Capital budgeting for renewable energy plants

I. Guaita-Pradas[1], L.M. Sánchez Ruiz[2], B. Marí Soucase[3]

[1] *Departament d'Economia i Ciències Socials, Universitat Politècnica de València, Spain, iguaita@esp.upv.es*
[2]*Departament de Matemàtica Aplicada. Universitat Politècnica de València, Spain, lmrs@mat.upv.es*
[3]*Departament de Física Aplicada. Universitat Politècnica de València, Spain, bmari@fis.upv.es*

Abstract

Engineering students require some basic knowledge of economic analysis techniques to complete their education and meet the multidisciplinary labour market demands. Apart from pure engineering techniques, project design usually involves economic valuation and profitability analysis. In this study we use both capital budgeting and energy production techniques for photovoltaic power plants. First of all, we describe the technical characteristics for a solar installation oriented to electricity production and we estimate the energy output, which depends on the solar irradiation hitting the solar modules. According to energy production results we apply capital budgeting techniques to assess the profitability of the investment. Regarding economics we describe the main concepts: the net present value, the internal rate of return and the payback. The former parameters are estimated for a photovoltaic power plant located in Spain and that starts the activity at present without any kind of economic incentive. These are standard viability indicators to assess the profits and assist the investor in business decisions. Indeed the addition of capital budgeting techniques expands the success chances in renewable energy projects.

Keywords: *Solar energy investments, Capital budgeting, Net present value, Profitability, Energy production of PV plants.*

1. Introduction

Sustainable development unavoidably includes the massive use of renewable energy sources. Therefore most of European Union (EU) countries are making efforts in this direction to battle climate change such as global warming and exhaustion of natural resources and are developing specific programmes to incentive the implantation of clean and non contaminant energy sources. In this regards some EU countries have launched disparate legislation in order to promote the use of sustainable energy sources with different degree of success. [1] A key issue to encourage the diffusion of sustainable technologies should meet simultaneously two issues; the technical effectiveness and economic efficiency. Technical effectiveness depends on the progress of technologies involved. Economic efficiency is essential for dissemination and progressively replacement of other technologies that do not meet sustainability requirements.

The Energy Sector has moved from a regulated and monopolistic sector to a deregulated, uncertain and highly competitive sector. Forecasting of growth for renewable energy sector is, without any doubt, a crucial fact. And this represents an opportunity business that engineers and companies could not afford to pass up. Indeed, investment decisions in renewable energies are based in the conviction that clean energies are crucial to keep a green planet but also in the profitability of such investment.

The present scenario concerning climate changes and global warming has favoured investments in alternative energy sources, which are characterised by their sustainability and respect for the environment. Among these conditions we can underline: economic stability, low interest rates, high-energy prices, and change in the cultural values. [2] 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. Despite all the above the promotion of clean energy strongly depends on incentive policies, as was the case in the countries were these technologies has developed: USA, Great Britain, German and Spain; even though these incentives have not been the panacea to the energy problems. [3] However, even in absence of incentive policies the existing photovoltaic (PV) technology is enough matured to be considered a lucrative business, at least in regions with high levels of solar irradiation. [4]

Engineering students should be aware of the most efficient technologies for generating green electricity but also they should be able to submit the related economical features to investors. Therefore a basic knowledge of economic techniques for justifying the investments is essential. To promote the dissemination of this technology for both small businesses and individuals, engineers have to show companies the related economic studies and be able to advise them as a way to diversify the business and achieve the return on assets. In case of domestic economies investment in renewable energies can be presented as a long-term, easy and safe investment that do not require any specific financial or technological knowledge.

In this paper, we analyse the competencies required for modern engineers regarding generation of green energy through PV installations. These competencies should include both technical and economical knowledge. Technical knowledge related to existing technologies and how to install and calculate the energy production of a PV plant and financial awareness for presenting return analysis and other financial parameters of PV installations. In particular we have developed an example of a medium size PV installation located in Spain. This example could be adapted to other locations by taking their respective solar irradiation data.

2. Energy production in photovoltaic solar plants

A photovoltaic cell, also known as a solar cell, directly converts light energy into electrical energy without the need for chemical reactions or fuel. The majority of solar panels are composed of numerous silicon wafers wired together to produce direct current (DC) electricity. The generated electric energy can be stored in suitable batteries or can be feed into the electric network by using a device named inverter, which is used to convert this DC electricity into alternating current (AC). Indeed since PV plants are able to feed AC electricity directly in to the network through the use of very efficient inverters the PV solar energy has boosted the implantation of PV solar energy plants because the simplicity and lower cost of this systems with respect to those using batteries. Indeed determining exact electrical output depends on complex factors, such as the angle, direction and efficiency of the panels, sunshine, temperature and weather. However, you can easily estimate the power output if some condition are met.

Electrical output varies and is dependent upon factors such as the amount of available light, the position and angle of the solar panels, ambient temperature, the efficiency of the panels and the voltage supplied by the system. Calculating how many kilowatt-hour (kWh) of electricity are produced by a solar system is often a challenged activity because conditions can change in seconds, but a good estimate of the average power production can be made using straightforward techniques.

Keeping panels clean, in full sunshine and pointing directly toward the sun will maximize output. However such systems involve the use of sun trackers to keep the surface of solar modules always perpendicular to sun. These kind of systems are already available but ion this example we are going to refer to static PV modules without sun trackers.

To get the most from solar panels, you need to point them in the direction that captures the most solar radiation. But there are a number of variables in figuring out the best direction. The best placement for solar panels depends on the situation they are installed. Solar panels should always face true south if you are in the northern hemisphere, or true north if you are in the southern hemisphere. It has been taken into account that true north is not the same as magnetic north. However, true north or south can be easily found by using the standard Global Position System (GPS) devices, which nowadays are available in practically any smart phone.

The next issue is related to the tilted angle from horizontal. Books and articles on solar energy often give the advice that the tilt should be close to the latitude where the PV installation is located [5]. Given the latitude in Europe all fixed PV installation should have an inclination between 35º and 50º with respect to the horizontal.

Peak sun hours are found by dividing the entire solar irradiance that falls on one square meter during the day by 1 kW/m^2. For example, if a location receives four peak sun hours, it has received the equivalent of four hours at 1 kW/m^2 per hour, although it may have been accumulated at varying rates over a much longer period. This information is available in specialized websites. See for example the link http://solargis.info/.

Equivalent Sun Hours (ESH) refers to the equivalent number of hours per day when solar irradiance averages 1 kW/m^2. For example, four peak sun hours means that the energy received during total daylight hours equals the energy that would have been received had the irradiance for four hours been 1 kW/m^2. This is a very interesting concept because it allows calculating, in a simple way, the electricity production of a PV installation over a given period. For obtaining the electricity production of a 20 kW PV installation the simplest method is to multiply the Equivalent Sun Time in the location by the peak power specified by the manufacturer for the PV modules. Actually all PV modules are tested under AM1.5 conditions which refers to a solar irradiation of 1 kW/m^2. Therefore the simplest way for calculating the electricity production of a PV installation over a period is to multiplying the equivalent Sun Time by the peak power of the modules specified by the manufacturer. Actually all PV modules are tested under AM1.5 conditions which refers to solar irradiation of 1 kW/m^2.

Table 1 displays the latitude and solar irradiation data of some European cities. The Equivalent Sun Time and the estimated energy production for a 20 kW PV plant is also including. As expected the higher the latitude the lower the solar irradiation and the electricity production of PV plants. The study is made for a PV plant of 20 kW PV because it meets the goals of the Spanish energy policy measures, being accessible to small companies or household and also the PV plant with this dimension, can be fitted on roof or facades of buildings fulfilled another aim of multifunctional.

Table 1. Solar irradiation data and estimated electricity production for a 20 kW PV plant in some European cities. (Source: http://solargis.info/)

Location	Parallel	Solar irradiation (Kwh/m^2)	Equivalent Sun Time (h/year)	Electricity production (Kwh/year)
Valencia (Spain)	40º N	1,720	1,720	34,400
Paris /France)	49º N	1,400	1,400	28,000
Berlin /Germany)	52º N	1,240	1,240	24,800
Riga (Latvia)	57º N	1,120	1,120	22,400

3. Economic study

The main aim for the investment analysis is to figure out if a company will be able to improve his economic position with expenditure. Then, when the firm purchases new assets the main hope is to enhance future results. For this reason, the first step is to state if the company should make the capital outlay in the new assets to carry out the investment. A forecast for the cash flow should be made in order to estimate the new yield. We have already controlled that a PV installation has got through all techniques, commercial and marketing viability test. [5]

The main economic parameters to be taken into account before take the decision of an investment are: (a) Capital Outlay, (b) Lifespan or Economic life and (c) Cash-flow. The Capital Outlay in an investment, are all necessary expenses that a company must to carry out for the start-up of new machinery and it begins to generate incomes from the production. In our case of study, we consider that the investment (or machinery) is the installation of solar panels for the production of electrical energy installed on warehouse rooftops.

The utile surface allows the fitting of about 200 square meters of Si-standard PV panels with a peak power of 20 kW. The market specific for the capital outlay in a PV plant is 60,000 €, which are distributed as described below:

Table 2. Capital outlay for a 20 kW PV Plant.

Solar panels	57,205.39 €
Activity licence	184.46 €
Starting activity	2,373.19 €
Urban certification	36.96 €
Locksmith	200.00 €
Total	**60,000.00 €**

Solar panel's technology use single-crystal silicon material on the basis of a large dissemination in the European market, with excellent technical results. As shown by the fact that many installations are near its lifespan and continuous working with profitability.

The second parameter is the lifespan, and it has been estimated in 25 years. This is justified into two reasons. The first one, is because the agreement with the public administration has a maturity of 25 years; and the second reason is due to the manufacturing firms for solar panels in single-crystal silicon guarantee a technique efficiency of up to 80 % of the potential production

The most arduous task is to forecast the cash-flow in an investment, given that it deals to estimate the income cashed or inflows and payments, or outflows, generated by the investment along the lifespan. So, being estimation, we should mention additional considerations:

- The income cashed and payments are the last day of each period.
- We do not take into account payments pertaining to financing. That is, we do not weigh up financial charges, principal refund, etc. The financing costs are reflected in the calculation of profits, and are used to obtain payment tax and the rate of return.
- Taxes are payment cash in the cash flow.

Cash Flows Inflows Outflows

Following considerations of the above, to estimate inflows we base our calculus in the published in BOE (*Boletin Oficial del Estado)* 10392/2010. As mentioned before technical specifications for the production of energy are based on the forecast of solar hours, location of panels and appropriate inclination of panels.

In our example the PV installation is located in Valencia (Spain). The estimated production is 34,400 kWh for each year. Following technical specifications of panels industry the power degradation is 0.5% annually. With this data it will be able to obtain an estimation of the electricity produced each year of the lifespan of the PV plant.

Next step is to assess annually income, thus we introduce the tariff that is multiplied by the production to achieve the cash income of the first year. On the date that the PV plant started the activity in 2013 the tariff was 15.0938 c€/kW. The updates for the annually tariff is made in accordance with the prevalent legislation and incorporating the inflation rate to the increase in the tariff. The projection for inflation is 2.20 % taking in account the macroeconomics targets for European Union, and OCDE forecasts.

In relation with payments in the PV plant, are associated with maintenance expenses in the solar installation and the insurance. On the basis of the information provided by the firm, maintenance expenses are about 3% on income and insurance 6 %. These values coincide with market criteria for other installations with similar characteristics. Thus, we can obtain the cash flow for every year of lifespan, as showed in Table 3. To obtain the Cash Flow after tax, in Table 3 we have previously count the profits of each year for work the taxes out in each year. In Spain the average weighted tax rate applicable to firms is 25% over profits. Detailed analysis in Table 2 and Table 3 show that inflow and income agree every year, because incomes are collected each financial period. On the other hand the payments and outflows don't coincide for two motives. The first one is depreciation that entails an expense but no an outflow for firm; and the second are financial charges associated obtain funds. We have assumed that capital outlay is supported by a loan in market conditions amortized in 7 years.

The same study can be done for any location in other European region or country. In this case student has to take in account two factors. The first is the latitude for obtaining the solar irradiation and/or ESH of the location and then the electricity production. And the second, the status quo of the energy policy to notice for details of tariff and conditions during the lifetime of the PV plant.

4. Methods for Investment Valuation

A company has to confront situations with limited capital, and managers have to satisfy shareholders expectative. Therefore, the firm must to invest in every project that is worth more than it cost. To make a property selection of investments, it has to be into account the time value of money and the risk involved the project proposed.

A techno-economic analysis has been used for project cost control, profitability analyses, planning, scheduling and the optimization of operational research, etc. For PV systems, it is necessary to work out their economic viability so that users of this technology can know its importance and can utilize the area under their command to their best advantage. An effective economic analysis can be done using cost analysis knowledge with cash flow diagrams. First of all, we defined Cash Flow as movements of money in and out of any business; indeed it is the primary indicator of business health. [6] Several Capital Budgeting Criteria have to be used to analyze the profitability of the investment made. Pay-Back (PB), Net Present Value (NPV) and Internal Rate of Return (IRR) are widely used to conduct profitability analyses. Let's go on to define these criteria. [7] [8].

PB is the number of years required to recover the initial investment exactly (Capital Outlay), and is computed by summing the annual cash flow values and by estimating the period throughout the relation. A PB analysis provides an easy-to-apply and intuitive decision process. However, PB undergoes many well-known deficiencies as an investment analysis tool, and the most obvious kind is the inability to distinguish between short- and long-lived investments.

The NPV is the difference between the value of incomes and the expenses incurred from an investment until the date the investment was made. Thus the NPV provides an estimate of the net financial benefit provided to the organization if this investment is undertaken. [9] A positive NPV means positive surplus, indicating that the investor's financial position will improve if the project goes ahead. Obviously, a negative NPV indicates financial loss.

$$NPV = -D + \sum_{t=0}^{n} \frac{CF_t}{(1+i)^t} \qquad (1)$$

where D is the capital outlay, i is the interest rate, and n is the technology life. [9]

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

The IRR is a discount 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 [10]:

$$0 = D + \sum_{i=0}^{n} \frac{CF_i}{(1+IRR)^i} \qquad (2)$$

The IRR is widely accepted and used in the appraisal of projects because it is an indicator of the project's expected return of profitability. The IRR is easily compared with the banking worth rates or the cost of the funds used to finance the project. [11]

Table 3. Cash Flow for a 20 kW PV plant producing 34,400 kWh of electric energy per year.

Year	Capital Outlay	Regulated Tariff c€/kWh	Inflation expected	Incomes	Maintenance Expenses	Insurance Expenses	Payments	Cash Flow	CF after Tax
2012	60,000.00 €							-60,000.00 €	-60,000.00 €
2013		15.0938	2.20%	4,510.03 €	135.30 €	270.60 €	405.90 €	4,104.12 €	4,104.12 €
2014		15.4258636	2.20%	4,609.25 €	138.28 €	276.55 €	414.83 €	4,194.42 €	4,194.42 €
2015		15.7652326	2.20%	4,710.65 €	141.32 €	282.64 €	423.96 €	4,286.69 €	4,286.69 €
2016		16.1120677	2.20%	4,814.29 €	144.43 €	288.86 €	433.29 €	4,381.00 €	4,381.00 €
2017		16.4665332	2.20%	4,920.20 €	148.79 €	295.21 €	444.00 €	4,476.20 €	4,476.20 €
2018		16.8287969	2.20%	5,028.44 €	152.06 €	301.71 €	453.77 €	4,574.68 €	4,574.68 €
2019		17.1990305	2.20%	5,139.07 €	155.41 €	308.34 €	463.75 €	4,675.32 €	4,675.32 €
2020		17.5774091	2.20%	5,252.13 €	158.82 €	315.13 €	473.95 €	4,778.18 €	4,778.18 €
2021		17.9641121	2.20%	5,367.68 €	165.86 €	322.06 €	487.92 €	4,879.75 €	4,879.75 €
2022		18.3593226	2.20%	5,485.77 €	169.51 €	329.15 €	498.66 €	4,987.11 €	4,987.11 €
2023		18.7632277	2.20%	5,606.45 €	173.24 €	336.39 €	509.63 €	5,096.83 €	3,950.03 €
2024		19.1760187	2.20%	5,729.79 €	177.05 €	343.79 €	520.84 €	5,208.96 €	4,036.93 €
2025		19.5978911	2.20%	5,855.85 €	179.89 €	351.35 €	531.24 €	5,324.61 €	4,126.27 €
2026		20.0290447	2.20%	5,984.68 €	183.85 €	359.08 €	542.93 €	5,441.75 €	4,217.04 €
2027		20.4696837	2.20%	6,116.34 €	187.89 €	366.98 €	554.87 €	5,561.47 €	4,309.82 €
2028		20.9200168	2.20%	6,250.90 €	192.03 €	375.05 €	567.08 €	5,683.82 €	4,404.63 €
2029		21.3802571	2.20%	6,388.42 €	195.87 €	383.31 €	579.17 €	5,809.25 €	4,501.73 €
2030		21.8506228	2.20%	6,528.97 €	200.18 €	391.74 €	591.92 €	5,937.05 €	4,600.77 €
2031		22.3313365	2.20%	6,672.60 €	204.58 €	400.36 €	604.94 €	6,067.67 €	4,701.98 €
2032		22.8226259	2.20%	6,819.40 €	209.08 €	409.16 €	618.25 €	6,201.15 €	4,805.43 €
2033		23.3247237	2.20%	6,969.43 €	213.68 €	418.17 €	631.85 €	6,337.58 €	4,911.15 €
2034		23.8378676	2.20%	7,122.75 €	218.38 €	427.37 €	645.75 €	6,477.01 €	5,019.19 €
2035		24.3623007	2.20%	7,279.46 €	223.19 €	436.77 €	659.96 €	6,619.50 €	5,129.61 €
2036		24.8982713	2.20%	7,439.60 €	228.10 €	446.38 €	674.47 €	6,765.13 €	5,242.47 €
2037		25.4460332	2.20%	7,603.27 €	233.12 €	456.20 €	689.31 €	6,913.96 €	5,357.80 €

Table 4. Profits.

Year	Capital Outlay	Regulated Tariff c€/kWh	Inflation estimated	Incomes	Payment	Depre-ciation	Financial Charges	Pre-Tax Profits	Taxes	After Tax Profits
2012	60.000.00 €									
2013		15.0938	2.20%	4,510.03 €	405.90 €	5,720.54 €	3,000.00 €	-5,022.32 €		-5,022.32 €
2014		15.4258636	2.20%	4,609.25 €	414.83 €	5,720.54 €	2,631.54 €	-4,572.50 €		-4,572.50 €
2015		15.7652326	2.20%	4,710.65 €	423.96 €	5,720.54 €	2,244.66 €	-4,102.46 €		-4,102.46 €
2016		16.1120677	2.20%	4,814.29 €	433.29 €	5,720.54 €	1,838.43 €	-3,611.26 €		-3,611.26 €
2017		16.4665332	2.20%	4,920.20 €	444.00 €	5,720.54 €	1,411.89 €	-3,100.23 €		-3,100.23 €
2018		16.8287969	2.20%	5,028.44 €	453.77 €	5,720.54 €	964.03 €	-2,563.66 €		-2,563.66 €
2019		17.1990305	2.20%	5,139.07 €	463.75 €	5,720.54 €	493.77 €	-2,002.74 €		-2,002.74 €
2020		17.5774091	2.20%	5,252.13 €	473.95 €	5,720.54 €		-1,416.31 €		-1,416.31 €
2021		17.9641121	2.20%	5,367.68 €	487.92 €	5,720.54 €		-1,328.71 €		-1,328.71 €
2022		18.3593226	2.20%	5,485.77 €	498.66 €	5,720.54 €		-1,232.09 €		-1,232.09 €
2023		18.7632277	2.20%	5,606.45 €	509.63 €			4,587.20 €	1,146.80 €	3,440.40 €
2024		19.1760187	2.20%	5,729.79 €	520.84 €			4,688.12 €	1,172.03 €	3,516.09 €
2025		19.5978911	2.20%	5,855.85 €	531.24 €			4,793.36 €	1,198.34 €	3,595.02 €
2026		20.0290447	2.20%	5,984.68 €	542.93 €			4,898.82 €	1,224.70 €	3,674.11 €
2027		20.4696837	2.20%	6,116.34 €	554.87 €			5,006.59 €	1,251.65 €	3,754.94 €
2028		20.9200168	2.20%	6,250.90 €	567.08 €			5,116.74 €	1,279.18 €	3,837.55 €
2029		21.3802571	2.20%	6,388.42 €	579.17 €			5,230.07 €	1,307.52 €	3,922.55 €
2030		21.8506228	2.20%	6,528.97 €	591.92 €			5,345.13 €	1,336.28 €	4,008.85 €
2031		22.3313365	2.20%	6,672.60 €	604.94 €			5,462.73 €	1,365.68 €	4,097.05 €
2032		22.8226259	2.20%	6,819.40 €	618.25 €			5,582.91 €	1,395.73 €	4,187.18 €
2033		23.3247237	2.20%	6,969.43 €	631.85 €			5,705.73 €	1,426.43 €	4,279.30 €
2034		23.8378676	2.20%	7,122.75 €	645.75 €			5,831.26 €	1,457.81 €	4,373.44 €
2035		24.3623007	2.20%	7,279.46 €	659.96 €			5,959.54 €	1,489.89 €	4,469.66 €
2036		24.8982713	2.20%	7,439.60 €	674.47 €			6,090.65 €	1,522.66 €	4,567.99 €
2037		25.4460332	2.20%	7,603.27 €	689.31 €			6,224.65 €	1,556.16 €	4,668.49 €

5. Results

Applying criteria of capital budgeting described above the results are as expected that investment in solar PV plant is efficient both in technical and economical point of view. Both profitability and return of this type of investment are positives in 25 years period. The value obtains for the NPV when the discount rate is 3% is:

$$NPV = -60000 + \sum_{i=0}^{25} \frac{CF_i}{(1+3\%)^i} = 18.264.21€$$

Values used for the CF_i are shown Table 3, and it has been applied the cash-flow after tax with the aim of take into account all expenses involved with the investment, even tax. This lets us to present to the students the difference between profits and cash-flow. If we repeat the operation with different discount rates, it is observed that after 5% the NPV becomes negative and that means that the investment after this rate does not provide profits. The firm has to know the cost of capital.

Table 5. Net Present Value.

Discount Rate (%)	NPV
0	53,501.52 €
1	39,634.24 €
2	28,029.15 €
3	18,264.21 €
4	10,003.05 €
5	2,976.45 €
6	-3,031.91 €

With the formula of the IRR, by taking data from the Table 3, also with CF after tax, the result is:

$$0 = -60000 + \sum_{i=0}^{25} \frac{CF_i}{(1+IRR)^i}$$

The IRR is 5.48% that means that gross return of the solar PV plant and it is workable for a firm that has a cost of capital below this IRR. Finally, the Pay back is about 12 years.

6. Conclusion

Under the multi-functionality principle of firms and markets, a modern engineer has the challenge to be addressed on matters of technologies and economics. We have shown in this paper how in higher education engineering' students should be trained in both disciplines. To spread engineers' competencies and facilitate their integration in the labor market both technological and financial abilities have to be incorporated to their background. With this aim in mind, particular attention must be paid to providing comprehensive information to engineer on the benefits of use of renewable energy. Chiefly in countries, as Spain, with an important potential for PV plants due to its high solar irradiation levels. Also we could highlight that the state of technology also has helped to arrive to the accessibility of investment in PV plants to small companies and household.

In our case focused in Spain, after several years of incentive policies for renewable energies mainly related to tariff regulations, the grid-parity for photovoltaic installations has been reached or they are very close. In spite of the apparent chaos occurred with the incentives the policies developed in Spain has succeeded. The incentives related to photovoltaic energy installations as well as the rest of renewable sources have been reduced in the last decade but the drop in the costs of photovoltaic installations has compensated the tariff reductions. To guarantee the future of renewable energies in Europe a legal frame has to be established in all countries and the suitable characteristic of new legal frame should guarantee its long-term stability.

We have shown in this paper the importance of including both technical and economical formation in the background of modern engineers. Such formation will allow future engineers to find their site in the promotion and business of renewable energies. Business in PV solar plants has low risk because the investment is mainly released in the beginning, the reliability of related technology is guarantee for 25 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 activity. However, we expect that in the near future the European Union be able to pave the way for allowing a rapid spread of renewable energies by setting stable rules in the overall EU for the promotion of such energies. Indeed, the multidisciplinary training of new engineers would influence in this challenge

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References

[1] R. Haas, C. Panzer, G. Resch, M. Ragwitz, G. Reece, A. Held, "A historical review of promotion strategies for electricity from renewable energy sources in EU countries", Renewable and sustainable Energy Reviews, Vol. 15, pp. 1003-1034, 2011.

[2] T. Couture, Y. Gagnon, "An analysis of feed-in tariff remuneration models: Implications for renewable energy investments", Energy Policy, Vol. 38, No 2, pp. 955-965, 2010.

[3] J. A. Lesser, X. Su, "Design of an economically efficient fieed-in tariff structure for renewable energy development", Energy Policy, Vol. 36, pp. 981-990, 2008.

[4] Inmaculada Guaita-Pradas, Bernabé Marí Soucase, ¨Endorse of renewable energy plants, still an alternative investment in Spain?", SOP Transactions on Economics Research (ER), Scientific Online Publishing (In Press), 2014.

[5] E. Lorenzo, G. Araujo, A. Cuevas, M. Egido, J. Minano, R. Zilles, *Solar Electricity: Engineering of Photovoltaic System,* Earthscan Publications Ltd., 1994, pp. 101-105.

[6] A. S. Suárez Suárez, *Decisiones óptimas de inversión y financiación en la empresa*, Madrid: Ediciones Pirámide, 2005.

[7] J. Jackson, "Promoting energy efficiency investments with risk management decision tools", Energy Policy, vol. 38, pp. 3865-3873, 2010.

[8] J. Jackson, *Energy Budgets at Risk (EBaR): a risk management approach to energy purchase efficiency choices,* Wiley, 2008.

[9] IDAE, *Energía Solar en España 2007. Estado actual y perspectivas*, Ministerio de Industria, Turismo y Comercio, Madrid, 2007.

[10] S. F Haka, "A review of the literature on capital budgeting and investment appraisal: past, present, and future musings", Handbooks of Management Accounting Research, Vol. 2, pp. 697-728, 2006.

[11] P. A Ryan, G. P Ryan "Capital budgeting practices of the Fortune 1000: how have things changed?", Journal of Business & Management, Vol. 8, No.2, pp. 355-364, 2002.

Authors

Principal author: Inmaculada Guaita-Pradas holds a BTech degree in Economics from the Universitat de Valància (Spain) and the PhD degree from the Universitat Politècnica de València (Spain). At present she is a Assistant Professor in the Department of Economy and Social Sciences at the Universitat Politècnica de València.

Co-author: Luis Sanchez holds a PhD degree in Mathematics from the Universitat de València (Spain). He is presently professor in Mathematics at the Universitat Politècnica de València. Presenting author.

Co-author: Bernabé Marí holds a PhD degree in Physics from the Universitat de València (Spain). He is presently a full professor specialising in Semiconductor Technology and Renewable Energies at Universitat Politècnica de València.