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Draft Country Report Industry Perspective

Deliverable 2.2

WP 2: Re-Launching STE Industry in Europe
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Project Coordinator, Work Package Coordinator and Lead Beneficiary

ESTELA, European Solar Thermal Electricity Association

Contributing Partners

CIEMAT, Centro de Investigaciones Energeticas, Medioambientales y Tecnologicas

ENEA, Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenible

DLR, Deutsches Zentrum Fuer Luft - Und Raumfahrt EV

METU, Middle East Technical University

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ABOUT THE PROJECT

HORIZON-STE is a Horizon 2020 funded project aiming at supporting the Implementation of the Initiative for Global Leadership in Solar Thermal Electricity (STE), also known as Concentrated Solar Power (CSP), which was launched by the European Commission and adopted within the Strategic Energy Technology Plan (SET Plan) of the European Commission.

Since more than a decade, Europe's Solar Thermal Electricity sector holds a worldwide technology leader until its further development abruptly hindered in Europe. To unlock this situation, the European Commission has launched a dedicated Initiative – Initiative for Global Leadership in Concentrated Solar Power focusing on 2 targets: a cost reduction target and an innovation target, in order to keep STE's global technology leadership and rebuild a home market in Europe.

Acting as competence centre of the Implementation Working Group within the Strategic Energy Technology Plan (SET Plan) of the European Commission, the overall goal of HORIZON-STE is to support the execution of the Implementation Plan regarding both STE Research and Innovation lines as well as First-Of-A-Kind projects that will help steer countries through political, legislative, and institutional shortcomings linked to various national policies concerning solar thermal electricity. Much of the focus centres on improving procurement of manageable RES and increased public funding for STE research.

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INTRODUCTION

Description of Task

The Country Report is part of the Work Package 2 "Re-Launching STE Industry in Europe" for which ESTELA is task leader. As a reminder, the overall objectives of WP2 are labelled as follows in the initial proposal:

> **"**Assessment of the conditions for replicating in European countries the commercial cost levels (<10 €cts/kWh) already achieved by the industry on CSP/STE world markets (financial conditions, type of auctions, contribution of innovations delivered by R&I) as one of the objectives of the Initiative and its Implementation Plan.**"**

This deliverable is the outcome of the tasks 2.2. and 2.3., corresponding to the combination of the "Analysis of relevant countries' energy needs and strategies" and a "Map and Match: Assessment and presentation of potential solutions using CSP/STE". The overall objective of these tasks was double:

- To first produce a general overview of the energy strategies embraced by each country of focus and understand the needs and expectations of political stakeholder
- To then provide industrial and political stakeholders with *ad hoc* propositions of STE uses to meet the strategy and system requirements

This task will last from M8 to M36 and is enriched in an ongoing basis, following the path of the country analyses. First focusing on individual cases, the compilation of countries will ultimately highlight potential cooperations and/or complementary needs between Member States. It is also based on the Report on Stakeholder Mapping, delivered in M7 (D.2.1.) which gave a framework to the country approach. Each country of focus in WP2 will be the object of a draft country report (the present document) which gathers, from the industry perspective:

- A summary of the country's needs
- The framework conditions and power plant basic configuration and siting vs other options
- The CSP added value (system value and macroeconomic value for the country)

Based on this, Deliverable D2.2. is directly in line with Deliverable D.2.3., "Integrated Country Report", which will combine both industry and R&I perspectives. It displays first findings in terms of policy recommendations and initial solutions to improve industry/trading opportunities.

Once each country profile is finalised, this industry report will be a key pillar for the writing of the Final Report. It will serve as a reference in the construction of strategic solutions to create the necessary conditions for further development of STE while matching countries' concerns.

CHAPTER 1: TURKEY

Turkey is the first country to be analysed within the scope of HORIZON-STE. The following chapters will describe the work undertaken in Turkey, as well as the challenges and opportunities met in the country.

1.1 *Structure of the document*

The deliverable D2.2. "Draft Country Report – Industry Perspective" aims to provide a first global and structured approach regarding potential interest in STE (as well as broader use of Concentrating Solar Technologies), from funding mechanisms to commercial purposes.

The present document takes into account the relevant information gathered during the main phases of WP2 concerning:

- **The expressed need for manageable RES energy** by each country of focus and their respective strategies on its procurement
- The possible changes in the framework conditions
- The interest for and reception of potential solutions using STE

Part 1.2 summarises the tasks which were carried out, describing first the initial plan and then the actual work carried out. This gives an overview of the intelligence collected and of the final key stakeholders and serves as a basis for spotting opportunities and challenges for STE in the given country. Activities typically involved:

- Meeting with relevant stakeholders, i.a. at Ministry, TSO and Regulatory Authority levels, as well as key players from local industries and civil society
- Brokerage event and joint industry-R&I national events

A deeper analysis of the context of the country is provided in part 1.3, first from the political point of view (1.3.1) followed by a focus on the regulatory (1.3.2) and transmission (1.3.3) aspects. The overview of the most striking financial opportunities (1.3.4) and of the current industrial landscape (1.3.5) closes this part. More precisely, the part aims at large to sketch the existing political strategies, the arising regulatory challenges and opportunities as well as to depict the current status and future requirements of the system in Turkey.

Based on these observations, key findings are drawn in part 1.4. They highlight encountered challenges and existing opportunities for the development of STE technologies in Turkey.

Last but not least, part 1.5 suggests strategic actions to continue opening doors for STE in Turkey, from an industrial point of view. It offers an overarching approach to further support the development of STE in Turkey and offers thorough advice.

1.2 *Summary of undertaken activities*

Turkey was under the scope of analysis from October 2019 to mid-March 2020. If WP2 and WP3 are targeting different activities to draw the landscape of Turkey from R&I and industry points of view, co-operation was soon implemented to maximise results. METU helped ESTELA find relevant interlocutors and shared its initial local knowledge of the context. Once data was collected on both sides, METU organised a workshop which brought together industry and R&I stakeholders in a common approach for launching CST in Turkey.

1.2.1 Foreseen activities and implementation challenges

To favour a sustainable launch of STE in studied countries, ESTELA designed a general process unfolding in three steps:

PHASE 1	
BACKGROUND RESEARCH AND FIRST MEETINGS	
General aim	To understand the need for manageable RES energy and Turkey's strategies on its procurement / possible changes in the relevant framework conditions
Encountered challenges	– To find the right interlocutor – Important information only available in Turkish – Low answer rate to interview request
Applied mitigation	– Help from METU (local partner) to identify relevant stakeholders with whom they are already in touch – Simplified translation of official documents from Turkish to English – Help from METU to collect consent from potential interviewees
PHASE 2	
BROKERAGE EVENT - INDUSTRY	
General aim	Assessment and presentation of potential industrial solutions using CSP/STE
Encountered challenges	– Gathering key stakeholders from industry sector – Matching research and industry potential
Applied mitigation	– Combined brokerage event Industry – R&I – Help from METU to identify relevant research projects matching industry reality and policy needs – Organisation of sessions interweaving capacities and existing activities
PHASE 3	
JOINT NATIONAL EVENT – INDUSTRY AND R&I	
General aim	Focus on possible synergies and macro-economic value
Encountered challenges	– Burst out of international public health crisis – Delay in the organisation of the event
Applied mitigation	– Rescheduling

1.2.2 Carried out activities – Industry perspective in Turkey

LIST OF ACTIVITIES	TIMELINE
BACKGROUND RESEARCH	Phase 1 Oct.-Dec. 2019

Aim: To collect relevant information to better understand the energy landscape in Turkey, the potential challenges for the development of STE and the needs of the country

Description

Desk research: Collect of information based on available information on official websites (e.g.: Ministry of Energy and Natural Resources [MENR], TEIAŞ, EMRA, etc.), academic studies or reports by consultancies

Stakeholder mapping: Analysis of the specific relevant departments and actors for each identified target group

Exchanges with HORIZON-STE Turkish partner (METU) on relevant contacts and existing knowledge of the local situation

PRELIMINARY VISITS	Phase 1 January 2020

Aim: To collect direct feedback regarding needs in terms of energy and more precisely manageable renewable energy sources (RES), the current and future energy strategies, the procurement system and the possible changes in the relevant framework conditions

Description

TSO: Meeting with representatives of TEIAŞ including the the Head of Foreign Affairs Department, Head of Planning and Investment Management Department and the Head of R&D Management Department

MENER: Two meetings

Meeting with the Head of DG Renewable Energy and two other representatives from the DG, including from the Solar Energy Unit

Meeting with the Head of Department of Energy Efficiency and Environment / Energy Advisor to the Minister

Regulatory Authority: Meeting with the Head of Electricity Market Department and members of other units, including the one in charge of the (upcoming) regulation on hybrid generation

PHONE INTERVIEWS	Phase 1 Feb.-March 2020

Aim: To collect more targeted feedback on political, industrial and economic factors regarding the development of Turkey's energy strategy and potential need for manageable RES

Description

Industry: Two interviews to gather insights into market conditions for the development of innovative technologies in Turkey, to capitalise on existing assets and favour their development, to optimise investment and return on investment

Interview with the founder of Greenway CSP in Turkey

Interview with the Department for Environment and Energy of the Istanbul Chamber of Commerce

Finance institution: Interview with the actors responsible for Project Financing and Credits and Project Finance Structuring, to understand the financing framework in Turkey for innovative projects, to determine the conditions to facilitate access

to funding, to foster high relevance between funding and market opportunities

Civil Society: Interview with the Marketing Director of the Energy Transition Centre to outline the existing potential in Turkey for the development of CSP/CST technologies, to facilitate synergies between research and commercial realisation of projects

WORKSHOP	Phase 2 February 2020

Aim: To have a broad overview of STE perspectives in Turkey through existing and potential solutions using STE, from both the R&I and industry sides.

Description

Participation in the ODAK$_{2023}$ project kick-off event. 95 people attended the event. 19% from industry, 65% from university, 5% Funding Agency, 4% Government, and 7% from other.

It has the purpose of "creating a common national vision for CST in Turkey in 2023". The workshop aimed to provide an open forum to start defining this common national vision and to promote collaboration between national stakeholders. The audience and speakers were composed of actors from the R&I and industry, who are working on different applications of STE, as well as of policy-makers.

ESTELA presented HORIZON-STE and the first outcomes of its research in the country, insisting on the necessity to embrace a two-fold approach when striving to further deploy STE/CST. More specifically, ESTELA enhanced the role of policy-makers to provide a favourable environment for R&I and industry to build synergies and grow further.

This event was considered as a "brokerage event" and as a dissemination event of the HORIZON-STE project. Although the initial approach for the "brokerage events" was to include only actors from the industry and key national stakeholders, it proved valuable execute it in this joint manner (similar to what was originally described as a "joint national event".

NATIONAL EVENT	Phase 3 Postponed

Aim: To provide a space for actors from the entire STE value-chain to meet and talk through their specific needs and expectations regarding the development of STE in Turkey. To focus on possible synergies and macro-economic value.

Description

Thanks to METU, ESTELA secured an afternoon slot at the SolarEx Fair of Istanbul to organise round-tables and panels for all relevant stakeholders involved in the STE sector or energy policy at large. In addition to local stakeholders, ESTELA planned to involve European industries, to exchange views on potential cooperation and development of business in Turkey.

Originally planned in April 2020, the event was postponed to September 2020 by the Turkish authorities due to the Covid-19 pandemy.

1.3 *Overview of the context in Turkey*

The desk research and the preliminary interviews helped ESTELA refine its understanding of the energy context in Turkey. The following subsections were enriched thanks to inputs from five key stakeholders: policy-makers, energy regulators, transmission system operators, financers and industries.

1.3.1 Energy policies and the place of STE in the landscape

The energy mix in Turkey represents a total of 90.4GW of installed capacity (as of July 2019[1]), of which 43.9GW of renewables[2]:

- 28.4GW of hydro
- 7.2GW of wind
- 5.4GW of solar
- 1.4GW of geothermal, and
- 1.5GW of others

Despite this share of renewables in its mix, the energy dependency of the country is still above 70% and is a point of concern to build the existing and future Turkish energy strategy.

Turkey has always looked at a variety of solutions for its energy mix and intends to keep going this way, making a priority of a diversified energy mixed. Hydro is the major renewable energy source, representing almost 50% of the total renewable energy installed capacity. Turkey has also a high potential for geothermal which will be further explored in the upcoming years, particularly as renewable heating and cooling is a serious matter of concern in the country. However, Turkey has also planned to almost double its resources in PV and wind by 2023 to strentgthen the share of renewables in the energy production and final consumption.

More precisely, Turkey has a series of targets to meet by 2027:

Type	Target	Deadline
Increase the level of renewable energy in total energy consumption (including hydro)	+30%	2023
GW of installed capacity	110GW	2023
PV capacity	13GW	2023
Wind capacity	14GW	2023
Geothermal capacity	3GW	2023
Share of RE and domestic sources in electricity generation	2/3	2023
Solar capacity	+10GW	2027
Wind capacity	+10GW	2027

Table 1: Renewable energy targets in Turkey

To reach these targets, an increase of the share of renewables in the system will have to be tendered. The current bidding system for renewables relies on a zone system (YEKA tenders). Each zone is delimited by the Ministry of Energy and Natural Resources (MENR) and is allocated a certain amount of additional capacity while incentivising local manufacturing of renewable generation assets. This system was implemented by a Regulation on Renewable Energy Resource Zones (YEKA) on October 9, 2016 and aims to[3]:

[1] *Source: Turkish Ministry of Foreign Affairs [online]*

[2] *Source: Turkish Ministry of Energy and Natural Resources [online]*

[3] *Source: Guide to Investing in Turkish Renewable Energy Sector, Investment Office, 2019*

- Commission renewable energy resources much more efficiently and effectively through identification of renewable energy zones on the public, treasury, or private-owned territories
- Realize the renewable energy investments much more rapidly
- Manufacture renewable energy equipment in Turkey
- Use locally-manufactured equipment/components
- Contribute to research and development activities through technology transfer

The Power Purchase Agreement (PPA) in YEKA tenders goes beyond ten years, which is in Turkey the Feed-in-Tariff (FiT) period determined by MENR. Until 2020, PPAs for a 1GW solar plant and a 1GW wind farm were fixed at 15 years. The usual bidding system is organised as a reverse auction, which means that the lower price is the one prevailing, and tenders are technology neutral. So far, even though CSP has not been explicitly excluded from the tendering processes, it has nevertheless no chance to win a bid. Indeed, when only based on LCOEs, CSP has no chance compared to PV, as acknowledged by policy-makers themselves. However, a new support mechanism is planned for the end of 2020, with unknown specifications at the moment of writing this report.

Two types of mechanisms can currently be applied in YEKA:

- An "Allocation on the Condition of Local Manufacturing": this mechanisms defines in the Terms of Reference the locally manufactured equipment and other local components to be used in the zone by the winner of the tender. The latter must also settle its equipment factory on the Turkish territory and establish a Research and Development Centre
- An "Allocation on the Condition of Using Locally-Manufactured Equipment": this system implies the use of components and equipments which have been locally manufactured by Turkish factories and which are composed of a certain ratio of local contents (defined in the Terms of Reference) and compatible with the national or international standards

Even though the possibility of CSP use is not rejected in Turkey, the current policy framework is however not encouraging its development nor private investors to get interested in it. No specification for dispatching renewable energy at night has been implemented so far and none is planned at the moment, which could be the trigger for private investors to support CSP deployment in the country.

1.3.2 Energy regulation in Turkey: towards new regulations

EMRA (Energy Market Regulatory Authority, "EPDK" in Turkish) is currently operating under two types of systems: the licensed and the unlicensed systems.

Licensed systems concern installations over 5MW installed capacity. Regarding wind and solar projects, tenderers need to apply for a pre-license and have on-site metering data of at least a full 1-year period that has been collected within the previous five years for the sites to be used for installation of power plants. For the licensed solar projects in particular, only half of the data must be collected on-site.

Capacities for wind and solar are announced in advance, for the year to come, by TEIAŞ. EMRA schedules then the application deadlines. The bidding process is a reversed auction based on the tariffs, determined by MENR for each resource, in Table 2. During its first ten years of operation, the infrastructure will be granted the reduced RES Support prices instead of the fixed tariff. This system makes it difficult for large STE plants to be built in Turkey, as stated by EMRA itself, given the auction system which regulates it. Indeed, STE and PV fall under the same "solar" FiT category. As Table 2 shows, the current support mechanism allocates them the same $13.3 cents without distinction between the two technologies. For instance, Greenway had a project to build a commercial STE plant in Konya area. However, as reported by its former founder, the idea had to be foresaken due to lack of financing support, which could not make the project eligible under the tendering terms at that time. In addition to this issue, this shows that there are structural problems for energy investors to adapt to the existing procedures. It is thus impossible for innovative entrepreneurs to adopt these procedures alone. Private investors are, after MENR, the main influencers of the Turkish energy system landscape.

SCHEDULE I (Provision of the law dated 29/12/2010 and numbered 6094)	
Type of Production Facility Based on Renewable Energy Resources	Feed-in-tariff Prices Applicable (US Dollar cent/kWh)
a. Hydroelectric production facility	7.3
b. Wind power-based production facility	7.3
c. Geothermal power-based production facility	10.5
d. Biomass-based production facility (including landfill gas)	13.3
e. Solar power based production facility	13.3

Table 2: Applied FiT prices until December 2020

The existence of Organised Industrial Zones (OIZ) has also implications in the possible location of STE plants, particularly when considering the production of process heat. Only very specific zones can welcome STE in Turkey, i.e. mainly the Anatolia area. Matching industries and renewable energy resource zones can prove challenging when it comes to STE and its specific DNI needs. As states the new Regulation for OIZ[4] " the establishment of the energy generation facilities using solar and wind power, other than the ones established for the OIZs' and their participants'needs, is not permitted."[5] "The ones established for the OIZ's and their participants' needs" is the key part here. These particularities are defined in the Article 65 of the new law: OIZs have the right to establish and operate electricity generation facilities, primarily for their own need, within the OIZ area and without the condition of establishing a separate company, provided that they get permission from the Ministry. Unlicensed power plants (up to 5MW) are therefore

[4] *OIZ Law, Resmî Gazete [online] (in Turkish)*

[5] *Souirce: Çakmak, "Turkish Energy and Infrastructure", Newsletter, Spring 2019 [online]*

allowed. With the upcoming new hybridisation regulation[6], localised off-grid solutions using CST / STE technologies for energy needs of the industry will also be supported.

At the moment, no connection capacity for licensed solar project is foreseen, as TEIAŞ has not announced any solar energy capacity for licensed generation since 2013. It is therefore not possible for EMRA to receive any license or pre-license application for solar energy until a formal call by the TSO has been made.

Contrary to licensed systems, **unlicensed systems** are not regulated by a yearly schedule: applications can thus run all around the year. Installations generating up to 5MW do not need a license but the connection point must be the same as the one of the consumption facility. Once built, the installation must be evaluated by the operator for its suitability to be confirmed within one year following the signing of the connection agreement[7]. Rooftop and façade installations follow a different procedure and can have a 10kW installed power capacity. The power purchase price is set for the first ten years.

Regarding CSP, there is one example of unlicensed project in Mersin (South-East Turkey). A 5MW CSP tower plant has been built by Greenway and is operating since 2013. This has been a premiere in Turkey and remains today the only example of operating STE installation in Turkey. However, the industry developers reported difficulties to have the plant evaluated by the operator, as no one had the relevant knowledge to properly carry out the evaluation, provoking further delay for the full operation of the Mersin installation.

In addition to foreseen changes in the support mechanisms at the end of 2020, EMRA is working in parallel on two new regulations. The first one, a **hybridisation regulation**, should be enforced on 1st of July 2020. There is already an open door in the exisiting legislation, with the article 46 64 of the Energy Market Law stating that a plant can use more than one energy source to be powered. The only limit is the available transfer capacity, which is announced by TEIAŞ every month. One of the aspects of the hybridisation regulation concerns combined solar integrated power plants. Namely, CST components could be added to a conventional thermal generation plant (i.e., coal or natural gas). This addition to an already licensed plant means that no further licensing would be needed for building the CSP infrastructure in the case of a hybrid system of old plants. However, the hybrid version of the plant cannot have a capacity higher than the one from the plant had before retrofitting. New plants presenting a hybrid model can also apply for license. This could be a key step for the STE sector to enter the Turkish energy market.

The second regulation in preparation is a **storage regulation**. EMRA wants to manage the flexible deployment of energy with the solution of demand-side participation. However, the complexity of the storage issue, in particular regarding the responsible stakeholder for it (i.e., TEIAŞ or the investors) implies that this regulation won't be enforced before the end of the year. This regulation will also clarify if the allocation of thermal storage without a solar field to a plant would be possible and under which conditions. This remains at the moment hypothetical and is to be further studied by EMRA's working group.

[6] *See below for further description*

[7] *Source: Guide to Investing in Turkish Renewable Energy Sector, Investment Office, 2019*

1.3.3 Energy transmission system in Turkey: the role of TEIAŞ

TEIAŞ, the Turkish TSO, has to answer the increasing demand of energy production while reaching the national objectives in terms of renewable energy integration to the system. Even though this level of integration is not yet significant enough to have any impact on its stability, the targets for wind and PV until 2027 might be a game changer. Taking these elements into account, TEIAŞ foresees a **need for storage of approximately 4000MW by 2025**. It has therefore launched, together with MENR, a study on pumped storage and batteries. Hydro is one of Turkey's geographical asset. The feasibility study defined places to build pumped storage, including coupled with standard hydro installations, as building new pumped hydro is very expensive. The study focused on the feasibility and the exisiting potential of the pump-storage hydrolelectric central systems. Five hydroelectric centrals were identified as possibe to renovate. The first project will be Gokcekaya HES. In Turkey, large scale hydroelectric power plants are located in regions where pump systems can be integrated with renewable energy power systems. Regarding the battery study, it revealed that the capacity offered by this technology is too low for transmission purposes and might be more appropriate for distribution operators. TEIAŞ is aware that, to avoid curtailment of renewable production, investing in advance in storage is key. Investment programmes have not been published yet but pumped hydro might be included in them.

However, following the national strategy implemented by MENR, TEIAŞ acknowledges the **need for a mix of solutions in terms of storage**. The combination of PV and STE, either on the same site or on different locations, appears as a promising one for the operator. Thermal storage is, both qualitatively and quantitatively, a solution seen as relevant, even more when compared to batteries. The presence of a rotating machine is the most appealing for a transmission system operator since it represents a real advantage in terms of system stability. Yet, without a clear decision from the Ministry of Energy and Natural Resources to clearly incentivise STE, investors will never support the integration of STE in the Turkish electricity market. To that extent, TEIAŞ is very interested in the Moroccan case, particularly regarding the clear renewable strategy implemented by the government. Several members are to participate in a workshop in Morocco in March to observe and gather information on renewables and their integration to the system.

In addition to the storage needed for further renewable integration, TEIAŞ is looking for increasing its **interconnection capacities**. The Turkish system is already interconnected with ENTSO-E through three points: one of 400kV with Greece and two of 400kV with Bulgaria. Studies are ongoing to see how these capacities coud be increased of at least two additional lines of 400kV each, one on each border. These interconnections are seen as decisive factors. They would not only impact the development of renewables and of storage but also reinforce Turkey's position as a bridge between Europe and Asia.

1.3.4 Financing energy projects: the example of Garanti BBVA

Garanti BBVA is the only bank in Turkey to directly invest in renewable energy projects. It focuses on the **electricity generation** and contributes to finance the **production sites**. As an integrated financial services group, Garanti BBVA has a 30% share in wind projects. Since 2015, it started significantly financing solar projects as well. As of 31 December 2019,

Garanti BBVA has allocated all its project finance loans for greenfield power plants to renewable energy projects[8]:

- $2.53 billion to wind power projects
- $2.42 billion to hydropower projects
- $263 million to geothermal projects
- $237 million to solar energy projects
- $22 million to biomass energy projects

The uncertainty around the continuation of the support mechanism and the form it would take is putting pressure on the financing system. The loaners are calling for benchmark prices to secure the continuation of financing. The current FiT which grants a maximum of $13.3 cents/kWh for solar projects for the next 10 years was an easy marker for modelling risk and finance plans. However, it is not clear yet if the new support mechanism will be labelled in dollars, Turkish lira or euros, which makes the entire question of the price blurry.

Apart from the FiT, banks are calling for:

- An **increase of the long-term financing**. They have been aligning on the 10-year FiT, but for instance 12 years would already be a stronger signal for investors
- This is directly linked to the need of **a sustainable cashflow**, such as a PPA. The limit is that PPAs in Turkey are not long-term (1 – 2 years) while a twelve-year guarantee would have a bigger impact on the financing side.
- A **need for guarantees**: a project should not have a merchant risk higher than 20% of the total of the loan once the support period is over. This means that if the government decides to go for a 5-year feed-in-tariff support mechanism, then the project would have to already limit its merchant risk to 20% of the total loan already after 5 years.

To be sustainably financed, innovative technologies should provide higher capacity factors. It should be approved by independent technical advisers. They would review the technology, the investment costs, the time it would take for the investment to be finalised and all the existing risk factors. Sponsors must also be seen as reliable.

Storage is considered an asset for the energy system, and thus a factor of market stability. As Garanti BBVA has never financed any kind of storage project, STE + thermal energy storage (TES) is seen as a new technology for them. They thus need a full risk-assessment and experts to turn to, to better grasp the full potential of the technology on the market and evaluate potential return on investment. For bankers to be able to value the flexibility provided by TES, there could be, for instance, a clause system in the project financing terms regarding the sales of electricity to the market. To observe the development of financed STE projects, the government should make a study to provide some **benchmark levels for the sales and fixed price** that it can offer (PPA, FiT, …). This would give banks a sustainable and reliable modelling.

[8] *Source: Garanti BBVA, Integrated Annual Report 2019, 2019 [online]*

1.3.5 A high-potential industry not yet fully-fledged

The STE sector is currently limited from an industrial point of view in Turkey, mostly due to the combination of lack of information and awareness about the technology and the **absence of mechanisms allowing a fair return on investment**. As a result, no private investor has been involved in the financing of such projects. Except one company, Greenway CSP, which was a precursor in building a 5MW tower in Mersin in 2013. According to its founder, the aim of Greenway CSP was to lower the LCOE for STE, focusing on the heliostats as well as on the different cycle pssibilities. For instance, Greenway wanted to focus on Brayton cycles which showed a maximum of 27% of efficiency: they found out that the use of small unit plants combining Rankine and Brayton cycles could increase the efficiency up to 60%.

This young industrial potential was stopped as administrative procedures delayed the process and sponsors were not easy to find. Greenway CSP has thereby ceased activities. However, the commercial interest in STE did not fade away. Turkish research in STE, in particular linked to METU-GÜNAM activities, is very active, as shown in the R&I part of this report. The participation of some companies such as Tekfen in CSP ERANET calls, whose aim is to "bridg[e] the gap between research and commercial deployment in the Concentrated Solar Power (CSP) technology"[9], is also an indicator of the **will of Turkish companies to diversify their involvement in energy technologies and to strengthen their presence on the energy market**. Finally, the recent launch of the $ODAK_{2023}$ programme, in which ESTELA took part, allowed ESTELA to paint a broad overview of the commercial potential of Turkey regarding the development of STE at a national level. The presence of several actors from a broad range of industry sectors showed the interest arising for commercial opportunities and positive initial conditions for vitalising the STE industry in Turkey. Companies working on solar trackers, heat recovery systems, thermal management systems, heat exchangers or storage tanks, *i.a.*, were presenting their current capacities to contribute to the launch of STE in Turkey.

Barriers to the commercial development of STE in Turkey therefore does not come from a lack of industrial interest. The lack of investors represent the main barrier faced by industries. The use of LCOE as main investment criteria for installing new energy capacity in Turkey is strongly deplored by the different industrial stakeholders. According to some actors from the solar sector, the figures which are put forward by the PV sector are not in favour of STE. Yet, **Turkish companies could contribute more in terms of capabilities to CSP technology than to PV**, which is almost exclusively relying on China's know-how and price competitiveness.

More than insisting on the competitive aspects, most of the companies and industrial stakeholders call for the **implementation of smaller projects and more cooperation and complementarity between technologies**. To combine STE with low-cost technologies like PV and to design precise and adapted criteria for construction and generation remuneration would help kick-start the deployment of STE. Former and current industry stakeholders underline that bringing technologies and manufacturers together to design small compact units would represent a turning point. Instead of half a billion-dollar for a 100MW project, it would be four times cheaper to build five small units of 20MW each for

[9] *Source: CSP ERANET website [online] [consulted on 23/03/2020]*

an estimate of about 20-30 million dollars investment. In addition, the versatility of STE, including thermal desalination, commercial activities, local steam production, multiplies the possibilities of use of the technology. These layers are most likely to be commercialised in the short run, which would in return ease the diffusion of the technology. Smaller projects would be a smart step towards bigger projects and would require less land to be used, facilitating an increasing presence of STE technologies in Turkey.

For industry stakeholders, know-how and procurement opportunities are a priority for them to commercially develop the sector. The local aspect comes second. They want to meet the market LCOE level, and not to always need the help of the government or the entities for loans or many regulations. Namely, virtual PPA opportunities create great investment opportunities – or at least has it done so in the US. To lower the price per kWh remains a priority, which can be achieved through the multiplication of small projects.

1.4 *Key findings*

The different actors involved in the energy sector, from the institutional side to the commercial one, showed no opposition to the deployment of STE in Turkey. Several signs opened the door to a deeper discussion on different STE application possibilities, even though some hurdles must be overcome for a sound and sustainable STE and mostly CST development to take place.

1.4.1 A three-pillar foundation for an STE business case

The most important element which must be accounted for when approaching stakeholders can be summed up by three key concepts.

First, the capitalisation on existing technological and research capacities. The current state of play regarding research and industry in Turkey – but not only – is of prime interest when looking for potential solutions to use STE. In Turkey, research on potential STE uses and improvements is already quite active, in particular through the work of METU-GÜNAM. Turkish companies or branches of international companies implemented in Turkey are already developing specific knowledge in fields such as cycle analysis, turbines, compressors, working fluid selection, receivers, heliostats and energy storage solutions.

Existing companies with a declared interest / experience in STE are the following ones:

	Name of the company	Area of expertise
1	Ekodenge	CST usage in industrial zones: to determine the environmental impact of the life cycle processes of products
2	Pars Makina	Solar tracking (normally used for PV); heat recovery; cycle analysis, turbine, compressor, working fluid selection, receiver.
3	Ileri Arge	Semiconductor. Experience in PV.
4	GKE energy	EPC provider for commercial and utility-scale PV, CPV, and CSP solar projects
5	OKYAY ENERJİ	Thermal system (Atomic Layer Deposition)
6	Sisecam	Flat glass production. Experience in cogeneration for industrial steam.
7	SOCAR	Oil and natural gas company. Storage. Solar pyrolysis, solar heating of industrial streams, catalytic reactions via concentrated solar power
8	Temiz Yaratıcı Teknolojiler (TYT)	Works on Hybrid Geothermal And Concentrated Solar System. EPC, O&M.
9	Tekfen Engineering	Storage, heliostats (as currently involved in a CSP Eranet call)

Table 3: First list of potential companies to actively contribute to the deployment of STE[10]

Each of these companies are already well established in Turkey and are willing to extend their current knowledge to different use of STE, from industry heat to electricity generation and storage systems. Keeping in mind the specificities of each of them and their needs in terms of R&I is of prime importance. This means not only including them in project planning but also favouring the local economy by involving national players in knowledge transfer.

This is the second pillar of a good business case for Turkey: the **localisation of resources**. To push the government to give more support to the deployment of STE technologies, it is essential to give national actors a key role to play. The economic impact of such a configuration would be the best argument for more support to the technology. The example of Spain is quite striking in this regard: if at the beginning the technology was 80% German and 20% Spanish, the proportion reversed after 10 years, broadly profiting the Spanish economy and industry. **The concept of knowledge transfer** must be taken seriously when preparing a project in Turkey. MENR has made it a priority to design energy policies targeting the development of national technology development capabilities. This implies the involvement of existing companies who showed willingness to deploy their offer in this sector and could pave the way for the creation of new industries and new dynamics in the energy sector to benefit the Turkish economy. On top of that, this would allow Turkey to develop a particular knowledge in the sector which could benefit other neighbour countries of the region while improving its energy security.

Last but not least, for any project to be considered, it must demonstrate that it helps **meet the system requirements**. This is not only defined by TEIAŞ but also, to some extent, by the government. If the TSO defines the energy needs to ensure the stability of the system, it is the government which designs the types of sources that should be added to the system. When considering an STE project, what matters is to demonstrate the true value of STE to the stability of the system. With the increasing penetration of variable renewable

[10] *Based on the list of interested stakeholders of the SolarTwins kick-off workshop*

energies, such as the additional PV and Wind capacities foreseen by 2027, the need for a sustainable base load will be more pressing (especially if it is intended to reduce fuel imports).

The combination of these three elements has been repeatedly underlined by the different stakeholders who helped shape potential STE solutions matching Turkey's energy needs. This combination is the first and main outcome to be considered when approaching Turkey.

1.4.2 A potential dynamic industry sector exists

Greenway CSP started paving the way of STE in Turkey, building the first (and only) operating CSP tower in the country. Its return on experience has provided important inputs for future companies but also to better understand the general frame in which energy projects are taking place in Turkey. Despite existing barriers (see **Error! Reference source not found.**), the main piece of advice from Greenway – which was confirmed by institutional actors – is to **attract industries to contribute to small projects**. The more projects are developed, the more companies get involved and the more technological knowledge is strengthened. Greenway started with a 5MW tower project. Even though no further projects could be unfold afterwards due to sponsoring problems, the company gained valuable experience. It acquired a first grasp of the technical and administrative hurdles, which would make future experiences smoother.

Even though, historically, only one company has really been active in the STE sector in the last decade, a **promising industrial pool** does exist in Turkey's industrial landscape. During the event held by METU in February 2020, thirteen different companies registered and showed interest in further deployment of STE in Turkey, as direct actors or potential beneficiaries. Nine out of thirteen can be considered as potential direct actors in the deployment of STE and have been listed in **Error! Reference source not found.** (cf.: **Error! Reference source not found.**). The variety of their fields of activities shows how Turkish industries could cover most of the value chain in the production of STE material, from heliostats to receivers, heat exchangers and storage. Some of them have experiences in other energy technologies, which can also be an advantage for the combination of technologies and more penetration of STE. For instance, SOCAR, being an important player in gas production, could lead the way to STE hybridisation. Others, such as Ileri Arge or GKE Energy, could make their PV experience benefit from STE thanks to storage opportunities, and thus support further their production capacity.

Finally, the other four companies which attended the event, if not directly relevant for material construction, appeared as potential off-takers of STE technologies. Indeed, sectors such as zoos, aquariums or logistic expressed interest in the use of solar applications to support their activities. Process heat, industrial steam and heat recovery are potential STE uses for Turkish companies. These industrial uses would not require a connection to the grid, which would make the construction of a unit easier – no license would be required. In that sense, the OIZ regulation is advantageous for any type of company settled in OIZ and which wants to establish a power plant (including the renewable energy technologies) to use for their own energy needs in industrial production.

There is thus a real potential for the development of Turkish STE actors. **Technical interest and potential demand from other industrial sectors** represents a strong foundation to develop further the technology in Turkey.

Three factors could possibly contribute to the dynamic of the CST sector at large in the near future: the need for storage, the need for heat and the upcoming regulation on hybridisation.

1.4.2.1 Future foreseen storage needs

The evolution of the energy landscape in Turkey has pushed the TSO and MENR to look into storage solutions so that system requirements are met. An estimate of 4000MW of storage, as expressed by TEIAŞ, would be needed by 2023 in order to ensure the stability of the system. Even though this storage issue is mostly considered under the scope of pump-hydro (see section 1.3.3 of this report), the use of STE and its thermal energy storage (TES) system is not *a priori* discarded by the system operator nor by any other authority.

This is a key argument for industrials to see a positive landscape to develop STE market in Turkey. With the upcoming hybridisation regulation, the combination of PV farms and STE with TES is also a solution to widen the perspective for the technology to unfold in the country.

1.4.2.2 Heat as a primary need in Turkey

However, the short-term potential for CST to unfold in Turkey at the moment relies majoritarily on industrial heat and heating and cooling. During meetings with representatives of the Ministry of Energy and Natural Resources, a significant emphasis has been put on the need for Turkey to develop more sustainable heating and cooling grids. As reported by MENR, the South of Turkey would in particular require cooling. It happens to be also the part of the country with the best DNI (approximately 1,800kWh/m²/year), wich makes it possible for CST to be explored. A possible combination with geothermal has also been mentioned by several representatives from MENR, as Turkey possesses very good geothermal resources and plans to deploy these applications in the upcoming years. This could be the opportunity for the CST technology to have small projects developing in the country, and thus show the performance of the applications.

The same could apply to industry heat. The multiplication of applications for process heat is looked at by the MENR. The new law for OIZ[11] could foster the development of such applications and therefore contribute to proving the efficiency and relevance of the technology for a potential electrical use in the mid to longer term.

1.4.2.3 Upcoming regulation on hybridisation

The new regulation on hybridisation represents a real opportunity for CST industries to grow. It will facilitate the processes for investors and innovators. The reduction of administrative burden which the possibilty of adding an additional source of power generation to an exisiting power plant without going through the licensing procedure.

As structural burdens have been identified as obstacles for industries to carry out STE projects, such as in the Greenway case, this new perspective sends a positive message towards industrial players.

[11] *See 1.3.2 of this report*

1.4.3 The general context indirectly influences the industrial canevas

Besides encouraging signs for STE in Turkey, the different existing hurdles must be born in mind to offer solutions which match the needs and interests of the country at best.

1.4.3.1 Fostering investment

The macroeconomic instability resulting from the global Covid-19 pandemy unfolding at the time of writing this report is a serious challenge to the development of innovative industries. Indeed, the uncertainty regarding recovery plans and also the global impact on companies, projects and support mechanisms is still unknown. Many projects which were financed with support mechanisms running until 2020 in many countries (as is the case in Turkey), may experience delay in delivery.

In order not to jeopardise the development of renewables and to help companies maintain their heads out of the water, the International Energy Agency has come up with three potential solutions[12]:

- To extend the deadlines for commissioning projects beyond 2020
- To include financing and incentives for renewable projects in upcoming stimulus packages
- To align short-term policy actions with new medium and long-term strategies to maintain the 2050 emission targets. This includes the development of electricity infrastructures and the funding of new technologies.

This could be the opportunity for CST to find the necessary investment ecosystem in Turkey, since a strong political signal would be sent to companies.

1.4.3.2 Support mechanisms

There is only one "solar" category under the current scheme, which is labelled "solar power based production facility". This means that no difference is made between PV and STE, which are both auctioned at $13.3 cents/kWh, regardless their different added-values. When combined with the problem of investors, this results in a dead end for STE and unfair terms of competition. Indeed, the comparison between the two technologies is not based on equivalent features. If STE is bluntly more expensive than PV in terms of CAPEX, the services offered are however not the same: manageability, higher energy capacity… As long as these added-values are not taken into account, STE will never be in position of competing with PV.

This is a vicious circle when added to the main challenge encountered for the deployment of STE as developed in 1.4.3.1. The lack of investment triggers no further development of projects, the lack of project development does not influence a drop in the costs, the high costs do not allow competing with PV, which does not attract investors. Hence, there is a need for the new support mechanism to take these limits into account.

[12] *Source: International Energy Agency, "The coronavirus pandemic could derail renewable energy's progress. Governments can help", 4 April 2020, IEA website [online]*

However, the **status of this support mechanism after 2020 remains unknown** while we are writing this report. To turn it into an asset for STE, the Ministry of Energy and Natural Resources should take into account several elements:

- To separate different technologies in different auction pools. **STE and PV can no longer be considered under the same category**. The use of LCOE as main criteria for the attribution of tenders can never benefit STE under these circumstances. PV would always provide cheaper LCOEs and show lower initial investment. This means that attracting investors would remain a challenge for STE projects and significantly hurdle their deployment;
- To consider labelling tenders which **take into account the production of renewable electricity at night**. This would have two benefits. First, this would make it possible for STE to enter the competition, thanks to its storage capapcity which allows the plants to dispatch energy even at night time. Second, this would contribute to more penetration of renewable energies in the Turkish energy mix: instead of a baseload made of coal or gas at night, solar energy could kick-in;
- To **auction solar energy production including storage**. This would give way to three solutions: PV+battery, STE, PV+STE and open a fair competition between the different possibilities. In addition to that, it would also strengthen the stability of the system, adding more storage possibilities which could relieve the system in times of tensions.
- To support generation of needed energy in industrial production from renewable energy technologies or hybrid systems rather than subsidising electricty used in industrial production

The past mechanism has taken into consideration some technological innovation system actors and their competencies, which created advantages for other renewables. However, until the new support mechanism conditions are known, it remains as such a barrier to the development of STE plants or applications in Turkey.

1.4.3.3 Turkey's energy strategy

Energy policy is highly strategic for Turkey. Energy security is one of the key concepts of the Turkish energy plan for 2023, as stated by the Turkish government[13]. The development of domestic production, particularly through renewables such as Wind and PV, is therefore a priority for the country. The more penetration of these two sources in the energy mix, the less need for energy import. However, the more variable renewable energy sources are incorporated in the energy mix, the more flexibility of the grid is required. STE could therefore play a role here, through its manageable characteristics, provided that potential entrepreneurs are made aware of the possibilities of this technology.

Turkey is stillrelying heavily on coal and shows interest in attracting foreign investors to further develop national coal exploitation [14]. Coal is still one of the prominent sources of fuel that can decrease the import dependency in Turkey's energy production, since

[13] *Source: Presidency of the Republic of Turkey, Strategy and Budget Presidency, "Eleventh Development Plan (2019-2023)", July 2019*

[14] *Source: Turkish Ministry of Energy and National Resources, "Investors' Guide for Electricity Sector in Turkey", Second Edition, October 2019, MENR website [online]*

Turkey has coal resources (even though very low in efficiency). Due to the energy strategy of Local and National (Yerli and Milli) levels, coal is still an important fuel in Turkey. Howewer, its existence can be seen as an opportunity for STE technologies: hybrid plants can be thougt here as an option for heat, and also to plan potential future retrofitting of these plants. As hybridisation is getting more attention thanks to the new regulation, STE / CST technologies can find a breach there to impose themselves and contribute to increasing the efficiency of energy production from the type of coal which is mined in Turkey.

Turkey is also opening a four-unit nuclear power plant of a total capacity of 4800MWe in Akkuyu, province of Mersin, with the help of the Russian VVER technology. It should be commissioned by 2023[15]. In addition to this nuclear plant, a second one should also be commissioned by 2023 in Sinop province, in collaboration with Japan. The construction of a third one in the Thrace region was announced in 2018 and will be built with China[16]. This strategic choice might constitute an obstacle for the development of big STE projects in the country, due to the costs of construction and also the relatively long-life duration of nuclear power plants.

On the renewable side, Turkey is already well advanced in hydro, which represents almost a third of the total installed capacity[17]. Thus, priority will be given to investments in existing capacities, to refurbish them and see how to increase the country's storage capacity. Turkey also showed interest in exploring geothermal power, since it possesses good resources, as located on an active tectonic zone. Thanks to the current projects under development, the geothermal capacity should amount 2GW by the end of 2020.- Investments in renewables is expected to be promoted in the future, especially because of the increasing prices of natural gas and the current debate on self sufficiency and energy security[18].

As a whole, even though the Turkish energy strategy is not at the moment investing in STE, the promotion of renewables in opposition to the use of natural gas, as well as potential hybridisations with coal power plants leave the door open for CST industries to develop their activities in the country.

1.5 *First Recommendations*

1.5.1 Launch a study to raise awareness on the technology and its advantages

To create a positive framework and allow the CST sector at large to develop in Turkey, a study should be launched to provide reliable data from unbiased and trustworthy

[15] *Source: Turkish Ministry of Energy and National Resources, MENR website [online]*

[16] *Reuters, "Turkey to build third nuclear plant in Thrace, cooperate with China", 8 August 2018, Reuters website [online]*

[17] *Source: TEIAŞ, "Turkish Electricity Capacity Production Capacity, 5 Year projection (2018-2022)", May 2018*

[18] *Source: Turkish Ministry of Foreign Affaires [online]*

stakeholders. Namely, TEIAŞ or the Ministry of Energy and Natural Resources could commission such a study to an independent consulting agency (*e.g.*, EY, Deloitte, etc…) or could turn to an independent organisation such as SHURA (the Turkish Energy Transition Centre). We recommend that this study embodies three key aspects which are not only of primary interest for Turkey but also represent preliminary requirements to pave the way for STE / CST to unfold: storage, flexibility and energy security. Indeed, STE and CST at large can contribute to bring these three concepts on the table and turn them into important aspects of the energy strategy of the country.

The study does not have to be only dedicated to STE but it should at least include it in its scope. A thorough overview of the existing technologies which are able to offer over a given time laps (*e.g.*, in the next ten years) at the same time storage, flexibility and to contribute to energy security should be given. Including CST in the scope of a general study applies with the principal of technological neutrality which the country is following and is also bringing legitimacy to the various technologies which are analysed, contrary to a study fully dedicated to one technology.

By covering electricity and heat application, the full potential of the CST sector could be highlighted, promoting a very versatile technology which can fit in a broader perspective. Such an encompassing study would also fit Turkey's strategy of diversification of energy sources, since it would depict all the key aspects of technologies and would allow:

- The government to evaluate the key assets to be taken into account when issuing tenders and which technologies to favour according to the needs of each region while reducing energy dependency on other countries;
- The TSO to better plan and rely on a manageable source while increasing the share of renewables in the energy mix;
- The Regulator to have an overview of where licenses might be needed and how to regulate installations;
- The investors to better assess the most interesting and commercially viable technologies;
- The companies to safely submit projects and stepping into innovative solutions.

Such a study can thus only open new possibilities for the CST industrial sector, by shading light on the technology and its possibilities on both the electricity and heat sectors.

1.5.2 Go small

The main advice which stood out from the discussions with various stakeholders, from official authorities to industry representatives and banks was to start with small projects. By multiplying small applications of STE or CST at large, financers could evaluate the reliability of the technology and be more motivated to invest into it and support new projects from innovative companies.

Different models can be thought of to disseminate the technology in the first place: demonstration projects, business examples, process heat applications, matching energy issues in industrial zones, renewable energy as a solution to high energy costs in industrial production… For instance, small heat applications would be the best entry door for companies willing to invest in the sector. As Turkey is particularly looking at heating and cooling – mostly cooling in the Southern part of the country – a real opportunity stands

here for industrial development. In parallel, industrial heat applications should also be looked at, as easier to implement, in particular under the OIZ law. The hybridisation regulation will also facilitate the implementation of new application and is an opportunity to be seized by companies.

Small electricity generation applications would only come in a second phase, once the technology has been demonstrated and proved reliable to the investors. This also depends on the new support mechanisms which will be developed after 2020, particularly if storage is clearly valued or not. Otherwise, the least cost approach system would still benefit to the PV sector and seriously hinder the unfolding of a new STE industry in Turkey.

1.5.3 Give a value to dispatchability

Directly linked to the idea of starting with small projects to showcase the whole potential of CST, it is key to make dispatchability recognised as a major asset. This would go through two paths:

- By developing demonstration projects which would allow companies to take risks while giving a reassuring framework to investors;
- By having manageability specifically labelled in tenders to send a signal of political commitment to investors and industries to also reward this added value.

When auctioning RES, and to give a chance for STE to compete with PV, the dispatchability factor should be recognised in tenders and other support mechanisms. At the moment, the least cost approach and the absence of differentiation between PV and STE in solar tender makes it impossible for STE to be competitive. A first step forward would be to dissociate the two technologies and see them as serving two thoroughly different purposes: one at the level of the consumer, the other at the level of the whole system. For industries to have room for manoeuvring, it is essential that the **politics temporarily offset (at least partially via balanced support mechanismes) the lack of competitiveness of a technology to allow it to enter the open market economy**.

To create the favourable conditions for this market to unfold, it is essential to bear in mind that all the recommendations in this document are interlinked. In this regard, launching a study is a key starting point, since it would also emphasise the value of flexibility which STE can provide to the grid.

1.5.4 Start with existing concerns and strategies

Pre-existing market conditions and political choices based on the preception of the Trukish national interest at macroeconomic level are the major trigger for new industries to develop. The return on national economy (namely business opportunities for a variety of sectors and in particular the effect on employment) is particularly scrutinised by decision-makers.

To **take advantage of the pre-empting political priorities and innovation ecosystem** which derives from them should be closely looked at by companies willing to develop the CST sector. The framework conditions emerging from this innovation ecosystem are one of the most relevant tools. It sets up the right context to speed up the offtake of innovations

by the market via risk capital and low administrative burdens and possibly tax support for spin-offs.

This means, as suggested in 1.5.2, for companies to first look at industry heat and district heating and cooling, since these sectors are clearly set as a priority by Turkey. In addition to that, the political commitment of extending solar tendering (+10GW between 2017 and 2027) and the expressed interest to extend geothermal applications are key indicators to be monitored by the industrial sector. Leaning on current political strategies would be a catalyser for the CST sector, because it would not require to push for the creation of a thorougly new environment. Even though not yet developed, good market conditions could soon emerge for a combination of STE and PV as well as STE with geothermal, provided that the added-value of the new technology is acknowledged (i.e., flexibility).

Last but not least, the Turkish priority regarding energy security is also an argument to be played with by the industries. The example of Morocco, notably with the Noor Ouarzazate Complex19, has shown that a clear political commitment to renewables creates the best framework. By developing a sound knowledge in a technology such as CST, Turkey can become a corridor for renewable energies, bridging the gap between Europe and Asia, as well as an industrial reference in the region. This would benefit the country not only on the geopolitical but also on the economic and industrial sides.

[19] *See "Noor Ouarzazate Solar Complex, Power Technology website [online]*

1.6 *Glossary*

CAPEX	Capital Expenditure
CSP	Concentrated Solar Power
DNI	Direct Normal Irradiation
EC	European Commission
EMRA	Energy Market Authority Regulator
ENTSO-E	European Network of Transmission System Operators
EU	European Union
FiT	Feed-in-Tariff
GWh	Giga Watt hour
H2020	Horizon 2020
IEA	International Energy Agency
IRENA	The International Renewable Energy Agency
kWh	Kilo Watt hour
LCOE	Levelised Cost of Electricity
MS	Member States (EU)
MW	Mega Watt
MW_e	Mega Watt of electricity
O&M	Operation and Maintenance
OIZ	Organised Industrial Zones
PPA	Power Purchase Agreement
PV	Photovoltaic
R&D	Research and Development
RE-ZONE	Renewable Energy Source Zones
RES	Renewable Energy Sources
SET-Plan	Strategic Energy Technology Plan
STE	Solar Thermal Electricity
TES	Thermal Energy Storage
TSO	Transmission System Operator
TWh	TeraWatt hour
YEKA	Renewable Energy Source Zone

1.7 Appendices

1.7.1 Reference

Turkey

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1.7.2 Meeting guidelines

1.7.2.1 Ministry of Energy DG Energy Affairs

Introduction (10')

- Presentations: visitors and the ESTELA association // thanks for availability
- check on practicalities (recording permission, notes, etc.)
- main purposes of HORIZON-STE, methodology (deepening of our understanding of the national perspective and how / consultation within the CSP sector and report by end of February where could Turkey could receive support from the CSP industry) , global targets, targets regarding Turkey

1. General perspectives of energy policy in Turkey (10')

1.1. General targets and objectives

- *Global energy policy drivers (economic, environmental, social, geopolitical)*
- *Potential contingencies, bottlenecks?*
- *Resulting priorities?*
- *Latest forecasts / prospects resp. perceived opportunities for the Turkish economy?*
- *Regional differentiation (get map)*

1.2. Status of the raft Regulation on Energy Storage? [*e.g.: Is any specific technology favoured in terms of energy storage? …*]

1.3. Support mechanisms for renewable energies?

- *current status?*
- *Any foreseen adjustments of these mechanisms? What could trigger such changes?*
- *What is the status of the (subsidised) long-term loans for renewable energy projects?*
- *What is the status of the renewable energy cooperatives? Exclusively intended for the PV sector? …*]

2. Particular aspects of interest for MENR regarding RES and CSP (20')

2.1. Complementarity /convergence of Turkish energy policies with the EU's Green Deal plan? [*e.g.: Is the possibility of cooperation mechanisms known or used? What is the foreseen development of green energy in Turkey? Is the EU green ambition a motivator for Turkish energy policy? …*]

2.2. Planned implementation / procurement of solar generation? [*e.g.: Would the installation of CSP plants considered, as three regions present enough DNI? …*]

2.3. Hybridisation of conventional power plants? [*e.g.: As coal is a very important asset in Turkey, could it be hybridised with CSP? …*]

1.7.2.2 Adviser to Energy Minister

Introduction (10')

- Presentations: visitors and the ESTELA association // thanks for availability
- check on practicalities (recording permission, notes, etc.)
- main purposes of HORIZON-STE, methodology (deepening of our understanding of the national perspective and how / consultation within the CSP sector and report by end of February where could Turkey receive support from the CSP industry), global targets, targets regarding Turkey
- Can we expect a participation of MENR at the national event on 26/2?

1. General perspectives of energy policy in Turkey (10')

1.1. General targets and objectives

- *Global energy policy drivers (economic, environmental, social, geopolitical)*
- *Potential contingencies, bottlenecks?*
- *Resulting priorities?*
- *Latest forecasts / prospects resp. perceived opportunities for the Turkish economy?*
- *Regional differentiation (get map)*

1.2. Status of the raft Regulation on Energy Storage? [*e.g.: Is any specific technology favoured in terms of energy storage? …*]

1.3. Support mechanisms for renewable energies?

- *current status?*
- *Any foreseen adjustments of these mechanisms? What could trigger such changes?*
- *What is the status of the (subsidised) long-term loans for renewable energy projects?*
- *What is the status of the renewable energy cooperatives? Exclusively intended for the PV sector? …*]

2. Particular aspects of interest for MENR regarding RES and CSP (20')

2.1. Complementarity /convergence of Turkish energy policies with the EU's Green Deal plan? [*e.g.: Is the possibility of cooperation mechanisms known or used? What is the foreseen development of green energy in Turkey? Is the EU green ambition a motivator for Turkish energy policy? …*]

2.2. Planned implementation / procurement of solar generation? [*e.g.: Would the installation of CSP plants considered, as three regions present enough DNI? …*]

2.3. Hybridisation of conventional power plants? [*e.g.: As coal is a very important asset in Turkey, could it be hybridised with CSP? …*]

Conclusion: Potential synergies through HORIZON-STE to be discussed at the 26/ 2 event in turkey)

2.4. Manageable and locally produced RES? *[e.g.: Which perception do you have of energy storage? What financial support scheme is foreseen? What is the status of the available public and private funding? What about the national industry champions? …]*

2.5. Increasing energy security through CSP? *[e.g.: Would the use of locally produced energy be a strong argument in the extension of the grid? Is there room in the energy needs of Turkey for CSP? …]*

2.6. Increased potential for being a major energy player in the region *[e.g.: Interest in interconnections? What is the current use of infrastructures and potential development plans? Are there any existing cooperation plans? …]*

1.7.2.3 TEIAŞ

Introduction (10')

- Presentation of ESTELA
- Presentation of HORIZON-STE
- Introduction of the stakeholders and their positions
- Why are we considering Turkey in this project?

1. General perception of Turkish electricity (10')

1.1. Evolution of demand and consumption? [*e.g.: What are the current challenges in the energy system? What do forecasts look like on the short / mid and long-term? …*]

1.2. Evolution of capacity connections? [*e.g.: what is the current use of the infrastructures? What are the development plans? …*]

1.3. Status of interconnections? [*e.g.: what is the current status of interconnections with the EU? Are any new interconnections planned with neighbouring EU countries? Bulk energy purchases? …*]

2. Particular needs and interests of TEIAS regarding RES and CSP (20')

2.1. Status of the TSO legal framework? [*e.g.: Is there any revision in preparation? …*]

2.2. Adaptability of the grid/evolution of the structure? [*e.g.: What are the current considerations regarding the extension of the grid? What would be the potential constraints to extensions /reinforcements of interconnections with, for instance, Bulgaria or Greece? …*]

2.3. Integrating renewables? [*e.g.: Would the interconnection between TEIAS and Greece respectively Bulgaria allow for exports of green energy? Any new developments in preparation to facilitate the integration of renewables to the*

system? What is the current link between the Mersin CSP tower and the electricity system? …]

3. Potential synergies through HORIZON-STE (15')
   - 3.1. Manageable RES and storage option? [*e.g.: Which perception do you have of energy storage? …*]
   - 3.2. Possibility to increase capacity and stability through CSP? [*e.g.: Would the use of locally produced energy be a strong argument in the extension of the grid? What would be the installation requirements? Unlicensed production? …*]
   - 3.3. A European energy perspective [e.g.: ?]

1.7.2.4 EMRA

Introduction (10')

- Presentations: visitors and the ESTELA association // thanks for availability
- check on practicalities (recording permission, notes, etc.)
- main purposes of HORIZON-STE, methodology (deepening of our understanding of the national perspective and how / consultation within the CSP sector and report by end of February where could Turkey could receive support from the CSP industry) , global targets, targets regarding Turkey

1. General situation of the electricity market in Turkey (15')

Current situation

- 1.1. How could the regulatory framework for electricity and gas evolve in Turkey in the mid-term?. *[E.g.: do you perceive the regulatory environment as favourable or not for achieving the objectives set by the government? What would you identify as successes and limitations of the current regulation so far?]*
- *1.2.* Tendering system and remuneration instruments (FiT, Renewable Energy Resources Support Mechanism)? *[E.g.: Would you deem the tendering system as still relevant/effective? What are its strengths and weaknesses? Would you consider that the current remuneration instruments have fulfilled their purpose in an adequate manner? …]*

Near-future situation

- *1.3.* Potential changes in the regulation in the next 1-3 years *[E.g.: Will the remuneration instruments and tendering schemes be kept or modified in the following years? How? What about other amendments on the Electricity Market Law? …]*

2. Particular needs and interests of EPDK (20')
   - 2.1. Perceived challenges and opportunities for the future development of the Turkish electricity market? [*e.g.: is there a need for market opening? Ideally,*

what would favour a bigger mix of electricity providers? What could be the potential changes affecting the schemes for funding renewables …]

2.2. Considering the potential of CSP? *[e.g.: Do you see any regulatory barriers that would prevent CSP power plants from being included in the electricity market system? If so, how would you consider that this could be fixed?*

3. Potential synergies with HORIZON-STE (15')

3.1. Increasing the stability and diversity of the electricity market *[E.g.: What is the status of the subsidised long-term loans for RE projects? Would RE cooperatives be considered, and if so, for which energy sources? …]*

3.2. Possibility to retrofit existing infrastructures *[E.g.: Are there any regulatory barriers for retrofitting existing conventional power plants with solar-thermal technologies (assuming they currently receive any kind of FiT? With the rise of VRES in the market, do you think that the current regulation is fit for the different flexibility solutions that could be included in the market (such as storage)…]*

1.7.3 Interview guidelines

1.7.3.1 Industry

INTRODUCTION (5')

- Presentation of the interviewer / of ESTELA
- Presentation of HORIZON-STE and of the aim of the interview [e.g.: to gather insights into market conditions for the development of innovative technologies in Turkey, to capitalise on existing assets and favour their development, to optimise investment and return on investment]

1. GENERAL LANDSCAPE (10')

1.1. Could you please present your company/organisation and its status within the Turkish market? *[e.g.: what is your main field of activity? Do you have project inside and outside Turkey? What is your experience with CSP/CST? What is your specific role? …]*

1.2. In general, how would you evaluate the framework for developing innovative technologies/businesses in Turkey? *[e.g.: What is very helpful? What is more of a challenge? What would you change? Do you think sometimes that it is easier to develop project in another country? …]*

1.3. Are you currently / Have you been involved in projects related to CSP/CST (in Turkey or abroad)? If yes, how many? *[e.g.: Do you also collaborate with foreign companies? Which benefit do you see in that? Would you say that the Turkish business framework favours collaborations between Turkish and foreign companies? …]*

2. CAPITALISING ON EXISTING AND DEVELOPING NEW ASSETS (10')
   2.1. According to you, what would be the necessary conditions for an innovative technology such as CSP/CST to really take off in Turkey? *[e.g.: Do you consider receiving enough support for developing your business? What are the signals which motivate you to take risks for business? …]*
   2.2. In your view, which actors are of capital importance to favour the development of a new technology? *[e.g.: Policymakers? The regulatory authority? Financing bodies? Foreign companies? Do you have specific expectations on each of these actors?]*
   2.3. How do you see the CSP/CST market in Turkey in the next 5-10 years? *[e.g.: Do you see any development opportunities? What would be your ideal scenario for the development of the technology? Are you interested in participating in research/FOAK projects? What do you think of knowledge transfer as a process to develop local business? …]*

CONCLUSION (5')

- How would you summarise the challenges and opportunities you met when trying to promote and increase solar energy usage in Turkey?
- Have you seen any change in the interests of different stakeholders when the Mersin Tower was built?
- What would be the main piece of advice you would give to a company which would like to develop CSP in Turkey?
- Should you have one request to favour the development of CSP/CST in Turkey, what would it be and to whom would it be addressed?
- Is there anything you would like to add?

Thank you for your time and for your help

1.7.3.2 Research

INTRODUCTION (5')

- Presentation of the interviewer / of ESTELA
- Presentation of HORIZON-STE and of the aim of the interview [e.g.: to outline the existing potential in turkey for the development of CSP/CST technologies, to facilitate synergies between research and commercial realisation of projects]

1. GENERAL LANDSCAPE: RESEARCH IN INNOVATIVE TECHNOLOGIES IN TURKEY (10')
   1.1. Could you please present your organisation and the role it plays in research on energy transition in Turkey? *[e.g.: what is the main field of projects which you are running? How do you define your research priorities? …]*
   1.2. In general, how would you evaluate the research framework regarding innovative technologies in energy in Turkey? *[e.g.: What is working well? What*

is more of challenge? What would you change? On average, do you think that the proposals you receive are relevant compared to what you perceive is needed? …]

1.3. Are you currently / Have you been involved in projects related to CSP/CST (in Turkey or abroad)? If yes, how many? *[e.g.: What kind of projects or studies are involved with? What usually triggers the launch of these types of projects? Have you seen any evolution regarding the interest for this field in the last ten years? …]*

2. The Necessary Complementarity of Research and Industry for the Development of CSP/CST in Turkey (10')

2.1. Currently, how do you see your role in supporting the development of CSP/CST in Turkey? *[e.g.: Do you think that the research/analysis you carry out can be seen as a kick-starter for CSP/CST commercial activities in Turkey? How do you think the dynamic between research and commercial applications could be improved? …]*

2.2. How would you describe the relationship between research and industry regarding the development of CSP/CST in Turkey? *[e.g.: How do you interact, if at all? Do you share progress or take part in working groups? Are any results from research or studies taken up by the industry afterwards? Do you think that your work can help unlock funding for commercial applications? …]*

2.3. In your view, what would be the best role for CSP/CST in Turkey? *[e.g.: Are current research / studies / energy modelling encompassing CSP/CST? If not, why? What could be done to change that? …]*

Conclusion (5')

- How do you see your role in the development of CSP/CST technologies in Turkey in the next 5-10 years?
- Should you have one request to favour the development of CSP/CST in Turkey, what would it be and to whom would it be addressed?
- Is there anything you would like to add?

Thank you for your time and for your help

1.7.3.3 Bank

Introduction (5')

- Presentation of the interviewer / of ESTELA
- Presentation of HORIZON-STE and of the aim of the interview [e.g.: to understand the financing framework in Turkey for innovative projects, to determine the conditions to facilitate access to funding, to foster high relevance between funding and market opportunities]

1. General landscape: Financing Innovative Projects in Turkey (10')

1.1. Could you please present your organisation and the role it plays in financing projects? *[e.g.: what is the main field of projects which you support? Are there specific criteria to fill? How long does it usually take between asking for funding and receiving it? …]*

1.2. In general, how would you evaluate the framework for financing innovative technologies in Turkey? *[e.g.: What is working well? What is more of challenge? What would you change? Would you say that the possibilities and conditions are enough clear for companies? On average, do you think that the applications you receive are relevant? Could there be more of them? …]*

1.3. Are you currently / Have you been involved in financing projects related to CSP/CST (in Turkey or abroad)? If yes, how many? *[e.g.: Can foreign companies also apply for funding? Which benefit do you see in that? Have you seen any evolution regarding the funding of this field in the last ten years? …]*

2. Financing as a Catalyst for Developing Innovative CSP/CST Technologies in Turkey (10')

2.1. How do you see your role in supporting the role of CSP/CST in Turkey? *[e.g.: Do you think that you should only or mainly incentivise Turkish companies? Should you give full support or be a kick-starter for additional support? Do you take Technology Readiness Levels (TRLs) into account when evaluating projects? …]*

2.2. In your view, what are the requirements for a project to be sustainable and receive funding? *[e.g.: What are the guarantees you are asking for? Are there any KPIs which you monitor to determine if full funding can be granted? Is the totality of the funding sometimes submitted to results? …]*

2.3. What would be the ideal scenario to facilitate the financing of innovative CSP/CST technologies? *[e.g.: Which stakeholder(s) play(s) a major role in sending positive signals to foster investment (political actors, companies, foreign investors, regulatory authority…)? Would you say that the existence of several small successful projects would trigger more easily funding for bigger projects? Is the presence of foreign companies a good sign for investment? …]*

Conclusion (5')

- How do you see your role in the development of CSP/CST technologies in Turkey in the next 5-10 years?
- Should you have one request to favour the development of CSP/CST in Turkey, what would it be and to whom would it be addressed?
- Is there anything you would like to add?

Thank you for your time and for your help

CHAPTER 2: PORTUGAL

Portugal has been the second country under the scope of HORIZON-STE. The following chapters will describe the work undertaken and analyse the challenges and opportunities met in the country.

2.1 *Structure of the document*

The deliverable D2.2. "Draft Country Report – Industry Perspective" aims to provide a first global and structured approach regarding potential interest in STE (as well as broader use of Concentrating Solar Technologies), from funding mechanisms to commercial purposes.

The present document is based on the information gathered during the main phases of WP2 concerning:

- The expressed need for manageable RES energy by each country of focus and their respective strategies on its procurement
- The possible changes in the framework conditions
- The interest for and reception of potential solutions using STE

Part 2.2 summarises the tasks which were carried out, describing first the initial plan and then the actual work carried out. This gives an overview of the intelligence collected and of the final key stakeholders and serves as a basis for spotting opportunities and challenges for STE in the given country. Activities typically involved:

- Meeting with relevant stakeholders, i.a. at Ministry, TSO and Regulatory Authority levels, as well as key players from local industries and civil society
- Brokerage event and joint industry – R&I national events

A deeper analysis of the context of the country is provided in 2.3, first from the political point of view (2.3.1) followed by a focus on the regulatory (2.3.2) and transmission (2.3.3) aspects. The overview of the current industrial landscape and its potential (2.3.4) closes this part. More precisely, the part aims at large to sketch the existing political strategies, the arising regulatory challenges and opportunities as well as to depict the current status and future requirements of the system in Portugal.

Based on these observations, key findings are drawn in 2.4. They highlight encountered challenges and existing opportunities for the development of STE technologies in Portugal.

Last but not least, as the study is still ongoing, part 2.5 suggests strategic next steps to continue opening doors for STE in Portugal, from an industrial point of view.

2.2 *Summary of undertaken activities*

Portugal has been under the scope of analysis since February 2020. The Covid-19 global pandemic has slowed down the process. As the HORIZON-STE consortium does not include any Portuguese partner, ESTELA could rely on two collaborations to find relevant interlocutors and share their local knowledge of the context:

- With the representative of the Directorate General for Energy and Geology (DGEG) in the CSP Implementation Working Group (IWG), and
- With LNEG, the National Laboratory of Energy and Geology, with whom ESTELA previously worked on common projects

2.2.1 Foreseen activities and implementation challenges

To favour a sustainable launch of STE in studied countries, ESTELA designed a general process unfolding in three steps with flexibility to adapt to specific country challenges:

PHASE 1	
BACKGROUND RESEARCH AND FIRST MEETINGS	
General aim	To understand the need for manageable RES energy and Portugal's strategies on its procurement / possible changes in the relevant framework conditions
Encountered challenges	– To find the right interlocutor – Low answer rate to interview requests – Mixed information received from different interlocutors
Applied mitigation	– Help from DGEG and LNEG to identify relevant stakeholders – General translation of official documents from Portuguese to English – Confrontation of different sources with the official source
PHASE 2	
BROKERAGE EVENT	
General aim	Assessment and presentation of potential solutions using CSP/STE
Encountered challenges	– Outbreak of covid-19 global pandemic – Little renewable solar in the energy mix and strong place of hydro
Applied mitigation	– Promotion towards ESTELA's members of the upcoming "2020 Solar Auction (with or without storage)" – Preparation of a business case to demonstrate the potential contribution of STE to the country
PHASE 3	
JOINT NATIONAL EVENT	
General aim	Focus on possible synergies and macro-economic value
Encountered challenges	– Outbreak of covid-19 global pandemic – Not enough data collected yet
Applied mitigation	– Awaiting the end of the pandemic to evaluate the possibilities

2.2.2 Carried out activities – Industry perspective in Portugal

LIST OF ACTIVITIES	TIMELINE
BACKGROUND RESEARCH	Phase 1 Feb.-March 2020
Aim: To collect relevant information to better understand the energy landscape in Portugal, the potential challenges for the development of STE and the needs of the country	
Description Desk research: Collect of information based on available information on official websites (e.g.: Directorate General for Energy and Geology [DGEG], Energy Services Regulatory Authority [ERSE], REN, European Commission, APREN …), academic studies or reports by consultancies Stakeholder mapping: Analysis of the specific relevant departments and actors for each identified target group Exchanges with DGEG and LNEG on relevant contacts and existing knowledge of the local situation Exchanges with APREN on existing challenges and potential creation of an STE business case to be presented to the Ministry	
PRELIMINARY TALKS	Phase 1 March-April 2020
Aim: To collect direct feedback regarding needs in terms of energy and more precisely manageable renewable energy sources (RES), the current and future energy strategies, the procurement system and the possible changes in the relevant framework conditions	
Description Ideally, this phase aims to establish a first physical contact with the three key stakeholders in Portugal regarding energy policy, namely the TSO, the Ministry and the Regulatory Authority. However, as the Covid-19 pandemic forced EU borders to be closed and travels to be restricted, HORIZON-STE could not organise these meetings and had to hold them online APREN: Interview with the President of the Portuguese Association of Renewable Energy (APREN) LNEG: Interview with the Director of LNEG, three researchers from the Renewable Energies and Energy Efficiency Unit and a technical officer from that same unit REN: Interview with three stakeholders respectively involved in Network Planning, Studies and Regulations, and Grid Connections	
PHONE INTERVIEWS	Phase 1 Pending
Aim: To collect more targeted feedback on political, industrial and economic factors regarding the development of Portugal's energy strategy and potential need for manageable RES	
Description Not realised yet	
BROKERAGE EVENT	Phase 2 Pending
Aim: To have a broad overview of STE perspectives in Portugal through existing and potential solutions using STE, from both the R&I and industry sides.	
Description Not realised yet.	

However, ESTELA has promoted the "2020 Solar Auction (with or without storage)" in Portugal which allows for the participation of CSP technologies, thanks to a third remuneration scheme which recognises the importance of valuing flexibility, and would thus compensate capacity and not only energy produced, as part of the criteria. The announced dates are on 24-25 of August 2020, for a total of 700MW/MVA total, in different lots, all located in regions of Alentejo and Algarve.

A solid participation of CSP companies in this auction would not only show the interest to develop the market in Portugal, but also give stronger arguments for a CSP business-case in Portugal.

NATIONAL EVENT	Phase 3 Pending

Aim: To provide a space for actors from the entire STE value-chain to meet and talk through their specific needs and expectations regarding the development of STE in Portugal. To focus on possible synergies and macro-economic value.

Description
Not realised yet

2.3 *Overview of the context in Portugal*

The desk research and the preliminary interviews helped ESTELA refine its understanding of the energy context in Portugal. The following subsections were enriched thanks to ESTELA's own desk research and inputs from three stakeholders: the Portuguese Renewable Energy Association (APREN), the TSO (REN) and the National Laboratory of Energy and Geology (LNEG). The latter has been very helpful, providing the consortium with a list of stakeholders to contact and sketching out a thorough context of energy policy in Portugal.

2.3.1 Energy policies and the place of STE in the Portuguese landscape

2.3.1.1 Current energy mix in Portugal

Portugal's primary energy consumption still mainly relies on fossil fuels (around 60%), as shown in Figure 1, with petroleum products representing more than a third of the total primary consumption. Portugal is therefore planning to massively electrify its energy consumption to decarbonise it, aiming to meet more than 60% of its final energy consumption by electricity.

In the power sector, renewables represent in 2019 51% of the generation[20], as shown in Figure 2. In 2019, Portugal had 20,208MW of installed capacity, whose composition is detailed in Table 4[21].

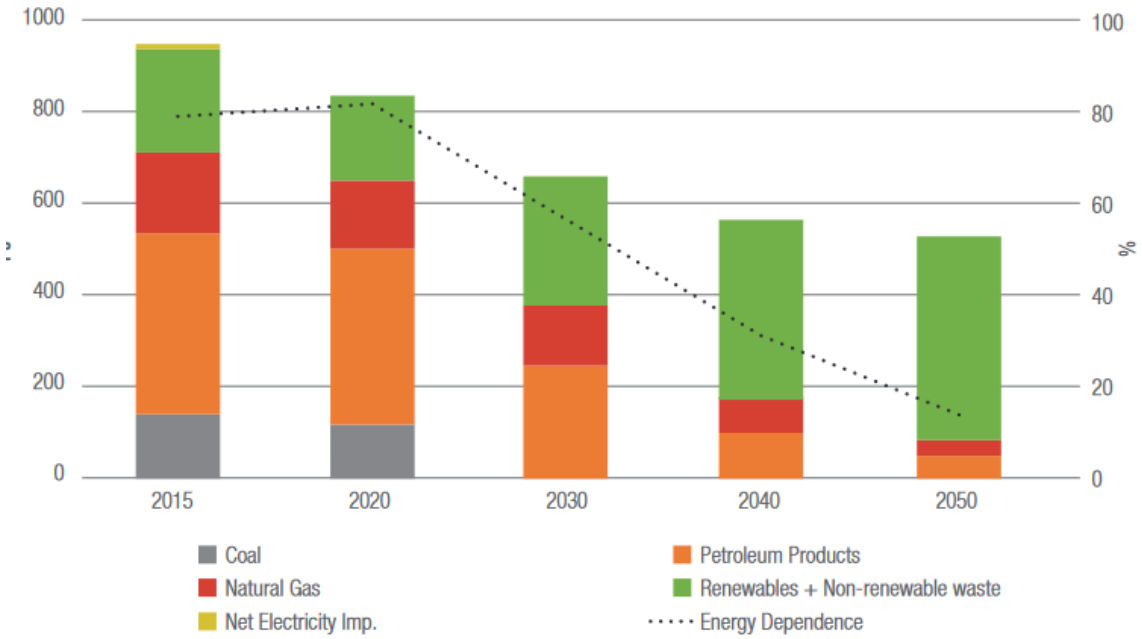

Figure 1: Primary energy consumption in Portugal (2015 - 2050)

Category		Installed capacity (MW)
Renewable		13,847
	Hydro	7,216
	Wind	5,208
	Biomass	693
	Solar (PV)	730
Non-renewable		6,361
	Coal	1,756
	Natural gas	4,597
	Others	8
Total		20,208

Table 4: Installed capacity as of 2019

[20] *Source: REN, Technical Data 2019, 2019 [online]*

[21] *Ibid.*

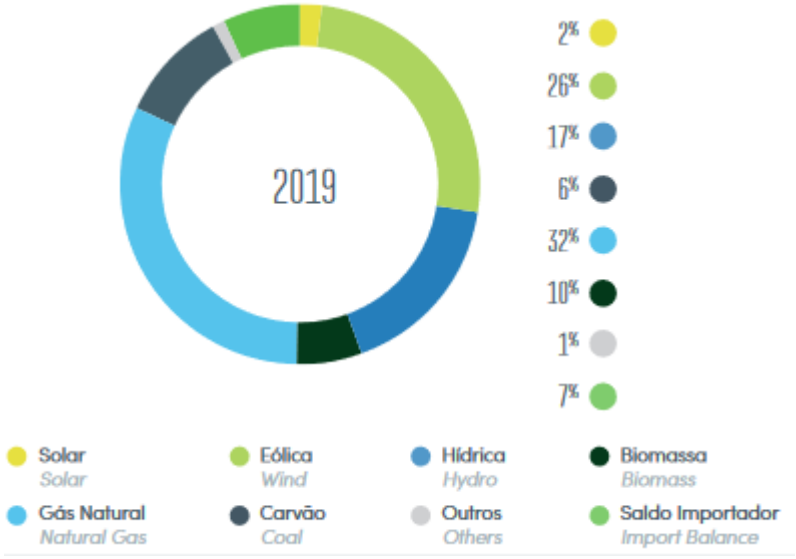

Figure 2: Electricity generation in 2019

According to LNEG, Portugal aims to reach a total installed capacity of around 30,000MW by 2030, achieving 9,000MW of PV and 9,300MW of wind. With its ambitious target of 80% of renewables by 2030, Portugal will face a storage challenge, as confirmed by REN.

The Roadmap for Carbon Neutrality 2050 (RCN2050) published by the Ministry of Environment and Energy Transition, gives an overview of the expected challenges and paths to be taken by the country to meet its targets. Amongst them, elements regarding generation capacity will have a tangible impact on the Portuguese energy mix:

- The end of coal-fired power production by 2029
- The end of gas-fired power production from 2040
- The decrease by 4% of power generation from hydro without pumping in 2040, compared to 2020, because of water scarcity
- By 2040, battery storage will represent 3 to 4% of the total installed capacity
- By 2050, it will represent 6%

In electricity generation, the transition is expected to be facilitated "by the reduction in the cost of renewable-based technologies for electricity generation that has been observed in recent years, especially in technologies associated with solar photovoltaics"[22]. This statement opens the door for hybridisation projects between STE and PV, which would contribute to accelerate the decarbonisation of the power system. Portugal plans to keep natural gas in its generation mix until 2040 to facilitate the transition. However, the development of STE plants could favour an earlier phasing out of the gas plants. The

[22] *Ministry of Environment and Energy Transition, Roadmap for Carbon Neutrality 2050 (RNC2050), June 2019 [online]*

RCN2050 also expects rapid falls in the cost of storage solutions. This would also work in favour of STE with thermal energy storage (TES). These two elements are part of the necessary conditions for Portugal to reach almost 100% renewables in its electricity production by 2050.

The use of batteries and the role they could play remains still hypothetical and relies on "hoped-for" developments, as their capacity should reach 4GW by 2050[23]. Being an already proven technology, TES could bring a bigger added value, in particular as solar PV capacity is expected to be multiplied by at least 7 by 2030.

Hydrogen is seen as one of the potential new energy vectors to be developed, in particular in hard-to-abate sectors such as transport. The RCN2050 foresees that, by 2050, 5 to 8% of the produced electricity will be used to generate hydrogen[24]. This is an interesting argument for the construction of STE plants in Portugal, given the potential of the technology to contribute to generate hydrogen, thanks to its high temperature capacity. Portugal aims to reach 35% of renewables in the transport sector by 2030, 60% in 2040 and 90% by 2050[25]. This will require an important production of green fuels, in which STE could participate.

Regarding industry, challenges are almost as high as for the transport sector, in particular for industrial processes for sectors such as the mineral and chemical industries. Portugal plans to reach a 72% of emission reduction by 2050, partially through electrification. Heat generation is foreseen to be covered by renewable co-generation for high temperature and solar heating for low/medium temperature.

The acknowledgement of the challenge represented by high temperature heat could also be explored with CST technologies solutions, as the adjunction of TES to some existing centrals can increase energy efficiency of the processes. In addition, as Portugal foresees an increase in the share of natural gas in industrial processes until 2030 and a progressive decrease afterwards, the hybridisation capacity of TES with gas could accelerate the decarbonisation process.

2.3.1.2 The Portuguese NECP and the potential for STE

Portugal aims to decrease its greenhouse gas emissions by 60% and increase the share of renewable energies up to 80% in its electricity generation by 2030.

The Portuguese NECP is one of the four NECPs mentioning the use of STE for electricity generation, with 300MW of new installed capacity foreseen by 2030. As a first step, 100MW are already expected by 2025. In this regard, the Portuguese government has already announced the execution of a competitive procedure for 700MW of solar energy by the third quarter of 2020, with the positive introduction of mechanisms to remunerate

[23] *Ibid.*

[24] *Ibid.*

[25] *Ibid.*

capacity and to consider solar technologies with and without storage (STE included). If CSP projects were awarded capacity, it would be, without a doubt, another important step in the reactivation of the sector in Europe and also a first step towards this projected installed capacity. ESTELA has advertised this tender to its members and encouraged them to take part.

During the discussion with LNEG, the question of the considerations about the complementarity between PV and STE was mentioned. Even though it has not been studied so far in the country, the new perspectives introduced by the NECP led them to start a new cooperation with the University of Evora, to have a first study on complementarity, with CSP and PV for a same injection point, in preparation of the Iberian and Latin American Solar Energy Conference in Autumn 2020.

As a summary, the current Portuguese energy policies may open the door for further CST technologies penetration in the energy mix, be it for electricity generation, energy storage or the decarbonisation of hard-to-abate sectors. The hybridisation characteristics of CST puts it as a strategic element for the future Portuguese energy mix. The outcome of the solar tender in August will weight on the potential future development of the technology in the country.

2.3.2 Energy regulation in Portugal: a strategy to include flexibility

At the moment, ESTELA could not secure a meeting with the Portuguese energy regulator, ERSE. However, the desk research which was performed paved the way for an interesting discussion later on and showed good potential for the introduction of STE in the Portuguese landscape.

ERSE has identified five strategic orientations for the period 2019-2022, which can be seen in Figure 3. In its Strategic Plan for the same period, the regulator sees four main challenges, for which STE, and CST technologies at large, could bring solutions:

- Sector integration
- Energy storage in batteries or renewable gases
- Solutions of greater importance. flexibility in system management
- Optimization of cross-border interconnections will also contribute to this end and to greater competition and security of supply in general.[26]

Flexibility is really a challenge which ERSE is aware of, while also considering it as an opportunity for further integration of renewable production in the system and an alternative to new networks. According to ERSE, "the sources of this flexibility will be multiple, and it will be up to the market to determine its viability"[27].

[26] *Source: Energy Services Regulatory Authority, ERSE's 2019-2022 Strategic Plan, September 2019 [online]*

[27] *Ibid.*

To ensure a fair remuneration of the flexible characteristic, ERSE plans to focus on the framework of regulatory incentives to "ensure a greater diversity of resources for the provision of flexibility, mitigating the usual logic that makes the provision of this type of services based on traditional agents in the sector". This can potentially be good news for the STE sector, as a proper remuneration framework for flexibility – as seems to already be the case with the solar tender to be auctioned in June 2020 – is a necessary condition for the development of the technology.

Amongst other solutions, ERSE considers the complementarity between renewable production and hydroelectric plants with pumping capacity as a good possibility to increase flexibility. However, as ERSE must regulate the electricity, natural gas, liquefied petroleum gas, oil derivatives fuels and biofuels sectors, it must take into account market's characteristics. Even if some RES are today competitive, the wholesale market price level is the most relevant criteria (signal) for new investments in generation. By supporting a balanced portfolio of solutions including renewable production, flexibility resources (including storage) and consumption, ERSE would make market players more competitive and decrease the risks they take. ERSE is therefore fully aware of the importance of regulatory models to be adapted to the redesign of a market model which can face these upcoming challenges.

If gas is also considered as a "backup" when renewables cannot deliver and to be a guarantee for system flexibility, discussing the potential of CST with ERSE might bring further information on the table and show the regulator that the upcoming challenges Portugal is facing can be mainly solved through renewable solutions.

These first elements are paving the way for interesting discussions between ERSE and the HORIZON-STE consortium. There is *a priori* no obstacle for STE to enter the Portuguese energy market, and the awareness of the role of flexibility, especially storage, appears as favourable for STE.

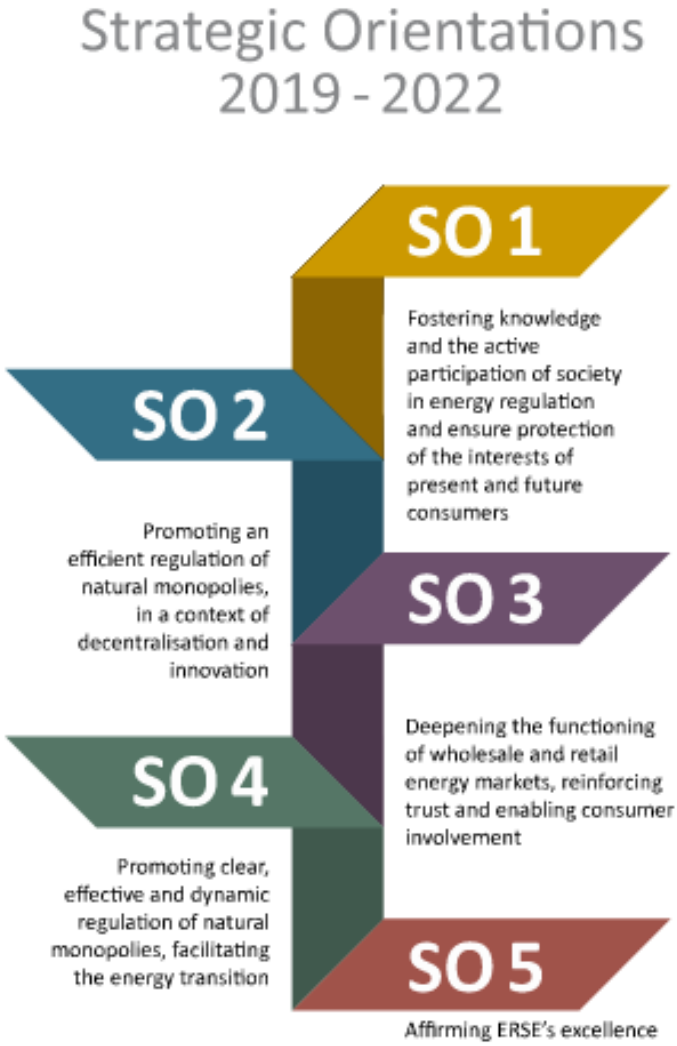

Figure 3: ERSE's Strategic Orientations (2019-2022)

2.3.3 Energy transmission system in Portugal: the role of REN

ESTELA had an interview with employees from REN, the Portuguese TSO, respectively involved in Network Planning, Studies and Regulations, and Grid Connections.

An important aspect of the Portuguese grid relies on its interconnections with Spain, as can be seen in Table 5. It is planned to reinforce the transfer capacity in the upcoming decade, in particular with a new high voltage line, which should be operational in 2022, in the North of Portugal, even though difficulties are experienced in this zone.

Transfer capacity	2019 (average)	2030
Import	2.6GW	4.2GW
Export	3.3GW	3.6GW

Table 5: Net transfer capacity between Portugal and Spain

Currently, the main production from renewables comes from hydro and wind, which are located in the central and northern parts of Portugal. PV, and potentially STE, will always be located in the Southern part of the country. However, there is an asymmetry between the consumption of energy in the South and North, as the biggest cities are located in the North of the country. This means that the transit of energy from South to North would need to be increased if more PV and STE would be installed in the South.

A new law introduced in June 2019 related to grid connection conditions opens now three different options:

- Promoters can submit new RES projects via the government's website to increase network capacity. Requests are then forwarded to the TSO if > 50 MVA, to the DSO for projects <50MVA. This option was so successful that after 1.5 months, no more capacity could be allocated in transmission network, since all the available transfer capacity had already been placed.
- New auctions to be introduced by the government:
  - In July 2019, the first auction took place for 1.4GW of PV, without any obligation to provide solutions for storage. 1 GW were requested at TSO level, 0.3GW at DSO level, 0.1GW was not auctioned, as the auction lot was without competitors. The reference tariff offered was of €45/MWh. The cheapest bid received was of €15/MWh, the average bid was of €21/MWh.
  - The second auction will take place on 24-25 August 2020 and will value solutions regarding storage and therefore consider a variety of solutions, *e.g.*, PV plant / PV + battery / CSP plant / PV+CSP hybridisation. 700MVA will be auctioned[28].
- A direct agreement between promoters and REN can be established when REN has not enough internal transmission capacity. In this case, such internal reinforcements are paid by promoters, thus allowing new capacity. Hundreds of requests were received. The rationale for taking such additional cost is to allow connections of RES projects in places, quantities or times not considered in the national development plan for transmission network, accelerating the contribution to reach renewables targets.

During the meeting, the future of storage in Portugal was also discussed. Pumped hydro has a very good potential in the country, with approximately 2.7GW installed capacity today and 3.6GW planned by 2023. It is expected, according to REN, to play an increasing role for managing the security of the whole system, also optimising possibilities with Spain. In particular, its use for seasonal storage and the possible variation of the pump mode from 70 to 100% is praised by the TSO. However, REN is not opposed to the use of

[28] *More information: https://www.portugalenergia.pt/*

STE and TES as a storage solution and to also solve the problem of inertia. The only problematic would remain the question of owning the storage capacity, as the EU currently does not allow the TSO to own storage connected to the grid

Since the first discussion with REN brought positive results and seemed to open the door to STE plants, a new call to discuss the decommissioning of old coal power plants (by 2030) and the extended possibilities to use TES is to be scheduled in the next months.

2.3.4 STE as a potential industry driver in Portugal

During the meeting with LNEG, the link between industry and research was mentioned. The topic of storage is an important one on the research side. LNEG has, for instance, been interested in the connection between bioenergy and solar energy. Regarding the industry side, there are some PV factories in Portugal but, what could be very interesting, is to show the possibilities for the Portuguese metallurgy industry to collaborate in the process of STE installations for instance. The glass industry would also be very interested in being involved in STE planning, according to LNEG.

If currently no Portuguese company is involved in STE projects, the solar tender including STE may create new perspectives for businesses to develop. In addition to the existing Portuguese areas of excellence, such as in metallurgy or glass, the development of STE could also bring a new dynamic to these sectors.

2.4 *First Key Findings*

No opposition to the deployment of STE in Portugal has been encountered so far. Even though it remains key to talk to policy-makers, several signs opened the door to a deeper discussion on different STE application possibilities, even though some hurdles must be overcome for a sound and sustainable STE and mostly CST development to take place. However, as the project is still under development, these key findings are only draft ones and may be subject to changes according to new information.

At the moment, the main striking points are:

1. Portugal stated in its NECP that 300MW of CSP would be built by 2030, which already shows a positive approach to the technology and consideration from policy makers

2. The existence of opportunities for STE in Portugal has also been acknowledged by both LNEG and REN, not only to increase the electricity production but also to contribute to the flexibility of the system. Research is ongoing regarding the question of storage, and the TSO is also looking for solutions, beyond pump hydro, to increase system flexibility

3. A potential fringe of the Portuguese industry could benefit from the development of STE plants in Portugal, in particular the metallurgy, glass and construction sectors.

4. The launch of a tender for 700MW of solar energy in the in regions of Alentejo and Algarve, through which the government recognises the importance of valuing flexibility. It will include a third remuneration scheme (adding to the two from the previous tender), which would compensate capacity and not only energy produced, as part of the criteria.

2.5 *Next steps*

Stakeholder	Task	Timeline
LNEG	– Discuss potential economic impact of the construction of STE plants on the Portuguese socio-economic landscape	July 2020
DG Energy and Geology	– Contact to organise a meeting – Prepare a narrative on the benefits from deploying STE in Portugal	September 2020
Secretariat of State	– Contact to organise a meeting – Prepare a narrative on the benefits from deploying STE in Portugal	September 2020
REN	– Set up a second call to discuss the potential of TES in the frame of retrofitting coal power plants – Monitor the outcome of the solar tender in August 2020	August 2020 – September 2020

2.6 *Glossary*

CSP	Concentrated Solar Power
CST	Concentrated Solar Thermal
DNI	Direct Normal Irradiation
EC	European Commission
EU	European Union
GWh	Giga Watt hour
H2020	Horizon 2020
kWh	Kilo Watt hour
LNEG	National Laboratory of Energy and Geology
MS	Member States (EU)
MVA	Megavolt Amperes
MW	Mega Watt
MWh	Mega Watt hour
NECP	National Energy and Climate plan
PPA	Power Purchase Agreement
PV	Photovoltaic
R&D	Research and Development
R&I	Research and Innovation
RES	Renewable Energy Sources
SET-Plan	Strategic Energy Technology Plan
STE	Solar Thermal Electricity
TES	Thermal Energy Storage
TSO	Transmission System Operator
TWh	TeraWatt hour

2.7 Appendices

2.7.1 Reference

Energy policies

Ministry of Environment and Energy Transition, Roadmap for Carbon Neutrality 2050 (RNC2050), June 2019 [online]

Portuguese NECP [online]

REN, Technical Data 2019, 2019 [online]

Regulator Authority

Energy Services Regulatory Authority, ERSE's 2019-2022 Strategic Plan, September 2019 [online]

2.7.2 Interview guidelines

2.7.2.1 REN

- Which is REN'S perspective on extensions of the interconnection capacity with Spain or another country (e.g. Morocco)?
- Which are at the most potential constraints to such extensions /reinforcements?
- Looking at the future targets regarding the inclusion of renewable energy sources in the electricity grid (mostly variable such as PV and wind), is there any foreseen need for storage to meet the future system requirements?

2.7.2.2 LNEG

DATE & VENUE: March 18th, 2020 – Phone conference

OVERALL OBJECTIVE: To understand the need for manageable RES energy in Portugal and the overall energy strategy within the relevant framework conditions

SPECIFIC OBJECTIVE FOR LNEG: To understand at a higher level Portugal's energy strategy policy, including research strategy

INTRODUCTION (10')

- Presentation of the interviewer [*presentation of ESTELA and of HORIZON-STE's overall objectives; brief description of intended methodology: importance of first understanding the national perspective, then deepening this knowledge by meeting local STE stakeholders and finally looking for synergies between research and industry to support further the deployment of CSP/CST projects in Portugal*]
- Presentation of the interviewees [*name; position in LNEG; field of research; status of your work with CSP / future work; …*]

3. GENERAL PERSPECTIVES OF ENERGY POLICY IN PORTUGAL (20')

3.1. General targets and objectives: **What is the role foreseen for renewables by Portugal to contribute to less carbon intensive energy / industry infrastructures?** [*Are there any specific studies on Portuguese energy strategy? If yes, which are the most relevant ones and do any of them (for CSP or other technologies) include economic perspectives? How do you think will the country achieve its energy transition goals? What are the challenges faced at national level? What are the global energy policy drivers (e.g. economic, environmental, social, geopolitical)?*]

3.2. Current policies: **What do you think of the current energy policies implemented by the government?** [*Are the followed trends correct? If no, what would you change? Who has set these trends (lobbying from specific sectors?)? Do you see any real possibility to change the current vision of the various technologies? And what about space for CSP?*]

3.3. The NECP foresees 80% of electricity generation from RES by 2030. Currently, 67.8% of electricity generation comes from RES; hydro represents more than half of the RES capacity. **In your opinion, what are the strengths and weaknesses of the measures announced in the NECP, regarding Portugal's energy strategy at large?** [*were you involved in the writing of the NECP? If yes, how? If no, do you consider that what is planned is achievable?*]

3.4. Your role in this general perspective: **What are your current lines of work and how are they defined** (e.g., government priorities, market developments)? [What are the tendencies which you have observed in the last five years regarding the work you have been conducting? *Which sectors of research have been the most prone to lead to commercial applications? Did you notice changes in the investors' sectors of interest? Did new technologies appear in the landscape?]*

3.5. **Which challenges and opportunities do you see arising from the NECP and the EU 2050 long-term decarbonisation strategy?** [*How do you see the current Portuguese energy mix and how do you imagine it in 10 years? Do you think that some resources might be under-used? To what extent do you think that Portugal's energy strategy is adapted to an accelerated decarbonisation? Do you consider that Portugal can be carbon neutral in 2050?*]

4. Challenges and Opportunities of CSP in Portugal's energy strategy (20')

4.1. From a national perspective, solar is expected to have the biggest increase of installed capacity between 2020 and 2030. **How do you think that the solar target of 2030 will be achieved (8.1 to 9.9GW)?** [*Do you know how this will be auctioned? Do you think that current research projects which you are carrying, such as NEWSOL, will have an impact on the upcoming solar auctions? What is your opinion on CSP to help achieving this target?*]

4.2. The input from more variable RES such as wind and PV will imply less stability of the grid. **Are you currently working on this issue / considering any solutions to this issue?** [*e.g.: What is the current storage capacity of Portugal and how do you evaluate its evolution by 2030? Do you think this could be a good opportunity for CSP to kick-in in the Portuguese energy landscape? …*]

4.3. Regarding your experience in CSP and in the projects you have been carrying out, **which challenges and opportunities do you see for the CSP sector to develop in**

Portugal? [*Do you think the 300MW of CSP foreseen in the NECP can be a trigger for more investment in CSP? Have you been consulted in this regard? Do you think that a hybrid model has more chances (e.g. PV+CSP), particularly regarding the auction mechanisms? Which part of the CSP value-chain would be more strategic to target for Portugal? In general, what would help the deployment of CSP?*]

Conclusion (5')

- How do you see your role in the development of CSP/CST technologies in Portugal in the next 10 years?
- Should you have one request to favour the development of CSP/CST in Portugal, what would it be and to whom would it be addressed?
- Is there anything you would like to add?

Thank you for your time and for your help

2.7.2.3 APREN

1. General situation of for renewables in PT & outlook for the next years (NECP?)
   1.1. How do you expect that the country will achieve its overarching goals regarding a transition to a less carbon intensive energy/industry infrastructures via renewables *(i.e. Official vs. Un-official positions, etc.)*?

2. Specific situation about CSP
   2.1. Who do you think would be more **relevant people to address** within the aforementioned institutions *(i.e. perhaps a priori not closed to CSP, best aware of the future system needs, etc.)*?
   2.2. What kind of **messages** do you think these people would be more likely to respond positively to?

3. Upcoming tender
   3.1. What is **the status of the upcoming tender including storage**? Is there an opportunity for CSP with the current design of it?

4. Other
   4.1. What are they working on now?
   4.2. Cooperation with Protermosolar?
   4.3. Possible visit when we go to PT to share our findings?

CHAPTER 3: DENMARK

Denmark has been under the scope of HORIZON-STE since January 2020, in parallel with Turkey and Portugal, with the status of non-priority country. The following parts will describe the work undertaken and analyse the challenges and opportunities met in the country.

3.1 *Structure of the document*

The deliverable D2.2. "Draft Country Report – Industry Perspective" aims to provide a first global and structured approach regarding potential interest in STE (as well as broader use of Concentrating Solar Technologies), from funding mechanisms to commercial purposes.

The present document takes into account the relevant information gathered during the main phases of WP2 concerning:

- The expressed need for manageable RES energy by each country of focus and their respective strategies on its procurement
- The possible changes in the framework conditions
- The interest for and reception of potential solutions using STE

Part summarises the tasks which were carried out, describing first the initial plan (1.2.1) and then the actual work carried out (1.2.2). This gives an overview of the intelligence collected and of the final key stakeholders and serves as a basis for spotting opportunities and challenges for STE in the given country. Activities typically involved:

- Meeting with relevant stakeholders, i.a. at Ministry, TSO and Regulatory Authority levels, as well as key players from local industries and civil society
- Brokerage event and joint industry-R&I national events

A deeper analysis of the context of the country is provided in Chapter 3, first from the political point of view (1.3.1) followed by a focus on the regulatory (1.3.2) and transmission (1.3.3) aspects. The overview of the current industrial landscape (3.3.4) closes this part. More precisely, this part aims at large to sketch the existing political strategies, the arising regulatory challenges and opportunities as well as to depict the current status and future requirements of the system in Denmark.

However, these observations could only be drawn from HORIZON-STE's own desk research, since no contact could be established by the time of writing this report. Despite ESTELA's attempts to retrieve information from the danish company Aalborg CSP or from a Danish representative in the SET-Plan or IWG Steering Group, no substancial interest was shown from their sides. The consortium is therefore unable to show any key finding or recommendations, even though heat applications appear as promising in the country.

3.2 *Summary of undertaken activities*

Denmark has been under the scope of analysis since January 2020. As the HORIZON-STE consortium does not include any Danish partner, ESTELA first turned to Aalborg CSP, a Danish company with a CSP branch. However, as exchanges were not fruitful, ESTELA turned to representatives to the SET-Plan and to the IWG Steering Group, both contacts provided by the European Commission. No answer has been received so far, depite reminders.

This has hindered the foreseen process of analysis and reduced HORIZON-STE's activity for Denmark to only background research. While Denmark seemed promising, with already good examples of heat applications, the absence of contact with major stakeholders prevented the project from performing further analysis. Hence, given that the consortium was not able to get relevant information from direct official sources to understand the country's needs, making concrete and suitable propositions for the further deployment our offtaking of CST in the country became impossible.

3.2.1 Foreseen activities and implementation challenges

To favour a sustainable launch of STE in studied countries, ESTELA designed a general process unfolding in three steps with flexibility to adapt to specific country challenges:

PHASE 1	
BACKGROUND RESEARCH AND FIRST MEETINGS	
General aim	To understand the need for manageable RES energy and Denmark's strategies on its RES procurement strategy/ possible changes in the relevant framework conditions
Encountered challenges	– No answer from contacted stakeholders, except for an industrial one but with heavier focus on the Spanish market, not on Denmark – No apparent interest in sharing contacts without a tangible benefit in return – Important information and documentation available only in Danish
Applied mitigation	– Sending reminders – Looking for alternative contacts – General translation of official documents from Danish to English
PHASE 2	
BROKERAGE EVENT	
General aim	Assessment and presentation of potential solutions using STE/CST
Encountered challenges	– Not possible to plan, as no contact with relevant stakeholders was achieved
Applied mitigation	– Looking for alternative contacts
PHASE 3	
JOINT NATIONAL EVENT	
General aim	Focus on possible synergies and macro-economic value

Encountered challenges	– Not possible to plan, as no contact with relevant stakeholders was achieved
Applied mitigation	– Looking for alternative contacts

3.2.2 Carried out activities – Industry perspective in Denmark

LIST OF ACTIVITIES	TIMELINE
BACKGROUND RESEARCH	Phase 1 Jan. – May 2020

Aim: To collect relevant information to better understand the energy landscape in Denmark, the potential challenges for the development of STE and the needs of the country

Description

Desk research: Collect of information based on available information on official websites (e.g.: Ministry of Climate, Energy and Utilities [EFKM], Forsyningstilsynet [Regulator], Energinet [TSO], European Commission, Danish Energy Agency …), academic studies or reports by consultancies

Stakeholder mapping:
- Analysis of the specific relevant departments and actors for each identified target group
- Exchanges with the European Commission for direct contacts
- Attempts to exchange with Aalborg CSP, a representative to the SET-Plan and a representative to the IWG Steering Group

PRELIMINARY TALKS	Phase 1 Feb. – May 2020

Aim: To collect direct feedback regarding needs in terms of energy and more precisely manageable renewable energy sources (RES), the current and future energy strategies, the procurement system and the possible changes in the relevant framework conditions

Description

Despite emails and reminders sent to the representatives of Denmark to the SET-Plan and the IWG Steering Group, no answer was received. It was later found out that the representative to the SET-Plan quit around March 2020 and no replacement is known at the moment.

PHONE INTERVIEWS	Phase 1 Feb. – June 2020

Aim: To collect more targeted feedback on political, industrial and economic factors regarding the development of Denmark's energy strategy and potential need for manageable RES

Description

ESTELA contacted several persons from Aalborg CSP, as the Danish company is very well advanced in CSP and heat applications in the country. After several emails with the CEO and the Vice-President of Aalborg CSP, they oriented the consortium towards the Spanish Sales Manager. Even though the person took time to talk to ESTELA, he could not provide us with information significantly valuable from the Danish market, since he was in charge of the Spanish branch. The only additional cooperation offered by the company, regarding digging the Danish market and interesting stakeholders, would have required a financial contribution.

Aalborg: Interview with Aalborg's Sales Manager in Spain

BROKERAGE EVENT	Phase 2

	Pending
Aim: To have a broad overview of STE perspectives in Denmark through existing and potential solutions using STE, from both the R&I and industry sides. Description Not realised yet.	
NATIONAL EVENT	Phase 3 Pending
Aim: To provide a space for actors from the entire STE value-chain to meet and talk through their specific needs and expectations regarding the development of STE in Portugal. To focus on possible synergies and macro-economic value. Description Not realised yet	

3.3 *Overview of the context in Denmark*

The following sections are based only on the desk research performed by ESTELA, to refine its understanding of the energy context in Denmark. None of the contacted Danish stakeholders expressed the will to answer ESTELA's questions regarding Danish energy needs and potential for concentrated solar thermal technologies in the country.

3.3.1 Energy policies and the place of STE in the landscape

3.3.1.1 Current energy mix in Denmark

Denmark is one of the most advanced European countries in terms of penetration of renewable energies in its energy mix. With currently 33% of renewables in its gross final energy consumption[29], the country is already ahead of its initial target of 30% for 2030[30]. The three main sectors for energy consumption in 2018 were transports (29%), households (29%), agriculture and industry (21%).

[29] *Source:* Danish Energy Agency, Annual and Monthly Statistics, Figures 2018, DEA website

[30] *Source: Eurostat, Renewable energy in the EU in 2018, News release, 23 January 2020 [online]*

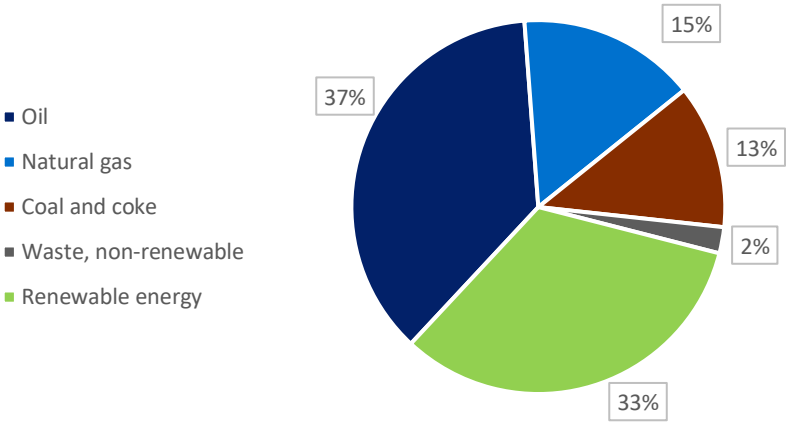

Figure 4: Danish global energy mix (2018)

Regarding electricity, as can be seen in Figure 5, renewables represent 69% of the generation, with wind accounting for 66% of the total generation by renewables. This means that wind represents around 46% of the total electricity generation in Denmark. A more detailed vision of the composition of the Danish electricity system can be seen in Figure 5 below and in Table 6[31].

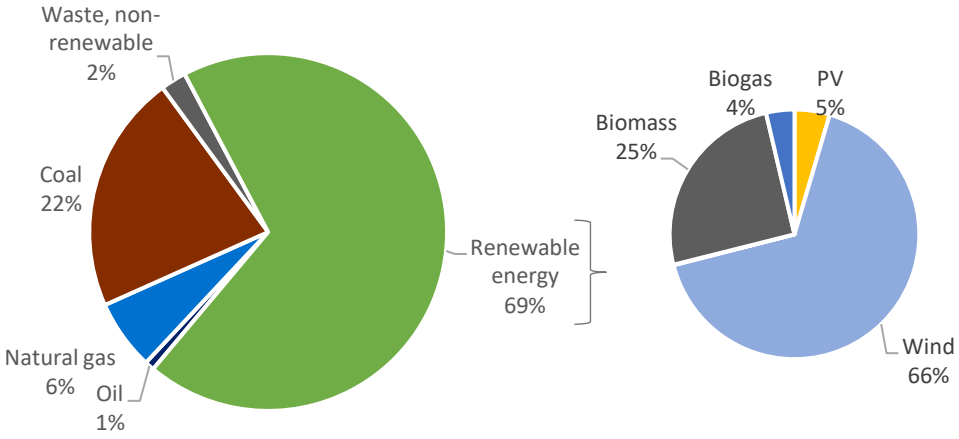

Figure 5: Electricity production

[31] *Source:* Danish Energy Agency, Annual and Monthly Statistics, Figures 2018, DEA website

Denmark's electricity system in 2018		
Total installed capacity		15,073MW
Amongst which:	Wind	6,121MW
	Solar	998MW
	Hydro	9MW
	CHP[32]	4,586MW
Total net electricity production		ca. 29,320.83GWh
Final electricity consumption		ca. 31,084.44GWh
Total import		15,634GWh
Total export		10,409GWh

Table 6: Danish electricity system (2018)

One characteristic of Denmark lies in its focus on developing combined heat and power (CHP), for both electricity and district heating production. It represents 71% in thermal electricity production and 66% in district heating production, as can be seen in Figure 6[33]. More than half of of district heating production relies on renewables (58%), of which 72% only produced by biomass (wood and straw). This means that in total, 42% of district heating is generated by biomass in Denmark[34].

What is interesting with district heating, is that storage is a very important feature to ensure the flexibility of the system. Heat can thereby be produced in excess during the day, stored and be dispatched at night when needed. That is why a potential for CST exists in Denmark. It could also be beneficial to deepen the penetration of RES in the energy mix, in particular of PV, which still represents a very low amount of installed capacity. CHP systems can also relay electricity production when not enough is available, thanks to this storage capacity.

[32] *Combined Heat and Power*

[33] *Source: Danish Energy Agency, Energy in Denmark 2018, March 2020 [online]*

[34] *Source: ibid.*

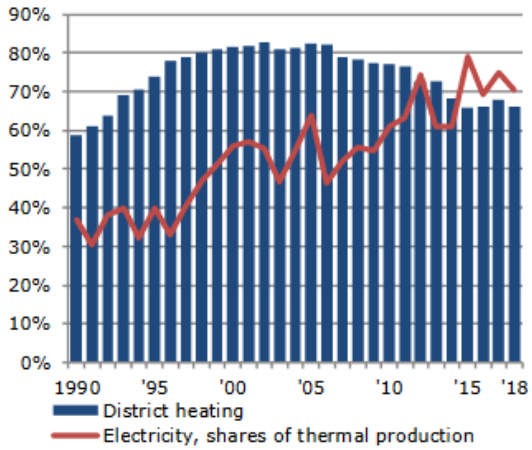

Figure 6: CHP shares of electricity and district heat production

3.3.1.2 The Danish NECP

In its NECP, Denmark is even more ambitious than the EU general binding targets are. Denmark is part of the group of countries which exceeded their 2020 targets in terms of renewables, and should also meet its targets for GHG emissions and energy savings[35], which included:

- a total renewables share of 30%
- a 20% CO2 reduction in non-ETS greenhouse gas emissions

For 2030, Denmark aims to reach a share of 55% of renewables in its energy system, phase out of coal in electricity production, and ensure that at least 90% of district heating production is base on other energy sources than coal, oil or gas[36].

Wind power will play a key role in increasing the share of renewables in the system, in particular offshore wind. Already 400MW of offshore wind are operational since 2013, an additional 1,350MW was tendered in 2019 (under three auctions of respectively 400MW, 600MW and 350MW)[37]. Three new offshore wind tenders are planned between 2020 and 2030, representing a total of minimum 2,400MW.

No objectives or targets for individual technologies have been set up by the government. The current subsidy system relies on multi-technology tenders for wind and PV, with the new ones planned for 2020-2024.

[35] *Source: Danish Ministry of Energy, Utilities and Climate, Denmark: energy and climate pioneer Status of the green transition, April 2018, EFKM website*

[36] *Danish NECP, p.29*

[37] *Ibid., p. 36*

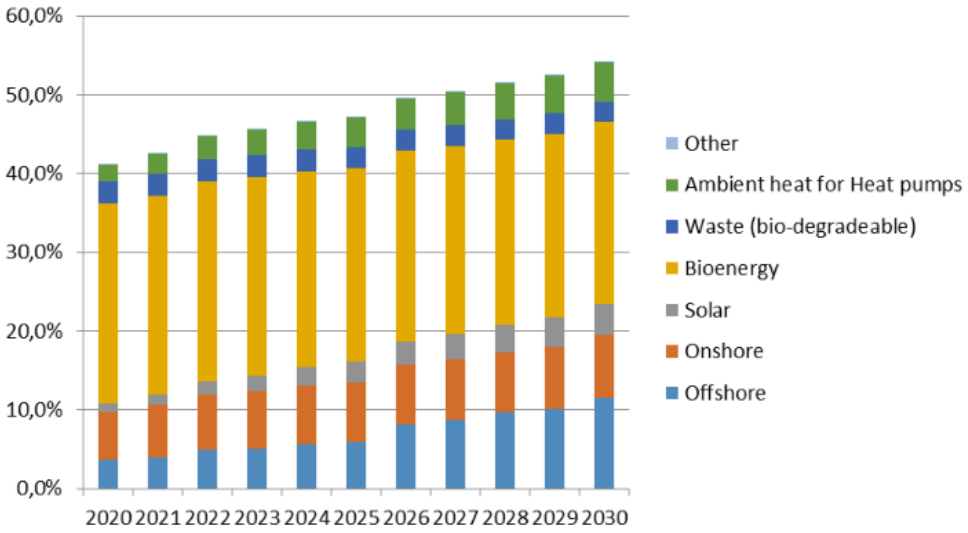

Figure 7: Estimated trajectory for the overall share of renewable

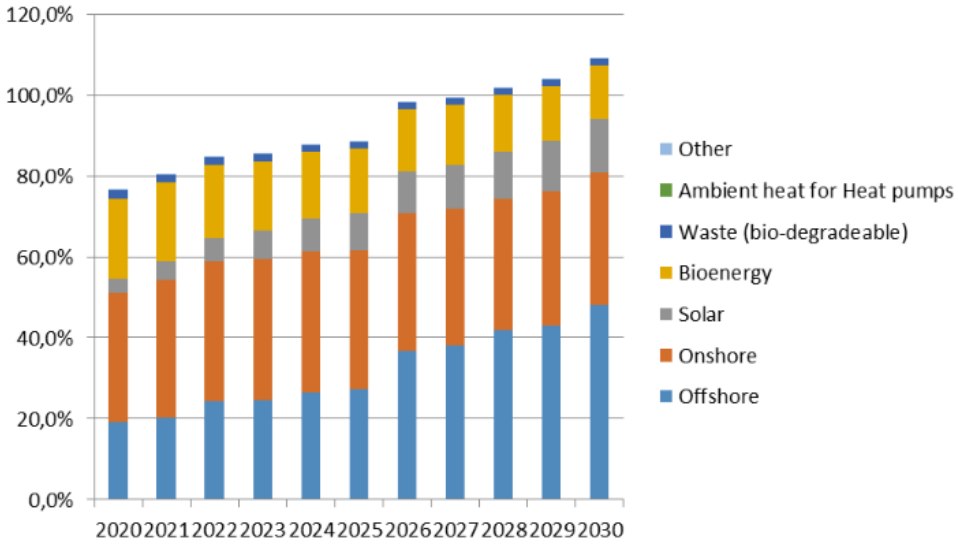

Figure 8: Estimated trajectory for renewables in electricity

By 2030, the estimated installed capacity of renewables for electricity production will be:

- 10,147MW of wind
- 7,842MW of PV
- 1,710MW of biomass
- 7MW of hydro

This large increase of variable renewables in terms of electric capacity highlights the importance of finding accurate storage solutions to secure a reliable and flexible system. In these terms, the clear mention of the NECP that "it is an objective to support structures

that favour demand response and energy storage markets"[38] could open interesting opportunities for CST technologies in Denmark, even though the district heating sector seems to be the favoured option.

According to the NECP, "Solutions regarding energy storage will also be promoted concretely through an Energy storage fund of 128 million DKK. In December 2019 money was granted to two Power-to-X-projects. The projects will establish big scale production and storage of green hydrogen. Both projects have an ambition to demonstrate production and consumption of green hydrogen on near market based conditions."[39] The focus on hydrogen also represents an opportunity window for the development of concentrated solar thermal technologies in the country, or its import.

In terms of GHG emissions, Denmark aims to reduce them by 70% by 2030. Aware of how ambitious this target is, the government stated within the NECP that this challenge will require "currently unknown methods"[40].

3.3.1.3 DECO19[41]: A scenario for 2030

DECO19 is a baseline scenario projection towards 2030 by the Danish Energy Agency, based on existing measures. One upcoming measure, if carried as planned, could be beneficial for the CST technology sector, namely the technology-neutral tendering rounds (2018-2024). The tendering rounds can be interesting if storage appears as a distinctive feature in the tendering process.

Denmark also plans to reduce the electricity tax for some businesses to the EU-minimum level and has set up a special task force to analyse possibilities to optimise the tariffs and tax regime to favour demand side management and flexible energy consumption. It would be interesting to have more information from EFKM regarding this task force. Incentives for renewables, manageability and flexibility might open the door for storage and heating processes offered by CST technologies.

In terms of energy consumption, the DECO19 foresees an annual increase of 0.4% of the final energy consumption, while the gross energy consumption would remain around the levels of 2017. Denmark's main source of increased consumption would come from data centres, according to the projection, which also opens the question of waste heat recuperation. This would represent an annual increase of 3% of electricity consumption.

Electricity generation will mainly be provided by wind power, and the share of RES in electricity consumption should exceed 100% from 2028 on, to reach 109% in 2030, as can be seen on Figure 9. Denmark is thereby expected to become a large net exporter of

[38] *Ibid., p. 64*

[39] *Ibid. p. 112*

[40] *Ibid., p. 29*

[41] *All references in this section, except when explicitly mentioned, are taken from the Danish Energy Agency, Denmark's Energy and Climate Outlook 2019, October 2019, DEA website [online]*

electricity. If no new measures are implemented, net exports of electricity could constitute 12% of electricity production in 2030.

However, achieving these shares highly depends on the phase out of large-scale coal-fired and small-scale gas-fired CHP. Natural gas consumption for production of electricity and district heating will be divided by almost four by 2030, while coal consumption will be divided by 12. All in all, the total final consumption of fossil fuels by 2030 for electricity and district heating production should decrease by 85% compared to 2017.

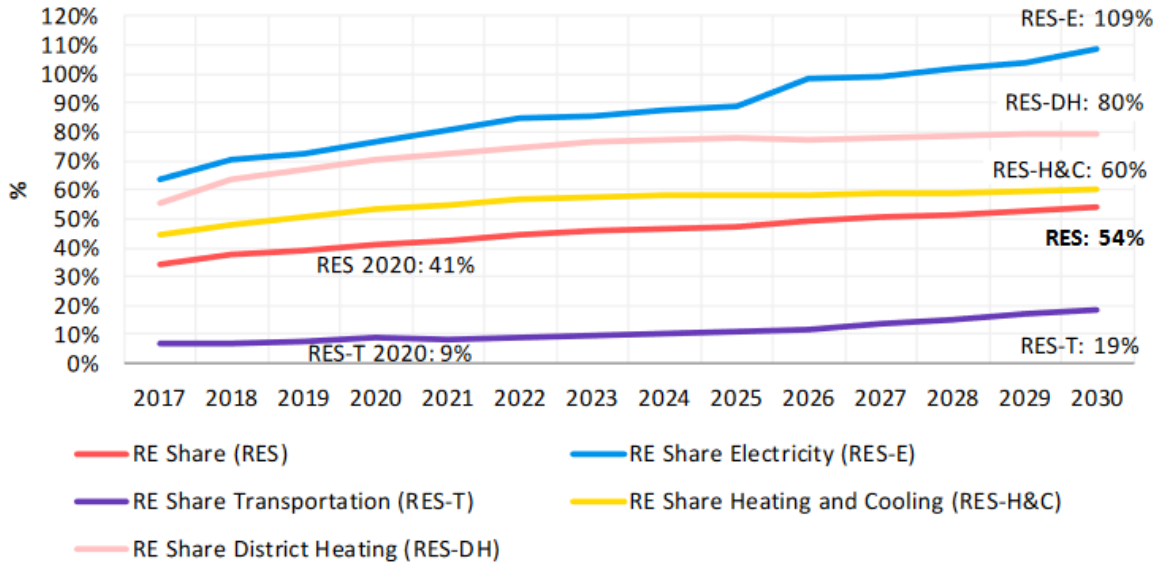

Figure 9: Renewables shares 2017-2030

Industry and services are expected to still be fossil fuel consumers by 2030, as shows Figure 10, while renewables would just represent 13% of the final energy consumption of these sectors in 2030. More than ¾ of this is expected to be used for medium- and high-temperature process heat in 2030.

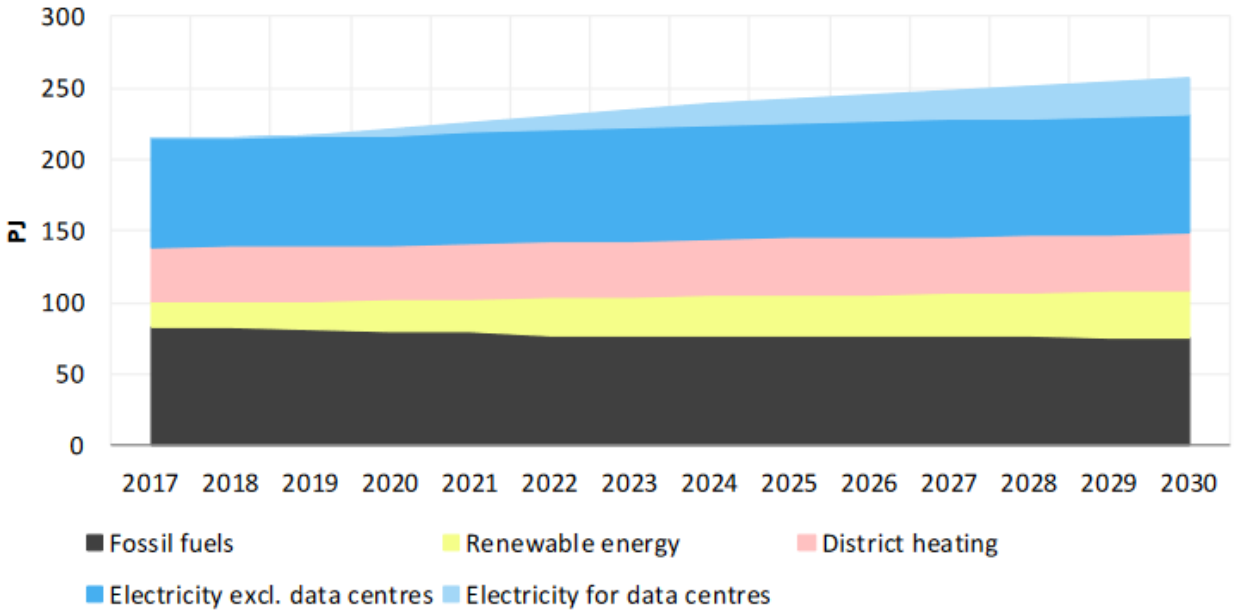

Figure 10: Final energy consumption by industry and services (2017-2030)

In terms of fossil fuels, Denmark is still counting on natural gas to favour its energy transition, in particular for hard-to-abate sectors. The country aims to produce renewable energy gas in the form of bio-natural gas. This means that biogas would be upgraded through blending with natural gas. At the same time, the consumption of coal is expected to be reduced by 90% in 2030 compared with 2017.

These forecasts, if actually unfolding, would put the question of storage at the heart of the Danish energy policy, as well as the problematic of heating. These two opportunities would have been further explored if ESTELA could have had meetings with the EFKW or the DEA.

3.3.2 Energy regulation in Denmark: towards new regulations for further renewable penetration

Forsyningstilsynet, the Danish Utility Regulator (DUR), supervises the electricity, gas and district heating utility sectors. It is currently working on an anthology on "Energy Regulation in the Green Transition", which should support a continuous reflection on the improvement of a regulation in line with an inclusive green transition[42]. Energy savings remain a priority in terms of actions for the DUR.

According to its NECP, Denmark aims to develop a new market model, with an improved regulatory framework, based on renewable energy sources in the most cost-efficient and

[42] *Source: DUR, "T he Danish Utility Regulator launches anthology project with prominent researchers on energy regulation and the green transition", Press release, 15 June 2020*

innovative ways[43]. It also aims to take into account all challenges which such a model, largely based on renewables, triggers, in particular the question of secure systems and flexibility. The Danish electricity market is open for participation from renewable energy, demand response and storage, including via aggregation.

In this new framework, the DSOs would be granted the role of "neutral market facilitators", through demanding flexibility. The country is thus aware of the importance for the market to accurately and adequately remunerate this characteristic of flexibility, as well as of the need to take into account the "rights and responsibilities of new players that may create value and provideflexibility in the electricity market"[44]. These changes are foreseen for the end of 2020.

Regarding tendering, Denmark started with technology specific support but is now involved in more multi-technology tenders, embracing a market-based approach. After a first wave of offshore wind tenders, as mentioned previously in 3.3.1.2, new technology neutral tenders are expected between 2020 and 2024, including wave and hydropower technologies.

Electricity will be further incentivised, so that its use is promoted over the use of other energies, especially for the heating sector. This includes support to biogas until the end of 2020, when:

- used to produce electricity or heat
- upgraded to biomethane
- used in hard-to-abate sectors (transport and industrial processes).

Solid biomass has also received strong incentives, in partiuclar for the retrofitting of coal and gas power plants. Since April 2019, three new support schemes were introduced:

- A fixed premium is maintain for existing non-depreciated installations, through the depreciation period
- A fixed premium has been introduced to support depreciated installations, based on the operating cost difference between the use of biomass and an alternative fossil reference
- A grant pool has been established for new installations and gives the possibility of aid to new capacity for the production of electricity through green gases

These current perspectives and priorities do not seem to leave many opportunity windows open for the development of CST technologies in the country. The use of technology neutral tenders, as well as favouring biomass for the conversion of fossil plants would difficult the competition for this technology.

[43] *Danish NECP, p.69*

[44] *Ibid.*

3.3.3 Energy transmission system in Denmark: the role of Energinet

Energinet is the Danish TSO. It defines itself its mission as contributing "to converting energy systems with the aim of ensuring that citizens and businesses use renewable energy for everything, with a high level of security of supply and at an affordable price"[45]. It has a three-fold priority: renewable energy, high level of security of supply, and affordability.

Energinet focuses on developing offshore wind, which represents a huge, not yet enough exploited, potential (40GW), combined with onshore wind and solar PV. Energinet foresees storage and system balancing as a challenge for the 2020 decade. However, this challenge is also perceived as one of the five expected effects of this strategy, allowing to achieve 100% renewable energy while ensuring security of supply. Four opportunities will be the focus of Energinet in the upccoming years:

- Sector coupling: use of green gases and conversion of electricity to hydrogen, heating and renewable energy based fuels to decarbonise sectors such as agriculture and transport
- Large-scale offshore wind power: this would contribute to achieve the global European targets
- Solar and wind power on market terms: new solutions will be needed to take the most out of the further development of renewables
- Collaboration with society: new infrastructures and technologies will be needed to accompany the green transition.

Regarding the need for new infrastructures, Energinet currently operates seven, amongst which five are related to electricity interconnections:

- Viking Link, interconnecting Denmark and Great-Britain, to be commissioned by December 2023 and allowing the countries to share up to 1.4GW of electricity. It is recognised as a PCI
- West Coast Line, to be commissioned by 2023, will interconnect Denmark and Germany with a 400kV double circuit, is linked to the Viking Link project and is also part of the PCI list
- Kassø-Frøslev, a 400 kV overhead line PCI project between Denmark and Germany, which will allow to increase the transmission capacity at this border up to 2500 MW. It should be operational by the end of 2020
- Kriegers Flak - Combined Grid Solution, the first offshore interconnector, should be operational at the end of the summer 2020. It will combine three wind farms, totalling a capacity of 936MW
- Cobracable, commissioned in 2019, interconnects Denmark and the Netherlands by connecting the 400kV AC grid to the DC cable

[45] *Energinet, Strategy: Winds of Change, December 2019, Energinet website [online]*

Energinet is also currently investigating the conditions for the construction of a new offshore farm, Thor, with a minimum capacity of 800 MW and maximum 1000 MW. It should be operational by 2027.

The priorities of the Danish TSO take into account the necessity of developing storage, to face the increasing share of variable renewables in the energy mix of the country. However, as already mentioned in the 3.3.1 section, it may be hard for the CST sector to find an entry point here, if no support or interest from the main industrial players or policy-makers is shown.

3.3.4 Industry: heat applications as a success

Aalborg CSP is a Danish company involved in CSP projects around the world and specialised in the storage of energy. It has used its know-how to offer innovative solutions for disctrict heating in Denmark. With a solid R&I implication, Aalborg CSP has also further developed the Thermal Energy Storage technology, to store wind and solar energy "at the lowest possible cost"[46].

Because of these characteristics, ESTELA deemed Aalborg CSP as a very relevant interlocutor to gather information on the Danish energy needs and potential for further development of CST technologies, in particular storage. Aalborg's experience shows that doors could be open in the Danish market for some parts of the CST technology value-chain, in particular regarding district heating and decarbonisation of the industry sector.

However, despite several mail exchanges and one phone contact, no relevant information could be exchanged. ESTELA was redirected towards the Spanish branch of Aalborg CSP, which was not relevant in this frame. When it came to market information and contact details, no apparent interest in sharing contacts was shown without a tangible benefit in return.

3.4 *Expected next steps*

The most detrimental effect on our research was the lack/level of response by the local company and entities in Denmark so far, in spite of our best efforts to explain the purpose of the project H-STE.

The next step would consist in updating and possibly extending the reported first assessments so far via renewed inquiries for interviews especially via the Danish representative in the SET Plan Steering Group.

[46] *Aalborg CSP website, "About Us" section.*

3.5 *Glossary*

CSP	Concentrated Solar Power
CST	Concentrated Solar Thermal
DEA	Danish Energy Agency
DUR	Danish Utility Regulator
EC	European Commission
EFKM	Danish Ministry of Energy, Utilities and Climate
ENTSO-E	European Network of Transmission System Operators
EU	European Union
FiT	Feed-in-Tariff
FiP	Feed-in Premium
GJ	Giga Joules
GWh	Giga Watt hour
H2020	Horizon 2020
kWh	Kilo Watt hour
LCOE	Levelised Cost of Electricity
MS	Member States (EU)
MW	Mega Watt
MW_e	Mega Watt of electricity
MW_{th}	Mega Watt of thermal energy
NECP	National Energy and Climate plan
PPA	Power Purchase Agreement
PV	Photovoltaic
R&D	Research and Development
RES	Renewable Energy Sources
SET-Plan	Strategic Energy Technology Plan
STE	Solar Thermal Electricity
TES	Thermal Energy Storage
TSO	Transmission System Operator
TWh	TeraWatt hour

3.6 Appendices

3.6.1 Reference

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Industry

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