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Executive Summary

This document shows how smart contracts can be leveraged for a legally compliant and automated operation of a local flexibility market, and which aspects have to be tackled in a traditional form of contractual agreements. The contracts are defined based on the requirements of the project and the foreseen business and use cases.

As a first step, a state of the art of blockchain technology was presented, with a specific focus on legally enforceable contracts and their challenges in respect to international regulations and privacy enforcement (GDPR). This showed that smart contract technology can be utilized for the operation of a local flexibility market. However, the best practices for legally-enforceable smart contracts present several arguments in support of hybrid smart contracts over stand-alone smart contracts. Human intervention is necessary for interpretation of the variations between the spirit and letter of the law. While smart contracts are rigid and inflexible, conventional contracts offer room for reason in their interpretation.

Hybrid smart contracts can use traditional documentation to cater for areas of contracts that may not translate easily in computer code. These include features such as the governing laws, dispute resolution, force majeure, fallback mechanisms and indemnification for coding errors and other issues. For these reasons the smart contracts developed in PARITY cannot be self-contained and legally enforceable but they will need to implement automatic mechanisms to be tied to terms and conditions described in traditional contract documents: SLA agreements, international and national laws and regulation.

Then the existing SLA from previous experience in Spain, Greece, Switzerland and Sweden were analysed, helping the description of SLA-best practices for PARITY business cases, with a clear separation of standard SLAs coming from existing use cases and business models and new types of contracts related to PARITY business cases. A survey performed with PARITY partners identified a set of recommendations to be used for the design and development of PARITY's local flexibility market and his components in following work package. The survey result showed that additional types of contracts and agreements are needed to manage the local exchange of energy and flexibility and to manage different types of grid status through the traffic light approach. In particular, the recommendation highlights that a local market has to take into account regulatory aspects especially for the DSO role, because of its natural monopoly on the local physical grid. This is crucial especially for the yellow and red state of the traffic light signals. The local techno-economical optimal operation cannot avoid these aspects.

Finally, the connection of SLAs to the smart contracts was explored, by looking at technical, legal and regulatory and social aspects. Important recommendation regarding the social aspects were identified. In particular, prosumers could prefer semi-autonomous mode, where they could interact with the system by setting important parameters. A smart contract-enabled local flexibility market could be quite challenging to understand, so the user interface for prosumers should be easy to understand but allowing the possibility to transparently check the operations if needed. Also, the revenue and fees model coming from the local flexibility market should be easy to understand. Most of the prosumers are willing to accept multiple contracts, but the priority should be given first to the energy consumption optimization before following any demand response signal.

The document results will be used for the design and development of PARITY local flexibility market.

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List of Acronyms and Abbreviations

Term	Description
ABCI	Application Blockchain Interface
ACER	Agency for the Cooperation of Energy Regulators
BC	Business Case
BFT	Byzantine Fault Tolerant
BRP	Balance
DER	Distributed Energy Resources
DHW	Domestic Hot Water
DLT	Distributed Ledger Technology
DR	Demand Response
DSC	Data Storage Contract
DSO	Distribution System Operator
DSR	Demand Side Response
EV	Electric Vehicle
EVM	Ethereum Virtual Machine
GDPR	General Data Protection Regulation
HV	High Voltage
HVAC	Heating, Ventilation and Air Conditioning
IBC	Inter-Blockchain Communication
IDAS	Electronic Identification, Authentication and Trust Services
IEC	Initial Energy Coins
KPI	Key Performance Indicators
LEC	Local Energy Community
LEM	Local Electricity Market
LEMO	Local Electricity Market Operator
LFM	Local Flexibility Market
LFMO	Local Flexibility Market Operator
LSC	Logic Storage Contract
LSC_ADDR	Logic Storage Contract Address
MO	Market Operator
MV	Medium Voltage
MW	Megawatt
NRA	National Regulatory Agency
P2P	Peer-to-peer
POD	Point of Delivery
PoS	Proof-of-stake
PoW	Proof-of-work
PV	Photovoltaic
RE	Renewable Energy

RES	Renewable Energy System
ROI	Return of Investment
SDK	Software Development Kit
SLA	Service Level Agreement
SO	System Operator
TPS	Transaction Per Second
TSO	Transmission System Operator
USEF	Universal Smart Energy Framework
VPP	Virtual Power Plant

1. Introduction

1.1 Scope and objectives of the deliverable

In order to facilitate the automated exchange of flexibility among actors in a manner acceptable to citizens/end-users of electricity, this deliverable analyses how new forms of energy contracts between different actors in the energy market could leverage the automation capability offered by smart contract technology. It will operate in parallel with T4.4, as input from the structure of the business model is useful in determining the concepts needed to regulate each contract.

The first goal of this deliverable is to show how far smart contract technology can be leveraged for a legally compliant and automated operation of a local flexibility market and which aspects have to be tackled in a traditional form of contractual agreements. This topic should not only be analysed from the technological perspective but also business, legal and social aspects have to be considered.

The second goal of this deliverable is to deliver a set of recommendations to be used as basis for the design and development of PARITY's local flexibility market and his components in following work packages.

1.2 Structure of the deliverable

In section 2 of this deliverable a state of the art of blockchain technology is presented, with a specific focus on legally enforceable contracts and their challenges with respect to international regulations and privacy enforcement (GDPR). In section 3, the existing SLA from previous experiences in Spain, Greece, Switzerland and Sweden are shown. Next, in section 4 SLA-best practices for PARITY business cases are described, with a clear separation of standard SLAs coming from existing use cases and business models and new types of contracts related to PARITY business cases. Finally, in section 6 the connection of SLAs to the smart contracts is explored, by looking at technical, legal and regulatory and social aspects.

1.3 Relation to other tasks and deliverables

For this report, input was received from the work performed in task T3.1 (Elicitation and analysis of business/use cases and requirements for the PARITY tool suite) that is described in the D3.1 (PARITY Business use cases & Requirements). As input also results from D4.3 (Integration of LFM into the existing Electricity) from task T4.3 (Investigation of LFM market models for TSO/DSO/Aggregator/Retailer collaboration) were considered. During the task's work also a close collaboration and ideas exchanges were performed with task T4.4 (Definition of business models for LFM actors). By analysing and defining the contracts needed for PARITY's business cases this report helps to refine the work in T4.4.

Furthermore, the output of task T4.2 will be an important element, not only for WP5 (Local Flexibility Market Platform), but also for WP6 (Smart Grid Optimization & Management) and WP7 (DER Flexibility Management & Storage-as-a-Service).

2. State of the art of blockchain technology

2.1 Blockchain, smart contracts, state-channels, sidechains and cosmos network

In the last few decades, there has been an upsurge in the rate at which digital technology is advancing. The growth of the internet has opened immense opportunities for innovations designed to simplify human interactions. As a result, every industry known to man has incorporated various digital solutions in its operations. These technologies have revolutionized financial applications, automation, data management, artificial intelligence and many others.

The blockchain is one of the most disruptive technology solutions developed in recent years. It was launched in 2008 to facilitate the deployment of Bitcoin, the first globally accepted digital currency. Yet, the blockchain has evolved to handle several different types of data and information such as property ownership, national records, outstanding loans, business mergers, shares and stocks.

The invention of the blockchain revolutionized how people understand and interact with data. It provided a reliable way to verify information and transactions without using third parties like lawyers and banks. This simplified digital transactions immensely. Blockchain improved the credibility, speed and affordability of digital transactions all over the world.

Yet, in its early days, the blockchain had several limitations. Incidentally, the ubiquitous acceptance of the technology opened up avenues for its improvement. One of the latest improvements to the technology is the blockchain system known as Cosmos.

Cosmos is a holistic technology that solves the fundamental challenges of using blockchain. It is a decentralized network of blockchains that are independent and parallel to each other. Cosmos is powered by BFT consensus algorithms like Tendermint that enable faster yet safer data verification. It also enables parallel independent blockchains to communicate and transfer assets to each other.

To fully appreciate the features of Cosmos, it is vital to understand how conventional blockchain works. With its unconventional design, Cosmos addresses three fundamental blockchain limitations. These are:

- **Scalability:** Enabling faster yet more affordable data verification on the blockchain
- **Usability:** Simplifying the process for developers to understand and build blockchain applications
- **Interoperability:** Unlocking siloed blockchain economies using Interblockchain Communication (IBC)

2.1.1 How Does Blockchain Technology Work?

While the blockchain performs a wide variety of functions, it is simply an immutable decentralized distributed digital ledger. The blockchain keeps a permanent record of verified information in a tamper-proof format. Each piece of information is encrypted and stored in a data unit called a block. The blocks are linked to each other with powerful cryptography to form chains. These form the ledger or database referred to as the blockchain.

Blockchain Data Validation

Conventional transactions need trusted third parties to verify the information presented by the traders. These third parties include banks, financial institutions, credit review boards and governmental agencies. You need to verify the authenticity of documents, ownership, identity and financial status of the traders before making a deal. These verification processes can be costly and time-consuming.

In the blockchain, transactions are verified by an independent network of validators or miners. The miners each manage an independent copy of the ledger that must have the same information in the same order. The synchronization of these distributed ledgers validates the blockchain's data.

The miners or validators commit powerful computational resources to verify the information in the ledger before committing it to a new block in the chain. Each new block needs to be verified by more than two-thirds of the validators in the network. If less than a third of the validators are faulty, or erroneous the data is accepted and added to a new block on the chain.

Blockchain Security

In the blockchain, every transaction or related data is verified and recorded in an individual block. The block is then permanently linked to any previous related transaction and corresponding ledgers. The links are characterized by complex cryptography that is unique to the users involved and the specific transaction. Each block is linked and validated by the previous one. This saves the time and money typically spent on conventional due diligence.

Also, the blockchain data is decentralized. Conventional ledgers can only be stored in one location at a time: probably in a vault or safety deposit box. However, data in the blockchain is stored in multiple ledgers that are updated simultaneously. This adds another layer of security against hackers and possible attacks.

To successfully tamper with any blockchain entry, a hacker would have to alter the entire chain. He would also need to edit the ledgers of everyone else on the network in question.

Blockchain Sovereignty

The blockchain is an independent database that is not owned or controlled by any government or regional authority. The distributed ledgers are managed by miners in various parts of the world. As such it is not limited by time zones, regional legislation or language barriers.

Participants on the blockchain use unique encrypted keys to access their information. They don't need to reveal true identities and can use pseudonyms or remain anonymous.

Anonymous participants interact by opening smart contracts and agreeing on terms that can be written in code and executed automatically. Real-world participants who simply want to use the blockchain to execute part of their transactions can form hybrid smart contracts. Hybrid contracts combine smart and conventional contracts and can be designed to abide by specific real-world laws or jurisdictions.

2.1.2 Understanding Blockchain Limitations

While its potential is recognized globally, blockchain technology has been held back by its inherent limitations. Ironically, the blockchain’s limitations are caused by the same features that promote its reliability. These are

- Transaction security protocols
- Speed of transaction verification
- Cost-effective transactions

By increasing the blockchains security protocols, the system compromises on speed and cost-effectiveness. Yet to increase the speed of transactions, it would need to simplify its security measures. Finally, the blockchain, in its fundamental state, cannot increase the speed or security protocols without raising the cost of transactions.

The above challenges have been described as the Blockchain Trilemma[2] and are fundamental for limiting the blockchain scalability nowadays. Verifying blockchain transactions takes time and a lot of computational power. Yet, these processes are part of what sets the blockchain apart from conventional transactions.

2.1.3 Blockchain Architectural Structure

While the above limitations seem straightforward, they are challenging to resolve. This is because they are ingrained in the essential structure of blockchain applications.

To understand the Cosmos solutions, it is best first to consider the blockchain’s internal architecture. It is also important to look at how the structures of the conventional blockchains, Bitcoin and Ethereum compare to Cosmos. The blockchain structure consists of the following three conceptual layers:

- The Application Layer
- The Networking Layer
- The Consensus Layer

The Application layer handles the state of the transactions. It is the program that holds and modifies a state when it receives inputs.

The Networking Layer propagates transactions and handles messages concerning consensus. It ensures that the blockchain is deterministic. This secures the consistency of repeated transactions and their resultant states.

The Consensus Layer is concerned with the validation of transactions. It ensures that the blockchain's honest nodes see the same state simultaneously. This transaction enhances the validation process.

Bitcoin Architectural Structure

Bitcoin was the first digital currency to be deployed using blockchain technology. It is a peer-to-peer digital currency which uses the Proof-of-Work (PoW) protocol as its consensus mechanism.

By 2017, just nine years after its inception, the Bitcoin was the 6th largest currency in circulation worldwide[3]. This rapid growth of bitcoin exposed its fundamental limitations. The demand for new applications and uses of the blockchain rose as the industry recognized its potential.

Yet, the bitcoin blockchain limitations created several bottlenecks. Its architectural makeup merged the three conceptual layers together. This made it difficult to isolate the application, networking and consensus functions of the blockchain. It was also coded in a limited scripting language that was difficult to understand.

In its defence, the bitcoin blockchain structure was designed specifically to facilitate the operation of Bitcoin currency. A role it has performed with precision. To develop other decentralized applications (dApps), developers only had two options: to build on top of the bitcoin codebase or to fork it. Both approaches needed advanced technical ability and equipment.

Ethereum Architectural Structure

Ethereum is considered the second generation of blockchain technology. It was proposed by cryptocurrency researcher and programmer, Vitalik Buterin in 2013 and launched in July 2015. Ethereum was the first successful attempt to improve the prevailing blockchain technology.

Ethereum developed the Ethereum Virtual Machine (EVM) which freed its application layer to function virtually. This enabled developers to build dApps on the blockchain. It liberates blockchain participants by allowing them to process permissionless smart contracts.

Yet, since the Ethereum's design uses a single platform to fit all use cases, it faces various limitations. Below are the three main limitations that users experience.

- Scalability
- Usability
- Sovereignty

Ethereum scalability is limited by the fact that it still used the Proof of Work (PoW) protocols to deter service abuses on the network. This approach limits the processing throughput of its blockchain to 10 to 15 Transactions Per Second (TPS). As such, dApps have to share the limited resources of the blockchain.

Ethereum usability is limited because all the dApps are developed on the EVM system. The system is also limited to a small number of programming languages. This limits the flexibility and freedom that developers have when designing applications.

Ethereum sovereignty is limited by the use of a single underlying environment. All the dApps are built on the EVM. This means that any modifications to the applications are subject to the EVM approval. As such, the governance is shared between the applications and the EVM. This creates bottlenecks in the execution of decisions, installation of upgrades and resolution of bugs among other functions.

Second Layer Blockchain Solutions

In a bid to overcome the blockchain trilemma and scale-up, the conventional blockchains developed side chains and state channels. These are second layer solutions that enable blockchains to free up computational power by performing predefined transactions off the main chain.

The side chains and state channels create a way to increase the blockchain TPS significantly without compromising on security or affordability. Here is a brief description of how these systems work.

What is a Blockchain State Channel?

A State Channel is a blockchain layer 2 solution that allows a group of participants to perform an unlimited number of private transactions off-chain. Unlike conventional on-chain transactions, the state channel transactions are not made public. They are only visible to participants on the channel. Only the initial and final state of the transactions is recorded in the main blockchain.

State channels enable people who need to make several exchanges between themselves to maintain a blockchain ledger. Recording multiple small exchanges is cumbersome on the blockchain. This is because each transaction needs to be verified and confirmed by miners. This can slow down the type of fast-paced exchanges the state channel participants need.

State channels enable groups to perform secure, fast and low-cost transactions using blockchain technology. The state channel solutions [4] in use today hold the promise of high scalability with some capable of doing thousands of transactions per second.

What is a Blockchain Side Chain?

Sidechains are smaller blockchains that run in parallel to the main blockchain. During operation, they transfer assets to and from the main chain to reduce congestion and facilitate scalability. Carrying out your transactions on a side chain can significantly increase the blockchain's TPS.

Sidechains have a similar structure and operational mechanism to the blockchain (main chain). Unlike state channels, every transaction in a side chain is recorded and forms a new block. Yet, side-chain blocks can be verified faster because they need fewer verifications and distributed consent than the main chain.

The sidechain is linked to the main chain via a two-way peg that allows the transfer of assets between the two chains. Assets are transferred at a predetermined rate such that the blockchain is consistently updated of the state of transactions on the side chain.

Performing transactions on side-chains ease the computational burden and congestion of the main chain. This allows participants to carry out faster transactions. Sidechains are permanent and not limited to a set group of users. They also facilitate cryptocurrency interchangeability.

2.1.4 The Cosmos Network Solution

The Cosmos Network is an ecosystem of blockchains that was launched in 2019 by Tendermint. Off the block, Cosmos solves the main challenges of scalability by enabling independent blockchains to interact with each other.

The developers of Cosmos took apart the fundamental blockchain technology and rebuilt it for scalability. As a result, the new structure allows developers to build independent application-specific blockchains capable of governing themselves. It liberates the blockchains to perform specific tasks and communicate with other blockchains when necessary. The Cosmos end goal is to create an unlimited internet of blockchains.

How Cosmos Works

The key feature of the Cosmos is that it enables people to build secure yet scalable and interoperable blockchains quickly. It does this by first restructuring the conventional architecture of the blockchains. It then provides open-source tools and avenues to simplify blockchain building. As an open-source community project, Cosmos puts the development power in the hands of the public. This provides a vast pool of human resources for the development of the cosmos ecosystem.

Cosmos Architecture

The Ethereum network gave developers partial sovereignty by allowing them to develop smart contracts on the EVM. This enabled them to develop dApps on top of the Ethereum blockchain. Instead, Cosmos gives developers full sovereignty by providing the tools to develop complete application-specific blockchains. It did this by providing open-source tools that gave developers the framework to build complete blockchains without redesigning the conceptual application, consensus and networking layers. These tools are listed below

- Tendermint BFT
- Cosmos SDK
- IBC

Understanding Tendermint BFT

The Tendermint BFT addresses the blockchain scalability challenge. It replaces the conventional blockchain Proof of Work (PoW) protocols with Cosmos Proof of Stake (PoS) protocol. This significantly increases the volume of transactions that a blockchain can validate in a period of time.

Tendermint was created by Jae Kwon in 2014. It is a state-of-the-art engine that packages the blockchain's networking and consensus layers together. This allows developers to focus on building applications rather than the entire blockchain framework from scratch. Bypassing the networking and consensus layers enable developers to complete applications in a fraction of the time.

Tendermint uses a byzantine fault-tolerant (BFT) consensus algorithm that guarantees the safety of up to a third of the malicious or faulty actors on a blockchain validation system.

To connect to applications, Tendermint BFT uses the Application Blockchain Interface (ABCI) protocol. This is a socket protocol that can be built with any programming language. ABCI eliminates the programming language limitations that developers faced with other blockchain technologies. Below are some of the additional benefits of using the Tendermint BFT.

- **Works with public or private blockchains:** It allows developers to determine the constitution of their validator sets. Public blockchains select their validators based on Proof-of-Stake (PoS) while private blockchains use a restricted set of pre-authorized validators.
- **Handles High-Speed Transactions:** It is a high-performance engine that can handle thousands of transactions per second. This significantly increases the scalability options of any blockchain developer.
- **Offers Minimal delays:** Tendermint's consensus algorithm uses instant finality features. This means that transactions are finalized, and new blocks are added to the chain as long as more than a third of the validators are credible.

Understanding the Cosmos SDK

The Cosmos SDK addresses the blockchain usability challenge. It provides the framework that enables developers to build interoperable, application-specific blockchains on Tendermint BFT. The Cosmos SDK is based on the following two principles.

- Modularity
- Capabilities-based Security

Cosmos SDK modularity

The Cosmos SDK provides developers with a set of modules that enable them to build application-specific blockchains easily. These modules free developers from the need to code the entire functionality of their applications from scratch. Developers can use the ready-made cosmos SDK modules by importing them into their applications.

Since anyone can develop modules for the cosmos SDK platform, its ecosystem will expand as the network develops. This will enable developers to build more complex applications as the technology evolves.

Cosmos SDK capabilities-based security

With a system that allows anyone to develop modules, it is to be expected that malicious programs may be developed. The Capabilities-based security system limits the interaction between modules that don't have pre-existing connectivity. This reduces the risk of unexpected interactions within the cosmos SDK system.

The Cosmos SDK systems are designed to set the ball rolling for the development of an expansive ecosystem of blockchains. As such the cosmos network is structured to allow the development of multiple SDKs that can work with other ABCI consensus engines besides Tendermint BFT.

Understanding Inter-blockchain Communication (IBC)

Conventional blockchain technologies are siloed. This means that information and transactions can only be performed within the specific blockchain technology. Herein lays the interoperability limitation. The Cosmos Network solves this challenge by implementing the inter-blockchain communication (IBC) protocol. It facilitates the transfer of value or data between independent or heterogeneous blockchains.

The IBCg protocol is directly applicable to blockchains that use fast-finality consensus algorithms such as the Tendermint instant finality property. Conventional blockchains like Bitcoin and Ethereum, which use Proof of Work protocols, cannot work directly with the IBC. They need to use proxy-chains called Peg-Zones to interact with the IBC.

Cosmos Scalability

The final stage of cosmos networks superiority is its ability to scale blockchain technology. It achieves this by combining all its modifications and leveraging them to achieve vertical and horizontal scalability.

Vertical scalability is currently being achieved by Cosmos three dynamic technologies. The implementation of Tendermint BFT, Cosmos SDK and the IBC increase the speed of application-specific blockchain deployment and the number TPS significantly.

Horizontal scalability is the next stage of Cosmos network development. It is working towards developing multi-chain architectures. This will enable multiple parallel chains to run the same application with common validator sets. With this type of solution, there is no limit to the scalability of blockchains.

2.2 Legally enforceable smart contracts

The nature of business transactions is constantly evolving. This evolution is driven by a wide variety of socioeconomic and geopolitical factors. Over the past few decades, globalization and industrialization have had a significant impact on how people do business across the globe [6]. As the market embraces new technologies, the necessary infrastructure grows to support it.

Smart contracts are among several disruptive technologies that have emerged in response to the e-commerce revolution. Supported by the blockchain infrastructure, smart contracts and several other solutions are reshaping business transactions globally.

Smart contracts are currently defined as computer codes that automatically execute all or parts of an agreement and are stored in blockchain-based platforms [17].

Global growth of digital Infrastructure

In the traditional marketplace, physical interaction was necessary when trading goods or services for a medium of exchange. Yet, the development of e-commerce is steadily eliminating such trade barriers[2].

Digitization has revolutionized the nature of goods, services, media of exchange and modes of interaction between transacting parties. It is estimated that e-commerce sales may exceed physical retail by 2024 [8].

According to the McKinsey Global Institute, MGI, the world is living in a new era of digital globalization. In a 2016 report, the institute reported that the cross-border flow of data was generating more economic value than the flow of conventional traded goods. MGI also found that, while the global flow of trade and finance was declining, the flow of data had grown 45 times between 2005 and 2014 [15]. Such trends have fuelled the development of several types of digital infrastructure and e-commerce technologies.

In November 2019, about a decade after its inception, bitcoin became the world's sixth-largest currency in circulation [16]. At about the same time, the value of all cryptocurrencies reached $0.25 trillion. This was a significant amount because the value of all US dollars and Euros in circulation at that time was $1.7 trillion and $1.4 trillion respectively [16].

The ubiquitous use of digital transactions enhances the demand for legally enforceable smart contracts. This notion is validated by the widespread shift from conventional paper to digital transactions. Digital globalization is steadily pushing more deals and transactions away from conventional paper to digital platforms.

The limitations of conventional text-based contracts are escalated when making digital agreements. Using conventional contracts to keep track of digital and e-commerce dealings can be counterproductive. This is evident when negotiating deals that don't require the physical contact of transacting parties or exchange of goods. Smart contracts not only facilitate but also enhance these kinds of operations.

2.2.1 Origin of Smart Contracts

The first authentic electronic transaction was done in 1995 with the sale and delivery of Amazon's first book. Within a year, more than 40 million people were connected to the Internet. Businesses worldwide went on to make online sales, exceeding US$1 billion by 1996. In the wake of this wave of digital sales, Nick Szabo, a computer scientist and cryptographer presented the concept of Smart Contracts [9].

In his 1996 publication, Szabo defined Smart Contracts as 'A set of promises, specified in digital form, including protocols within which the parties perform these promises'. The use of the term "smart" did not refer to the incorporation of artificial intelligence systems. Rather it was to differentiate the digital self-executing contracts from the conventional inanimate paper contracts [9].

Two years after his smart contracts publication, Szabo developed the mechanism for a decentralized digital currency known as "Bit Gold" in 1998. Although it was not implemented, Bit Gold broke the ground for the development of Bitcoin and the Blockchain ten years later [10].

2.2.2 How Smart Contract Works

Nick Szabo's most famous illustration of how a smart contract worked was a basic vending machine. A buyer would initiate a smart contract by inserting a coin into the vending machine and selecting the desired product. This would trigger an automated fulfilment of the request, driven by a series of coded checks [9].

The vending machine's process would follow a predetermined sequence to deliver the desired product if all checks were met. The process was fully automated and could not be interrupted once initiated. Also, the security of the process was in the degree of difficulty to manipulate the system. The cost of tampering with the system far exceeded the value of the products [9].

The vending machine analogy is one of the simplest ways to describe the operation of a smart contract. Smart contracts vary in complexity from straightforward payments to intricate deals involving multiple stakeholders. They can be used to structure insurance payouts, sports betting and pay-as-you-go services among others [11][12].

Nick Szabo's 1996 definition is widely accepted as the original description of Smart Contracts. Yet, a new definition was necessary after the global integration of Bitcoin and Blockchain as digital financial mechanisms.

A smart contract is now defined as a piece of code which is stored within the blockchain network or another distributed ledger technology (DLT) database. A smart contract is also referred to as "Smart Agreement", and similar to a Service Level Agreement (SLA) it defines curtain conditions to which all parties agree to, and if these conditions are met the executed contract is taking certain actions. As smart contracts are implanted using software, they are able to re-engineer themselves dynamically, and be self-enforced and self-executed, depending on whether the defined conditions are met. To understand how smart contracts work, it is necessary to first consider how the blockchain works.

<u>Impact of Blockchain Versatility</u>

Blockchain started as the technology that facilitated the use of bitcoin. Yet, it has grown to encompass several other avenues of interaction. Blockchain has developed beyond digital currency transactions. It can now store several different types of digital information.

This growth of blockchain-enabled the actualization of Nick Szabo's idea of Smart Contracts. With the advent of Blockchain 2.0, the world of blockchain was moved to the second stage, introducing the Ethereum network, pioneered Vitalik Buterin, and bringing to life Szabo's idea of smart contracts [25]. The rapid adoption of blockchain technology has warranted the necessity of scaling the blockchain. This will enable the blockchain to keep up with the speed of other e-commerce middlemen such as VISA and SWIFT [14].

Storing smart contracts on the blockchain enhances their reliability and validity. They benefit from all the advantages of information stored on the blockchain. This includes immutability, irreversibility and autonomy.

Smart contracts on the blockchain are faster and cheaper to execute than conventional contracts. Transacting parties avoid the additional costs of involving third parties such as lawyers, banks and escrow companies in the deal. The blockchain itself acts as the third party that verifies the transactions.

<u>Types of Smart Contracts</u>

For the most part, businesses need legally binding agreements for security during operations. Contractual agreements are especially important when dealing with parties with whom you don't have a direct relationship.

Conventional contracts were written up, verified and enforced by objective third parties. These could be lawyers, banks, insurance firms and others. Yet, legally enforceable smart contracts allow direct communication between the transacting parties.

Smart contracts are increasing in popularity because they can save time and money. They also reduce the degree of human input during the fulfilment of contractual obligations.

Conventional and smart contracts are fundamentally varied in the way they are developed and presented, as depicted in Figure 1. Conventional contracts are written in legal or legible human languages. Yet, smart contracts are written in code [18].

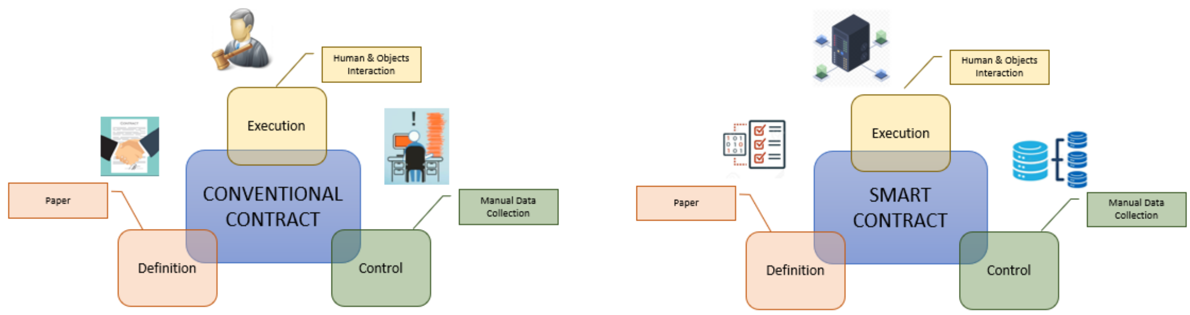

Figure 1. Comparison between conventional and traditional contracts

There are two main types of smart contracts. These are stand-alone and hybrid smart contracts [19].

Stand-Alone Smart Contracts

Stand-alone smart contracts are fully written in computer programming code. They are also known as code-only smart contracts [17].

Stand-alone smart contracts are fully autonomous and can operate without human input once initiated. They are also legally recognized and can be enforced without the support of natural language documentation [18].

Hybrid Smart Contracts

Hybrid smart contracts use a combination of computer code and natural language or text-based documentation for execution. They are also known as ancillary smart contracts [17].

The degree of natural documentation versus computer code distinguishes the various types of hybrid smart contracts [18]. The three main types of hybrid smart contracts are as follows:

Conventional contracts with encoded digital functions

This is a type of contract that is written in a natural language yet uses computer coding to perform simple functions. The most common encoded function is the automated processing of payments. Transactions can be initiated and negotiated conventionally but paid for using digital mechanisms.

Conventional contracts with automated performance mechanisms

This is a conventional written contract using a natural language whose implementation is supported by encoded performance mechanisms. In this type of contract, digital automated functions go beyond basic payment functions. They form integral parts of the contract execution processes.

Coded contracts with supporting conventional documentation

This is a type of smart contract that is written in computer code and is supplemented by a conventional schedule in natural language. While the majority of the functions in this type of contract are encoded, it still requires the support of conventional documentation for its implementation.

2.2.3 *What Makes A Contract Legally Enforceable?*

Where a smart contract has a legally binding force, the technology in which it is implemented may often give rise to legal enforceability problems (especially in the case of a permission-less distributed ledger). A key feature of a smart contract is that once the code is entered on the blockchain, it becomes irreversible, and once a trigger event has been fulfilled, its output cannot be arbitrarily prevented or varied by any party. The novel problem of smart contracts is what happens when an arrangement can be executed not by enforcers of public law but by the terms and conditions laid down in the contract itself [27]. The accused party would need to go to court with a smart contract to resolve a contract that has either been or is in the process of being enforced. This is because a smart contract is already being executed by definition, or in the process of being executed by the time the court hears the case. In order to understand how smart contracts could be placed within the law, formation, performance, and breach should be taken into consideration.

A contract is an agreement between two or more parties with mutual obligations that can be enforced by law. Legally enforceable contracts are validated on the presence of the elements listed below [20].

i. Mutual Assent
ii. Expression and acceptance of a valid offer
iii. Adequate Consideration
iv. The Capacity to enter a binding contract
v. Legality

Even if, the incorporation of smart contracts within business brings several benefits, there are also practical and legal considerations to be considered by the parties when developing and implementing smart contracts on a blockchain. To be legally enforceable, smart contracts must meet the primary attributes of a conventional written contract. The use of legal terms and language when developing conventional contracts ensures compliance with the above requirements.

Yet, smart contracts are written using computer codes that are read and carried out by machines. As such, broader considerations go into the interpretation and compliance requirements to make smart contracts legally enforceable. Two regulatory authorities considered for this report are

- The Rome I Regulations for contracts in the EU [21]
- The United States Contract Law [22]

The US contract law simplifies the requirements for an agreement to qualify as a legally binding contract into the following three considerations.

- There must be a meeting of the minds
- There must be an offer and acceptance
- There must be an exchange of consideration

Meeting of the Minds

A meeting of the minds refers to consensual formulation or entry into the agreement. All the parties of the agreement should be aware of the terms and conditions of the contract. It can also be termed as mutual assent [19].

Offer and Acceptance

An offer and acceptance refer to the initiation and response to the terms of the agreement. The offer must include the mutual obligations of the transacting parties. Smart contracts may use electronic messaging with Public Key Infrastructure to present and accept the offers securely [18].

Consideration

The 'consideration' requirement refers to an exchange of value between the parties as part of the contract's mutual obligations. The value exchanged can be financial or the fulfilment of mutually agreed-upon obligations.

Additional governing laws in the US support the use of "electronic agents" and the legal validity of digitally executed contracts. These include the Federal E-SIGN Act and the Uniform Electronic Transaction Act (UETA).

The enforcement of smart contracts abides by the same extenuating circumstances as conventional contracts. This means that breaches of contractual law during the formation of the smart contracts can void their validity. Examples of these breaches include violation of public policy, the advocating of criminal activities and entering a binding contract with a minor among others [19].

2.2.4 Smart Contract Enforcement Challenges

Fundamental features of the smart contracts such as coding protocols and the blockchain technology cause enforcement challenges. They may occur even in contracts that comply with all the attributes of a conventional binding agreement. This section features some of the most common challenges faced in the enforcement of smart contracts.

Jurisdiction

The blockchain is a decentralized public ledger that is not subject to any central government or authority. While this is one of the blockchain's main advantages, it creates jurisdictional challenges in the prosecution of smart contracts.

Conventional contracts are formulated under a specific set of laws or jurisdiction of implementation. Smart contracts can rely on Article 3 of the Rome I Regulation that facilitates the principle of Party Autonomy. This principle allows contract parties to choose governing laws for their agreement without having a territorial connection to that jurisdiction [23].

However, courts in the US can overrule the choice of law where a substantial connection to the territory is absent. The courts can also disregard the choice of law if its application violates public policy [19]. Other provisions that disputing parties can use to determine the jurisdiction for enforcement of smart contracts include

- The domicile of the transacting parties
- The IP address of the transacting parties
- The location where the contract was negotiated, coded or executed
- Any prior agreements involving the parties.

Blockchain Anonymity

Transacting parties on the blockchain have the liberty to use pseudonyms or remain anonymous. This feature adds a layer of security and discretion to individuals or organizations that transact on the blockchain. Yet, anonymity creates a challenge when enforcing smart contracts by law. This is because the courts cannot prove the identity of the disputing parties.

Automation and Immutability

Smart contracts are designed to work autonomously. Storage on the blockchain also makes these contracts immutable. This means that any error that exists in the smart contract code will occur automatically and cannot be reversed or changed.

These features increase the complexity of resolving smart contract disputes. This is especially challenging is dispute resolution protocols were not built into the smart contract code.

Legal considerations

While smart contracts are self-executed, they are not *fundamentally* legally enforceable, along with their output. A smart contract and the mechanisms used for "agreeing" to a smart contract should include all the characteristics that uphold conventional contracts to be legally enforceable, as mentioned in the previous Section. For instance, as stated by Jeffrey D. in Practical Law [26], smart contracts may not be legally enforceable in transferring legal ownership of (physical or digital) assets tokenized on the blockchain. In order to effectively achieve a shift in the legal ownership of a tangible asset, a smart contract needs to meet specific conditions for the transfer of legal ownership.

2.2.5 Blockchain Enabled Smart Contracts and GDPR

In the near future, smart contracts are expected to evolve and develop to take automated decisions that may be driven by data from EU residents. As a result, decisions and measures made under the GDPR law may be challenged. In the case of a stored smart contract within a public blockchain, which does not contain any programmability to deal with the reversal of the decisions it will take, consequentially it will not comply with GDPR, and the smart contract issuer could be held liable [28].

In order to resolve this issue, one could assume that personal data of EU residents could not be included within a smart contract. Following this solution though, the context moves away from the legally enforceable smart contract, since this could reduce the usefulness of the smart agreement, such as health record tracking, supply chain tracking and more. To resolve the above-mentioned issue, it should be ensured that all stored personal data within a smart contract are encrypted. At this point, a question arises, whether encrypted and hashed person data are still personal data. This analysis highlights the difficulty in determining whether data that was once personal data can be "anonymized" enough in order to meet the GDPR threshold.

Although the issues mentioned before are under debate, blockchain technology and smart contracts might be a suitable tool to achieve some of the GDPR's underlying objectives. Blockchain and DLTs can be built to allow data sharing without the need for a third-party and provide transparency to the accessed data. Moreover, smart contracts can also automate data sharing, thus reducing transaction costs [29].

It should be emphasised that, even if the automated decision-making process is necessary to verify or execute a contract between the data subject and the data controller, the controller is obliged to take some necessary measures.

- Ensure that the data subject is able to receive human input (thus violating full process automation),
- Express different point of views on the relevant results and
- Contest decisions that may arise from the proceedings.

2.2.6 Smart Contract's Regulation in Europe

The European Union (EU) is persuaded that blockchain technology will play a crucial role in developing the Single Digital Market for Europe, driving important developments in the industry. It is important to note that currently "smart contracts" actually have no legal consequences, they are not enforced by the law. It is only a piece of code recorded on the blockchain that will auto-execute once it has been deployed. Thus, the interaction of blockchain, smart contracts, and law is essential. In order to harmonize those technologies, there are some points to be considered to create a holistic European regulatory framework. Based on the European Blockchain Observatory and Forum those include [30]:

- Create simple and usable definitions of blockchain technology and smart contracts that can be used as shared definitions for EU and Member State regulators.
- Widely communicate legal definitions, in order to have a mutual understanding among regulators such as IDAS (Electronic Identification, Authentication and Trust Services) and the GDPR (General Data Protection Regulation).

- Blockchain and smart contracts' regulation should harmonize the law and interpretations in all European countries.
- Develop a common understanding of the technology, to train accordingly the regulators and policy makers.
- Focus on mature smart contract use cases.

With these in mind, United Kingdom has taken some significant steps towards this direction. In November 2019, Geoffrey Vos, Chancellor of the UK High Court, announced the launch of a *"Legal Statement on Crypto Assets and Smart Contracts,"* which he described as a "watershed moment" for English Law. Among other key points, in the statement is pointed out that a smart contract has all the attributes of a contract under English law: (i) two or more parties have reached an agreement; (ii) the parties intend to create a legal relationship; and (iii) the terms of the relationship depend on the parties' words and conduct *"just as it does with any other contract"*. Also, it is stated that wherever rules require a written signature, those requirements can very likely be met using a private key, or a code element *"recorded in source code"*. Overall, the takeaway is that *"there is no reason why the normal rules should not apply just because a potential contract is a smart contract"*. It is obvious that the flexibility of English law helps to adapt new technologies such as blockchain enabled smart contracts [31].

2.2.7 Smart Contract's International Regulation

From the international point of view, in light of the recent blockchain boom, many US states have passed blockchain specific laws, such as Arizona, Delaware, Nevada, Tennessee and Wyoming. As of July 2019, Wyoming passed 13 blockchain-enabling laws to follow the "*Delaware of Digital Asset Law"* position and include a system in which blockchain users and developers have a room that respects their property rights and offers regulatory relief [29]. From the other hand, the state of Arizona is making fewer progressive steps, focusing mainly on how legal terms can be translated into code without mistakes, and who is going to be responsible in case such mistakes are made. In order to explain their position, smart contract advocates usually expect that businesses and the public at large will eventually trust the blockchain and smart contract framework [30].

2.2.8 Round-Up

Legally enforceable smart contracts have come a long way since their inception. Yet, the continuous evolution of technology puts constant pressure on judicial systems to adapt to overcome enforcement limitations.

The best practices for legally-enforceable smart contracts present several arguments in support of hybrid smart contracts over stand-alone smart contracts. Human intervention is necessary for interpretation of the variations between the spirit and the letter of the law. While smart contracts are rigid and inflexible, conventional contracts offer room for reason in their interpretation.

Hybrid smart contracts can use traditional documentation to cater for areas of contracts that may not translate easily in computer code. These include features such as the governing laws, dispute resolution, force majeure, fallback mechanisms and indemnification for coding errors and other issues [19].

3. Existing SLAs from previous experiences

This section presents examples of existing or ongoing SLAs to be applied at pilot sites across different European countries, based on PARITY partners' experiences. For each case, a short description of the site, stakeholders and their roles, contracts and compulsory regulations are provided.

3.1 SPAIN

3.1.1 Pilot project description

The Granada Living Lab is envisioned as a "living" energy ecosystem, which contains much more than a technical environment, as characterized by a set of energy generation and storage devices, communication, control, and IT infrastructure. The Granada Living Lab aims to create a test platform to implement new ideas and business models supported by the digital utility of the future. There are 2 main characteristics that differentiates the Granada Living Lab from other real-life demonstrators:

1. Its openness to the community of researchers, innovators, and entrepreneurs working in the energy field to test innovative technology approaches, prototypes, and business models within the scope of smart grids
2. A community of end users willing to, not only test new technologies, but to actively participate in the product/service development process. People sharing their pains, their motivations and, which is very important, giving feedback. It is believed this will help innovators not only build new products, but what is most important, to build products people cherish.

A portion of the distribution network operated by Grupo Cuerva in the region of Granada will be used as the main electricity infrastructure to set the Living Lab. The MV distribution grid is connected to the ENDESA HV network by a substation also operated by Grupo Cuerva. This distribution network feeds two small communities nearby Granada city: Escúzar and Láchar.

Láchar area has a peak load close to 3 MW, mostly residential consumers, and a photovoltaic generation of 8,2 MW peak. Due to its small size and isolatable conditions, this area is ideal for exploring microgrid related use cases or testing different early-stage approaches for distribution grid operation, since a significant impact can be achieved only with low-capacity control and storage devices as well as with a small number of participant consumers. Additionally, in this area, ten fast-charging Tesla Supercharger of 120 kW each have been installed. The Superchargers are being fed by 1 MW transformer of 20kV/400V.

The Escúzar area has a peak load of 13 MW and a photovoltaic power plant of 4.3 MW peak. This part of the grid will be used to explore use cases involving grid scale control and storage technology and massive consumers’ participation. Also, the connection with the substation can be used to explore bottom-up energy services, i.e., from the distribution to the transmission system.

3.1.2 Stakeholders and roles

The main actors/roles and the involved stakeholders are shown below.

- DSO: Cuerva
- Retailer: Cuerva (through CHC Energía) & others
- Aggregator: N/A
- Prosumers / Users: people who live in the Granada Living Lab
- Community engagement & Living Lab Development: Turning Tables

3.1.3 Contracts

1. Contract between the DSO and the Retailer

A contract per each supply point is signed between the DSO and the Retailer to allow the network access for electricity supply in the supply point.

2. Contract between the DSO and each new self-consumption installation

The DSO has the responsibility to verify if the new installation is in accordance with the Spanish legislation. After that, a contract between the DSO and the self-consumption installation owner must be signed, where:

- All the general conditions for the electricity delivery are set.
- The technical conditions of the new installations are defined.
- All the exploitation conditions of the installation are set.
- All the modification or termination clauses are well defined.

- The contract duration and interpretation are set.
- The toll for the access to the transport and distribution network for electricity producers is defined according to the Royal Ordinance 1544/2011.

3. **Contract between the DSO and the prosumers.**

Through Turning Tables, different contracts with prosumers have been established:

<u>Contract for prosumer´s participation in Solar as a Service Project inside Living Lab</u>

A contract is signed between each prosumer and Turning Tables. This contract allows the installation, maintenance and management of PVs systems for prosumers inside the Living Lab area. The contract duration is usually per 10 years. The prosumers will pay a monthly remuneration in exchange for the full management of the solar PVs by Turning Tables.

<u>Contract for prosumer´s participation in Comfort Project inside Living Lab</u>

A contract is signed between each prosumer and Turning Tables. This contract facilitates the monitoring of the electrical water boiler of each prosumer with the goal of providing a higher level of comfort and to optimize their energy consumption. With this contract Turning Table is in charge of the installation of all the devices that allow this monitoring. The contract duration is usually per 3 years and there is not a remuneration between the prosumer and the company for that service.

<u>Contract for prosumer´s participation in Transparency Project inside Living Lab</u>

A contract is signed between each prosumer and Turning Tables. This contract facilitates the monitoring of the electrical consumption of each prosumer through the installation and deployment of smart meters devices that provide great transparency about their habits and behaviour and how it affects the electricity consumption. The contract duration is usually per 5 years and there is not a remuneration between the prosumer and the company for that service.

3.1.4 Compulsory regulations

This European guideline on electricity balance GL EB [34] establishes the European regulatory framework for the development, implementation, operation and monitoring of balance markets of the future Internal Energy Market (MIE or IEM) in the field of electricity. The GL EB thus establishes as an objective model:

- Establishment of a schedule for the implementation of European platforms for the exchange of balance services, under a TSO-TSO model, especially in the field of balance energies (2019-2021).
- Framework for the harmonization of the different balance sheet markets at European level (contracting and settlement of reserves for frequency containment, reserves for frequency recovery and replacement reserves), as well as a common methodology for the activation of reserves for recovery of frequency and replacement reserves, through common principles and standards.

This GL is committed to an active participation of all production facilities, regardless of their technology, demand and storage facilities in the balance markets. Its implementation will help to increase the supply and competition of the same, as well as to increase the efficiency in the use of international interconnections (after the adjustments carried out by market participants in the Intraday Market), guaranteeing at all times the safety in electrical systems.

3.2 GREECE

3.2.1 Pilot project description

An ongoing pilot in Greece, which is related to energy communities, and thus, relevant to PARITY project, is located near the city of Xanthi. It is one of the pilot sites of the EU H2020 project Renaissance [35]. Renaissance project will deliver a community-driven scalable and replicable approach, to implement new business models and technologies supporting clean production and shared distribution of energy in local communities. CERTH and CIRCE are two of the participants in the project.

The pilot site is located in a rural area about 1 km west of the city of Xanthi and includes a building complex (11 buildings) owned by Democritus University of Thrace (DUTH), which is used for the accommodation of its students (social housing). Apart from the students' residences, an electromechanical equipment building, a restaurant and an amphitheatre are included. The heating and DHW of the buildings is performed centrally through a piping network. This network serves all students' residences and the amphitheatre, while the restaurant has a separate heating and DHW system. Each student's residences building has a hot water storage tank for covering the hot water demand. The building complex is connected through a substation with the MV grid operated by HEDNO. DUTH has invested in RES (wind turbines, PV) and thermal plants for reducing energy bills and CO_2 emissions footprint. Nevertheless, total electricity consumption is significantly higher than the electricity generated locally by the installed RES systems. An innovative credit-incentive program to the students is going to be validated. In order to engage end-users (mainly students) and eventually influence their consumption behaviour, smart meters will be installed. Installation of smart meters for both thermal and electrical consumption will increase observability and transparency of consumption profiles, enabling to test demand-response schemes and innovative market models.

Energy and service scenarios in DUTH [44] are illustrated in the figure below. Electricity transactions are performed by using the blockchain technology. The microgrid of the DUTH student housing community consists of (i) Energy consumers that are mainly the students of the dorms, a local industry and the Municipality of Xanthi, and (ii) Energy producers/providers that are:

1. DUTH community of RES energy production
2. The Municipality of Xanthi and local industry
3. The national grid

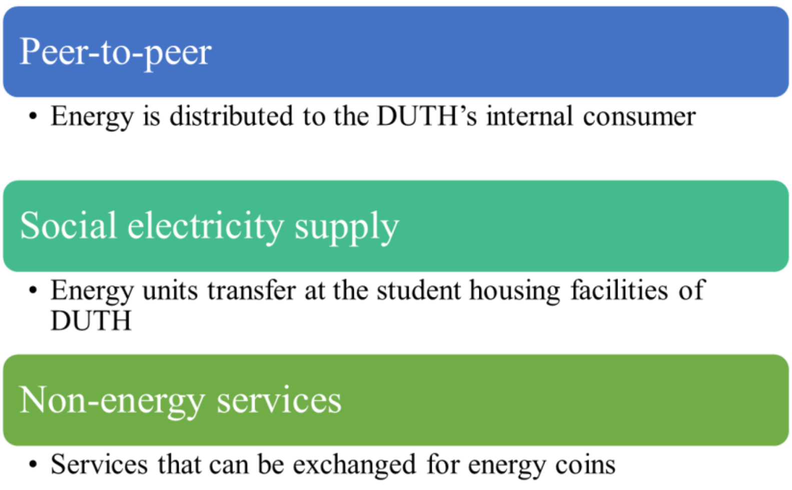

Figure 2. Energy and service scenarios in DUTH

3.2.2 Stakeholders and roles

The main actors/roles are the prosumers, the grid operator and the local market operator. Involved stakeholders for each role are shown next.

Prosumers: DUTH, Municipality of Xanthi city, Local industry

Grid operator / DSO: HEDNO

Local market operator: DUTH

3.2.3 Contracts

Smart contracts have the potential to allow shared automatic control of energy transfer within networks in a replicable, secure, verifiable and trustworthy way. The use of smarts contracts is explored for shared control of energy units at DUTH University and optimization of energy usage while providing opportunities for trading excess energy.

Each student, resident of the DUTH student housing facilities, will be credited every year with a predefined number of energy coins. Different pricing will apply for energy coins (representing kWh consumed) depending on who delivers the energy consumed within the community. The students will be charged less for kWh consumed from the DUTH Energy Community (i.e., produced through RES). On the contrary, students will be "charged" more if they consume energy generated from the municipality or the local industry, and even more if they consume from the national grid. Therefore, it is very important to raise student's awareness of changing their behaviours to consume thermal and electricity when RES is mostly available.

The smart contract objectives for energy transfer at the students housing facilities of DUTH are:

- Increase observability of energy consumption behaviours
- Optimise energy consumption behaviour
- Reduce primary energy consumption and CO_2
- Earn benefits as a non-financial support to students
- Reduce cost of energy for student housing for DUTH
- Promote social innovation in student housing
- P2P energy exchange
- Engage end-users in responsible consumption

Indicative different types of smart contracts that have been designated are the following:

- Student Management
- Student Energy Coin Management
- Excess Energy Management
- Excess Energy Trade Management

3.2.4 Compulsory regulations

Regarding the regulation framework in Greece, it can be mentioned that is in its infancy. Only recently, in 2016, a law on virtual metering was established, referring to municipalities and farmers in Greece. This was a first official attempt towards collective energy sharing. Two years later, the law N4513/2018 on energy communities was introduced, expanding the concept of virtual net metering. The law on energy communities defines clearly the activities, the number of members and how all these are related to the location of the energy community as well as the cooperation and ownership rights among the members of the community and between energy communities having their headquarters in the same region. Moreover, this law establishes the energy communities as partnerships aiming to promote and support economy and innovation in the national energy sector in terms of alleviating energy poverty and fostering sustainability, self-consumption, electricity distribution, storage, supply and security in isolated areas. Finally, it is expected that this law will pave the way towards a more energy-efficient, sustainable society where procedures like cogeneration, energy self-production and smart management of demand loads will be facilitated and fostered, providing thus local and regional geographical areas with many benefits.

3.3 SWITZERLAND

3.3.1 Pilot project description

The Lugaggia Innovation Community (LIC) is an energy self-consumption community located in a small district belonging to Lugaggia 6 km north of Lugano (Switzerland). This district is fitted with 18 buildings (residential houses and a kindergarten). The yearly total electricity consumption of these buildings is 184 MWh and the yearly end-user average consumption is 10 MWh. Among these 18 buildings heat-pumps, electrical boilers, auxiliary resistances, EV stations, and solar panels are installed. The total PV installed capacity is 90 kWp, with a total estimated yearly production of 103 MWh.

For each user of the pilot site AEM installed Landis+Gyr E450 smart meters, which are able to supply indications on active and reactive power and the tension level for each POD. AEM established a dedicated broadband for collecting all those data every 15 minutes. AEM also installed a district battery with a storage of 50 kWh and a bidirectional charge/discharge capacity of 50 kW to store the photovoltaic solar energy not immediately needed.

AEM is also setting up smart contracts with all the end users inside the pilot and two balancing tools, one centralized with OPTIMATIK and the other one decentralized with HIVE POWER. More detailed information about the LIC pilot is written in D9.1.

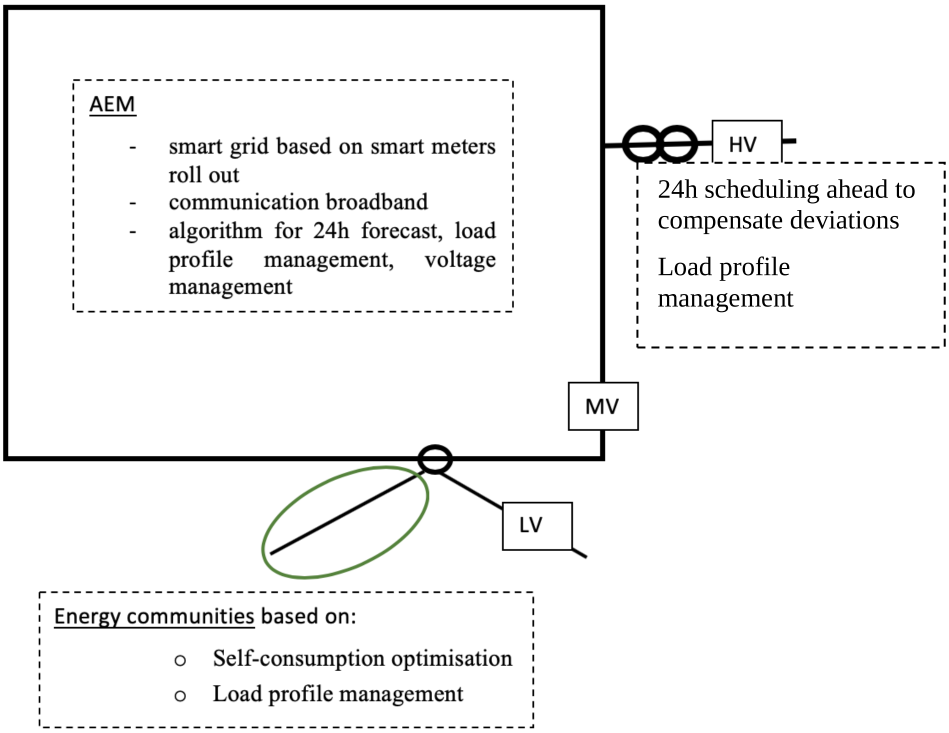

Figure 3. Energy community concept by AEM

3.3.2 Stakeholders and roles

Roles:

- DSO: AEM
- Aggregator: LIC Manager (AEM)
- Prosumers / Users: people who live in the community buildings

Actors:

- Manager (LIC) responsible for:
    - Tariffs level for self-produced and consumed power
    - Ancillary services
        - EN 50160
        - Optimisation of self-consumption and peak load
    - Billing
    - Grid maintenance
    - Front office
    - Flexibility trading
- Users
    - Have a smart home
    - Subscribe a contract to purchase power and to set flexibility available to the manager
    - Respect general rules
- Prosumers
    - As a user but also
    - Subscribe a supply contract for power and flexibility

3.3.3 Contracts

<u>Contract between the DSO and the aggregator</u>

As AEM is acting as both DSO and aggregator in the LIC project no specific contracts are signed.

<u>Contract between the aggregator and the prosumers/users</u>

Principles underlying the agreement between the parties (LIC/aggregator – prosumers and users):

- The implementation of the "Lugaggia Innovation Community" (LIC) does not entail any financial burden for its users, nor a change in the quality of service, guaranteed by AEM.
- The activity of LIC focuses on technological processes and system efficiency. The user can expect:
    - a reduction in his own tariff
    - an operational and financial enhancement of local production compared to the AEM tariff for the withdrawal of energy from the grid
    - an improvement (with a view to the future) in the quality of delivery.

<u>Conditions for entry into force of the delivery</u>

The contract binds the parties and enters into force in full when the following conditions precedent and cumulative conditions are fulfilled:

- the smart meters have been set up and are operational;
- the Customer has provided all the information and data necessary to implement the electricity supply.

This contract is stipulated on the basis of the regulations applicable to the electricity sector at the time of signature.

<u>Customer Obligations</u>

The Customer undertakes during the entire validity of this contract to:

- purchase from the LIC all the electricity necessary for its needs, at the financial conditions defined in point 7 of the contract;
- pay to LIC the amounts due for the supply of energy at the conditions defined in this contract;
- promptly inform LIC of any foreseeable and significant change in electricity consumption in its consumption centres;
- inform LIC immediately in case of anomaly in the withdrawal of electricity or malfunctioning of the measuring equipment;

- if the user has a heat pump, to allow LIC, at its own expense, to connect the control cables to the meter;
- In order to optimize the load profile of the community, reducing imbalances, LIC makes use of the option to regulate (disconnect) private loads taking care to minimize inconvenience to individuals. Respectively, according to the same criteria, to manage the decentralized production both through a reduction/limitation of the activity of the plants and the action on the "Cos Phi" to regulate the reactive energy and thus reduce voltage increases.

Price of electricity and meters

The all-inclusive electricity supply tariff corresponds for the first year at most to the A tariffs valid for the DSO distribution area [36]. Thereafter the tariffs valid for the following year will be communicated by 31 August of the previous year.

In accordance with the provisions of the Energy Ordinance (EO), it undertakes to publish data on its procurement costs and any reduction in relation to the tariffs set out in paragraph 1 within two months of the end of the calendar year, which will be reflected in the first subsequent quarterly bill.

The customer shall also pay an annual subscription covering the costs of the measuring instrument and related services, similar to that provided for in DSO tariff schedule and published annually on the company's website.

Obligations of prosumers

The independent producer undertakes to transfer to LIC, which undertakes to purchase it, the energy in excess of its own consumption produced by its own PV system, which LIC can either use directly (simultaneous production and consumption) or store in its own storage system.

The energy that cannot be used in the LIC area will be fed into the DSO grid and paid for at the tariff conditions set by the latter in accordance with the relevant federal legislation.

Tariff for energy collection

For the entire duration of the contract, the LIC will pay the independent producer CHF 0.09 for every kWh that he uses (directly or by accumulation) in his own network.

3.3.4 Compulsory regulations

A *raggruppamento ai fini del consumo proprio* (RCP) shares a connection to the public grid and is recognised as a legal entity in front of the local power company. From the connection it is possible to feed excess solar energy produced into the grid or, if necessary, to purchase additional energy.

Once established, the RCP receives only one bill from the electricity supply company. The billing and the allocation of costs between the parties is carried out entirely by the grouping itself.

RCP requirements:

- Consent and contract signed by the tenants
- The solar output of the PV system must be at least 10% of the maximum deliverable power.
- Solar energy must be consumed on site.
- Electricity producer and end consumer share a connection.

As regards the choice of the legal form of the RCP, the parties are free to act in accordance with the law, it being understood that the most common form among groupings for own consumption purposes is the "simple society".

Costs of setting up a grouping for own consumption purposes shall be borne by all members of the grouping.

The lessees / co-owners of plans are free to decide for themselves whether to join the RCP.

Reference laws:

- Legge federale sull’energia - art.15-18 [37]
- Ordinanza sull’energia - art. 10-18 [38]
- Ordinanza sulla promozione della produzione di elettricità generata a partire da energie rinnovabili [39]
- Ordinanza sull’approvvigionamento elettrico [40]
- Legge sull’approvvigionamento elettrico [41]

4. SLA best-practice for PARITY business cases

4.1 PARITY business cases description

In this chapter, the initial PARITY Business Cases (BC) are retrieved from D3.1 [42] and slightly adapted in order to align it with the PARITY market design developed in D4.3 [43].

Latter introduces a Traffic Light Concept (TLC) specifically for PARITY that determines which market operations are active in which grid operation regime. The active grid operation regime is determined by the DSO. According to that, the four initial Business Cases are also applicable only in specific grid operation regimes as stated in Table 1.

Table 1. Initial PARITY Business Use Cases and their applicability in the different grid operation regimes of the TLC

Business Case #	Main role	Applicable in grid operation regime	
		LFM explicit	LFM implicit
1	Aggregator	GREEN	GREEN & YELLOW
2	Supplier	GREEN	GREEN & YELLOW
3	DSO	YELLOW	YELLOW
4	DSO	RED	RED

In the following sections the Initial Business Cases are described in detail.

4.1.1 *Business Case 1: Aggregator*

Initial description: Aggregator as an active player in the LFM and national energy/ancillary services markets (including optimal trading of flexibility under control across available markets for revenue maximization and adequate liquidity safeguard)

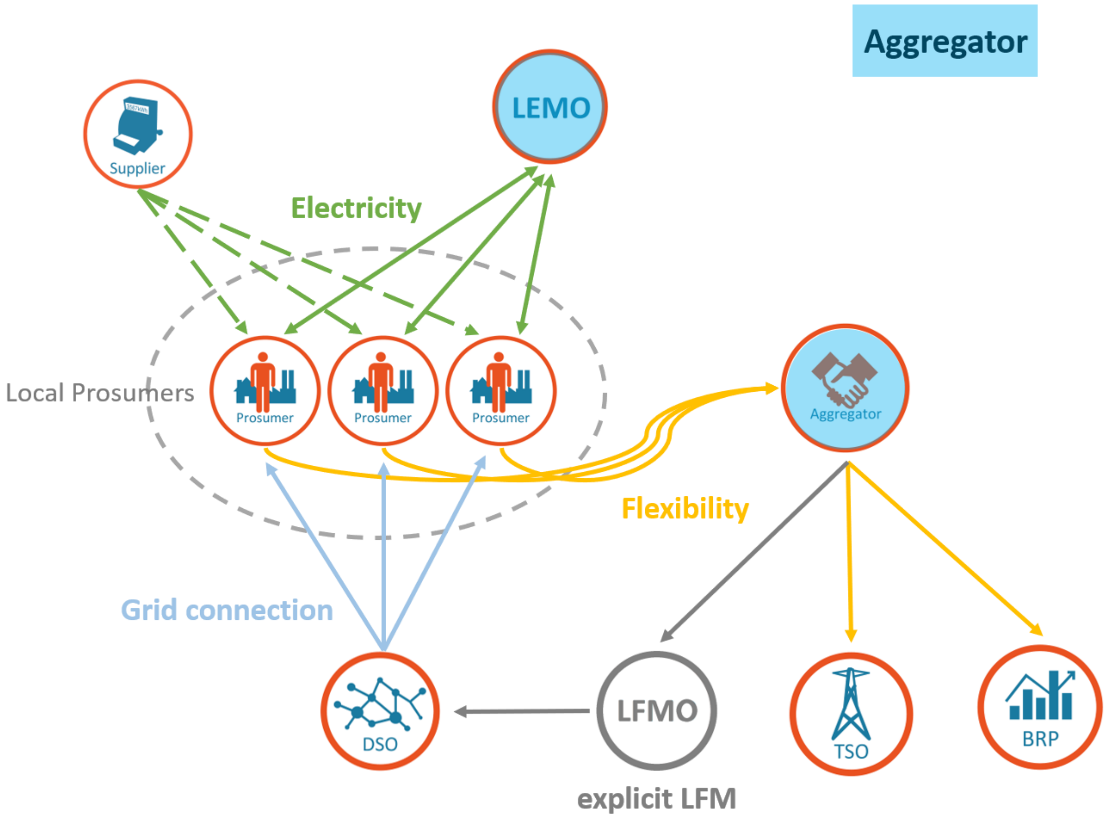

Figure 4. Aggregator business case roles diagram

Table 2. Grid state and roles

Applicable in grid state		Roles assumed by the aggregator
LFM explicit	**LFM implicit**	
Green	Green	Aggregator
-	Yellow	LEMO, optional

The first element of this BC is the **typical business model of a DR aggregator**. Here, the aggregator controls devices at the prosumers' premises that have a relevant potential for load shifting. The aggregator then offers the aggregated loads at various flexibility markets to flexibility requesting parties (in this case towards TSO on the balancing market or towards BRPs on the wholesale market). In return the prosumers will get a financial remuneration from the aggregator for providing their flexibility. By applying this explicit DR model, the aggregator is linking the local prosumers to wholesale and ancillary services markets.

The second element is **the aggregator assuming the role of the LEMO, facilitating peer-to-peer trading** among prosumers. In this case, the aggregator would provide the necessary peer-to-peer trading platform and therefore clear and settle the LEM. Depending on the specific pricing model, the aggregator is incurring a fee for this service. However, peer-to-peer trading can be considered as an experimental scenario in this BC, since current regulatory framework may need revisions in order to support it.

Generally, these **two elements may compete with each other**. The aggregator's mission is to maximise its profit and consequently the profit for the prosumers. This means that the aggregator will either prefer to offer bids of bundled flexibility on the balancing/wholesale market or try to self-balance the local community via peer-to-peer trading. However, the electricity supplied from local peers may be subject to a reduced grid tariff where only charges for the local grid apply. If this results in a significant reduction of the grid costs for the prosumers, **it is expected, that the first priority will be self-balancing of the local community**. In this case only the residual flexibility will be offered at the balancing/wholesale market.

This BC deals with the LEM and participation in the balancing and wholesale markets. As a result, if the LFM is designed as an **explicit** market this BC is applicable only in the **green grid state**, whereas if the LFM is **implicitly** included in the LEM, it is applicable in **green and yellow grid state**.

4.1.2 Business Case 2: Supplier

Initial description: Energy Retailer as a P2P flexibility trading facilitator (including flexibility, day-ahead, intraday, balancing & ancillary market trading optimisation)

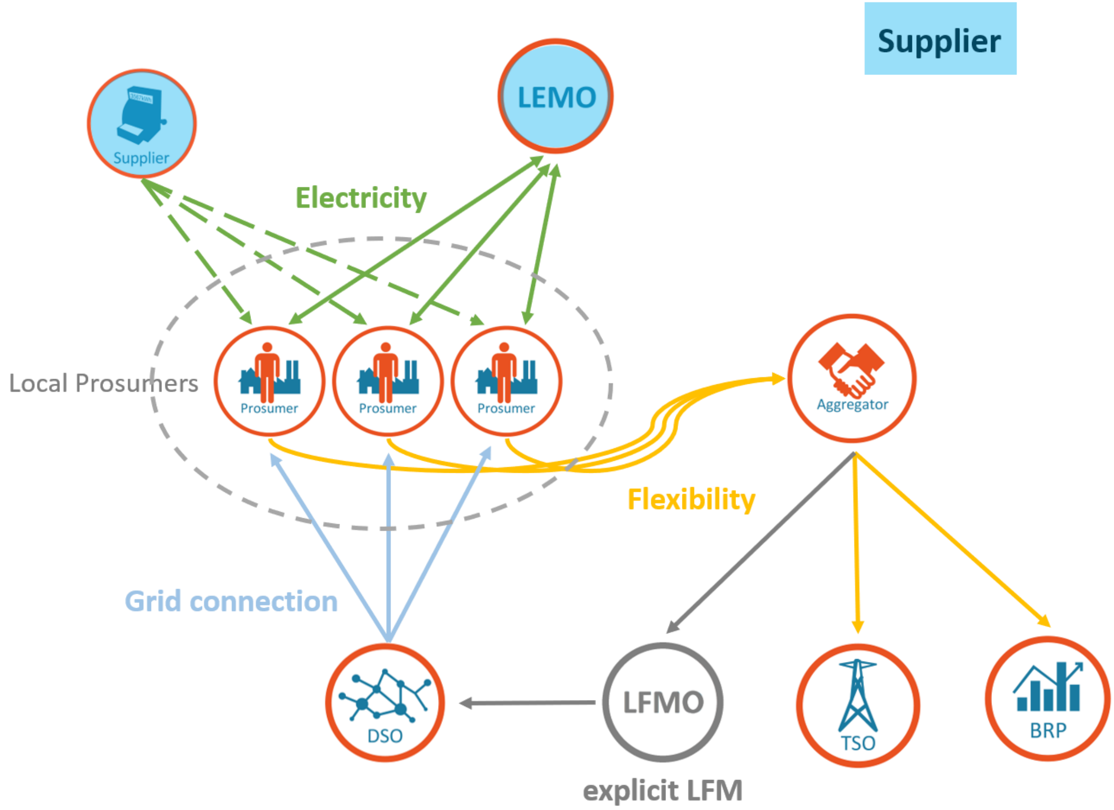

Figure 5. Supplier business case roles diagram

Table 3. Grid state and roles

Applicable in grid state		**Roles assumed by the supplier**
LFM explicit	**LFM implicit**	
Green	Green	LEMO
-	Yellow	Supplier

In the second BC, an **energy supplier assumes the role of the Local Electricity Market Operator (LEMO)**, providing the peer-to-peer trading platform. Here, the core business of a supplier – electricity supply to the prosumers – is combined with facilitating peer-to-peer trade between local prosumers. In this context, it needs to be considered, that prosumers have the right to choose their electricity supplier independently. This means prosumers don't necessarily need to have a supply contract with the supplier operating the LEM.

Taking this into account, there **are two possible business strategies for a supplier** in this BC:

1) The supplier taking the role of the LEMO requires LEM members to subscribe to one of its supply tariffs as a condition for LEM participation.
2) Prosumers may switch their supplier at any time and still participate in the LEM. In this case a specific fee towards the LEMO applies. By offering attractive tariffs specifically for LEM members, the supplier assuming the role of the LEMO tries to retain the prosumers.

If the LFM is designed as an **explicit** market this BC is applicable only in the **green grid state**, whereas if the LFM is **implicitly** included in the LEM, it is applicable in **green and yellow grid state**.

4.1.3 Business Case 3: DSO as LFM operator

Initial description: DSO as a market coordinator (the trusted party capable to operate an LFM to ensure independence and fairness to all involved market actors)

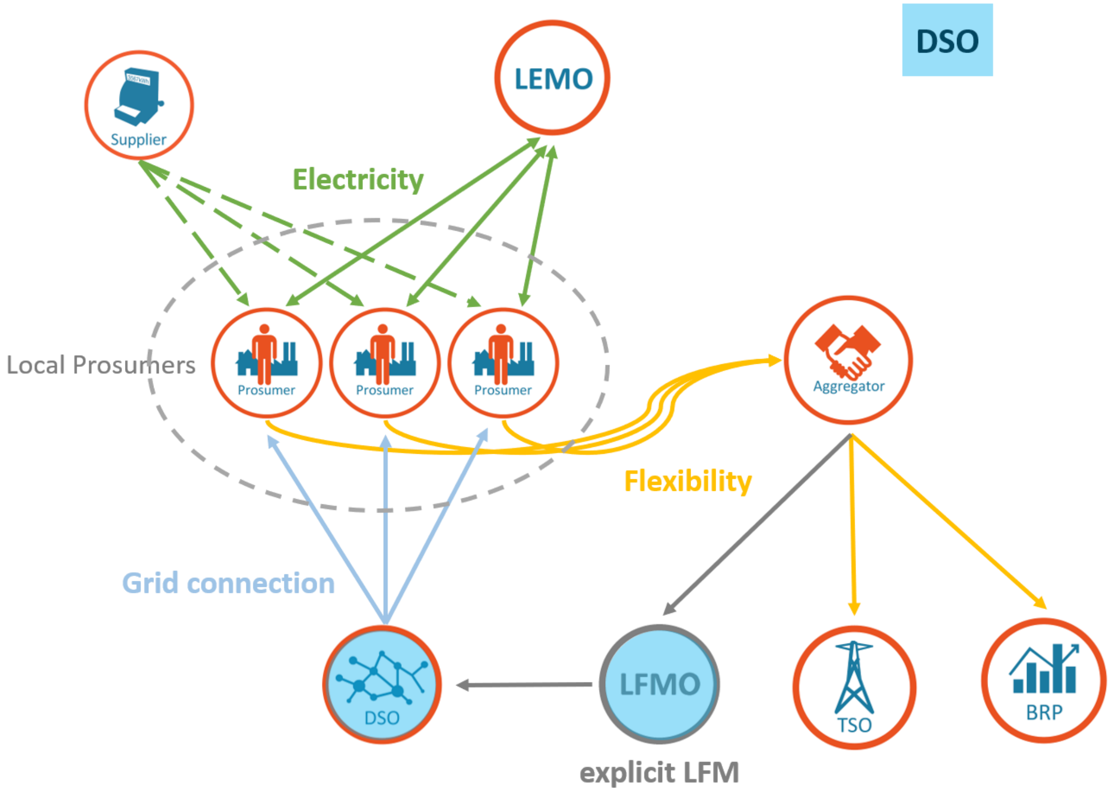

Figure 6. DSO as a LFM operator business case roles diagram

Table 4. Grid state and roles

Applicable in grid state		Roles assumed by the DSO
LFM explicit	LFM implicit	
Yellow	Yellow	LFMO
-	-	DSO

This BC deals with the operation of the LFM and therefore it is only applicable in **yellow grid state**. The activities in this BC depend on the design of the **LFM either as an explicit or implicit market**.

In case the LFM is an **explicit** market, the **DSO assumes the role of the Local Flexibility Market Operator (LFMO)**. The DSO provides the market platform for the LFM and in this way **procures flexibility for performing voltage control and congestion management**. By doing so, the DSO needs to ensure fairness among all market participants. Regulation has to make sure, that in this role, the DSO is not using its monopsony position (as a single buyer on the LFM) to keep prices down.

In case the LFM is **implicitly** included in the LEM, there is **no such role of an LFMO**. However, the DSO is in charge of **determining and incurring the locally varying grid prices** in yellow grid state. By doing so, the DSO is forecasting potential constraints in the distribution grid (by applying smart grid monitoring tools) and calculating the grid prices according to the constraints detected (by applying an optimization algorithm).

4.1.4 Business Case 4: DSO as DER enhanced network operator

Initial description: DSO as a DER enhanced network operator (including the use of novel smart grid management tools and infrastructure that enable more cost-efficient ways to ensure power quality and grid stability in the distribution grid and consideration of flexibility as an alternative to network upgrades).

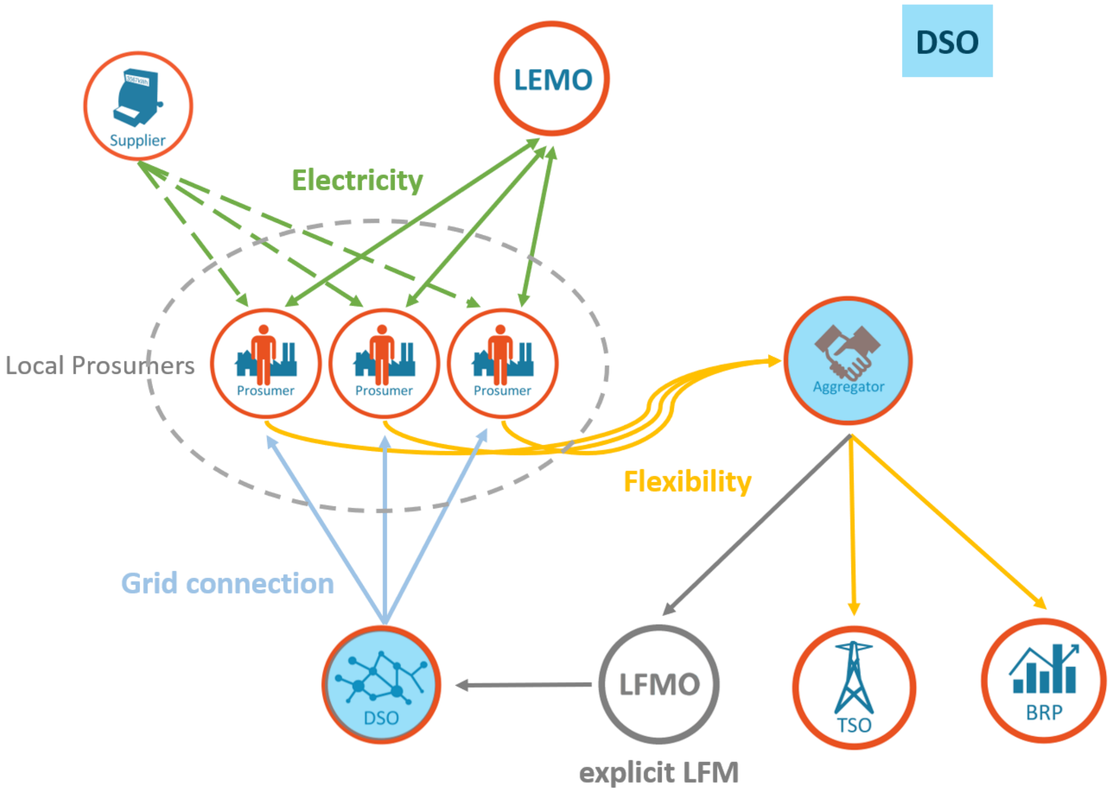

Figure 7. DSO as a DER enhanced network operator business case roles diagram

Table 5. Grid state and roles

Applicable in grid state		Roles assumed by the DSO
LFM explicit	LFM implicit	
Red	Red	DSO
-	-	Aggregator (for enforcing direct load control)

In this BC, the **DSO is actively controlling the loads** at prosumers' premises in order to gain flexibility for the distribution grid and **solve critical grid constraints** severely endangering grid stability. This means, in order to fulfil the DSO's core competency (operating the distribution grid and guaranteeing grid stability), it is acting as an aggregator solely for meeting the flexibility needs of the distribution grid. By doing so the DSO can override existing contracts of the free market. This direct load control can be executed via the aggregators' or the DSO's own infrastructure. A remuneration for the affected prosumers (and also the aggregators if their infrastructure is used) needs to be agreed on in advance.

As this BC overrules all market-based contracts, it is only applicable in **red grid state**.

4.2 Contract analysis

In this chapter the PARITY business cases are taken as an input and the relationships between parties and their roles are analysed. This approach enables to identify a list potential contracts that are needed for realizing the PARITY business cases. The result of this analysis is shown in the following tables, one for each business cases. In grey are highlighted the standard contracts already available in the current energy system. The other contracts are identified as novel contracts needed for the innovation introduced in the project.

Table 6. Contract analysis – Business case 1

	Parties / Roles		Type of contract
1	Aggregator	Prosumer	DR aggregation
2	Aggregator	TSO	Balancing market participation
3	Aggregator	BRP	Wholesale market participation
4	Supplier	Prosumer	Energy sales
5	DSO	Prosumer	Grid connection service
6	LEMO (Aggregator)	Prosumer	Prosumers sell and buy from LEM
7	LEMO (Aggregator)	DSO	Changing traffic light signal status. Setting grid prices for green and yellow state

Table 7. Contract analysis – Business case 2

	Parties / Roles		Type of contract
1	Aggregator	Prosumer	DR aggregation
2	Aggregator	TSO	Balancing market participation
3	Aggregator	BRP	Wholesale market participation
4	Supplier	Prosumer	Energy sales

5	DSO	Prosumer	Grid connection service
6	LEMO (Supplier)	Prosumer	Prosumers sell and buy from LEM
7	LEMO (Supplier)	DSO	Changing traffic light signal status. Setting grid prices for green and yellow state

Table 8. Contract analysis – Business case 3

	Parties / Roles		Type of contract
1	Aggregator	Prosumer	DR aggregation
2	Aggregator	TSO	Balancing market participation
3	Aggregator	BRP	Wholesale market participation
4	Supplier	Prosumer	Energy sales
5	DSO	Prosumer	Grid connection service
6	LFMO (DSO)	Aggregator	Aggregator sells flexibility
7	LFMO (DSO)	DSO	DSO buys flexibility

Table 9. Contract analysis – Business case 4

	Parties / Roles		Type of contract
1	Aggregator	Prosumer	DR aggregation
2	Aggregator	TSO	Balancing market participation
3	Aggregator	BRP	Wholesale market participation
4	Supplier	Prosumer	Energy sales
5	DSO	Prosumer	Grid connection service
6	DSO	Aggregator	Usage and remuneration of DR management infrastructure for indirect DR usage
7	DSO	Prosumer	Remuneration for direct DR usage

4.3 Standard SLAs

The contract analysis connected to the PARITY business cases highlighted standard SLAs that are already covered by the current energy system (Table 10).

Table 10. Contract analysis – Standard contracts

	Parties / Roles		Type of contract
1	Aggregator	Prosumer	DR aggregation
2	Aggregator	TSO	Balancing market participation
3	Aggregator	BRP	Wholesale market participation
4	Supplier	Prosumer	Energy sales
5	DSO	Prosumer	Grid connection service

4.3.1 1 - Aggregator/Prosumer: Demand Response (DR) Aggregation

To keep the prosumer active on the market, it became necessary to develop innovative demand response services, giving to them increased control over their energy consumption. This arrangement facilitates the prosumer's access to the market and offers a platform for exploring the prosumers' flexibility potential [45].

This section examines how the demand response aggregation works by checking out the parties' duties, the remuneration processes, and the regulations guiding the arrangement.

Key Terms

Aggregator: An aggregator is a party whose role is to accumulate flexibility from prosumers and sell it to parties who request it. Essentially, an aggregator increases the value of that flexibility, as much as possible, and then sells it to the highest bidder.

Prosumer: coined from two words; producers and consumers. This refers to the set of people/parties who not only consume but also produce energy services. They are people/groups who value new technologies and innovations, the Green users concerned with environmentally sustainable solutions, and the Value seekers interested in economic benefits and product performance, quality, and security [46].

Demand response aggregator: this refers to a third-party company or individual specializing in electricity demand-side participation. Article 2(45) of the Energy Efficiency Directive defines this party as a demand service provider who combines multiple short-duration customer loads for sale or auction in an organized energy market [47].

The Duties of the Parties

Generally, the **aggregator** has to make sure that the prosumer benefits from the demand response aggregation. But, on a narrower level, an aggregator should perform the duties below to avoid imbalance in the system.

Sourcing cost payment: As a market participant, it is mandated that cost is borne for expenses in the electricity procuring process. That is, the energy supplier of involved prosumers should be fairly remunerated for energy supplied [48].

Aggregators bring in small-scale renewable generation and battery storage into the marketplace by pooling and therefore help reduce the cost of participation on behalf of the clients [49].

The **prosumer** contributes to the market by contributing to the demand and supply of energy. This way, they help to liberalize and keep up the competition in the market. They supply their excess energy to the grid through the aggregator who, in turn, auctions these energies to energy suppliers [45].

Remuneration of the Parties

The Demand-side response aggregator gets a percentage value that results from the avoided consumption to reduce peak demands, balance intermittent generation, provide a balancing service, or increase the security of supply [4].

The Normative/Regulations

The following regulations were extracted from the DCC regarding the Demand side aggregation. Although there have been proposals for specific adjustments in the regulation, this happens to be the current regulation released for the market:

- Demand response, as an important instrument for increasing flexibility available in the internal market, should be based on the consumer's action or based on the action of the third party engaged by them.
- The owner of a demand facility can provide demand responses to the energy market and the DSOs for security. Suppose the owner of the demand response facility decides to provide services to the DSO. In that case, the units used in offering these services must comply with the requirements in the regulations either as an individual or through a third party.
- Those requirements cover the principles of non-discrimination and transparency as well as the principles of efficiency (lowest costs for all involved parties)
- Any requirement covering the distribution system connected to a transmission or another distribution system should ensure the transmission systems' progress, efficiency, and operability.
- To minimise critical events, the requirements regarding the demand units utilized by a demand facility to provide services to relevant DSOs and TSOs should ensure the capacity to use the demand response over system operational ranges.
- Consumers should not be burdened unnecessarily with administrative tasks given their role in transitioning to a low carbon society. Demand response provision cost should be kept minimal [52].

Conclusion

In conclusion, it would be oblivious not to notice the tremendous benefits of the demand response in that it helps to increase the adequacy of the energy systems and also reduces, to a large extent, the need for investment in peaking generation by lowering high demands. Furthermore, it stabilizes the system and acts as a cost-effective balancing resource for renewable generation.

However, the relationship between the prosumer and the aggregator leads to the fact that whatever the aggregator does would affect the prosumer/consumer's bill. They should have access to the bills/data relating to demand response regularly instead of the said "at least once in a year" basis. This is so that customers can be encouraged to be active in the market due to the demand response bills and information's credibility.

4.3.2 2 - Aggregator/TSO Contract Type: Balancing Market Participation

Both the Aggregator and the TSO play a delicate role in effecting well-balanced market participation. The balancing market plays a decisive part in the trading of electric energy; however, this is not to say that it is any less critical. Therefore, the need for TSOs and Aggregators to strike a fair balance has never been more apparent [53].

This section will give an insight into a typical contract that will ensure balanced market participation between TSOs and Aggregator, examining their duties, remuneration processes, and regulations already set up between both parties.

Key Terms

Aggregator: An aggregator is a party whose role is to accumulate flexibility from prosumers and sell it to parties who request it. Essentially, an aggregator increases the value of that flexibility, as much as possible, and then sells it to the highest bidder.

Flexibility: This refers to the possibility of modifying patterns of energy production and consumption in response to a signal to contribute to different services [48]. Some may describe it as power modification.

Prosumer: Essentially, a prosumer refers to a person who is both a producer and a consumer. In other words, an end-user, who not only consumers energy but also produces it [54]. They are also the parties who operate Distributed Energy Resources (DERs). However, for the prosumer to gain access to the flexibility market, the aggregator must act.

Wholesale Market: The Wholesale Market constitutes an electricity exchange where other actors in the market can trade. Essentially, the Wholesale Market serves as a source of revenue generation.

Transmission System Operator (TSO): the TSO's function is to move energy in a given sector from the centralized producers to dispersed industrial prosumers and distributed system operators over its high-voltage grid [55]. The TSO ensures that the electrical energy system can also meet the demands of electrical transmission.

The Duties of the Parties

The duties of the Aggregator: The first, and perhaps, most important task of the Aggregator is to drive up the value of flexibility. The Aggregator also has the sole responsibility of invoicing the process associated with the delivery of flexibility. The Aggregator, alongside the prosumer, decides on the terms and conditions of the acquisition and control of flexibility [55].

Finally, the role of a facilitator of trades between prosumers may sometimes fall to an aggregator.

The duties of Transmission System Operators (TSO): TSOs maintain, operate, plan, and extend the electricity system network while ensuring that it is expansive and cost-efficient. They provide electricity market players with access to the power grid accordingly to transparency rules [56].

Also, they make sure that the power grid is stable to protect the consumer's security of uninterrupted supply. TSOs specify the minimum operational rules and responsibilities regarding the protection of the network.

Finally, they forecast electricity demands over a middle-term period and provide information on possible investments, including internal lines and connections between borders.

Remuneration of the Parties

Aggregators charge a commission on each successful business deal that they facilitate. That is, they operate on a rate-per-purchase basis from the partner. So, before the start of any transaction, the aggregator already has an agreed-upon cut of the financial proceedings.

According to an EU Commission Regulation 'electricity balancing' means "all actions and processes, through which **TSO**s ensure, the maintenance of system frequency within a predefined stability range." Therefore, the **balancing market** is the final platform, through which the **TSO**s settle any deviations between demand and supply remaining after the closure of intraday wholesale markets and after the determination of the final schedules.

In other words, on the balancing market so-called "control energy" is procured by the **TSO** or the responsible *LFC* or *CA* operator. Consequently, control energy describes the total need for flexibility products and comprises the net imbalance among all balance groups

There may be different approaches on how to distribute the costs arising from the different flexibility services such as FCR, aFRR and mFRR. In Austria, for instance, the costs for tertiary control (mFRR) are billed to the **BRP**s according to their individual imbalance, as imbalance costs. In order to minimise their imbalance costs, **BRP**s may procure flexibility by trading on the wholesale market. Costs for primary control (FCR), in contrast, are charged to large *producers* and for secondary control (aFRR) an intermediate approach is applied

A party offering flexibility on the balancing market can be referred to as a **BSP**. Each bid from a BSP is assigned to one or more **BRP**s. Further explanations of balancing market mechanism are described in PARITY D4.3 [43].

The Normative/Regulations

According to the CEP, regulation put forth by the EU Commission, the following regulations were stated to ensure balance in the market:

- The balancing market is the final platform through which TSOs can resolve any deviation between the demand and supply forces. However, they do this only after intraday wholesale markets close, and they've determined the final schedules.
- While the Aggregators maximize the value of flexibilities, the TSOs will procure control energy (also known as balancing market). Relatedly, control energy refers to the overall need for flexibilities and encompasses the total imbalance among all balance groups [58].

Note that the Aggregator provides an aggregate of all activated power to the TSOs in real-time. With this data, TSOs can maintain a system frequency as per a predefined stability range.

By doing this, TSOs ensure balanced and equal participation between the powers of demand and supply. This, of course, translates to the all-too-important balance of electricity between production and consumption. As such, service level agreement will contain all necessary details, including the stability range and fees from the partner.

While the aggregators drive up the value of flexibility, the TSOs must maintain the delicate balance. If consumption exceeds production, the TSO must procure up-regulation (buy extra energy from suppliers). If the reverse is the case, then the TSO purchases a down-regulation. The extra energy - better called regulating energy – is what restores the balance between demand and supply.

Conclusion

One way to facilitate and increase flexibility in the energy market is to allow the parties to aggregate their resources more freely, enabling small scale producers to participate in the market, thereby increasing the available flexibility. From a TSOs point of view, any changes to the current market design should ensure that they carry free and transparent solutions that would pave the way for socio-economic development.

4.3.3 3 - Aggregator/BRP Contract Type: Wholesale market Participation

To ensure the participation of wholesale market trader in the energy market, the aggregator and BRP play a vital role. Without a doubt, wholesale market traders are an integral part of the overall energy market. Without them, there is no one to bridge the gap between retailers and final consumers. Therefore, the total efficiency of the electricity system – from production to consumption – will drop.

This section examines the relationship between the BRP and the aggregator in the wholesale market by exploring their respective duties, method of remuneration, and the rules guiding their collaboration in the energy market.

Key Terms

A trader is either a buyer or seller on the wholesale market [59]. The wholesale electricity market is where electricity trading occurs before delivery to consumers.

Aggregator: An aggregator is an entity whose role it is to accumulate flexibility from prosumers and their DERs and sell it to any party requesting it. Therefore, the aggregator and its prosumers have an agreement on commercial terms and conditions for the purchase and control of flexibility [55].

Distributed Energy Resource, DER: DER refers to controllable goods, distributed generation, and energy storage [60]. So, DER describes the party that can provide any type of flexibility as a decentralized source.

Flexibility: A flexibility is a possibility of adjusting patterns of generation and consumption of energy in reaction to signals to contribute to different services [48]. Flexibility may exist as either a product (when an aggregator sells flexibility to another participant) or a service (when the market participant buys flexibility and uses it).

Energy Supplier: A supplier's duty is to provide, transfer, and invoice energy to its customers.

Balance Responsible Party (BRP); The role of a BRP is to actively balance the supply and demand of a portfolio of producers, suppliers, wholesale traders, aggregators, and prosumers, with the means granted by those actors [55]. At each grid access point, there must be a designated BRP.

Duties of the Parties

The aggregator works as an intermediary by acquiring energy and supplying it to energy suppliers who, in turn, can sell it to another participant in the wholesale market. The aggregators possess the ability to influence a group of grid users via a suitable communication interface.

Aggregators impact the BRP in two ways; (i) the market profits (ii) the retail profit.

Balance Responsible Party, BRP, is responsible to aggregators for balancing their supply and demand portfolio with whatever means suggested by the aggregators. To guarantee this, each party connected to the grid must be a part of a Balance Group (BG) [61].

Remuneration of the Parties

Balancing Responsible Parties generate revenue by reducing imbalance in the market. When the remaining balance between generation and consumption of the BRP's perimeter is positive, then the imbalance is positive. On the other hand, when the remaining balance between generation and consumption of the BRP's perimeter is negative, then the imbalance is negative [62].

The BRP tries to minimise its imbalances because, otherwise, it has to pay an imbalance fee. As long as the balance is not 0, there are imbalances (positive or negative imbalances).

However, the BRP can buy/sell energy on the wholesale market to minimise these imbalances. Furthermore, the BRP can earn additional income by adjusting their generation or consumption to support the system balance. The reward system for a BRP is essentially based on the balance they induce into the energy market.

The revenue generation for Aggregators is similar to the marketplace business model. The other participants in the market are the source of remuneration. For example, the prosumers. [63]

So, the aggregator and prosumer may enter a deal before transacting their trade. The aggregator makes a mark-up on the transaction price and adds their percentage profit, say 5%. It is also possible that the aggregator earns on a commission rate-per-purchase basis. In this case, for every successful market trade, the aggregator takes a cut off the profits [64].

The Normative/Regulations

Wholesale market traders play a crucial role in maintaining the balance of the energy system. However, there must always be consistency, transparency, and integrity in the dealings to encourage customers' participation. To ensure order and transparency in the market, the REMIT, Regulation on Wholesale Energy Market Integrity and Transparency, was adopted and passed as a regulatory act in 2011.

The summary overview of REMIT

- All market actors or participants that plan to make reportable transactions must register with its NRA
- According to article 2(7) of REMIT, a market participant trades on the wholesale energy market and is required to make reports to the Agency for the Cooperation of Energy Regulators (ACER).
- The market participant must still register even if the parent or subsidiary has registered already.
- Entities do not need to be a principal to the transactions before being acknowledged as a participant.
- Any transaction required to be reported to the ACER is grouped under wholesale energy products [65].

Conclusion

Now that there is an increased distributed generation, there may be technical challenges due to the reverse in energy system flow. If not attended to, the prices can be affected indirectly, which would be a big disadvantage to the markets and its participants.

Also, there could be a consideration for local markets because it would bring greater pricing efficiency. After all, all regions in the EU energy system require different levels of flexibility and reserves. The local market could provide services to such regions in case of a challenge in the system regarding flexibility demands and others.

4.3.4 4 - Energy Supplier/Prosumer Contract Type: Energy sales

Over the last 35 years, there have been changes in the energy systems that required the termination of predominant energy sources (fossil fuels) to ensure a low-carbon future based on clean and safe energy for all [66].

As a result of these transformations, there have also been changes in the energy systems i.e., from a centralized where there was power flowed from utility to the consumer towards a decentralized energy system where power flows in multiple directions because of the energy production role added to the consumers' initial role [67].

This section is to examine the relationship between energy suppliers and prosumers as regards energy sales.

Key Terms

Prosumers: coined from two words; producers and consumers. This refers to the parties who not only consume but also produce goods or services. They are parties who value new technologies and innovations, the Green users who are concerned with environmentally sustainable solutions, and the Value seekers who are interested in the economic benefits and product performance, quality, and security [67].

Energy supplier: this refers to the totality of all industries into the production and sale of energy. They buy energy from the energy market and supply to the consumers billing them for the amount of energy used. The prosumers/consumers have the rights to choose or switch energy suppliers without hitch or obligations that would prevent the switching [52].

Trading/energy sales: this refers to how the energy prosumer trade their excess energy produced.

Duties of the Parties

As an energy prosumer, certain roles are expected to meet basic energy policy goals. Before the shift in roles from a consumer to a prosumer, i.e., they help to prevent energy monopolies by increasing competition since they can choose or decide to switch energy suppliers in the energy markets. Due to the constant transitioning in positions, the consumers' role has also shifted from the role mentioned above to that of a prosumer.

As a prosumer, there are two options available; The first option is to disconnect off the grid to avoid any cost related to the grid and system maintenance. This will cause an upset in the normal expense frequency as there would be an increase in the grid maintenance cost for those who remain on the grid.

The second option is to stay on the grid, participating actively in the electricity market by feeding surplus/excess energy produced to the grid. This translates to the fact that the prosumer keeps contributing to market demand and supply management [68].

To keep the prosumers from disconnecting from the grid, efforts are being made by the European Commission to keep prosumer on the grid as it is necessary for a balanced market. Although there is no definite way to keep prosumers on the grid yet, it is anticipated that prosumers use the grid for three reasons.

The first reason is to use the grid as a backup for their produced energy to prevent a shortage. The second reason is to sell off their excess energy for financial remuneration. And the third option is to use the grid as a virtual battery in the net metering case.

The energy supplier has a role in supplying the prosumer with energy services [68].

Remuneration of the Parties

There are several remuneration models on how prosumers get paid. The first model is the **net metering model**, where prosumers feed their excesses to the electricity grid and consume it when needed, paying only when they use more than they fed into the grid. Net metering allows prosumers to use electricity as their storage source.

Another model is the **Feed-in tariffs (FiTs)**, where prosumers pay retail prices for what they consume from the electricity grid but are offered 10-25 years of contracts paid by large energy providers at an above the market value [50].

Feed-in premium (FiPs) is a model similar to FiTs only that the model introduces a short-term market. Just like FiTs, this model also implies long term contacts but takes the form of a bonus plus the present market value [51].

Competitive auctions and requests for tenders is also a model, but it helps decide who to allocate the FiTs and FiPs. The bidders contend compensation for producing a volume of electricity.

On the other hand, **the energy suppliers** get paid by the prosumer for the energy supplied to them.

The Normative/Regulations

The European commission targets two primary reasons for implementing the SLA, which is to keep the activities of prosumers in check while using their energy contribution maximally and see to it that the grid is stable and favourable to the users. However, does the prosumer get to keep his consumer protection right even while he supplies energy to the grid?

In the new directive released by the European Commission (EU) 2018/2001 on the promotion of electricity from renewable energy resources, energy prosumers are allowed to keep the protection right as a consumer [69].

But recently, the following regulations in the Clean energy package (CEP) was adopted by the EU to regulate the energy market [70].

“Active Consumers,” Art. 15 IMD

This part of the article shows the EU's vision, which states that the prosumer can participate in all energy markets as an equal. The following were listed in article 15 as prosumers’ entitlement:

- operate either directly or through aggregation,
- sell self-generated electricity including through power purchase agreements,
- participate in flexibility and energy efficiency schemes,
- Be subject to cost-reflective, transparent, and non-discriminatory network charges [71].

Conclusion

The rise of prosumers in the energy market is, no doubt, a relief to the energy system. Their activities have a positive effect on the natural environment, economic development, and have provided more energy choices, leading to innovation in the energy sectors. Measures should be taken to research advanced storage systems and other grid modernization systems to encourage prosumers to stay on the grid and ensure that prosumers have flexibility and options with their energy supply.

4.3.5 5 - DSO/Prosumer Contract Type: Normal Grid Connection Service

In recent years, Europe's energy system has witnessed a transition towards a low carbon economy, which means that there is a more significant role for renewable energy sources. Consumers also now have the roles to contribute to the system by becoming prosumers. Now, the markets have to be redesigned to encourage further production of energy and involvement of prosumers in the grid connection system [72].

This section will review the relationship between the DSO and prosumers in the standard grid connection service, to examine the duties of the DSO and prosumers in the grid connection service, the remuneration process, and regulations guiding the typical grid connection arrangement.

Key Terms

Prosumer: coined from two words; producers and consumers. This refers to the parties who not only consume but also produce goods or services. They are people/companies who value new technologies and innovations, the Green users concerned with environmentally sustainable solutions, and the Value seekers interested in economic benefits and product performance, quality, and security [46].

DSO: The DSO, Distribution System Operator, maintains and develops the network to provide non-discriminatory access to energy generators and consumers. They provide a secure, reliable, and efficient delivery in electricity between access points [73].

The Duties of the Parties

The DSO's main duty is to ensure grid security and reliable energy supply. It is the DSO's duty, according to article 25, to ensure the long-term ability of the energy distribution system. As well as ensure that there is security, reliability, and efficiency in the energy distribution system. They are also in charge of measuring the household consumers' energy used and measuring devices for small scale producers [74].

The prosumer's role in the grid connection service is to feed their excess energy into the grid connection, in partner with the DSO. So, while the DSO manages the grid, the prosumer stays active in the energy market by feeding or demanding from the grid.

Remuneration of the Parties

To stay on the grid and constantly contribute to the energy market, prosumers are expected to gain economic and financial benefits from this act.

Models are net metering, Feed-in Tariffs (FiTs), Feed-in Premium (FiPs) and competitive actions and requests for tenders.

DSO remuneration: When the DSO connects DER to the distribution system, the total cost of normal business management networks will most likely increase.

The DSO is remunerated by grid tariffs. Grid tariffs consist of a (i)fixed, (ii)energy-based and (iii) power-based component. Additional DSOs make a profit when they optimize their operations while distributing energy across the grid such that they incur less cost in the process [73].

The Normative/Regulation

The EU recently adopted a clean energy package, which contains a set of rules for regulating the energy markets as regards grid connection; below is the framework put out to guide the activities [71].

Art 15 of the IMDII tackles one of the most disturbing barriers for prosumers: bureaucracy. It lessens the long procedure of getting into the market for the prosumer.

The EU encourages residential storage facilities. Hence, Art. 15 compulsories the Member States to ensure that active customers own a storage facility:

- have the right to a grid connection within a reasonable time,
- are not subject to any double charge, including network charges, for stored electricity remaining within their premises and when providing flexibility services to system operators,
- are not subject to disproportionate licensing requirements and fees,
- are allowed to provide several services simultaneously.
- accessibility of self-consumption to all final customers, including low-income or vulnerable households,
- other possible unjustified regulatory barriers to renewable self-consumption, including for tenants,
- incentives for building owners to create opportunities for self-consumption, including for tenants [71].

Conclusion

It is a proven fact that the DSO's optimal performance benefits the consumer in the grid and other stakeholders in the energy market, and further research by the CEER has shown that innovative solutions such as the smart grid system are a stem to achieving this.

Therefore, regulations that would favour the ideas should be implemented since the innovative solutions can achieve the DSO's primary task and, on a broader note, one of the EU's core goals, which is to maintain an unbiased distribution system in the grid.

4.4 New types of contracts related to PARITY business cases

During the PARITY business cases analysis, novel contracts needed for the innovation introduced in the project has been identified. These contracts result from an analysis of the relationship between the parties and their roles. The identified contracts are depicted in Table 11.

Table 11. New contracts related to PARITY Business Models

#	BC	Parties / Roles		Type of contract
1	1	LEMO (Aggregator)	Prosumer	Prosumers sell and buy from LEM
2	1	LEMO (Aggregator)	DSO	Changing traffic light signal status. Setting grid prices for green and yellow state
3	2	LEMO (Supplier)	Prosumer	Prosumers sell and buy from LEM
4	2	LEMO (Supplier)	DSO	Changing traffic light signal status. Setting grid prices for green and yellow state
5	3	LFMO (DSO)	Aggregator	Aggregator sells flexibility
6	3	LFMO (DSO)	DSO	DSO buys flexibility

7	4	DSO	Aggregator	Usage and remuneration of DR management infrastructure for indirect DR usage
8	4	DSO	Prosumer	Remuneration for direct DR usage

An internal survey has been performed within PARITY pilot and technical partners to identify important aspects and requirements for each identified contract. The recommendations are grouped by a standard structure for a contract:

- Offer: a promise to act in exchange for agreed upon terms.
- Acceptance: clear terms how the offer is accepted
- Consideration: the value that each party brings to a contract is referred to as a consideration.
- Competency and capacity: both parties are legally competent and have the capacity to undertake its terms.

4.4.1 1 – BC1 - Prosumers sell and buy from LEM

Roles: LEMO (Aggregator) - Prosumer

Offer

The prosumer will buy and sell energy from the LEM. Remaining energy will be bought/sold by the supplier.

Important aspects and requirements from PARITY pilot and technical partners

- on-, mid-, and off-peak pricing scheme is established when prosumers sell/buy energy from the LEMO
- The prosumers' gain - loss relation for the actions. A risk function for the action should be created and the human should set his threshold or its risk - payment curve.
- Make sure all details of the offer are described: Who makes the offer, expiration date of the offer, under which circumstances the offer is no longer valid, terms of the offer
- A verbal offer does not represent a real compromise, it should be written.
- The proposed price of all energy transactions
- Any limits on the energy transactions
- The period of validity of the contract
- The offer must include amount of flexibility available and when it is going to be available. When it is going to be activated and how, also the DERs related with the flexibility offered should be noted.
- Ideally the contract should not refer to specific quantified and/or technical restrictions related to offered flexibility. Instead, prosumer flexibility should be managed in a seamless (as-a-service) manner.

Acceptance

In case of explicit LFM: The prosumer is not obliged to participate to the LEM and can exit in any moment. In implicit LFM, prosumers are not obliged to participate in LEM (in P2P trading), they are just subject to varying grid prices. They can also just react to these price signals by adapting their load profiles without trading on the LEM.

Important aspects and requirements from PARITY pilot and technical partners

- on-, mid-, and off-peak pricing scheme is agreed between the prosumers and the LEMO. The agreed pricing scheme is valid until the end of the contract with the LEMO or the termination for another reason

- The needs to avoid entering in a yellow or red status of the grid plus the minimization of the overall cost of operation
- An addition or change in an offer will always lead to new Acceptance
- A commercial contract does not represent enough compromise between aggregator-prosumer and decentralized P2P market participants.
- Clear options and rules for the participation withdrawal
- Any penalties for non-compliance with the terms
- Remuneration must be included, terms of payment, the flexibility committed must be available by the prosumer.
- System should act on prosumer loads in an automated manner and without requiring human intervention. Prosumer should be able to bypass system actions at any moment. However, this would be an opt-out process not an opt-in, in the sense that automated actions are performed ideally without people realizing and people can simply react - which typically means that user profiling has not yet aligned with human preference profiles.

Consideration

The remuneration is market based.

Important aspects and requirements from PARITY pilot and technical partners

- Energy selling scheduling towards the LEMO relies on the prediction of prosumers profiles for renewables and electricity loads. The remuneration is market based on the agreed pricing scheme (peak hours)
- The grid should not worsen its status with the transaction. Prosumers should be allowed to override the decision taken by the smart contract with a penalization.
- Clearly define the conditions for each consideration
- Define the consequences if e.g., an expected promised act could not be performed
- A consideration is legally armoured, therefore represents the ideal writing compromised to act for flexibility provided prosumers and P2P decentralized participants in the LEM. In P2P bilateral contracting is obligated to sign an energy exchange to be submitted to the SO. In the case of the energy optimization of the LEM through self-balancing (P2P) there would be stated the real compromised and requirements and obligation to act according the stated conditions fixed in the programming unit of the aggregator, availability at the same time that stated fixed economic benefits for participants derivate from the economic benefits from the aggregator. In the case of the SO balancing services, it is necessary too to sign availability and economic benefits as the request could come directly from the OS as a schedule action at the same time that the system should allow the direct contact from the prosumer to the aggregator (in real time orders) to enable the aggregator to bid flexibility in the local flexibility market. Terms allowing load control shifting of prosumers and smart metering installation.
- When it is confirmed, the prosumer must not be available to offer the same DERs and flexibility for the timeslot committed until the flexibility is provided.
- Intuitive contracts should be designed that incentivize prosumers to participate in mutually beneficial transactions with other prosumers with complementary needs/features as well as by uncertainty reduction by aggregated and coordinated forecasting and management of DERs etc.

Competency and Capacity

New grid regulation about LEM is needed. In special cases (ex. Switzerland, a LEM can already be setup in a private network, a self-consumption community). New regulation is also needed to enable P2P supply from a third party that is not the official supplier.

Important aspects and requirements from PARITY pilot and technical partners

- The prosumer is legally bonded with the LEMO to the pricing scheme agreed in the contract
- Forecast should be provided by the prosumers. A real time feedback interface should be provided to the prosumers.

- For Capacity, pay attention especially in the case of individual persons that are part of a contract (e.g., residential prosumers)
- For Competency, get/check legal and background information of company that wants to be involved in a contract
- The prosumers should be the owners of the buildings. An aggregator should be certificated in the national energy market (to bid) owner of programming units for balancing in compliance with national legislation.
- Regulation in each country
- Prosumers must guarantee that the flexibility and DERs committed are available.
- Pre-qualification should assess the technical competence of prosumers and align them with candidate contract schemes.
- Optimal VPP synthesis necessitate for top-down design which defines both the terms of VPP operation and the minimum capabilities for active participation.
- All energy exchanges should comply with the safety regulation for grid operation.

4.4.2 2 – BC1 - Changing traffic light signal status and setting grid prices

Roles: LEMO (Aggregator) - DSO

Offer

The DSO is responsible for the technical operation of the grid in the area of the LEMO. It will decide when the area is in GREEN, YELLOW and RED status. In the implicit LFM, it will set grid prices according to current grid conditions.

Important aspects and requirements from PARITY pilot and technical partners

- The amount of load that can be shifted from the LEM towards flexibility markets is pre-defined.
- Price per amount of flexibility (in terms of power and or energy)
- DSO to promise that (a) status of grid area is always known / can be retrieved, (b) status changes are published as soon as technologically possible, (c) describe how grid prices are affected, (d) how many times per year network is expected to be in yellow / red states.
- A verbal offer does not represent a real compromise, it should be written.
- The proposed price of all energy transactions according to the grid state and the amount of energy
- Any limits on the energy transactions
- The period of validity of the contract
- How it is changed the status must be regulated in the offer and how prosumers by the aggregator can react to price signals. The offer must include amount of flexibility available and when it is going to be available. When it is going to be activated and how, also the DERs related with the flexibility offered should be noted.
- DSO could act in different time windows:
  - pre-configuration of DER attributes based on their Grid location - once off process
  - pre-validation of market clearance compliance to grid constraints and avoidance of unwanted dispatch control signals that would lead to congestions - continuous
  - prioritized bids when in YELLOW regime - ideally performed together with other bids
- The safe and uninterrupted grid operation should be ensured.

Acceptance

The PROSUMERS CAN follow the grid prices. The LEMO is actually not affected by the varying prices, they just trigger LEM activities. The LEMO just has to follow the traffic light (explicit LFM: pause the LEM in YELLOW and RED; implicit LFM: pause the LEM in RED).

Important aspects and requirements from PARITY pilot and technical partners

- The aggregator CANNOT perform load shifting without restrictions. The aggregator can shift loads in respect to the balance of the LEM. It is contracted that the LEM balance is a priority, based on the prosumer's profiles. In case the grid state is violating the LEM balance the aggregator should compensate the LEMO in terms of energy and pricing.

- The status of the grid is not worsening. The overall cost of the solution is optimized.
- LEMO acts according to the status of grid area. LEMO must inform the prosumers about current status of grid area
- A commercial contract does not represent enough compromise between aggregator-prosumer and decentralized P2P market participants.
- Withdrawal options
- Any penalties for non-compliance with the terms
- Remuneration must include terms of payment, the flexibility committed must be available to the DSO
- In automated control, maybe prosumer notification when in YELLOW or RED regime should be appropriate.
    - Explicit LFM: LEM and LFM have different spatial boundaries. What happens with prosumer LEM transactions when these are not related to congestions during YELLOW. Why should these be paused?
    - Implicit LFM: implicit flexibility through human interaction is not reliable enough to address YELLOW state as it is perceived (and may even cause different problems like unwanted peaks or rebound effects). If instead implicit LFM is performed automatically then price schemes with higher spatiotemporal granularity could also be considered, in order to avoid new peaks from uniform simultaneous responses or rebound effects. Also, more focused and dynamic prices reflecting locational restrictions on specific time slots (that cannot be addressed by uniform prices even if they were dynamic).

<u>Consideration</u>

No remuneration between LEMO and DSO. This contract is regulated by national authorities. This is not an actual contract, but a regulated fact.

Important aspects and requirements from PARITY pilot and technical partners

- The remuneration for the prosumers is market based (i.e., based on the amount the aggregator should provide back to the LEM)
- Market based operation
- A consideration is legally armoured, therefore represents the ideal writing compromised to act for flexibility provided prosumers and P2P decentralized participants in the LEM. In P2P bilateral contracting is obligated to sign an energy exchange to be submitted to the SO. In the case of the energy optimization of the LEM through self-balancing (P2P) there would be stated the real compromised and requirements and obligation to act according the stated conditions fixed in the programming unit of the aggregator, availability at the same time that stated fixed economic benefits for participants derivate from the economic benefits from the aggregator. In the case of the SO balancing services, it is necessary too to sign availability and economic benefits as the request could come directly from the OS as a schedule action at the same time that the system should allow the direct contact from the prosumer to the aggregator (in real time orders) to enable the aggregator to bid flexibility in the local flexibility market. Terms allowing load control shifting of prosumers and smart metering installation. DSO should have an agreement with the aggregator to allow aggregator to access smart data from prosumers. The economic terms from DSO benefit are stated in legislation but for the billing process (BRP), BRP need the billing information from DSO.

<u>Competency and Capacity</u>

Grid prices set by DSO are supervised by the national regulation authority.

Important aspects and requirements from PARITY pilot and technical partners

- The aggregator is going to need increased forecasting capabilities and a good management of risk operations.

- DSO is equipped with the tools to monitor the status and communicate with the LEMO Grid prices set by DSO are made available for check by authorities
- The prosumers should be the owners of the buildings. An aggregator should be certificated in the national energy market (to bid) owner of programming units for balancing in compliance with national legislation.
- Regulation in each country
- The aggregator must guarantee that the flexibility and DERs committed are available.
- All energy exchanges should comply with the safety regulation for grid operation.

4.4.3 3 – BC2 - Prosumers sell and buy from LEM

Roles: LEMO (Supplier) - Prosumer

Offer

From a contract perspective the Prosumers are buying energy from the Supplier=LEMO (the LEMO sources energy from the peers, either decided automatically or according to the prosumers preferences)

Important aspects and requirements from PARITY pilot and technical partners

- The prosumers are buying energy from the supplier with a "Validity License"
- The supplier has no control over the personal data that are made available by the prosumer.
- Centralized or distributed credit score techniques (as used in P2P software) to incentive the active and recurrent participation on the market
- LEMO (Supplier) offers the possibility to prosumer to participate in LEM
- LEMO (Supplier) defines the price for its service that provides in LEM
- A verbal offer does not represent a real compromise, it should be written.
- The proposed price of all energy transactions
- Any limits on the energy transactions
- The period of validity of the contract
- The offer must include amount of flexibility available and when it is going to be available. When it is going to be activated and how, also the DERs related with the flexibility offered should be noted.
- How can more servitized models also be addressed (i.e., heating as a service) and SLAs based on the core human centric performance aspects related to human comfort identified? How can the supplier facilitate through its contracts different types of P2P transactions matching different prosumer profiles and preferences (depending on the contract prosumers may opt for different performance aspects focusing energy cost, green energy, maximum comfort, etc.)
- Network tariffs should be accepted, and grid operation ensured.

Acceptance

In both cases: Prosumer is obliged to participate in the LEM when signing a supply contract with the Supplier=LEMO

Important aspects and requirements from PARITY pilot and technical partners

- Since the prosumers are obliged to participate in the LEM when signing the supply contract, both parties should agree to a validation period - "Validity License" (e.g., 1 year contract)
- Without a provision, in consideration of the existence of the directions provided by the prosumer, the express approval of the prosumer or the legal duty, the supplier shall not send the consumption data to other parties or the mechanism for reasons other than selling energy.
- Grid "distance" between the two parties. Minimization of external energy resources used.
- Prosumer participating in LEM can be characterized as seller, buyer or seller & buyer

- Define possible penalties if prosumer cannot deliver amount of energy promised to sell
- Prosumer can have ability to set max. amount of energy to make available to LEM and set preferences (e.g., selling time intervals) that LEMO will respect
- A commercial contract does not represent enough compromise between aggregator-prosumer and decentralized P2P market participants.
- Withdrawal options
  Any penalties for non-compliance with the terms
- Remuneration must include terms of payment, the flexibility committed must be available by the prosumer.
- System should act on prosumer loads in an automated manner and without requiring human intervention. Prosumer should be able to bypass system actions at any moment. However, this would be an opt-out process not an opt-in, in the sense that automated actions are performed ideally without people realizing and people can simply react - which typically means that user profiling has not yet aligned with human preference profiles.

Consideration
The remuneration is market based.

Important aspects and requirements from PARITY pilot and technical partners

- The remuneration is market based. The license can be extended automatically. The value of the license can be reduced in the light of inappropriate payment patterns toward the supplier
- Both parties ensure that personal data will be stored on the basis stated in the GDPR.
- The transaction should not increase the risk of a change in the grid status
- LEMO is expected to assist in selecting the proper selling peer and ensure fairness among the peers and benefit for the buyer peer. This could be an added value service of LEMO. LEMO is expected to inform other prosumers about any buying requests if there are no active sellers.
- A consideration is legally armoured, therefore represents the ideal writing compromised to act for flexibility provided prosumers and P2P decentralized participants in the LEM. In P2P bilateral contracting is obligated to sign an energy exchange to be submitted to the SO. In the case of the energy optimization of the LEM through self-balancing (P2P) there would be stated the real compromised and requirements and obligation to act according the stated conditions fixed in the programming unit of the aggregator, availability at the same time that stated fixed economic benefits for participants derivate from the economic benefits from the supplier. In the case of the SO balancing services, it is necessary too to sign availability and economic benefits as the request could come directly from the OS as a schedule action at the same time that the system should allow the direct contact from the prosumer to the aggregator (in real time orders) to enable the supply to bid flexibility in the local flexibility market. Terms allowing load control shifting of prosumers and smart metering installation.
- Intuitive contracts should be designed that incentivize prosumers to participate in mutually beneficial transactions with other prosumers with complementary needs/features as well as by uncertainty reduction by aggregated and coordinated forecasting and management of DERs etc.
- Market prices should be decoupled from more intuitive remuneration schemes to prosumers (like for example more advanced green tariffs that take into consideration spatiotemporal parameters and track real energy flows, or flexible credits).
  Also, "supplier based" P2P models is only one case. Alternative models should be considered as well (by independent vendors, or public blockchain approaches, etc.)

Competency and Capacity
New grid regulation about LEM is needed. In special cases (ex. Switzerland, a LEM can already be setup in a private network, a self-consumption community).

Important aspects and requirements from PARITY pilot and technical partners

- Make sure prosumer will be able to have available the energy to sell

- The prosumers should be the owners of the buildings. A supply should be certificated in the national energy market (to bid) owner of programming units for balancing in compliance with national legislation.
- Regulation in each country
  System operating framework in each country by the DSO
- Prosumers must guarantee that the flexibility and DERs committed are available.
- Pre-qualification should assess the technical competence of prosumers and align them with candidate contract schemes.
  Optimal VPP synthesis necessitate for top-down design which defines both the terms of VPP operation and the minimum capabilities for active participation.
- Contracts should ensure that the technical operation of the grid is not violated and the operation of LEM should not interfere in the operation of other markets. New regulation is necessary for the Greek energy market too.

4.4.4 4 – BC2 - Changing traffic light signal status and settings grid prices

Roles: LEMO (Supplier) - DSO

Offer

The DSO is responsible for the technical operation of the grid in the area of the LEMO. It will decide when the area is in GREEN, YELLOW and RED status. In the implicit LFM, it will set grid prices according to current grid conditions.

Important aspects and requirements from PARITY pilot and technical partners

- DSOs need to provide to the LEMO access to participate in all LEM services
- The prosumers' gain - loss relation for the actions. A risk function for the action should be created and the human should set his threshold or its risk - payment curve.
- A verbal offer does not represent a real compromise, it should be written.
- The proposed price of all energy transactions according to the grid state and the amount of energy
  Any limits on the energy transactions
  The period of validity of the contract
- How it is changed the status must be regulated in the offer and how the supplier can react to price signals. The offer must include amount of flexibility available and when it is going to be available. When it is going to be activated and how, also the DERs related with the flexibility offered should be noted.
- Ideally the contract should not refer to specific quantified and/or technical restrictions related to offered flexibility. Instead, prosumer flexibility should be managed in a seamless (as-a-service) manner.
- Through this SLA the DSO should ensure the operation of the grid during the GREEN state and be able to define the limits determining the traffic light approach.

Acceptance

The PROSUMERS CAN follow the grid prices. The LEMO is actually not affected by the varying prices, they just trigger LEM activities. The LEMO just has to follow the traffic light (explicit LFM: pause the LEM in YELLOW and RED; implicit LFM: pause the LEM in RED).

Important aspects and requirements from PARITY pilot and technical partners

- All resources (generation, storage and demand) connected to transmission or distribution grids should be able to participate in LEM and offer services to the LEMO
- The needs to avoid entering in a yellow or red status of the grid plus the minimization of the overall cost of operation
- A commercial contract does not represent enough compromise between supply-prosumer and decentralized P2P market participants.
- Withdrawal options

Any penalties for non-compliance with the terms

- Remuneration must include terms of payment, the flexibility committed must be available to the DSO
- System should act on prosumer loads in an automated manner and without requiring human intervention. Prosumer should be able to bypass system actions at any moment. However, this would be an opt-out process not an opt-in, in the sense that automated actions are performed ideally without people realizing and people can simply react - which typically means that user profiling has not yet aligned with human preference profiles.

Consideration

No remuneration. This contract is regulated by national authorities. This is not an actual contract, but a regulated fact.

Important aspects and requirements from PARITY pilot and technical partners

- Appropriate market framework should be supported by the DSO
- The grid should not worsen its status with the transaction. Prosumers should be allowed to override the decision taken by the smart contract with a penalization.
- A consideration is legally armoured, therefore represents the ideal writing compromised to act for flexibility provided prosumers and P2P decentralized participants in the LEM. In P2P bilateral contracting is obligated to sign an energy exchange to be submitted to the SO. In the case of the energy optimization of the LEM through self-balancing (P2P) there would be stated the real compromised and requirements and obligation to act according the stated conditions fixed in the programming unit of the supply, availability at the same time that stated fixed economic benefits for participants derivate from the economic benefits from the supplier. In the case of the SO balancing services, it is necessary too to sign availability and economic benefits as the request could come directly from the OS as a schedule action at the same time that the system should allow the direct contact from the prosumer to the aggregator (in real time orders) to enable the supply to bid flexibility in the local flexibility market. Terms allowing load control shifting of prosumers and smart metering installation. DSO should have an agreement with the aggregator to allow aggregator to access smart data from prosumers. The economic terms from DSO benefit are stated in legislation but for the billing process (BRP), BRP need the billing information from DSO.
- Intuitive contracts should be designed that incentivize prosumers to participate in mutually beneficial transactions with other prosumers with complementary needs/features as well as by uncertainty reduction by aggregated and coordinated forecasting and management of DERs etc.

Competency and Capacity

Grid prices set by DSO are supervised by the national regulation authority.

Important aspects and requirements from PARITY pilot and technical partners

- Forecast should be provided by the prosumers. A real time feedback interface should be provided to the prosumers.
- The prosumers should be the owners of the buildings. A supply should be certificated in the national energy market (to bid) owner of programming units for balancing in compliance with national legislation.
- Regulation in each country
  System operating framework in each country by the DSO
- The supplier as operator must guarantee that the flexibility and DERs committed are available.
- Pre-qualification should assess the technical competence of prosumers and align them with candidate contract schemes.
  Optimal VPP synthesis necessitate for top-down design which defines both the terms of VPP operation and the minimum capabilities for active participation.
- Contracts should ensure that the technical operation of the grid is not violated and the operation of LEM should not interfere in the operation of other markets.
  Grid prices are already regulated by the NRA in Greece.

4.4.5 5 – BC3 - Aggregator sells flexibility

Roles: LFMO (DSO) - Aggregator

Offer
The aggregator can sell his flexibility on the LFM.

Important aspects and requirements from PARITY pilot and technical partners

- DSO requests flexibility for managing the market
- DSO as an independent LFM operator
- Aggregator offers flexibility to DSO. Specific terms to be defined when network is in yellow state.
- A verbal offer does not represent a real compromise, it should be written.
- The proposed price and conditions for the flexibility transactions
- Any limits on the transactions
- The period of validity of the contract
- The offer must include amount of flexibility available and when it is going to be available. When it is going to be activated and how, also the DERs related with the flexibility offered should be noted.
- How can the aggregator combine P2P transactions in its portfolio? The VPPs could be hybrid in the sense that they prioritize P2P transactions and appropriately integrate P2P transactions into aggregated VPP clusters of self-organized prosumers.
- The aggregator can sell the available flexibility in the LFM during the YELLOW state. This flexibility procurement is an emergency handling mechanism and not a permanent DSO operational process.

Acceptance
The aggregator is not obliged to participate to the LFM. But usually during YELLOW status it should be profitable. The LFMO runs the market.

Important aspects and requirements from PARITY pilot and technical partners

- a) The aggregator has contract with the DSO. The aggregator sells flexibility to the DSO. The latter is the one responsible to coordinate and manage the flexibility.
  b) DSO operate the LFM, calling for a flexibility service when needed in order to solve congestions in the market.
- The prosumers' gain - loss relation for the actions. A risk function for the action should be created and the human should set his threshold or its risk - payment curve.
- Aggregator accepts that will preferably sell flexibility (with high priority) to DSO when network is in yellow state.
  Pricing: DSO and aggregator accept that the price will be determined based on current market status after negotiation/bidding.
- A commercial contract does not represent enough compromise between supply-prosumer and decentralized P2P market participants.
- Withdrawal options
  Any penalties for non-compliance with the terms
- Remuneration must include terms of payment, the flexibility committed must be available by the aggregator
- During YELLOW state maybe participation should be obligatory?

Consideration
The remuneration is market based; the aggregator is not obliged to sell on the LFM

Important aspects and requirements from PARITY pilot and technical partners

- The DSO is independent and the only one procuring flexibility to the LFM. The enumeration is market based and managed by the DSO
- The needs to avoid entering in a yellow or red status of the grid plus the minimization of the overall cost of operation
- Aggregator is expected to respond to DSO flexibility requests when in yellow state, on behalf of the prosumers (opportunity to increase prosumers' profit)
- A consideration is legally armoured, therefore represents the ideal writing compromised to act for flexibility provided by the aggregator to the DSO in order to grid congestion management and voltage control. DSO should have an agreement with the aggregator to allow aggregator to access smart data from prosumers. The economic terms from DSO benefit are stated in legislation but for the billing process (BRP), BRP need the billing information from DSO.

Competency and Capacity
New grid regulation about LFM is needed.

Important aspects and requirements from PARITY pilot and technical partners

- The procurement of flexibility services for DSOs is not allowed in most European countries. However, there are a few exceptions: in Germany and Belgium, a contractual agreement can already be established.
- The grid should not worsen its status with the transaction. Prosumers should be allowed to override the decision taken by the smart contract with a penalization.
- DSO is both a market coordinator and market participant in this scenario. Must be obligated to ensure fairness to all market participants
- An aggregator should be certificated in the national energy market (to bid) owner of programming units for balancing in compliance with national legislation. DSO follows national legislation.
- Regulation in each country
- The aggregator must guarantee that the flexibility and DERs committed are available.
- Pre-qualification should assess the technical competence of prosumers and align them with candidate contract schemes.
  Optimal VPP synthesis necessitate for top-down design which defines both the terms of VPP operation and the minimum capabilities for active participation.
- Appropriate VPP formation based on distribution network topology- locational awareness.
- Accurate for the Greek regulatory framework

4.4.6 6 – BC3 - DSO buys flexibility

Roles: LFMO (DSO) - DSO

Offer
The DSO buys the flexibility on the LFM

Important aspects and requirements from PARITY pilot and technical partners

- The DSO is legally contracted for a specific time period with the LFMO
- DSO and LFMO should cooperate in the contract level, on the definition of controllability procedures and find the solution to allow DSO to change the state of the market, in alert and emergency system states.
- The prosumers' gain - loss relation for the actions. A risk function for the action should be created and the human should set his threshold or its risk - payment curve.
- A verbal offer does not represent a real compromise, it should be written.
- The proposed price and conditions for the flexibility transactions
  Any limits on the transactions

The period of validity of the contract

- The offer must include amount of flexibility available and when it is going to be available. When it is going to be activated and how, also the DERs related with the flexibility offered should be noted.
- The possibility of the DSO transactions being prioritized rather than being the only ones under YELLOW state should be considered - see also comment in BC1 – Of course if the market is run by the DSO and the DSO is the only buyer this can simply be addressed when deciding on the co-existence and interplay between the LFM and other markets

Acceptance

As a single buyer the DSO is obliged to participate to the LFM by a regulatory framework.

Important aspects and requirements from PARITY pilot and technical partners

- The DSO is able to buy flexibility only for the LFMO that has contract with (during the time frame of the contract). If the DSO decided to change LFMO a fee should be paid towards the LFMO
- DSO and LFMO should work together to detect when, and in which, active power management situations coordination is needed and what level of coordination is required, actions have a mutual impact.
- The needs to avoid entering in a yellow or red status of the grid plus the minimization of the overall cost of operation
- A commercial contract does not represent enough compromises.
- Withdrawal options
  Any penalties for non-compliance with the terms
- Remuneration must include terms of payment, the flexibility committed must be available by the aggregator
- The use of flexibility should not be employed as an investment avoidance tool for the DSO, but as a cost-effective solution in cases where investments are not favoured based on a Cost Benefit Analysis (CBA). DSOs may prefer to participate in the LFM, but in some cases it may be not be profitable for them. So, they can be obliged to participate by the NRAs.

Consideration

The remuneration is market based; the aggregator is not obliged to sell on the LFM

Important aspects and requirements from PARITY pilot and technical partners

- The grid should not worsen its status with the transaction. Prosumers should be allowed to override the decision taken by the smart contract with a penalization.
- A consideration is legally armoured, therefore represents the ideal writing compromised to act for flexibility provided by the DSO in order to grid congestion management and voltage control. DSO should have an agreement with the prosumers to access smart data from prosumers. The economic terms from DSO benefit are stated in legislation.

Competency and Capacity

New grid regulation about LFM is needed.

Important aspects and requirements from PARITY pilot and technical partners

- DSO should be certificated in the national energy market.
- Forecast should be provided by the prosumers. A real time feedback interface should be provided to the prosumers.
- Regulation in each country
- The aggregator must guarantee that the flexibility and DERs committed are available. DERs from the DSO side should be noted
- LFM terms of participation should also reflect the capabilities of DER/prosumers as in BC1

4.4.7 7 – BC4 - Usage and remuneration of DR management infrastructure for indirect DR usage

Roles: DSO - Aggregator

Offer

Usage and remuneration of DR management infrastructure for indirect DR usage

Important aspects and requirements from PARITY pilot and technical partners

- Resources should be able to value their potential where it is the most efficient
- Aggregator offers flexibility to DSO when network area is in red state directly and not through the market, so a bilateral agreement is needed to be established before the emergency DR activation request from DSO
- A verbal offer does not represent a real compromise, it should be written.

Acceptance

The DSO offers the aggregator to use the controlled DR during the RED grid status. In exchange of a remuneration the aggregator will give up the control to the DSO.

Important aspects and requirements from PARITY pilot and technical partners

- Aggregators may enter into a contract with DSOs setting out criteria for the controllability and successful energy management of DRs due to the growing effect of distributed energy on the overall function and preparation of the market.
- The actions should be the less costly way to return to green status
- Agree on minimum and maximum amount of flexibility that can be provided and price (can be done automatically every day for the next 24-hours)
- A commercial contract does not represent enough compromise.

Consideration

Remuneration is fixed. Available DR will change accordingly to the comfort level.

Important aspects and requirements from PARITY pilot and technical partners

- Remuneration is fixed.
- The DSO should be monitored by the national regulator to not make any excessive use of its power
- On an emergency DSO request, Aggregator is expected to respond within a reasonable time (specify max response time)
- Aggregator is expected to calculate/estimate the amount of flexibility that can be provided
- A consideration is legally armoured, therefore represents the ideal writing compromised to act for flexibility provided by the DSO in order to grid congestion management and potential control. DSO should have an agreement with the prosumers to access smart data from prosumers. The economic terms from DSO benefit are stated in legislation. Aggregator would manage, invoice prosumers and DER producers. Aggregator would have contracts with DER producers and DSO.
- Comfort levels should be defined carefully in order to achieve fair remuneration. Remuneration should define by the NRAs as aggregators are obliged to assist DSOs for the safe grid operation during critical situations (i.e., red state).
- It is probably necessary to distinguish the types of installations, in order to define a threshold. Installations that are below the power limit are used by the DSO and their remuneration is in the tariff; what is above the power limit (such as for example the columns for the rapid recharging of electric vehicles) enter instead into a private market negotiation. In the case of the DSO, the payment could be made with a discount on the network tariff.

Competency and Capacity
New regulation about DR usage by DSO needed

Important aspects and requirements from PARITY pilot and technical partners

- New regulation about DR usage by DSO needed
- New regulation is required
- DSO should be certificated in the national energy market. Aggregator should be certificate as MO to bid energy. Producers should certificate as Energy agents.
- Accurate for the Greek regulatory framework.

4.4.8 8 – BC4 - Remuneration for direct DR usage

Roles: DSO - Prosumer

Offer
Remuneration for direct DR usage. Maybe it is not a real offer to prosumers, but more an emergency intervention the DSO performs anyway. Using the aggregator's infrastructure, the intervention is not that radical than it would be if the DSO would turn off a whole connection point. The remuneration might be rather a regulated compensation for the prosumer's inconvenience.

Important aspects and requirements from PARITY pilot and technical partners

- Enabling the market participation of DR will require removing all barriers to aggregation from the DSO.
- Anyone. The system is at red status so the DSO would do as required
- A verbal offer does not represent a real compromise, it should be written.

Acceptance
The DSO offers the prosumer to use the controlled DR during the RED grid status. In exchange of a remuneration the aggregator will give up the control to the prosumer.

Important aspects and requirements from PARITY pilot and technical partners

- Consistency between wholesale market prices and local market contracts must be increased.
- The actions are the less costly way to return to green status
- Prosumer must be informed that flexibility can be delivered to DSO in emergency situation
- A commercial contract does not represent enough compromise.

Consideration
Remuneration is fixed. Available DR will change accordingly to the comfort level.

Important aspects and requirements from PARITY pilot and technical partners

- Prosumers should be able to aggregate regardless of their connection points and that exclusive markets limited to a particular DSO area would imply an inefficient limitation of the potential of aggregation of consumers.
- The DSO should be monitored by an external agency to not make any excessive use of its power
- Compensation for the prosumer's inconvenience
  Prosumer's preference about minimum acceptable comfort levels
- A consideration is legally armoured, therefore represents the ideal writing compromised to act for flexibility provided by the DSO in order to grid congestion management and voltage control. DSO should have an agreement with the prosumers to access smart data from prosumers. The economic terms from DSO benefit are stated in legislation.
- Comfort levels should be defined carefully in order to achieve fair remuneration. Remuneration should define by the NRAs as aggregators are obliged to assist DSOs for the safe grid operation during critical situations (i.e., red state).

- In the case of the efficiency of the tariffs, it is necessary to structure system tariffs based on the peak, so that the principle of causality can be applied and that the user who offers flexibility, respectively the aggregator, can carry out an economic analysis of convenience between the costs that they risk bearing in order to make available the flexibility and the income that the latter can generate.

<u>**Competency and Capacity**</u>
New regulation about DR usage by DSO needed

Important aspects and requirements from PARITY pilot and technical partners

- New regulation about DR usage by DSO needed
- New regulation is required
- DSO should be certificated in the national energy market. Producers should certificate as Energy agents.
- Accurate for the Greek regulatory framework

4.5 General comments from PARITY pilot and technical partners

- What would be useful is to also describe the operational time window of the LEM and LFM in relation to other markets for the different Business Cases. This would allow us to better understand the context under which prosumers are called to utilize their flexibility and participate in competitive contracts and products.

- Also, more focused business cases (not only around the market operators) would probably allow us to study closer the different services and contract types. See a relevant comment on BC2 - Remuneration schemes. --- In this case for example only a single type of P2P frameworks is addressed, run by suppliers and this way the study of cases where P2P can be performed based on public Blockchains or vendor-based platforms etc. could be missed. The market operator perspective is ideal to provide an overall context, however more vertical and indicative Business models will allow us to study on different PARITY platform features and services.

- The comparison with the market presents two problems:
  - The size of the flexibility. In the case of domestic installations (heat pumps, boilers), so with a few kilowatts of power available, the overall remuneration is likely to be less than the cost of the time needed to conclude the contract and to manage the administrative part of the contract.
  - Conflict between private interest and public interest. The DSO must ensure the proper functioning of the grid, but also the efficiency of grid tariffs. If for example an aggregator provides to a third party the flexibility of the boilers of a group of houses between 16.00 and 18.00, after this hour normally begins the period of peak in the domestic distribution networks, and the boilers must start operating because otherwise there would be a lack of hot water in the houses, provoking an artificial increase of the peak and therefore an increase of the grid costs. This imbalance is also paid by those (the tenants) who do not have flexibility to sell on the market.

- The pricing, so the incentive that can be given to holders of flexibility:
  - By the DSO is a function of how much it can save by optimizing its load profile at the point of connection to the high-voltage grid, respectively on the potential savings on grid reinforcement interventions (long-term effect) and on the hypothetical costs of restoration (partial or total) of the grid in case of default (but it is difficult to evaluate).
  - For the aggregator is a function of the value of the bids for primary, secondary and tertiary control called by the TSO. Pricing distribution modes are given by the remote-control unit registers.

- From the point of view of flexibility, it must be considered that an external operator, be it DSO or aggregator, can remotely manage only a limited number of domestic installations, normally the larger ones. Smaller systems, such as air conditioning, washing machine, dishwasher, etc., which aggregates make up an interesting flexibility, cannot be controlled because of the limits of connections on the devices interfacing with the central unit and also because of the cost that these connection operations involve, and therefore cannot be offered on the market. Still, their management is interesting for the domestic economy (and the network) in presence of a peak rate. It can therefore exist a sub-market of the flexibility to micro-local level.

5. Connecting SLAs with the blockchain

5.1 Technical aspects

5.1.1 SLAs and smart contract relationships

The usage of smart contracts within blockchain technology in the automated management of agreements between two entities is raising as an interesting and promising approach in the past years. In the public blockchains such as the Ethereum network, the provision of a distributed, shared and secure ledger, where custom functionalities can be developed and deployed, is a cornerstone to create specific agreements between different entities, such as a Service-Level Agreement (SLA). Under a generic point of view, SLA is a contract between a service provider and its customers, which mainly documents what services the provider will offer. Moreover, SLA defines the standards of the service that the provider is obligated to meet. Basically, SLA has to include the following main sections:

- A summary, with an overview of the agreement
- A detailed description of the services
- A clear definition of the parties involved in the agreement and with the related responsibilities.
- A precise establishment of key-performance-indicator (KPI) in order to enable the process reviewing.
- A termination process.

Currently, a collection of smart contracts can guarantee the proper automation of the features mentioned above in a blockchain. The usage of the smart contracts for SLA agreements has remarkable features, which are reported in the following list:

- **Open-source**: typically, the smart contract's code is open and readable from the blockchain. Consequently, any user allowed to connect to the network (e.g., everyone in a public Ethereum network) is able to download and analyse the entire code of the smart contracts.
- **Immutability**: each transaction performed by a user on the smart contract is recorded and cannot be deleted. Thus, the blockchain is an effective ledger where all operations related to the agreement (e.g., the reaching of a KPIs) are stored.
- **Safety**: all the data are securely stored in the blockchain and can be modified only using the rules defined in the smart contracts.
- **Sharing**: the data contained in the smart contracts can be shared with different level of access between the parties of the SLA.

The features reported in the previous list show how smart contracts are a promising approach to automate agreements between parties. Unfortunately, if the technical issues can be considered as completed, smart contracts are not currently valid under a legal point of view. This aspect, mainly due to the significant inertia typically related to regulatory aspects, has the significant consequence that, currently, it is not possible only to have a digital implementation via smart contracts. As a result, a proper correspondence between an agreement deployed on a collection of smart contracts and an SLA with a real legal status must be established and accepted by the parties. The usage of the combined versions of the agreement (i.e., smart contracts and SLA with recognized legal status) has the following two meaningful consequences. The former is that the adoption of smart contracts can significantly increase the ordinary agreement management in terms of velocity in the procedures and costs saving. The latter is that, if an extraordinary event occurs (e.g., a disaster recovery plan has to be actuated), the SLA version can be used to properly manage the peculiar situation under the legal point of view. Consequently, the combined adoption of the approaches, which can be summarized with the usage of the smart contracts during the regular management and of the SLA for the extraordinary situations, can be considered as a convenient and flexible strategy to use blockchain technology to manage agreements between parties.

5.1.2 Practical examples of SLAs and smart contracts relationships

In this section, two examples regarding the relationships between SLAs and smart contracts are described in detail in the following. The former shows how references that identify a SLAs can be managed in a smart contract. The latter describes how a smart contract can be upgraded to change its functionalities.

References between SLAs and smart contracts

A generic SLA contract always contains mandatory information that is used to identify it. Usually, this data is named Agreement ID; it is univocal and immutable. To properly manage the reference between an SLA and a smart contract deployed on a blockchain, the ID has to be saved on the smart contract just after its deployment. The smart contract functionalities have to guarantee the immutability of the identifier, i.e., no entity will be allowed to change it. Moreover, different levels of access can be implemented for read-only privilege. The secure storage of the ID is mandatory to identify the relationship between an SLA and a smart contract, but it is not sufficient. Other information has to be stored on the blockchain to use the smart contract automation during the ordinary agreement management (e.g., the customer, the service provider, the KPIs, etc.). Thus, in the development phase of the smart contract, proper storage and maintenance of these data should be designed and implemented. Moreover, similarly to the ID case users are allowed to read and update these data with different level of access. For example, only a trusted account can modify the KPIs registers. Instead, both the service provider and the customer are allowed to read the KPIs.

Smart contracts upgradability

Like any other software, also a smart contract can contain errors and bugs in its code. Thus, the possibility to perform an upgrade on it is required. On the other hand, it is known how a blockchain is, roughly, a ledger; as a consequence, it is impossible to delete from the blockchain a deployed smart contract. This dichotomy, i.e., an immutable code that has to be upgraded, can be solved taking into account the following directives during the design of the smart contracts:

1. Two smart contracts (or collections of smart contracts) have to be developed. The former, named DSC, relates only to data storage. It has to be as generic as possible and comprehensive of all the significant SLA information 2 (e.g., Agreement ID, KPIs, etc.). Moreover, DSC has an administrator, which is a trusted account. The logic inside this smart contract should be as minimal as possible. Essentially, DSC is a list of functions used only to update and read values (usually named setters and getters). The unique logic inside the smart contract is that only an account, saved in a DSC register named LSC_ADDR, is allowed to access the data. Only the administrator can change this register. LSC_ADDR relates to the latter smart contract, named LSC, which contains the logic for the proper SLA management but no data about it.
2. Regarding the basic data management in LSC, basically it needs an internal state and an administrator (typically the same of DSC), which is a trusted account. When the contract has not to be upgraded, its internal state is set by the administrator as active, i.e., it can be used by the accounts (e.g., the service provider, the customer) to interact with it and with DSC.
3. A simple mechanism has to be implemented in LSC for upgrade management. When LSC has to be changed, the administrator sets its state to inactive, i.e., the smart contracts will never execute transactions.

If the functionalities mentioned above are implemented, the administrator has to perform the following operations to upgrade LSC sequentially:

1. Set the state of the deployed LSC to inactive
2. Deploy a new version of LSC on the blockchain
3. Set LSC_ADDR register of DSC with the address of the new LSC

5.2 Legal and regulatory aspects

The usage of smart contract technology can offer technical benefits due their highly automated behaviour, and the reduction of needs of intermediaries. However legal and regulatory aspects have to be considered, as discussed in chapter 2. To be legally enforceable, smart contracts must meet the primary attributes of a conventional written contract. The following challenges have been identified:

- **Jurisdiction**: blockchain by its decentralized nature is not tied to a specific national or regional authority.
- **Anonymity**: courts need to be able to precisely identify the disputing parties
- **Immutability**: if not designed for upgradability blockchain smart contracts are immutable by their nature. If dispute resolution protocols are not built-in the smart contract itself litigation and disputes could be challenging to be resolved.
- **Legal consideration**: smart contracts should include all the characteristics that uphold conventional contracts to be legally enforceable.

The best practices for legally-enforceable smart contracts present several arguments in support of hybrid smart contracts over stand-alone smart contracts. Human intervention is necessary for interpretation of the variations between the spirit and letter of the law. While smart contracts are rigid and inflexible, conventional contracts offer room for reason in their interpretation.

Hybrid smart contracts can use traditional documentation to cater for areas of contracts that may not be translated easily in computer code. These include features such as the governing laws, dispute resolution, force majeure, fallback mechanisms and indemnification for coding errors and other issues.

For these reasons the smart contracts developed in PARITY cannot be self-contained and legally enforceable but they will implement automatic mechanisms following terms and conditions described in traditional contract documents: SLA agreements, international and national laws and regulation.

5.3 Stakeholder and social aspects

Taking into account that our genre of study is related to contemporary smart contracts for automated trading systems, this study follows a user-centred approach through speculative design, design fiction or design probes [75]. The rationale behind this approach is to address the design of future energy contracts informed from the insights that emerged from a qualitative analysis of fictional futures that participants provided in a series of online questionnaires.

Participants were introduced to automatic trading systems via a use case fictional scenario that illustrated a system similar to the P2P energy trading system. Smart contracts even if they are a sound and mature technology, might be misconceived as a disruptive technology and their acceptance by the end-users should be further investigated. In order to assess any potential social barrier, a survey targeting citizens was devised and carried out. As smart contracts are a highly technical concept that regular citizens are not familiar with, the surveys use a simile on a water distribution system (speculative scenario). This way not only the smart contract technology is hidden but also the relation with the energy utilities that could introduce a negative bias (this, some citizens may have a good or bad experience with their energy retailer. Therefore, this approach helps remove such subjective opinions from their answers [76]).

The survey was divided in three parts. The first section was related to a speculative scenario describing an automatic trading system:

> *"Imagine that you are someone who harvests water from rain and you have created a system to store the water you are not using. Sometimes, you have surpluses and sometimes you might find yourself with less water than you need. Fortunately, you are not isolated but you belong to a community of other people that also harvest water and all of you have decided to establish a trading system. As the community is constantly doing exchanges (overall in rainy and dry seasons) all of you agree that this is a very*

time-consuming task. Therefore, the community decides to establish a mechanism to automatically trade water through innovative technologies.

In a nutshell, the trading system is working as follows:

1. *Everyone sets up their preference for trading (e.g., to what level of water they consider a surplus or a shortage so the trade can start)*
2. *The system is monitoring each water-tank within the neighbourhood in real-time.*
3. *Whenever one of the preferences from the members is met, the system publishes an offer for buying or selling water.*
4. *The rest of the monitoring systems analyse the offer and take an autonomous decision on the basis of the current level of water, their potential necessities for the rest of the day, the weather forecast, or the price (cost-benefit).*
5. *If the deal is accepted, the transaction of water starts (ideally all the houses are connected with pipes)."*

The study presented in this section was based on an online survey that explores the perception of users on automatic trading systems. This is done via the previous speculative scenario related to a community-based water trading system established among citizens and retailers. The scenario was structured around several questions:

1. Would you be willing to participate in such a market?
2. Do you feel comfortable relaying the burden of trading to an autonomous system?
3. Would you increase your participation in such a market if it is hosted/regulated by reliable third parties? Who is reliable for you?
4. What are the risks and threats associated with this trading system?

Finally, the third part of the study was devoted to obtaining several demographic information to control the answers to previous sections.

Participants were recruited through Prolific [77], a popular crowdsourcing platform for academic studies. Only two prerequisites were determined for participation: being over 18 years of age and living in one of the countries represented in the PARITY project or living in northern Europe. Furthermore, some socio-economic information has been obtained, such as gender, socioeconomic status, employment status, whether they are or not students, type of household where they live, whether this was owned by them or rented and finally two questions about emerging technologies and energy sector literacy. A study completion time of 6 minutes has been estimated and a £1 incentive for participation (£7.53/hr) has been provided. The survey questions are shown in Annex A.

5.3.1 Survey results

The final sample consists of 832 answers. Two answers were deleted as they contain empty results (due probably to a failure of the recording system or a user error submitting de results). The sample is almost well gender balanced: 62 % Male, 38 % Female (see Figure 8).

In particular, the number of answers from Switzerland was a little bit low. Please note that these are only 37 % of the total sample as samples from across Europe has been collected. The distribution per climate region (Figure 10) is also a little bit unbalanced towards the Mediterranean and Continental climate groups: Cold (Denmark DK, Finland FI, Norway NO, Sweden SE) 15 %; Continental (Austria AT, Germany DE, The Netherlands NL, Switzerland CH) 35 %, Mediterranean (Spain ES, Italy IT, Greece GR) 45 % and Other 5 %. Please, it is worth noting that the Cold climate has far less population than the rest so this imbalance is expected.

The age distribution is skewed towards the young people (Figure 11). The mean age of the answers is 30, while, according to Eurostat, the mean age is 10 years more. The distribution of the main occupation seems correct (Figure 12)[78].

The main group is the employed and self-employed that combined account for 62 % of the answers and the next group are the students that represent the 30 %.

A large majority (57 %) of the persons surveyed live in flats. Houses represent 31 % of the persons surveyed (Figure 13). Moreover, half of the persons surveyed rented the place where they live (Figure 14).

Finally, the people self-describe themselves as neutral in knowledge about the energy and IoT sectors (Figure 15).

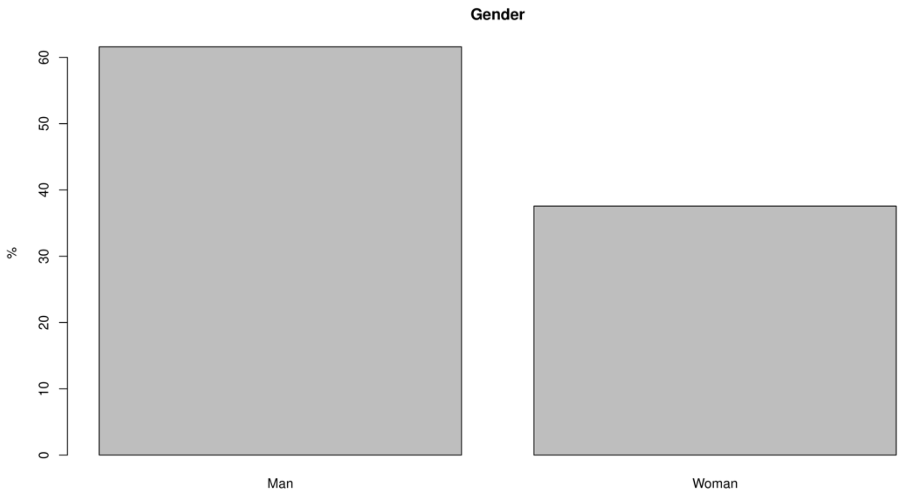

Figure 8. Gender distribution of the sample

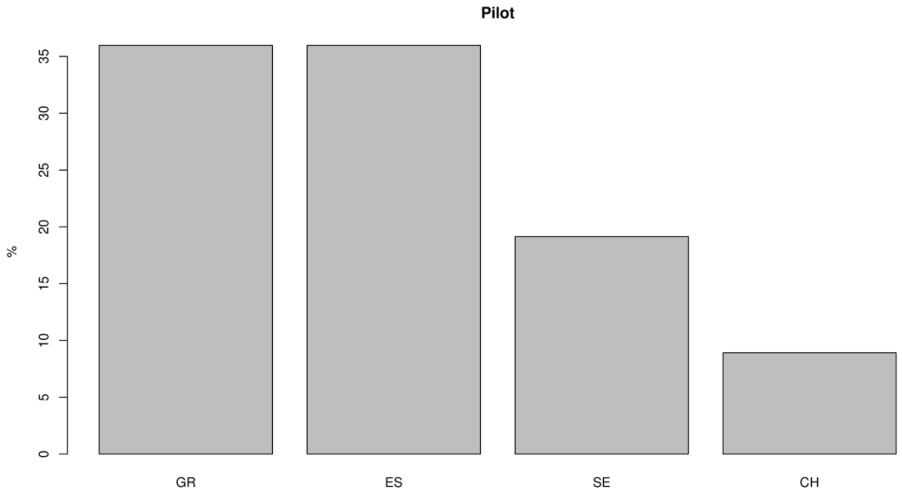

Figure 9. Distribution of the sample per pilot

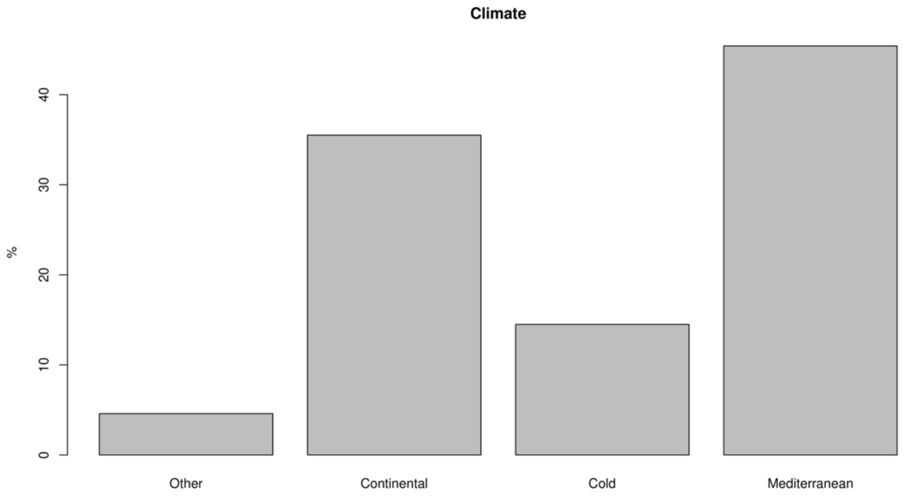

Figure 10. Distribution of the sample per climate zone

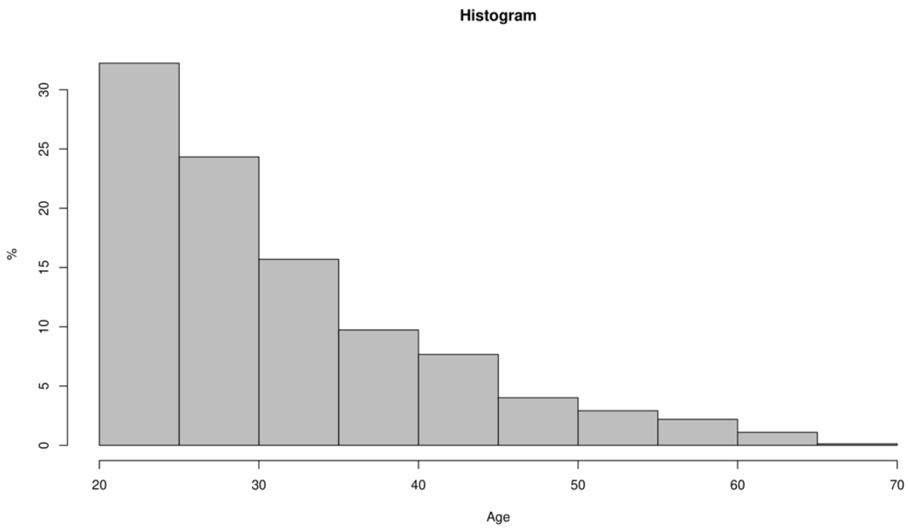

Figure 11. Age distribution of the sample

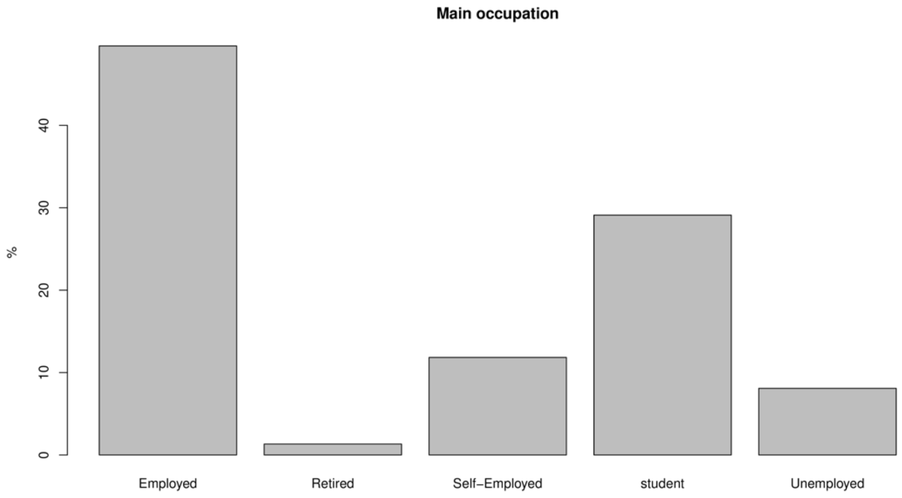

Figure 12. Main occupation of the sample

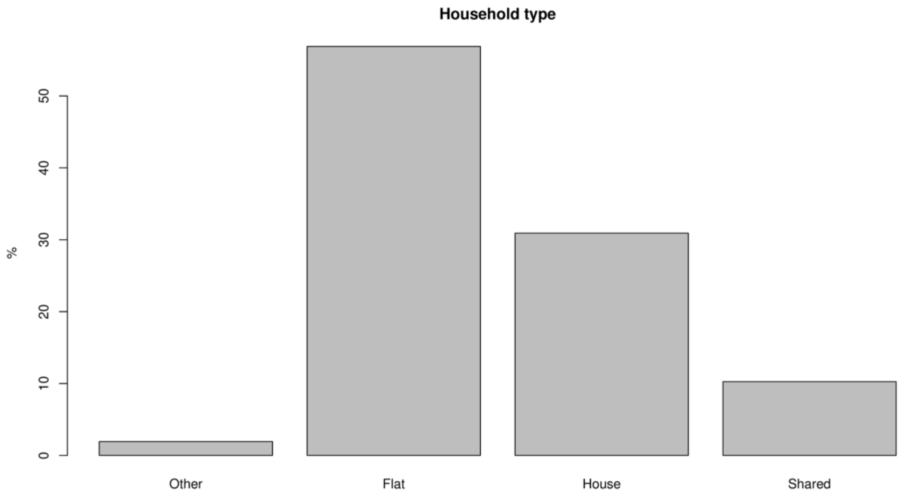

Figure 13. Type of house of used by the sample

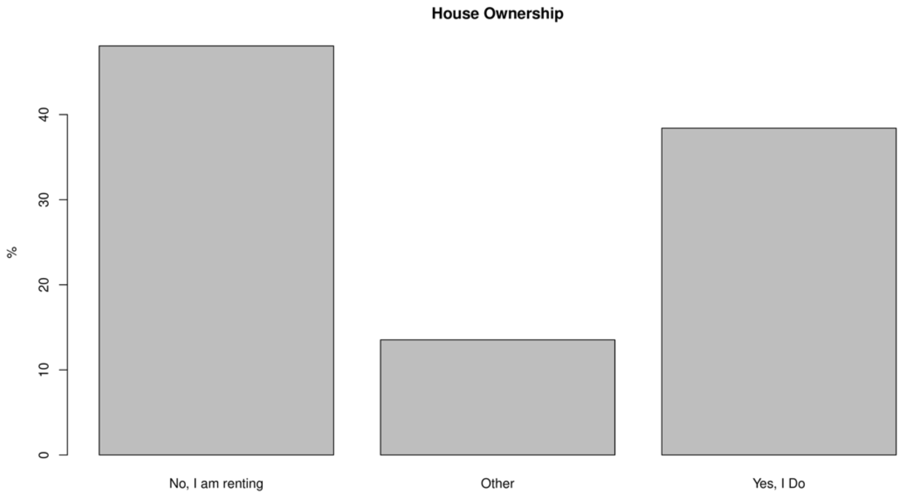

Figure 14. Type property of the houses used by the sample

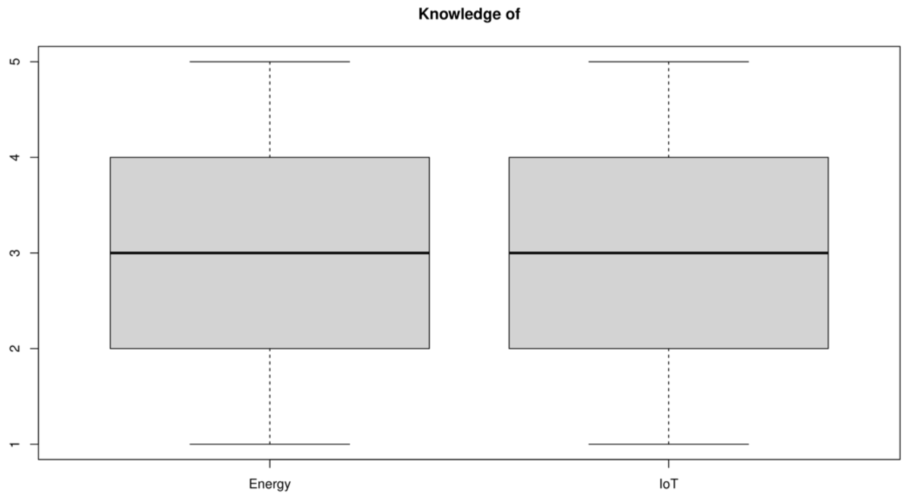

Figure 15. Amount of knowledge on different technologies

Quantitative results

The people surveyed seem to be mostly in favour of participating in flexibility markets (66 %) but a non-negligible 30 % would have its concerns. A more comprehensive view can be consulted in the qualitative results section. A large majority of the people surveyed (52 %) would like to supervise each decision taken by the system (Figure 17) and around 38 % would trust the system as it is (40 % if the one that would like to have a trial period before trusting the system are included). With respect to the market operator, according to the survey it should be a private company, but neutral (e.g., third-party market operator), hired by all parties or by the relevant public authority (Figure 18). Please note that only 15 % of the surveyed people would like to have a fully decentralized system. With respect to the fee to pay the Market Operator, most of the surveyed people (3^{rd} quartile) are willing to pay less than 10 % which seems to be a quite interesting amount to take into account when the business scenarios will be put in place in PARITY's pilot-sites. In fact, the median is 5 % and the mean value is around 7 %. Please note that some outliers have been removed in this question as the answer was not restricted and data such as 50 or 70% has been collected, which cannot be valid answers.

More than 60 % of the surveyed people think that the system should trade both surpluses and needs (Figure 19). In fact, the system should not only trade but also should optimize first the consumption (both energy efficiency and demand response, 49 %) before going to market (Figure 20). Finally, the people surveyed will mostly complain (57 %) under failures but will not leave the program. In fact, a non-negligible amount of people (34 %) would be willing to change their behaviour to reduce the possibility of a system failure next time.

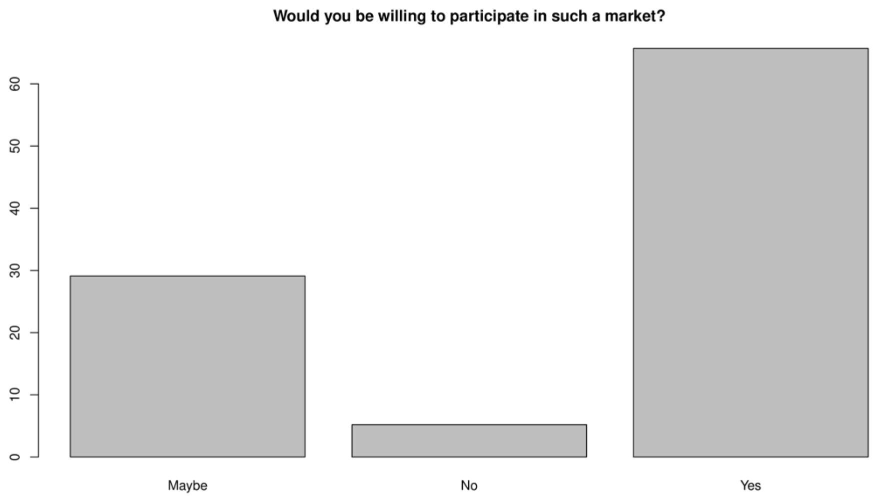

Figure 16. Amount of people that would participate in flexibility markets

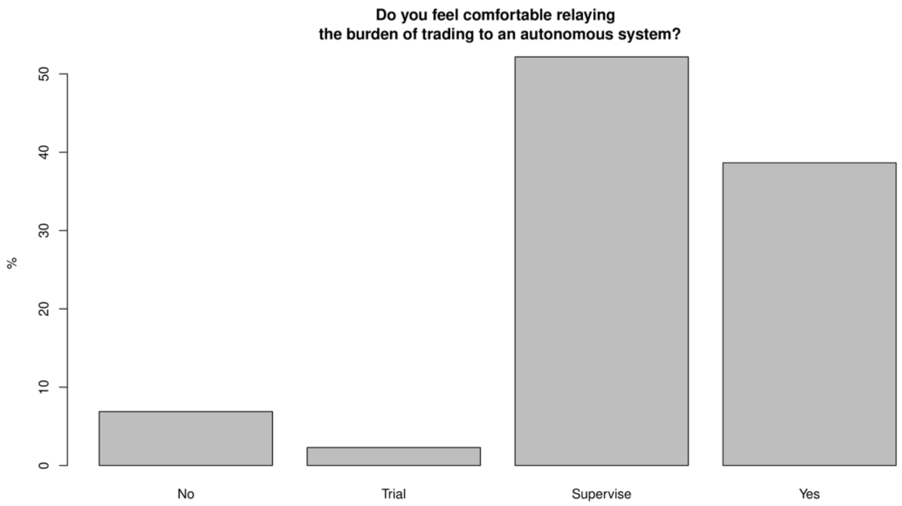

Figure 17. Amount of people that would trust the solution

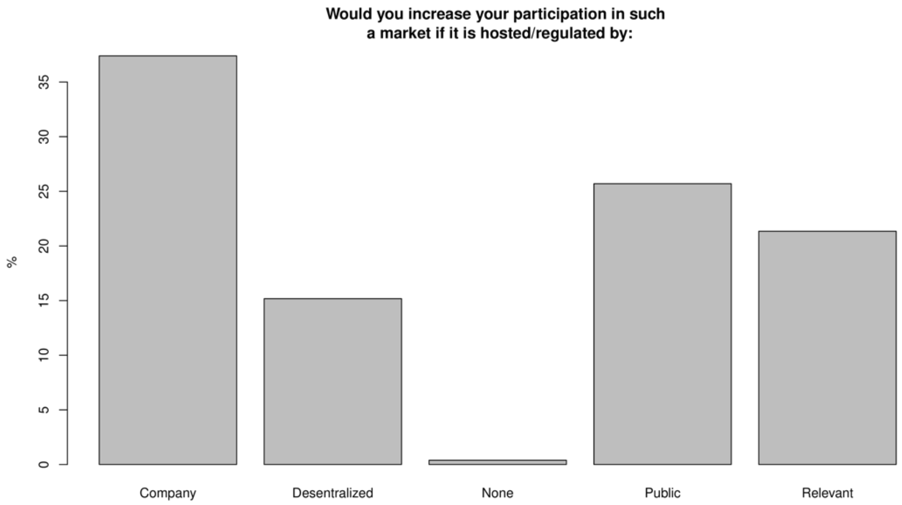

Figure 18. Entity that should be the market operator

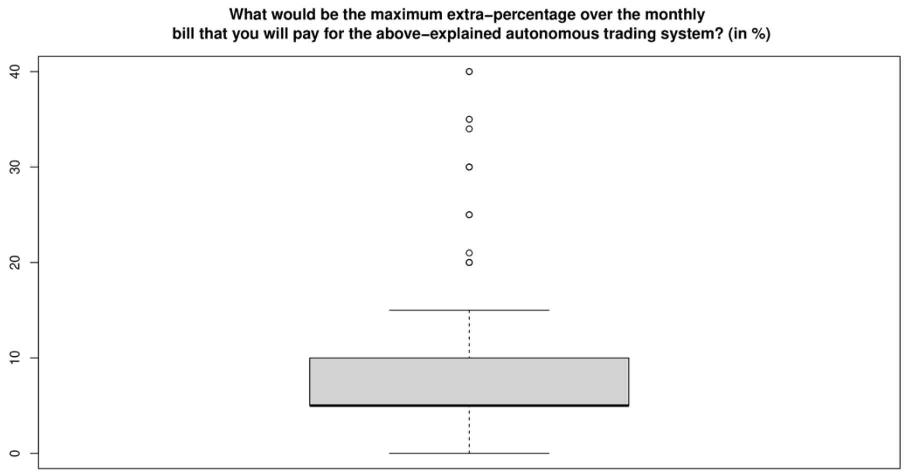

Figure 19. Distribution of the fee to the market operator

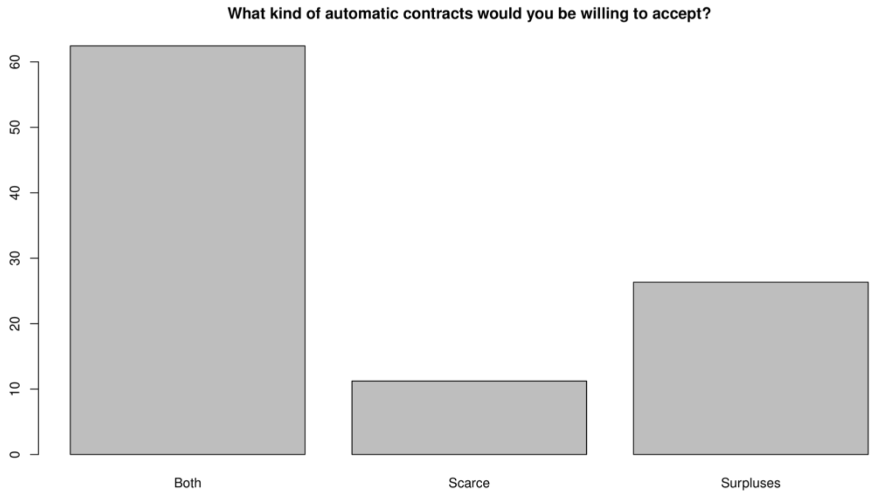

Figure 20. Type of contracts that should be made

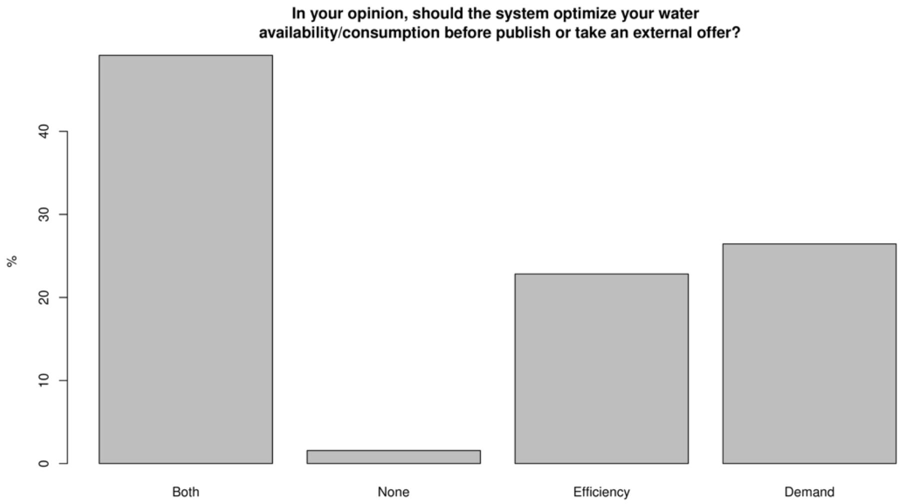

Figure 21. Type of optimizations carried out before going to market

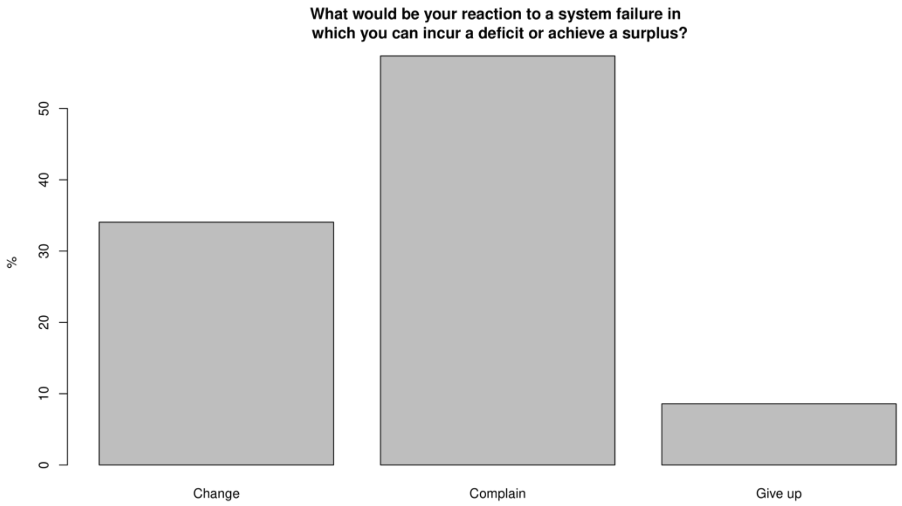

Figure 22. Behaviour of people after a system failure

Qualitative results

The results obtained in the qualitative section of the questionnaire referred to the risks and threats associated with this automatic trading system are presented below. As observed in Annex A, where the whole questionnaire is presented, the participants have been asked to provide as many risks and threats they identified for such an autonomous system. From the 832 responses 1291 unitary risks have been obtained (i.e., respondents provided more than one threat per entry).

The unitary risks were analysed via thematic analysis [79], a qualitative method in which codes are generated from the data rather than relying on pre-existing categories. Initially, the codes started to emerge from the data. However, at one point of the analysis showed that the codes were pretty similar to the barriers encountered in Deliverable 4.1 (Analysis of obstacles to Innovation under current & future regulatory & socio-economic context for LFM proliferation) when it came to analyse Local Energy and Flexibility Markets (see picture below). Therefore, it was decided to use these categories and subcategories to tag each risk associated to smart energy contracts and use the label “Other” if any of the barriers in the taxonomy below did not fit with the risk or “None” if one participant provided any risk.

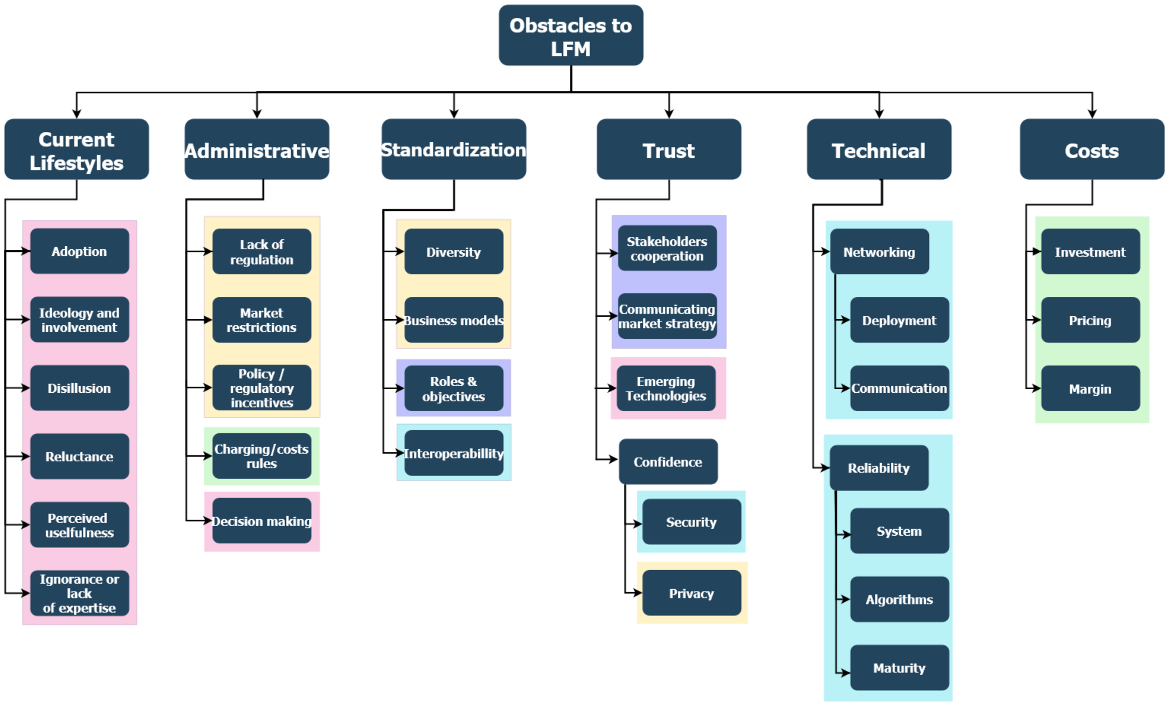

Figure 23. Obstacles to LFM

In the following it is provided an overview of the codes extracted under the two categories. Thus, the researcher labelled each risk with the main level of barriers (Current Lifestyles, Administrative, Standardization, Trust, Technical and Cost) and with the second level (all the labels under the first category's branch).

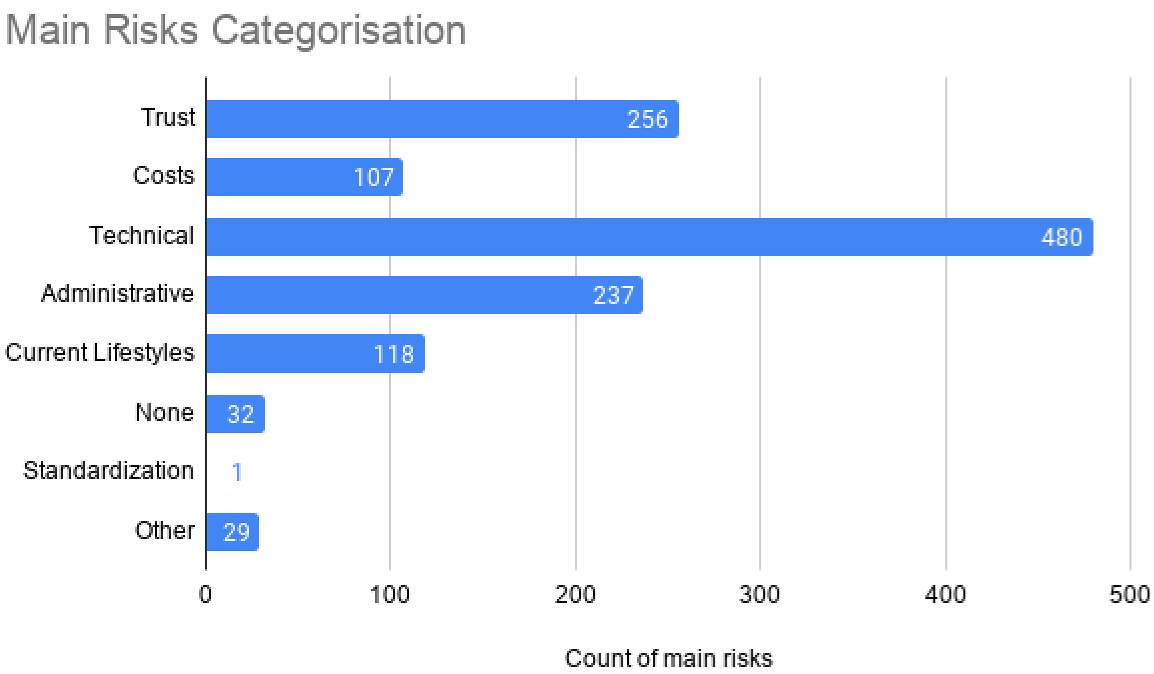

Figure 24. Main Risks Categorisation

The first plot gives an overview that the main risks associated with autonomous systems and smart contracts are related to their technical feasibility followed by concerns on trust on autonomous systems and how these can be fairly administered to avoid abuse or resources hoarding. In a lower position appear concerns related to the system cost or how these new smart systems impact on current lifestyles.

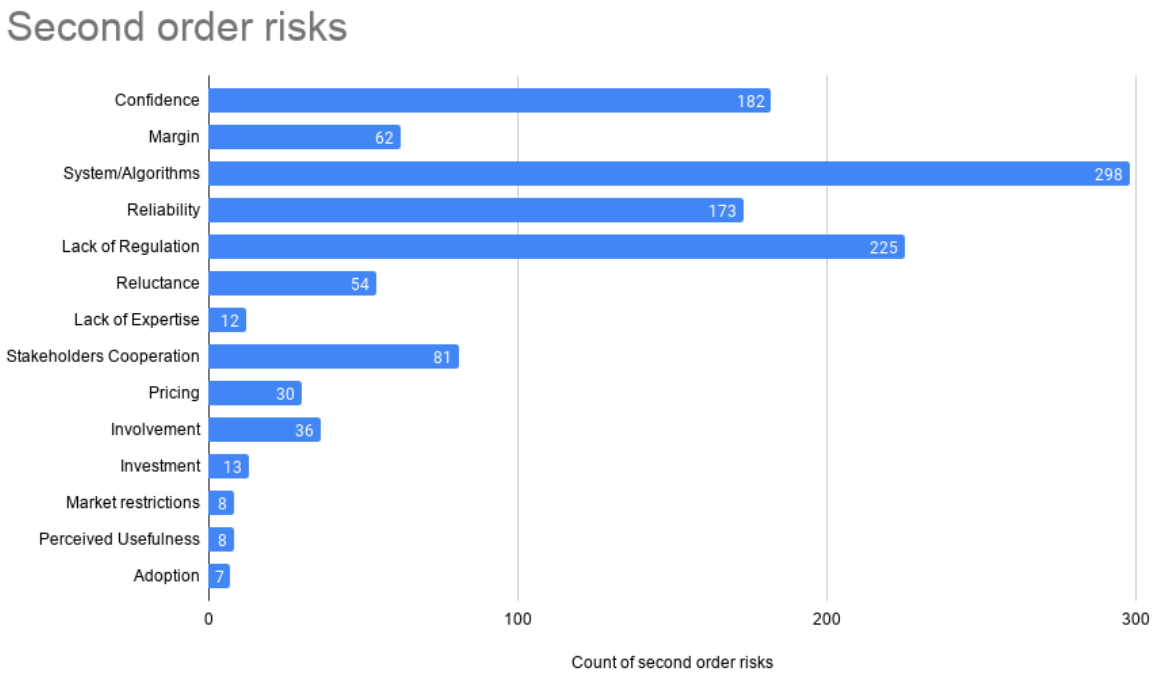

Figure 25. Second Order Risks

When breaking down each of the different main risks in their specific second order risks more insights come to the floor. Still, the overarching risk is associated with the technical feasibility of such a system. Specifically, it can be observed that the main threat is related to the biases the trading algorithms may have in their conception and development phases ("*no information about how the system makes the decisions*"), as well as the risk related to system failures such as errors in the distribution equipment. For example, one of the responders reported: "*First of all, if it's all automatic there is always the risk of irregular consumption so the system might buy water when it's not actually needed" or "selling a surplus that I actually needed thus not having enough water"*. In some cases, participants were concerned on how the autonomous system will deal with unexpected circumstances: "*inability to modify your need for water according to differences in consumption (for example, you may be having overnight visitors and hence need more water at some point*". Such a threat is very connected with the system's reliability. As can be observed in the plot, 173 comments referred to the stability of the overall system. Overall, the concerns where related to ensuring always have water when needed: "*participants get frustrated with possible water shortages and pull out of the trading system before giving it a chance to optimise its parameters or make changes to be more stable*". In this regard, many respondents voiced the geographical factor as a risk for a system that relies on the environmental conditions to work: "*everyone has a deficit at the same time if we all live in the same area*".

The lack of regulation of the system was a recurring concern among participants from all member states. In the quantitative data it has been observed that people preferred a system managed form a private and external contractor. However, 225 excerpts were related to system abuse, hoarding, monopoly, corruption or non-neutrality. Interestingly for the proposal of blockchain use for smart contracts, some respondents reported that a risk could be: "*not transparent transactions*", "*The possible corruption of* *the company which is in charge of the trade*" or "*If everyone goes automated, with very strict decision making, this market could easily be gamed by someone with enough capital*".

As was observed in the main risks plot, *Trust in the system* is identified as a major risk. Specifically, the risks were related to Confidence (Security and Privacy) and Stakeholders Cooperation. The former refers to all threats related to system compromise because of hackings, anonymisation or bugs. One respondent reported: "*Main risk would be a cyber-attack that messes with the prices of the trades for someone's advantage*" also there were concerns related to system openness: *"Lack of transparency on the mechanism*". The latter referred to the trust peers have on other peers and neighbours with whom they share the autonomous trading system. In this case, distrust appeared with voices such as Respondent 48 pointing out: "*Someone might want to profit more than other participants and try to exploit the system*" or Quote 1033: "Homeowners with larger surface area (wealthy homeowners) collect and sell more water compared to small-home owners so the price per litre of water is not equal for everyone which creates social issues". Depending on others when their society is more habituated to centralised systems or they live in individualist societies was a factor that emerged in some comments: "*you are dependent on others*", "*lack of oversight by some members"*, or "*neighbour loyalty*".

The majority of risks associated with Cost were related to the Return of Investment, the high price of entry into the system and the low margins it may bring. The pecuniary comments were very related to the reliability on the system: "*If there is a smart contract error in the system it could all go wrong and my water could be sold for a very low price or I would be buying at a very high price*", "*ending up with a huge bill because the system bought super-expensive water during an unexpected circumstance such as a drought*" or "*Assuming the system doesn't take into account the amount of income for the transaction, you can find yourself with a debt you didn't expect*".

Finally, there were several risks associated with the impact of autonomous systems in Current Lifestyles, overall concerning the lack of control over the system (Involvement and Reluctance): "*do not have fully control of* the process", "*automation without human error management*" or not being able to adjust the system manually: "*it's not clear whether you can change the system to temporarily to reflect your new needs*". Again, sometimes participants reported concerns when it comes to unexpected situations that they cannot control: "*if the sellers or buyers themselves cannot check the system and everything runs automatically this could lead to problems when there are certain unforeseen situations holidays, increase of people in one of the households, etc*". Also, overreliance in technology was identified as a risk for some participants: "*People could become too reliant on an automated system and if something goes wrong the threat will be serious*" or "*Relying too much on a technical system without backups or emergency plans*".

To finalise this analysis, two different automatic Natural Language Processing tools have been employed to make a summary of all the data retrieved in this part of the questionnaire related to risks. The outputs are written down here for comparative purposes in order to triangulate results:

- Possible manipulation of the system by people for their own profit - system errors that result in losses for households and retailers. In the scenario that this trade system is regulated by a company there is a possibility that people can take advantage of people in need for water and sell it higher. If you need to use more water one day, maybe the system couldn't provide you enough water. Electricity failure leads to system failure, the electricity system must be reliable in order for it to work. Automatic trading system trying to get profit for itself it might have system failure and this will be against the people who buy the water.
- Possible manipulation of the system by people for their own profit – system errors that result in losses (money-wise) for households and retailers. If you need to use more water one day, maybe the system couldn't provide you enough water. Electricity failure leads to system failure, the electricity system must be reliable in order for it to work. I can't intervene the so called "cold start", until the network has a sufficient number of participants how do you foresee the satisfaction of the water needs for each household (in a completely autonomous system where

you use only your own harvested water) selling water for too low of a price or buying for too high of a price so overall losing money by being part of the trading system. System failure, abuse by outside parties, too much reliance on a system. The participants can't fully understand problems when automatic system fails - especially if you are low on water and the system doesn't provide you with any water.

As can be observed the main risks were well grasped by both automatic tools and are pretty much in line with the insights provided in the Thematic analysis.

5.3.2 Main recommendations

The communication activities should focus over the 30 % of persons that have concerns over flexibility markets. A quick look to the demographic results of this group does not show any conclusive characteristic. Tend to be younger, to live in flats and rent the place where they live. Nevertheless, the key issue is that they self-score much lower in the knowledge of the energy and especially in the IoT sector.

Seems like the solution should have two modes of operation: a complete autonomous mode for the *lazier* people and a semi-autonomous made where the system would collaborate with the owner. Please note that the default mode should be the semi-autonomous mode as it is the most solicited (around 60 % of the surveyed people and it is in line with some of the risks identified related to involvement). In fact, the system should also allow end users to audit each transaction and complain about any error found (this is very in line with the risks associated with Current Lifestyles and Trust, overall, under unexpected circumstances such as friends coming to the house or working at home). Please note that 60 % of the user will complain if an error in the system is found but would not leave the system immediately. In fact, if the system is able to provide explanations of what had happened and cues about how the user could avoid these problems in the future (openness and explainability of the autonomous system and a hybrid approach seem to be quite relevant here), around 35 % of the end users would be willing to follow them.

The platform should be run by a neutral company hired by the participant (near a 40% of answers) and it has put a lot of emphasis on convincing users about their neutrality and intentions to not make profit or abuse the system. In fact, according to the risks results, they should make the people think that the system is reliable and robust under potential system errors or cyberattacks. A platform run by a public authority could also be an option (25 %) but a fully decentralized solution seems like not very appealing to the end users (only 15 %). In fact, this has been highlighted in the risk assessment when the respondents provided low confidence in the Stakeholders cooperation. A hybrid solution seems to be the ideal option.

If the revenue model for the platform is based on a fee per transaction, the maximum amount that could be charged should be around 5 % of each transaction. Simulations should be run in order to assess if this fee is enough to recover the costs and leave a margin of profit. If not, improvement on the system should be carried out or another stream of revenues should be sought. However, there is a major risk that people will not participate because the initial investment is too high or because they do not rely on the potential ROI.

There does not seem to be any issue with the type of contracts that the end users would be willing to accept (more than 60 % of the end users would be willing to accept both types of contracts). Nevertheless, half of the answers consider that the system should also optimize the energy consumption of the house (including energy efficiency and energy conservation actions) before following any demand response signal. The main risk here is that people need that the system ensures the resource (electricity, water) at any time and upon any unexpected circumstance. If the system has to buy more energy/water to ensure the availability of the resource and the transaction is monetary speaking higher than the usual, the user should always have to give the last consent.

6. Conclusions

This deliverable analyzed how energy contracts between different actors in the local energy market proposed by PARITY, could leverage the capability offered by smart contract technology. The smart contract-enabled energy SLAs proposed in this deliverable aim to facilitate the automated exchange of flexibility among actors in a manner acceptable to citizens/end users of electricity.

Firstly, a state of the art of blockchain technology was presented, with a specific focus on legally enforceable smart contracts and their challenges in respect to international regulations and privacy enforcement (GDPR). Then existing SLAs from previous experience in Spain, Greece, Switzerland and Sweden were shown, describing the key stakeholders and roles foreseen by them, as well as the energy contracts' type. Next, a detailed analysis of SLA-best practices for PARITY business cases were described, with a clear separation of standard SLAs coming from existing use cases and business models and new types of contracts related to PARITY business cases. Finally, the connection of SLAs to smart contracts was explored, by looking at technical, legal, regulatory and social aspects.

The deliverable concludes that smart contract technology can be leveraged for a legally compliant and automated operation of a local flexibility market. However, the best practices for legally-enforceable smart contracts present several arguments in support of hybrid smart contracts over stand-alone smart contracts. Human intervention is necessary for interpretation of the variations between the spirit and letter of the law. While smart contracts are rigid and inflexible, conventional contracts offer room for reason in their interpretation. Hybrid smart contracts can use traditional documentation to cater for parts of the contracts that may not translate easily in computer code. These parts may include features such as the governing laws, dispute resolution, force majeure, fallback mechanisms and indemnification for coding errors and other issues. For the abovementioned reasons, the smart contracts that are going to be developed in PARITY cannot be self-contained and legally enforceable, but they will need to implement automatic mechanisms to be tied to terms and conditions described in traditional contract documents (i.e., SLA agreements, international and national laws and regulation).

Additionally, a set of recommendations to be used for the design and development of PARITY's local flexibility market and his components in following work packages was delivered. The set described that additional type of contracts and agreements are needed to manage the local exchange of energy and flexibility and to manage different type of grid status trough the traffic light approach. In particular, the recommendation highlights that the PARITY local market has to take in account regulatory aspects especially for the DSO role, because of its natural monopoly on the local physical grid. This is crucial especially for the yellow and red state of the traffic light signals. The local techno-economical optimal operation cannot avoid these aspects. Another important recommendation is regarding the social aspects. In particular, prosumers could prefer semi-autonomous mode, where they could interact with the system by setting important parameters. Although, a smart contract-enabled local flexibility market could be quite challenging to understand. Thus, the prosumers' user interface that is going to be developed by PARITY should be easy to understand, and at the same time allow the transparent observation and monitoring of the market's operations. The platform should be run by a neutral company. Also, the revenue and fees model coming from the local flexibility market should be easy to understand. Most of the prosumers are willing to accept multiple contracts, but the priority should be given first to the energy consumption optimization before following any demand response signal.

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ANNEX A: Prolific Questionnaire

List of questions included in the survey to retrieve the perception of automatic trading systems:

- Would you be willing to participate in such a market?
  - Yes
  - No
  - Maybe
- Do you feel comfortable relaying the burden of trading to an autonomous system?
  - Yes, completely
  - Not really, I would like to always supervise each decision
  - I do not rely on such a system. I prefer to take informed decisions by myself
  - Other
- Would you increase your participation in such a market if it is hosted/regulated by? (Mark all the responses that apply to you)
  - a relevant (but neutral) company hired by the participants
  - a relevant (but neutral) company hired by a public authority or relevant player in the market
  - a public authority or a relevant player in the market
  - nobody (fully decentralized)
  - Other
- Assuming that each household has to monthly do payments for the maintenance of the pipe system and its regulation, what would be the maximum extra-percentage over the monthly bill that you will pay for the above-explained autonomous trading system? (please answer only with numbers)
- What kind of automatic contracts would you be willing to accept? (i.e. without any intervention from your side)
  - Selling my water surpluses
  - Buying when my water resources are scarce
  - Both
- In your opinion, should the system optimize your water availability/consumption before publishing or take an external offer?
  - The system should apply an efficient-water-mode in my household (e.g. restrictions in the time the tap-water can flow) when a signal warns the system about a low level of the water tank
  - The system should optimize the water consumption (e.g. move the watering to a better time slot during the day)
  - Both
  - Other
- What would be your reaction to a system failure in which you can incur a deficit or achieve a surplus (e.g. not selling water or not buying when necessary)?
  - complain to the organization in charge of that system
  - give up and not use it anymore
  - change my behaviour to more sustainable habits
  - Other:
- In your opinion, what are the risks and threats associated with this trading system? Please, separate each threat identified with a semi-colon ";"
- Additional feedback about the survey.