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The future of the Feed-in Tariff (FiT) scheme in Europe: The case of photovoltaics

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HIGHLIGHTS

- Feasibility conditions of FiT schemes examined focusing on the treasury of 4 countries.
- FiT's drawbacks led to its collapse less than a decade from its application.
- Model for the prediction of the performance of the FiT scheme introduced.
- Allocation of the economic growth to penetration rate affects FiT positively.
- RES penetration into the energy mix has the highest impact on FiT's sustainability.

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ABSTRACT

The key objective of this study is the examination of the regulatory and policy framework of the feed-in-tariff (FiT) scheme, specifically its effect on both the electricity pricing as well as the local and European renewable energy sources (RES) market, and accordingly the definition of its feasibility as a scheme for the further development and promotion of renewable energy technologies (RETs). This work discusses the FiT scheme implementation for photovoltaics (PVs) in four case study countries - Denmark, Germany, Cyprus, and Spain. A model describing the conditions under which a FiT scheme is led to collapse is also introduced and a parametric analysis towards revealing the sensitivity of the different parameters affecting it, is delivered. The study concludes with significant policy implications that should be considered for future implementation of the scheme. For the prevention of the collapse of the scheme, the tariff's value ought to be determined by each country's government based on a set of influencing factors including the operational, capital and investment costs of each RET, the standard cost of renewable energy (RE) generation and the avoidance cost, which would be regularly reviewed depending on the excess of the annual capacity.

1. Introduction

Several financial support schemes have been adopted worldwide for the successful integration of Renewable Energy Technologies (RET) into the energy mix without impairing the stability of electricity production and national economies. Increased renewable energy sources (RES) exploitation is safeguarding to countries improved energy security, economic development via innovation and novel manufacturing mechanisms and Green-House Gases (GHGs) emissions reductions (Muller et al., 2011). Along with the successive technological progress and integration of RET into the local electricity mix, there has always been the uncertainty whether the large penetration of RES into the grid would impair the stability of electricity production. Comparable level of concern also exists on the durability of generous tariffs of various schemes offered to Renewable Energy (RE) producers, and in particular to solar Photovoltaic (PV) electricity producers (Frondel et al., 2008; Papadopoulos and Karteris, 2009).

The Feed-in Tariff (FiT) scheme has been considered as an effective economic tool for the promotion of active investment, deployment and utilization of Renewable Energy Sources (RES) worldwide. Within this scheme, large energy providers offer long-term contracts to smaller-scale Renewable Energy (RE) producers to sell their generated renewable electricity to the market under a fixed tariff above the market rate. The attractive FITs and the reduced capital costs of solar PV systems lead to the blooming of the solar Photovoltaics (PVs) market, followed though by re-evaluations, halts and collapses due to the distortion of electricity prices,

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Nomenclature

Abbreviations

CHP	Combined Heat and Power
CSP	Concentrated Solar Power
EC	Electricity Consumption (kWh/a)
EG	Economy Growth Rate (%)
EF	Feed in Tariff Fund Cumulative Expenses
EP	Electricity End Price (€/kW h)
FR	Fossil fuel energy revenue
FiT	Feed-in Tariff
FiTR	Feed-in Tariff Rate
FP	Feed-in Tariff Percentage of the electricity and price
GHG	Green-House Gas
LP	Levy as a percentage to the cost of electricity (%)
N	Year (dimensionless)
PR	Penetration Rate (%)
PSO	Public Service Obligation
PURPA	Public Utility Regulatory Policies Act
PV	Photovoltaics
R	Energy produced by renewable energy (kWh/a)
RE	Renewable Energy
RES	Renewable Energy Sources
RET	Renewable Energy Technologies
RF	Feed in Tariff Fund Cumulative Revenue
RPS	Renewable Portfolio Standard
StrEG	Stromeinspeisungsgesetz
VAT	Value Added Tax

economic instabilities and bankruptcy of the responsible funding bodies, especially in the Mediterranean countries.

The key objective of this study is the investigation of the viability conditions of FiT schemes for the promotion and development of RETs. Within this context, the background of FiT and the currently available FiT schemes are reviewed in Section 2. The case studies of FiT adoption on solar PV are presented and discussed in Section 3 in four European countries with the highest electricity prices; Denmark, Germany, Spain, and Cyprus,. Through the examination of the electricity prices and levies for RES, the regulatory and policy frameworks, and the PV markets, the conditions that led to the FiT scheme collapse phenomenon in the case study countries is documented. A model for the definition of the conditions under which a FiT scheme may collapse are introduced in Section 4. A sensitivity analysis of the model is also implemented to reveal the significant parameters affecting it. Finally, the main conclusions on the feasibility of the FiT schemes and the relevant policy implications based on the analysis of this work are presented in the last section of this study.

2. Theoretical background

2.1. Background of the Feed-in Tariff (FiT) scheme

FiT is defined as a policy mechanism designed to accelerate investment in RET, by offering long-term contracts to RE producers, typically based on the cost of generation of each technology. The establishment of such schemes is considered essential for the promotion of RET development, since the installation of a RE system has several expenses upon the owner and the grid utility, including the capital and installation costs, the operational and maintenance costs, and the costs of interconnecting and maintaining the installation on the grid. FiT schemes aim to support the technological maturity of RET, towards achieving grid parity in a short-term period. A clear final goal, with a time line for achieving intermediate goals, helps in the development of the potential targets and regulators may monitor the progress to implement and enforce it (Haas et al., 2008). A flexibility of such a framework is essential so people can spot and fix problems without disrupting the plan. For the establishment of a whole regulatory and policy framework for the FiT scheme, the following parameters should be considered (Haas et al., 2008; Huenteler, 2014):

- Risks and returns associated with RE investments
- Financial constraints
- Electricity infrastructure and regulations
- Potential and previous situations of market failure related to investment in innovation

According to REN21 in 2014 68 countries worldwide applied the FIT scheme (REN21, 2014). The FiT rate is apparently determined by each country's government based on; the operational, capital and investment costs of each individual RE source (Campoccia et al., 2014), the standard cost of RE generation plus a value typically set by the policymakers or regulators, a fixed price incentive or an auction-based price (Couture et al., 2010). However, in some cases the irregularity of auction mechanisms was also criticised for the discontinuity and instability of the RET development, due to extremely low bids by investors for projects to be proven financially feasible, and high price of the safety net (Kylili and Fokaides, 2015).

The first FiT policy is considered to be the Public Utility Regulatory Policies Act (PURPA) of 1978 in the USA. This act required utilities to buy produced electricity from RE facilities at a pre-set price per kWh based on the cost that could be avoided by using an alternative supply source. In Europe in 1990, Germany was the first country that adopted the Stromeinspeisungsgesetz (StrEG) policy requiring utilities to purchase electricity generated from RES at a percentage of the retail electricity price (Act on Feeding Renewable Energies into the Grid, 1990), followed by Switzerland in 1991, Italy in 1992 and Denmark and India in 1993. The percentage FiT payment plan in Germany was dropped in 2000, when the fixed FiT plan was adopted. The FiT payment plan was adopted in Spain in 1994 and in Cyprus in 2003 (Institute for Building Efficiency, 2010).

EU Member States have developed a number of different strategic paths in prospect of RES expansion, in line with the RE policy goals of EU, namely to reduce the GHGs emissions, to foster the energy independence of EU and to contribute to the European economic development by creating new job positions in the market (Couture et al., 2010). The motivation for new RET installations is provided by guaranteed access to the grid, and long term contracts with a guaranteed purchase price, set according to the actual cost of RE generation, the current electricity fuel price or in some cases a fixed price. Typically, the FiT schemes have contracts ranging from 10 to 25 years and vary according to the maturity of the technology, the capacity size, the resource quality and the location of the project. Additionally, they may be steady for all installations below a certain capacity or may vary if they according to the installation purpose (i.e. self-consumption).

2.2. Feed-in Tariff (FiT) payment plans

As a result of the different FiT scheme developments, various payment plans have been established to address the problem of maturity and a big/small penetration of the RES into the electricity grid. The available FiT payment plans are outlined in this section (Mendonça, 2009).

2.2.1. Percentage Feed-in Tariff (FiT) payment plan

Older FiT policies in Europe determined that the FiT payment level was a percentage – 80–90% - of the retail prices, linking the payment to the market price and creating the need to produce electricity at peak times (Couture et al., 2010). A percentage based payment scheme was easier to implement as it did not depend on each RE technological advances and a simple modification of the percentage was enough to control the market growth. One of the challenges faced by this payment method was that non-wind RE resources struggled to ensure cost recovery and deployment in the electricity grid. Germany and Denmark abandoned this payment method in 2000. Spain initially abandoned it in 1998, reintroduced it in 2004 to promote solar energy plants and abandoned it again in 2006 (Couture et al., 2010).

2.2.2. Fixed Price Feed-in Tariff (FiT) payment plan

In this payment plan the payment received by the RES producers remains independent from the electricity market price and lasts for a pre-determined period. This fixed price however as it has been seen throughout the years is subjected to re- evaluations, adjustments for cost reductions and variations due to inflation or technology maturity. To decide on the initial tariff value and the responsive tariff digression several key elements should be considered such as the type of technology and the quality of the source at the site (irradiation for solar systems, wind speed for wind farms etc.) and the capacity and location of the project. FiT fixed schemes are popular because of their lower risk of failure and are more cost effective than premium models.

2.2.3. Premium Feed-in Tariff (FiT) payment plan

The FiT premium payment plan offers a price above the current electricity price, aiming the diffusion of RES into the electricity mix. The payment is proportional to the electricity market price. In the case of Denmark, the specific payment plan offers the operators of RES a variable bonus, above the market electricity price.

3. FiT evolution in EU: the case of PVs in Denmark, Germany, Cyprus and Spain

Four countries were examined in terms of their PV share in electricity, their future potential and their current FiT status, specifically on the measures taken for its promotion or stabilisation, Denmark, Germany, Cyprus and Spain.

The specific four EU countries were chosen due to the fact that the electricity prices in these countries is the highest in EU. The electricity prices before and after taxes for the countries under examination since 2007 are presented in Fig. 1. These high prices can be explained as EU countries tax residential electricity for producing electricity (property taxes, environmental taxes, nuclear production taxes), for transporting electricity, for RES and for sales of electricity (consumption taxes, Value Added Tax (VAT)). Typically, the incentives provided to RES producers are funded by adding incremental costs to the electricity bills, including use of tax revenues, use of carbon auction revenues, utility tax credits or by combining the incremental costs with the tax revenues.

The FiT schemes; in Denmark net-metering was encouraged and a premium FiT scheme was preferred. Germany's FiT scheme evolved in 2014 with a very low return on investment. Even though the administrative process was simple and lean there was always the risk of grid tariff imposition. In Spain the support scheme for PVs stopped in 2012 due to generous tariffs,

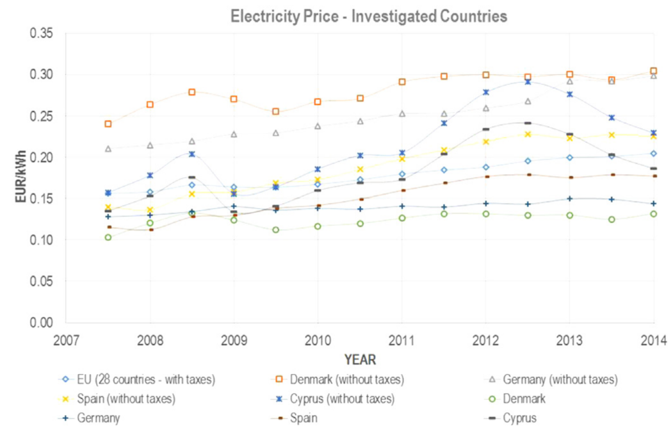

Fig. 1. The electricity prices of the countries under investigation (Eurostat, 2014).

overcapacity and tariff deficits. Currently the administrative processes are slow and no significant development is observed as it is hard to revitalise the PV sector without incentives. In Cyprus there is a slow steady increase of the PV penetration into the market as the FiT scheme was introduced the past decade in Cyprus. Due to the accident in Vasilikos power station, a further incentive was given to PVs market but administrative process is slow but steady. The price of tariffs provided for the RES projects in the case study countries are compared for the two years in Table 1.

After the Spanish boom of PV installation in 2008, Germany was established as the leading market in 2009, while the rest of European PV market was limited, partly due to the financial recession, but also because of the fact that 2009 could be considered the year of stabilisation after the blooming of 2008. In 2010, Germany, Italy and the Czech Republic achieved record installation numbers. In 2013, more than 38 GW of PV were installed globally, 11 GW of which were in Europe, totalling to 139 GW worldwide. The European cumulative installed capacity exceeded 81 GW by 2013, however a sharp drop in installations was observed for 2013 considering that the number of PV installation two years prior to that was 22 GW. The evidently lower numbers for 2013 were a result of the shrinkage of two of the largest PV markets, namely Germany and Italy. Regarding the rest of the European markets, they remained stable at around 6 GW (EPIA, 2014). Table 2 presents the size of the market at each country under examination in this work for the years 2012 and 2013, as well as their cumulative solar PV installed capacity.

3.1. Denmark

3.1.1. FiT scheme evolution

The FiT system was introduced in the Danish market in 1993. Specifically through the Danish carbon tax and a partial refund on the energy tax wind projects were reimbursed. In 1996 a plan was set that envisaged the energy consumption in 2005 to be 12–14% depended on RE and 35% by 2030. Three years later another target specifically for electricity consumption was pursued to be 20% from RE. Moreover, Denmark abandoned the FiT system for wind energy with a final tariff of 0.058€/kW h in 2001 and decided to promote Renewable Portfolio Standard (RPS) mechanism with a system of tradable green certificates. The phasing out of the FiT schemes created stagnation in the wind sector that continued for 7 years (DEA (Danish Energy Agency), 2010). However, the FiT scheme continued to apply for biogas, solar, wave and tidal energies. The price of FiT tariff was set at 0.08€/kW h for new installations with duration 10 years and the next 10 years the price would drop at 0.054€/kW h (de Jager and Rathmann, 2008).

In 2009, in compliance to the European Renewable Energy

Table 1
Feed-in Tariff (FiT) purchase price (€/kW h) for the RES projects in the case study countries for the years 2007 and 2014.

Spain		
Technology	**YEAR: 2007**	**YEAR: 2014**
Wind Farms	0.073	Suspension of FiT scheme
Large Photovoltaic Systems (21–100 kW)	0.440	
Small Photovoltaic Systems (– 20 kW)	0.440	
Small Scale Hydro	0.078	
Biomass (< 2 MW)	0.065–0.159	
Geothermal and Ocean	0.069	
Cyprus		
Technology	**YEAR: 2009**	**YEAR: 2014**
Wind Farms	0.166	0.145
Large Photovoltaic Systems (21–150 kW)	0.34	0.138
Small Photovoltaic Systems (– 20 kW)	0.36	N/A
Solar Thermal Systems	0.26	N/A
Biomass Utilization	0.135	0.135
Germany		
Technology	**YEAR: 2009**	**YEAR: 2014**
Wind Farms	0.092(onshore)/ 0.13(offshore)	0.0495–0.089(onshore)/ 0.039–0.194 (offshore)
Large Photovoltaic Systems (< 500 kW)	0.4091	0.1095
Small Photovoltaic Systems (10–40 kW)	0.4301	0.1225
Hydropower	0.1267	0.015–0.1052
Biomass (< 150 kW)	0.1167	0.0385–0.2073
Geothermal (< 5 MW)	0.16	0.232
Denmark (Premium tariff above market value)		
Technology	**YEAR: 2012**	**YEAR: 2014**
Wind Farms	0.08	0.02
Photovoltaic Systems (< 400 kW)	0.17	0.08 for years 1–100.054 for years 11–20

Table 2
PV market in the years 2012 and 2013 for the countries under investigation.

	Market 2012 [MW]	**Cumulative 2012 [MW]**	**Market 2013 [MW]**	**Cumulative 2013 [MW]**
Denmark	316	332	216	548
Germany	7604	32,441	3304	35,715
Spain	332	5221	118	5340
Cyprus	7	17	15	32

Directive 2009/28 EC, Denmark set a new target that aspires the attainment of a 30% share of RE by 2020, and a 100% share by 2035 (Irena-Gwek, 2012).

3.1.2. Electricity prices

Denmark had the most expensive electricity price in Europe in 2014 (0.3042€/kW h) from which the taxes and levies were 0.173 €c/kW h and accounted for 56.84% of the price (Eurostat, 2014). The electricity rate in Denmark was subjected to consumption and production tariffs, an electricity tax and VAT (25%). According to Energinet.dk there were three consumption tariffs applied in the settlement between Energinet.dk and the grid companies; the grid tariff, the system tariff and the Public Service Obligation (PSO) tariff. The grid tariff concerned the costs relating to the Danish transmission grid (0.0056 €/kW h in 2015). The system tariff covered the cost for reserving capacity, system operation etc. (0.0039 €c/kW h). The PSO tariff corresponded to the costs relating to subsidies for RE and local Combined Heat and Power (CHP) units and was reviewed every 3 months (0.0309 €c/kW h for last quarter of 2014 and 0.0287 €c/kW h for the second quarter of 2015). The revenues from the PSO tariff were used for research and development of environmentally friendly electricity generation and energy-efficient electricity use and to support fixed and premium FiT schemes. The production tariff is 0.004 €/kW h (Johann, 2014).

3.1.3. PV penetration into energy mix

The decreasing prices of the photovoltaic cells globally induced large changes in the Danish electricity mix. 2012 is called the Danish PV boom year, as 70.221 PV systems corresponding to 406 MW were put in operation. At that year net-metering at a level of approx. € 0,3/kW h was agreed. During 2012 the PV deployment in Denmark was stimulated seriously, as the installed grid connected capacity grew from about 13 MW to approx. 406 MW, a growth rate of more than 30 times (IEA, 2013). The most of Denmark's PV installations have a capacity lower than 6 kW, representing 73% of the total PV cell capacity of the country. Their combined electricity production was estimated in 597 GWh for 2014, a percentage around 2% of the country's total electricity production. It is anticipated that by 2024 the total installed capacity of PV cells will reach 1140 MW, corresponding to 1082 GWh electricity production, a percentage of 3% of the total electricity consumption (ENERGINET.DK, 2014).

3.2. Germany

3.2.1. FiT scheme evolution

The electricity feed in law in Germany was established in 1991. In 2000, the Renewable Energy act replaced the previous law, stating that the feed-in prices would no longer be linked to electricity retail prices, but a fixed tariff would be set for period of 20 years. Moreover, assuming that a maturity of the technologies was settled, there was a digression of tariffs; from 2002 new installations would receive lower tariffs and every year the new installations receive a lower tariff than the previous year. In addition, to support the financial economy the tariffs varied for each RES based on the generation cost of each energy plant. Furthermore, the FiT schemes would be reviewed every two years at first and then every four years to account for any technological developments or any price re-evaluation (Held et al., 2007). The amending law of 2004 stated that the tariffs should have been adjusted to reflect the cost situation of RES and therefore higher tariffs applied for geothermal electricity, PV installations and for certain partitions of biomass energy. Regarding wind energy for onshore the tariffs decreased moderately and for offshore the FiTs were high for the initial 12 years after installation. With this law large hydropower plants were now included to the FiT schemes with some conditions (Held et al., 2007). Specifically, the EEG: Renewable Energy Law granted priority grid access to the RES. Also the tariffs for new installations would decrease every year by a specified percentage, 2% for wind energy, 6.5% for PVs and 1.5% for biomass and biogas (de Jager and Rathmann, 2008).

Germany's goal is to generate 35% of the electricity from RES by 2020% and 50% by 2030. Risk factors regarding the promotion of RE would be according to Auer and Anatolitis, (2014).

- the potential significant increase in electricity power costs,
- a delay or non-implementation of RE projects, in case RE producers would lose state funding
- the sharp declination of if the utilization of fossil-fuel power plants in case of insufficient profitability.

3.2.2. Electricity prices

Germany has the second most expensive price of electricity price in Europe. The electricity price in Germany in 2015 was 0.2881 €/kW h and of which 0.154 €/kW h was for the taxes and levies (Eurostat, 2014). The taxes and levies accounted for 51% of the final electricity rate. Specifically the electricity price in Germany was comprised by the cost of power for suppliers (7.1 c/kWh), grid charges (6.7 c/kWh), a concession fee (average: 1.79 c/kWh), a levy for renewable energies (EEG-Umlage 2012) that changes yearly (in 2015: 6.17 c/kWh), a levy for CHP (KWK-Aufschlag 2012) that would change yearly (in 2015: 0.25 c/kWh), a levy for grid charges to large users (0.24 c/kWh), sales tax (4.6 c/kWh) and a standard electricity tax of 2.0 c/kWh. Moreover, above the final price with the taxes the VAT of 19% was added. All these taxes and levies aimed to promote the RES, reduce the number of operating nuclear plants in the country and reduce electricity generation from coal. Replacing the nuclear and coal facilities with RES is responsible for this high electricity cost in Germany.

3.2.3. PV penetration into energy mix

For a decade since the year 2000, Germany observed a steady growth of its PV market, while for the three successive years 2010, 2011, 2012, the new installations remained stable at around 7.5 GW. In 2013, a dramatic drop was observed with only 3.3 GW of new installations. The EEG amendments that revised the tariffs to a lower price constrained the capacity of new installations subjected to the FiT scheme and were the main cause that led to the slight halt in the German PV market. Nevertheless, the German PV market is considered to be the most developed market, with a total installed capacity of almost 36 GW (by 2013), which satisfy the 6% of the country's electricity needs.

3.3. Cyprus

3.3.1. FiT scheme evolution

As an energy insular island, Cyprus faces a number of difficulties in introducing and integrating green energy generation into its electricity mix. Cyprus heavily relies on imported fuels for electricity generation, with Heavy Fuel Oil (HFO) dominating its electricity generation. The absence of indigenous energy resources, the limited infrastructure, the lack of storage, and the flexibility of the power generators to meet seasonal needs promote further the domination of fossil fuels (Poullikkas et al., 2010; Fokaides and Kylili, 2014; Fokaides et al., 2014). However, significant efforts have been done that managed to bring the percentage of RES contribution to the total electricity generation from zero in 2006 to 7.5% by 2013. The island's green energy is currently derived from wind power, biogas and solar photovoltaics (Observ'ER, 2013). In 2003, according to the law (N.33(I)/2003) for the promotion of RES and Energy Efficiency there was a 1.8% annual increase of the electricity consumers' bills ($\sim$0.22 €/kW h) in Cyprus to form a special fund (annual income $\sim$10 million euro) for the support of RES and Energy Efficiency projects (Chrysis, 2009). Under the FiT scheme, the sole electricity provider in the island was obligated to buy the electricity generated by small and large RES systems for a fixed tariff for a time period of 20 years. However, a very different picture is expected in the data to be published for the subsequent years. In combination to the financial recession, the Cyprus Special Fund for RES and Energy Efficiency is expected to collapse, also indicating the collapse of the FiT scheme, while at the same time other schemes that also targeted the further development of the PV market, the auction mechanism in particular, has also been reported to have failed (Kylili and Fokaides, 2015).

3.3.2. Electricity prices

Cyprus is the fifth country in expensive electricity price with 0.236 €/kW h electricity price of which 0.044 €/kW h accounts for taxes and levies which accounts for 18.72% of the total price (Eurostat, 2014). Added to the electricity standard price of 0.1453 €/kW h and the monthly electricity consumption is a standard distribution charge of 3.86€, the levy for promoting RES and energy conservation set at 0.005 €/kW h (as of 15/05/2012), a levy for public service obligations set at 0.00136 €/kW h (as of 1/8/2010) (EAC, 2012), a levy for CO_2 emissions that varies monthly depending on the cost of the CO_2 allowance deficiency at 0.006509 €/kW h. Moreover, the recent destruction of the Vassilikos Power station in July 2011 caused a temporary surcharge of 6.96% (as of 1/10/2011) and it was reduced to 5.75% (as of 1/08/2012) (Fokaides et al., 2014). Added to all the taxes, levies and standard price is the VAT at a rate of 19%.

3.3.3. PV penetration into energy mix

The solar PV market of Cyprus got a late start, observing a significant number of new installations after 2013. In particular in 2015, 50 MW of PV were installed, almost doubling the size of the local market compared to 2013 numbers (Cyprus Transmission System Operator, 2015). The slow development of the PV market in Cyprus in comparison to the rest of the European is partly attributed an accident, which destructed 60% of the island's energy production system a few months after the adoption of the national action plan for the promotion of energy production from renewable sources (European Parliament and of the Council), but also to the bureaucratic, time- consuming licensing procedures for the development of RES projects (Poullikkas et al., 2010; Fokaides et al., 2013). The average time to issue a comprehensive permit for a RET project in Cyprus is between 12 and 24 months, thus greatly decelerating the development of RET projects in Cyprus and also resulting to a series of problems for the RES investors. The hindering of the implementation of RES projects due to unclear timetables is causing devastating financial consequences for the investors. Additionally, the long interval between the launching of the licensing process and the implementation of the project causes investors to redesign their projects according to the state- of- the-art equipment at the time of project implementation. Furthermore, a climate of mistrust in the market to investments in the RES sector has been created, due to the unclear structure of their promotion (Fokaides et al., 2013).

3.4. Spain

3.4.1. FiT scheme evolution

Spain is a country that bloomed in the deployment of the RES, starting from 9.9% in 1997, continuing with a 19.6% share in 2004 (Energy Strategy for Europe, 2007) and reaching a 30.3% RES share in the electricity production by 2012. In 2004, the Royal Decree 436/2004 to ensure the stability and predictability of the model offered to the producer the decision to choose among selling to the electricity distributor at a regulated tariff or selling on the open market through the bidding system. With this decree the operators of large installations ($>$10 MW) were obliged to provide the distributor with a forecast of the electricity they give to the grid at least 30 h earlier (Ministerio de Economia, 2004). This measure aimed to an improved functioning of the system and assurance of the availability of electricity any time. According to the Royal Decree 661/2007; minimum and maximum price was set for the overall remuneration level and the variable premium was determined on an hourly basis. Moreover, the increase of the biomass energy resulted in changes of the biomass tariffs (Ministerio de Industria, 2007). However, in September 2008, a sudden reduction of the FiT by 30% for new PV installations was decided, and another unplanned FiT reduction followed in November 2010, while a month later the production hours for PV installations were limited. A moratorium (Royal Decree Law 1/2012) suspending any support with FiT schemes to all new PV installations followed in January 2012. In January 2013, all PV system owners were obligated to pay 7% tax on income from electricity production. In

February 2013, new tariffs were applied with a 2.7% FiT reduction for all PV installations connected to the grid for the period 2009–2011 (EPIA, 2013). The Royal Decree Law 2 of 2013 in Spain scrapped the option of renewable premium, so only fixed FiTs schemes remained. By 2014, the Royal Decree 413 of 2014 established new FiT formulae and procedures (Philip, 2014). Currently there is a tariff deficit for the FiT scheme that grows further, while the government raised regulated access tariffs to final customers and cut down on remuneration payments to operators.

3.4.2. Electricity prices

The Spanish (sixth place) electricity price is 0.2252€/kW h of which the taxes and levies are 0.051€/kW h, a percentage of 21.38% (Eurostat, 2014). Households in Spain are subjected into an electricity special tax of 5.113% and a VAT of 21% upon the electricity standard price. However, the companies generating electricity either being CHP plants, wind farms or nuclear plants are all subjected to several other taxes such as operation tax, state tax on the production of spent nuclear fuel and radioactive wastes (only applied to companies owners of nuclear generation plants), tax on activities which have an impact on the environment, tax for dumping polluting gases into the atmosphere, tax on visual and environment impacts produced by wind turbines (only applied to the company owner of the wind farm), levy on wind electricity generation and water related taxes (i.e. waste water tax etc.).

The electricity mix in Spain as in most countries was dominated by fossil fuels. However, for the first trimester of 2015 the electricity generation mix was 23.7% wind, 14.5% hydroelectric, 2.5% solar PV, 1.7% thermal renewable, 1.2% solar thermal, 22.7% nuclear, and 33.7% from conventional energy sources; resulting in an overall 43.6% share of RE electricity production (included hydroelectric). Wind and hydroelectric energies account for the largest share in the RE electricity production, followed by solar and biomass. Spain has high potentials for solar energy with solar irradiation at some areas of about (1700 kWh/m^2), producing 11.9 TW h from PV and Concentrated Solar Power (CSP) installations in 2012.

3.4.3. PV penetration into energy mix

Comparing the FiT prices in 2007 with the other investigated countries shows that the purchase price was similar to the rest. Yet, within the context of the financial recession, the FIT scheme created huge overcapacities in the electricity sector that led to strong opposition towards PV from the public authorities and the private electricity sector. The sudden reduction of the FiT by 30% in 2008 led to approximately 46 thousands job losses in the Spanish PV industry, while the measures taken in 2013 not only resulted in a significant reduction of the PV market - with only 118 MW of new installations- but also caused many companies to bankrupt. Furthermore, the levy imposed on prosumers and the discouraging tariffs for grid connection in 2013 is anticipated to further inhibit the development of the Spanish PV market. Another cut of solar subsidies from the Spanish government is the proposed legislation in early June 2015 by the Ministry of Industry, Energy and Tourism which proposed new fees on consumers using batteries for storage of electric power produced by their own solar panels. If this legislation passes then the impact on solar power industry will be tremendous.

The future of the European market is uncertain as the modifications of the current FiT schemes are evidently pushing down the market for the next years. Even in the countries where the PV capacity exceeds 1 GW, there is instability as market confidence is not expected to be restored (Masson et al., 2014).

4. Model for Feed-in Tariff (FiT) schemes viability

According to the FiT evolution in the four examined case countries, the scheme failed due to the weakness of the competent authorities to take justified decisions at the right time. A dynamic model which would consider the appropriate parameters, would allow the realistic prediction of the energy market evolution, and it would prevent the collapse of the scheme. In this section, a model is introduced which describes the feasibility conditions for a FiT scheme. The model is based on the comparative assessment of the prediction of the required capital to support ascending participation of incentive supported RET power plants through the FiT scheme versus the savings resulting from a levy on the electricity price. A parametric assessment of the delivered model is performed, revealing crucial parameters for the feasibility conditions of FiT schemes.

The model assumes a constant annual increase of the electricity price as well as an ascending electricity consumption. The rate of growth is assumed in both cases to be equal to the average rate of growth of the GDP (EG). Also the model is based on an annual steady increase of the contribution of RET to the energy mix of the discussed systems. The model assumes a fixed price in FiT. This price is given as a percentage of the cost of electricity in year 1 and it is adjusted annually based on the cost of electricity at the given year.

The mathematical formulation of the model is given in Eqs. (1)–(8).

- The electricity consumption (EC) in year n is given with the use of the following equation

$$EC_n = EC_{n-1}{*}(1{+}EG) \tag{1}$$

- The contribution of RET (R) in the energy mix of the examined cases in year n is calculated based on a constant penetration rate (PR):

$$R_n = EC_{n-1}{*}(1{+}EG){*}PR{*}n \tag{2}$$

- The revenue from fossil fuel based electricity (FR) in year n is given with the use of the following equation

$$FR_n = EP_n{*}(EC_n - R_n) \tag{3}$$

where EP is the electricity end price in year n given as

$$EP_n = EP_{n-1}{*}(1{+}EG) \tag{4}$$

- The cumulative revenue of the FiT fund (RF) in a period of x years is calculated with the use of a constant levy (LP), given as a percentage of the cost of electricity at year of hypothesis:

$$RF = \sum_{n=1}^{n=x} (ER_n){*}EP_n{*}LP \tag{5}$$

- The cumulative expenses to support the RE production with the FiT scheme (EF) are calculated by assuming a fixed FiT rate (FiTR) using Eq. (6)

$$EF = \sum_{n=1}^{n=20} (R_n){*}FiTR_n \tag{6}$$

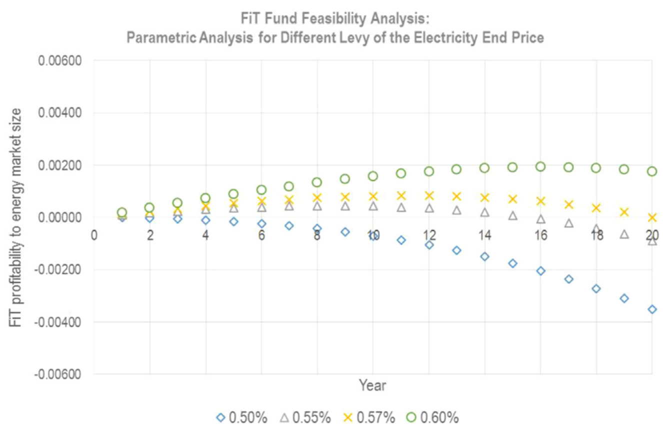

Fig. 2. FiT fund feasibility analysis: Parametric Analysis for Different Levy of the Electricity and Price.

- For the purpose of this model, the FiT rate is calculated as a percentage of the cost of electricity (FP) at year n

$$FiTR_n = EP_n^{*}FP \tag{7}$$

Based on the above analysis, the viability condition for FiT funding scheme is that the cumulative revenue of the FiT treasury (RF) should be greater at any time of the analysis than the cumulative expenses to support the RE production with the FiT scheme (EF).

$$\sum_{n=1}^{n=x} (ER_n)^{*}EP_n^{*}LP > \sum_{n=1}^{n=x} (R_n)^{*}FiTR_n \tag{8}$$

In Fig. 2–4 graphical solutions of the proposed model are depicted. The parametric analysis of the study is represented in the form of curves through functions of a different variable. The model assumes the input of Table 3. Fig. 2 examines the impact of the levy as a percentage to the end electricity price. In Fig. 3 the impact of the RE penetration rate (PR) is analysed and in Fig. 4 the sensitivity analysis of the economic growth rate (EG) is performed.

As it can be retrieved from Fig. 2, with the given parameters in Table 3 the FiT the sustainability of the FiT fund is achieved for a levy as a percentage to the cost of electricity (%) (LP) of 0.567%., a lower price compared to the existing levies in the examined countries, as discussed in Section 3. In Fig. 3 it is also revealed that the penetration rate (PR) of RE in the energy mix of the examined countries is a highly sensitive parameter, as the viability of the FiT fund is significantly affected by its variation. Particularly for higher PRs (1.2%) the fund becomes non-feasible just within the third year of its operation, whereas for PRs at 1%, the fund meets its break-even point at the end of the investigated period (20 years). Apparently lower PRs result to less requirements for the FiT treasury, resulting to a feasible scheme. In Fig. 4 the impact of the economic growth rate (EG) is examined. Surprisingly it is revealed that the counter impact of financial recession to the energy consumption, and thus to the penetration rate of renewables affects positively the performance of the FiT treasury. It is also revealed that the impact of the EG is of less magnitude compared to the corresponding impact of the other two examined parameters (levy to fossil fuel energy revenue, renewables penetration rate).

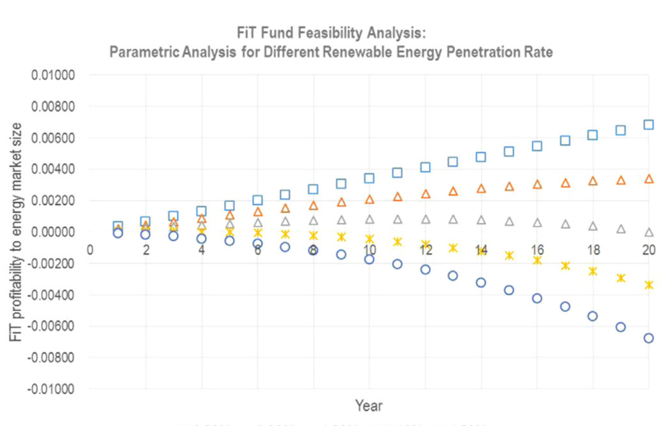

Fig. 3. FiT fund feasibility analysis: Parametric Analysis for Different renewable energy penetration rate (PR).

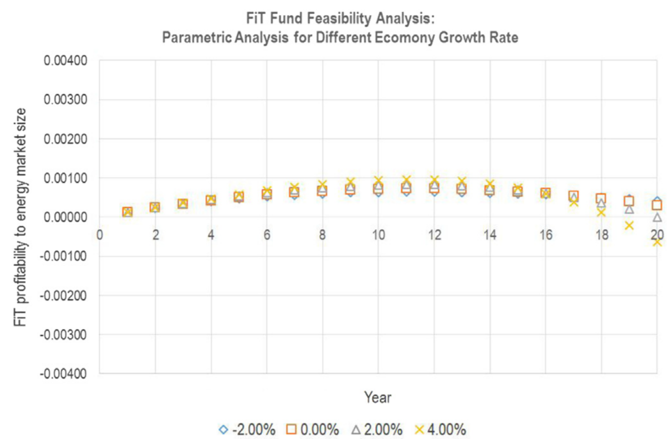

Fig. 4. FiT fund feasibility analysis: Parametric Analysis for Different Economic Growth Rate.

Table 3
Assumptions of FiT scheme viability model solution, depicted in Fig. 2–4.

Data	Fig. 2	Fig. 3	Fig. 4
Period of analysis (x)	20 years	20 years	20 years
Renewable Energy annual penetration rate (PR)	1%	0.8–1.2% (step of 0.1%)	1%
Economy annual growth rate (EG)	2%	2%	−2 −4% (step of 2%)
Cost of Electricity at year 1 (EP1)	0.20 €/kW h	0.20 €/kW h	0.20 €/kW h
Levy as a percentage to the cost of electricity (%)	0.5–0.6% (step of 0.05%)	0.57%	0.57%
Percentage of electricity end price of FiT rate	50%	50%	50%

5. Policy implications

The analysis in Section 4 revealed the conditions under which a FiT could collapse. Low levies and high FiT rates, together with the high penetration rate of renewables constitute the parameters that led to the collapse of the FiT schemes. The FIT scheme collapse in Cyprus and Spain was caused when the renewable production reached a level so high that it started to impose a positive net cost on the system (Ciarreta et al., 2014), while the most recent data for Demark and Germany indicate the reluctance of RES investors to new projects due to the discouraging low tariffs.

PVs prices have decreased the past years rapidly, challenging the FiT policy makers as the annual digression rate and the high interest in installing PV systems could not pre- defined. Therefore countries applying FiT schemes are required to re-evaluate their tariff payment levels for PVs to offer a less aggressive deployment of PVs in the electricity grid without disorientating the existing scheme. Although PVs have high potential for further exploitation, the initial cost for installation is still high and government support is required. Nonetheless, generous tariffs lead to higher profit to the RE producers but cause an economic instability, whereas low tariffs may prevent investment on RES (Ciarreta et al., 2014).

By reviewing the regulatory and policy framework on the FiT schemes, their history and how the solar PV markets of the case study countries were affected by the FiT schemes, it becomes evident that the schemes adopted by the regulatory authorities targeted the promotion and development of RES exploitation. It cannot be argued that the FiT schemes have been proven very successful and effective in the first years of their implementation. However, the fact that the solar sector in Europe has grown considerably, could be attributed to the feed-in-tariff laws, and it may be considered as a success of the scheme. Europe has watched the blooming of the PV market in 2008, due to the introduction of very attractive FITs, in combination with the significant reductions achieved in the capital costs of solar PV systems.

Though, the FiT schemes in the case study countries have been recorded to have failed the subsequent years up to the present. The generous tariffs supplied to the RE producers by the FiT schemes led to the rapid development of the technology and extremely high profits to the RE producers, which were typically guaranteed for the next 10–25 years. The adoption of the specific scheme has led in most cases to economic instability and distortion of the electricity prices. The electricity prices with taxes and levies were increased by 27% in Denmark, 42% in Germany, 46% in Cyprus and 60% in Spain from 2007 to 2014. Accordingly, the re-evaluation of the FiT scheme was the next likely step. In 2014, 20 out of the 68 countries worldwide implementing the FiT scheme are subjected to its amendment (REN21, 2014).

Exemplified from the four investigated countries the revision of the FiT scheme has concluded to very low tariffs or other additional taxes that are not only discouraging, but in some cases such as in Spain are prohibitively for the implementation of new RES projects. Consequently, a stand- still of the European PV market is currently observed. For the prevention of the collapse of the scheme, the tariff's value ought to be determined by each country's government based on a set of influencing factors including the operational, capital and investment costs of each RET, the standard cost of RE generation, the avoidance cost, which would be regularly reviewed depending on the excess of the annual capacity. A successful FIT scheme should be a tool for policy makers in order to achieve sustainability in the energy sector at the minimum social cost (Boemi and Papadopoulos, 2013).

Another issue to be raised here regards the grid parity of RES. Grid parity is defined as the threshold at which a grid-connected RES system supplies electricity to the end user at the same price as grid-supplied electricity. Grid parity varies for solar PVs as they produce power at different costs in different locations but also their installation costs vary according to the labor, permitting and maintenance costs. It is a fact that the price of PVs in 1977 was $76.67/W and dropped to $0.34/W by 2014 for crystalline silicon solar cells, while at the same time recent evidence suggest that solar PV grid parity has already been reached in countries of the Mediterranean basin, such as Cyprus (Energy Trend, 2014; Fokaides and Kylili, 2014). Since grid parity is considered the peak of RES, should any financial incentives still be available for the RE producers? Or should the policy- makers take measures that would make the specific technology a standard?

Undoubtedly, the potential for development of the RES electricity market, and in particular of the solar PV market is huge in the European countries. Based on the findings of the financial analysis conducted in this paper, the current tariff schemes rather represent the unwillingness of the governing authorities for the further development of the RES market. Nevertheless, part of the responsibility for the collapse of the FiT schemes should also be credited to the deep financial recession the majority of the European - and especially the Mediterranean - countries are currently found. The recession has also led to the unwillingness of the banking sector to fund almost any sort of medium- or long-term investments, although they are otherwise considered to be sound investments (Boemi and Papadopoulos, 2013). Despite other externalities, FiT schemes should reflect a realistic compensation for the investor, which is neither overoptimistic nor discouraging, as well as a reasonable burdening cost for the energy consumer. The great potential for the further growth of the European RES market will be unlocked once efforts and resources are distributed strategically and wisely along with regular monitoring.

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