GENTE

STAKEHOLDERS' NEEDS SPECIFICATION

Deliverable 3.2

SUMMARY

This document describes the processes in specifying stakeholders' needs in local energy systems with high renewables.

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Abstract

This report presents the summary of the stakeholders' needs in local energy systems distributed governance toolbox being developed in GENTE as part of WP 3. In this report, stakeholders and need-owners are used interchangeably. This task's deliverable is vital in meeting GENTE's technical and non-technical objectives especially as it relates to incorporating need owner requirements in platform design and replication toolkit. This toolkit comprises tools supporting scale-up, engagement of the market (investors, industry), joint procurement, operational learning etc. Therefore, specifying the need-owners' needs will help in defining the future scenarios and applicable use cases for demonstrations. GENTE aims to develop a distributed governance toolbox for local energy communities (LECs). This toolbox includes advanced digital technologies such as the internet of things (IoT), distributed ledger technology (DLT), edge processing and artificial intelligence (AI) for autonomous energy resource management within and across LECs and for flexibility provisions to energy networks. The toolbox will be used in addressing stakeholders' needs as it relates to renewables energy integration, grid resilience, and energy management enhancement. However, the knowledge of general overview of stakeholders in local energy systems and their specific needs are important for developing the toolbox.

In this report, relevant stakeholders, their motivations, and interests in the GENTE project are captured and analysed using a scientific methodology. A participatory approach i.e., stakeholders' engagement through surveys was used in determining the need-owners' needs. Part of the important considerations before specifying the needs is a thorough review of legislations/policies guiding LECs existence in the locality to ensure the specified needs are within legislative and policies frameworks. Questionnaires were administered to need-owners and the results showed that economic, technical, and environmental protection needs are the major needs. The result of the analysis indicates that the needs of similar stakeholder groups are quite similar in context but might differ in order of priority. A good example is where 75% out of a total of 4 end-users, 66.7% out of a total of 3 prosumers, 100% out of a total of 1 asset owner respondents agreed on the need for additional revenues, but 75% out of a total of 4 energy operators do not believe that it should be a priority. They believe that futureproof motivations with long-term advantages (environmental and technical) should be the priority rather than focusing on direct financial gain.

Cost reduction was found to be a common interest among energy users, prosumers, and other investors. For the asset owners and other big investors, return on investment is an important need. However, it is instructive to note that there still exists a knowledge gap in flexibility market and its advantages to stakeholders especially the end-users, hence, need for adequate sensitization and enlightenment campaign to bring those ones up to speed. Regulatory complexities and cybersecurity threats were also found to be popular obstacles to efficient operation on the part of the operators.

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AI	Artificial Intelligence
AMI	Advanced Metering Infrastructure
BEMS	Building Energy Management System
DH	District Heating
DLT	Distributed Ledger Technologies
DMS	Distribution Management System
DSO	Distribution System Operator
ESCO	Energy Service Company
EMS	Energy Management System
ESS	Energy Storage Solution
EU	European Union
GENTE	Distributed Governance for green ENergy communiTiEs
HP	Heat Pump
LEC	Local Energy Community
IoT	Internet of Thing
TRL	Technology Readiness Level
TSO	Transmission System Operator
ZEV	Zero Emission Vehicle

1. Introduction

1.1. Background

GENTE mandate is basically to proffer technological solutions for energy resource management within and across local energy communities (LECs) as well provide some level of flexibility to local communities' energy networks. These solutions will firstly be validated at the lab levels at various demonstration sites before extending to full-scale deployment in real environments within the scope of the project to increase technology readiness levels (TRL). Several pilots across countries like Sweden, Switzerland, and Turkey was chosen with total of 6 demonstration sites and each of the site is expected to demonstrate solutions to a new type of technologies and services that satisfies both technical, environmental and market contexts.

This deliverable is focused on specifying the need-owners needs in the GENTE project so the needs could be integrated into the new technology and systems being developed that would provide the LECs the opportunity to realize their economic, environmental, and social potentials. Engagement of all relevant stakeholders in a participatory way to determine their needs and wishes can be a helpful means to create supported LEC designs that incorporate these stakeholders' values. Identification of need-owners needs is a veritable tool in energy market planning and business models development. If the needs are carefully specified using platforms which engages stakeholders across the energy value chain directly, then the goal of ensuring LECS shares resources, knowledge, and expertise can be easily achieved. Energy community federation that allows achievement of common energy-related goals is part of GENTE mandate.

In this report the step-by-step process of identifying the stakeholders within the local energy communities as well as specifying their individual needs is presented. Stakeholders' analysis within the LECs started with stakeholders mapping. Stakeholder mapping in this context involves the identification of the interested parties, their interests, possible impacts, and influences and how they interact between themselves or within the process. National and European Union regulations and policies that cover LECs is also captured in this report as well as the previous, current, and future landscape of LECs as relates to electricity markets in Europe, particularly Sweden.

1.2. Motivation

In the last 10 years or before, energy systems have been shifted from a traditional, centralized energy model to a more decentralized, sustainable, and community-driven approach. This transition is expected to continue in the coming years, with a focus on further integration of renewables, grid resilience, and enhanced energy management at the local/community levels. These changes have been driven by a combination of factors, including advances in technology, shifts in energy policy, and changing consumer preferences. Renewable energy sources integration, new energy storage

technologies, and energy equity etc., are some key trends and developments that have shaped the landscape of local energy communities over the past decade.

As GENTE develops new technology that could support clean and green energy transitioning process and integration of renewables, it is important the most crucial part of the stakeholders' needs is co-opted into the plans and technologies being developed. Local energy projects can only be successful if all motivations and interests of the stakeholders are made to count. Various research initiatives and finds have shown that stakeholders engagement processes as well as the assurances of their interest protection have a positive influence on their attitudes toward participating in the energy initiatives [1].

1.3. Objectives and Scope

The objective of this report is to:

- Identify the need-owners across the energy value chain and carefully specified their individual needs that could enable easy creation of community federations to ensure resources, knowledge, and expertise are shared, and viable business models developed.
- Link the identified needs to relevant GENTE technologies like energy optimization, distributed ledger technologies (DLT), Internet of Thing (IoT), Edge processing and Artificial Intelligence (AI) for optimal operation.

This deliverable provides an overview of general and context-specific elements that need to be considered for identification and specification of stakeholders' needs. Within this document, stakeholders' engagement processes through questionnaires with the intention of obtaining their preferences and needs in local energy systems are described. It is expected that the identified stakeholders and their specified needs will then be use in achieving the objective of work package (WP) 3, which is centred on defining the future scenarios for local systems and specify the need owners to create highly applicable use cases.

1.4. Report Structure

This report provides a step-by-step process of identifying the stakeholders within the local energy communities and specifying their individual needs.

- *Section 1* provides introduction to the content of the report.
- *Section 2* presents the stakeholders analysis and regulations enabling LEC participation.
- *Section 3* creates a methodology for stakeholders/need-owners' needs specification.
- *Section 4* analyses the questionnaires and specifies different stakeholders/need-owners' needs.
- *Section 5* concludes the report, presents the findings, and makes recommendations.

2. LECs Stakeholders Analysis

2.1. Background

Stakeholders are defined as the range of actors who are likely to use a system or be influenced either directly or indirectly [2]. However, stakeholders in the context of local energy community are referred to individuals, groups, organizations, or entities that have a vested interest in the planning, development, operation, or outcomes of a community-based energy system. These stakeholders often include a diverse range of participants with different roles and perspectives. Table 1 provides an overview of the general stakeholders (based on a case study of [3]) that could traditionally be found within the local energy community's energy market. These stakeholders were identified from the stakeholders' analysis carried out in local community energy pilot project.

Table 1 - Typical energy market stakeholders

Stakeholder	Description
Transmission System Operator (TSO)	Entity responsible for the transport of energy usually on a voltage level of between 220 kV and 380 kV and over long distances [3]
Distribution System Operator (DSO)	Entity responsible for the distribution system for transporting energy from high to lower voltage areas. This incumbent is highly triggered by an increase in renewable energy sources (RESs) [4]
Regulator	Actor that regulates the energy markets and guarantees energy networks
Energy Supplier	Actor responsible for providing energy to end consumer, ensuring a reliable and continuous supply of energy
Consumer	Energy end-user
Energy Producer	Entity responsible for energy production, traditionally based on centralized energy sources and fossil fuels
Asset Owner	Private person or private or public entity owning an energy producing or regulating unit that is part of the LEC system
Government	Public entity responsible for decision-making at higher levels

Stakeholders in local energy communities have a variety of interests, ranging from environmental sustainability and energy cost reduction to grid stability and community empowerment. Engaging and collaborating with these stakeholders is vital to the success of any local energy project and the development of resilient and sustainable energy systems. Literature have it that one of the most important prerequisites for the deployment of LEC and the infrastructure linked to it is community acceptance [5].

Several efforts have been made in determining the stakeholders' objectives in local energy projects using different methods or strategies. [3] used participatory method through four Flemish pilot cases in determining the objectives of relevant stakeholders that joined an LEC and the importance of each of these objectives.

2.2. Stakeholder/Need-Owners Mapping

As mentioned earlier in the introduction, stakeholder mapping involves the identification of all interested parties, their interests, possible impacts, and influences and how they interact between themselves or within the process. These stakeholders fall into three categories: primary, secondary, and key stakeholders which is based on their level of involvement. The following questions were used in stakeholders' mapping.

- Who are possible beneficiaries of projects on local energy systems with high renewables?
- Who are the contributors to the projects?
- Who are those that maybe impacted by these projects, directly or indirectly?

1. Primary stakeholders – those beneficiaries of the local energy community project who have an interest in the outcomes of the new technologies being developed are regarded as the primary stakeholders. These stakeholders include energy users, residential building owners, facility managers and district heating providers/operators, prosumers etc.

2. Secondary stakeholders – are those beneficiaries of the local energy community project that may benefit from the outcomes of the project without their direct involvement or input or significant interest. A typical example of this category is the aggregators, municipalities, promoters of energy democracy, renewable energy investors and financiers, and utility companies etc.

3. Key stakeholders – are those contributors to the local energy community project whose efforts can significantly impact the outcomes of the new technologies being developed but may or may not be directly impacted by the outcomes. A good example of this stakeholder is technology developers, research institutes etc. This category includes the research institutions, technology providers, technology integrators like energy service companies (ESCOs), utilities and grid operators etc.

2.3. National and EU Regulations on LECs

Several EU directives provide the legal framework and regulatory support for the operation of energy communities in the EU, facilitating their participation in the transition to a more sustainable and decarbonized energy system. Both Swedish and European legislation made energy community participation to be open and voluntary, autonomous, and effectively controlled by shareholders or members that are in the proximity of the renewable energy projects that are owned and developed by that legal entity [6]. Renewable Energy Directive (2009/28/EC) [7] establishes binding targets for renewable energy use, requiring member states to implement measures or schemes to increase the share of renewable energy in their energy mix. Consequently, countries like Switzerland, Sweden and Spain adopted various incentives and support strategies including feed-in remuneration at cost, Bonus-Malus system, which provides financial incentives for the purchase of low-emission and zero-emission vehicles, and incentivized program for efficient and sustainable mobility (MOVES), respectively. Sweden introduced climate policy framework with target to achieve net-zero greenhouse gas emissions by 2045 and 100% renewable electricity production by 2040 despite the fact it has the highest share of renewables in its consumption (62.6%) [8].

Article 2(24) of EU directive 2018/2001 [6] defined two types of energy communities: a citizen energy community (CEC) and a renewable energy community (REC) [6]. This directive builds upon [7] and sets more ambitious renewable energy targets for the EU, aiming for at least 32% renewable energy in the EU's final energy consumption by 2030. It also made provisions for self-consumption, renewable energy financing, and allows energy communities to take the form of any legal entity including an association, a cooperative, a partnership, a non-profit organisation, or a limited liability company. For fair competitiveness, no specific characteristics was defined for local renewable energy communities in terms of size, ownership structure and the number of projects, rather member state were allowed to choose any form of entity for renewable energy communities, provided rights and obligations of such entity is exercised. However, non-availability of national and regional definitions as a case of Sweden, on local initiatives involving energy sharing in energy market informed the choice of LEC in relating to both CEC and REC in this report. According to Energy Communities Repository [9], no data is available on existing policies and regulations for energy communities in the Clean Energy Package context for some of the participating countries in GENTE like Sweden, Switzerland, and Spain.

Directive 2019/944/EU [10] as part of the clean energy for all Europeans package integrates renewable energy into the electricity market by enabling consumers including LECs to participate actively in the energy transition by generating, consuming, storing, and selling renewable energy. It also allowed aggregation of production and supply over larger regions where aggregators are to play intermediary roles between customer groups and the market. For internal electricity market participation, the directive on common rules allows individual or citizen energy communities active participation in all energy markets, by generating, consuming, sharing, or selling electricity, or by providing flexibility services through demand-response and storage. However, the right to participate in electricity generation has not been fully operational in some countries. For instance, in the last decade in Spain, cooperatives or individuals due to delayed regulation and cultural scepticism were not allowed to generate electricity except for self-consumption but could distribute and market generated electricity.

Before the EU's clean energy package, energy cooperatives operation is regulated by civil law on cooperatives. A Royal Degree 23/2020 on RECs addresses this limitation and empowers citizens and local authorities to produce, consume, store, and sell renewable energy through renewable electricity purchase contracts. Similarly, cultural prejudice against cooperative model as well as low trust environment, and lack of energy market's legitimacy has been part of the impeding factors against fully participation of cooperatives in Türkiye.

For energy trading, 'peer-to-peer trading' between market participants is expected to be through the means of an energy contract with pre-determined conditions both for the automated execution and settlement of the transaction. This could either be directly between market participants or indirectly through a certified third-party market participant, such as an aggregator. The right to conduct peer-to-peer trading shall be without prejudice to the rights and obligations of the parties involved as final customers, producers, suppliers, or aggregators. To encourage self-consumptions, self-consumers, individually or through aggregators are allowed to sell their excess production of renewable electricity, including through renewables power purchase agreements, electricity suppliers and peer-to-peer trading arrangements, without being subject:

1. In relation to the electricity that they consume from or feed into the grid, to discriminatory or disproportionate procedures and charges, and to network charges that are not cost-reflective.
2. In relation to their self-generated electricity from renewable sources remaining within their premises, to discriminatory or disproportionate procedures, and to any charges or fees.

Spain for example added a national legislation to strengthen collective self-consumption by inserting modalities to prevent the injection of excess energy into the transmission or distribution network except for facilities close to and associated with consumption facilities. The directive also allows installation and operation of electricity storage systems combined with installations generating renewable electricity for self-consumption without liability for any double charge, including network charges, for stored electricity remaining within their premises. Article 53 of the regulation empowers EU DSO, to 'facilitate demand-side flexibility and response and distribution grid users' access to markets. EU directive allows LECs contribute to ancillary services provision to DSOs and TSOs and support the overall operation of the grid. These supports can come in several ways such as participating in demand response programs, aggregating and coordinating DERs, such as solar panels, wind turbines, energy storage systems, and electric vehicle chargers to provide services like frequency regulation, voltage control, and ramping support to the grid, aggregating the flexible capacity of multiple DERs and offer them as grid services to DSOs and TSOs, and peer-to-peer energy exchange facilitation among members within the community to optimize local energy distribution and reduce reliance on the central grid.

Revised renewable energy directive (European Commission, 2021a) propose national regulatory frameworks for: the provision of flexibility and balancing services, of small or mobile systems such as domestic batteries and electric vehicles, both directly and through aggregation, and consider demand response, energy storage and smart solutions as part of efforts to increase efficiency of the integrated energy system. Figure 1 chronicle the European legislations relating to local energy community regulation in member states starting from 2009 to 2022.

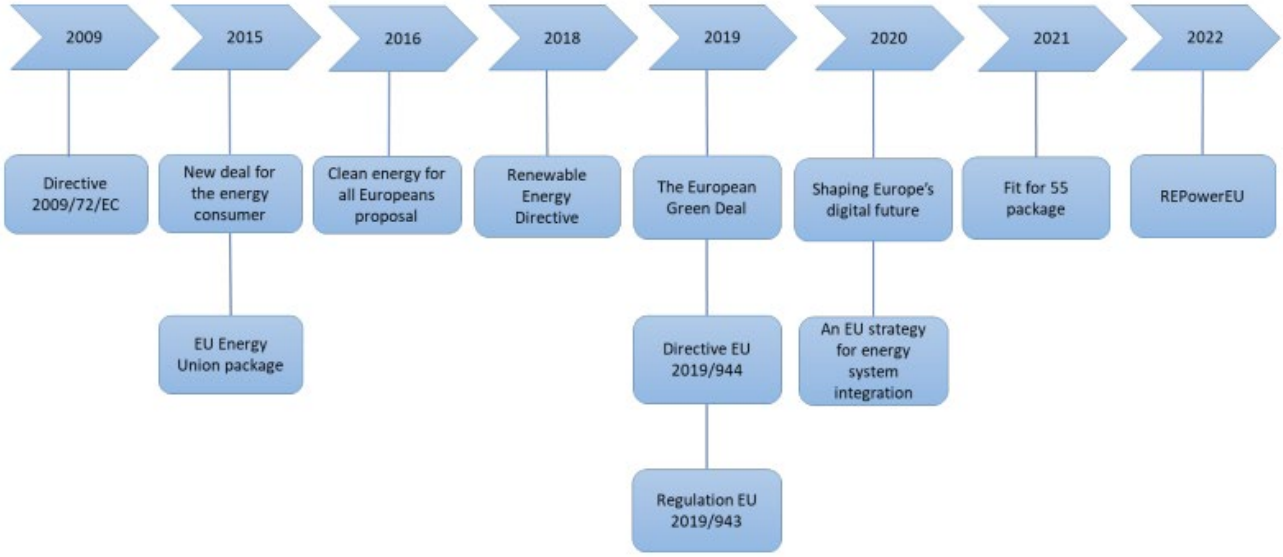

Figure 1 - Energy policy documents with references and relevance to LEC operation (Source: JRC technical report, 2022 [11])

3. Methodology for need-owners specification

A participatory approach involving surveys was used. A step-by-step process is deployed to ensure different need-owners' needs are captured. The flowchart shown in Figure 2 describes the processes.

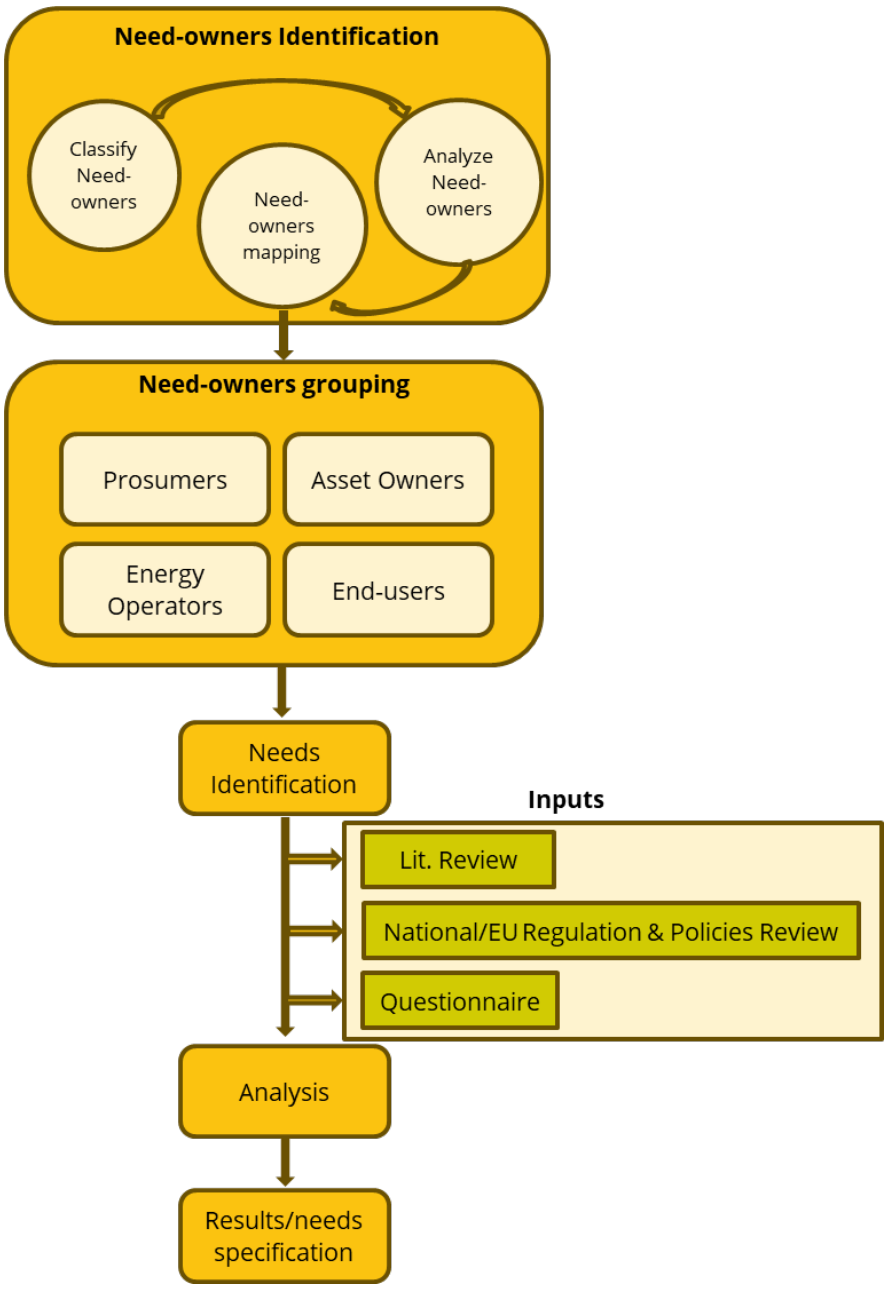

Figure 2 - Flowchart for specification of stakeholders' needs

3.1. Identify the possible need-owners

Identifying the relevant need-owners to LEC/Local energy systems is the first step towards determining their specific needs like the need for development and distribution of new materials and devices (technology), new or more specific legislation and rules to address the current realities and exploit the advantage of the possibilities that a LEC provides to the energy system (regulations), or the investment required to build new infrastructure (financial).

3.1.1. Need-owner classification

The first step towards analysing the need-owners in GENTE is a first classification of the way need-owners interact with the project. As stated earlier, GENTE project proposes a toolbox of components including advanced digital technologies such as the internet of things (IoT), distributed ledger technology (DLT), edge processing and artificial intelligence (AI) for autonomous energy resource management within and across LECs and for flexibility provisions to energy networks. Each of the need-owners is identified based on attributes like their motivations for the project, business model, technical expertise, and other relevant components. The need-owners are therefore classified as shown in Table 2 and described below:

1. Direct beneficiaries: those who directly benefits from the aspect(s) of the energy systems associated with the proposed toolbox. These beneficiaries would utilize GENTE toolbox and platforms in their interactions and communication with the energy systems for a sustainable, energy efficient, low carbon and climate-friendly economy.
2. Indirect beneficiaries: Other stakeholders who benefit from the outcomes of GENTE.

Table 2 - GENTE need-owner classes

Direct beneficiaries	Indirect beneficiaries
• Facility managers and operators • Flexibility market operators • ESCOs • Energy users • Residential building owners • DH provider/operators • DSOs • Aggregators • Prosumers	• EV owners • DER owners • Electricity retailers • Microgrid asset owners • Municipalities • TSOs • European Commission • Energy market regulators • Energy Suppliers • Research institutions • Promoters of energy democracy

Stakeholders in LECs often encompasses major and minor stakeholders. But this report identified and analysed the need-owners of the new technology being developed in GENTE as the primary

stakeholders as obtained in the stakeholders mapping of section 2.2. The relationship between the identified need-owners and these new technologies is shown in Table 3. The technologies are juxtaposed with the appropriate need-owners. For instance, edge processing and artificial intelligence (AI) will be very useful to need-owners such as residential building owners, facility managers, grid operators in autonomous energy resource management as well as flexibility provisions to energy networks. The new technology also includes mobile application that every end user can use for seamless operation of their energy systems.

Table 3 - GENTE Technologies and their links to different need-owners

Technologies	Need-owners
• Edge computing/Internet of Things (IoT) platforms – to interface/ interact with all tools developed.	Residential building owners, facility managers, grid operators
• Data analytics (forecasting algorithms, local optimization)	DER owners, residential building owners, DSOs, Prosumers, technology providers
• Management software	Community federation managers, aggregators, energy managers
• DLT-based prosumer account platform	Prosumers, aggregators, end-users
• DLT-based community manager platform	Energy/flexibility aggregators, Building/DERs owners, DSOs
• Mobile application	End users/LEC
• IoT BEMS including heat pumps	DSOs, LEC and technology providers (heat-pump developers)
• Data collection tools, submetering IoT platform	LEC, system operators (DSO, TSO)
• Advanced Building Energy management system (BEMS) – for flexibility services	Prosumers, LEC, residential building owners

3.1.2. GENTE components correlation with need-owners' motivations

Each stakeholder listed in Table 2 is analysed with focus on the direct beneficiaries to evaluate what GENTE can bring to their operations in terms of energy optimization using the new technologies being developed. For this, the core business motivations of the need-owners are identified: what is the prime focus of these organizations? Answer to this question provides an insight into the most relevant component for each need-owner. Therefore, a narrative is built to explains how the need-owners can leverage relevant components of GENTE toolbox in achieving their core motivations: how each need-owner can make use of the components/outcomes of the GENTE project in their daily operations? This analysis is presented in Table 4.

Table 4 - Need-owner motivations and narratives

Actors	Motivation	Relevant Components developed in GENTE	Narratives
Consumers/Energy Communities	Cost reduction, reliable energy access, capacity to set own sustainability goals	• BEMS • Forecast Algorithm • Mobile App	Consumers and energy communities will utilize energy services provided by GENTE to gain an additional revenue.
Distributed Energy Resource (DER) owners	Storage efficiency increase, curtailment reduction, increased integration of distributed energy	• AI resource optimization • EMS • community federation/asset aggregation models	DERs owners will benefit from GENTE next generation energy network technologies for autonomous energy resource integration within and across LECs.
Energy/flexibility Aggregators (incl. Virtual Power Plant)	Portfolio size increase, increase of number of services to DSO,	• EMS • DLT • Decision support tool • Forecast & optimization software	Aggregators will leverage the optimal management of the local resources enabled by the GENTE to maximise profits by providing energy services to the grid, as well as participating in wholesale market.
District Heat (DH) providers/ network operators	Increased services and flexibility	• BEMS • IoT platforms	DH providers will benefit from the flexibility market opportunity created by thermal storage technologies etc.
Energy retailers	Provision of premium price to customers	• DLT platform • Forecast Algorithm • Data collection tools • Submetering IoT platform	Retailers can utilize GENTE generation and demand forecast algorithms for more efficient trading with best pricing to their customers.
Facility managers	Reliable energy supply to tenants, promotion of renewable energy usage.	• BEMS • Decision support tool • Forecast Algorithm • DLT platform	Facility managers will have access to reliable energy, optimize local consumption and reduce grid dependency and achieve environmental goals.
DSOs	Improved grid management/reliability, high resolution grid	• All	DSOs will benefit from the grid monitoring/grid management technologies

	monitoring		like forecast algorithms, decision support tools, etc. GENTE business model for DSOs is geared towards service-based other than asset-based.
Municipalities	Reliable energy services to residents, and promotion of the use of renewable energy and local content	• Optimization algorithms • Decision support tools	Optimization algorithms will help in reducing energy costs for municipal facilities and operations.
Technology providers (heat-pump developers, ICT providers)	Increase market opportunity for technology	• EMS • Data collection tools • IoT platforms	The GENTE new energy management technologies will be integrated into the technology providers' portfolio.

3.2. Need-owners' grouping

Similarity of interest amongst need-owners and its correlation to various components of GENTE necessitated need-owners grouping for easy of engagement using questionnaire or other tools. The grouping is particularly useful in constructing the questionnaires administered to the need-owners to obtain their needs. The four distinct groups are as follows:

- **Assets Owners:** these are the owners of renewable energy generation assets, such as solar farms, wind turbines, and hydroelectric plants, transmission asset like microgrid, distribution assets, energy storage facilities as well as the technology providers. This group also includes renewable energy generators, DER owners, residential and commercial property owners etc.
- **Energy Operators:** this involves those that manage and operate the infrastructure and assets within the local energy communities; providing expertise and technical knowledge in different areas such as grid integration, energy management, smart energy solutions and resource management. This group is made up of virtual power plant (VPP) Operators, smart grid technology providers, TSOs, DSOs, microgrids operators, and energy storage system operators.
- **Prosumers:** they are investors in renewable energy systems, such as solar panels and wind turbines, that generates their electricity with objective to reduce dependence on centralized power grids. This group also includes energy/flexibility aggregators, LECs or housing association/cooperatives, public institutions (schools, hospitals), and residential and commercial prosumers.
- **End Users:** they are individuals, businesses, organizations, or entities that utilize renewable energy sources and expected to use the new toolbox being developed in GENTE to meet their energy needs. This group comprises of the consumers in both residential, commercial, industrial, and transport sectors etc.

3.3. Processes of identifying each need-owners needs

Though there is no list describing each need-owners needs in local energy community in literature, it is assumed that their objectives and motivations for joining LEC, professional experience as well as what they can offer as input can provide an insight into their potential needs. Engaging with stakeholders in a transparent, inclusive, and collaborative manner is crucial for accurately identifying and addressing their energy needs and preferences. However, obtaining these need-owners needs can be very challenging because of divergent views and varieties of interest by each stakeholder though surmountable with holistic stakeholders' engagement strategy.

3.3.1. Tools for the identification of needs

Several stakeholders' engagement methods are reported in literature. To encapsulate the needs (indirectly and directly) of all stakeholders, following resources are utilized in identifying the need-owners' needs:

1. GENTE project objectives
2. Literature review of local energy initiatives
3. National/EU regulations and policies
4. Survey (i.e., administered questionnaire)

Several studies showed that need-owners' interests mainly focused on community/organization interests and financial gain and less on environmental advantages. Review of literature, national and European Union regulations and policies is pivotal to simplifying these divergent needs. EU Directive 2018 for instance streamlined EU expectations for member states which includes energy cost reduction, technological improvement, environmental impact reduction, and security of energy supply and grid integration. The revised EU Directive 2023 expects additional 11.7% reduction in energy consumption/cost by 2030. These areas of interest can be linked to different need-owners/groups in LEC. On the hand, reviewed literature shows possibilities of similarity of interest existence amongst need-owners, prompting the need-owners grouping listed in section 3.2. These groups encapsulate GENTE task 9.1 "Definition of test cases and assessment framework and KPIs for validation" for community energy resource integration, prosumer energy contract and service management, and monitoring/control of community energy resources through the community or federation manager. Use Cases defined for different need owners for future energy systems as shown in Figure 3 have been developed in WP 3.3 using both technical objectives (TOs) and non-technical objectives (NTOs). The main use cases to be validated are defined along the following objectives:

- **Grid Flexibility –** making concerted effort to manage fluctuations in electricity supply and demand for more stable, reliable, and resilient power grid. Stability of the grid for security of energy supply can be achieved through flexibility measures like self-consumption optimization and peak load management.

a) **Self-consumption Optimization –** maximizing the usage of locally generated or stored energy for on-site consumption, to reduce reliance on grid power.

b) **Peak Load Management –** implementing electricity consumption strategies capable of shaving peak demand periods either through load shifting or other initiatives like demand response programs and direct load control programs to incentivize consumers to reduce electricity usage during peak periods.

- **Energy Efficiency –** deploying and promoting energy-saving initiatives capable of reducing the amount of energy required for daily energy needs of energy users within the LEC. Achieving this goal could be through the following:

a) **Reduction in community energy costs –** implementing strategies and initiatives to lower energy expenses through consumption reduction, increase in renewable energy use, and active participation in energy flexibility market.

b) **Increase in community autarky –** increase of independency of the community in meeting its energy and resource needs through additional support for renewable energy projects, provision for battery storage facilities, and promoting local resilience, reducing environmental impact, and fostering a more sustainable and self-reliant future.

- **Community Federation –** creating energy community federation that could collectively share resources, knowledge, and expertise for the purpose of achieving common energy-related goals.
- **Community CO2 Emissions Reduction –** implementing initiatives and strategies with various stakeholders to reduce carbon dioxide (CO2) emissions within LEC.

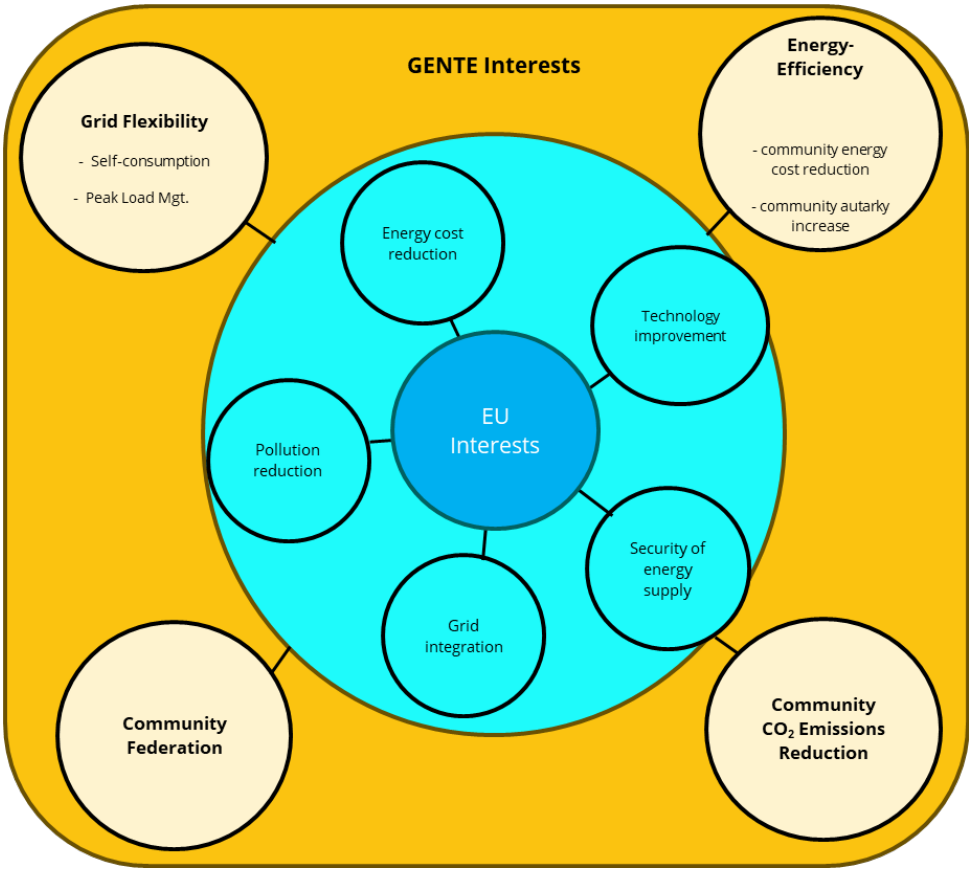

Figure 3 - Schematics of Test Cases for demonstration in GENTE as relates to National/EU Directives

3.3.2. Survey Questions

The survey questions are tailored to the need-owners' grouping with the goal of understanding their current practices and set out objectives to achieving reliability, efficiency, and sustainable operation of their systems to reduce running cost or maximize profit. See Appendix A, B, C, D for the detailed questionnaires. Some of the survey questions includes:

1. How do you optimize energy and reduce cost?
2. What is the most effective strategy to peak load management?
3. What are your motivations for participating in energy flexibility markets?
4. What technologies or solutions do you believe can reshape energy market in the future?
5. What business model is best suited to you?

4. Specifying the need-owners needs

4.1. Survey Analysis

In this section, questionnaires administered to energy stakeholders are analysed. The needs were identified in accordance with their level of importance. In the survey, the stakeholders were directed to assess their perceived needs on a 5-point scale. Thereafter, a structured approach leveraging both quantitative and qualitative analysis techniques is applied to extract valuable insights from the stakeholders' responses. The step-by-step processes followed for the analysis are as follows:

- Data collection/preparation
  - Organizing the responses
  - Checking for completeness of the responses
- Quantitative analysis
  - Descriptive Statistics
  - Frequency Analysis
- Interpretation and Insights
  - Identify Key Findings
  - Contextualize Results

The survey was distributed through various means including a professional social media platform such as LinkedIn as well as GENTE homepage. A good number of the survey were sent directly to partners in the local energy community project as shown in Table 5. However, the number of responses received were not up to 50% in all stakeholders' group. Based on these limited responses, the conclusions derived from the survey cannot be generalized directly but could serve as a guide to have an idea of what the likely needs of the stakeholders are.

Table 5 - Survey Statistics

Category	No. of Surveys sent out	No. of Surveys received	Completion of the received answers (%)
Energy Operators	12	3	100
End-users	15	4	100
Prosumers	10	3	100
Asset Owners	5	1	94

4.2. Identified need-owners needs

After the analysis of the responses from different stakeholders with various needs and motivations, the most popular needs (see Table 6) amongst same stakeholders' groups are selected, and relevant technology being developed in GENTE is suggested or recommended to address those specific needs.

Colours indicates the relevance of the need to need-owners. A need deemed very relevant is indicated with green and relevant with yellow. For instance, cost reduction strategies were found to be one of the pressing needs of end users, prosumers, and asset owners with 66.7% rating. No doubt, this reduction is necessary to lower the financial burden on residents and businesses as well as to make the community to be more sustainable and economically viable. Environmental protection, security and need for technologies like blockchain and digital platforms have a consensus across all stakeholders' categories. This implies interest on sustainability and underscores the importance/relevance of the innovative technologies being developed in GENTE. On the hand, a need such as peer-to-peer energy trading is most relevant need to prosumers probably because of their quest to trade energy they generated at better price. It was discovered that need for additional income is a strong motivation for most prosumers in becoming a member of local energy community. For financial support, even though this need is revenant to all groups but its most relevant to prosumers and asset owners because of the heavy investment they needed in infrastructure.

Table 6 - Key needs from the survey result

#	Needs	End-user	Prosumer	Asset-owner	Energy operator
1	Cost reduction - on a 5-point scale, 66.7% rated this need 3 while 33.3% rated 5.				
2	Reduce carbon footprint - on a 5-point scale, 66.7% rated this need 4 while 33.3% rated 3.				
3	Energy storage & management solutions - 66.7% rated this need 4 while 33.3% rated 2.				
4	Efficient energy pricing & tariffs - 66.7% respondents considered this need important				
5	Peer-to-Peer energy trading platform - 66.7% respondents rated this need 4.				
6	Flexibility services - Majority needed these services for cost control, DRM, grid stability and energy storage integration. Financial constraints were found to be a major barrier to its procurement.				
7	Grid stability/DRP - on a 5-point scale, 66.7% rated this need 4 while 33.3% rated 5.				
8	Blockchain and digital platforms – there was a consensus on the potency of such platforms in shaping the future energy landscape				
9	Environmental protection – at least 66.7% at each category rated this need 4.				
10	Security – data and assets security are considered as very important needs.				
11	Battery energy storage				
12	Free electricity/peer-to-peer market				

13	Technology innovations				
14	Financial support				

Very Relevant	Relevant

4.3. Relevant GENTE technology for the needs

Several relevant technologies developed in GENTE has the capacity to address most of the identified needs in Table 6. Some of the technologies identified to address the summary of the identified needs are listed in Table 7.

Table 7 - Technologies proposed to meet the needs

Technologies	Needs to be addressed
ESSs, BEMS	Energy independence, flexibility market opportunity, cost reduction, peak load shading etc. Peak load control by heat-pumps/buildings for grid stability, flexibility provision etc.
DLT	Security and data confidentiality, community energy resources identification and traceability.
Decentralised monitoring and control system -Edge computing	Community assets monitoring, available flexibility, and financial status calculation for onward interaction with external actors, facilitate communication to grid operators' control systems (e.g., SCADA/DMS).
BEMS, Data analytics (forecasting & local optimization algorithms)	LECs and end-users' flexibility services support within the connected energy networks.
Management software	Energy contract and service management for prosumers/aggregators

4.4. GENTE objectives mapping to the identified needs

In previous section various stakeholder needs have been specified based upon different motivations prompting a stakeholder to join a local energy community project. All possible stakeholder which might affect GENTE pilot project outcomes are considered and classified in section 2.2. This section presents the links between the identified needs and preferences at each stakeholder's category to GENTE technical objectives (TOs) and non-technical objectives (NTOs). This is important because the specified need-owners needs are expected to be met at living lab testing stage before deployment at real full-scale environments to increase TRL levels of GENTE solutions. Once solutions have been validated, business models can be developed, and replicability and scale-up plans can be made to bring the solutions to the market. However, some popular needs identified across different objectives are shown in Table 8.

Table 8 - Needs specifications and solutions provided by GENTE

Needs Specification	Solutions provided by GENTE
Flexibility Market	GENTE is optimizing renewable energy integration and grid stability through BEMS, resource optimization etc., to enable LECs participate in the flexibility market. They can participate by adjusting their energy consumption patterns to meet their sustainability, efficiency, reliability, and economic objectives. However, surveys conducted showed that there is still lack of awareness in flexibility market and its inherent gains.
Peak Load Management	The proposed technology in GENTE leverages the potentialities of ESS, EMS, and data analytics to curtail peak loads and reduce grid congestion and variability. However, grid modernization and use of advanced grid control systems can also be considered.
Environmental Protection	Combination of BEMS, ESS, EV, and other renewable energy integration efforts will help in significant reduction of CO_2 emission.
Technology Assistance	Survey showed that technical limitation is a serious obstacle to most need-owners' operations and quest to achieve energy cost reduction and efficiency. Hence, GENTE's EMS, energy storage technology and IoT-enabled platforms provides solution to this key need.
Additional Finance	Business model being develop in GENTE would allow need-owners to gain an additional revenue and bring more business opportunities. Though financial gains are the main drivers of every business, LECs inclusive, they are often not decisive objectives.
Business Model	To support economic viability of local energy initiatives, GENTE is developing business model that is service-based rather than asset-based. For instance, services like incentivized flexibility and self-consumption incorporated as a motivation for demand response programs will not only help to maximize profit, but grid stability and efficiency. This business model supports Net Metering and peer-to-peer energy trading.

5. Conclusion

This report presents the specification of need-owners needs to be addressed in the new technology and solutions being developed in GENTE. This proposed technology is demand-driven in such a way that solutions are tailored to each stakeholders' profile for a successful implementation. It is expected that actors (initiators and developers) of LEC projects like business park managers, cooperatives, and institutions etc, should incorporate the outcome of this findings in their designs to ensure the needs and interests of their stakeholders are met. The report offers a ready-to-use framework that can be applied whenever a new technological initiative is introduced to LECs, to ensure that the concepts considered and developed from the design to roll-out stage are relevant and satisfying to the needs of all relevant stakeholders.

It was discovered that the interests of similar stakeholder groups in a largely similar context have variations but in general turn out to be quite similar. A typical example is when almost all stakeholders agreed on need for additional revenues, but some do not believe that it should be a priority. They believe that futureproof motivations with long-term advantages (environmental and technical) should be the priority rather than focusing on direct financial gain. For end user stakeholders' category, the major need is cost reduction, efficient and reliable energy system, and environmental protection, however, they still lack energy flexibility market knowledge. Majority perceived EMS to be the most effective cost reduction technology, while community energy sharing, or peer-to-peer energy trading could be the most effective strategy. Prosumers see load shifting, energy storage solutions and energy efficiency appliances as veritable tools to carbon emission reduction and energy sustainability. Energy autarky being their ultimate goal, they believe demand response programs and additional renewable energy sources can help in attending self-sufficiency.

Asset owners' major need is technological advancement to maximize profit. They strongly believe that grid integration technologies like grid-interactive water heaters, advanced metering infrastructure (AMI), energy storage systems, such as batteries, supercapacitors, and pumped hydro storage can influence their choice of business model. This need-owners want market access, less regulatory complexity as well as coordinated grid to attend energy sustainability goals. For the energy operators, they want some sort of technological advancement and system automation to optimize performance and maximize profit as well as operational flexibility market that could allow businesses participate as providers of flexibility services.

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Appendix A

Questionnaire - Energy Operators' needs to improve financial and sustainability objectives in LEC/LES

This survey is part of our stakeholder engagement program to specify stakeholders' needs in local energy systems with high renewables. It will help us to understand how energy operators' can achieve reliability, efficiency, and sustainable operation of their systems to maximize profit. It contains four parts: (1) current practices and objectives, (2) peak load management, (3) cost-efficient operations and sustainability, (4) flexibility services procurement. The collected data will be handled with care and stored without possibility to identify the respondent when submitting technical report. The data will only be used for research purposes.

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General Information

1. What is your Role/Position?

- ◯ Grid Operator
- ◯ Utility Representative
- ◯ Energy Services Provider
- ◯ Energy Consultant
- ◯ Regulatory Authority
- ◯ Other: _____

2. Briefly describe your current role and responsibilities in the energy sector.

Your answer

Part 1: Current Practices and Objectives

3. Which of the following practices and strategies does your organization employ to achieve her financial and energy sustainability objectives? (Select all that apply)

- [ ] Energy Efficiency Measures like energy audit, Energy Management System, appliance/equipment upgrade etc.
- [ ] Renewable Energy Adoption
- [ ] Sustainability Initiatives like CO2 reduction, waste reduction, and sustainable sourcing etc.
- [ ] Employee Engagement in terms of training and incentives and wellness programs provision.
- [ ] Technology and Automation
- [ ] Financial Strategies like energy performance contracts (EPCs) or power purchase agreements (PPAs) etc.
- [ ] Supply Chain Sustainability
- [ ] Regulatory Compliance
- [ ] Other: _____

4. What are your organization's primary objectives in your energy operations? (Select all that apply)

- [ ] Maximize Profits
- [ ] Ensure Grid Reliability
- [ ] Enhance Energy Efficiency
- [ ] Promote Environmental Sustainability
- [ ] Regulatory Compliance
- [ ] Security and Resilience
- [ ] Other: _____

5. Please rate the seriousness of the following challenges or obstacles to achieving efficient energy operations in your organization on the scale of 1 to 5, where 5 is the highest and 1 is the lowest.

	1	2	3	4	5
Technical Limitations	○	○	○	○	○
Cost Constraints	○	○	○	○	○
Regulatory Complexities	○	○	○	○	○
Environmental Concerns	○	○	○	○	○
Grid Congestion	○	○	○	○	○
Data Management	○	○	○	○	○
Cybersecurity Threats	○	○	○	○	○
Other...	○	○	○	○	○
None	○	○	○	○	○

Part 2: Peak Load Management

6. What challenges or obstacles have you encountered in peak load management? (Select all that apply)

- [ ] Peak Demand Variability - fluctuations and changes in electricity demand that occur during peak or high-demand periods within an electrical grid or system.
- [ ] Grid Congestion - situation where the capacity of the grid's transmission and distribution infrastructure is insufficient to accommodate the electricity flows, leading to bottlenecks, constraints, or limitations in the efficient and reliable transmission and distribution of electrical energy.
- [ ] Technical Limitations
- [ ] Cost Constraints
- [ ] Regulatory Hurdles
- [ ] Data Management
- [ ] Other: _____

7. Please rate the importance of the solutions you believe could address peak load management challenges in your organization on the scale of 1 to 5, where 5 is the highest and 1 is the lowest.

	1	2	3	4	5
Demand Response Programs	○	○	○	○	○
Energy Storage Solutions	○	○	○	○	○
Advanced Grid Control Systems	○	○	○	○	○
Distributed Energy Resources	○	○	○	○	○
Grid Monitoring and Analytics	○	○	○	○	○
Regulatory Support	○	○	○	○	○
Other...	○	○	○	○	○

Part 3: Cost-efficient Operations and Sustainability

8. What cost-efficient practices or technologies do you believe offer the greatest potential for enhancing both financial savings and sustainability in your industry?

- ○ Advanced Grid Control Systems
- ○ Energy Storage Integration
- ○ Renewable Energy Adoption
- ○ Demand Response Programs
- ○ Energy Efficiency Measures
- ○ Regulatory Support
- ○ Sustainability Initiatives
- ○ Other: _____

7. Please rate the importance of the solutions you believe could address peak load management challenges in your organization on the scale of 1 to 5, where 5 is the highest and 1 is the lowest.

	1	2	3	4	5
Demand Response Programs	○	○	○	○	○
Energy Storage Solutions	○	○	○	○	○
Advanced Grid Control Systems	○	○	○	○	○
Distributed Energy Resources	○	○	○	○	○
Grid Monitoring and Analytics	○	○	○	○	○
Regulatory Support	○	○	○	○	○
Other...	○	○	○	○	○

Part 3: Cost-efficient Operations and Sustainability

8. What cost-efficient practices or technologies do you believe offer the greatest potential for enhancing both financial savings and sustainability in your industry?

- ○ Advanced Grid Control Systems
- ○ Energy Storage Integration
- ○ Renewable Energy Adoption
- ○ Demand Response Programs
- ○ Energy Efficiency Measures
- ○ Regulatory Support
- ○ Sustainability Initiatives
- ○ Other: _____

9. Please rate the importance of under-listed cost-efficient practices and technologies to your organization with regards to financial and sustainability objectives, in the scale of 1 to 5, where 5 is the highest and 1 is the lowest.

	1	2	3	4	5
Energy management systems	○	○	○	○	○
Grid Modernization	○	○	○	○	○
Data analytics and AI	○	○	○	○	○
Electric Vehicle (EV) Charging Infrastructure	○	○	○	○	○
Distributed Energy Resources (DERs) Integration	○	○	○	○	○
Energy storage technologies	○	○	○	○	○

Part 4: Flexibility Services Procurement

10. Which of the following strategies does your organization utilize to procure flexibility services? (Select all that apply)

- ☐ Demand Response Programs Participation
- ☐ Distributed Energy Resources (DERs) Investment
- ☐ Installation of Energy Storage Systems
- ☐ Power Purchase Agreements (PPAs) Engagement
- ☐ Curtailment Agreements Engagement
- ☐ Aggregation of Flexibility Services
- ☐ Virtual Power Plants (VPPs) Participation
- ☐ Energy Management Systems (EMS) Usage
- ☐ Microgrids Investment
- ☐ Peer-to-Peer (P2P) Energy Trading
- ☐ Engagement of Flexibility Markets Aggregators
- ☐ Blockchain and Smart Contracts Technologies Deployment
- ☐ Capacity Markets Participation
- ☐ Regulation and Policy Compliance
- ☐ Other: _____

11. What are the primary objectives for procuring flexibility services in your organization? (Select all that apply)

- [ ] Grid Stability and Reliability
- [ ] Integration of Variable Renewables
- [ ] Demand Response Management
- [ ] Energy Storage Integration
- [ ] Regulatory Compliance
- [ ] Cost Control
- [ ] Environmental Sustainability
- [ ] Other (please specify): _____

12. What barriers or challenges have you encountered in procuring flexibility services? (Select all that apply)

- [ ] Market Complexity
- [ ] Technical Integration Issues
- [ ] Regulatory Barriers
- [ ] Financial Constraints
- [ ] Lack of Data and Analytics
- [ ] Grid Congestion
- [ ] Community Acceptance
- [ ] Other (please specify): _____

13. Which of these key trends and developments do you think could shape the energy landscape evolution in the future in terms of cost-efficient operations and flexibility service procurement? (Select all that apply)

- [ ] Decentralization and proliferation of distributed energy resources (DERs), including rooftop solar, wind turbines, and energy storage systems.
- [ ] Advanced grid infrastructure like grid modernization
- [ ] Energy storage technologies expansion
- [ ] Electrification and electrified transportation increase
- [ ] Blockchain and digital platforms
- [ ] Artificial intelligence (AI) and predictive analytics
- [ ] Energy as a Service (EaaS) models prevalence
- [ ] Hydrogen and green fuels prominence
- [ ] Energy communities and microgrids expansion
- [ ] Climate adaptation and resilience strategies

14. Which of these innovative technologies, grid resilience, and efficient energy management expertise do you believe energy operators like you could influence in shaping the future energy landscape to maximize cost-efficiency and flexibility? (Select all that apply)

- [ ] Grid modernization and resilience to contain extreme weather events, cyber threats, enhance grid reliability, reduce downtime, and minimize energy losses.
- [ ] Integration of renewable energy sources into the grid
- [ ] Investment in energy storage infrastructure to store excess energy during low-demand periods and release it when demand is high.
- [ ] Implementation and promotion of demand response programs that encourage consumers to reduce energy consumption during peak periods.
- [ ] Advanced metering infrastructure and data analytics tools deployment to gather real-time data on energy consumption
- [ ] Development and operation of flexible energy markets designs that allow businesses to participate as providers of flexibility services.
- [ ] Offering grid services like frequency regulation, voltage support, and reserve capacity to improve grid reliability and flexibility.
- [ ] Promotion and participation in VPPs that aggregate DERs and distributed storage resources
- [ ] Embracing blockchain and digital platforms for transparent and secure energy trading.
- [ ] Smart grid technologies investment, in the areas of advanced sensors, automation, and communication networks.
- [ ] Flexibility market participation
- [ ] Collaboration with stakeholders, including businesses, communities, and government entities, to develop integrated solutions that meet collective energy needs while optimizing cost-efficiency and flexibility.
- [ ] Other:

Submit Clear form

Appendix B

Questionnaire - End-users' needs to improve user satisfaction in LEC/LES

This survey is part of our stakeholder engagement program to specify stakeholders' needs in local energy systems with high renewables. It will help us to understand the end-user's satisfaction with their energy services. It contains four parts: (1) satisfaction with current energy services, (2) cost reduction and energy efficiency needs, (3) challenges and barriers, (4) needs and solutions. The collected data will be handled with care and stored without possibility to identify the respondent when submitting technical report. The data will only be used for research purposes.

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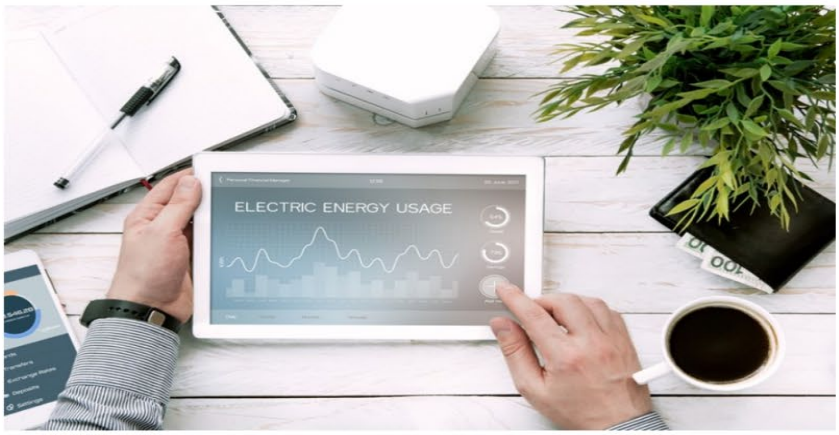

General Information

1. What is your Role/Position?

- ◯ Homeowner
- ◯ Business Owner/Manager
- ◯ Facility Manager
- ◯ Energy Consumer
- ◯ Energy Consultant

Part 1: Satisfaction with Current Energy Services

2. How satisfied are you with the current services from your electricity provider?

- ◯ Very Satisfied
- ◯ Satisfied
- ◯ Neutral
- ◯ Dissatisfied
- ◯ Very Dissatisfied

3. Please rate the importance of the aspects of your energy services that satisfies your needs in the scale of 1 to 5, where 5 is the highest and 1 is the lowest.

	1	2	3	4	5
Reliability	○	○	○	○	○
Cost	○	○	○	○	○
Environmental Impact	○	○	○	○	○
Customer Service	○	○	○	○	○
Energy Efficiency	○	○	○	○	○
Renewable Energy Options	○	○	○	○	○
Other (please specify): _____	○	○	○	○	○
None	○	○	○	○	○

4. What are your primary energy needs and expectations in a high-renewable energy local system? (Select all that apply)

- ☐ Lower Energy Costs
- ☐ Reliable Energy Supply
- ☐ Reduced Carbon Footprint
- ☐ Energy Independence
- ☐ Energy Conservation
- ☐ Environmental Stewardship
- ☐ Other: _____

Part 2: Cost Reduction and Energy Efficiency Needs

5. Are you interested in reducing your energy costs and improving energy efficiency?

- ○ Yes
- ○ No

6. Please rate the importance of the following cost reduction and energy efficiency needs in the scale of 1 to 5, where 5 is the highest and 1 is the lowest.

	1	2	3	4	5
Lower Energy Bills	○	○	○	○	○
Reduced Carbon Footprint	○	○	○	○	○
Energy Independence	○	○	○	○	○
Energy Conservation	○	○	○	○	○
Renewable Energy Integration	○	○	○	○	○
Energy-Efficient Technologies	○	○	○	○	○
Other (please specify): _____	○	○	○	○	○

7. Are you aware of the concept of energy flexibility markets, where energy consumers and prosumers can offer or adjust their energy consumption or generation in response to grid needs for a financial incentive?

- ◯ Yes
- ◯ No

8. Have you or your organization ever participated in an energy flexibility market?

- ◯ Yes
- ◯ No

Part 3: Challenges and Barriers

9. Please rate the seriousness of challenges or barriers you have encountered in achieving your cost reduction and energy efficiency goals in the scale of 1 to 5, where 5 is the highest and 1 is the lowest.

	1	2	3	4	5
High Implementation Costs	◯	◯	◯	◯	◯
Lack of Information or Expertise	◯	◯	◯	◯	◯
Regulatory Hurdles	◯	◯	◯	◯	◯
Technical Challenges	◯	◯	◯	◯	◯
Lack of Incentives	◯	◯	◯	◯	◯
Data Privacy and Security Concerns	◯	◯	◯	◯	◯
Other...	◯	◯	◯	◯	◯
None	◯	◯	◯	◯	◯

10. Please rate the importance of the solutions, technologies, or services you believe would help in addressing the challenges and your needs as an end-user in a high-renewable energy local system in the scale of 1 to 5, where 5 is the highest and 1 is the lowest.

	1	2	3	4	5
Energy Storage Solutions	◯	◯	◯	◯	◯
Grid Monitoring and Control	◯	◯	◯	◯	◯
Demand Response Programs	◯	◯	◯	◯	◯
Energy-Efficient Appliances	◯	◯	◯	◯	◯
Energy Management Software	◯	◯	◯	◯	◯
Time-of-Use Tariffs	◯	◯	◯	◯	◯
Community Energy Sharing	◯	◯	◯	◯	◯
Other...	◯	◯	◯	◯	◯
None	◯	◯	◯	◯	◯

11. What support or solutions do you believe would encourage greater participation in energy flexibility markets by both end-users and prosumers? (Select all that apply)

- [ ] Information and Education
- [ ] Technical Assistance
- [ ] Regulatory Clarity
- [ ] Transparent Compensation Models
- [ ] Energy Management Software
- [ ] Market Access Facilitation
- [ ] Other: _____

12. Please rate the importance of the support or solutions you believe would encourage greater participation in energy flexibility markets by both end-users and prosumers in the scale of 1 to 5, where 5 is the highest and 1 is the lowest.

	1	2	3	4	5
Information and Education	○	○	○	○	○
Technical Assistance	○	○	○	○	○
Regulatory Clarity	○	○	○	○	○
Transparent Compensation Models	○	○	○	○	○
Energy Management Software	○	○	○	○	○
Market Access Facilitation	○	○	○	○	○
Other...	○	○	○	○	○
None	○	○	○	○	○

13. What changes or improvements would you like to see in your energy services to better achieve your cost reduction and energy efficiency goals, and participate in energy flexibility markets as an end-users? (Open-ended response)

Your answer

Submit Clear form

Appendix C

Questionnaire - Prosumers' needs to improve self-consumption in LEC/LES

This survey will help us to understand prosumers experiences, needs and self-consumption optimization suggestions to reduced carbon emissions, increased energy independence, and create a more sustainable energy future. It contains four parts: (1) current status and goals, (2) strategies and effectiveness, (3) opportunities and challenges, (4) business model. The collected data will be handled with care and stored without possibility to identify the respondent when submitting technical report. The data will only be used for research purposes.

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General Information

1. What is your Role/Position?

- ◯ Residential Prosumer
- ◯ Commercial Prosumer
- ◯ Industrial Prosumer
- ◯ Energy Manager
- ◯ Renewable Energy Developer
- ◯ Energy Consultant
- ◯ Regulatory Authority
- ◯ Other: _____

Part 1: Current Status and Goals

2. What are your primary goals as a prosumer? (Select all that apply)

- ☐ Lower Energy Costs
- ☐ Reduce Carbon Footprint
- ☐ Energy Independence
- ☐ Generate Additional Income
- ☐ Grid Reliability
- ☐ Environmental Stewardship
- ☐ Other: _____

3. Please rate the importance of your goals in the previous question in the scale of 1 to 5, where 5 is the highest and 1 is the lowest.

	1	2	3	4	5
Lower Energy Costs	○	○	○	○	○
Reduce Carbon Footprint	○	○	○	○	○
Energy Independence	○	○	○	○	○
Generate Additional Income	○	○	○	○	○
Grid Reliability	○	○	○	○	○
Environmental Stewardship	○	○	○	○	○
Other...	○	○	○	○	○

4. What challenges or issues have you encountered as a prosumer? (Select all that apply)

- ☐ Grid Connection and Net Metering - a billing arrangement that allows owners of grid-connected renewable energy systems to receive credit for the excess electricity they produce and feed into the grid.
- ☐ Energy Storage and Management - sustainable strategy to balance energy supply and demand, improve efficiency, and reduce environmental impacts.
- ☐ Energy Pricing and Tariffs - relating to how electricity is priced and billed to consumers
- ☐ Regulatory Compliance- adherence and conformance to laws, regulations, standards, and guidelines established by governmental authorities and industry bodies to ensure the safe, reliable, and environmentally responsible operation.
- ☐ Energy Generation Reliability - consistent and dependable production of electricity or other forms of energy by power generation systems.
- ☐ Data Monitoring and Management - systematic process of collecting, observing, recording, storing, analyzing, and maintaining data for various purposes.
- ☐ Technical Support - specialized assistance and services provided to address technical issues, challenges, or inquiries related to the planning, operation, maintenance, troubleshooting, and optimization of energy-related equipment, systems, and technologies.
- ☐ Other:

5. Please rate the importance of the following support or services in addressing the challenges and meeting your goals as a prosumer in the scale of 1 to 5, where 5 is the highest and 1 is the lowest.

	1	2	3	4	5
Energy Storage Solutions	○	○	○	○	○
Real-Time Energy Monitoring Tools	○	○	○	○	○
Grid Interaction and Demand Response Programs	○	○	○	○	○
Regulatory Assistance	○	○	○	○	○
Energy Efficiency Measures	○	○	○	○	○
Peer-to-Peer Energy Trading	○	○	○	○	○
Other...	○	○	○	○	○

6. Do you currently utilize self-consumption strategies to optimize your energy use?

- ○ Yes
- ○ No

7. What self-consumption optimization strategies are you currently using? (Select all that apply)

- [ ] Load Shifting - shifting energy-intensive activities, such as charging electric vehicles or running heavy machinery, to times when your self-generated energy is abundant, reducing reliance on grid electricity.
- [ ] Energy Storage Solutions - storing excess energy generated during periods of high production (e.g., sunny days) for use during times of low or no energy production (e.g., nighttime, or cloudy days).
- [ ] Demand Response Programs - that incentives for reducing energy consumption during peak demand periods or when the grid is stressed.
- [ ] Energy Efficiency Appliances and Lighting - upgrade to energy-efficient appliances and LED lighting to reduce overall energy consumption and make better use of self-generated energy.
- [ ] Combined Heat and Power (CHP) - implement combined heat and power systems that simultaneously produce electricity and usable heat from a single energy source.
- [ ] Time-of-Use Tariffs - consume more energy during off-peak hours when electricity is cheaper and reduce consumption during peak hours when rates are higher.
- [ ] Behavioral Changes - adopt energy-efficient behaviors, such as turning off lights and equipment when not in use.
- [ ] Other: _____

8. Please rate the seriousness of the following challenges or issues often encountered in optimizing self-consumption for a sustainable energy future in the scale of 1 to 5, where 5 is the highest and 1 is the lowest.

	1	2	3	4	5
High Implementation Costs	○	○	○	○	○
Technical Challenges	○	○	○	○	○
Lack of Energy Data	○	○	○	○	○
Regulatory Barriers	○	○	○	○	○
Market Access	○	○	○	○	○
Grid Integration Challenges	○	○	○	○	○
Data Privacy and Security Concerns	○	○	○	○	○
Lack of Incentives	○	○	○	○	○
Other...	○	○	○	○	○

Part 2: Strategies and Effectiveness

9. What self-consumption optimization strategies do you believe are most effective in reducing carbon emissions and increasing energy sustainability? (Select all that apply)

- [ ] Load Shifting - shifting energy-intensive activities, such as charging electric vehicles or running heavy machinery, to times when your self-generated energy is abundant, reducing reliance on grid electricity.
- [ ] Energy Storage Solutions - storing excess energy generated during periods of high production (e.g., sunny days) for use during times of low or no energy production (e.g., nighttime, or cloudy days).
- [ ] Demand Response Programs - that incentives for reducing energy consumption during peak demand periods or when the grid is stressed.
- [ ] Energy Efficiency Appliances and Lighting - upgrade to energy-efficient appliances and LED lighting to reduce overall energy consumption and make better use of self-generated energy.
- [ ] Combined Heat and Power (CHP) - implement combined heat and power systems that simultaneously produce electricity and usable heat from a single energy source.
- [ ] Time-of-Use Tariffs - consume more energy during off-peak hours when electricity is cheaper and reduce consumption during peak hours when rates are higher.
- [ ] Behavioral Changes - adopt energy-efficient behaviors, such as turning off lights and equipment when not in use.
- [ ] Other: _____

Part 2: Strategies and Effectiveness

9. What self-consumption optimization strategies do you believe are most effective in reducing carbon emissions and increasing energy sustainability? (Select all that apply)

- [ ] Load Shifting - shifting energy-intensive activities, such as charging electric vehicles or running heavy machinery, to times when your self-generated energy is abundant, reducing reliance on grid electricity.
- [ ] Energy Storage Solutions - storing excess energy generated during periods of high production (e.g., sunny days) for use during times of low or no energy production (e.g., nighttime, or cloudy days).
- [ ] Demand Response Programs - that incentives for reducing energy consumption during peak demand periods or when the grid is stressed.
- [ ] Energy Efficiency Appliances and Lighting - upgrade to energy-efficient appliances and LED lighting to reduce overall energy consumption and make better use of self-generated energy.
- [ ] Combined Heat and Power (CHP) - implement combined heat and power systems that simultaneously produce electricity and usable heat from a single energy source.
- [ ] Time-of-Use Tariffs - consume more energy during off-peak hours when electricity is cheaper and reduce consumption during peak hours when rates are higher.
- [ ] Behavioral Changes - adopt energy-efficient behaviors, such as turning off lights and equipment when not in use.
- [ ] Other:

10. Please rate the importance of the self-consumption strategies you selected in the previous question in reducing carbon emissions and increasing energy sustainability in the scale of 1 to 5, where 5 is the highest and 1 is the lowest. .

	1	2	3	4	5
Load Shifting	○	○	○	○	○
Energy Storage Solutions	○	○	○	○	○
Demand Response Programs	○	○	○	○	○
Energy Efficiency Appliances and Lighting	○	○	○	○	○
Combined Heat and Power (CHP)	○	○	○	○	○
Time-of-Use Tariffs	○	○	○	○	○
Behavioral Changes	○	○	○	○	○
Other...	○	○	○	○	○

11. Are you aware of the concept of energy flexibility markets, where energy consumers and prosumers can offer or adjust their energy consumption or generation in response to grid needs for a financial incentive?

- ○ Yes
- ○ No

12. Have you or your organization ever participated in an energy flexibility market?

- ○ Yes
- ○ No

Part 3: Opportunities and Future Expectations

13. What changes or improvements would you like to see in the energy system to better accommodate prosumers like yourself? (Open-ended response)

Your answer

14. Which of these opportunities and benefits associated with self-consumption optimization do you see more relevant in the energy industry in the future? (Select all that apply)

- [ ] Solar energy maximization to reduce the need to rely on grid electricity and lower utility bills.
- [ ] Energy storage solutions to enhance energy reliability and reduce grid dependence.
- [ ] Environmental impact reduction in terms of carbon emissions and mitigation of environmental impact of energy production.
- [ ] Load shifting to reduce the need to draw electricity from the grid during peak times.
- [ ] Grid resilience for homes and businesses to withstand power outages or grid disruptions.
- [ ] Grid decentralization to reduce the need for large, centralized power plants and enhance the flexibility of the grid.
- [ ] Technology innovation in energy storage, smart grid technologies, and energy management systems.
- [ ] Adaptation to Electric Vehicles (EVs) to reduce carbon footprint in transportation.
- [ ] Peer-to-Peer energy trading that allows excess energy to be shared within the community.
- [ ] Energy independence to reduce exposure to fluctuations in energy prices and supply disruptions.
- [ ] Other:

Part 4: Business Model Preferences

15. What business model do you believe is best suited for renewable energy prosumers to achieve a sustainable and cost-effective energy ecosystem? (Select all that apply)

- [ ] Self-Consumption Model - that allows consumers to take control of their energy production and usage, for self-reliance and friendly environment.
- [ ] Net Metering Model - that allows owners of grid-connected renewable energy systems to receive credit for the excess electricity they produce and feed into the grid.
- [ ] Peer-to-Peer Energy Trading - decentralized and innovative approach to buying and selling electricity among consumers within a local or distributed energy system.
- [ ] Community Energy Projects - initiatives that allows a group of individuals, local residents, businesses, or organizations to collaboratively develop, own, or participate in energy-related endeavors within their community.
- [ ] Energy Storage and Backup - storing electricity when it is available, either from the grid or from renewable sources, and release it during power outages to ensure a continuous power supply.
- [ ] Collaborative Microgrid - self-contained and resilient energy infrastructure developed and operated through collaboration and cooperation among multiple stakeholders.
- [ ] Other:

16. Please rate the importance of factors that influence your choice of business model in the scale of 1 to 5, where 5 is the highest and 1 is the lowest.

	1	2	3	4	5
Cost Savings	○	○	○	○	○
Energy Independence	○	○	○	○	○
Environmental Sustainability	○	○	○	○	○
Income Generation	○	○	○	○	○
Energy Resilience	○	○	○	○	○
Regulatory Framework	○	○	○	○	○
Technology Availability	○	○	○	○	○
Other...	○	○	○	○	○

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Appendix D

Questionnaire - Asset Owners' needs to improve flexibility in LEC/LES

This survey is part of our stakeholder engagement program to specify stakeholders' needs in local
energy systems with high renewables. It will help us to understand the necessary system improvements by asset owners to achieve grid flexibility and integration, and optimize their investments. It contains four parts: (1) current portfolio and objectives, (2) grid response, adjustments, and technologies, (3) opportunities and challenges, (4) business model. The collected data will be handled with care and stored without possibility to identify the respondent when submitting technical report. The data will only be used for research purposes.

alexndife2003@gmail.com Switch accounts

Not shared

General Information

1. What is your Role/Position?

- ◯ Renewable Energy Project Owner
- ◯ Renewable Energy Asset Manager
- ◯ Investment Manager
- ◯ Energy Consultant
- ◯ Regulatory Authority
- ◯ Other:

Part 1: Current Portfolio and Objectives

2. Please describe your current renewable energy portfolio and investment objectives related to grid flexibility, stability, reliability, resilience, and integration.

Your answer

3. How would you describe the current state of interaction between renewable energy generators and the grid in terms of power output adjustment to meet grid needs?

- ◯ Highly Responsive and Efficient
- ◯ Moderately Responsive and Efficient
- ◯ Neutral
- ◯ Insufficiently Responsive
- ◯ I don't know

4. What are the primary challenges or issues you currently face in managing grid flexibility or in adjusting power output to meet grid needs? (Select all that apply)

- ☐ Grid Congestion
- ☐ Voltage and Frequency Variability
- ☐ Grid Stability Issues
- ☐ Regulatory Compliance Challenges
- ☐ Curtailment of Renewable Energy
- ☐ Lack of Real-Time Grid Information
- ☐ Data Privacy and Security Concerns
- ☐ Other:

5. Please rate the importance of the most important need(s) as an asset owner in contributing to grid flexibility, stability, reliability, resilience, and integration in the scale of 1 to 5, where 5 is the highest and 1 is the lowest.

	1	2	3	4	5
Grid Integration Support	○	○	○	○	○
Grid Stability and Reliability Enhancements	○	○	○	○	○
Energy Storage Integration	○	○	○	○	○
Demand Response Management	○	○	○	○	○
Regulatory Compliance	○	○	○	○	○
Sustainability and ESG Goals	○	○	○	○	○
Risk Management	○	○	○	○	○
Other...	○	○	○	○	○

6. How would you describe the current state of grid flexibility in terms of managing supply and demand variations?

- ○ Highly Flexible and Efficient
- ○ Moderately Flexible and Efficient
- ○ Neutral
- ○ Inflexible and Inefficient
- ○ I don't know

Part 2: Grid Response, Adjustments, and Technologies

7. How do you currently adjust the power output of your renewable energy generators to meet grid needs? (Select all that apply)

- ☐ Curtailment of Generation
- ☐ Ramp-Up or Down Generation
- ☐ Demand Response Programs
- ☐ Energy Storage Integration
- ☐ Grid Signals and Market Participation
- ☐ Smart Inverters or Controllers
- ☐ Other:

8. What methods or technologies are you currently using in storing excess electricity to be discharged during peak demand or low renewable energy production times? (Select all that apply)

- [ ] Battery Energy Storage
- [ ] Pumped Hydro Storage
- [ ] Compressed Air Energy Storage
- [ ] Flywheel Energy Storage
- [ ] Thermal Energy Storage
- [ ] Hydrogen Energy Storage
- [ ] Other: _____

9. Are you currently utilizing advanced grid control systems, intelligent energy management software, or grid monitoring solutions to enhance grid flexibility?

- ◯ Yes
- ◯ No

10. Which of the following advanced technologies or solutions are you currently using or planning to use to improve grid flexibility? (Select all that apply)

- [ ] Advanced Grid Control Systems
- [ ] Intelligent Energy Management Software
- [ ] Real-Time Grid Monitoring Solutions
- [ ] Distributed Energy Resource Management Systems (DERMS)
- [ ] Advanced Distribution Management Systems (ADMS)
- [ ] Microgrid Solutions
- [ ] Smart Grid Communications
- [ ] Other: _____

11. Please rate the effectiveness of the advanced technologies or solutions you selected in the previous question in improving grid flexibility.

- ◯ Ineffective
- ◯ Somewhat Effective
- ◯ Effective
- ◯ Very Effective
- ◯ Extremely Effective
- ◯ I don't know

Part 3: Opportunities and Challenges

12. What challenges or barriers do you foresee in implementing advanced grid control systems, energy management software, and monitoring solutions for improved grid flexibility? (Select all that apply)

- [ ] High Implementation Costs
- [ ] Regulatory Hurdles
- [ ] Resistance to Technological Change
- [ ] Data Privacy and Security Concerns
- [ ] Lack of Skilled Workforce
- [ ] Integration Challenges
- [ ] Other: _____

13. What challenges or barriers do you foresee in implementing effective power output adjustments to meet grid needs? (Select all that apply)

- [ ] Technical Challenges
- [ ] Regulatory Barriers
- [ ] Market Access
- [ ] Data Privacy and Security Concerns
- [ ] Lack of Grid Coordination
- [ ] Lack of Incentives
- [ ] Other:

14. Please rate the seriousness of the challenges or barriers you foresee in achieving greater grid flexibility through energy storage solutions in the scale of 1 to 5, where 5 is the highest and 1 is the lowest.

	1	2	3	4	5
Technical Challenges	○	○	○	○	○
Regulatory Barriers	○	○	○	○	○
Market Access	○	○	○	○	○
Data Privacy and Security Concerns	○	○	○	○	○
Lack of Grid Coordination	○	○	○	○	○
Lack of Incentives	○	○	○	○	○
Other...	○	○	○	○	○

15. Please rate the importance of business model you believe is best suited for renewable asset owners to optimize grid flexibility, stability, reliability, resilience, and integration in the scale of 1 to 5, where 5 is the highest and 1 is the lowest.

	1	2	3	4	5
Independent Power Producer (IPP)	○	○	○	○	○
Energy Service Company (ESCO)	○	○	○	○	○
Energy Storage Provider	○	○	○	○	○
Distributed Energy Resource (DER) Aggregator	○	○	○	○	○
Collaborative Community Energy Projects	○	○	○	○	○
Other...	○	○	○	○	○

16. Please rate the key factors influencing your choice of business model in their order of importance, within scale of 1 to 5, where 5 is the highest and 1 is the lowest.

	1	2	3	4	5
Revenue Generation	○	○	○	○	○
Grid Support Services	○	○	○	○	○
Regulatory Compliance	○	○	○	○	○
Sustainability and ESG Goals	○	○	○	○	○
Risk Management	○	○	○	○	○
Market Dynamics	○	○	○	○	○
Grid Integration Technologies	○	○	○	○	○
Other...	○	○	○	○	○

17. How can stakeholders including renewable energy generators, grid operators, technology providers, energy storage operators and regulatory authorities collaborate more effectively to achieve grid flexibility? (Open-ended response)

Your answer

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