Energy Tariff Policies for Renewable Energy Development: Comparison between Selected European Countries and Sri Lanka

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Review

Energy Tariff Policies for Renewable Energy Development: Comparison between Selected European Countries and Sri Lanka

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Abstract: This article is written within the European Project "THREE-Lanka" which has the aim of modernizing the higher education related to Renewable Energy (RE) in Sri Lanka. The paper presents the outcomes of analysing various incentive schemes to stimulate RE development. In Europe, there was substantial growth in RE installation through generous incentives in the first years. Then, to regulate this growth, in recent years, the auction system has been introduced to improve the competition among companies that install RE plants. In Sri Lanka, on the other hand, the main energy tariff policies focus on the spread of PhotoVoltaics (PV) through contributions based on the electricity fed into the grid. This paper provides an updated view of the evolution of the energy tariff policies in the relevant European countries with respect to Sri Lanka, covering some recent policy developments. Within the Sri Lankan framework, four case studies involving residential, commercial, and industrial users are outlined to suggest better mechanisms (in the case of not adequate current incentive tariff) for supporting the deployment of grid-connected PV systems in a wide power range. Such knowledge transfer in the THREE-Lanka project will demonstrate the enormous potential RE capacity in a developing country, still depending on fossil fuels but willing to follow the path towards sustainability.

Keywords: renewable systems; energy policies; feed-in tariffs; contract for difference; incentive; auction

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1. Introduction

Energy policies are key elements of the sustainable development involved in the energy transition currently in progress. The European Green Deal introduced in December 2019 is a set of energy policies accepted by all states in the European Union (EU), having the objectives of increasing the sustainability of the European economy for reaching a zero-carbon economy by 2050 and decoupling the economic rise from the utilisation of natural resources [1,2]. The declared target set by the European Green Deal with the European Climate Law is to reach climate neutrality by 2050. An intermediate target of reducing net greenhouse gas emissions by at least 55% by 2030 compared to the values recorded in 1990 was presented in the "Fit for 55" package. This package aims to align the EU legislation with the 2030 goal by revising the legislation on climate, energy, and transport [3]. To reach the objectives of the European Green Deal, significant incorporation of new green energy capacity will be necessary for a limited time period. Solar photovoltaic (PV) is considered one of the most promising technologies which have achieved a high level of development, being now the one considered to lead the transition to zero emissions in the EU [2,4,5].

The ability of countries to efficiently address climate change problems requires substantial financing. An important rise in the renewable energy (RE) share in the energy mix is decisive for reaching a CO_2 emission level consistent with the Paris Climate Agreement [6] signed in December 2015 by 190 countries. The Paris Climate Agreement is the first framework for legally binding climate change. Its goals include limiting the global temperature rise and setting a global emission peak of about 40% by 2030 [7].

The diffusion of RE technologies for electricity generation is the core of energy sector decarbonisation [8,9]. Public policies to promote RE technologies have been applied in developed countries since the 1980s within a niche market strategy. Since the 2000s, more developing countries have implemented support policies [10]. After a sharp cost decrease in some RE technologies (e.g., PV and wind [11]), these policies aim at a prevailing RE share in the electricity mix.

Different incentives or support schemes or mechanisms are used for supporting RE policies around the world [12], for example:

➢ Investment subsidies: given by a Government to refund (part of) the investment in RE technologies, defined in EUR/kWh or as a percentage of the total investment. In particular, capital subsidies may be applied to capital, interest rates, or other ways to reduce the cost of capital [13].
➢ Feed-in Premium (FiP) schemes: the RE producers receive an additional revenue (premium) with respect to the market price. The premium can be constant or variable. The RE producers can earn good additional revenues when the market price is high. However, they are exposed to the risk of having low revenues when the market price is low. The risk can be reduced by introducing caps to the payment.
➢ Feed-in Tariffs (FiT): define the rate that is paid to a RE producer for the electricity generated by the RE system and fed into the grid. The FiT generally depends on the RE technologies, which have different generation costs. FiT is not a competitive support scheme because the Government establishes a price for the energy to be purchased by utilities, and all RE producers search for a contract to sell RE at that price. The choice of the RE producers is based on the principle of first-come-first-served until the desired quota is finished.

The FiT contains three key points:

- Access to the electrical network is provided.
- There are long-term (15–25 years) contracts for electricity generation.
- The specific costs of each RE source influence the buying prices (usually higher than market prices). Tariffs may change between the different power generation sources, influenced by the place where the PV plant is installed (e.g., ground-mounted or rooftop), the project size, and the technology used (PV, wind, etc.). FiT offers a guaranteed acquisition for electricity generated from RE sources with long-term contracts [14].

The reference [13] specified that by 2003, 18 European countries had implemented the FiT incentive. According to the annual reports from 2005 to 2015 of Renewable Global Status Report REN21, FiT has then become one of the most used incentives in the world due to its financial stability in the long term.

➢ Tradable Green Certificates (in Europe) and Renewable Portfolio Standard (RPS) (in the US and in Japan), issued by a regulatory agency: for each MWh of electricity generated by RE sources, the producer receives a certificate that can be traded with other producers. Thus, any producer can cover its RE production target through its own or purchased certificates, even with insufficient RE production. Different from other markets, a dedicated financial market can be set up for green certificates. In this market, the RE producer receives additional payment for the energy generated with respect to the revenues obtained from the energy market [15]. The market price for trading certificates depends on the RE technology and the energy demand and supply in the market. If the market price is high, RE producers are incentivised to produce more renewable electricity [16]. The Renewable Portfolio Standard (RPS) is also known as the Renewable Electricity Standard in the US and Renewable Energy Certificates (RECs) or Renewables Portfolio Obligations (RPO) in the UK. The RPS establishes a quota (with which the energy suppliers are obliged to include RE sources as part of their energy supply mix) for RE as the final objective. The RE suppliers will compete in price to obtain a market share of this pre-set quota. The RPS policy usually imposes the duty for the electricity providers to produce a specified part of their electric energy from RE sources. That would mean the electricity providers would receive a minimum percentage of their power from RE sources, which is clarified by RE certificates. The certified RE generators receive certificates for each electricity unit produced and can sell the certificates with their electricity to other suppliers [14].

➢ Contract for Difference (CfD): The CfD is a bidirectional support payment representing the difference between the striking price of electricity and the market reference price, considering that the market reference price is variable with time while the strike price is predetermined and fixed. In the case of RE projects, the strike price reflects the investment cost related to certain technology and is established through auction. The market reference price is obtained from the historical evolution of the market prices. There are two possibilities for the CfD payments, as shown in Figure 1:
  - if the market reference price (grey rectangle) is less than the strike price, the electricity generator is paid by the CfD counterparty (green rectangle);
  - if the market reference price is higher than the strike price, the CfD counterparty is paid by the electricity generator (yellow rectangle) [17].

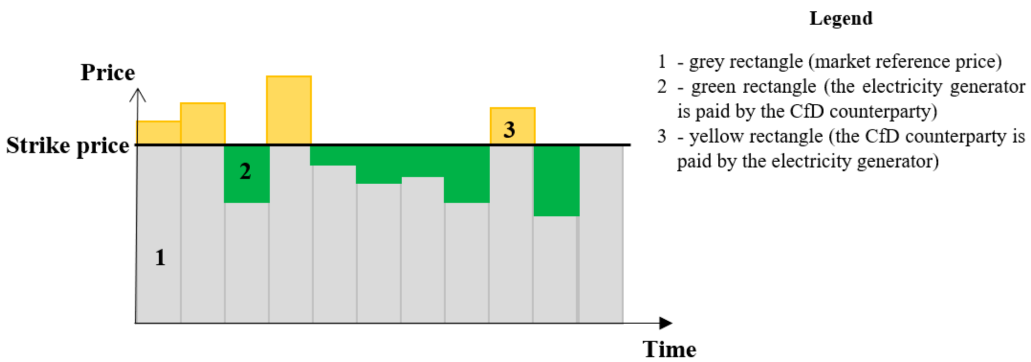

Figure 1. Representation of the CfD payments [17].

➢ Tenders for contracts: RE producers are invited by a public institution to compete based on a given budget. The contract is given to the winner of the tender, generally the RE producer that sent the cheapest offer. The tenders can be different for different RE technologies. Tenders with competitive bidding for allocating RE payments are indicated as auctions [18]. The number of auctions in Europe has increased in recent years [19], as foreseen in the early review presented in [20]. The elements for designing an auction include financial pre-qualifications (to ensure that the offers are viable), deadlines for the implementation of the project or activity referring to the auction, possible flexibility for adapting the targets, and penalties applied to the RE producers in case of non-compliance to the targets (even with the exclusion from future auctions) [19,21,22]. Another aspect is the difference between technology-neutral auctions (in which any RE technology can participate) and discriminatory auctions (in which there is a distinction among different classes of participants). The possible conflicts among the targets of these different types of auctions are discussed in [23].

- ➢ Power Purchase Agreements (PPAs): In these agreements, the RE system is installed on the property of the user. However, the RE system is owned, operated, and maintained by a third party [24]. There are different versions of the PPAs. In physical PPAs, the user has a financial arrangement to receive the electricity produced at an agreed price. The third-party benefits from possible incomes generated by selling electricity and tax credits. In virtual PPAs, the third party sells energy to the market. If the market price is higher than the price agreed upon by the user, the user will receive the difference. However, if the market price is lower, the user is hedged and has no payment.
- ➢ Net metering schemes: Net electricity is the difference between the electrical energy generated by the user's plant and fed into the grid and the electrical energy supplied by the distribution grid to the user. The use of a net metering scheme requires the presence of a bi-directional meter to identify the energy injected into or taken from the distribution system. Customers pay only for the net electricity used [25,26].
- ➢ Fiscal instruments: Various instruments can provide fiscal discounts or fiscal exemptions from energy taxes, tax refunds, and reduced Value Added Tax (VAT) rates for RE producers.

The overview of energy policies [27] in three non-European countries (the U.S., China, and Brazil), found a strong connection between the RE development and subsidy schemes. Other examples are found in Australia, where the Large-scale Renewable Energy Target (LRET) provides incentives for investing in RE stations [28]. In Japan, the new FiP scheme introduced in April 2022 supports RE sources in addition to the existing FiT scheme [29]. The situation is in rapid progress, accelerating the path to decarbonisation.

A different context appears in the countries with high fossil fuel production. The governments of the Gulf Cooperation Council (GCC) countries have as the targets the decarbonization for 2030. Over time, the GCC countries may become uninhabitable due to climate change if governments do not adopt a dynamic energy policy focused on reducing dependence on fossil fuels. GCC countries must include more RES in their energy mix and diversify their energy resources. To achieve this goal, governments must focus on different strategies and reforms at the political and social levels. In this case, the GCC countries' success in adopting RE will be a perfect model for other countries in North Africa and the Middle East [30]. The last research on RE development in some Arabian Gulf states (e.g., Qatar) highlights that a deep understanding of the people on the environmental issues, as well as the action and the support of the governments, are useful to expand renewables, decreasing per capita electricity consumption, and encourage behavioral amendments in the energy consumption [31,32]. At this moment, there are few incentives to decrease individual energy consumption [31], but the authors of [32] highlight that it is improbable that these proposed ambitions will be obtained in an opportune manner.

In the Gulf countries, there are no taxes compared with the European tax incentives that are motivational. This shows that economic diversification should come first, as there is a lack of economic incentives to motivate the citizens to agree and use RE [31,33]. There are no clear government incentives to limit electricity demand due to many fossil fuel resources. The electricity financial affordability combined with the warm climate results in high demand for cooling and raised total electricity consumption.

This paper provides an updated view of the evolution of the energy tariff policies in a group of relevant European countries, with the aim of providing a summarised framework for possible application in Sri Lanka. The selected European countries are the EU partners of the "THREE-Lanka" project (Italy, Romania, and the UK). Moreover, Spain and Germany were added for a wider coverage of the solutions implemented over time in the EU. The various alternative policies have been applied and changed on the basis of the impacts of each policy, the technological evolution, and the opportunities for profitability offered to the users from the various policy solutions. The focus on Sri Lanka comes from the framework of the European Project "Training Hub of Renewable Energy Technologies for Sri Lanka (THREE-Lanka)" [34], under which the contents of this paper have been elaborated (The THREE-Lanka project aims to modernize and internationalize higher education in engineering sciences related to renewable technologies in selected Universities in Sri-Lanka. It is done through the innovation of the technician, MSc, and project manager curricula according to the labour market demand and the new development in the area). The aim is to provide a broad discussion on the historical policies developed with different strategies in the selected European countries, using the results of the discussion in the debate for promoting effective RE policies in Sri Lanka. Regarding renewable sources, in this paper, more attention is given to the policies for PV development, which is of predominant importance in the "THREE-Lanka" project for Sri Lankan development, according to the survey presented in [35]. This paper also presents four case studies involving residential, commercial, and industrial users. Better mechanisms for supporting the deployment of grid-connected PV systems are proposed in the case of not adequate current incentive tariffs.

The rest of the paper is organised as follows: Section 2 describes energy policies in selected EU countries. Section 3 assesses the RE policies in South Asia. Section 4 deals with RE policies in Sri Lanka with a particular focus on new tariffs proposed for PV systems of residential users and commercial/industrial users. The final section contains the concluding remarks.

2. Analysis of RE Policies in Selected EU Countries

2.1. General Aspects

The EU has updated its energy policies in recent years. Among the main reasons for this update, there are the energy dependence on other states, the high and volatile prices of electricity, the increase in demand, the risks and security of supply, and climate change. On this last issue, the EU has undertaken very important actions and set the Green Deal ambitious objectives. To achieve these goals, the first step is the decarbonisation of the energy sector by encouraging electricity production from RE sources. In this scheme, each Member State must undertake long-term national political actions in line with the goal stipulated by the Paris Agreement (i.e., keeping the global temperature increase below 2 °C compared to 1990). As for RE sources, the EU Directive 2018/2001 set the goal of reaching 32% of energy consumption produced from RE sources [36]. Additionally, in 2021 an increase to 40% by 2030 was proposed. Each country sets its own goals and individual actions through ten-year development plans, showing progress every two years.

In the past, when the gap between the cost of producing electricity from traditional and RE sources was wide, FiT was useful to incentivise RE diffusion because of the low investment risk. Thereby, most EU Member States supported RE by implementing FiT in a cost-effective way, leading to high investments in RE. Later, FiT and FiP were considered the main instruments in 20 European countries [37], with a trend towards FiP to motivate the producers to respond to market developments [38]. Some EU countries used FiT as the only incentive (e.g., Germany). Other EU states used quota obligations to sustain electricity from RE (e.g., Sweden, Poland, and Romania). In addition, Spain, Italy, Slovenia, the Netherlands, Estonia, Denmark, Finland, and the Czech Republic used FiP as the main instrument or a part of the instrument mix.

More recently, it has been considered that auction mechanisms could reduce investment risk [5]. Hence, auction mechanisms, which were removed in past years, appeared again in Italy, France, and The Netherlands. In most cases, the same type of support is used for all RE technologies, though to different extents. Auction mechanisms, such as FiT, support RE technologies close to becoming competitive in the relevant markets. In the review carried out in 2018–2019 for EU countries [39], the main four RE support schemes were FiT, FiP, green certificates, and investment grants.

In the following sub-sections, policies for the development of renewables in selected European countries are presented. The selected countries are the EU partners of the "THREE-Lanka" project (Italy, Romania, and the UK). Moreover, Spain and Germany are included for a wider coverage of the solutions implemented over time in the EU, due to their historical importance in RE policies and the current high installed power.

2.2. Energy Policy Analysis in Italy

In Italy, the FiT was supported by the "Conto Energia" (CE) program and was abolished starting on 5 August 2013 for new PV systems. The FiT development in Italy is analysed in [40] and in [41]. From 2005 to 2012, the scheme for PV systems was changed five times. In its latest version, which came into force in 2012, the PV plants were divided into three categories: traditional PV plants (TPV), PV plants integrated with buildings (BIPV), and concentrating PV (CPV) systems (in which sunlight is focused onto the solar cell with the help of optical devices [42]).

The article [43] highlights the FiT incentive system in Italy and its evolution over time. Each CE version has set objectives for installing new plants; when certain objectives were achieved, the incentive scheme was modified. Up to the fourth CE version, a premium rate was paid for each kWh of electricity fed into the grid. Between the first and fourth versions, the tariff was reduced. In the fifth version, an all-inclusive tariff was introduced for the electricity fed into the grid. The premium tariff was only applied to self-consumed energy. In this way, the on-site electricity consumption by the producer was promoted, limiting the sale of energy. In the previous CE versions, all the kWh produced by PV plants received incentives.

In the latest version of the CE, the incentive rate is on average 0.11 EUR/kWh and is limited to self-consumption for PV systems [44]. The results of energy policies in Italy are discussed in [45]. Through the implementation of the CE program, Italy has increased the installed power of PV systems by 120% per year, installing 17.6 GW by 2018. One of the primary benefits of this scheme was the reduction in the installation cost of new PV systems, from 7.2 EUR/W to 1.3 EUR/W.

Another incentive scheme widely used in Italy is the "Scambio sul Posto" (SSP) [40,46]. One of the main advantages of RE systems (e.g., PV and wind) is the possibility of combining these systems directly with a load: the consumer is able not only to consume energy but also to produce it. Within this context, the SSP is used as an economic incentive for the consumer. Through this system, the distribution grid is used as a virtual storage system for electrical energy. Surplus PV energy is fed into the grid, while the energy demand not met by the PV system is taken from the grid. The energy withdrawn from the grid is generally paid at the market price; thanks to the SSP system, it is partially reimbursed by the grid operator. This refund is calculated by accounting for the energy fed into the grid and the energy withdrawn from the grid [47]. This calculation also considers the difference in the price of electricity in the market, based on the day and year. The calculation of the SSP rate, shown in [45], considers various parameters, such as the economic value of the energy withdrawal, evaluated based on the national electricity price. The economic value of the input depends on the zonal price of electricity. In addition, some bonuses are also considered (e.g., tax refunds). A reference example in [48] shows the SSP calculation for a PV system of 150 kW for 2012. Making some assumptions, the energy fed into the grid is valued at 10 cEUR/kWh and withdrawn at around 18 cEUR/kWh. Through these values and with the energy measurement, it is possible to calculate the value of the economic contribution that the Energy Services Manager (GSE) recognises to the customer on an annual basis. The services share allows the costs incurred for the use of the grid to be returned to users. The Legislative Decree n. 199 of 8 November 2021 abolished the SSP. For the energy plants operating under this scheme, a gradual conversion to other mechanisms is planned from 31 December 2024 [49].

To promote the installation of small, medium, and large size RE plants, competitive procedures have also been used in Italy. Following the Ministerial Decrees of 6 July 2012 and 23 June 2016, the Ministerial Decree of 4 July 2019 planned the use of the auction and register mechanism. Based on the power (p) to be installed, plants can participate in register ($p > 1$ kW or 20 kW for PV plants and $p < 1$ MW) or auction ($p \geq 1$ MW) procedures. Depending on the size of the plant, it is possible to choose between two incentive mechanisms: an all-inclusive tariff or an incentive applied on the minimum between the net production and the energy injected into the grid. For each source and type of system, the all-inclusive tariff is calculated by subtracting from the reference tariff a percentage determined in the competitive procedure (offered tariff). The offered tariff may be reduced further if certain constraints and deadlines are not respected. The incentive is calculated by subtracting the hourly zonal price of electricity from the all-inclusive tariff, and it is applied when the energy remains available to the producer, i.e., the energy is not withdrawn by GSE. Up to now, nine competitive procedures have been completed, and the tenth public call for registration in registers and auctions closed on 30 October 2022 [50].

For the electricity not consumed on-site and fed into the grid, a simplified scheme called "Ritiro Dedicato" (RD) has been available since 2008. If RE producers decide to join the RD, avoiding direct participation in the national electricity market, the energy fed into the grid is purchased by GSE. Unlike the SSP, the grid is not used as virtual storage, but each kilowatt-hour injected into the grid is transferred to the GSE, which pays the producer a price depending on the type of plant and on any additional incentive granted to it. The producer can request the application of the minimum guaranteed prices, set annually by the Italian Authority for Electricity, Gas, and the Water System (ARERA), and differentiated by energy source and amount of energy produced. Otherwise, the price is the hourly zonal price determined on the electricity market and depending on the time of energy injection and on the market area in which the plant is located. The RD is not compatible with the SSP and other incentive mechanisms that already consider the remuneration of electricity fed into the grid [51].

2.3. Energy Policy Analysis in Germany

Germany was one of the first nations in the world to take political action to subsidise the deployment of RE. Following the Electricity Supply Act, introduced in 1991, from 1991 to 1999, thanks to the Stromeinspeisungsgesetz (StrEG) system, the tariff was paid by the distributor to the producer, according to the market analysis of the previous two years. The main incentive that played a key role in the extension of RE in Germany is the Renewable Energy Sources Act or Erneuerbare Energien Gesetz (EEG), adopted in 2000 and revised several times. The first major amendment for EEG in 2004 extended and increased support for solar energy. From 2009 to 2012, other amendments adjusted the legislation to fast innovation in the PV sector as well as to quickly drop PV module prices [52]. From 2014 to 2016, the amendments progressively introduced RE auctions [53].

The EEG is based on a FiT or FiP scheme to support renewable electricity. The costs from FiT were covered by consumers through a surcharge on the electricity bill (EEG surcharge) [53,54]. The EEG mechanism is based on three features:

- ✓ A payment system with fixed revenues, higher than the market price, different depending on the technology, and guaranteed for 20 years. A different manner represents the quota system under which the element fixed is the quantity of RE or capacity and not the price per kilowatt-hour of the electricity fed in from RES.
- ✓ Feed-in priority for the electricity produced.
- ✓ The network operators guarantee to connect the plant installed, choosing the connection point in the nearest location most appropriate in terms of voltage level. Among the technical procedures of the systems to be connected, there is the remote-control capability to temporarily decrease the feed-in capacity for the network. Network operators must buy renewable electricity and accord priority access to the network. Commercial companies transfer the financial deficit (feed-in tariff minus market price) toward end users by imposing a surcharge [55–57].

The cost calculation analysed in [58] results in the difference between the price guaranteed to suppliers for the energy injected and the actual market price. According to this study, the surcharge has increased over the years, reaching 6.9 cEUR/kWh in 2017, compared to 2.1 cEUR/kWh in 2010. However, the incentive rate has decreased over the years. Solar PV equals 12.2 cEUR/kWh in 2017 if the installed power is less than 10 kW, but in 2006 the tariff was 51.8 cEUR/kWh. The use of this scheme brought the installed PV power from 2.9 GW (2006) to 42.3 GW (2017).

As regards the wind power sector, the incentive system in Germany for this source up to 2014 is analysed in [59].

In [60] it is determined that the FiT system has had little success in recent years. This is due to the increase in the surcharge that each consumer must pay to subsidise the plants. Moreover, strong popular criticism has shown that large consumers, such as very energy-intensive companies, are exempt from paying this surcharge. The strong growth in the installation of PV systems found the German Government unprepared: many PV plant manufacturers were unable to compete in the market with technologies from China. For this reason, the Government was forced to introduce an import tax for Chinese modules.

In the last few years, there has been a significant drop in the prices of the PV systems to be installed on the rooftop. In addition, battery storage to increase the self-consumption has become more economically viable. In Germany, the principal share of RE production is given by wind power, ground-mounted PV, and biomass [56].

Germany was one of the first countries in the world to use the auction system as an incentive scheme [61]. The efficiency and effectiveness of the RE auction in Germany are illustrated in [62]. After the success of a pilot program started in 2015 for ground-mounted PV, which increased by 400 MW, since 2017, all PV plants with sizes starting from 750 kW had to participate in an auction to receive incentives [22]. In [63] it is discussed how the German EEG has been changed from 2017 onwards. The system of incentive tariffs was abandoned, and a new system was introduced, in which the incentive is paid thanks to the competitive systems of auctions. During the auction phases, the power account is assigned, while the incentive is paid for each kilowatt-hour produced.

The auctions are divided according to the technology and the size of the plants. Participants specify the prize they would prefer to receive for each kWh produced. The plants that win the auction sell the energy produced on the market at market prices and subsequently receive the incentive as the difference between the price determined at the auction and the market price. In [63], the results of some auctions held in Germany for PV and wind systems are shown. For PV, the price of the offers was 9.2 cEUR/kWh in 2015 and 4.9 cEUR/kWh in 2019, showing a constant decline until 2018 and a slight increase in 2019. There was a rapid decline in prices in its first year (2017) for wind power, going from 5.7 cEUR/kWh in the first months of the year to 3.8 cEUR/kWh in November.

In Germany, there are no direct subsidies for the increase of storage systems. However, several strategies have been put in place to increase the installation of these systems. For example, for small-sized PV plants (less than 30 kW) combined with a storage system, funds that allow loans with subsidised rates and subsidies are available. With the "Battery 2020" program, grants of up to 50% of the capital are provided for the design of new lithium-ion systems [64]. In [65], it is shown that the increase in the price of electricity and the reduction of FiT were other important elements for the diffusion of storage systems. With the Government's willingness to shut down several nuclear power plants, the price of electricity has risen. This difference between the price of the energy injected and withdrawn pushed many users to invest in storage systems.

In 2022, Germany passed the largest energy policy revision in decades. Five legislative acts have been amended to accelerate the expansion of RE (the EEG, the Offshore Wind Energy Act, the "Act to Increase and Accelerate the Expansion of Onshore Wind Energy Installations", the Federal Nature Conservation Act, and the Energy Industry Act). The German goal is to double the share of RE in gross electricity consumption in less than ten years. In particular, the revision of the EEG sets out the new RE capacity targets and the measures to achieve them [66]. In addition, it eliminates the EEG surcharge from the electricity bill since July 2022.

2.4. Energy Policy Analysis in Spain

In Spain, through the "Real Decreto 661/2007" [67], the production of energy from renewable sources and cogeneration technology was encouraged. The incentive system depends on two schemes. The first one provides for the payment of a regulated tariff to plants that decide to inject electricity into the distribution or transmission grid. The second one provides that the producer receives a tariff calculated according to the electricity market prices plus a possible production premium. For solar PV plants and wind farms, the incentive system is determined by the regulated tariff. Moreover, the sale price is invariable for each kWh fed into the grid. In the case of solar PV plants, the tariff is divided into three categories according to the installed power: 44.0 cEUR/kWh (p <100 kW), 41.8 cEUR/kWh (100 kW < $p \leq$ 10 MW), and 23.0 cEUR/kWh (10 < $p \leq$ 50 MW). In the case of the wind power installed onshore, the tariff is equal to 7.3 cEUR/kWh for the first 20 years and 6.1 cEUR/kWh for the following years.

Applying the "Real Decreto 661", the PV systems installed had an exponential increase, far overtaking the objectives established by the decree. For this reason, a new decree ("Real Decreto 1578/2008" [68]) was useful in regulating the diffusion of PV technology. In this new decree, the goal was based on new technological advances. In the Real Decreto 1578/2008, the systems are divided into two categories, those installed on a lot with urban cadastral reference (buildings, parking lots, etc.) and all the others. The new regulated tariff is equal to: 34.0 cEUR/kWh for plants of the first type (I.1) with an installed power of less than 20 MW and 32.0 cEUR/kWh for plants greater than 20 MW (I.2) and all plants of the second category (II).

Through the "Real Decreto 1565/2010" the incentive scheme was reduced again, and in 2013 the FiT was equal to 24.8 cEUR/kWh for Type I.1, 17.5 cEUR/kWh for type I.2, for Type II was equal to 11.5 cEUR/kWh. In addition, a restriction was placed on the operation of PV systems. In other words, the incentive rate was no longer paid when the equivalent solar hours reached a certain limit. When this constraint was further reduced, many plants exceeded the corresponding maximum number of hours. So, the FiT was suspended and consequently, many plants were no longer profitable. For fixed-axis PV systems, the maximum value of solar equivalent hours was 1250 kWh/kW until 2013. Finally, in 2012 the FiT incentive system was removed for new plants, not just photovoltaic ones [34].

In 2015, the "Real Decreto 900/2015" [69], commonly named as "impuesto al sol", came into force in Spain, which is a tax based on the self-consumption of electricity produced by PV systems. The principle with which this tax was enacted was to make the user pay a tax for the use of the grid when the PV systems fail to meet the load [70]. Plants with an installed power of less than 10 kW, plants not connected to the grid, and systems installed on islands were excluded from the payment. In 2018 through the "Real Decreto-ley 15/2018", it was abolished. Thanks to this regulation, the integration of distributed generation (mainly solar PV) in Spain has doubled yearly since 2018. The Government detected in recent years various administrative procedures that prevent individual consumers from installing domestic solar PV. Issues such as the relatively long time the distribution system operators take to elaborate the corresponding certificate to approve the grid connection of solar PV installations and the time the local administration takes to approve it as well. These issues are directly tackled by the "Real Decreto-ley 29/2021" [71] and, very recently, the "Real Decreto-ley 14/2022" [72], stating maximum response periods for the administration and penalizations for Distributor System Operators in case of delays in solving the above-mentioned technical certificates for the grid connection of solar PV installations.

In [73], it is described how Spain has also adopted an auction system for the promotion of renewable sources (large scale, mainly wind, and solar PV). In particular, with the "Real Decreto-ley 23/2020" [74], it is described how the auctions are based on the remuneration price of electricity. Only small-scale plants or some projects may not participate in these as they are not competitive. During the first auction, incentives were awarded for over 3 GW of wind and photovoltaic plants. The incentive takes place on the energy produced; in particular, for PV, the average price was 24.5 EUR /MWh, and for wind power was 25.3 EUR /MWh. The installable power is up for auction, and the owners offer the price they wish to receive. In addition, the minimum volume of energy that must be sold is also defined. In the second auction in 2021, approximately 3.3 GW are made available, of which

600 MW for wind and photovoltaic plants are already available, 700 MW for PV systems, and 1500 MW for onshore wind. This "Real Decreto-ley 23/2020", also introduced the possibility of installing energy storage systems in large renewable-based power plants so as to ease their grid integration and participation in energy markets. The impact of this measure applies to 22 GW of installed wind power and 8 GW of installed solar PV. Again, the latest "Real Decreto-ley 14/2022" [«BOE» núm. 184, 2022], eases the installation of energy storage systems in large renewable-based power plants by making explicit how the energy generated by these power plants should be measured and adding the possibility of being hybridized with storage. This is in line with the objective of achieving 6 GW of energy storage capacity in Spain by 2030, according to the latest "Plan Nacional Integrado de Energía y Clima 2021–2030" [75].

2.5. Energy Policy Analysis in Romania

The Romanian power generation in 2022 is reported in [76]. The sum of the installed power for wind and PV plants reaches 24% (of which 8% for PV). However, looking at the energy production, as reported in [77] for the month of May 2022, the sum of the energy produced by hydro, wind, and PV plants is limited to 12% (of which 3% for PV).

The high share of coal-fired power plants makes electricity prices strongly dependent on the increase in the prices of the CO_2 emissions certificates, which occurred in particular since the autumn of 2021. The electricity market prices reached successive peaks in the next period, as shown in Figure 2 [77], where "m.u." means "monetary unit".

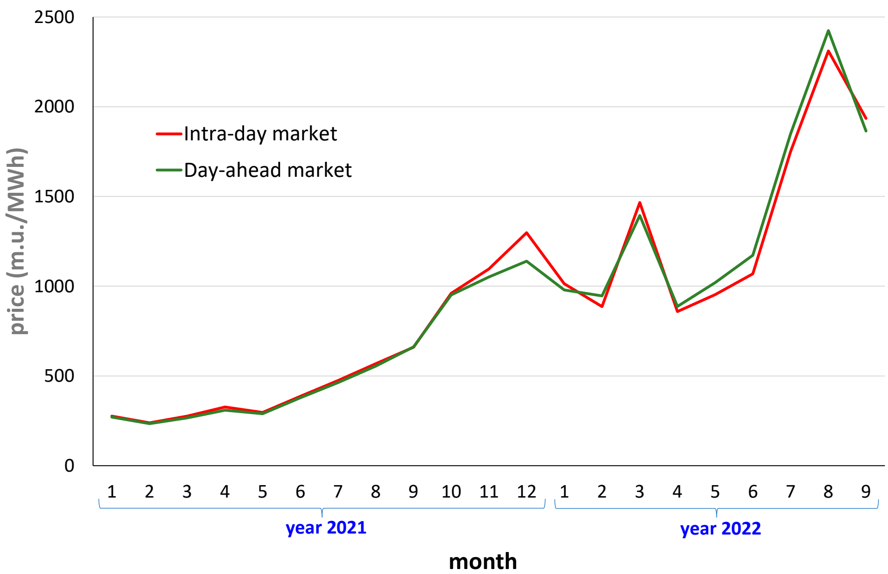

Figure 2. Evolution of the electricity prices (January 2021–September 2022).

Romania was one of the first European countries to implement green certificates [6]. One green certificate corresponds to the production of 1 MWh from RE sources [78]. The scheme of the tradable green certificates was established to be valid for 15 years after the beginning of the RE plant operation for RE plants that started operation after 1 January 2004. As a long-term scheme already in force, changes to different schemes such as FiT are improbable in the Romanian energy market. In addition to the green certificates, various funding programmes for RE projects are established in Romania to support RE investments of local interest [38].

The implementation of the RE promotion scheme with Law 220/2008 [79,80] and the National Renewable Energy Action Plan (NREAP) [81] led to increasing RE production over time [82]. Since 2011, the highest subvention was given to solar PV, with six green certificates for each MWh produced for the new capacity commissioned until the end of 2013 and three green certificates for the capacity commissioned between 2014 and 2016 [82,83].

The budget needed for the investments came from different types of support allocated from the European Regional Development Fund and the Cohesion Fund, for each MW installed, with different amounts for each technology considered [84].

The initial success of the green certificate scheme posed the problem of excessive RE development, with possible issues for connecting to the electrical grid. Hence, the support to RE sources was reduced over the years, with the progressive reduction of the number of green certificates that the new producers receive starting from 1 July [85]. Moreover, the green certificates could be used only by RE producers with rated power over 1 MW. In 2014, there was a change referring to the green certificates for the capacity already commissioned, postponing trading two out of the six certificates until 2021 [2]. In 2017 there was a further change to the law, in which the producers were enabled to recover the green certificates that were postponed, starting from 2018 to 2025, by applying equal monthly rates, also giving the possibility to trade the new green certificates to be awarded until 2024 [86]. The evolution of the PV installations in the period 2011–2018 is reviewed in [78]. In the same period, wind power projects attracted investments, leading to an installed capacity double that of PV systems [82].

A specific point of the evolution of the rules in Romania is the situation occurring for the PPAs. At the beginning of the electricity market restructuring, the PPAs were allowed in the Romanian market. In 2012, a change in the legislation did not allow PPA transactions between the producers and final users in an explicit way. This fact blocked the evolution of PV installations after 2016. The situation changed in 2020, after the EU Regulation 2019/943 [87] was applied in the National legislation (Official Gazette GEO no. 143/2021), removing the ban on the PPAs.

To reinforce RE production, since 2018, the Renewable Energy Act introduced specific rules to prosumers, consumers with local energy production, which are connected to the electrical grid [88]. The prosumers with a capacity up to 27 kW_p were enabled to produce, store and sell to the grid the excess of generation, in the latter case being rewarded at the regulated price [89]. Successively, the Renewable Energy Act increased the limit for prosumers to 400 kW_p. The result is a remarkable increase of prosumers in Romania, about tens of thousands.

At the end of December 2021, the Romanian Ministry of Energy organised a public online event that made known the intention concerning the launch of a new support scheme for renewable projects (wind, solar, hydro, biomass) representing a support mechanism for low-carbon electricity [17]. The European Bank for Reconstruction and Development (EBRD) supports the Romanian Ministry of Energy in implementing this new support scheme of CfD.

The CfD scheme analyses the electricity market price, regulatory, and inflation risks. The CfD scheme facilitates end-users to benefit from the cheapest form of renewable energy through the market competition determined by CfD auctions. The first CfD auctions are expected to be organised at the end of 2022 or early 2023. In addition, the CfD support scheme will provide auction winners with stable remuneration over a period of 15 years [17].

In the present situation, Romania needs to install additional capacity to fit the European Green Deal objectives of RE share of 30.7% in the gross final energy consumption [2]. Some sources indicate that this implies commissioning about 6 or 7 GW of new RE capacity from PV and wind generation by 2030 [80]. The 2021–2030 Integrated National Energy and Climate Plan in Romania has set a target of about 3.5 GW_p of PV capacity. The recent funding sources available from different European channels (e.g., the Just Transition Fund [90], the Modernisation Fund [91], and the Cohesion Policy [92]) could speed up the installation and startup of the new RE plants.

2.6. Energy Policy Analysis in the United Kingdom

In the United Kingdom, the electricity generation from renewable sources accounted for 39.7% of the total electricity production (308.1 TWh) in 2021. In particular, wind and solar PV energy alone contributed 24.9% of total production. Wind is the largest source of renewable electricity in the UK: in 2021, the energy produced by onshore and offshore wind farms was 29.2 TWh and 35.5 TWh, respectively, while PV energy generation was 12.1 TWh. The share of RE in the generated electricity decreased compared to 2020. However, this reduction can be attributed to less favourable weather conditions for wind, photovoltaic and hydro generation [93]. Regarding the installed power, in 2021 onshore and offshore wind capacity reached 14.5 GW and 11.6 GW, respectively, while PV installations increased to 13.8 GW [94].

Renewable energy deployment in the United Kingdom has been supported by different policy schemes over the last decade. Three main support schemes promoted renewable electricity generation: the renewables obligation, the feed-in tariffs, and the contracts for difference.

The renewables obligation scheme was introduced in 2002 with the aim of placing an obligation on electricity suppliers to source part of their electricity from renewables. According to this mechanism, electricity suppliers must have Renewable Obligation Certificates (ROCs) for each megawatt-hour supplied. The Office of Gas and Electricity Markets (Ofgem), which is the National Regulatory Authority, issues ROCs to renewable producers who can sell them to suppliers or traders through negotiation. However, there are also certificate trading exchanges. Suppliers who are unable to demonstrate to Ofgem their compliance with the obligation have to pay for each ROC. The money from these payments is collected in a fund and transferred on a pro-rata basis to suppliers who present ROCs. The cost for ROCs, borne by energy suppliers, is passed on to end users through their electricity bills. The renewables obligation scheme was replaced by the contracts for difference on 31 March 2017. From 2002 up to the end of the scheme, 25,156 power stations with a total capacity of 29.2 GW were accredited by Ofgem. Thanks to renewables obligation, 28.3 million tons of CO_2-equivalent emissions were avoided through renewable electricity generation.

The FiTs scheme was introduced in 2010 to support the deployment of small-scale low-carbon electricity generators. This mechanism incentivizes both renewable generation systems (PV, onshore wind and hydroelectric) and micro cogeneration and anaerobic digestion. Under this scheme, producers receive a generation tariff for every kilowatt-hour produced and an export tariff on the electricity exported to the local grid. These tariffs are regularly revised to promote investment in small-scale low-carbon electricity generators, while avoiding overcompensation. In addition to the tariffs, producers can benefit from reduced energy costs by consuming energy produced onsite (self-consumption). As for the previously described scheme, the cost for feed-in tariffs, borne by electricity suppliers, is passed on to consumers through their electricity bills [95]. Since 2010, this scheme has supported more than 850,000 installations with a total capacity of about 6.5 GW, mainly photovoltaic (almost 80%) [96].

The contracts for difference were introduced in 2013 as a support mechanism for large-scale low-carbon energy generation. A contract for difference is a long-term contractual agreement between a low-carbon electricity producer and the government-owned Low Carbon Contracts Company (LCCC). The contract, won through a competitive process, guarantees a certain electricity price (called a strike price) over the lifetime of the contract, typically 15 years. If the market price for electricity is lower than the strike price, LCCC pays the producer the difference, using money provided by a levy on electricity suppliers (who pass this cost on to consumers). Vice versa, when the strike price is lower than the market price, the producer pays the difference to LCCC, and the money is returned to suppliers. Due to the fixed price for the sale of electricity, the contracts for difference improve the predictability of the income. Therefore, this scheme reduces risks for investors and lowers the cost of capital for developers, supporting investment in renewable technologies. Thanks to these contracts, significant reductions in the costs of some renewable technologies, particularly offshore wind, have occurred [95]. In terms of capacity, the contracted projects exceed 5 GW [97].

3. Analysis of the Renewable Energy Policies in South Asia

Over the years, the Strengths, Weaknesses, Opportunities, Threats (SWOT) methodology [98] was used by many researchers to assess the development of the RE sector. The SWOT methodology is a decision tool and is divided into four parts (Strengths—RE potential, Weaknesses—difficulty in procuring RE technologies, Opportunities—energy policies used by the state, and Threats—political instability, energy dependence on other countries, and the presence of fossil sources in the territory). In this case, the strengths and weaknesses of the internal environment and the opportunities and threats of the external environment are identified. An analysis of the internal and external environment of the RE sector of some South Asian countries such as Sri Lanka, India, Pakistan, Bangladesh, and the Philippines by means of SWOT methodology was carried out in [99]. Among the countries analysed, India has the highest amount of energy supplied from RE sources. The Indian renewable energy sector is more developed than that of other South Asian nations. In fact, India stands third in the Renewable Energy Country Attractiveness Index (RECAI) ranking, whereas Pakistan is in 36th place India provides large subsidies on starting capital; however, it has the highest interest rates compared to other countries (12–15%). India also prefers to develop domestic manufacturing industries, thus setting an import tax. Pakistan prefers to develop new projects, often importing technologies from other countries. There are no general policies for subsidising RE development, and countries with similar resources use different incentive schemes. Table 1 shows the energy policies in some South Asian countries.

Table 1. Energy Policies in Selected South Asian Countries.

Country	Policy
Sri Lanka	- Net Metering incentivised by the tariff structure - Net Accounting and Net Plus (9.6 cEUR/kWh for the first 7 years and 6.8 cEUR/kWh from 8th to 20th) [101] Interest rate: the Government sets the interest rate for investments in PV systems on the roof and loans up to 1540 EUR at 6% [99,102].
India	- Competitive bidding - Subsidy: the Government offers subsidies of up to 30% of the cost of initial capital for new RE plants - Generated-based incentives: a subsidy of 0.6 cEUR/kWh produced is given. However, this type of incentive is valid only for wind generators. - Net Metering Subsidy for PV rooftop: the Government offers subsidies from 30% to 70% of the cost of capital to install new PV systems on the roof. The subsidy varies according to the region of installation [99].
Pakistan	- Carbon credit - Net metering - Refinancing scheme: distributed generators can receive incentives with interest rates of 6% Non-Income tax: no income tax for the sale of electricity from RE sources [99].
Bangladesh	- Feed-in Tariff Depreciation: 100% for PV (first year) e wind power (first 5 years) [99].
Philippines	Feed-in Tariff: for a PV system equal to 15.7 cEUR/kWh, for a wind generator equal to 13.3 cEUR/kWh [100].

The effect of the "Feed-in Tariff" (FiT) energy policy on the RE sources diffusion in developing countries is shown in [100], with the Philippines as a case study. It is highlighted how this kind of policy is the most advantageous for encouraging small RE (e.g., PV and wind) plants. This incentive reduces the problem linked to the uncertainty of the source, making the investment safer. In the Philippines, the FiT equals 15.7 cEUR/kWh for PV systems and 13.3 cEUR/kWh for wind generators. It is also shown how large generation plants, both renewable and traditional, which cover a large part of the baseload, are less attracted by this type of incentive. This occurs because these projects have long development and construction cycles and prefer Project Finance (PF) incentives. The PF is a long-term investment that companies collect in the project phase based on the future revenues that the plant will be able to guarantee.

4. Renewable Energy Tariff Policies in Sri Lanka

In 1992, the National Environmental Action Plan (NEAP) was drafted, focusing on the problems of climate change. In 1993, the Government of Sri Lanka also joined the United Nations Framework Convention on Climate Change (UNFCCC) [103]. The decisive moment for the state was the creation of the Climate Change Secretariat (CCS) in 2008; by means of the CCS institution, the National Climate Change Policy (NCCP) was initially formulated in 2010. In 2016, Sri Lanka decided to sign the Paris Agreement outlined during COP-21 [104]. Then, indicators and set constraints (INDC) were established by the state to be implemented by 2030.

The first approach to RE incentives in Sri Lanka was already analysed in the early 1990s [105]. The FiT incentive encouraged electricity generation mainly from small hydroelectric plants. By means of this incentive, the electricity selling price from RE sources was maintained at a higher level. In this case, the tariff was based on avoided costs in the contract period of fifteen years. The first initiative beyond the avoided cost tariffs was to pay a premium of LKR 2.50 per kWh for biomass power plants. The Sri Lanka Sustainable Energy Authority's predecessor organisation Energy Conservation Fund implemented this program through a tool known as the Sri Lanka Energy Fund, using funds from the Government treasury to pay the premium on the actual power generation on a monthly basis. This model was developed further, leading to the cost-based, technology-specific three-tier tariff. With the latter scheme, the tariff is designed to cover the costs of the initial capital and those of operations and maintenance established in the design phase. The incentive policy changed to a competitive bidding process in 2016, realising significant tariff reductions compared to incentives given before 2012 (e.g., the wind tariff fell from 24.99 to 13.60 LKR/kWh).

Prahastono et al. [106] present a document of the policies implemented in 2010 and then updated in 2016 within the "Soorya Bala Sangramaya" program to encourage the development of RE in the country using solar PV rooftop systems as a technology. In the period 2010 to 2016, the Net Metering (NM) scheme was used to encourage on-site power generation from any RE source on a fifteen-year contract. An NM scheme works by accounting for the net energy consumed by the customer, or rather from the metering of the energy withdrawn and fed into the grid. Through a bidirectional meter, the prosumer is charged for net energy consumption at the end of the billing period. The utilisation of this incentive allows the use of the distribution grid as a virtual storage system saving the installation costs of electrochemical batteries [107].

Jayaweera et al. [102] present the Tariff Structure of electricity prices in Sri Lanka to encourage the NM scheme. In this structure, the electricity price has been made proportional to the monthly consumption of electricity. In this way, by installing solar PV systems with a bidirectional meter, less energy is purchased from the main electricity grid. This aided in lowering the total consumption and the cost, as illustrated in Table 2.

Table 2. Tariff structure of electricity consumption—Sri Lanka.

Tariff block [kWh per month]	0–60	61–90	91–120	121–180	>180
Unit rate [cEUR/kWh]	3.4	4.4	12.2	14.0	19.7

With NM, if the active user (or prosumer) produces more energy than imports, the prosumer will only have to pay a minimal flat fee, and the net energy fed into the grid will be used as a credit for subsequent billing, which can be carried forward for a period of ten years. If, on the other hand, the prosumer imports more energy than what is produced plus any previous credits, it is required to pay a tax based on the net energy consumed in addition to the fixed charge [101].

In addition to NM, the Sri Lankan Government introduced two other programs in 2016 to enhance solar energy generation, called Net Accounting and Net Plus [102]. The Net Accounting scheme is similar to the NM system, but it is applied only to rooftop PV systems. Rather than being converted into credits, extra net energy produced is sold to the grid operator for 9.6 cEUR/kWh for the first seven years and 6.8 cEUR/kWh from the 8th to the 20th year. If the imported energy is higher, the consumer will have to pay the net energy at the market price. With the Net Plus scheme, the consumer will be able to feed electricity into the grid, which will be paid at the same rate as Net Accounting. The consumption will be quantified by another meter, and the energy imported from the grid will be paid by the consumer at market rates [101]. Table 3 summarises the information on the two incentive schemes.

Table 3. Main Information for Net Accounting and Net Plus Schemes.

	Net Accounting	**Net Plus**
Differences	The net energy is incentivised by the distribution grid. If the energy withdrawn from the grid exceeds the energy fed in, the net energy is paid by the consumer at the rate stipulated by the grid operator.	The consumer sells the electricity produced to the distribution grid. The imported electricity will be measured by another meter and will be billed according to the current electricity tariff stipulated by the distributor operator.
Common aspects	- Billing period: 30 days - Duration of the incentive: 20 years - Incentive valid only for PV systems - Electricity incentive tariff: 9.6 cEUR/kWh for the first 7 years and 6.8 cEUR/kWh from the 8th to the 20th year	

A mathematical model and an implementation algorithm for NM applied to a PV system are presented in [107]. The algorithm considers the values from the solar meter and bidirectional meter. The results indicate a reduction in unit consumption, minimising the electricity bill.

In [108], a study was conducted on the various factors that influence people's attractiveness to use NM, conducted for Sri Lanka. It was determined that this kind of incentive is technologically useful to satisfy an increase in electricity demand by reducing the purchase costs from the grid. The study concludes that the slowed NM development does not concern technical reasons but the Tariff Structure. In particular, the proportional scheme of the electricity tariff based on consumption prompted many large consumers to use the NM scheme. The electricity company that subsidises this scheme could suffer serious financial losses. The operator is forced to raise the price of electricity with serious effects on small consumers. The NM scheme is very functional in encouraging self-consumption when generation and load are simultaneous. In the case of Sri Lanka, the domestic demand is higher from 6 p.m. to 10 p.m., so when there is no generation by PV systems. For these reasons, the NM development in Sri Lanka saw only the high-volume residential energy users benefitting at the expense of other customers and the utility's profitability.

According to a report published by the Sri Lanka Sustainable Energy Authority titled "Grid Connected Non-Conventional Renewable Energy (NCRE) Projects up to June 30, 2020", 260 RE projects have been grid-connected since 1998 [109]. Table 4 summarises the variation in the capacity expansion and the number of grid-connected projects before and after the significant tariff reductions in 2016.

Table 4. The Effect of Tariff Policy Change in 2016 on RE Capacity Expansion.

Time Frame	Type	Number of Projects	Capacity Addition (MW)
1998–2015 (646.39 MW)	Dendro Biomass (2008–2015)	12	43.61
	Small Hydro (1998–2015)	211	422.97
	Solar PV (2010–2015)	8	51.36
	Wind (2008–2015)	15	128.45
SINCE 2016 (32 MW)	Solar PV (2018–2019)	12	12
	Wind (2018)	2	20

According to the indications reported in Table 4, the pace of RE project development suffered due to a legal impediment related to the purchase of energy without a competitive procurement process. Changes in public attitude towards small hydro projects and biomass supply chain issues also contributed to the poor growth in micro-hydro, dendro/biomass-based RE capacity. There is a total of 12 MW of solar PV and 20 MW of wind capacity addition until June 2020, within a 5-year period from the introduction of the new tariff in 2016. According to Ceylon Electricity Board data, the total addition of solar PV systems to the grid by July 2021 was 33 MW, with an additional 77 MW of solar power plants planned to be completed by the end of 2022. Considering the current RE capacity of Sri Lanka, these figures are still low, and the slower growth in this pace is generally attributed to the long delays in land acquisition experienced by renewable energy project developers. Sri Lanka had 32,411 roof PV installations with a combined capacity of 367 MW at the end of April 2021. Thus, there are 16,472 Net Metering installations (121 MW), 14,392 Net Accounting installations (113.5 MW), and 1547 Net Plus installations (132 MW) [110]. Since 2016, the total RE capacity connected to the grid by the end of 2021 includes 20 MW of wind, 33 MW of solar power plants, and 367 MW of roof solar installations. In Sri Lanka, there are no direct incentives for purchasing electrical storage systems, but the energy policies applied by the state could encourage the spread of such systems, mainly integrated with PV systems.

Regarding the production chain of the PV industry, the chain can be divided into two main parts: manufacturing PV cells and assembling PV modules. Solar-grade silicon is the first essential ingredient needed for the manufacturing of PV cells, and it is produced by fusing quartz sand at extremely high temperatures [111]. Sri Lanka is a quartz sand producer, but it is currently lacking in the facilities and technologies for producing solar-grade silicon. Furthermore, the solar cell manufacturing process requires high technology levels and related high investments, but Sri Lanka is not currently able to invest under the current economic and energy crisis. Thus, in this status, only PV modules assembly is possible. It mainly consists of the electrical connection of PV cells and their encapsulation, using cells imported from other countries (mainly from China) [112]. The creation of a photovoltaic supply chain, starting from the assembly of PV modules, could be an opportunity to develop more competences in PV technology, and better use the available natural resources. Unfortunately, there is no such strategic plan in the current government policies in Sri Lanka.

Four Case Studies for Residential, Commercial, and Industrial Users in Sri Lanka

In this subsection, the financial analysis of the investment for four grid-connected PV systems of different rated power (from 1 kW to 1 MW) is presented. First, the application of the existing incentive schemes for PV systems in Sri Lanka is investigated. Then, a modified version of the current support schemes is proposed for two of the four cases with the aim of making the investment in PV systems more cost-effective.

In the first case (CASE#1), the Net Accounting scheme previously described is applied to a 1 kW rooftop PV system. The unitary investment cost for residential PV systems is assumed to equal to 1200 EUR/kW, while the maintenance cost is 1% of the investment cost. After 15 years of operation, it is necessary to replace the inverter, with a cost of about 240 EUR/kW. Regarding the revenues, the yearly bills are reduced thanks to self-consumption, which is supposedly equal to 30% (typical value for residential PV plants). The avoided cost is equal to the cost of grid-supplied electricity: assuming a yearly load of 1400 kWh and a monthly consumption in the range of 91–120 kWh, the cost of electricity provided by the grid is 12.2 cEUR/kWh, according to Table 2. In addition, the PV energy surplus injected into the grid is sold at the price established by the Net Accounting scheme (9.6 cEUR/kWh for the first 7 years, 6.8 cEUR/kWh from the 8th to the 20th year). To actualize the annual cash flows, a discount rate of 10% is assumed due to the ongoing economic recession in Sri Lanka. Table 5 shows the ratio of the 20-year Net Present Value (NPV) to the Investment Cost (IC), the Internal Rate of Return (IRR), and the Discounted Payback Period (DPP) of CASE#1 applying the Net Accounting scheme.

Table 5. Economic results of CASE#1 with the current Net Accounting scheme.

Economic Indicator	Value
NPV/IC	NPV < 0
IRR	-
DPP	>20 years

Considering the above-listed assumptions and applying the Net Accounting scheme to CASE#1, the investment results are not profitable. If the remuneration of the PV energy injected into the grid in the first 7 years is increased to 15 cEUR/kWh (about 50% more than the current value), the investment returns within the incentive period, i.e., before 20 years, as shown in Table 6.

Table 6. Economic results of CASE#1 with the modified Net Accounting scheme.

Economic Indicator	Value
NPV/IC	1.6%
IRR	10.3%
DPP	19 years

If the economic analysis on the 1 kW PV system had been carried out in a national context with a larger number of small PV systems installed, the results shown in Table 5 would have been different. Indeed, as a consequence of economies of scale (the passage from a few thousand to hundreds of thousands of rooftop PV systems in Sri Lanka), the so-called experience curve, expressed by Wright's law unit cost curve, justifies the reduction of about 20% in the installation cost every time the total cumulative installed PV power doubles. Thus, the DPP applying the Net Accounting support scheme would be 10 years in a national context with four times the installed capacity of small rooftop PV systems.

In the second case (CASE#2), the same support scheme applied in CASE#1 (Net Accounting) is applied to a 10 kW PV system. A generation system of this scale is representative of a PV plant supplying an aggregation of residential users or a small commercial user. In this case, the unitary investment cost is assumed to be lower than in CASE#1 (1000 EUR/kW) as well as the cost for the inverter replacement (200 EUR/kW). A higher local consumption of PV energy is expected: thus, a self-consumption of 45% is assumed. Finally, a higher yearly load (14,000 kWh) and a higher monthly consumption (>180 kWh) with respect to CASE#1 are supposed. According to Table 2, the cost of electricity provided by the grid, and consequently the avoided cost due to self-consumption, is 19.7 cEUR/kWh. Table 7 shows the economic results of CASE#2.

Table 7. Economic results of CASE#2 with the current Net Accounting scheme.

Economic Indicator	Value
NPV/IC	43.5%
IRR	16.6%
DPP	9

Unlike CASE#1, the Net Accounting scheme applied on a PV system with a rated power ten times larger pays back the investment in the 9th year of operation.

In the third case (CASE#3), the Net Plus support scheme is applied to a commercial/industrial PV system with a rated power of 100 kW. In this case, the unitary investment cost for the PV system is 700 EUR/kW, while the maintenance cost is about 7 EUR/kW/year (1% of the initial investment). After 15 years of operation, it is necessary to replace the inverter, with a cost of about 140 EUR/kW. The revenues consist of remuneration for PV energy fed into the grid, regulated by the Net Plus scheme (9.6 cEUR/kWh for the first 7 years, 6.8 cEUR/kWh from the 8th to the 20th year). As in the previous cases, the discount rate is set equal to 10%. The economic results of CASE#3 are summarized in Table 8.

Table 8. Economic results of CASE#3 with the current Net Plus scheme.

Economic Indicator	Value
NPV/IC	29.7%
IRR	14.9%
DPP	10 years

In this case, the 20-year NPV is positive, and the investment returns within the incentive period. However, the DPP is too long for the majority of commercial/industrial investors who usually require around eight years. If the initial remuneration tariff for PV energy injected into the grid (9.6 cEUR/kWh) is increased by 10%, the DPP is reduced to eight years, as shown by the results in Table 9.

Table 9. Economic results of CASE#3 with the modified Net Plus scheme.

Economic Indicator	Value
NPV/IC	39.1%
IRR	16.7%
DPP	8 years

If the analysis on the 100 kW PV system had been carried out in a national context with a doubled installed capacity of PV systems with similar rated power, the costs would have been lower due to economies of scale and the DPP with the current Net Plus scheme would have been reduced to about six years.

In the fourth case (CASE#4), the Net Plus support scheme is applied to a utility PV system with a higher rated power (1 MW) than in the previous case. Some economic assumptions are different with respect to CASE#3: the unitary investment cost is lower (650 EUR/kW) as well as the maintenance cost (6.5 EUR/kW/year) and the inverter replacement cost (130 EUR/kW). The economic results of CASE#4 are shown in Table 10.

Table 10. Economic results of CASE#4 with the current Net Plus scheme.

Economic Indicator	Value
NPV/IC	40.7%
IRR	16.7%
DPP	8 years

Unlike CASE#3, the Net Plus scheme applied on a 1 MW commercial/industrial PV system pays back the investment within 8 years.

The results presented in this Subsection demonstrated that the existing incentive scheme for PV systems in Sri Lanka should be improved. The reason is that incentives are not effectively calibrated according to the size of the plants. PV systems with a rated power of ≈10 kW (CASE#2) and big plants (CASE#4) are already adequately incentivized. On the other hand, residential PV systems with a rated power of ≈1 kW (CASE#1), and medium sizes plants (≈100 kW, CASE#3) do not receive a sufficient incentive. Thus, a new incentive scheme should be implemented: for the small plants, the incentive should be increased to about 50% more than the current value. In the case of medium size plants, it should be increased by at least 10%.

5. Discussion

In terms of the results of the EU policies, the capacity of PV plants and wind turbines increased dramatically in most of the analysed countries [111]. Germany, as the nation in the first place, since the beginning, in the ranking of European countries for the installation of PV and wind systems, was one of the promoters of the FiT scheme in Europe. In Germany, in the timeframe 2010–2020, there was a high and constant increase in the production from renewables: it was 50 TWh in 2010 and it reached 180 TWh in 2020, mainly thanks to the installation of new wind farms. This constant increase was possible thanks to a constant update of the policies. The FiT reduction and the introduction of an auction system were properly done. The FiT reduction followed the reduction of the installation cost of RES, but it was always done to guarantee the effectiveness of the investments in PV and wind.

The FiT mechanism was adopted in many other states. For example, in Italy, during the first years of the incentive (until 2012), the tariff was very high, on average around 20–40 cEUR/kWh. As a result, the PV and wind energy production increased from 11 TWh/year in 2010 up to 32 TWh/year in 2012, mostly thanks to PV. Finally, after the end of the high FiT in 2012, in the last 10 years, the energy production increased up to 45 TWh/year, thanks to lower but proper mechanism of incentivisation, such as auctions and tax reductions. In the UK, the wind and PV production in 2010 was 18 TWh/year, and, mainly thanks to wind farms, it raised to 88 TWh/year; these results were obtained first with important FiT mechanisms, then with contracts for difference. Regarding Spain, wind farms produced 44 TWh in 2010, and this amount increased to 57 in 2013, thanks to regulated tariffs. These tariffs were strongly reduced in 2013 with almost a stop in new plants until 2019, also due to the introduction of mechanisms not favorable for RES (such as the tax based on the self-consumption of electricity produced by PV systems). The turnaround occurred in 2018–2020, with the removal of the above-mentioned tax and the introduction of an auction system, and other mechanisms; thus, PV and wind production reached 72 TWh in 2020. Finally, in Romania, the PV production was negligible in 2010, while wind farms produced 0.3 TWh. Thanks to the implementation of the "green certificates" mechanism, production reached 9 TWh in 2014. Nevertheless, due to issues related to the management of the grid due to this energy amount from fluctuant renewables, the value of the green certificates was reduced by the government. As a result, the increment of new installations is negligible since 2014 [113]. In the last two years, the Romanian government has been working on new mechanisms to increase RES share according to EU goals.

The generous tariffs were offered about 20 years ago for two main reasons. First, the costs of PV modules and inverters were so high that a high revenue was necessary to justify an important investment and to have remarkable NPV in the long term. Secondly, there was the need to create and train a whole sector of companies, engineers, workers, etc., with skills in installing and operating RE plants. The FiT system had great results, with exponential growth in installing new systems, especially photovoltaic plants. Indeed, the high incentives allowed the development of RE technology at both residential (small plants up to 20 kW) and commercial/industry levels (from a few tens of kW up to multi-MW plants). Thanks to the tariff, the investment was always repaid within the lifespan for a residential user and in about eight years for large systems.

The investments in these technologies increased the widespread installation of RE technologies around the world, with a consequent strong reduction in manufacturing costs. In less than 10 years, the cost of PV modules was reduced by more than two-thirds (from about 1 EUR/W to less than 0.3 EUR/W). In addition to the decrease in costs, in EU countries, many companies were already skilled in RE generation. As a result, installing RE systems, especially wind farms and PV plants, is considered among the safest investments and is increasingly bought by investment funds and pension funds. Then, in many EU countries, high FiT is no longer necessary. Many EU countries decided to reduce or abandon the FiT and foster competition among the companies replacing it with another incentive system to guarantee an adequate increase in new installations and reach the emission reduction goals.

Currently, many EU countries have divided the policies for the development of RE according to the capacity of the plants. In the case of big plants, the auction system is the most used: all the EU countries analysed in this paper are using this incentive system. In this way, a competitive system is created to try to reach the optimal compromise between the installation of new plants (necessary for the reduction of emissions) and the revenues of private companies. In the case of small plants, many EU states use other methods, such as SSP and tax refunds in Italy, grants of up 50% of the capital in Germany, or other benefits that will be introduced in 2023 for prosumers in Romania.

In the case of Sri Lanka, prior to RE tariff policy changes in 2016, some hundreds of RE projects were referring to grid-connected plants, in particular, two-thirds of the total were dendro/biomass and small-hydro plants. However, after 2016, there were no more dendro/biomass and small-hydro projects due to technical limits. From 2016 to 2021, some hundreds of MW of PV plants (both rooftop and ground-mounted PV arrays) and a few tens of MW of wind power systems have been installed. The poor performance of the policies in Sri Lanka is attributed to problems experienced in the competitive bidding process for large-scale RE plants and the issues related to acquiring the corresponding amounts of land for utility-scale wind and solar PV projects.

Furthermore, in the 1–1000 kW range, it has been demonstrated by using well-known indicators (NPV, IRR, and DPP) that the current economic performance for solar PV systems is moderate. In two of the four case studies analysed (CASE#1 and CASE#3), more generous incentive tariffs are required to make the PV investment profitable. In particular, the small plants (few kW) should receive an incentive at least of 15 cEUR/kWh, which is ≈50% higher than the current remuneration tariff for PV energy injected into the grid. In the case of medium size plants (≈100 kW), the remuneration should be increased by at least 10%.

In this context, it can be concluded that since 2016, there has been a focus on bringing more prosumers to the grid system rather than developing new network infrastructure for RE in Sri Lanka. Indeed, the introduction of competitive bidding in a market that depended heavily on feed-in-tariff, without room for the gradual transformation of the process, contributed to dampening the enthusiasm of the developers to engage in RE sector infrastructure development. As a result, small hydro, dendro/biomass, large-scale solar PV, and wind power plants had little or no capacity additions.

6. Conclusions

The RE policies of a selected number of European countries have been reviewed to identify the solutions adopted and the paths followed over time for policy upgrading. The review analysis concludes that a plan is needed in Sri Lanka for a complete overhaul of the system to procure renewable energy and attract large-scale investments for the RE development program.

This plan will have to include the development of the grid infrastructure, the financial support of offshore RE plants, and the creation of a transition phase between the feed-in tariffs and the competitive bidding logic. Following the example of the EU, this transition phase can be different according to the RE technologies and differentiated accordingly to the size of the new installations.

Finally, another key point for RE development in Sri Lanka is to allocate investments for the creation of a photovoltaic supply chain, starting from the assembly of PV modules. Benefits will be many: e.g., more competencies in design, installation, operation, and maintenance, and in the future, reduced costs for the widespread use of PV technology in the island.

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Acronyms

ANRE	National Regulatory Authority for Energy
BIPV	Building Integrated Photovoltaic
CCS	Secretary for Climate Change
CE	Conto Energia
CfD	Contract for Difference
CPV	Concentrating Photovoltaic
DPP	Discounted Payback Period
EEG	Renewable Energy Act or Erneuerbare Energien Gesetz
EBRD	European Bank for Reconstruction and Development
EU	European Union
FiP	Feed-in Premium
FiT	Feed-in Tariffs
GSE	Energy Services Manager
IC	Investment Cost
INDC	Indicators and Set Constraints
IRR	Internal Rate of Return
LRET	Large-scale Renewable Energy Target
NCCP	National Climate Change Policy
NCRE	Non-Conventional Renewable Energy
NEAP	National Environmental Action Plan
NREAP	National Renewable Energy Action Plan
NM	Net Metering
NPV	Net Present Value

PF	Project Finance
PPA	Power Purchase Agreement
PV	Photovoltaic
RE	Renewable Energy
RPO	Renewable Portfolio Obligations
RPS	Renewable Portfolio Standard
StrEG	Stromeinspeisungsgesetz
SSP	Scambio sul Posto
SWOT	Strengths Weaknesses Opportunities Threats
TPV	Traditional PV plants
UNFCCC	United Nations Framework Convention on Climate Change
VAT	Value Added Tax

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