, sun irradiation, is obtained at zero cost and its supply is guarantee during the lifetime of the PV installation.

6. Conclusion

The present profitability of PV solar energy installations allows secure investments in the field. In these context developing countries as India and Pakistan should take advantage of its suitable land position related to solar irradiation, which improve the efficiency of PV electricity solar plants in terms of production. With this kind of investments it would be easier to achieve the challenges related to sustainable economic growth, following at the same time the recommendations of international institutions such as the OECD and others.

We have demonstrated in this paper that the required investment in PV solar plants has low risk because the investment is mainly released in the beginning, the reliability of related technology is guarantee for 15 years and the raw materials (Sun irradiation) are assured at zero cost. The main risk factor involves the legal frame in which this business has to survive. Tariff limits, limitations in irradiation sun time or any kind of new taxes for producing clean energy are the main risks of this business. However, when this kind of policy incentives are not present the above mentioned risks vanish, which is presently the case in countries such as Indica and Pakistan.

Taking a capital cost of 10% the brut profitability (IRR) measured through the NPV has been revealed to be positive. The average Payback is shorter than 7 years, which taking into account that the life of a PV solar plant is longer than 15 years inversion the payback would be about 40%.

To guarantee the future of renewable energies in developing countries a legal frame has to be established and the suitable characteristic of new legal frame should its long-term stability. Owing to the special climate conditions in India and Pakistan and the development need in some areas, obtaining power with solar PV plants, that avoid other costs as the construction of a grid, can improve the development index.

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