NEW AVAILABLE REGULATORY OPTIONS FOR INTEGRATION OF RES

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Renewables
Working group
(RES WG)

ABSTRACT
This document aims to call attention to the evolution of the power system. It starts with the recent development of renewables (RES) and changes in support policies. It builds upon the 2019 MEDREG report "Analysis of auction mechanisms to promote RES" and presents the changes in the current policies in the MEDREG countries after analysing responses to a second questionnaire from its members. Different types of self-consumption models are explained along with the presentation of case studies from MEDREG countries. Recent changes, along with disruptive innovations such as blockchain and Internet of Things (IoT), are demonstrated. Barriers for regulators to integrate RES in the power system are illustrated with the respective remedies. The report ends with a set of recommendations for regulators and policymakers to prepare them for the new power system era.

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ABOUT MEDREG

MEDREG is the Association of Mediterranean Energy Regulators, bringing together 27 regulators from 22 countries across the European Union (EU), the Balkans and North Africa.

Mediterranean regulators work together to promote greater harmonisation among the regional energy markets and legislations, seeking progressive market integration in the Euro–Mediterranean basin. Through constant cooperation and information exchange among the members, MEDREG aims at fostering consumer rights, energy efficiency, infrastructure investment and development based on secure, safe, cost-effective and environmentally sustainable energy systems.

MEDREG acts as a platform providing information exchange and assistance to its members as well as capacity development activities through webinars, training sessions and workshops.

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RELATED DOCUMENTS

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EXECUTIVE SUMMARY

Regulations and policies can act as accelerators or decelerators for renewable energy sources (RES) integration. Different support schemes have been used to kickstart RES adoption in the power system. However, today there are countries with high shares of RES in the energy mix. In addition, new technologies and business models have empowered customers to become the most important stakeholder in the energy transition. Electricity customers are future investors, operators and consumers of the power system. National regulatory agencies must adjust and upgrade the current regulations and policies to foster the energy transition, distribution innovation and evolution of the power system. This report provides insights to policymakers and regulators into the future outlook of the power system and applicable recommendations for the new reality.

Background

As part of its 2020–2022 Action Plan, MEDREG considers it important to implement activities that respond in a structured and comprehensive way to its members' national needs, one that reflects and relates concretely to national developments. The plan should support a higher regulatory awareness, particularly in Southern and Eastern shore members, contributing to a more recognisable and effective role of regulators in the Mediterranean energy markets.

Thus, MEDREG has prepared a report that includes case studies of members in terms of self-consumption regimes with a reference to the definition, the legal framework in place and the installed capacity. The analysis focuses on how to access the self-consumption, the possible tariffs in place and the incentives provided by MEDREG countries. It takes into consideration the information provided by members regarding the new regulatory options for the integration of RES. The report focuses on the results of the questionnaires on RES auction schemes and other support schemes in Mediterranean countries.

This chapter provides a comparison with the results of the 2019 MEDREG report on RES auction schemes and the main support mechanisms for the integration of RES used in MEDREG member countries.

Objectives and Contents of the Document

This document provides an overview of the guidelines and principles of self-consumption regimes for renewables provided by MEDREG case studies. The second section of the report will focus on the result of the second edition of the questionnaire on the RES auction mechanism as well as a comparison of developments in the previous report.

The report provides ideas and recommendations concerning the development of the regulatory framework necessary to implement effective and transparent RES auction mechanisms in the MEDREG region. It also evaluates the progress of the implementation of previous recommendations.

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INTRODUCTION

The New Available Regulatory Options for the integration of RES represents the second report presented by the Cyprus (CERA) and Portuguese (ERSE) energy regulators as chairs of the Environment, Renewable Energy Sources and Energy Efficiency Working Group RES WG for the second-year mandate (2018–2020).

In 2019, the RES WG presented the report "Analysis of auction mechanisms to promote RES", which is available on MEDREG's website[1] . This report seeks to analyse the renewable energy auction mechanisms applied in the Mediterranean basin and on an international level.

Several policies were used to promote the development of renewables in the Mediterranean area. Feed in tariffs (FIT), feed in premium (FIP) and auction mechanisms are some examples of these policy options. Over the last year, RES WG has addressed these options in several documents. These policies helped increase renewable energy shares in the energy mix, which imposed new challenges upon the power system. These challenges were related to the acceptance of these new capacities with peculiar properties (for instance, intermittency) without compromising the security of the electricity supply or increasing costs for the power system. In addition, new technologies that can disrupt the traditional value chain of electricity supply have been discussed to shed light on national regulatory agencies (NRAs) with regard to the expected regulatory challenges that will surface in the next few years.

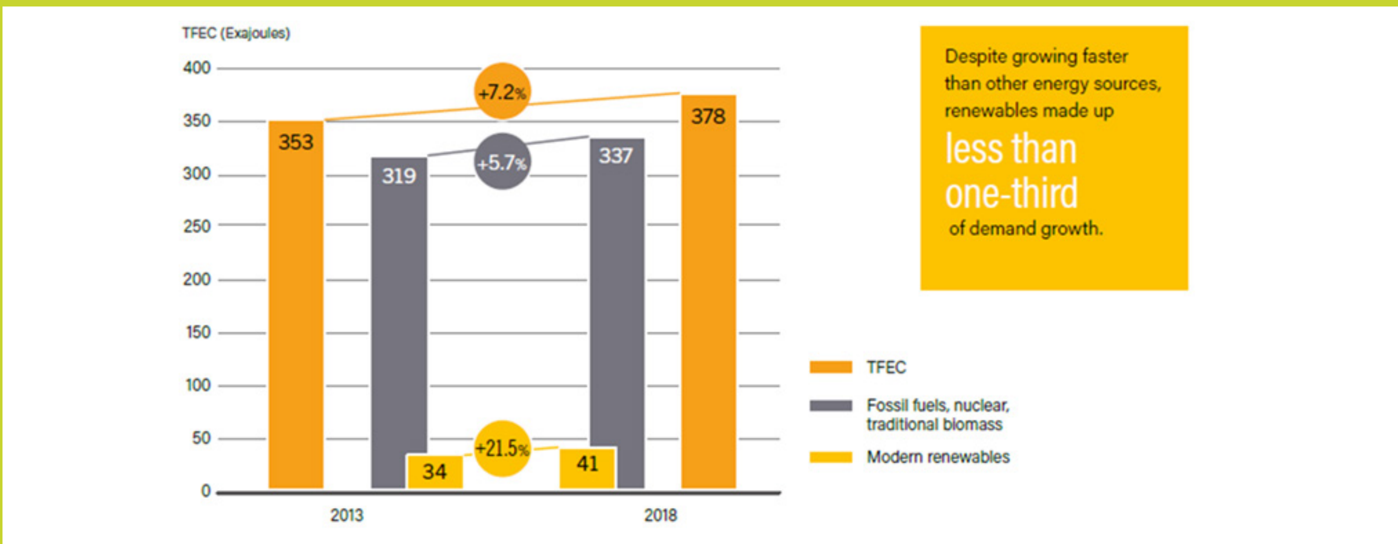
Given the importance of the theme, this report was included in MEDREG's Action Plan for 2020–2022 as the RES WG delivery for the year 2020. MEDREG RES WG worked on preparing this report to be presented to its members as a response to the increasing challenges arising from the high shares of RES.

Investments in renewable energy are escalating at a fast pace. This is due to their positive impact on the climate and the economy. According to the REN21 Global Status Report 2020 and based on IEA data, global growth in renewable energy outpaced the total final energy consumption (TFEC) during the period 2013–2018[2] , as depicted in Figure 1. Moreover, the growth of renewable energy is thrice that of fossil fuels and nuclear energy during this period.

1 http://www.medreg-regulators.org/Portals/_default/Skede/Allegati/Skeda4506-434-2019.12.3/Analysis%20of%20auction%20mechanisms%20to%20promote%20RES.pdf?IDUNI=zditdqi05bt4kxyqr0btvzcz998

2 REN21, Renewables Global Status Report (based on IEA data), 2020, P.33, https://www.ren21.net/wp-content/uploads/2019/05/gsr_2020_full_report_en.pdf

Figure 1 . Estimated global growth in RES compared to TFEC, source: REN21



The costs of electricity generation from RES are decreasing and becoming more competitive with other conventional sources such as coal and oil. However, the cost is not the main driver of the current energy transition, which is mainly conducted by policy[3]. We can safely assume that the cost reduction of renewable energy technologies is a result of implementing successful policies. We are not suggesting that technology is not important or does not have a role but that policies have the main role in the energy transition the world is experiencing. Since the mid-1990s, governments have adopted several policy tools to reduce carbon emissions and decarbonise energy systems by increasing renewable energy shares in the TFEC.

Policies to decarbonise energy systems can be divided into two types. The first type concerns policies that aim to directly stimulate different renewable energy technologies' deployment. These include feed-in tariffs, feed-in premiums, green certificates and tax credits. The aforementioned policies support the decline in energy prices and an increase in the generation of power from renewable resources. The second type concerns policies that aim to reduce carbon emissions directly. These include carbon taxes and emission trading systems and tend to reduce energy production from resources that have negative impacts and harmful externalities such as coal and oil.

A growing number of countries are adopting policies that expand the usage of RES. In 2019, 143 countries had power regulatory policies in place with some ambitious targets in the energy mix. In 2004, the number of countries with such enabling policies was under 50. Regarding national targets for renewable energy in power generation, 166 countries have set targets to be achieved in the next decades. The most ambitious target was set by Denmark: achieving 100% renewable energy by 2050[4].

Several MEDREG countries have set ambitious targets for renewable energy production. Table 1 exhibits the targets by MEDREG countries for electricity production from RES or TFEC[5,6]. The numbers in black represent the targets for electricity production, and the numbers in brown represent the targets for TFEC.

It should be noted that at the European level, there is a clear drive towards climate neutrality by 2050. The new European Commission acknowledges that although Europe is currently on track to meet its 2030 emission reduction targets and the goals enshrined in the Paris Agreement, reaching climate neutrality by 2050 will require more ambitious contributions from all sectors. In view of this increased ambition, the Commission presented the European Green Deal, which includes even more ambitious proposals in the area of energy and climate change.

At the same time, the Governance Regulation[7], which established the framework for the National Energy and Climate Plan (NECP), aims to ensure the achievement of the Union's 2030 long-term objectives and targets in line with its international commitments under the Paris Agreement. A bottom-up approach has been adopted whereby the EU Member States present their fair and ambitious efforts and contributions towards mitigating climate change and a decarbonised energy system. While the Governance Regulation sets the basis for the development of this plan, it is complemented by a package of new EU legislation targeting energy efficiency, renewable energy, energy security and market design (appropriately referred to as the "Clean Energy for all Europeans Package").

EU legislation requires each member state to adopt a 10-year NECP to map out how they will contribute to the binding climate and energy targets for 2030. Each MEDREG member who is also an EU member state has prepared and submitted an NECP that follows the scope of the Energy Union and covers its five dimensions: decarbonisation, energy efficiency, energy security, internal energy market and research, innovation and competitiveness. The

3 Jorge Blazquez, A road map to navigate the energy transition, The Oxford Institute for Energy Studies, Energy Insight, P.59, 2019.
4 REN21, Renewables Global Status Report, 2020, P.56, https://www.ren21.net/wp-content/uploads/2019/05/gsr_2020_full_report_en.pdf

5 Maged Mahmoud, Ali Habib, Arab Future Energy Index (AFEX), 2019, RCREEE, https://www.rcreee.org/sites/default/files/final_afex_re_2019_final_version-1.pdf
6 REN21, Renewables Global Status Report, 2020, P.212, https://www.ren21.net/wp-content/uploads/2019/05/gsr_2020_full_report_en.pdf
7 Regulation (EU) 2018/1999 of the European Parliament and of the Council on the Governance of the Energy Union and Climate Action.

five dimensions are considered as being closely related and mutually reinforcing and are treated, correspondingly, as such within the plans.

As seen in Table 1, the targets for electricity generation from RES require effective policies to be integrated with a high level of resilience. Most RES are intermittent; solar and wind power plants, in particular, can see significant swings in energy production over a short period of time, which requires a high degree of flexibility from generators and transmission system operators (TSOs).

MEDREG countries are working relentlessly to achieve the targets depicted, as demonstrated in figure below. The figure 2 shows the renewable energy capacity – PV, onshore wind, offshore wind, hydro and geothermal – added between 2015 and 2019. It is worth noting that countries that have low RES capacities are doing a good job considering the different barriers they are faced with (scarce land resources, economic situation, etc.).

The balance between supply and demand must be maintained in the electricity grid. Balancing authorities are responsible for dispatching the power plants to follow the change in net load using existing reserves. Since building new power plants is capital intensive, there is a need for new ways and innovations to integrate renewable energy power generation into the grid. New regulations and policies are required to support the integration processes in different systems.

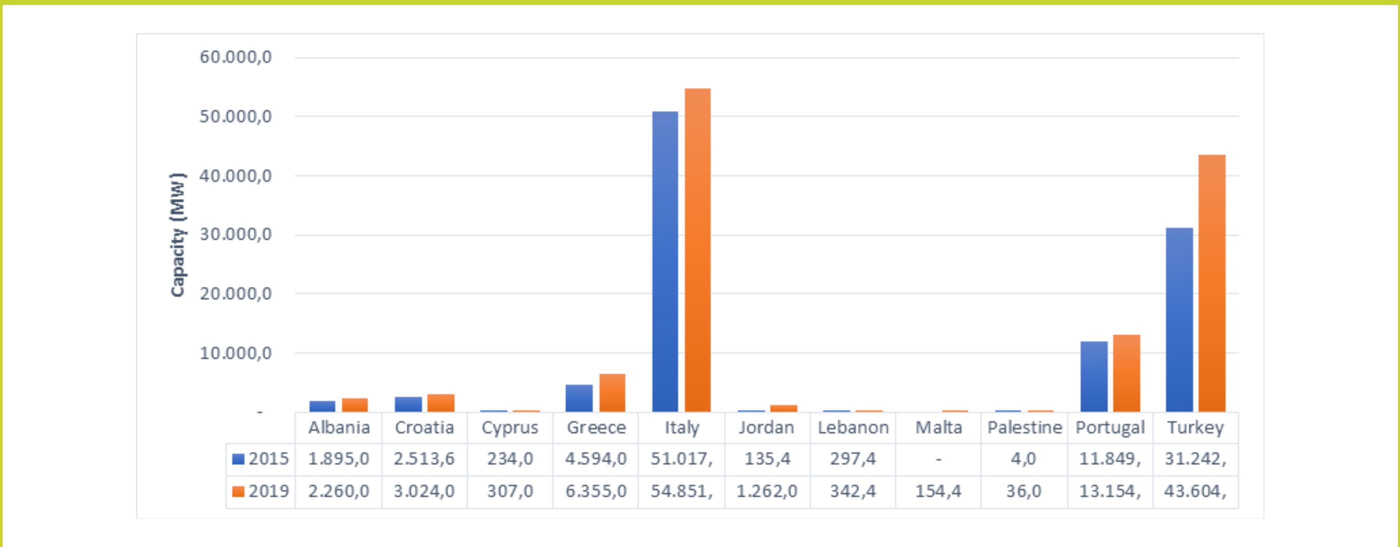
There are six phases of the system integration of renewables. Table 2 presents these phases as well as areas for policy intervention to overcome challenges at each phase.

Table 1 . MEDREG countries' national renewable energy targets in electricity production or TFEC, source: see footnotes 5 and 6.

	2022	2025	2030	2035
Albania			42%	
Algeria			27%	
Croatia			36.4%	
Cyprus			22.9%	
Egypt	20%			42%
France			40%	
Greece	38.6%	46.8%	61%	
Israel			17%	
Italy			30%	
Jordan		20%		
Lebanon			30%	
Libya			20%	
Malta			11.5%	
Morocco			52%	
Palestine			12%	
Portugal			80%	
Slovenia			27%	
Spain			74%	
Tunisia	22%		30%	
Turkey	65%[1]			

1 In Turkey the target is set for 2023

Figure 2 . RE capacity change 2015–2019, source: MEDREG countries[1]



1 For Greece, large hydro (15MW and +) are not considered

Table 2 . Phases of renewable energy system integration

Phase	Phase characteristics	Policy/regulation intervention areas[1,2,3]
Phase 1	The share of renewable energy and the associated variability is insignificant and the effect is localised (e.g. grid connection points).	• Upgrading grid codes. • Variable renewable energy (VRE) incorporation in system operations. • VRE technology mix that is friendly to system operation. • Grid expansion optimisation.
Phase 2	With growing shares of renewables and VRE, generation is becoming more noticeable in system operation. In this phase, an additional consideration for the grid code and upgrading operation practices is crucial.	
Phase 3	Net load suffers from greater net load swings and variability. More power system flexibility is required. This flexibility usually cannot be fulfilled by existing assets and requires new dispatchable power plants that are more flexible.	• Demand side management • Advanced flexible power plants • Change in roles and responsibilities • Integrated planning among stakeholders
Phase 4	VRE generation is able to cover most of the power demand at certain periods (e.g. low demand on weekends). The stability of the system is the main concern in this phase and the contingencies to unexpected disruptions.	
Phase 5	VRE output frequently exceeds power demand, which leads to large-scale curtailment. New demands need to be introduced via electrification or electric vehicles.	
Phase 6	The main challenge of this phase is to meet the demand during low VRE output. Bridging supply and demand will require large-scale energy storage.	

1 IRENA, IEA, REN21, Renewable Energy Policies in a Time of Transition, 2018, P.79 https://www.irena.org/publications/2018/Apr/Renewable-energy-policies-in-a-time-of-transition
2 IEA, System Integration of Renewables, 2018, P. 17–19, https://www.iea.org/reports/system-integration-of-renewables
3 For examples of policy areas intervention, please visit source No.6, P.96

All MEDREG countries are not in the same phase of renewable energy integration. Some countries are more advanced and have a larger share of RES in their energy mix. As seen in Table 2, each phase has a distinct intervention. Additionally, new technologies help to accept new capacities of RES into the power system. However, they also impose new regulatory challenges for NRAs.

The report discusses new regulatory options that can facilitate RES integration into current energy systems and analyses the support mechanisms of RES and assess whether new regulatory options are available for their integration.

Chapter Two outlines the main support mechanisms for the integration of RES used in MEDREG member countries during the last decade and their evolution in the period.

Chapter Three assesses new regulatory options available for RES integration such as the integration of RES in distribution systems, smart grids, demand side management and others.

Chapter Four analyses non-technical barriers for renewable energy sources for electricity (RES-E) integration and proposes some guidelines to overcome them, describing the role of energy regulators in this process.

Lastly, Chapter Five highlights the main findings of the new regulatory tools for RES integration and presents some insights and guidelines for good practice useful fo r NRA and MEDREG members.

METHODOLOGY

The present report is based on a collection of members' responses to the questionnaire developed for the report "Analysis of auction mechanisms to promote RES", which was revised and updated by the RES WG to collect 2019 data "RES auction schemes and other support schemes in Mediterranean countries".

The questionnaire comprises 25 questions – a combination of open and multiple-choice questions – divided into four sections:

- Section A: Overview of support schemes
- Section B: General questions
- Section C: Competitive auction schemes
- Section D: Other support schemes

Table 3 presents a list of the NRAs that have contributed via the new questionnaire, that update and complement the previous questionnaire.

A template for national case studies was distributed among the members in order for each country to describe their experience with a self-consumption regime. In cases where the concept had not yet been applied in a country, members were asked to explain if there was a debate regarding its introduction in the future and, if so, they were requested to specify the framework being discussed.

The case study template addressed the following topics:

- General description
- Main policy goals
- How to access the activity
- Costs and tariffs involved and the billing arrangements

Table 3 . List of MEDREG regulators that responded to the questionnaire

Country	NRA
Albania	Albanian Electricity Regulatory Authority (ERE)
Croatia	Croatian Energy Regulatory Agency (HERA)
Cyprus	Cyprus Energy Regulatory Authority (CERA)
France	Regulatory Commission of Energy (CRE)
Greece	Regulatory Authority for Energy (RAE)
Italy	Italian Regulatory Authority for Energy, Networks and Environment (ARERA)
Jordan	Energy and Mineral Regulatory Commission (EMRC)
Lebanon	Lebanese Centre for Energy Conservation (LCEC)
Malta	Regulator for Energy and Water Services (REWS)
Palestine	Palestine Electricity Regulatory Council (PERC)
Portugal	Energy Services Regulatory Authority (ERSE)
Turkey	Energy Market Regulatory Authority (EMRA)

- Incentives
- New information and communication technology (ICT) tools

Table 4 depicts the NRAs that have contributed to national case studies.

In addition to the questionnaire, MEDREG members provided Excel sheets containing benchmarking data. This data encompassed capacity generation classified according to technology – oil, gas, PV, wind, geothermal, hydro, etc. – CO2 emissions, monthly RES generation, barriers for RES sector development, legislative and regulatory framework and promotion mechanisms.

The report includes data from the most recent publication issued by international organisations specialised in energy sectors such as IRENA, IEA and REN21. In addition, information from past MEDREG reports has been included. It tackles different state-of-the-art technologies that disrupt the traditional paradigm of power systems and resolve some of the challenges arising from these new technologies by giving recommendations to NRAs to facilitate the various challenges facing them.

Table 4 . List of MEDREG regulators that replied to the case study on self-consumption regime.

Country	NRA
Cyprus	CERA
France	Regulatory Commission of Energy (CRE)
Italy	Italian Regulatory Authority for Energy, Networks and Environment (ARERA)
Lebanon	Lebanese Centre for Energy Conservation (LCEC)
Portugal	Energy Services Regulatory Authority (ERSE)
Turkey	Energy Market Regulatory Authority (EMRA)

3

EVOLUTION OF THE MAIN POLICY OPTIONS FOR THE INTEGRATION OF RES DURING THE LAST DECADE

3

EVOLUTION OF THE MAIN POLICY OPTIONS FOR THE INTEGRATION OF RES DURING THE LAST DECADE

IRENA classifies the main policies for RES into two categories: regulatory and pricing policies and non-regulatory policies[8]. Regulatory and pricing policies include quotas, renewable certificates, FIT, FIP, auctions, net metering, etc. In Figure 3, the aforementioned policies are classified further according to stakeholders. Non-regulatory policies include financial and fiscal incentives and voluntary programs.

Current trends in renewable energy policies are witnessing a shift towards auctions and tender mechanisms in lieu of feed-in policies for large-scale projects. In 2019, the total number of countries adopting auctions and tenders was 109, rising drastically from 20 countries in 2009, as shown in Figure 4[9]. Auctions and tender mechanisms are becoming more popular due to their effectiveness, resulting in low bids. In August 2020, the Portuguese government announced a world-record low solar bid that reached $ 0.01316/kWh[10]. Currently, competitive auction schemes exist in nearly all MEDREG countries[11].

MEDREG countries use a variety of support schemes to promote renewable energy. FIT and competitive auction schemes are currently the most popular policies in MEDREG countries[12]. The least used policy is open window. Some policies, such as tradable green

8 IRENA, IEA, REN21, Renewable Energy Policies in a Time of Transition, 2018, https://www.irena.org/publications/2018/Apr/Renewable-energy-policies-in-a-time-of-transition

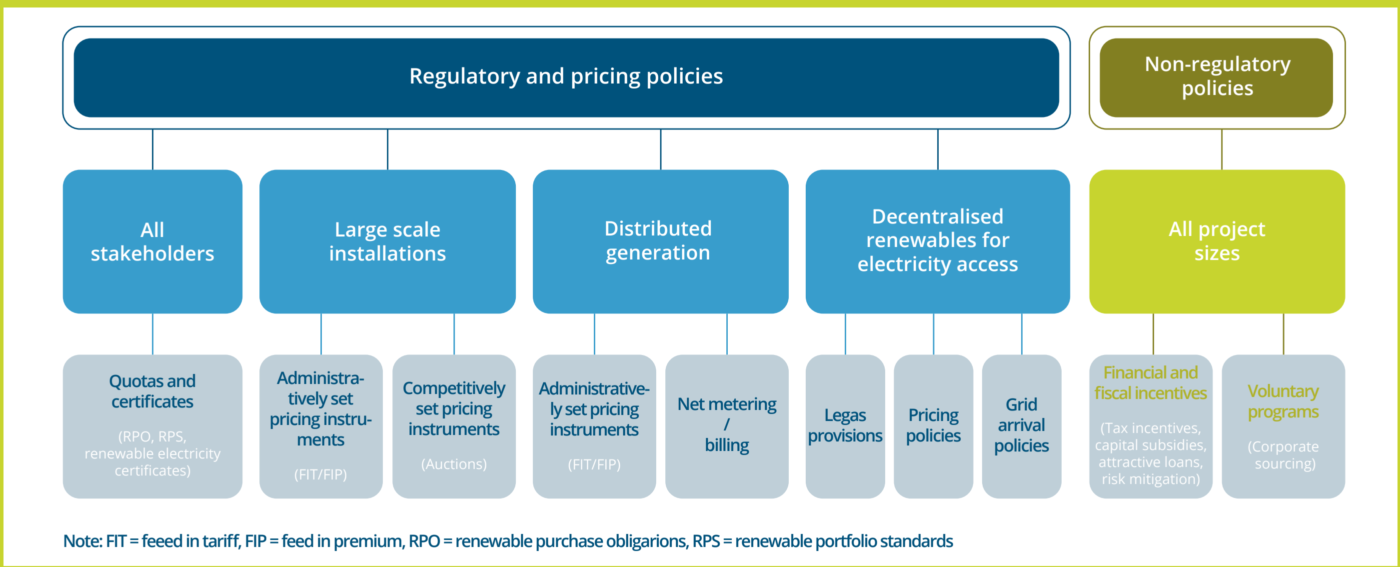
9 REN21, Renewables Global Status Report, 2020, P.72, https://www.ren21.net/wp-content/uploads/2019/05/gsr_2020_full_report_en.pdf

10 Emiliano Belline, PV magazine, 27 August 2020, Accessed on 15 October 2020, https://www.pv-magazine.com/2020/08/27/portuguese-government-confirms-world-record-solar-price-of-0-01316-kwh/

11 MEDREG, Analysis of auction mechanisms to promote RES, 2019, MED19-28GA-3.2.2, P.37.

12 Data presented in Table 6 are collected from the regulators' responses to the second RES support scheme questionnaire and an updated version from the table in the MEDREG report "Analysis of auction mechanisms to promote RES", 2019, MED19-28GA-3.2.2, P.37.

Figure 3 . Policy classification, source: IRENA



certificates (TGCs), did not exist until recently. Table 6 summarises the current support schemes used in MEDREG countries. Some changes have been seen since the last overview presented in the 2019 MEDREG report "Analysis of auction mechanisms to promote RES". The changes will be elaborated on in the following paragraphs.

In **Albania** and **Greece,** TGCs schemes have been introduced. Although the old FIT scheme is not available in **Croatia**, a new FIT and FIP are active. The first pertains to power plants up to, and including, 500kW, and the latter will pertain to power plants larger than 500kW. Prices for individual power plants entering these schemes will be determined through a competitive tendering procedure. **Egypt** decided that the second round for FIT, which was announced in late 2016 for wind and solar PV projects, would be the last. The government of Egypt resorted to competitive auctions and direct proposal submissions[13] .
Three new countries are presented in Table 5: Malta, Morocco and Tunisia. **Malta** reported the use of FIT, a competitive auction investment grant and others. **Morocco** opted to use the competitive auction scheme and, to some extent, a net metering scheme under Law 58-15 (2015). However, it has not been fully implemented[14]. In **Tunisia** as well the government uses competitive auction and net metering schemes.

On the one hand, implementing RES support schemes is very effective in promoting renewable energy projects. On the other hand, support schemes have risks and limitations that must be avoided or mitigated. Countries generally use multiple schemes according to the size and location of the renewable energy project. Table 5 summarises the risks and limitations of each support mechanism[15].

Countries have different approaches to financing renewable energy support schemes. Some countries impose taxes on all citizens while others use grants or levies on electricity bills. More than half the MEDREG countries use non-tax levies that are paid by consumers via electricity bills to finance renewable energy support schemes. Grants are also a popular option and used in some countries such as Algeria, Jordan and Lebanon. Table 7 exhibits the updated results extracted from MEDREG countries' responses to the questionnaire.

13 Maged Mahmoud, Ali Habib, Arab Future Energy Index (AFEX), 2019, RCREEE, P.53 https://www.rcreee.org/sites/default/files/final_afex_re_2019_final_version-1.pdf

14 Maged Mahmoud, Ali Habib, Arab Future Energy Index (AFEX), 2019, RCREEE, P.55 https://www.rcreee.org/sites/default/files/final_afex_re_2019_final_version-1.pdf

15 IRENA, IEA, REN21, Renewable Energy Policies in a Time of Transition, 2018, P.74 https://www.irena.org/publications/2018/Apr/Renewable-energy-policies-in-a-time-of-transition

Figure 4 . RE policies evolution, source: REN21

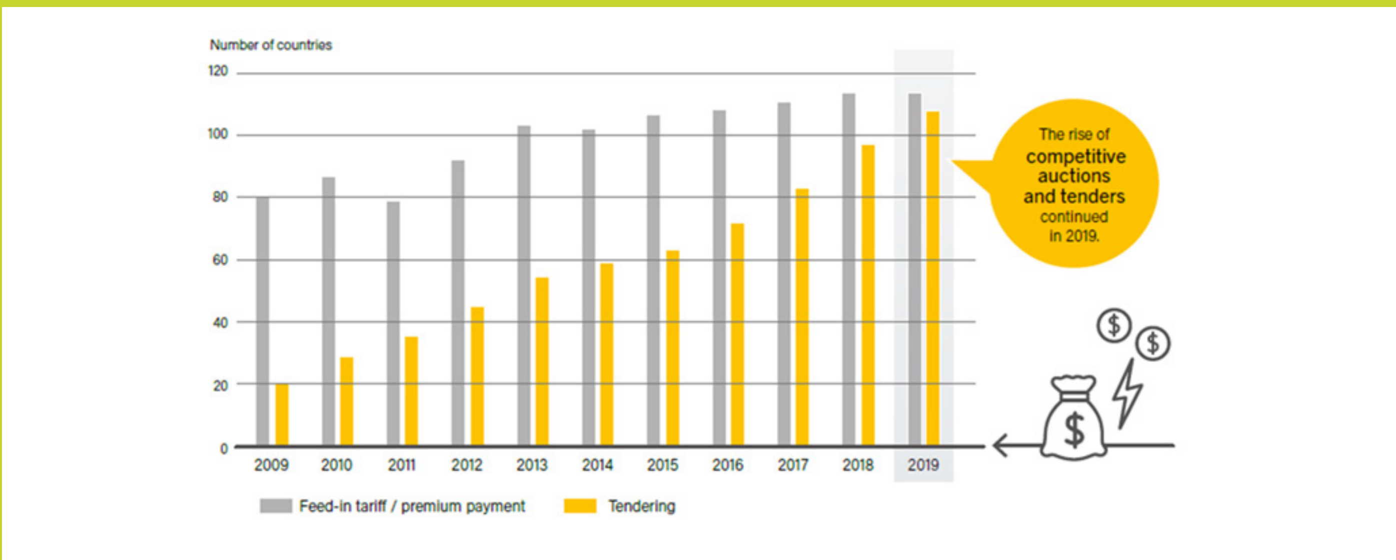


Table 5 . Risks and limitations of RES support schemes.

Support mechanism	Risks and limitations
Quotas and obligation	Risk of failure if the monitoring and compliance measures are weak or not implemented. They must be tied to other mechanisms at times (e.g. tradable certificate).
FIT	Market integration is complex when the share of VRE is high. Challenges of setting and adjusting the tariff arise when the cost structure changes.
FIP	There are windfall profits for generators when the market price is high but it is risky for the generator when the market price is low. Additional costs such as transaction, balancing and forecasting costs might be imposed on the producer.
Competitive auctions and tenders	These may involve the risk of underbidding, collateral, bad auction design, etc., which may drive small and new players out of the market.
Tradable certificate	A robust enforcement and compliance mechanisms must be in force.
Financial incentives	In some cases, it does not relate to the quantity of electricity produced. Political priorities can heavily influence the level of support according to political needs.
Net metering	If the distributed generation levels are high, there is a risk of cross-subsidisation between participating customers and non-participating customers. Moreover, the retail tariff may not reflect the actual value of electricity in each location and period.
Net billing	In some cases, there is a risk of uncertainty regarding when net billing payments would be made and the frequency and form of payment.
Targets for the medium and/or long term	This is not effective on its own and requires the support of another policy. It can be changed, altered or even cancelled depending on the political commitment.

Table 6 . Overview of the current support schemes in MEDREG countries.

	FIT	FIP	TGCs	Competitive auction schemes	Investment grants	Open window	Tax exemption/ incentives	Other
Albania	■	■	■	■				
Algeria				■				
Croatia	■	■						
Cyprus	■			■	■		■	■
Egypt				■				■
France	■	■		■		■	■	
Greece	■	■	■	■	■		■	
Israel	■			■			■	
Italy	■	■		■			■	
Jordan				■	■		■	■
Lebanon				■			■	■
Malta	■			■	■			■
Morocco				■				■
Palestine	■			■			■	■
Portugal	■			■				
Slovenia	■	■		■				
Tunisia				■				■
Turkey	■			■			■	

Table 7 . How renewable energy policies are financed.

Country	Taxation paid by all citizens	Non-tax levies paid by some or all customers via the electricity bill	Others
Albania		■	
Croatia		■	■
Cyprus		■	
France			■
Greece		■	■
Italy		■	
Jordan			■
Lebanon	■		■
Malta	■		
Palestine			■
Portugal		■	
Turkey			■

For weighted average price per MWH that results from auctions, the lowest price for PV technology is in Portugal, who achieved € 20.33/MWH in 2019, followed by Albania. In onshore wind technology, the lowest price is US$ 34.8/MWH scored by Turkey in 2017. Table 8 depicts the weighted average price per MWH reported by MEDREG countries in the questionnaire.
Implementing national support schemes accelerated RES scaling in MEDREG countries. However, financing these support schemes places a burden on the national budget or electricity consumers. The increasing shares of RES and the development of competitiveness and generation costs require MEDREG countries to change and adapt their support schemes towards higher market integration using cost-efficient mechanisms.

To reach full market integration, RES must operate at the same level as conventional producers. For instance, they must bear the same responsibilities and have access to the same markets. The market should be arranged to be non-discriminatory and reflect marginal costs[16]. Full market integration is a long-term objective, and NRAs are recommended to start laying down the foundation for this market using new regulatory options that will be discussed in the next chapter.

16 CEER, Key Support of RES in Europe: Moving Towards Market Integration, 2016, C15-SDE-49-03, P. 41, https://www.ceer.eu/documents/104400/3728813/C15_SDE-49-03+CEER+report+on+key+support+elements_26_January_2016.pdf/28b53e80-81cf-f7cd-bf9b-dfb46d471315

Table 8 . Weighted average price per MW.

Country	PV	Wind Onshore	Wind Offshore	Biomass	Other
Albania	**2020** (€ 24,9/MWh)				
Cyprus	**2013** (€ 93/MWh)				
France	**2019** (€64/MWh) for ground-mounted PV, (€93/MWh) for rooftop PV	**2019** (€64.8/MWh)	**2019** (€44/MWh)	**2019** (€112.9/MWh)	**2019** (€87.1/MWh) Hydro
Greece	**2019** (€61.37/MWh)	**2019** (€62.52/MWh)			
Italy	**2019** (€60/MWh)	**2019** (€56/MWh)			
Lebanon	**2019** ($ 57/MWh) [1]	**2018** [2] ($ 96/MWh)			
Malta	**2019** (€137.2/MWh)				
Portugal	**2019** (€20.33/MWh)				
Turkey	**2017** ($ 69.9/MWh)	**2017** ($ 34.8/MWh)			

1 The lowest price, as announced by the Minister of Energy and Water, is USD 57/MWh in the Bekaa region.
2 104.5 USD /MWh for the first three years and 96 USD /MWh for the next 17 years

4

NEW REGULATORY OPTIONS FOR THE INTEGRATION OF RES

4

NEW REGULATORY OPTIONS FOR THE INTEGRATION OF RES

4.1 Overview and definition

As described in the first two chapters, there are a variety of policies to promote the deployment of RES. However, these policies are not always accompanied by vigorous policies and regulations to integrate RES in existing power systems. Integration policies should increase system flexibility and utilise distributed energy resources (DERs) to reduce costs and increase system reliability. NRAs should ensure the timely adoption of integration policies and synchronise their deployment with RES emplacement.

What is RES system integration? The system integration of RES includes all technical, policy, regulation, institutional and market design changes and modifications required to enable the uptake and acceptance of high shares of RES in the energy system without compromising system security or increasing costs[17]. Most NRAs in MEDREG countries have specific responsibilities to implement or oversee the implementation of RES promotion and integration policies alongside their traditional regulatory role. NRAs seek to establish appropriate electricity market ecosystems to enable the integration of RES in competitive settings. This chapter presents some technologies and related regulatory options to help NRAs decide the best approach to use. We will start by providing an overview of the Green Deal to facilitate the discussion of the next topics.

4.2 European Green Deal

The European Green Deal is a response to several climate challenges. It reaffirms the European Commission's commitment to tackle environmental challenges. The Green Deal aims to transform the EU into a fair and prosperous society that uses resources efficiently in a competitive economy. The Green Deal targets net zero greenhouse gas (GHG) emissions by 2050 and economic growth to be decoupled from resource use[18].

Energy usage across economic sectors and energy production account for more than 75% of the EU's GHG emissions. To achieve the abovementioned climate objective, large shares of renewable energy must be introduced into the European energy system. This must be complemented by the phasing out of coal and other fuels that emit GHGs. It is also essential to have a fully integrated, interconnected and digitised European energy market that is technology neutral.

The European Commission stresses that the clean energy transition should involve and benefit energy consumers. The cost drivers of renewables should be combined with the careful design of integration policies that impact household energy bills. Smart integration of energy efficiency and renewable energy can help achieve this above target at the lowest possible cost.

The energy transition intended in the Green Deal requires smart infrastructure along with cross-border and regional cooperation to realise the benefits of such a transition at affordable prices. Moreover, innovative technologies and infrastructure such as energy storage, smart grids, hydrogen and many more are enabling factors for the transition. Lastly, all the above indicate that the European regulatory frameworks for energy infrastructure need to be reviewed and updated

17 IRENA, IEA, REN21, Renewable Energy Policies in a Time of Transition, 2018, P.12 https://www.irena.org/publications/2018/Apr/Renewable-energy-policies-in-a-time-of-transition

18 European Commission, Communication from the Commission to the European Parliament, The European Green Deal, 2019, https://ec.europa.eu/info/sites/info/files/european-green-deal-communication_en.pdf

to ensure consistency with the objectives of the Green Deal[19].

4.3 New regulatory options

Renewable energy for power generation is not limited to the large scale. That was the case in the past when the viability of small-scale systems was not encouraging enough for investment. For instance, a distributed PV project was not cost competitive. Nevertheless, with the decreasing costs of PV now, small-scale power generation is drawing the attention of investors and policymakers. In addition, small-scale RES is an effective solution for countries with scarce land resources such as Malta and Palestine. There are several options for the implementation of small-scale power generation such as collective self-consumption and energy communities.

4.3.1 Self-consumption

Self-consumption can be defined as the use of power generated on site by an energy consumer to reduce, at least in part, the purchase of electricity from the grid[20]. Three policies mainly govern consumption and sales from the distributed generation projects[21]:

1. Buy-all, sell-all model
2. Net metering model
3. Real-time self-consumption model

In the first model, all the self-generated power is sold to the system according to an agreement between the generator (prosumer) and the utility at a fixed tariff for a fixed duration, similar to the FIT scheme. Some countries use auctions to set the price according to the highest bidder. The self-generator consumes all the electricity from the grid, which is why their activity as a generator is separated from that as a consumer. Two meters are required for this approach.

19 European Commission, Communication from the Commission to the European Parliament, The European Green Deal, 2019, P.6, https://ec.europa.eu/info/sites/info/files/european-green-deal-communication_en.pdf
20 CEER, Status Review of Renewable Support Schemes in Europe for 2016 and 2017, 2018, P.37, https://www.ceer.eu/documents/104400/-/-/80ff3127-8328-52c3-4d01-0acbdb2d3bed
21 Manfred Hafner, The geopolitics of the global energy transition, Springer Open, ISBN 978-3-030-39065-5, P.216, https://link.springer.com/book/10.1007%2F978-3-030-39066-2

In the net metering model, self-generators consume all their electricity production and reduce their consumption from the grid. The excess energy production is delivered to the utility for an energy credit, which can be used as a deduction to electricity consumption at other times. The process of net metering provides system owners the opportunity to gain extra revenue by selling their excess power to the grid while making up for shortfalls via the grid. If the amount of energy generated is more than that consumed, the owner gets compensated for the excess amount. However, if the amount of energy consumed is more than that generated, it is imported from the utility grid and the owner pays only the net amount. The validity of the energy credit varies according to the scheme the prosumer is contracted for. The duration of the credit's validity influences the viability of the net metering scheme – the longer the period, the more attractive the scheme is for the self-generator. This system requires a bidirectional meter.

The third model involves generating and self-consuming by selling the excess electricity to the grid. However, unlike the net metering scheme, the accounting of the metering for the sold and consumed electricity is calculated in a short time window in a very short time interval (can be less than a one-hour span). Excess electricity price is often based on the wholesale or retail electricity price. This system too requires a bidirectional meter.

With the advent of the sharing economy, interests escalated in the direction of the sharing of electricity between prosumers themselves or with the final consumer, which is known as collective self-consumption. Collective self-consumption is recognised in the national legal frameworks of some countries such as Austria, France, Spain and Portugal. The Clean Energy for Europeans Package marks the first time this concept is being officially recognised in the European legislation[22]. Directive (EU) 2018/2001 establishes that "jointly acting renewables self-consumers" means a group of at least two jointly acting renewables self-consumers in accordance with point (14) that are located in the same building or multi-apartment block.

22 CEER, Regulatory Aspects of Self-Consumption and Energy Communities, 2019, P.11, https://www.ceer.eu/documents/104400/-/-/8ee38e61-a802-bd6f-db27-4fb61aa6eb6a

Individual self-consumption frameworks are well established in most MEDREG countries through net metering schemes. However, from a regulatory point of view, NRAs should consider some remarks regarding collective self-consumption as it is an emerging concept (it has already been implemented in some MEDREG countries; consult case studies in Annex 2). The following questions should be considered while designing the legal framework:

- Should all technologies be allowed to participate in this scheme or should it be restricted to renewable energy technologies?
- Do the scheme participants need to form a legal entity or can they participate individually with less complex procedures?
- If the grid is used, will there be an exemption to encourage this scheme or will network charges be applied? Further, would network charges be eliminated if the utility grid is not used or would some sort of tax be applied?

4.3.2 Energy communities

The term "energy communities" refers to the broad domain of collective energy actions taken by citizens to participate in the energy system. The EU's Clean Energy Package introduced energy communities into the legislation. Currently, there are two types of energy communities. The first is the Citizen Energy Community (CEC) and the second is the Renewable Energy Community" (REC). The latter is defined in Renewable Energy Directive (EU) 2018/2001 (RED II) as follows[23]:

REC means a legal entity: (a) which, in accordance with the applicable national law, is based on open and voluntary participation, is autonomous, and is effectively controlled by shareholders or members that are located in the proximity of the renewable energy projects that are owned and developed by that legal entity; (b) the shareholders or members of which are natural persons, small- or medium-sized enterprises or local authorities, including municipalities; (c) the primary purpose of which is to provide environmental, economic or social community benefits for its "shareholders or members or for the local areas where it operates, rather than financial profits".

The second type of CEC is defined in the recast Electricity Market Directive (EU) 2019/944 as follows:

Legal entity that (a) is based on voluntary and open participation and is effectively controlled by members or shareholders that are natural persons, local authorities, including municipalities, or small enterprises; (b) has the primary purpose to provide environmental, economic or social community benefits to its members or shareholders or to the local areas where it operates rather than to generate financial profits; (c) may engage in generation, including from renewable sources, distribution, supply, consumption, aggregation, energy storage, energy efficiency services or charging services for electric vehicles or provide other energy services to its members or shareholders.

Table 9 summarises the main differences between the two types of energy communities[24,25].

There are many ongoing energy community projects across Europe. Examples include farms and schools that have windmills or solar panels installed on the roof or in the building proximity. However, few of these existing projects use renewable energy technologies. Nevertheless, new communities have a host of reasons to invest in renewable energy technologies, and several activities are available for new projects[26].

Several activities are to a certain extent not problematic from the regulatory perspective and fall within most electricity market regulations such as:

- **Generation:** Using or owning generation assets such as wind and solar where members do not

23 CEER, Regulatory Aspects of Self-Consumption and Energy Communities, 2019, P.11, https://www.ceer.eu/documents/104400/-/-/8ee38e61-a802-bd6f-db27-4fb61aa6eb6a

24 CEER, Regulatory Aspects of Self-Consumption and Energy Communities, 2019, P.12, https://www.ceer.eu/documents/104400/-/-/8ee38e61-a802-bd6f-db27-4fb61aa6eb6a
25 Aura Caramizaru, Energy communities: An overview of energy and social innovation, JRC Science for Policy Report, 2020, P.11, https://publications.jrc.ec.europa.eu/repository/bitstream/JRC119433/energy_communities_report_final.pdf
26 Aura Caramizaru, Energy communities: An overview of energy and social innovation, JRC Science for Policy Report, 2020, P.12, https://publications.jrc.ec.europa.eu/repository/bitstream/JRC119433/energy_communities_report_final.pdf

self-consume the generated power and sell it to the network instead.

- **Supply:** Using aggregation activities by combining customer loads or generating electricity for sale, purchase or auction in electricity markets.
- **Distribution:** Ownership or management of the local electricity network or a small grid.
- **Electro-mobility:** Owning and managing charging stations, car-sharing and carpooling.
- **Energy service:** Includes energy efficiency, ancillary services, smart grid, flexibility services, energy storage, etc.

Nevertheless, energy sharing defies the classical supplier–customer relationship and, consequently, demands special attention from NRAs. Another point worth mentioning is that an energy community must not disturb the existing market principles (e.g. unbundling, cost-sharing principle, etc.) and should compete with other market players[27]. Below are a few points that should be considered by NRAs:

27 CEER, Regulatory Aspects of Self-Consumption and Energy Communities, 2019, P.35, https://www.ceer.eu/documents/104400/-/-/8ee38e61-a802-bd6f-db27-4fb61aa6eb6a

Table 9 . Differences between CEC and REC

	Renewable energy communities	Citizen energy communities
Membership	Natural persons, local authorities, including municipalities, or small enterprises and microenterprises, provided that participation for the private undertakings does not constitute their primary commercial or professional activity.	Natural persons, local authorities, including municipalities, or small enterprises and microenterprises.
Permitted activities	Can be active in all energy sectors: production, consumption and selling of renewable energy.	Limited to activities in the electricity sector such as electricity generation, distribution, and supply, consumption, aggregation, storage or energy efficiency services, generation of renewable electricity and charging services for energy services to its shareholders or members.
Technologies	Limited to renewable energy technologies.	Technology neutral.
Geographic limitations	The shareholders or members must be in proximity of the renewable energy projects owned and developed by the REC.	There are no geographic limitations; MS can choose to allow cross-border CECs.
Autonomy	The definition refers to the capability of remaining autonomous from individual members and the other market actors that participate in the community as members or shareholders.	The definition does not include autonomy; however, the decision-making should be limited to members or shareholders with precautions of conflict of interest
Effective control	Can be controlled by micro, small and medium enterprises in proximity of the project.	Medium and large enterprises are excluded from being able to exercise effective control.

- It will be common for one point of delivery to be supplied by more than one supplier. This situation will add a new layer of complexity. A well-designed and transparent contractual agreement can address this issue.
- The network charges for using the public grid should be adequate and not affect the participant.
- The problem of cost duplication arises if the energy community is in DSO territory.
- The risks of inefficient consumption management can lead to higher grid usage.

4.3.3 Peer-to-peer electricity trading

With an increasing share of DERs connected to the utility grid, and with the intention to further deploy the distributed power generation, prosumers are allowed to sell their electricity to other consumers directly peer-to-peer (P2P). P2P is a business model based on an interconnected platform that functions as an online marketplace where producers and consumers can meet to buy or sell electricity without the need for an intermediary[28].

A P2P setup can be among neighbours within a single local community as well as among several communities. In the latter case, a mini-grid can facilitate electricity trading. Alternatively, trading can be enabled by interconnected networks owned by DSO, which needs to be remunerated accordingly. A P2P model can contribute greatly to the energy transition in the following ways:

- Increase RES deployment and flexibility for prosumer and consumer empowerment.
- Aid in grid balancing and congestion management with efficient operation.
- Provide ancillary services to the main power grid.
- Improve electricity access for the consumer.

For the first time, the European Commission defined P2P trading in EU Directive 2018/2001 as part of the Clean Energy Package legislation. P2P is defined as follows:

The sale of renewable energy between market participants by means of a contract with pre-determined conditions governing the automated execution and settlement of the transaction, either directly between market participants or indirectly through a certified third-party market participant such as an aggregator. The right to conduct peer-to-peer trading shall be without prejudice to the rights and obligations of the parties involved as the final customers, producers, suppliers, or aggregators.

It is crucial to point out that P2P requires strong ICT infrastructure. Distributed ledger technologies such as blockchain are among the most prominent technologies used in P2P trading platforms for their advantages, especially in decreasing transaction costs. ICT and its roles will be discussed later in the report.

To harvest the benefits of P2P electricity trading, NRAs would need to ensure a level playing field for platform-based businesses vis-à-vis traditional utilities and retailers. Below are some steps for regulators to implement P2P effectively in energy systems[29]:

- Set up market operation roles for P2P schemes.
- Determine clear roles and responsibilities of the stakeholders involved in P2P trading.
- Set up regulations on data collection, cybersecurity and access to ensure the privacy of the platform.
- Design supportive policies to promote the decentralisation of power systems and better utilisation of the existing grid infrastructure.
- Polices to encourage the distribution system operator to procure flexibility from P2P platforms are needed.

28 IRENA, Innovation landscape brief: Peer-to-peer electricity trading, 2020, P.6, https://irena.org/-/media/Files/IRENA/Agency/Publication/2020/Jul/IRENA_Peer-to-peer_trading_2020.pdf?la=en&hash=D3E25A5BBA6FAC15B9C193F64CA3C8CBFE3F6F41

29 IRENA, Innovation landscape brief: Peer-to-peer electricity trading, 2020, P.17, https://irena.org/-/media/Files/IRENA/Agency/Publication/2020/Jul/IRENA_Peer-to-peer_trading_2020.pdf?la=en&hash=D3E25A5BBA6FAC15B9C193F64CA3C8CBFE3F6F41

- Determine network charges when P2P trading is using the main grid.

4.4 Smart grid and ICT

Smart grids can be defined as follows[30]:

An electricity network that can cost-efficiently integrate the behaviour and actions of all users connected to it – generators, consumers and those that do both – in order to ensure economically-efficient, sustainable power systems with low losses and high levels of quality and security of supply and safety.

Countries have set ambitious targets for RES shares in the electricity sector. High shares of renewables require new approaches for effective management of the grid. Currently, some smart elements are being used in the grid, mainly to balance the supply and demand. A smart grid effectively integrates ICT into every single aspect of the electricity supply chain such as electricity production, transmission, distribution and consumption. This integration can result in lower environmental impact, enhanced reliability and service, minimised losses, better markets and reduced costs.
Smart grids can play a crucial role in energy transformation and renewable energy integration and can result in a favourable impact on RES intermittency, costs, grid management and control and distributed generation[31]. For RES intermittency, smart grids can address the challenges of supply and demand balance. For instance, smart grids tied to several variable RES and consumers and using ICT can control the loads to match the generation or engage storage/electric vehicles to supply electricity when the generation is less than the demand.

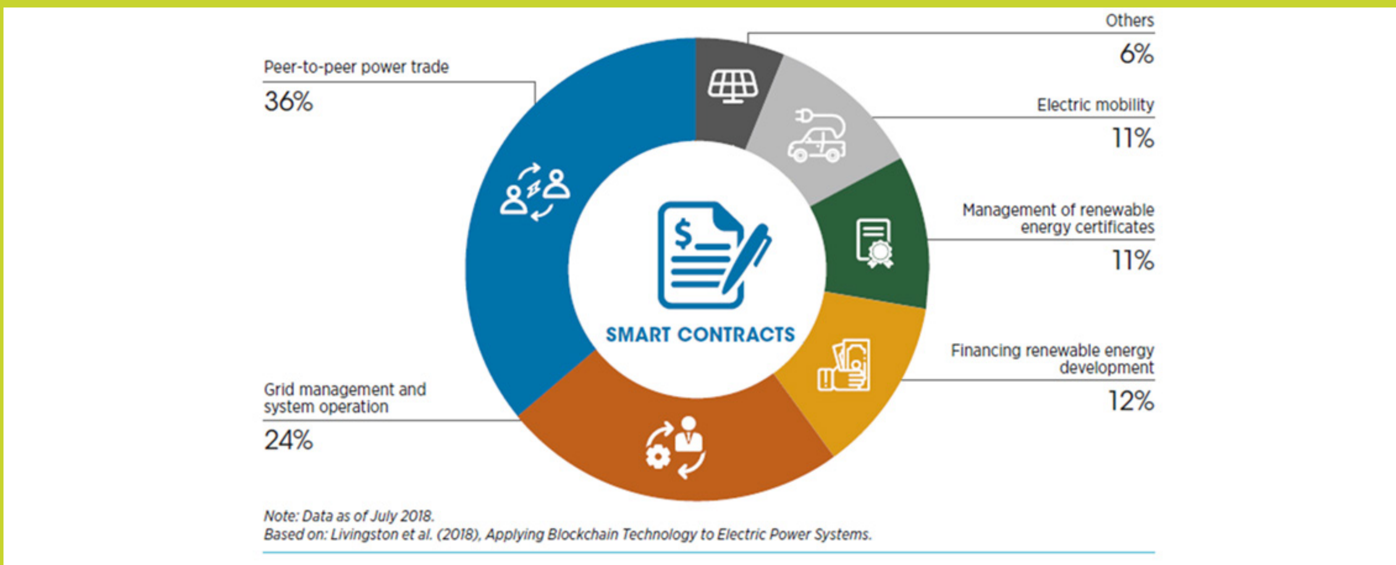
Reducing costs is also one of the benefits of incorporating smart grids. DERs that are controlled by smart grids can be integrated into the grid without strict limitations. This will decrease the investments required to install large power plants and increase customer involvement by allowing them to install small power plants on their premises.

Smart grids require ICT to be implemented properly. Currently, many new inventions and technologies are being used or have a high potential to be used in the electricity grid. Two of these options are discussed here as they have promising potential in the energy transition –blockchain technology and the IoT.

30 CEER, CEER Status Review of Regulatory Approaches to Smart Electricity Grids, 2011, P.9, https://www.ceer.eu/documents/104400/-/-/eb88c212-491a-6aa8-274f-772ba68282fc

31 Ruud Kempener, Smart Grid and Renewable; A Guide for Effective Deployment, IRENA, 2013, P.17, https://www.irena.org/publications/2013/Nov/Smart-Grids-and-Renewables-A-Guide-for-Effective-Deployment

Figure 5 . Blockchain initiatives in the power sector, source: IRENA



I. Blockchain

Blockchain is a technology that facilitates P2P trading without using an intermediary and by using decentralised storage to record all transactions. The first blockchain application was in the financial sector and was known as the cryptocurrency "bitcoin". Blockchain functions as a distributed database, and it grows continuously as it stores data in blocks. Each block is encrypted, time stamped and shared, and it unrelatable and connected the preceding blocks. Data in each block can constitute batches of individual transactions. Each transaction is verified by the network's computers that belong to the users (nodes). If a hacker wants to manipulate the data, he must reconfigure the data in each node, which is theoretically impossible[32].

New possibilities are now feasible using blockchain technology. This includes efficient and cost-effective management of power generation and distribution, billing, payments, trading and contracting. The latest has enormous value using smart contracting. Smart contracting is a digital contract programmed to self-execute when the specified conditions are met without the need for central authority[33], such as a P2P transaction between supplier and consumer. A consumer may have a condition to buy 30 kWh at a rate of Euro .09/kwh. Once the condition is met, the transaction will take place – the consumer will get 30 kWh and the supplier will get Euro 2.7.

Blockchain has the potential to accelerate power system transformation. It can contribute to almost every aspect of the power sector, such as grid management, trading and financing. Figure 5 presents blockchain initiatives in the power sector.

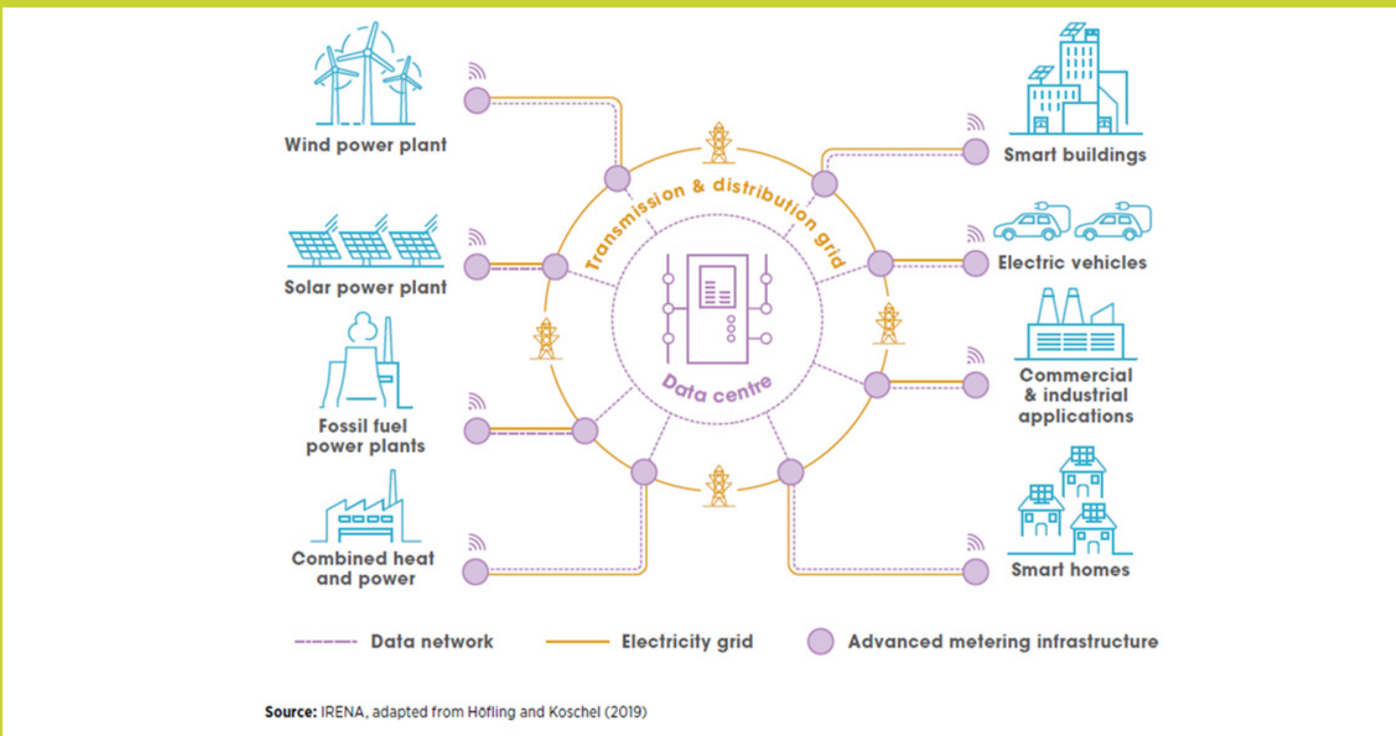
There are several regulatory requirements for the effective integration of blockchain technology:

- Regulations to legalise the use of blockchain applications in electricity trading.

32 Dena, Blockchain in the energy transition. A survey among decision-makers in the German energy industry, Deutsche Energie-Agentur GmbH, 2016.

33 IRENA, Innovation landscape brief: Blockchain, International Renewable Energy Agency, 2019, P.8, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Feb/IRENA_Landscape_Blockchain_2019.pdf?la=en%26hash=1BBD2B93837B2B7BF0BAF7A14213B110D457B392

Figure 6 . Smart grid supply and demand side devices connected by using IoT, source: IRENA



- Market regulations that enable electricity exchange between consumers and prosumers (for P2P trading applications) and between prosumers and system operators (for grid transactions).

- There is a need to develop regulations to organise the interaction between blockchain-based trading with the existing or new electricity trading regulations.

- Policies for the market to increase adaptation/ promotion of electricity trading through blockchain applications.

II. IoT

The complexity of the power system increases with every additional innovation. IoT applications enhance the communication, data handling, visibility and responsiveness of grid-connected devices. IoT (also called "connected devices" or "smart devices") is the internetworking of physical devices embedded with electronics, software, sensors and exchange data[34]. Every device is transformed to be smart and be able to communicate and interpret information from other devices in real time. The connection is done through the internet, which eliminates the need for wires. Each device has a unique IP address.

IoT could be a game changer in making our electricity system smart. In fact, it is one of the main pillars of smart grids. All the actions of users and producers will be integrated in an intelligent manner to achieve a resilient, reliable and cost-efficient electricity grid. This will help attract and integrate more decentralised resources in the power system. Figure 6 depicts how IoT can connect different devices from the supply and demand side.

With the connection of millions of devices in the entire electricity value chain, a complete disruption to the power system can be expected. IoT can lead to vast opportunities for the integration of RES into the power system. For the generation, IoT could provide better RES generation forecast and accurate automated control of power plants.

For transmission and distribution, IoT can maintain and enhance grid stability and reliability. IoT can also support the aggregation and control of DERs, operations of mini-grid and the automation of demand side management. All the above would lead to the operation of an optimised market. Policies and regulations are needed to give a push for IoT technology. Below are some points that could help the promotion of the technology:

- Policies are needed to encourage customers to participate in demand side management and prosumer schemes and install smart devices.

- The foundation of regulatory sandboxes is required to try out new business models.

- Data privacy policy and regulation is needed for all stakeholders.

- Schemes and regulations must be developed to incentivise distribution system operators to invest in smart grids.

- Appropriate market climates are needed to value flexibility in the operation of generation fleet (as well as demand response, batteries, etc.) using IoT.

4.5 Tariffs and billing arrangements

Many countries have implemented schemes to encourage citizens and companies to invest in renewable energy and install systems on their premises. Such schemes include net metering schemes and FIT. These schemes compensate consumers for injecting electricity into the grid and help increase RES shares in the systems. Currently, with the continuously evolving power system, new schemes must be introduced to reflect the real value of renewable electricity at the time of injection into the grid. This can also help solve several challenges that arise when integrating high shares of renewables.

In a study by the Rotterdam School of Management, "The economic consequences of electricity tariff design in a renewable energy era", to explore the economic consequences of the traditional tariffs with the advent of distributed energy resources (DERs), the researchers found that traditional tariffs are less fair and social welfare decreases with an increase in DERs. Traditional tariffs allow

34 IRENA, Innovation landscape brief: Internet of Things, International Renewable Energy Agency, 2019, P.7, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Sep/IRENA_Internet_of_Things_2019.pdf

for large wealth transfers to DER owners from non-owners. The study suggests that time-based tariffs (TOU) and real-time dynamic pricing results in better economic efficiency and fewer signs of cross-subsidisation. The schemes discussed here present better options for greater tariff fairness[35]:

i. Net billing scheme

Net billing is a market-based compensation mechanism as the prosumer's compensation is based on the actual market value of the kWh consumed or injected into the grid. The invoice issued by the retail supplier to the consumer is based on the value of the withdrawn electricity after subtracting the value of the injected energy[36]. Table 10 explains several methods to determine the appropriate compensation for consumers[37].

Knowing the method of tariff calculations, the prosumer can decide when to self-consume and when to inject electricity into the grid. When the generation and consumption are located in different places, net billing is known as "net billing advanced arrangement" or "virtual net billing". Alternatively, the scheme could be applied to multi-apartment buildings and the net credits split among the consumers. This would promote community-owned power generation projects (energy communities).

Net billing is a key contribution to VRE integration in the power system. It will increase the system's flexibility by promoting and engaging more prosumers in the system. Second, it will provide savings or income to prosumers. Lastly, it prevents the suboptimal electricity supply from DER. Prosumers under some net metering or FIT are incentivised to produce electricity continuously even if there is no demand, and this causes losses for retailers and utilities. Net billing arrangements help manage this problem.

However, implementing net billing schemes requires supportive regulations that boost the decentralisation of the power system, liberalisation of the electricity market, especially the retail side, and clear rules of valuation methods for the electricity injected into the grid. These schemes require a strong ICT infrastructure for real-time communication and metering.

35 Mohamed Ansarin, The economic consequences of electricity tariff design in a renewable energy era, Applied Energy, P. 275, 2020, https://www.sciencedirect.com/science/article/pii/S0306261920308291
36 IRENA, Innovation landscape brief: Net billing schemes, International Renewable Energy Agency,2019, P.7, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Feb/IRENA_Net_billing_2019.pdf?la=en&hash=DD239111C-B0649A9A9018BAE77B9AC06B9EA0D25
37 RENA, Innovation landscape brief: Net billing schemes, International Renewable Energy Agency, 2019, P.7.

Table 10 . Tariff determination methods

Method		Description
Time-of-use tariffs	Static	Tariffs are based on the historical power system balance.
	Dynamic	Tariffs are linked to the wholesale electricity market price or determined in real time based on actual power system balance.
Location-varying tariffs		Grid congestion at different nodes set the tariffs (nodal pricing) including, among other things, environmental factors.
Tariffs based on avoided cost of electricity		Tariffs are based on the marginal cost of electricity procurement that was avoided by retailers/system operators because of the injection of one unit of renewable electricity into the grid.

ii. Capacity subscription [38]

With increasing shares of VRE, the need for backup generation also increases due to the fluctuation of electricity production from RES. Utilities that supply electricity during peak hours experience declining losses of the revenues year after year and face complete shutdown or, at least, the risk of being mothballed. Shutting down the peak power plant will increase the risks of blackouts and impact grid reliability.

Capacity subscription is a mechanism where the consumer decides the peak demand they want to consume during the hours of shortage and pay monthly related to their decision. The advantage is that the consumer can choose and pay for their own security of supply. This can be done by installing fuses that limit their demand according to the fuse size. This device is called load limiting devices (LLDs). In normal conditions, the fuse is inactive, but in case of capacity shortage, LLDs are activated by the system operator and the demand is limited. Suppliers will know the capacity needed according to the sum of fuse size and invest in peaking plants accordingly.

Capacity subscription is one of the most convenient solutions in markets that have high shares of VRE to increase reliability and security of supply. Nevertheless, this solution has a high risk of leakage. If capacity subscription is applied in one country and other countries with interconnection lines have a shortage, a leakage will occur and result in high peak prices. Therefore, this mechanism requires a rigorous regulatory framework.

4.6 Flexibility to support network operation and system management

The global energy system is undergoing a noticeable transformation from large power plants, which are fossil fuel based, to another system that is based on VRE and decentralised power plants. This transformation is accelerated by the advance of technologies and a fall in the costs of renewable energy power plants. Power system flexibility is crucial for solving the problems of RES intermittency. Power system flexibility is defined as "the ability of a power system to reliably and cost-effectively manage the variability and uncertainty of demand and supply across all relevant timescales, from ensuring instantaneous stability of the power system to supporting long-term security of supply"[39].

The traditional power system is already designed with a certain degree of flexibility. However, with the advent of renewable energy and growing shares of renewables, flexibility needs are growing and evolving. Power system flexibility has three layers: hardware and infrastructure layer, policy/ regulatory/ market framework layer and institutional layer. Figure 7 depicts the three power system flexibility layers[40].

From the hardware layer, we can find four main technologies for flexibility: storage, demand side response, interconnection line and dispatchable generation. The second layer defines how this flexibility can be enabled. The third layer distributes the roles among the institutions and determines who is responsible for which functions.

Flexibility can exist in each phase of the electricity supply chain: generation, transmission, distribution and load. Figure 8 depicts some of the flexibility solutions in each phase[41].

4.7 Investment rationale and role of interconnections

Investments are needed to obtain high shares of the renewable energy goals set by MEDREG countries. Currently, investments in renewable energy assets are being driven by the regulatory and support schemes that are attracting investors. While investment in traditional power plants is

38 Gerard Doorman, Capacity subscription: Solving the peak demand challenge in electricity markets, IEEE Transactions on Power Systems, 2005.

39 IEA, Status of Power System Transformation, International Energy Agency, 2019, P.3, https://webstore.iea.org/status-of-power-system-transformation-2018

40 IEA, Status of Power System Transformation, International Energy Agency, 2018, P.4, https://webstore.iea.org/status-of-power-system-transformation-2018

41 IRENA, Solutions to integrate high shares of variable renewable energy (Report to the G20 Energy Transitions Working Group (ETWG)), International Renewable Energy Agency, 2019, P.18.

Figure 6 . : Smart grid supply and demand side devices connected by using IoT, source: IRENA

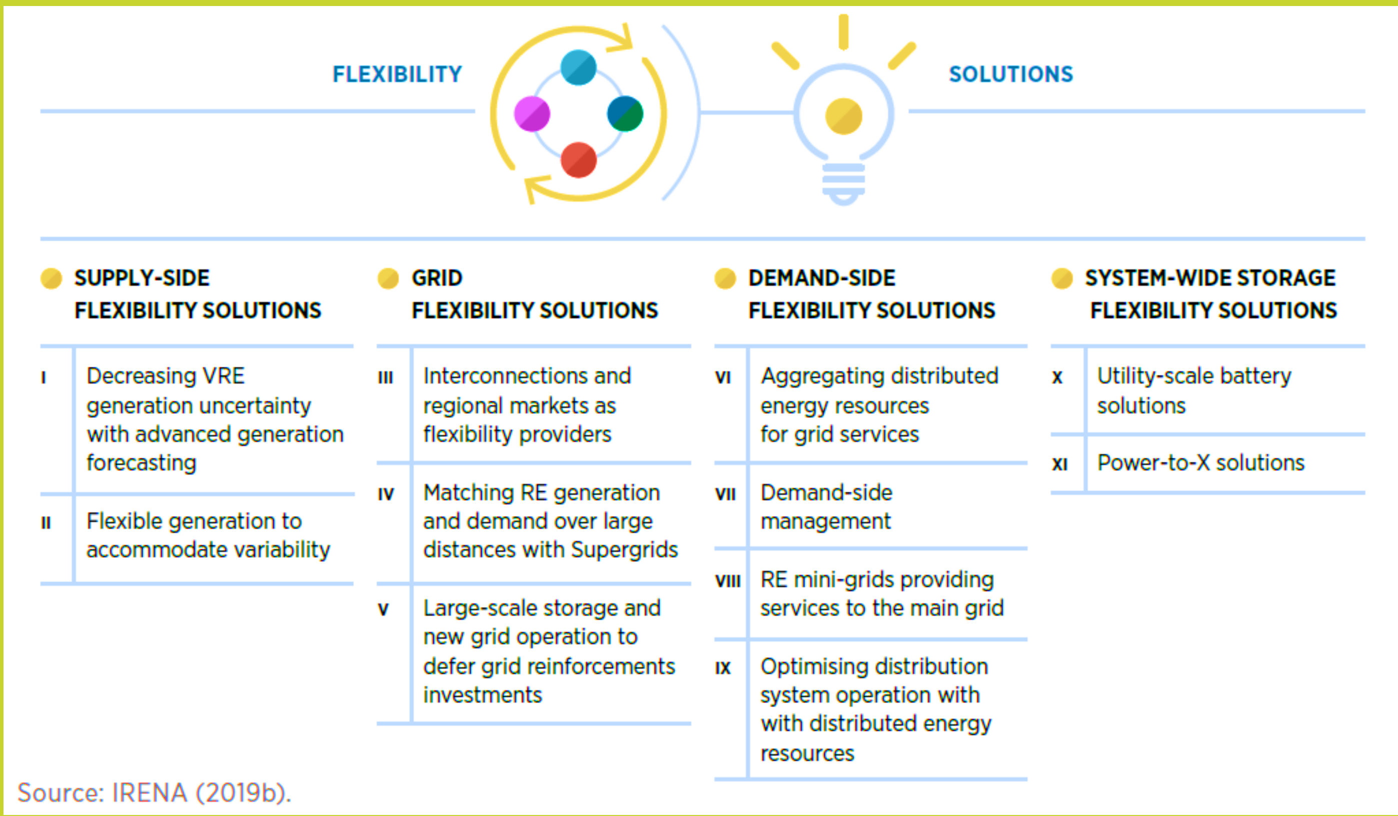
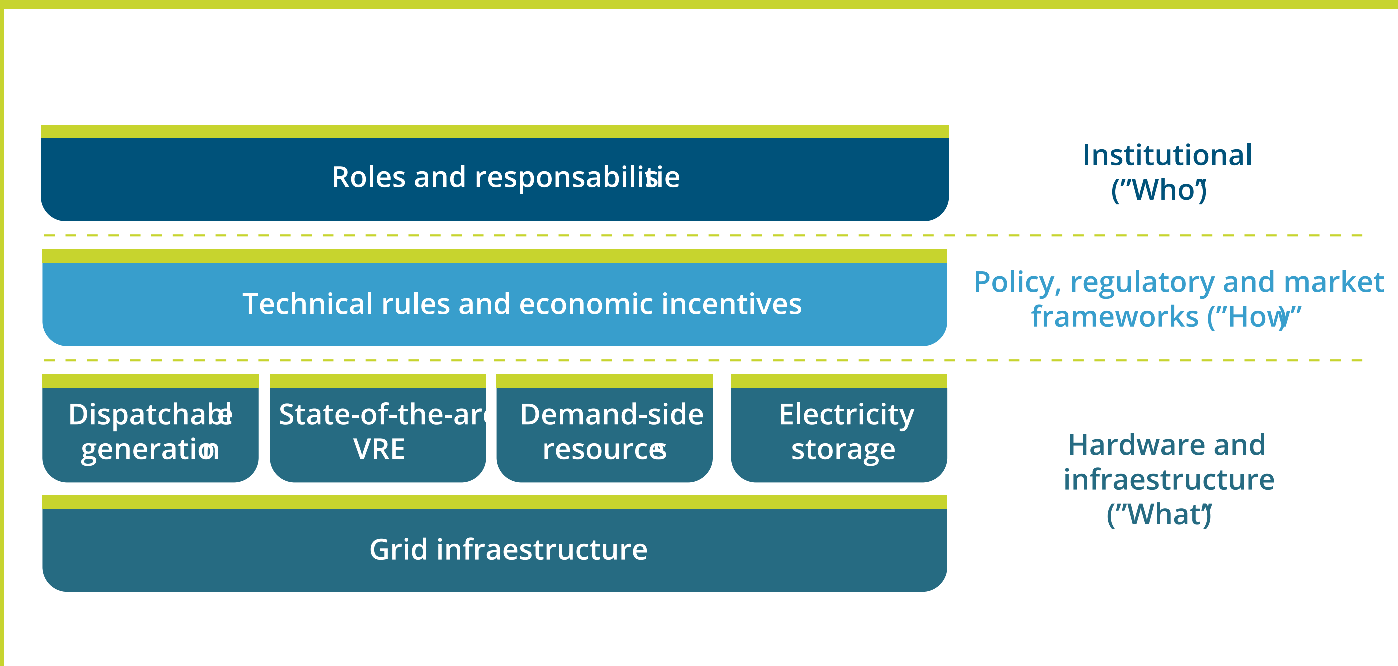


Figure 7 . Power system flexibility layers, source: IEA



still needed, at least to back up the intermittency of RES, it is not desirable for the perception of future market conditions. Regarding grid investment, an insufficient rate of return, lack of support schemes and regulatory requirements can hinder investments[42]. Table 11 summarises the impact of a set of drivers and barriers to investments in the power sector on various energy sector actors.

The EU has several funds and grants to accelerate investments in electricity infrastructure. Approximately EUR 1.5 billion is available annually in grants and EUR 12.5 billion in financial instruments (loans, guarantees, equity, etc.) for energy-related projects[43].

42 Trinomics, European Energy Industry Investments, European Parliament, 2017, P.39, https://www.eesc.europa.eu/sites/default/files/files/energy_investment.pdf
43 Trinomics, European Energy Industry Investments, European Parliament, 2017, P.65, https://www.eesc.europa.eu/sites/default/files/files/energy_investment.pdf

4.8 Role of DSOs, TSOs and other market players

With the expansion and increased penetration of DERs, new market players have emerged to perform a vital role. These include prosumers, aggregators and active consumers. These market players now want to exploit the new opportunities arising from the power system transformation. System operators facing this new reality must respond and adjust their roles accordingly. Regulatory frameworks must evolve as well and offer new regulations and mechanisms to foster and facilitate the energy transition.

The traditional power system was unidirectional and centralised. Electricity flowed from power generation plants to transmission, then to distribution and finally to the consumer. Currently, DSOs have access to several distributed flexibility resources such as storage, demand-side response and distributed generation. To harvest the benefits of the available flexibility, DSOs could provide

Table 11 . Drivers and barriers for power sector investment

Drivers and barriers	Transmission	Interconnections	Distribution	RES generation	Traditional generation
RES support	Positive	Positive	Positive	Positive	Negative
Smart metering target			Positive		
Price volatility and regulation				Negative	Negative
Interconnection target	Positive	Highly positive			
Lack of national policies		Highly positive		Negative	Highly negative
Lack of feasibility to realise cross-border investment		Highly positive			
Low cost of capital and access to investment	Negative	Highly positive	Negative	Negative	Negative
Risk perception	Negative	Negative	Negative	Negative	Negative
Efficient grid tariffs	Positive		Positive	Positive /Negative	Positive /Negative

services besides being active system operators. They could also provide ancillary services such as voltage support, congestion management and reactive power support after buying it from network users to defer costly investment. Figure 9 exhibits the old and new roles of DSOs[44].

Effective coordination between TSOs and DSOs is crucial for the power system transformation. Five different models have been envisaged for coordination between TSO and DSO system operators. The models are distinct depending on the market design as well as the different roles of TSOs and DSOs. Table 12 summarises each model's characteristics, benefits and challenges[45]. Regulatory frameworks have a crucial role in empowering TSO and DSO to evolve and adjust their responsibilities in order to empower energy transition. Below are some suggestions NRAs should consider:

- Policies and regulations to encourage/mandate investments in advanced metering structures – smart meters – and smart grid infrastructure to facilitate communication with DERs.
- Clear and transparent regulations that define DSO and TSO roles and ensure they are acting in a neutral manner when procuring services.
- Regulations that allow DSOs to be active and neutral market facilitators.
- Policies and regulations to construct functioning ancillary service markets that promote and adopt innovative technologies and reduce costs.
- Regulations to allow the participation of DER aggregators in ancillary service markets and define the minimum size of DERs for participation.
- Regulations to ensure the security and privacy of system and participant data.

44 IRENA , Innovation landscape brief: Future role of distribution system operators, International Renewable Energy, 2019, P.7, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Feb/IRENA_Landscape_Future_DSOs_2019.PDF?la=en&hash=EDEBEDD537DE4ED1D716F4342F2D55D890EA5B9A

45 IRENA, Innovation landscape brief: Co-operation between transmission and distribution system operators, International Renewable Energy Agency,2020, P.8–12, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Jul/IRENA_TSO-DSO_co-operation_2020.pdf?la=en&hash=5D78444F4339DC130204A0F9A99A30753368AABC

Figure 9 . DSOs roles, source: IRENA

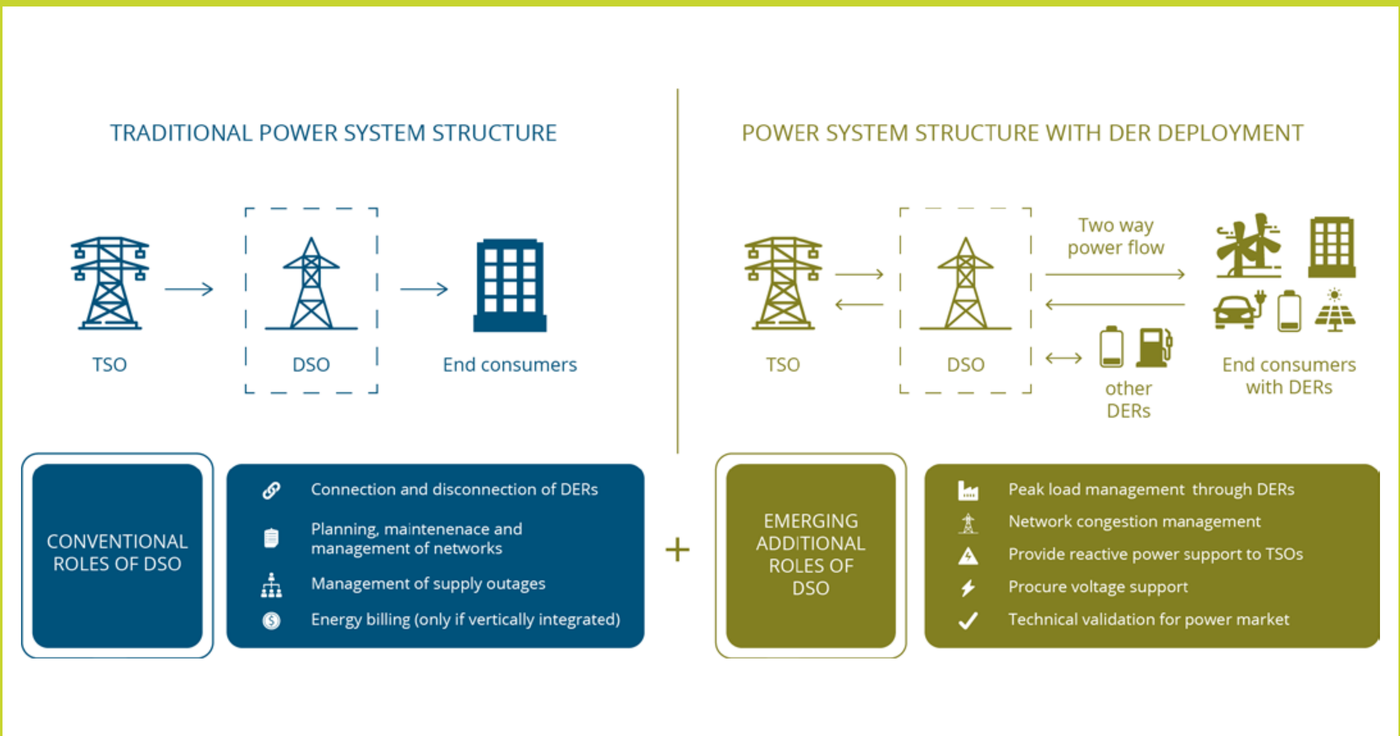


Table 12 . Oarket models and TSO, DSO roles

Model	Description	DSO role	TSO role	Benefits	Challenges
Centralised ancillary services market	A common market for ancillary services for both resources connected at the transmission and distribution levels and procured by TSO.	DSO plays a limited role, checking for constraints in the distribution grid and providing technical validation without being involved in the process of acquiring services.	TSO acquires ancillary services directly from DERs and manages the ancillary service market. Resources at the distribution level are aggregated and compete with the other centralised resources in the market.	If case distribution networks do not have significant constitution, this model is optimal and compatible with current regulatory framework. It has a low operational cost and follows a standardised process.	Constraints in distribution grid are not always respected.
Local ancillary services market	Local market for flexibility service operated by DSO alongside the centralised market operated by TSO	Operation of local ancillary service market, local congestion management and aggregate and the transfer of the remaining capacities to TSO.	TSO is responsible for centralised market for ancillary services and can acquire the remaining local flexibility from the local DSO market.	DSO has the priority to use local flexibility and a lower entry barrier for small-scale DERs.	Central and local market are cleared sequentially; there is a need for extensive coordination between the two markets.
Shared balancing responsibilities	Similar model to the local flexibility market model with the exception that the remaining local flexibility is not offered on TSO.	DSO is responsible for solving local grid constraints and balancing.	TSO is responsible for the resources connected at the transmission level.	TSO will have to procure lower amount of ancillary services; there are clear roles for DSO and TSO.	Local market should have a sufficient size and several actors to guarantee competition.
Common TSO–DSO ancillary service	System operator with the highest needs will acquire flexibility from a common market.	DSO and TSO jointly manage a common ancillary services or flexibility market. The flexibility resources are acquired jointly or in co-operation so as to minimise the total system cost.		Minimising total system costs for ancillary services and the optimal use of flexibility resources.	Cost allocation is not easy; complexity in solving constraints in one mechanism.
Integrated flexibility market	Common market for ancillary services that is operated by independent market operators.	Bidding in the common market to obtain the needed flexibility in the local market.	Bidding in the common market to obtain the needed flexibility.	Competitive prices due to high rivalry and increased alternatives for resolving imbalances.	An independent market operator needs to be established to operate the common market.

4.9 Electric vehicles

According to the Paris declaration on electro-mobility and climate change and call to action, at least 20% of all global road transport vehicles to be electrically driven by 2030[46]. Utilising electric vehicles (EVs) paves the road to use renewable energy instead of fossil fuels in the transport sector. As EV shares increase, electricity power systems can use them to support energy transition. EV grid integration has five levels, which are described in Table 13[47] (V1G, V2G refers to Vehicles to Grid and V1H, V2H refers to Vehicles to home).

After reaching level 4 (V2G), EVs can support and provide flexibility services to DSO and TSO. Figure 10 exhibits the different flexibility services that can be provided by adopting EVs. These services will secure revenue streams for EV owner by DSO or aggregators.

A new concept that will disrupt the whole power system is being investigated at TU DELFT under the name "Our car as power plant". The idea is based on the fact that, on average, our car is parked 90% of the time. Using a fuel cell car that produces electricity and heats then stores it in the car battery can supply electricity to the national grid while the car is parked. Assuming a 50 kW battery for an EV, around 10,000 cars – if aggregated – can substitute a power plant without much investment[48].

The integration of EVs into the power system requires several regulatory arrangements. These arrangements start with contracts that facilitate the engagement of EV owners in supplying flexibility services to DSO or aggregators without compromising their needs. Three types of contracts were envisioned: price based, volume based, and control based. Table 14 describes the contract types with the associated control parameters[49].

4.10 Other regulatory issues

Energy power systems are transforming rapidly, and innovative solutions are emerging in every aspect: innovation in technology, business model, financing and so on. The role of the regulatory is to set up an environment that is conducive to inventions and filter out the inventions that are not desirable (socially, economically, morally and ethically). Moreover, regulations minimise risk and maximise benefits. However, present power system regulations can be an obstacle if they do not respond or adjust to the current transformations are driven by innovation in the whole energy system.

Regulators must respond and align with innovation to foster sector transformation. Regulatory alignments have several aspects, namely normative, institutional, instrumental, organisational and cultural alignment[50]. Normative alignment is concerned with consistency and coherence across all institutional levels. Institutional alignment differs from normative alignment in that the former is horizontal, as it reveals the fit between institutions at any level and innovation, and the latter is vertical and refers to cohesion among different governance levels. Instrumental alignment is the suitability of the present regulatory instruments for the task at hand. Organisational alignment can be defined as the alignment of the internal structure of an organisation with the targets and goals set. Lastly, cultural alignment is the uniformity between norms and values associated with specific innovation. The institutional setting is of utmost importance.

The acceleration of the power sector transformation is enabled by digitalisation and new technologies. Another important issue

46 United Nations Climate change, The Paris Declaration on Electro-Mobility and Climate Change and Call to Action, 2015, https://unfccc.int/news/the-paris-declaration-on-electro-mobility-and-climate-change-and-call-to-action
47 Charin, The five levels of grid integration, The Charging Interface Initiative e.V., 2019, https://www.charinev.org/news/news-detail-2018/news/the-five-levels-of-grid-integration-charin-ev-grid-integration-roadmap-published/
48 Ad van Wijk, Our car as power plant, iOS press BV., 2014, http://www.profadvanwijk.com/wp-content/uploads/2014/02/our-car-as-power-plant-ad-van-wijk.pdf

49 Esther H., Park L., Conceptualization of vehicle-to-grid contract types and their formalization in agent-based models, Hindawi Volume 2018, https://www.researchgate.net/publication/323622258_Conceptualization_of_Vehicle-to-Grid_Contract_Types_and_Their_Formalization_in_Agent-Based_Models
50 Thomas Hoppe, Innovation in the European Energy Sector and Regulatory Responses to It: Guest Editorial Note, Sustainability 2018,10, 416, P.6.

Table 13 . EV grid integration levels

	Grid-compliant charging	Level 1 – V1G controlled charging	Level 2 – V1G/H cooperative charging	Level 3 – V2H bidirectional charging.	Level 4 – V2G aggregated (bidirectional) charging.
Description	· Compliance of EV and EVSE with the local requirements, regulations and guidelines. · Charging power is below the level that requires load management by DSO.	· DSO influences the charging event either by lowering the charging power or shifting the time of charging according to the grid condition.	· EV and EVSE can negotiate the charging parameters based on user preferences (tariffs, monetary incentives, grid constraints). · Local aggregation or aggregation per charging spot.	· Energy exchanges between EVs and consumer home system according to different drivers (power outage, economics, charging EV from rooftop solar, etc.) · Supports behind-the-meter use cases.	· EVs and EVSE can offer services to all levels of power system (balancing services, flexibility services, etc.). · Support in front of meter services. · Aggregation across larger area (state or country level).
Technical requirements	· Local regulations and standards per country.	· Local regulations and standards per country. · Demand response.	· Local regulations for EV and EVSE. · ToU tariff structure. · Telematics grid and EVSE.	· Local regulations for EV and EVSE. · See level 2. · Many requirements are still missing.	· Local regulations for EV and EVSE. · See level 2. · See level 3. · Many requirements are still missing.

Table 10 . Flexibilities provided by EVs, source: IRENA

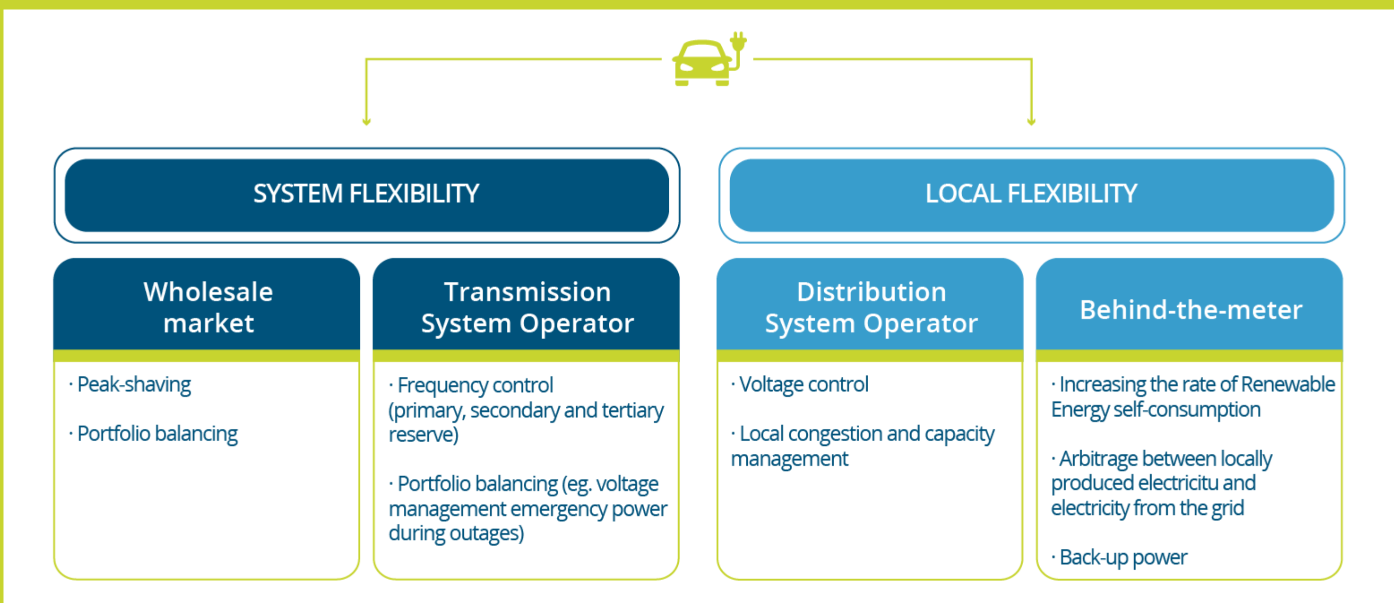


Table 14 . Contract types between EV owners and DSO or aggregators

Contract parameter	Description
Price-based contracts	
Minimum V2G price	Minimum price for activation as defined by driver.
Guaranteed fuel/energy level	Minimum level of hydrogen in the tank/ energy in the battery guaranteed after operation.
V2G remuneration	Remuneration for energy supply (for instance, min. V2G price).
Volume-based contracts	
Time interval	Time interval (start + duration) for availability.
Maximum volume	Maximum volume usable for V2G.
V2G remuneration	Energy and capacity remuneration.
Guaranteed fuel/energy level	Minimum level of hydrogen in the tank/energy in the battery guaranteed after operation.
Minimum fuel required at plug-in	Calculated level of fuel required in the vehicle before plug-in.
Control-based contracts	
Time interval	Plug-in time (voluntary or pre-committed).
V2G remuneration	Energy and capacity remuneration.
Guaranteed fuel/energy level	Minimum level of hydrogen in the tank/energy in the battery guaranteed after operation.

that comes to the surface is consumer rights. There are a set of consumer rights in place in the EU since July 2007. These rights guarantee electricity connection to the local electricity network, the right of customers to freely choose their supplier and change between them, clear contract information and the right of withdrawal and accurate information on the consumption and billing[51]. Unfortunately, this is not sufficient because tremendous data is transferred between market players. Not only communication but data also needs to be secured.

4.11 MEDREG case studies on self-consumption regime

The case studies of some MEDREG countries demonstrate the self-consumption policy mechanisms in place. The case studies were prepared by the countries and cover six areas: general description, main policy goals, activity access, costs, tariffs, billing arrangements, incentives and new ICT tools. Policies varied from FIT to net metering and net billing. Collective self-consumption was also noted in some countries.

Overall, the case studies show that MEDREG countries are using a variety of tools to promote small-scale DERs and integrate these resources into the power system.

4.11.1 Cyprus

General description

Self-consumption was regulated in Cyprus by law in the period 2003–2018. Support schemes for self-consumption produced from RES were implemented as national policy to promote RES electricity. Since 2013, net metering has been implemented and is expected to continue, with some modifications to enhance the self-consumption for small systems.

In 2017, a support scheme for a cogeneration system fuelled by biogas or biomass was put in action based on net billing principles for capacities up to 5 MW. There is another support scheme called “Solar Energy for All” that encompasses the on-site production and consumption of RES for own use that provides the following:

(a) Installation of net metering PV systems with capacity up to 10KW connected to the grid for all consumers (residential and non-residential).
(b) Self-generation systems with capacity up to 10MW for commercial and industrial consumers.

Main policy goal

According to the National Action Plan for Energy and Climate submitted in 2019, Cyprus targets 13% RES in 2020 and 10% RES in transport. The former is overachieved, and the latter is more difficult to reach. The target for 2030 is 23% and it can be reached. The support scheme for the generation of electricity from RES for self-consumption has been effective since April 2020 in order to realise the RES targets. The following categories are supported:

- Category A: PV systems connected to the grid with a net metering method. Household applications are under A1 and non-household application is under A2.
- Category B: RES-E Systems (PV, biomass/biogas, high-efficiency cogeneration units) connected to the grid with the net billing method.
- Category C: RES-E autonomous systems are not connected to the grid.

Activity access, costs, tariffs and billing arrangements

In case of net metering scheme

The scheme is available for capacities up to 10kW installed on the roof of legally constructed buildings or on the ground within the building premises. Both residential and non-residential consumers can participate in this scheme. A total of 20 MW capacity is available for installation under net metering – 15 MW for household consumers and 5MW for non-household consumers.

The net electricity is calculated by the supplier either every month or every two months depending on the consumer category. Any surplus will be transferred to the next period, while any deficits will be priced normally. The final settlement of surplus

51 European Commission, https://ec.europa.eu/energy/topics/markets-and-consumers/energy-consumer-rights/protecting-energy-consumers_en

or deficit is calculated at the end of one year. Any surplus cannot be transferred to the next year. Consumers pay only for the net electricity used plus a cost that reflects the cost of the electricity grid to support continuous supply and taxes (VAT, RES levy) in this scheme.

In case of net billing scheme

The maximum capacity for an individual system is 10 MW, provided that it does not exceed 80% of the installed load in the property. Under this scheme, 40 MW is available, out of which 3MW will be allocated exclusively for the Rural Development Programme 2014–2020 of the Ministry of Agriculture.

System owners are required to install telemetry and data recording system for the generation of electricity for systems over 20kW, and its cost, including that of purchasing and installing the meter, shall be fully borne by the prosumer. The telemetry system must comply with the requirements of the DSO or TSO. In case the cost of electricity exported is less than that of imported electricity, the prosumer will pay the difference resulting from the cost of exported and imported electricity in each billing period. Alternatively, the excess amount of money will be credited for the next billing period. The final settlement takes place at the end of one year, and like net metering, the surplus cannot be transferred to the next year.

Incentive schemes

A support scheme was in operation from 2018 to 2020 for buildings before 2017 with a funding of €300 per installed kW of PV and a maximum funding of €1,200. The maximum amount of funding per application can reach up to €3,000. The support applies for houses built before 21st December 2007 and provides for retroactive effect for installations carried out after 1st October 2019.

A second category for houses built before 1st January 2017 provides for retroactive effect for installations carried out after 1st October 2019. Funding of €250 per installed kW of PV is provided, with a maximum funding of €1,000 for systems installed in residential consumer homes and funding of €750 per installed kW of PV for systems installed in the houses of vulnerable consumers with maximum capital funding of €3,750.

4.11.2 France

General description

There are two types of self-consumption recognised by the law: individual (Article L315-1 of the French Energy Code) and collective (Article L315-2). In France, self-consumption is eligible for support via FIT and auctions. At the end of the second quarter of 2019, individual self-consumption totalled 200 MW and 52,000 installations and was planned to be increased to 200,000 photovoltaic self-consumption sites in 2023. As for collective self-consumption, there were about 20 entities in operation at the beginning of 2020, and the target for 2023 is to reach 50 collective self-consumption operations. The self-consumption scheme is open to all technologies, but the schemes in place mainly support solar projects.

Main policy goal

The main goals for self-consumption policy are promoting the clean energy transition by increasing the share of RES. In addition, the policy aims to reduce the negative impacts of self-consumption on electricity networks and associated costs.

Activity access

For the connection to the grid, the Linky meter, France's electricity smart meter, is required for up to 100 kVA. No additional work is necessary if the production does not impose stress on the network. If production does generate stress for the network, the consumer will pay for extension costs. For power greater than 100kVA, if the production generates constraints not taken into account in the structures provided for under an S3REnR scheme, the user will take charge of the work corresponding to their own structures (S3REnR schemes, for schémas régionaux de raccordement au réseau des énergies renouvelables, are regional development plans intended to anticipate and accelerate the connection of RES plants to the network; therefore, they already take into account some of the impact RES plants have on the network.)

Costs, tariffs and billing arrangement

Network charges are composed of three components: counting, management and withdrawal. Specific management components are applied for individual self-consumption. DSO is responsible for balancing activities for small installations (< 3 kWp). The proceeds of the sale of this electricity are retained by the DSO to cover its costs for the electricity fed into the grid.

For collective self-consumption, if all the participants are connected through the same sub-station, they are eligible for an optional withdrawal component. This component differentiates between the flows of self-consumed electricity and sold electricity. A different network tariff is applied to each of those two situations (network charges generated by self-consumed flows are lower than the ones for grid fed flows).

Photovoltaic installations on rooftops < 100 kW benefit from FITs for a duration of 20 years. The government intends to increase the eligibility threshold for FITs up to 300 kW.

Incentives

Projects with a capacity between 100 kW and 1 MW can apply for support through fixed premiums for the electricity produced. The beneficiaries of the aid are selected through auctions. There is a strong incentive to self-consume electricity.

Above 1 MW, there is no specific support for self-consumption, but installations can still participate in other RES tenders and get a feed-in-premium for the electricity which is fed into the grid.

4.11.3 Italy

General description

With Legislative Decree 115/08 (and subsequent amendments and additions) and with Decree 244/16 (converted with Law 19/17), the different self-consumption configurations can be implemented after they are better defined. ARERA, with resolution 578/2013/R/eel and subsequent amendments and additions, defined the procedures for regulating connection, metering, transmission, distribution, dispatching and sales services in the case of simple production and consumption systems (Italian acronym: SSPC for Sistema Semplice di Produzione e Consumo), including efficient user systems (Italian acronym: SEU for Sistema Efficiente di Utenza).

Main policy goal

The main goal is to promote small-scale generation located close to consumption (above all renewable generation in order to reach the national RES targets), develop distributed generation and increase energy efficiency.

Activity access

It is necessary to obtain all the necessary authorisations and submit the connection request to the network manager (DSO or TSO), referring to the connection point of the consumption unit where the power plants will be installed. The connection procedure must respect the procedural, technical and economic conditions defined by ARERA with the Integrated Text for Active Connections (Italian acronym: TICA for Testo Integrato Connessioni Attive defined with ARERA resolution ARG/elt 99/08). There are no limits to the nominal power of the plants, and at the end of the connection procedure, a bidirectional meter will be installed at the connection point to measure electricity withdrawals and injections.

Costs, tariffs and billing arrangement

In Italy, transmission and distribution tariffs, dispatching charges and related general system charges are always paid with reference to the electricity withdrawn from the grid, even in the case of SSPC. Therefore, the greater the share of electricity self-consumed with respect to the total electricity consumed, the greater the implicit economic benefit for the SSPC. As far as the metering service is concerned, the tariffs envisaged for final customers and the general regulations envisaged for final customers and producers are still applicable.

New ICT tools

The provisions for the installation and use of 2G meters apply.

4.11.4 Lebanon

General description

Two main technologies fall under the self-consumption scheme: solar PV and private diesel generator. Due to power shortage problems such as electricity outages and blackouts, consumers rely on private diesel generators for self-consumption. Consumers can feed electricity generated by the distributed solar PV systems to the national grid under the net metering scheme. The regulatory framework for net metering remains within the jurisdiction of the Ministry of Energy and Water, the Ministry of Finance, based on Decision 318-32/2011 taken by EDL Board of Directors and approved by both ministries.

By 2019, around 2.3 MW (152 for low-voltage connections) and around 5.8 MW (for medium-voltage connections) was approved by EDL. A pilot project has been developed by UNDP Lebanon under the "Village 24" initiative to highlight the potential for collective net metering applications.

Law No. 462, established in 2002, sets the rules and principles governing the electricity sector. Currently, a broader legal framework is being considered as part of the updates for the law. Moreover, a framework law for distributed renewable energy is being drafted, which will suggest the legal framework for the net metering scheme and other schemes such as single owner net metering, basic meter aggregation, tenant meter aggregation, multi-site aggregation, and "virtual" or "community" net metering as well as P2P applications.

Main policy goal

The goal of the self-consumption policy is to reduce the electricity demand from the national grid by promoting the use of decentralised solar PV systems and encouraging prosumers. This policy is considered an important milestone to reach national renewable energy targets and reduce the emissions of GHGs.

Activity access

Potential participants need to apply to a net metering scheme by filling an application and uploading all the required documentation online. The approval is subject to the required technical standards and safety requirements. The agreement is free of charge.

Costs, tariffs and billing arrangement

Self-consumption is measured via a net meter. The surplus of electricity is deducted from the prosumer's electricity consumption from the utility. No monetary compensation is given to prosumers for the energy injected into the grid. The net meter resets each year, so the prosumer cannot benefit from surplus electricity generated during the previous year.

New ICT tools

The EDL is considering the implementation of data hubs via the deployment of smart meters for a better understanding of the dynamics of the electric loads.

4.11.5 Portugal

General description

After issuing Decree-Law 153/2014, consumers may generate electricity within their installations for self-consumption. Prosumers can share renewable generation with other consumers nearby according to Decree-Law no 162/2019.

Main policy goal

The main policy goal is to promote small-scale renewable generation and enable community-scale projects for renewable generation. Self-consumption is an important means for the country to meet its national targets regarding GHG emission reduction. By the end of 2019, the installed power in self-consumption units was around 30,000 self-consumers with a capacity 216 MW and an annual renewable generation of 270 GWh.

Activity access

Above 0.350 kW of installed generation capacity is required to access the activity. Individual self-consumers must register in a dedicated electronic platform following a simplified process. For above 30 kW generation capacity, prosumers must go through licencing procedures. The meter equipment costs are borne by the self-consumer, and excess generation may be sold to an aggregator (the supplier or another entity).

Costs, tariffs and billing arrangement

For collective self-consumers (where generation is located outside the consumers' installations), both generation and consumption installations must be nearby. The costs arising from meter adaptation are borne by the self-consumer (smart meters are required). The generated electricity is allocated to each participant and discounted from the meter reading of his installation. The net consumption, calculated for each 15-minute interval, is attributed to the supplier, whereas any excess generation may be sold to an aggregator at market price.

In general, prosumers are not charged any network tariffs. However, if energy sharing is facilitated through a distribution network, network tariffs shall apply, but only for the voltage level the installations are connected to.

Incentives

The government can decide on granting exemptions regarding public service obligation costs embedded in network access tariffs. Along with the possibility of selling generation surplus to an aggregator on the market, an aggregator operating under the public license will be responsible for generation surplus, guaranteeing that the excess energy will be bought by someone at a market price. Finally, the fiscal incentives shall be approved, during 2020, to apply to investments in the generation for self-consumption by households.

4.11.6 Turkey

General description

Article 14 of Law 6446 lays down the legal basis for self-consumption. The principles and conditions of unlicensed power generation were regulated by the by-law on Unlicensed Electricity Generation in the Electricity Market since 2013. On 12th May 2019, a new regulation was enforced upon its publication in the Official Gazette and the regulation on Unlicensed Electricity Generation in the Electricity Market dated 2013 was abolished.

Main policy goal

The new regulation reflects a policy preference towards self-consumption rather than electricity trading purposes for unlicensed facilities investments. It allows all individuals and companies to establish solar-based production facilities with roofing as per their own consumption. The main purpose of this regulation is, among other things, to provide an entrance of the small power plants into the electricity market, provide electrical energy for consumers and reduce loss in electrical energy.

Activity access

Up to 5 MW installations are exempt from the obligation to obtain an electricity generation license and are not required to be owned by a legal entity. By the end of March 2020, a total of 6.4 GW was installed under the self-consumption scheme, of which 5.9 GW was solar power plants.

An application can be made by real or legal persons willing to generate electricity in power plants under the by-law by completing the unlicensed generation connection (self-consumption) application form. The application is made directly to the transmission company, the relevant regional distribution utility or the relevant Organised Industrial Zone distribution license holder. The applications are assessed against the set criteria such as the use of RES in power plants and whether the power plant is located within the same location as the consumption unit.

Costs, tariffs and billing arrangement

For participants under the new regulation, the relevant network operator will determine the amount of energy generated and charged by the generation facilities to the grid on an hourly basis. The settlement will rely on the data from the meter installed at this point, which is determined in the system connection agreement. Unlicensed generators are not addressed directly with the market operator and the RES support mechanism. They receive the revenue for the excess electricity every month through regional assigned retailers. Surplus generation is utilised under energy price, i.e. persons are paid for surplus electricity generation based on the source tariff of the current energy price.

5

NON-TECHNICAL BARRIERS OF RES-E SYSTEM INTEGRATION AND POSSIBLE INCENTIVES

5

NON-TECHNICAL BARRIERS OF RES-E SYSTEM INTEGRATION AND POSSIBLE INCENTIVES

The energy transition is not insignificant. Energy systems are highly intertwined and difficult to modify in a short period. Any transition has winners and losers. As an example, investors compete for RES projects and abstain from fossil fuel projects, and those on the losing side will resist change and lobby against it. On the policy side, energy systems depend upon highly established regulations, subsidies and taxes. Transforming the market requires political will, time and effort. This chapter identifies the challenges for power system transformation and renewable energy integration as well as some recommendations to overcome these barriers.

Investment in electricity networks

Electricity networks have a key role as enablers for renewable energy integration. For this reason, infrastructure investments are urgently required, namely in energy transmission and distribution networks and ICT. Transmission infrastructure takes a long time to build and operate. Investors refrain from grid investments due to the risks associated with them. Regulatory and policy instruments are needed to de-risk electricity network investment in support of renewable energy integration. As an example, for supportive policy, in the United Kingdom, a “cap-and-floor” regulation mitigates the risks in merchant interconnection projects, capping the revenue in high-revenue years in exchange for protecting investors in case of low returns[52].

Using DERs for flexibility services

DERs hold remarkable potential for increasing renewable energy shares and reducing losses in electricity networks. In case studies of MEDREG members (Annex 2), countries used several schemes for DERs such as FIT, net metering and net billing to reduce emissions and promote the share of renewable energy. However, DERs offer significant flexibility potential if aggregated together and leveraged to provide system flexibility services at the DSO and TSO power system levels. Nevertheless, these require changes in the regulation, market rules and connection codes. One of the main barriers to the adoption of DERs as a flexibility source is the high associated transaction costs with upgraded DERs for market participation. Under the current connection codes, DERs are subject to the same requirements as large-scale resources. As an example for the way forward, we note the approach in Ireland, where DERs provide short-term flexibility under the DS3 program[53].

Exploiting traditional fossil fuel power plants

The roles of traditional plants are getting smaller as RES shares in power systems increase. This implies reduced operating hours and less revenue gained from energy sales with high fixed costs. This will lead to questions regarding the viability of new fossil fuel power plants, which are critically needed to provide capacity and flexibility.
New approaches are required to reward these power plants. Modified policy and regulations can be used to match the flexibility requirements with the existing system resources using the “day-ahead market” and “enhanced real-time commitment” to complement real-time markets. This approach is currently used by independent electricity system operators in Ontario[54].

In addition, policies and regulations should allow and incentivise retrofits to be installed in power

52 IEA, Status of Power System Transformation 2019: Power System Flexibility, International Energy Agency, P.4.

53 IEA, Status of Power System Transformation 2019: Power System Flexibility, International Energy Agency, P.21.
54 IEA, Status of Power System Transformation 2019: Power System Flexibility, International Energy Agency, P.14.

plants for flexibility provision. Traditional power plants in the United States are being fitted with battery storage (hybridisation) to be able to receive remuneration for flexibility services[55].

Implementation of smart grids and new ICT tools

Countries are promoting DERs and self-consumption using different schemes. The excess generated electricity can be fed to the grid or traded with other households. The latter case implies that utilities can be bypassed. The traditional model of owning a few large assets is currently under distribution and transforming towards a number of small assets. The conventional value chain and transaction costs will be altered. In this new reality, regulatory intervention and the centralisation of decision-making will eventually be heavily constrained when there are millions of decision-makers. Markets will become increasingly important for providing real-time and long-term efficient price signals.

The need for smart grids to facilitate millions of transactions is becoming more relevant with time. Also, new ICT tools based on innovative technologies such as blockchain must be stimulated. Moreover, new business models need to be invented. Network operators may resist changes that disrupt the existing business models. In countries with a regulated power sector, innovation lag may occur and prevent countries from reaching their RES goals. NRAs urgently need to find ways to encourage network operators to choose innovative solutions so they will not be left behind and will resist power system transformation. The current policies need to be modified and enhance the definition of national objectives and policies at the political level.

In addition to the above barriers, MEDREG countries reported several barriers that hinder RES system integration. These are summarised below. The report stresses that MEDREG countries are taking several actions to overcome these barriers and pave the way to accept new RES capacities.

Complex license and permit/authorisation procedures

While licencing and permits are essential in any project to ensure that the developer complies with different standards, the complex process may inhibit investors from considering RES projects. This is especially the case if the process is not transparent and straightforward. Simple licence procedures are pivotal to encourage more investment in RES projects.

Cost of land, physical and spatial limitations

In countries that have scarce land resources or tough land topography that does not allow for RES installation, RES projects costs can skyrocket. Here, investors may think twice due to the low project viability. As a response from MEDREG countries, small DER systems are encouraged and adopted by issuing different incentive policies to attract consumers to invest in these systems. The case studies demonstrate several policies to address this problem.

Regulatory (laws), financial and commercial barriers

Some MEDREG countries are in the process of developing robust institutional and regulatory systems. Until then, they will remain a barrier that require continuous work to eliminate. It is worth noting that even though these barriers exist, MEDREG countries keep adding new RES capacities, as seen in Chapter One.

55 IEA, Status of Power System Transformation 2019: Power System Flexibility, International Energy Agency, P.2.

6

CONCLUSIONS AND RECOMMENDATIONS

6

CONCLUSIONS AND RECOMMENDATIONS

The energy transition can be envisioned as a three-phase transformation. Phase I is the traditional value chain using fossil fuels power plants, a small share of RES and a niche deployment of decentralised renewable energies. In Phase II, RES and DERs rise to become major players in the supply portfolio, enabled by governance, which provides value for the necessary system flexibility requirements. Phase III is characterised by decentralised renewable energy as the dominant player within a flexibly operating system. Table 15 summarises the characteristics of each phase[56] .

NRAs should be prepared for power system transformation. Below are some recommendations and remarks on how NRAs can prepare for the energy transition:

- **Focus on customers and enabling them to choose**

  In future energy systems, customers will be investors, operators and consumers who pay for electricity services. Customers need to be well-informed about the regulations and policies as well as the opportunities arising from the energy transition. As investors, they need to be encouraged and guided on how to invest and, as operators, they need customer-friendly platforms and applications so they can manage their installation and connection with the grid.

- **Availability and transparency of data**

  All stakeholders should have access to all data (electricity prices, current electricity production, demand response, etc.) and be encouraged to engage in system operation. Policies to increase digitalisation will facilitate stakeholders to have access to affordable and secure data.

- **TSO and DSO preparation for new roles**

  The central grid that will co-exist with DERs, TSOs and DSOs must have a high level of coordination among them for effective and secure power system operations. Flexibility services will be key to enabling the production of power from RES and DERs to be efficiently integrated into the system. This requires a more active role for TSOs and DSOs and a greater focus on a bottom-up approach to system operation.

- **Re-evaluation of infrastructure investment in long-distance transmission grids**

  If DERs are prevalent in a country and cheap flexibility resources are available and effective, expensive network upgrades may not be required and reliability problems may be less relevant, thereby, keeping a cap on increases in infrastructure cost. However, the report does not suggest demoting transmission investment. There is always a trade-off and subtle compromises when considering such projects. The report recommends careful evaluation of long-distance transmission projects, taking into account the opportunities and barriers.

- **Upgrade the electricity market model**

  The electricity market model must be improved by appropriate regulatory policies that ensure well-functional, well-coordinated and strongly interconnected supranational

56 Burger, C., Froggatt, A., Mitchell, C. and Weinmann, J. 2020. Decentralised Energy – A Global Game Changer, P. 261–275. London: Ubiquity Press. DOI: https://doi.org/10.5334/bcf.t. License: CC-BY 4.0

Table 15 . Three phases of energy transformation

	Phase I	Phase II	Phase III
Description	Grid-based and centralised system with small shares of RES and DERs.	Larger shares of RES and DERs and partial autonomous solutions.	DERs are the dominant players with fully autonomous solutions.
Triggers	Incentives to promote RES.	Adding flexibility to supply and demand – different technologies are in competition without incentives or subsidies.	
Governance	Centralised system: policies to promote renewables.	Performance-based regulations to evaluate DER generation costs versus network costs, integrating customers and increasing flexibility.	Consumer-focused and ambition-driven regulations where users can choose the level and methods of their security of supply and co-existence of centralised and decentralised systems and regulations.
Regulatory framework	Top-down approach (utility scale RES deployment, TSO and DSO driven).	Share of renewables endanger security of supply; regulatory incentives are reduced.	Bottom-up approach (active customer/ prosumer, distributed market facilitator).
Risks		Risk of stranded investment in fossil assets.	Risk of stranded investment in transmission grids.
Business models	Asset ownership evolves from central to crowdfunding (communities)		
	Asset ownership evolves from central to crowdfunding (communities)		
	Asset ownership evolves from central to crowdfunding (communities)		

markets, together with local markets, in all time horizons from long term to real time. While promoting the current integration of national markets, regulators must introduce into this complex process a new perspective related to the local dimension.

- **Upgrade the grid access tariff structure**

  The development of DERs efficiently calls the attention of regulators to enhance the tariffs structure and computation of appropriate grid access tariffs to ensure efficient cost allocation that is more dynamic and better adapted to the system incurred or avoided costs. This will help avoid the cost subsidisation between conventional consumers and the prosumers or owners of DERs.

- **Smart grids**

  NRAs should consider regulatory policies that promote the development of smart grids that effectively integrate ICT into every aspect of the electricity supply chain, such as electricity production, transmission, distribution and consumption. This integration can result in lower environmental impact, enhanced reliability and service, minimised losses, a better market and reduced costs.

- **Integrative approach to sector regulation**

  NRAs should consider regulation and policies that apply simultaneously to large and decentralised generation and all sector actors. Moreover, regulatory instruments must be coordinated across all energy system actors, such as heat, mobility and the power sector for the complete decarbonisation of the energy system. Regulators have to be flexible to establish new processes and encourage innovation across sectors.

ANNEX 1: LIST OF ABBREVIATIONS

Term	Definition
CEC	Citizen energy community
DERs	Distributed energy resources
DSO	Distribution system operator
EU	European Union
EV	Electric vehicle
EVSE	Electric vehicle supply equipment
FIP	Feed-in-premium
FIT	Feed-in-tariff
GHG	Greenhouse gases
ICT	Information and communication technology
IoT	Internet of Things
LLDs	Load limiting devices
MEDREG	Mediterranean energy regulators
NRAs	National Regulatory Agencies
P2P	Peer-to-peer
REC	Renewable energy communities
RES	Renewable energy sources generation
SEMCs	Southern and Eastern Mediterranean Countries
SMEs	Small and medium-sized enterprises
TFEC	Total final energy consumption
TGC	Tradable Green Certificate
TSO	Transmission system operator
VRE	Variable renewable energy
V2G	Vehicle-to-grid
V2H	Vehicle-to-home

ANNEX 2: EXAMPLES FROM MEDREG COUNTRIES ON SMART GRID AND ICT

The following are examples from MEDREG countries of the new ICT technologies and their applications in the power system. These examples can make envisioning the future power systems easier for NRAs and help them prepare for the new era and the required evolution in the regulations to cope with these disruptive changes.

The examples also cover most of the points discussed in Chapter Four such as P2P, collective consumption, blockchain, energy trading and DER management.

IBERDROLA – Spain [1]

Iberdrola has finished testing a project that uses blockchain technology to guarantee that the energy supplied to consumers is from renewable resources. The experiment was done with the financial entity Kutxabank, which was able to track, in real time, the origin of the energy supplied by Iberdrola from the generation asset to the point of consumption.

The company also has other initiatives to use blockchain in power systems. Iberdrola is testing a project to try out blockchain-based transactions in wholesale energy and natural gas markets. This project utilises P2P transactions without the need for intermediaries. The participants will trade energy directly without a regulated market, and their transactions will be registered on the platform anonymously and in an encrypted form to be verified by other operators.

Enel – Italy [2]

Enel, the Italian electric utility, cooperated with E – the German power provider – to trade electricity in a new marketplace that uses blockchain technology. The transaction lasts only few seconds with the need for an intermediary or central broker. By eliminating the middle step costs, customers can profit from this direct electricity trading via blockchain and, thus, from the cost reduction.

SUNCHAIN – France [3]

The French private company uses blockchain technology to optimise collective self-consumption. The company has demonstrated several operating projects on their website. Sunchain's solutions help consumers be active in power systems without the need for installations on their roof, thus reducing the energy bill. On the other hand, they help producers opt for the most suitable location for the solar PV system.
GREENEUM – Cyprus / Israel

This company uses their energy prediction software with a software-based Distributed Energy Resource Management System to increase the efficiency of various solar arrays and form a virtual power plant. Moreover, after avoiding energy production fluctuation and better control over the plant output, the costs reduced and the rearing was maximised.

Nice Grid Project – France

Nice Grid Project is supported by a consortium of seven members, including the DSO Enedis and TSO RTE. The objective is to develop an integrated approach, which includes demand side management, PV integration, test power storage and grid management. The idea is also to trigger new behaviours of participants and test the capacity of energy autonomy at the level of a neighbourhood. This publication was produced with the financial support of the EU. Its contents are the sole responsibility of MEDREG and do not necessarily reflect the views of the EU.

GREENEUM – Cyprus / Israel [4]

This company uses their energy prediction software with a software-based Distributed

1 Iberdrola web site, Accessed on 13 November 2020, https://www.iberdrola.com/press-room/news/detail/iberdrola-uses-blockchain-guarantee-that-energy-supplies-consumers-100-renewable

2 Sandra Enkhardt, Eon and Enel trade power using Blockchain technology for the first time, PV Magazine, Accessed on 13 November 2020, https://www.pv-magazine.com/2017/10/06/eon-and-enel-trade-power-using-blockchain-technology-for-the-first-time/

3 SUNCHAIN website, Accessed on 13 November 2020, https://www.sunchain.fr/#autoconso

4 GREENEUM website, Accessed on 13 November 2020, https://www.greeneum.net/company#team

Energy Resource Management System to increase the efficiency of various solar arrays and form a virtual power plant. Moreover, after avoiding energy production fluctuation and better control over the plant output, the costs reduced and the rearing was maximised.

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5 MEDREG, Smart Grids in the Mediterranean Countries, 2018, MED18-26GA-4.4.1, P. 53, http://www.medreg-regulators.org/Portals/_default/Skede/Allegati/Skeda4506-321-2018.12.14/Smart%20Grids%20in%20the%20Mediterranean%20Countries.pdf?IDUNI=r0ql2h34ncprjd4mxy112ess347

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MEDREG – Association of Mediterranean Energy Regulators
Via Fieno 3, 20123 Milan, Italy –Tel: +39 3402938023
info@medreg-regulators.org www.medreg-regulators.org

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