# Local Energy Markets: A Market Transformation Survey Towards Segments of Interest

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**Abstract.** Given the rapid growth of distributed energy generation and the anticipated rise in demand-response, one of the most important issues is how to integrate the energy resources into the existing market. The energy sector has undergone a considerable transformation during the past years due to changing legislation, technologies and consumer behavior. Therefore, this work explores the patterns that form the energy market transformation, measures awareness regarding energy market and gain insights on energy market tools and services, through a survey implemented within the innovative project PARITY. Moreover, the knowledge gained from the participants is used to identify segments of interest. The main findings from the market transformation survey include among other topics, that the energy market is envisioned to be entirely based in DERs by the end of 2035, while the primary barrier for the latter are the lack of EU and national regulations, as well as the inadequate technological design, lack of standardization, and interoperability. The survey also revealed that smart energy contracts, load forecasting mechanisms, personalized profile models and dynamic pricing schemes are some of the services that can increase the productivity and profitability within local energy markets. Finally, this report is based on research carried out in early 2022, drawing from professionals within the H2020 project PARITY and were from a variety of industries with an emphasis on energy production, analysis, and consulting.

**Keywords:** Local Energy Market · Market Penetration · Market Transformation · Survey · Segments of Interest

## 1 Introduction

The unifying objective of reaching net-zero greenhouse gas emissions by the year 2050 was reinforced when the European Parliament proclaimed a state of climate and environmental emergency in November 2019 [1]. In that sense, the most polluting aspect of human activity is the energy sector, which is responsible for 33% of the greenhouse gas emissions in the atmosphere [2] and could be considered as the first factor towards a cleaner energy. The repercussions of Russia's invasion to Ukraine are a second factor driving the shift to cleaner energy. According to Fisher [3], Russia provides 40% and


M. Papadaki et al. (Eds.): EMCIS 2022, LNBIP 464, pp. 537–551, 2023.
https://doi.org/10.1007/978-3-031-30694-5_38

27%, respectively, of the natural gas and oil that the European Union (EU) imports. This conflict exposed the EU's reliance on Russian resources, highlighting the importance of diversifying energy supply toward renewables for achieving energy stability [4, 5, 34–37].

However, the latter demands the adaptation of grid infrastructures, in order to handle the capacity of renewable Distributed Energy Resources (DERs) [6, 7]. The idea of an energy community is growing in this context [8, 38], usually offering advanced services, such as self-consumption, energy storage, peer-to-peer trading and management of DERs [9, 39]. An example is the HORIZON 2020 project named PARITY [10], which also implements a model of an energy community, named Local Energy Market (LEM). In order to encourage the incorporation of more DERs into the energy system, LEMs have emerged as a key strategy and are designed to encourage small energy prosumers to trade energy with one another towards supply and demand balance [12, 40, 41].

Thus, the current work's contribution is focused on identifying the patterns that form the energy market transformation, measuring awareness related to LEMs and gaining insights on relevant tools and services, through a qualitative data analysis. The remainder of this paper is organized as follows: Sect. 2 provides the research methodology, while Sect. 3 presents the data analysis and results. Section 4 discusses the knowledge gained, focusing on identifying segments of interest within the LEMs. Finally, Sect. 5 concludes the paper.

## 2 Research Methodology

In this paper, the methodology followed to investigate the energy market transformation in LEMs is based on quantitative research [12], through the use of a survey, as a mean of data collection. Even though surveys are used in a wide range of areas, market research is one of their primary applications. The rationale behind the selection of the researcher lies in the fact that survey research supports the investigation of characteristics and opinions of a group of people in a specific matter (i.e., local energy market transformation). Through survey research the current work will understand the participants' needs, preferences and perspectives on the concept of LEM and will identify factors and barriers to the progress of local renewable energy development.

To that end, the survey was distributed primarily to the PARITY project experts, including distributed system operators, aggregators, retailers etc. Moreover, we included a secondary target group of experts outside PARITY, with an understanding of emerging technologies in the area of energy. The survey was administered to participants within European countries and the total responses were 50. The distribution of the participants is presented in Fig. 1. The questionnaire survey was divided into four sections: (a) Demographics, (b) Energy transformation insights, (c) Market Change and (d) Market Segments. The detailed presentation of the questionnaire as well as the (anonymous) data outcomes are open source and can be found in Zenodo [13].

# 3 Data Analysis and Results

The main results related to the energy market transformation elaborated from the questionnaire, are presented below. Initially, the background knowledge and the familiarity of respondents with the LEM technologies are investigated. Then, energy market transformation insights, as well as market segments are presented.

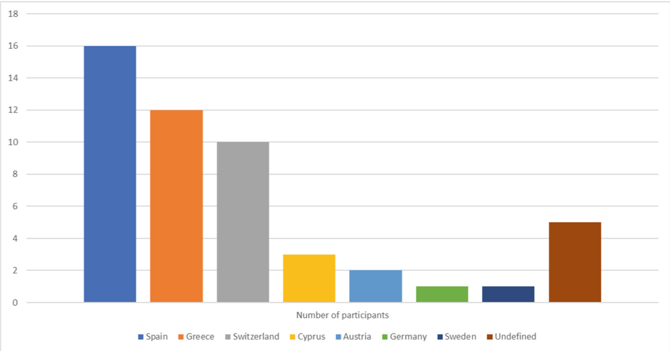


**Fig. 1.** Questionnaire survey distribution

## 3.1 Preliminary Data Analysis

The preliminary data of the survey was related to the demographics and was used to understand the participants' background. The majority of the respondents were male. Regarding their age, range between 30 and 39 are over-represented in the sample, young adults aged 18–24 are under-represented, while people above 60 are not represented. The education background was also investigated, with the majority of the participants holding a master's degree (55,3%), while an important part holds a Doctorate (29,8%). An important parameter of the current survey is that most of the respondents have experience in emerging technologies in the energy sector, such as renewable energy, microgrids, smart meters, blockchain and energy storage. Specifically, the majority of the respondents (51,1%) has a very strong understanding of such technologies, while 6,4% do not really understand their benefits.

## 3.2 Energy Transformation Insights

This section provides a review related to the energy transformation the energy market is currently facing. To begin with, data shows that the majority of the respondents know from where their final energy consumption is coming from, while a small percentage (8,5%) is not. Most energy consumption is coming from residual mix (59,6%), pure renewable energy sources are coming next with 17%, energy coming from power stations burning fossil fuels represent the 14,9% of the responses, while none of the respondents consumes energy coming exclusively from nuclear sources. An interesting aspect regarding the origin of the energy consumed nowadays is depicted also in Fig. 2, where it is evident how each country mostly consumes energy. From the data coming from the conducted survey, we can say that Sweden, Switzerland, Austria, Germany and Cyprus are moving rapidly towards greener energy consumption since all of the energy consumed is coming either from residual mix or from pure renewable energy sources. On the other hand, Spain and Greece are still consuming some amount of energy coming from power stations burning fossil fuels.

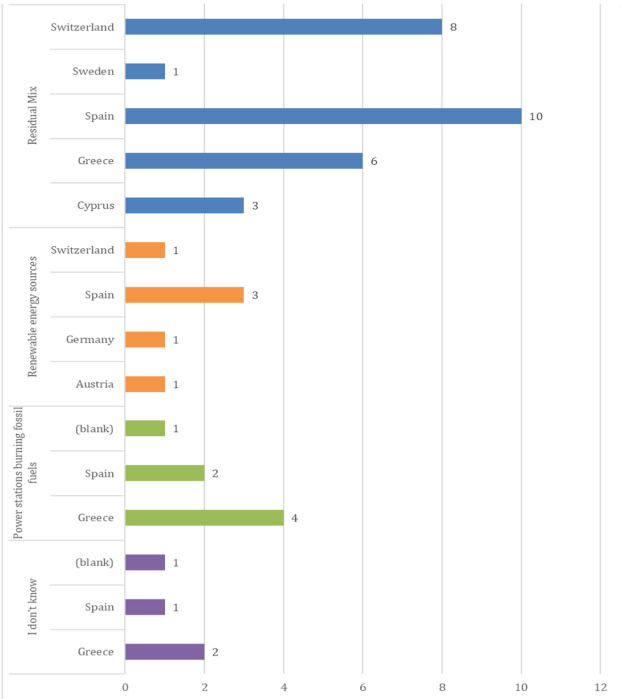


**Fig. 2.** Main source of energy consumption per country

In relation to their energy bill, most respondents state that they are satisfied in terms of costs (51,1%). A significant percentage though does not find its current energy bill reasonable (33,3%). It is worth mentioning though, that the majority of people consuming energy from residual mix are feeling satisfied with their energy bill. The large majority of the sample (85,1%) considers that the risk is higher with energy systems based on more centralized energy 'generation', compared with the 8,5% of the total sample which thinks the risk is lower, and the 4,3% which thinks is the same. Trying to identify why the majority of the sample thinks the risk is higher, we tried to categorize possible risks electricity markets based on more centralized generation are facing. Most of the participants state that the highest risk in more centralized energy markets are the emissions and/or the air pollution. The second risk in line is identified as medium by the majority of the respondents and is related to the energy availability and supply risk of the centralized markets, while also cyberattack, bulk generation of energy and the risk of unjusting pricing schemes are considered as medium risks as well (Fig. 3).

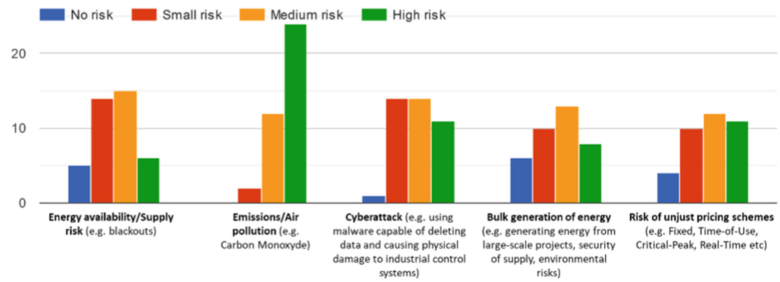


**Fig. 3.** Main risks of centralized energy generation

Regardless their belief related to the risk of the more centralized energy markets, the respondents were asked in how many years they anticipate the energy market to be based on DERs. The response was distributed almost equally, making it difficult to extract a clear prediction. A slightly higher percentage believes that by the end of 2035 the energy market will be based mostly on DERs, although there were some comments from the respondents stating that they anticipate it later (2050 onwards) or never. Additionally, it is believed that especially EVs will be widely applied by 2025, but in a rural area, centralized power plants (e.g., hydro, gas) will still play a significant role in electricity production. Based on the respondents, the anticipation is due to the fact that EU and national regulations and legislations are considered as the obstacles having the highest impact in the fast adoption of LFMs, as shown in Fig. 4. Insufficient technological design, lack of standardization as well as lack of interoperability between equipment and stakeholders are obstacles that are also having a medium impact.

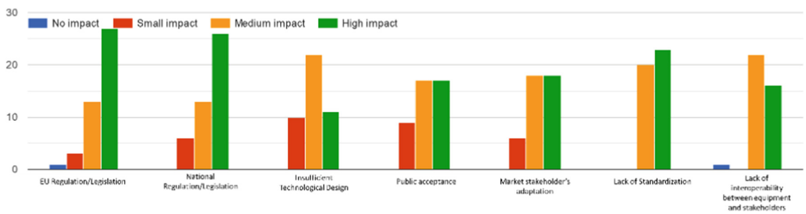


**Fig. 4.** Impact of obstacles in the fast adoption of LFMs

## 3.3 Market Change

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

Since local energy communities are entering the hype, the adoption of peer-to-peer (P2P) electricity trading will turn individual consumers from passive to active participants in LEMs. Such a marketplace can relieve constraints on the growing system and offer an alternative to costly grid reinforcements. The above statement is proved also through the survey, considering that 70,2% of the respondents believe that there are financial benefits within a local energy community. Additionally, 66,6% thinks that there are attractive business opportunities for new stakeholders, while another 66,6% find it reasonable to participate in such markets due to the increased investment in DERs (e.g. PVs, EVs etc.). As most of the respondents agree that there is a significant financial benefit for the prosumers, it was necessary to investigate in how many years it is anticipated to have some sort of flexible energy assets established in new or existing households. Percentage of 54,3% stated that most new buildings will have some sort of flexible assets established, 23,9% believes that most buildings will have some flexible assets, while only 8,7% thinks that all buildings will provide such capabilities (Fig. 5). The most important concepts that are foreseen to change the current energy market are the EVs, the large-scale centralized renewable energy generation as well as the distributed energy generation (Fig. 6). Local energy systems and infrastructure were characterized as of medium importance, while the majority of the respondents agree that large-scale fossil fuel power generation will have no importance at all in the future. Consequently, distributed and renewable enabled energy market that will mostly be based on DERs is becoming a reality.

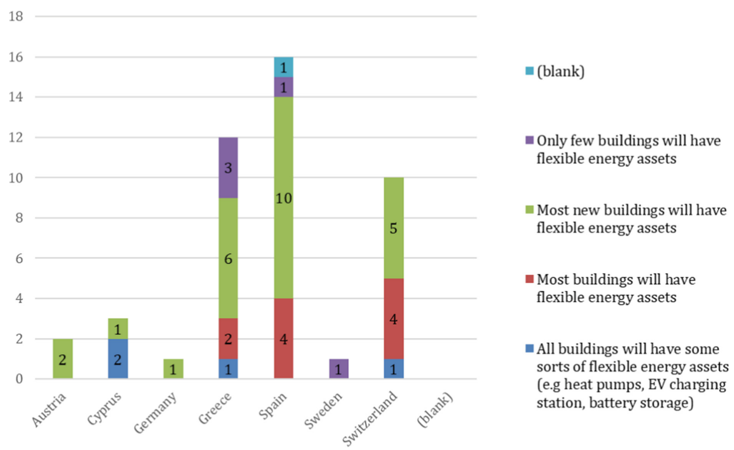


**Fig. 5.** Adoption of flexible energy assets within households per country in 5 to 10 years

## 3.4 Market Segments

At the final stage of this survey, the participants were asked questions related to specific energy market tools and services. Thus, this section provides a review related market segments and possible trends. The participants were asked to indicate which tools and

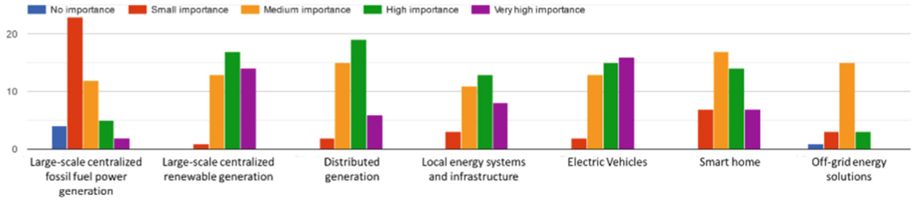


**Fig. 6.** Technological concepts of high importance for the next years

services they think may boost the profitability and efficiency. As it was anticipated, the majority of the respondents believe that DERs personalized profile models (66%), load forecasting mechanisms (57,4%), dynamic pricing schemes (55,3%) and smart energy contracts (51,1%) are the services that have the ability to accelerate the profitability and efficiency of DERs (Fig. 7).

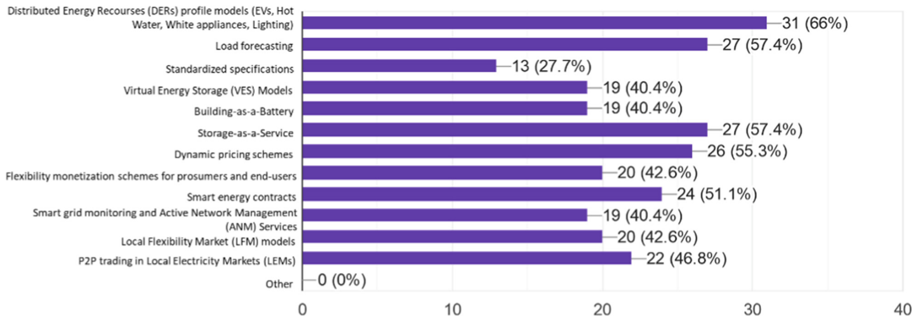


**Fig. 7.** Technological Services that will boost the profitability and efficiency of DERs

Moreover, considering that smart energy contracts could accelerate the profitability and efficiency of DERs, the respondents were asked if they find blockchain enabled smart contracts useful for that matter. The majority of the sample (66,7%) responded yes, leading to the outcome that blockchain technology and smart contracts specifically is a promising technology and could be a trend within LEMs (Fig. 8).

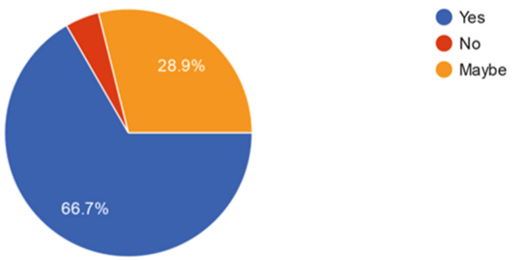


**Fig. 8.** Blockchain and smart contracts for LEM/LFM

Finally, since European funding schemes are considered an important parameter in the acceleration and development of technological solutions, the participants are determined that European funds should be primarily related to energy efficiency solutions (73,3%) and flexibility solutions (71,1%). Additionally, energy storage (68,9%) along with energy monitoring and control (64,4%) are functionalities that should also be investigated.

## 4 Discussion

Despite the advent of the global pandemic and the economic contraction, decarbonization strategies continued to be declared. Despite the absence of a clear opportunity for green infrastructure growth in the economic stimulus initiatives implemented in reaction to COVID-19, sustainable energy demand remained robust as renewables and storage saw decreasing prices and increasing Capital Expenses (CapEx) [14]. Also, it is expected that the percentage of electricity used in end-use sectors will need to rise from roughly 20% in 2015 to 40% in 2050, as low-carbon electricity becomes the dominant energy carrier [16]. For instance, as it is evident from the research results described in the previous section, heat pumps and EVs, would spread widely throughout the world. While the use of renewable energy would be accountable for a sizable part of energy use in industry, buildings and transportation, renewable power would still make up a little under 60% of all renewable energy consumption.

Towards this direction, after analyzing the market in the previous section, the current section is going to provide segments of interest based on information available on the literature as well as knowledge extracted from the conducted survey.

### 4.1 Segments by Country

**Spain – Country Profile and Forecasts.** Solar energy has become a major source of electricity production, and its share in Spain is rising. In the forthcoming years of 2020–2025, the renewables market in Spain is projected to develop at a CAGR of more than 6%. Indicators like promoting government policies and efforts to satisfy increasing power demand with clean energy sources and reduce reliance on fossil fuels, are projected to play a major role in market development [17]. Moreover, the Spanish government took ambitious measures, such as eliminating the sun tax in 2018, establishing a National Energy Technology Plan, and implementing a Low Emission Strategy 2050, to place the country as a world leader in the green sector and reducing its carbon footprint at an unprecedented pace [17]. Solar energy, with a projected expansion of more than 35 GW by 2030, will dramatically drive the renewable Spanish sector, with the government planning to install 37 GW of solar plants by 2030 in order to raise renewable share by 74%. Additionally, during the upcoming years, Spain is focusing on solar energy generation and integration of emerging technologies in smart buildings (e.g., energy storage through battery technologies, demand response, real time metering data etc.).

**Switzerland – Country Profile and Forecasts:** Switzerland's renewable energy market is projected to expand at a CAGR of more than 3% between 2020 and 2025 [18].

Increasing concerns over greenhouse gas pollution, which cause environmental harm and global warming, are forcing the government to search for cleaner electricity generation alternatives. This is expected to fuel the Swiss renewable energy market. However, Switzerland's stagnant power demand is likely to limit the nation's renewable energy market [17]. It is worth mentioning though, Switzerland signed an agreement in 2017 to limit greenhouse gas emissions by half by 2030, expected to open up a number of potential prospects for the Swiss green energy industry in the upcoming years. Additionally, the country's growing installed capacity for solar and hydro power is expected to boost the Switzerland renewable energy market. Moreover, Apox proceeded with the installation of a solar plant of over 6,000 photovoltaic modules on the Glarus Alps site, which covers a surface of 10,000 square meters [19]. The plant can generate 2.7 gigatons of energy per year, which is equivalent to the demand of 600 households. As a consequence of the above, the Switzerland green market is projected to be powered by rising renewable energy installed capacity during the upcoming years period.

**Greece – Country Profile and Forecasts:** As stated in the 2020 Greek Energy Market Report [20], Because of the COVID-19 epidemic, gross energy usage fall in 2020. Greece has a high degree of solar energy and 2.9 GW of solar thermal systems deployed, with photovoltaic installations accounting for the majority of RES in the country. [20, 21]. Solar PV generated 25,43% of RES electricity and 8.2% of total electricity, due in part to the 512 GWh provided by the Special Photovoltaic Rooftop Program. Additionally, the Hellenic Energy Exchange, which offers high-quality, open, and socially responsible services to environmental market players, was a pivotal move for the region. Working against the EU target image and combining its economy with neighboring nations, not to mention providing low-income families with grants covering up to 60% of the construction costs of solar water heaters, Greece illustrates a strong penetration of renewable energy in the sector as well as an attempt to implement European and national strategies [21]. RES objectives are set to allow a cumulative contribution of 20% to overall final energy consumption, among other items. RES is expected to account for 75% of total energy generated in Greece by the end of 2025, while by 2030, overall, RES capacity will increase by 61–64%, with PV having the largest share in Greece [20].

**Sweden – Country Profile and Forecasts:** During the projected timeline of 2020–2025, the Swedish renewable energy market is estimated to grow at a CAGR of more than 2%. Government efforts to reduce greenhouse gas emissions in the country are expected to propel the Swedish clean energy industry. However, problems in operating renewable energy plants are likely to restrict Sweden's renewable energy market. Sweden plans to target 100% clean energy power generation by 2040 and 0% greenhouse gas emissions by 2045. These goals are likely to provide a great potential for the Swedish green energy industry. Furthermore, the country's growing renewable energy installed capacity and future developments are expected to boost the Swedish renewable energy market. The European Union has set goals for reducing their carbon footprint, and Sweden is increasing its renewable installation capacity to meet those targets [22]. Regardless, Sweden requires innovative ways to achieve the above-mentioned aggressive policy target of achieving 100% clean energy by 2040. IRENA has therefore suggested four tailor-made options [23] focused on a holistic approach to solve the country's unique difficulties in scaling up Variable Renewable Energy (VRE) in collaboration with the Swedish Energy Agency. The solutions are highly linked with emerging technologies such as batteries, IoT technologies, EV smart charging, as well as blockchain and smart contract technologies. Additionally, the solutions envision innovative market design based on ancillary services, local markets and time of use tariffs.

### 4.2 Segments by Type

**Solar PV:** Solar PV, or solar photovoltaic energy, is a form of solar energy that uses photovoltaic technology to turn sunlight into electricity. Solar power is probably the most trustable and sustainable green energy source. While hydropower remains the most cost-effective renewable energy source, steadily dropping prices have rendered solar PV the primary market for investment. Particularly, in a variety of countries around the globe, solar PV-generated electricity nowadays cost competitive with fossil fuels [24]. Companies are increasingly shifting towards the use of renewable energy sources for electricity production, especially solar energy and wind power, as a result of strict government legislation and regulation related to carbon emissions. This is expected to boost the solar PV market's growth in the future years [24].

**Solar Thermal - Heating and Cooling:** Solar thermal has the possibility to be a significant source of heating and cooling in Europe as an incredibly convenient heating source based on a basic principle improved by cutting-edge technologies [25]. As technology has improved, solar thermal is becoming not only a better alternative for more conventional applications like domestic hot water processing, but also a potential approach for modern and more advanced applications like industrial process heat. Moreover, the provision of district heating facilities will boost the viability of centralized solutions such as large-scale sustainable heating and cooling systems, such as solar-thermal. Several thermal heating and cooling technologies, such as solar-thermal, might be much affordable at scale, but delivery requires a district heating grid. The district heating system, on the other hand, is not always financially viable to construct [25].

**Wind Power:** Wind power capacity continues to expand rapidly, fueled by an established track record and precedent from the previous decade, as well as low levelized cost of energy (LCOE). International Wind Energy Council (GWEC) study [26] states that despite the global offshore wind industry having a great year in 2021 in terms of new capacity, it is still expected to fall behind of the net zero goals set by the International Energy Agency by 2030. The trade association also stated that it was extremely likely to increase installation projections this year as nations sought to modernize their energy infrastructure in reaction to the volatility of fossil fuel prices, which was made worse by the invasion of Ukraine [27].

**Bio-Energy:** Bio-energy (or biomass) is a significant renewable energy source that will help Europe achieve its climate goals in 2020 and 2030, when renewable energy sources must account for 32% of total energy demand in the EU [28]. Regardless of the fact that international investment in biomass and waste-to-energy fell by 29% from 2014 to 2015, this sector ranks third behind wind and solar energy. Bioenergy has the potential to play a major role in meeting the EU's renewable energy goals by 2030 and beyond [29]. According to the European Commission's sustainability scenario, gross inland bioenergy consumption would range from 170 to 252 Mtoe (i.e., million or mega tonnes of oil equivalent) by 2050 [28]. Bioenergy can also act as a versatile carrier, allowing for higher shares of renewable energy sources such as wind and solar power in power grids [28].

### 4.3 Segments by End-Use

**Building Sector:** Gas heaters, lighting, central air conditioning, refrigeration, and electric and gas water heating are the facilities that use the most electricity in the residential sector [30]. In comparison, the reliability picture for light bulbs, as well as electric and gas water heating use, shows less effectiveness so far. Lighting provides many opportunities for productivity improvements, both because removing incandescent lamps with fluorescent bulbs saves a considerable amount of electricity and because the first cost tends to decline. Fluorescent and incandescent lighting, air-conditioning, office appliances, supply/return fans, and bundled heating are the main electricity appliances in the commercial sector [31].

**Transportation Sector:** Transportation is critical to the global economy because it facilitates the flow of people and global commerce. However, it comes at an expense, since it is a big source of carbon due to the current reliance on fossil fuels. Although it accounts for one-third of global energy consumption, it is also the field with the least amount of renewable energy usage but with the greatest potential [32]. There are some preferred green alternatives for some modes of transportation, but not all [33]. Despite considerable progress in energy efficiency, especially in road transport, global energy demand in the transport sector has steadily increased over the last decade, owing primarily to the increasing number and scale of vehicles on the world's roads. Even if all announced policy initiatives are adopted, the transportation industry is projected to increase GHG emissions by 60% by 2050, owing primarily to increased freight and non-urban transportation. If no steps are taken, road transport is expected to account for at least 70% of GHG emissions by 2050 [33]. Thus. it is clear that green energy strategies for the road transport sector must be incorporated in a broader system of measures that also decrease demand for transportation facilities, change transportation modes, and improve vehicle quality [32].

**Industrial Sector:** Industry accounts for more than one-quarter of global energy-related Carbon Dioxide ($CO_2$) emissions, and manufacturing activities account for a further 8% of global $CO_2$ emissions [29]. Iron and steel, aluminum and plastics account for more than 85% of manufacturing energy and process-related pollutants, and account for more than two-thirds of overall industrial energy consumption. There are actually only a few commercially feasible options for reducing $CO_2$ emissions at scale in these manufacturing industries [33]. According to the "buildings section" of this deliverable, electricity usage in commercial buildings accounts for almost two quads of annual energy use. The ITP Best Practices Program does not discuss the construction aspects of energy use in the sector and focuses primarily on process and plant utility energy use. Finally, there are many opportunities in the lighting, HVAC, and building covering [33].

## 5 Conclusions

Under the scope of this work, a high-level market penetration took place, exploring the patterns that form the energy market transformation, measure awareness regarding energy market and gain insights on energy market tools and services through a survey implemented within the PARITY project [9]. Within this work, we considered market penetration as a measurement on how much PARITY related products and services are being used by potential customers. Additionally, within the market penetration phase, we evaluated potential customers' opinions on the concept of LEMs, to identify factors and barriers to the progress of local renewable energy development based on their knowledge and what would motivate people to participate in such markets. The current market needs were also identified and analyzed. Finally, after evaluating the research outcomes, segments of interest were presented.

In a summary, the market transformation survey, revealed among others that the energy market is anticipated to be fully based in DERs by the end of 2035, while it is forecasted that by the end of 2025 eV will be widely applied. To that end, the main obstacles for the faster energy transformation are the lack of EU and national regulations and legislations, as well as the insufficient technological design, lack of standardization and lack of interoperability between equipment and stakeholders. Furthermore, distributed, and renewable enabled energy market that will mostly be based on DERs seems that is becoming a reality. Finally, a main outcome of the market transformation survey is linked with future trends. Specifically, the survey revealed that DERs personalized profile models, load forecasting mechanisms, dynamic pricing schemes and smart energy contracts are the services that can accelerate the profitability and efficiency of DERs.

The knowledge gained from the current survey as summarized before, it will help the PARITY project to succeed and be established within the market, but at the same time it provides research outcomes relevant to energy policy makers, energy operators, organizations as well as researchers in this area. The following benefits were provided during the discussion of this work: (a) gain holistic view of the market, (b) potential customers retention, (c) identify gaps and give actionable insights, (d) gain a competitive advantage.

**Acknowledgements.** This work has been partially supported by the PARITY project, funded by the European Commission under Grant Agreement Number 864319 through the Horizon 2020.

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