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DELIVERABLE D10.1
Market Intelligence on LFM tools plan

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Executive Summary

This document is a deliverable within Work Package 10 "Exploitation and Business Innovation" of the PARITY project, funded from the European Union's Horizon 2020 research and innovation programme. The scope of T10.1 includes a thorough analysis of the market related to the PARITY products, and especially to the LFM tools and systems. The purpose of this task was to survey and define the market opportunities and penetration of relevant products and services. Alternative use cases and market opportunities are also investigated, in order to identify segments of interest for individual PARITY components.

The deliverable provides an overview of the market for smart energy systems and tools using existing sources of information to understand the hype on the market, what the challenges are, what is being done by competitors, what is being accomplished by customers or consumers and what is likely the market potential for new products or services, based on past activities and responses. Additionally, a market feasibility analysis related to energy markets, flexibility on demand, smart grids among with the related tools and systems, as well as identification of current threats and challenges in the above-mentioned fields, is presented. Moreover, the current document explores the patterns that form the energy market transformation, measure awareness regarding energy market and gain insights on energy market tools and services through a survey implemented within T10.1 and disseminated to PARITY experts and experts outside the PARITY project, with a very strong/strong understanding of emerging technologies. Finally, alternative use cases and market opportunities are investigated to identify segments of interest for individual PARITY components and at the same time to present and analyse new market trends. The current deliverable closes with a proposition of an adoption roadmap related to the PARITY offering.

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List of Abbreviations

Term	Description
AC	Alternating Current
ANM	Active Network Management
BCN	Blockchain
BESS	Battery Energy Storage System
BEVs	Battery Electric Vehicles
CAES	Compressed Air Energy Storage
CAGR	Compound Annual Growth Rate
CapEx	Capital Expenses
CCS	Combined Charging System
CEP	Climate and Energy Package
CHP	Combined Heat and Power
CO2	Carbon Dioxide
dApp	Distributed Application
DC	Direct Current
DER	Distributed Energy Resource
DES	Distributed Energy Storage
DG	Distributed Generation
DLT	Distributed Ledger Technology
DN	Distributed Network
DR	Demand Response
DSO	Distribution system operator
EC	European Commission
EEU	European Energy Union
EMDII	Electricity Market Directive
ESCO	Energy Service Company
ESCO	Energy Service Company
EU	European Union
EV	Electric Vehicle
G2V	Grid to Vehicle
GDPR	General Data Protection Regulation
HDI	Human Development Index
HVAC	Heating, Ventilation and Air Conditioning
ICO	Initial Coin Offering
IoT	Internet of Things

IT	Information Technology
LCOE	Levelized Cost of Electricity
LEM	Local Energy Market
LFM	Local Flexibility Market
LTLF	Long-Term Load Forecast
LV	Low Voltage
LV	Low Voltage
LVRTU	Low Voltage Remote Terminal Units
MB	Megabyte
MV	Megavolt
MV	Medium Voltage
NECP	National Energy and Climate Plan
OEM	Original Equipment Manufacturer
P2G	Power to Gas
P2P	Peer-to-Peer
PHS	Pumped Hydro Storage Systems
PoW	Proof of Work
PV	Photovoltaic
REDII	Renewable Energy Directive
RES	Renewable Energy Source
SDN	Smart Distributed Network
SDS	Smart Distribution System
SG	Smart Grids
STLF	Short-Term load Forecast
SLA	Service Level Agreement
SNG	Synthesized Gas
V2G	Vehicle to Grid
V2H	Vehicle to Home
VPP	Virtual Power Plant

1. Introduction

Since 2007, the European Union (EU) has proposed in September 2020 to raise the 2030 greenhouse gas emission reduction target, including emissions and removals, to at least 55% compared to 1990[1] . Based on the 2030 targets, 32% of the energy consumed should be produced from Renewable Energy Sources (RES) and at least 32.5% improvement in energy efficiency should take place. ss energy should have been consumed. Moreover, by 2050, the EU expects to cut the greenhouse gas emissions by 85-90% [1]. With the rapid growth in distributed solar generation and storage, and the anticipated rise of engaged users participating in demand response, a primary issue must be addressed: *how to incorporate the versatility resources offered by these emerging technologies and players into the existing energy market?* Figure 1 presents the EU progress towards climate and energy targets by 2020 [2].

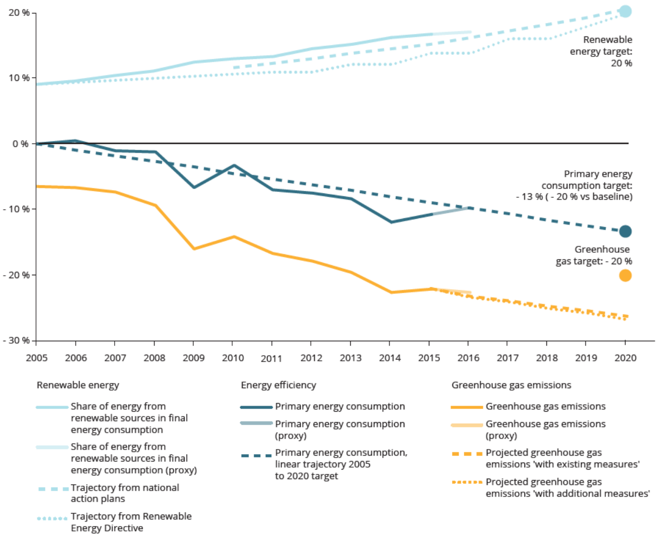


Figure 1: EU progress towards climate and energy targets by 2020

A promising approach for addressing the energy and environmental challenges that we are currently facing, is the adoption of smart grid with renewable energy resources, through micro-grids implementation. New concepts, innovations and scalable approaches for intelligent energy production continue to be built in smart grids to promote optimized strategies for electricity and power transfer. Specifically, energy trading is undergoing a transformation from clustered to distributed paradigm as an integral component of energy management. Increased green energy technologies should be shared for mutual gain with all market participants (e.g., Distributed System Operators, aggregators, consumers), addressing the power imbalances (i.e. the disparity between the power consumed and the power produced is referred to as power imbalance.). Towards this direction, the EU has focused on building a European Energy Union (EEU) which tries to integrate national electricity systems through intermittent renewables and market coupling into a broader European network. Additionally, allowing technology such as smart meters and sensors opened the prospect of developing new market models and users in different forms of electricity systems. Some of the emerging market structures are Peer-to-Peer energy trading, Internet of Things (IoT) and smart contracts enabled energy transactions as well as Distributed Energy Resources (DER) profiling. Although enhanced connectivity and data sharing are increasingly needed between various areas of the smart grid, making central control and activity more difficult. Thus, local distributed management and control techniques are needed to respond to the aforementioned trends in decentralization and digitalisation. Moving a step forward, blockchain and Distributed Ledger Technology (DLT) were mainly designed for avoiding central authority and allowing distributed transactions. Therefore, blockchain has the potential to fundamentally change tools and services related to energy. Even though the local energy market, enhanced with emerging technologies, has a wide spectrum of opportunities, they are also facing some obstacles and prevents the widespread adoption of the technology in the market. Towards this direction, Deliverable 10.1, presents a market intelligence analysis on Local Flexibility Market (LFM) tools and, aiming to highlight market opportunities and possible threats that local energy markets are facing nowadays.

[1] European Commission, "2030 Climate Target Plan", https://ec.europa.eu/clima/policies/eu-climate-action/2030_ctp_en

Currently a large proportion of variable generation is connected to distribution grids originally designed to deliver electricity supplied through the transmission grid by large-scale projects, typically at the scale of 100s-1000s of megawatts, using a variety of technologies: wind, solar Photovoltaic (PV), solar thermal, gas etc. The current energy operators lack the necessary mechanisms for fully automated, cost-effective distributed control. Thus, the aim of the newly developed LFM concept is to open up the energy market towards a new, decentralized and more flexible model [96].

Toward this direction, PARITY is a Horizon 2020 research project that envisions to go beyond the traditional "top-down" grid management practices by providing a unique local flexibility management platform via the integration of IoT and Blockchain technologies [97]. The project aims to allow LFM to be set up and operated at the level of the distribution network, through a comprehensive package that will provide. The three key innovations of PARITY include a) a smart contract compliant, blockchain-based LFM that will facilitate all peer-to-peer energy/flexibility transactions, b) various IoT enabled DERs flexibility management tools, and c) smart grid monitoring and management tools that will allow DSO to control the low voltage distribution network in an optimized manner. The goal of PARITY is to offer a transactive flexibility framework that will increase the durability and efficiency of the electrical grid while at the same time allowing more Renewable Energy Sources (RES) to be adopted through enhanced real-time control of DER flexibility based on new active network management features.

1.1 Scope and Objectives of the Deliverable

The deliverable D10.1 “Market Intelligence on LFM tools plan” is the outcome of task 10.1 “Market Intelligence on LFM tools and systems” and the deployment of activities to prepare a market analysis related to energy markets, flexibility on demand, smart grids among with the related tools and systems and explore the patterns that form the energy market transformation.

The scope of this deliverable is to provide a thorough analysis on the market related to the LFM tools and service, as researched, developed and evaluated within the PARITY project. The deliverable surveys and defines the market opportunities and penetration of relevant products and services, as well as investigates alternative use cases and market opportunities, in order to identify segments of interest for individual PARITY components. In more detail, the deliverable is divided in three main parts: market opportunity, market penetration and market development. The extended analysis that will be presented in those sections will help PARITY project to grow through market intelligence. More specifically this includes providing the view of the energy market using existing sources of information to understand the hype on the market, what the challenges are, what is being done by competitors, what is being accomplished by customers or consumers and what is likely the market potential for new products or services, based on past activities and responses. During the Market Opportunity analysis, the current document will provide a market feasibility analysis related to energy markets, flexibility on demand, smart grids among with the related tools and systems, as well as identify current threats and challenges in the above-mentioned fields. Then, during the chapter on Market Penetration, the current document explores the patterns that form the energy market transformation, measure awareness regarding energy market and gain insights on energy market tools and services through a survey implemented within this task and disseminated to PARITY experts and general public. Finally, during the Market Development part, alternative use cases and market opportunities will be investigated to identify segments of interest for individual PARITY components and at the same time to present and analyse new market trends.

1.2 Structure of the Deliverable

The current deliverable begins (Section 2) providing a detailed description of the methodology followed within T10.1 towards achieving its objectives. Following the methodology overview, the current document is divided in four parts: market relevance, market opportunity, market penetration and market development.

In the first part (Section 3), a market relevance is provided for the purposes of dominant position and concentration analysis. Specifically, the authors are setting up the scene and provide background information related to the renewable energy market, distributed energy resources and blockchain technologies.

In the second part (Section 4) the market opportunity is provided, synthesising market research and industry data to identify opportunities for growth in the renewable energy market. Specifically, opportunities and challenges are identified in the areas of DLTs and blockchain, smart distribution systems and DERs, business development services for Local Flexibility Market (LFM) / Local Energy Market (LEM), smart grid monitoring and management, IoT and smart contracts enabled energy transactions and DERs flexibility profiling.

In the third part of D10.1 (Section 5), the market penetration takes place, providing a summary of the current market activity, based on our primary research across the LFM tools and services provided by PARITY. Additionally, patterns that form the energy market transformation were identified through a survey disseminated to PARITY experts and experts outside the PARITY project, with a very strong/strong understanding of emerging technologies.

The final part of this deliverable is dedicated to market development, identifying and developing new market segments for the PARITY tools and services, providing specific segments of interest and new market trends. The market development closes with a market development roadmap related to the PARITY offerings.

1.3 Relation to Other Tasks

The development of PARITY Market Intelligence on LFM tools Plan is linked to various of WP activities' outcomes. Additionally, it establishes the ground knowledge providing inputs towards many tasks.

The documents that feed the design of PARITY Market Intelligence on LFM tools Plan are presented below:

- D3.1 PARITY Business use cases & Requirements
- D3.5 PARITY System Architecture: A description of system architecture and PARITY framework operation.
- D4.1 Barriers that hinder LFM proliferation
- D4.2 Next-generation Energy contracts
- D4.3 Integration of Local Flexibility Market into the existing Electricity Trading Frameworks
- D5.1 PARITY IoT Tools design and specifications
- D5.2 Market Models and Flexibility routes
- D5.3 PARITY Off-chain Components
- D5.4 Smart Contracts

The documents that are fed from the PARITY Exploitation and Business Innovation Plan are presented below:

- T10.2 Evaluation and assessment of Business viability of LFM actors
- D10.3 Exploitation and business innovation plan
- D10.4 Recommendations on Policy Reforms
- D10.5 Report on PARITY results replication roadmap

2. Methodology

The methodology designed to prepare the PARITY Market Intelligence on LFM tools plan was applied throughout the whole lifetime of T10.1, with main focus the information relevant to PARITY's market trends, competitor and customer monitoring, gathered and analysed specifically for the purpose of accurate and confident decision-making in determining strategy in areas such as market opportunity, market penetration strategy, and market development.

The methodology that was followed within T10.1, and applied also in this deliverable, is divided in four phases, as depicted also in Figure 2:

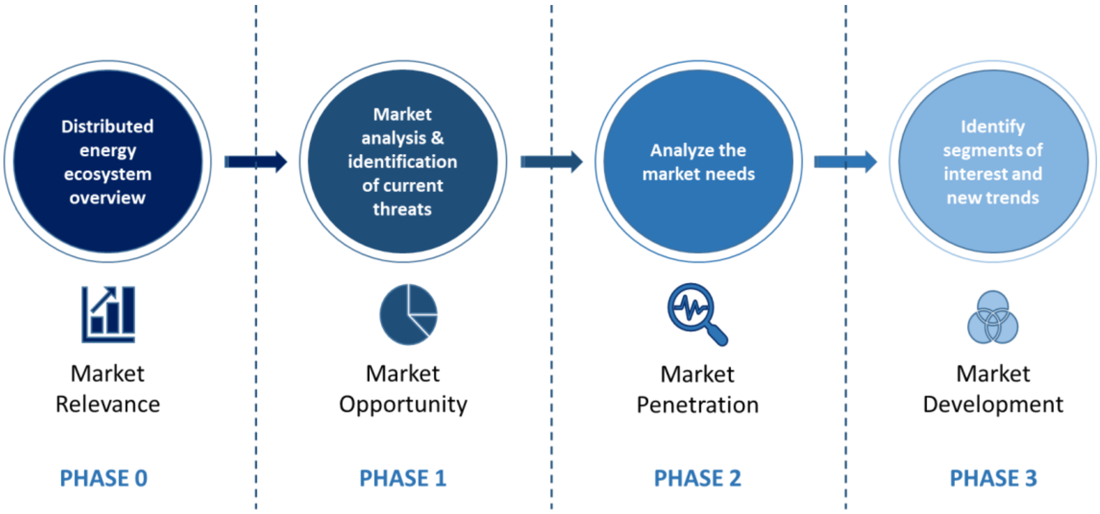


Figure 2: Definition of D10.1 methodology

- **Phase 0: Market Relevance – Distributed energy ecosystem overview:** Phase 0 provides the view of the energy market using existing sources of information to understand the hype on the market, what the challenges are, what is being done by competitors, what is being accomplished by customers or consumers and what is likely the market potential for new products or services, based on past activities and responses.
- **Phase 1: Market Opportunity – Market analysis and identification of current threats:** Phase 1 provides a market feasibility analysis related to energy markets, flexibility on demand, smart grids among with the related tools and systems, as well as identify current threats and challenges in the above-mentioned fields. This phase synthesizes the market research and industry data to identify opportunities for growth in the renewable energy market. Specifically, opportunities and challenges are identified in the areas of DLTs and blockchain, smart distribution systems and DERs, business development services for LFM/LEM, smart grid monitoring and management, IoT and smart contracts enabled energy transactions and DERs flexibility profiling.
- **Phase 2: Market Penetration – Analyze the market needs:** Phase 2 document explores the patterns that form the energy market transformation, measure awareness regarding energy market and gain insights on energy market tools and services through a survey implemented within this task and disseminated to PARITY experts and general public.
- **Phase 3: Market Development – Identify segments of interest and new trends:** Phase 3 provides alternative use cases and market opportunities, highlights new market segments for the PARITY tools and services, provides specific segments of interest and new market trends. The market development closes with a market development roadmap related to the PARITY offerings.

3. Distributed Energy Ecosystem

Technological progress, new products and services allowed by digitization, and the rapid growth of transportation sector electrification, have unleashed a cascade of experimentation. Such research would rewrite the rules for how to produce and use energy well into the future. Thus, in this Section an overview of the Distributed Energy Ecosystem was made, trying to identify the consumer-centred energy transition, to a network of properties, customers and value exchanges.

3.1 Renewable Energy

Renewable Energy sources are a key focus for the EU, as the main driver for EU Climate and Energy package [1] towards a sustainable, more liable and affordable energy system. EU is aiming to reduce greenhouse gas emissions below 1990 level by 2030, to deal with high energy prices and the EU economy's vulnerability to future price rises (especially for oil and gas), to EU's dependence on energy imports, and replace and upgrade energy infrastructure and provide a stable regulatory framework for potential investors. More specifically EU is committed to:

- Cut down greenhouse gas emissions by 40%, until the end of 2030,
- Renewable Energy consumption to reach 32% of the overall energy consumption by 2030 (reviewed 2018) and
- 32,5% increase in energy efficiency, supported by the energy efficiency directive.

The renewable energy includes wind power, solar power (thermal, photovoltaic and concentrated), hydropower (tidal power, wave and ocean energy), geothermal energy, biomass (renewable of waste and liquid bio-fuels) [3] and renewable energy from heat pumps. The shares of renewable energy consumption are indicated by the energy delivered to final customers compared to the gross final energy of all energy sources (including the transmission and distribution losses for electricity and heat).

It is a growing sector and during 2018, the proportion of renewable energy in the EU's energy mix, reached 18,9%, increasing from 2017 (17,5%) and doubled compared to 2004 (9,6%) [4] The momentum though, has decreased from 2014-2017 with an average increase of 0,44 percentage points per year, which is lower than the annual average increase of 0,83 that was expected to reach the 2020 targets [5]. The Renewable Energy progress is clearly depicted in Figure 3 [6].

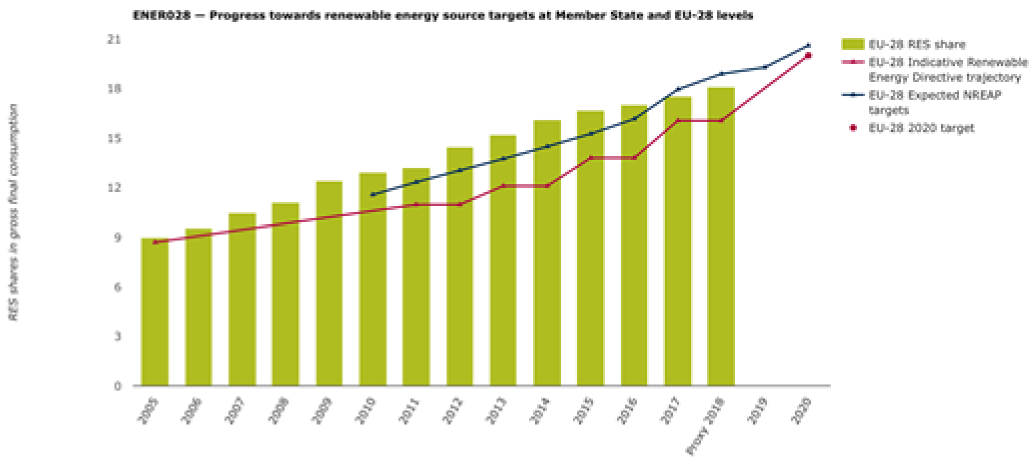


Figure 3: Renewable energy progress

As indicated in the EU Renewable Energy progress report, some countries have already reached the national energy goals like Bulgaria, Czechia, Denmark, Estonia, Greece, Croatia, Italy, Latvia, Lithuania, Cyprus, Finland and Sweden, as presented in Figure 4 [7].

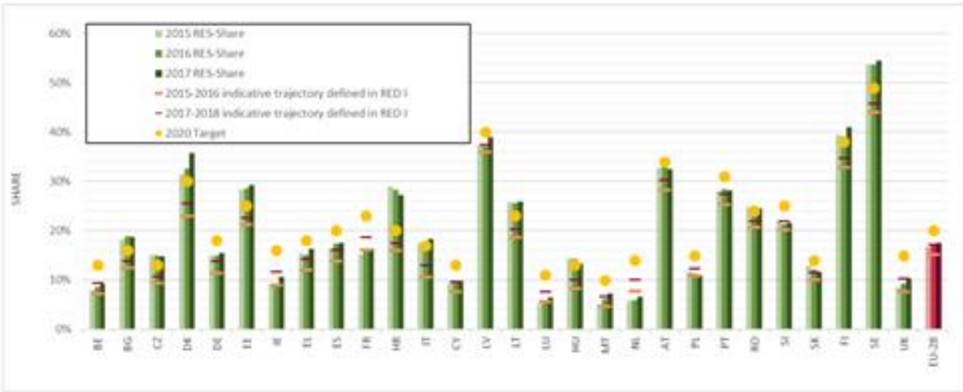


Figure 4: EU and Member States renewable energy shares in gross final energy consumption 2015-2017

The Renewable Energy sources consumption is divided into three sub-sectors: electricity consumption, heating and cooling and transport. The renewable energy share in electricity consumption during 2018 has doubled since 2004 (from 14,2% to 32,1%) and this was achieved due to wind power, solar power and solid biofuels. The level of electricity that was generated in the EU from solar power in 2018 was 15,5 times higher than 2008 and the one generated from wind turbines in 2018 was 2,9 times higher compared to 2008. During 2018, Thermostats accounted for 21.1% of the overall energy demand from renewable energy sources, which was increased from 11,7% in 2004 and was realized in industrial and building sectors. Figure 5 presents the average share for Renewable energy in transport has increased from 1,5% in 2005 to 7,1% in 2016 [8]. In 2018 the proportion of renewables in transp The anticipated modernization needs to investigate the potential key enablers and associated developments, in planning and ort activities is 8,3%, towards the target of 10% by 2020 (i.e., including liquid biofuels, hydrogen, biomethane, 'green' electricity, etc.).

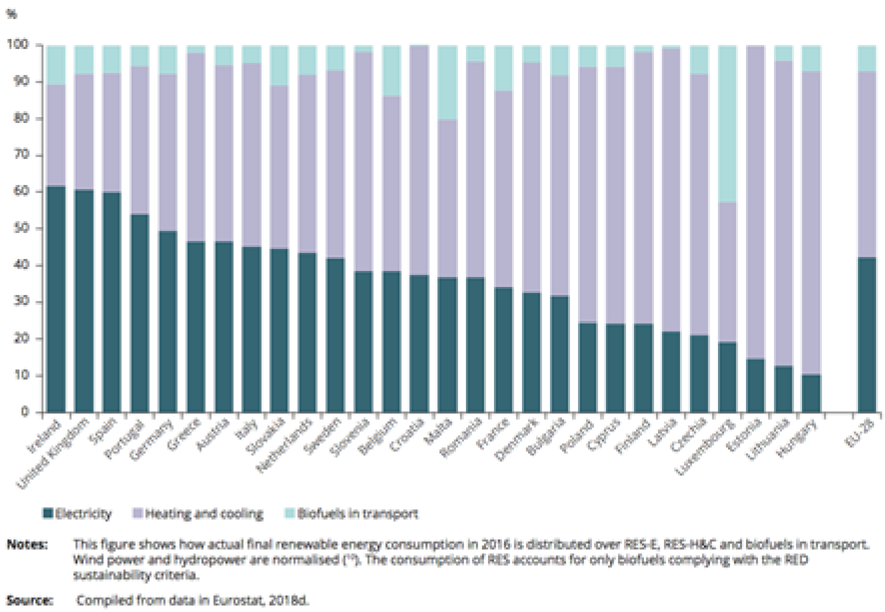


Figure 5: Shares in 2016 RES consumption of renewable electricity, renewable heating and cooling and biofuels in transport

Furthermore, the Renewable Energy Sector has a br VECW 73RQ2=oader impact on the fields of Energy security, Market integration, Energy efficiency, decarbonisation and innovations. Based on the progress report [9] there is a benefit of €16 billion from savings in fossil fuel imports in 2015, and this is projected to rise to €58 billion in 2030. Under the 'Clean Energy for all Europeans" package, there is a growth of cheaper and new technologies that will unlock the potential of renewable sources to have an equal share with other energy sources and it is estimated that the sector has 30% of global patents. Moreover, Renewable power is estimated to improve buildings energy performance and reduce consumption. In 2015, the greenhouse emissions were reduced by the amount equal to Italy's total emissions. Regarding economic growth, the market size of Renewable sources industry in 2014 was €144 billion and more than 1,4 million people are working in the sector.

3.2 Smart Grids and Smart Distribution

Smart grids are the distribution and transmission systems that use the Information Technology (IT), telecommunication and high-level automation resources to significantly increase energy quality and operational efficiency. Due to the high level of aggregate technology, Smart Grids (SG) are able to respond to various demands of modern society, in terms of energy needs and also considering sustainable development [10]. Smart Grids represent for many people the revolution in the electric sector and, consequently, the revolution of the world economy. The reason for this is that all the main economic transformations of history happened when a new communication technology converges with new energy systems. Communication infrastructure eliminates time and reduces distance, connecting people and markets, facilitating new business relationships.

It should be stated also, that the Smart Grid concept is very close to the consumers. The innumerable advantages that these intelligent systems can provide for the electrical system, the technological advancement of the equipment and the constant growth of the demand for electric power, drive research on the subject. Smart Grid enables real-time metering and bidirectional communication, ensuring user participation in the power grid. Home appliances built into smart grids make it possible to determine the power consumption characteristics, allowing the user to control their consumption and reduce their energy tariff costs or adapt their consumption patterns. To put the smart grid into practice, it is necessary to consider the modernization of infrastructure, installation of digital layers, with high-capacity data processing software, which is the essence of smart grid.

The competitive electricity market and service requirements close to the technical limits of current technology, have resulted in overstressed grid operations (at the transmission/distribution level), particularly in the Distribution Network (DN). Conventionally, the DN has purposely been planned to retain unidirectional power flow with radial topology, aimed at efficient power delivery to the end consumer [11]. However, escalating load requirements over large geographical distances have resulted in serious technical issues in DNs, predominantly higher system losses, lower voltage regulation, compromised power quality, reliability concerns, and expensive planning alternatives [12]. The possible solution strategy calls for planned (long/medium/short-term) modernizations that include countermeasures to deal with technical and commercial issues. In order to design and upgrade traditional DNs into Smart DNs, the expected modernization must explore possible key enablers and accompanying advancements. Still, smooth transition to SDNs is a concept that is easier said than done. The forthcoming DN, is expected to be linked in terms of design and operation complexity, including the usage of DERs with significant penetration. For that there are some issues that SDN will have to overcome, such as:

- Limitations in current DN infrastructure restrict the maximum utilization of DERs.
- Acceptance of SDN may be endangered if the aforementioned smart technologies and infrastructure changes are not acquired [13].
- Technological and cost-related constraints at the distribution level may have a long-term detrimental impact on customers.

3.3 Blockchain

This section provides an initial introduction, definition and development history of the blockchain technology. Moreover, its main characteristics are going to be presented, as well as the overall process.

A blockchain is a distributed system that comprises multiple devices cooperating in a decentralized network. This infrastructure consists of distributed computers which are documented in a manner that prevents their subsequent modification. Blockchain technology helps to increase security, accelerates information exchange in a manner that is more cost-effective and transparent, and also is a key technology for validation and verification of any kind of applications and services [14]. Thus, a blockchain is essentially a virtual contract allowing an individual party to conduct any kind of transaction (e.g., a sale of electricity) directly P2P with another party. Traditional third parties, such as a big scale electricity company, are no longer necessary under this model, since the other network participants (i.e., peers) serve as witnesses of each transaction between a provider and a consumer. Figure 6 depicts in a comprehensive way the overall blockchain process.

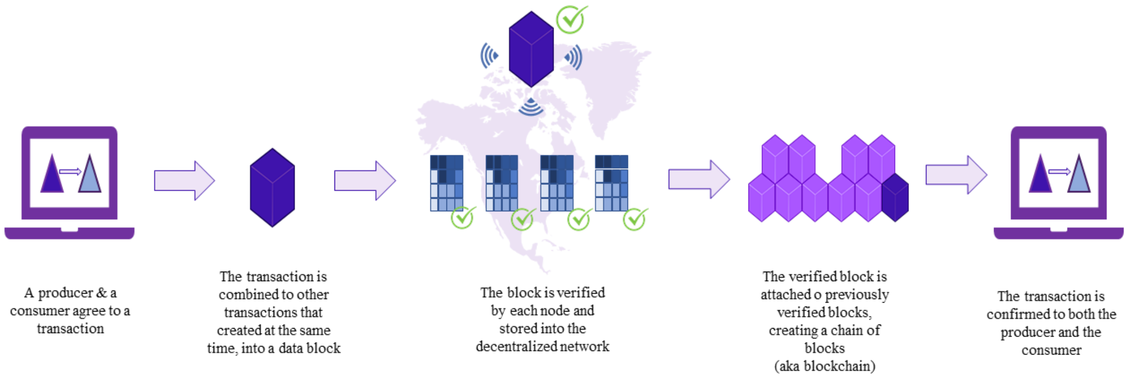


Figure 6: The blockchain process

Depending on their stage of development, Today's blockchain implementations can be classified into three broad categories, namely stages 1.0, 2.0 and 3.0.

- *Blockchain 1.0* – Cryptocurrencies*:* The anonymous inventor of Bitcoin, Satoshi Nakamoto, introduced to the world the blockchain technology. During that period, it reflected the application of distributed DLT to its most apparent use case, that was the use of digital assets or cryptocurrencies for transactions and ownership transfers. Bitcoin was the first blockchain platform which allowed P2P virtual money (i.e., bitcoins) exchange, through a digital payment system [15].
- *Blockchain 2.0* – Smart Contracts: The world of blockchain was moved to the second stage, introducing the Ethereum network, pioneered by the young Vitalik Buterin. Ethereum brought to life the concept of smart contracts, which are considered to be autonomous codes, that function within the blockchain, and perform tasks on the basis of predetermined conditions [16].
- *Blockchain 3.0* – Industry Ready: The current stage of blockchain is the 3.0, which envisions creating high autonomous systems on top of blockchain technology, benefiting from its capabilities (i.e., immutability, transparency and no need for third parties) [17].

The key characteristics that could describe the blockchain technology include the a) DLTs, b) DApps, c) Smart Contracts and c) Consensus Algorithms. An overview of these concepts is described below.

- *Distributed Ledger Technologies (DLTs):* One form of a distributed ledger is blockchain. Autonomous computers (i.e. nodes) are used in distributed ledgers to record, verify, and coordinate transactions in their separate electronic ledgers, instead of storing the data in a centralized manner [91].
- *DApps:* Distributed Applications (dApps) are open-source applications that represent a contract

between a network and its users and operate on a ledger, such as the Bitcoin or Ethereum blockchains. The user interface of a dApp does not look any different than any website or mobile app today. The smart contract represents the core logic of a decentralized application [92].

- *Smart Contracts:* A smart contract is an arrangement for self-enforcement implemented in a blockchain-managed computer code. The code includes a set of rules under which the smart contract parties agree to communicate. If the predefined rules are met, the agreement will be followed automatically [93].
- *Consensus Algorithms:* One of the big advantages of blockchain is the verification of the data. The purpose of the verification process is to reach consensus about the distributed ledger content. Consensus-based verification is a decentralized and distributed process, implemented on the blockchain itself. The consensus algorithm is an important part of a blockchain since it ensures the confidentiality and reliability of the network. The first consensus algorithm to be created was the Proof of Work (PoW), which was designed by Satoshi Nakamoto and implemented on Bitcoin as a way to overcome the Byzantine faults [15].

In the context of energy, information and interactions related to energy generation and consumption may be recorded in a secured, transparent, and decentralized ledger using blockchain. Additionally, smart contracts can promote the interconnection between prosumers and/or provide a direct link between energy suppliers and energy consumers, leading to the decentralisation of energy systems. By adopting blockchain application in the energy sector, a decentralised energy transaction and supply system could become possible in the near future. In more detail, energy generated at distributed generation stations would be transported through smaller networks (i.e., smart grids) to end users (i.e. prosumers). Smart meters would control the amount of energy produced and consumed while smart contracts would monitor energy trading activities and cryptocurrency transactions and execute them through the blockchain [21].

4. Market Opportunity

In today's energy ecosystem it is never a certainty to achieve growth and profitability. Technological and scientific advances shorten product and service life cycles, alter market models and new competitors emerge outside industry. This persistent uncertainty necessitates the quest for new market opportunities. In this Section, the market opportunities and current threats and challenges are going to be presented for the different PARITY LFM tools and services, in order to identify business growth prospects on the market.

4.1 Distributed Ledger Technologies and Blockchain

4.1.1 Market Analysis

Blockchain has a transformative potential for the energy market. Applications are being pursued internationally and new technology start-ups and projects are emerging. The energy industry uses blockchain and DLT in multiple use cases, as it leverages decentralized P2P technology, where both people and energy devices share a common distributed ledger [20]. Thus, one of the most intriguing emerging technical advancements is blockchain technology, with a market size valued at USD 1,590.9 million in 2018, and anticipated to grow at a compound annual growth rate (CAGR) of 69.4% from 2019 to 2025, as stated from the relevant report of Grand View Research [22]. More precisely, Gartner stated that by 2025 blockchain technology would generate a market value of more than $176 billion, and by 2030 value of $3.1 trillion [23]. It is obvious that the various advantages involved in creating such blockchain applications have already drawn interest and, subsequently, investments from the financial sector as well as other technology giants. DLTs not only have the potential to change the way the financial sector currently operates, but will also have consequences for many other sectors, including energy, IoT and telecommunications. Blockchain innovation is emerging as the ultimate response in the technical world with the introduction of better advances. It's a series of interconnected algorithms designed to store, access, and distribute data. Developing accentuation on the decentralization of information records has caused the blockchain invention to expand [24]. The technology encourages the immutable essence of the operations of the database, making the interactions transparent. Applications focused on blockchain pick up a slick speed, covering several industry areas, as mentioned before, and thus having enormous business opportunities. Ms. Litan stated in Gartner that there are several advances in blockchain technology which will change the existing paradigm, making by the end of 2023 blockchain systems scalable, interoperable, and able to enable intelligent contract portability and cross-chain applications [25]. Moreover, very interesting findings were analysed in a new study conducted by Grand View Research, Inc [26]. Below, the most important ones are presented:

- From 2019 to 2025, the public segment is projected to rise at the highest CAGR of 70%. This growth can be linked to the increasing desire to inculcate transparent and productive transactions by organizations and government.
- In the next six years the Asia Pacific region is projected to emerge as the fastest rising regional market, increasing the adoption of blockchain technology by banks and other financial institutions in order to drive regional market growth, reduce operational costs and streamline business operations.
- R3, Ripple, Chain Inc., Linux Foundation, Digital Asset Holdings, Eric Industries, IBM Corporation and Safello are key blockchain technology market actors.

Over the past few years, many of the above-mentioned companies (e.g., IBM, Microsoft) have been leading the development of energy-related blockchain applications worldwide and it is believed that more are also working on incorporating blockchain solutions, but are still not noticeable on the energy market.

Moreover, the way blockchain is applied worldwide is influenced by new blockchain projects in various countries and regions. Based on Deloitte’s 2019 Global Blockchain Survey, it appears that China, Singapore, Israel and United States are emerging countries of innovative blockchain technologies, focusing on their own common goals and strategies. Figure 7 below, differing attitudes about blockchain along a number of metrics, for the respective countries [27].

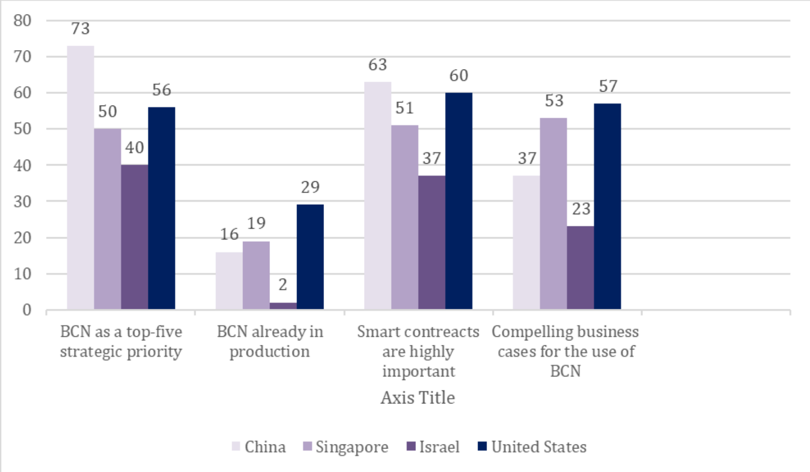


Figure 7: Blockchain (BCN) adoption in emerging countries

Apart from those big blockchain enabler countries, in Figure 8 it is clear that day by day in the market people moving towards Blockchain technology, as in 2016 blockchain revenue by region was below $5,000 and it will be $20,000 until 2025, as described by M. Niranjanamurthy et al. [28].

Figure 8: Blockchain revenue by region (2016-2025)

Last but not least, there are many signs that blockchain changes the market environment in a fundamental way including: a) tokenization, b) initial coin offerings (ICOs) and c) enterprise software platforms.

4.1.2 Current Threats and Challenges

While businesses try ways to incorporate blockchain into their current business models, or more specifically, how to adapt current processes and structures to work with blockchains, emerging disrupters developed their businesses around blockchain from the outset. This theoretically makes them more flexible and versatile than rivals, and less constrained by similar obstacles that hinder acceptance by their more developed competition. As the blockchain environment progresses and various use-cases arise, organizations in all business sectors should face a dynamic and potentially divisive array of problems, as well as new dependencies. The key blockchain market adoption challenges are depicted in Figure 9 below.

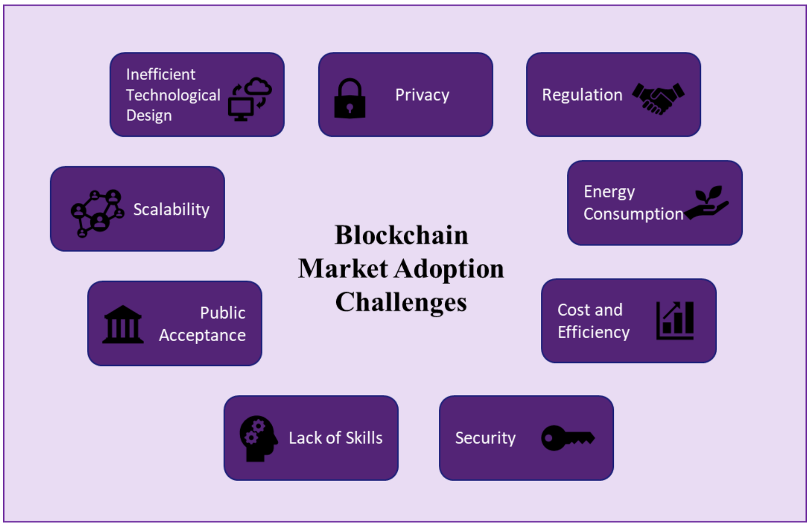


Figure 9: Blockchain Market Adoption Challenges

- **Inefficient Technological Design:** While blockchain technology has many market opportunities, in many technical ways it still lacks. For instance, the decentralized applications, built with Ethereum blockchain help developers built dApps for a plethora of use cases. Some of them, however, seem to have a question of miscoding and loopholes, leading to vulnerabilities and hack-issues into the program. Additionally, as Deloitte refers in a recent report [94], the issue with many existing solutions is that they remain stove-piped, meaning that companies are creating their own blockchains and operating on top of them. Therefore, many different chains are being established by many different organizations to many different characteristics in any one business market. This defeats the distributed ledgers aim, fails to leverage competitive advantages and may be less successful than current approaches.
- **Scalability:** Scalability is a key barrier when applying blockchain to real business environments. Firstly, the throughput of a blockchain system is related to the total number of transactions in a block and block time period. Taking the Bitcoin blockchain as an example, the block cycle time is about 10 minutes, the total number of transactions in a block is restricted by the block size, which is one megabyte (MB). Thus, to support a huge amount of real-world transactions, appropriate schemes need to be carefully built to maximize throughput. Secondly, each node will process and store the complete transaction back to the genesis block, within the conventional blockchain system. Therefore, blockchain cannot be extended directly to actual business environments, where nodes have restricted storage and computational capacity. Hence, learning how to efficiently store data in blockchain nodes with limited resources is important. Finally, networking is the third factor influencing the scalability of blockchain and DLT systems. The conventional blockchain network, is a “broadcast medium”, through which each node relays all transactions. This data transfer mode cannot be extended to accommodate a large number of transactions due to the network bandwidth constraint [29].
- **Energy Consumption:** Energy use poses another obstacle for blockchain adoption. The mining process require enormous amount of machine power to solve difficult equations, putting up increasing amounts of order to achieve it. Miners currently use 0.2% of total worldwide electricity consumption, and if it continues to expand, then miners can take on more power than the planet can produce by 2020. Therefore, it is now becoming one of this network's biggest challenges [30].
- **Cost and Efficiency:** The speed and reliability with which blockchain networks can carry out peer-to-peer transactions comes at a high aggregate cost, higher for certain blockchain forms than others. This inefficiency occurs because in an effort to be the first to find a solution each node executes the same functions as any other node on its own copy of the data. For example, the Bitcoin network, which uses a proof-of-work approach, the overall operating costs associated with the validation and exchange of public ledger transactions are projected to be as

high as $600 million per year and rising. It should be also taken in mind that this amount does not include the capital costs associated with the purchase of specialist mining equipment [31].

- **Privacy and Security:** Security problem and blockchain technology has been discussed intensively. Several professionals and academic experts have argued that blockchain technology is inconsistent with privacy laws like the EU General Data Protection Regulation (GDPR) [32]. Although cryptocurrencies such as Bitcoin provide pseudonymity, other future blockchain implementations allow smart transactions and contracts to be unquestionably connected to established identities, posing serious concerns about privacy and data protection stored and available on the public ledger. Participants who transmit personal data to the blockchain are more likely to be called GDPR controllers as they specify the processing information, while blockchain nodes who only collect personal data are more likely to be processors as they simply promote the function of the blockchain network. This decision, however, is not easy, because not all blockchain networks function in the same way, and there could be various types of members conducting different activities [33-35].
- **Regulation:** Many organizations are transforming blockchain technology into a transactional tool, without following clear guidelines, resulting to technologies like DLT and blockchain to completely by-pass regulation and tackle inefficiencies in traditional intermediated payment networks entirely. A critical issue for regulators about decentralized structures is who will be kept responsible for violations of law and regulation. This is analogous to the problem of assessing network transparency before blockchain emerges [36].
- **Lack of Adequate Skill Sets:** Besides the necessary software and hardware, appropriate trained personnel to handle the blockchain technology is needed in order to be adopted in the market. Blockchain is still in its early stages of development, and only a few professionals have the necessary skills to support it [37].
- **Public Acceptance:** Last but not least, the main issue with blockchain is a lack of technological expertise, especially in non-banking sectors (e.g. the energy and sustainability sector) and a general lack of understanding of how it functions. The vast majority of the people are still unaware of the characteristics of DLTs and how they will be used in the future. While technology is making progress, it is still insufficient to attract new customers.

Concluding, distributed ledger technologies and blockchain guarantees trust, immutability/transparency and facilitates disintermediation, as well as providing extra protection for transactions that have been executed. Those are substantial benefits that cannot be overlooked. Although, its cost-of-implementation drawback can be depreciated and minimized in a short period of time, as more expertise is obtained and blockchain becomes a core technology [38].

4.2 Smart Distribution Systems and Distributed Energy Resources

Distribution networks in the power system are profoundly engaged in the task of incorporating non-dispatchable energy sources (e.g., solar, wind), which rely on meteorological conditions for the electricity production. Thus, in this Section a market analysis and current challenges related to the smart distribution systems and distributed energy resources are going to be presented.

4.2.1 Market Analysis

The innovation environment offers an overview of an advancement in business design, allowing DERs to provide grid services, engage in wholesale and ancillary services markets and be exposed to market prices. The goal of DERs' market integration is to achieve better integration of these tools into the grid and use them to increase the efficiency of the smart distribution systems.

Distributed Energy Resources: Distributed energy resources (DER) are small energy producing units or flexible loads. Rahimi & Ipakchi [39] identifies them as either Demand Response (DR), Distributed Generation (DG) or Distributed Energy Storage (DES). There is hope that DER will play a central role in the transition towards a more efficient energy system, and studies suggest that an overwhelming majority of EU households have potential to contribute with active DER in the system [40].

Distribution System Operators & Distributed Energy Resources: These DER come in many forms including booming technologies like stationary battery storage, electric vehicles, solar PV but also traditionally common resources like hot water boilers, heat pumps and appliances equipped with smart control devices. It is important to separate DER from larger sized installations of the respective technologies when understanding incentives for certain market behaviour. The rate of installation is high for PV, EV charging infrastructure and battery storage. A report by Wood Mackenzie estimates annual installation of home battery storage systems in Europe to rose from just over 200 MW in 2018 to more than 550 MW in 2024 [41].

The Council of European Energy Regulators defines a smart grid as an electricity network that can cost-effectively incorporate the actions and behaviour of all users who have access to it (e.g. generators, consumers, prosumers etc) to ensure economic sustainability, reliable energy systems with low losses, quality, protection, and security. Consequently, a smart grid defined in distribution level is a Smart Distribution System (SDS). In line with the definition above, an SDS has to have the possibility to integrate and utilize all DER included in the distribution network with high levels of efficiency and reliability. The means and methods to achieve this is a main topic for DSOs around the European Union.

Smart Distribution System: The ideas and examples on how to follow SDS principles are manifold. Some methods are in essence incentives, while others are direct control mechanisms. Dynamic power tariffs are being introduced for lower fuse sized grid connections than before, to also incentivize DER to adjust to time varying capacity constraints. Such tariffs have the advantage of being technology neutral, but have the disadvantage of not being a direct control mechanism.

Other more direct control alternatives include solutions with battery storage, flow batteries and hydrogen for dispatch at strategically chosen spots with regards to congestion management, completely operated by the DSO. While this can be a quick way to increase capacity locally, the smartness of this solution is questionable since producing or building grid level energy storage can undermine efficient integration of DER. For DSOs to receive precise control over connected DER, some sort of system for transactions needs to be present, or a local flexibility market (LFM). The way that DSOs approach operation and/or management of LFMs is key to the success of SDS.

In addition to business model adjustment, technical aspects of a distribution system can be equally interesting for SDS development. Adjustable MV/LV transformers between 380 and 420V LV can enable a larger amount of PV in the grid during daytime while maximizing utilization of the grid infrastructure during night. Additionally, infrastructure allowing for better data access is key for SDS success. This includes higher measurement time resolution in line with or higher than the EU regulated 15 minutes, as well as real time data from substation power flows, transmission and distribution line temperature, significant consumers and flexibility providers. Introduction of smart meters are central to this infrastructure, but not exclusive.

4.2.2 Current Threats and Challenges

A significant challenge within smart distribution systems and distributed energy resources, is that legislation is moving slower than technology. Distribution grids are natural monopolies, therefore the tariffs charged by DSOs are strictly regulated, and rightfully so. Unfortunately, there are cases where these regulations are counterproductive in terms of incentives for resource efficiency that could be achieved with smarter grids. Monopoly situation limits incentives for DSOs to implement innovative cost-efficient solutions, thus slowing down the transition towards SDS.

These tariffs, or grid fees, main income for DSOs, are usually based on the investment made in grid infrastructure by a DSO. Meaning that their turnover and opportunity for profit increase with such investments. One aim of SDS is to mitigate grid infrastructure, meaning there is a conflict of interest. EU level organizations ACER and CEER are both working on policies to address this issue *"DSOs are evolving to become neutral market facilitators, gathering and managing data on the actions and schedule of the electricity users connected to their grid. (...) The presence of innovation is a key element when considering the effectiveness of any regulatory framework. (...) Innovation is increasingly a crucial and widespread condition to achieve several main targets, such as quality of service, cost efficiency and security of supply. Innovation may come in different forms, and so may the underlying regulatory aims".*

There are few legal frameworks regarding the LFM concept today. Potentially, DSOs will not at all engage in management of marketplaces. Instead they could work with more dynamic grid fees, increase the power-based share of tariffs and reduce the energy share, and let engaged grid customers handle their own power and energy optimization (or hire service providers for it). Alternatively, they will provide platforms for local capacity trading, which would then in essence be LFMs.

The Renewable Energy Directive (REDII) and the Electricity Market Directive (EMDII) are both describing collective self-consumption communities as components of the future energy landscape of the EU. Such energy sharing, possibly only allowed within substation areas, could create very local LFMs. Possibly managed by the local participants themselves but more likely by external specialized service providers [42-46].

4.3 Business Development Services for LFM

An important outcome of PARITY is the experience gathered throughout the project concerning the feasibility of business models in the context of local flexibility markets. Therefore, this section addresses opportunities for exploiting this expertise by providing consulting services on how to set up an LFM and make it economically viable.

4.3.1 Market analysis

The probably most promising target group implementing LFMs in the future are the so-called (Local) Energy Communities. Generally, Energy Communities as legal entities can cover various parts of the value chain. Often, energy communities are focusing on jointly investing in nearby RES projects, thereby participating in the simple investment opportunity and related returns. But there are also energy communities providing more complex solutions to its members, including self-consumption combined with storage, peer-to-peer trade, balancing, management of the distributed energy resources and in some cases even of the distribution grid [47]. For this concept a variety of definitions exists. The EU set out definitions for Renewable Energy Communities (according to the Renewable Energy Directive) and Citizen Energy Communities (Internal Electricity Market Directive), the latter having a slightly broader scope in their activities. However, there are also other definitions that already have been established in a national context. An important example is so-called Citizens' Energy Companies (*Bürgerenergiegesellschaften*) in Germany, which are entities of different legal forms (often cooperatives) characterised as communities of locality with a non-financial mission under the control of citizens (i.e. natural persons) [48]. The concept of energy communities is increasingly popular among citizens, resulting in growing numbers of initiatives. The German Citizens' Energy Companies, which have been legally defined already in the year 2000, serve as a promising example for the potential future market uptake of energy communities all over Europe. The increasing numbers of registered Citizens' Energy Companies are shown in Figure 10 [48]. According to several case studies conducted by JRC 2020 [49], the drivers for establishing energy communities are manifold, as presented in Figure 11. These drivers range from environmental consciousness and a desire to produce green electricity to greater ownership of local energy infrastructure and financial motives. However, as energy communities are initiated by citizens or municipalities, but not by experienced profit-oriented electricity market players, high demand for support and consultancy services for setup and optimisation is expected. Implementing an LFM can be considered as the most advanced model of an energy community. Specifically, for this most complex application, the following points are assumed to be highly relevant consulting issues in the near future:

- Legal requirements for establishing an energy community (e.g., choosing legal structure, obtaining permissions etc.)
- Definition of the community's use/business case,
- Assessment of economic viability,
- Technical feasibility assessment, identification of technical requirements.

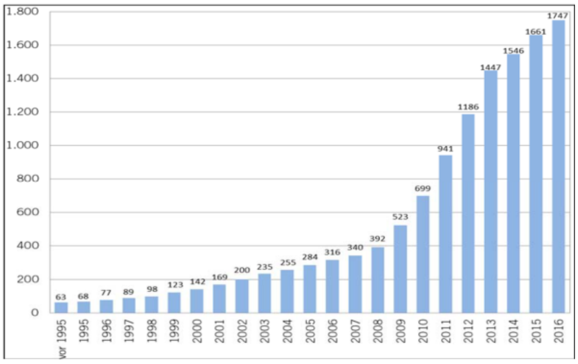


Figure 10: Total number of Citizens'Energy Companies in Germany until 2016

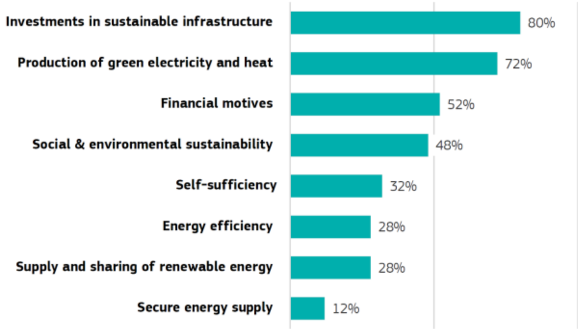


Figure 11: Drivers motivating participation in energy communities according to several case studies

4.3.2 Current threats and challenges

Threats and challenges that may emerge regarding consultancy services for energy communities implementing an LFM, are generally twofold. On the one hand, threats may arise due to the nature of local energy communities as customers. This means, for instance, that the future increase in newly established energy communities applying an LFM may have been overestimated, resulting in a lack of need for consultancy services. On the other hand, challenges could relate to the consulting service itself. For example, the value proposition offered may be not convincing, which leads to a lack of interest in these services. In the following paragraphs both of these aspects are discussed in detail.

Challenges for energy communities: There is a range of barriers that could hinder the increase of energy communities all over Europe. Figure 12 [50] shows the results from an extensive literature review among articles with a research focus on Germany, UK and USA. The purpose was to identify barriers impeding the formation and resilience of "Community Energy Initiatives", which can be considered a very broad definition of energy communities. Here, the mostly cited barrier is the lack of resources, which includes mainly funding, costs for professional consultancy, institutional costs and lack of human resources for communication and networking. Also, issues related to coping with the organizational and legal framework seem to be highly relevant. Regulations often make setting up energy communities extremely difficult, small initiatives may not generate enough surplus revenue to cover transaction costs and if they are big enough, they may grow to rather professional entities with only limited need for consultancy. Additionally, also a general level of scepticism towards energy communities among citizens is a major barrier [50].

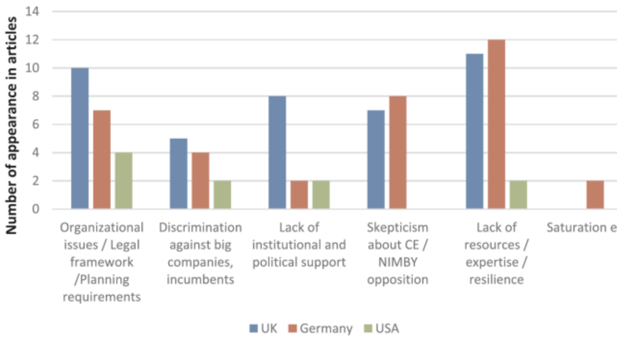


Figure 12: Barriers for Community Energy Initiatives, aggregated reference count

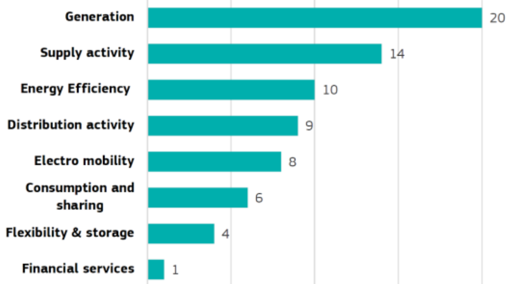


Figure 13: Overview of energy communities' activities according to several case studies

In addition to the general barriers for the increase in energy communities, there may be a lack of interest among them in applying the LFM concept. As shown in Figure 13 [49] existing energy communities are mainly pursuing activities such as renewable energy generation and supply, but the aspects of energy sharing (e.g., P2P trading) and the provision of flexibility, which are characteristics of an LFM as proposed in PARITY, seem to be mostly non-core activities. Also, the drivers in Figure 11 indicate that sharing is not a key motivation and flexibility provision may only be interesting for energy communities if there is a significant financial benefit.

Challenges for business development services: A key challenge for a consultant is to offer a convincing value proposition for their clients. It is crucial to address the right aspects, where a significant need for advice exists. Furthermore, the financial ability of energy communities for contracting a consultant needs to be considered and only those services can be offered that make economic sense. For instance, a small initiative may only be able to procure some legal advice, whereas a larger one may require an extensive economic and technical feasibility study. In initiatives by citizens, there could also be the risk that outsourcing of any activities to an external consultant is unwanted.

However, there could also simply be no need for any consulting. On the one hand, this could be the case, if the regulatory and administrative framework is very clear and lots of best practice examples are already available. On the other hand, other market players, such as aggregators, Energy Service Companies (ESCOs) or maybe retailers could offer full packages for setting up and consequently operating energy communities, diminishing the need for external consultants.

Finally, there is a risk that within the framework of the PARITY project no sufficient experience could be generated for providing these kinds of consultancy service.

4.4 Smart Grid Monitoring and Management

4.4.1 Market Analysis

During the projection year 2023, at the completion of PARITY project, the European smart grid distribution management segment is anticipated to expand at the fastest rate, with the greatest CAGR (Compound Annual Growth Rate) during the forecast period estimated at 9.100M€ by 2023. The following are the key aspects that are predicted to drive the smart grid market: a) modernization of grid infrastructure that is more than a decade old, b) digitalization, modernization and decarbonization of the energy system, and c) raising awareness of the need to limit one's carbon footprint [51]. Those drivers will necessarily engage more investment in the coming years to be able to cover with technology the challenges that the future smart grids represent [52].

The transformation of networks presents relevant challenges for operators in planning and operation of the network of the future and is a key for the trend developments. These issues need a bunch of technologies and systems that have been and will be rolled out in the smart grid. The first example is the smart meter, a first stone in the smart grid deployment, and from that, technology will be made more present in the distribution networks day by day.

In addition, the new investment that is arriving in the smart grid is made on components with shorter life and amortization periods. Digitalization assets have shorter functioning periods than cables or power transformers. It is expected that renovation of components will be more frequent thereto, leading to higher investments needs in the future. In what refers to PARITY project and flexibility, we find two main frameworks in which the components will be installed.

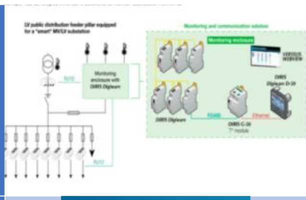
Firstly, and depending on the Distribution System Operators, we have the digitalization of the LV network through the deployment of technology in secondary substations. A huge market is opened here, as digitalization of LV is a well-accepted need in the European sphere. The main potential customers here are the European Distribution System (EDS), which represents up to 70% of European customers, four of them PARITY´s partners, as depicted in Figure 14.

Figure 14: Potential consumers

In Vlerick Business School's 2020 Outlook [53] on the European DSO Landscape, 65% of respondents believe that multi-futility is the future of DSO's business and 77% of respondents expect the level of investment in DSO's electricity business to increase substantially for the coming years. This explains why 94% consider asset management to be a core activity to generate value from their asset portfolio. Key asset management tools include asset databases (91%), total cost of ownership (88%) and asset management standards (82%). Also, it is important to include as other potential partners those that are distributed by its future investments on smart grids issues.

Therefore, for the digitalization of the LV network in secondary substations we can use low voltage remote terminal units whose prices, according to several providers, range from 180 to 400 €, depending on functionalities. The number of secondary substations in Spain is over 200.000 and in Europe over 2.000.000, so that the potential market is huge. Some of the relevant European devices for this remote terminal units are presented in Table 1.

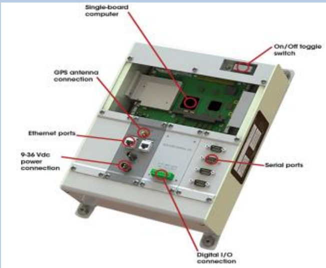
Table 1: European remote terminal units

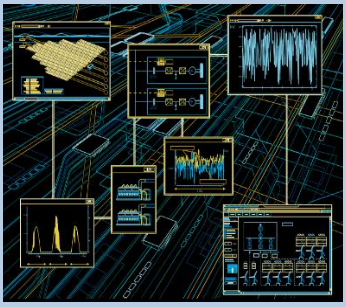
Socomec		**Low voltage monitoring in an MV/LV substation** **1. Monitoring of a 3-Phase + N transformer: to monitor transformer load and detect possible back f the MV network.** **2. Voltage monitoring: a single three-phase voltage tap enables a full analysis to be carried out.** **3. Monitoring of the 3-phase + N feeders: to monitor each live conductor of each feeder, including the n in real time. Imbalances between phases are detected and events analyzed.** **4. Monitoring temperatures: of the transformer (DGPT2 probe), inside and outside the substation.**
Emsni		Changes to the power demand caused by low energy lighting, heat pumps, electric vehicles, as well as sin three phase solar and wind generation connected at LV has led to a need to monitor the LV network to ass impact and to predict future changes. eMS has designed a specific instrument for logging the real and reactive power on each phase of each feed a substation, as well as the voltages, currents and relevant power quality (PQ) parameters like harmonics and The number of feeders is extensible, and the present limit is 12. The measurements are max, min and average every 10 minutes and there is an option to increase this to every 1 minute. The measurements are synchron the system clock.
Merytronic		Main functions: 1. Real-time communication with the electricity company. 2. Sending connectivity data to the electricity company's server. - Generation of XML reports on electrical magnitudes - Average and maximum values for V, I, P, Q - Incremental energy values P, Q, S 3. Changing alarm threshold settings on SBT cards. 4. Remote firmware/software updates for all equipment. 5. General configuration (IP address, FTP, alarms…).
4SLV ZIV AUTOMATION		4SLV is an advanced low voltage supervision solution to monitor LV fuse panels and outgoing feeders. Key features: 1.Head of the feeder LV supervisor meters (5CTIs) connected by RS485 bus. 2.Communication with up to 16 LV feeder supervision units. 3.Low voltage Distribution Transformer (DT) supervision function performed by an internal three-phase meter. 4.PRIME LINE DETECTION algorithm which gives an up to date LV circuit topology, mapping each end cu meter to the LV feeder and phase in which it is connected.
SABT CIRCUTOR		The system has 3 key components: R-SABT, T-SABT and CAP 1.R-SABT is the equipment responsible for collectingT-SABT line monitoring card data as well as measu of supply quality and ground leak detection. The equipment communicates with T-SABT cards through RS 2. T-SABT is the analyser that allows the three-phasemeasurement for voltage and current for each output order to send the data, via RS-485, to the advanced low voltage R-SABT. The device is directly installed base (CAP), located at the output of thegeneral low voltage switchgear. 3. CAP is the base that is installed at the output of the lowvoltage switchgear, which incorporates three l with individual current transformers, and a connectorfor voltage measurement. These signals are captured through the T-SABT card for the monitoring and calculation of electrical parameters

The second framework that exist are the micro-grids, located downstream the secondary substations. These kinds of schemes will become more common in the future scenario, as the connection of Electric Vehicle (EV) chargers, distributed generation at house or building level and other kind of assets will allow certain energy management capabilities at that level, and therefore, the possibility to provide flexibility services. There are substantial differences between the type of components and controllers needed at this level and the previously described Low Voltage Remote Terminal Units (LVRTU). LVRTU will be necessarily installed at secondary substations and therefore owned by the DSO, while micro-grids managers will be owned and installed by the owners of the micro-grid or final facility, which offers a much wider opportunity window. There are few solutions in the market and some of them can be seen in Table 2 below.

Table 2: Smart grid monitoring and management solutions

Company	Photo	Technical description
Schweitzer Engineering Laboratories		powerMAX for Mobile Microgrids is the only system that allows to upgrade existing assets incrementally and integrate dispersed generation and loads in stages without the need for large procurement budgets. Benefits of powerMAX: microgrid resiliency with no single point of failure; interoperability between diesel gensets, regardless of make, model, size, or type; distinct dispatch solutions for either optimal fuel use or maximum resiliency; low-inertia system control without system instability issues; plug-and-play configuration; compliance with MIL-STD-TMS. https://cdn.selinc.com/assets/Literature/Product%20Literature/Flyers/Microgrid%20Systems_PF00344.pdf?v=20180831-142630 https://cdn.selinc.com/assets/Literature/Product%20Literature/Flyers/Microgrid%20Economic%20Dispatch_PF00611.pdf?v=20191206-145253
Energy Box **CIRCE**		Energy Box is a solution for micro grid management. It is a multi-purpose concentrator for the operation in various scenarios of advanced electrical networks and Smart Grids. In addition to its versatile communication capabilities, it contains an embedded computer that provides computing and processing capacity to implement distributed computing: capture and storage information, execution of algorithms and control of the installation, among others. It has been designed with different physical communication interfaces: Ethernet, serial connectors, ZigBee and Wi-Fi. https://www.fcirce.es/en/
Opus One Solutions	opusone solutions	GridOS™ is a smart grid game-changer that deploys advanced power system analytics throughout the grid, from utility control room to substation to customer microgrid. It enables power engineering to emerge from utility planning environments into real-time operations and grid automation. **Benefits**: an electrical network model including a dynamically changing processor; Unbalanced three-phase AC power flow in real time; state estimate of feeder voltage profiles, line currents, and system losses; load and generation forecasts; dynamic volt-VAR optimization; online connection impact assessment of distributed generation; optimal scheduling and dispatch of energy storage devices; active demand response including electric vehicle charge management; microgrid management and energy transactions with the main grid.

		https://www.opusonesolutions.com/uncategorized/opus-one-launches-gridos-suite-ruggedapps-grid-intelligence-backbone/
Encorp		"Encorp's Egility is a modular and configurable microgrid control platform that enables the agile integration and control of multiple distributed energy resources". **Features**: a customizable and flexible approach for building and managing a smart grid; could provide disrupted competitive price power for critical loads with or without a conventional utility grid connection; maximise the use of renewable, power storage, and fossil generation set by the market; can be stabilized to sustain both cyber and physical risks, which is critical in high-security environments such as power grids, jails, and military bases. http://encorp.com/egility-control-platform/
S&C Electric		The GridMaster Microgrid Control System easily integrates and communicates with a host of different energy assets. The system is embedded with a military-grade cybersecurity protocol to mitigate the growing threat of cyberattacks and offers an intuitive user interface and the flexibility to scale as your needs change. Its main advantages are: it optimizes performance and maximizes resiliency; has a military-grade embedded cybersecurity with 7 security layers built into the system; it is user-friendly and scalable; the software and hardware system are built specifically for secure microgrid applications; its redundant architecture eliminates single points of failure. https://www.sandc.com/en/products--services/products/gridmaster-microgrid-control-system/
PowerSecure	PowerSecure	Microgrid 360 is a state-of-the-art microgrid campus that optimizes PowerSecure's vertically-integrated solutions and is itself an advanced microgrid, consisting of ultra-clean and modular Tier 4 Final engines, a solar array, fuel cells and battery energy storage system, all managed by the company's proprietary PowerControl platform. The system meets essential micro-grid requirements to: design and engineer all components of the microgrid including operational performance requirements; obtain the required regulatory approvals and permits; create the electrical interconnection between the utility and the consumer; produce integrated generation/resource systems, switchgear, and control systems Our systems are purposefully intended to operate together to create a completely integrated installation. 365 days a year, 24 hours a day, seven days a week, the system is monitored and serviced; optimize performance by stacking the value streams to improve the economics from the microgrid. https://powersecure.com/distributed-infrastructure/microgrid/
Emerson Electric		The Ovation™ compact controller, model OCC100, provides a robust automation solution with a smaller footprint for processes and equipment controlled by PLCs. The modular architecture of the controller allows it to be downscaled for independent, power-slide equipment or natively incorporated into a bigger, plant-wide Ovation distributed system. Built-in wide-area network capability, using cell or wireless communication technologies, helps power producers cost-effectively manage vital distributed assets. The compact controller, which combines the modular design and robustness of a PLC with the power and simplicity of incorporation of the Ovation control system, is a flexible automation platform for every power generating or

		water/wastewater business that requires control to be situated near the equipment. https://www.emerson.com/en-us/catalog/ovation-occ100-controller
CleanSpark	-Confidential-	Cleanspark can provide systems utilizing a variety of operating modes to meet a wide range of single or multiple generator applications. Single generator applications can operate in open or closed transition modes. Multiple generator applications can be in an isolated bus or utility paralleled modes. **Characteristics** of the Llow Voltage Switchgear: UL 1558 & 891, ANSI, NEMA & CSA; optional Service Entrance Rated and Labeled; front and rear accessible; LV circuit breakers: up to 6000A; 65 to 200 kA interrupting capacity: up to 10,000 a bus; NEMA 1 or NEMA 3R (Non Walk-in & Walk in). https://cleanspark.com/switchgear
ABB		The MGC600 is designed to manage and automate power generation systems that utilize different energy resources such as diesel, HFO, gas, geothermal, hydro, wind, solar, and tidal. It allows and preserves cost-effective and energy-efficient grid utilization of distributed and conventional generators. Both the electric grid operator and the ecosystem gain from maximizing the usage of renewable energy and optimizing the output of conventional power plants. The technology behind the controller consists of the IDC´ (Intelligent Distributed Controllers) hardware. The platform has the ability of enabling plant-independent control systems to be configured for interfacing to various manufacturers. The control systems have an in-house developed software architecture and support remote software upgrade in the field via Ethernet. Information for event analysis and long-term planning is recorded by using DataRecorders. Remote access to the control system is provided through a standard CISCO gateway/route. https://new.abb.com/Errors/FileNotFound.html?aspxerrorpath=/docs/default-source/ewea-doc/microgrid-controller-600_en_lr(dic2013).pdf
OATI	OATI	The OATI microgrid automated controller, OATI GridMind™, addresses the needs of commercial and industrial businesses looking for more stable energy prices by self-generating power. GridMind is a vital resource for both customers and utility-owned microgrids since it is an advanced microgrid controller capable of intelligently optimizing local distributed generation, providing load prioritisation, and providing ancillary services to the grid. GridMind arranges available sources of energy efficiently and orchestrates the execution of priority loads to guarantee microgrid's reliable and higher exchange rate. This microgrid technology also connects a number of DERs with a number of additional control layers in order to balance output and demand. The dependable microgrid control system may be tailored to optimize economic value, enhance dependability, and/or reduce environmental impact. When there is a grid interruption, it may be set to function in Grid Connected and islanded mode. GridMind may also introduce the microgrid to relevant energy markets as a VPP participating in grid services initiatives. https://www.oati.com/solution/smart-energy/microgrid-optimization

Eaton		Eaton's Microgrid Energy Systems help assure electrical energy surety independent of the utility grid availability or help provide demand/load management. To do this, different generating sources, such as generators, solar, wind, and energy storage, may be incorporated on a single grid framework, with essential loads smoothly islanded from or paralleled with the main grid. Eaton works closely with its customers on concept, scope, design and cost for design, development, implementation and maintenance of a microgrid energy system. Eaton can perform all necessary work as the turnkey provider for the project. Eaton's Microgrid Energy System **concept** includes: system optimization software; automaton and product services; LV load control; smart inverter suite; supporting electrics; smart MV grid-tie connection; utility automation products. https://www.eaton.com/Eaton/ProductsServices/Electrical/ProductsandServices/MicrogridEnergySystem/PCT_1549790#tabs-1
General Electric		The Grid IQ™ Microgrid Control System (MCS) enables distribution grid operators to integrate and optimize energy assets with the goal of lowering total energy costs for a local distribution system, often known as a "microgrid". **Benefits**: allows the integration of renewable energy resources with traditional fossil-fuelled generators; improves DER dispatch to decrease overall energy and microgrid operation costs; provides a safe and stable power supply for mission-critical loads in 'islanded' mode; maximizes the utilization of renewable assets for decreased GHG emissions and environmental effect. https://www.gegridsolutions.com/multilin/catalog/mcs.htm
Lockheed Martin		GridStar® Flow provides long-duration storage – with superior durability, flexibility and safety – backed by the engineering excellence of Lockheed Martin. Together with LM Energy's systems integration experience and intelligent control platform, GridStar Flow establishes the new standard in energy storage durability, flexibility and safety. GridStar Flow, a patented technology developed by LM Energy, employs designed electrolytes manufactured from planetary materials with features that enable reduced cost balance-of-plant parts, greater round-trip efficiency, and longer useful life than current flow battery solutions. **Applications**: Integration of large-scale renewables; deduction of generation & distribution assets; big manufacturing energy management; utility sustainability efforts and peak power; and support for smart grids https://www.lockheedmartin.com/en-us/capabilities/energy/energy-storage.html
Schneider Electric		Maximizes renewable energy use; Simple, robust and scalable. Centralized topology engine. Compatible with existing microgrid DER1 control solution (brownfield). Advanced cybersecurity features. Shorter commissioning time and cost. Easy operation and maintenance. Grid-connected energy optimization by adding EcoStruxure Microgrid Advisor (Schneider Electric EMS2). https://www.se.com/ww/en/product-range-presentation/65897-ecostruxure-microgrid-operation/

Siemens		High performance of the power supply system + excellent grid quality. Microgrids reliably meet the stringent requirements of autonomous grid operation. Simple optimization capabilities guarantee cost-effective operations. The integration of renewable energy meets the climate protection targets that promote CO2 reduction. Resource-conscious use protects the environment and minimizes costs. Functionalities: Blackout detection, black start, and automatic grid modes Automatic start of backup generators. Optimization of operating points. Reserve monitoring. Peak shaving. State-of-charge management https://new.siemens.com/global/en/products/energy/energy-automation-and-smart-grid/microgrid/sicam-microgrid-controller.html
CIEMAT	-confidential-	Set of measures to use loads and local generation to support network management/operation and improve power supply quality. https://www.futured.es/wp-content/uploads/2016/01/Scientific-technological-electricity-grid-capabilities-inventory-in-Spain.pdf

Moreover, smart grid management could act as the energy policy maker, supported by analysis tools. These individual devices make choices that optimize the site´s energy usage:

- Energy procurement-purchasing energy and negotiating delivery contracts.
- Managing energy consumption priorities for the non-critical facility loads such as Heating, Ventilation and Air Conditioning (HVAC) systems, fleet management of EV chargers, facility lighting control, etc.

The new opportunity is to optimize assets with assistance from the grid provider and a commercial aggregator to understand the various multigrid strategies that may be implemented:

- Utilize all practical and cost-effective means of local production (distributed energy resources) and optimize self-consumption.
- Improve energy flexibility through a commercial aggregator.
- Benefit from advanced smart grid control that manages DER flexibility and reduces energy bills through tariff management optimization.
- Smart grid management can prioritize investments and optimize energy efficiency (minimizing KWh consumed) and the KW price.

4.4.2 Current Threats and Challenges

Smart grid monitoring R & D and demonstration projects require large investment, and uncertainties related to the maturity of the technology, the regulatory framework and the evolving business models can negatively affect investment decisions. Global energy demand is closely linked to human progress as stated by the United Nation, which identifies the Human Development Index (HDI) increase in consumption due to human development and well-being. This is becoming more prominent in developing countries [54].

The three main threats and challenges for the deployment of smart grids monitoring and management technologies are:

- **Security:** Many of the technologies discussed above to support Smart Grid, such as smart meters, sensors, and advanced communications networks, can themselves increase the vulnerability of the grid to cyber-attacks. Accordingly, it is essential that Smart Grid deployment leverage the benefits of increased threat awareness while mitigating against heightened security concerns. It will be a difficult task, but one that can be addressed by being aware of the risks and leveraging security best practices from other industries. In conclusion, characteristics such as data protection, interoperability and cybersecurity are of major concern in the integration of smart grids monitoring [55].

- **Country's Characteristics & European context:** The overall level of activity of a country are its size, population and electricity consumption and the generally good state of the electricity grid, is key otherwise it caused by surges, spikes, or sags in supply can impact voltage and frequency; these can also cause stress and premature aging of distribution assets.
- Also, the level of digitalisation of the economy and the overall positive climate for innovation, would have suggested a higher number of smart grid projects. The interaction between the local/national regulatory authorities are indeed noteworthy for the favourable national or regulatory environment. In Europe, the smart grid market needs to comply with regulations from the European Environment Agency. Regulation establishes the price and remuneration of the investment in power networks, so to have an effective deployment of smart grids monitoring and management technologies, it is necessary to have the appropriate regulation coverage, so that the distribution system operators commit themselves to such investments.
- In a human sense, the most common threats encountered in smart grid monitoring are related with the consumer's trust in the adoption of these new technologies: acceptance from the consumer, the accuracy, privacy and health issues or potential threats.
- **Lack of Standardization:** Lack of technology standards has been considered as a major obstacle to smart grid deployment. A Smart Grid is a new integrated operational and conceptual model for utility operations. This requires it to both implement a system-wide installation of monitoring device and to maximally communicate with components. However, developing this kind of system will usually cost multi-years. Currently, smart grid monitoring is still an emerging concept and the technologies that there is misunderstanding amongst consumers, regulators, policymakers, what its costs and benefits are. Standardization is also key to achieve market competitiveness, as it makes it more difficult to have vendor locked solutions and the distribution companies can benefit from multiple vendors competing for individual projects. It also improves the level of functionalities and added value provided by each single asset, something really relevant when talking about smart grid [56].

All these factors add value to the examples detailed at this sub-section, which concludes:

- An important percentage of the smart grid monitoring devices already installed in Europe have a limited capacity for data storage and the telecommunications needs to be remodelled to meet the growing needs of customers [57].
- USA has the most LVRTU pilot installations already working, so it is expected that this country will collect and improve their developments faster than Europe or Asia. It can be explained because of the support of the US regulations, its government grants or its production incentives centralized by Federal Investment Tax Credits and State renewable Portfolio Standards.
- Nevertheless, the nations' scenarios have certain characteristics, such as continued economic development and a transition toward a lower emissions, but they differ in terms of policy, technology, and behavioural assumptions. For this purpose, COP conference and RE100, both global, are also supporting these practices to test new business models and practices and creating opportunities for other organizations to learn and grow worldwide.
- The industry also needs to harness the necessary technology and develop a regulatory and market structure necessary to access, monitor, control and manage smart grids. As Smart grid security, communications mature, the next developments for Smart Grid distribution management are emerging until being the most challenger by 2025 [58].

4.5 IoT and Smart Contracts Enabled Energy Transactions

4.5.1 Market Analysis

The Internet of Things (IoT) market was valued at USD 193.60 billion worldwide in 2019 and is expected to reach USD 657.31 billion by 2025, at a CAGR of 21% over the forecast period 2020 – 2025 [59], as shown in Figure 15.

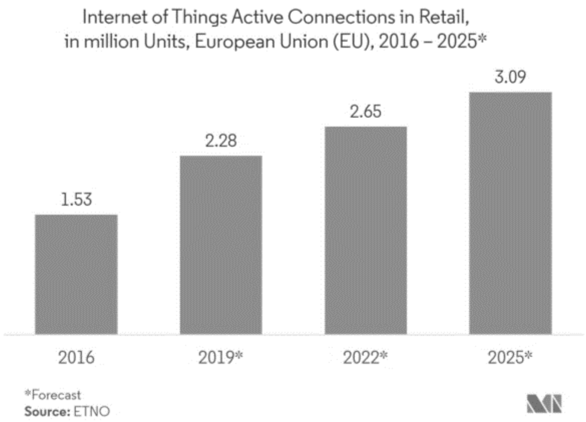


Figure 15: IoT active connections in retail, European Union 2016 -2025

The breakthrough will be boosted by the emergence of advanced data analytics, a reduction in the cost of connected devices, and overall, by the increase in cloud platform adoption.

The latest recent statistics on the global Infrastructure as a Service (IaaS) industry from the research and consultancy firm Gartner shows annual revenues of 32.4 billion USD. A 31.3% growth from 24.7 billion USD in 2017. Based on Gartner, five providers controlled over 80% of the global IaaS cloud market share in 2018. Amazon (47.8%), Microsoft (15.5%), Alibaba (7.7%), Google (4%), and IBM (1.8%) are among these providers [60]. The Internet of Things (IoT) technology industry is expanding rapidly as a result of the increasing usage of Artificial Intelligence (AI) and linked devices based on machine learning. The global AI market size was 20.67 billion USD in 2018 and it is projected to reach 202.57 billion by 2026, with a CAGR of 33.1% during the forecast period [61]. The IoT fast growing markets are in Asia and Australia, followed by North America and Europe, as visually depicted in Figure 16 [49].

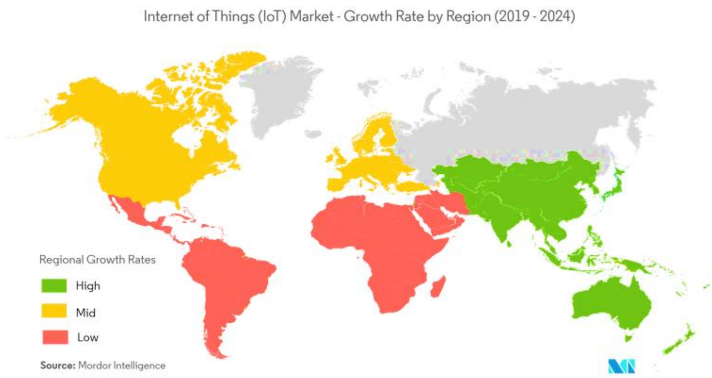


Figure 16: IoT market – growth rate by region 2019 – 2024

Additionally, Figure 17 presents the IoT main application are financial services and agriculture [62].

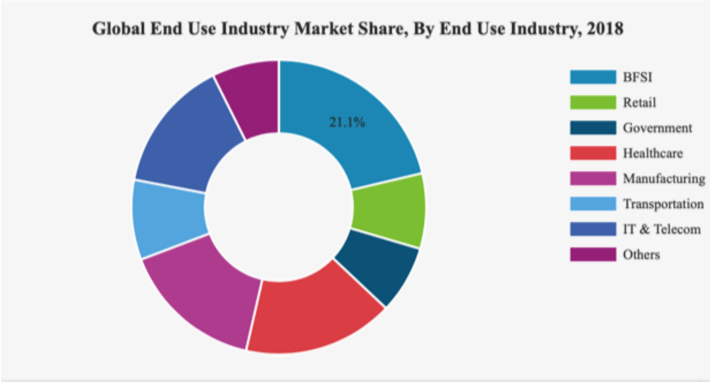


Figure 17: Global end use industry market share, 2018

Additionally, the global smart home market size was USD 79.90 billion in 2018 and is projected to reach USD 622.59 billion by 2026, exhibiting a CAGR of 29.3% during the forecast period, as indicated in Figure 18 [63].

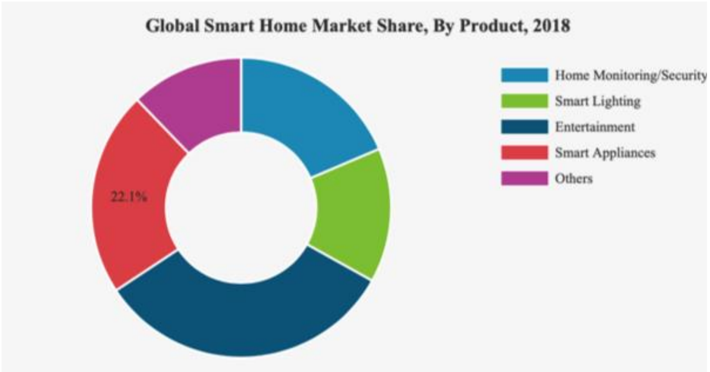


Figure 18: Global smart home market share by product, 2018

Also, the global IoT in utilities market size is expected to grow from USD 28.6 billion in 2019 to USD 53.8 billion by 2024, at a CAGR of 13.5% during the forecast period. The advent of IoT in utilities is expected to reduce challenges faced by the utility sector and help evolve it, as clearly stated in Figure 19 [64].

Figure 19: Opportunities in the IoT in Utilities market

The electric meter typically defines the ownership boundary between a DSO and the customer/prosumer. Several of the IoT applications for the utility industry are being powered by digitalization at the grid edge. While the Internet of Things (IoT) covers a wide range of hardware and software technologies, edge computing and analytics particularly are pushing the level of digitalisation in distribution networks.

There are numerous technological and business motivations for combining edge analytics with cloud technology, including:

- Edge computing and storage are becoming more affordable, paving the way for the creation of intelligent gadgets that are cyber secure by design and remotely accessible and managed. These novel field devices enable the processing of streaming data at the grid edge.
- Edge computing brings gateway communication closer to field sensors and controllers, allowing previously unattainable wired and wireless communications linkages to datasets.
- Transferring all field data to the cloud and analysing it there might result in high storage and computing expenses. More computational processes performed at the grid edge are an efficient approach to minimize cloud computing expenses.
- Edge computing decreases the latency of analytics. Round-trip latencies to the cloud might be unacceptable in some instances, such as terminating a local control loop on a detected anomaly.
- Identifying data cleaning, preparation, filtering, aggregation, desensitization, and analytics at the edge decreases data transit bandwidth needs to the cloud.
- Consolidating, encrypting, and/or anonymizing sensitive information at the grid edge can be a successful method for addressing data privacy and security concerns.
- When cloud connectivity is broken – either purposefully (e.g., by a cyberattack) or accidentally — edge computing delivers a new level of robustness (e.g., act of nature) [65].

Markets forecasts the Smart Electric Meter market is projected to reach USD 11.33 billion by 2023, from an estimated USD 9.06 billion in 2017, at a CAGR of 4.11%. In Figure 20, is clearly shown that the market is set to witness growth due to the increased need for efficient data monitoring systems coupled with favourable government policies [66].

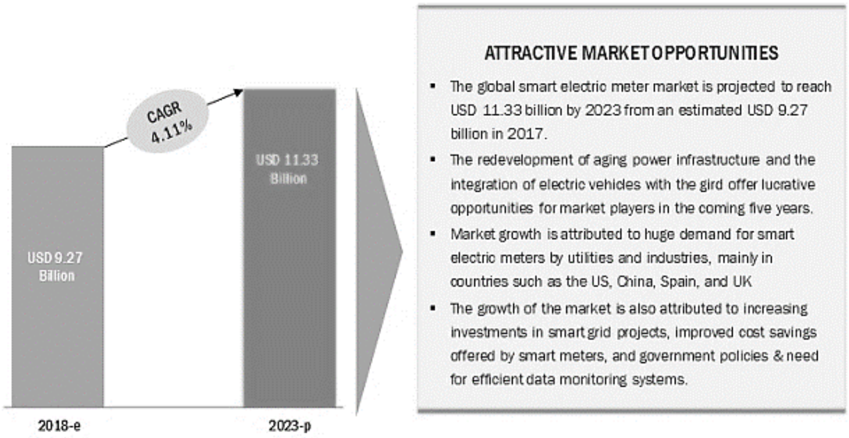


Figure 20: Opportunities in Smart Electric Meter market

Also, in Figure 21 the worldwide Edge Computing market is expected to expand at a CAGR of 26.55 from USD 2.8 billion in 2019 to USD 9.0 billion by 2024 [67].

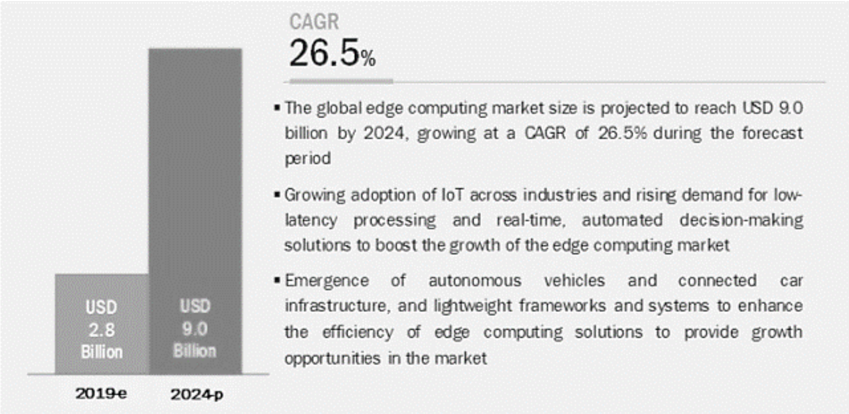


Figure 21: Opportunities in the Edge Computing market

The market for Smart Contracts is segmented on the basis of Blockchain platform, technology, end user and by region. Based on Blockchain platform, the segmentation is further divided into Bitcoin, Sidechains, NXT and Ethereum. Numerous consumers are represented in the industry, including banking, governments, management, supply chain, transportation, real estate and healthcare (Figure 22).

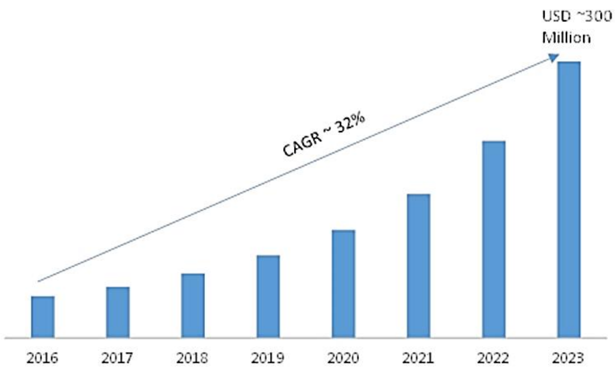


Figure 22: Global Smart Contracts Market, USD Million

The smart grid is being projected as a solution to potential energy supply problems with the convergence of the Internet of Things. However, protection and privacy problems in electricity data use and trading face significant challenges when implementing the smart grid. Even though smart contracts have the potential to spark a new wave of innovation in corporate operations, there are a number of obstacles to overcome. Specifically, the main challenges to the fully exploitation of these opportunities are related to the following:

- **The legal frame to ensure data privacy and property:** The legal frame assigns the data's property to the prosumer and it protects customers' privacy and therefore it is setting some limitations to the DSO, which is usually the meters owner and the data collector. In Switzerland data's download <15 min. has to be explicitly approved by the user (opt in) and like in the EU zone, the data cannot be used for commercial purposes or sold to third parties without the users' endorsement. The real issues to get a correct application of these rules are:
    - to correctly inform the user about his rights, the data's value, and the legal frame.
    - the Authority shall have full inspection's capacity for tacking any misuse.
    - the data set public has to be neutralized, so that no personal user's information can be delivered.

  If those activities are not correctly fulfilled, there exists a high risk of misuse and, as consequence, of long legal/judicial procedures, which may endanger digital penetration.

- **A fast-growing capacity on the broadband connection enabling data exchange:** To enable an LFM the data's download (i.e., from meters to either a centralized or edge computing unit) shall be continuous, reliable and economically sustainable. When considering the legal frame ensuring data privacy and property, it shall be clarified:
  - the most suitable transmission technology(ies) for matching the sustainability and privacy issues.
  - if the connection can be a dedicated one or not.
  - if those connections can be used for other purposes and the connected risks.
  - who is bearing the costs?
- **The differences in accessing tools and services (digital divide issue both socially and by location):** In the real world the "local community" is based on people with different ages, different cultural and technological background, different investment potentiality, different sensitivity. Similarly, the building's portfolio is marked by differences in age, domestic connection, electrical structure, available devices, etc. Dealing with such a patchwork when building up a "smart market" is not a "smooth sailing", it is time consuming and needs an accurate working scheme to meet a suitable (both technically and socially) compromise, where the market's incentives are not always playing a major role. The consequence is reflected into an implementation timetable, which may differ from area to area and which is therefore subject to a technological risk.
- **A coordination between the different users' layers:** Local smart communities are not, in most of the cases, stand alone. The connection with the regional, national, and international grid will stay in place and play an important role. Therefore, coordination among local, regional, and national layers has to be defined and established in order to ensure consistency across the whole system. The main risk resides in the differences among the grid layers in load profile, balancing needs, etc., which can lead to contradictory actions threatening the grid security and its efficiency (and the related costs). New strategies of coordination need to be set in place, probably changing the present hierarchy. Moreover, because of those issues and because the legal frame is trailing behind the technological and social evolution and the issues electricians have to deal with risk to remain floating in the future, the legislation shall provide (as the Swiss Government is doing) a "sand box" for allowing to check and test, in the reality, new option before being institutionalized.
- **The real maturity of the different components (for instance capability of the HES to fully process and deploy data in real time):** Power market is living a transition phase, therefore some commercial devices meant to support smart applications are not yet mature enough to meet business requirements or to perform as instructions are claiming.
- **Lack of full interoperability between components and risk of getting inefficient redundancies:** Communication standards among devices (of different producers) are still unavailable or not performing reliably. This is troubling the functionality of projects and, more important, slowing down the smart project penetration.
- **Absence of hierarchy among the different processes:** The same product deployed by DER (for instance flexibility or data) could, in theory, be applied by different use cases. The uncertainty about the main driver (or the main criteria for choosing among different uses) may lead to conflicts and troubles and consequently it could slow down smart projects penetration. It could also lead to an implementation managed by the State, which may not be the most efficient.
- **Risk of edge computing:** Edge computing processes analyses only a subset of data, discarding raw information and incomplete insights. Companies must consider what level of information loss is acceptable. Edge computing can increase attack vectors. With the addition of the IoT, network-connected devices, and built-in computers, the opportunities have increased for attacks and malicious hackers to infiltrate the devices and access sensitive data. Finally, edge computing requires more local hardware. For example, to transfer video information over the web, IoT cameras require a built-in computer, as well as a more complex computing process for more complicated process applications, such as motion-detection or facial-recognition algorithms.

4.6 DER Flexibility Profiling

4.6.1 Market Analysis

One of the main key objectives of the Energy Union strategy is a less carbon-intensive energy sector. As described in the introduction section, in order for the share of energy production from renewable sources to reach 32% by 2030, as is targeted by the European Union, the deployment of variable renewable energy generation technologies such as solar and wind power will have to continue increasing. Consequently, growing share of Renewable Energy Sources will increase the demand for flexibility. Flexible DER as energy storage, demand response and distributed generation can provide the desirable flexibility to the grid.

As the share of renewables rises, the electrification of the heating and cooling sector and the increase in EVs continues, the value of energy storage in flexibility provision is substantial. As a flexibility solution, energy storage systems can store excess energy during periods of high RES generation, for later use during peak hours. The deployment of Pumped Hydro Storage Systems (PHS) and Compressed Air Energy Storage (CAES) technologies varies within the EU members and the investment costs are significantly high [68]. However, due to its capacity PHS dominates electricity storage (representing 96 % of global storage capacity in mid-2017) [68-69].

Moreover, batteries are expected to have an important role in the clean energy transition. The investment costs are declining at a significant rate 400k€/MW [69] and unlike PHS and CAES, battery discharge time is typically a couple of hours, so their role can be particularly important in the provision of regulation services. They are extremely suitable for the frequency containment reserve (primary reserve) of balancing services and voltage control services, as both require a rapid response time.

Also, EVs can be considered as mobile energy storage due to their potential for storage and flexible demand. With technology improvements, growing investment in the field and decreasing prices of batteries, annual EV sales are projected to grow by 30 percent annually between 2020 and 2030, as depicted in Figure 23 [69]. They can bring additional flexibility to the grid by shifting charging to low demand periods, 'grid-to-vehicle' (G2V) operation or by discharging power from their battery during peak hours 'vehicle-to-grid' (V2G) operation [71].

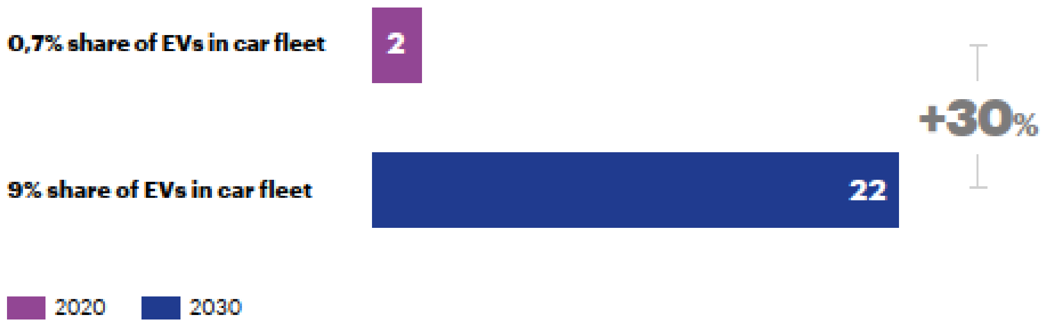


Figure 23: EU-28 EV fleet (millions)

Demand-response, or demand-side management, is the ability of the demand-side to modify its consumption responding to price signals or other incentives. It can be deployed in different sectors such as the industrial, residential and transport. In residential and transport demand-response provides the desired flexibility by delaying or shifting consumption (e.g., domestic hot water, electric vehicle battery charging, etc.), whereas in the industry sector, demand-response can also take the form of load shedding. In many countries industrial consumers are already offering flexibility to the system operators. Figure 24 depicts the demand response potentials in the European countries, based on the report of the European Commission about Mainstreaming RES [69].

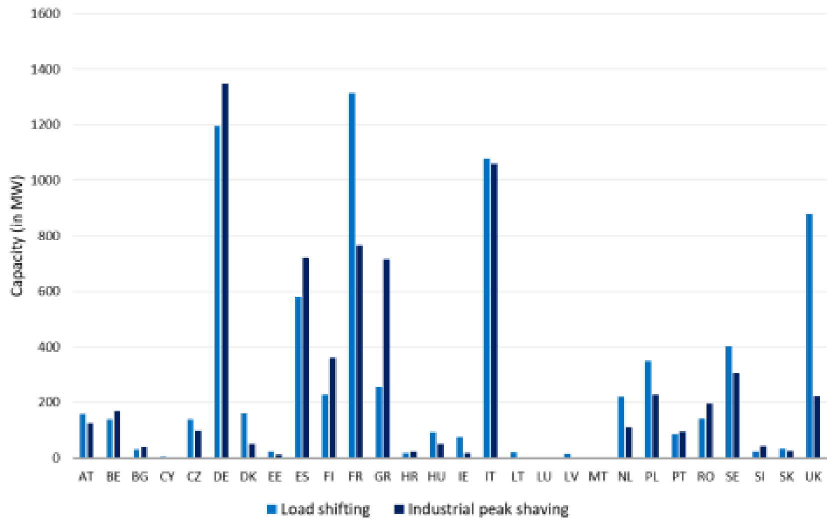


Figure 24: Demand-response potentials in the EU

Distributed generation units such as variable RES, biogas power plants or CHP can provide additional flexibility to the grid. The role of Combined Heat and Power (CHP), which captures heat from electricity generation to heat buildings and industrial processes, is expected to grow [70] in 2017 the electrical and heat capacity of CHP units in Europe was 117,5 GW and 278,3 GW respectively [71]. High penetration of RES may require a limited amount of curtailment as a source of flexibility. Although flexibility market research focuses mainly on power solutions (e.g., batteries and curtailment), new cases are currently investigated based on gas solutions. Recently smart gas solutions like micro-CHP, hybrid systems or fuel cells are proposed as flexibility services providers: micro or mini-CHP solutions can provide local flexibility services, hybrid solutions allow a trade-off between gas and power consumption depending on technical or price signals [71].

The Power to Gas (P2G) technology provides an innovative solution by transforming surplus supplies of electricity from wind and solar sources into Synthesized Gas (SNG), that can be injected into the natural gas network [71].

Europe's electricity distribution system is facing a significant transformation in order to reach the decarbonisation targets set in the EU Climate and Energy Package (CEP). In the scope of the EU's directives Member States are already in the process of developing Integrated National Energy and Climate Plans (NECPs) for the period 2021 to 2030 and long-term strategies (2050 long-term strategy) [72]. Most of them have already submitted the final version of their NECPs which are available in European Commission's website [73]. EC provided essential guidance and assistance to the EU member in order to set national objectives with regards to flexibility, to report on measures to increase the flexibility of their energy systems and achieve optimal use of DER flexibility in the future [69]. The growing interest from the European energy sector indicates the significant role of flexibility provided by DERs in the energy transition.

4.6.2 Current Threats and Challenges

In order to analyse DER flexibilities and assess their optimized integration into the electricity system, various challenges are faced. An increasing share of variable RES such as PV and wind power, challenges the way of planning and operating electricity networks. The difficulty to forecast generation patterns, both in short- and long-term, requires other DER flexibility assets to "ramp up or down sufficiently quickly so as to maintain supply and demand at all time" [87].

It is suggested to perform a whole system analysis, including the characteristics of each flexibility solution on at least hourly resolution with modelling horizons up to annual levels. Therefore, local requirements such as annual climate data, variations in generation and consumption, characteristics of the local energy system and RES deployment need to be considered in order to create an optimized portfolio of flexibilities. Incorporating all these aspects, the flexibility challenge cannot be met by a “one-size-fits-all” solution [88].

The importance of a clear definition and differentiation of flexibilities also is examined in [89]. Split into four categories, “flexibility needs are considered from over-all system perspectives (stability, frequency and energy supply) and from more local perspectives (transfer capacities, voltage and power quality)”. Based on that, flexibility resources with their specific technical advantages and constraints can be identified and selected to serve a distinct purpose.

Similarly, [90] refers to the impacts of solar and wind variability and uncertainty. A wide range of flexibility needs to be available and accessible to ensure the system’s short- and long-term stability. Addressing distribution and transmission system planning to cope with long distances between generation and load, the “planning for flexibility within a dynamic environment” is identified as “key to successfully transforming the power sector”. Thus, the power system is considered as being flexible itself, able “to respond to both expected and unexpected changes in demand and supply”.

A growing share of RES (and in a wider perspective also battery solutions) connected to the electrical grid via power electronics and displacement of synchronous generators in parallel, is inherently connected with a loss of inertia. Inertial response can be generated synthetically (synthetic inertia, synchronverters), therefore inverter-based RES requires stimuli for further improvement. On the other hand, curtailment of RES affecting their economic attractiveness and system benefits, could be a consequence of not doing so [73-75].

Study presented in [71] attributes a key role to the DSO in Europe’s energy transition. To cope with an increasing proliferation of flexible units, it is suggested the DSOs have “access to flexibility for their own use”. To locally manage the grid by integrating storage capacity in a congested area, this might have a huge impact on a level playing field between all stakeholders, posing a threat to potential prosumers. A stronger cooperation between TSOs and DSOs will be needed to guarantee the current level of security of supply.

Nonetheless it needs to be considered, that services delivered by a flexibility (i.e., providing reserves to the TSO) may pass the distribution grid. Bottlenecks on the distribution system could prevent this delivery which is why pooling of flexibilities at different locations seems appropriate. Detailed flexibility profiles and their planned usage, available to the DSO, would however ensure that market schedules are not in conflict with network operations. A common marketplace for flexibility should be further explored as an option that would allow to coordinate the actions of all involved agents, by enabling well-structured and organized exchange of data between all relevant parties, especially TSO(s) and DSO(s) [76]. Further aspects about the conflict of ownership and operation of storage devices and its imminent connection to unbundling can be found in [77]. In addition, effective demand response depends on a structured co-ordination of loads of various sizes and characteristics [71].

A mix of flexibility sources in terms of response/reaction time, duration, up and down regulation (ramping), can prevent flexibility gaps originating from both, the supply and demand side. Hopes rest also on advances in low-cost technology, IoT and artificial intelligence, exploiting flexibility potential by expanding it to a variety of equipment and efficiently managing a large portfolio of devices.

If energy is business-critical, predetermined flexibility schemes must be set in place to avoid conflicts with operating processes. To unlock additional flexibility capacity, standards for interoperability and smart energy management technologies represent a relevant criterion [78-80].

The number and size of potentially connected flexibility assets differs a lot between the distribution and transmission grid. To communicate with and coordinate these flexibilities, proper infrastructure needs to be set in place. Smart meters, bidirectional communication and remote control offer possibilities for integration and utilization.

With regard to loads, only small shares of consumption can actually be shifted in time. Storage technologies have restricted capabilities as for example batteries suffer from low full cycle efficiency and a limited number of cycles while power-to-gas facilities operate with a low full cycle efficiency of less than 40% [81].

When investigating “interactions between stakeholders and the technical and economic potential of local flexibilities”, the h2020-project Interflex [82] highlighted complementary aspects.

Availability and reliability of flexibilities need to be sufficiently predictable. At the same time, access and aggregation of accurate data for flexibility management must respect all data privacy rules.

During the demonstration phase, difficulties to ensure efficient allocation of flexibility when residential loads were activated directly by the DSO, were identified. Another challenge refers to direct control mechanisms, which require “a full commitment from the regulator and industry to accept” new standards. Considering P2H involving heat pumps, district heating represents strong cross-energy carrier synergies. However, urban thermal networks are not equally widespread across Europe yet.

Implementing stationary battery applications, the time response of power electronics as well as power and energy characteristics to match business-related battery services, led to complex and expensive solutions.

Finally, the so-called rebound effect can be found when investigating the influence of thermostatically controlled loads on the electrical grid, causing peak shifting and unwanted power oscillations accompanied by an increased energy consumption when recovering to their normal operation after activation [83-85]. In terms of energy efficiency [86], improper utilization of flexibility assets may lead to an increase in energy consumption.

5. Market Penetration

From the analysis presented in the previous sections, it is evident that there is a significant change in the energy market, resulting from a mix of evolving regulations, technologies and customer behaviour. Thus, we are moving towards a new way in which we view, generate and use energy. Thus, a survey was conducted in order to penetrate the market. Market penetration is defined as the process of introducing a new product into an established market when existing or comparable items already exist and capturing market share from competitors. [98].

5.1 Data Collection: Survey with PARITY experts

In this section, the survey performed with stakeholders and end-users is described. The survey tried to explore the overall patterns that will form the energy market transformation and the consumer's perspective. The survey aims to evaluate participants' opinions on the concepts of LEM and LFM, to identify factors and barriers to the progress of local renewable energy development based on the participants' knowledge and what would motivate people to participate in such markets. Additionally, the goal of this survey is to analyse the current market needs, as well as investigate what is driving the energy markets transformation and where it is leading the energy market transformation survey highlights are presented in Figure 25.

The survey was primarily distributed to the PARITY project experts (DSO, Aggregators, Retailers etc). Afterwards, our target group was mixed, including both the PARITY energy experts, as well as experts outside the PARITY project, with a very strong/strong understanding of emerging technologies. The questions that have been distributed to all the stakeholders of this research have been introduced at the end of this report found at Appendix 1 – Questionnaire Questions. The results of this report are based on analysing the data collected from the respondents considering the specific questions. The questionnaire was divided into four sections: (a) Demographics, (b) Energy transformation insights, (c) Market Change and (d) Market Segments.

- **Demographics:** The first section of the survey is related to the audience demographic characteristics. Demographic data enables us to better comprehend particular backgrounds, such as their age, gender, country of residence, education, their knowledge level in emerging technologies in the energy sector and if they are professionally involved in them. By asking such demographic questions in our survey, we gather information about current and potential customers and in turn, help us design a market segmentation strategy to reach the right clients.
- **Energy transformation insights:** The second section aims to explore the overall patterns that will form the energy market transformation,
- **Market Change:** The third section aims to explore participants' experience on LEM and LFM so far, identify factors that might determine who is probable or unlikely to be interested in offering flexibility, electricity or other resources in the local

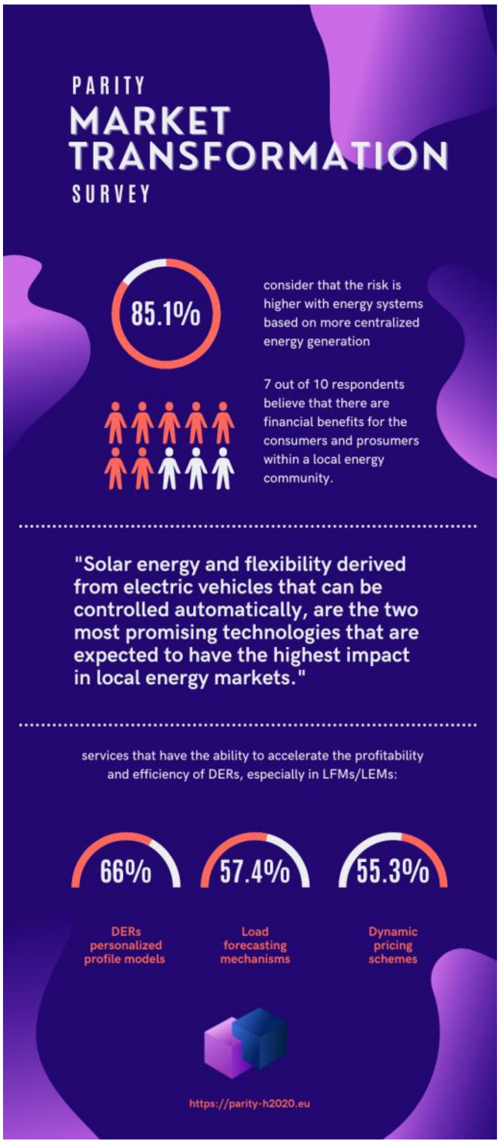


Figure 25: Survey highlights

energy market and what would motivate people to participate in such markets.
- **Market Segments:** Finally, the last part of the questionnaire is dedicated to market segmentation related questions, aiming to gain insights on energy market tools and services and identify market segments and trends.

Moreover, the survey was conducted in two phases. During the first phase, apart from the responses to the questions we also received from several participants a set of recommendations and clarification remarks. Thus, we updated the questionnaire based on the feedback received directly from the participants and distributed again during the second phase, in order to enhance our outcomes and enrich the information received already.

The survey was administered to participants within the European countries during the period October 2020 – January 2021. The total responses are 50 and their distribution is the following: Spain (16 responses), Greece (12 responses), Switzerland (10 responses), Cyprus (3 responses), Austria (2 responses), Germany (1 response), Sweden (1 response) and 5 responses where the country is undefined.

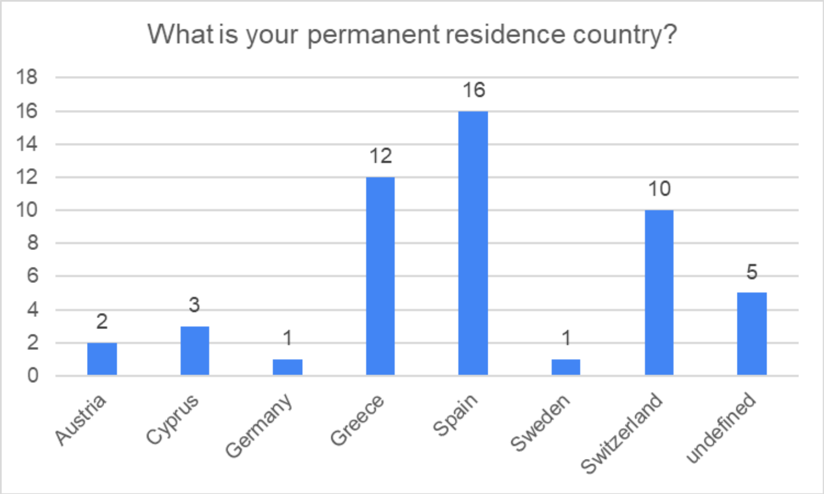


Figure 26: Market survey - Permanent residence country

5.2 Data Analysis: Survey results

The main results related to the energy market transformation and the customers' perspective elaborated from the questionnaire, are presented below. Initially, the background knowledge (i.e., demographics) and the familiarity of respondents with the local energy market technologies analysed. Then, energy market transformation insights, as provided in the answers of the respondents, are shown. It is notable in this questionnaire, that most of the respondents in this survey are coming from the Spanish and Greek market area and it should be remembered that the results reflect quite strongly the vision of the actors in those countries, as presented in Figure 26.

5.2.1 Background Knowledge

This section provides a review of the data collected from the respondents. There are analyses relating to the background of the respondents. The background of the respondents directly influences the outcomes of this type of survey, and thus the division between different types of background should be as flexible as possible.

There are totally 47 respondents, which have answered the part of the questionnaire that is dealing with demographics. Figure 27 depicts the age range of survey respondents. Adults between the ages of 30 and 39 are over-represented in this survey sample, young adults ages 18-24 are under-represented, while older people above the age of 60 are not represented at all. The gender of the responders is depicted in Figure 28 and the majority of them male.

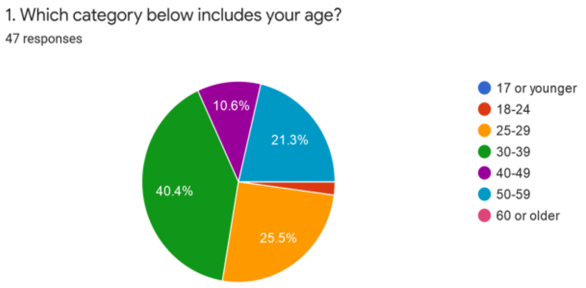


Figure 27: Market survey – Aging demographics

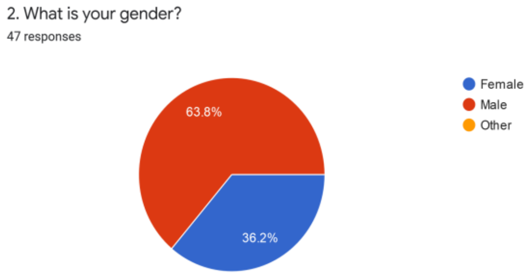


Figure 28: Market survey – Gender demographics

The education background of the respondents can be seen from Figure 29. The majority of the participants hold a Master's degree (55,3 percent), while an important part holds a Doctorate degree (29,8 percent).

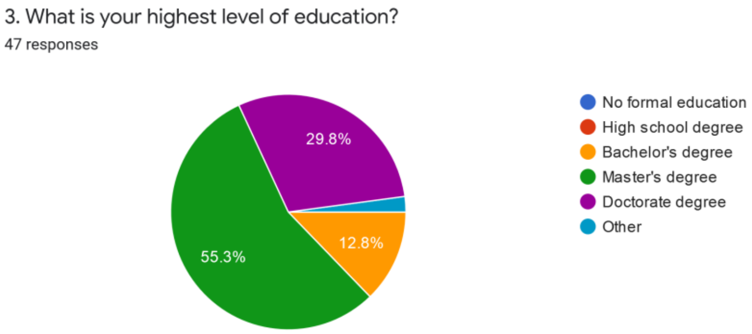


Figure 29: Market survey – Education demographics

An important parameter of the current survey is that most of the respondents have knowledge/experience in emerging technologies in the energy sector, such as renewable energy, microgrids, smart meters, blockchain and energy storage (Figure 30). Specifically, the majority of the respondents (51,1%) has a very strong understanding of such technologies, while only 6,4% of the respondents have heard of them, but not really understand what they are or their benefits.

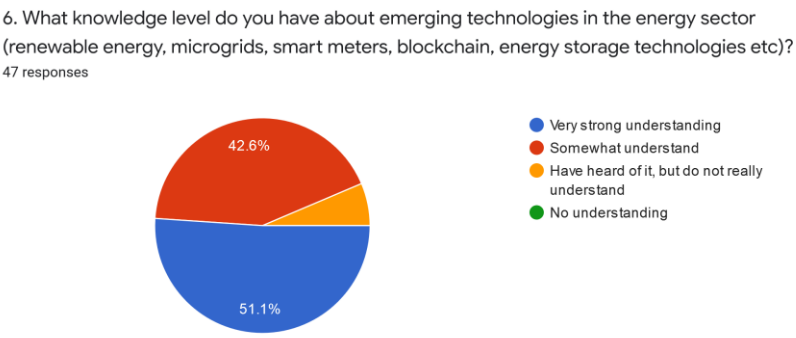


Figure 30: Market survey – Experience in emerging technologies

Regarding the awareness and understanding of emerging technologies, data shows (Figure 31) that national average scores are similar in the different countries, with Spain and Greece lying above the overall mean and Germany and Sweden positioned below.

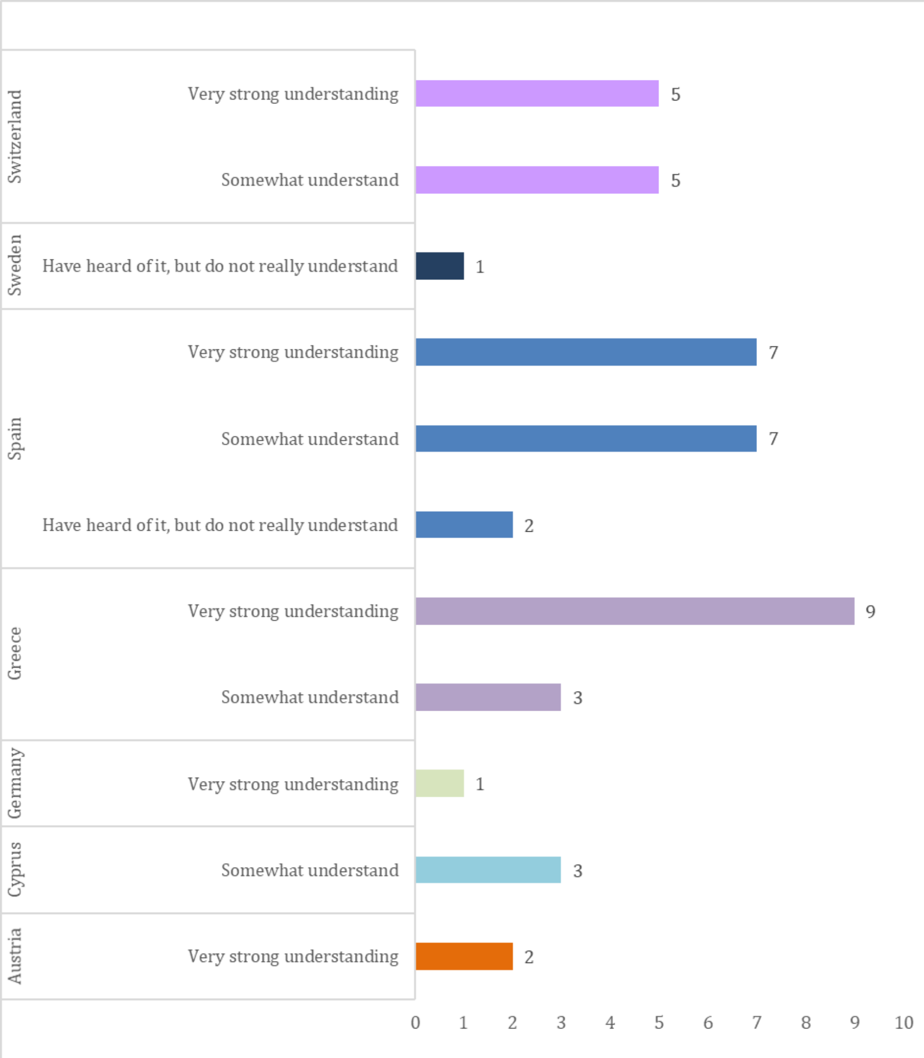


Figure 31: Market survey – Emerging technologies awareness per country

5.2.2 Energy transformation insights

This section provides a review related to the energy transformation the energy market is currently facing. The main focus of this section is to measure the awareness regarding energy market transformation.

Regarding the awareness of the final energy origin, data shows that the majority of the respondents know from where their final energy consumption is coming from, while a small percentage (8,5%) are not aware. As Figure 32 shows most energy consumption is coming from residual mix (59,6%), pure renewable energy sources are coming next with 17%, energy coming from power stations burning fossil fuels represent the 14,9% of the responses, while none of the respondents consumes energy coming exclusively from nuclear sources.

An interesting aspect regarding the origin of the energy consumed nowadays is depicted also in Figure 33, where it is evident how each country mostly consumes energy. At this stage, the authors of this deliverable would like to disclaim that the answers received through the conducted survey are not representative for the involved countries. Additionally, the authors would like to highlight that in order to reach such conclusions we would need the real generation data coming from different countries. From the data coming from the conducted survey, we can say that Sweden, Switzerland, Austria, Germany and Cyprus are moving rapidly towards greener energy consumption since all of the energy consumed is coming either from residual mix or from pure renewable energy sources. On the other hand, Spain and Greece are still consuming some amount of energy coming from power stations burning fossil fuels, although the majority of the respondents coming from those countries state that their electricity is coming from residual mix.

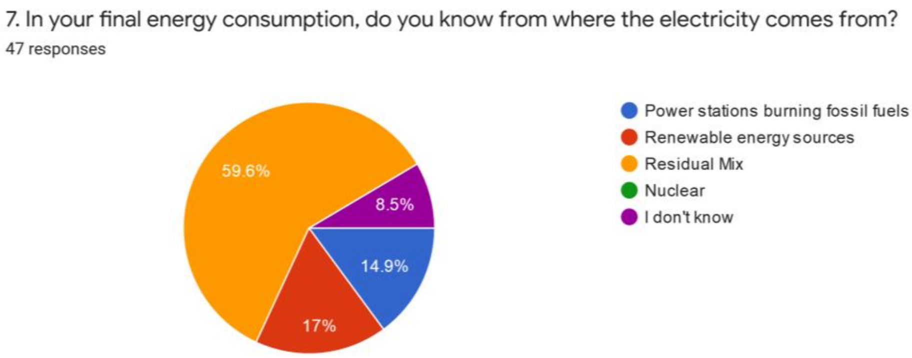


Figure 32: Market survey – Main source of energy consumption

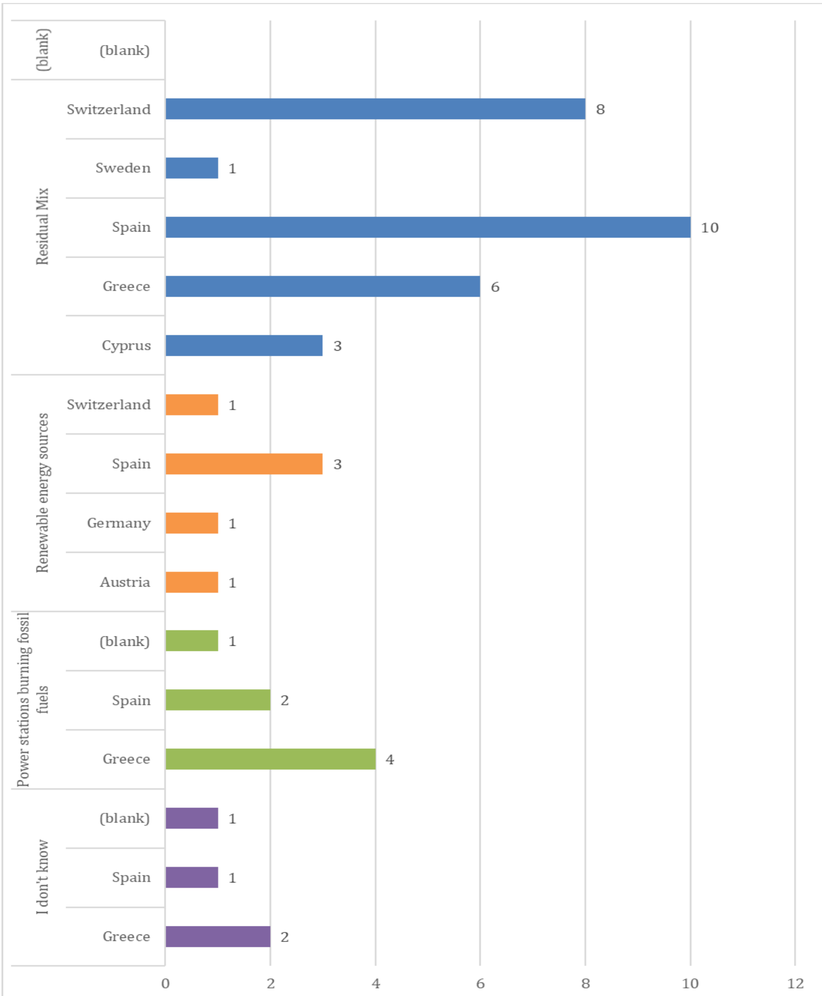


Figure 33: Market survey – Main source of energy consumption per country

Additionally, in relation to their energy bill most respondents state that they are satisfied in terms of costs (51,1%), as depicted in Figure 34. A significant percentage though does not find its current energy bill reasonable (33,3%), while an important part of the respondents does not have a clear opinion in terms of the financial aspects (15,6%). It is worth mentioning though, that as shown in Figure 35, that the majority of people consuming energy from residual mix are feeling satisfied with their energy bill, while none of them find it reasonable when it comes to energy coming from power stations that are burning fossil foils.

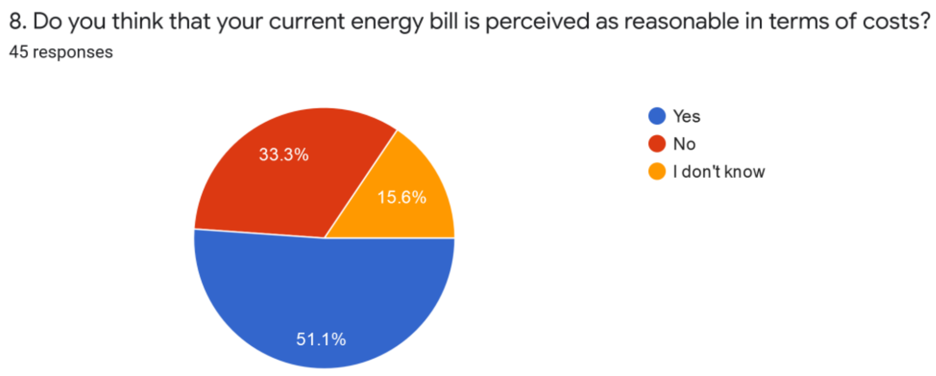


Figure 34: Market survey – Perception of energy bill pricing

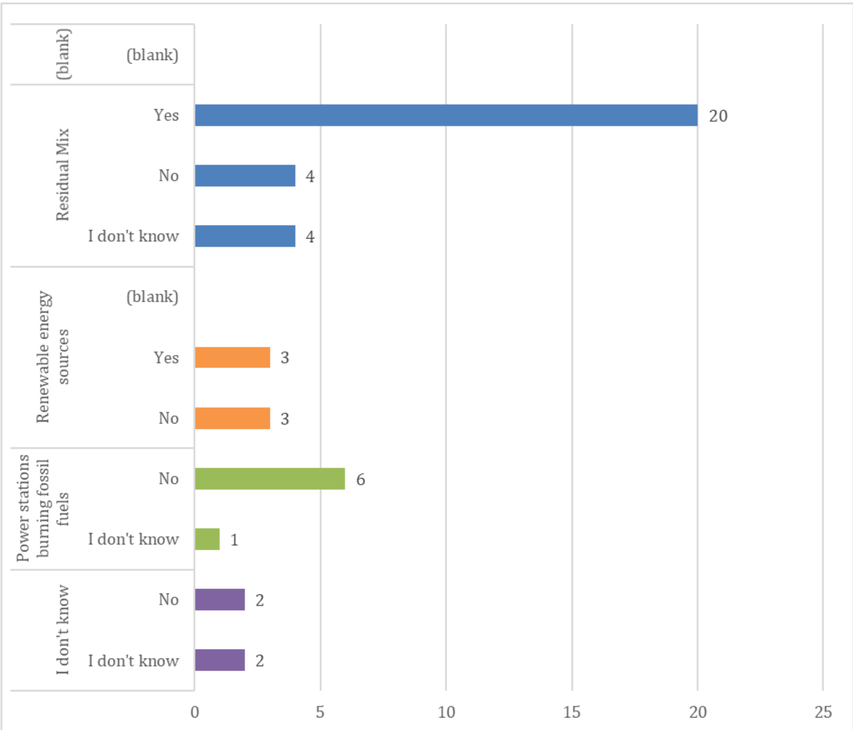


Figure 35: Market survey – Perception of energy bill pricing per country

The large majority of the sample (85,1%) consider that the risk is higher with energy systems based on more centralized energy 'generation', compared with the 8,5% of the total sample which thinks is lower and the 4,3% which thinks is the same, as depicted in Figure 36.

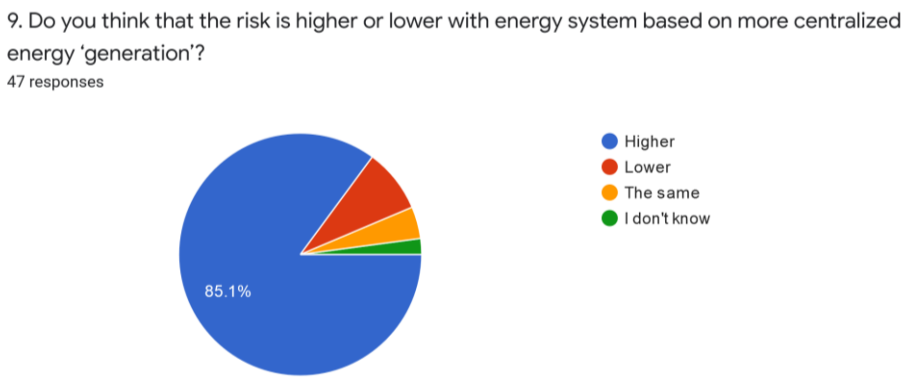


Figure 36: Market survey – Risk in centralized and decentralized energy generation

Trying to identify why the majority of the sample think the risk is higher, we tried to categorize possible risks electricity markets based on more centralized generation are facing. Most of the respondents state that the highest risk in more centralized energy markets are the emissions and/or the air pollution. The second risk in line is identified as medium by the majority of the respondents and is related to the energy availability and supply risk of the centralized markets, while also cyberattack, bulk generation of energy and the risk of unjust pricing schemes are considered as medium risks as well (Figure 37).

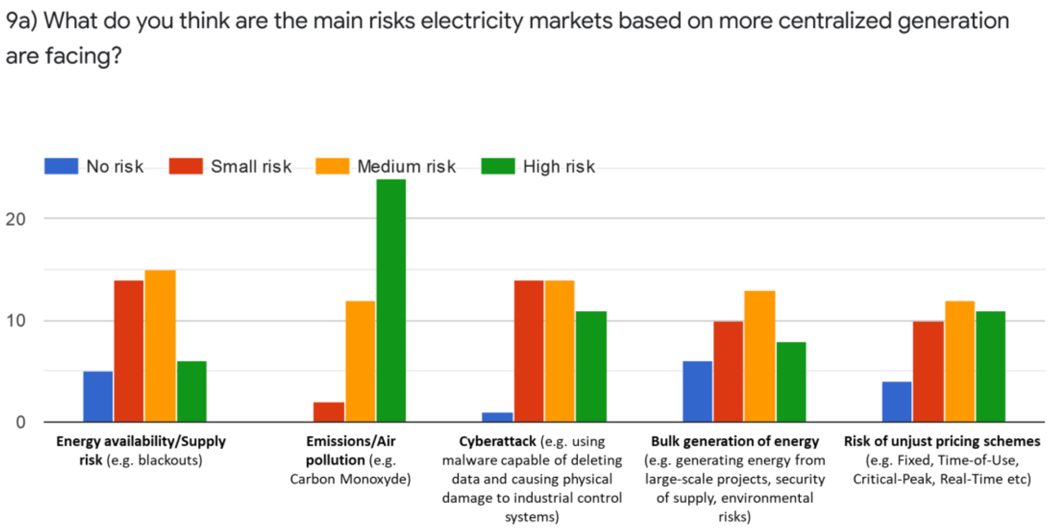


Figure 37: Market survey – Main risks of centralized energy generation

Regardless their belief related to the risk of the more centralized energy markets, the respondents were asked in how many years they anticipate the energy market to be mostly based on DERs such as photovoltaics and electric vehicles. The response was distributed almost equally, making it difficult to extract a clear prediction, as shown in Figure 38. A slightly higher percentage believes that by the end of 2035 the energy market will be based mostly on DERs, although there were some comments from the respondents (5 out of 47 responses) stating that they anticipate it later (2050 onwards) or never. Additionally, as also stated by one participant, DERs (especially EVs) will be widely applied by 2025, but in a rural area, centralised power plants (e.g., hydro, gas) will still play a significant role in electricity production.

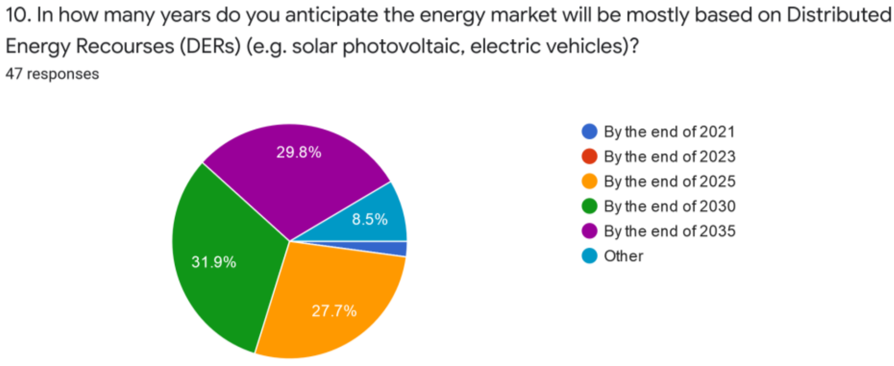


Figure 38: Market survey – Adoption of DERs anticipation

Based on the respondents the aforementioned anticipation is due to the fact that EU and national regulations and legislations are considered as the obstacles having the highest impact in the fast adoption of LFMs, as shown in Figure 39. Insufficient technological design, lack of standardization as well as lack of interoperability between equipment and stakeholders are obstacles that are also having a medium impact as highlighted by most of the respondents. Moreover, the attitude of the market's stakeholders is also considered to play a key role in the adoption of such markets.

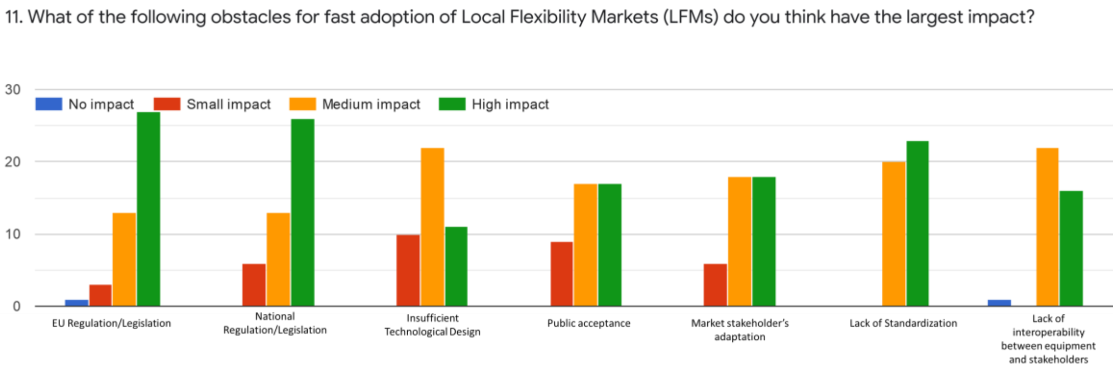


Figure 39: Market survey – Impact of obstacles in the fast adoption of LFMs

Question 12 links directly from the previous question with regards to resources (i.e., funding/monetary incentives, information material, regulatory incentives) available to promote the development of renewable energy in the respondents' country, particularly for small renewable energy producers and citizens. In the online survey 76,6% said that they are available resources in their country, 17% said that they are not, while a further 6,4% does not have the knowledge to answer, as depicted in Figure 40 and 41.

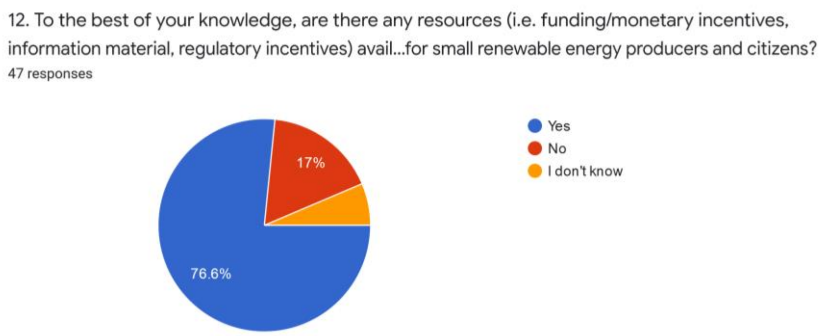


Figure 40: Market survey – Available informative resources

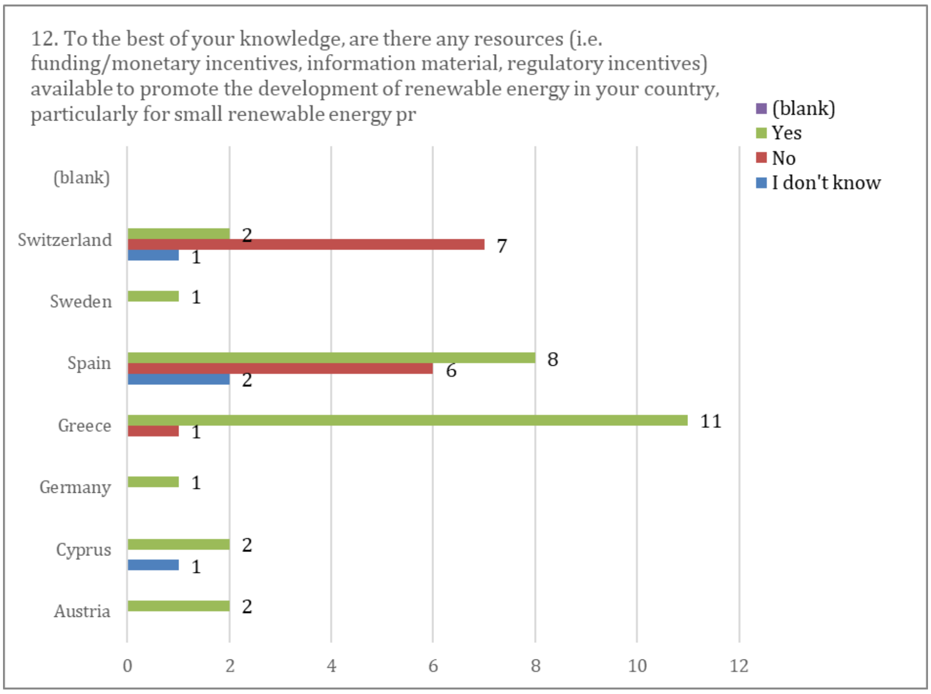


Figure 41: Market survey – Available informative resources per country

Additionally, to the available resources, in the online survey 59,6% said that they are feed-in tariffs in their country, to accelerate investment in renewable energy technologies by offering long-term contracts to renewable energy producers, with the majority of them being present in Greece and Spain. Although, there are countries that do not provide such policy mechanisms, considering the 31,9% of the respondents who answered "No". The majority of them are coming for Switzerland, as shown in Figure 42 and 43.

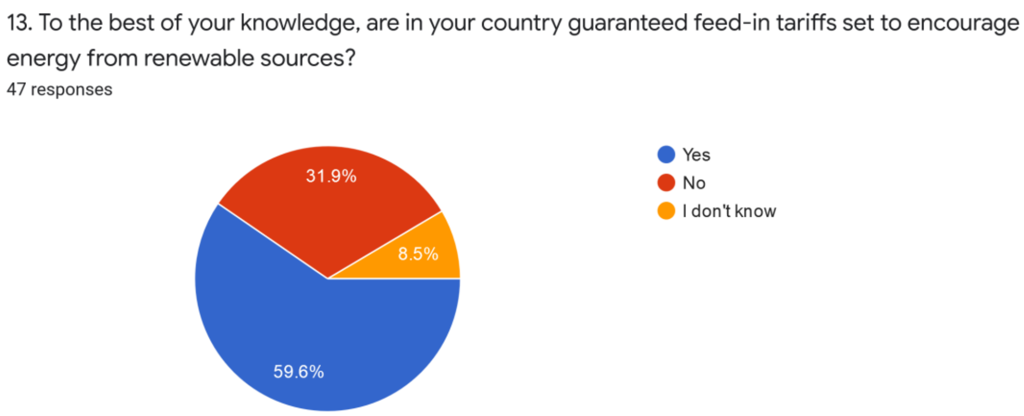


Figure 42: Market survey – Feed-in tariffs for encouragement

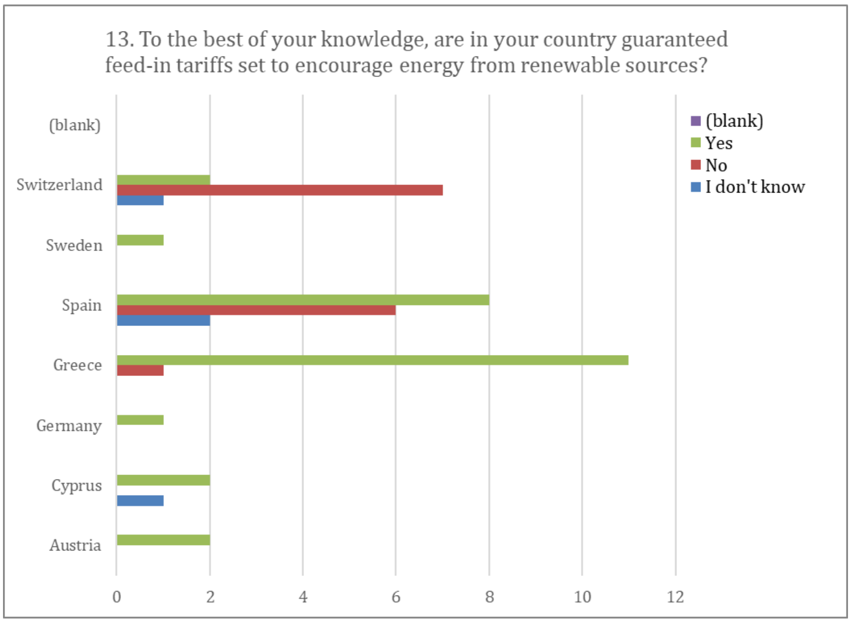


Figure 43: Market survey – Feed-in tariffs for encouragement per country

5.2.3 Market Change

Moving on to the next section of the survey, it is becoming evident that a number of changes have taken place within the global energy market. Thus, this section provides a review related to the energy market change, evaluating the participants' opinions on the concept of LEM and LFM, and focusing on what would motivate people to participate in such markets.

Since local energy communities are entering the hype, the adoption of peer-to-peer (P2P) electricity trading will turn individual consumers from passive to active managers of their networks. Such a marketplace can relieve constraints on the growing system and offer an alternative to costly grid reinforcements. The above statement is proved also through the survey, considering that 70,2% of the respondents believe that there are financial benefits for the consumers and prosumers within a local energy community (Figure 44). Additionally, a 66,6% percentage thinks that there are attractive business opportunities for new stakeholders, while another 66,6% find it reasonable to participate in such markets due to the increased investment in renewables (e.g., PV) and other DERs (heat pumps, battery storage, EV etc.).

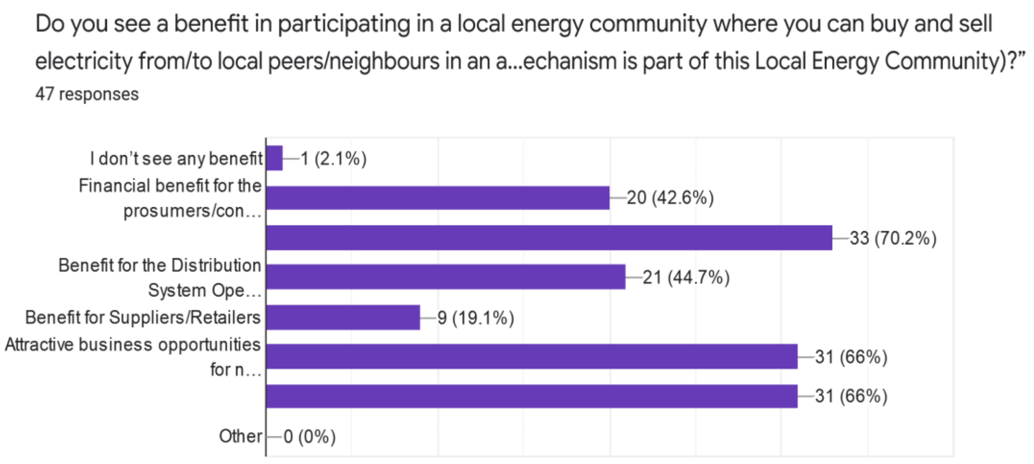


Figure 44: Market survey – Participation in local energy community benefits

As most of the respondents agree that there is a significant financial benefit for the prosumers, it was necessary to investigate in how many years it is anticipated to have some sort of flexible energy assets established in new or existing households. 54,3% of the sample stated that most new buildings will have some sort of flexible assets established, 23,9% believes that most buildings (new or existing) will have some flexible assets, while only 8,7% thinks that all buildings will provide such capabilities (Figure 45). The above statements are relevant to all countries that participated in the survey, with Spain taking the lead in the belief that most new buildings will provide such capabilities in 5 to 10 years from now. Although, a significant 13% coming primarily from Sweden and Greece, and secondary from Spain thinks that only a few buildings will have some sort of flexible energy assets (Figure 46).

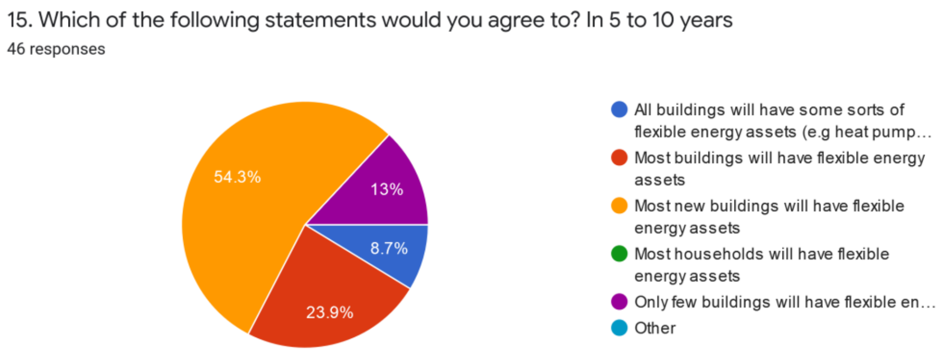


Figure 45: Market survey – Adoption of flexible energy assets within households

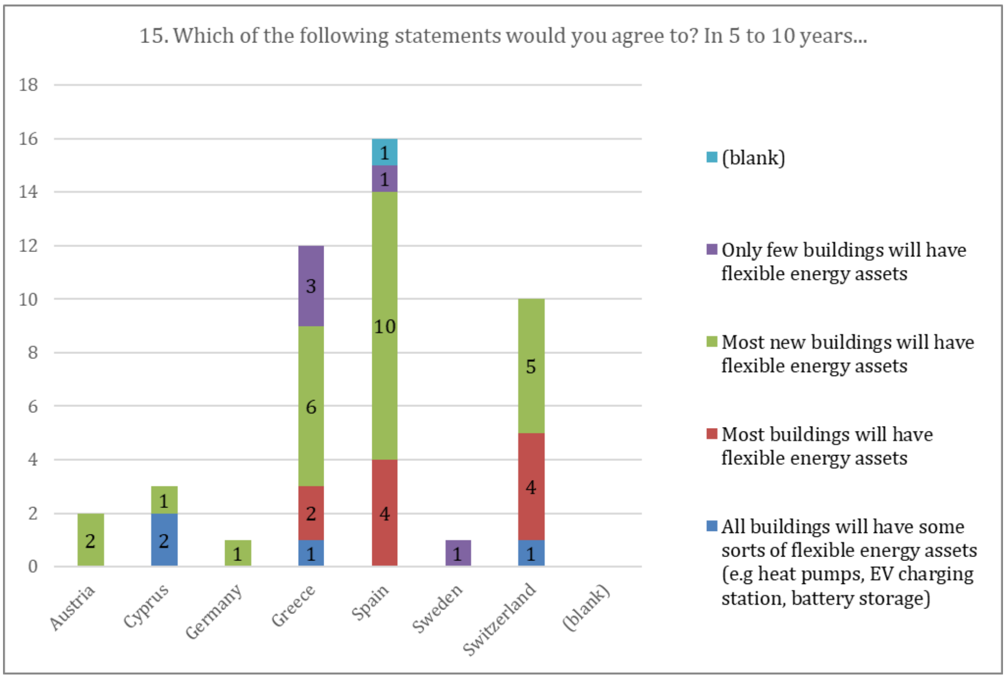


Figure 46: Market survey – Adoption of flexible energy assets within households per country

As derived from the responses, solar energy and flexibility derived from electric vehicles that can be controlled automatically, are the two most promising technologies that are expected to have the highest impact in local energy markets, along with the distributed energy storage through battery technologies, which is coming in third place (Figure 47). On the other hand, off-shore wind electricity generation, nuclear electricity generation and natural gas turbine electricity generation is forecasted to have no impact at all.

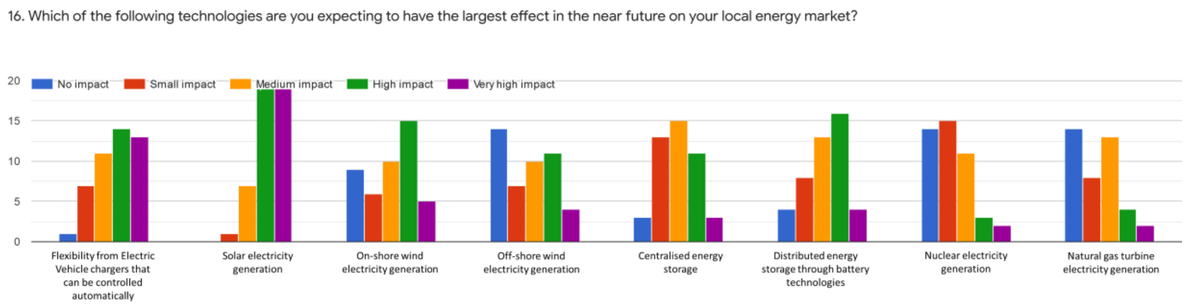


Figure 47: Market survey – Most effective technologies in LEMs

Nevertheless, the current energy market is expected to undergo significant change in the near future, as the 41,3% of the respondents agree that the market will have a significant change, while the 23,9% agree to have a very significant change (Figure 48).

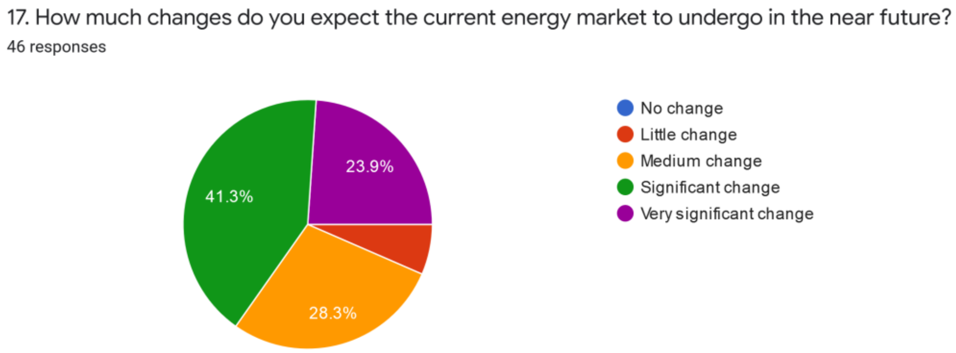


Figure 48: Market survey – Anticipated changes in the energy market

The most important concepts that are foreseen to change the current energy market are the electric vehicles, the large-scale centralized renewable energy generation as well as the distributed energy generation (Figure 49). Local energy systems and infrastructure were characterized as of medium importance, while the majority of the respondents agree that large-scale fossil fuel power generation will have no importance at all in the near future. From the above outcomes, it is obvious that we are moving rapidly in a distributed and renewable enabled energy market that will mostly be based on solar energy generation and flexibility that will come from electric vehicles' chargers.

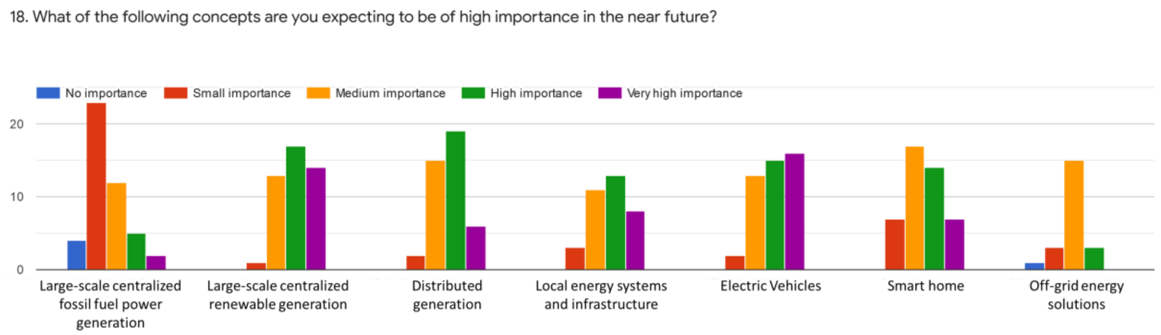


Figure 49: Market survey – Technologies of high importance for the next years

In regards to the changes in business models on the electricity markets, 85,1% of the sample anticipates the expansion of renewable energy, 68,1% the shift towards distributed generation and a significant 53,2% anticipated more competition to take place between different energy providers (Figure 50).

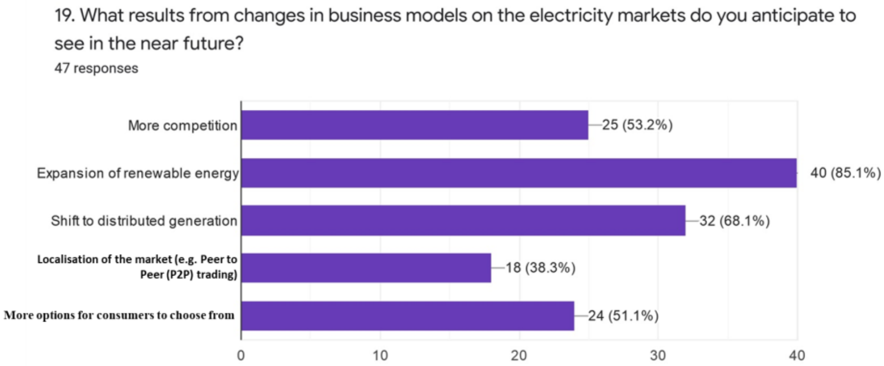


Figure 50: Market survey – Anticipated changes in the business models

In relation to the different capabilities in terms of the feasibility of the energy market business models, the majority of the respondents agree that smart control, dynamic pricing optimization mechanisms, efficient management of the energy assets as well as data security and confidentiality are of high importance (Figure 51).

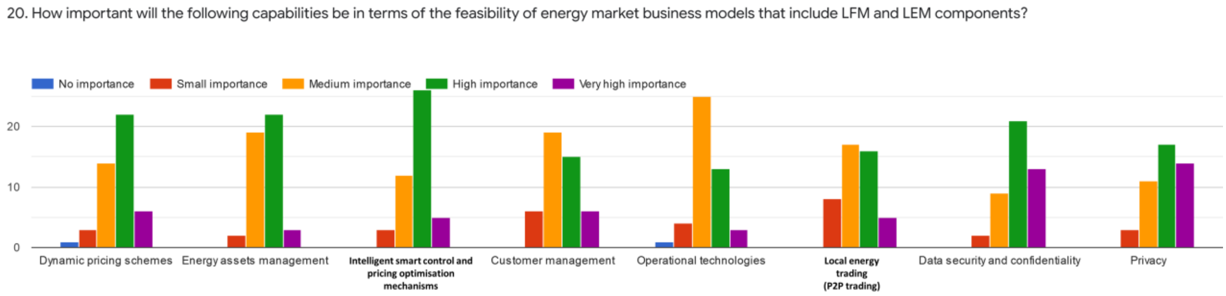


Figure 51: Market survey – Feasibility of business models that include LFM/LEM components

5.2.4 Market Segments

At the final stage of this survey, the sample was asked questions related to energy market tools and services. Thus, this section provides a review related market segments and possible trends.

The survey's participants were asked to indicate which tools and services they think may boost the profitability and efficiency in use of DERs. As it was anticipated considering the abovementioned outcomes, the majority of the respondents believe that DERs personalized profile models (66%), load forecasting mechanisms (57,4%), dynamic pricing schemes (55,3%) and smart energy contracts (51,1%) are the services that have the ability to accelerate the profitability and efficiency of DERs, especially in LFMs/LEMs (Figure 52).

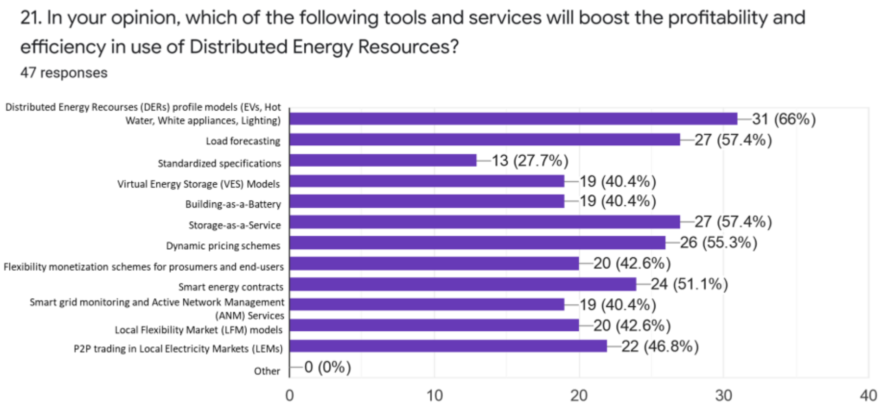


Figure 52: Market survey – Services that will boost the profitability and efficiency of DERs

Additionally, apart from the aforementioned services, 87,2% of the sample strongly believe that real-time metering data is necessary to maximize the usefulness of LFMs/LEMs (Figure 53), while another 74,5% thinks that price prediction tools will increase the revenue by exchanging flexibility assets within such markets (Figure 54).

Moreover, considering that smart energy contracts have the ability to accelerate the profitability and efficiency of DERs, the respondents were asked if they find blockchain enabled smart contracts useful for that matter. 66,7% of the sample responded yes, leading to the outcome that blockchain technology and smart contracts specifically is a promising technology and could be a trend within local energy markets in the next years (Figure 55).

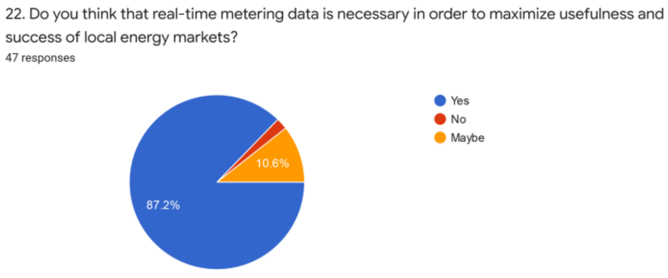


Figure 53: Market survey – real-time metering insights

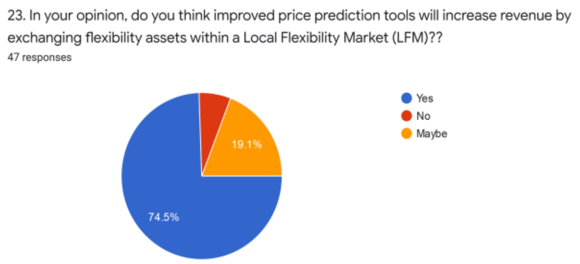


Figure 54: Market survey – Price prediction tools insights

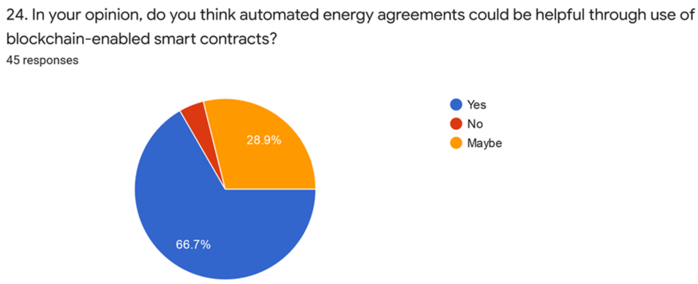


Figure 55: Market survey – Blockchain based agreements insights

Finally, since European funding schemes are considered an important parameter in the acceleration and development of technological solutions the survey participants were asked their opinion regarding what should be the focus in the future. Based on the responses, European funds should be primarily related to energy efficiency solutions (73,3%) and flexibility solutions (71,1%). Additionally, energy storage (68,9%) along with energy monitoring and control (64,4%) are functionalities that should also be focused and investigated more extensively (Figure 56).

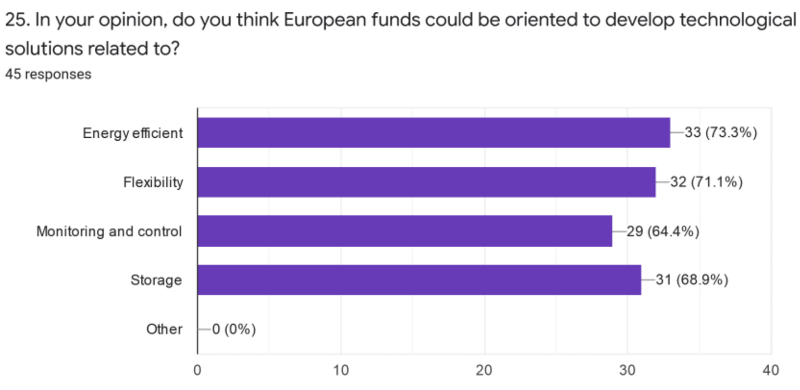


Figure 56: Market survey – Orientation of European funds

6. Market Development

Despite the advent of a global pandemic and an economic contraction in 2020, towns, infrastructure, and companies continued to declare or pursue decarbonisation strategies. Despite the absence of a clear opportunity for green infrastructure growth in the economic stimulus initiatives implemented in reaction to COVID-19, sustainable energy demand remained robust as renewables and storage saw decreasing prices and increasing Capital Expenses (CapEx). Renewables have surpassed coal in power for 153 days as of early December 2020, compared to 39 days in 2019. The US Energy Information Administration (EIA) predicts that energy consumption would fall by 3.9 percent in 2020 and grow by 1.3% in 2021.

The capacity for increased green energy growth, as well as the electrification of the transportation and manufacturing sectors, as well as corporations' plans to expand their presence in the electricity value chain, are both driving energy market convergence. These patterns can encourage cooperation, resulting in new business models and a faster energy transition.

Towards this direction, after analysing the market in the previous section, the current section is going to provide insights and recommendations based on information available on the literature as well as knowledge extracted from the conducted survey. The aim of the Market Development section is to firstly identify different segments of interest within the market, then to provide future market trends based on the PARITY tools and services and finally provide a market adoption roadmap for the PARITY offerings.

6.1 Segments of Interest

The method of splitting a target group into smaller, more defined segments is known as market segmentation. It divides consumers and viewers into categories based on shared characteristics such as backgrounds, preferences, needs, or location. Market segmentation is important because it will allow PARITY to concentrate on marketing strategies on targeting the most valuable markets and achieving its objectives. Additionally, market segmentation will help PARITY to get to know its clients, define what is expected in their market segment, and decide if the provided products and services will better satisfy their needs. Moreover, market segments should ideally consist of segments of the population or organisations who are similar in terms of how they react to a certain tool/product/service.

6.1.1 PARITY Stakeholders and Value Chain

Peer to Peer energy trading in the smart grid, has caused a disruptive shift for all actors in the traditional energy exchange value chain along with their business models; as it has opened the door to new stakeholders, such as Distribution System Operators (DSOs) and prosumers (i.e., users that could act both as power consumers and producers).

PARITY's focus is aimed at the whole value chain of the renewable energy sector and it expands in order to reach other groups and communities that are critical to create the widest impact possible with the project results. Figure 55 illustrates the simplified value chain of PARITY and where each of the partners is placed in it. PARITY's stakeholders detailed description is presented and analysed within D4.3, while the consortium partners that undertake the current roles are presented in D2.1. In a nutshell, the PARITY consortium is conducted by DERs Facility Managers, ESCOs, Aggregators, DSOs, Prosumers and Office Building users. The diversity of the partners, making it ideal for studying and analysing the energy market and providing recommendations for new trends and segments of interest. PARITY´s stakeholders value chain is depicted in Figure 57.

6.1.2 Segments by Country

From the conducted survey and the obtained results, it is obvious that the key energy market that PARITY should be focused on is Spain, Switzerland, Greece and Sweden (Figure 25). The aforementioned markets seem to have the highest engagement with LFMs and LEMs, thus further demographic details of them are presented below in terms of population and growth. This kind of information is important, since it will help us decide if the Swiss, Spanish and green market is large and profitable enough.

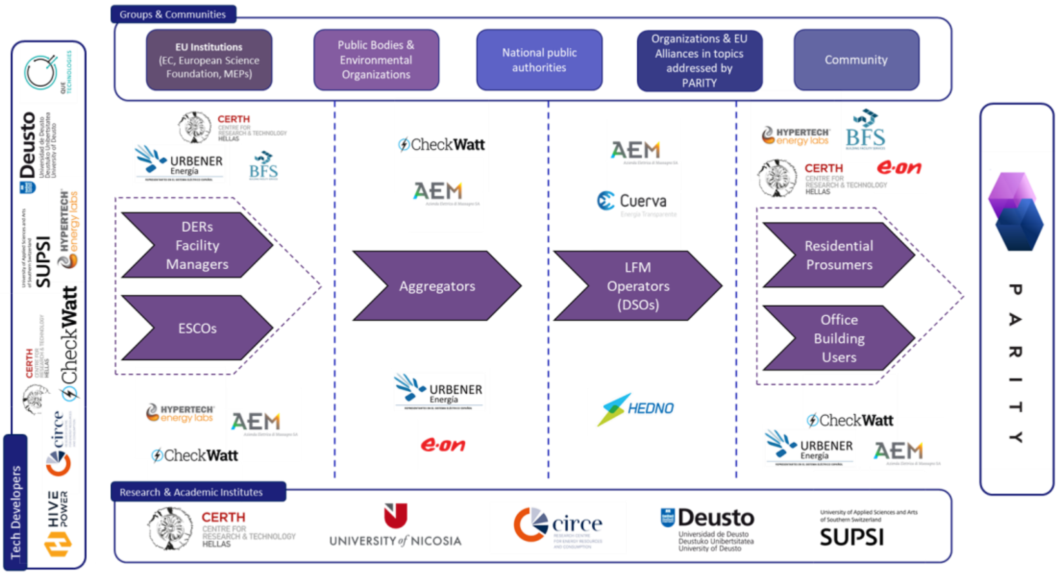


Figure 57: PARITY´s stakeholders value chain

Spain – Country Profile and Forecasts:

Spain has a population of 47.3 million people in early 2020 as stated in Eurostat [99]. Solar energy has become a major source of electricity production, and its share in Spain is rising. Back in 2018, solar had a 4.5 percent share of net installed power capacity. In the forthcoming years of 2020-2025, the renewables market in Spain is projected to develop at a CAGR of more than 6%. Indicators like promoting government policies and efforts to satisfy increasing power demand with clean energy sources and reduce reliance on fossil fuels, are projected to play a major role in market development [100].

In 2017, initiatives totalling 8000 GW were auctioned, culminating in the installation of a record-breaking 4000 MW of solar projects in 2019, leading to a net 8.7 GW of solar power by the end of 2019. With the successful completion of the Nez de Balboa project in 2019, Spain established a 500 MW project housing 1.4 million solar PVs, which is the largest in Europe and will supplement the national grid [100]. The Spanish government took ambitious measures, such as eliminating the sun tax in 2018, establishing a National Energy Technology Plan, and implementing a Low Emission Strategy 2050, to place the country as a world leader in the green sector and reducing its carbon footprint at an unprecedented pace [100]. Solar energy, with a projected expansion of more than 35 GW by 2030, will dramatically drive the renewable Spanish sector, with the government planning to install 37 GW of solar plants by 2030 in order to raise renewable share by 74%.

Furthermore, heating (42.7%) and electrical appliances (26.7%) accounted for 69.4% of building energy production in 2018. Building usage expanded by 1.8% per year between 2000 and 2018, led by a rise in energy demand (+3.1% per year). Heating consumption has been increasing at a slower rate (+0.1 % per year), contributing 9% less to total energy production. Except for refrigeration (+9%/year), consumption related to other purposes has held steady. Because of efficiency increases in heating appliances, unit heating consumption in general continues to decrease [101].

From the above mentioned, in the upcoming years Spain is focusing on solar energy generation and integration of emerging technologies in smart buildings (e.g., energy storage through battery technologies, demand response, real time metering data etc.).

Switzerland – Country Profile and Forecasts:

According to Eurostat [99], Switzerland has a total of 8.606 million inhabitants in early 2020. Switzerland's renewable energy market is projected to expand at a CAGR of more than 3% between 2020 and 2025. Increasing concerns over greenhouse gas pollution, which cause environmental harm and global warming, are forcing governments to search for cleaner electricity generation alternatives. This is expected to fuel the Swiss renewable energy market. However, Switzerland's stagnant power demand is likely to limit the nation's renewable energy market [100]. Switzerland's government signed an agreement in 2017 to limit greenhouse gas emissions by half of what they were in 1990 by 2030, largely by reductions in household pollutants. This agreement is expected to open up a number of potential prospects for the Swiss green energy industry in the upcoming years. Additionally, the country's growing installed capacity for solar and hydro power is expected to boost the Switzerland renewable energy market. In 2018, renewable energy accounted for more than 30 percent of total energy production in the country, with nuclear energy accounting for the remainder. The Swiss government intends to cut greenhouse gas emissions by half by 2030 by establishing many renewable energy production projects. Renewable energy generated around 40 GWh of electricity in 2018. The gross installed capacity of renewable energy generation plants in 2018 was around 17 MW, that was higher than the installation capacity in 2017.

An important aspect is that after six years of research, the *Romande Energie Corporation* launched the first phase of its floating solar project in Bourg-Saint-Pierre in 2019. A solar panel installation capable of powering over 6,000 houses has been installed in an alpine lake in southern Switzerland [102]. Moreover, *Apox* proceeded with the installation of a solar plant of over 6,000 photovoltaic modules on the Glarus Alps site, which covers a surface of 10,000 square meters. The plant can generate 2.7 gigatons of energy per year, which is equivalent to the demand of 600 households. As a consequence of the above, the Switzerland green market is projected to be powered by rising renewable energy installed capacity during the forecast period.

Greece – Country Profile and Forecasts:

Greece has a population of 10.709 million people in early 2020, down from about 11 million in 2011. The demographic loss can be attributed to the extreme economic recession and the subsequent brain drain [99].

As stated in the 2020 Greek Energy Market Report [103], Because of the COVID-19 epidemic, gross energy usage is projected to fall in 2020, but it is expected to quickly recover within 2021. Overall, the fall in consumption during 2020 is due to a decrease in general demand for Natural Gas, Oil, and Coal. According to current forecasts, the energy sector will revert to previous projections after two years (around 2022) and will be in line with the National Plan for Energy and Climate.

In 2016, lignite accounted for 23,55 percent of the built volume of the integrated grid, natural gas for 28,4 percent, hydropower for 19,10 percent, and renewable energy for 29.33 percent. Greece has a high degree of solar energy and 2.9 GW of solar thermal systems deployed, with photovoltaic installations accounting for the majority of RES in the country. [103, 104]. Solar PV generated 25,43% of RES electricity and 8.2 percent of total electricity, due in part to the 512 GWh provided by the Special Photovoltaic Rooftop Program.

Additionally, The Hellenic Energy Exchange, which offers high-quality, open, and socially responsible services to environmental market players, was a pivotal move for the region. Working against the EU target image and combining its economy with neighbouring nations, not to mention providing low-income families with grants covering up to 60% of the construction costs of solar water heaters, Greece illustrates a strong penetration of renewable energy in the sector as well as an attempt to implement European and national strategies [104].

RES objectives are set to allow a cumulative contribution of 20% to overall final energy consumption, among other items. Greece is forecast to meet the 20% target set for 2020, according to Eurostat. Since both coal and oil are expected to decline, RES is expected to account for 75% of total energy generated in Greece by the end of 2025. By 2030, overall RES capacity will increase by 61-64 percent, with PV having the largest share in Greece [103].

To achieve greater RES penetration, flexible and emerging technologies such as energy storage through batteries and demand response are needed.

Sweden – Country Profile and Forecasts:

Sweden has a population of 10327.6 million people in early 2020 as stated in Eurostat [99]. During the projected timeline of 2020-2025, the Swedish renewable energy market is estimated to grow at a CAGR of more than 2%. Government efforts to reduce greenhouse gas emissions in the country are expected to propel the Swedish clean energy industry. However, problems in operating renewable energy plants are likely to restrict Sweden's renewable energy market. In 2018, hydro energy remained the primary source of power generation in Sweden, and it is expected to continue to regulate the industry. Furthermore, Sweden plans to target 100% clean energy power generation by 2040 and 0% greenhouse gas emissions by 2045. These goals are likely to provide a great potential for the Swedish green energy industry. Furthermore, the country's growing renewable energy installed capacity and future developments are expected to boost the Swedish renewable energy market. The European Union has set goals for reducing their carbon footprint, and Sweden is increasing its renewable installation capacity to meet those targets [116].

Regardless, Sweden requires innovative ways to achieve the above-mentioned aggressive policy target of achieving 100% clean energy by 2040. IRENA has therefore suggested four tailor-made options [117] focused on a holistic approach to solve the country's unique difficulties in scaling up Variable Renewable Energy (VRE) in collaboration with the Swedish Energy Agency. The solutions are highly linked with emerging technologies such as batteries, IoT technologies, EV smart charging, as well as blockchain and smart contract technologies. Additionally, the solutions envision innovative market design based on ancillary services, local markets and time of use tariffs.

6.1.3 Segments by Type

Solar PV:

Solar PV, or solar photovoltaic energy, is a form of solar energy that uses photovoltaic technology to turn sunlight into electricity. Solar power is probably the most trustable and sustainable green energy source. The United States, China, and Spain have the most abundant solar resources on the planet. The high demand for clean energy and the dropping unit cost of silicon-based solar panels are the biggest drivers moving the solar PV industry forward. While hydropower remains the most cost-effective renewable energy source, steadily dropping prices have rendered solar PV the primary market for investment. Particularly, in a variety of countries around the globe, solar PV-generated electricity nowadays cost competitive with fossil fuels [105]. As demand for electricity increases, most countries are rising their power generating capacity by extending their existing plants or providing new ones. Companies are increasingly shifting towards the use of renewable energy sources for electricity production, especially solar energy and wind power, as a result of strict government legislation and regulation related to carbon emissions. This is expected to boost the solar PV market's growth in the future years [105].

Solar Thermal - Heating and Cooling:

Solar thermal has the possibility to be a significant source of heating and cooling in Europe as an incredibly convenient heating source based on a basic principle improved by cutting-edge technologies. As technology has improved, solar thermal is becoming not only a better alternative for more conventional applications like domestic hot water processing, but also a potential approach for modern and more advanced applications like industrial process heat [106]. At the end of 2017, the total global solar thermal power in use was 472 GWth. In contrast to 2016, concentrated solar capacity increased by 3.5%. Additionally, in 2017, the equivalent annual solar thermal energy production was 388 TWh, equating to a gain of 41.7 million tons of oil and 135 million tons of CO_2 [106]. Moreover, the provision of district heating facilities will boost the viability of centralized solutions such as large-scale sustainable heating and cooling systems, such as solar-thermal. Several thermal heating and cooling technologies, such as solar-thermal, might be much affordable at scale, but delivery requires a district heating grid. The district heating system, on the other hand, is not always financially viable to construct [107].

Wind Power:

Wind power capacity continues to expand rapidly, fuelled by an established track record and precedent from the previous decade, as well as low levelized cost of energy (LCOE). Since 2014, this sub-sector has grown by 17%, with global capacity reaching 433GW by the end of 2015, with China, the United States, and Germany leading the way [108]. During the forthcoming years, the European wind power market is projected to develop at a CAGR of around 6.1%. Also, during the forecast period, considerations like the decreasing cost of wind power generation, increasing vulnerability to environmental issues, and economic assistance from various governments worldwide are expected to boost wind power demand. At the end of 2018, Europe had 18.498 GW of installed offshore wind capacity. Currently there are 105 offshore wind farms and 4,543 grid-connected wind turbines in different European countries, including locations with limited grid connectivity. The gross installed capacity of Europe's offshore installations increased to 22 GW in 2019. Significant technological advancements have driven the development of the offshore wind industry in Europe, lowering the production costs and, in some examples, making offshore wind farms equivalent to onshore wind farms in terms of economic efficiency. As a result, the offshore wind power market is projected to grow during the forecast period. [109].

Bio-energy:

Bio-energy (or biomass) is a significant renewable energy source that will help Europe achieve its climate goals in 2020 and 2030, when renewable energy sources must account for 32% of total energy demand in the EU [110]. Regardless of the fact that international investment in biomass and waste-to-energy fell by 29% from 2014 to 2015, this sector ranks third behind wind and solar energy (6 billion USD). While developed countries, the majority of which are centred in Europe, account for 75% of this, developing countries such as India, China, and Brazil have also been involved in this field [108]. Bioenergy has the potential to play a major role in meeting the EU's renewable energy goals by 2030 and beyond. According to the European Commission's sustainability scenario, gross inland bioenergy consumption would range from 170 to 252 Mtoe (i.e., million or mega tonnes of oil equivalent) by 2050 [110]. Agricultural residues, by-products, and waste are examples of ways to increase bioenergy use. Bioenergy can also act as a versatile carrier, allowing for higher shares of renewable energy sources such as wind and solar power in power grids [110].

6.1.4 Segments by End-Use

Building Sector:

Gas heaters, lighting, central air conditioning, refrigeration, and electric and gas water heating are the facilities that use the most electricity in the residential sector [111]. In comparison, the reliability picture for light bulbs, as well as electric and gas water heating use, shows less effectiveness so far. Lighting provides many opportunities for productivity improvements, both because removing incandescent lamps with fluorescent bulbs saves a considerable amount of electricity and because the first cost tends to decline. Fluorescent and incandescent lighting, air-conditioning, office appliances, supply/return fans, and bundled heating are the main electricity appliances in the commercial sector [112]. It is important to mention also that funding agencies, demographic factors, contractors, the need for utilities, advertisers, and codes and standards are the key factors that affect the decision-making in the construction industry as a whole. Retailers and suppliers are both important decision-makers in the machinery and appliance industry [113]

Transportation Sector:

Transportation is critical to the global economy because it facilitates the flow of people and global commerce. However, it comes at an expense, since it is a big source of carbon due to the current reliance on fossil fuels. Although it accounts for one-third of global energy consumption, it is also the field with the least amount of renewable energy usage but with the greatest potential. There are some preferred green alternatives for some modes of transportation, but not all [114]. Despite considerable progress in energy efficiency, especially in road transport, global energy demand in the transport sector has steadily increased over the last decade, owing primarily to the increasing number and scale of vehicles on the world's roads. As a result, global GreenHouse Gas (GHG) emissions from the transportation industry have increased, even though emissions in some regions have decreased. In 2019, the sector contributed to about a fifth of global energy-related GHG emissions. Even if all announced policy initiatives are adopted, the transportation industry is projected to increase GHG emissions by 60% by 2050, owing primarily to increased freight and non-urban transportation. If no steps are taken, road transport is expected to account for at least 70% of GHG emissions by 2050. Thus, renewable technology would need to play a critical part in emerging transportation networks. The future transportation infrastructure will be much more complicated, with many participants, technology, and direct links to the power grid.

It is clear that green energy strategies for the road transport sector must be incorporated in a broader system of measures that also decrease demand for transportation facilities, change transportation modes, and improve vehicle quality [115].

Industrial Sector:

Industry accounts for more than one-quarter of global energy-related Carbon Dioxide (CO2) emissions, and manufacturing activities account for a further 8% of global CO2 emissions. Iron and steel, aluminium and plastics account for more than 85 percent of manufacturing energy and process-related pollutants, and account for more than two-thirds of overall industrial energy consumption. There are actually only a few commercially feasible options for reducing CO2 emissions at scale in these manufacturing industries [114]. According to the "buildings section" of this deliverable, electricity usage in commercial buildings accounts for almost two quads of annual energy use. The ITP Best Practices Program does not discuss the construction aspects of energy use in the sector and focuses primarily on process and plant utility energy use. Finally, there are many opportunities in the lighting, HVAC, and building covering [113].

6.2 New Market Trends

Market trends that tend to be heavily influenced by consumer habits and behaviours, as derived from the survey outcomes. This sub-section provides a new market trends analysis, focusing on the products, innovation, future product development and market potential.

6.2.1 Solar electricity generation

EU member states installed 18.2 GW of solar power capacity in 2020, an 11% improvement over the 16.2 GW deployed in the previous year. The European Union increased the cumulative installed solar power capacity by 15% to 137.2 GW at the end of 2020. The Top 10 EU solar markets (Germany, Italy, Spain, France, Netherlands, Belgium, Poland, Greece, Hungary, Austria) reached 125.8 GW installed solar power capacity in 2020. The Medium Scenario now forecasts additions of 22.4 GW in 2021, 27.4 in 2022, 30.8 GW in 2023 and 35 GW in 2024, bringing total installed solar power capacity to 253 GW [119].

Drivers for solar in Europe only getting stronger:

- Solar’s cost reduction continues.
- Various EU policy initiatives in the context of the EU Green Deal striving for carbon neutrality and the Recovery Packages will directly or indirectly boost solar.
- Constantly increasing energy storage volumes will further allow the inclusion of renewable energy sources.

The main categories in the PV sector are the Solar Portfolios, the solar park developers, the PV modules manufacturers and the PV inverters manufacturers. Namely the leaders in each category are listed below:

- Top 10 European Solar Portfolios (2019): Enerparc AG, Encavis, Octropus Investments, Foresight Group, EF Solare Italia, NextEnergy Capital Group, Aquila Capital, Engie, Sonnedix, EDF Energies Nouvelles [120].
- Top 10 European solar PV developers in Europe (2018): Juwi AG, EDF Renouvelables, Belectric, Enerparc, Lightsource BP, Voltalia, Enel Green Power, Scatec Solar, ENGIE Green [121]
- Top 10 solar PV module manufacturers worldwide (2019): Jinko Solar, Ja Solar, Trina Solar, LONGI Solar Risen Energy, GCL System Integration Technology, SFCE (China) – Canadian Solar (Canada) – Hanwha Q Cells (South Korea) – First Solar (USA).
- Top 10 global PV inverter market leaders: Huawei, Sungrow Power Supply, Sineng, Growatt, Ginlong Solis (China) – SMA (Germany) – Power Electronics (Spain) – Fimer (ABB) (Italy) – Solaredge Technologies (Israel-USA) – TMEIC (Japan) [122]

Key policy files are also presented below:

- **Clean Energy Package 2.0:** in September 2020, the European Commission proposed to increase the 2030 Greenhouse gas (GHG) emissions target from at least 40% to at least 55%.
- Overcoming the carbon pricing deficit: raising the EU's 2030 GHG emission reduction from 40% to at least 55% requires EU policy makers to strengthen carbon reduction efforts across all economic sectors. A higher carbon price on electricity will foster the deployment of renewables at the expense of fossil-based generation.
- **Solar to Hydrogen:** unlocking solar's potential beyond power: there are sectors where full electrification could be too expensive, such as chemicals, parts of heavy industry, long-haul heavy-duty road transport, aviation and shipping. Renewable hydrogen will play a crucial role in these industries, opening up a huge market potential for solar in Europe. Hydrogen generated by electrolysis and driven by solar energy emits no greenhouse gases. By 2030, the EU committed to installing at least 40 GW of renewable hydrogen electrolysers in the EU and 40 GW of renewable hydrogen electrolysers outside the EU, to produce up to 10 million tons of renewable hydrogen supporting the decarbonisation of EU heavy industries.
- **Sustainability and circularity:** with Ecodesign and Energy Label rules for solar PV modules, inverters, and systems expected to enter into force as of 2023, the Commission is going forward with the definition of sustainability criteria, parameters, and metrics to strengthen the sustainability of the solar sector, and establish new standards on quality, recycling and product efficiency.
- **An EU Industrial Strategy for Solar:** reshoring a strong industrial value chain and supporting exports of solar goods and services. The European innovation leadership in developing cutting-edge solar PV technologies is a solid basis to develop manufacturing activities – from wafers, to new cell concepts and modules, as well as inverters and other important parts of solar systems – and lead to a new wave of industrial investments. The European Commission presented in March 2020 a new Industrial Strategy.

Key future trends are highlighted below:

- **Solar with Battery Energy Storage Systems (BESS):** Deeper penetration of RES impacts the voltage reliability at distribution grids. Solar plants in conjunction with BESS can handle overvoltage issues and manage power networks [123]. Direct benefits include profits for providing flexibility based on forecasting results - the situation of distribution grids - electricity tariffs, reduction of network reinforcement investment costs and also profits that come from storing solar electricity when the exchange prices are low and using it when the exchange prices are high (peak-demand periods) [123, 124].
- **Bifacial Solar Modules:** Bifacial solar modules can produce electrical energy when illuminated on both its surfaces, front or rear [124]. Most of them use nanocrystal cells and can be framed or frameless. Increase in production compared to monofacial modules can reach 30% or even more, depending on the type of the ground or roof (deserts, grounds with white rocks or white roofs are ideal) installed [125]. The additional cost of bifacial PV varies between 1-5% [126]. Bifacial proved to be more productive when the installation's tilt angle is greater.
- **String Inverters and Microinverters:** The price decline as well as the increase in high voltage offerings lead to the expansion of string inverters even in large-scale projects. Thanks to maximum power point tracking (MPPT) technology, string inverters achieve a better performance, optimize management of trackers, achieving maximum power output under all conditions. String inverters offer the capability of easier exchange of the whole inverter in case of damaged units, in contrast to central inverters that require qualified personnel for restoring normal operation in case of faults (the replacement of string inverters due to their high cost and dimensions is not financially viable). Also, DC wiring for the panel arrays is simpler, when installing string inverters [127, 128].
- **Solar rooftops:** Up to 90% of Europe's roof surfaces remain unused, only 90 GW installed till 2020 [119].
- **Solar's versatility:** Examples include rooftop solar for car parks allowing direct EV charging or floating solar and Agri-PV that promise owners of water/land areas to enter energy production while benefiting from further advantages as solar panels offer shading facilities, which reduces evaporation in water reservoirs [119]. Other innovative applications at application level include

Building Integrated PV (BIPV) panels and solar power desalination. BIPV provide both passive functions, such as thermal and acoustic insulation, as well as active functions, mainly electricity generation that can be directly used in the building. This solution is proved to be cost efficient in many applications [129].

6.2.2 Large scale centralized renewable generation

In the twenty-first century, the electrical grid is undergoing significant transformations all over the world in order to become smarter, cleaner, more efficient, and reliable. Among the several different renewable energy sources, wind and solar energy are gaining popularity in most countries. Nevertheless, due to the variable existence of renewable energy sources in terms of electricity, including actual and reactive power, output voltage, and frequency, integrating large-scale wind and solar PV energy into the grid is a major challenge for the current power industry [130].

Nevertheless, there are over 69.68 GW of PV and 250 GW of wind power generation installed worldwide, while more than 200 PV power plants have already been installed in the world, each of them generating an output of more than 10 MW. 34 of these factories are in Spain, while the remaining 26 are in Germany. Furthermore, a lot of major PV power plants is anticipated to increase further, with more than 250 PV power plants set to be constructed in the next years [130]. In addition, the output maximum power of today's biggest wind generators has exceeded 10 MW. For example, the Haliade-X offshore turbine features a 14 MW capacity, 220-meter rotor and a 107-meter blade. Vestas Wind Systems in 2021 unveiled its latest model the V236-15.0 which is expected to provide a capacity of 15 megawatts, when in production in 2024 [131]. Those production units will allow for large-scale centralized wind and solar energy production.

In parallel the concentrated solar power systems produce power by using mirrors or lenses to concentrate a large area of sunlight onto a receiver, providing an electrical capacity of 50MW to 510MW. The biggest solar power system unit is the Ouarzazate Solar Power Station, located in Morocco, with a capacity of 510MW, which is expected to reach 582 MW at peak when finished [132]. In terms of global market, concentrated solar power had a global total installed capacity of 6,451 MW in 2019, increased by an estimated 34% [133]. Despite this extraordinary growth, the solar energy system is still falling short of the International Energy Agency's Sustainable Development Scenario, which calls for annual growth of about 24% until 2030. Policy strategies highlight the importance of solar power plant storage will be critical in attracting more investment (Figure 58).

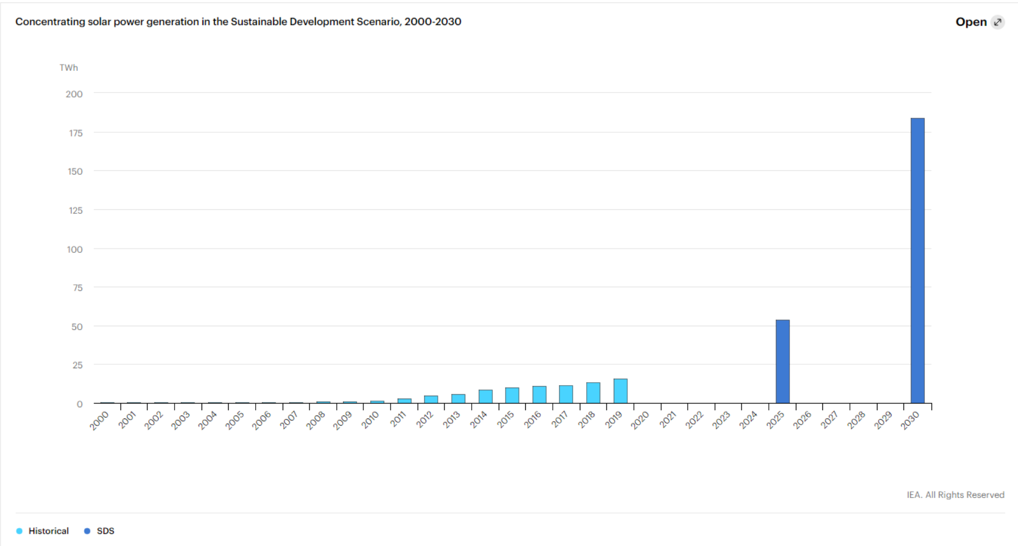


Figure 58: Concentrating solar power generation in the Sustainable Development Scenario, 2000-2030

The worldwide focusing attention solar power market is expanding due to growing energy demand and increased government support for the use of renewable technologies. Furthermore, increased worry about environmental pollution caused by traditional power plants, as well as rising concerns about global warming, are fueling market expansion. The market is hampered, however, by the high capital expenditures necessary for the deployment of concentrated solar power production plants. Market development is hampered by a lack of vast areas in high solar radiation zones, restricted access to water, and limited connection to the transmission grid. On the other hand, market participants' high adoption and acceptance of concentrating solar power projects, as well as partnerships among companies, are projected to generate market possibilities [134].

In terms of energy production costs, it has been investigated if bigger wind and solar power plants will produce cheaper energy due to economies of scale. The following chart (Figure 59) shows the economies of scale data for wind farms by size. It is clear that very small projects—less than 5 megawatts—cost much more per kilowatt. The savings for size continues, but much less dramatically, for larger projects. Nevertheless, there are two caveats about data showing lower prices for larger projects: the price of competition and the cost of transmission and as a result the savings from building the largest wind farms may not outweigh the cost to transmit the power to cities, compared to building smaller scale plants closer to load [136].

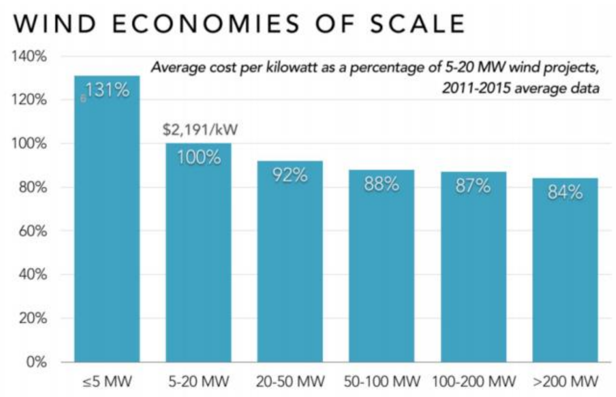


Figure 59: Cost per kilowatt for wind farms as a percentage of projects sized 5 to 20

As for solar plants, in the following chart the inflation-adjusted levelized cost of electricity is presented. Data presents the levelized cost of electricity for a $2.50 per Watt solar array of 6.71¢ per kilowatt-hour, adjusted accordingly for the other capital costs. From this chart it is made clear that bigger power plants produce cheaper electricity, but usually most projects over 5 MW, require higher transmission costs due to their remote location. As a result, the specific electricity production cost of each project is case sensitive, depending on the size of the plant, but also on the distance of the plant to the consumers.

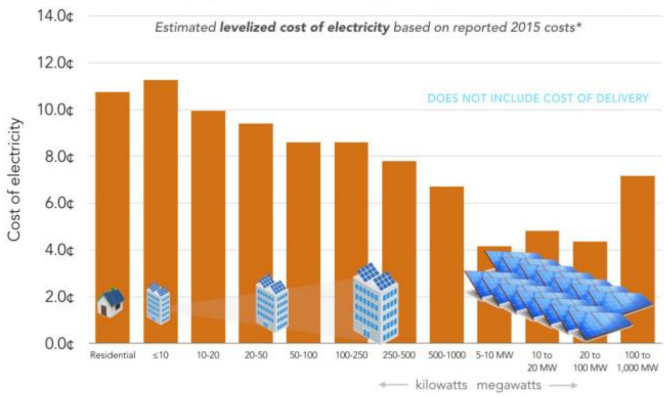


Figure 60: Cost per kilowatt for solar plants according to the size of the plant

6.2.3 Flexibility from EVs chargers

The market for Battery Electric Vehicles (BEVs) is steadily growing all over Europe. Market-ready EVs are increasingly meeting users' requirements (e.g., in terms of range and price level), but also political targets foster the deployment of BEVs. This trend is shown in Figure 61.

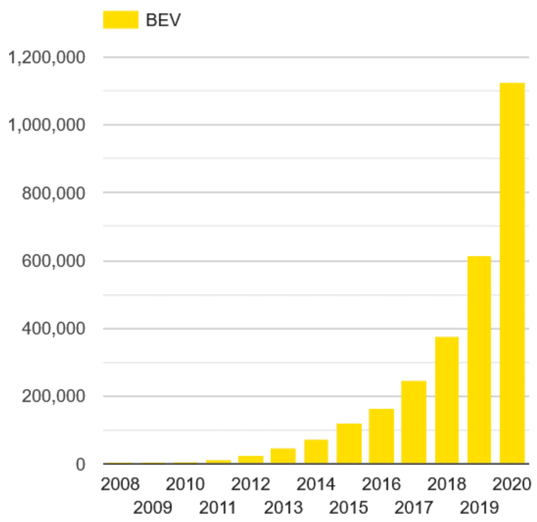


Figure 61: Total number of BEV passenger cars in the EU

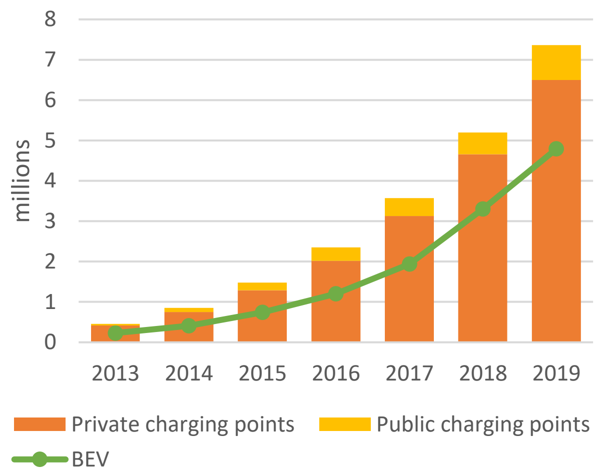


Figure 62: Worldwide EV car deployment and charging points installed

Regarding charging infrastructure for BEVs, the roll out of public charging points is well documented (e.g., by EAFO), but there are only few reliable figures for the roll out of private chargers. However, it can be considered that the majority of vehicle charging will happen at the end-user's homes, followed by their workplaces, and therefore in the private domain. This is supported by the Global EV Outlook of the IEA [138] reporting an estimated number of BEVs and charging points on global level (Figure 62). This indicates that in total there will be even more charging points than EVs, considering that most EVs will have a private (home) charger and additionally there will be public (slow and fast) chargers.

In order to make use of the flexibility potential of BEVs, two general approaches can be considered. On the one hand, an EV can be seen as a consumer of energy ("smart charging") and its load curves can be altered to activate flexibility. On the other hand, BEVs can be used as storage units that can be deployed in times when the vehicle is parked at the charging point. This is referred to as Vehicle to Home (V2H), where electricity can be fed back to building-level consumption, and V2G, where electricity can be fed back to the public grid.

In order to make use of smart charging, a load management system is required. Firstly, this may be a local system, where several charging points at a single site are controlled in a way that realises favourable conditions for the whole charging station (e.g., through local peak shaving). Secondly, smart charging can also be a response to dynamic electricity prices, which can also be applied to charging stations with single charging points.

In order to assess the number of charging points that will be ready for smart charging in the future, VITO et al. [140] draw an educated guess based on interactions with different stakeholders. According to that, it is assumed that in 2030 there will be 75% of the charging points ready for smart charging.

For V2H and V2G, a main technical requirement is the transformation from Direct Current (DC) to Alternating Current (AC). This can be implemented either in the car or the charger. Because of this, and other still existing barriers, V2G is not yet commercially applied [141] and currently only tested in various pilot projects. Currently, most BEVs only support unidirectional charging. However, there are emerging EV models that also support bidirectional charging and therefore V2G also in their commercially available versions. The probably most prominent model is the Nissan Leaf with all new

EVs ready for bidirectional charging. The main barrier for EV manufacturers to include this feature in their models are concerns about reduced battery lifetime due to V2G.

On the level of charging points, also not all of the currently used standards support V2G. Currently, only the Japanese standard is able to conduct reverse charging. The Combined Charging System (CCS) standard, which is the dominant and preferred standard within the EU, does not yet facilitate bidirectional charging. However, with the ISO 15118-20, a standard is under development supporting bidirectional charging both through AC and DC charging [142] and will be implemented in the CCS standard around the year 2025 [143].

Depending on the technical approach (smart charging, V2H, V2G) and the desired flexibility service, the following use cases for exploiting the flexibility of EV chargers can be identified [144].

- **Behind the meter optimization (smart charging, V2H):** Currently, this is the main use case for smart charging stations and comprises mainly cost savings through load management for optimal usage of a dynamic or ToU supply pricing scheme and reduction of costs (OPEX and CAPEX) for the installed power capacity of a building. With increasing on-site renewable production (e.g., PV), self-consumption maximization will become an important goal and with the advent of V2G, also aspects such as security of supply will become relevant in this context.
- **Energy community optimisation (smart charging, V2G):** This is similar to the above, but with a larger scope extending from building level towards the level of local communities. Here, the public grid (or local microgrid) is used for the energy distribution, making V2G relevant instead of V2H.
- **Grid aware charging and discharging (smart charging, V2G):** Whereas the above energy community optimization only deals with energy balances on local level, this use case also includes services to facilitate grid management for the DSO (or microgrid manager). Main issues are congestion management and voltage control.
- **Electricity market trading (smart charging, V2G):** Day-ahead and intraday market trading is another use case for EVs, but only as part of an aggregated pool of vehicles. Aggregators or energy suppliers play a key role in this use case.
- **System services (smart charging, V2G):** Services to the overall energy system includes primarily the provision of balancing energy. Especially aFRR markets are especially interesting for aggregated EV fleets, because of the high power that can be delivered within seconds.

As only smart charging is currently commercially available, the following roles are considered as relevant market players in the provision if flexibility through EV chargers:

- **Energy suppliers:** Incumbent energy suppliers mostly run the public charging infrastructure and are also often market leaders for private charging solutions (as a sales and service partner). They act as a one stop shop for charging services, including billing and energy provision.
- **Technology providers:** They provide the innovative charging hard and software enabling flexibility activation in the first place. Mostly they are limited to these services, but some players are also entering the domain of a full-service provider (installation, billing, marketing of flexibility etc.)
- **Car manufacturers:** Are usually limited to manufacturing and financing the EVs, but also here there are tendencies towards providing mobility instead of selling the car. A prominent example for a car manufacturer entering the energy and flexibility business is *elli* [145], a brand of the Volkswagen group.
- **Aggregators:** Finally, aggregators are relevant players for the future. Most likely, this role will be taken by companies emerging from the above players, but with a clear focus on extracting flexibility from EV fleets.

Summing up, currently only smart charging plays a role in flexibility provision through EV chargers, but V2G and V2H will be commercially available most probably by 2025. Current key players are incumbent energy suppliers, but also increasingly the automotive industry and innovative technology providers widening their core business.

6.2.4 Energy storage through battery technologies

The field and industry of energy storage through battery technologies is in considerable transition and pointed out as a key technology for the energy system transition in general. Below are a few main statistical points illustrating the growth projections.

- The Battery Energy Storage System (BESS) market is expected to grow with a compound annual growth rate of 33% from 2019 to 2024 with promising opportunities in the residential, non-residential and utility industries, globally.
- Technical development and cost reduction are expanding the scope of applications in which BESS is favoured over competing technologies. One study suggests that BESS using lithium ion technology will be preferred for applications in need of discharges lasting less than 10 hours with a frequency of less than 1000 cycles per year (1).
- Residential BESS market in Europe:
  - According to a Mid-Scenario, the yearly growth rate is expected to be in the two-digit range again at 14% in 2021, catching up after the COVID-19 slowdown and boosted by recovery packages, then slowing down to an 11% growth rate in 2022, before it moves up again to a growth level of 13% in 2023 and 16% in 2024.
  - End-user and household level applications mainly consist of BESS connected to PV panels, but may also be combined with small wind generators.
  - BESS technology is more widely introduced in both the US and China than in the EU. The United States has been world leading in realizing energy storage projects and demonstration applications since 2008. Several demonstration projects and lithium-ion BESS of kW-MW grade have also been tested in China.

A selection of future trends is presented below to further paint the picture of the fast evolving and emerging field of energy storage through battery technologies.

- **Hybrid inverters:** PV installers move towards using hybrid inverters as standard equipment, allowing for quick and seamless installation of BESS. Simplifies permit process with DSO.
- **DC-coupled systems**: are more efficient and will probably replace AC-coupled BESS
- **FLESCOs entering the market:** Simply increasing self-consumption from PV is not enough for most residential, as grid tariffs increase, and energy prices decrease during sunny hours. Manufacturers included software proves to be insufficient. FLESCOs entering the market.
- **Continued subsidies for equipment and installation for private customers:** Leading countries in EU/Europe include Germany, Italy, Austria, UK, Switzerland
  - Italy: tax incentive scheme as a part of COVID19 recovery programme, VAT rebate, regional grants.
  - Austria: The country’s investment subsidy for residential solar and storage systems has been renewed recently for the period 2020-2023, with an overall budget of 24 million EUR per year (of which 12 million EUR will be specifically dedicated to storage systems).
  - UK: the new Smart Export Guarantee (SEG) scheme, some electricity retailers have started to offer tariff structures optimised for energy storage systems owners that strongly improve the business case for coupled solar and storage systems.
  - Switzerland: recovery stimulus for solar sector, may affect batteries.

Besides use cases for BESS that are included in PARITY, there are other applications for stationary batteries. Presented below is a selection of such use cases.

- **Uninterrupted power supply (UPS).** Industry and critical functions such as hospitals are starting to embrace stationary battery storage as a supplement or substitute to fossil powered systems.
- **Buffer grid connection to avoid upgrading fuse.**
- **EV fast charge boosting:** Highway fast chargers are expected to utilize stationary batteries to boost charging output over grid connection, given the high willingness to pay nature of the application.
- **Energy arbitrage in areas with extreme energy price volatility.**

- **Decrease climate impact:** better climate performance evaluation of implementing batteries (using hourly data for carbon intensity of electricity usage) may speed up implementation of battery storage since other drivers than pure economics are stimulated.

Broadly, the high demand for battery cells from the vehicle industry creates an attractive market for manufacturers and subsequently many new Original Equipment Manufacturer (OEM) competitors in the field. Competition among OEMs is expected to harden as demand is met and since buyers are expected to stay price sensitive. Options to virgin products as stationary energy storage are also expected to emerge, for example second-life battery systems andV2G solutions.

On the application and operation side, a number of software providers are competing in different market nieces and applications for stationary storage with the focus to create value for asset owners. However, the field is still underdeveloped and one can argue that the significant competition comes from grid development. Overdevelopment of the grid could become a less cost-efficient solution to problems that could be solved using energy storage.

6.2.5 Load forecasting

Efficient load distribution across supply lines, proper load demand planning and adequate long-term maintenance of generation, transmission and distribution lines are essential for effective grid management. Therefore, accurate load forecasting will greatly maximise planning efficiency in the power generation industries. Similarly, in order to improve the accuracy of power demand forecasting, numerous statistical and computational techniques have been applied to improve forecasting models [160]. There are different ways to classify the load forecast: the type of forecast (short-term load forecast (STLF) for a few minutes, hours to a day in advance or a week, medium-term load forecast (MTLF) is from a week to a year (possibly two years), and long-term load forecast (LTLF) ranges from a few years to 10-20 years in advance)), according to the forecasting model (conventional, IA and hybrid), depending on the forecast load (commercial, residential and combined) and the model's evaluation metrics [161-163].
From the various analyses and studies reviewed, and more specifically from one of them providing a review of some 67 previous relevant papers published in academic journals (2010-2020) on electricity demand forecasting, it states that of the algorithms mainly used, 90 % of them were based on AI artificial intelligence, 28 % being ANN model (Figure 63). Such ANN models were mostly used to STFL, where power consumption characteristics are more complex than in LTLF. The Traditional Autoregressive Integrated Moving Average ARIMA was utilized in 17.5 percent of the studies due to its efficacy in LTLF where load variations and periodicity are less significant [164-166].

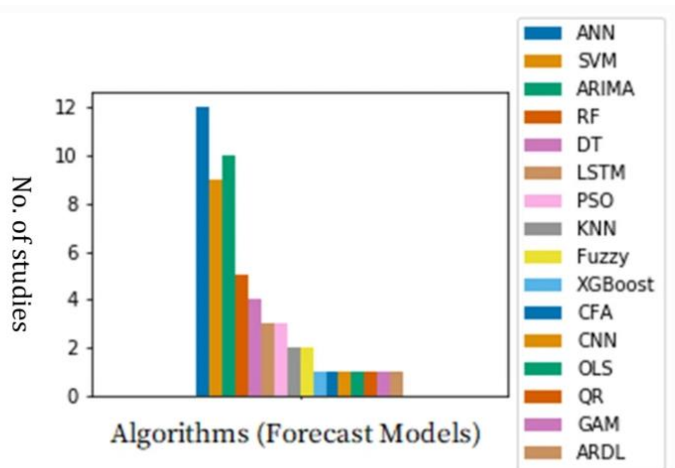


Figure 63. Top most used algorithms for electricity forecasting

It was also observed that a high percentage of regression models are used for LTLF prediction. The studies also show how AI is used in the field of economics and profitability. Similarly, it could be observed in the most recent studies that SVM, PSO and Fuzzy are becoming increasingly popular, which leads to the conclusion that researchers are becoming more and more interested in these algorithms in electricity demand forecasting [167].

Another interesting fact is that 50% of power demand estimates are based on economic and meteorological characteristics, 8.33% on historical energy usage, 8.33% on home lifestyles, and 3.33 percent on stock market indexes (Figure 64).

Input variables	No. of studies	Percentage (%)
Weather and economic	30	50
Household lifestyle	5	8.33
Historical energy consumption	23	38.33
Stock indices	2	3.33

Figure 64. Parameter used in electricity load forecasting

Regarding the type of load forecasting, 80% of the studies were short term (STLF), 15% medium term (MTLF) and 5% long term (LTLF). From these results it is concluded that further studies on the challenges associated with LTLF and MTLF load forecasting are needed.

Depending on the objective to be achieved, various use cases arise for load forecasting as a result. The main ones stand out:

- **Forecasting and analysis of the electricity market:** to define PPAs, it is essential to know the value of the energy that is bought and sold, as well as for new business models, to draw up financing strategies and to search for synergies with other companies.
- **Price forecasting:** in order to value the portfolio as well as risk management and hedging to reduce or eliminate losses arising from unfavourable movements in market prices.
- **Energy production forecasting:** in order to optimise and plan production to ensure demand requirements. In addition, developing forecasting applications for TSOs, DSOs and utilities will be essential to calculate energy consumption in smart cities.
- **Customer portfolio forecasting and analysis:** for marketers to plan the energy needs of the customer portfolio, as well as being able to provide consumption forecasts to their own customers.

From the above, it can be concluded that energy forecasting is a topic that is becoming popular globally. Load consumption and demand forecasting plays an essential role in the planning and operation of today's electricity system.

At the same time that energy companies are trying to develop their own load forecasting algorithms and models, a new player is emerging in the energy sector. These new players offer their load forecasting services to these companies. Several examples are described below:

- **Aleasoft:** which offers services of Energy price forecasting[2] and Demand and renewable energy forecasting[3] to big consumers and electro-intensives, utilities, retailers, TSOs, traders, renewables, investment funds and banks.
- **Nnergix:** offers tailored digital solutions for an efficient energy transition through the combination of 3 areas of knowledge: data analytics, software development, and relevant meteorological data for renewable energy management as a solar forecasting tool web-based and aimed at improving access to solar forecasting in order to make it a common practice among dispatch centres.
- **Etap:** provides a tool for industrial customers and utilities to anticipate future short-term loading in the system in a reliable and precise manner (adaptative bus load forecasting, real-time

[2] https://aleasoft.com/energy-price-forecasting/

[3] https://aleasoft.com/en/energy-demand-forecasting/

trending, load profile library, forecasting scenario archiving, predict loading up to seven days ahead, user-adjustable weather variables and load profiles, etc.).

- **Instituto de Ingeniería del Conocimiento (ICC):** through big data, it provides services such as Wind Power Production Forecast, Energy Predictive Models, Energy Forecasts Visualization, etc.)
- **Meteo Systems:** delivers ground-breaking solutions from fluctuating wind and solar power for precise predictions, marketing, and grid integration. Also, it offers grid[4] and plant operators[5] as well as power traders[6] the following services: real-time projections for solar power, including behind-the-meter generation and grid-oriented forecasts (vertical grid load forecasts and dynamic line rating).

In conclusion, there is still much to be discovered about load forecasting. However, it is starting to play a really important role due to the energy revolution that is taking place. Companies in the energy sector are going to face different main challenges where these tools will play a crucial role:

- Planning and managing microgrids
- Responding quickly to local flexibility markets
- Planning grid congestion avoidance requirements
- Planning growing energy demand and managing it effectively

In this scenario, wide opportunities and challenges may rise for DSO in the management of the electrical system. Also, the exponential demand for EV chargers and their management and operation, the deployment of DERs, the new topic of VPP which is rising, smart grids demand and other grid assets will require energy companies to increase their load forecasting efforts to be ready to face the needs of the current and future energy market.

6.2.6 Real time metering data

Smart grids are expected to contribute to the long-term vision of the European Council to become the world's first major economy to go climate neutral by 2050, by improving energy efficiency and achieving a 27% share of renewable energy penetration by 2030 [146]. The significant investment in smart grid projects allowed it to reach a fairly mature stage of smart metering, with almost 40% of the 281 million electricity consumers in the EU having a smart meter in 2017, expected to grow to 70% by the end of 2022 [147], as depicted in Figure 65.

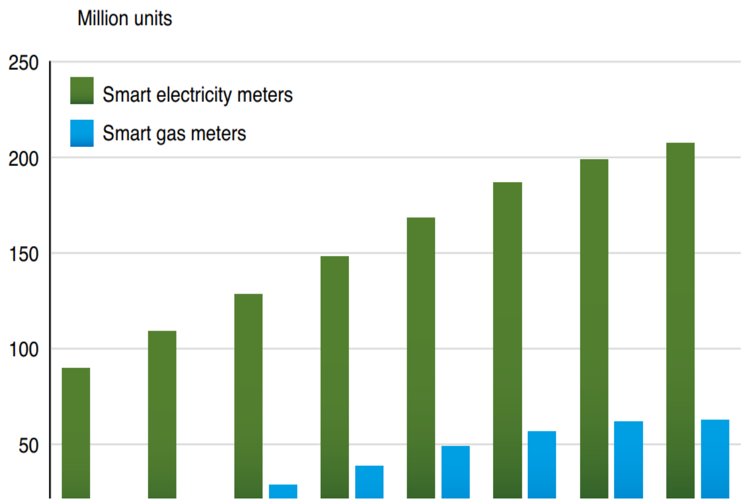


Figure 65. Installed base of smart electricity and gas meters

4 https://www.energymeteo.com/customers/grid_operators.php

5 https://www.energymeteo.com/customers/wind_solar_plant-operators.php

6 https://www.energymeteo.com/customers/power-traders.php

An EU-commissioned survey from 2018 indicated that all but two EU member states have conducted at least one cost-benefit analysis for a large-scale rollout of electricity smart meters to at least 80% by 2020, with mostly "positive" results, as shown in Figure 66. The most common benefits related for DSOs to support a full deployment are the operational savings through remote readings, the reduction of non-technical losses, and the consumer's bill reduction [148].

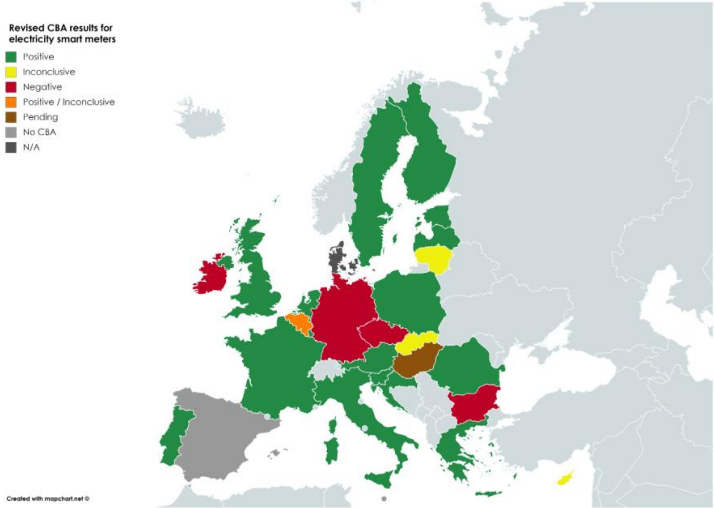


Figure 66. Qualitative results of cost-benefit analysis for a large-scale smart meters rollout up to 80% by 2020

In the rolling-out of devices, France, Spain and UK are expected to lead, with substantial contributions coming also from Austria and the Netherlands. The early adopters for a first nationwide smart meter deployment were Italy, Sweden, and Finland (Figure 67), where a second wave of rollouts is now expected, with an estimated 28 million of installed devices in Italy in the next decade.

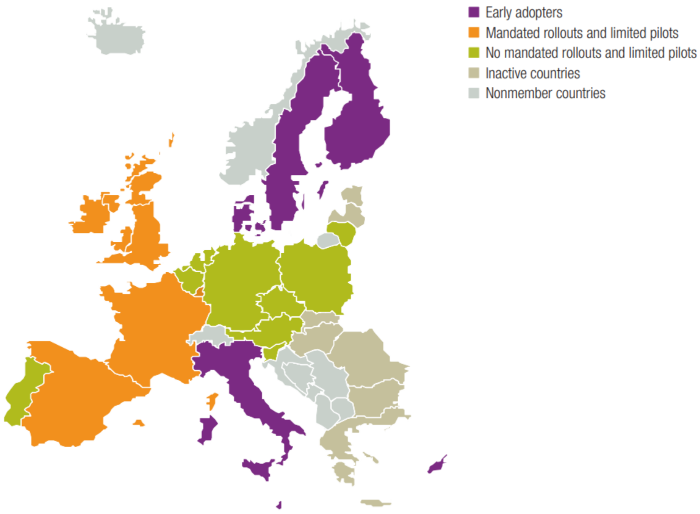


Figure 67. Smart meter deployment by EU member states

In the year 2021, up to 35 million units are expected to be installed in EU member states, compared to the 21 million of 2019, approaching a total of 123 million installed units (43% penetration rate [148]). Considering a weighted average cost of 172 Euro per metering point, the European-wide deployment required an investment of approximately 21 billion Euro [148]. Figure 68 summarizes the key figures for different electricity smart meters deployment scenarios in Europe.

	Number of electricity smart meters installed (in million)	Penetration rate at EU level (%)	Induced overall investment (€ billion)
2020 original target in households (ref. COM (2014)156)	~200 million	~72% in households	€45 billion based on original costing
Estimated 2020 State of play (households & SMEs)	123	43	21
Estimated 2024 State of play (households & SMEs)	223	77	38
Estimated 2030 State of play (households & SMEs)	266	92	46

Figure 68: Key figures for different electricity smart meters deployment state

According to a study conducted by McKinsey [149], the main barriers preventing a wider smart grid deployment in the last decade were the lack of a clear regulatory framework and specific incentives, the absence of customer demand for smart grid services, and segment-specific issues. For segment-specific issues is to be highlighted the lack of universal communication standards and protocols, as shown in Figure 69. To address these challenges, the European Commission has launched in 2009 the dedicated expert's platform of the Smart Grid Task Force to provide recommendations on privacy, cyber-security, policies, and standards for smart grid applications.

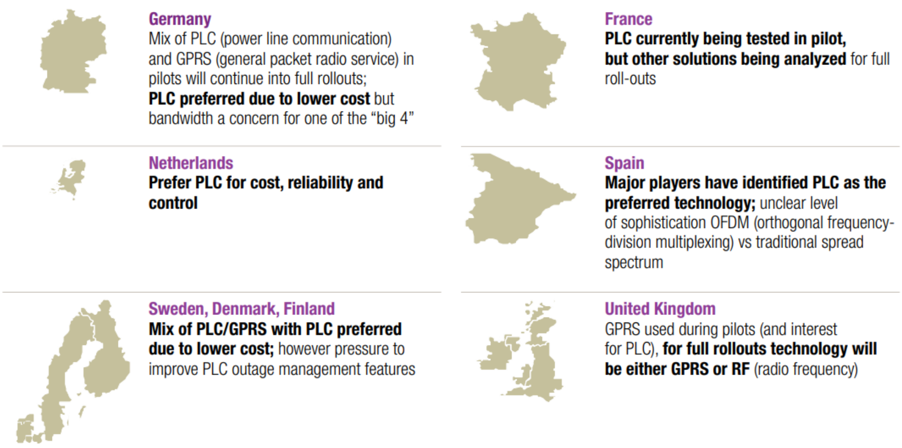


Figure 69. Several technical standards for smart meters in major EU nations

The potential value propositions enabled by smart meters are divided into standard and advanced value propositions [149]. Standard value propositions allow consumers to better understand and control their energy consumption with a clear impact on energy costs:

- **Comparison with peer consumers:** Leverage real metering data to compare electricity consumption with peers.
- **Bill forecasting:** Use historical data to forecast electricity costs.
- **Real-time consumption:** Increase awareness of electricity consumption aiming at reducing costs.
- **Real-time cost:** Help to obtain a better understanding of the electricity bill.
- **Unusual usage alert:** Help reduce electricity consumption, during specific periods of high usage.
- **Historical consumption:** Help consumers compare consumption during specific periods and understand their usage.

- **Real-time carbon impact:** Create an energy consumption footprint (e.g., in tCO_2 equivalent) and raise awareness.
- **Prepayment:** Introduce new payment capabilities as pay-as-you-go.
- **Implicit demand response:** Allow consumers to react accordingly to the electricity tariff, by reducing their consumption.

Advanced value propositions, require instead further technology development and market/regulatory contexts:

- **Flexibility provision:** Provide better information to consumers and allow them to react accordingly to dynamic tariffs (e.g., peak tariff). Valorise flexibility to the power markets through existing suppliers or by signing Service Level Agreements (SLAs) with aggregators.
- **Fuel poverty detection:** Detect fuel deprivation to households through data analytics to increase safety to vulnerable users.
- **Smart charging of EV:** Reduce the impact of EV charging by considering market and grid constraints, possibly lowering the cost of charging.
- **Smart charging of batteries:** Optimize battery charging based on grid constraints, tariff prices and PV production.

The worldwide smart energy market is fairly competitive, with leading players competing on price, performance, and market penetration [150]. A selected list of key vendors is reported here:

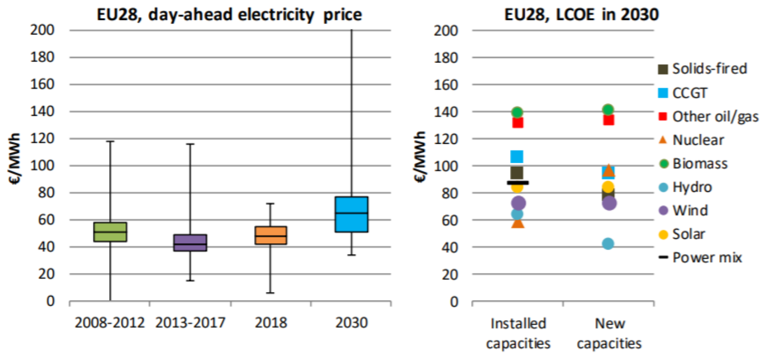
- **GE Energy:** one of the major players in the smart energy market, offers services, equipment and energy management solutions for energy supply (wind, solar, biogas among others). GE Energy provides a wide range of smart grid solutions such as smart meters and controls, software, analytics tools, grid diagnostics.
- **Itron:** one of the major players in the market with a product portfolio which includes electricity, gas, water and energy measurement technology as well as consulting services and communication systems.
- **Landis + Gyr:** Metering systems for electricity, gas, and water are available. It provides grid management systems, grid analytics software, and energy storage management solutions.
- **Siemens:** smart grid services and energy automation solutions. Siemens is one of the largest producers of energy-efficient and resources-saving solutions.
- **ABB:** provide different equipment for smart grid applications such as smart meters, electric vehicle charging equipment, automation systems, inverters and transformers.
- **S&T:** offers smart energy technologies and is a major supplier of smart energy technology products.

6.2.7 Price prediction tools

Hourly power rates are now decided by a variety of market processes rather than cost-based engineering estimates, thanks to the introduction of competition [151].

Historically, price forecasting has been performed with least-cost optimization models. These models compute marginal cost based on assumptions about system loads, power plant availability, and fuel prices. These models do not explain price fluctuations in a market system that are connected to business strategy and buyer and seller behaviour. In this volatile context, statistical models, which by definition reflect real market results, are better suited to short-term forecasting. The value of price prediction and forecasting has gained importance over the last years, with the opening of the European electricity markets and with the rise of renewables in the energy sector. However, it has also made it a challenge to obtain a balance between supply, demand, and prices [152].

Figure 70 presents the estimated range in which the price of electricity will be found for the period 2030-2050 in Europe, in national EU-28 markets.



Note 1: the box plots show the minimum observed in a given period (lower whisker), the first quartile (lower bar), the median (black line), the third quartile (upper bar) and the maximum (upper whisker).
Note 2: for visualisation purposes the left graph has been capped to 200 €/MWh.[13]
Note 3: costs for storage and additional interconnections are not accounted for in this Figure.
Note 4: historical prices are in current euros, values for 2030 are in 2013 euros. Prices and costs are averaged over the EU28.

Figure 70: EU28 electricity and fuel price trends for 2030

Figure 70 explores energy and fuel price trends in relation to the costs of energy investments, particularly in relation to Levelized Cost of Electricity (LCOE) which captures the capital and operating costs that must be covered [153].

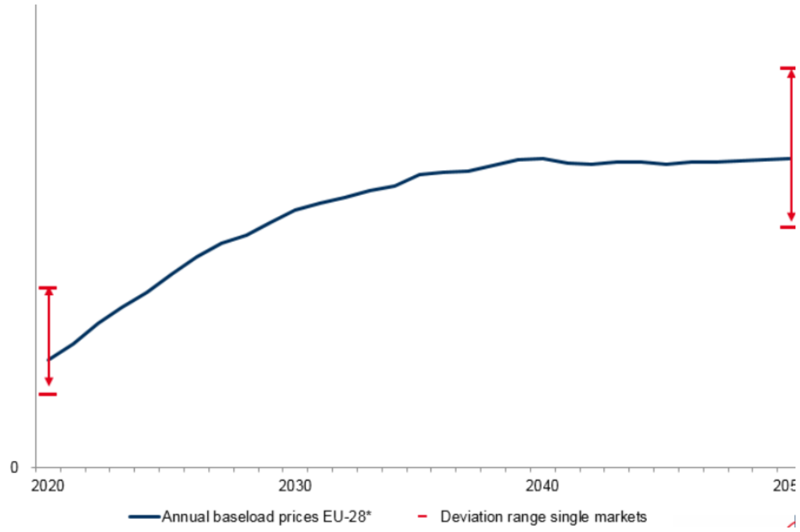


Figure 71: Power prices (real EUR2015) and deviation range in national EU-28 markets

Figure 71 shows energy prices (real EUR2015) and deviation range in EU-28 national markets, according to Energy Brainpool's Power2Sims simulation tool.

These references show an inherent increase in the electricity price in the European market, hence the importance of having tools that allow large companies and sectors involved in the electricity market, a reliable prediction of the price of energy seasonally or daily to improve productivity and knowing when they can reduce electricity costs.

This situation has resulted in a higher volatility on the electricity market, particularly on the short-terms market. Those who participate in the electricity market normally manage a commercial exchange between bidding in a day-by-day lower price market with higher volume or seeking for a lower volume market but with potentially better returns.

Market price predictions for the energy sector have become a fundamental input to everyone involved in the sector, mainly for the decision-making procedures at corporate level. Excessive price volatility, which can be up to two times higher than any other commodity or financial asset, has pushed market participants to guard against not only volume but also price risk, and the use of accurate electricity price forecasts based on machine learning tools to keep energy costs under control, allowing market participants and the industries to reduce the risks exposures and could probably obtain new sources of revenue or other opportunities [154].

Over the years it has been known that the electricity market has quasi-deterministic standards, rather than being based on assumption, therefore the need to forecast the price based on variables that can describe the outcome of the market. Many studies address this problem from a purely statistical approach or through lapses of variables, but frequently they focus only on the analysis of time series and do not give value to what the study of the sections that locally congest and increase the price could contribute.

Currently there are technologies, companies and European projects that are dedicated to the activity of energy prediction tools based in different methods and aiming to different sectors, some of them are described in the presented below:

- **WEAM4i – Water & Energy Advanced Management for irrigation:** Project aimed at optimising energy expenditure from irrigation activities in the agricultural sector. To this end, a price prediction tool for the wholesale electricity market was developed to adapt the demand for growing water to the cheapest electricity hours and thus reduce energy costs. The variables considered in the study included the availability for generation of the different technologies, weather forecasts, generation, demand, and derivatives markets. As a result, the hourly electricity matching price was estimated using an algorithm designed by Creara that considered the variables analysed. This algorithm is updated daily as input variables change.
- **AleaSoft:** Provides short-, medium- and long-term energy price forecasts in a variety of markets of the energy industry. It has supplied energy price forecasting for the major European electricity markets, providing services for traders, retailers, large clients, and electricity companies. AleaSoft supplements electricity price prediction with projections of additional price-related factors of importance to market participants, such as commodities prices projections (oil, gas, coal, CO2 emissions), production by technologies, and climatic variables impacting the energy business. The forecasts are offered in product format and service format. The product format comprises of the installation of an application that works automatically to update the data and provide forecasts. The service format consists of the daily transmission of updated price estimates as well as the major explanatory variables.
- **N-SIDE Electricity Price Forecasts:** The technology allows us to better predict price changes, manage the risks associated with them, and transform these into possible opportunities. The machine learning algorithms make advantage of 50K free parameters and 500 data sources, including weather conditions, electricity grid demand, and recent pricing changes.
- **Power2Sims by Energy Brainpool:** A software application that replicates hourly power costs for all nations in the European Union, as well as Norway and Switzerland, until the year 2050. The majority of the projections for the scenario are based on the IEA's "EU Energy [..] Trends to 2050" and "World Energy Outlook 2016." Energy Brainpool adjusts the assumptions based on national objectives. Results for individual countries vary strongly in some cases. For sound market assessments, solid modelling of individual national markets, including sensitivity analyses, is indispensable.
- **OMIE:** OMIE is the designated electricity market operator (NEMO, according to European terminology) for managing the daily and intraday electricity market in the Iberian Peninsula. The company actively participates in the coupling of the wholesale electricity markets in the EU, together with all the NEMOs designated in each Member State. The functions they perform are classified into the functionality of the market, rules and adhesion contracts, information to market agents, information to third parties, transparency, independence and objectivity.
- **E·SIOS:** Red Eléctrica has developed an information system called the System Operator Information System (e · sios) to carry information and management tasks of the processes related to the electricity market. The system allows RE to communicate with OMIE, Market

Subjects (SM), the technicians of the System Operator, the operators of the electrical systems of neighbouring countries, publish the results of the different markets and schedules, seek involvement in the deflectable resource auctions, the auction calls and their outcomes, preserve both the information that enters the system and that which results from the various processes in its history database.

The quarterly report of the European Commission on European Electricity Markets (issue 3, for the third quarter of 2020) describes that the third quarter of 2020 brought a gradual shift toward more normal conditions in European electricity markets. The removal of lockdown measures and the relaxation of limitations on social and economic activities aided in the recovery of power demand, which returned to pre-pandemic levels in September. Electricity consumption in the EU was 3% fewer in Q3 2020 compared to the previous month a year earlier, a significant improvement from the 11% yearly decline in Q2 2020 [152].

Wholesale prices across the continent continued to recover from record lows reached in April and May as electricity demand gradually returned to normal levels. However, price dispersion was still relatively high even in September, with Nord Pool system price moving around 16 €/MWh at one end and Italy and Greece registering prices three times higher at the other end of the spectrum. The European Power Benchmark averaged 34 €/MWh in Q3 2020. This was 15% less than in the same quarter last year [152].

The new opportunity of the activities on price predicting tool on the PARITY project brings the possibility of offering a more flexible electricity market, detecting the sections that congest the network, and therefore, make the market and energy prices fluctuate more, to find ways to solve these problems and stabilize energy costs, favouring consumers and sellers. This tool seeks, in addition to estimating electricity intraday prices, to detect the problems that locally disrupt the network and who can regulate it, that is, to serve as a congestion management tool.

In addition, the possibility of penalizing only those who cause congestion in the network and those who cause an inordinate high in energy costs is being analysed and studied, and thus favour and help those who maintain stable consumption during their active hours.

6.2.8 Blockchain enabled smart contracts

In 2020, the blockchain industry was estimated to be worth USD 3.67 billion. From 2021 to 2028, it is projected to rise at a CAGR of 82.4% and it is considered as a technology with a lot of potential. Global blockchain technology revenues are anticipated to rise in the coming years, with the industry reaching over 39 billion US dollars, according to forecasts by the end of 2025. Nonetheless, the global smart contract industry is expected to hit $300 million by the end of 2023. This can be achieved with an estimated annual growth rate of 32% from 2017 to 2023. The smart contract industry is currently booming in Europe, which is the major hub. This is mostly attributed to the accelerated digitalization of European business markets during the last decade. A large number of European organizations are incorporating digital technologies to increase their productivity, and smart contracts are an important part of their development [155]. Additionally, according to Gartner, Inc., by 2023, companies using blockchain smart contracts would improve their average data quality by 50% while decreasing data availability by 30% [156].

While it would necessitate considerable time, resources, and effort expenditures, blockchain adoption in the renewable energy industry might boost exposure, increase operational efficiencies, and streamline regulatory reporting. The energy industry's interconnected architecture makes it ideally suited for blockchain technology developments, despite the fact that it seems to be attracting mostly in financial services. With the advent of IoT, the energy industry's processes may soon be turned into a global network of smart objects, all feeding digital data into a platform that can collect and exchange data during runtime.

The worldwide blockchain industry within the energy field is forecast to rise at a CAGR of 78.32% to $7,110.1 million by 2023, from an estimated $394.3 million in 2018. This rise can be due to the growing popularity of blockchain technologies in the energy market, the need to handle networks and other business operations with fast transaction rates and immutability, and global security issues. Next are presented some use cases and market trends that illustrate the potential of blockchain and smart contracts within the energy sector [157].

Trading:

Renewable energy transparency and global exchange are two of blockchain technology's most ambitious use cases. The planet is turning away from the use of gas, coal, and petrol and toward green energies. As a result, blockchain will play an increasingly important role in connecting renewable technologies, grids, and smart applications to individuals and communities. Blockchain is a distributed ledger that can accept information such as the amount of energy created by smart devices like solar panels. It keeps track of this information, assigns a price to it, sends it to smart homes via the grid, and keeps track of incoming payments for energy purchased [158]. Since microgrids allow the trading of power within a given region with the main grid, market vendors may benefit from their expanded usage. Since both sides are using the same network, energy transfers can be recorded and settled nearly immediately via blockchain, with no need for a "middle-man" and little to no need for consultation. Furthermore, an application may contain executable machine-readable code that represents a contract's terms, resulting in a "smart contract" that validates transactions automatically without the need for human interaction. Its suitability as an effective and dependable open trading network could be used for both physical and financial trading of energy commodities across the globe [159].

Regulatory reporting and compliance:

Alternative renewable energy industry is expanding and system reliability at the local, global, and European levels is the primary target of power grid management. Direct P2P trading with virtual power plant (VPP) aggregation is a feasible option that could be built on blockchain technology." With the spike of "prosumers" across countries, there is a need for regulatory structure and licensing guidelines. Only by regulations will the existence of prosumers in the energy sector be established, and the use of blockchain for trading with these prosumers would be standardized. Regulators are constantly demanding that energy companies have massive quantities of data that can be reviewed to identify noncompliance and other regulatory concerns. Although, there is a substantial risk that the data will fall into the hands of the wrong individuals and be mishandled, revealing confidential corporate knowledge and placing a company at a competitive disadvantage. Blockchain has the ability to remove the majority of these problems, facilitating accountability and allowing authorities to safely access clean, tamper-proof data, while also allowing businesses to keep tight control over what information is available and who is entitled to access it. A significant side effect of having such a platform to exchange information with regulators is that it will provide a common data format for the industry (i.e., standardization), which is currently unavailable.

Ricardian Contracts:

A Ricardian contract is a legally binding human-readable document that is negotiated upon and ratified by all parties to the contract. Following that, it is translated into a machine-readable contract that specifically specifies the stated intentions of all parties concerned. This contract's flow will effectively simplify operations on different blockchain applications based on this technology. A Ricardian contract can be stated as a smart contract and it is both machine and human-readable [18].

Certificate verification:

The authenticity and timeliness of certificates act as the foundation for trust among business partners. The Blockchain's digital encryption assists enterprises in their regulatory activities and compliance to rules and regulations. Certificates produced with blockchain technologies are tamper-proof and can be accessed transparently by all network participants. As a result, providers of such solutions guarantee that audits and certification, for example, can be performed successfully. However, digital certificates may also serve as evidence of possession or origin.

Secure Digital Identity:

When we communicate on the internet, extensive digital footprints are left behind. Digital identification technologies will assist in the protection of our web presence and will dramatically reduce online fraud and identity theft. Data is maintained in a decentralized, trusted, and permanent manner using blockchain technologies. Blockchains will guarantee that a user's exclusive digital identification is safely and incorruptibly held. This unified digital identity will still be kept up to date with the most recent user details. Online networks are designing and incorporating a range of digital identity solutions.

The blockchain industry in the energy sector is intensely competitive, with a variety of big players. In terms of market share, the market is currently dominated by a few big players. These business leaders are concentrating their efforts on expanding their consumer base in international countries. Furthermore, these players are relying on strategic partnership strategies to grow their market share and profitability. Companies in the industry are now acquiring start-ups focused on blockchain in energy technology in order to improve their product capabilities. **Microsoft, Accenture, IBM, Infosys, and SAP SE** are among the major players in the global blockchain in the energy market. The major players are pursuing a range of methodologies in order to maximize their share of the blockchain in the energy market. Other players in the market include **BigchainDB, BTL Group Limited, Deloitte, Grid+, Infosys, Nodalblock, AWS, Oracle, Power Ledger, WePower,** and **Lo3 Energy, Inc** [158]. Promising blockchain start-ups routinely receive hundreds of millions of dollars in funding for their initial offerings, with especially promising ones, such as EOS, raking in billions [160].

This technology is a game-changing confidence mechanism that will reduce the need for expensive intermediaries and create an unparalleled degree of accountability, collaboration, and knowledge exchange in the energy industry—all while enabling businesses to maintain leverage over confidential information that gives them a competitive edge in the market. As a result, it has enormous potential to increase both productivity and efficacy, thus adding value to the whole sector. However, reaping the full benefits of this technology would necessitate a multi-pronged endeavour.

6.3 Market Adoption Roadmap for PARITY Offering

While it is certain that LEMs and LFMs combined with emerging technologies such as DERs, blockchain and smart contracts bring multiple benefits for companies, the proper adoption roadmap is still confusing and can vary depending on the industry and the company culture. The adoption of blockchain enabled LEMs/LFMs technologies within the company projects must start with a strong roadmap to overcome the challenge identified in this document as well as the technological, economic and social barriers identified in D4.1 of the PARITY project [19].

PARITY aims to enable the set-up and operation of local flexibility markets at the distribution network level via a holistic offering with three key pillars:

1. **A smart contract enabled, blockchain based local flexibility market platform (LFM)** which will facilitate both peer- to-peer energy/flexibility transactions as well as the sell/purchase of flexibility to Smart Grid actors. Energy/flexibility credits will be used to stimulate liquidity in the local market and to provide the means for market coupling with national energy & ancillary service markets through a mechanism that will link these virtual credits to actual currency.
2. **IoT enabled DER Flexibility management tools** – Both in a P2P distributed manner and through a centralized aggregator, these tools range from technologies that uncover unexpressed demand flexibility in building (e.g., P2H solutions) and flexibility from sources that are not yet fully exploited in the current market ecosystem (e.g., EVs) to techniques for analysing, organizing, and managing these distributed flexibility sources.
3. **Smart Grid monitoring and management tools** to enable the DSO to optimally manage the low voltage distribution network in the presence of increasing intermittent RES penetration and with the aim to contain the problems they create to grid stability. These tools will comprise both software tools for the real-time monitoring and control of the network assets as well as an innovative grid component (STATCOM) which can physically manage power flows on the grid and facilitate the containment of instability and its resolution via services for power quality restoration.

Moreover, PARITY offers the management and analytic tools needed from a renewable energy project without the need of combining solutions from different providers along the adoption roadmap.

Additionally, PARITY components developed within the project provide tools and services for the different actors (e.g., DSOs, aggregators, prosumers, retailers etc.) in the adoption of LFM/LEM projects.

Four business cases and twelve use cases in four demonstration sites across Europe are implemented within PARITY project (details can be found in D3.1 "PARITY_D3.1_PARITY Business use cases & Requirements", while D8.5 "Report on the operation and use of the PARITY Framework during pilot testing" shows how PARITY offering has been used from the definition of the business use cases to the implementation and integration with existing organisation and IT systems.

Following the technical process for the adoption of PARITY offering in the project business cases, and considering the opportunities and challenges mentioned in the previous sections, we propose an adoption roadmap that comprises of six phases, relevant to individuals, organisations and/ or households who wish to adopt the PARITY solution, as depicted in Figure 72.

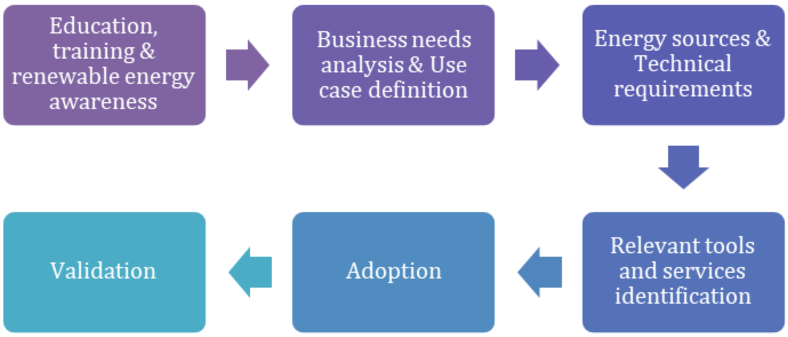


Figure 72: Market Adoption Roadmap for PARITY Offering

Phase 1: Education, Training & Renewable energy awareness:

The starting point for the adoption of a more efficient electricity system into organisations and/or households (or even at an individual level) is an initial phase of awareness and knowledge about big data benefits and opportunities for the organisation. This phase aims at overcoming the cultural reluctance of the abovementioned (potential) customers to adopt smart systems based on DERs, as well as blockchain and smart contracts technologies for high reliability and safety.

Within this phase, the interested parties gather information on their market context, LFM/LEM landscape, realise the value of monitoring and controlling the generation, storage and energy consumption from smart systems, analyse how blockchain and smart contracts could help to support market coupling with national energy & ancillary service markets through a mechanism that will link energy/flexibility credits to actual currency and investigate the opportunities of IoT enabled DER flexibility management tools.

Phase 2: Business needs analysis & Use case definition:

Following the initial stage, the interested party must extract corporate/household objectives and priorities, as well as identify the challenges and needs to attain those goals, and then transform them into a business case with quantifiable results. Furthermore, the interested party should define the success factors and KPIs, as well as the roles of the participants in the use case.

Phase 3: Energy sources & Technical requirements:

Once business use cases have been defined, the party should assess their landscape and what type of energy sources are needed for the use case: available DER, local energy market capabilities, infrastructure available etc. Moreover, within this phase, technical requirements are evaluated to determine the technological readiness for adopting LEMs and LFMs combined with emerging technologies: technical roles, existing IT systems, IoT devices available, blockchain requirements, storage capabilities, etc.

Phase 4: Relevant tools and services identification:

Depending on the business case and objectives of the interested party, it is necessary to choose which PARITY products and services are most suited to handle them. Furthermore, an assessment of the current systems and technologies that will be integrated with the PARITY solution should be performed to minimize integration bottlenecks.

Phase 5: Adoption:

At this stage, the local flexibility management platform will be in place, thanks to the integration of IoT and Blockchain technologies provided by PARITY solutions, allowing for the effective usage of local micro-transactions and reward flexibility in a cost-reflective and symmetric manner, via price signals with higher spatio-temporal granularity based on the real grid operating condition. The interested party should ensure that each participant understands how PARITY tools will help the daily needs within such flexibility market. Trainings and workshops will be held to teach teams how to use the PARITY solution to gain actionable insights and gain a competitive advantage.

Phase 6: Validation:

At the final adoption phase, the assessment of the KPIs and criteria success factors should take place and the advantages gained using PARITY solutions in the business use cases should be clearly identified. Evaluation of the implementation cost of PARITY solutions and measurement of the ROI should also take place.

7. Conclusions

Within the six chapters of the D10.1 PARITY Market Intelligence on LFM tools Plan, the methodology and market insights are presented, which are considered as the baseline for the PARITY market profitability. Within this document, market intelligence is defined as the information that is derived by the PARITY tools and services from the energy market, to contribute in the determination of market segmentation, market penetration, market potential, and current market parameters. Market intelligence is regarded as an essential component of PARITY initiative, as it assists us in understanding the condition of the market as well as collecting competition intelligence, which helps becoming lucrative.

Following the background information provided within the distributed energy ecosystem, a series of market analysis regarding Local Flexibility Markets and Energy Market tools and services were presented. A detailed market analysis was made around DLTs and blockchain, smart distribution systems and DERs, business development services for LFM/LEM, smart grid monitoring and management, IoT and smart contracts enabled energy transactions and DERs flexibility profiling. Specific opportunities and challenges were identified in the above-mentioned areas. Afterwards, a high-level market penetration took place, exploring the patterns that form the energy market transformation, measure awareness regarding energy market and gain insights on energy market tools and services through a survey implemented within this task and disseminated to PARITY experts and general public. Within this deliverable, we considered market penetration as a measurement on how much PARITY related products and services are being used by potential customers. Additionally, within the market penetration phase, we evaluated potential customers' opinions on the concept of LEM and LFM, to identify factors and barriers to the progress of local renewable energy development based on their knowledge and what would motivate people to participate in such markets. The current market needs were also identified and analysed. Finally, during the market development phase, segments of interest were presented. Market segmentation is of high importance since it will allow PARITY to concentrate on marketing strategies on targeting the most valuable markets and achieving its objectives. Additionally, market segmentation will help PARITY to get to know its clients, define what is expected in their market segment, and decide if the provided products and services will better satisfy their needs. Moreover, future market trends based on the PARITY tools and services were presented and a market adoption roadmap for the PARITY offerings is proposed at the end.

During the work carried out within T10.1 and presented in D10.1, it was realised that market intelligence not only will help PARITY to distinguish its offerings from its competitors but will also help in providing valuable information to succeed and be established within the market. The following benefits were provided during the analysis carried out within this deliverable: (a) gain holistic view of the market, (b) potential customers retention, (c) identify gaps and give actionable insights, (d) gain a competitive advantage.

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ANNEX A: Survey Questions

In this annex, the survey created to get information about the energy market transformation and the customers' perspective is presented.

Demographics:

1. *Which category below includes your age?*
    - 17 or younger
    - 18-24
    - 25-29
    - 30-39
    - 40-49
    - 50-59
    - 60 or older
2. *What is your gender?*
    - Male
    - Female
    - Other
3. *What is your highest level of education?*
    - No formal education
    - High school diploma
    - Bachelor’s degree
    - Master’s degree
    - Doctorate degree
    - Other – Please specify
4. *What is your permanent residence country?*
    - Please specify
5. *Which of the following categories best describes your employment status?*
    - Self-employed
    - Full time employment
    - Part-time employment
    - Retired
    - Unemployed
    - Other – Please specify
6. *What knowledge level do you have about emerging technologies in the energy sector (renewable energy, microgrids, smart meters, blockchain, energy storage technologies etc)?*
    - Very strong understanding
    - Somewhat understand
    - Have heard of it, but do not really understand
    - No understanding

Energy transformation insights:

The following questions aim to explore the overall patterns that will form the energy market transformation.

7. *In your final energy consumption, do you know from where the electricity comes from?*
    - Power stations burning fossil fuels
    - Renewable energy sources,
    - Residual Mix
    - Nuclear
    - I don’t know

8. *Do you think that your current energy bill is perceived as reasonable in terms of costs?*

- 1 – Yes
- 2 – No
- 3 – I don't know

9. *Do you think that the risk is higher or lower with energy system based on more centralized energy 'generation'?*
    - 1- Higher
        - What do you think are the main risks electricity markets based on more centralized generation are facing?
            - Energy availability/Supply risk (e.g. blackouts)
                i. 1 – No risk
                ii. 2 – Small risk
                iii. 3 – Medium risk
                iv. 4 – High risk
            - Emissions/Air pollution (e.g. Carbon Monoxide)
                i. 1 – No risk
                ii. 2 – Small risk
                iii. 3 – Medium risk
                iv. 4 – High risk
            - Cyberattack (e.g. using malware capable of deleting data and causing physical damage to industrial control systems)
                i. 1 – No risk
                ii. 2 – Small risk
                iii. 3 – Medium risk
                iv. 4 – High risk
            - Bulk generation of energy (e.g. generating energy from large-scale projects, security of supply, environmental risks)
                i. 1 – No risk
                ii. 2 – Small risk
                iii. 3 – Medium risk
                iv. 4 – High risk
            - Risk of unjust pricing schemes (e.g. Fixed, Time-of-Use, Critical-Peak, Real-Time etc)
                i. 1 – No risk
                ii. 2 – Small risk
                iii. 3 – Medium risk
                iv. 4 – High risk
    - 2 - Lower
    - 3 - The same
        - Why do you think so?
            - *Free text*
    - 4 - I don't know

10. *In how many years do you anticipate the energy market will be mostly based on Distributed Energy Recourses (DERs) (e.g. solar photovoltaic, electric vehicles)?*

- By the end of 2021
- By the end of 2023
- By the end of 2025
- By the end of 2030
- By the end of 2035
- Other – Please specify

11. *What of the following obstacles for fast adoption of Local Flexibility Markets (LFMs) do you think have the largest impact?*

- EU Regulation/Legislation
    i. 1 – No impact
    ii. 2 – Small impact
    iii. 3 – Medium impact

   iv. 4 – High impact
- National Regulation/Legislation
   i. 1 – No impact
   ii. 2 – Small impact
   iii. 3 – Medium impact
   iv. 4 – High impact
- Insufficient technological design
   i. 1 – No impact
   ii. 2 – Small impact
   iii. 3 – Medium impact
   iv. 4 – High impact
- Public acceptance
   i. 1 – No impact
   ii. 2 – Small impact
   iii. 3 – Medium impact
   iv. 4 – High impact
- Market stakeholder's adaptation
   i. 1 – No impact
   ii. 2 – Small impact
   iii. 3 – Medium impact
   iv. 4 – High impact
- Lack of standardization
   i. 1 – No impact
   ii. 2 – Small impact
   iii. 3 – Medium impact
   iv. 4 – High impact
- Lack of interoperability between equipment and stakeholders
   i. 1 – No impact
   ii. 2 – Small impact
   iii. 3 – Medium impact
   iv. 4 – High impact

12. *To the best of your knowledge, are there any resources (i.e. funding/monetary incentives, information material, regulatory incentives) available to promote the development of renewable energy in your country, particularly for small renewable energy producers and citizens?*

- Yes
- No
- I don't know

13. *To the best of your knowledge, are in your country guaranteed feed-in tariffs set to encourage energy from renewable sources?*

- Yes
- No
- I don't know

Market Change:

The following questions aim to explore participants' experience on LEM and LFM so far, identify factors that might determine who is probable or unlikely to be interested in offering flexibility, electricity or other resources in the local energy market and what would motivate people to participate in such markets.

14. *New Suggestion: Do you see a benefit in participating in a local energy community where you can buy and sell electricity from/to local peers/neighbours in an autonomous way (assuming that a Collective Self-Consumption mechanism is part of this Local Energy Community)?"*
   - I don't see any benefit
   - Financial benefit for the prosumers/consumers
   - Non- financial benefit for the prosumers/consumers ("green spirit")
   - Benefit for the Distribution System Operator (DSO)

- Benefit for Suppliers/Retailers
- Attractive business opportunities for new stakeholders
- Increased investment in renewables (e.g. PV) and other DERs (heat pumps, battery storage, EV etc.)
- Others - please specify

15. *Which of the following statements would you agree to? In 5 to 10 years…*
    - All buildings will have some sorts of flexible energy assets (e.g. heat pumps, EV charging station, battery storage)
    - Most buildings will have flexible energy assets
    - Most *new* buildings will have flexible energy assets
    - Most households will have flexible energy assets
    - Only few buildings will have flexible energy assets
    - Other – Please specify

16. *Which of the following technologies are you expecting to have the largest effect in the near future on your local energy market?*
    - Flexibility from Electric Vehicle chargers that can be controlled automatically
        i. 1 – No impact
        ii. 2 – Small impact
        iii. 3 – Medium impact
        iv. 4 – High impact
        v. 5 – Very high impact
    - Solar electricity generation
        i. 1 – No impact
        ii. 2 – Small impact
        iii. 3 – Medium impact
        iv. 4 – High impact
        v. 5 – Very high impact
    - On-shore wind electricity generation
        i. 1 – No impact
        ii. 2 – Small impact
        iii. 3 – Medium impact
        iv. 4 – High impact
        v. 5 – Very high impact
    - Off-shore wind electricity generation
        i. 1 – No impact
        ii. 2 – Small impact
        iii. 3 – Medium impact
        iv. 4 – High impact
        v. 5 – Very high impact
    - Centralised energy storage
        i. 1 – No impact
        ii. 2 – Small impact
        iii. 3 – Medium impact
        iv. 4 – High impact
        v. 5 – Very high impact
    - Distributed energy storage through battery technologies
        i. 1 – No impact
        ii. 2 – Small impact
        iii. 3 – Medium impact
        iv. 4 – High impact
        v. 5 – Very high impact
    - Nuclear electricity generation
        i. 1 – No impact
        ii. 2 – Small impact
        iii. 3 – Medium impact
        iv. 4 – High impact
        v. 5 – Very high impact
    - Natural gas turbine electricity generation
        i. 1 – No impact

ii. 2 – Small impact
iii. 3 – Medium impact
iv. 4 – High impact
v. 5 – Very high impact

17. *How much changes do you expect the current energy market to undergo in the near future?*

- 1 – No change
- 2 – Little change
- 3 – Medium change
- 4 – Significant change
- 5 – Very significant change

18. *What of the following concepts are you expecting to be of high importance in the near future?*

- Large-scale centralized fossil fuel power generation
    i. 1 – No importance
    ii. 2 – Small importance
    iii. 3 – Medium importance
    iv. 4 – High importance
    v. 5 – Very high importance
- Large-scale centralized renewable generation
    i. 1 – No importance
    ii. 2 – Small importance
    iii. 3 – Medium importance
    iv. 4 – High importance
    v. 5 – Very high importance
- Distributed generation
    i. 1 – No importance
    ii. 2 – Small importance
    iii. 3 – Medium importance
    iv. 4 – High importance
    v. 5 – Very high importance
- Local energy systems and infrastructure
    i. 1 – No importance
    ii. 2 – Small importance
    iii. 3 – Medium importance
    iv. 4 – High importance
    v. 5 – Very high importance
- Electric Vehicles
    i. 1 – No importance
    ii. 2 – Small importance
    iii. 3 – Medium importance
    iv. 4 – High importance
    v. 5 – Very high importance
- Smart home
    i. 1 – No importance
    ii. 2 – Small importance
    iii. 3 – Medium importance
    iv. 4 – High importance
    v. 5 – Very high importance
- Off-grid energy solutions
    i. 1 – No importance
    ii. 2 – Small importance
    iii. 3 – Medium importance
    iv. 4 – High importance
    v. 5 – Very high importance

19. *What results from changes in business models on the electricity markets do you anticipate to see in the near future?*

- More competition

- Expansion of renewable energy
- Shift to distributed generation
- Localisation of the market (e.g. Peer to Peer (P2P) trading)
- More options for consumers to choose from

20. *How important will the following capabilities be in terms of the feasibility of energy market business models that include LFM and LEM components?*

- Dynamic pricing schemes
  i. 1 – No importance
  ii. 2 – Small importance
  iii. 3 – Medium importance
  iv. 4 – High importance
  v. 5 – Very high importance
- Energy assets management
  i. 1 – No importance
  ii. 2 – Small importance
  iii. 3 – Medium importance
  iv. 4 – High importance
  v. 5 – Very high importance
- Intelligent smart control and pricing optimisation mechanisms
  i. 1 – No importance
  ii. 2 – Small importance
  iii. 3 – Medium importance
  iv. 4 – High importance
  v. 5 – Very high importance
- Customer management
  i. 1 – No importance
  ii. 2 – Small importance
  iii. 3 – Medium importance
  iv. 4 – High importance
  v. 5 – Very high importance
- Operational technologies
  i. 1 – No importance
  ii. 2 – Small importance
  iii. 3 – Medium importance
  iv. 4 – High importance
  v. 5 – Very high importance
- Local energy trading (P2P trading)
  i. 1 – No importance
  ii. 2 – Small importance
  iii. 3 – Medium importance
  iv. 4 – High importance
  v. 5 – Very high importance
- Data security and confidentiality
  i. 1 – No importance
  ii. 2 – Small importance
  iii. 3 – Medium importance
  iv. 4 – High importance
  v. 5 – Very high importance
- Privacy
  i. 1 – No importance
  ii. 2 – Small importance
  iii. 3 – Medium importance
  iv. 4 – High importance
  v. 5 – Very high importance

Market Segments:

The following questions aim to gain insights on energy market tools and services and identify market segments and trends.

21. *In your opinion, which of the following tools and services will boost the profitability and efficiency in use of Distributed Energy Resources?*

- Distributed Energy Recourses (DERs) profile models (EVs, Hot Water, White appliances, Lighting)
- Load forecasting
- Standardized specifications
- Virtual Energy Storage (VES) Models
- Building-as-a-Battery
- Storage-as-a-Service
- Dynamic pricing schemes
- Flexibility monetization schemes for prosumers and end-users
- Smart energy contracts
- Smart grid monitoring and Active Network Management (ANM) Services
- Local Flexibility Market (LFM) models
- P2P trading in Local Electricity Markets (LEMs)
- Other – Please specify

22. *Do you think that real-time metering data is necessary in order to maximize usefulness and success of local energy markets?*

- Yes
- No
- I am not sure

23. *In your opinion, do you think improved price prediction tools will increase revenue by exchanging flexibility assets within a Local Flexibility Market (LFM)??*

- Yes
- No
- I am not sure

24. *In your opinion, do you think automated energy agreements could be helpful through use of blockchain-enabled smart contracts?*

- Yes
- No
- I am not sure

25. *In your opinion, do you think European funds could be oriented to develop technological solutions related to?*

- Energy efficient
- Flexibility
- Monitoring and control
- Storage
- Other – Please specify