H2020- EEB - 2017 - 2015 - 766464 – SCORES

Self Consumption Of Renewable Energy by hybrid Storage systems

D 2.3 Market analysis on hybrid storage components

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1 Background

"The SCORES project aims to develop and demonstrate in the field a building energy system including new compact hybrid storage technologies, that optimizes supply, storage and demand of electricity and heat in residential buildings, increasing self-consumption of local renewable energy in residential buildings at the lowest cost. Combination and optimization of multi-energy generation, storage and consumption of local renewable energy (electricity and heat) brings new sources of flexibility to the grid and giving options for tradability and economic benefits, enabling reliable operation with a positive business case in Europe's building stock. SCORES project optimizes self-consumption of renewable energy and defers investments in the energy grid."

To properly evaluate the SCORES project solutions and their most promoting target countries, a market assessment is necessary. This deliverable D2.3 Market analysis on hybrid storage components aims to reveal the most important responses for the market assessment core questions. The deliverable will be used as a basis for the subsequent business model development – D2.5 due in M36.

2 References

2.1 Applicable Documents

	Document	Reference	Issue
AD-01			
AD-02			
AD-03			

2.2 Reference Documents

	Document	Reference	
RD-01			
RD-02			
RD-03			

3 Terms, definitions and abbreviated terms

BTM	Behind-the-Meter
BEMS	building energy management system
DG	distributed generation
ESS	energy storage systems
EV	Electric vehicles
FIP	Feed-in premiums
FIT	Feed-in tariffs
CLC	Chemical Looping Combustion
ITC	Investment tax credit
MACRS	modified accelerated cost recovery system
P2P	peer-to-peer
PCM	phase change material
PHS	Pumped Hydro Storage
PV	photovoltaic and solar collectors
PVT	photovoltaic thermal and solar collectors
ROI	Return on investment

4 Executive summary

The present document constitutes a market assessment within the framework of the project titled "Self-Consumption Of Renewable Energy by hybrid Storage systems" (Project Acronym: SCORES; Grant Agreement No.: 766464).

The SCORES project aims to develop and demonstrate in the field a building energy system including new compact hybrid storage technologies, that optimizes supply, storage and demand of electricity and heat in residential buildings, increasing self-consumption of local renewable energy in residential buildings at the lowest cost.

This Deliverable is divided into three main sections. The initial part of the Deliverable concerns with the theoretical understanding and method definition. The following section revolves around SCORES exploitable results definition and project description in general. Section called "Market assessment" presents questions, which the market assessment concerns with. Answers to these questions constitute the market assessment.

Hybrid storage market	How is the global market with hybrid storage systems developing?
	How is the global thermal storage market developing?
Thermal market	Who are the future key players (size, development) among world in the energy storage market?
Energy storage market	Where are the estimations for the future potential in revenues and deployments of energy storage systems?
	What are market drivers, trends and barriers in energy storage?
Second Life	How the market environment of the Lithium-ion batteries looks like and what is its future development and potential?
Li-ion Electric vehicle batteries market	What are the future market conditions for Second Life Li-ion EV batteries? (volume, accessibility and type of batteries)
	Which countries produce the most batteries suitable for second life battery usage now and in the future?
	What are the principal methods to sell electricity to the grid?
Regulatory framework	Which countries pay the highest prices (tariff) for electricity sold back to the energy grid; and what share of total spending it covers?
	What trends influence electricity selling for small home owners?

The fourth section deals with competitor analysis, which reveals that rather high number of energy sustainable solutions exist on the market. Detailed competitor analysis with factors such as price, dimensions, capacity, effectiveness, lifespan, and anticipated savings will be provided in the updated version of this Deliverable. The last chapter defines some of the CANVAS building blocks, namely, Market Problem, Substitutes and Competitors, Customers, Value Proposition, and Solution. This activity illustrated that target countries for SCORES technology are Bulgaria, Czech Republic and Sweden.

5 Theoretical understanding and methodology

Following parts explain the main used theoretical terms, concepts and approaches which are used to identify crucial business and market parts to draw up a market evaluation for the SCORES project.

5.1 Market assessment

Evaluation of the defined market for the SCORES project should include complex data which respect current and future market situation with reflection of project approach and its development. According to this fact, the most suitable and complex market exploration will be presented.

Market analysis has to reflect demand and supply trends of the proposed SCORES market solution. In case of new ideas and innovative solutions, it is crucial to precisely identify the specific problem of the customers which is solved/satisfied by the proposed business solution (product or service).

Due to this fact, a most suitable method for market assessment would be to perform general market analysis by identifying several building blocks from Lean Canvas Business model: namely, Market Problem (substitutes, competitors), Customer Segment (Early adopters), Value proposition, and Solution.

A business must engage in a variety of tasks to complete the market research process. It needs to gather information based on the market sector. The business must analyse and interpret the resulting data to determine the presence of any patterns or relevant data points that it can use in the decision-making process.

5.2 Market analysis performed by Lean Canvas building blocks

As above mentioned, a Lean Canvas Business model building blocks (Market problem, Customer segment, Value proposition, Solution) will be used to perform a market assessment.

Lean Canvas Business model is a single-page business plan template tool, that helps break down the entrepreneur ideas. Lean canvas is specifically designed tool for startups and new market innovation products/services/projects/ideas to summarise all crucial business parts. Lean Canvas Business Model consist of nine business building blocks which are sorted in a specific chronological structure. This concept enables to develop the (startup) business model from the bottom to the top place emphasis on harmonic combination of all business model parts.

All building blocks defined at Lean Canvas Business Model has to be defined in following order: 1. Problem; 2. Customer Segments; 3. Value Proposition; 4. Solution; 5.Channels; 6. Revenue Streams; 7. Cost Structure; 8. Metrics; 9. Unfair Advantage

It is useful to analyse first four building blocks from Lean Canvas Business model: 1. Problem; 2. Customer Segments; 3. Value Proposition; 4. Solution as the assessment of the presented building blocks leads to wide market understanding.

Figure 1 Lean Canvas Business model transformation

Problem	Solution	Value Proposition	Unfair Advantage	Customers
SUBSTITUTES, COMPETITORS	Metrics		Channels	*EARLY ADOPTERS*
Cost Structure		Revenue Structure		

Lean Canvas Business model adjustment

Problem

This building block has to be specified in the first place. Entrepreneurship should be seen as a way how to solve a specific customer problem within a market. The problem is tightly linked to a customer segment. A particular problem (unfulfilled wants, need, desires, etc.) has to be specified and briefly but accurately described. The problem building block includes also a ***competitor and substitutes*** part. To estimate the power of market supply, it is necessary to reveal all potential competitors whose product/service should give to the entrepreneur an inspirational view to the problem inside the market segment. Substitutes on the market should be used as a bench mark for the price policy, performance benchmark etc.

Customer Segments

Customer segment building block is closely linked with a Problem building block. Entrepreneur must carefully select a suitable customer segment whose problem is the most intense and who probably appreciates the business solution which solves the problem the most. If the business solution aims to attract more than one customer segment, it is possible to write a Lean Canvas for each customer segment. The customer segment building block also includes an ***Early adopters*** part which stands for that customer segment which is considered as first customers/buyers who probably starve for the business solution for their problems (wants, needs, desires, etc.)

Unique Value Proposition

Unique Value Proposition is situated in the middle of the Lean Canvas building blocks. A promise of value to be delivered to the customers is called a value proposition. This should be the main reason (incentive) a prospective buyer has to buy from the business supply. Understanding why a company product is dissimilar, and why should the Customer Segments want to buy or invest in it is the best way to understand Unique Value Proposition.

Solution

After a problem and customer segment definition, an entrepreneur should start to design a business solution. It is not nescessery to develop whole complex solution in the early stage of the business***. Minimum viable product (MVP)*** is the elemental form of a product which consist only the main parts of a final product. MVP is not a final business product but it is able to solve a main identified problem. MVP is usually a demo or a product in testing so the price, design, distribution and linked services are not at the final targeted level. Due to this fact, it is possible to offer the imperfect product/service on the market and find out if it is able to solve the market problem, and if the specified cusmoters segment wants to pay for it. From the recevied feedback, the entrepreneur is than able to change the main characteristics of the product/service, targeted customers segments or change a main problem which has to bo solved.

The assessment and evaluation of presented building blocks will lead to a deeper understanding of SCORES market, potential and future development.

5.3 SWOT analysis

In order to estimate market position, the strengths, weaknesses, opportunities and threats factors (SWOT) should be identified. SWOT analysis is a useful technique to understand the strengths and weaknesses of an organization, project or business venture, and to identify both the opportunities and the threats existing in the market to be faced. It involves specifying the objective of the business venture or project and identifying the internal and external factors that are favorable and unfavorable to achieve that objective. What makes SWOT particularly powerful is the fact that, with a little thought, it can help uncover opportunities that are well-placed to exploit. Also, by understanding the weaknesses of the business, the threats can be managed and eliminated in advance. Moreover, by looking at the competitors using the SWOT framework, one can craft a strategy that helps distinguish a company/product from the competitors, so that they can compete successfully in the market.

SWOT analysis aims to identify the key internal (the strengths and weaknesses internal to the organization) and external factors (the opportunities and threats presented by the environment external to the organization) seen as important to achieve an objective. Analysis may consider the internal factors as strengths or as weaknesses depending upon their effect on the organization's objectives. What may represent strengths with respect to one objective may be weaknesses (distractions, competition) for another objective. The factors may include all of the 4Ps as well as personnel, finance, manufacturing capabilities, and so on. The external factors may include macroeconomic matters, technological change, legislation, and sociocultural changes, as well as changes in the marketplace or in competitive position. The results are often presented in the form of a matrix. SWOT analysis may be used in any decision-making situation when a desired end-state (objective) is defined. SWOT analysis may also be used in pre-crisis planning and preventive crisis management.

Figure 2 SWOT strategy matrix

SWOT	Opportunities (external,positive)	Threats (external,negative)
Strenghts (internal,positive)	**Strength-Opportunity strategies** Which of the company's strengths can be used to maximize the opportunities you identified?	**Strength-Threats strategies** How can you use the company's strengths to minimize the threats you identified?
Wekenesess (internal, negative)	**Weakness-Oportunity strategies** What action(s) can you take to minimize the company's weaknesses using the opportunities you identified?	**Weakness-Threats strategies** How can you minimize the company's weaknesses to avoid the threats you identifies?

6 SCORES project overview

The SCORES concept is based on a hybrid system combining effectively and efficiently solutions that harvest electricity and heat from the sun, store electricity, convert electricity into heat, store heat, and manage the energy flows in the building.

6.1 SCORES hybrid system description

SCORES will develop a hybrid system with technologies that store both electricity and heat. It will be demonstrated in two different climatic regions, with and without connection to a district heat grid, balancing the supply and demand of electricity. The coupling of new advanced thermal and electric storage technologies with the BEMS developed in SCORES will optimize the storage in order to synchronize as much as possible supply and demand in the residential buildings. Storage technologies developed in SCORES will increase the local renewable self-generation and self-consumption. SCORES will demonstrate the technical and economic viability of short-term and seasonal compact thermal storage technologies. PV/PVT, renewable heat and heat pumps are used to produce electricity and heat with high efficiency in a hybrid storage system. SCORES will develop second life Li-ion batteries, and new heat storage devices based on Phase Change Materials and Chemical Looping Combustion. These technologies have energy densities between 75 and 350 Wh/l and are combined in a system that will bring flexibility to the grids (electricity and heat) and increase generation and self-consumption of local renewable energies.
In SCORES, the developed technology will be demonstrated for a full year in a real residential building demo A (Northern climatic region) connected to a district heating grid, demo C (Northern climatic region) not connected to a district heating grid for (demo case A,C) and building not connected to a district heating Southern (demo case B) climatic regions.

6.2 SCORES results description

The main goal of SCORES is to demonstrate in the field the integration, optimization and operation of a building energy system including new compact hybrid storage technologies, that optimize supply, storage and demand of electricity and heat in residential buildings and that increase self-consumption of local renewable energy in residential buildings at the lowest cost. Intended SCORES impact includes CO2 reduction, energy self-sufficiency, competitive European industry, Cheaper EV batteries, Energy independency, More renewables, jobs creation, and grid stability.

SCORES hybrid energy system removes the technical barriers for better use of available energy sources in two ways:

- At the local level increases and optimizes the self-consumption of local renewable generation. Bridges the gap between supply and demand for electricity and heat considering renewable energy.
- At the global (energy grid) level introduces new sources of flexibility for the grids: SCORES will also increase the storage capacity of the grid as it enables home-owners to offer storage of energy in their homes to the grid operator in order to provide an additional source of grid-flexibility

SCORES targets these objectives to overcome the main technical and non-technical barriers regarding the hybrid system:

Table 1 SCORES technology objectives

Objective	Specific Characteristics
Develop **second life Li-ion batteries** *electricity storage in buildings*	Affordable (<500 €/kWh capacity, including converter) High efficiency (90% including converter; 95% if only battery is considered) High energy density (>75Wh/L including converters and battery cabinets) Reasonable power density (>30 W/L) Long lifetime (20 years, 6000 charge/discharge cycles with 2 battery swaps)
Develop **compact thermal storage using a phase change material (PCM)** *short term storage for SH*	Affordable (<300 €/kWh capacity) Low static thermal losses (<50W/kWh) High energy density (100Wh/L) High power density (30 W/L) Long lifetime (20 years or 5000 charge/discharge cycles)
Optimize, integrate **high performance hot water heat-pump** *supplied by hybrid photovoltaic and solar collectors (PVT)*	Affordable, reducing used surface area Instantaneously available High power during peak loads DHW Continuously provide 55 to 60°C at the tank exit Reduce PV cell temperature and increase efficiency (from 11-12% to 13-14%) Long life time (warranted to produce at least 80% of rated power after 20 years)
Improve, optimize **Chemical Looping Combustion (CLC)** *long term/seasonal heat storage*	Affordable (<75 €/kWh capacity) High energy density (>350 Wh/L) Long lifetime (20 years or 400 charge/discharge cycles) Virtually no thermal losses during storage
Develop **building energy management system (BEMS)** *optimizes the operation of different technologies*	Affordable (minimum equipment required, possibility to operate as a service in the cloud) Flexible (suitable to fit various building types) Versatile (regarding interfaces) User friendly to operate Remotely accessible by all project partners

source 1 Grant Agreement (number—766464—SCORES)

Other SCORES objectives are linked with demonstration cases and economic objectives of the project:

Table 2 SCORES other objectives

Objective	Specific Characteristics
Demonstrate **the developed hybrid energy system** *in two buildings, different climate and energy system configurations for 3 cases*	A) Rep. building connected with a heat grid and using hot water for SH B) Rep. building connected without a heat grid using solar thermal energy for SH C) Rep. building using (renewable) electricity for SH
Evaluate **technical, economic and environmental performance** *of building energy system*	a) at the level of the system I. For residential buildings not connected to District Heating: net energy reduction > 20 % with ROI < 10 years II. For residential buildings connected to District Heating: net energy reduction > 30 % with ROI < 20 years b) at the level of each developed technology c) for the customer and for the grid operator d) identifying the next steps to be implemented to enable the market introduction

SCORES contain five key technologies that are integrated to the final business solution and would be proposed on the market. Following table present the list of them:

Table 3 Key technologies of SCORES project

Key technology	Description
Key technology 1	electric driven heating with intraday PCM heat storage
Key technology 2	PV/PVT collectors combined with water-to-water heat pump:
Key technology 3	2nd life electrical batteries
Key technology 4	Chemical Looping Combustion (CLC):
BEMS	Building Energy Management System (BEMS)
Technology	Hybrid Systems

Key technology 1 - electric driven heating with intraday PCM heat storage:
Electric space heaters with intraday heat storage in PCM: The use of PCM in a heat storage unit will contribute to the important objective in heating systems of typical residential houses:

- It will balance the electric demand for typical residential houses, decreasing the electricity consumption during peak hours. The electric heater with PCM can operate outside peak hours charging the PCM heat storage. During peak hours the electric heater can be switched off or decrease its electrical consumption, the PCM will provide the missing energy during that period.

PCM are less suitable for long term heat storage due to standby losses. However, heat storage in PCM can be very beneficial for intraday storage. To our knowledge PCM's have never before been integrated with direct electric heaters.

Key technology 2 - PV/PVT collectors combined with water-to-water heat pump:
Photovoltaic and Thermal (PVT) collector is a solar energy technology using PV as the absorber. A PVT solar collector combines solar thermal and photovoltaic technology in a single unit, thereby, producing higher overall efficiency at less roof-space. Combination of PV/PVT with heat pumps will provide the innovation for the hybrid system approach.
The expected increase of the SPF (seasonal performance factor) for a heat pump combined with PVT is between 35-45 % compared to geothermal water-to water heat pumps, for climate conditions in Central Europe.

Key technologies 3 - 2nd life electrical batteries:
Compact and cheap storage of electricity: reduced cost of electricity storage with second life Li-ion batteries: The electrical storage system will enable electrical storage complementary to the thermal storage. The total cost will be reduced by using a second life battery. Total energy capacities of 50 – 200 kWh per demonstration are targeted. The electrical storage system will integrate 2 main components:

- A battery made of used EV battery modules (Li-ion electrochemical cells, electrical connection between cells, casing, and battery controller (also called Battery Management System))
- A power converter (including 'inverter') made of AC-DC converter, DC-DC converter, Filter, Protection and safety devices (fuse, brakers, etc.), and control and measurement board of the converters.

Compact and cheap storage of electricity: reduced cost of electricity storage with second life Li-ion batteries: The battery system cost (around 1200-1600 €/kWh) will stay higher than the benefits coming from electricity flexibility offered to the system (global and local). The SCORES project will develop affordable electrical storage technology using end of life Electric Vehicle (EV) batteries. When the battery of an EV reaches 75 % of initial capacity and/or 40 % increase of the internal resistance, the EV performances are significantly reduced (less autonomy, less acceleration), making the battery unsuitable for EV use.
In SCORES "second life batteries", will be developed by the partner Forsee Power, that are much cheaper than new Li-ion batteries – currently around 500 €/kWh vs. 1200 €/kWh for new ones – and will still present the storage density and performance that are required for their use in buildings.

Key technologies 4 - Chemical Looping Combustion (CLC):
Seasonal thermal storage in a Chemical Looping Combustion (CLC) heat battery: Typical novel technologies such as thermo-chemical storage (TCS), which exploits chemisorption, heat storage densities is up to 1 GJ/m^3. The buffer sizes storage capacity is usually required of 10-30 GJ that typically means volumes in the range of 10 to 30 m^3.ultra-compact storage can be realized by utilizing technology based on fixed-bed Chemical Looping Combustion (CLC), by which storage densities up to 6 GJ/m 3 on material level can be realized 12, which is more than 36 times more compact than a sensible heat (hot water) storage, making it a much better technology than chemisorption or physisorption. Moreover, since heat is stored chemically and in a loss-free way, the CLC technology is ideal for long term / seasonal storage of heat. TNO has a unique knowledge and patent position in the field of CLC as they are one of only a few institutes who develop CLC in a fixed bed configuration. Seasonal storage volumes of 0.20 – 0.25 m 3 per apartment are targeted in the two demonstrations.
CLC batteries are based on redox reactions and have the potential to store heat with a very high storage density (~6 GJ/m 3 on material level) at very competitive cost (<75 €/kWh storage capacity).

Building Energy Management System (BEMS):
Project partner Siemens will control and monitor the various sub-systems according to technical and economic parameters, optimizing the balance between supply and demand of electricity and heat, more specifically the optimization of self-consumption and peak-shaving of the electricity grid and heat grid. Desigo is a flexible, integrating and energy-efficient building automation and control system that covers all relevant building services. Desigo is not confined to heating, ventilation and air conditioning, but includes lighting, window blinds and electrical power distribution. It is a modular and very flexible platform, applicable from small to large configurations.

6.3 Demonstration cases

SCORES demonstrates the integration, optimization and operation of the developed hybrid energy system in two buildings representative of different climate and energy system configurations for 3 cases:
Technical, economic and environmental performance of the building energy system goal:

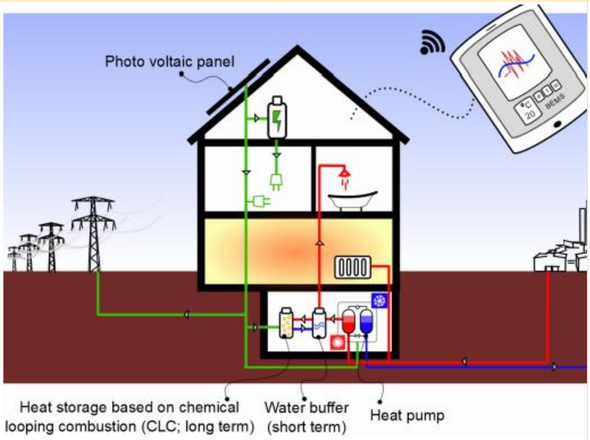
- For residential buildings not connected to District Heating: net energy reduction > 20 % with ROI < 10 years
- For residential buildings connected to District Heating: net energy reduction > 30 % with ROI < 20 years

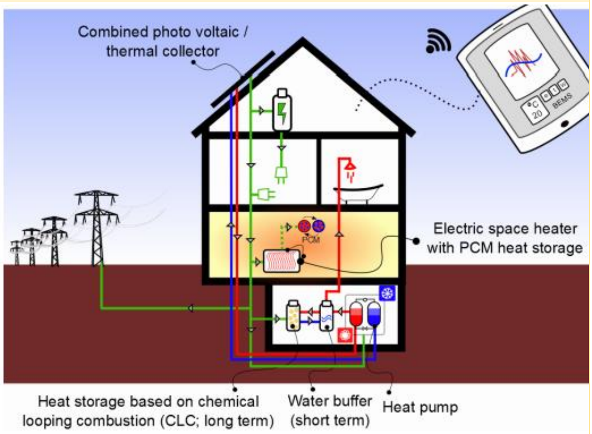
Table 4 SCORES demonstration cases

source 2 Grant Agreement (number—766464—SCORES)

Demonstration cases specification

Configuration A, C (Austria)		**Configuration B (France)**
Reference case A: The system measures count with an electricity grid as well as with a low-temperature DH grid	**Reference case C:** The system measures count with an electricity grid but not with a low-temperature DH grid	The building is not connected to a district heating grid





Definition of reference case

Characteristic	Ref A	Ref C
Total Heated Area	1,025m 2 (6 houses + office space)	1,025m 2 (6 houses + office space)
Space Heating	District Heating Grid	Gas Boiler
Domestic Hot Water	District Heating Grid	Gas Boiler
Electrical Appliances	Electric Grid	Electric Grid

Characteristic	Value
Total Heated Area	5,630m 2 (115 flats)
Space Heating	Electric Heaters (from Grid)
Domestic Hot Water	Electric Boilers (from Grid)
Electrical Appliances	Electric Grid

Key Features of each Simulation

Characteristic	Demonstration Case
Space Heating Area	Office: 875 m^2 Apartments: 150 m^2
PV Area	25 m^2
Electric Battery Capacity	31.95kWh
CLC Capacity	240kWh
Heat Pump Capacity	24kW
Additional Buffer Size	2000l

Characteristic	Demonstration Case
Space Heating Area	5,631 m^2
PV Area	213 m^2
Electric Battery Capacity	63.9kWh
CLC Capacity	240kWh
Heat Pump Capacity	36kW
HelioPack DHW Buffer Tanks	7000l

Building Model Characteristics	
• Building Envelope consists of 7 Thermal Zones: • 1 Zone for office Space (575m 2 considered for space heating) • 6 Zones for Residential buildings (450m 2 considered for space heating) • Dymola Building Envelope generated using TEASER Online Web tool • Model to be tweaked to ensure that total annual space heating demand is close to that of the actual demonstration site. • Weather data for typical meteorological year in Graz	• Building Volume divided into six Thermal Zones: • Ground Floor: North and South wing • Middle Floors (1st-3rd): North and South wing • Upper Floors (4th-5th): North and South wing • Same methodology used as for Demo A reference case: • TEASER online tool used to generate building model • DHW calc tool v2.0 to generate demand profiles • Load Profile generator tool used to generate loads for electrical appliances • Weather data for a typical meteorological year for Bordeaux from Energy Plus database used as input for reference case.

Expected impact (residential buildings connected to district heating, Demo A)
Demonstration of the economic viability of the overall storage systems with return of investment of less than 20 years and proof of the potential for market penetration. Technologies which are reliable and operating for a minimum of 30 years. Provide compact systems (volume of storage limited to 1 m^3). Overall net energy gain of minimum 30%. Validated contribution to energy system flexibility.

Expected impact (residential buildings not connected to district heating, Demo B,C)
Demonstration of the economic viability of the overall storage systems when operating in real conditions in residential buildings with a return of investment period of 9-10 years and proof of the potential for market penetration. Technologies which are reliable and ensure a minimum of 20 years lifetime. Solutions compatible with existing building configurations – with compact systems using limited spaces in existing building (volume of storage limited to 3 m^3). Demonstration of an overall net energy reduction by 20 %. Validated contribution to energy system flexibility.

7 SCORES Market assessment

Following scheme describes answered questions which cover the main focus of the SCORES project from the business, market and end-user point of view related to the target market.

Hybrid storage market	How is the global market with hybrid storage systems developing?

Thermal market	How is the global thermal storage market developing?
	Who are the future key players (size, development) among world in the thermal energy storage market?

Energy storage market	Where are the estimations for the future potential in revenues and deployments of energy (electricity/thermal) storage systems?
	What are market drivers, trends and barriers in energy storage?

Second Life Li-ion Electric vehicle batteries market	How the market environment of the Lithium-ion batteries looks like and what is its future development and potential?
	What are the future market conditions for Second Life Li-ion EV batteries? (volume, accessibility and type of batteries)
	Which countries produce the most batteries suitable for second life battery usage now and in the future?

Regulatory framework	What are the principal methods to sell electricity to the grid?
	Which countries pay the highest prices (tariff) for electricity sold back to the energy grid?
	What trends influence electricity selling for small home owners?

7.1 SCORES related markets development and overview

For precise understanding of the following energy storage market overview it is crucial to define and describe the main terms which may clarify the sense of the performed figures, analysis and conclusion.

Energy – stands for all energy sources in the household consumption (e.g. household energy consumption of electricity for running appliances and thermal energy for running hot water and heating devices (gas)). In this deliverable both electricity and thermal energy is represented by this term.

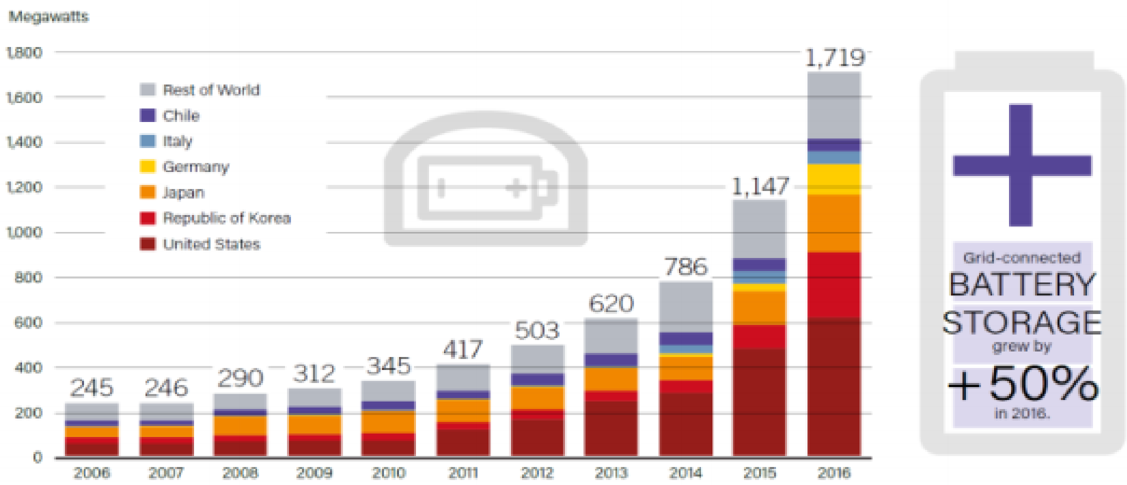
Solar energy – stands for electricity gathered by PV panels

Energy bill – according to the paragraph of the analysis (linked with thermal or electricity market conditions) the energy bill stands for electricity/gas household bill for energy consumption.

7.1.1 Hybrid battery storage market development

According to the Hybrid storage market assessment research[1] the hybrid storage market is becoming an important component of the energy grid. A correlation can be drawn between the growth in renewable energy and the expected growth in battery storage. Since 2004, world variable renewable energy installed capacity (largely solar and wind) has grown 25% annually. The market for battery storage today in many ways reflects the market for renewable energy in 2004. The growth in battery storage, however, is expected by some to be even more dramatic. As shown in following figure, global hybrid battery storage capacity increased seven-fold in 10 years and by 50%.[2]

Figure 3 Hybrid battery storage installations 2004-2016



source 3 Hybrid Storage Market Assessment https://www.nrel.gov/docs/fy18osti/70237.pdf

Thermal energy storage market has been analyzed with respect to four regions, namely, the Americas, Europe, Asia-Pacific, and the Middle East & Africa. The Middle East & Africa is expected to dominate the global thermal energy storage market during the forecast period, (2004-2016) owing to enormous solar resources, and large energy intensive industries. The region is expected to be the fastest growing market among other regions, during the forecast period.

In emerging markets around the world, there is only limited experience with energy storage, yet vast potentials exist to benefit from the technology. Many of these markets share similar energy market dynamics and needs for new resources. Driven by growing urban populations, many emerging markets have a significant need for new electricity reserve capacity, particularly to meet peak demand.

7.1.2 Thermal energy storage market development

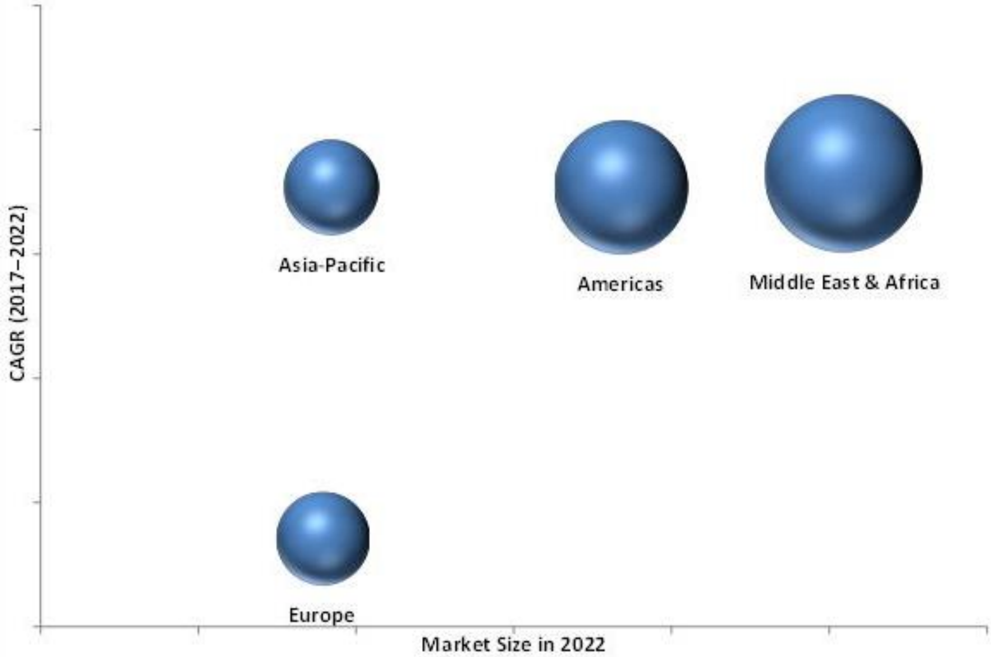
The thermal storage market in Eastern Europe & Central Asia is dominated by a single technology, pumped hydro storage. This region has a significant installed base of thermal

[1] Hybrid Storage Market Assessment https://www.nrel.gov/docs/fy18osti/70237.pdf
[2] ibidem

energy storage resources with 9.3 GW of pumped hydro capacity installed, and an additional 3.5 GW that is either under construction or in planning stages.

According to the Figure 4, it is seen that the most developing markets with the highest CAGR (Compound Annual Growth Rate) are located in Asia-Pacific, America, Middle East and Africa. Europe area stays still strong and perspective market, but without as significant CAGR. From the market size point of view, the rank is following: Middle East and Africa, America, Europe and Asia-Pacific at the end.

Figure 4 Thermal Energy Storage Market, by Region, 2022 (USD Billion)



source 4 Thermal Energy Storage Market, https://www.marketsandmarkets.com/Market-Reports/thermal-energy-storage-market-61500371.html

In Eastern Europe storage systems are spread among 10 countries in the region. The countries with the largest thermal energy capacity are Ukraine with 2,568 MW, Poland with 1,158 MW, and the Czech Republic with 1,102 MW. This existing capacity of thermal energy storage resources will limit the need for additional largescale storage providing peak capacity and resource adequacy in the region in the near-term. New demand for thermal energy storage will be driven by the need for grid support/resiliency and the integration of variable renewable generation.

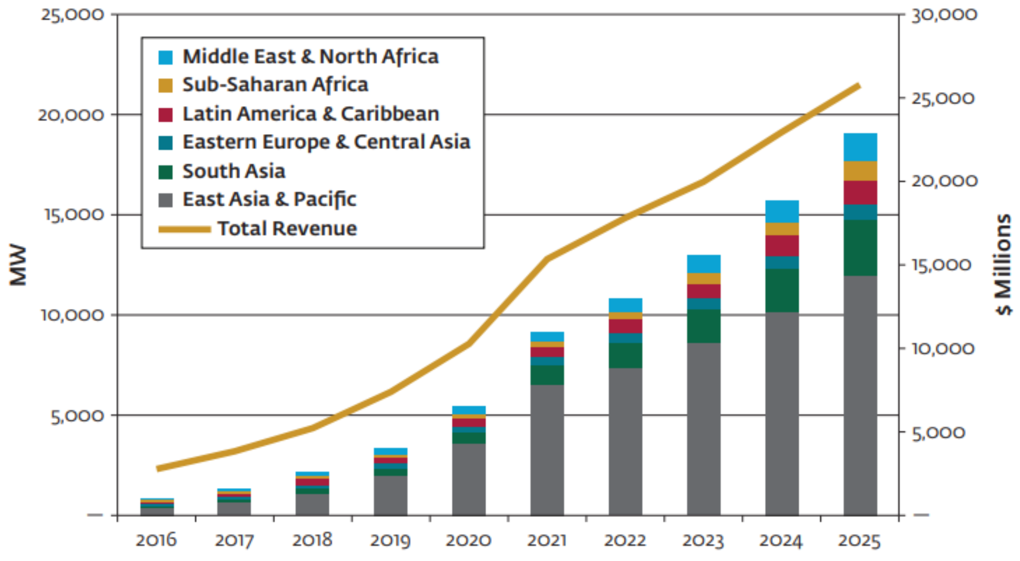
There are several **market barriers** linked to Eastern Europe market thermal energy storage systems implementation: already existing PHS (Pumped Hydro Storage) resources; limited need for new ESS (Energy Storage Systems), current energy generation reach over-capacity (this excess capacity can limit the need for new renewable generation and energy storage because the grid has sufficient flexibility to accommodate fluctuations in demand); Highly regulated, state-run energy markets, Lack of financing and vendors for distributed renewables and storage.

7.1.3 Energy storage market future potential and development

Following Figure 5 shows the market position according to the world regions in the meaning of the highest revenues from stored energy and the number of stationary energy storage deployments among the world.

The total global revenue from energy storage is projected to rise sharply until the 2025. The projection estimation of the market revenue is to rise from the level of 2,5$ millions in the 2016 to ca. 26$ millions in the 2025.The most developing global regions are East Asia and Pacific, South Asia, and Middle East and North Africa.

Figure 5 Annual stationary energy storage deployments. Power capacity and Revenue by region, 2016-2025



source 5 Energy storage trends and opportunities, https://www.ifc.org/wps/wcm/connect/ed6f9f7f-f197-4915-8ab6-56b92d50865d/7151-IFC-EnergyStorage-report.pdf?MOD=AJPERES

7.2 *Energy storage Market drivers, barriers and trends*

Market drivers and trends

While the specific drivers to develop energy storage markets vary by region and market segment, the overarching goal of ESS (energy storage systems) deployments is to make the electricity and thermal grid more efficient, resilient, secure, cost-effective, and sustainable, as well as to expand the menu of available electricity/thermal energy market services.[3]

To date, back-up power has been one of the major selling points for energy storage. Both distributed customers and utilities are interested in utilizing battery systems in homes to

[3] Energy Storage Trends and Opportunities in Emerging Markets, https://www.ifc.org/wps/wcm/connect/ed6f9f7f-f197-4915-8ab6-56b92d50865d/7151-IFC-EnergyStorage-report.pdf?MOD=AJPERES

improve the resilience of their power supplies, heat their homes effectively and to help mitigate the effects of power outages caused by natural disasters or grid equipment failures. To enable an adequate supply of backup power, the sizing of an ESS is crucial. If there is too little power or energy capacity (measured in kW and kWh, respectively), the system will not be able to support critical loads during an outage thus electric and thermal energy is not available. However, an oversized system will be prohibitively expensive compared to alternatives.

The ability to provide back-up power (electric/thermal) is particularly key to the value proposition of battery storage systems. While controllable water heaters and other forms of thermal energy management can reduce electricity costs and can provide some services to grid operators, they will not be able to provide power for critical loads during an outage.
In large BTM (Behind-the-Meter) energy storage markets, such as the United States, the main driver for these systems has been the ability to reduce electricity/thermal expenses. This is primarily done by reducing peak demand and time-of-use (TOU) rates. Demand charges are charges levied by electric utilities based on the maximum electricity demand of a customer over a period ranging from 15–60 minutes, typically over an interval of 30, 60, or 90 days.

A key component of the energy storage value proposition in developed and emerging markets is consuming the majority of energy generated by onsite solar photovoltaic (PV) and other distributed generation (DG) systems. In most developed countries, the compensation structure for solar PV discourages the use of ESSs because PV system owners are guaranteed payment for any excess energy that their system generates at a rate that is equal to or higher than the retail cost of electricity.

By storing excess solar PV energy produced throughout the day, customers can avoid purchasing energy from the grid during evening peak demand periods when electricity rates may be highest in markets with dynamic pricing or use prepared HW or DH thermal energy from storage. In places such as Hawaii, Germany, and Australia, the distributed storage industry is being fueled by the decrease in solar PV compensation and high retail rates of electricity, encouraging a model of storage operation known as self-consumption.

Most distribution equipment was not designed to handle significant back-feeding of electricity, and either requires adding upgrades to the equipment or setting limitations on the amount of variable generation produced. BTM storage allows customers to keep onsite the excess energy generated, preventing many of these issues. These systems can also automatically respond to grid signals to correct frequency, voltage, and reactive power, thereby greatly improving grid stability and reducing barriers and objections to increasing deployments of distributed renewables.

Market Barriers

Countries around the world will experience growth in the energy storage market at different rates, driven by differing factors. Numerous factors are limiting the growth of the stationary energy storage market worldwide. Several of these barriers include:

- Lack of familiarity with storage technology among utilities, regulators and financiers
- High upfront costs
- The need for highly skilled and experienced technicians to maintain and operate systems correctly

- Regulations preventing third-party or customer ownership of certain DERs
- Regulations preventing storage from competing in energy, ancillary services, or capacity markets

There are a number of crucial barriers to deployment of current PCM heat storage products. They are available for field trials in limited domestic applications. Despite the interest in the technology, there is a lack of fully commercial products and associated learning from in-field applications.[4]

- Limited customer knowledge.
- A lack of a supply chain for PCM products.
- From manufacturing to installation capability, there is an overall skills shortage as PCM is primarily part of R&D efforts.
- The availability of safe, reliable PCM materials with melting points suitable for most heating technologies.
- PCM stores are also limited to applications where a small temperature range between input and output is tolerable further narrowing the overall market potential.

With regards to the potential market, the relatively slow uptake of renewable heating technologies reduces opportunities for PCM products in the residential space. There would be high potential for PCM stores to provide short term storage (e.g. 3-4 hours) to allow electric heating / CHP to operate more flexibly in response to electricity system price signals. As long as the market lacks strong signals to motivate such behaviours the advantages of PCM over hot water tanks is limited, unless the customer faces space constraints in their property. Additionally, the uptake of combi boilers also proves a barrier for domestic PCM.

7.3 Second Life Li-ion Electric vehicle batteries market

Batteries are the most expensive component of an electric car. At the end of their service life in electric vehicles, the retired batteries could still retain 60-80% of their initial capacity. Recycling is necessary in the end but before that, giving those retired but still capable batteries a 'second-life' in less-demanding applications such as stationary energy storage not only improves material efficiency, but also has the potential to bring great value to a wide range of stakeholders across the energy sectors, as well as to the society and environment.[5]

According to a recent report by research group Circular Energy Storage, the global market for end-of-life lithium-ion batteries is expected to be worth $1.3 billion in 2018 with a future potential to $4.2 billion by 2025.[6]

[4] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/545249/DELTA_EE_DECC_TES_Final__1_.pdf

[5] Second-life Electric Vehicle Batteries 2019-2029,https://www.idtechex.com/research/reports/second-life-electric-vehicle-batteries-2019-2029-000626.asp?viewopt=desc

[6] Circular Energy Storage, online: https://www.pv-magazine.com/2018/08/03/second-life-ev-battery-market-to-grow-to-4-2-billion-by-2025/

While recycling batteries is common for portable devices, it can be postponed through 'second-life' applications in the case of EV batteries, with applications such as the use in energy storage systems. The report states EV batteries have optimal properties to be reused for energy storage, with regards to their capacity and remaining life-cycles.

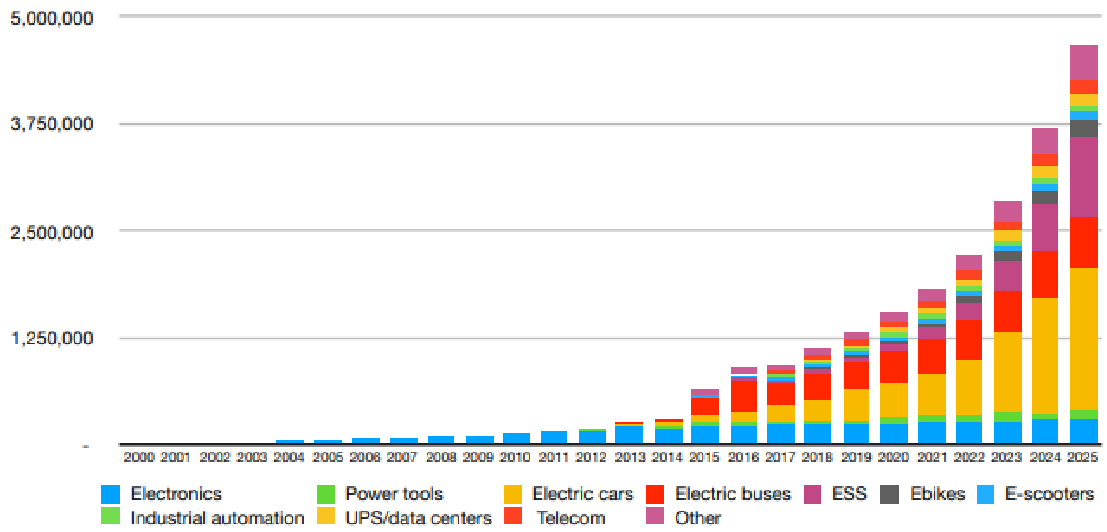
A range of car manufacturers have announced cooperation with battery storage plant operators for the supply of second-life EV batteries. As the batteries often retain 60-80% of their original capacity, they are in good enough shape for frequency response, as discharging cycles for this type of energy usually extend to just a few minutes and rarely reach an hour or more.

Equally important is the potential to recover the materials in waste batteries for the reuse in new batteries. With the unprecedented growth in the market the demand for raw materials has increased significantly and recycled materials can be a positive contribution from both an environmental and an economical perspective.

Depending on chemistry, size, configuration and purpose a lithium-ion can perform between 500 to over 10 000 cycles of charging and discharging. This means that a battery that is used every day in a power tool by a professional craft worker might reach end-of-life in a few months while a battery used in some energy storage applications can last for over 20 years.

Following Figure 7 shows the projected development of Lithium-ion batteries placed on the global market to the year 2025. The main source for secondary life batteries is projected from electric cars, electric buses and Energy storage systems.

Figure 6: Lithium-ion batteries placed on the global market (cell level, tonne)

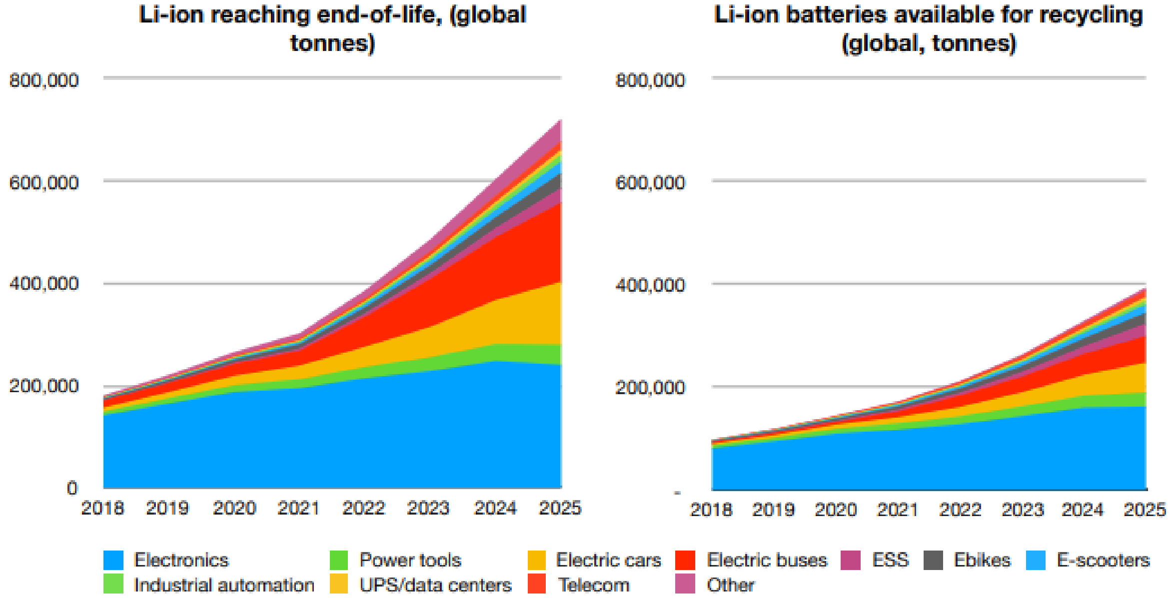


source 6 The lithium-ion battery end-of-life market, http://www3.weforum.org/docs/GBA_EOL_baseline_Circular_Energy_Storage.pdf

The fact that the batteries reach the end of their lives does not mean that they automatically become available for recycling. In fact, only about 50% of the batteries that reach end-of-life find their way to recyclers around the world. The reasons for this are many: batteries are stored or hoarded, they are disposed but not recycled, or they are reused in other applications.

According to the report, titled 'The lithium-ion battery end-of-life market 2018–2025', 179,000 tons of batteries will reach their end of life in the 2018. As illustrated in the Figure 8 portable devices, such as laptops, smartphones and power tools, will account for 83% of this volume. Only 20,000 tons will come from electric vehicles. Of the total volume reaching end of life, 97,000 tons will be recycled. Out of these 97,000 tons as much as 67,000 tons will be processed in China and 18,000 tons in South Korea. The two countries host a significant share of the manufacturing of battery materials, as well as the production of cells. This has created a strong demand for raw materials, which consequently lays the foundation for an important market for recyclers, or opportunities for material companies to become recyclers themselves.

Figure 7 Li-ion end of life and batteries available for recycling on the market



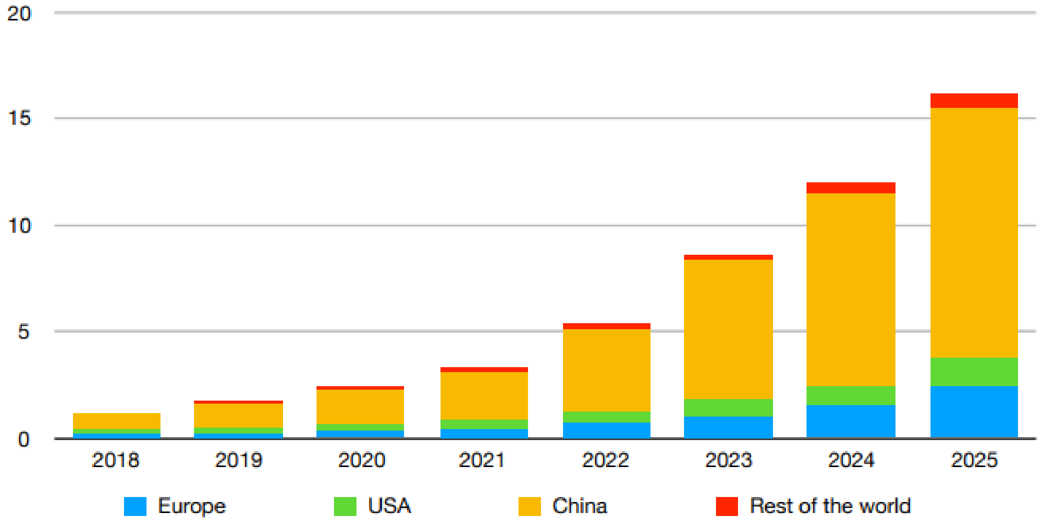
source 7 The lithium-ion battery end-of-life market, http://www3.weforum.org/docs/GBA_EOL_baseline_Circular_Energy_Storage.pdf

It is also important to focus on geographical locality of batteries usable for recycling and second life. As it is presented in Figure 9, current situation and future trends indicate that China, in particular, will dominate lithium-ion battery role for reprocessing.

With the strong growth of the lithium-ion battery market, it is predicted that the volume of the second life batteries will be defined by the supply of batteries rather than its demand. The demand, together with the supply and cost efficiency of new batteries will define the value.

Today second life batteries are traded at between **$60 and $300 per kWh**, depending on market and application. These prices are predicted to follow the price development of the general market and is estimated to reach **$43 per kWh in 2030**, primarily as a response to decreasing prices of new batteries.[7]

Figure 8 Lithium-ion batteries available for second life by geography (GWh)



source 8 The lithium-ion battery end-of-life market,
http://www3.weforum.org/docs/GBA_EOL_baseline_Circular_Energy_Storage.pdf

Future development of the market

Although the end-of-life market for lithium-ion batteries already shows some clear patterns, it is still a young market with room for innovation and change such as different circular models that can cut waste and marginal costs out of the value chain.

For automotive and battery makers, there is a challenge to retain control of the battery in order to squeeze out as much value as possible without losing value in unnecessary transactions. Models such as leasing of the battery has already been proven. The model makes even more sense for professional fleets of buses, taxis and delivery vehicles as these are cycled much heavier than privately owned cars and therefore need more frequent replacements of the batteries.

7.4 Regulatory Framework

Energy markets were originally designed with a separation between generation, transmission, and consumption. Battery storage does not fit readily into any of these categories, although it can provide generation, transmission, and customer services; therefore, in many jurisdictions, current market regulations do not fully compensate storage for its services.[8]

Resource participation in electric markets is governed by participation models that consist of market rules for different types of resources. Regulatory reform is continuously evolving,

[7] The lithium-ion battery end-of-life market, online: http://www3.weforum.org/docs/GBA_EOL_baseline_Circular_Energy_Storage.pdf
[8] Hybrid Storage Market Assessment, https://www.nrel.gov/docs/fy18osti/70237.pdf

suggesting that battery storage projects must consider not only which services can be provided but also which services may be monetized today and in the future. Market rules addressing customer-sited storage are often less mature than wholesale market structures, which prohibits clear approaches for remuneration of possible multiple value streams to the distributed system owner and negatively impact the system economics.

Combining battery storage with generation can allow the hybrid resource to meet regulatory requirements, such as minimum production times and minimum ramp rates, that the storage or generator could not meet on its own.

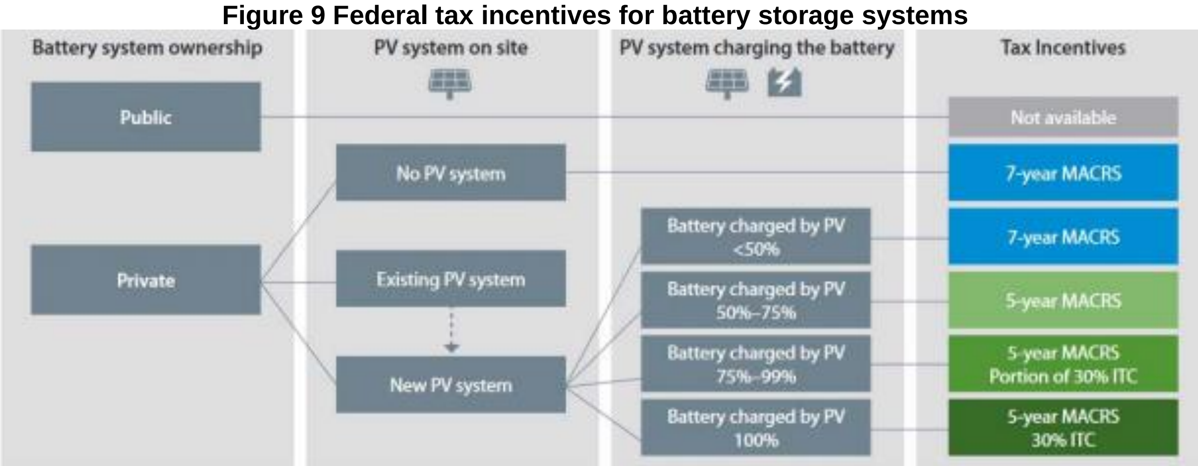
7.4.1 Illustration from Federal and State Incentives in US

Policy incentives vary by region and are often different for utility-scale and behind-the-meter applications. Furthermore, some incentives are only applicable to batteries paired with renewables.

At the federal level, storage charged with renewable energy is eligible for a 30% federal investment tax credit (ITC) and an accelerated depreciation schedule. Following Figure 9 displays the structure of the ITC and the modified accelerated cost recovery system (MACRS). Battery storage charged with at least 50% renewable energy follows a 5-year depreciation schedule instead of a 7-year schedule. Storage that is charged from at least 75% renewable energy receives a tax credit equal to 30% of the portion charged by renewables.[9]

Because the storage and generation must be in close proximity and under common ownership to receive the tax benefits, these tax incentives are especially beneficial to renewable hybrid systems.

Figure 9 Federal tax incentives for battery storage systems



source 9 Hybrid Storage Market, Assessmenthttps://www.nrel.gov/docs/fy18osti/70237.pdf

[9] For example, a system charged by renewables 80% of the time receives a 30% x 80% = 24% tax credit.

7.4.2 European incentives to support renewable energy storage systems connection with energy market

Key mechanisms in national renewable energy support policies include: Feed-in tariffs (FIT), Feed-in premiums (FIP), Quota obligations with tradable green certificates, Loan guarantees, Soft loans, Investment grants, Tax incentives and Tendering schemes.[10]

Following analysis aim on two mainly used groups: Feed-In Tariffs (FiTs) and Net Metering. Those three are the most frequent incentives among the Europe.

Feed-In Tariffs (FiTs)
Tariff-based incentives that result in favorable tariff payments to the entity providing electricity. The price is generally designed to promote investments in renewable energy, by guaranteeing investors a revenue stream that covers costs and a return on capital sufficient to motivate investment. The FiT can be uniform or differential across technologies for a fixed period of time (and can include escalator or de-escalator clauses).
The feed-in tariff purchase prices are usually based on the cost of renewable energy generation paired with considerations as to social cost, investor requirements and policy targets. With a FiT, any customer or entity is normally eligible to sell energy under the terms of the tariff.[11]

Net Metering
A tariff system based on an incentive (or payment scheme) for renewable energy whereby electricity produced in excess of the customer's load is sold back to the interconnecting utility. The producer is generally compensated at the retail electricity rates but concerns over the incidence of distribution costs have driven more systems to compensate producers at the avoided costs of generation. This typically requires more advanced metering technology. Net Metering is generally applicable to consumers who own relatively small renewable facilities. The system owner (of a solar or wind facility) receives a credit on her electricity bill. Unlike the case a Feed-in Tariff, the owner is not paid a prescribed amount per unit produced. Since most electricity meters can run in both directions, the meter serves as a mechanism for reducing bills and (possibly) making money for the small customer. To reduce transactions costs, the savings might be rolled over to the next month. Net metering could apply variable pricing using (more expensive) Time of Use meters.[12]

Following Table 6 summarize the possibilities of electricity selling to the grid among the distinct European countries. Most of the European countries incentives contain mostly only one way for electricity selling to the electricity grid. Only following countries among the Europe currently do not provide any of the main incentives (FiT, NM): Czech Republic, Estonia, Ireland, Slovenia and Spain.

[10] Renewable Energy Support Policies in Europe online: https://climatepolicyinfohub.eu/renewable-energy-support-policies-europe
[11] Infrastructure regulation glossary, online: http://regulationbodyofknowledge.org/glossary
[12] ibidem

Table 5 Different support schemes for the EU 28 countries in solar energy sector

	Austria	Belgium	Bulgaria	Croatia	Cyprus	Czech Rep.	Denmark	Estonia	Finland	France	Germany	Greece	Hungary	Ireland	Italy	Latvia	Lithuania	Luxembourg	Malta	Netherlands	Poland	Portugal	Romania	Slovakia	Slovenia	Spain	Sweden	UK
FIT	X		X	X						X	X	X	X					X	X			X		X				X
NM		X			X		X					X	X		X	X	X			X								

**FIT: Feed-in Tariff; NM: Net metering*

Due to the interconnectedness of the European countries (members of EU and not members of EU but nearby countries) it is useful to analyze electricity selling conditions also from all EU nearby countries. According to Table 7, only Iceland has no incentive support for electricity selling to the grid performed by individual household.

Table 6 Different support schemes for the EU nearby countries in solar energy sector

	Albania	Bosnia & H	Iceland	Kosovo	Liechtenst.	Macedonia	Moldova	Montenegro	Norway	Serbia	Switzerland	Turkey	Ukraine
FIT	X	X		X	X	X		X		X	X	X	X
NM	X						X						

**FIT: Feed-in Tariff; NM: Net metering*

Distinct conditions, terms of use, requirements, law and incentive settings require deep analysis among all distinct EU28 and nearby countries. Conditions to selling the electricity was analyzed only for the electricity generated by renewable technology via solar systems.

The distinction among the countries is often in the way the PV is installed on the building. If it is necessary to be directly mounted on the roof, on the wall, or if it can be put on the ground in the nearby locality, the difference in those terms is significant. There are also other factors related to the local law and conditions that could not be easily scaled for the purposed of clearly arranged analysis. To perform a contributive analysis in the field of European incentives for electricity selling to the grid a following factors were observed separately for Feed-in tariffs and Net-metering.

Eligible solar technology: this parameter of the analysis describes the maximum, minimum or range of capacity in kW/MW of devices (PV) that must be used for solar electricity generation. Under certain conditions, only some PV systems could join the incentive scheme and are able to sell electricity to the grid.

Duration of the contract: A given operator of solar renewable energy plant is entitled to the purchase of electricity exported and to the payment of the tariff applicable on the date on which the contract is concluded, for settled number of years starting on the date on which the plant is put into operation.

Parameter: from - to (€ct/kWh): this numbers reflect the range of prices (tariffs) paid for a kwh to the owner of the operating plant. It describes the revenue per kWh for the owner of the solar plant. For the analysis purposes an average tariff amount is put into consideration.

According to the presented parameters Table 8 is performed and raking the list of countries with Feed-in tariff according to the highest tariff (price) paid for kWh.

Table 7 Feed-in tariff conditions among the Europe

Feed-in tariff	Eligible Solar tech.	Duration of the contract	from (€ct/kWh)	to (€ct/kWh)	average (€ct/kWh)	*source*
Albania	max. capacity of 2 MW	15	100	/	100,00	3
Greece	more than 5kW	25	55	/	55	2
Portugal	max. capacity of 10MW	20	25,7	/	25,7	1
Bosnia Herz.	2 kW up to 23 kW	12	15,78	27,7	21,74	1
France	max. capacity of 100 kW	20	12,6	24,6	18,60	2
Ukraine	max. capacity 30 kW	20	17,2	19	18,10	4
Malta	max. capacity 980 kW	20	14,05	15,5	14,78	1
Macedonia	max. capacity of 1 MW	15	12	16	14,00	1
Kosovo	no specification	12	13,64	/	13,64	1
Serbia	no specification	12	12,4	14,6	13,50	1
Luxembourg	max. capacity of 30 KW	15	12,1	12,55	12,33	1
Montenegro	max. capacity of 1 MW	12	12	/	12,00	1
Turkey	no specification	10	11,7	/	11,70	1
Switzerland	minimum capacity of 30 kW	15	9,7	11,7	10,70	1
Germany	max. capacity of 500 kW	20	8,51	12,3	10,41	1
Hungary	between 50 kW - 0.5 MW	17	9,89	/	9,89	1
Liechtenstein	no specification	10	9	/	9,00	1
Bulgaria	max. capacity of 30 KW	15	10,83	6,71	8,77	4
Slovakia	max. capacity of 30 KW	15	8,4	/	8,40	1
Austria	5 kW up to 200 kW	13	7,67	/	7,67	1
Croatia	max. capacity of 500 kW	12	7,14	/	7,14	4
UK	no specification	25	1,78	4,36	10,37	1

Source:
1: Renewable energy policy database and support, LEGAL SOURCES ON RENEWABLE ENERGY, online: http://www.res-legal.eu/search-by-country/
2: International Energy Agency, Renewable Energy Feed-in Tariffs (III), https://www.iea.org/policiesandmeasures/pams/france/name-24112-en.php (2016)
3: PV magazine (Albania FITs) https://www.pv-magazine.com/2018/02/22/albania-grants-first-two-fits-licenses-for-pv-projects-up-to-2-mw/
4: PV magazine (Feed-in tariffs (FITs) in Europe)

For Net-metering the conditions are linked the most with the capacity of the device. Solutions which will exceed the maximum capacity are not able to join energy grid and use the net-metering system benefits.

Table 8 Net-metering conditions among the Europe

Net-metering	Eligible Solar technology max. capacity
Cyprus	5 MW
Albania	500 kW
Greece	501 kW
Italy	502 kW
Moldova	200 kW
Lithuania	100 kW
Hungary	50 kW
Denmark	50 kW
Belgium	10kW
Latvia	no specification
Netherlands	no specification

source 10 distinct country Net-metering conditions (described in abbreviation)

7.4.3 Trends in electricity selling (Peer-to-peer solar energy trading)

As solar & battery storage systems increase, more people are talking about peer-to-peer electricity trading (also known as p2p or ptp trading). The system allows consumers to take advantage of other users who produce more energy than they need. Those consumers can sell their excess power for profit. The main advantages are[13]:

- No middleman – people make deals on their own terms
- Everyone saves money
- Transparent dealings directly with other consumers
- Respected as much as large businesses

A new idea is that electricity is a commodity. For example, an electron is an electron regardless of its source (coal, solar) and its ability to power devices at home. People can choose how they use it and who they do business with.

P2p lets the participants: trade their solar energy to friends and family for free or at a discount; choose to buy solar energy from a neighbor, local wind or solar farm; choose to source as much energy as possible from distributed rooftop solar systems or home battery banks, or even neighbor.

P2p electricity trading in the national electricity market currently face a significant market entry barrier. In p2p energy trading, the size as a generator or consumer is important. To be on the National Electricity Market, households must have a generator no smaller than 5 megawatts –

[13] https://www.energymatters.com.au/misc/peer-to-peer-solar-energy-trading-guide/

about 1,000x 5kW solar systems. Obviously, this is out of the question for the average home owner.

However, in p2p **solar electricity** trading, the law is favourable and everyone from a 1.5kW solar system homeowner can engage in peer-to-peer solar energy depending on which software or technology is used to participate in the market.

A smart grid helps a prosumer. It cleverly brings users together to create a streamlined energy delivery system. It uses innovative products and services with intelligent monitoring, control, communication and self-healing technologies. Without this form of grid, peer-to-peer trading cannot work well.

A number of trials and projects on p2p energy trading have been carried out in recent years. Some of them focus on business models and platform for energy markets acting similarly to the supplier's role in the electricity sector. Others are targeted at the local control and ICT systems for microgrids.

Hooking solar and batteries up to this system creates a Virtual Power Plant (or VPP). This means that when there is a grid power shortage, you can supply the energy to companies for a premium.

The Australian Renewable Energy Agency (ARENA) is supporting a new pilot trial for power-trading between neighbors. It uses blockchain to help households and business to trade or share power with one another. AGL Energy Limited (AGL) is leading the project to evaluate a virtual trial at Melbourne homes. It mixes solar panels, batteries to store electricity, and 'smart' air conditioning.

Market early start projects:

- Decentralized Energy Exchange or "deX."

Funded by ARENA, the deX will create an open marketplace for the value of energy generated by solar panels and stored in batteries.

This is traded between consumers, businesses, communities and network utilities. Basically, deX will allow households and businesses to generate renewable energy to reduce their demand on the grid by using technologies like battery storage during peak times.

- Sonnen

A different approach is provided by German battery system maker Sonnen. It is revolutionizing the electricity delivery model.

SonnenFlat combines all the benefits and opportunities associated with distributed battery storage e.g. solar self-consumption, energy self-sufficiency, p2p. It uses smart software to bring solutions to both households and the different parts of the electricity sector.

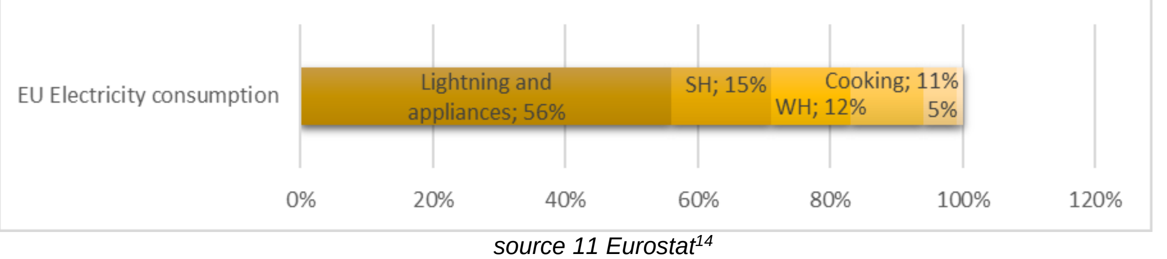
The program relies on controlling energy from its customers to create a virtual plant, a real alternative to the grid.

7.5 European electricity market: SH, WH, Appliances

Most EU Member States (9 Member States) use electricity as the main source for meeting their energy needs in the residential sector. Most of the EU final energy consumption in the residential sector is covered by natural gas (37.1 %) and electricity (24.5 %). Electricity covers 100 % of the energy needs for lighting and space cooling in the EU but also 94 % of the other end-uses and 49.2 % for cooking.

Final electricity consumption in the residential sector by type of end-uses is distributed as following: 56% for lightning and appliances, 15% for space heating, 12% for water heating, 11% for cooking, 5% for other end uses and 1% for space cooling.

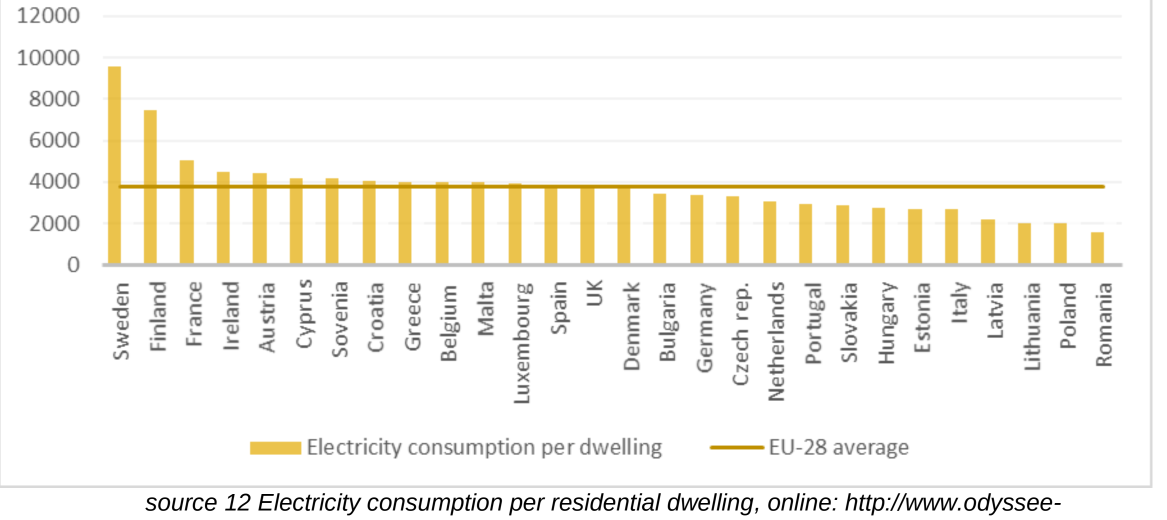
Figure 10 Final electricity consumption in the residential sector by type of end-uses



source 11 Eurostat[14]

Average EU 28 electricity consumption per dwelling is **3773 kWh/year**. Countries above the EU average are: Sweden, Finland, France, Ireland, Austria, Cyprus, Slovenia, Croatia, Greece, Belgium, Malta, Luxembourg, Spain, UK. From this list, the most distinct electricity consumption should be observed in Sweden (9589 kWh per dwelling) and in Finland (7454 kWh per dwelling).

Figure 11 Electricity consumption per residential dwelling, 2015 (kWh/year).



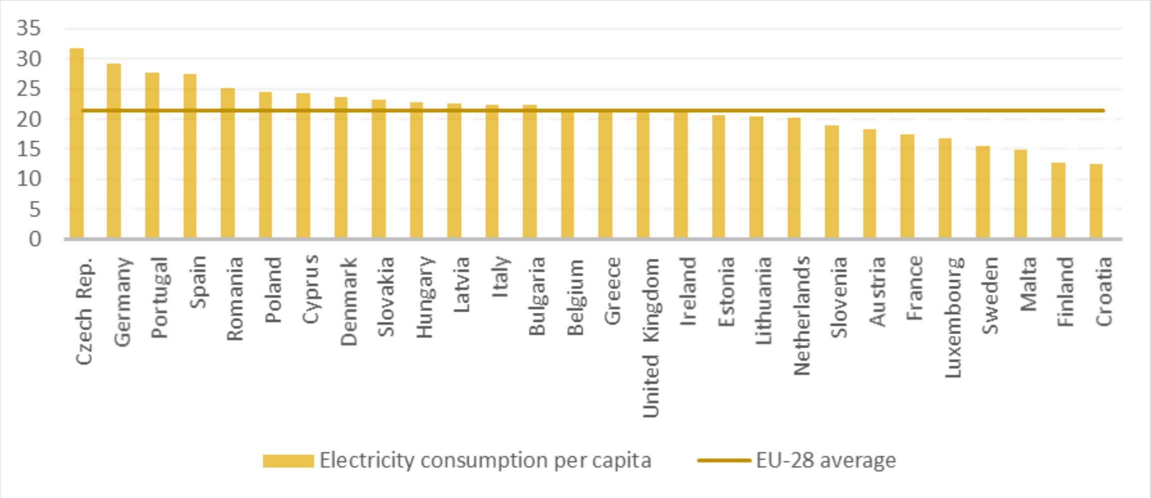
source 12 Electricity consumption per residential dwelling, online: http://www.odyssee-mure.eu/publications/efficiency-by-sector/households/electricity-consumption-dwelling.html

[14] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Final_energy_consumption_in_the_residential_sector_by_type_of_end-uses_for_the_main_energy_products,_EU-28,_2016_.png

Electricity consumption and its prices should lead to the need to find market solution enabling downsizing the electricity bill. Due to this fact, a following rank of countries according their electricity prices (in c€/kWh) were found.

Average EU price for a **kWh is 21,69c€**. Countries above the average are: Czech Rep. (31,82); Germany (29,16); Portugal (27,73); Spain (27,42); Romania (25,06); Poland (24,57); Cyprus (24,34); Denmark (23,56); Slovakia (23,15); Hungary (22,84); Latvia (22,57); Italy (22,45); Bulgaria (22,43); Belgium (21,63).

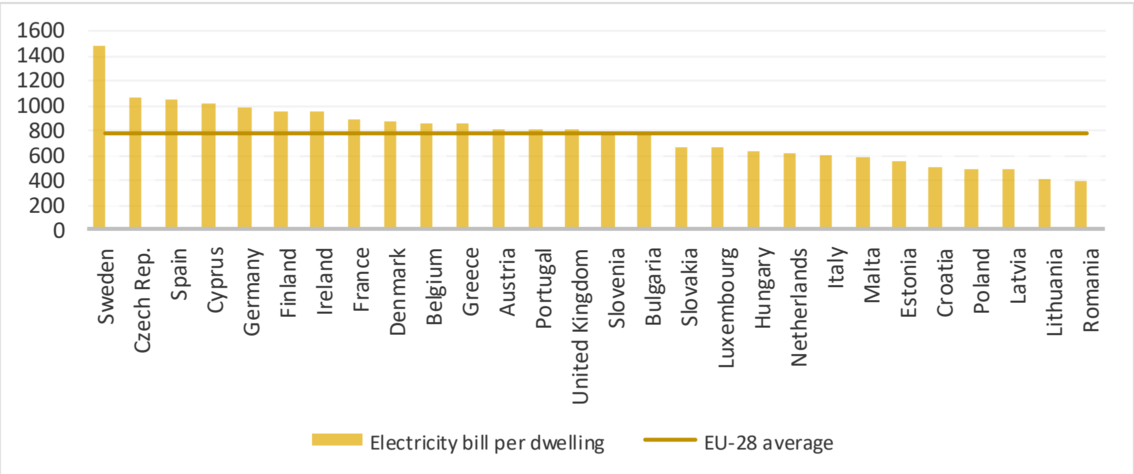
Figure 12 EU-28 Residential electricity prices including taxes at PPS (2019), c€/kWh



source 13 Energy price index, online: https://www.energypriceindex.com/latest-update

Diversification of electricity prices and its consumption vary a lot among the countries. To acquire the most possible target markets who should be interested in electricity bill savings it, is necessary to join together both previous findings from Figures 11 and 12. According to this data, Figure 13 shows the potential average electricity bill per dwelling for individual member states.

Figure 13 EU-28 Average year electricity bill per dwelling (in €)



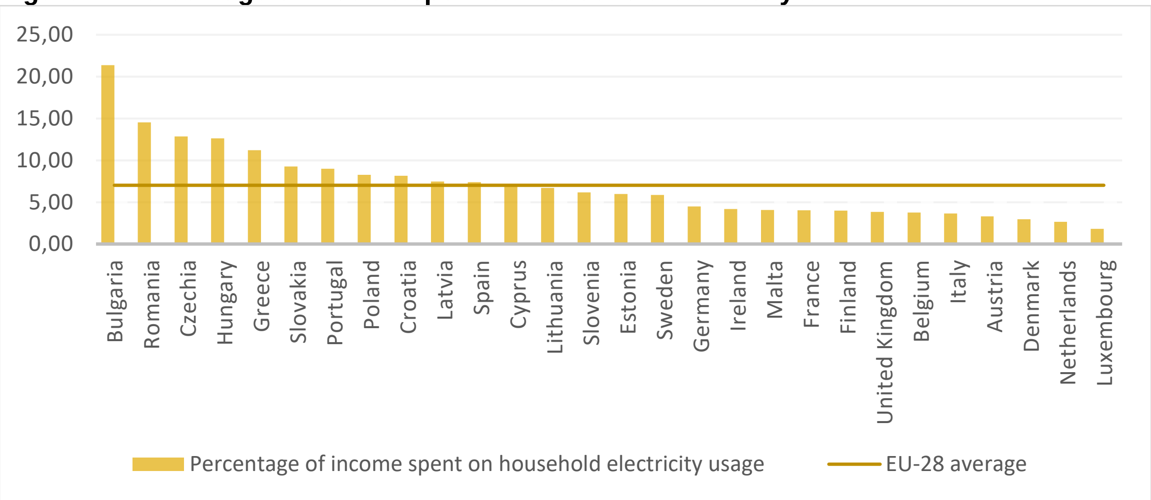
source 14 self-made from introduced data

The average bill per dwelling is **771,58 € per year**. Countries above the average are: Sweden (1484 €); Czech Rep. (1063 €); Spain (1047 €); Cyprus (1020 €); Germany (984 €); Finland (954 €); Ireland (954 €); France (886 €); Denmark (868 €); Belgium (861 €); Greece (852 €); Austria (816 €); Portugal (815 €); United Kingdom (807 €); Slovenia (786 €).

Percentage of yearly household income spent on household electricity consumption

Eurostat yearly pubic the median income for habitants among the EU countries.[15] This report consists of all employable habitants of the country (single person, one adult younger than 64, one adult 65 year over and single person with dependent children). According to this research a ratio between the median income and household expenses for the electricity is displayed on the following figure. It describes the distinct position of the EU countries according to the ratio of income spent for the electricity used by household.

Figure 14 Percentage of income spent on household electricity bill



source 15 Eurostat- Mean and median income by household type; Figure 13-household electricity bill

Among the EU countries households in average spent **7,02%** of a yearly income for household electricity bill. The list of countries who spent the above average ratio of the income for the household electricity bill is following: Bulgaria (21,36%), Romania (14,51%), Czech Republic (12,84%), Hungary (12,62%), Greece (11,21%), Slovakia (9,27%), Portugal (8,99%), Poland (8,26%), Croatia (8,14%), Latvia (7,45%), Spain (7,37%), Cyprus (7,04%).

This list of countries (markets) would most likely seek a solution which would be able decrease their electricity bills.

[15] Mean and median income by household type - EU-SILC survey, online: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=ilc_di04&lang=en

7.6 European Gas market: SH and WH

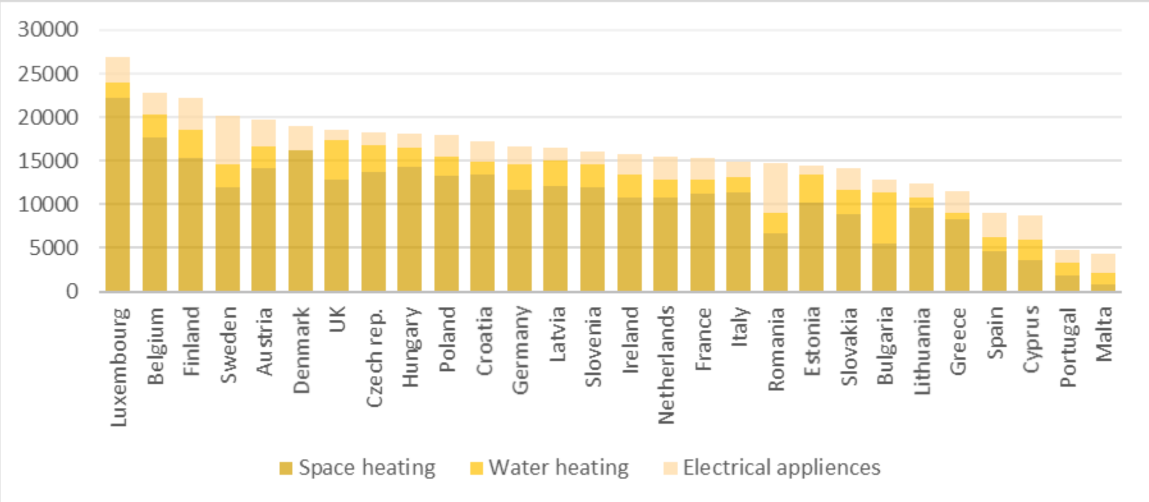
In the EU, the main use of energy by households is for heating their homes (64.7 % of final energy consumption in the residential sector). Heating of space and water consequently represents 79.2 % of the final energy consumed by households.

Space heating is among the EU 28 covered by following sources of energy: electricity: 5,6%; Derived heat: 9,2%; Gas: 43,4%; Solid Fuels: 4,8%; Oil and Petroleum products: 14,8%; Renewables and Wastes: 22,2%.[16]

Water heating is among the EU 28 covered by following sources of energy: electricity:19,3%; Derived heat:11,1%; Gas: 47,9%; Solid Fuels: 1,7%; Oil and Petroleum products:10,4%; Renewables and Wastes: 9,6%.[17]

Combined space and water heating is among the EU 28 covered by following sources of energy: electricity: 12,45%; Derived heat: 10,15%; Gas:45,65%; Solid Fuels: 3,25%; Oil and Petroleum products: 12,6%; Renewables and Wastes: 15,9%.[18]

Figure 15 Final EU- 28 energy consumption in the residential sector for space heating, water heating and electrical appliances 2015 (kWh)



source 16 Energy consumption in households, online: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Energy_consumption_in_households

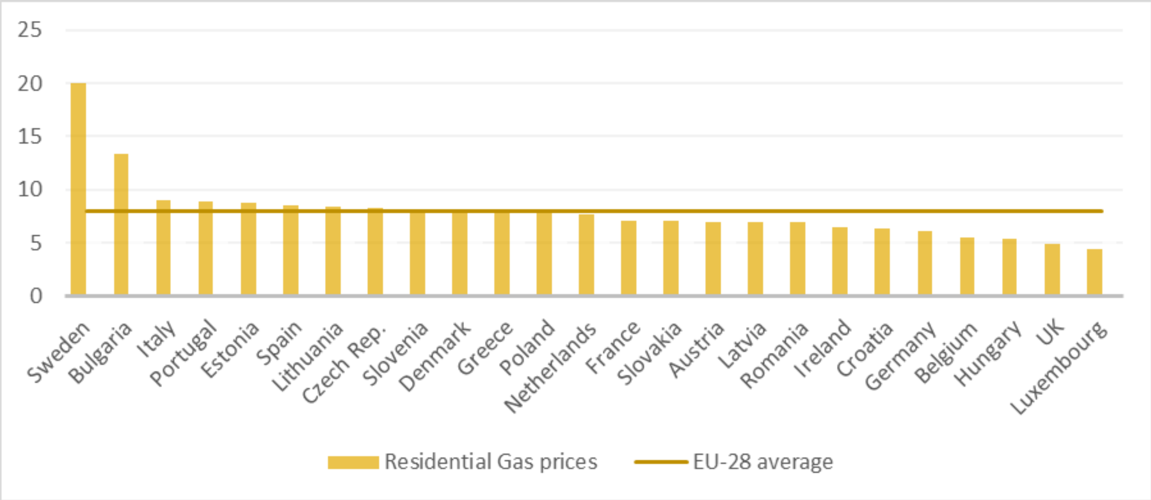
Figure 15 shows the distinction in residential gas consumption for space heating and water heating among the EU members. As illustrated, the highest consumption is located in Luxembourg, Belgium, Finland, Sweden, Austria, Denmark, United Kingdom, Czech Republic, Hungary and Poland.

For the purpose of the analysis, the individual gas prices among the member states were examined. Figure 16 shows that the highest gas prices are paid in Sweden, Bulgaria, Italy,

[16] Energy consumption in households: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Energy_consumption_in_households
[17] ibidem
[18] ibidem

Portugal, Estonia, Spain and Lithuania. Average price for the gas is in EU settled on 7,93 c€/kWh.

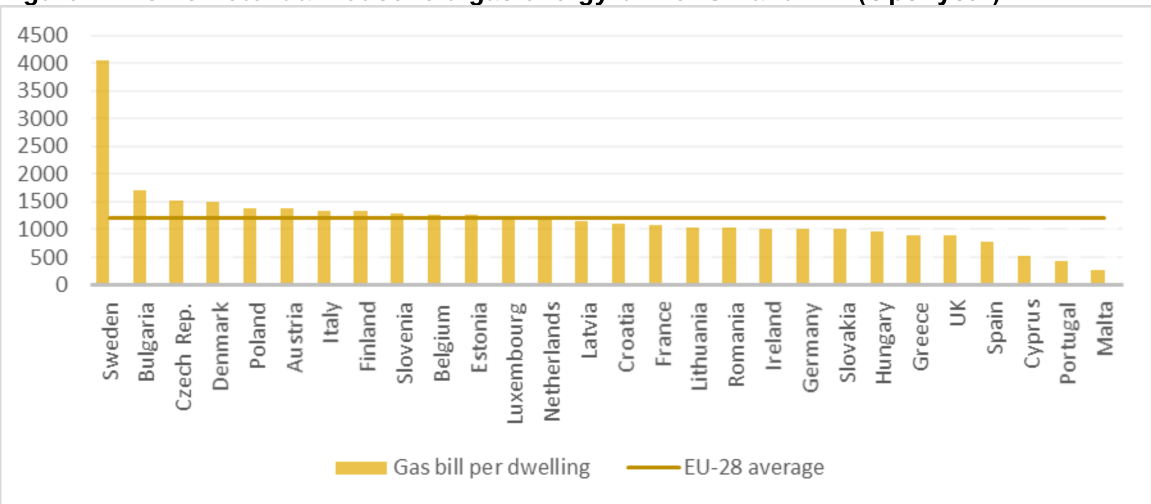
Figure 16 Residential gas prices including taxes at pps in capital cities (2019), c€/kWh



source 17 Electricity and gas prices, HEPI, online: https://www.energypriceindex.com/latest-update

Based on the analysis, consumption amount and its prices create a list of countries according to their thermal energy bill for gas in € per year.

Figure 17 EU 28 Potential household gas energy bill for SH and WH (€ per year)

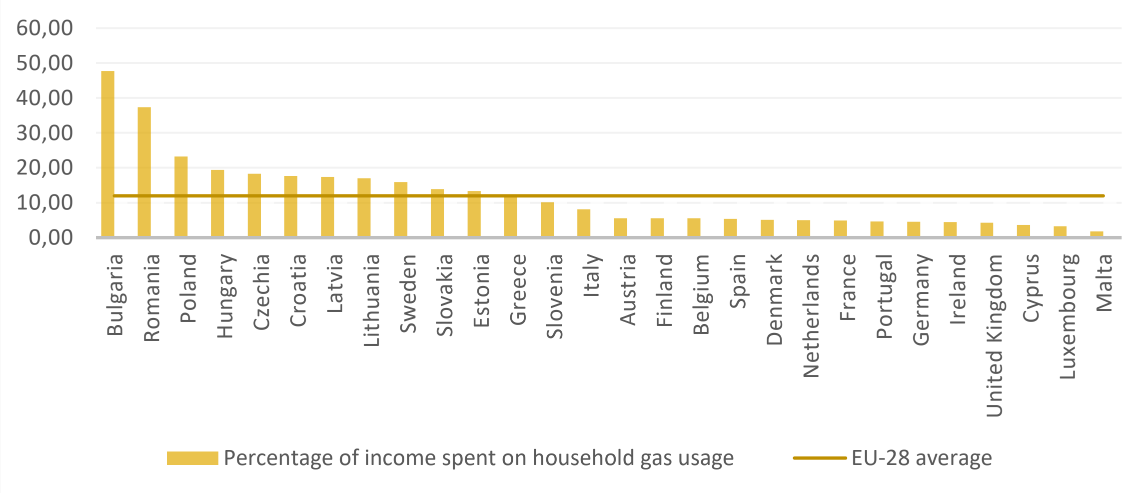


source 18 self-made from introduced data

The potentially highest thermal energy gas bills are paid in Sweden, Bulgaria, Czech Republic, Denmark, Poland, Austria, Italy, Finland and Slovenia. The Average gas thermal energy bill for SH and WH is 1198 € per year.

Eurostat yearly pubic the median income for habitants among the EU countries.[19] This report consists of all employable habitants of the country (single person, one adult younger than 64, one adult 65 year over and single person with dependent children). According to this research a ratio between the median income and household expenses for the gas is displayed on the following figure. It describes the distinct position of the EU countries according to the ratio of income spent for the gas used by household.

Figure 18 Percentage of income spent on gas household bill



source 19 Eurostat- Mean and median income by household type; Figure 17-household gas bill

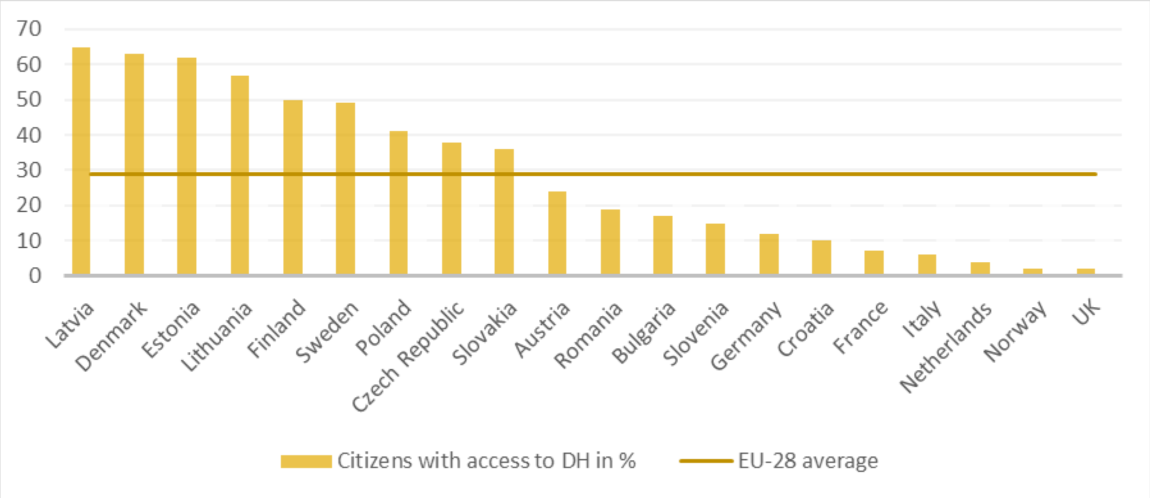
Among the EU countries households in average spent **11,09%** of a yearly income for household electricity bill. The list of countries who spent the above average ratio of the income for the household electricity bill is following: Bulgaria (47,74%), Romania (37,38%), Poland (23,29%), Hungary (19,37%), Czech Republic (18,31%), Croatia (17,69%), Latvia (17,40%), Lithuania (16,97%), Sweden (15,93%), Slovakia (13,93%), Estonia (13,38%).

7.7 European District heating market: SH and WH

Not every European citizen have an access for the district heating. Figure 17 shows the percentage of citizens who have access to the district heating. The dominant players are: Latvia (65%), Denmark (63%), Estonia (62%), Lithuania (57%), Finland (50%), Sweden (49%), Poland (41%), Czech Republic (38%), and Slovakia (36%).

[19] Mean and median income by household type - EU-SILC survey, online: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=ilc_di04&lang=en

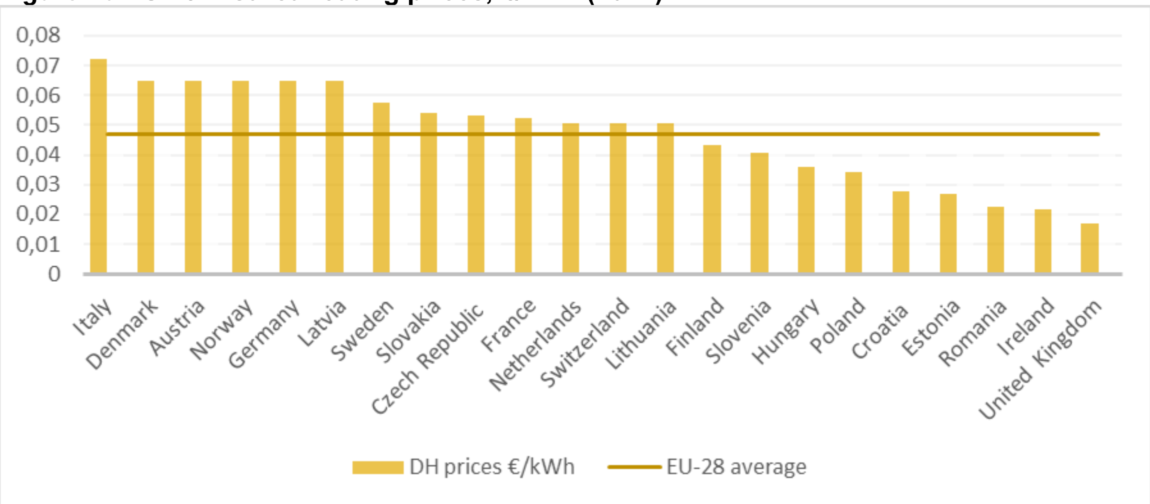
Figure 19: Citizens with access to DH (in %)



source 20 District heating and cogeneration in the EU-28: Current situation, online: https://ec.europa.eu/energy/sites/ener/files/documents/1_EN_autre_document_travail_service_part1_v6_0.pdf

According to this fact, it is useful to analyze district heating prices among the EU member states. The above the average prices in €/kWh are paid in Italy, Denmark, Austria, Norway, Germany, Latvia, Sweden, Slovakia, Czech Republic. France, Netherlands, Switzerland and Lithuania. The average price paid for kWh is **4,7c€ per kWh**.

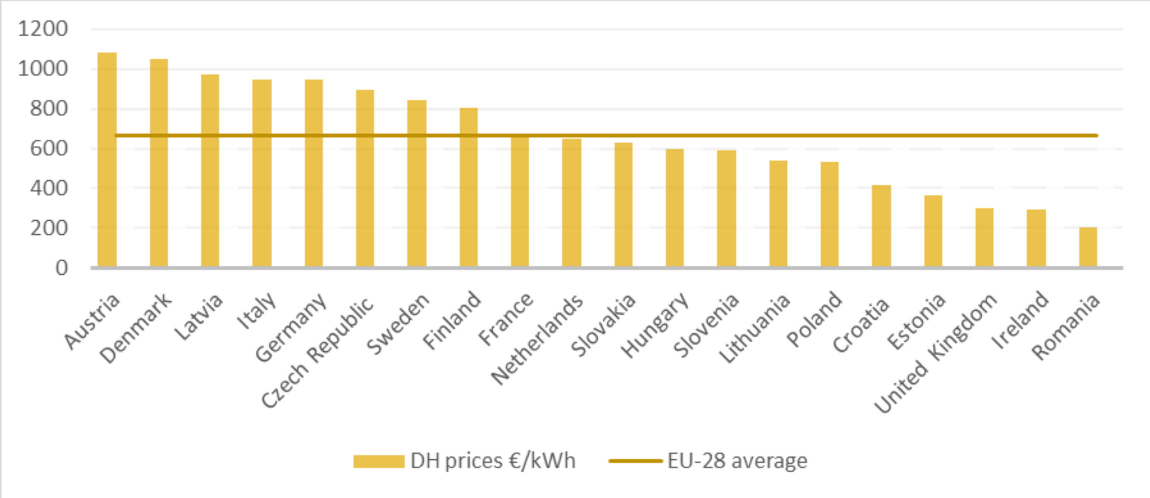
Figure 20 EU 28 District heating prices, €/kWh (2012)



source 21 District heating and cogeneration in the EU-28, online: http://kchbi.chtf.stuba.sk/upload_new/file/Miro/Proc%20problemy%20odovzdane%20zadania/Pomothy/%5B3%5D.pdf

Figure 19 shows the potential for district heating energy bill among the countries. EU average energy bill paid for district heating is **665,67€ per year**. Potentially the highest energy bill for district heating is paid in Austria (1080€), Denmark (1047€), Latvia (973€), Italy (946€), Germany (945€), Czech Republic (895€), Sweden (840€) and Finland (673€).

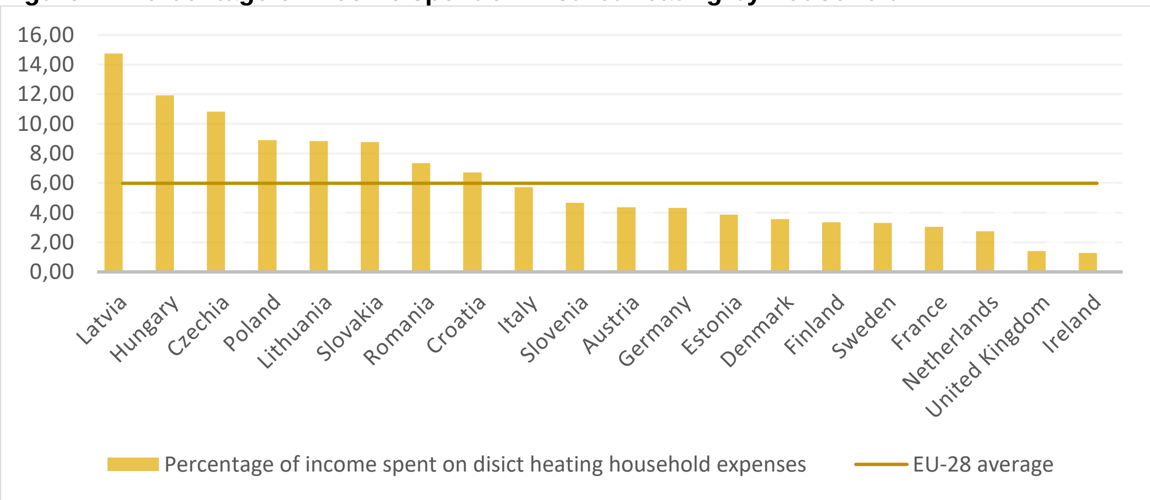
Figure 21 EU potential thermal energy bill for district heating (€ per year), 2012



source 22 self-made from introduced data

Eurostat yearly pubic the median income for habitants among the EU countries. [20]This report consists of all employable habitants of the country. According to this research a ratio between the median income and household expenses for the district heating is displayed on the following figure. It describes the distinct position of the EU countries according to the ratio of income spent for the district heating used by household.

Figure 22 Percentage of income spent on District heating by household



Among the EU countries households in average spent **5,98%** of a yearly income for household district heating bill. The list of countries who spent the above average ratio of the income for the household DH bill is following: Latvia (14,74%), Hungary (11,92%), Czechia (10,81%), Poland (8,90%), Lithuania (8,83%), Slovakia (8,76%), Romania (7,35%), Croatia (6,72%).

[20] Mean and median income by household type - EU-SILC survey, online: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=ilc_di04&lang=en

8 Competitors analysis

Competitors analysis is performed for the purpose of revealing market environment and number of competitors. Performed analysis should be useful to analyse innovation potential of the SCORES project or compare the current project solution to the existing solutions on the market.

Company	Description/ Lessons learned
Redflow	Z-Cell is Australian-designed energy storage system built around Redflow unique ZBMM2 zinc-bromine flow battery. It can deliver 10 kilowatt hours (kWh) of stored energy each day, harvesting energy from solar panels or lower-cost of-peak power, for use when needed. ***https://redflow.com/products/redflow-zcell/***
C&D Technologies	C&D's VR Solar series offer multiple battery footprints and form factors that all incorporate industry leading DCS Technology for the highest cycle life from a VRLA battery. C&D Lithium-Ion systems provide a high energy density, small footprint solution for those applications that require these capabilities. In addition to the energy storage products, C&D offers all the associated equipment for these systems including racks, trays, cabinets, battery monitoring, automated watering systems, and battery chargers. ***https://www.cdtechno.com/product/lithium/lithium.html***
Enersys	EnerSys energy storage is an advanced, market-leading technology that is just as easy and convenient to use as any other household appliance. The only 24/48V domestic solution to include a battery monitoring system, EnerSys energy storage is on a different level to other lead-based storage. The unique, user-friendly system is as simple to operate as any other household appliance. The monitoring system gives you important information about the battery status through a user-friendly, color touchscreen. It also allows you to control the operation and condition of the battery, for maximum confidence and protection of your investment. ***http://www.enersys-emea.com/reserve/pdf/EN-HESS-BR-001_0615.pdf***
Princeton Power Systems	The Princeton Power Systems' Energy Storage Systems (ESS) makes adding a turnkey energy storage component to a facility or project fast, easy and cost-effective. The ESS is designed to be scalable and available in pre-engineered PEMS solutions as well as custom ISO containers and sized to your unique power (kW) and energy (kWh) needs using multiple inverters and battery racks in a weatherproof enclosure. The systems use inverter building blocks and can support several battery technologies including, but not limited to, sealed lead acid, large-format lithium iron phosphate and hybrid batteries. Each ESS comes equipped with all the appropriate balance of system components and safety features. Princeton Power Systems and its partners have pre-engineered solutions with the world's leading battery manufacturers. Contact us today to talk about these available solutions. Battery agnostic. Compatible with various battery types such as lead-acid, lithium-iron-phosphate, and hybrid lead-acid. ***http://www.princetonpower.com/products/energy-storage-systems-iso-container.html***

Surrette battery, Rolls	Rolls Battery premium AGM and Flooded deep-cycle batteries reputation precedes them. Their batteries are known for their durability and reliability, dual container construction, high-density polyethylene materials and unique resistox plate design provide a longer life expectancy in the energy storage industry. Surette Rolls batteries stand out in their vertical for high cycle life, and the company shows it by backing them with up to 10-year warranties on select models. Rolls batteries are known to last up to 15 or 20 years if your battery bank is sized properly and maintained correctly. Brief description: Long cycle life, outlasts most other batteries in the industry, Thick lead plates using resistox plate design, Quality non-breakable dual container construction prevents acid leaks, Larger liquid reserve requiring lower maintenance, 3000+ cycles to 50% depth of discharge, 2000+ cycles to 80% depth of discharge. **https://www.solaris-shop.com/brands/Surrette-Rolls.html**
BYD energy storage	The Modular Outdoor Energy Storage System includes the outdoor battery cabinet and outdoor Power Control System (PCS) cabinet. The IP55 certified system functions well in an environment with a relative humidity (RH) of 95% and a temperature range from -20℃ to + 55℃, making it suitable for outdoor use. It is expected to become commercially available between the end of 2018 and early 2019. BYD's energy storage products are capable of playing a significant role in reducing the end user's reliance on the power grid while reducing their electricity costs in light of successive subsidy cuts in Europe. In addition, these products can enhance power security for cities, so as to promote the industry's healthy development. Recently, BYD's energy storage solution has won favor from investors in countries such as Belgium and Poland, a demonstration of the powerful competitiveness of its products. BYD delivered a 1.26MW/2.52MWh ESS container to Poland in May and has signed a contract to provide another 1.26MW/1.34MWh ESS container to its Belgium partners. **Link for more information about the BYD energy storage system**[21]
Eos Energy Storage	The Eos Aurora® is a low-cost DC battery system designed specifically to meet the requirements of the grid-scale energy storage market. With 4 hours of discharge capability, immediate response time, and modular construction, the Eos Aurora® system can be scaled and configured to reduce cost and maximize profitability in utility, commercial and industrial, and military market segments. The Eos Aurora® offers many competitive advantages including a 100% depth of discharge standard-use case and a wide temperature range to enable implementation without the use of HVAC. **https://eosenergystorage.com/products-technology/**
Powervault	Powervault 3 is designed and assembled in the UK. It has been designed specifically to store solar energy or cheap, off-peak electricity in either residential or commercial premises in the UK. It is compatible with all solar systems and is very quick and easy to install. Powervault 3 uses high-performance Lithium-polymer (Li-MNC) cells, which offer a long-life and come with a 10-year warranty. ***https://www.powervault.co.uk/technical/technical-specifications/***

21 http://www.byd.com/sites/Satellite?c=BydArticle&cid=1514427745378&d=Touch&pagename=BYD_EN%2FBydArticle%2FBYD_ENCommon%2FArticleDetails

Bosh	Bosch energy storage systems provides ability to store the excess solar energy produced during the day, allowing to power a house throughout the night. A solar panel system will be producing energy, even when it is not needed. Installing a Bosch battery storage system will save this energy for when it is needed. Bosch storage system: 5kW PV Inverter, 4.4kWh - 12kWh Integrated Battery Storage, 15 Year Warranty ***http://www.geogreengroup.com/power-battery-storage-systems/bosch-battery-storage-systems***
REST	REST specialises in efficient solar battery solutions for homes and businesses, providing total control of the energy consumption through the use of innovative technologies. The efficient solar battery storage system enables to store the energy generated by a solar system for usage at any time – night or day. With this battery storage solution, it is possible to use every bit of electricity produced and further reduce dependency on traditional power providers. The best part is that the owner gets paid under the Feed-In Tariff scheme for storing unused energy rather than sending it back to the grid. ***https://rest-uk.com/battery-storage/***
Moixa	Moixa has launched its latest residential energy storage unit, utilising 4.8kWh of storage capacity to offer homeowners greater benefits from time of use tariffs and arbitrage models. The new 'family-sized' smart battery, which will be showcased at Solar & Storage Live next week, is the company's largest following its 2kWh and 3kWh systems, and is intended to reflect the emerging energy tariffs that are becoming more readily available across the domestic retail supply market. The 4.8kWh lithium-ion battery will retail at £3,950 including VAT and installation, while a package offer including a 4kWp solar PV system will be sold for £8,500. **Link for more information about the Moixa energy storage system**[22]
Samsung	Samsung SDI's ESS technology is able to meet various needs of the users and provides customized solutions for the various purposes of the electric power market. Our ESS provides not only the economy but also strong reliability through its long-lasting life, safety, and excellent performance. Spanning from the size of kWh to MWh, Samsung SDI supplies various ESS solution – residential, utility, commercial, UPS and base transceiver station - applicable to your everyday life, leading the green energy industry. A better choice for tomorrow: Samsung SDI is creating the world of green energy with the environment-friendly production of electric power and its smart use. Everywhere in the world – your home, power plant, large-sized office and mobile base station, ESS goes with your everyday life. ***http://www.samsungsdi.com/ess/index.html***
Tesla	The Powerwall and Powerpack are rechargeable lithium-ion battery stationary energy storage products manufactured by Tesla, Inc. The Powerwall is intended to be used for home energy storage and stores electricity for solar self-consumption, time of use load shifting, backup power, and off-the-grid use.[1] The larger Powerpack is intended for commercial or electric utility grid use and can be used for peak shaving, load shifting, backup power, demand response, microgrids, renewable power integration, frequency regulation, and voltage control. ***https://www.tesla.com/powerwall***

22 https://www.solarpowerportal.co.uk/news/moixa_launches_family_sized_smart_battery_to_target_emerging_residential_bu

Calmac	IceBank model C tanks are second generation thermal energy storage. They come in different sizes to accommodate differing space constraints and offer a significant benefit— tanks can be bolted to each other due to their modular, internalized main headers. That means less distribution piping is needed. The result is reduced installation costs, due to reduced field piping, connections, insulation, and storage footprint. Internalized headers eliminates 80% of external piping which results in a 20% smaller footprint requirement and more flexibility in siting arrangements, which also reduces the cost and time of installation. ***http://www.calmac.com/icebank-energy-storage-model-c***
Sunamp	These heat batteries are fitted with AC electric heaters and are heated by a solar PV system by means of a power diverter controller as shown schematically in figure 1.9. Therefore, it Increases PV self-consumption and hence lower fuel bills and the Feed-In Tariff (FIT) income from the PV system is unaffected. UniQ ePV Heat battery designed for utilising excess on-site behind-the-meter solar PV electricity (above what is consumed by on-site AC electricity loads) and which is fitted with AC electric heaters and is heated by means of AC electricity diverted by a power diverter controller. The stored heat can be used for DHW heating and/or SH. ***https://www.sunamp.com/***
CCT	The modular energy storage unit, named as TED (Thermal Energy Device), was developed by Climate Change Technologies (CCT) company. TED accepts any type of electrical input–fossil, wind, solar, waste, or grid energy–then uses it to heat and melt silicon in a well-insulated compartment. With the melting of this unique phase-change material, TED is able to store el. energy as thermal energy rather than as an electrical charge. Now, whenever this energy is required, a heat engine is used to retrieve the energy by converting it back into electricity. ***https://www.cctenergystorage.com/***
Home power solutions	Picea is an all-in-one energy storage system, which combines energy storage, heating support and indoor ventilation in one compact system. Based on its high-performance energy management system, Picea is able to meet the complete electrical energy needs of a single-family home. In addition, all waste heat produced is used to provide the house with heat, thus lowering the costs of heating. Picea can be combined with all commercially available heating units and technologies. Compared to commercially available battery solutions, Picea has a hundred times more storage capacity with twice the output. Picea is energy efficient and provides energy in all seasons. This allows Picea to provide complete energy self-supply and independence from the grid.[23] Home Power Solutions (HPS), the Berlin-based energy solutions provider for single-family homes which fulfils the need for energy independence. On May 15, 2019, they announced that the crowdfunding campaign conducted with the GLS Crowd has reached the EUR 1.25 million target in just one day. All proceeds will be immediately available to the company and will be used to expand the sales and Picea production capacities at the Berlin-Adlershof location. ***http://www.homepowersolutions.de/en***

[23] https://www.dgap.de/dgap/News/corporate/hps-home-power-solutions-gmbh-raises-eur-million-through-gls-crowd-within-one-day/?newsID=1149999

Table 9 Additional key competitors operating in the field of energy storage market

Energy storage market major players		
JLM Energy	SunPower Corporation	Cryogel
Peak NRG	Stem	Energy Storage Association
Sunverge Energy, Inc.	UGE International	Cristopia Energy Systems
ABB	ENGIE Storage Services NA	Ice Energy
Sonnen GmbH	Sharp	Solar Reserve
Tabuchi Electric	Greensmith Energy	Chicago Bridge & Iron Company
SolarCity Corp	Samsung SDI Co. Ltd	Panasonic Corporation
EVAPCOInc.	LG Chem Ltd	Saft Groupe S.A

Table 10 Additional key competitors operating in the field of thermal energy storage market

Key players in the global thermal energy storage market		
Abengoa Solar	Cristopia Energy Systems	Steffes
Brightsource Energy	Dc Pro Engineering	Tas Energy
Solarreserve	Dunham-Bush	Evapco
Baltimore Aircoil	Goss Engineering	Fafco
Caldwell Energy	Ice Energy	Icelings
Burns & Mcdonnell	Natgun	Sunwell Technologies
Qcoefficient	Finetex EnE	

As shown, there is a lot of current ESS solutions on the market. Energy storage market is currently on the upturn and hard competitiveness of the different solution should be expected.

For the purpose of the deeper understanding of the SCORES potential according to the competitors provided, it would be useful to compare particular system characteristics. As price, dimensions, capacity, effectiveness, lifetime, and final anticipated saving related to the local end-user environment conditions. This analysis will be performed in the updated version of this Deliverable.

9 Canvas building blocks overview

Precision definition and widening of building blocks: Market problem, Competitors, Customers, Value proposition and Solution would be made in the SCORES business model deliverable. The purpose of market assessment is to provide relevant data and market environment description. Attached list of questions for every single building block is answered in performed market assessment.

Market Problem statement assessment

Assessment of the Problem building block reveals the main unfulfilled wants, needs, desires and incentives to buy of SCORES solution. Precise definition of needs will help the startup to customize and adjust a final business solution. SCORES market problem should be briefly described as a desire for energy bill savings. Customers of SCORES system would be mostly **interested in electricity, savings, heat savings, and district heating savings**. According to this fact, a following structure of questions were answered and performed via market assessment:

Table 11 Questions for market assessment related to the market problem

Household Energy bill	Who would appreciate the most the SCORES solutions and benefits? Who want to reach the energy savings the most?	
Electricity savings	How much electricity is consumed in residential dwellings among the EU?	Figure 11
	Which EU member pay the highest prices for the electricity?	Figure 12
	How much do the most expensive countries pay for their energy bill?	Figure 13
	Which countries pay the highest ratio of a yearly income for electricity bill?	Figure 14
Heat savings	Which source of energy is mostly used for space heating among the EU?	Chapter 7,6
	Who has the highest share of energy used for space and water heating?	Figure 15
	How much energy (in kWh) is used for SH, WH and electrical appliances among the EU?	Figure 15
Gas savings	Which EU member pay the highest prices for gas?	Figure 16
	According to the average consumption per dwelling, which country pay highest gas energy bill for SH and WH?	Figure 17
	Which countries pay the highest ratio of a yearly income for gas bill?	Figure 18
District heating savings	Which EU member pay the highest prices for district heating?	Figure 20
	According to the average consumption per dwelling, which country pay highest gas energy bill for SH and WH?	Figure 21
	Which countries pay the highest ratio of a yearly income for DH bill?	Figure 22

Substitutes and competitors' assessment

Competitors and substitutes help to reveal the way how is the identified market problem (unfulfilled wants, need, desires etc.) solved in the current situation; thus, the comparison for SCORES business solution is valuable.

According to the performed analysis, a great variety of competitors were identified and the list of the main competitors for the ESS market was precisely described for the future deeper analysis of particular competitors' products characteristics compared to the SCORES solution.

Customers

Assessment of the Customer segment building block revels the most interesting customers and their business profile for better definition and targeting (Country, specific characterization, preference orientation and classification according to their needs). Early adopters' definition further represents the main important segment of customers who appreciate the most the SCORES business solution.

Table 12 Countries with possible highest energy bill, dividing according to the source used

Electricity savings	How much do the most expensive countries pay for their energy bill?	Figure 13
Above EU average countries: highest electricity bill	Sweden (1484 €); Czech Rep. (1063 €); Spain (1047 €); Cyprus (1020 €); Germany (984 €); Finland (954 €); Ireland (954 €); France (886 €); Denmark (868 €); Belgium (861 €); Greece (852 €); Austria (816 €); Portugal (815 €); United Kingdom (807 €); Slovenia (786 €).	
Gas savings	According to the average consumption per dwelling, which country pay highest gas energy bill for SH and WH?	Figure 17
Above EU average countries: highest gas bill	Sweden (4044 €); Bulgaria (1712 €); Czech Rep. (1516 €); Denmark (1499 €); Poland (1388 €); Austria (1376 €); Italy (1343 €); Finland (1334 €); Slovenia (1287 €); Belgium (1260 €); Estonia (1256 €).	
DH savings	According to the average consumption per dwelling, which country pay highest gas energy bill for SH and WH?	Figure 19
Above EU average countries: highest DH bill	Austria (1080 €); Denmark (1047 €); Latvia (973 €); Italy (946 €); Germany (945 €); Czech Republic (895 €); Sweden (840 €); Finland (803 €); France (673 €).	

Table 13 Countries habitants who pay the highest proportion of their income for energy bill

Electricity savings	Who pay proportionally to the income highest electricity bill?	Figure 14
Above EU average countries: highest electricity bill ratio	Bulgaria (21,36%), Romania (14,51%), Czech Republic (12,84%), Hungary (12,62%), Greece (11,21%), Slovakia (9,27%), Portugal (8,99%), Poland (8,26%), Croatia (8,14%), Latvia (7,45%), Spain (7,37%), Cyprus (7,04%).	
Gas savings	Who pay proportionally to the income highest gas bill?	Figure 18
Above EU average countries: highest gas bill ratio	Bulgaria (47,74%), Romania (37,38%), Poland (23,29%), Hungary (19,37%), Czech Republic (18,31%), Croatia (17,69%), Latvia (17,40%), Lithuania (16,97%), Sweden (15,93%), Slovakia (13,93%), Estonia (13,38%).	
DH savings	Who pay proportionally to the income highest DH bill?	Figure 22
Above EU average countries: highest DH bill ratio	Latvia (14,74%), Hungary (11,92%), Czechia (10,81%), Poland (8,90%), Lithuania (8,83%), Slovakia (8,76%), Romania (7,35%), Croatia (6,72%).	

Table 14 Yearly paid expenses for household energy bills (€)

	Top 10 highest elect. bill	expenses (€/year)	Top 10 highest gas bill	expenses (€/year)	Top 10 highest DH bill	expenses (€)	Total bill for energy
Sweden	X	1484	X	4044	X	840	**6370**
Czech R.	X	1063	X	1516	X	895	**3474**
Denmark	X	868	X	1499	X	1047	**3415**
Austria		816	X	1376	X	1080	**3274**
Finland	X	954	X	1334	X	803	**3092**
Bulgaria		766	X	1712			**2479**
Italy			X	1343	X	946	**2289**
Belgium	X	861	X	1260			**2121**
Slovenia		786	X	1287			**2073**
Germany	X	984			X	945	**1929**
France	X	886			X	673	**1560**
Poland			X	1388			**1388**
Estonia				1256			**1256**
Spain	X	1047					**1047**
Cyprus	X	1020					**1020**
Latvia					X	973	**973**
Ireland	X	954					**954**

source 23 compilation of figures 13,17,19

Table 15 SCORES potential target markets, Energy bills as ratio of yearly income (%)

Country	Electricity bill	*rank*	Gas bill	*rank*	DH bill	*rank*	Total
	as ratio of yearly income (%)						
Bulgaria	21,36	*1*	47,74	*1*			1
Romania	14,51	*2*	37,38	*2*	7,35	*7*	2
Hungary	12,62	*4*	19,37	*4*	11,92	*2*	3
Czechia	12,84	*3*	18,31	*5*	10,81	*3*	4
Poland	8,26	*8*	23,29	*3*	8,90	*4*	5
Latvia	7,45	*10*	17,40	*7*	14,74	*1*	6
Croatia	8,14	*9*	17,69	*6*	6,72	*8*	7
Lithuania	6,71	*13*	16,97	*8*	8,83	*5*	8
Slovakia	9,27	*6*	13,93	*10*	8,76	*6*	9
Sweden	5,85	*16*	15,93	*9*	3,31	*16*	10
Estonia	5,96	*15*	13,38	*11*	3,87	*13*	11
Greece	11,21	*5*	11,81	*12*			12
Slovenia	6,18	*14*	10,13	*13*	4,67	*10*	13
Italy	3,65	*24*	8,12	*14*	5,72	*9*	14
Portugal	8,99	*7*	4,63	*22*			15
Germany	4,49	*17*	4,58	*23*	4,32	*12*	16
Austria	3,30	*25*	5,56	*15*	4,37	*11*	17
Finland	3,98	*21*	5,56	*16*	3,35	*15*	18
Spain	7,37	*11*	5,42	*18*			19
France	4,01	*20*	4,93	*21*	3,05	*17*	20
Denmark	2,96	*26*	5,10	*19*	3,57	*14*	21
Cyprus	7,04	*12*	3,60	*26*			22
Netherlands	2,65	*27*	5,01	*20*	2,75	*18*	23
Ireland	4,17	*18*	4,44	*24*	1,27	*20*	24
UK	3,85	*22*	4,25	*25*	1,41	*19*	25
Belgium	3,78	*23*	5,53	*17*			26
Malta	4,05	*19*	1,81	*28*			27
Luxembourg	1,83	*28*	3,31	*27*			28

source 24 compilation of figures 14,18,22

Table 14 display the rank of countries according to their total energy bill (in €). Those countries pay the highest total sum for the energy used in their homes. The total sum paid for energy bill may not indicate the market problem and do not completely reveal the precise target market which may appreciate the most energy savings but it indicates the market potential from a different side.

In selected countries with high energy prices and energy bills the SCORES possible total savings may be the most visible. High energy prices are mostly linked with high living standards which may increase the probability due to higher adoption probability of new innovative technologies. Households in high living standards countries are also most likely to be able to afford the new technology solution.

According to this fact, following list of top 10 countries whose total energy bill is the highest were identified: **Sweden, Czech Republic, Denmark, Austria, Finland, Bulgaria, Italy, Belgium, Slovenia and Germany.**

Table 15 display the rank of countries according to their ratio of yearly income (in %) paid for household energy usage. This ranking directly indicate possible countries who may have the market problem which is SCORES solution able to solve and thus evince the potential target customers. Those countries may potentially the most appreciate the energy bill savings.

Following list of top 10 countries whose ratio of early income paid for energy bill were identified as following: **Bulgaria, Romania, Hungary, Czech Republic, Poland, Latvia, Croatia, Lithuania, Slovakia, Sweden.**

By linking together both countries ranking the SCORES target market and customers who may the most appreciate the SCORES solution would be revealed. Countries which are in the intersection of both groups and thus SCORESS most suitable target markets are: **Bulgaria, Czech Republic and Sweden.**

Value proposition assessment

Value proposition Assessment put together all SCORES benefits, advantages, and characteristics which may influent a decision buy process of relevant customers. Performed analysis may be than compared to the SCORES total contribution in the comparison with existing solutions. Unique value proposition definition of SCORES solution help to describe the specific distinction of SCORES proposed solution.

Following table puts together all SCORES characteristic from the end-user and market substitutes point of view:

Table 16 Value proposition of a SCORES system

SCORES hybrid system:		
enable Space heating (electricity, district heating)	enable water heating (electricity, district heating)	enable running appliances independently from the energy grid (electricity)
store heat	Include intraday storage	reduce heat generation capacity costs
store electricity	convert electricity into heat	reduce electricity costs

harvest electricity and heat from the sun	manage the energy flows in the building	CO_2 emissions reduction
Include long term storage	balance the supply and demand of electricity	Contribute to fossil fueled energy reduction/removal
Support renewable/waste heat usage and generation	Enable connection for district heat grid	Provide back up power to avoid blackouts
bring flexibility to the grids (electricity and heat)	Enable connection for electricity grid	reduce grid charges to customers
increase generation and self-consumption of local renewable energies	provide technical and economic viability of short-term and seasonal compact thermal storage technology	enable energy arbitrage: stores energy when prices are low and sells energy when prices are high
increase profitability and ROI of power generating systems	provide resilience and reliability	

Solution

Solution business block assessment serves for market comparison of existing solutions and for customizing the own proposed market solution and its distinction. Precise solution was described in chapter 6 where all current and available data related to the SCORES hybrid system was mentioned and described also for the future purpose and analysis related to subsequent deliverables.

10 Conclusion

This deliverable D2.3 Market analysis on hybrid storage components aims to reveal the most important data about the SCORES related markets, especially the energy storage market, electricity market, gas market, district heating market and generally the household market conditions for space heating, water heating and residential appliances operation and their potential expenses for household energy bill.

Performed assessment serves as a basis for future business model (D2.5) Due to this fact, an analysis methodology and structure is adjusted to be in a line with the future utilization of Canvas business model approach (by RINA)

The structure of market assessment is related to core posed questions which have to be answered before entering the market or developing the other business plan, strategies and project focus. Posed questions are divided into four parts.

First part of market questions focuses on ESS market as a general, its developing potential, global trends, market barriers and drivers. Identification of key market players, deep understanding of market opportunity and composition of regulatory framework for the SCORES project.

During the ESS market assessment, it was concluded that since 2004, world variable renewable electric energy installed capacity (largely solar and wind) has grown 25% annually, global hybrid battery storage capacity increased in 10 years by 50% and the countries with the largest thermal energy storage capacity in the Europe are Ukraine with 2,568 MW, Poland with 1,158 MW, and the Czech Republic with 1,102 MW. The market leader worldwide region for ESS is located in Middle East and Arica.

The global market for end-of-life lithium-ion batteries is expected to be worth $1.3 billion in 2018 with a future potential to $4.2 billion by 2025. Today second life batteries are traded at between $60 and $300 per kWh, depending on market and application. Development of the general market is estimated to reach $43 per kWh in 2030, primarily as a response to falling prices of new batteries.

Current regulatory framework for electricity selling back to the grid vary among the distinct EU members and nearby countries. Two main ways for electricity selling were identified: Feed-in tariffs and Net-metering. Those two approaches were analyzed separately with the aim to discover the market most suitable conditions among the EU and nearby countries for SCORES solution.

Second part of market questions aims to analyze market conditions for market problem building block. Performed analysis focus on who would appreciate the SCORES proposed solution the most and its value proposition. According to this, it was concluded that it would be those countries whose energy bill paid by households for SH, WH and electrical appliances is the highest among the EU countries and also countries who pay the highest ratio of their yearly income for the energy purposes. The following list of countries were identified as the most suitable target markets who may the most appreciate the energy bill savings and the contribution of SCORES system: Bulgaria, Czech Republic and Sweden. Those countries possible expenses for energy bill are above the EU average expenses.

Third part of market questions aims to analyze market conditions competitors and SCORES value proposition. Significant number of competitors were discovered; thus, the competitive environment should be marked as highly competitive. ESS market is still considered from the end-user point of view as in the early beginning, there is a lot of innovations, and the development is substantial. Based on these market characteristics, the SCORES project should anticipate the market new challenges, changes and be prepared for new evolution of the ESS market.

Finally, the options of how to sell electricity is analyzed in the Annex of this Deliverable. The factsheet is provided for all European countries.

11 Attachment

Regulatory conditions for selling solar electricity back to the grid. Conditions for EU and nearby countries.

	Albania		**Feed-in Tariff**
General info	The public utility is obliged to purchase electricity from renewable energy sources for a tariff set by the Albanian Energy Regulator (Art. 22, § 4, Renewable Energy Law). The tariff is granted for 15 years (Art. 9, § 8, Renewable Energy Law).		
Eligible Solar tech.	PV plants up to 2 MW are eligible. The power purchase agreements are signed for 15 years		
Amount	2017: WACC: 8.8% LCOE: € 1.400 per MWh	2018: WACC: 8.0% LCOE: € 1.300 per MWh	2019: WACC: 7.5% LCOE: € 1.000 per MWh
			Net-metering
General info	The public utility is obliged to purchase electricity from renewable energy producers. For small and medium-sized companies as well as private households, a net-metering scheme for solar and wind installations <500 kW is in place (Art. 15 Renewable Energy Law).		
Eligible Solar tech.	Installations up to 500 kW are eligible.		
Amount	The net balance of produced and consumed electricity is metered on a monthly basis (Art. 15, § 3, Renewable Energy Law). The metered excess electricity is sold to the universal service provider and remunerated according to the universal service price defined by ERE, which depends on the voltage level (Art. 15, § 3 Renewable Energy Law, ERE Prices Q1 2017).		

	Austria	**Feed-in Tariff**
General info	In Austria, electricity from renewable sources is supported mainly through a feed-in tariff, which is set out in the Ökostromgesetz (ÖSG) 2012 and the regulations related thereto. The operators of renewable energy plants are entitled against the government purchasing agency, the so-called Abwicklungsstelle für Ökostrom AG (hereinafter called "Clearing and Settlement Agency"), to the conclusion of a contract on the purchase of the electricity they produce ("obligation to enter into a contract") unless the promotional volume for the FiT is exhausted.	
Eligible Solar tech.	The installation's capacity shall exceed 5 kWp up to 200 kWp The power purchase agreements are signed for 13 years	
Amount	2018: €ct 7.91 per kWh 2019: €ct 7.67 per kWh (§ 6 para. 1 ÖSET-VO 2018) In addition to the feed-in tariff, an investment subsidy of 30% of the investment costs up to 250 € per kWp is granted for PV installations on buildings (§ 6 para. 1 ÖSET-VO 2018)	

	Belgium	**Net-metering**
General info	In the Brussels-Capital region, small prosumers of green electricity are entitled to benefit from a compensation mechanism for the difference between the amount of electricity taken from the grid and the amount of electricity fed into the grid (net-metering). Please note: The decree of 17 December 2015 foresees the termination of the net-metering system for the electricity produced by renewable energy installations when the new MIG 6 regulation starts. (Art. 41, Arrêté du 17 décembre 2015).	
Eligible Solar tech.	**Brussels:** Renewable energy plants with a capacity of maximum 5kW are eligible for net-metering ("mécanisme de compensation"), however only until the MIG 6 regulation begins. This is foreseen somewhere in 2020 (Art. 41, Arrêté du 17 décembre 2015). In order to benefit from net-metering, the installation shall be equipped with two different meters: a bi-directional meter (A+/A-) installed by Sibelga and a "green meter", certified by Brugel, measuring the electricity produced by the renewable energy plant (detailed information on the website of Bruxelles Environnement as well as on the website of Sibelga).	

	Flanders: Installations with a maximum capacity of ≤10 kW are eligible for the net-metering scheme. Installations with a capacity >10 kW need to apply for a separate access point or meter to the grid operator. **Wallonia:** Prosumers producing electricity through a renewable energy plant with a capacity of ≤ 10 kVA and connected to the distribution grid are eligible for net-metering, provided their installation has been certified and registered as a green electricity production plant by the CWaPE The power purchase agreements are signed for 13 years
Amount	The producer benefits from the compensation mechanism for the period between two meter-readings. The compensation applies for the amount of electricity fed into the distribution grid, provided that the latter does not exceed the amount of electricity taken from the grid (Art.34, Arrêté du 17 décembre 2015).

Bosnia and Herzegovina	**Feed-in Tariff**
General info	The RES Operator (Federation of Bosnia and Hercegovina) and the Support Scheme Operator (Republic of Srpska) are statutorily obliged to purchase electricity from renewable energy sources at an incentive price.
Eligible Solar tech.	in particular micro-plants from 2 kW – 23 kW The power purchase agreements have a duration of 12 years
Amount	Micro: KM 0.49075 (approx. €ct 27.70) per kWh Mini: KM 0.30696 (approx. €ct 18.31) per kWh Small: KM 0.25971 (approx. €ct 15.78) per kWh

Bulgaria	**Feed-in Tariff**
General info	In Bulgaria, renewable energy installations with a capacity below 4 MW are supported through a feed-in tariff. The feed-in tariff applies to producers of electricity from renewable sources who inject their electricity into the public grid. The amount of tariff is determined annually by the Energy and Water Regulatory Commission (art. 32 par. 1 ERSA). As of 1 July 2018, the statutory obligation of NEK and the other off-takers to purchase the energy output of RES Producers under FiTs is terminated. RES Producers, which enjoyed PPAs and FiT are offered to execute Premium contracts with the ESSF by 1 July 2018.
Eligible Solar tech.	Feed-in tariff is applicable to new roof top or facade photovoltaic installations with a maximum installed capacity of 30 KW and to certain installations using combined cycle and indirect use of biomass. The power purchase agreements have a duration of 15 years
Amount	-

Croatia	**Feed-in Tariff**
General info	Privileged producers owning RES installations, which do not exceed a capacity of 500 kW, can conclude a power selling contract at a guaranteed purchase price, if they have won a public tender carried out by the Croatian Energy Market Operator.
Eligible Solar tech.	The eligible installation must not exceed a capacity of 500 kW The duration of the contract is 12 years
Amount	The amount of the guaranteed purchase price for the delivered net electricity is determined in the decision of the HROTE, which selects the lowest bidder in the public tender. Basically, the guaranteed purchase price does not change for the duration of the contract between the installation owner and the HROTE. However, the guaranteed purchase price of electric energy will be adjusted every year in relation to the established corrected guaranteed purchase price of electric energy

	from the previous year by applying the average annual consumer price index (Art. 35 § 6 RES Act). The maximum guaranteed purchase price of electric energy will be determined by the HROTE based on the methodology of guaranteed purchase prices of electricity defined in the RES Promotion Decree.
Amount	

	Cyprus	**Net-metering**
General info	Support Scheme for Electricity Production from RES for own consumption" is a net-metering/ net-billing system in Cyprus. Households and public administration entities are eligible (PV installations) as well as legal entities (off-grid PV installations).	
Eligible Solar tech.	For households: PV (aggregate installed capacity 5MW)	
Amount	-	

	Czech Republic	**Feed-in Tariff**
General info	A feed-in tariff can only be granted to operators of RES plants with an installed capacity up to 100 kW (30 kW in case of rooftop or façade PV installations or 10 MW in case of hydro power plants). PV and biogas plants are only eligible if put into operation before 31 December 2013. Wind, hydro, geothermal or biomass plants up to 100 kW are eligible only if they were put into operation before 31 December 2015 and the building permit was issued before 2 October 2013. Responsible for the payment of the feed-in tariffs are the "mandatory purchasers" selected by the Ministry of Industry and Trade (MPO)	
Eligible Solar tech.	Only installations on rooftops or façades are eligible and the maximum capacity must not exceed 30 kW (§ 4 par. 5 Letter d Act No. 165/2012). The installation must have been put into operation until 31 December 2013 (§ 4 par. 10 Act No. 165/2012). Only one installation per rooftop or façade is eligible (§ 4 par. 5 Letter d Act No. 165/2012). The tariff for all eligible technologies is statutorily guaranteed for 20 years	
Amount	From 1 July – 31 December 2013: CZK 2,739 (€ 105) per MWh for installations with a capacity between 5 to 30 kW (No. 1.10. Price Decision of the Energy Regulatory Office No. 3/2018).	

	Denmark	**Net-metering**
General info	Electricity producers using all or part of the electricity produced for th Electricity producers using all or part of the electricity produced for their own needs are totally or partly exempt from paying Public Service Obligation on this electricity. The Public Service Obligation is a charge levied to support renewable energy.eir own needs are totally or partly exempt from paying Public Service Obligation on this electricity. The Public Service Obligation is a charge levied to support renewable energy.	
Eligible Solar tech.	For solar energy installations > 50 kW the plant has to be connected to a private supply system or the plant has to be located at the place of consumption (§ 3 BEK 999/2016). For solar energy installations up to 50 kW the plant has to be connected to a private supply system (§ 4 BEK 999/2016).	
Amount	The following plants are exempt from the whole PSO tariff: Solar energy installations up to 50 kW The following plants are exempt from the surcharge for the support of renewable energy: Solar energy installations > 50 kW	

	France	**Feed-in Tariff**
General info	In France, the generation of electricity from certain renewable energy sources is promoted through a feed-in tariff scheme. Operators of renewable electricity plants are contractually entitled against the suppliers (EDF and private suppliers) to payment for electricity exported to the grid. The distribution grid operator is obliged to enter into agreements on the purchase of electricity at a price fixed by law ("obligation to conclude agreements").	
Eligible Solar tech.	Only plants installed on buildings whose installed capacity does not exceed 100 kW are eligible. The tariff for all eligible technologies is statutorily guaranteed for 20 years.	
Amount	The tariff applies to photovoltaic and thermodynamic installations and plants below a maximum power capacity of 100 kW fixed on buildings. The tariffs depend on the type and the total capacity of the installation, without distinction of the use of the building. Every quarter, the degression coefficients Sn and Vn will be adjusted to the number of grid connection requests adopted in the previous quarter (Arrêté du 9 mai 2017 soleil). The French regulatory authority will publish the new coefficients and the resulting changes in tariff levels online approx. 3 weeks after the end of each quarter (art. 14 Arrêté du 9 mai 2017 soleil). The tariffs are published at the following addresses: www.cre.fr/operateurs/producteurs/obligations-d-achat	

	Germany	**Feed-in Tariff**
General info	For power plants up 100 kW the support system is based on a feed-in tariff, which the grid operator pays to the plant operators. The amount of tariff is set by law and is usually paid over a period of 20 years. The plant operators can also opt for the market premium. Plants with a capacity higher than 100 kW can be supported through the feed-in tariff in exceptional cases.	
Eligible Solar tech.	Building-mounted systems must comply with additional pre-requirements depending on their nature (attached to or on top of building-roofs, facades, noise barriers, other buildings): (§ 48 par. 1, no.1, par 2 and 3 EEG 2017). Ground-mounted systems: The installation has to be erected within the territorial application of a formal development plan (e.g. a local development plan) (§ 48 par. 1 no. 2-3 EEG 2017). Installations erected within the territorial application of a local development plan drawn up after 1.9.2003 must be located on certain plots of land such as areas next to speedways, railroad tracks as well as on sealed and conversion areas (§ 48 par. 1 no. 3 abc EEG 2017). The tariff for all eligible technologies is statutorily guaranteed for 20 years.	
Amount	specific building-mounted systems (e.g. roofs, facades, noise barriers, other building) €ct 8.91 – 12.70 per kWh (§ 48 par. 1 and 2 EEG 2017) minus €ct 0.4 per kWh (§ 53 no. 2 EEG 2017);	

	Greece	**Feed-in Tariff**
General info	The scheme supports electricity generation by rooftop PV installations of up to 10 kWp through a guaranteed feed-in tariff. The (national) energy supplier measures the electricity exported to the grid and sends electricity bills to the operators of PV installations. If the feed-in tariff for the electricity produced exceeds installation operator's electricity charges, the (national) supplier shall pay the difference. If the tariff exceeds the installation operator's electricity bill, he will receive the exceeding amount. The scheme applies to private individuals, small enterprises and public entities.	
Eligible Solar tech.	Roof-mounted PV installations of up to 10 kWp on the mainland and rooftop off-grid installations of up to 5 kWp (art. 1 par. 1, 2 and 3 FEK 1079/2009).	
Amount	Since February 2017: € 105 per MWh (art. 3 par. 3 FEK 1079/2009).	

	Net-metering
General info	The amendment of Law No. 3468/2006 introduces net metering for all RES for autonomous producers, while "virtual net metering" is applicable to PV and small wind power plants only in certain cases. The net metering process is stipulated in FEK B' 3583/2014. Furthermore a similar PV (virtual) net metering scheme was introduced in 2017.
Eligible Solar tech.	Interconnected system: 500kWp Non-interconnected islands: 20kWp (50kWp for non-profit legal person) Island of Crete: 100kWp (300kWp for non-profit legal person).
Amount	Primarily, the electricity produced by an installation or plant is offset with self-consumed energy. Any surplus electricity is fed into the grid without any obligation for remuneration. Apart from that, PV installed on public buildings in the context of the EU funded programmes can receive up to 20% of the value of the total annual electricity production (art.14A par.4 Law No.3468/2006).

Hungary	**Feed-in Tariff**
General info	In Hungary, electricity generated from renewable energy sources and waste is promoted through feed-in tariffs if the plant's capacity is between 50 kW and 0.5 MW or in case of a demonstration project. The eligibility period and the maximum amount of eligible electricity are determined for each eligible electricity producer by the Hungarian Energy and Public Utility Regulatory Authority (HEA).
Eligible Solar tech.	are eligible for the feed-in tariff, if their capacity does not exceed 0.5 MW Photovoltaic (fixed): for maximum 17 years and 4 months. The plant has to be operational 2 years after confirmation of eligibility at the latest. Photovoltaic (sun-tracking): for maximum 17 years and 4 months. The plant has to be put into operation 2 years after confirmation of eligibility at the latest.
Amount	Plants of up to 0.5 MW or less: HUF 31.77 per kWh (approx. € 0.0989); No difference between peak, valley and deep-valley period.
	Net-metering
General info	Household-sized power installations (HMKE) with a capacity of maximum 50 kVA are eligible for net metering in case that the power plant connects to the low-voltage grid (§ 5 (6) Government Decree No. 273/2007 (X. 19.) in conjunction with § 3 No. 24 Act No. LXXXVI of 2007) and the performance of the power plant does not exceed 3x63A (§ 29 (1) Decree No. Decree No. 10/2016 (XI. 14.) The electricity surplus fed into the grid is remunerated by the electricity supplier with the retail electricity price. Connection to the public grid is only possible with an operational approval. If the approval is given, the local electricity traders or the universal supplier ("egyetemes szolgáltató") is obliged to feed the electricity into the grid (§ 4 Government De-cree No. 273/2007 (X. 19.).
Eligible Solar tech.	Eligible with a maximum capacity of 50 kVA.
Amount	…

Ireland	**Feed-in Tariff**
General info	In Ireland, electricity from renewable sources was promoted through a feed-in-tariff scheme. As of January 2016, there is no support scheme available for renewable energies, pending the introduction of a new support scheme in 2019.
Eligible Solar tech.	No solar
Amount	No solar

	Italy	**Net-metering**
General info	In Italy, RES-E producers can make use of the Scambio sul Posto if their plant's capacity does not exceed 500 kW (Art. 2bis,2 e 612/2014/R/eel) The principle of Scambio sul Posto is based on the balance of the energy fed in and consumed (Art. 1, 2 570/2012/R/efr). Under scambio sul posto, the plant operator pays the supplier for the electricity consumed, while GSE gives credit for the electricity fed in. This method can lead to a surplus on behalf of the plant operator (Art. 1 par. 1 a 570/2012/R/efr). The balance is calculated once a year (Art. 8 par. 2 570/2012/R/efr). More specifically, the owner of such plants will receive a compensation equal to the difference between the value of electricity exported to the grid (e.g. for PV installations the energy fed in during daytime) and the value of the electricity consumed in a different period. If more energy is fed in than consumed, plant operators are entitled to have an economic compensation, (Art. 6 570/2012/R/efr). If they feed in less than they consume, the difference is subject to a payment. Plant operators receive credit for the produced electricity. This credit will be available for an unlimited period of time (Art. 6 par. 7 570/2012/R/efr).	
Eligible Solar tech.	All plants generating up to 500 kW are eligible	
Amount	Plant operators receive as much energy for free as they produce (Art. 6 par. 2 570/2012/R/efr). Furthermore, in case the electricity fed in the grid is more than the one taken from the grid, plant operators are entitled to have an economic compensation, based on the formulas in Art. 6, 570/2012/R/efr.	

	Kosovo	**Feed-in Tariff**
General info	The public supplier is obliged to purchase electricity from renewable energy sources for a tariff set by the Energy Regulatory Office.	
Eligible Solar tech.	Preferential tariffs are provided for solar PV, wind, small hydro power and biomass. Annual capacity limits for each technology are defined (Decision on FiT).	
Amount	€ 136.4 per MWh (Decision on FiT, No. VI)	

	Latvia	**Feed-in Tariff**
General info	Latvia's RES support scheme is temporarily suspended.	
Eligible Solar tech.		
Amount		
		Net-metering
General info	Net-metering applies to clients who are producers of electricity, which are at the same time connected to the electricity grid through a connection smaller than or equal to 3*16A. Clients have to apply for an offer from the responsible grid operator for injecting electricity to the grid. For small-scale clients, energy costs apply to the net electricity consumption only, defined as the difference between electricity obtained from and fed-in to the grid. Furthermore, clients are required to pay a grid-use charge (§ 30 par. 1, 2, 3, 4 Electricity Market Law).	
Eligible Solar tech.	Net-metering applies to all technologies connected to the electricity grid through a small-scale connection (≤3*16A) in practice the net-metering applies mainly to photovoltaic installations.	
Amount		

	Leichtenstein	Feed-in Tariff
General info	The principality of Liechtenstein promotes the use of solar energy for the generation of electricity by granting a feed-in tariff. The amount of tariff paid by the grid operator differs and depends on the installed capacity of the installation. In addition to the support given through the feed-in tariff, the principality of Liechtenstein is also promoting the actual construction of the installation through an additional support mechanism. The tariff is eligible for a period of 10 years after commissioning of the installation.	
Eligible Solar tech.	Liechtenstein operates a feed-in tariff for the generation of electricity from PV-installations.	
Amount	PV installations with a capacity ≤250 kW receive a tariff of 10 Rp./ kWh (€ct 9/ kWh) from the grid operator (art. 13 EEV). Plants that have been constructed before the entry into force of EEG receive a tariff of 55 Rp./ kWh (€ct 48.4/kWh) from the grid operator (art. 19 par. 2 EEV). In addition to the feed-in tariff, the law is also granting payments for the development and construction of installations: For the construction of PV installations with a capacity ≤250 kW, the amount of payment is 400 CHF/installed kW (€ 352/installed kW) (art. 11b par. 1 EEV). For the construction of PV installations with a capacity ≤250 kW, the amount of payment is 650 CHF/installed kW (€ 572/installed kW), if the plant operator markets the electricity produced by his installation himself in accordance with art. 16 (2) EEG (art. 11b par. 2 EEV). For the construction of PV installations with a capacity ≤250 kW on vertical surfaces, the amount of payment is 750 CHF/installed kW (€ 660/installed kW) (art. 11b par. 3 EEV). The construction of PV installations with a capacity of 40 kW or more is promoted with up to 400,000 CHF (€ 343,039) (art. 15 EEG).	

	Lithuania	Net-metering
General info	Eligible for net-metering are solar, wind and biomass power installations operated by natural persons, including farmers whose annual income from agricultural activities accounts for less than 50% of all income received (≤ 10 kW), and legal persons, including farmers whose annual income from agricultural activities accounts for more than 50% of the received income (≤ 100 kW).	
Eligible Solar tech.	Eligible for net-metering are solar power installations operated by natural persons, including farmers whose annual income from agricultural activities accounts for less than 50% of the received income (≤ 10 kW), and legal persons, including farmers whose annual income from agricultural activities accounts for more than 50% of the received income (≤ 100 kW) (Chapter III Art. 20 Par. 1 Law on Energy from Renewable Sources).	
Amount	-	

	Luxembourg	Feed-in Tariff
General info	In Luxembourg, electricity from renewable sources is promoted through a feed-in tariff. All renewable electricity generation technologies are eligible, except for geothermal energy (Art. 5 RGD du 1 août 2014). The amount of feed-in tariff	

	differs for the various technologies and depends on the size of the plant. The feed-in tariff is guaranteed for a period of 15 years (Art. 6 RGD du 1 août 2014).
Eligible Solar tech.	PV installations shall have a capacity of less than 30 kW
Amount	Electricity from PV installations ≤ 30 kW fed into the grid receive a tariff amounting to €ct 12,1 per kWh (Art. 17 RGD du 1 août 2014) Electricity from PV installations between 30 kW and 100 kW fed into the grid receive a tariff amounting to €ct 13,12 per kWh (Art. 17 RGD du 1 août 2014) Electricity from PV installations between 100 kW and 200 kW fed into the grid receive a tariff amounting to €ct 12,55 per kWh (Art. 17 RGD du 1 août 2014)

Macedonia	**Feed-in Tariff**
General info	In the Republic of Macedonia, the electricity market operator is obliged to pay a fixed feed-in tariff to RES plant operators for the electricity generated from renewable energy sources. Electricity suppliers and retailers are obligated by the electricity market operator to buy the quantity of electricity produced by the preferential producers, corresponding to electricity demand of their consumers, understood as certain percentage of the total envisaged electricity demand of in FYR Macedonia.
Eligible Solar tech.	Eligible if the capacity does not exceed 1 MW
Amount	≤ 0.050 MW -> €ct 16 per kWh > 0.050 MW -> €ct 12 per kWh

Malta	**Feed-in Tariff**
General info	A feed-in tariff (FiT) is paid for the production of renewable electricity from solar PV installations.
Eligible Solar tech.	Eligible for photovoltaic installations with a maximum capacity up to 1,000 kWp, installed in residential or domestic premises, non-residential or institutional households (Art. 3 SL 545.27). The feed-in tariff shall be allocated for a period of guaranteed payment of 20 years.
Amount	Between 2 January and 30 December 2019, the following feed-in tariff is applicable: € 0.155 per kWh of electricity generated and exported to the grid by a PV installation which did not benefit from any form of grant or subsidy and having an installed capacity of more than 1 kWp but less than 40 kWp (2nd Schedule LN 200/2019). € 0.1405 per kWh of electricity generated and exported to the grid by a PV installation which did not benefit from any form of grant or subsidy and having an installed capacity of more than 40 kWp but less than 1 MWp (2nd Schedule LN 200/2019).

Moldova	**Net-metering**
General info	According to the new law on renewable energies, the final consumer has the right to inject into the grid the excess electricity produced from renewable energy sources and get it back when no electricity is produced (net-metering). All types of installations operating on renewable energy sources with a capacity below 200 kW are eligible for net-metering. However, the total installed capacity of installations that benefit from the net-metering support scheme should not exceed 5% of the maximum power registered in the previous year by the DSO to which the installations are connected.
Eligible Solar tech.	All plants generating up to 200 kW are eligible
Amount	

Montenegro	Feed-in Tariff
General info	Every year in January, a new incentive fee is adopted, which is applied to the end-costumers, who bore the costs from RES. The amount of incentive fee to encourage the production of electricity from renewable energy sources and cogeneration in 2018 is 0.47316 c€/kWh (Art. 1 Incentive Fee Decision). The Energy Market Operator (COTEE), who is legally obliged to buy the electric energy from privileged producers, pays the incentive for a period of 12 years after having concluded a formal agreement (Art. 95 Nr. 7 Energy Law). The exact amount is determined in the Tariff System Decree and mainly depends on the type of RES technology.
Eligible Solar tech.	Eligible for residential and commercial rooftop systems (Art. 4 Tariff System Decree) not exceeding 1 MW
Amount	The tariff amounts to 12 ct€/kWh (Art. 4 Tariff System Decree) for power plants using solar energy on buildings and engineering constructions equally (Art. 4 Tariff System Decree).

Netherlands	Feed-in Tariff
General info	Net-metering applies to clients who are at the same time producer of electricity, which are connected to the electricity grid through a connection with a throughput value smaller than or equal to 3*80A. Clients need to apply for an offer from the responsible grid operator for injecting electricity to the grid and are required to pay a grid use charge (art. 95(a) and (c) in conjunction with art. 31(c) Electricity Act). For small scale clients, energy taxes only apply to the net electricity consumption, defined as the difference between electricity obtained from and fed-in to the grid (art. 50 (1) and (2) WBM).
Eligible Solar tech.	Net-metering applies to all technologies connected to the electricity grid through a small-scale connection (≤ 3*80A). Generally, all RES-E technologies are eligible, however in practice net-metering applies mainly to photovoltaic installations.
Amount	The exact level of support depends on the amount of electricity fed-in the grid and the client's electricity consumption.

Portugal	Feed-in Tariff
General info	In Portugal, the FiT regime for industrial plants continues to apply only to renewable energy installations that were registered until November 2012, date on which DL 215-B/2012 came into force. A new regime for Small Production Units (UPP) and Self-consumption Units (UPAC) was introduced by DL 153/2014 and replaced the remuneration regime previously applicable to micro and mini generation units, which continues to be applicable only to installations registered until January 2015, date on which DL 153/2014 came into force through Ordinance 14/2015. There are common regulations and certain particularities for UPACs and UPPs under the new regime, in force since January 2015. UPPs can have an installed capacity of up to 250 kW, whereas UPACs can have an installed capacity between 200 W and more than 1 MW (art. 2 and 4 DL 153/2014). The most important changes are that UPPs are supported through a bidding scheme, while UPACs are able to have more capacity (more than 1 MW) and are also able to connect to the national grid. In addition, Decree-Law 35/2013 provides for alternative remuneration regimes for the electricity produced from wind power plants (as defined in Annex II of DL 189/1988 before the entry into force of DL 33-A/2005). These plants might choose to accede to an alternative remuneration regime for an additional period of five or seven years after the end of the period of guaranteed remuneration upon the commitment to contribute to the sustainability of the National Electric System (SEN) through the payment of a compensation (Art. 1 DL 35/2013).

Eligible Solar tech.	In general, all renewable energy generation technologies are eligible for the new support in case of small production and self-consumption units.
Amount	For existing photovoltaic installations as defined in DL 132-A/2010, the Indicative average rate of the FiT is € 257 per MWh (DL 132-A/2010). For existing concentrated photovoltaics (CPV) with Installations with a capacity ≤ 1 MW up to a limit of 5 MW of installed power on the national level the indicative average rate of the FiT is € 380 per MWh (Ordinance 1057/2010). For existing Concentrated Solar Power (CSP) installations with a capacity ≤ 10 MW the Indicative average rate is € 267-273 per MWh (DL 225/2007). For UPPs, the FiT consists of 100% of the reference tariff (art. 3 of Ordinance 15/2015). The reference tariff in 2018 is € 95/MWh (art. 2 of Ordinance 15/2015 in conjunction with art. 2 of Ordinance 32/2018, which kept the same tariffs from Ordinance 20/2017).

	Serbia	**Feed-in Tariff**
General info	The plant operators need to obtain the status of a „privileged power producer" („povlašćeni proizvođač električne energije") in order to acquire the right to a price support for the generated electricity under the legal requirements. After having concluded a power purchase agreement with the plant operator, the guaranteed supplier Elektroprivreda Srbije is legally obliged to buy the specified amount of electric energy from privileged producers at an incentive price (Art. 23 Nr. 2 Regulation on Incentive Measures).	
Eligible Solar tech.	In general, all technologies are eligible	
Amount	Roof-mounted power plants up to 0.03 MW: €ct 14.60-80*P per kWh (Art. 4 Nr.. 6.1 Regulation on Incentive Measures) Roof-mounted power plants with a capacity from 0.03 - 0.5 MW: €ct 12.404 - 6.809*P per kWh (Art. 4 Nr. 6.2 Regulation on Incentive Measures) Ground-mounted power plants: €ct 9 per kWh (Art. 4 Nr. 6.3 Incentive Measures Decree) "P" stands for the value in MW of the installed power of the power plant. The maximum operation time for one year of the incentive period for solar energy is 1,400 hours.	

	Slovakia	**Feed-in Tariff**
General info	In the Slovak Republic, electricity from renewable sources is supported mainly through a fixed feed-in tariff. The feed-in tariff consists of two parts: the price of electricity for losses (market price) and a surcharge. The market price is paid for all electricity supplied from RE facilities up to a support limit of 125 MW. The surcharge is billed by the plant operator for the electricity generated, less the internal technological consumption of electricity (§ 3 par. 1 Letter b in conjunction with § 6 par. 1 RES Act). In the case of photovoltaics, the surcharge only applies to roof-top or façade integrated installations up to 30 kW. For all other renewable energy plants with an installed capacity of more than 5 MW (15 MW in case of wind power plants), the surcharge is paid only for the proportionate amount of electricity produced annually.	

	Please note: In October 2018, the major reform of RES Act (No. 309/2018 Coll.) was approved by the National Council of the Slovak Republic. Under the new legislation, the so-called local energy source (up to the capacity of 500 kW) promoting self-consumption, new large-scale RES-E installations' promotion solely via system of auctions or the single buyer principle will be introduced. The future amendment of the RES Act is entering into force on 1 January 2019. Since the amendment of RES Act has not come into force yet, the information provided do not reflect the new legislative changes starting from 1 January 2019.
Eligible Solar tech.	Only PV installations on rooftops or façades with an installed capacity of no more than 30 kW are eligible
Amount	Roof-top or façade-integrated installations of up to 30 kW, from 1 January 2017: € 84.98 per MWh

	Switzerland			Feed-in Tariff
General info	The increased use of domestic and renewable sources for the generation of electricity is one major aim according to art. 1 c of the Energy Act (EnG). Since May 2008, the EnG grants producers of electricity generated from renewable energy sources a feed-in tariff for a period of up to 25 years. The amount of funding differs depending on the used technology and installed plant capacity.			
Eligible Solar tech.	Only PV-installations with a minimum capacity of 30 kW are eligible.			
Amount	Performance category	Tariff (CHF/kWh) Start of operation 1 October 2016 - 31 March 2017	Tariff (CHF/kWh) Start of operation 1 April 2017 - 31 December 2017	Tariff (CHF/kWh) Start of operation 1 January 2018
	≤ 100 kW	0.133 (11.7 €ct/kWh)	0.121 (10.7 €ct/kWh)	0.11 (9.7 €ct/kWh)
	≤ 1000 kW	0.122 (10.8 €ct/kWh)	0.115 (10.2 €ct/kWh)	0.11 (9.7 €ct/kWh)
	> 1000 kW	0.122 (10.8 €ct/kWh)	0.117 (10.3 €ct/kWh)	0.11 (9.7 €ct/kWh)

	Turkey	Feed-in Tariff
General info	In Turkey, renewable electricity production is mainly promoted through a guaranteed feed-in tariff. The YEK-Law differentiates the amount of the fixed feed-in-tariffs depending on the technology and whether the plant components were produced in Turkey or not.	
Eligible Solar tech.	Eligible, both PV and CSP	
Amount	PV: feed-in tariff: USDct 13.3 (€ct. 11.7) per kWh local-content bonus: USDct 0.6-6.7 (€ct 0.5-5.9) per kWh CSP: feed-in tariff: USDct 13.3 (€ct 11.7) per kWh local-content bonus: USDct 0.6-9.2 (€ct 0.5-8.1) per kWh Since 31 December 2013, the Council of Ministers is authorised to determine the total capacity of new installed solar installations which have a YEK permission. (§ 6/C art. 5, YEK)	

	Ukraine	**Feed-in Tariff**
General info	The guaranteed buyer is obliged to buy the electricity generated by renewable energy plants at “green tariff” rates. The “green tariff” is granted to all RES technologies (up to a capacity of 10 MW in the case of hydro power). Additionally, the electricity produced from private households equipped with solar panels or wind turbines, both technologies having a capacity up to 30 kW, can also benefit from feed-in tariffs. There is also an additional premium for producers using at least 30% of equipment of Ukrainian origin.	
Eligible Solar tech.	Eligible is electricity from PV system, (ground-mounted and rooftop) produced both by business entities and private households	
Amount	All tariffs on: http://www.res-legal.eu/search-by-country/ukraine/single/s/res-e/t/promotion/aid/feed-in-tariff-green-tariffs/lastp/350/	

	United Kingdom	**Feed-in Tariff**
General info	In Great Britain, eligible renewable energy plants with a capacity of up to 5 MW must generally undergo an accreditation process, which may differ according to plant size and energy source. Once this process is completed and the plant has been accredited, the electricity exported to the grid by the plant is bought by a FiT licensee, i.e. an electricity supplier, at rates fixed by the FTO 2012 and corrected yearly by the Gas and Electricity Markets Authority (Ofgem). This system only applies in Great Britain, i.e. Scotland, England and Wales. The Order is not applicable in Northern Ireland. With some exceptions, until 31 March 2017 plants between 50 kW and 5 MW are entitled to choose between the above-mentioned system and the Renewables Obligation.	
Eligible Solar tech.	PV installations are eligible (art. 2 (2), 3 FTO 2012). In order to be accredited, installations of less than 50 kW shall take part in the Microgeneration Certification Scheme (MCS), an independent scheme that certifies microgeneration products of less than 50 kW and installers in accordance with consistent standards.	
Amount	All tariffs on: http://www.res-legal.eu/search-by-country/united-kingdom/single/s/res-e/t/promotion/aid/feed-in-tariff-5/lastp/203/	