



Spain's energy outlook: A review of PV potential and energy export



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ABSTRACT

Spain must reduce its energy consumption by 23% and achieve 100% renewable energy in electricity generation by 2030. This paper presents the current energy scenario in Spain, and the outlooks for different renewable options, with special focus on photovoltaic (PV) solar energy. In 2012, Spain was the number two European country in terms of installed renewable energy power. Solar PV technology has the potential to meet Spain's future energy demand and its associated environmental challenges. This paper gives a review of solar energy economy at global scale for both PV and thermal power technologies. The Spanish energy scenario shows actual trends and progress made by solar power. Economic concepts of levelised cost of electricity and grid parity are presented. The financial analysis shows that PV electricity achieves grid parity at a plant profitability rate up to 7.26%.

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1. The Spanish energy scenario

1.1. Background information

Energy demand in Spain has followed a parallel growth of the economy. Fig. 1 shows the growth of primary energy demand in Spain. It highlights the impact of hydrocarbons in the Spanish energy supply, and also the fact that periods of high inflation affect investment in energy, especially nuclear [1]. The oil crisis in the seventies not only meant a return to coal and the problematic development of nuclear energy, but also resulted in high inflation and low economic growth. A strong growth in energy demand following the 2008 crisis was based on lower oil prices, although they rebounded in 2012. In the last two decades, the Spanish economy has experienced an important upward trend. Gross Domestic Product (GDP) has increased 61.7% in the period of 1990–2010 [2], 21 points higher than the 30 founded Organization for Economic Co-operation and Development (OECD) countries, in which Spain is included. In the same time period, the population of Spain increased 18.1% [2], leading to an increase of CO₂ emissions

during that period of 30.7% [2]. The Spanish energy model shows signs of unsustainability very similar to the global energy model: runaway growth in demand and CO₂ emissions, as well as very high dependence on fossil fuels [3]. Energy intensity has remained a growing trend, contrary to the EU-15. A similar trend is apparent with the intensity of CO₂. Both energy consumption (140 GJ/capita) and CO₂ emissions (6.17 t CO₂/capita) are fast approaching the European average [3,4].

The Spanish economy has concentrated its activities in steel, cement and brick products associated with construction. All this leads to the assumption that the Spanish economy has been based on sectors that lead to an unsustainable energy model. Construction and low-cost tourism have provided spectacular economic growth, but with high energy demands. Meanwhile, the most advanced economies in the EU-15 have specialised in higher value-added activities, thus reducing its energy intensity and emissions.

Fossil fuels represented 77% of the primary energy sources used in Spain in 2011 (oil 44.9%, natural gas 22.1% and coal 9.9%) [5] (Fig. 2). Nuclear power represented 11.5%, while renewables accounted for 12% of the energy sector. In terms of electricity production, the share of renewables in Spain was 31.8% in 2012 (Fig. 3), mostly from wind and hydraulic energy [6]. Spain is the second country in Europe with the most installed capacity of wind energy behind Germany, with 22,796 MW installed at the beginning of 2013 [7].

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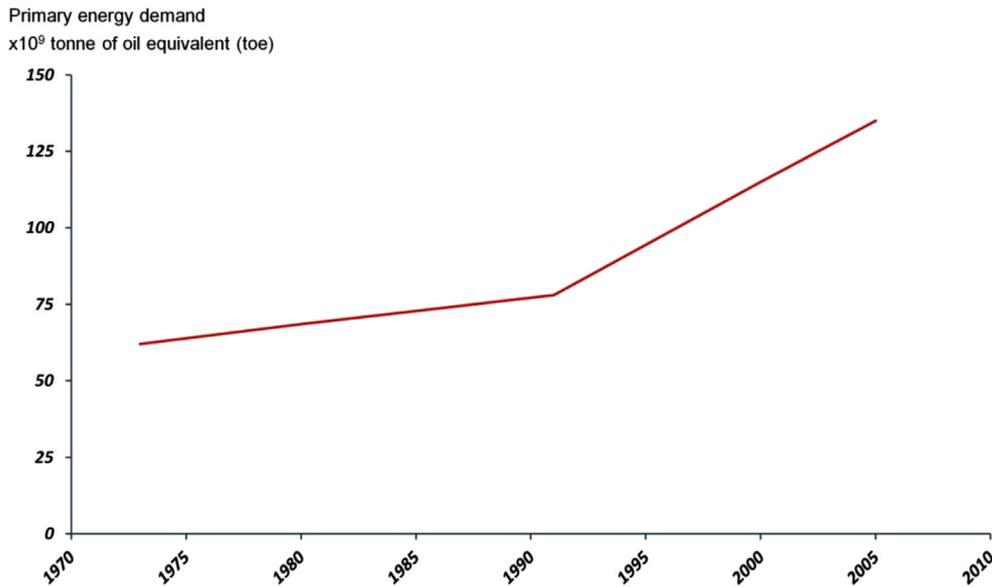


Fig. 1. Historical data of the primary energy demand in Spain. Source: Comisión Ejecutiva Confederal de UGT.

1.2. Energy and environmental challenges

The analysis of the current energy production model and its comparison with the evolution of energy consumption clearly reflects the limited nature of conventional energy resources as well as the progressive deterioration of the environment [8,9]. The dramatic increase in energy consumption in the European Union (EU) since the Industrial Revolution has brought with it a dependence on external energy sources that could reach 70% in 2020 [10]. Fortunately, there is a growing social awareness of the negative environmental impacts of fossil fuel energy as well as the environmental problems related to the use of nuclear energy. This new social conscience of environmental problems and possible solutions will have a direct effect on how energy challenges are met in the future. This will doubtlessly signify a reduction in fossil fuel energy consumption as well as an increase in the production of renewable energies or energies generated from natural resources [11].

Spain must reduce its energy consumption by 23% and achieve 100% renewable energy in electricity generation by 2030 [3]. The ultimate aim is halving greenhouse emissions by 2030 and by 80% in 2050 (compared to 1990) [3]. Increased use of renewable energies offers a workable solution for environmental problems

caused by other energy sources [9]. For this reason, current European policies are focused on the development and use of renewable energy [12].

1.3. Renewables trends

The potential of renewable energy in Spain is vast and well above the national energy demand and existing fossil energy resources. Renewables are the main energy asset of Spain. The potential of solar energy is the highest, and expressed in terms of installable electrical power, it is of several terawatts (TW). Second is wind power, with the potential assessed in about 340 GW [13]. The hydropower potential, estimated at about 33 GW is also very high, although most of this potential has been developed. Other potential technologies accredit close to 50 GW, highlighting the potential of wave energy and geothermal energy; about 20 GW in both cases. In the field of thermal uses, the potential is also very high, highlighting the opportunity of over 20 million tonnes of oil equivalent (Mtoe) of biomass, the potential over 15 Mtoe of solar thermal or 12 Mtoe of geothermal energy. Unlike electricity, thermal potential in an area is closely related to the thermal energy demand; but unlike electricity, thermal energy cannot be carried over long distances [13].

Counting the development of renewables, the contribution of these sources to the national primary energy balance in 2011 was found to be 12% [5]. The sum of all renewable contributions in 2011 was 15,727 thousand tonnes of oil equivalent (ktoe) over a total primary demand of 131,225 ktoe [5]. The contribution of renewable energy in 2011 in terms of primary energy was covered in about two thirds by electricity generation, about 26% through thermal uses, and about 10% in biofuels for transport. Table 1 shows the evolution of energy production from different renewable sources from 2005 to 2011, measured in terms of primary energy [5].

1.4. Solar PV progress in Spain

The potential for solar energy in Spain is massive, determined by the level of solar irradiation. Spain receives annually an average global irradiation of 1640 kWh/m² on its horizontal surface, which puts the country at the head of Europe [14]. Izquierdo et al. [15],

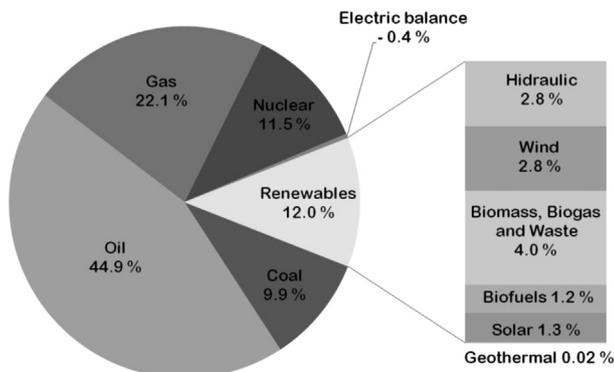


Fig. 2. Primary energy sources in Spain (2011). Source: MITyC, 2012.

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