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Market choice for foreign market entry for an innovative start-up Volts Battery Ltd.

Diploma thesis

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Introduction

Volts Battery is a start-up founded in 2017 in St. Petersburg. Company is engaged in the development, manufacturing and integration of residential energy storage systems. Its main product "VOLTS" is a smart home energy storage device that is a modern alternative to fuel-powered generators. VOLTS can be used to store energy from solar, wind systems or from traditional power lines. The product is designed to be used as an energy back up source in case of interruption in power supply (both from renewable and traditional sources of energy).

The company has been on the Russian market for four years and has made 51 installations. However, these sales are not sufficient to cover company operational expenses and money invested in the development of the product. According to Alexander Kiyanitsa, Volts Battery CEO, company fails to get the necessary traction to reach break-even point and risks to go bankrupt if no significant measures are taken.

Company is present only on the Russian market. According to analysis made by company management and their experience from years of operation on the market, Volts Battery will not be able to reach profitability unless it enters other foreign markets with better market conditions.

Russian market has several defining factors that do not stimulate Residential energy storage market development. Firstly, Government does not provide stimuli for solar or battery systems acquirement. Electricity prices are relatively low comparing to markets with high battery storage systems penetration. The income of an average Russian citizen is far lower than income in most western Europe. In addition, on the Russian market the concern for environment is not an active pain that customers are looking to solve.

Company investors and managers put global expansion as the top priority for 2021. The company management has provided the following list of markets that they view as their top priority:

- Germany
- Luxembourg
- Portugal
- Malaysia
- Vermont

Volts Battery needs to enter foreign markets, but there is no clear understanding on what market should be penetrated first. As a result, Alexander Kiyanitsa has defined the managerial problem as an absence of market prioritization for company global expansion.

The bachelor diploma thesis is a consulting project. The goal of the paper is to analyse foreign markets and propose a particular market for entry.

In order to achieve the abovementioned goal, the following objectives were set

- Analyse the conceptual base used for problem solving
- Develop a framework for choice of potential markets for entry
- Analyse in detail the chosen target markets
- Propose the most attractive market

The object of the thesis is Volts Battery, a technology start-up in the industry of residential energy storage. The subject of the thesis is the global expansion strategy of Volts Battery.

This diploma thesis comprises three chapters. In the first chapter overview of the Porter's Diamond model, Porter's Five Forces, the General Electric multifactor model, the Directional Policy matrix and PESTEL model is provided. In addition, limitations in relation to Volts Battery case are given. The main purpose of the methodologies analysis was to find the criteria that will be further used for the market prioritization.

In the second chapter a framework for marker analysis and prioritization is developed. The criteria for market prioritization are described and explained in detail. In the second part of the chapter the scorecard model is provided.

In the third chapter a detailed market analysis is provided based on the criteria defined in the second chapter. Five regions are analyzed and prioritization table is provided. In addition, general recommendation on the market entry are provided.

Conceptual base of the thesis

In order to solve the problem that was stated by the Volts Battery top management team the following information sources, frameworks and instruments were used.

Information sources

Primary information sources:

Alexandr Kiyanitsa, CEO of Volts Battery – he is the founder of the company and is involved in all aspects of company operations.

Stephan Jacob, CEO of Enerix – manager of a distributor company present on the European market. This source was used in order to get insights into analysis of European countries.

Various data sources were required in order to obtain information about the audience in the target market: government statistical data on population, prosperity indexes, economic indexes such as GDP per capita, average annual salary. All of these sources were used to gain insights into the target markets.

Data from web-sites of the electricity suppliers, solar panels integrators and energy storage suppliers was analyzed. Every company uses digital channels in order to communicate with their customers and the society. Due to this reason such source was analyzed.

Data from government renewable energy reports and utility companies' annual reports was analyzed. In order to get an idea into what government and utility companies plans are it is necessary to look into their reports where plans are communicated to outside stakeholders.

In addition, articles with the expert opinions and industry news were analyzed. The renewable energy industry attracts a lot attention and various publication resources have plenty of valuable information on the market dynamics, event that happen in the target region and interviews with experts.

Original scholar articles on market analysis frameworks were used for the definition of market prioritization criteria. In order to understand the ideas that guide widely used methodologies it is necessary to analyses their original forms presented by the authors themselves.

Secondary information sources:

Academic papers were analyzed. In order to get another point of view on the methodology and to learn its limitations it is necessary to analyze peer reviews and adaptations of the widely used models.

Industry reports were analyzed that include interpretation of various data gathered by third parties. In order to understand where the market is going it is essential to utilize the already provided analysis.

Articles with market analysis were looked through and important information was taken into consideration.

Instruments and methodologies used:

Unstructured interview with Alexandr Kiyanitsa, CEO of Volts Battery. Due to the specifics of the industry and problem there was required a close communication with the company management team.The unstructured interview was chosen in order to let the company CEO to speak in his own words and to obtain information, that would not be obtained in case all of the questions were specified in the beginning. Unstructured interviews were conducted for reaching the following objectives:

- Obtaining information about the product and company
- Obtaining information about the international presence
- Obtaining information on possible criteria for market analysis
- Final definition of market analysis criteria

Unstructured interview with the Stephan Jacob, CEO of Enerix distribution company. Due to the lack of information available in public sources, the manager of European distribution company was interviewed in order to:

- Obtain information on utility companies in Luxembourg
- Obtain information on market structure and trends in the chosen markets
- Obtain information on the criteria for market analysis

In case of other primary and secondary sources, data was analyzed and most important factors were aggregated and interpreted in the paper.

PESTEL model was taken into consideration during the market analysis process. PESTEL model provides a structured approach to market analysis and incorporates various macro factors essential for the market evaluation.

The General Electric multifactor portfolio model was used for the development of prioritization framework. This model introduces a systematic approach for the evaluation of market/industry attractiveness and business competitive capabilities on the chosen market. The multifactor system is very valuable for the analysis of complex industries where various factors need to be taken into consideration.

Directional Policy Matrix can be used to gain valuable insights into corporate strategy based on the market-firm fit. The methodology provides a systematic approach for grading qualitative factors related to markets analysis and company's operations. Due to this reason, the model can be used as a basis for the creation of the score system that will be used for the market analysis of the countries provided by Volts Battery management team.

Porter's five forces framework is essential for industry analysis and formulation of company's competitive strategy. In order to spot the opportunities and threats coming from the external environment it is necessary to keep a close eye into what is happening in the industry.

Porter's Diamond model was analyzed. Porter's diamond model is very valuable for analysis of region's competitiveness as it incorporates many factors under one framework. By analyzing the defined factors, it is possible to predict whether the national environment will lead to company's competitive advantage development.

Company overview

The company was founded in 2017 in Saint-Petersburg. In 2021 company has over 20 employees involved in company development, has established an office in Abu-Dhabi. In 2019 company has attracted attention of a start-up accelerator Catalyst, located in UAE. In cooperation with this fund there was completed the seed round. The investment funds were received in 2020 and consequently office in Abu-Dhabi was open. Up until now company has zero sales in markets outside of Russia. Company struggles to reach profitability due to the lack of supporting factors on the Russian market. Volts Battery produces residential energy storage systems.

The main value of Volts product is that it significantly improves solar system efficiency. With solar systems there is a problem of power supply being highly unstable. Solar generation varies during the day and reaches its peak in the midday. In most cases client is absent from their homes and the energy is lost. At the same time, the amount of power generation is tied to weather conditions and a household cannot rely on such system as on a main source of power generation. The abovementioned problems can be solved by adding an energy storage system to the solar system. Energy storage can be utilized to store the excess energy and to stabilize the power supply.

The main functions of the product are:

- Serving as a back-up power source
- Load management and stabilization of power supply
- Effective utilization of excess energy from the solar system

Characteristics of the product:

- The product has expandable capacity. Depending on the size of the house, clients' energy needs and production potential the storage capacity of the systems can be adjusted accordingly.
- The product has a customizable design. In comparison to other systems, client can choose a customized front panel that suits his interior.
- The product is completely silent. This factor is an important advantage considering the fact that a noise diesel generator is one of the product substitutes.
- System can be managed via a smartphone. The app can be used remotely to access to the energy system, to manage it and check all the statistics.

- Volts unit can be used to optimize the EV charging and to enable other technologies related to EV charging.
- The product has intelligent operational system. It analyses various data points, such as weather forecasts and current capacity, gains insights into how to further improve the system, how to bring more value to the customer and optimize charging cycles.

VOLTS positions itself not as a hardware manufacturing, it is energy solutions provider. Company places significant focus on improving its software and algorithms and being at the forefront of the market. Company makes its best to provide a highly differentiated value-proposition. Being aware of the competitors with vast resources, the company has chosen to address customer needs in a different way focusing on user experience and product customization.

At the moment, company management is focused on further improving its product and it is working on penetrating other market. Company management is actively involved in negotiations with possible foreign market entry partners and investors who can support the global expansion.

In the paper the Photovoltaic systems (PV system/ solar systems/ solar panels) market and residential energy storage systems (RESS) market are analysed. Volts Battery produces RESS, RESS is a supplementary product of PV systems. As an independent product it has very little value, due to his reason, it is tightly related to the photovoltaic industry dynamics.

CHAPTER 1: MARKET ANALYSIS METHODOLOGY

There are various methodologies that are used for market analysis and market prioritization.

To define the necessary criteria for market analysis and prioritization several methodologies were analyzed. In this chapter overview of PESTEL analysis, the Porter's Diamond model, the Porter's five forces, the General Electrics multifactor and the directional policy matrix is provided. Limitations of the frameworks are provided and specifics of Volts Battery case are taken into consideration. The main goal of the methodologies analysis is to form a basis for custom framework development that will be used for market analysis and prioritization.

1.1 PESTEL Analysis

Changes in business environment can create great opportunities for organization and cause significant threats. Opportunities can come from new technologies that help reach new customers, from new funding streams that allow to invest in better equipment, and from changed government policies that open up new markets.

PESTEL Analysis is a simple and widely used tool that helps analyze the Political, Economic, Socio-Cultural, and Technological, Environmental and Legal factors that affect business operation in the chosen market. The model identifies the changes and the effects of the external macro environment on a firm's competitive position. Strategists seek to understand external factors and evaluate how business models will have to evolve in order to adapt to their environment.[1]

Harvard professor Francis Aguilar is thought to be the creator of PESTEL Analysis. He included a scanning tool called ETPS in his 1967 book, "Scanning the Business Environment." It began as ETPS and encompassed four broad factors of the environment: Economic, Technical, Political and Social influences. Later another two factors added and PESTEL methodology was born, where "L" stand for "Legal" and second "E" stand for "Environment".

PESTEL Analysis is a useful tool for several reasons:

- It's a simple framework

[1] Swot and PESTEL. Understanding your external and internal context for better planning and decision-making // https://sites.unicef.org/knowledge-exchange/files/SWOT_and_PESTEL_production.pdf (accessed 24.05.2021)

- It facilitates an understanding of the wider business environment
- It encourages the development of external and strategic view
- It can enable an organization to anticipate future business threats and take action to avoid or minimize their impact
- It can enable an organization to spot business opportunities and exploit them fully
- It can help you break free of unconscious assumptions when you enter a new country, region, or market

Political stability and the extent to which politicians can interfere with the commercial environment are critical factors in a PESTEL analysis. It is the political structure that creates the conditions for doing business and can determine the success or failure of an enterprise. In some countries, policies promote and encourage some sectors to develop. For example, recently there has been a tendency to preserve the environment. The EU countries act as a major driver of investment in clean technologies and low-carbon solutions and use CO2 quota trading market as a tool for the environmental regulations.[2]

Political stability guarantees the protection of business from factors beyond the control of the company. When analyzing the political situation, it is also necessary to consider trade, tax, labor and environmental laws.

Economic factors influence the attractiveness of the market. A country with a stable, growing economy is more predisposed to provide good conditions for doing business. Economic growth rates and level of development define living standards. The better off the society, the higher the life expectancy, the better the medicine, the higher is the purchasing power. Concern for the environment is also characteristic of rich countries.

An example of a country with unfavorable economic conditions is Bulgaria. The agricultural economy, reports that more than half of the population in the rural areas of Bulgaria is at risk of poverty or social exclusion. Low wages and limited employment opportunities create lasting patterns

[2] Daniel Fozer , Flora Zita Sziraky, Laszlo Racz, Tibor Nagy, Ariella Janka Tarjani, Andras Jozsef Toth, Eniko Haaz, Tamas Benko, Peter Mizsey. (2017). Life cycle, PESTLE and Multi-Criteria Decision Analysis of CCS process alternatives. Journal of Cleaner Production. 2 January 2017.

of poverty in rural areas. The constant level of the long-term unemployed, which is almost three times higher in rural areas, is a worrying indicator[3].

Social trends dictate work models and attitudes, consumer tastes and preferences. Monitoring social trends allows the firm move your products or services to match changing customer expectations. For example, customer education influences customer awareness of the current situation in the world, of the problem, trends and tendencies. Educated people understand the need to be careful with energy, as well as the advantages of switching to alternative sources. They understand the ways and possible potential benefits. [4]

The development of technology and innovation is an extremely important factor to be considered in the analysis. The development of innovation is strongly corrected with the development of entrepreneurship, which in turn create new innovative products. Technological breakthroughs give rise to some sectors and decay others. So at the moment the energy sector is undergoing dramatic changes. Most developed countries are switching to renewable energy sources, which are replacing traditional reserves of which are rapidly depleting. Technology and innovation help make our lives more comfortable. This is how home energy storage systems help control, conserve and use energy efficiently in the home. Company must be constantly informed about any technological developments in the industry and know how they can affect his future attractiveness and profitability.

For example, Indonesia, where there is a shortage of strategic oil reserves. Energy security will be achieved from a mix of technologies taking advantage of the great potential of Indonesia includes advanced technological developments in the biofuels sector as well as utilization of the geothermal energy potential, where Indonesia is among the countries with the highest recovery potential globally.[5]

Environmental factors concern the ecological impacts on business. As weather extremes become more common, businesses need to plan how to adapt to these changes. These factors relate to

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[3] Mihaela Mihailova. (2020). The state of agriculture in Bulgaria – PESTLE analysis. Bulgarian Journal of Agricultural Science. 2020. Unicef

[4] P.J.M. Thomas a, P. Sandwell, S.J. Williamson, P.W. Harper. (2021). PESTLE analysis of solar home systems in refugee camps in Rwanda. Journal of Cleaner Production. (2021).

[5] Satya Widya Yudha, Benny Tjahjono, Athanasios Kolios. (2018) PESTLE Policy Mapping and Stakeholder Analysis of Indonesia's Fossil Fuel Energy Industry. Energies. (2018).

the influence of the surrounding environment and the impact of ecological aspects. With the rise in importance of CSR (Corporate Sustainability Responsibility), this element is becoming more important. Examples of CSR initiatives include carbon footprint reduction efforts and transitions into renewable material and energy sources.

An organisation must understand what is legal and allowed within the territories they operate in. They also must be aware of any change in legislation and the impact this may have on business. If an organisation trades globally this becomes a very tricky area to get right as each country has its own set of rules and regulations.

Process of PESTEL Analysis

1. Identification of the current and future factors in the firm's external political, economic, social, and technological, environmental and legal environments

2. Analysis of the possible effects on the firm's competitive position of each factor

3. Categorization of each factor into opportunities or threats for the firm

4. Prioritization of the strategic importance of each set of PESTEL opportunities and threats. Ranking is based on the extent and the period of the impact on the firm

5. Development of strategic action to correct or preempt negative effects and build on positive effects[6]

There are several limitations of the framework. Firstly, the number of factors that fit into the framework is limited. PESTEL analysis takes into account only six factors. In strategic planning, this may not be enough. PESTEL analysis provides an insight into the basic components of a business environment. PESTEL is often used in conjunction with other analyzes.

For a successful analysis, one need to be able to work well with information. There are many sources of information in the modern world, but not all of them provide reliable data, so it is easy to make a mistake and get the wrong idea about the market.

[6] Swot and PESTEL. Understanding your external and internal context for better planning and decision-making // https://sites.unicef.org/knowledge-exchange/files/SWOT_and_PESTEL_production.pdf (accessed 24.05.2021)

1.2 Porter's diamond model

The Diamond model was developed by Michael porter in his book "The competitive advantage of nations" published in 1990. With his work he created a foundation for the research field of competitive dynamics and explains why certain nations gain competitive advantage in the international markets.

M. Porter argued that the conditions in the home country have a direct impact on the success of the firm in the international market. National factors significantly affect company's ability to rapidly improve the technologies and methods used and their efficiency. Eventually the formation of company's competitive advantage is defined by the national conditions and company strategic decisions. The national conditions affect the environment in which the company operates and can create positive opportunities for gaining competitive advantage in the international market. Even though this model is mainly used to explain why certain nations succeed in the development of internationally competitive industries, factors described in the model can be used to analyze the attractiveness of the markets and to design market entry strategy.

Before the detailed analysis of the methodology it is worth looking into the definition of the competitive advantage. According to Porter[7] competitive advantage "grows fundamentally out of value a firm is able to create for its buyers that exceeds the firm's cost of creating it. Value is what buyers are willing to pay, and superior value stems from offering lower prices than competitors for equivalent benefits or providing unique benefits that more than offset a higher price. There are two basic types of competitive advantage: cost leadership and differentiation." Based on the provided definition Porter's Diamond model defines the determinants that stimulate or hinder company's cost leadership or differentiated market positioning.

In his book Porter states that four groups of factors define national environment:

1. Factor conditions
2. Demand conditions
3. Related and supporting industries
4. Firm strategy, structure and rivalry

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[7] Porter, M. E. (1985a). Competitive advantage: Creating and sustaining superior performance. New York: Free Press.

According to Porter the determinants create the environment in which the company operates: "the availability of resources and skills necessary for competitive advantage in an industry; the information that shapes what opportunities are perceived and the directions in which resources and skills are deployed; the goals of the owners, managers, and employees that are involved in or carry out competition; and most importantly, the pressure on firms to invest and innovate." In the figure 1 presented the visualization of the relationships between the four determinants. In addition to the abovementioned factors Porter proposes two external determinants: "Chance" and "Government".

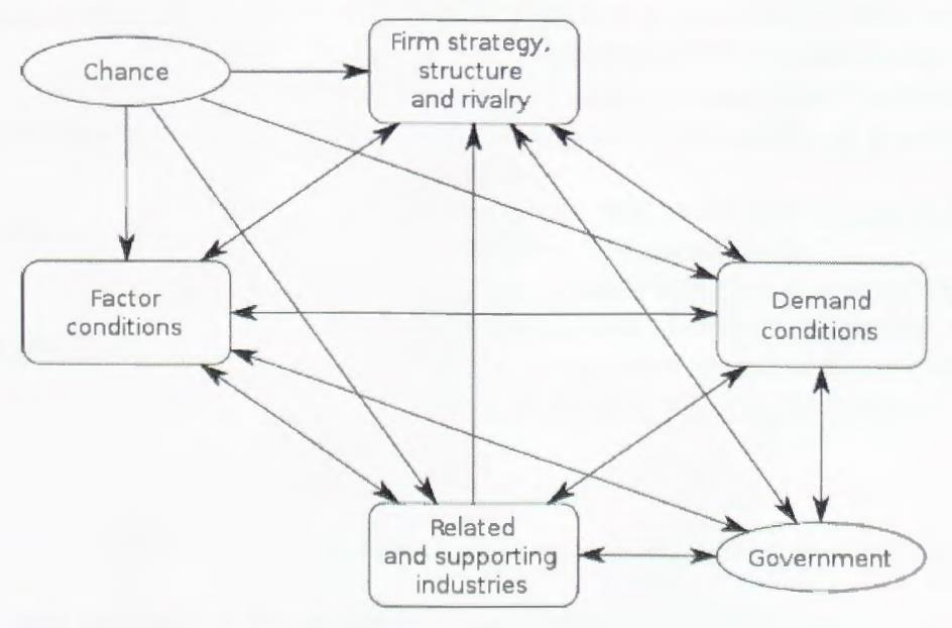

Fig.1. *Porter's Diamond model*

Source: Porter, 1998, p127

Determinants overview

From the analysis of Porter's original paper and other scientific papers (Vlados et al., 2019; Kharub et al., 2016) the determinants can be defined in the following way:

Factor conditions relate to nation's availability of various factors of production, such as skilled labor, materials or infrastructure that are required for development of competitive advantage in the chosen region. Factors can be divided into several groups based on their relation to the industry. Porter states that factors that are specially related to the certain industry are of higher importance. The

advanced and specialized factors need significant investments for the development of industry competitiveness.

Demand conditions characterize the nature of national demand for the industry products and services[8]. In a competitive environment firms respond to customer needs and adjust their offerings accordingly. Porter states that the nature of needs and the clearness of their communication define the product development process and can positively affect company's competitiveness on the international markets. Customer with clear demand and high expectations stimulate industry players to perfect their products. Eventually, in case customer needs in the national markets are shared by potential customers in foreign markets, the firm will enter foreign markets with a superior product suitable for the target audience needs.

Related and supporting industries define the extent to which company can utilize related industries infrastructure. In addition, companies can create additional value from the cooperation with players from the related industries. This factor describes the availability of other related players whose position can be used for company's advantage. These can be suppliers with superior costs effectiveness and components availability or other firms that provide valuable cooperation opportunities.

Firm strategy, structure and rivalry comprises factors both of internal and external nature to the firm. The company's choice on how to pursue the competitive advantage and how to organize the internal processes significantly affects the chances of obtaining the advantage. Even though management styles vary across the same nation certain characteristics specific to the nation lead to certain styles being more widespread than other. The example that Michael Porter provides is the German market where there is a prevailing strive for methodological process improvement and overall propensity to create hierarchal organizational structure. According to the author, such national characteristic can be attributed to the success of German technological sector on the international field. This is implied from the assumption that strong hierarchy and focus on product improvement positively affects performance of companies related to manufacturing and technology development.

[8] Helvick, Harneker. (2005). The competitive advantage of nations and choice of entry strategies – a three scenario case study. Norges handelshøyskole.

Intensity and structure of the competitive rivalry can become a stimulus for the development of company's competitive advantage. Facing a lot of pressure from other market players company is forced to improve its product offering, to invest in innovation and look for new opportunities. In an environment with low competition level established companies see few incentives for product innovation and therefore are less inclined to place a focus on operations and product improvement.

Chance is a determinant the company has no effect on. Such events as technological breaks through, political conflicts, natural factors affecting the industry, global market dynamics are out of the reach of the firm. At the same time, all of these factors have a significant effect on the industry and affect company operations. Events related to the "chance" determinant can create a shift in the market and open the company to new opportunities or create a threat to its existing competitive advantage.

Government is a determinant that incorporates all the factors related to actions made by the elected officials. This determinant can significantly industry development and availability of factors positively affecting company's competitiveness. Such actions as introduction of antitrust laws, introduction of new regulations, investment in certain sectors, subsidizations affect the industry functioning. Government actions can both create new opportunities for the firm, support its development as well as hinder its growth opportunities and undermine its competitive advantage.

Porter's diamond model is very valuable for analysis of region's competitiveness as it incorporates many factors under one framework. By analyzing the defined factors, it is possible to predict whether the national environment will lead to company's competitive advantage development.

It is worth mentioning that there are certain limitations of the model in relation to the diploma thesis managerial problem. The original model was designed to evaluate the availability of factors positively affecting company chances to successfully internationalize its operations. However, the main goal of the paper is to define markets' attractiveness for market entry. The model focuses on the prerequisites necessary for national competitiveness[9], it does not provide clear insights into whether this national market is attractive for entry of a foreign company. The model focuses on the competitive

[9] Vlados, Charis. (2019). Porter's Diamond approaches and the Competitiveness Web. International Journal of Business Administration.

advantages obtained by the local firms in respect to their internationalization. Due to the different nature of the methodology, it cannot be applied in its original form.

While the model provides insights into how to choose market analysis factors and how to group them, there should be made modifications both to the determinants and factors that are grouped under the same category. Implications from the Porter's Diamond analysis are discussed in detail in the "Framework for market analysis section".

1.3 The General Electric multifactor portfolio model

This methodology was developed by McKinsey& CO in cooperation with General Electric in the early 1970s in USA. The model was developed to evaluate General Electric's business units prospects in order to invest funds in the most attractive ones[10]. In comparison to BCG matrix that was developed earlier, this model takes into consideration various factors for classification of the business units. While BCG matrix places relative market share and market growth rate on the axes, GE model implies the implementation of a multifactor scoring system.

To assess the industry attractiveness a set of critical external factors is defined. These factors cannot be affected by company actions and are relevant and important for the industry under analysis. After the factors are defined, each factor is given a weight which is defined by its importance. Company rates the appropriate criteria, rates are multiplied by the weights and summed up in order to evaluate the industry attractiveness[11].

For the assessment of company competitive capabilities, the same steps are performed. The only difference being that in this case critical internal factors should be defined. These factors are largely controlled by the firm and are relevant to the analyzed business unit.

Hax and Maijluf[12] propose the following approach to using GE model:

1. Define critical external factors

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[10] Jobber, D. (2007). Principles and practice of marketing (5th ed.). Berkshire, England: McGraw Hill

[11] Wilson, R.M.S., & Gilligan, C. (1992) Strategic marketing management: Planning, implementation and control (2nd ed.). Oxford, England: Elsevier Butterworth Heinemann

[12] Hax, A. C. and Maijluf , The use of Industry Attractiveness-Business Strength Matrix in strategic planning. England: John Wiley & Sons

2. Make an assessment of the external factors
3. Define critical internal factors
4. Make an assessment of the internal factors
5. Position the business in the attractiveness-strengths matrix

In the same work the authors propose the following criteria for measuring market attractiveness: size, growth, pricing, market diversity, competitive structure, industry profitability, technical role, inflation vulnerability, cyclicality, customer financial, energy impact, social, environmental, legal, human (Appendix 1). For the analysis of the business competitiveness the following factors were proposed: market share, business unit's growth rate, breadth of product line, sales distribution effectiveness, price competitiveness, advertising and promotion effectiveness, capacity and productivity, raw materials costs, experience curve effects, value added, relative product quality, R&D advantages, personnel qualification, company image (Appendix 2).

The General Electric multifactor portfolio model introduces a systematic approach for the evaluation of market/industry attractiveness and business competitive capabilities on the chosen market. The multifactor system is very valuable for the analysis of complex industries where various factors need to be taken into consideration.

General limitations that are highlighted by the scholars are that there is no standard list of the criteria to be used. Due to this fact implementation of the model requires additional adjustments made to the model and there is a certain level of uncertainty on how to use the model. Additionally, the definition of the scores attributed to each factor are based on subjective opinion [13]of the experts involved in the process. The methodology does not take into consideration possible future dynamics of the industry and their effect on the company strategy.[14]

It is worth mentioning that in relation to the case analyzed in this diploma thesis the analysis of the internal environment is irrelevant due to the early stage of company development and due to the fact that company is not yet present on the markets.

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[13] Aaker, D.A. (1995). Strategic Management (4th ed.). New York, NY: John Wiley & Sons Ltd.

[14] Hill, C.W.L., & Jones, G.R. (1989). Strategic management: An integrated approach. Boston, MA: Houghton Mifflin Company

1.4 The directional policy matrix

This model was developed by Shell company in 1975 for internal use. The methodology is attributed to portfolio analysis frameworks and is a modification of the Boston Consulting Group matrix and the General Electric multifactor portfolio model. In comparison to BCG matrix and GE model Directional policy matrix enables firms to incorporate a wider set of the decision factors.[15]

The model was designed to systematically analyze qualitative factors attributed to an organization. The methodology was created in a way to predict firm's performance in a particular market independent form financial forecasts. The model has two axes: company's competitive capabilities and market/ industry attractiveness. Each of the two axes are split into three categories. Company's competitive capabilities are defined as weak, average or strong. Business sectors were given the unattractive, average and attractive categories[16]. The model visualization in presented in the figure 2.

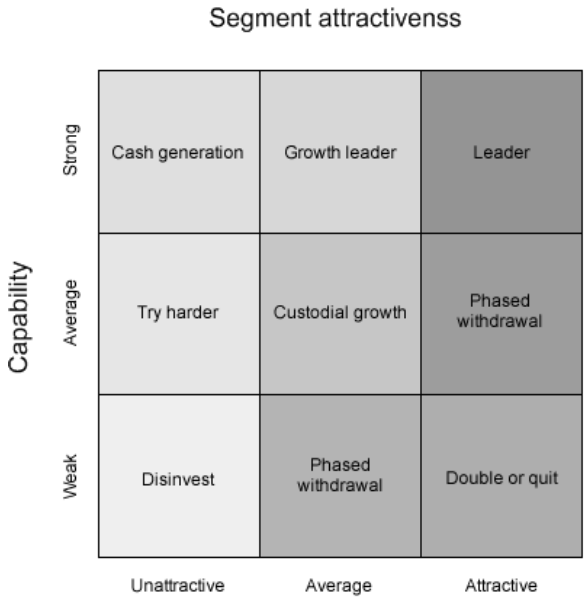

Fig.2. *Directional policy matrix*

[15] Robinson, Hichens, Wade. (1978) The directional policy matrix—tool for strategic planning. Long Range Planning. Volume 11, Issue 3.

[16] Wilson, M.S. & Gilligan, C. (1992). Strategic marketing management: Planning. Implementation and control (2nd ed.).Elsevier Butterworth-Heinemann

Source: Shell Co. (1975)

The business sector analysis is based on such criteria as environmental consideration, market growth rate, market quality and industry situation. Company competitiveness was analyzed by its position on the market, product research and development and production capability[17]. Though, these criteria are not fixed and can be adjusted depending on particular case.

Companies can use the results of the analysis to evaluate the prospect of its various business units and decide on the appropriate strategy. The model defines certain strategies that should be used to manage the business units place in the respective intersections. Below you can find the summary of strategies described by Bank (2011)[18]:

- Leader. Company's major resources should be focused on this strategic business unit in order to maintain the leading position.
- Try harder. This position can become vulnerable over time, but at the moment no active measures are required.
- Double or quit. A deeper analysis should be made and business units from this category should be left or should be given a financial backing necessary for the improvement of market position.
- Growth. Company should invest in the business unit to help it grow. It is expected that such businesses generate enough cash to support itself and do not pose additional pressure on other company branches.
- Custodial. This business unit is similar to the "cash cow" presented in the BCG matrix[19].
- Cash generator. This is a business that is rather similar to the custodial with the difference that there are almost no long-term prospective for the future. Cash generated by such businesses is used for supporting other business initiatives.

[17] Philip T.(2012). Portfolio Analysis Models: a review. European Journal of Business and Management. 4 (18).

[18] Bank, D. (2011). Shell Directional Policy Matrix for portfolio analysis.

[19] Thompson, A.A., & Strickland, A.J. (1996). Strategic management: Concepts & cases (9th ed.). Boston, MA: Irwin McGraw Hill

- Phased withdrawal. This SBU has no future and cash should be moved to business units with greater potential.
- Divest. Company needs to get rid of the business as soon as possible.

Directional Policy Matrix can be used to gain valuable insights into corporate strategy based on the market-firm fit. The methodology provides a systematic approach to grading qualitative factors related to markets analysis and company's operations. Due to this reason, the model can be used as a basis for the creation of the score system that will be used for the market analysis of the countries provided by Volts Battery management team.

However, it is worth stating that company's position in relation to various foreign markets does vary significantly. Company's existing competitive capabilities have almost no variation across the markets. Company has no presence in other foreign markets and its supply and distribution are set in such a way that company's competitive position cannot be graded on the 3 level scale. Company has only one business unit, due to this reason, division by business units is also inapplicable.

Nevertheless, the axis related to the market analysis can be applied for the purposes of this paper. The only difference from the original model is that on the vertical axes there will be only one line and company's internal factors will not be taken into consideration.

In addition, the set of factors used in the model should be adjusted for the analyzed case. As was stated in by Lancaster and Massingham[20]: 'the DPM assumes that the same set of factors is universally applicable for assessing the prospect of any product/business". This is the weakness of the model that caught attention of various researchers and should be taken into consideration when the framework for market analysis will be defined.

Finally, the framework implies that all the criteria have the same weights which limits the usage of the original model in field not related to the resources extraction (the main field of Shell operations).

[20] Lancaster & Massingham (1998). The Shell Directional Policy Matrix.

1.5 Porter's five forces

To define the criteria for market analysis and prioritization it is necessary to analyze one of the fundamental frameworks used industry analysis. The Porter's five forces framework was developed by the famous management scholar in 1979. This methodology places focus on external factors and states that opportunities emerge from the external environment. Therefore, to catch the opportunity, companies need to have a close look into the industry dynamics. As a result, the competitive strategy needs to be derived from the knowledge on the market, its relationships and structures.

The five forces framework enables the search of business development opportunities from outside. The framework takes an outside-in[21] perspective and analyses microeconomic factors that define company profitability and formation of its competitive advantage. Industry structure indirectly defines company's success on the market. Industry stricture and its characteristics can be used predict the effectiveness of organizational strategy as any action taken by the company faces a response from the external environment. Porter's five forces model enables deeper market analysis and better understanding on how the value generated and who are the main industry players (figure 3).

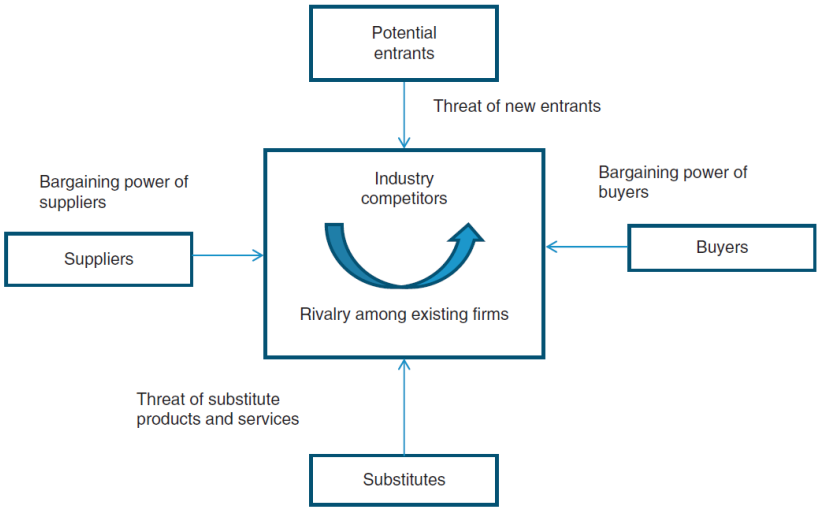

Fig.3. *Porter's five forces*

[21] Johnson, G., Scholes, K., & Whittington, R. (2008). Exploring corporate strategy: Text & cases. Researchgate.net.

Source: adjusted from Porter (1985)

The framework requires the analysis of the following factors[22]:

Competitive rivalry. The intensity of the rivalry defines in many ways what actions are taken by the industry players. A high intensity of competition may lead to prices discounting, product innovation, marketing campaigns aimed at increasing current market shares of the players. According to Hubbard and Beamish[23] the extent to which industry players are actively employing competitive strategies is defined not only by the intensity of competition, but also by the industry costs, number of companies that compete in the market, customer switching costs, exit barriers and other.

Threat of new entrants. According to Porter [24]"new entrants to an industry bring new capacity, and the desire to gain market share that puts pressure on prices, costs and the rate of investment necessary to compete". New entrants can be of various sizes and can present a significant threat to the incumbent companies. Particularly, in the case of established companies diversifying their business portfolio. Such type of new entrants can have significant financial resources and other capabilities that they can utilize to gain the competitive advantage over incumbent companies.

Power of suppliers. Suppliers can have a very significant effect on company's profitability. In case suppliers rank high on power they can demand higher prices for the products they supply and can affect the supply conditions. The factors that determine suppliers' power are concentration, availability of substitute customers, risk of integrating forward. In addition, suppliers have high power when the product that they supply is essential for clients operations and cannot be easily substituted.

Power of buyers. Company's buyers affect the established operations by demanding change in quality, pricing, value and by switching to competitors or subsidies. Buyers have higher power

[22] Porter, M. (1979). How competitive forces shape strategy. Harvard Business Review, March Issues.

[23] Hubbard, G., & Beamish, P. (2011). Strategic management: Thinking, analysis, action. 4th Ed. Strategic management: Frenchs Forest N.S.W.: Pearson Education Australia.

[24] Porter, M. (1985). On competition. Updated and Expanded Edition. Boston, MA: Harvard Business School Publishing.

when they are concentrated, when the number of suppliers exceeds the number of buyers, when customers purchase large groups of products and when the risk of backward integration is high[25].

Bruijl defines the following buyer concentrations that can be found across industries[26]:

- Competitiveness – many buyers and suppliers
- Mutual dependence – few buyers and suppliers
- Monopoly power – few suppliers and many buyers

The power of the buyer affects the relationship established between them, practices employed by the sellers and decision power of the customer. When the

Threat of substitutes. The threat of substitutes is high when there are several products with a functional value similar to company's products. Relatively lower prices of the substitute and low switching costs have an adverse effect on company's profitability. Unless company finds a way to differentiate its product from the substitutes, the opportunities for profit growth are limited. Company cannot increase prices and its growth potential is limited.

Porter's five forces framework is essential for industry analysis and formulation of company's competitive strategy. In order to spot the opportunities and threats coming from the external environment it is necessary to keep a close eye into what is happening in the industry.

One of the limitations of the framework stated by other scholars is the fact the factors presented in the framework are insufficient for complete industry analysis and strategy formulation. Other factors such as industry stage of development and complementary assets are not included in the framework[27]. In his work, Porter argues that such factors as complementary products, technology and innovation affect the industry structure but are still taken out of the framework[28].

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[25] Baburaj, Yamuna & Narayanan, V.K.. (2016). Five Forces Framework. 10.

[26] Bruijl, Gerard. (2018). The Relevance of Porter's Five Forces in Today's Innovative and Changing Business Environment. SSRN Electronic Journal. 10.2139/ssrn.3192207.

[27] D.J. 1986. Profiting from technological innovation: Implications for integration, licensing and public policy. Research Policy. 15.

[28] Porter, M.E. 2008. The five competitive forces that shape strategy. Harvard Business Review. 86.

CHAPTER 2: FRAMEWORK FOR MARKET ANALYSIS

Due to the limitations of the frameworks, specifics of the company and the nature of the problem the abovementioned frameworks and theories were adjusted to create a new framework that is used for the market analysis and market prioritization in the following chapter. The detailed information on the criteria chosen and prioritization procedure is provided in the chapter.

The criteria for market analysis are based on the insights gained from the analyzed methodologies, preliminary results of company and industry analysis and results of unstructured interview with the company CEO Alexander Kiyanitsa and Enerix CEO Stephan Jacob. All of the following criteria for market analysis were defined in cooperation with company management and all company management comments were taken into consideration.

2.1 Basis for custom framework development

In this part of the chapter, frameworks and methodologies adaptation is explained and the basis for the determinants of market attractiveness is provided.

Five methodologies for market analysis are reviewed in the paper. All of them contributed to the development of the final analysis and prioritization framework.

PESTEL analysis was used for the definition of the first group of factors. The framework provides a valuable structure for market analysis. In the market analysis framework 8 categories of factors are analyzed. They are defined in the following way: political, economic, social, technological, environmental, legal, market players, threat of substitutes. The first six come from the analysis of PESTEL framework. It is worth mentioning that most of the factors within the categories are industry and business specific and are not frequently used in the PESTEL analysis. While the structure and logic was taken from the original framework, the specific factors for market analysis were adjusted based on the company analysis and interview with the company representative. In addition, the idea for attributing scores is adopted and used in the final prioritization process.

In relation to the Porter's Diamond model, the factors used in the framework were added to the custom framework. Factor conditions, demand conditions, rivalry, supporting industries and governmental factors were analyzed. For example, the demand conditions were added to the social and economic blocks of factors where the purchasing power and the structure of housing market were

analyzed in order to predict the potential demand for the energy storage systems. The idea of factor conditions analysis led to the addition of "solar potential" factor to the environmental group of factors. In addition, Porter suggest that government should be analyzed, in the custom framework this aspect of the methodology is attributed to the Political group of factors where state renewable energy agenda is analyzed and policies are determined. Rivalry and supporting industries are analyzed in the "Market players" section, where potential partners and competitors analysis is provided.

While the General Electric multifactor model could not be used in its original form, the evaluation criteria and the overall approach can be used for the market prioritization process. The introduction of weight system is also of a great value considering the fact that various market analysis factors have different impact on the attractiveness of market entry. In the final prioritization scorecard, the weight system is introduced and a similar approach for factor evaluation is used. In addition, this model provides flexibility in the evaluation of qualitative factors and this is particularly important considering the fact that some of the market analysis determinants imply qualitative comparison.

The Directional policy matrix is an adaptation of the General electric model and is limited in respect to the analyzed case. Based on the limitations mentioned in the previous chapter, the original model cannot be used in its original form, still there are certain elements that can be used in the development of the custom model. The main contribution of the methodology analysis is the three step analysis. In the final framework there will be used three step grading system for the evaluation of the factors. Such grading system facilitates the comparative analysis due to the inherent complexity of comparing qualitative results of market analysis.

Based on the Porter's five forces analysis the last two groups of factors were defined. The original model suggests that the following market analysis categories should be used: threat of new entrants, bargaining power of buyers, threat of substitute products and services, bargaining power of suppliers and industry competition. The idea of analyzing bargaining power of buyers contributed to the definition of "purchasing power" and "private housing" factors in the final model. The threat of substitutes is one of the eight groups of factors used for market prioritization. The availability of substitute services such as feed-in tariffs and net metering is analyzed. Bargaining power of suppliers is not included in the analysis due to the fact that company management is not clear on the manufacturing system that will be used for global expansion and the suppliers' analysis is dependent on it. This factor might be included in future elaborations of the research. Competitive rivalry is added

to the “market players” block of factors where direct competitors are analyzed. Threat of new entrants is not analyzed in its full form. This factor may be added in case the study will be further elaborated. In addition, the overall analysis of the market attractiveness may be used to predict the chances of other companies entering the market.

2.2 Description of the determinants of market attractiveness

In this section of the paper the detailed description of market analysis factors is provided. In the list provided below there are factors that were added to the framework based on the results of interview with the company management and company partner. The motivation for using these factors is provided in their description.

Political factors

State RE agenda

National decarbonization plans established by regional governmental bodies lead to higher involvement by corporations, local officials and citizens into the growth of the renewable energy industries.

State policy defines in many ways the attractiveness of the market. Those states that have sustainable development on their agenda are more prone to take active measures supporting companies and initiatives in the field of renewable energy.

It is necessary to look into the renewable energy projects implemented by the government. Types of projects explain how the country approaches the energy transition, what RE sources it focuses on, what direction it is action on.

State support

One of the ways that governments use to support the industry are various subsidies and exemptions. Subsidies provided by the government to private individuals installing solar systems and batteries decrease the payback period and improve economic attractiveness of the product.

Economic factors

Purchasing power

It is necessary to look into purchasing power of the target market audience. Volts energy storage prices start at 5000 dollars and price for top version is above 10000 dollars. The payback period for such investment is more than 5 years in attractive market conditions and over 20 years in markets with no external stimuli for energy storage purchase. Due to this fact, markets with low population prosperity have limited potential due to low purchasing power.

Electricity tariffs

Electricity is supplied at a certain price per kWh. The electricity pricing has direct effect on solar system payback period. Electricity generated from solar panels is an alternative to power supplied via general grid. As a result, the lower are the electricity prices the longer is the payback period for the solar and energy storage systems. Such countries as Germany and Austria with the highest electricity prices have the most developed solar and energy storage markets.

Based on the interview with Volts CEO customers are very concerned with the economic value that the product provides. Due to the high costs of installing solar and energy storage systems many customers are interested in return on investment. The problem is that system has positive return on investment only in cases when electricity prices are high.

Another factor that should be considered is the availability of time-of-use tariffs. Electricity prices may vary during the day. In most cases prices are higher during the evening hours when there is peak demand on the grid. Utility companies set higher tariffs in order to cover their costs of starting additional power supply systems in the peak hours. When such tariffs are introduced, energy storage can be used to accumulate solar energy during peak generation hours and used later at night to economize on the electricity bills.

In addition to the basic tariffs based on the price paid for a kWh of consumed energy, there can be imposed additional taxes or payments that increase total costs of electricity consumption.

Social factors

Private housing

Another important factor is the number of private property units and share of ownership. The main function of the energy storage is that it enables a higher share of solar energy in household electricity consumption. Due to this fact it is tightly related to solar systems and availability of private rooftops where solar panels can be installed. The higher is the number of private houses the larger is the pool of potential clients.

Another factor that can help evaluate the market attractiveness is the rate of ownership. Individuals who live in their own houses rather than in a rented dwelling would purchase the battery system with higher probability. Owners of a rented house or its temporary tenants are not expected to invest in a system with a long or no payback period.

Technological factors

Stability of power supply

Another factor that should be included in the analysis is the stability of power supply. This factor can be evaluated based on the frequency and average duration of outages. Every power outage risks damaging electrical appliances and put customers at a discomfort. Due to the fact that Volts energy storage provides a function of electricity backup and performs stabilization functions, a high number of power outages provides additional stimuli for purchase of the product.

By knowing what regions are the most affected it is possible to predict the variation in the demand for back-up systems.

Power generation

By looking at how the energy is produced several insights can be gained. The lower is the RE penetration the more efforts will the country apply to dwcarbonize its power supply system. In addition, it worth looking into the availability of resources that are used as inputs for power generators. Countries with limited access to carbon resources are more inclined to invest in renewable sources of energy.

Environmental factors

Solar generation potential

The amount of solar energy that can be produced via a solar system varies across territories. The higher is the solar potential the shorter is the payback period, the more open are the people living on this territory to the idea of installing solar systems. This factor directly influences perceived and economic attractiveness of a solar system and as a consequence the battery system.

Legal factors

One of the ways the state can facilitate the development of the industry or create additional obstacles is via the regulation of the electricity market. In some countries the installment of solar system or solar batteries needs to be accredited by a state authority, there are complex procedures and additional fees are payed. All of these factors decrease the attractiveness of the battery system. One of such markets is the UAE market, where there is a limited number of accredited by the government solar panels installers. In UAE there is a complex procedure of planning and installing the solar system, the process requires several weeks and fees payed to various entities.

Market players

Direct competition

In order to evaluate market attractiveness, it is essential to understand the competitive environment of the market. Energy storage systems are sold by local distributors, representatives, local branches of energy storage producers and solar system integrators. In certain cases, companies that specialize on installment of solar panels diversify their portfolio of products and make agreement with energy storage producers on distribution of their products. All of these players should be analyzed in order to evaluate the competition intensity and availability of partnership opportunities for Volts.

PV integrators

Residential energy storage market is tightly related to photovoltaic systems market. Solar systems integrators can become valuable partners for market entry. In this section it necessary to look into the structure of the market in order to understand whether there are possible.

Utility market structure

To understand the market conditions, it is necessary to provide utility companies (electricity suppliers) analysis. In this section it is worth looking into the number of utility companies present in the market, their concentration, renewable energy development agenda, decarbonization plans.

At the moment all of Volts potential customer are connected to the grid and utility companies are the ones who supply electricity. By offering solar systems and energy storage Volts provides a substitute to their services and places a threat to their market share.

At the same time, utility company with established market share and wide audience reach can become a valuable partner for market entry. Volts energy storage can improve value proposition of the electricity suppliers. Seeing the growing demand for electricity produced from renewable sources, utility companies are actively diversifying their portfolios. Residential solar systems and energy storage are one of the possible diversification opportunities.

In addition, energy storage installed nearby the final consumption point can be used for grid optimization and cost reduction of power supply in peak hours. Such technologies are being developed in several countries. Generally, utility companies are aware of the trends in the power supply industry and this opens them to discussion of possible pilot projects with energy storage manufacturers. Volts has been already contacted by utility companies in Italy, Luxembourg and UAE on possible pilot projects related to micro grid technologies.

Threat of substitutes

Supply to the grid

In addition to the electricity prices, it is important to know whether market has a feed-in tariffs (individuals get money for supply electricity into the grid) or net metering scheme (individuals

get credit for electricity supply into the grid) that support the supply of excess electricity generated from solar panels into the grid. During the day, when there is a peak of solar power generation the majority of system owners are absent from their homes or do not need the generated power. This excess energy can be stored in energy storage systems or sold to the grid. In this case, selling to the grid is alternative to purchasing solar battery. As a result, the more attractive it is to sell energy to the grid the less attractive energy storage becomes.

2.3 Prioritization scorecard

Based on the abovementioned factors the following scorecard was developed (Figure 4).

Section	Determinant	Weight	High attractiveness score if
Political	State RE agenda	1	Country government makes active steps to decarbonize its energy sector
	State support	1.5	Government stimulates the demand for residential renewable energy systems
Economic	Purchasing power	1.5	Population has high prosperity
	Electricity tariffs	1.5	Market has high electricity prices
Social	Private housing	1	There is a high number of private individual dwellings
Technological	Stability of power supply	0.5	Power outages are frequent
	Power generation	0.5	There is low RE penetration
Environmental	Solar generation potential	1.5	There is high solar power generation potential
Legal	PV panels and RESS usage regulation	1	There are no regulatory obstacles for residential renewable systems integration
Market players	Direct competition	2	Market shows low competition intensity
	PV integrators	1	Market shows high competition intensity
	Utility market structure	1	Market shows high competition intensity
	Utilities' RE agenda	1	Utilities show high focus on RE development
Threat of substitutes	Supply to the grid	1.5	There is low stimuli for energy supply to the grid

Fig.4. *Custom factors evaluation*

Source: custom table

Market attractiveness is evaluated based on eight group of factors. Political, Economic, Technological and Market players groups of factors have multiple determinants. For these categories the final score was taken as an average of the scores given to determinants added to the group. For

every factor a score of 1 to 3 is given, where “low attractiveness” score is 1, “average” is 2 and “high attractiveness” is equal to 3 points.

The points are attributed based on the country by country review of market analysis based on the defined criteria. The points are attributed based on the collective decision of the group of experts. The group of experts included the CEO of VOLTS Battery, the CEO of Enerix and the author of the paper, the student of the fourth year of bachelor studies of the Saint-Petersburg state university, Yurchanka Sviataslau. The attributed scores are not comparative and the same countries may have the values for the same criteria.

The final process of market prioritization was the following:

1) The results of market analysis are presented to the experts
2) The results for market analysis are discussed
3) Points are attributed based on the expert opinion
4) The attributed points are multiplied by the weights
5) The final points are calculated for every group of factors. In case there are multiple factors in the category the average is calculated
6) The resulting scores are summed up for every country
7) The countries are prioritized based on the resulting scores

Weights were added to the framework in order to differentiate the factors based on their impact on the country attractiveness score. Weights were adjusted from 1 with step of 0.5, where 2 is the maximum weight and 0.5 is the minimum.

State support is given 1.5 weight due to its importance for the economic attractiveness of the system. Purchasing power, electricity tariffs, solar potential and availability of substitutes all have been given the increased score due to their direct impact on the perceived value of the energy storage system.

The highest weight is attributed to the competition factor. Company does not have resources for the market entry with high competition intensity, due to this reason markets with lower competition intensity have higher priority.

Technological factors have been given a decreased priority as they are used as a supplementary decision factors and do not have direct impact on company's competitiveness or easy of entry, but rather enables better understanding of customer needs and industry dynamics.

CHAPTER 3: MARKET ANALYSIS

Based on the predefined criteria the markets given by the company management were analysed. In the first part of this chapter deep market analysis is provided. In the second part, prioritization scores are provided, the most attractive market is defined and general recommendations on market entry are given.

3.1 Analysis of German market

Political factors

Stare RE agenda

Germany's long-term goal is to become greenhouse gas-neutral by 2050. The German target also reflects the country's particular responsibility as a leading industrialized nation and the EU's strongest economy.

The Climate Action Plan 2050 maps out the process for achieving Germany's climate targets for all areas of action in line with the Paris Agreement. These areas of action are energy, buildings, transport, trade and industry, agriculture and forestry. The plan also lays down the first emission reduction targets for individual sectors for 2030, which will provide guidance for strategic decisions over the coming years. In addition, the plan envisages monitoring and public participation.

Restructuring the energy sector is a key aspect of the plan. The energy transition laid important groundwork in this sector. The further expansion of renewable energies and the gradual phasing out of electricity from fossil fuels will reduce the energy sector's emissions by 61 to 62 percent by 2030 compared to 1990[29]. One measure for this sector involved the establishment of a commission by the German government for growth, structural change and regional development. The government set up the commission in June 2018 as part of the Federal Ministry for Economic Affairs and Energy with the involvement of other ministries. The commission comprised representatives of the federal states, municipalities, trade unions, affected businesses and sectors and regional stakeholders. The

[29] Clean Energy Wire. (2014). Germany's greenhouse gas emissions and energy transition targets. [online] Available at: https://www.cleanenergywire.org/factsheets/germanys-greenhouse-gas-emissions-and-climate-targets#:~:text=Compared%20to%201990%2C%20German%20emissions [Accessed: 03.06.2021]

commission presented its final report in January 2019. It recommended the phase-out of coal-fired power generation in Germany by 2038 at the latest, if possible by 2035. The commission also made recommendations on specific prospects for the coal regions.[30] In the table below governmental plans are presented categorized by the target sector (Figure 5).

Fields of action	1990 (in million tons of CO_2 equivalent)	2014 (in million tons of CO_2 equivalent)	2030 (in million tons of CO_2 equivalent)	2030 (reduction in percent compared to 1990)
Total	1248	902	543 to 562	56 to 55
Energy industry	466	358	175 to 183	62 to 61
Building	209	119	70 to 72	67 to 66
Traffic	163	160	95 to 98	42 to 40
Industry	283	181	140 to 143	51 to 49
Agriculture	88	72	58 to 61	34 to 31
Partial total	1209	890	538 to 557	56 to 54
Others	39	12th	5	87

Fig.5. *Emissions in the areas of action contributing to the target*[31]

State support

Federal government, states, municipalities and suppliers offer various options for funding a PV system. There are subsidies with grants for investment costs when purchasing a solar system and subsidies that support the operation of the system financially. There following funding options:

- Low-interest loans
- Statutory feed-in tariff for photovoltaic systems
- Regional funding programs
- Grants from energy suppliers[32]

[30] Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit. (2016). Climate Action Plan 2050 – Germany's long-term emission development strategy. [online] Available at: https://www.bmu.de/en/topics/climate-energy/climate/national-climate-policy/greenhouse-gas-neutral-germany-2050/. [Accessed: 03.06.2021]

[31]Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit. (2016). Climate Action Plan 2050 – Germany's long-term emission development strategy. [online] Available at: https://www.bmu.de/en/topics/climate-energy/climate/national-climate-policy/greenhouse-gas-neutral-germany-2050/. [Accessed: 03.06.2021]

[32] www.photovoltaik-angebotsvergleich.de. Photovoltaik Förderung 2021 Welche Fördermöglichkeiten gibt es? [online] Available at: https://www.photovoltaik-angebotsvergleich.de/photovoltaik-foerderung.html. [Accessed: 03.06.2021]

There are numerous of programs to promote solar power at both state and local level:

- As part of the State Economic Program (LPW), the State of Schleswig-Holstein supports you with funds from the European Regional Development Fund (ERDF) in optimizing energy in educational institutions for general, political and cultural education
- The state of Rhineland-Palatinate supports you in investing in electrical shore connections for commercial inland vessels so that they do without diesel-powered motors and generators to generate electricity during cargo handling or the waiting time at the berths
- The State of Hesse support with the following municipal investments conversion of industrial, traffic and military fallow land so that it can then be used commercially or industrially and development and expansion of industrial and commercial areas.
- The Sachsen-Anhalt investment bank supports you from the state's own "Fund for Housing Promotion Saxony-Anhalt" in the modernization of residential buildings that you use or rent yourself.[33]

To promote renewable energy sources, the German government is participating in a project to support home energy storage.

Some of the regional funding programs active for 2021. Since April 1 2021, Baden-Württember[34]g has had the funding program “Grid-compatible photovoltaic battery storage", which was already very well received in 2018 and 2019. The investment in a stationary, grid-friendly battery storage in connection with a newly installed PV system connected to the distribution network is funded. Both home storage and commercial storage are funded. The maximum grant amount is 30% of the net investment costs of the battery system. Storage with PV systems up to an output of 30 kWp can be subsidized with 200 euros per kWh, larger systems and storage with 300 euros per kWp. The

[33]Öffentlichkeitsarbeit, B. für W. und E., Referat Fördersuche. [online] www.foerderdatenbank.de. Available at:https://www.foerderdatenbank.de/SiteGlobals/FDB/Forms/Suche/Expertensuche_Formular.html?gtp=%2526816beae2-d57e-4bdc-b55d-392bc1e17027_list%253D2&submit=Suchen&filterCategories=FundingProgram&templateQueryString=photovoltaikanlagen. [Accessed: 03.06.2021]

[34]Baden-Württemberg.de. Netzdienliche Photovoltaik-Batteriespeicher. [online] Available at: https://um.baden-wuerttemberg.de/de/energie/informieren-beraten-foerdern/foerdermoeglichkeiten/pv-speicher/ [Accessed: 03.06.2021]

maximum funding amount is 45,000 euros. The funds made available totaling 10 million euros have already been exhausted for the time being due to the high demand, so new applications can no longer be submitted.

The "10,000-house program EnergieBonusBayern[35] " promotes the purchase of solar storage units with at least 3 kWh of storage capacity through the "PV storage program", which are installed on detached or two-family houses together with a new PV system with at least 3 kWp output. A prerequisite is that the homeowner lives in the apartment where the solar power is used. The subsidy amount for a storage facility with 3 kWh capacity is 500 euros; each additional kWh storage capacity is subsidized with 100 euros. The upper limit for eligible storage systems is a capacity of 30 kWh.

There is also financial support for a photovoltaic battery storage system in Lower Saxonyr in connection with the new construction or the expansion of an existing PV system. The funding consists of a grant of up to 40% of the costs for the battery storage system. An important prerequisite is that the newly installed PV system has an output of at least 4 kWp or that the existing system is expanded by at least 4 kWp. In addition, bonuses can be granted for the installation of a charging point for electric vehicles and for systems with an output of over 10 kWp as well as for the roofing of parking areas or other structural systems with elevated PV systems. The maximum funding amount is 50,000 euros. The program can be combined with other federal or EU funding.[36]

Economic factors

Purchasing power

Every year the German economy grows and the standard of living rises. Germany's GDP per capita was 40,116 euros in 2020. The average monthly gross income of households in Germany amounted to 4,734 euros in 2019, according to results of the continuous household budget surveys. Earnings from employment (65%) were the main source of income. An average amount of 3,063 euros

[35] Bayern.de. (2020). Energie-Atlas Bayern - Bürger - 10.000-Häuser-Programm. [online] Available at: https://www.energieatlas.bayern.de/buerger/10000_haeuser_programm.html [Accessed: 03.06.2021]

[36] www.photovoltaik-angebotsvergleich.de. Photovoltaik Förderung 2021 Welche Fördermöglichkeiten gibt es? [online] Available at: https://www.photovoltaik-angebotsvergleich.de/photovoltaik-foerderung.html. [Accessed: 03.06.2021]

per month was received from dependent employment or self-employment. Average disposable income is 3,645 euros.[37]

It should be noted that Germany is one of the 10 countries with the highest quality of life, and the Gini coefficient is 0.29, which indicates a slight stratification of society. Germany is 8th in the overall Prosperity Index rankings. Since 2010, Germany has remained at the same position.[38]

Electricity tariffs

Germany is one of the most expensive countries worldwide for electricity supply. Prices for households using between 1.000 and 2.500 kWh peaked in the first half of 2019 at 34.53 [39]euro cents. Prices for households using between 2.500 and 5.000 kWh reached a peak at 30.88 euro cents in the first half of 2019 (Figure 6). By the second half of 2020, German households consuming between 1.000 and 5.000 kWh payed over 30 euro cents per kilowatt-hour.

Although production is cheap, additional taxes and fees increase the final cost. The renewable surcharge is one of such additional fees hiking up end costs. In 2019, this surcharge made up 21 percent of the final composition of power prices for German households. This levy is to support Germany's renewables expansion, such as wind, solar, biomass and hydropower installations.

[37]Federal Statistical Office. Income, receipts, expenditure. [online] Available at: https://www.destatis.de/EN/Themes/Society-Environment/Income-Consumption-Living-Conditions/Income-Receipts-Expenditure/_node.html. [Accessed: 03.06.2021]

[38]Legatum Prosperity Index 2020. Germany (Ranked 8th) : [online] Available at: https://www.prosperity.com/globe/germany [Accessed: 03.06.2021]

[39]www.verivox.de. Verbraucher-Atlas: Strompreise in Deutschland. [online] Available at: https://www.verivox.de/strom/verbraucheratlas/strompreise-deutschland/#:~:text=Die%20Strompreise%20in%20Deutschland%20sind [Accessed: 03.06.2021]

Period	1.000-2.500 kWh	2.500-5.000 kWh
2020 S2	33.43	30.06
2020 S1	34.3	30.43
2019 S2	32.44	28.78
2019 S1	34.53	30.88
2018 S2	33.42	30
2017 S2	33.61	30.48
2017 S1	33.62	30.48
2016 S2	32.97	29.77
2016 S1	32.63	29.69

Fig.6. *Electricity prices, euro cents*[40]

Time of use tariffs are a new concept, designed to incentivize customers to use more energy at off-peak times, in order to balance demand. These tariffs charge cheaper rates at certain times of night or day, when demand is at its lowest, and higher rates at popular times.

The TOU tariff in Germany corresponds to an increase in the price level during the peak period by about 20.9%, and to a decrease in the price level during the off-peak period by about 31.6% for the average TOU group household.

In 2010 for households in the TOU pilot the tariff rate of 27.4 € ct/kWh during peak times (10 am to 6 pm) was almost twice as high as during off-peak times (15.5 € ct/kWh).[41]

The electricity price in Germany is essentially subject to three factors. These influence the amount of electricity costs per kilowatt hour.

Duties, taxes and surcharges: The electricity tax taxes the consumption of electricity in Germany. A large part of the surcharges is now used to promote renewable energies. Also included, of course: VAT. At 52.5 percent, these legally stipulated shares make up more than half of the electricity price.

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[40] Statista. (2010). Germany: electricity prices 2010-2018 Statista. [online] Available at: https://www.statista.com/statistics/418078/electricity-prices-for-households-in-germany/. [Accessed: 03.06.2021]

[41] Joachim Schleich. Peak demand and time-of-use pricing in a field study of residential electricity demand in Germany. 2013

Network charges: The transport and distribution of energy to end consumers is the responsibility of the network operator. They receive the so-called network usage fees for this. The charges make up 24.6 percent of the electricity price.

Electricity purchase, service and sales: The price for electricity is traded on the electricity exchange and depends on the respective market conditions. Other components are costs for customer service, offers, employee costs and sales. Only these price components can be influenced by us as an energy supplier and make up a share of 22.9 percent[42]

Social factors

Private housing

In 2019 there are around 15.9 million single-family homes in Germany. Single-family houses are residential buildings with one or two apartments. The number of single-family houses in this country has been increasing every year since 2001. This also increases the proportion of private households that own a single-family home.

At the beginning of 2018, 31% of the households in Germany owned a single-family house. Based on results of the sample survey of household income and expenditure, the Federation Statistical Office reports that single-family houses continued to be the most frequent form of real property ownership.[43]

Germany has the second lowest share of homeowners of all OECD countries - 45%. This is driven by housing policies that produce incentives to rent. New studies show that alternative policies could increase the homeownership rate and reduce wealth inequality.

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[42] www.westfalica.de. Wie setzen sich die Energiepreise zusammen? [online] Available at: https://www.westfalica.de/magazin/wie-setzen-sich-die-energiepreise-zusammen [Accessed: 03.06.2021]

[43] Federal Statistical Office. Housing. [online] Available at: https://www.destatis.de/EN/Themes/Society-Environment/Housing/_node.html. [Accessed: 03.06.2021]

Germany has high transfer taxes on buying real estate, no mortgage interest tax deductions for owner-occupiers, and a social housing sector with broad eligibility requirements.[44]

Technological factors

Stability of power supply

To evaluate the stability of power supply SAIDI index can be used. According to the historic data over the years the power supply has become more stable, over the period of 2014-2016 SAIDI index was equal to 22 (Figure 7).

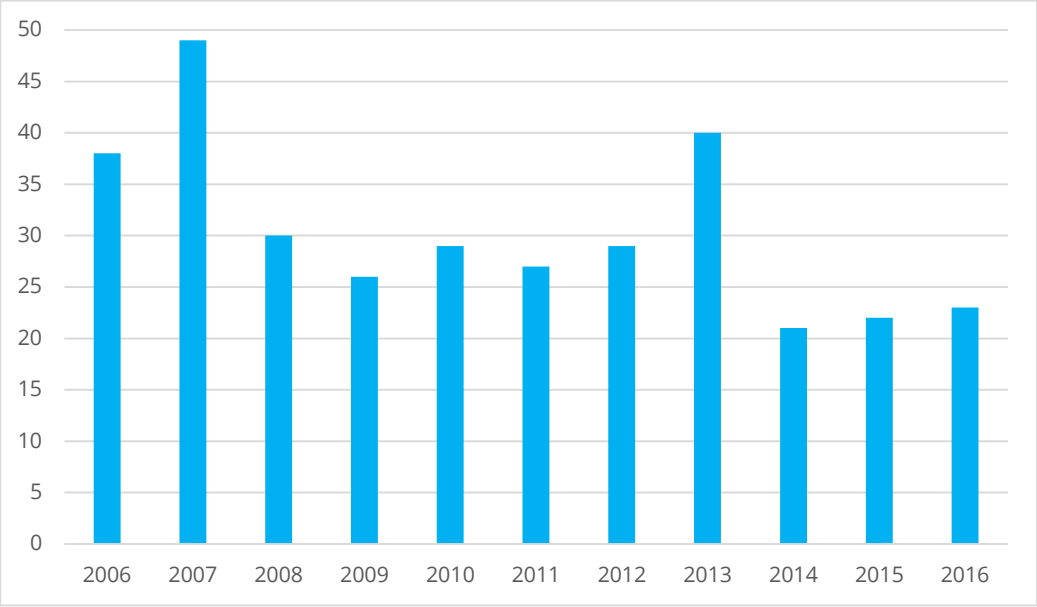

Fig.7. *Planned and unplanned SAIDI, including exceptional events, minutes per customer*[45]

[44]www.bundesbank.de. Reasons for the low homeownership rate in Germany. [online] Available at: https://www.bundesbank.de/en/publications/research/research-brief/2020-30-homeownership-822176 [Accessed: 03.06.2021]

[45]Clean Energy Wire. (2015). Germany's electricity grid stable amid energy transition. [online] Available at: https://www.cleanenergywire.org/factsheets/germanys-electricity-grid-stable-amid-energy-transition#:~:text=The%20statistic%20is%20based%20on [Accessed: 03.06.2021]

Another index that can be used to assess the stability of power supply is the System Average Interruption Frequency Index (SAIFI index). Over the years of 2014-2016 the average number of interruptions per customer was equal to 0.42 (Figure 8).

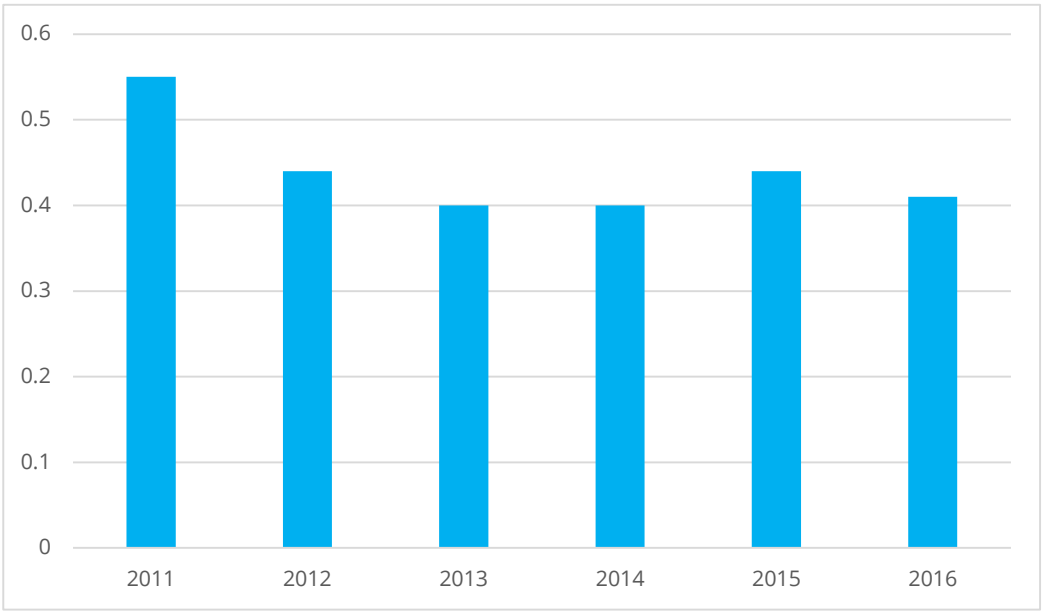

Fig.8. *Planned and unplanned SAIFI, including exceptional events, interruptions per customer*[46]

The reliability of the German power grid remains at a very high level. This is proven by the average power interruption duration, which according to statistics in 2018 was 13.3 minutes per customer (2017: 12.2 minutes). If cases of force majeure are taken into account, the average interruption time per electricity customer in 2018 was 17.1 minutes (2017: 20.0 minutes). The largest proportion of the unavailability due to force majeure had various hurricanes in 2018, including Friederike.[47]

[46] Clean Energy Wire. (2015). Germany's electricity grid stable amid energy transition. [online] Available at: https://www.cleanenergywire.org/factsheets/germanys-electricity-grid-stable-amid-energy-transition#:~:text=The%20statistic%20is%20based%20on [Accessed: 03.06.2021]

[47]www.vde.com. FNN Störungs- und Verfügbarkeitsstatistik 2018 zeigt 13,3 Minuten Stromausfall pro Kunde - VDEFNN. [online] Available at: https://www.vde.com/de/fnn/arbeitsgebiete/versorgungsqualitaet/versorgungszuverlaessigkeit/stoerungsstatistik-2018#:~:text=Die%20H%C3%A4ufigkeit%20der%20Versorgungsunterbrechung%20pro [Accessed: 03.06.2021]

There is little chance of overloading since the German Grids basic program assumes a temperature variation from -11 Degrees to + 38 Degrees Celsius - so unless the weather suddenly changes after 150 years - there is little chance of a blowout.

Act of God is possible but Germany has its own measures to prevent this. Weather Forecasting is crucial, but there are readymade crews and units to handle any sudden blackouts in various areas.

The southern part of Germany (Bavaria and Baden-Wurttemberg) and North Rhine Westphalia exhibit the highest outage costs, whereas the eastern part of Germany and the federal state Saarland exhibit significantly lower costs from power interruptions.[48]

Power generation

Their share in the German electricity mix is growing and broke the 50 percent mark for the first time in 2020. In the first half of 2020, the electricity mix in Germany, i.e. electricity that actually comes from the socket, contains 55.8 percent renewable energies. In 2019, this proportion was around 46 percent. The second most important source of electricity is lignite with a 13.7 percent share in the electricity mix. For comparison, in 1990 this proportion was 31.1 percent. Nuclear power has lost much of its importance. In the first half of 2020, their share was still 12.3 percent, less than half of what it was 25 years ago (Figure 9).

[48]Wetzel, H. (2013). AUTHORS Christian Growitsch (EWI) Raimund Malischek (EWI) Sebastian Nick (EWI) The Costs of Power Interruptions in Germany -an Assessment in the Light of the Energiewende. [online] . Available at: https://www.ewi.uni-koeln.de/cms/wp-content/uploads/2015/12/EWI_WP_13-07-Costs-of-Power-Interruptions-in-Germany.pdf [Accessed: 03.06.2021]

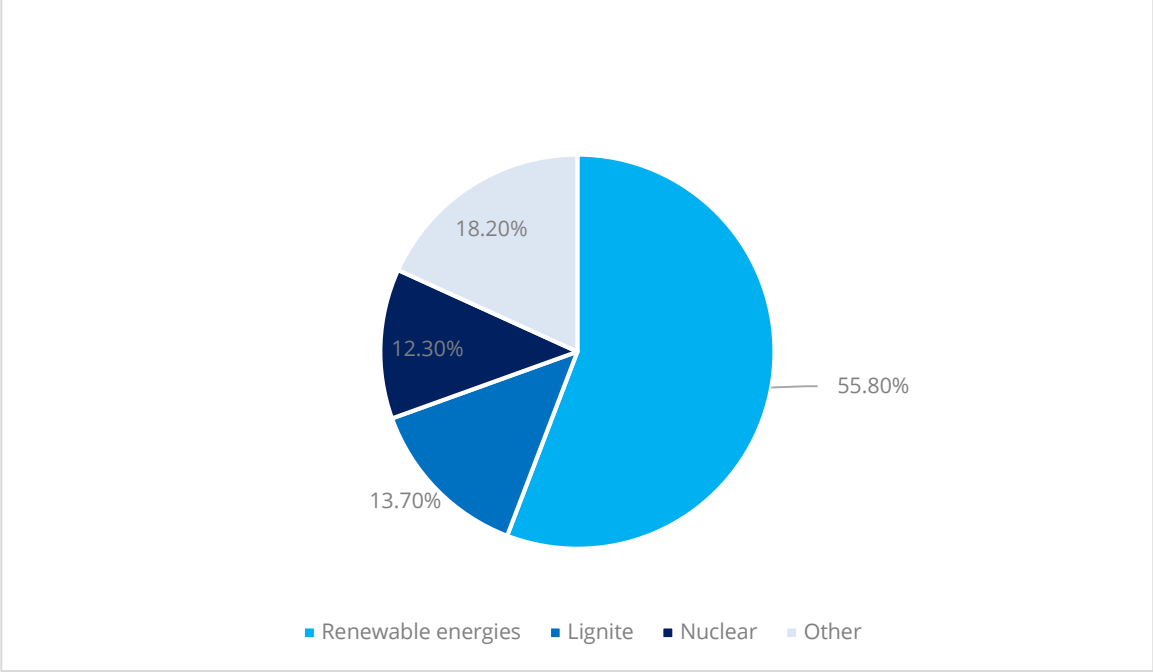

Fig.9. *Share RE in power supply*[49]

Despite being among the countries with the least sunshine hours, Germany is one of the largest solar power producers in the world. With an installed capacity of over 49 gigawatt (GW) in 2019, the country ranked 4th in the world after leading the charge for several years.

The technology can contribute a much greater share to the German power mix at particularly sunny times. In April 2020, it reached a new record share of 23 percent over a whole week and a daily record of almost 28 percent. At about noon, when both sun intensity and usually also power consumption are at peak levels, solar power can account for more than 40 percent of Germany's power production. Overall, solar power arrays fed over 47 TWh of power into the grid in 2019.

Some 192 TWh of electricity has come from renewable energy, almost 46 TWh has come from solar in 2020. Solar power generation has risen 13% in Germany compared 2019. This trend is

[49] EHA Energie, Messung, Controlling und Beratung. Strommix in Deutschland: Rekordhoch für erneuerbare Energien. [online] Available at: https://www.eha.net/blog/details/strommix-in-deutschland.html#:~:text=Im%20Strommix%2C%20sprich%20bei%20dem [Accessed: 03.06.2021]

related to the plan to achieve 65% of renewable energy sources.[50] Utility companies present on the market have relatively low renewable sources penetration (Figure 10).

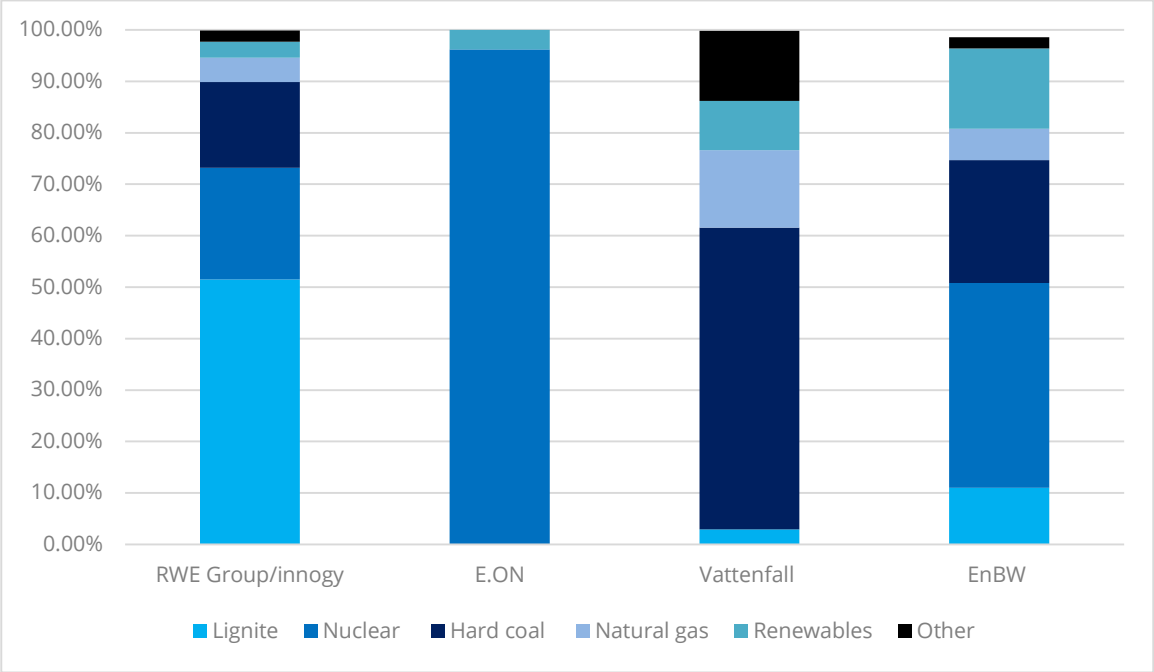

Fig.10. *Sources of power used by utilities*[51]

[50]Wehrmann, B. (2019). Solar power in Germany – output, business & perspectives. [online] Clean Energy Wire. Available at: https://www.cleanenergywire.org/factsheets/solar-power-germany-output-business-perspectives. [Accessed: 03.06.2021]

[51] Clean Energy Wire. (2017). Germany's largest utilities at a glance. [online] Available at: https://www.cleanenergywire.org/factsheets/germanys-largest-utilities-glance. [Accessed: 03.06.2021]

Environmental factors

Solar generation potential

Germany has a temperate climate throughout the country with warm summers and cold winters, however long periods of frost or snow are rare. Rain falls throughout the year.[52] Therefore, the number of sunny days in Germany is low. It has 158 full sunny days per year.[53].

Average theoretical PV potential (GHI) is 2,978 kWh/m^2. Global horizontal irradiation is from 2,75 to 3,34 kWh/m^2, and this parameter estimates more than 3 kWh/m^2 on 36,8% of areas in Germany (Figure 11, 12, 13).[54]

Germany is on the 217th place, almost in the end of the ranking[55]. Average practical PV potential is 2,961 kWh/kWp[56]. Specific photovoltaic power output (PVOUT) is from 2,72 to 3,32 kWh/kWp, and this parameter estimates more than 3 kWh/kWp on 30,8% of areas in Germany.[57] Overall, the environmental factors are beneficial for the development of solar market in Germany (Figure 14, 15, 16).

If we observe changes of Practical PV Potential during the year, monthly variation of photovoltaic power output in Germany is big, from 1.6% to 4,3[58].

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[52] Climate and Average Weather in Germany: the number of sunny days: Climate and weather /Climate in Germany//[online resourse] https://weather-and-climate.com.. (access: 25.05.21)

[53]Sunshine in Germany: the number of sunny days: Business, work and life in Germany in English /The country of Germany/Climate and weather /Sunny days in Germany//[online resourse] https://ru-geld.de. (access: 25.05.21)

[54]Germany: Global Solar Atlas/ Insights//[online resource] https://globalsolaratlas.info (access: 25.05.21)

[55] Global Photovoltaic Power Potential by Country: Global Solar Atlas //[online resourse] https://globalsolaratlas.info/global-pv-potential-study (access: 25.05.21)

[56] Global Photovoltaic Power Potential by Country: Global Solar Atlas //[online resourse] https://globalsolaratlas.info/global-pv-potential-study (access: 25.05.21)

[57] Germany: Global Solar Atlas/ Insights//[online resource] https://globalsolaratlas.info (access: 25.05.21)

[58] Global Photovoltaic Power Potential by Country: Global Solar Atlas //[online resourse] https://globalsolaratlas.info/global-pv-potential-study (access: 25.05.21)

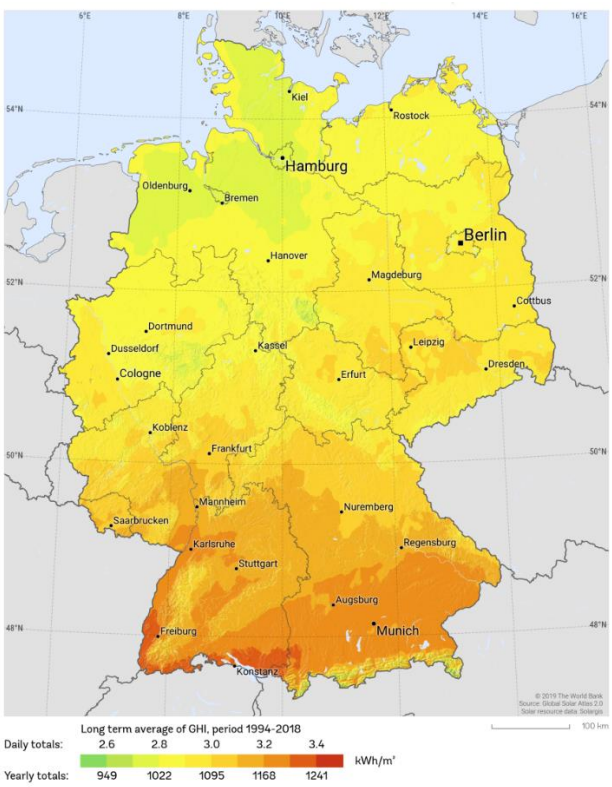

Fig.11. *GHI in Germany*[59]

[59] Germany: Global Solar Atlas/ Map and data downloads//[online resource] https://globalsolaratlas.info/download/germany (access: 25.05.21)

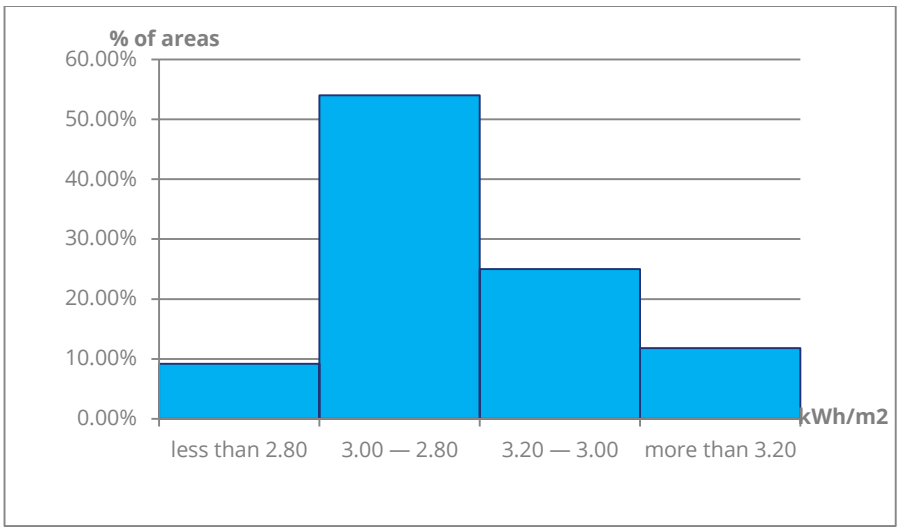

Fig.12. *Distribution of Global horizontal irradiation*[60]

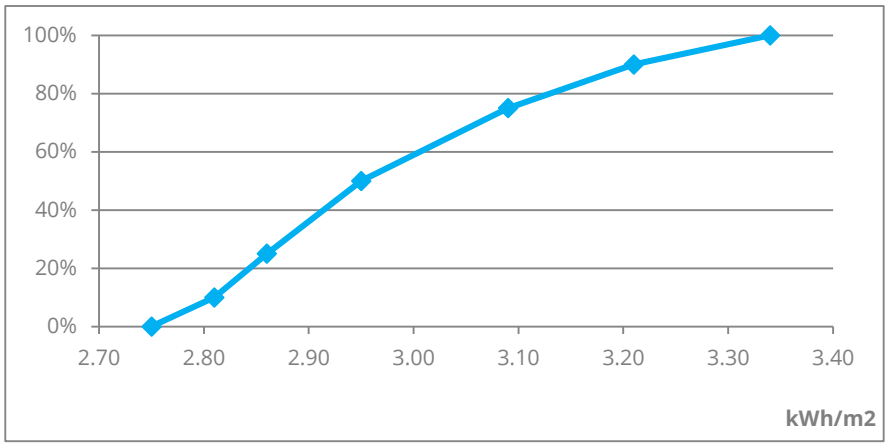

Fig.13. *Statistics of Global horizontal irradiation*[61]

[60] Germany: Global Solar Atlas/ Insights//[online resource] https://globalsolaratlas.info (access: 25.05.21)

[61] Germany: Global Solar Atlas/ Insights//[online resource] https://globalsolaratlas.info (access: 25.05.21)

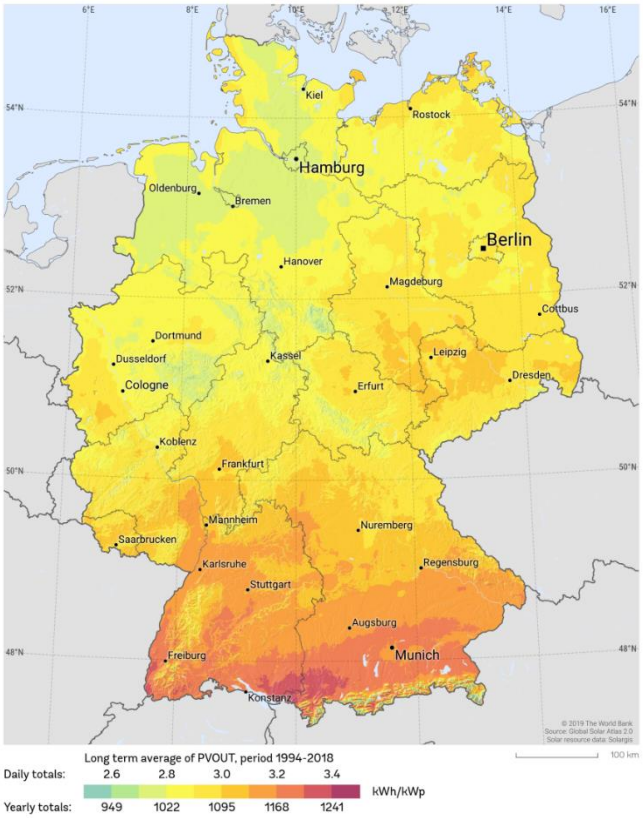

Fig.14. *PVOUT in Germany*[62]

[62] Germany: Global Solar Atlas/ Map and data downloads//[online resource] https://globalsolaratlas.info/download/germany (access: 25.05.21)

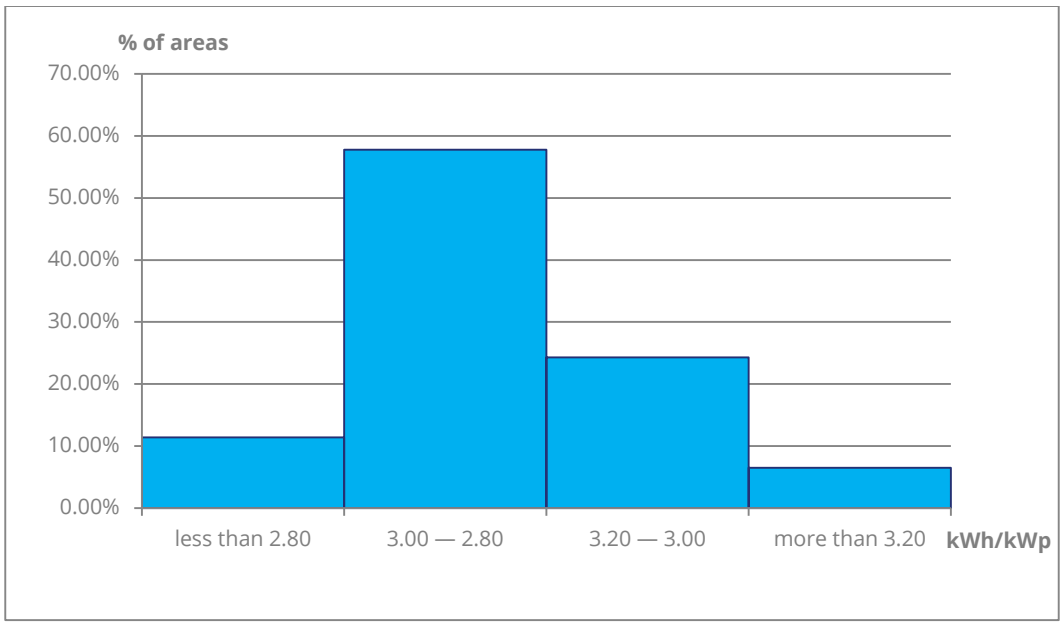

Fig.15. *Distribution of Specific photovoltaic power output*[63]

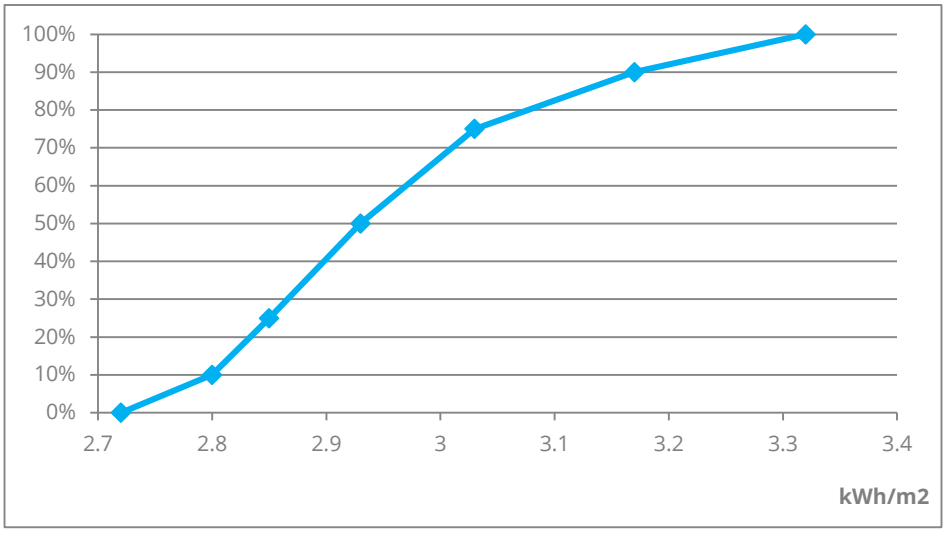

Fig.16. *Statistics of Specific photovoltaic power output*[64]

[63] Germany: Global Solar Atlas/ Insights//[online resource] https://globalsolaratlas.info (access: 25.05.21)

[64] Germany: Global Solar Atlas/ Insights//[online resource] https://globalsolaratlas.info (access: 25.05.21)

Legal factors

The Law on the placement, return and environmentally sound disposal of batteries and accumulators contemplates some restrictions on the use of solar batteries.[65]

- Distributors may only offer batteries to end users if they ensure that the end user can return used batteries in accordance with the law.
- Before a manufacturer puts batteries on the market he is obliged to register with the competent authority.
- The manufacturers or their authorized representatives are obliged to collect the old batteries taken back by the distributors.
- Every distributor is obliged to take back used batteries from the end user at or in the immediate vicinity of the retail store.
- All foreign manufacturers, before placing their products on the German market, must complete the registration procedure in the "Register of electrical appliances" - "Stiftung Elektroaltgeräte Register" and pay the corresponding registration fee.
- Foreign manufacturers can register themselves or appoint an authorized representative based in Germany.

Market players

Direct competitors

In 2019 BYD and sonnen had the highest market shares with 19 percent and 20 percent and dominated the market in the field of energy storage for private households. The overall demand for energy storage systems for private households in Germany continued to increase in 2019. With a total of 206,000 home storage systems installed, the market volume doubled in just two years (Figure 17).

[65]Energy, F.M. for E.A. and Renewable Energy Sources Act (EEG 2017). [online] www.bmwi.de. Available at: https://www.bmwi.de/Redaktion/EN/Downloads/renewable-energy-sources-act-2017.pdf%3F__blob%3DpublicationFile%26v%3D3. [Accessed: 03.06.2021]

In 2020 the top duo sonnen and BYD were able to further establish themselves in 2020 as a whole. Together with third place E3 / DC and SENEC in fourth place, a top group of providers is formed, which already accounts for 72 percent of the market (Figure 18).

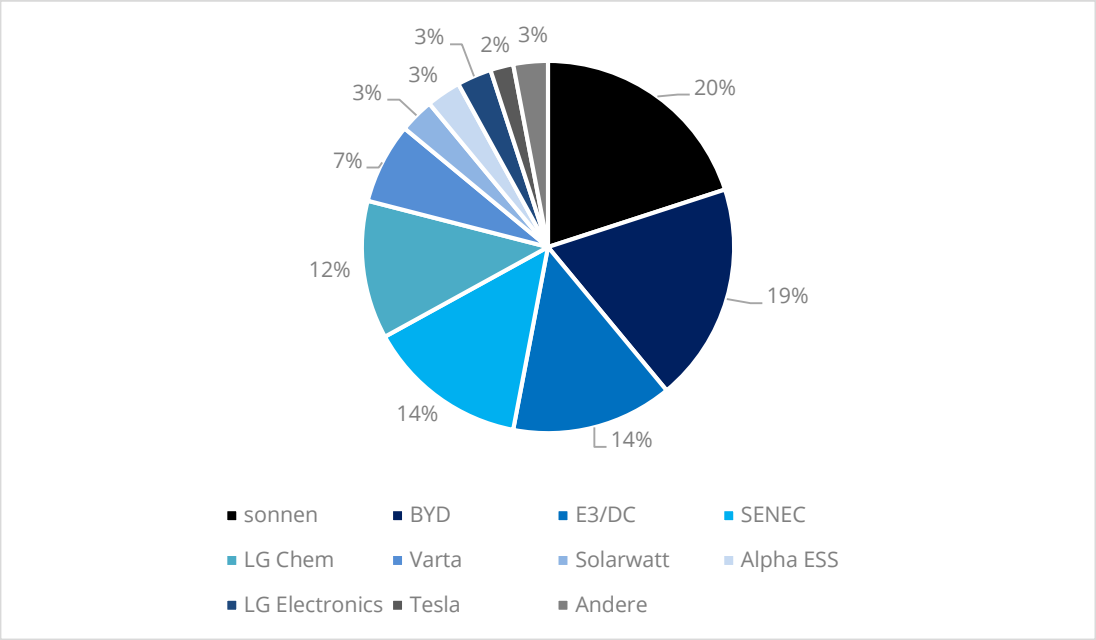

Fig.17. *German RESS market structure, 2019*[66]

[66] www.solaranlagen-portal.com. Marktübersicht Photovoltaik Speicher: Blei, Lithium Solarstromspeicher. [online] Available at: https://www.solaranlagen-portal.com/photovoltaik/stromspeicher/photovoltaik-speicher [Accessed: 03.06.2021]

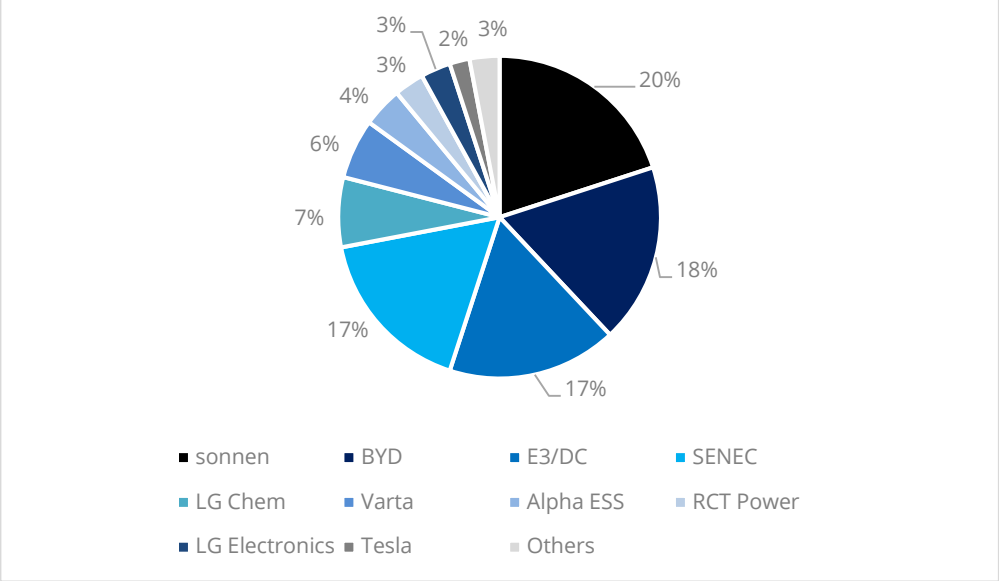

Fig.18. *German RESS market structure, 2020*[67]

Sonnen is a German manufacturer of lithium power storage systems from Wildpoldsried in Oberallgäu. Sonnen GmbH was one of the first practical PV power storage systems on a lithium-ion basis and was launched on the German and Austrian markets in January 2011. In addition, sonnen GmbH has been offering the sonnenCommunity since 2016, Germany's first electricity community for sharing decentrally generated electricity.

In 2015 sonnen company set up the world's largest platform for electricity sharing. SonnenCommunity connects homes with batteries and solar panels together, allowing them to share energy in what the company calls a "decentralized energy community.[68] It unites people who produce and store energy. All sonnenBatterie owners are virtually and intellectually connected to each other in the sonnenCommunity and can - depending on requirements and weather conditions - supply surplus electricity to or from the community. In addition, sonnen has many specialized partners. These

[67] www.solaranlagen-portal.com. Marktübersicht Photovoltaik Speicher: Blei, Lithium Solarstromspeicher. [online] Available at: https://www.solaranlagen-portal.com/photovoltaik/stromspeicher/photovoltaik-speicher. [Accessed: 03.06.2021]

[68] www.solaranlagen-portal.com. Marktübersicht Photovoltaik Speicher: Blei, Lithium Solarstromspeicher. [online] Available at: https://www.solaranlagen-portal.com/photovoltaik/stromspeicher/photovoltaik-speicher. [Accessed: 03.06.2021]

are regional solar and electric companies that are familiar with sonnenBatterien installation and maintenance, PV system assembly and other on-site services.[69] It is also known that Sonnen has partnered with Tiko Energy Solutions to create a network of energy storage systems integrated into a virtual power plant.

BYD is a high-tech multinational company founded in 1995, based in Shenzhen, China. The BYD product portfolio - the Zero Emissions Energy Ecosystem - includes power storage solutions for solar systems, electric vehicles and monorail systems. BYD Company Ltd. is one of the largest private companies in China, has offices in more than 50 countries and regions, and is listed on the Hong Kong and Shenzhen stock exchanges.

The BYD company creates its own ecosystem. It is known not only for energy storage devices, but also for electric vehicles. The Chinese car and commercial vehicle manufacturer has received an order from Germany for the first time. The Bochum-Gelsenkirchen trams (Bogestra) and the Herne-Castrop-Rauxel tram have jointly ordered 22 E-Bus units from the Chinese manufacturer.[70]

E3 / D3 from Osnabrück - E3 stands for saving, renewable, effective and DC for direct current - has also been producing the S10 home power plant since 2012 in addition to the wallbox. The S10 power storage can be expanded to include DC generation and AC storage and can be cascaded for larger buildings and apartment buildings. The goal of the electricity storage manufacturer E3 / DC is to sustainably achieve new standards for home supply with maximum performance and quality. E3 / DC GmbH works directly with certified sales partners. The company also cooperates with construction companies like OKAL Haus GmbH, one of the leading companies in prefabricated houses.[71]

The Leipzig EnBW subsidiary Deutsche Energieversorgung adopted the brand name of its products as a company name in October 2018 and has since been called Senec GmbH. SENEC has established itself as a driver of innovation in the industry in recent years with the SENEC. Home series

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[69] sonnen.de. sonnenCommunity - eine Gemeinschaft von Unabhängigen. [online] Available at: https://sonnen.de/sonnencommunity/ [Accessed: 03.06.2021]

[70] E3/DC. Partner werden. [online] Available at: https://www.e3dc.com/partner-werden/#Installationspartner [Accessed: 03.06.2021]

[71] www.hagergroup.com. E3 / DC celebrates a five-year partnership with OKAL. [online] Available at: https://www.hagergroup.com/en/detail/e3-dc-celebrates-a-five-year-partnership-with-okal/e82684/?backpageid=83&backblockid=b59208348 [Accessed: 03.06.2021]

of electricity storage systems developed and produced in Germany and the innovative SENEC.Cloud electricity solution.

LG Chem Ltd. As part of the largest chemical company in South Korea, has been active in the development and production of highly functional electricity storage systems since 1998. Among the newly developed battery systems RESU systems, which are characterized by its compact and lightweight design, joined at the end of 2016 with the 7H and 10H two High-voltage variants are added, which are intended to complement the portfolio of the three conventional 48-volt models as 400-volt variants.

VARTA Storage GmbH, a company of the VARTA Micro group of companies, is a leading company in the field of energy storage. The company, based in Nördlingen in Bavaria, specializes in innovative lithium-ion energy storage systems.

VARTA Storage and the North German energy company EWE established partnership on EWE myEnergyCloud. In the electricity community, private solar system owners can save electricity they have produced themselves like a credit and access it again cheaply at any time.

VARTA Storage is also presenting the new cooperation with innogy at Intersolar. The energy supplier has launched a complete package consisting of twelve high-performance modules, the appropriate inverter and a VARTA energy storage device with a capacity of 3.3 kilowatt hours. With the complete solution, most of your own solar power can be used in the house.

The company has also partnered with the Smappee app, which shows which consumers are consuming a lot of electricity at what time of day, so that information can now be targeted to save energy.[72]

SOLARWATT GmbH is one of the pioneers in the solar industry and has successfully aligned itself strategically in the course of a successful restructuring in 2012 under new management. In 2015, SOLARWATT GmbH presented the MyReserve power storage system. The battery storage

[72]PV magazine (2018). VARTA Storage mit starken Netzwerkpartnern auf der Intersolar. [online] pv magazine Deutschland. Available at: https://www.pv-magazine.de/unternehmensmeldungen/varta-storage-mit-starken-netzwerkpartnern-auf-der-intersolar/ [Accessed: 03.06.2021]

is compatible with all common PV inverters and can therefore also be integrated into existing PV systems without retrofitting costs.[73]

The table shows the prices for products from various manufacturers. Producer prices vary depending on price segment, brand strength and market presence. The prices are taken from the official web-sites of the manufacturers and distributors.

The analysis of prices presented below shows that systems are sold at a level that enables VOLTS to have positive margin using the production process established at the moment. Relatively high population prosperity enables higher price setting. In addition, there is significant variation between the players which might imply the high impact of brand value (Figure 19).

[73]energie-experten Die wichtigsten Stromspeicher-Hersteller im Überblick. [online] energie-experten. Available at: https://www.energie-experten.org/erneuerbare-energien/photovoltaik/stromspeicher/hersteller [Accessed: 03.06.2021]

Product	Price,EUR
sonnenBatterie 10 (5 kWh)	7794
sonnenBatterie 10 (11 kWh)	10708
sonnenBatterie 10 (27,5 kWh)	20109
BYD B-Box HVM 11.0	5800
BYD B-Box HVM 13.8	7404
BYD B-Box HVM 22.1	10797
E3/DC s10 blackline	17999
LG Chem RESU 6.5	3243
LG Chem RESU 10	4389
LG Energy Storage System Home 10	8260
LG Energy Storage System Home 8	9000
Tesla Powerwall	9600
BMZ Hyperion 7.5	4236
BMZ ESS 9.0	3960
VARTA element 9	9754
VARTA element 6	7426
HUAWEI LUNA2000-10-S0	5869
HUAWEI LUNA2000-15-S0	7920

Fig.19. *Residential Energy Storage Systems prices*

Source: custom table

PV integrators

The Renewable Energy Sources Act (EEG) introduced in 2000 with its legally guaranteed feed-in tariff laid the foundations for the solar boom. With the first amendment to the EEG in 2004, a rapid expansion of photovoltaics began in Germany; growth then stagnated at a high level from 2010 to 2012 (approx. 7.5 GWp per year). After 2012, the demand for PV collapsed by 80%. The Federal Association for the Solar Industry (BSW) saw the cause in the fact that various EEG amendments have massively worsened the framework conditions for photovoltaics in Germany.[74] From 2012 the

[74]Stellungnahme des BSW-Solar zur Marktanalyse Photovoltaik-Dachanlagen [online] Erneurbare-energien Available at: https://www.erneuerbare-

fee-in-tariffs were lowered significantly, this fact had an adverse effect on the German solar market. As a result, in the following years the number of solar integrators significantly decreased.

The worsened legal framework had a devastating effect on the German solar industry: "The massive collapse of the internal PV market has long had serious effects on all stages of the value chain in the German PV industry. The number of employees in the solar industry has already more than halved, hundreds of companies have shut down their PV business operations or even had to file for bankruptcy", the BSW wrote in its 2015 statement. Of the once around 350 solar companies in Germany, there were only a few dozen left. A total of around 80,000 jobs were lost in the German solar industry.[75]

In 2012 there were 60 German manufacturers of PV panels, 15 companies have been able to overcome the change in legal regime and the supply of Asian PV modules. German manufacturers include, for example, Antec Solar, AXITEC, AxSun, Heckert Solar, Schott Solar, SI Module, SOLARWATT and Q-Cells. Many German manufacturers have relocated production abroad for cost reasons. The solar module manufacturers producing exclusively in Germany are presented in the table below (Figure 20).

energien.de/EE/Redaktion/DE/Stellungnahmen_Marktanalysen/bsw.pdf?__blob=publicationFile&v=3 [Accessed: 03.06.2021]

[75] SOLARWATT GmbH. Investition in die Zukunft mit Strom aus der Sonne - Solarenergie in Deutschland. [online] Available at: https://www.solarwatt.de/photovoltaikanlage/photovoltaik-know-how/solarenergie. [Accessed: 03.06.2021]

Manufacturer	Location
ALGATEC SOLAR	Brandenburg
Antec Solar	Thuringia
AxSun Solar	Laupheim-Baustetten
Calyxo	Bitterfeld-Wolfe
Heckert Solar	Chemnitz
SI modules	Freiburg
SOLARA	Hamburg
SOLARWATT	Dresden
Solar power factory	Wismar

Fig.20. *PV modules manufacturers*[76]

Utility market structure

The German electricity market is dominated by four large suppliers that between them had a 67 percent share of the conventional power market in Germany and Austria in 2013. The "big four" – RWE Group/Innogy (RWE owns 77 percent of Innogy's shares), EnBW, E.ON and Vattenfall – are involved in primary power production, distribution and sales (Figure 21, 22).

Company	Revenue (bn euros, 2016)	Market share (2016)	Power generation (2016)
RWE Group	45.8	28%	216.1 TWh, thereof 133.8 TWh in Germany
innogy	43.6	27%	10.8 TWh, thereof 3.5 TWh in Germany
E.ON	38.2	24%	48.3 TWh, thereof 38.1 TWh in Germany
EnBW	19.4	12%	52.8 TWh, all in Germany
Vattenfall	14.7	9%	119.2 TWh, 20.6 TWh in Germany

Fig.21. *German utility companies*[77]

[76]Solar.red Photovoltaik für Unternehmen. (2020). Deutsche Solarmodule, PV-Module Preise Hersteller Vorteile kaufen. [online] Available at: https://solar.red/deutsche-pv-module/#:~:text=Zu%20den%20deutschen%20Herstellern%20geh%C3%B6ren [Accessed: 03.06.2021]

[77] Clean Energy Wire. (2017). Germany's largest utilities at a glance. [online] Available at: https://www.cleanenergywire.org/factsheets/germanys-largest-utilities-glance. [Accessed: 03.06.2021]

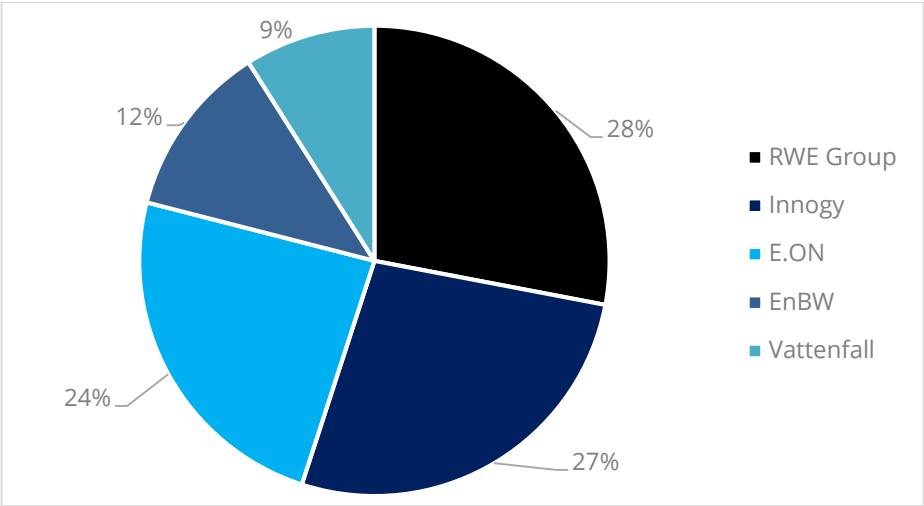

Fig.22. *Market share of utilities companies*[78]

Utilities' RE agenda

German energy giant RWE aims to achieve carbon neutrality by 2040. RWE's CO2 reduction plan is resolute and responsible phasing out of fossil fuels – massive investments in wind and solar energy as well as high-performance storage technologies.[79]

Vattenfall in cooperation with SSAB, LKAB created HYBRIT (Hydrogen Breakthrough Ironmaking Technology (HYBRIT) is a groundbreaking effort to reduce CO2 emissions and decarbonize the steel industry.

Energy company E.ON has called for a green gas quota to help to reduce the share of fossil gas in the country's energy mix. The company said only a quota can cut emissions and ensure increased sales of green gases, such as green hydrogen.[80]

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[78] Clean Energy Wire. (2017). Germany's largest utilities at a glance. [online] Available at: https://www.cleanenergywire.org/factsheets/germanys-largest-utilities-glance. [Accessed: 03.06.2021]

[79]RWE The new RWE: carbon neutral by 2040 and one of the world´s leading renewable energy companies. [online] www.group.rwe. Available at: https://www.group.rwe/en/press/rwe-ag/2019-09-30-the-new-rwe [Accessed: 03.06.2021]

[80]Nhede, N. (2021). E.ON explores use of gas networks to decarbonise heating sector. [online] Smart Energy International. Available at: https://www.smart-energy.com/industry-sectors/finance-investment/e-on-explores-use-of-gas-networks-to-decarbonise-heating-sector/ [Accessed: 03.06.2021]

EnBW underpins its sustainable corporate strategy and aims to become climate-neutral by 2035. Company set to halve CO2 emissions by 2030, exit from coal-fired generation planned by 2035, fuel switch options examined and submit the extensive packet of measures aimed at achieving environmental, commercial and social sustainability.[81]

Utility EnBW plans to build Germany's largest solar power farm and intends to run the installation without claiming any support payments in a first for the country that has supported the technology with dozens of billions of euros since the beginning of the century. The solar farm with a capacity of up to 175 megawatts (MW) would be built near Berlin and could theoretically power up to 50,000 households, the company says in a press release.[82]

German electric utility EnBW) has started construction work on two subsidy-free solar projects of 150 MW each in the northeastern German state of Brandenburg. The company announced a decision to proceed with the investment in the two projects in December. The solar duo will add to EnBW's recently completed 187-MW Weesow-Willmersdorf solar photovoltaic (PV) park in Werneuchen, Brandenburg. The plants will have a total 700,000 solar panels installed to generate enough power for 90,000 households[83]

RWE Renewable's offshore wind farm projects Kaskasi is one of RWE Renewables' major projects under construction with 38 turbines and a planned installed capacity of 342MW. Located 35 km off the coast of Heligoland (North Sea).[84]

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[81] EnBW becomes climate-neutral by 2035, parts much earlier. EnBW becomes climate-neutral by 2035, parts much earlier EnBW. [online] Available at: https://www.enbw.com/company/press/enbw-becomes-climate-neutral.html. [Accessed: 03.06.2021]

[82]Clean Energy Wire. (2019). Utility EnBW plans to build Germany's largest solar farm with zero support. [online] Available at: https://www.cleanenergywire.org/news/utility-enbw-plans-build-germanys-largest-solar-farm-zero-support. [Accessed: 03.06.2021]

[83]Renewablesnow.com. EnBW starts building two 150-MW solar projects in Germany. [online] Available at: https://renewablesnow.com/news/enbw-starts-building-two-150-mw-solar-projects-in-germany-735033/ [Accessed: 03.06.2021]

[84]RWE Project proposals for renewable energy. [online] www.group.rwe. Available at: https://www.group.rwe/en/our-portfolio/innovation-and-technology/project-proposals/construction-projects-renewables. [Accessed: 03.06.2021]

EWE launched its “My Energy Cloud” - an electricity community for its photovoltaic and storage customers, who in the future will be able to supply themselves almost completely with self-generated solar electricity.

In contrast to other models, EWE plans to retain the full EEG remuneration. The operators of the photovoltaic and storage systems thus saved themselves the need to register with the tax office.

The participants in the electricity community would be supplied 100 percent with green electricity. Behind the cloud is the balancing group of a virtual power plant. EWE is buying in the necessary residual electricity. In any case, it is also about green electricity, according to the product manager.

RWE Group is the largest utility company in Germany. It offers many services and products to the renewable energy sector. Examples include contracts with landowners for the placement of opportunities on land for the restoration, modernization and upgrading of old wind turbines, as well as consulting in the field of renewable energy sources. RWE Wind Services is full-service provider of operations, maintenance and other wind services.[85]

Vattenfall develops and offers charging solutions for electric cars, buses and trucks. Together with partners company has built one of Europe's largest charging networks, InCharge.[86]

[85] RWE RWE Renewables – Land for wind power. [online] www.group.rwe. Available at: https://www.group.rwe/en/our-portfolio/our-products/land-for-wind-power [Accessed: 03.06.2021]

[86] Vattenfall. Electrification of transportation with electric cars and vehicles. [online] Available at: https://group.vattenfall.com/what-we-do/roadmap-to-fossil-freedom/transportation [Accessed: 03.06.2021]

Threat of substitutes

Supply to the grid

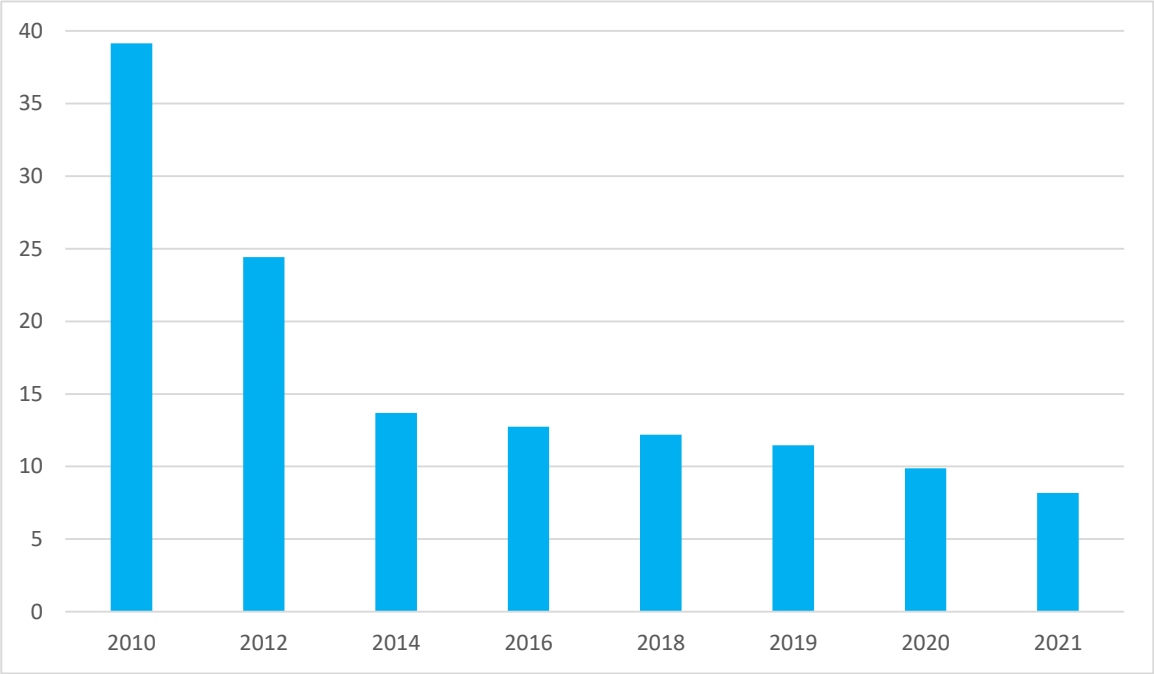

Fig.23. *Feed-in-tariffs*[87]

With the aim to promote the production of renewable energy (RE), the first German Feed-in Tariff (EEG) came into force in 2000. Since then it has been amended several times. The feed tariffs are presented in the figure 23.

The Act on the Digitisation of the Energy Transition heralds the launch of the smart grid, smart meter and smart home in Germany. The new legislation centres on the introduction of smart meters and obliges prosumers with PV installations over 1 kW to pay metering fees from 60 to over 100 Euros per year.[88]

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[87]Schiller, C. . [online] . Available at: https://www.db.com/cr/en/docs/German_FIT_Update_2012.pdf [Accessed: 03.06.2021]

[88]Energy, F.M. for E.A. and The digitisation of the energy transition. [online] www.bmwi.de. Available at: https://www.bmwi.de/Redaktion/EN/Artikel/Energy/digitisation-of-the-energy-transition.html#:~:text=The%20Act%20on%20the%20Digitisation [Accessed: 03.06.2021]

Initially, measurement systems will be replaced in households that have their own energy production systems, such as photovoltaic systems or mini combined heat and power installations. Smart meters support such "prosumers" by measuring how much self-generated electricity they feed into the electricity grid as well as how much electricity they draw from the grid when necessary. Appliances with a particularly high consumption will also be outfitted with smart meters in the first phase of the rollout.

Subsequently, all meters in Germany will be replaced successively starting in 2020. This is expected to be completed by 2032.

According to the green tariff scheme for solar PV installations on the roof, only PV systems with an output of up to 300 kW will be eligible for the feed-in tariff at current levels. Installations with a capacity of 300-750 kW will receive only half of the payment.

3.2 Analysis of Portuguese market

Political factors

State RE agenda

As stated by the Portuguese Energy Minister in 2019, “In the next 10 years the country aims to reach 80 percent in electricity production from renewable sources. More than realistic, these are necessary goals. I would say that we have no alternative. It is also the scenario that creates more wealth and more jobs in the country.” [89] Several government programmes are in place, with ambitious targets to be achieved. Since Portugal is one of the European countries with the highest solar exposure (Portugal has approximately three thousand hours of sunshine per year), the Government launched the Strategy XVIII in 2010, which aims to multiply, every 10 years, the target for investment in solar energy (from 150MW to 1500MW). Portugal's national renewable energy action plan shows what action it will take to meet its renewables targets. Government policy is set out in the National Energy and Climate Plan 2030 (PNEC 2030), approved by Council of Ministers Resolution The following objectives apply:

[89] www.roedl.com. Renewable energy in Portugal. [online] Available at: https://roedl.com/insights/renewable-energy-portugal [Accessed: 03.06.2021]

- Decarbonization of the economy, towards carbon neutrality by 2050.
- A national target to reduce greenhouses gas emissions by between 45% and 55% by 2030, compared to 2005 levels.
- 80% of electricity consumption to be from renewable energy sources.
- National energy consumption to continue to decline, down by 35% in primary energy by 2030.

Solar is expected to play a leading role in the Portuguese government's new energy plan, which includes goals of providing 80% of the country's power demand from renewables by 2030, and electrifying 65% of the economy by 2050.[90] In this sense, the National Energy and Climate Plan 2030 (PNEC 2030), which will be the main instrument of energy and climate policy for the period 2021-2030, is essential to ensure the achievement of energy and climate goals on the 2030 horizon and is oriented to the future and long-term goals of Portugal. Among the 8 national objectives for the 2030 horizon established in the PNEC 2030, is the "Goal 3. Reinforce the investment in renewable energies and reduce the energy dependence of the country" which aims to strengthen the diversification of energy sources through a growing and sustainable use of endogenous resources, promote increased electrification of the economy and encourage R&D&I in clean technologies.[91]

In July 2020 the government promoted an auction of solar photovoltaic (PV) plants, to ensure price and facilitate financing. It involved a total of 670MW. Applicants were able to offer a discounted tariff or compensation to the network. The tender achieved a world record low tariff of EUR11.14/MWh, which may benefit electricity prices for the next decade. All lots in the auction were assigned. About 75% of the capacity included battery storage, reinforcing the security of the national electrical system.[92]

In June 2019, Portuguese government made an auction of 1,150 MW of solar energy capacity. The event mainly attracted international players, such as the Spanish Iberdrola, the French Akuo

[90] pv magazine International. Portugal drafts new rules to boost rooftop solar. [online] Available at: https://www.pv-magazine.com/2019/10/25/portugal-drafts-new-rules-to-boost-rooftop-solar/ [Accessed: 03.06.2021]

[91] Leiloes-renovaveis.gov.pt. (2020). LEILÕES DE ENERGIA SOLAR. [online] Available at: https://leiloes-renovaveis.gov.pt/ [Accessed: 03.06.2021]

[92]signon.thomsonreuters.com. Practical Law UK Signon. [online] Available at: https://uk.practicallaw.thomsonreuters.com/6-564-1565?transitionType=Default&contextData=(sc.Default)&firstPage=true [Accessed: 03.06.2021]

Energy, the British Aura Power and the German Enerpac Projects. The auction set a world record minimum price per megawatt-hour of 14.6 euros, with the average auction price being 20 euros MWh, less than half the base price.

Portugal has plans to further accelerate investments, relaunching the second auction of solar licenses in June 2020. The hydrogen-producing complex attracted between 4,000 and 5,000 million euros of private funds and is due to start in 2021.[93]

This second auction of 700 megawatts (MW) of new solar capacity will help Portugal to reach the ambitious goal of having 7,000 MW of renewable energy by 2030, Portugal currently had only 828 MW of installed solar capacity in 2020. In comparison to the auction in 2019, the new auction adds energy storage systems to the contract, which are fundamental for the security of the electrical system given the intermittency of the solar.

The government emphasizes the importance of hydrogen power. The government is working on the installation in Sines. The process will be powered by a solar power plant of up to 1 gigawatt in capacity. According to Portuguese minister of environment, Matos Fernandes, it is a private investment project of between 4,000 and 5,000 million euros in land that belongs to the State. The minister predicts that it will start in 2021 and will start operating in 2023, aimed at the domestic market, but also at export. Portugal has allies in this project with the Dutch government, companies and national utilities such as EDP and Galp. The government wants 1000 MW of hydrogen production capacity by 2030.[94]

State support

In 2020, the Portuguese government was offering new photovoltaic solar customers a subsidy that covers up to 70% of the investment within a limit of € 2,500. When the program was put forward the dates for submitting applications to the incentive were from September 7 2020 to December 31,

[93]Dinheiro Vivo. (2020). Governo acelera investimentos em energia "verde" a partir de junho. [online] Available at: https://www.dinheirovivo.pt/economia/governo-acelera-investimentos-em-energia-verde-a-partir-de-junho-12692044.html [Accessed: 03.06.2021]

[94] Welle (www.dw.com), D. Green Flamingo: Portugal hopes to export green hydrogen to EU DW 20.11.2020. [online] DW.COM. Available at: https://www.dw.com/en/green-flamingo-portugal-hopes-to-export-green-hydrogen-to-eu/a-55673203 [Accessed: 03.06.2021]

2021 or until the total amount available is exhausted. This program was deemed temporary and the funds available for 2020 were exhausted before the end of the year. At the moment it is closed but is expected to reopen in 2021 (Figure 24).

Project type	Limit, €
Heat pump	2500
Thermal solar system	2500
Electric boilers when coupled with other systems that use renewable energy (heat pumps and solar panels)	750
High efficiency biomass boilers and recuperators	1500
Installation of photovoltaic panels and other equipment for the production of renewable energy for self-consumption	2500

Fig.24. *Portugal subsidies*[95]

Economically vulnerable consumers with a contracted power up to 6.9 kVA are entitled to a social tariff discount to be reflected in the network access tariff. This discount is identical across the regulated market and the liberalized market.[96]

Economic factors

Purchasing power

Portuguese people earn USD 25 367 per year on average, much less than the OECD average of USD 43 241. [97]The average salary in Portugal in the second half of 2018 was €1,148.29, according

[95]Fundoambiental.pt. (2021). Resumo Do Programa De Apoio - Edificios Mais Sustentáveis. [online] Available at: https://www.fundoambiental.pt/avisos-2020/mitigacao-das-alteracoes-climaticas/programa-de-apoio-a-edificios-mais-sustentaveis/resumo-do-programa-de-apoio-edificios-mais-sustentaveis.aspx [Accessed: 03.06.2021]

[96] Tariffs and electricity [online] Available at: https://www.erse.pt/en/activities/market-regulation/tariffs-and-prices-electricity/ [Accessed: 03.06.2021]

[97]www.oecdbetterlifeindex.org. OECD Better Life Index. [online] Available at: http://www.oecdbetterlifeindex.org/countries/portugal/#:~:text=Portuguese%20people%20earn%20USD%2025 [Accessed: 03.06.2021]

to data from Trading Economics. That's up from €1,144.61 in the previous period. This makes Portugal one of the lower-paying countries in the EU[98].

The national minimum wage in Portugal in 2019 is €600 per month. The minimum wage in Portugal is considerably lower than in some EU countries, where the national minimum salary is above €1,000. Portugal's minimum wage is in line with countries such as Slovenia, Greece and Malta[99].

By 2022 it is estimated the number of individuals in Portugal with a net worth of over five million US dollars will reach 5.65 thousand, an expected increase of nearly 1.1 thousand from 2017[100].

The figures released by the OECD also show that 11.3% of Portuguese with privately rented homes spend more than economists recommend - they spend more than 40% of their disposable income on housing, which exceeds the recommended effort rate.[101] Consumption per capita is 31% lower than the EU average at 2.1 toe, 4 700 kWh of which is electricity (15% below the EU average) (2019).[102]

Tarification

Electricity tariffs have been stable since 2013 and settled approximately at €11.5c/kWh for industrials and €21.7c/kWh for residential consumers in 2020 (Figure 25).[103]

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[98] Expat Guide to Portugal Expatica. Average salary and the minimum wage in Portugal Expatica. [online] Available at: https://www.expatica.com/pt/working/employment-law/minimum-wage-in-portugal-927429/. [Accessed: 03.06.2021]

[99] Expat Guide to Portugal Expatica. Average salary and the minimum wage in Portugal Expatica. [online] Available at: https://www.expatica.com/pt/working/employment-law/minimum-wage-in-portugal-927429/. [Accessed: 03.06.2021]

[100] Statista. Number of HNWIs Portugal 2012-2022. [online] Available at: https://www.statista.com/statistics/814401/number-of-high-net-worth-individuals-portugal/ [Accessed: 03.06.2021]

[101] idealista.pt/news. Portugal é o país com mais casas por habitante, mas 12,5% estão vazias. [online] Available at: https://www.idealista.pt/news/imobiliario/habitacao/2019/12/26/41927-portugal-e-o-pais-com-mais-casas-por-habitante-mas-12-5-estao-vazias [Accessed: 03.06.2021]

[102] www.enerdata.net. Portugal Energy Market Report Energy Market Research in Portugal. [online] Available at: https://www.enerdata.net/estore/country-profiles/portugal.html [Accessed: 03.06.2021]

[103] www.enerdata.net. Portugal Energy Market Report Energy Market Research in Portugal. [online] Available at: https://www.enerdata.net/estore/country-profiles/portugal.html [Accessed: 03.06.2021]

Group	Annual electricity consumption, kWh		Prices in € / kWh		
	Min	Max	Prices excluding taxes and fees	Prices excluding VAT and other recoverable taxes	Prices including all taxes
Group A	< 1 000		0.2024	0.3218	0.3862
Group B	≥ 1 000	< 2 500	0.1251	0.1920	0.2340
Group C	≥ 2 500	< 5 000	0.1139	0.1729	0.2120
Group D	≥ 5 000	< 15 000	0.1081	0.1641	0.2016
Group E	≥ 15 000		0.1028	0.1559	0.1917

Fig.25. *Electricity tariffs*[104]

Consumers can choose between three main types of contracts, which simulate different consumption behavior. The simple tariff: consumers pay a uniform price for energy, regardless of the time of day or the day of the week of use. Bi-hourly tariff: Here consumers pay different prices depending on the day and day of the week. Three-hour tariff: This is similar to the two-hour tariff, but with three different time slots.[105]

EDP is one of the utility companies that offers such tarification. For a system of 6.9 Kw the following prices are offered (Figure 26).

[104]ec.europa.eu. Database - Energy - Eurostat. [online] Available at: http://ec.europa.eu/eurostat/web/energy/data/database [Accessed: 03.06.2021]

[105]Prêmio Os Melhores Hoje da CGIP. Liberalização do mercado da energia em Portugal - uma visão geral. [online] Available at: https://www.osmelhoreshoje.pt/consumer-infos/liberalizacao-do-mercado-da-energia-em-portugal-uma-visao-geral/ [Accessed: 03.06.2021]

Tariff	€/kWh
Simple	0.1358
Weekly bi-schedule	0.1726
Daily bi-schedule	0.1726
Weekly tri-schedule	0.2757
Daily tri-schedule	0.2757

Fig.26. *Time-of-use tariffs*[106]

Tariffs differ depending on the power potential. In addition, prices slightly differ depending on the type of payment used. VAT is 23% in Portugal, and the various additional taxes make the country one of the most expensive to provide electricity. All consumers pay the network access tariff, regardless of whether they are in the regulated market or in the liberalized market. Access tariffs reflect the cost of infrastructures and all services used by all consumers in a collective manner. This tariff results from the sum of the global technical system operation tariff, the transmission network tariff, the distribution network tariffs and the supplier switching operation tariff. Consumers, who are still in the regulated market pay the energy tariff and the supply tariff, set by ERSE. In the liberalized market, each supplier defines freely the corresponding value, being in competition with other suppliers. The government is responsible to define VAT and other taxes, which are the same across the regulated and the liberalized market.[107]

[106] edp - eletricidade e gás no mercado livre. Tarifários de Eletricidade e Gás Natural para Particulares EDP. [online] Available at: https://www.edp.pt/particulares/energia/tarifarios/ [Accessed: 03.06.2021]

[107] Tariffs and Prices - ERSE [online] Available at: https://www.erse.pt/en/activities/market-regulation/tariffs-and-prices-electricity/ [Accessed: 03.06.2021]

Social factors

Private housing

In 2017, there were around 3.6 million classic residential buildings and 5.9 million dwellings in Portugal, which represent increases of 0.19% and 0.16%, in comparison to the year 2016[108]. Out of these 5.859 million houses spread throughout the Portuguese territory, approximately 12.5%, about 750 thousand, are empty.[109] In 2017, the median price of dwellings sales in Portugal was 932 €/m2, an increase of 7.6% compared to the the previous year. The median house price remained above the national value in the regions of Algarve (1 383 €/m2), Área Metropolitana de Lisboa (1 262 €/m2) and Região Autónoma da Madeira (1 126 €/m2). In 2016 36.8 percent of the Portuguese population lived in detached houses and 18.1 percent occupied semi-detached houses.[110]

25.2% of Portuguese people choose to rent a house[111]. In 2017, the median house rental value of the 84 383 new lease agreements registered in Portugal was 4.39 €/m2 . The median rent stood above the national value in the regions of Área Metropolitana de Lisboa (6.06 €/m2), Região Autónoma da Madeira (5.15 €/m2), Algarve (5.00 €/m2) and Área Metropolitana do Porto (4.58 €/m2).

In 2017 the House price index hit record, an increase in the average level of prices of traded dwellings, was significantly higher than the inflation rate, which is measured by the Consumer Price Index (CPI) change rate. Effectively, the average annual rate of change was +9.2% in 2017 (+2.1 p.p. vis-à-vis 2016), while the CPI annual change rate was +1.4% (+0.8 p.p. vis-à-vis 2016). By category, prices of already existing dwellings increased more intensely than that of the new dwellings (+10.4% and +5.6%, respectively). The prices continued to rise in the following years and during the year of

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[108] Estatísticas da Construção e Habitaçã. Instituto nacional de estatistica. Statistics Portugal. 2017

[109] idealista.pt/news. Portugal é o país com mais casas por habitante, mas 12,5% estão vazias. [online] Available at: https://www.idealista.pt/news/imobiliario/habitacao/2019/12/26/41927-portugal-e-o-pais-com-mais-casas-por-habitante-mas-12-5-estao-vazias. [Accessed: 03.06.2021]

[110] Statista. Housing conditions by dwelling type in Portugal 2016. [online] Available at: https://www.statista.com/statistics/536487/distribution-of-the-population-in-portugal-by-dwelling-type/ [Accessed: 03.06.2021]

[111] idealista.pt Only a quarter of Portuguese choose to rent. [online] idealista. Available at: https://www.idealista.pt/en/news/property-rent-portugal/2018/03/05/48-only-quarter-portuguese-choose-rent [Accessed: 03.06.2021]

2020, residential property prices in Portugal rose by 6.32% (6.56% in real terms) to a median price of €1,144 (US$1,381) per square meter (sq. m).

Technological factors

Stability of power supply

To evaluate the stability of power supply SAIDI index can be used. In case of Portugal Saidi index is calculated as the average duration of interruptions per exit point (min/exit point): the quotient of the overall duration of interruptions of the exit points over a specific period and the total number of exit points at the end of the period considered.[112] In Portugal, overall SAIDI only include low voltage. According to the historic data over the years the power supply has become more stable, over the period of 2014-2016 SAIDI index was equal to 70 (Figure 27).

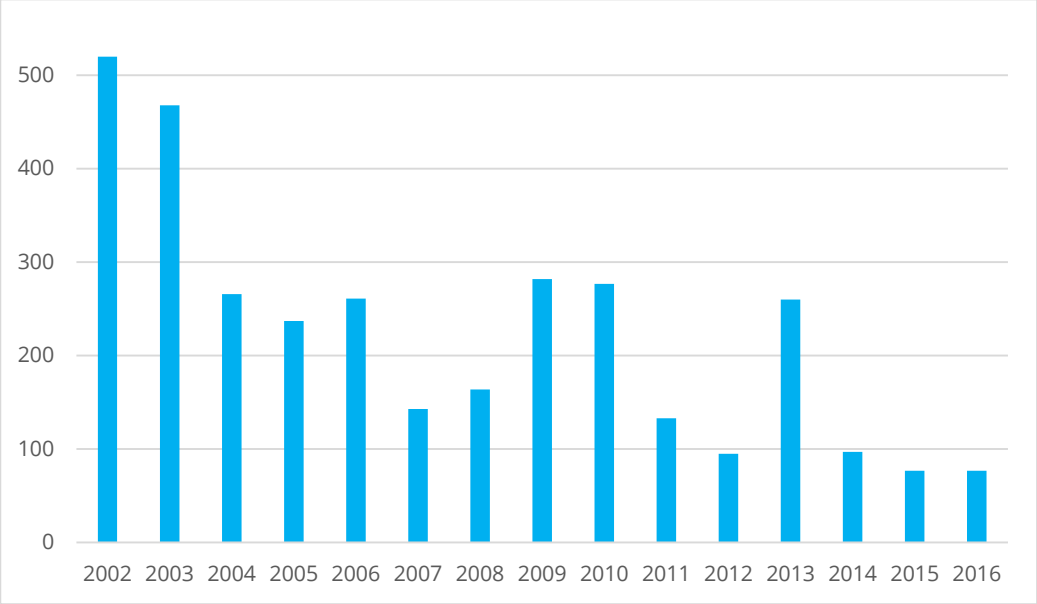

Fig.27. *Planned and unplanned SAIDI, including exceptional events, minutes per customer*[113]

[112]www.emissions-euets.com. System Average Interruption Duration Index (SAIDI) - Emissions-EUETS.com. [online] Available at: https://www.emissions-euets.com/internal-electricity-market-glossary/2069-system-average-interruption-duration-index-saidi [Accessed: 03.06.2021]

[113]www.emissions-euets.com. System Average Interruption Duration Index (SAIDI) - Emissions-EUETS.com. [online] Available at: https://www.emissions-euets.com/internal-electricity-market-glossary/2069-system-average-interruption-duration-index-saidi [Accessed: 03.06.2021]

Another index that can be used to assess the stability of power supply is the System Average Interruption Frequency Index (SAIFI index). Over the years of 2014-2016 the average number of interruptions per customer was equal to 2 (Figure 28).

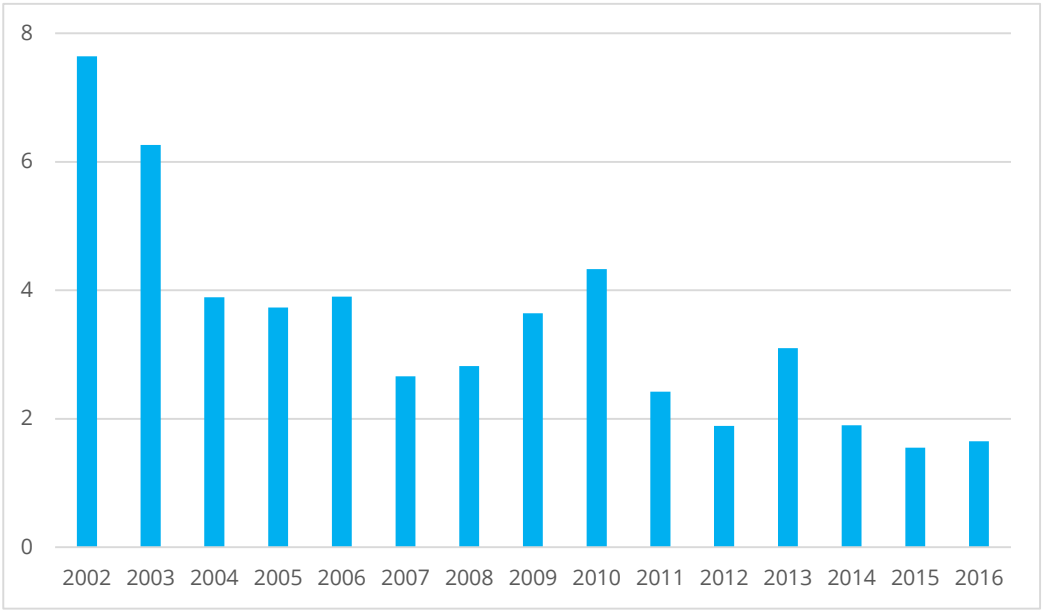

Fig.28. *Planned and unplanned SAIFI, including exceptional events, interruptions per customer*[114]

It should be noted that indicators representing the number of interruptions are not always easily comparable among countries. The reason for this is that the aggregation rules for interruptions differ across Europe. In some countries, all interruptions occurring during a specific defined time period are considered to be a single interruption.

Cold weather and telecommuting cause power outages in urban areas. EDP Distribuição says remote work is contributing to change in consumption pattern and leads to increase in power outages due to low voltage network is being overloaded. EDP Distribuição recorded interruptions in the supply

[114] www.emissions-euets.com. System Average Interruption Duration Index (SAIDI) - Emissions-EUETS.com. [online] Available at: https://www.emissions-euets.com/internal-electricity-market-glossary/2069-system-average-interruption-duration-index-saidi [Accessed: 03.06.2021]

of electricity. The company attributed these failures to the increase in consumption due to the drop in temperature and the increase in telework[115]. According to REN (the company that manages the electricity system) most of the power outages happen in winter when in order to warm houses electricity and natural gas are used actively by the citizens[116].

Power generation

In the April of 2021 the renewable incorporation in electricity generation was 58% (2136 GWh). In turn, fossil thermal power generation centers accounted for 42% (1544 GWh). The extent to which renewable sources are used varies significantly throughout the year. The power generation from fuel sources increases in the second and third quarters of the year.

Looking at the period of January-April 2021 17 942 GWh of electricity were generated in mainland Portugal, of which 75.1% were from renewable sources. Solar contributed 2.3%, Coal – 2%, Natural gas – 14.21%, Fossil cogeneration – 8.71%, Hydro -41.14, Wind - 25.73%, Bioenergy – 5.91%.

According to Mordor Intelligence[117], in 2018, out of total electricity generated by renewable sources, approximately 45% of the electricity was produced by hydropower in the country. The electricity produced in 2018 by hydropower was 13757 gigawatt-hour, which was almost two times higher than that generated in 2017, 7632 gigawatt-hour.

Portugal is on the way to minimize the share of electricity produced from fossil sources. One of the coal-fired plants have been already closed and other are going to be close by the end of the year

[115]Pplware. (2021). Problemas com eletricidade? Portugal com dificuldades no fornecimento. [online] Available at: https://pplware.sapo.pt/informacao/problemas-com-eletricidade-portugal-com-dificuldades-no-fornecimento/ [Accessed: 03.06.2021]

[116]PÚBLICO Reserva Federal reduz taxa de juro para 1,25 por cento. [online] PÚBLICO. Available at: https://www.publico.pt/2021/01/09/economia/noticia/frio-teletrabalho-provocam-falhas-electricidade-zonas-urbanas-194565 [Accessed: 03.06.2021]

[117] www.mordorintelligence.com. Portugal Renewable Energy Market Growth, Trends, and Forecast (2020 - 2025). [online] Available at: https://www.mordorintelligence.com/industry-reports/portugal-renewable-energy-market [Accessed: 03.06.2021]

2021.[118] Between the 24th and 28th of December 2020 Portugal managed to set a new record for using energy originating from non-carbon sources for 111 hours in a row. The information was provided to the Public by Redes Energéticas Nacionais (REN) in a statement. According to the statement, this is a new record, made possible thanks to the "reduction in consumption during the Christmas period, associated with high wind and water availability". "The previous maximum period without conventional thermal had occurred in April 2018, totaling 88 hours. This year, the contribution of coal to supply electricity consumption was 4%, when it usually exceeded 20%" (Figure 29, 30, 31).[119]

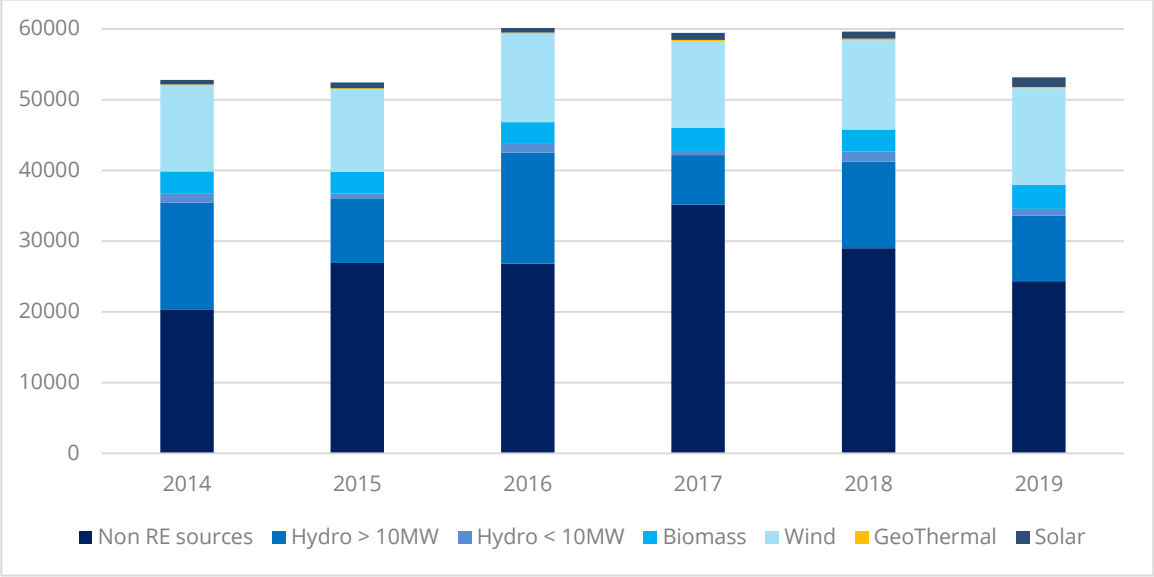

Fig.29. *Power generation in Portugal, 2014-2019*[120]

[118]www.portugal.gov.pt. Sines receberá o maior investimento estrangeiro das últimas décadas. [online] Available at: https://www.portugal.gov.pt/pt/gc22/comunicacao/noticia?i=sines-recebera-o-maior-investimento-estrangeiro-das-ultimas-decadas [Accessed: 03.06.2021]

[119] Pplware. (2021). Portugal bate recorde na produção de energia sem carvão. [online] Available at: https://pplware.sapo.pt/planeta/portugal-bate-recorde-na-producao-de-energia-sem-carvao/ [Accessed: 03.06.2021]

[120] Pplware. (2021). Portugal bate recorde na produção de energia sem carvão. [online] Available at: https://pplware.sapo.pt/planeta/portugal-bate-recorde-na-producao-de-energia-sem-carvao/ [Accessed: 03.06.2021]

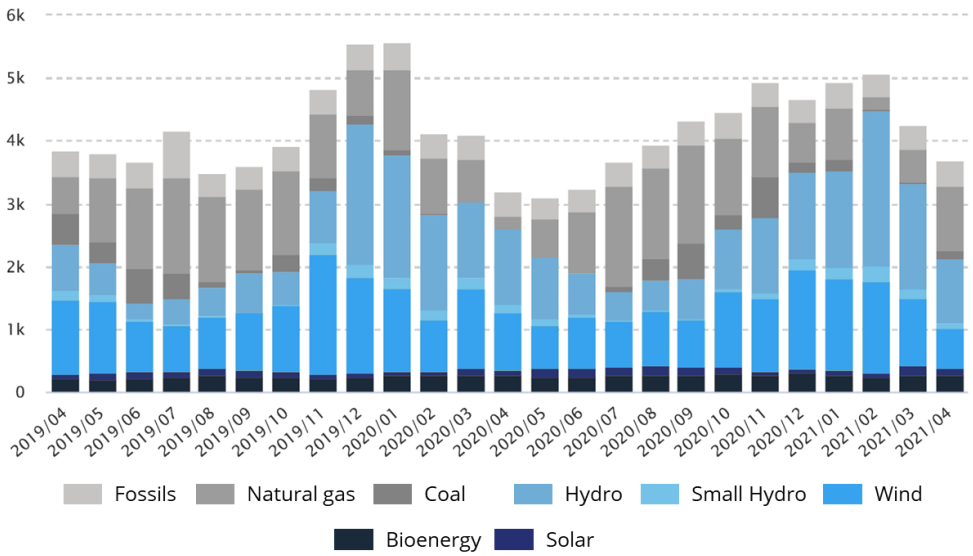

Fig.30. *Portugal power generation sources*[121]

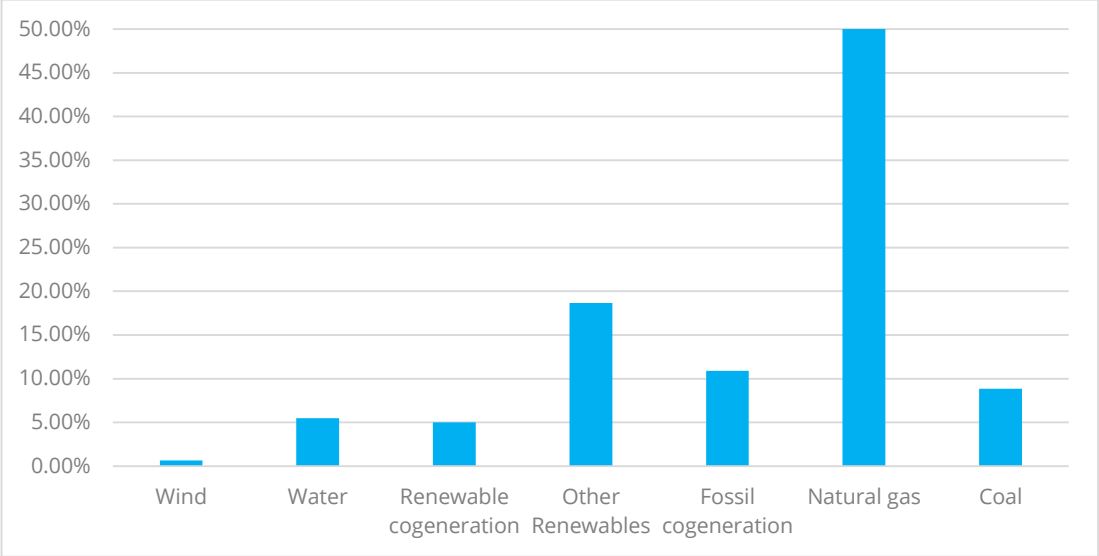

Fig.31. *EDP power generation sources*[122]

[121] Apren.pt. (2019). APREN - Produção. [online] Available at: https://www.apren.pt/pt/energias-renovaveis/producao. [Accessed: 03.06.2021]

[122] edp - eletricidade e gás no mercado livre. Origem da Energia - Particulares EDP. [online] Available at: https://www.edp.pt/origem-energia/ [Accessed: 03.06.2021]

Environmental factors

Solar generation potential

Portugal has one of the highest solar potential in the whole Europe (only Cyprus has higher values), with values reaching 70% more than those of Germany. [123] It has approximately three thousand hours of sunshine per year[124].

Theoretical PV Potential or Global horizontal irradiation measures the long-term amount of solar resource available on a horizontal surface on Earth. Average Global horizontal irradiation equals 4.566 kWh/m^2. GHI varies from 3.41 to 5.08 kWh/m^2 in different territories and estimates more than 4.4 kWh/m^2 on 73,2% of areas in Portugal[125]. Global Horizontal Irradiance annual variability in Portugal is estimated to be from 1.6% to 3.0%, for the locations with higher GHI availability and from 3.5% to 5.0% for the remaining locations[126]. The value of Solar Radiation has low fluctuation during the year, therefore, there is low seasonality in solar photovoltaic output (Figure 32, 33, 34).

Practical PV Potential Photovoltaic power output of a PV system or PVOUT shows the long-term power output produced by a utility scale installation with fixed-mounted, monofacial c-Si modules with optimum tilt. In ranking of countries, which is based on zonal statistics of PVOUT Portugal is on the 109th place and on the 4th place in Europe after Cyprus, Malta and Spain, it means, that Portugal is one of the best countries in Europe for solar panels' and energy storages' installation.[127]

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[123]*E.Proença* Photovoltaic solar energy in Portugal state-of-the-art and perspectives of development//[online resource] https://www.roedl.com/insights/renewable-energy-portugal (access: 25.05.21) https://fenix.tecnico.ulisboa.pt

[124]Renewable energy in Portugal: Rödl & Partner/ Insights//[online resource] https://www.roedl.com/insights/renewable-energy-portugal (access: 25.05.21)

[125] Portugal: Global Solar Atlas/ Project detail//[online resourse] https://globalsolaratlas.info (access: 25.05.21)

[126]*A.Cavaco, H.Silva, P. Canhoto, S.P. Neves, J. Neto, M. Collares-Perreira* Annual Average Value of Solar Radiation and its Variability in Portugal. December 2016[online resource] –Access mode:https://www.researchgate.net (access:data 25.05.21)

[127] Global Photovoltaic Power Potential by Country: Global Solar Atlas //[online resourse] https://globalsolaratlas.info/global-pv-potential-study (access: 25.05.21)

Average practical PV potential equals 4.316 kWh/ kWp. PVOUT varies from 3.11 to 4.72kWh/kWp, and estimates more than 4.40 kWh/kWp on 39.3% of areas in Portugal (Figure 35, 36, 37).

Fig.32. *GHI in Portugal*[128]

[128] Portugal: Global Solar Atlas/ Map and data downloads//[online resource] https://globalsolaratlas.info/download/portugal (access: 25.05.21)

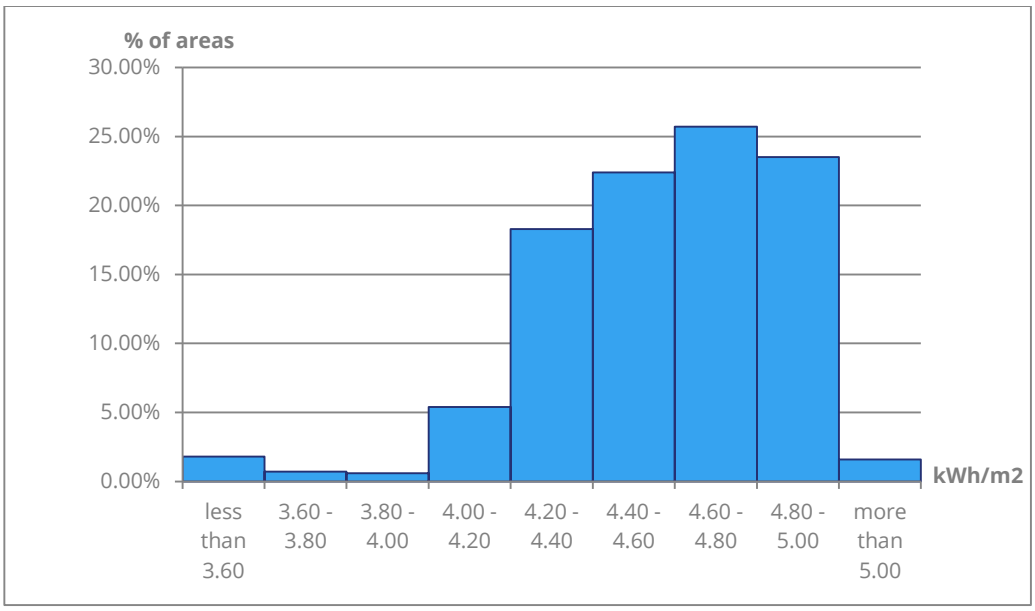

Fig.33. *Distribution of Global horizontal irradiation*[129]

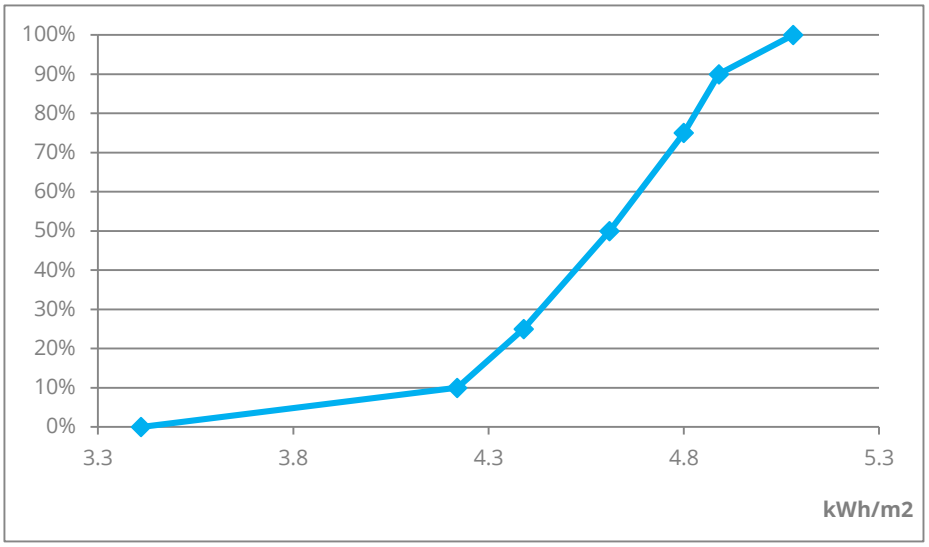

Fig.34. *Statistics of Global horizontal irradiation*[130]

[129] Portugal: Global Solar Atlas/ Project detail//[online resource] https://globalsolaratlas.info (access: 25.05.21)

[130] Portugal: Global Solar Atlas/ Project detail//[online resource] https://globalsolaratlas.info (access: 25.05.21)

Fig.35. *PVOUT in Portugal*[131]

[131] Portugal: Global Solar Atlas/ Map and data downloads//[online resource] https://globalsolaratlas.info/download/portugal (access: 25.05.21)

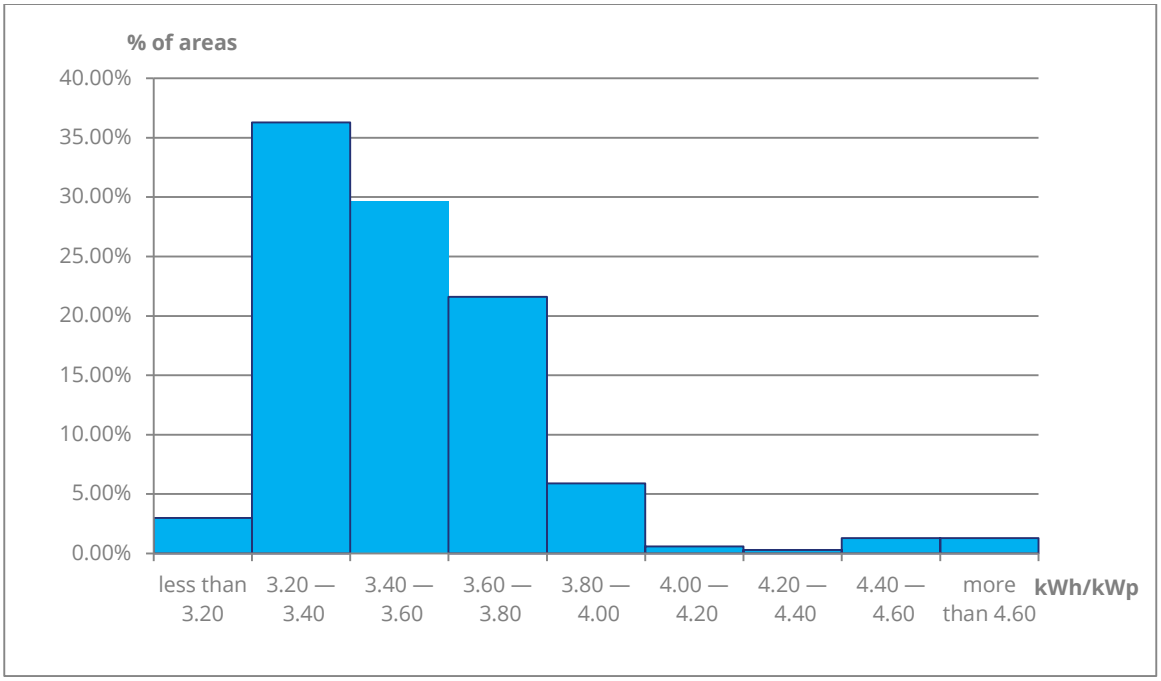

Fig.36. *Distribution of Specific photovoltaic power output*[132]

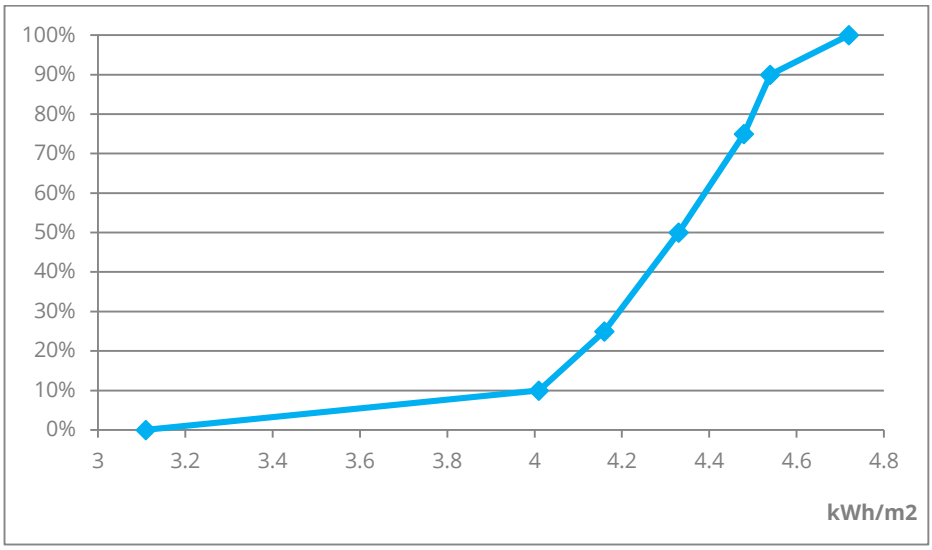

Fig.37. *Statistics of Specific photovoltaic power output*[133]

[132] Portugal: Global Solar Atlas/ Project detail//[online resourse] https://globalsolaratlas.info (access: 25.05.21)

[133] Portugal: Global Solar Atlas/ Project detail//[online resourse] https://globalsolaratlas.info (access: 25.05.21)

Legal factors

Previously, self-consuming renewable energy producers had to register with the Direção-Geral de Energia e Geologia DGEG. Since 1 January 2020, no prior notification is required for installations up to 350W. Depending on the size of the projects, the conditions are as follows: self-consumption photovoltaic installations above 350W have to be notified to the DGEG; projects above 30kW are subject to registration with the DGEG and to obtaining a certificate of operation; 1 MW installations need a license for production and operation[134].

In 2019 The Portuguese Government reformulated the legal regime of production units for self-consumption, trying to simplify the licensing and the rules for those who want to produce their own electricity.[135]

The Government published in the Diário da República the new legal regime for the production of renewable energy for self-consumption, with a decree-law that covers all the rights and duties of citizens and entities that intend to invest in small solar installations. The new rules took effect on January 1 2020.

To install panels up to 350 watts, the consumer-producer does not need any registration. Installations between 350 watts and 30 kW are subject to prior notification to the Directorate-General for Energy and Geology. Projects from 30 kW to 1 megawatt (MW) need to register with DGEG and obtain an exploration certificate. Units with power above 1 MW need a production and exploration license. The rules that were in force before the reform obliged all producers (even those with less than 350 w) prior notification to DGEG. Only installations with more than 30 kW (equivalent to more than 100 solar panels) will need civil liability insurance.

According to the new rules, collective self-consumption units (for example, in a condominium or shared by a group of companies in an industrial park) are required to have a telecount (that is, a smart meter that communicates in real time with the network operator production and

[134] SOLVasto. (2020). What changes in 2020 for photovoltaic self-consumption in Portugal?l I SOLVasto. [online] Available at: https://solvasto.pt/self-consumption-4/?lang=en [Accessed: 03.06.2021]

[135]Há novas regras para produzir energia solar em casa. Eis o que tem de saber se quer investir [online] Available at: https://amp.expresso.pt/economia/2019-10-25-Ha-novas-regras-para-produzir-energia-solar-em-casa.-Eis-o-que-tem-de-saber-se-quer-investir [Accessed: 03.06.2021]

consumption data). This tele-counting obligation is extended to individuals who have units with more than 4 kW (installations with 16 traditional 250 kW panels will already be subject to this).

Systems with a power between 20.7 kW and 1 MW are subject to inspections every 10 years. Inspections above 1 MW will be carried out every eight years. If there is a change in the holder of the electricity supply contract to which the production unit is associated, this must be communicated on the DGEG portal.[136]

Systems with an installed power greater than 350W are mandatorily performed by a technicians responsible for the execution of electrical installations, (Law No. 14/2015, of 16 February; Decree-Law No. 96/2017, of 10 August). Installer or the responsible technician must ensure that the equipment to be installed is certified. Technical costs are presented below (Figure 38).

Procedure	Power (kW)	Registration with electricity supply to the grid	Registration without electricity supply to the grid
Examination of the application for registration	≤ 30 kW	Free	Free
	> 30 kW and ≤ 100 kW	€ 200	€ 140
	> 100 kW and ≤ 250 kW	€ 400	€ 240
	> 250 kW and ≤ 1000 kW	€ 600	€ 400
Examination of the application for an exploration certificate with DGEG inspection	> 30 kW and ≤ 250 kW	€ 240	€ 240
	> 250 kW and ≤ 1000 kW	€ 360	€ 360

Fig.38. *Registration of a PV system*[137]

[136] Doutor Finanças - Cuidamos da sua saúde financeira. (2020). Quer produzir energia solar em casa? Conheça as regras. [online] Available at: https://www.doutorfinancas.pt/vida-e-familia/habitacao/quer-produzir-energia-solar-em-casa-conheca-as-novas-regras-de-2020/ [Accessed: 03.06.2021]

[137] Doutor Finanças - Cuidamos da sua saúde financeira. (2020). Quer produzir energia solar em casa? Conheça as regras. [online] Available at: https://www.doutorfinancas.pt/vida-e-familia/habitacao/quer-produzir-energia-solar-em-casa-conheca-as-novas-regras-de-2020/ [Accessed: 03.06.2021]

Market players

Direct competition

Portugese RESS market is limited by few solar panels integrators who have partnerships with energy storage manufacturers and distribute their products. Their core products are PV, water heat pumps (sometimes with solar heating system) and air conditioning, RESS systems are not just supplementary goods. Below is presented the list of companies present on the portugese market and their product offerings (Figure 39):

Name	Offers	RESS USED
EDP	Solar Mobile App EV charging	LG CHEM
Solar-algarve	Solar systems RESS distribution HEAT pumps Cooling	BYD Victron MultiPlus-II
solarpower	EV chargers Pool Heater Home cooler	BatterX System from VisionUPS BYD
Eaton	Solar systems RESS production	xStorage
Solar2power	Solar systems RESS distribution	BYD B-box

Fig.39. *Solar market players*

Source: custom table

EDP, one the biggest energy companies in the Portugal, is offering solar systems supported by energy storage. Tesla has chosen Portugal as one of the markets of its focus. BYD battery box is sold on the market via distributors.

Analysis of companies supplying products related to solar systems shows that solar kits with cheap accumulators are offered on the market. This small squared battery is a technology that precedes the smart battery technology market. The availability of such offering combined with limited access to smart energy storage can lead to two hypotheses. Firstly, the target audience does not have the

sufficient purchasing power for smart batteries. Secondly, the penetration of technology similar to Volts products is not yet notable.

There are several energy storage start-ups in the Portugal, one of them are Ampere energy and Meterboost. Ampere energy offers a residential energy storage system with a unique design and a software system for energy management. Meterboost is a company that has already got traction on the market and has attracted investment for further expansion. Company is analyzed in detail below.

Meterboost, a Mafra company, is a local producer of RESS. It gives a ten-year warranty and promises savings on the monthly bill that can reach 100%.

The first prototype appeared in 2017 and a year and a half later the first lithium battery for photovoltaic power plants for residential use arrived on the market. The company promotes its systems as a product made in Portugal, "with quality guarantee and competitive prices". Focused mainly on the domestic segment and with the expansion hampered by the pandemic, the company founded and led by Sérgio Rodrigues will close 2020 with 10 megawatts of installed power, operations in nine countries, namely in Africa, in addition to Spain, and sales of 1 million euros. Value that the management wants to double in 2021. In 2021 the company plans to enter into the industrial segment. The management's goal is to reach 2023 with a turnover of 8 million euros.

The company was born in March 2019, in Mafra, in a partnership between Sérgio Rodrigues and Luís Pereira, who has more than 20 years of experience in the solar panels sector, and today has 15 employees. It should end the year with 1 million euros in revenue, half of what was forecast - the pandemic came to delay the expansion. "In February, we were in Madrid, at Genera, the most important fair in the sector, and we had excellent expectations for growth. But with covid-19, we were practically until the end of July unable to establish contacts. The fact that this is a market "dominated" by such companies as Panasonic, Samsung, LG or Sony, among others, also did not help." – business owner says.

In addition, he states that even though the product is made in Portugal they have great difficulty in showing customers that it is an article developed and produced in Portugal. Company need to bring customers to the factory so that they can see for themselves.[138]

In the spring 2020, company developed its own BMS (Battery Management System). From January 2021, BMS was planned to be produced in Mafra. Before this moment the company imported it from Asia. Company tries to integrate as many national or European components as possible. Battery cells could not be supplied from European companies, so they are imported from china. Meterboost had the support and know-how in this R&D process from the founder of ISA - Intelligent Sensing Anyway, a world leader in telemetry in the energy sector. Basílio Simões, also known for his business angel activity, meanwhile, invested in the company, taking a minority position in the capital, which "will help support the expected growth and expansion". Expansion on the way. Until the end of 2021, Meterboost will invest around half a million in R&D and new product lines, with a view to the corporate and industrial business. Sérgio Rodrigues hopes to double the team, reaching 30 employees, as well as sales. A goal that he maintains for the next two years, hoping to reach the end of 2023 with a turnover of eight million euros.

PV integrators

Portugal solar energy market is expected to grow at a CAGR of more than 8 % during the forecast period 2020-2025[139]. The Portugal solar energy market is moderately consolidated. Some of the key players in the market include Voltalia SA, Iberdrola S.A., SGS SA, Acciona SA, and Gesto Energia S.A.[140] The Portugal renewable energy market is fragmented. Some of key players in this

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[138] Baterias de lítio 100% made in Portugal à conquista da indústria [online] Available at: https://www.dinheirovivo.pt/empresas/amp/baterias-de-litio-100-made-in-portugal-a-conquista-da-industria-12956881.html [Accessed: 03.06.2021]

[139]https://ksusentinel.com/2021/03/06/portugal-solar-energy-market-industry-analysis-2020-overview-by-top-players-voltalia-sa-iberdrola-s-a-sgs-sa-acciona-sa/ [online] Available at: https://www.dinheirovivo.pt/empresas/amp/baterias-de-litio-100-made-in-portugal-a-conquista-da-industria-12956881.html [Accessed: 03.06.2021]

[140] https://ksusentinel.com/2021/03/06/portugal-solar-energy-market-industry-analysis-2020-overview-by-top-players-voltalia-sa-iberdrola-s-a-sgs-sa-acciona-sa/ [online] Available at: https://www.dinheirovivo.pt/empresas/amp/baterias-de-litio-100-made-in-portugal-a-conquista-da-industria-12956881.html [Accessed: 03.06.2021]

market include Acciona SA, Energias de Portugal (EDP Group), Iberdrola SA, Brookfield Renewable Partners LP, and Ciel et Terre International SAS[141].

IKEA, through its partnership with Contigo Energía, offers solar systems installation. For all of its systems IKEA gives 5 year warranty. For 680 Wp system base price starts from € 1,690 incl. VAT. For 2kWp system base price starts from € 3,400 incl. VAT. For 3.4kWp system base price starts from € 4,590 incl. VAT. Contigo Energía offers a 15% discount to the IKEA family members. According to company web-site, the entire purchase process can take 1 to 2 months.

Contigo Energia´s offer does not include batteries. A decision was made to exclude it from the portfolio. Contigo Energía has decided to wait until batteries will become more accessible and, thus, guaranteeing a faster return on investment. For this reason, Contigo Energía included a battery-compatible inverter in its offering, for those who are interested in investing in a battery in the future.[142]

Iberdolla is present on the residential photovoltaic market and offers its own installation. The fact that energy companies are diversifying their portfolios and entering residential markets shows that there is demand for such products. It is only a matter of time till Iberdola will add to their offering a battery system that is designed to support solar systems.[143]

Utility market structure

There are almost 25 companies offering electricity products and services to Portuguese consumers (Figure 40). In the segment of domestic customers measured by consumption, EDP remains the main electricity supplier, with a share of around 76%. Iberdrola and Endesa follow in second and third place in terms of household customer consumption, with 6.5% and 6.3%, respectively. Galp is the fourth company with a market share of over 5%. GN Fenosa, Goldenergy and PH are other major players, while the rest of the electricity suppliers do not yet play an important

[141] www.mordorintelligence.com. Portugal Renewable Energy Market Growth, Trends, and Forecast (2020 - 2025). [online] Available at: https://www.mordorintelligence.com/industry-reports/portugal-renewable-energy-market. [Accessed: 03.06.2021]

[142] www.ikea.com. Painéis Solares SOLSTRÅLE. [online] Available at: https://www.ikea.com/pt/pt/product-guides/energy-services/solar/ [Accessed: 03.06.2021]

[143] www.iberdrola.pt. Energia Solar para a sua Casa - Smart Solar Iberdrola. [online] Available at: https://www.iberdrola.pt/casa/energia-solar/smart-solar [Accessed: 03.06.2021]

role in the market.[144] Portugal has the second highest rate of switching electricity suppliers in Europe.[145] It is worth mentioning that the total number of registered electricity traders is 99.[146]

At the moment Endesa has half a million customers in Portugal and wants to continue to increase its market share in the country in a sustained manner. According to company CEO, Portugal is a key market for the development of business and company has ambitious goals for the energy transition. Endesa is prepared to increase its renewable power in Portugal. Company has already won a 99 MW lot at the 2020 solar auction. Company has several partnerships in Portugal, with Hyperion Endesa are developing a project of 257 MW in Divor, Évora. Company plans to support the project with batteries that will provide flexibility to the electrical system.[147]

[144]Prêmio Os Melhores Hoje da CGIP. Quotas de mercado das principais empresas de electricidade. [online] Available at: https://www.osmelhoreshoje.pt/consumer-infos/quotas-de-mercado-das-principais-empresas-de-electricidade-em-portugal/ [Accessed: 03.06.2021]

[145] www.electricchoice.com. Energy Deregulation Around the World: A Comprehensive Guide. [online] Available at: https://www.electricchoice.com/blog/energy-deregulation-world/. [Accessed: 03.06.2021]

[146]www.dgeg.gov.pt. Comercializadores de Eletricidade em Regime de Mercado. [online] Available at: https://www.dgeg.gov.pt/pt/areas-setoriais/energia/energia-eletrica/servicos-e-redes/comercializadores-de-eletricidade-em-regime-de-mercado/ [Accessed: 03.06.2021]

[147]Jornal Expresso. Endesa quer mais visibilidade sobre planos do Governo para a energia solar e hidrogénio. [online] Available at: https://expresso.pt/economia/2021-02-24-Endesa-quer-mais-visibilidade-sobre-planos-do-Governo-para-a-energia-solar-e-hidrogenio [Accessed: 03.06.2021]

Electricity traders (Comercializadores de Eletricidade de Último Recurso)	Marketing area
Cooperativa Eléctrica de Vale D'Este	Municipality of Vila Nova de Famalicão - Parishes of Nine, St Eulália, Jesufrei, Lemenhe, Mouquim, Louro, Outiz, Gondifelos and Cavalões Barcelos Municipality - Parishes of Silveiros, Monte de Fralães, Viatodos, Grimancelos and Minhotães
Cooperativa Eléctrica de Vilarinho, C.R.L.	Parish of Vilarinho (Santo Tirso Municipality)
Cooperativa Eléctrica de Loureiro, C.R.L.	Vila de Loureiro, Oliveira de Azeméis Municipality
Cooproriz - Cooperativa de Abastecimento de Energia Eléctrica, CRL.	Parish of Roriz and a part of the parish of S. Mamede de Negrelos, both from the Municipality of Santo Tirso
A Eléctrica Moreira de Cónegos, CRL	Parish of Moreira de Cónegos
A CELER - Cooperativa de Electrificação de Rebordosa, CRL	Parish of Rebordosa
Casa do Povo de Valongo do Vouga	Parish of Valongo do Vouga - Municipality of Águeda
Junta de Freguesia de Cortes do Meio	Cortes do Meio and Cortes de Baixo parish places
Cooperativa Electrificação A Lord, CRL	Parish of Lordelo
Cooperativa Eléctrica S. Simão de Novais	Parishes of Novais, Ruivães, Carreira, Bente, Seide and Part of Landim and Castelões, in the Municipality of Vila Nova de Famalicão
EDP Serviço Universal	All other continental territory not indicated in the previous lines

Fig.40. *Last resort electricity traders*[148]

The ordinary regime has been operating on a competition basis since 2007, after the implementation of MIBEL (Iberian Electricity Market). Since then, generation activities were liberalized and plants began to offer their energy on a common, integrated Iberian energy platform. The markets comprised in MIBEL are managed by the Iberian Energy Market Operator. The Portuguese Center (OMIP) is responsible for managing the forward market.[149] There is a free market

[148]www.dgeg.gov.pt. Comercializadores de Eletricidade de Último Recurso. [online] Available at: https://www.dgeg.gov.pt/pt/areas-setoriais/energia/energia-eletrica/servicos-e-redes/comercializadores-de-eletricidade-de-ultimo-recurso/ [Accessed: 03.06.2021]

[149]EDP Portugal. Energy sector in Portugal. [online] Available at: https://portugal.edp.com/en/edp-portugal/energy-sector-portugal#hydric-and-thermal-generation [Accessed: 03.06.2021]

regime for supplying electricity to end consumers. Retail supply only requires registration with the DGEG. Registration must be confirmed by the DGEG but is considered tacitly approved if there is no decision within 30 days.[150]

Utilities' RE agenda

In 2018, Spanish utility Iberdrola announced to build three new dams and power plants in Portugal. The dams are expected to be located on the Tâmega and the Torno rivers of the larger Douro River, which rises in Spain and flows across northern Portugal to the Atlantic Ocean. The projects are expected to have a total capacity of 1158 MW and are likely to start operations by the end of 2023. In 2019, Iberdrola entered Portugal's solar market with 149 megawatts (MW) of solar projects.

EDP is actively investing in the development of RE industry. According to Spanish press [151] "The pioneer of floating solar power plants, French company Ciel & Terre (C&T) International has collaborated with Portuguese energy firm EDP (Energias de Portugal) Group to design and build the first floating solar project at an existing hydro-electric power station at a dam located at the mouth of Rabagão river in Montalegre, Portugal. Working with EDP subsidiaries, C&T developed a 220kWp floating solar power plant, using 840 solar modules on its 'Hydrelio' mounting platform, occupying an area of around 2500m2 and cost around €450,000.

Threat of substitutes

Supply to the grid

In the past there were support mechanisms for renewable energy based on feed-in-tariffs, tax benefits and investment subsidies. As part of the financial assistance plan, support mechanisms for

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[150] signon.thomsonreuters.com. Practical Law UK Signon. [online] Available at: https://uk.practicallaw.thomsonreuters.com/6-564-1565?transitionType=Default&contextData=(sc.Default)&firstPage=true. [Accessed: 03.06.2021]

[151] PV Tech. (2017). First ever hydro-electric and floating solar project operating in Portugal. [online] Available at: https://www.pv-tech.org/first-ever-hydro-electric-and-floating-solar-project-operating-in-portugal/ [Accessed: 03.06.2021]

electricity generation were reviewed. Currently there are no such support mechanisms, except for new or experimental technology (such as offshore wind and wave energy) and small cogeneration.[152]

Legal regime still allows families with production units for self-consumption to sell surplus energy to the grid that they do not consume, but there is no official mechanism that supports such activities. The selling price is freely fixed between small producers and the traders who contract the purchase of energy. The regime that was in force before October 2019 also allowed it, but with a pre-defined price that is equivalent to 90% of the wholesale price of electricity in the Iberian market (a ceiling that discourages over-dimensioned installations).[153]

In order to supply electricity to the grid household owner needs to meet certain requirement. A net meter needs to be put in place. After that a contract should be renegotiated with the electricity producer. After these stages are completed solar system owner need to contact electricity companies and set a contract for selling electricity. Average sale price is 0.035 € per KWh or less.[154]

In Portugal, self-producers can inject electricity into the grid. To receive the funds for electricity supply system owners, need to follow official procedure and receive a compensation contract.

3.3 Analysis of Luxembourg market

Political factors

State RE agenda

On February 27 2019 the Minister of the Environment, Climate and Sustainable Development, Carole Dieschbourg, and the Minister of Energy, Claude Turmes, presented the

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[152]signon.thomsonreuters.com. Practical Law UK Signon. [online] Available at: https://uk.practicallaw.thomsonreuters.com/6-564-1565?transitionType=Default&contextData=(sc.Default)&firstPage=true. [Accessed: 03.06.2021]

[153]Há novas regras para produzir energia solar em casa. Eis o que tem de saber se quer investir [online] Available at: https://amp.expresso.pt/economia/2019-10-25-Ha-novas-regras-para-produzir-energia-solar-em-casa.-Eis-o-que-tem-de-saber-se-quer-investir [Accessed: 03.06.2021]

[154]Pedro Andersson. (2021). Como faço para vender a eletricidade dos meus painéis solares? [online] Available at: https://contaspoupanca.pt/2021/05/06/como-faco-para-vender-a-eletricidade-dos-meus-paineis-solares/ [Accessed: 03.06.2021]

objectives and guidelines of the the Climate and Energy Plan. This document defines Luxembourg's objectives in terms of reducing renewable CO2 and energy efficiency by 2030. The objectives stated:[155]

- National climate objective: -50% CO2 (in comparison to 2005)
- Development of a law regulating activities affecting climate change
- Increasing share of the renewable sources in final consumption to 25%
- Introduction of tenders for large scale photovoltaic stations
- Renovation of energy system
- Reaching 40 to 44 % energy efficiency
- Focus on the development of electric mobility

In the field of renewables the following actions will be taken:

- Support of wind turbine stations
- Support of photovoltaic systems
- Development of geothermal energy

On the way to improving the regional energy status the following initiative were introduced by the government:[156]

- 2016 - Luxembourg Green Exchange (LGX), the first global green bonds listing platform is launched.
- 2015 - Climate Finance Task Force is launched with the primary aim of developing initiatives in the field of green and sustainable finance.
- 2017 - Climate Finance Accelerator which offers technical support for investment fund managers wishing to invest in innovative projects having a positive impact on the climate

[155]gouvernement.lu. (2018). Toutes les actualités. [online] Available at: https://gouvernement.lu/fr/actualites/toutes_actualites.gouv_mea%2Bfr%2Bactualites%2Barticle%2B2018%2B02-fevrier%2B27-pnec.html [Accessed: 03.06.2021]

[156]gouvernement.lu. (2017). Dossiers. [online] Available at: https://gouvernement.lu/fr/dossiers.gouv_mfin%2Bfr%2Bdossiers%2B2018%2Bfinance-verte-durable.html [Accessed: 03.06.2021]

State support

Several subsidies programs are available in Luxembourg for photovoltaic solar panels. Currently government offers a financial aid for the purchase of the following products:

- Photovoltaic panels and fixing rails
- Inverter and DC and AC electrical wiring directly linked to the photovoltaic installation
- Peripheral equipment (bidirectional meter, electrical protections, presentation panel)

State grants up to 20% of the investment in a solar system, maximum amount 350 euros per kW of peak power (maximum 30 kWp). Before the year 2021 the maximum amount was 500 euros per kW of peak power.[157] The subsidy does not cover installation costs.

In addition, there is the Neistart Lëtzebuerg program that encourages households to install PVs and sell electricity to the grid with a premium price. The duration of the program is 15 years. The program enables individuals to apply for $500 subsidy.[158]

Municipalities (local authorities) may also profit from a state support equal to 15% of the investment costs in solar systems with a maximum of 900 Euro per kWp. A prior approval by the Ministery of Environment must be required[159].

In Luxembourg certain measures are taken in order to support the energy storage industry with 30% cost compensation (excluding VAT) of the study in the field of energy storage (solar battery). In addition, there is 1500 euros compensation for an installation of an energy storage system combined with a photovoltaic system (self-consumption of the energy produced) and an intelligent charging infrastructure for electric vehicles. Only valid for the combination of the 3 installations.

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[157]myenergy. Photovoltaïque. [online] Available at: https://www.myenergy.lu/fr/communes/soutien-financier/vous-souhaitez-beneficier-d-une-aide-a-l-investissement/photovoltaique [Accessed: 03.06.2021]

[158] myenergy. Einspeisetarife und Beihilfen. [online] Available at: https://www.myenergy.lu/de/cleversolar/private-anlagen/einspeisetarife-beihilfen [Accessed: 03.06.2021]

[159]www.erg.lu. Services. [online] Available at: http://www.erg.lu/English/Activities/Eco-Energy/Photovoltaics/Financial_supports/Financial_supports.htm [Accessed: 03.06.2021]

Economic factors

Purchasing power

The number of people living in households declaring themselves unable to meet unforeseen financial expenses decreases over time and reached 16,8% in 2019 from 19,7% in 2018.

Median disposable income in 2018 is 41885 euros (Figure 41), Gini coefficient is 0.318. Purchasing power parity in 2019 is 0.847, in 2020 is 0.864 (National currency units/US dollar). GDP per capita in 2019 is $114704.6. Big Mac Index in 2020 is 5,16.

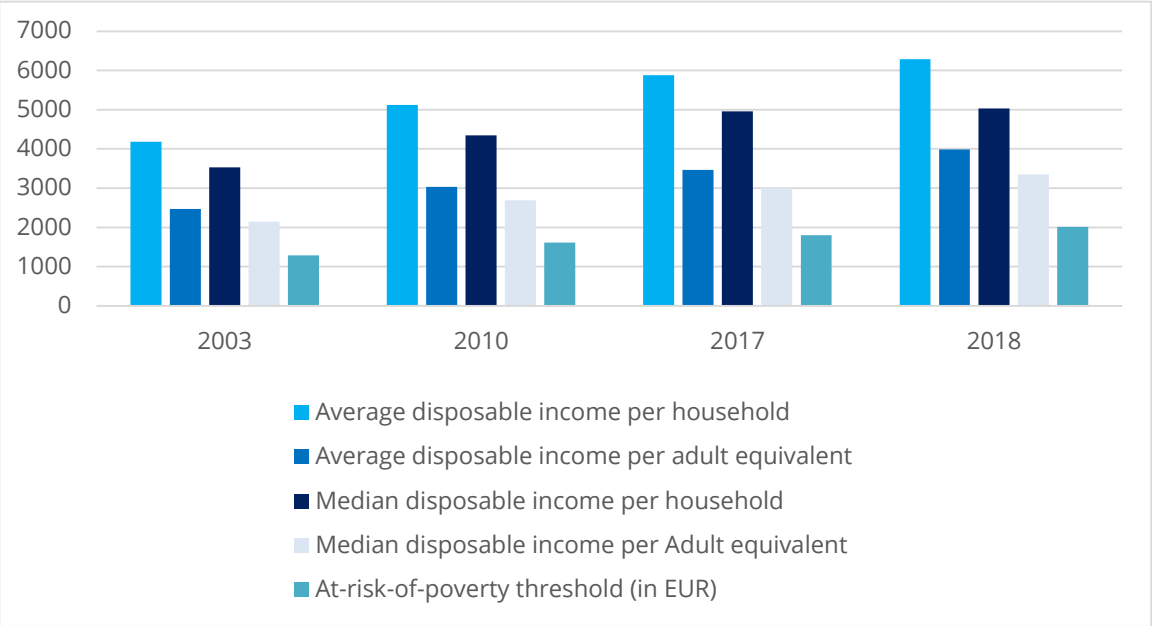

Fig.41. *Purchasing power data*[160]

Electricity tariffs

In Luxembourg private households for 1000 kWh would pay on average 330 euros. The price varies by electricity supplier and is affected by the amount of yearly consumed energy. As yearly consumption grows the base price per kWh significantly decreases. Among other factors that affect

[160]Luxembourg in zahlem[online] Available at: https://statistiques.public.lu/catalogue-publications/luxembourg-en-chiffres/2020/luxemburg-zahlen.pdf [Accessed: 03.06.2021]

final electricity prices are taxes and fixed costs which make a significant contribution and can amount up to 50% of the yearly bill (Figure 42, 43).

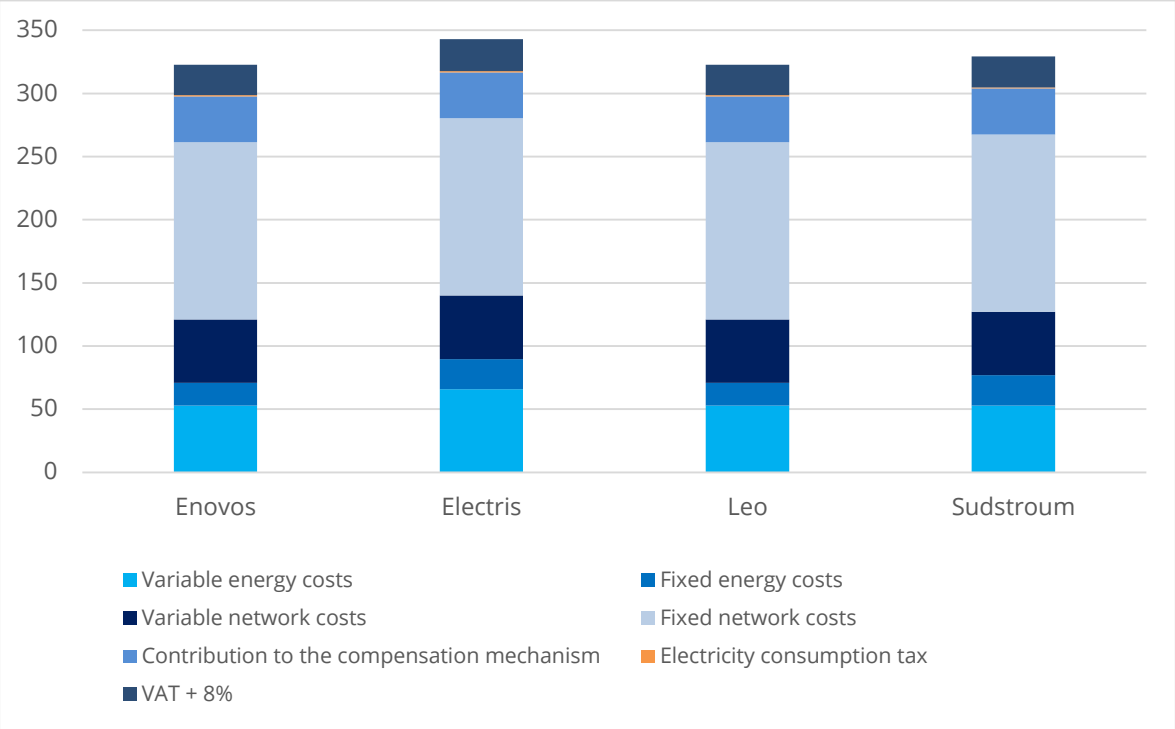

Fig.42. *Electricity prices*[161]

[161] www.calculix.lu. Calculix Private - www.calculix.lu. [online] Available at: https://www.calculix.lu/fr/calculix-public-private#/product-details/ [Accessed: 03.06.2021]

Group	Annual electricity consumption, kWh		Prices in € / kWh		
	Min	Max	Prices excluding taxes and fees	Prices excluding VAT and other recoverable taxes	Prices including all taxes
Group A	< 1 000		0.2913	0.3286	0.3550
Group B	≥ 1 000	< 2 500	0.1810	0.2183	0.2358
Group C	≥ 2 500	< 5 000	0.1465	0.1838	0.1986
Group D	≥ 5 000	< 15 000	0.1219	0.1593	0.1720
Group E	≥ 15 000		0.1122	0.1492	0.1611

Fig.43. *Average electricity tariffs*[162]

Social factors

Private housing

In the region there are 37726 privately owned houses and 32822 privately owned detached or semi-detached houses. The rate of ownership is 29%. 65% of the population lives in detached houses . Housing market is growing mostly in the field of apartment construction. There are both old and new buildings. In regards to detached houses, there are more new buildings (constructed in 1971 and newer). Semi-detached and row houses are older in general, while the collective houses are newer. The value of property market increases 5% annually.

The population is growing while native people move to other regions. In 2020 there were around 50%[163] of foreigners in the state and there will be a trend of increasing number of commuting foreigners in the country. High number of people coming to the region leads to the 25% of all households living in a rented space (Figure 44).

[162] ec.europa.eu. Database - Energy - Eurostat. [online] Available at: http://ec.europa.eu/eurostat/web/energy/data/database. [Accessed: 03.06.2021]

[163] Luxembourg real estate2020: building blocks for success. – PWC Luxembourg – //URL: https://www.pwc.lu/en/real-estate/docs/pwc-re2020-2015-en.pdf [Accessed: 1 April 2021]

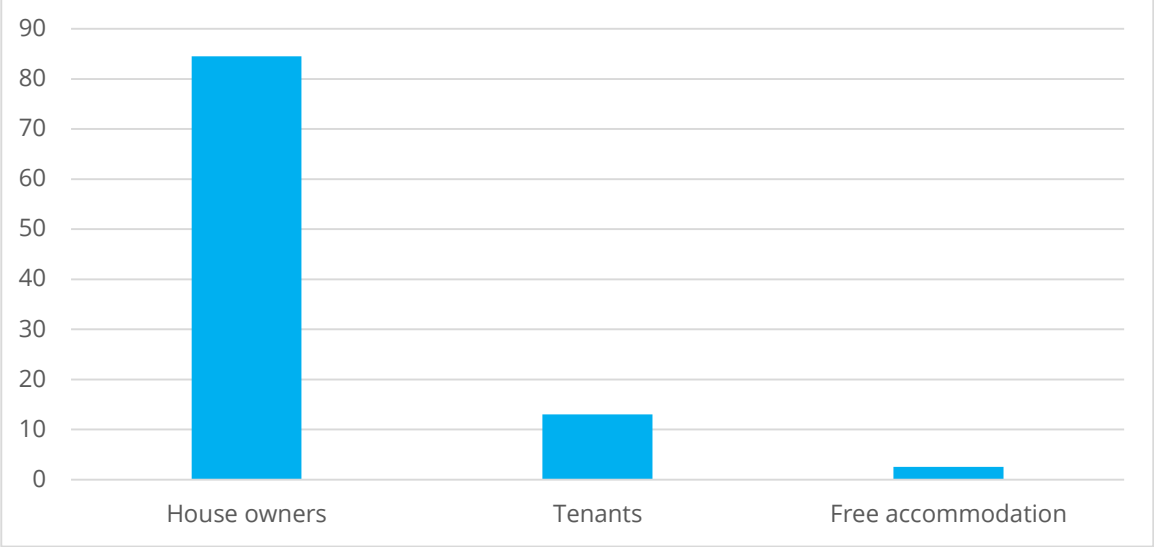

Fig.44. *Occupation status*[164]

Luxembourg is at the forefront of sustainability in terms of properties: 13% of office stock has already obtained green certifications (eco-efficient). By 2020 there is more than 1 200 000 sqr meters of certified buildings.[165]

Technological factors

Stability of power supply

To evaluate the stability of power supply SAIDI index can be used. According to the historic data power supply in Luxembourg is relatively stable, over the period of 2014-2016 SAIDI index was equal to 25 (Figure 45). There were 450 power interruptions planned in 2019 (decreases from 607 in

[164]statistiques.public.lu. Affichage de tableau. [online] Available at: https://statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=12958&IF_Language=fra&MainTheme=3&FldrName=1&RFPath=29 [Accessed: 03.06.2021]

[165] Luxembourg real estate2020: building blocks for success. – PWC Luxembourg – //URL: https://www.pwc.lu/en/real-estate/docs/pwc-re2020-2015-en.pdf [Accessed: 1 April 2021]

2016). There were 523 unplanned in 2019 (increases from 493 in 2016) - mostly due to third party damage and internal causes. Overall, electricity supply in the region is highly reliable.[166]

Another index that can be used to assess the stability of power supply is the System Average Interruption Frequency Index (SAIFI index). Over the years of 2014-2016 the average number of interruptions per customer was equal to 0.35 (Figure 46).

Most prominent causes for the power interruptions are internal causes related to utility companies' operations and third party damages (Figure 47).

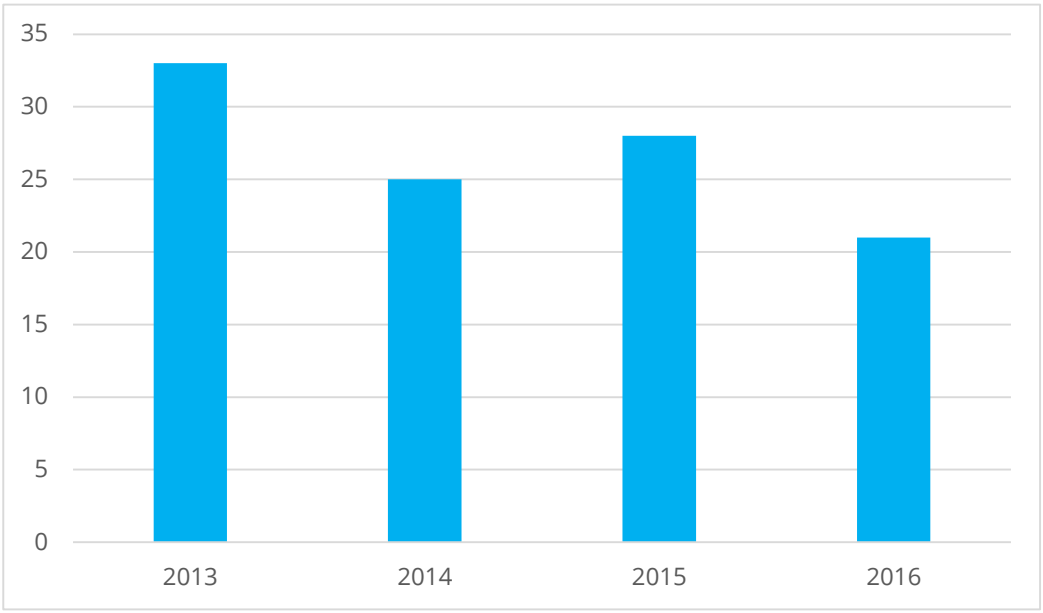

Fig.45. *Planned and unplanned SAIDI, including exceptional events, minutes per customer*[167]

[166] Bericht über die Versorgungssicherheit im Strombereich in Luxemburg. [online] . Available at: https://mea.gouvernement.lu/dam-assets/energie/electricite/VS-Bericht-Strom-2020.pdf [Accessed: 03.06.2021]

[167] www.emissions-euets.com. System Average Interruption Duration Index (SAIDI) - Emissions-EUETS.com. [online] Available at: https://www.emissions-euets.com/internal-electricity-market-glossary/2069-system-average-interruption-duration-index-saidi. [Accessed: 03.06.2021]

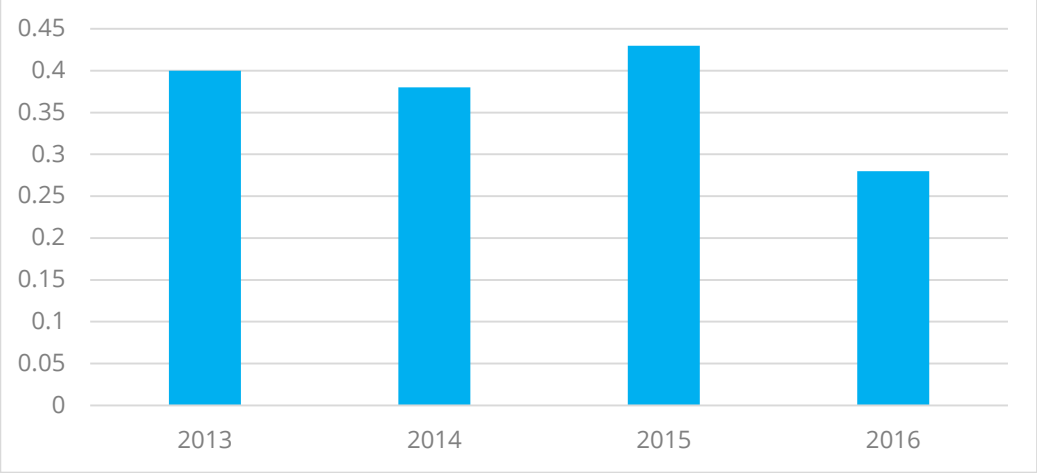

Fig.46. *Planned and unplanned SAIFI, including exceptional events, interruptions per customer*[168]

[168] www.emissions-euets.com. System Average Interruption Duration Index (SAIDI) - Emissions-EUETS.com. [online] Available at: https://www.emissions-euets.com/internal-electricity-market-glossary/2069-system-average-interruption-duration-index-saidi. [Accessed: 03.06.2021]

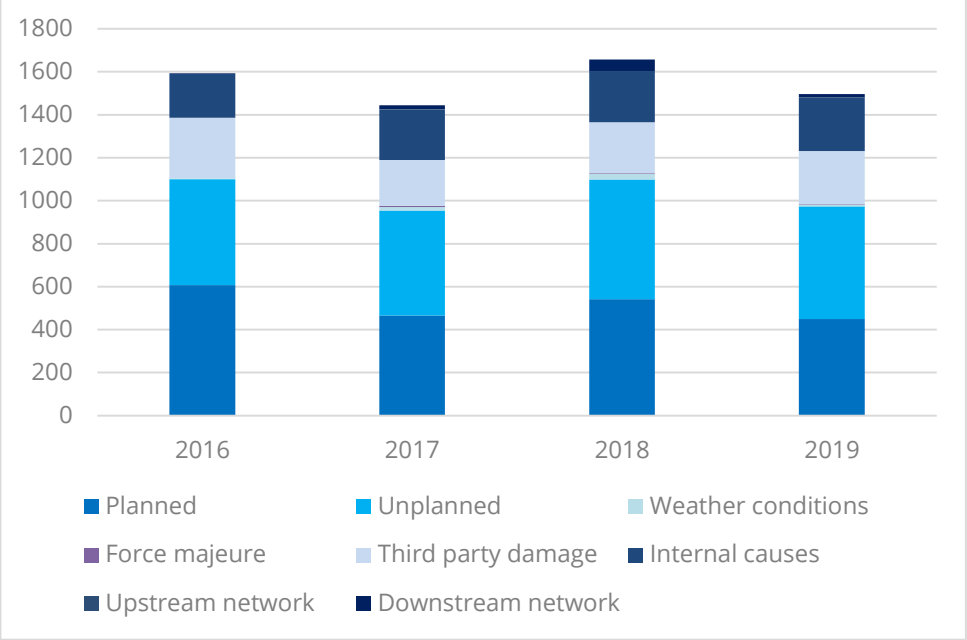

Fig.47. *Outages causes*[169]

[169] Bericht über die Versorgungssicherheit im Strombereich in Luxemburg. [online] . Available at: https://mea.gouvernement.lu/dam-assets/energie/electricite/VS-Bericht-Strom-2020.pdf. [Accessed: 03.06.2021]

Power generation

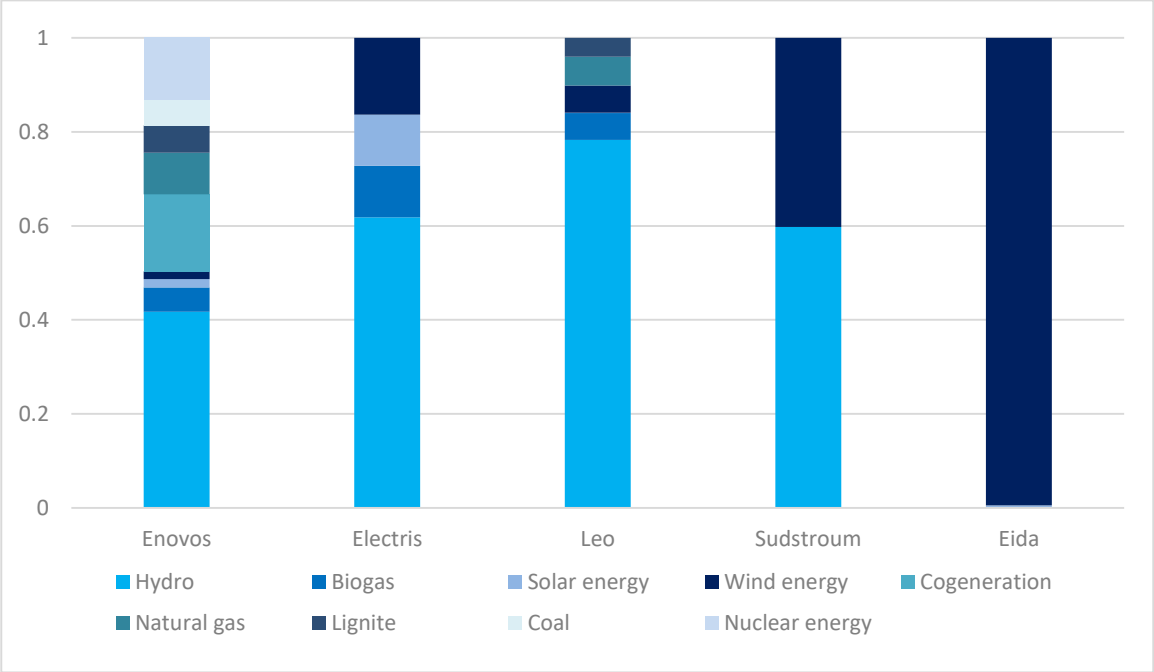

Fig.48. *Sources of power generation*[170]

The sources of power used by utility companies is presented above (Figure 48). Solar and Wind energy represent relatively small proportion.

Between 2013 and 2018, the country great progress in the field of wind and solar energy. In these years the number of photovoltaic systems has increased by 60 percent. There are also improvements in the area of wind power, the government had a total of 18 wind turbines built between 2013 and 2018. Outdated wind turbines have been modernized, the electricity generated by wind power is expected to be doubled in the years 2020-2025[171].

[170] www.calculix.lu. Calculix Private - www.calculix.lu. [online] Available at: https://www.calculix.lu/fr/calculix-public-private#/ [Accessed: 03.06.2021]

[171] Author, N. (2020). Erneuerbare Energie / Luxemburg weit entfernt vom Klimaziel. [online] Tageblatt.lu. Available at: https://www.tageblatt.lu/nachrichten/luxemburg/luxemburg-weit-entfernt-vom-klimaziel/ [Accessed: 03.06.2021]

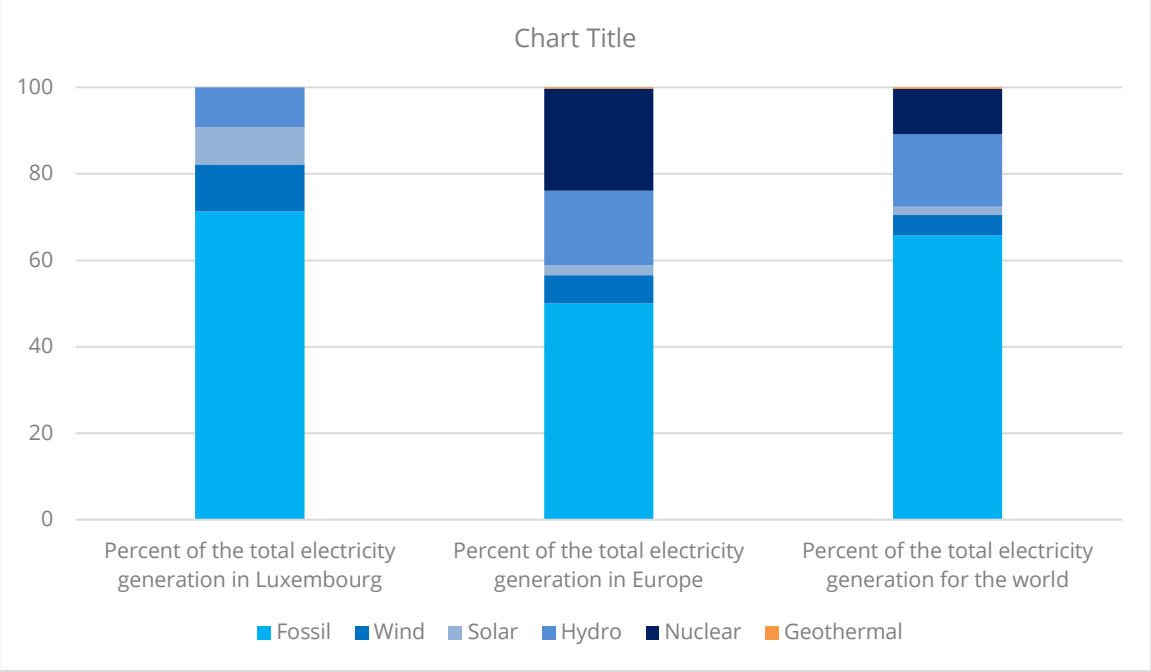

Fig.49. *Power mix in Luxembourg*[172]

According to the minister of energy, Luxembourg currently gets 7.67 percent of its electricity from renewable energies (Figure 49). Three quarters of this energy (6.72 percent of the total workload) is produced on national territory. The remaining part comes from Lithuania and Estonia. Luxembourg has set a cooperation agreement with both countries in order to be able to achieve the target of 11 percent renewable energy in 2020. Since the two Baltic countries have already achieved their climate goals, they are selling part of their renewable energy to the Grand Duchy. In a Eurostat analysis from 2017, Luxembourg was in the last place in terms of using RE in energy production. The value was 6.4 percent.[173]

[172] GlobalPetrolPrices.com. Luxembourg: energy mix for electricity generation. [online] Available at: https://www.globalpetrolprices.com/energy_mix.php?countryId=206 [Accessed: 03.06.2021]

[173]Anteil erneuerbarer Energiequellen [online] Available at:https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Anteil_erneuerbarer_Energiequellen,_2017_(in_%25_des_Bruttoendenergieverbrauchs)_FP2019-de.png [Accessed: 03.06.2021]

Environmental factors

Solar generation potential

Luxemburg is located in modified continental climatic zone with mild winters and cool summers. As a result, there are about 69 days of sunshine per year [174]

Average theoretical PV potential (GHI) equals 3.017 kWh/m^2. GHI varies from 3.41 to 5.08 kWh/m^2 in different territories and estimates more than 3.00 kWh/ m^2on 63,4% of areas in Luxemburg[175] (Figure 50, 51, 52).

If we observe changes of Theoretical PV Potential during the year, Global Horizontal Irradiance annual variability in Luxemburg is small, from about 1% in winter to 4,5%.in summer[176].

In ranking of countries, which is based on zonal statistics of practical PV power potential Luxemburg is on the 219th place between Germany and Netherlands.

Average practical PV potential is 2.948 kWh/kWp[177].Specific photovoltaic power output or PVOUT is 2.79—3.03 kWh/kWp, and this parameter estimates less than 3.00 kWh/kWp on 89,9% of areas in Luxemburg[178] (Figure 53, 54, 55).

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[174] Climate Luxemburg: climatedata.eu //[online resourse] https://www.climatedata.eu/climate.php?loc=luxx0003&lang=en (access: 25.05.21)

[175] Luxemburg: Global Solar Atlas/ Insights//[online resource] https://globalsolaratlas.info (access: 25.05.21)

[176] Global Photovoltaic Power Potential by Country: Global Solar Atlas //[online resourse] https://globalsolaratlas.info/global-pv-potential-study (access: 25.05.21)

[177] Global Photovoltaic Power Potential by Country: Global Solar Atlas //[online resourse] https://globalsolaratlas.info/global-pv-potential-study (access: 25.05.21)

[178] Luxemburg: Global Solar Atlas/ Insights//[online resource] https://globalsolaratlas.info (access: 25.05.21)

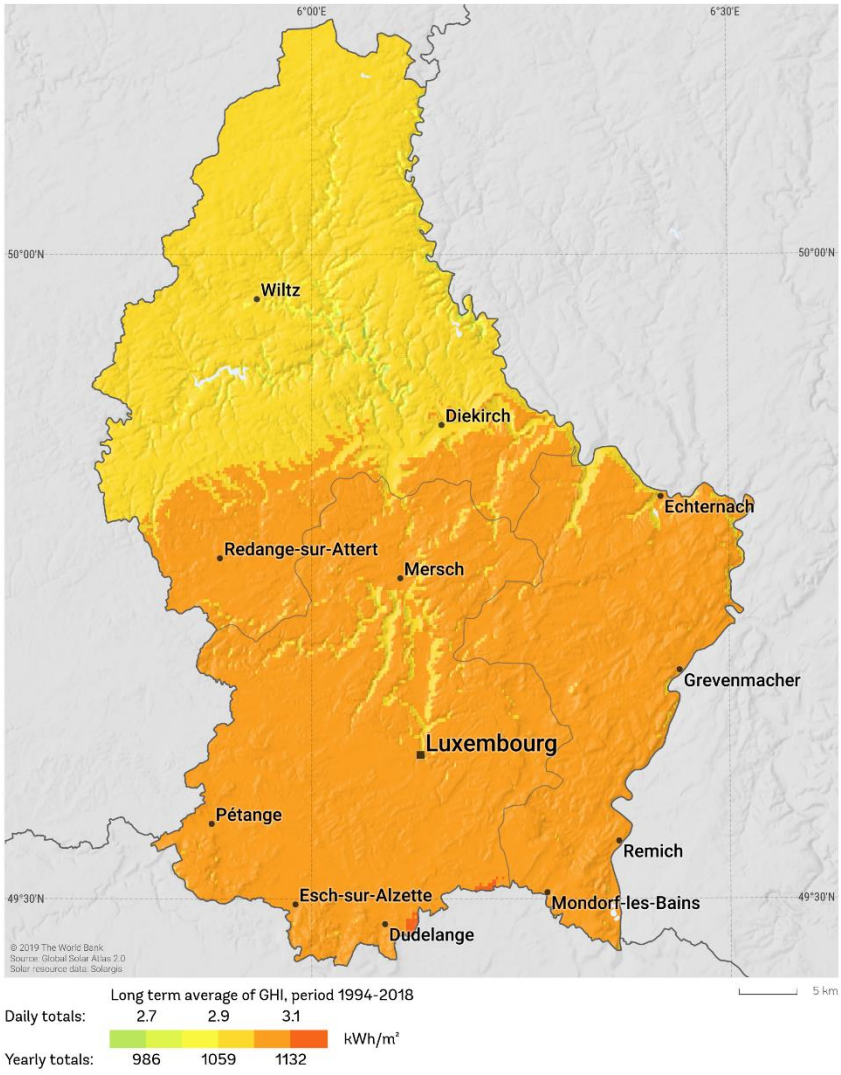

Fig.50. *GHI in Luxemburg*[179]

[179] Luxemburg: Global Solar Atlas/ Map and data downloads//[online resource] https://globalsolaratlas.info/download/luxembourg (access: 25.05.21)

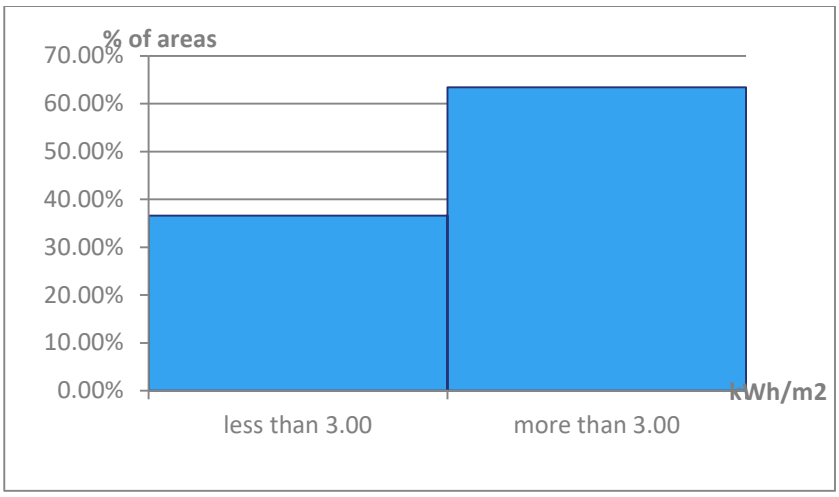

Fig.51. *Distribution of Global horizontal irradiation*[180]

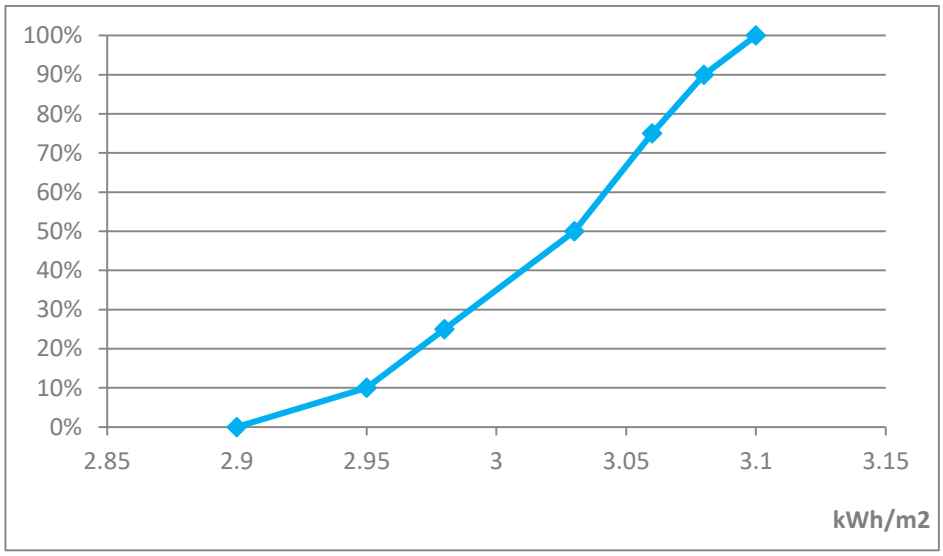

Fig.52. *Statistics of Global horizontal irradiation*[181]

[180] Luxemburg: Global Solar Atlas/ Insights//[online resource] https://globalsolaratlas.info (access: 25.05.21)

[181] Luxemburg: Global Solar Atlas/ Insights//[online resource] https://globalsolaratlas.info (access: 25.05.21)

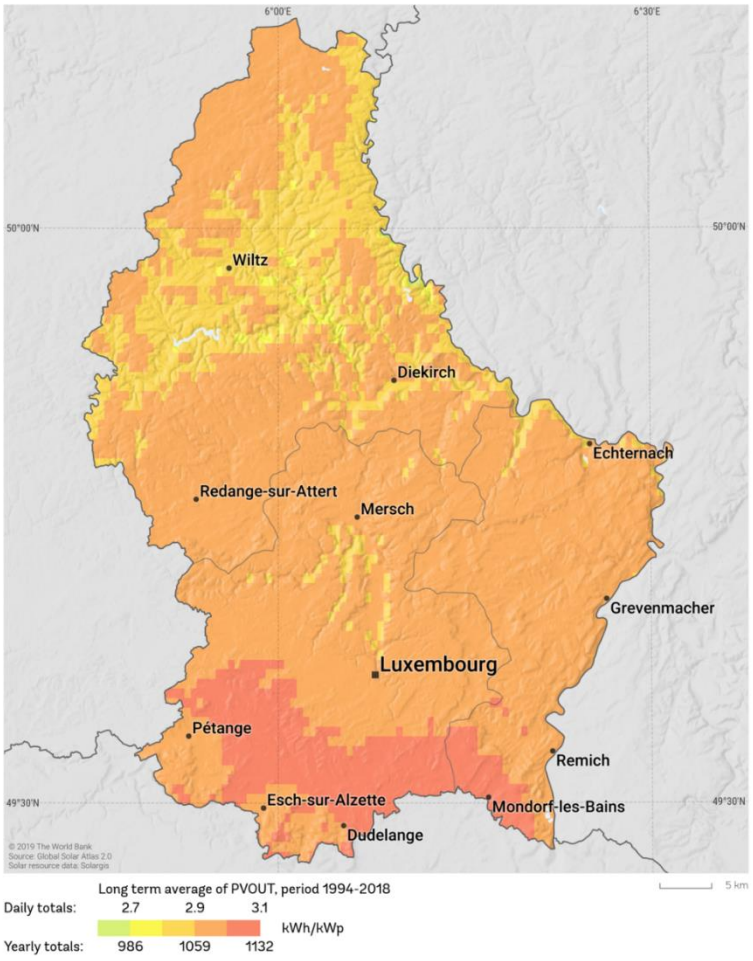

Fig.53. *PVOUT in Luxembourg*[182]

[182] Luxemburg: Global Solar Atlas/ Map and data downloads//[online resource] https://globalsolaratlas.info/download/luxembourg (access: 25.05.21)

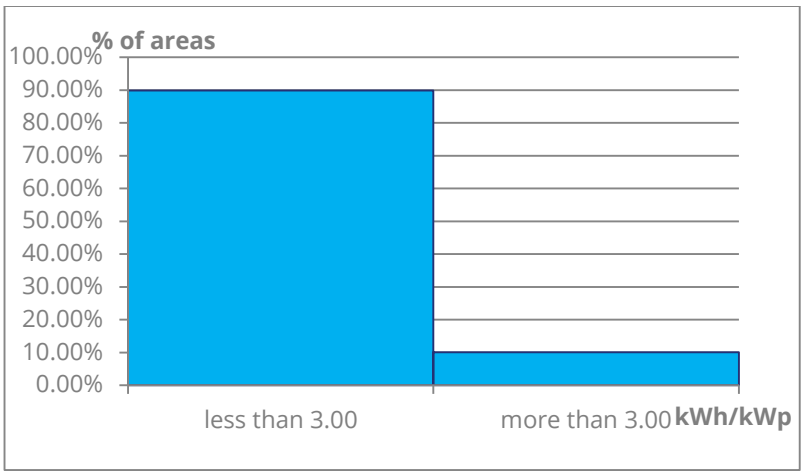

Fig.54. *Distribution of Specific photovoltaic power output*[183]

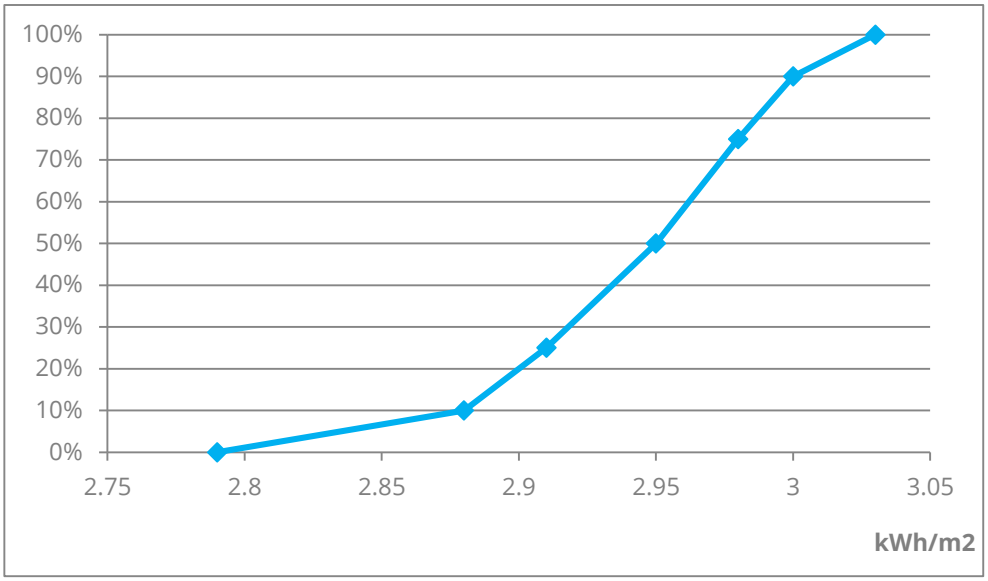

Fig.55. *Statistics of Specific photovoltaic power output*[184]

[183] Luxemburg: Global Solar Atlas/ Insights//[online resource] https://globalsolaratlas.info (access: 25.05.21)

[184] Luxemburg: Global Solar Atlas/ Insights//[online resource] https://globalsolaratlas.info (access: 25.05.21)

Legal factors

It is required to inform local authorities about your plans of PV installation (a building permit might be required). Luxembourg is particularly dependent on the functionality of the regulations of the European internal electricity market, even in exceptional situations.[185] The network operator must approve and finally accept each power generation system before the act of installment. The feed-in tariff contract should be concluded with the relevant network operator who carries out the final inspection and accepts of the system. Profit from the PV system must be listed in the tax return and is taxed. Systems with a total output of less than 4 kWp are excluded.

Market players

Direct competition

There are several companies selling present on the market that sell residential energy storage. Batterx offers carbon batteries, LifePo4 battery units, residential and utility scale energy storage systems. Their solutions are supported with a proprietary management software.

Tesvolt is another local company selling residential energy storage system. They offer modular systems with 70% depth of discharge after 8000 cycles. Company uses its own cell units in the system.

In addition to local developers of RESS there are distributors who offer systems of well-known brands. Winwatt is an official distributor of Tesla batteries. Company specializes on solar panels integration and offers battery units as a support product.

Alma Solar, one of the biggest solar integrators on the market also distributes solar batteries. From their web-site clients can purchase such brands as BYD, LG Chem, Triple Power, Enphase. In addition, batteries without a smart management systems are sold on the market. Another company that specializes on distribution of energy storage systems is Im.Solar. The prices presented below are taken from their official web-sites (Figure 56).

[185] myenergy. Private Photovoltaikanlagen. [online] Available at: https://www.myenergy.lu/de/privatpersonen/photovoltaik/private-pv-anlage-wie-gehe-ich-vor [Accessed: 03.06.2021]

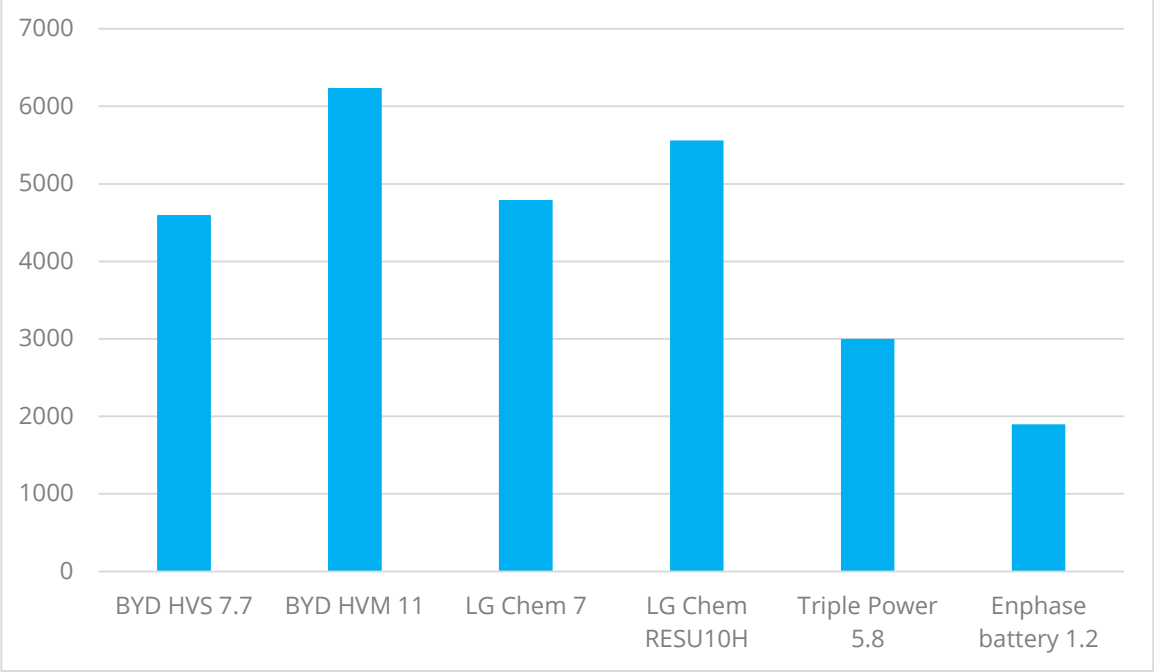

Fig.56. *RESS prices*[186]

Even though there are few local companies, there are a lot of alternatives across Europe. The central location of the Luxembourg opens it to all the competitors from other European states. Due to this fact in order to evaluate the competition factor there should be performed a market analysis of the neighboring states.

PV integrators

There are 23 PV integrator companies that implement mostly residential PV projects and projects for medium-sized businesses. In addition, it is worth mentioning the following market players: Steca, a company that produces controllers, invertors and enter equipment for RESS (no batteries). Victron Energy, a company that sells all the necessary equipment for RESS separately (no

[186] www.alma-solarshop.com. Buy your batteries at the best price. [online] Available at: https://www.alma-solarshop.com/121-solar-batteries#/show-all [Accessed: 03.06.2021]

unit product). On average the prices for solar panels are 150 euros per kWh capacity: The complete list of registered solar integrators and their characteristics is presented below (Figure 57).

Name	Specialization
WINWATT	RPV and Industrial Reseller of Tesla Powerwall
Adblux	RPV and Industrial
Allochauffage	RPV and Industrial
Avantag-energy	Industrial
Haustechnik-bohr	RPV
Electricitebettendorf	RPV
Zahnen	RPV and Industrial
Erg	RPV and Industrial
Born-meyer	Commercial and Industrial
Enerdeal	Commercial and Industrial
Energiepark	RPV and Industrial
Enovos	RPV and Industrial
Solarconcept	RPV and Industrial
Nillesguy-toitures	RPV
Koehl-at	Industrial
Electricite-maraga	RPV and Industrial
Schaal	RPV
Schaus	RPV
Schütz & Ries	RPV
Solarwood	RPV
Technique-energy	RPV
Tmenercoop	Commercial and Industrial
Topsolar	RPV
Wbs	RPV and Industrial
Barthel	RPV
Alma solar energy	RPV and Industrial

Fig.57. *Solar market players*[187]

[187] dir.list.solar. Solar Energy companies in Luxembourg. [online] Available at: https://dir.list.solar/l/luxembourg/ [Accessed: 03.06.2021]

Utility market structure

In Luxembourg energy is supplied by companies that purchase electricity on the wholesale market. Market is liberalized and consumers have the right to conclude a supply contract with the supplier of their choice. In principle, any supplier authorized in Luxembourg can supply electricity to any customer anywhere in Luxembourg. However, some suppliers are specialized in serving certain types of customers (f.e. industrial customers), others are limited to supplying customers in a certain region. Below is the list of suppliers who specialize on residential energy provision:[188]

- Eida SA
- Electris by Hoffmann Frères Energie et Bois s.à rl
- Enovos Luxembourg SA
- LEO SA
- NordENERGIE SA
- Steinergy SA
- Sudstroum S.à rl and Co Secs

Another important market player is a grid operator. Their functions include: transporting electricity from production sites to places of consumption; taking care of the technical services related to connection to the network and meter reading. The network operators hold monopoly for the management of the network. Household owners cannot switch network operators. List of electricity distribution network operators:

- Creos Luxembourg SA
- City of Diekirch
- Hoffmann Frères Energie et Bois s.à rl
- City of Ettelbruck
- Sudstroum S.à rl & Co Secs

[188]ilr.lu. Institut Luxembourgeois de Régulation. [online] Available at: https://web.ilr.lu/FR/Particuliers/Electricite/Informations-utiles/Les-acteurs-du-marche/Pages/default.aspx [Accessed: 03.06.2021]

Utilities' RE agenda

The biggest utility company Enovos provides programs supporting the implementation of renewable energy projects. The company has established a fund "Nova Naturstroum" to fund various projects related to renewable energy technologies.[189]

€ 3,000 is given for solar thermal hot water installation with a gross surface of the panels greater than 18m2 or with the surface of vacuum tubular collectors greater than 14 m2.

Up to 1000 euros for electric energy storage system or 10% of the purchase price (base price excluding VAT and excluding installation costs) of a stationary storage system with a capacity of minimum 5 kWh (excluding mobile installations, such as electric cars or others).

1500 euros for a photovoltaic system combined with a battery and a charging infrastructure for electric vehicles. Only valid for the combination of the 3 installations and if the photovoltaic installation and / or the battery were already in use before January 1, 2021.

Threat of substitutes

Supply to the grid

Under the amended Grand-Ducal regulation of March 31 2010 supply systems are classified into three categories. The settlement "ILR / E20 / 63" of 18 December 2020 sets the contribution rate compensation mechanism in categories A and B for 2021, while the contribution of category C is fixed by Grand-Ducal Regulation[190] (Figure 58):

- Cat. At <= 25,000 kWh / year: 0.0363 euros / kWh
- Cat. B> 25,000 kWh / year: 0.0121 euros / kWh (with the exception of supply points which are classified in category C)
- Cat. C: € 0.75 / MWh: 0.075 ct / kWh

[189] media.enovosgroup.eu. fonds nova naturstroum. [online] Available at: https://media.enovosgroup.eu/enovos/brochures/enovos/fnn/2021/fr/10/ [Accessed: 03.06.2021]

[190] ilr.lu. Institut Luxembourgeois de Régulation. [online] Available at: https://web.ilr.lu/FR/Professionnels/Electricite/Acteurs/Energie-renouvelable-et-Cogeneration-a-haut-rendement/Mecanisme-de-Compensation/Pages/default.aspx [Accessed: 03.06.2021]

As part of the Neistart Lëtzebuerg program for a green and sustainable economic development, household owners can benefit from feed-in tariffs for the electricity supplied into the grid. The following feed-in tariffs apply from April 1 2021 to December 31 2021 and are set for 15 years from the first feed-in:

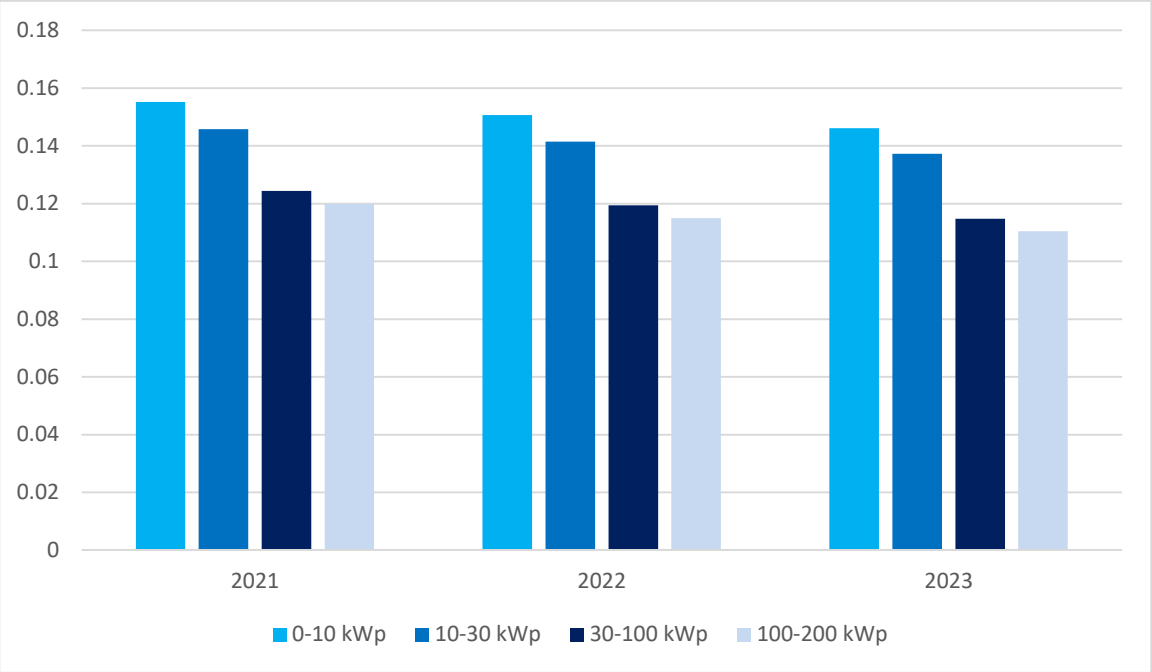

Fig.58. *Feed-in tariffs*[191]

3.4 Analysis of Vermont market

Political factors

State RE agenda

In order to support the decarbonization process Vermont's Renewable Energy Standard (RES) was introduced by the state legislature in 2015. The RES requires electric utilities to have specific amounts of renewable energy in their electricity generation portfolios. The amount of renewable energy increases over time, the plan is to bring all Vermont electric utilities to 75% share

[191] myenergy. Einspeisetarife und Beihilfen. [online] Available at: https://www.myenergy.lu/de/cleversolar/private-anlagen/einspeisetarife-beihilfen. [Accessed: 03.06.2021]

of renewables in their power mix by 2032. Utilities are able to buy and sell Renewable Energy Credits (RECs) to meet their requirements for the RES. It also encourages utilities to provide incentives to customers who complete projects that reduce carbon dioxide emissions.

The Renewable Energy Standard took effect in 2017 and is comprised of 3 components, commonly referred to as "tiers."[192]

Tier 1 of the RES requires utilities to purchase renewable energy equivalent to a certain percentage of their retail sales each year. The Tier 1 requirement was set at 55% in 2017 and increases steadily until reaching 75% in 2032.

Tier 2 of the RES stipulates that utilities purchase increasing amounts of energy from renewable distributed generators. The Tier 2 requirement was set at 1% of each utility's retail sales in 2017 and increases to 10% in 2032. Tier 2 purchases also count towards the Tier 1 requirement.

Tiers 1 and 2 of the RES are similar to renewable portfolio standards in many states across the country. However, Vermont's RES contains a unique third tier that requires utilities to procure additional amounts of energy from distributed renewable resources or to complete projects that result in a reduction in fossil fuel use and greenhouse gas emissions from their customers. Tier 3 programs can consist of thermal efficiency measures, electrification of the transportation sector, and converting customers that rely on diesel generation to electric service, among other things.[193]

In the autumn of 2019 Vermont created a task force in an effort to create a necessary strategy that would enable the state to reach its climate goals after several years of stalled progress. Vermont was an early leader on climate, adopting emission goals in 2006. After several years of progress, annual emissions increased over the last decade. In 2018 emissions totals were up 4% from the 1990 levels.[194] The state legislature passed the Global Warming Solutions Act in September, the law

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[192] Vermont.gov. (2020). Renewable Energy Standard Public Utility Commission. [online] Available at: https://puc.vermont.gov/electric/renewable-energy-standard [Accessed: 03.06.2021]

[193] VPPSA. Renewable Energy Standard. [online] Available at: https://vppsa.com/energy/renewable-energy-standard/ [Accessed: 03.06.2021]

[194]Vermont Climate Council plans to revamp lagging clean energy progress [online] Available at: https://energynews.us/2020/12/07/vermont-climate-council-plans-to-revamp-lagging-clean-energy-progress/ [Accessed: 03.06.2021]

changed Vermont's emissions goals to requirements, allowing for legal action if state administrators fail to adopt rules that would enable Vermont to meet the requirements.

The legislation also created the Vermont Climate Council, a 23-member group that is responsible for creating four-year climate plans to meet the targets, including reducing emissions 40% from 1990 levels by 2030, and 80% by 2050. The state under the law is set to achieve carbon neutrality by 2050.

Government supports the move toward sustainable energy provision: funded programs, through upstream or direct incentives as well as technical assistance, to promote cold-climate heat pumps, electric vehicles, electric buses, EV charging stations, battery storage, line extensions to diesel generator-powered maple syrup producers and lumber mills and other custom projects that reduce fossil fuel use[195].

State support

State offers The federal Investment Tax Credit. This solar incentive allows photovoltaic system owners to deduct 26 percent of the total system cost from federal taxes. For example, a solar energy system installation that costs $15,000 will qualify for a tax deduction of $3,900. This advantageous incentive lasts until the end of 2022 - the tax credit amount steps down to 22 percent for 2023. The federal ITC is eliminated for residential solar installations after 2023, but commercial solar energy system owners can still deduct 10 percent of a commercial solar system cost from their taxes beyond 2023.[196] Besides the federal ITC, Vermont has additional incentives for going solar that are dependent on area and utility company.

Before the recent investment tax credit the following incentives were introduced:

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[195] 2020 Annual Energy Report A summary of progress made toward the goals of Vermont's Comprehensive Energy Plan. (2020). [online] . Available at: https://legislature.vermont.gov/assets/Legislative-Reports/2020-Annual-202be-report-Final.pdf. [Accessed: 03.06.2021]

[196] www.energysage.com. Vermont Solar Panels 2020 Pricing & Savings EnergySage. [online] Available at: https://www.energysage.com/solar-panels/vt/. [Accessed: 03.06.2021]

1975 - Vermont's first solar incentive policy, the Local Property Tax Exemption, that exempted homeowners of the additional property taxes that come with a solar installation, if permitted by their city or town.

1999 - Renewable Energy Systems Sales Tax Exemption with the sales tax rate of 6 percent.

2013 - the Uniform Capacity Tax and Exemption for Solar revised the original legislation to fully exempt the property taxes for all solar systems up to and including 10 kilowatts (kW).

Economic factors

Purchasing power

Median household income is $61973 (Figure 59) (ranked 22nd in USA). 38% of the population have a university degree (in comparison to 32.2% US average). Approximately 11% of population is at the poverty line (Figure 60).

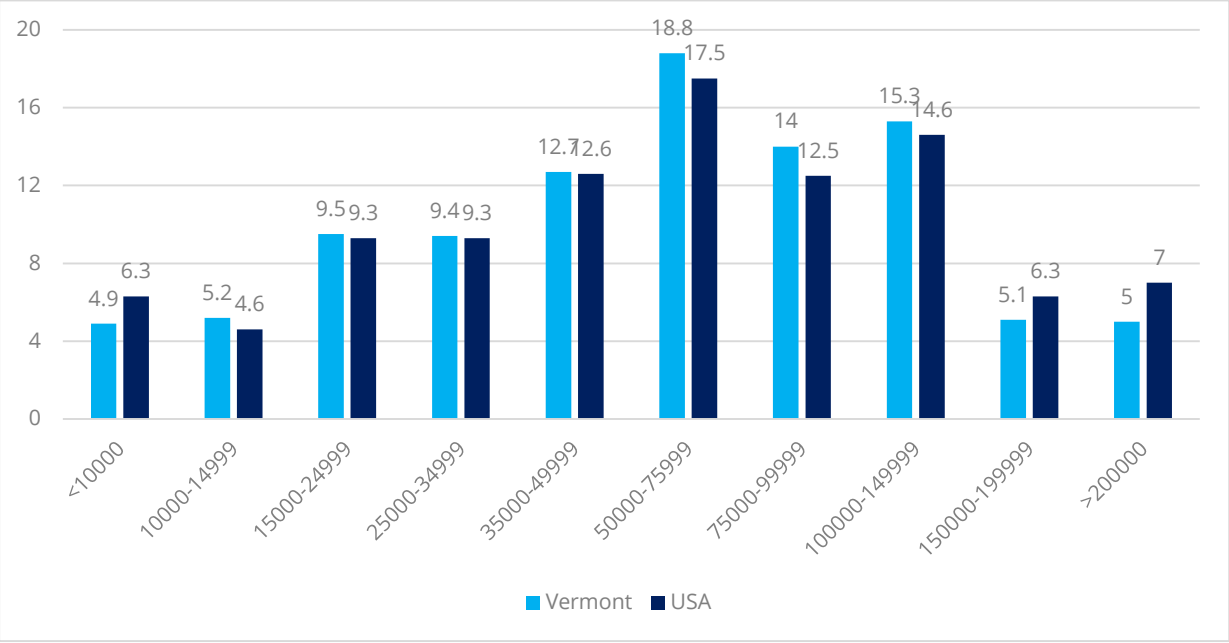

Fig.59. *Vermont Household income distribution*[197]

[197] Anon, Pillar: Vermont Demographics Vermont Futures Project. [online] Available at: https://vtfuturesproject.org/vermonters-visitors/ [Accessed: 03.06.2021]

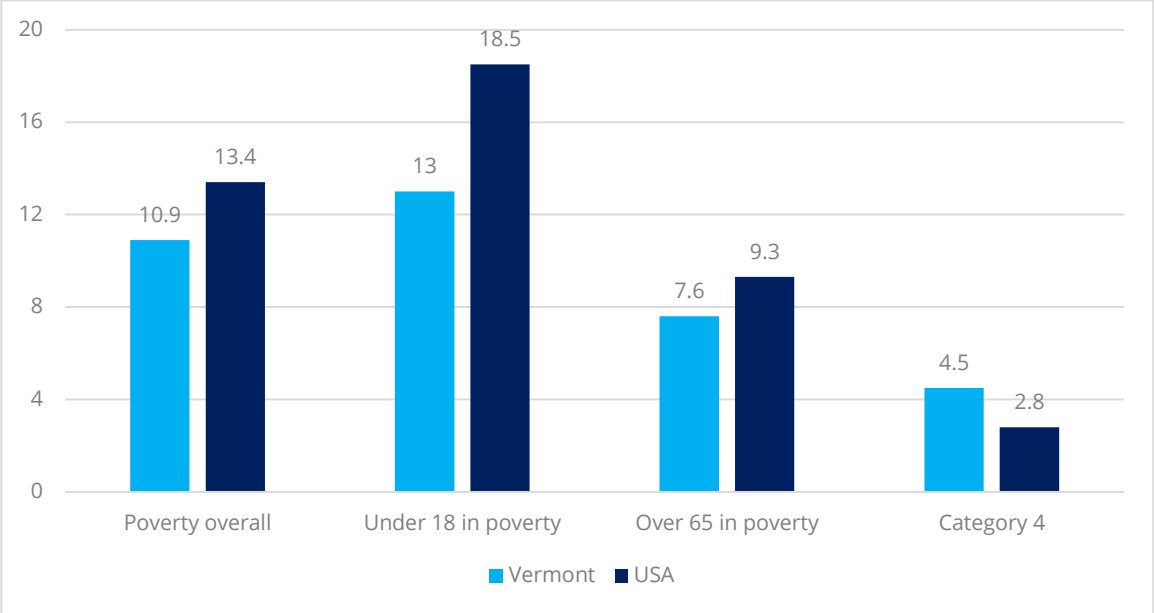

Fig.60. *Vermont poverty*[198]

Electricity tariffs

The following tariffs are present on the market (categorized by the utility company):

- Green mountain power offers $0.16859 per kWh + $0.492/day
- Vermont electric cooperative offers $0.09016 per kWh (first 100) + $0.18199 per kWh (exceeding first 100) + $17.79 per month
- Burlington electric department has $0.108068 per kWh (first 100) + $0.147735 per kWh (exceeding first 100) + $8.21 per month + $0.00894 per kWh (EEC)
- Barton village electric department (If usage does not exceed 2000 kWh per month for at least two consecutive months) offers $0.09216 per kWh (first 100) + $0.19393 per kWh (exceeding first 100) + $10.34 per month. If usage exceeds 2000 kWh per month for at

[198] Anon, Pillar: Vermont Demographics Vermont Futures Project. [online] Available at: https://vtfuturesproject.org/vermonters-visitors/ [Accessed: 03.06.2021]

least two consecutive months' electricity prices are the following: $0.09216 per kWh (first 100) + $0.15074 per kWh (exceeding first 100) + $10.34 per month + $7.91 demand charge

In addition to the basic tariffs Green Mountain Power offers time-of-use tariffs are the following: at the peak $0.26114/kWh, off-peak $0.11131/kWh (peak hours Monday-Friday 1:00pm – 9:00pm). At peak hours the electricity prices have a significant increase.

In addition to the monthly tariffs companies charge fixed household consumption tariff and a variable part, in addition, some have franchise payments. Households may choose this option, but it is less beneficial and is required when consumption is very high.

Social factors

Private housing

Other data on households includes: 67% (Figure 61) of houses are one unit detached; 4% of houses are 1 unit attached - row houses, townhouses, double houses and duplex; Housing density is 36,3 houses per sqr mile; Number of houses increases slightly (3.9% change in the number of housing units between 2010 - 2020); Median home price is $227700 (63% are with mortgage); Median Monthly Owner Cost is $1241 (20% of household income); Average family size is 3 persons (are 258535 households [29,62% - 1 person, 39,22% - 2 persons, 31,17% - 3 or more persons]); Median number of rooms in a house is 5.6 There are 59% of houses that are older than 1979 (25,6% are built 1939 or earlier). Number of private households is 234499, 47.08% of all houses in Vermont are detached private houses. 70.8% of houses are owned, so approximately 47.08% of all houses in Vermont are detached private houses.

Number of housing units (homes)	334999
Housing density, houses per sqr mile	36.3
2010 - 2020 change in the number of housing units	3.9%
Median home price	$227700
Median Monthly Owner Cost	$1241
Median Monthly Owner Cost as percentage of household income	20%
Average family size	3
Median number of rooms in a house	5.6

Fig.61. *Housing data. Vermont*[199]

It is projected that in Chittenden the number of households would increase significantly. In Franklin the increase would be less significant. In other areas the number of households would remain the same.

Technological factors

Stability of power supply

Power outages in Vermont are common since there are a lot of trees that due to winter ice and snowstorms fall on power lines There were 11 major disturbances in 2020 that affected Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island and Vermont. Almost all customer outages are a result of issues on the distribution system rather than the transmission system

[199] www.towncharts.com. Vermont Housing market data real estate research. [online] Available at: https://www.towncharts.com/Vermont/Vermont-state-Housing-data.html [Accessed: 03.06.2021]

Not so large power outages are also the case: 41 during 2020. Approximately 37% of households in Vermont were affected by power outages in 2020 for more than 212 hours. The main source of outage is severe weather conditions - trees that due to winter ice and snowstorms fall on power lines.[200]

Power generation

The biggest utility company Green mountain power's electricity supply is 94% carbon free and more than 63% renewable (Figure 62). Most of their supply comes from hydro power, both from small local hydro facilities in Vermont and large facilities in Quebec.

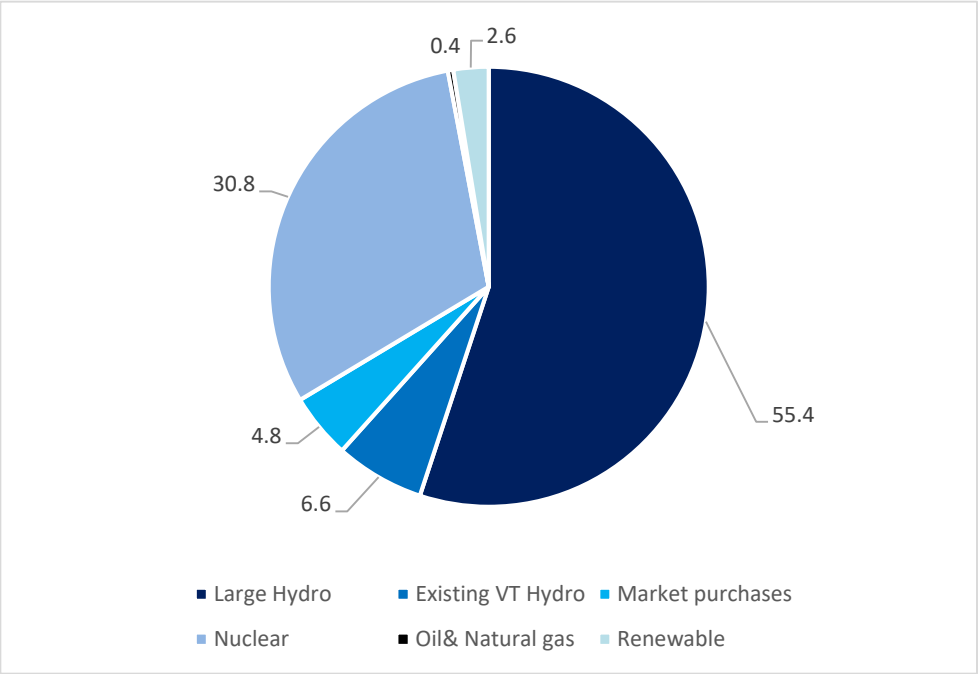

Fig.62. *Green Mountain Power Mix*[201]

Due to weather conditions large share of household electricity costs are associated with heating. Most popular heating sources are oil, kerosene (43.0%), utility gas (17.5%), wood (16.5%),

[200] www.eia.gov. Electric Power Monthly - U.S. Energy Information Administration (EIA). [online] Available at: https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_b_1. [Accessed: 03.06.2021]

[201]Green Mountain Power. Energy Mix. [online] Available at: https://greenmountainpower.com/energy-mix/#:~:text=Most%20of%20our%20supply%20is [Accessed: 03.06.2021]

bottled or LP gas (15.8%), electricity (4.9%) and others (coal, solar, other fuel). As can be seen from the figure 66 solar energy is not yet as widespread as others (Figure 63).

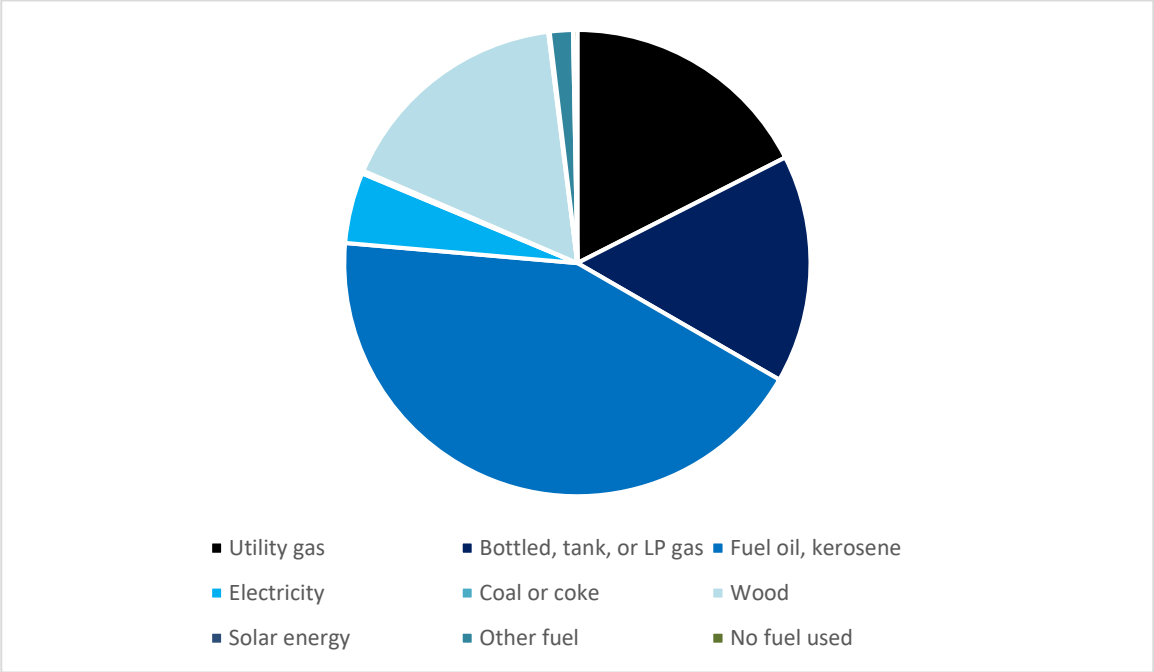

Fig.63. *Power sources used by population*[202]

Environmental factors

Solar generation potential

Vermont is one of the cloudiest states in the USA. Lake Champlain, the Atlantic Ocean, and the Green Mountains are just a few of the factors that account for Vermont's huge number of overcast

[202]Completed for the Vermont Department of Housing and Community Development. (2020). [online] . Available at: https://accd.vermont.gov/sites/accdnew/files/documents/Housing/VT%20HNA%202020%20Report.pdf [Accessed: 03.06.2021]

days. With a highly active climate, Vermont only sees 58 days of full sunshine each year.[203] and 101 partly sunny days[204] (Figure 64, 65, 66).

Global horizontal irradiation (GHI) from 3.41 to 3.84 kWh/m^2, and this parameter estimates more than 3,6 kWh/ m^2 on 62,8% of areas in Vermont[205].

Specific photovoltaic power output (PVOUT) ranges from 3.35 to 3.86 kWh/kWp, and this parameter is more than 3,6 kWh/kWp on 58,5% of areas in Vermont (Figure 67, 68, 69).

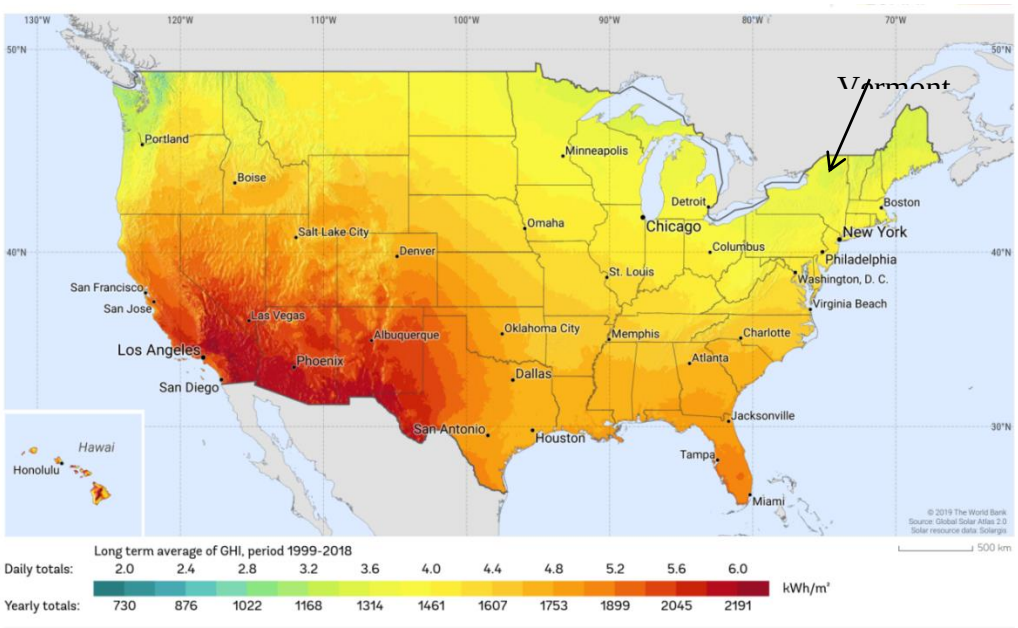

Fig.64. *GHI in the USA*[206]

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[203] Top 10 Cloudiest U.S. States: Farmer's Almanac //[online resourse] https://www.farmersalmanac.com/top-10-cloudiest-u-s-states-22480#:~:text=With%20a%20highly%20active%20climate,of%20full%20sunshine%20each%20year. (access: 21.01.21)

[204] Amount of Sunshine Vermont Gets Each Month: Current Results/USA/Vermont//[online resourse] https://www.currentresults.com (access: 25.05.21)

[205]Vermont: Global Solar Atlas/ Insights//[online resource] https://globalsolaratlas.info/map (access: 25.05.21)

[206]USA: Global Solar Atlas/ Map and data downloads//[online resource] https://globalsolaratlas.info/download/usa (access: 25.05.21)

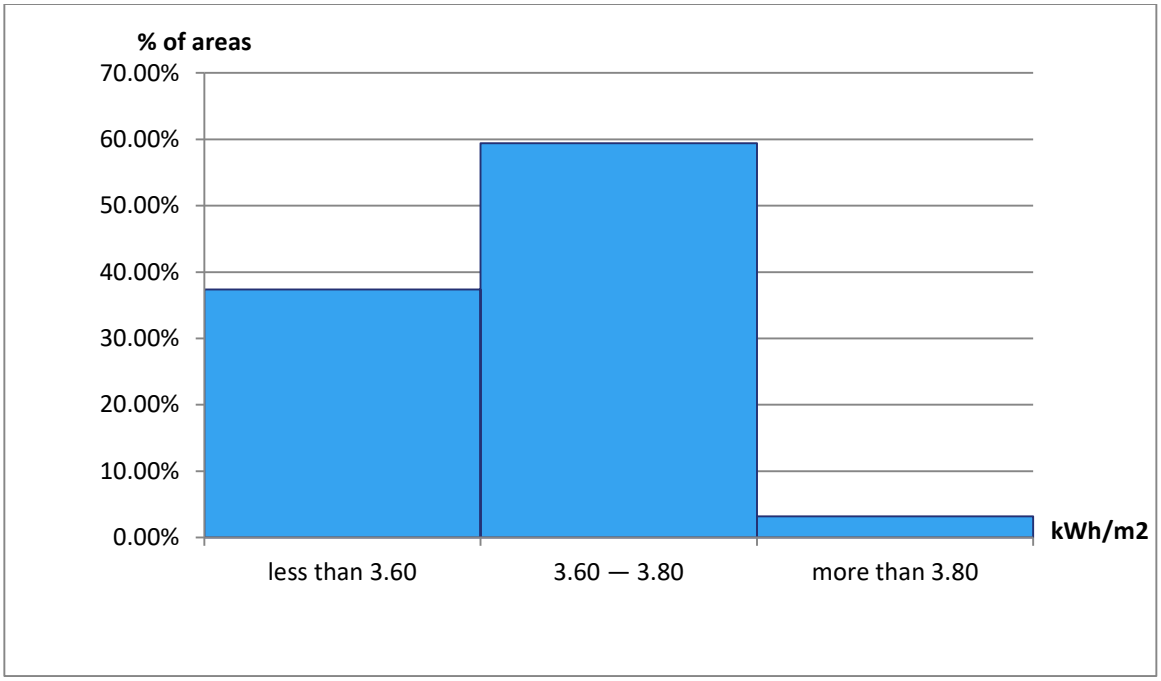

Fig.65. *Distribution of Global horizontal irradiation*[207]

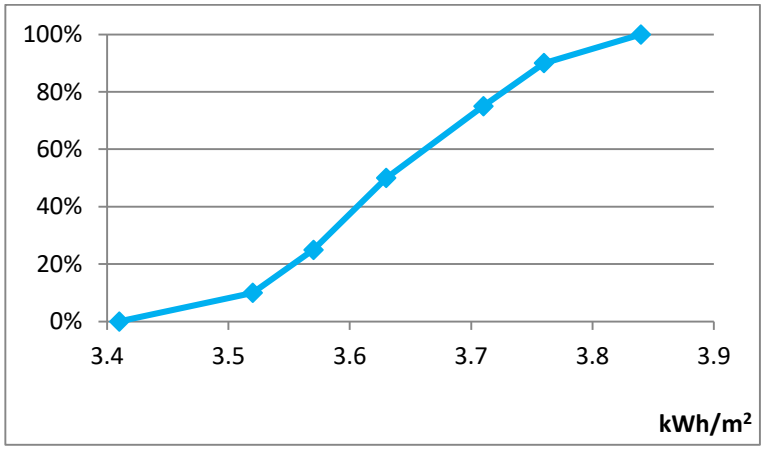

Fig.66. *Statistics of Global horizontal irradiation*[208]

[207] Vermont: Global Solar Atlas/ Insights//[online resource] https://globalsolaratlas.info/map (access: 25.05.21)

[208] Vermont: Global Solar Atlas/ Insights//[online resource] https://globalsolaratlas.info/map (access: 25.05.21)

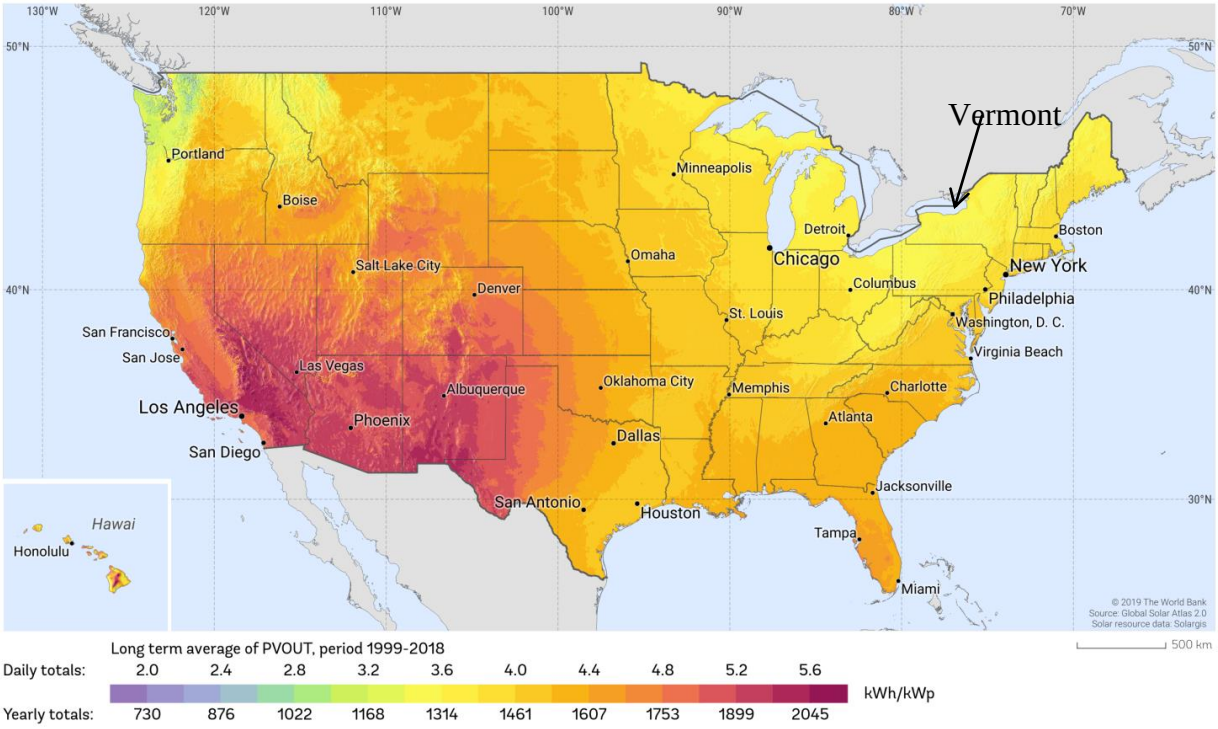

Fig.67. *PVOUT in the USA*[209]

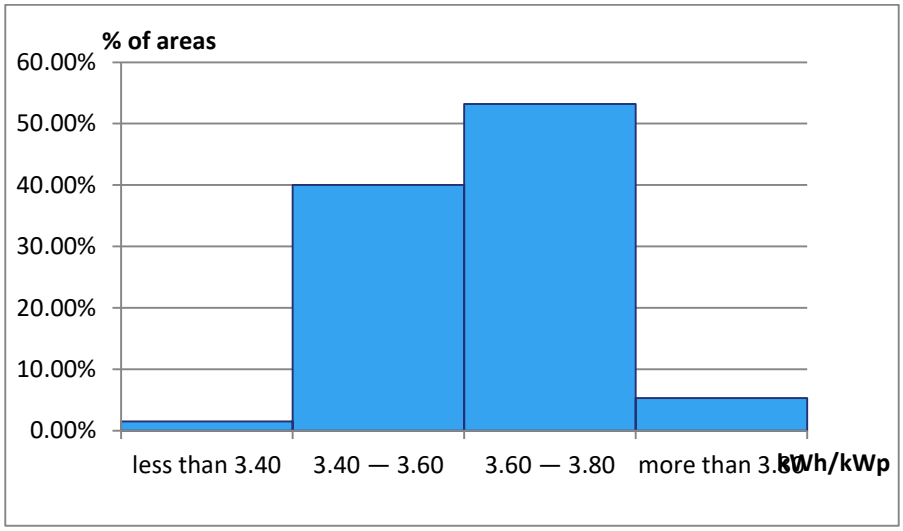

Fig.68. *Distribution of Specific photovoltaic power output*[210]

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[209] USA: Global Solar Atlas/ Map and data downloads//[online resource] https://globalsolaratlas.info/download/usa (access: 25.05.21)

[210] Vermont: Global Solar Atlas/ Insights//[online resource] https://globalsolaratlas.info/map (access: 25.05.21)

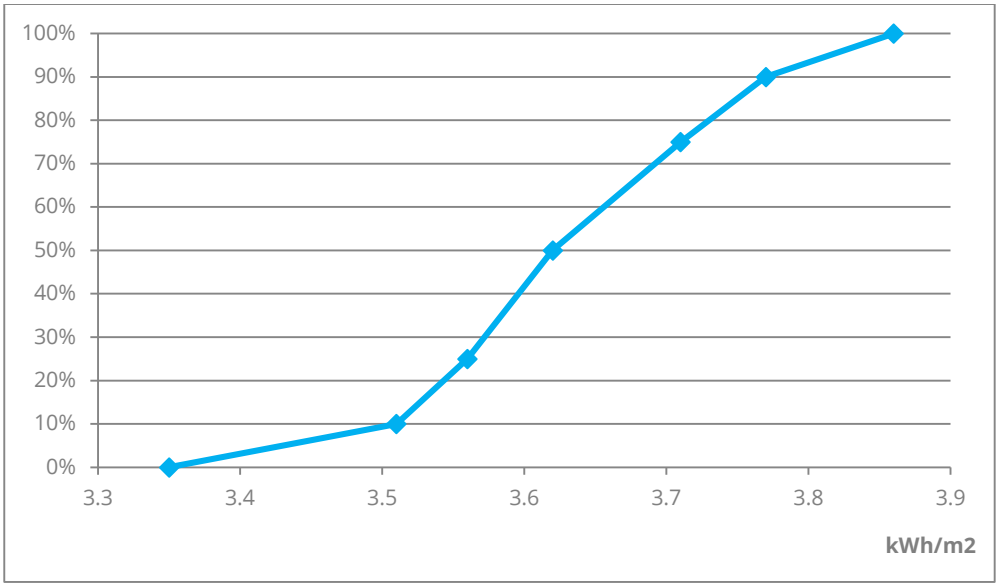

Fig.69. *Statistics of Specific photovoltaic power output*[211]

Legal factors

PV panels usage regulation

Certain requirements are introduced for solar systems and energy storage installations. In order to connect home PV system to the grid there is a requirement for obtaining a Certificate of Public Good (CPG). To sell energy storage systems on the territory of the state there should be obtained accreditation from the Department of public services. The governmental body checks whether the system complies with the defined standards.

Solar installation is performed in the following steps: energy assessment team makes a visit and takes measures; an agreement with solar installer is signed. The installation process usually only takes three to four days.

[211] Vermont: Global Solar Atlas/ Insights//[online resource] https://globalsolaratlas.info/map (access: 25.05.21)

Market players

Direct competition

Several companies offeing RESS are present on the market: Green Mountain Power, SunCommon, Grassroots Solar, Catamount Solar, Building Energy, Dynapower. These companies vary in their specialization and in addition to battery storage offer photovoltaic systems, solar heating and other energy related products and services. They sell the following brands: StorEdge, Sonnen Battery, Sunverge Battery, Generac PWRcell, Tesla Powerwall.

Tesla Powerwall has joint project with the major electricity provider - GMP and is very strong. Green Mountain Power if the biggest utility company that also distributes RESS systems. Second strongest competitor is Sonnen batteries, they do not have any programs, but are available in many resellers. Glassrootssolar is one of the companies that officially distributes sonnen batteries.

Sunrun is one of the prominent solar integrators offers LG Chem and Tesla Powerwall in support of the solar systems installed to their customers. The overview of the battery distributors is presented below (Figure 70). Based on the prices analysis USA based energy storage producers are able to offer lower prices than foreign entrants (Figure 71).

Name of company	About	RESS brands present
Green Mountain Power	Major utility company that also provides RESS that is developed in pertnership with Renewable Energy Vermont	Sonnen Battery Sunverge Battery Generac PWRcell Tesla Powerwall 2.0
SunCommon	Provides customers with PV cells and batteries in partnership with Tesla	Tesla Powerwall
Grassroots Solar Inc.	Vermont's leading solar and battery back-up company + follow-the-sun tracker. Authorized dealer of Sunpower	Sonnen Battery
Catamount Solar	Solar and battery back-up company. Participates in GMP powerwall program	Tesl Powerwall Sonnen Battery Generac
Building Energy	Solar PV cells company, stimulates customers to go green. Has cases of batteries installation	Generac
Encore Renewable Energy	Implements large utility-or-community-scale PV cells and battery projects (20 MWh energy storage)	Tesla

Fig.70. *Distributors of RESS systems*

Source: custom table

Product	Capacity	Price
Tesla Powerwall	13.5 kWh	$6,700
Sonnen Battery SONNENCORE	10 kWh	$9000 - $15000
Sonenn ECO	5 kWh-20 kWh (in 2.5 kWh steps)	$9000 - $15000
Sonnen ECOLINX 30	30 kWh	$16500 - $32000
Sonnen ECOLINX 30	12 kWh-20 kWh (in 2 kWh steps)	$12000 - $15000
Generac	9.0kWh	$10000 - $34000
Sunverge SIS - 6848	11.6 - 19.4 kWh	$26,000
Pika Energy (panasonic - part of generac)	17.1 / 14 kWh	$21,500

Fig.71. *Vermont RESS prices*

PV integrators

In the market there are 60 companies that operate in the photovoltaic market. 10 are manufacturers, there are 33 solar panels integrators, most of them offer energy storage systems as well and 17 other related organizations.[212] The manufacturers are Solaflect energy, Norwich solar technologies, Quick-pull Inc., Aegis renewable energy, SunGard solar hot water, Bee Cool inc, NRG systems, Versatilis LLC, Dynapower, Allearth renewables. In detail solar companies are analyzed below (Figure 72, 73).

[212] SEIA. Vermont Solar. [online] Available at: https://www.seia.org/state-solar-policy/vermont-solar [Accessed: 03.06.2021]

Name	About
Trilandpartners	Develops community-scale PV projects
Eeiservices	Implements energy-efficiency projects on the scale of government and comercial sphere
Isasolar	Does both commercial (small, large scale, for municipalities and schools) and residential PV and RESS projects as well as integrated systems and community solar projects
Power-guru	Tesla powerwall certified installer, participates in GMP supporting program and BYOD program; installs residential, commercial and community-scale solar projects
Svtsolar	Tesla powerwall certified installer, participates in GMP supporting program and BYOD program; installs residential, commercial solar projects
Solarprovermont	Installs PV projects for households
Vermontsolarfarmers	Commercial-scale solar PV projects (larger than 500 kW) also specialize in larger, off-grid, residential solar systems with battery back-up
Grassroots Solar Inc.	Vermont's leading solar and battery back-up company + follow-the-sun tracker. Authorized dealer of Sunpower (sonnen)
Saxtonsriversolar	Installs household roof and ground mount PV on location
Samesunvt	Installer of panasonic and pika energy batteries + solaredge; does residential, commerical, non-profit and schools PV projects
Norwichsolar	Provides solar projects for towns, schools, communities, businesses, farms
Edf-RE	Large-scale storage projects; large-scale PV projects; community-scale solar projects and micro-grids for EV charging
Solaflect	Sonnen authorized dealer; provides household RESS and residential RESS
Catamount Solar	Solar and battery back-up company. Participates in GMP powerwall program. Distributes Tesla Powerwall, Sonnen Battery, Generac
Ienergyvt	installs solar projects for towns, schools, communities, businesses, farmsI

Fig.72. *Vermont PV integrators #1*

Source: Custom table

Name	About
Acorn Energy Coop	Provides installation of solar roofs. Promotes customers to go green
Bristol Electronics	Provides installation of solar roofs. Promotes customers to go green
Harvestarpower	Residential solar panels
Smithmcclain	Certified sonnen battery reseller
Novusenergydev	Creates community-scale PV projects
Solartechvt	Creates residential PV projects
Verarenewables	Community-scale PV projects
Greenlanternsolar	Installs solar projects for towns, schools, communities, businesses, farms
Suncommon	Provides PV projects for small businesses and households
Dynapower	Provides Utility-Scale Solar with DC-Coupled Energy Storage, integrated Energy Storage Systems for Behind-the-Meter and Utility-Scale Applications and inventors
Building Energy	Solar PV cells company, stimulates customers to go green. Has cases of batteries installation
Isunenergy	Off-grid projects, solutions for smart cities
Allearthrenewables	Community and commercial PV projects
Efficiency Vermont	Provides smart gadgets, heating, cooling, refrigerators, renewable energy sollutions (including solar), EV chargers
Encore Renewable Energy	Implements large utility-or-community-scale PV cells and battery projects (20 MWh energy storage)
Packetizedenergy	Residential PV systems

Fig.73. *Vermont PV integrators #2*

Source: Custom table

Utility market structure

On the market there are 17 utility companies: 1 investor-owned, 2 member-owned rural electric cooperative and 14 municipal electric departments. GMP is the major electicity provider with a market share of 71,83%; VEC is the second utility that has 10,52% of market share; BED is on the third position with 5,5% market share; Others serve only around 15% of houses (Figure 74).

Name of the company	Number of households	% of households
Green Mountain Power (investor-owned utility)	270000	71,83%
Vermont Electric Cooperative (member-owned rural electric cooperatives)	39546	10,52%
Burlington Electric Department (municipal electric departments)	20686	5,50%
Washington Electric Co-op (member-owned rural electric cooperatives)	12271	3,26%
Village of Lyndonville Electric Dept. (municipal electric departments)	5701	1,52%
Village of Hardwick (municipal electric departments)	4468	1,19%
Village of Stowe Electric Dept. (municipal electric departments)	4168	1,11%
Village of Morrisville Water & Light Dept. (municipal electric departments)	4048	1,08%
Swanton Village Electric Dept (municipal electric departments)	3672	0,98%
Ludlow Electric Light Dept (municipal electric departments)	3670	0,98%
Village of Northfield (municipal electric departments)	2212	0,59%
Village of Enosburg Falls (municipal electric departments)	1729	0,46%
Barton Village Electric Department (municipal electric departments)	1081	0,29%
Village of Jacksonville Electric Dept (municipal electric departments)	1003	0,27%
Village of Johnson (municipal electric departments)	950	0,25%
Village of Orleans (municipal electric departments)	670	0,18%
Village of Hyde Park (municipal electric departments)	21	0,01%

Fig.74. *Utility companies market share distribution*[213]

Utilities' RE agenda

Green mountain power plans to become 100% carbon free energy provider via boost of local energy generation and battery storage deployment. Due to its renewable energy focus company provides various related products state's citizens: company provides Energy Bundle program that includes solar roof top, RESS, grid energy and EV in one monthly payment; possibility for businesses to install energy storage systems; possibility to purchase digital energy consumption monitor, yard

[213]vtpsd.maps.arcgis.com. ArcGIS Web Application. [online] Available at: https://vtpsd.maps.arcgis.com/apps/webappviewer/index.html?id=9f9b060d475d4ed49795fdd98aa895fc [Accessed: 03.06.2021]

appliances and other tools; company has utility-scale batteries and PV systems.[214] GMP is committed to being 100% carbon free by 2025 and 100% renewable by 2030.

Vermont has put a high focus on the decarbonization. One of the companies that drive the transformation is the Northwest Vermont's integrated energy services company that serves 53000 families and businesses in Franklin, Chittenden and Addison Counties. According company statement it has set an ambitious strategy to transform the company and eliminate greenhouse gas emissions by 2050. The company outlined three key strategies to achieve the near-term goal of a 30% greenhouse gas reduction in customers' homes and businesses by 2030:[215]

- Doubling energy efficiency savings with a $20 million upfront investment;
- Significantly expanding renewable natural gas for customers;
- Strengthening partnerships to advance projects such as district energy in Burlington and Middlebury, and a net zero home pilot program.

Another energy market player Vermont Electric Cooperative (VEC) also plans to reach carbon neutrality by 2023 and transition fully to renewable, carbon-free energy sources by 2030. Organization has 32000 members and it is the state's largest consumer-owned energy distributor in Vermont, serving seventy-five communities and eight counties. Currently, around 75% of power distributed by VEC is already produced carbon-free. In the 2020-2022, VEC will seek to phase out the remaining quarter of its energy produced from fossil fuels.[216]

Green mountain power provides various stimuli for green energy projects. The company provides citizens with rebates for a EV, E-bike, e-cycle purchase + free level-2 chargers + low tariffs for charging Self-generating households recieve RECs that could then be sold (one for each 1 kWh

[214] Green Mountain Power. (2021). GMP Announces Pioneering Microgrid in Panton, Vt., Designed to Keep the Lights on with Clean, Local Power During Outages. [online] Available at: https://greenmountainpower.com/gmp-announces-pioneering-microgrid-in-panton-vt/ [Accessed: 03.06.2021]

[215] Vermont Gas. Who We Are. [online] Available at: https://www.vermontgas.com/about/who-we-are/. [Accessed: 03.06.2021]

[216]Vermont Electric plans for carbon neutrality by 2023, renewable energy by 2030 [online] Available at: https://middleburycampus.com/55372/local/vermont-electric-plans-for-carbon-neutrality-by-2023-renewable-energy-by-2030/ [Accessed: 03.06.2021]

generation capacity) [217]They highly support households to install RESS Home energy storage program provides households with up to $10 500 (the sum depends on battery capacity and whether you installed solar panels) when they choose to install batteries and share it capacity with the grid. People may choose the device and volume of shared capacity[218] A program in partnership with Tesla: 500 customers per calendar year statewide can participate in the option of paying $55 per month or $5,500 upfront for two Powerwall batteries in this 10-year lease agreement.

Other utilities present on the market also provide stimuli for green energy deployment. Vermont electric cooperative provides $500 credit to members who purchase a Zero Energy Modular (ZEM) home. Company introduced Clear Air Program, cost compensation for those who install electric energy generators instead of diesel or other fossil fuel. It has net metering program that allows to get $.15831 per kilowatt-hour bill credits if a household has a <15 kW renewable energy systems that is connected to the grid. The company promotes off-peak consumption and has community solar program that pays monthly electricity bill credits to those who install solar panels. In addition, self-generating households receive RECs that could then be sold (one for each 1 kWh generation capacity).

Burlington Electric Department supports customers' purchases of different home appliances, but no exact info about RESS. It provides opportunity to get 30% federal discount for the cost of your solar project. Households who sell electricity to the grid might get a 5 cents per every kWh generated perimium over the retail price (adder or several adjustors). Solar systems under 50 kW are exempt from both state and local property taxes, otherwise they are charged state property taxes of $4/kW. Self-generating households recieve RECs that could then be sold (one for each 1 kWh generation capacity)[219]

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[217]Green Mountain Power. Bring Your Own Device. [online] Available at: https://greenmountainpower.com/rebates-programs/home-energy-storage/bring-your-own-device/ [Accessed: 03.06.2021]

[218] Green Mountain Power. Bring Your Own Device. [online] Available at: https://greenmountainpower.com/rebates-programs/home-energy-storage/bring-your-own-device/ [Accessed: 03.06.2021]

[219]Arcgis.com. (2021). [online] Available at: https://burlingtonvt.maps.arcgis.com/apps/Embed/index.html?webmap=bb1b9156d8294e308ecfe803131e8c00&extent=-73.2731 [Accessed: 03.06.2021]

Threat of substitutes

Supply to the grid

In 1998, Vermont introduced net metering, which has been crucial for the solar energy industry nationwide by allowing residents to send surplus net energy to the electric grid and receive compensation for it on their energy bill. Net metering in the Green Mountain State has been revised several times, including most recently in 2017. Previously, utilities provided compensation for excess solar generation at the retail rate, rather than the wholesale or avoided-cost rate used in other state net metering programs. Today, Vermont offers a blended residential retail rate, which is typically in the range of the retail rate for electricity.[220]

The amount paid for the supply of the electricity to the grid varies based on the utility company. Any customer net excess generation (NEG) is credited at the blended residential rate and carried over to the customer's next bill. The blended residential rate is calculated in a way to get the most accurate retail rate for electricity. In addition, each kWh sent to the grid from a home solar system smaller than 15-kW earns an additional $.01/kWh on top of the retail rate credit. This means that electricity production can earn surplus money. It is worth mentioning that if in 12 months more energy is supplied to the grid than is used, energy supplier loses the credit for that energy.[221]

In the state there is an option of Virtual Net Metering (VNM). Like net metering for rooftop solar power, VNM allows households or businesses to receive the net metering credits associated with a renewable energy project installed at a remote location. These credits are worth as much or close to as much as what they would pay for electricity from their utility.[222] Vermont's community solar program enables customers to get solar energy without putting panels on the roof. Under this policy, Vermont residents can participate in an off-site shared solar installation and earn credits to cover their utility bill, plus an additional incentive for the first 10 years.[223]

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[220] www.energysage.com. Vermont Solar Panels 2020 Pricing & Savings EnergySage. [online] Available at: https://www.energysage.com/solar-panels/vt/. [Accessed: 03.06.2021]

[221] www.solarreviews.com. Guide to Vermont incentives & tax credits in 2021. [online] Available at: https://www.solarreviews.com/solar-incentives/vermont [Accessed: 03.06.2021]

[222] Energysage.com. (2019). Community Solar: What is it? EnergySage. [online] Available at: https://www.energysage.com/solar/community-solar/community-solar-power-explained/. [Accessed: 03.06.2021]

[223] www.energysage.com. 2021 Vermont Solar Incentives, Tax Credits & Rebates EnergySage. [online] Available at: https://www.energysage.com/local-data/solar-rebates-incentives/vt/. [Accessed: 03.06.2021]

3.5 Analysis of Malaysian market

Political factors

State RE agenda

In 2009, the government endorsed the Malaysia Electricity Supply Industry (MESI) 1.0 initiatives; these aimed, in the years 2010–14, to transform the power sector. The objectives were: to improve the tariff mechanism, enhance fuel supply and security, and achieve governance effectiveness in managing the power sector. The MESI 1.0 initiatives prompted the establishment of the ring-fenced Single Buyer model. In 2018, the government announced the second stage of reform initiatives and the country plans to transform its electricity industry through the implementation of the MESI 2.0 objectives. The objectives are:[224]

- Implement competitive electricity tariff by removing distortions, modifying the tariff structure, and increasing integration of renewables in the system.
- Encourage third-party access to distribution and transmission system.
- Decentralize and move towards capacity and energy market model to allow for more efficient and flexible use of resources.

Minister of Science, Technology, Environment and Climate Change, Yeo Bee Yin, states that Malaysia should increase its use of renewable energy to 20 percent by 2025.[225] 40% are planned to be reached by 2035. It is planned to be achieved through the Malaysian Electricity Supply Industry Plan (MESI) 2.0. Under MESI 2.0, the industry would see multiple reforms including the liberalization of the electricity retail market by opening the segment up to new competitors, trial run for the third-party access of TNB's transmission assets, as well as independent sourcing of coal and gas from third parties for independent power producers (IPPs), instead of from TNB and Petroliam Nasional Bhd as currently practiced.

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[224]Kumar, M. (2021). Electricity supply industry reform and design of competitive electricity market in Malaysia. [online] . Available at: https://www.oxfordenergy.org/wpcms/wp-content/uploads/2021/01/Electricity-Supply-Industry-Reform-and-Design-of-Competitive-Electricity-Market-in-Malaysia.pdf [Accessed: 03.06.2021]

[225]Ruzki, R.M. (2020). Malaysia tidak akan guna nuklear sebagai sumber tenaga diperbaharui - Tun M. [online] Berita Harian. Available at: https://www.bharian.com.my/berita/nasional/2020/02/654328/malaysia-tidak-akan-guna-nuklear-sebagai-sumber-tenaga-diperbaharui [Accessed: 03.06.2021]

Overall, country plans to reduce the intensity of carbon emissions in gross domestic product by 45 per cent by 2030.

The Malaysian state of Johor plans to build a 450 MW solar power plant in Pengerang. The MYR1.4bn (US$345m) Sultan Ibrahim solar project, which is developed under the 2030 Johor Sustainable Development Plan, should be commissioned by 2023. The plant will also include an energy storage system.[226]

For the support of the RE development the Supply Agreement on Renewable Energy (SARE) was introduced. The program includes a 'Solar Leasing' concept whereby consumers are able to lease solar panels and install them at their households without the need to pay for the system. With this policy, users have no upfront cost to install PV panels, and payment for the monthly leasing fee, or solar energy usage, can be made to the solar company involved.

The government of Malaysia introduced the LargeScale Solar (LSS) programme in 2016 in order to expand the share of this resource in the generation mix. The Energy Commission (EC) of Malaysia has started the competitive bidding process for LSS to offer a total of 434 MW for Peninsular Malaysia, with a tariff ranging from 39.95 to 44.95 sen/kWh (Abdullah et al., 2019). In 2020, Malaysia opened competitive bidding for 1 GW of solar plants worth about RM4 billion, the largest capacity offered under its LSS scheme – two packages offered through the tender are 500 MW for capacity between 10 MW and 30 MW, and another 500 MW for capacity between 30 MW and 50 MW (NST, 2020). These initiatives are expected to increase the share of solar PV in the generation mix of Malaysia significantly.

Foreign participation in Malaysian renewable energy market remains restricted. "Foreigners are generally only allowed to own up to 49% of the controlling interest in project entities. This reduces attractiveness of the market to many international solar energy IPPs (independent power producers), which in turn reduces competition"[227]

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[226] www.enerdata.net. Johor (Malaysia) plans a new 450 MW solar power plant Enerdata. [online] Available at: https://www.enerdata.net/publications/daily-energy-news/johor-malaysia-plans-new-450-mw-solar-power-plant.html [Accessed: 03.06.2021]

[227] Mag, S. Malaysia Solar Energy Profile: A Global Solar Manufacturing Hub, Malaysia Cautiously Steps Up Efforts to Boost Growth, Liberalize Domestic Market. [online] Solar Magazine. Available at: https://solarmagazine.com/solar-profiles/malaysia/. [Accessed: 03.06.2021]

State support

The country is committed to energy efficiency measures and focuses on the penetration of renewable power in the electricity supply. According to the Malaysian government, 20% of the energy is expected to be generated from renewable sources by the end of 2025. Moreover, it focuses on replacing fossil fuels with renewable energy to reduce the emission of greenhouse gases. Finance Minister Lim Guan Eng announced the green tax measures to help the nation achieve its target of 20% renewable energy mix by 2025 when the 2020 Budget was being defined. "In addition, tax incentives will also be introduced to companies implementing solar leasing activities with income tax exemption of 70% for up to 10 years," he said.[228]

Green Income Tax Exemption is granted to qualifying companies which provides green technology services which have been verified by GreenTech Malaysia and listed under the MyHIJAU Directory. The list of activities which qualify as green technology services include services related to renewable energy project such as system design and feasibility study, advisory and consultancy, testing and commissioning of renewable energy[229].

Banks have also started offering financing programmes specifically for those who want to purchase solar power systems. United Overseas Bank (M) Bhd, for instance, rolled out its U-Solar programme in October 2019. The programme targets both companies and homeowners who wish to purchase a solar power system from one of its partners — ERS Energy Sdn Bhd, Plus Solar Systems Sdn Bhd and Solarvest Holdings Bhd — by offering a 0% interest instalment plan of up to 36 months. In addition, Bank Islam offers up to 100% financing for the purchase of a solar PV package from GSPARX with a floating rate of 4.67%.

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[228] The Star. Budget 2020: Green tax exemptions extended to 2023. [online] Available at: https://www.thestar.com.my/news/nation/2019/10/11/budget-2020-green-tax-exemptions-extended-to-2023 [Accessed: 03.06.2021]

[229] www.legal500.com. Legal Updates on the Solar Energy Industry in Malaysia – Legal Developments. [online] Available at: https://www.legal500.com/developments/thought-leadership/legal-updates-on-the-solar-energy-industry-in-malaysia-2/ [Accessed: 03.06.2021]

It is worth mentioning that most of the incentives are given to the organizations and there are almost no financial stimuli for residential installations. This leads to the existent demand for the industrial and commercial systems and low demand for residential systems.[230]

You can lease your solar panel via the solar power purchase agreement (PPA) and solar lease programs offered by solar panel service providers. This would require no upfront payment on your end and you get to enjoy services such as maintenance and repair, system monitoring, insurance, and roof penetration warranty – in exchange for a fixed monthly payment for a designated time period.

Economic factors

Purchasing power

In 2019, the median wealth per adult in Malaysia was at around 8.9 thousand U.S. dollars per year. In that year, 53.4 percent of the adult population had wealth valued at under 10000 U.S. dollars.[231]

While in 2019, there were around 20.45 thousand millionaires living in Malaysia.[232] Average monthly income of top 20 per cent of households in Malaysia is this $4.3k. In 2019, the average mean monthly salary in Malaysia was around 3.2 thousand Malaysian ringgit (780$).[233]

According to the Department of Statistics Malaysia said, the number of households belonging to the poor category in 2019 was 405,441. The 2019 poverty rate is 5.6 percent (405,441 households), the poverty rate in 2016 was 7.6 percent (525,743 households).[234]

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[230]The Edge Markets. (2020). Solutions: Getting financing for your solar power system. [online] Available at: https://www.theedgemarkets.com/article/solutions-getting-financing-your-solar-power-system [Accessed: 03.06.2021]

[231]Statista. Malaysia: median wealth value 2019. [online] Available at: https://www.statista.com/statistics/957203/malaysia-median-wealth-value/#:~:text=In%202019%2C%20the%20median%20wealth [Accessed: 03.06.2021]

[232] Statista. Malaysia: number of millionaires 2018. [online] Available at: https://www.statista.com/statistics/785029/malaysia-number-of-millionaires/. [Accessed: 03.06.2021]

[233]Statista. Malaysia: number of millionaires 2018. [online] Available at: https://www.statista.com/statistics/785029/malaysia-number-of-millionaires/. [Accessed: 03.06.2021]

[234] Mohamad, H.F. (2020). Had pendapatan kemiskinan dinaikkan dari RM980 kepada RM2,208. [online] Berita Harian. Available at: https://www.bharian.com.my/bisnes/lain-lain/2020/07/709264/had-pendapatan-kemiskinan-dinaikkan-dari-rm980-kepada-rm2208. [Accessed: 03.06.2021]

Electricity tariffs

Tariffs for residential units are presented in the figure below (Figure 79). Including taxes and additional fees tariffs for the first 200 kWh (1 -200 kWh) per month are 0.1044 $/kWh. For the next kWh (201 kWh onwards) per month 0.12216 $/kWh (Figure 75). Historically, tariffs in Malaysia increased at a rate of 4.5% year-on-year. The tariff rate for customers in the Basic Consumption Band (0-200 kWh) has been maintained at the same level since 1997, the taxes and additional fees are the only variable factors. The tariff rate for the 201-300 kWh consumption band has been maintained at the same level since 2009.

Tariff Category	Unit	01-Jun-11	01-Mar-09
For all kWh (up to 200 kWh a month)	$/kWh	0.0828	0.078
For all kWh (above 200 kWh a month)	$/kWh	0.09048	0.08352

Fig.75. *Electricity prices Malaysia*[235]

However, for the period January 2021 to June 2021, the Government has decided to give rebates to all customers with monthly consumption of 300kWh and below. The government hopes that the rebate will help ease the cost of living for the people as well as reduce the cost of doing business affected by the COVID-19 pandemic and the cessation of BPE electricity discounts in December 2020. Apart from that, the government has allocated an electricity subsidy of 9.6 dollars specifically to domestic customers of the poor and the hardcore poor who are registered with the E-Kasih program.[236]

[235] TNB Better. Brighter. (2018). TNB Better. Brighter. [online] Available at: https://www.tnb.com.my/residential/pricing-tariffs. [Accessed: 03.06.2021]

[236] TNB Better. Brighter. TNB Better. Brighter. [online] Available at: https://www.tnb.com.my/faq/bm-tarif/ [Accessed: 03.06.2021]

Social factors

Private housing

According to the Malaysia Property Market Centre (NAPIC), there are almost 7 million properties in Malaysia. That number includes almost 5.8 million residential properties, alongside offices, shopping complexes, shops, serviced apartments, industrial buildings, and hotels.[237] Almost 70% of houses in Malaysia fall under the landed property category. It makes up 40% of the total property stock in 2020 (Figure 76).

Property	Total Units	% of Total Residential Properties
2-3 Storey Terraced	1,291,971	22.40%
Single-Storey Terraced	1,075,205	18.60%
Low-Cost House	689,116	11.90%
Detached	486,765	8.40%
Single-Storey Semi-Detached	213,654	3.70%
2-3 Storey Semi-Detached	206,372	3.60%

Fig.76. *Types of residential units*[238]

Technological factors

Stability of power supply

If there were outages, average duration of a typical electrical outage (hours) in Malaysia was reported at 3.8 hours.[239] Malaysia Is formed by several islands. The stability of power supply varies across the territories. On the time horizon of 2011-2017 the average duration of outages is going down.

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[237]Wait A Minute, How Many Properties Are There In Malaysia? [online] Available at: https://www.tnb.com.my/faq/bm-tarif/ [Accessed: 03.06.2021]

[238]Wait A Minute, How Many Properties Are There In Malaysia? [online] Available at: https://www.tnb.com.my/faq/bm-tarif/ [Accessed: 03.06.2021]

[239] tradingeconomics.com. Malaysia - If There Were Outages, Average Duration Of A Typical Electrical Outage (hours) - 2007-2015 Data 2021 Forecast. [online] Available at: https://tradingeconomics.com/malaysia/if-there-were-outages-average-duration-of-a-typical-electrical-outage-hours-wb-data.html [Accessed: 03.06.2021]

However, while on the main peninsula the SAIDI index was 54 in 2017 on the Perlis island, SAIDI reached 144 (Figure 77). This again shows how unequally Malaysia is developed.

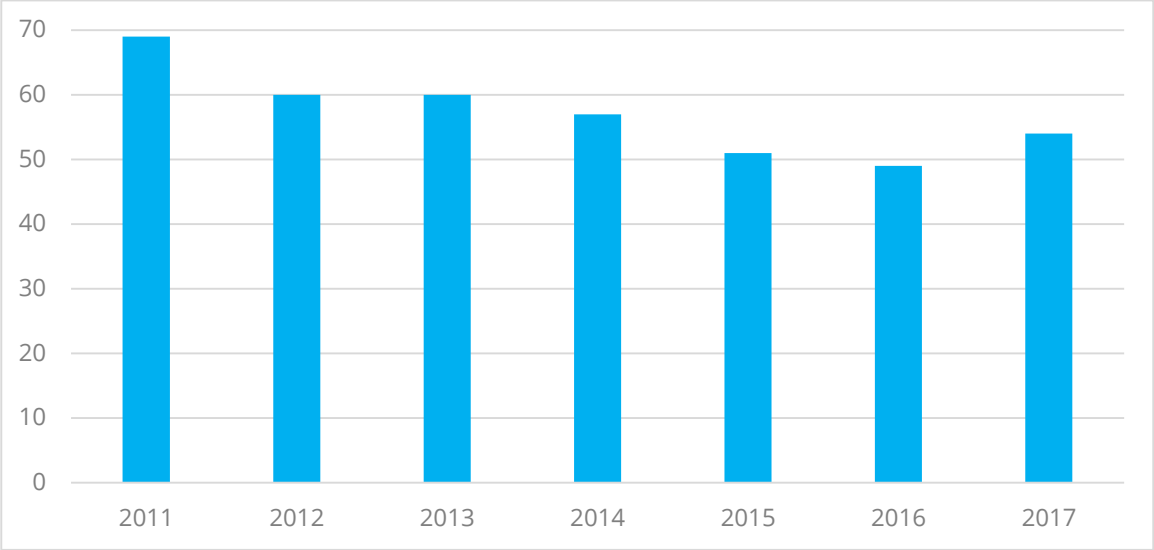

Fig.77. *Malaysia SAIDI*[240]

Power generation

According to national news resources 80 percent of the country's electricity is generated using gas and the rest using coal, oil and hydro (Figure 78). There are proposals to increase the use of nuclear energy for electricity generation, but the debate on it has not yet reached a point and a decision at the Cabinet level. When PETRONAS discovered oil deposits in national waters in the 1970s, the function of the Malaysian Nuclear Agency from originally developing alternative sources to oil, was restructured with efforts limited to the use of nuclear science and technology in national development. As can be seen from the map presented below, in the recent years government has invested in the development of renewable energies such as solar and hydro.

[240]www.data.gov.my. System Average Interruption Duration Index_SAIDI by State in Peninsular Malaysia - system average interruption duration indexsaidi by state in peninsular malaysia x - MAMPU. [online] Available at: https://www.data.gov.my/data/en_US/dataset/saidi/resource/2f8bdab1-8581-4bcd-8852-db2f1cd727a9 [Accessed: 03.06.2021]

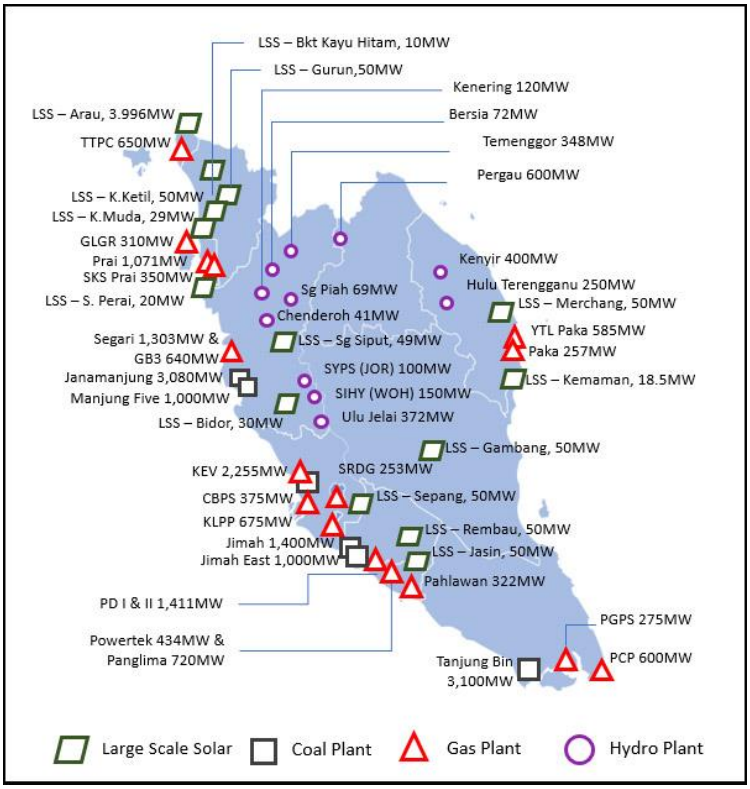

Fig.78. *Power sources*[241]

Environmental factors

Solar generation potential

Malaysia has the highest potential for solar uptake as it is located near the equator. The average annual amount of sunshine hours is:2220 hours[242].

Average theoretical PV potential (GHI) is 4.706 kWh/m^2. Global horizontal irradiation is from 4.05 to 5.20 kWh/m^2, and this parameter estimates more than 4.6kWh/kWp on 68,5% of areas

[241] www.st.gov.my. Energy Commission - Lokasi Stesen Janakuasa di Semenanjung Malaysia. [online] Available at: https://www.st.gov.my/ms/web/general/details/273/ [Accessed: 03.06.2021]

[242] Average Monthly Hours Of Sunshine In Kuala Lumpur (Kuala Lumpur Federal Territory): Weather&Climate/Malaysia/Kuala Lumpur/Sunshine//[online resourse] https://weather-and-climate.com/average-monthly-hours-Sunshine,Kuala-Lumpur,Malaysia (access: 25.05.21)

in Malaysia[243]. The irradiation is higher during North-East monsoon when the wind direction coming from central Asia to South China Sea through Malaysia and finally to Australia between November and March. Lower irradiation during South-West monsoon when the wind direction changes and proceeds from Australia and moves towards Sumatera Island before reaching the Straits of Malacca between May and September. Generally, Malaysia has a high potential for solar generation taking into consideration its hot and sunny weather all year round[244].

If we observe changes of Theoretical PV Potential during the year, Global Horizontal Irradiance annual variability in Portugal is small, from 1.6% to 3.0%, for the locations with higher GHI availability (typically the region south of the river Tejo) and only 3% to 4,75% for the remaining locations[245] (Figure 79, 80, 81).

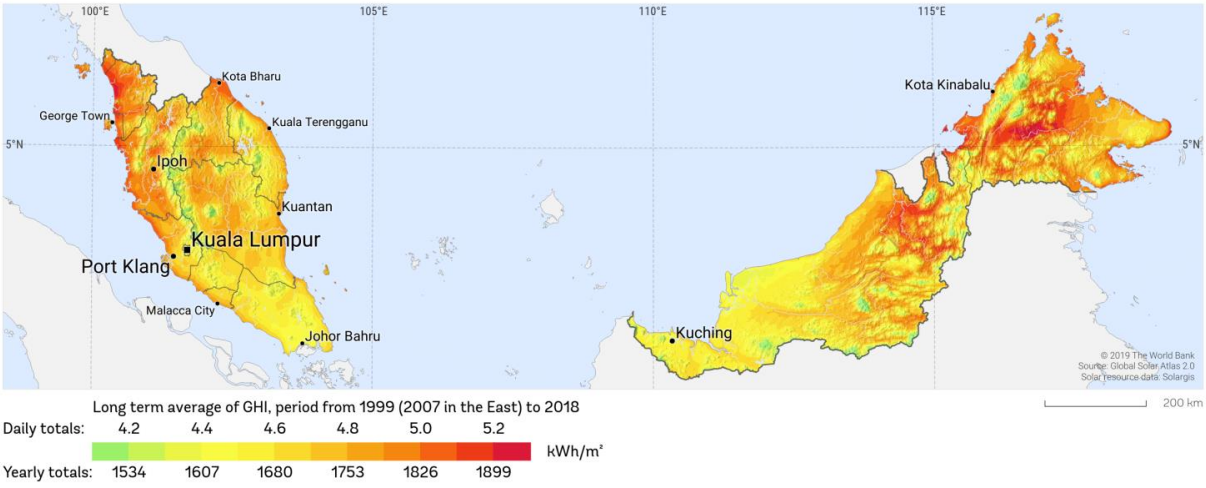

Fig.79. *GHI in Malaysia*[246]

[243]Malaysia: Global Solar Atlas/ Insights//[online resource] https://globalsolaratlas.info (access: 25.05.21)

[244] *W.Syakirah, W.Abdullah, M.Osman, M.Zainal, A. Ab Kadir, R.Verayia* The Potential and Status of Renewable Energy Development in Malaysia. 25 June 2019[online resource] –Access mode:https://www.mdpi.com/1996-1073/12/12/2437/pdf#:~:text=Malaysia%20has%20among%20the%20highest,MJ%2Fm2%20%5B35%5D.&text=Estimated%20potential%20for%20solar%20generation,to%206500%20MW%20%5B18%5D. (access:data 25.05.21)

[245] Global Photovoltaic Power Potential by Country: Global Solar Atlas //[online resourse] https://globalsolaratlas.info/global-pv-potential-study (access: 25.05.21)

[246] Malaysia: Global Solar Atlas/ Map and data downloads//[online resource] https://globalsolaratlas.info/download/malaysia (access: 25.05.21)

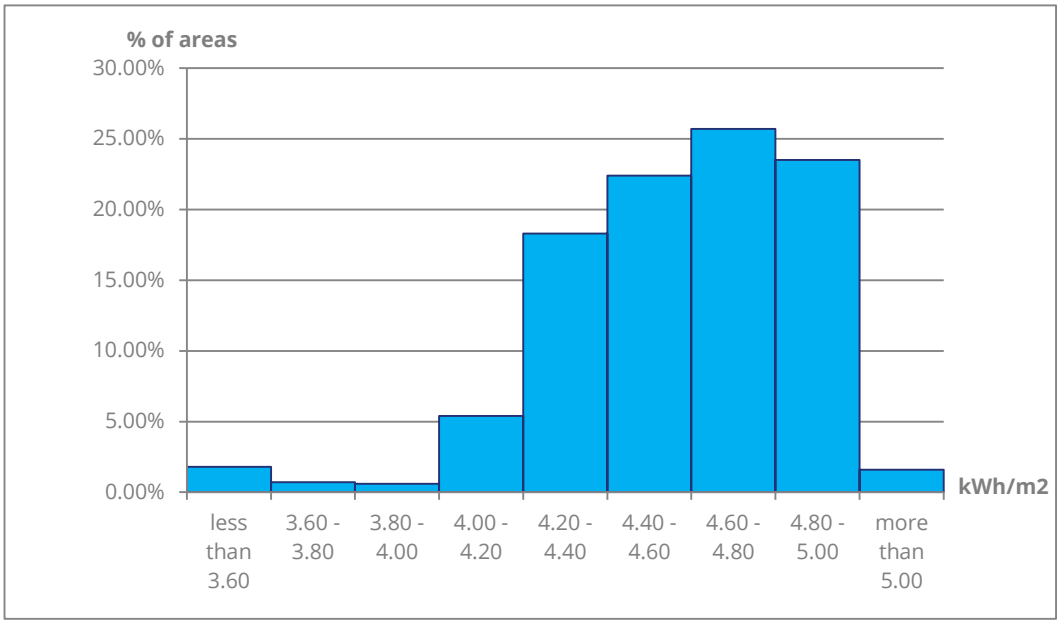

Fig.80. *Distribution of Global horizontal irradiation*[247]

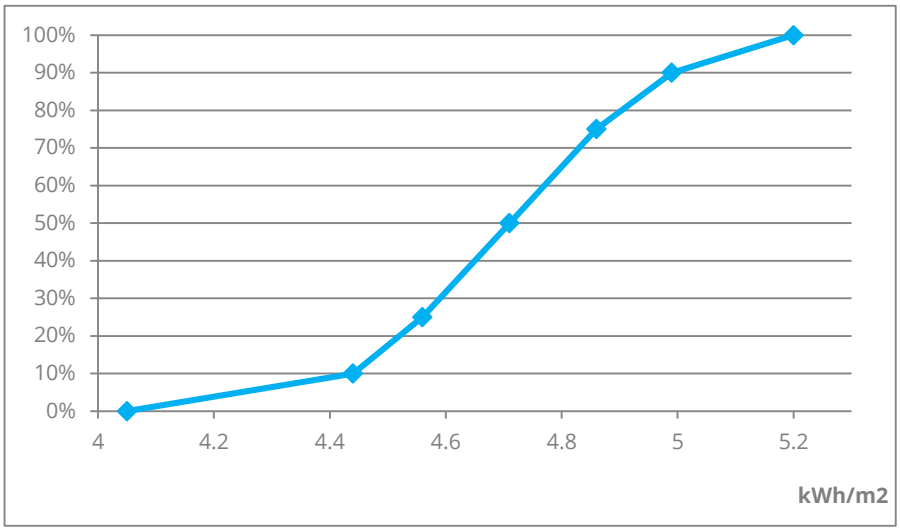

Fig.81. *Statistics of Global horizontal irradiation*[248]

[247] Malaysia: Global Solar Atlas/ Insights//[online resource] https://globalsolaratlas.info (access: 25.05.21)

[248] Malaysia: Global Solar Atlas/ Insights//[online resource] https://globalsolaratlas.info (access: 25.05.21)

In ranking of countries, which is based on zonal statistics of practical PV power potential Malaysia is on the 179th place[249]. Average practical PV potential is 3.740 kWh/kWp[250]. Specific photovoltaic power output(PVOUT) is from 3.26 to 4.10 kWh/kWp, and this parameter estimates more than 3,8 kWh/kWp on 75% of areas in Malaysia.[251] Overall, the environmental factors are beneficial for the development of solar market in Malaysia [252] (Figure 82, 83, 84)

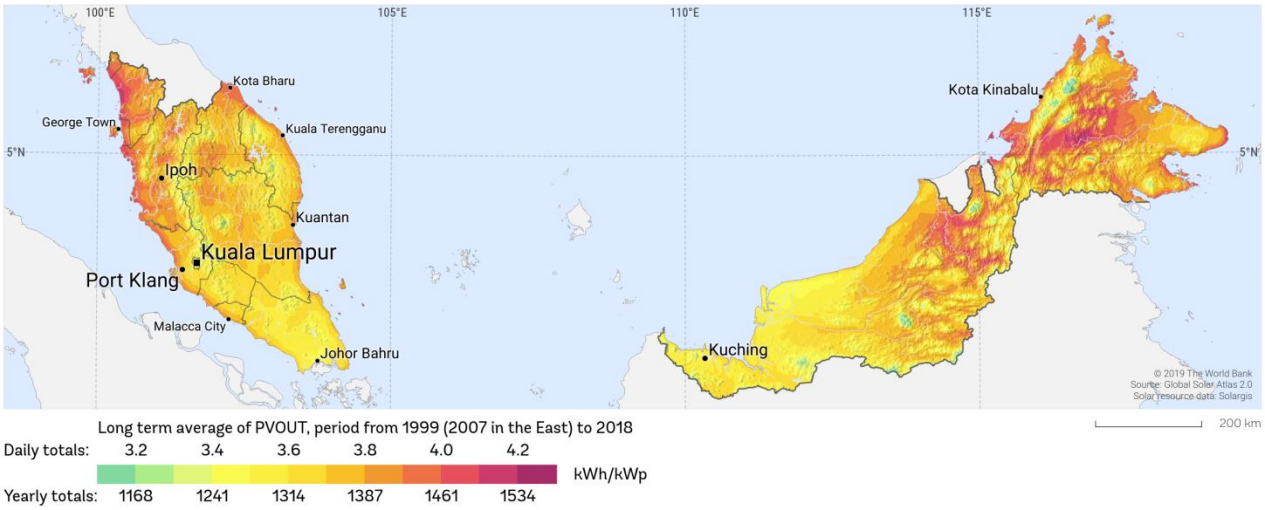

Fig.82. *PVOUT in Malaysia*[253]

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[249] Global Photovoltaic Power Potential by Country: Global Solar Atlas //[online resourse] https://globalsolaratlas.info/global-pv-potential-study (access: 25.05.21)

[250] Global Photovoltaic Power Potential by Country: Global Solar Atlas //[online resourse] https://globalsolaratlas.info/global-pv-potential-study (access: 25.05.21)

[251] Malaysia: Global Solar Atlas/ Insights//[online resource] https://globalsolaratlas.info (access: 25.05.21)

[252] *W.Syakirah, W.Abdullah, M.Osman, M.Zainal, A. Ab Kadir, R.Verayia* The Potential and Status of Renewable Energy Development in Malaysia. 25 June 2019[online resource] –Access mode:https://www.mdpi.com/1996-1073/12/12/2437/pdf#:~:text=Malaysia%20has%20among%20the%20highest,MJ%2Fm2%20%5B35%5D.&text=Estimated%20potential%20for%20solar%20generation,to%206500%20MW%20%5B18%5D. (access:data 25.05.21)

[253] Malaysia: Global Solar Atlas/ Map and data downloads//[online resource] https://globalsolaratlas.info/download/malaysia (access: 25.05.21)

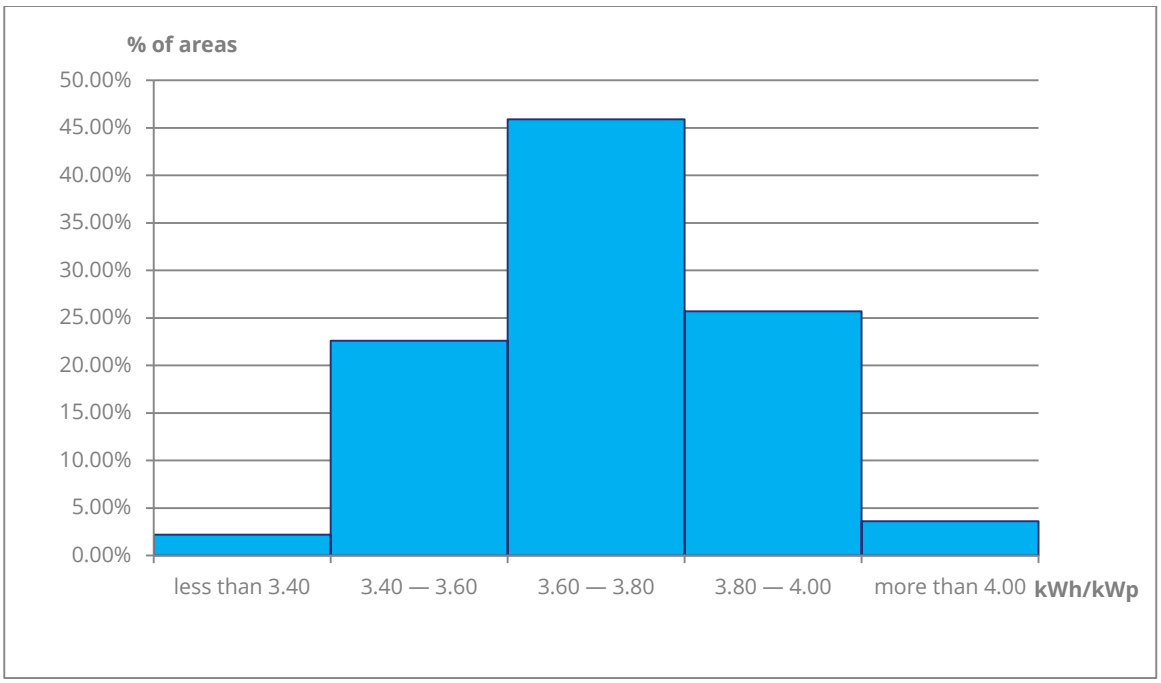

Fig.83. *Distribution of Specific photovoltaic power output*[254]

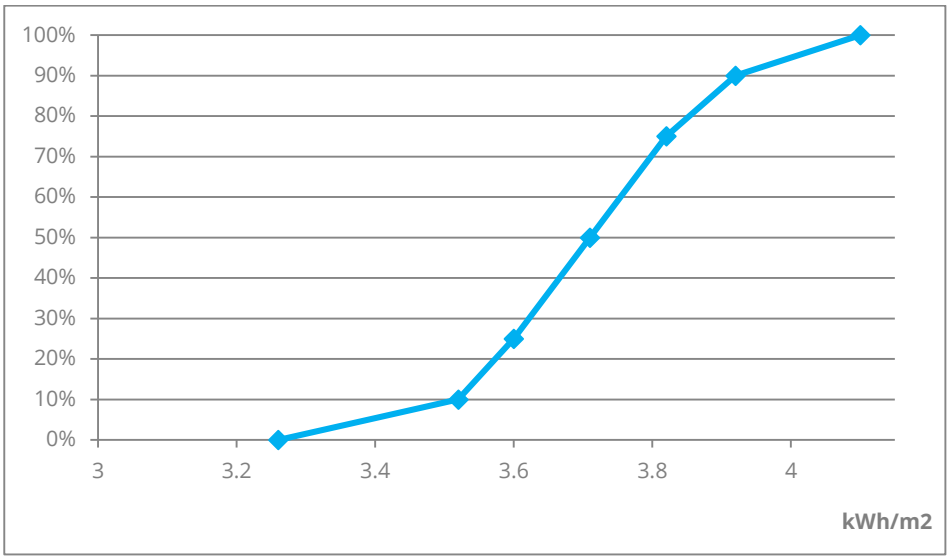

Fig.84. *Statistics of Specific photovoltaic power output*[255]

[254] Malaysia: Global Solar Atlas/ Insights//[online resource] https://globalsolaratlas.info (access: 25.05.21)

[255] Malaysia: Global Solar Atlas/ Insights//[online resource] https://globalsolaratlas.info (access: 25.05.21)

Legal factors

PV panels usage regulation

Firstly, potential photovoltaic system owners need to fila an application to the sustainable energy development authority. Once your application is approved, the following steps must be completed will:[256]

- Sign the Renewable Energy Power Purchase Agreement with Distribution Licensee;
- Register the signed agreement with SEDA;
- Review and sign the financial agreement the required conditions to the first drawdown;
- Allow service provider to install solar PV panels and FiT meter;
- Complete the Acceptance Test assigned by the hired certified expert;
- Proceed to engage SEDA and Distribution Licensee about the progress, focusing on details such as your commencement date, duration, and monthly payment details;

Market players

Direct competition

The Malaysia battery market is expected to grow at a CAGR of more than 6.6% over the period of 2020-2025. Factors such declining lithium-ion battery prices along with increasing demand for lead-acid batteries is expected to drive the Malaysia battery market during the forecast period. However, the country relies on pumped hydro storage rather than battery storage systems. This factor, in turn, is likely to hinder the growth of battery-based energy storage systems and the battery market in the coming years. The lead-acid battery type is expected to dominate the market during the forecast period.[257]

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[256]Solar Panel In Malaysia: Should You Install This For Your Home? [online] Available at: https://www.propertyguru.com.my/property-guides/solar-panel-malaysia-what-you-need-to-know-22910 [Accessed: 03.06.2021]

[257] www.mordorintelligence.com. Malaysia Battery Market Growth, Trends, and Forecast (2020 - 2025). [online] Available at: https://www.mordorintelligence.com/industry-reports/malaysia-battery-market [Accessed: 03.06.2021]

Just as in case of Portugal residential energy storage manufacturers do not have their own subsidiaries and are present via solar systems integrators. Out of the analyzed list of solar integrators only two provide energy storage systems which imply very low level of RESS penetration of the market.

PV integrators

At the moment there are over 100 solar PV service providers registered with SEDA Malaysia. Several companies are present on the Malaysian photovoltaic market. Q-cells is the company that provides both energy storage and photovoltaic systems. Overall, there is very low presence of smart residential energy storage on the market. On the one hand it opens opportunities for early market entry, on the other hand, it may imply that there is insufficient demand from the population for energy storage systems. Analysis of solar market players is presented below (Figure 85).

Company	Activities
Scatec	Solar panels integrator
Gsparx (owned by TNB)	Solar residential; C&I; Housing developers solution
Q-cells	Solar panels Manufactorer; Energy storage system; Full solar install; Mobile app
Solar System Malaysia	Solar Residental on grid, off grid; Solar bataries: Gel type, AGM, Flooded type, RVz; Commercial: solar lightning, commercial PV projects and design, complex commercial solar system (on grid)
nextenergy	Solar Photovoltaic (PV) Solutions; Solar Energy System Installation; Large Scale Solar Farms (LSS)
i2 Energy Sdn Bhd	Solar residential and C&I; Engineering, designing and installing; Operations & Maintenance
Atlantic Blue Sdn Bhd	Rooftop solar; Large Scale Solar (capacity ranging from 1MW to <30MW); Operations & Maintenance
Hasilwan (M) Sdn Bhd	Rooftop solar pv systems; engineering, procurement, construction & commissioning (epcc) for power grid systems; service & maintenance; high voltage products and medium voltage products; renewable energy and energy storage
Gading Kencana Sdn Bhd	Solar street lights; Off and on grid solar PVs; Large scale solar
SFG Technology (M) Sdn Bhd	ESS for ancillary services, renewable integrations (Utility); ESS for rural electrification, off-grid & stand alone system; ESS for Fast Charging Electric Vehicle
Solar Skyworks Sdn Bhd	Solar On grid; Off grid
Maqo Technologies (M) Sdn Bhd	Solar leasing; Solar PV; NEM
BSL ECO Energy Sdn Bhd	Solar PV; Solar Inventors; Solar MOUNTING
Suria Infiniti Sdn Bhd	Solar dryers; Solar Lighters; Solar PV panels
Pensolar Sdn Bhd	BIPV (Building Integrated PV); Solar PV; On off grid
ERS Energy Sdn Bhd	EV Charging solutions; PV solar ; Large scale & Residental; ESS used: Tesla PowerWall, MB Energy storage, LG CHEM

Fig.85. *Solar market players Malaysia*

Source: custom table

Utility market structure

Malaysian electricity market is highly concentrated. Malaysia's three electrical companies: Tenaga Nasional, supplying the Peninsular Malaysia, Sabah Electricity, which serves the state of Sabah and Labuan (owned by Tenaga Nasional Berhad (TNB) (80%)) and Sarawak Energy.

Based on annual household electricity sales by TNB in Peninsular Malaysia of 24,828 GWh in 2017 (TNB had a total of 7.2 million household consumers in 2017).[258] The current Malaysian energy sector framework is based on a single-buyer model whereby IPPs and the power generation arm of TNB are responsible for generating electricity, which is sold to the Single Buyer unit of TNB (in Peninsular Malaysia), Sarawak Energy (in Sarawak) and the SESB (in Sabah). The single-buyer units are thereafter responsible for distribution and retailing electricity in their respective jurisdictions The Single Buyer model is a market framework in which a government-backed central agency is responsible for the procurement of electricity from generators, often through term contracts.[259]

Utilities' RE agenda

To date, TNB's total renewable energy portfolio is 2,732.3 megawatts (MW) in Malaysia (including 2,536.1MW of large hydro) TNB also wants to expand its total renewable energy portfolio to 8,300MW by 2025 (including hydro large)[260]. The company aims to generate 1,700 megawatts of renewable energy by 2025 in line with the government's target to generate 20 per cent of electricity through renewable energy sources by 2030.[261]

Another big utility company Sarawak Energy Bhd states to be the main leader in reducing the country's carbon emission intensity by 45 per cent by 2030. Its largest hydroelectric power plant in Sarawak has reduced carbon intensity for power generation by 68 per cent from 2011 to 2019. Sarawak hydroelectric projects such as Bakun, Murum, Batang Ai and finally Baleh are counted in Malaysia's renewable energy target of 31 per cent by 2025 and 40 per cent by 2035.

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[258]TNB Better. Brighter. TNB Better. Brighter. [online] Available at: https://www.tnb.com.my/about-tnb/corporate-profile#:~:text=CUSTOMER%20BASE%20%3A%209.2MILLION%20CUSTOMERS [Accessed: 03.06.2021]

[259] Aziz, S.-F.A. and Khor, K. Spotlight: the energy markets in Malaysia Lexology. [online] www.lexology.com. Available at: https://www.lexology.com/library/detail.aspx?g=137e4498-55d0-4651-a559-390006029c1c [Accessed: 03.06.2021]

[260] Dagang News. TNB teroka pasaran tenaga boleh diperbaharui Singapura. [online] Available at: https://dagangnews.com/tnb-teroka-pasaran-tenaga-boleh-diperbaharui-singapura [Accessed: 03.06.2021]

[261]Berita Harian. (2019). TNB, DBKL kaji usaha sama tenaga boleh diperbaharui. [online] Available at: https://www.bharian.com.my/bisnes/lain-lain/2019/07/590157/tnb-dbkl-kaji-usaha-sama-tenaga-boleh-diperbaharui [Accessed: 03.06.2021]

Apart from successfully commissioning the first integrated hydrogen production plant in Southeast Asia and a refilling station in Kuching in 2019 under a Sarawak government-funded project, Sarawak Energy also aims to have about four per cent solar photovoltaic (PV) in its combined power generation by 2030. following plans to commission its first floating solar power plant at the Batang Ai dam.

According to Abdul Hamed, Sarawak Energy also introduced the first renewable energy (REC) certification in Sarawak to enable greater participation of companies in a more sustainable energy future so that they get 100 per cent electricity from renewable sources and increase consumption. as well as the integration of renewable energy. As the energy arm of the Sarawak government, Sarawak Energy's corporate vision and business model are designed to lead the transition to a sustainable energy future at the national and regional levels. Commenting on the agreement, he said Sarawak Energy would supply 90 megawatts of electricity to the Malaysia LNG Complex in Tanjung Kidurong, Bintulu for a period of 20 years starting March 2024.[262] Sarawak will have another source of renewable energy when the Baleh Hydroelectric Dam Project with a capacity of 1,285MW is expected to start operating in 2026.[263]

Threat of substitutes

Supply to the grid

In January 2020 the Net Energy Metering system was revamped by the Sustainable Energy Development Authority Malaysia (SEDA). It allows NEM participants to export excess power generated back to the grid on a “one-on-one” offset basis, which means every 1kWh exported to the grid will be offset against 1kWh consumed from the grid, instead of a displaced cost.

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[262] energy.bernama.com. Sarawak Energy peneraju utama kurangkan pelepasan karbon negara. [online] Available at: http://energy.bernama.com/newsbm.php?id=1937765 [Accessed: 03.06.2021]

[263]www.utusanborneo.com.my. (2021). Empangan Hidroelektrik Baleh mula beroperasi 2026, satu lagi sumber tenaga boleh diperbaharui Sarawak. [online] Available at: https://www.utusanborneo.com.my/2021/03/04/empangan-hidroelektrik-baleh-mula-beroperasi-2026-satu-lagi-sumber-tenaga-boleh [Accessed: 03.06.2021]

Previously, excess solar energy was sold to Tenaga Nasional Bhd at a displaced cost of 0.0744 $/kWh, compared with the domestic electricity tariff, which ranged from 0.05 $ to 0.136 $ per kWh. The lower selling price resulted in a low take-up rate of the previous NEM programme.[264]

Malaysian government has introduced a peer-to-peer energy trading. P2P is one of the strategies that is explored by the authorities under the Renewable Energy Transition Roadmap (RETR) 2035. study being undertaken by SEDA to augment the solar PV rooftop market. Peer-to-peer energy (P2P) energy trading is the buying and selling of energy between two or more grid-connected parties. Motivation for prosumers & consumers: prosumers have small financial gains while consumers have small energy savings. P2P energy trading occurs when solar photovoltaic (PV) producer sells excess solar electricity on an energy trading platform to another consumer. Participating consumers have the choice of purchasing solar electricity from the P2P and from the grid.

Customers committed to rooftop solar panel installations are also automatically signed up for the Malaysian government's revised Net Energy Metering 2.0 (NEM 2.0) mechanism of 2019. The concept of NEM is that the energy produced from the installed solar PV system will be consumed first, and any excess will be exported to the grid. NEM mechanism offers the same tariff for selling and buying electricity and from the consumers' perspective this gives an incentive to opt for solar PV. The quota for this mechanism is up to 500 MW on a first-come, first-served basis, and the mechanism will end by 31 December 2020 even if the quota is not reached. Following the success of Net Energy Metering (NEM) 2.0, in 2021, the Energy and Natural Resources Ministry (KeTSA) introduced the Net Energy Metering (NEM) 3.0 programme to encourage more users to install Solar PV systems on their rooftops for electricity bill reduction. For the NEM 3.0 the same quota size as the previous one is offered from February 1 2021 to December 31 2023, entailing all energy consumers (e.g., residents, commercial and industrial).

3.6 Markets prioritization

Based on the conducted analysis and the score distribution procedure described in the second chapter the following prioritization scorecard was developed (Figure 86).

[264]The Edge Markets. (2020). Solutions: Getting financing for your solar power system. [online] Available at: https://www.theedgemarkets.com/article/solutions-getting-financing-your-solar-power-system. [Accessed: 03.06.2021]

Section	Determinant	Weight	Germany score	Weighted score	Portugal score	Weighted score	Luxembourg score	Weighted score	Vermont score	Weighted score	Malaysia score	Weighted score
Political	State RE agenda	1	3	3	3	3	3	3	3	3	2	2
	State support	1.5	3	4.5	2	3	2	3	3	4.5	1	1.5
Economic	Purchasing power	1.5	3	4.5	2	3	3	4.5	2	3	1	1.5
	Electricity tariffs	1.5	3	4.5	3	4.5	3	4.5	2	3	1	1.5
Social	Private housing	1	3	3	2	2	1	1	2	2	2	2
Technological	Stability of power supply	0.5	1	0.5	3	1.5	1	0.5	2	1	3	1.5
	Power generation	0.5	1	0.5	2	1	3	1.5	2	1	3	1.5
Environmental	Solar generation potential	1.5	2	3	3	4.5	2	3	2	3	3	4.5
Legal	PV panels and RESS usage regulation	1	3	3	3	3	3	3	3	3	2	2
Market players	Direct competition	2	1	2	2	4	1	2	1	2	3	6
	PV integrators	1	2	2	2	2	3	3	3	3	3	3
	Utility market structure	1	1	1	3	3	2	2	1	1	1	1
	Utilities' RE agenda	1	3	3	2	2	2	2	3	3	3	3
Threat of substitutes	Supply to the grid	1.5	2	3	3	4.5	2	3	1	1.5	1	1.5
		Total	18.75	22.75	20.75	24.75	17.5	20.75	17	19.5	16	18

Fig.86. *Final prioritization*

Source: custom table

The final scores were attributed in cooperation with company CEO Alexander Kiyanitsa and CEO of Enerix Stephan Jacob. The scores were based on the qualitative and quantitative analysis of the target markets. Based on the prioritization scorecard Portugal has been chosen as the primary market for foreign market entry for Volts Battery. The evaluation of Portuguese market attractiveness assessment is given at the end of the chapter, where basic recommendations on the market entry are also given.

Germany is placed the second place with a small difference from the primary market. German market has been the catalyst for the development of residential energy storage industry and is leading in terms of installed storage capacity. Overall, German market has many factors that are beneficial for the residential energy storage industry development. The availability of state subsidies both for energy storage and solar systems combined with high electricity prices lead to short payback period and higher economic attractiveness of such systems Based on the market evaluation scorecard almost all of the criteria had maximum attractiveness points.

The main factor that led to Germany having the second place is high intensity of competition. Being one of the most mature markets, Germany has multiple RESS manufacturers and distributors. Global industry leaders are present on the market and having the highest weight, competitive intensity has a significant impact on the definition of market attractiveness.

Luxembourg has been placed the third. The country shares its borders with multiple European countries and one of them is Germany. The energy storage systems can be easily installed by German or French companies. Keeping in mind the ease of trade between European Union members, this factor significantly decreases Luxembourg attractiveness. In addition, relatively smaller size of the region leads to lower potential target audience size represented by the number of private houses.

Vermont and Malaysian markets share the last two positions. Vermont has put high priority on the development of renewable energies and some policies supporting photovoltaic systems were introduced many years ago. Due to this fact, the market is mature and several energy storage manufacturers are present on the market. The electricity supply market shows high concentration and the biggest utility company has a partnership with global residential energy storage providers.

Malaysian market has high solar power generation potential, government is interested in the development of renewable energies, but the low population prosperity, lack of support from the government and low electricity prices do not stimulate solar and battery systems penetration.

Portuguese market evaluation

Portuguese market has been chosen as a primary market for the entry. High solar potential, simple regulatory framework, low intensity of competition and low substitution threat has led to such a high score. In addition, relatively high electricity prices provide an additional stimulus for the purchase of solar and battery systems.

Based on the market analysis, the following recommendations for market entry can be given. Volts battery management should focus on the creation of partnerships with established energy market players. At the beginning company should enter the market via a distributor or create a joint venture.

As the Uppsala model[265] states the company should enter the market in a consecutive steps learning about the market and establishing valuable relationships. Utility market is liberalized and there is concern for renewable energy penetration. This fact may lead to higher utility companies' openness to possible partnerships with residential energy storage manufacturers. Electricity suppliers already have a customer base that can be utilized in order to sell energy storage. Another potential partner with an established market presence is a solar panels integrator. By adding energy storage to their portfolios solar panels integrators can bring more value to their offering and differentiate themselves from other competitors.

Entering the market via partnership is important due to lack of experience of Volts Battery management in the international expansions and lack of knowledge about the market. One of the possible ways to facilitate a market entry is by finding a local investor that will provide additional resources and who could utilize his network in order to promote the company. Volts Battery has managed to get such partner in the MENA region, where it managed to attract an investment round from a startup accelerator founded by UAE state fund.

At the moment company does not have sufficient resources to enter the market on its own. Company management is already working on the attraction of investment funds. Taking into consideration that Portuguese market has been chosen as a primary market, additional resources should be put into search for local investors who can support the Portuguese market entry.

On the market there are present local startups that have established their own production facility. This company uses its local position in its marketing activities and will pose a threat to the Volts Battery market expansion. Marketing strategy should be adjusted in a way that will enable competitiveness against local producers and incoming foreign companies.

The abovementioned fact can serve as an additional argument for the market entry via a partnership with local company. By doing so Volts Battery will be able to be associated with a local entity. In addition to using established sales channels, Volts Battery will use its partner brand image

[265]Zohari, T. (2012). The Uppsala Internationalization Model and its limitation in the new era . [online] Digit Pro. Available at: https://www.digitpro.co.uk/2012/06/21/the-uppsala-internationalization-model-and-its-limitation-in-the-new-era/. [Accessed: 03.06.2021]

to address groups of customers who can have prejudice against companies originating in foreign regions.

In addition to finding a distribution partner, company needs to establish its supply and production chains. The design of the product and its assembly process enables usage of the local subcontractors. Local assembly in comparison to the import of the system will bring the positioning benefit of being assembled locally. This fact will alleviate the possible negative influence of being a foreign company.

Due to its size and capabilities Volts Battery cannot offer lower prices, company needs to differentiate its product offering and positioning. A further market research is necessary in order to define the marketing strategy and ways to beneficially position the company on the market.

Conclusion

The main goal of the paper was achieved, chosen markets were analyzed and prioritization provided. All of the initially set objectives were met:

- Conceptual base for the problem solving was analysed. Several methodologies were overviewed, their limitations defined.
- A framework for market analysis was created based on the methodologies analysis and interview with the company related stakeholders.
- The chosen markets were analysed in detail based on the market criteria defined. Extensive data on the five primary markets was gathered based on the developed methodology and analysis provided.
- The most attractive market was defined, basic recommendations on the market entry given.

The scorecard method brought the following prioritization order:

1) Portugal
2) Germany
3) Luxembourg
4) Vermont
5) Malaysia

It is worth mentioning that there are certain limitations to the work. The approach of setting scores had a subjective nature. Some of the chosen factors could not be compared to each other using some quantitative measure. In order to increase the accurateness of the framework additional quantitative criteria should be added and additional data obtained.

To improve the accurateness of the comparison process factors can be evaluated relatively to each other and relative score can be obtained. Certain criteria had quantitative criteria that could be used for creation of a scorecard for every determinants based on particular ranges of values.

Moreover, there is a need for additional market analysis in order to provide the final recommendations on market entry strategy. The market analysis provided in the paper gives an overview of the markets and helps to prioritize them, but final decision on the market entry should be made after deeper analysis of the chosen market is provided.

Another limitation is that the scores for qualitative criteria were set only by three experts. For an experiment more people should be involved in criteria distribution in order to check, whether different experts will give similar results judging from the same data.

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Appendix

Appendix. GE multifactor model: Industry attractiveness evaluation example[266]

Attractiveness criterion	Weight	Rating	Weighted score
Size	.15	4	.60
Growth	.12	3	.36
Pricing	.05	3	.15
Market diversity	.05	2	.10
Competitive structure	.05	3	.17
Industry profitability	.20	3	.60
Technical role	.05	4	.20
Inflation vulnerability	.05	2	.10
Cyclicality	.05	2	.10
Customer financial	.10	5	.50
Energy impact	.08	4	.53
Social	GO	4	-
Environmental	GO	4	-
Legal	GO	4	-
Human	.05	4	20
	1.00		3.38

[266] Hax, A. C. and Maijluf , The use of Industry Attractiveness-Business Strength Matrix in strategic planning. England: John Wiley & Sons

Appendix. GE multifactor model: business competitiveness capabilities evaluation example[267]

Critical success factor	Weight	Rating	Weighted score
Market share	10	5	.50
SBU growth rate	X	3	-
Breadth of product line	.05	4	.20
Sales distribution effectiveness	.20	4	.80
Proprietary and key account advantages	X	3	-
Price competitiveness	X	4	-
Advertising and promotion effectiveness	.05	4	.20
Facilities and location and newness	.05	5	.25
Capacity and productivity	X	3	-
Experience curve effects	.15	4	.60
Raw materials costs	.05	4	.20
Value added	X	4	-
Relative product quality	.15	4	.60
R&D advantages/position	.05	4	.20
Cash throw-off	.10	5	.50
Caliber of personnel	X	4	-
General image	.05	5	.25
	1.00		4.30

[267] Hax, A. C. and Maijluf , The use of Industry Attractiveness-Business Strength Matrix in strategic planning. England: John Wiley & Sons

Appendix. Types of buildings in Luxembourg[268]

	Number of buildings		Inhabitants	
Farm, agricultural building	2509	1,93%	7290	1,42%
Detached house (4 facades)	49321	37,91%	141434	27,60%
Semi-detached house (3 facades)	32586	25,05%	97019	18,94%
Row house / townhouse (2 facades)	26775	20,58%	82371	16,08%
Other detached	1968	1,51%	5652	1,10%
Collective building entirely intended for housing	10927	8,40%	118927	23,21%
Collective mixed-use building	5340	4,10%	48605	9,49%
Multi-family building mainly for non-residential use	247	0,19%	790	0,15%
Hotel, boarding house	79	0,06%	725	0,14%
Boarding school for pupils and students	7	0,01%	98	0,02%
Home for children and young people	59	0,05%	544	0,11%
Home for adults	61	0,05%	1060	0,21%
Home for the homeless	7	0,01%	322	0,06%
Retirement home, nursing home	68	0,05%	5297	1,03%
Institution for patients	13	0,01%	232	0,05%
Religious institution	30	0,02%	267	0,05%
Other buildings	94	0,07%	1720	0,34%
	130091		512353	

[268] Le logement : immeubles d'habitation, ménages, propriétaires et locataires – Statec – //URL: https://statistiques.public.lu/catalogue-publications/RP2011-premiers-resultats/2013/08-13-FR.pdf [Accessed: 03.06.2021]

Appendix**.** Date of construction of buildings in Luxembourg[269]

	Total	Isolated house	Semi-detached house (3 facades)	Row house / townhouse (2 facades)	Collective building entirely intended for housing
before 1919	13.6%	9.0%	13.8%	18.3%	7.0%
1919-1945	15.1%	5.9%	16.7%	30.3%	11.5%
1946-1960	13.5%	8.4%	16.3%	19.3%	14.4%
1961-1970	9.7%	10.0%	10.5%	8.5%	11.6%
1971-1980	12.9%	18.0%	11.8%	7.4%	11.3%
1981-1990	11.1%	18.0%	8.5%	4.5%	7.8%
1991-2000	12.5%	19.0%	9.6%	4.8%	15.3%
2001-2010	11.5%	11.7%	12.8%	6.7%	21.2%

[269] Le logement : immeubles d'habitation, ménages, propriétaires et locataires – Statec – //URL: https://statistiques.public.lu/catalogue-publications/RP2011-premiers-resultats/2013/08-13-FR.pdf [Accessed: 03.06.2021]