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Evaluating the 2014 retroactive regulatory framework applied to the grid connected PV systems in Spain

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HIGHLIGHTS

- Analysis of the RD 413/2014 new economic and regulatory framework for GCPVS.
- Description and formulation of the new remuneration scheme.
- The simplified model proposed is able to identify the most influential regulatory parameters.
- The economic indicators of the undertaken case study reveal a substantial lost in profitability.

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ABSTRACT

The RD 413/2014 new economic and regulatory framework for producers of electricity from renewable energy sources in Spain has been here analysed, putting the focus on its impact on the economic results of the existing grid connected PV systems. A complete formulation of the new remuneration scheme is first presented, making evident its high complexity and the great number of regulatory parameters involved. Then, in order to facilitate the discernment of its operating mechanism a simplified model is proposed. This approach has proven to be a useful tool to identify the most influential regulatory parameters and also which could be the plausible future regulatory actions in order to contain the cost to the Spanish Electricity System. Finally, the NPV and the IRR among other indicators are calculated for a representative case study facility, evidencing a substantial profitability reduction in the transition from the former economic and regulatory framework to the RD 413/2014 new remuneration scheme.

1. Introduction

From early 2000s, the renewable energy policy of the European Union (EU) has boosted the electricity from renewable energy sources (RES-E) throughout Europe [1,2]. As a result, in the recent period 2011–2013 at least three EU countries (Germany, Spain and Italy) were among the top 5 performers in the world with highest rates of renewable capacity per capita (excluding hydropower) [3–6]. Moreover, in the case of photovoltaic (PV) capacity, these good results were even better. Since 2006, the EU has accounted for more than half of the total worldwide PV capacity. Once again, at the top of the PV global rank in 2013 were Germany (35,715 MW), Italy (17,928 MW) and Spain (5,340 MW).

All the countries occupying the first positions in the PV promotion had adopted the feed-in-tariff (FIT) mechanism [3–7]. Notwithstanding the excellent results achieved, the fact remains that the FIT has been blamed for some malfunctions in the electricity sectors of the implementing countries. One of the most important malfunctions was the so called "call for inversion" effect, responsible for the exponential growth of the PV capacity and the cause of the overrun cost to the electricity systems of these countries.

Despite these malfunctions the FIT mechanism continues to be used and, consequently, is one of the key elements analysed in the scientific literature of the last years. For example, attention has

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Acronyms

RD Royal Decree
EU European Union
FIT feed-in tariff
GCPVS grid connected photovoltaic systems
IRR Internal Rate of Return
MO Ministerial Order
NPV Net Present Value
PV photovoltaic
RDL Royal Decree-Law
RES-E electricity from renewable energy sources
SES Spanish Electricity Sector
SR Specific Retribution

Variables

a the year in which the operating permit is obtained
$C_{j,a}$ coefficient representing the investment cost of a GCPVS obtaining the operating permit in the year a that cannot be recovered with the market revenue within j
$Cexp_i$ standard mean total operating cost for $i < p$ per unit of installed power (€/MW)
$Cexpf_i$ future estimated cost per unit of installed power within the year i (€/MW)
C_Eexpf_i standard operating cost per unit of generated energy in the year i (€/MW h)
$C\_Eexp\_e_i$ standard operating cost per unit of generated energy in the year i under the regulatory frameworks prior to RD 413/2014 (€/MW h)
$C\_Eexp\_real_i$ real operating cost per unit of energy (€/MW h)
d_i coefficient correcting the annual revenue according to Nh_inst_i
E_i total energy generated within the year i (MW h)
$EBITDA_i$ earnings before interest, taxes, depreciation and amortization of the GCPVS in the year i (€)
E_max_i maximum value of E_i eligible for perceiving the Ro_i (MW h)
Ing_i standard mean total income for $i < p$ per unit of installed power (€/MW)
$Ingf_i$ future estimated operating income per unit of installed power within the year i (€/MW)
Inv_R_i the remuneration for the investment in the year i (€)
j three-year half-period
K_j capital recovery factor
K_R the yearly degradation rate (%)
LR reasonable profitability level
$LI1_{i,j}, LI2_{i,j}$ lower limits for the calculation of $Vajdm_{i,j}$
$LS1_{i,j}, LS2_{i,j}$ upper limits for the calculation of $Vajdm_{i,j}$
$Market\_Revenue_i$ market revenue perceived in the year i (€)
$Nh_{i,j}$ standard equivalent operating hours within the year i of j (h)
Nh_ei standard equivalent operating hours for the year i under the regulatory frameworks prior to RD 413/2014
Nh_inst_i number of equivalent operating hours within the year i (h)
$Nh\_max_{(Ro)i}$ maximum value of Nh_inst_i eligible for perceiving the Ro_i (h)
Nh_min_i minimum value of Nh_inst_i that does not entail a reduction of $SR\_Revenue_i$ (h)
Op_R_i the remuneration for the operation in the year i (€)
$Operating\_Cost_i$ total cost for running the facility (€)
p first complete year of j
P_{peak} installed capacity of the PV panels, considered at the inverter DC input (MW_p)
P_n nominal power, considered at the inverter AC output (MW)
Pm_i yearly average energy market price per unit of generated energy in the year i (€/MW h)
Pmf_i estimated future market price per unit of generated energy for the year i (€/MW h)
Pm_ei revenue per unit of generated energy from the energy sales in the year i under the regulatory frameworks prior to RD 413/2014 (€/MW h)
$Revenue_i$ total revenue perceived in the year i (€)
$Rinv_{j,a}$ remuneration for the investment per unit of installed power for every year i within j of a GCPVS obtaining the operating permit in the year a (€/MW)
Ro_i the remuneration for the operation per unit of generated energy in the year i (€/MW h)
sm number of years of j
SB_j average yield during determined period of the 10-year Spanish bonds in the secondary market within j
$SR\_Revenue_i$ SR revenue perceived in the year i (€)
t_j per unit discount rate within j corresponding to the reasonable profitability
Uf_i threshold of Nh_inst_i for perceiving $SR\_Revenue_i$
$Vajdm_{i,j}$ coefficient adjusting the deviations of Pm_i
$VNA_{j,a}$ net value per unit of installed power within j of a GCPVS obtaining the operating permit in the year a (€/MW)
VR_j remaining number of years at the beginning of j to the end of the facility VU (years)
VI_a standard value of the initial GCPVS investment per unit of installed power (€/MW)
VU regulatory lifetime (years)
ΔC_Eexpf_i differential over C_Eexpf_i (€/MW h)
Δt_j basis points differential added to SB_j for determining t_j

recently been focused on the FIT for promoting RES-E in the United Kingdom as a vehicle towards to a low carbon transition, reviewing again the pros and cons of this mechanism, specially its inherent boost effect [8–11]. As well, concerning the effectiveness of the FIT mechanism in avoiding CO_2 emissions, it is possible to find recent studies related to countries such as Germany, Taiwan, Malaysia or Australia [12–15]. The German experience has also been used as a reference for comparing the German FIT against other promotion mechanisms [16], and for countries such as Japan and Kenya, the prospects of the evolution of the grid connected PV systems (GCPVS) have been analysed taking into account the FIT mechanism in their models [17,18]. Likewise, when analysing different values and grades of support to energy storage systems facilitating the large-scale the integration of wind energy, the FIT mechanism has been praised as an effective tool [19,20].

Nevertheless, two new regulatory trends appeared in the countries that applied FIT mechanisms and experienced a power capacity boom far exceeding their policy objectives, especially for GCPVS. The first of these trends was the introduction of limiting regulatory elements for the new facilities to be installed [21]. Spain, which due to the malfunction of the FIT mechanism led the PV market in 2008 [22], was one of the first countries that introduced these modifications in the international context [23]. In this regard, Italy, the second country in the PV global rank in