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Implementation of the
Initiative for Global Leadership in
Solar Thermal Electricity

Integrated Country Report

Deliverable 2.3

WP 2 & 3: **Industry / R&I Impact Maximisation**

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HORIZON STE

Implementation of the Initiative for Global Leadership in Solar Thermal Electricity

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This report should be cited as:

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

DISCLAIMER

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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 Integrated 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 task 2.4., corresponding to "Integrated country/regional reports (combined R&I and industry perspective)". 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 on 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 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 D.2.3., "Integrated Country Report" combines industry and R&I perspectives, based on D.2.2. "Draft Country Report Industry Perspective". It displays first findings in terms of policy recommendations and first solutions to improve funding mechanisms and industry/trading opportunities.

Once finalised with each country profile, this integrated 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. At the moment, only Turkey compiles both the industry and research perspectives. The next version of this deliverable will be updated with additional countries.

1 Chapter 1: Turkey

Turkey is the first country to be under the scope of HORIZON-STE. The following chapters will describe the work undertaken in Turkey and analyse the challenges and opportunities met in the country.

1.1 Structure of the document

The deliverable D2.2. “Draft Country Report” is presented here in its broader version (D.2.3.) as an “Integrated Country Report”. It aims to provide a first global and structured approach of the different country profiles regarding potential interest to STE, from funding mechanisms to commercial purposes.

The present document takes into account the relevant information gathered during the main phases of WP2 and WP3 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
- The construction of a defined framework for funding and its reception by relevant audiences
- The evaluation of performance of the funding frameworks

Part 1.2 summarises the tasks which were carried out, both on the R&I (1.2.1) and industrial (1.2.2) sides. 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:

- Proposition of a reshaped funding framework based on feedback from stakeholders and the Implementation Working Group (IWG)
- Dissemination of information about the funding opportunities and impact evaluation
- 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 events and joint industry-R&I national events

A deeper analysis of the context of each country is provided in 1.3, first for the research part (1.3.1) and then for the industry (1.3.2). Each of these sections provides a global overview of the different factors influencing the development of funding and commercialisation of STE applications. More precisely, it aims 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, for both research and industry. They highlight encountered challenges and existing opportunities and finally draws a picture of the potential synergies between R&I and industry structures.

Last but not least, section 1.5 suggests strategic actions to continue opening doors for STE in Turkey, from a research and then industrial point of view. It finally offers an overarching approach to further support the development of STE in Turkey, combining R&I and industry perspectives to offer thorough advice.

1.2 Summary of undertaken activities

1.2.1 R&I-Methodology

To understand the current situation in Turkey in both global context and European context, we made a qualitative analysis of expert interviews and quantitative analysis of bibliometrics.

In **qualitative analysis**, the motivation is to understand the current situation in CSP/STE Research & Innovation and Industrialization & Marketization in Turkey from key experts' perspectives. The technique used was qualitative semi-structured interviews. These interviews were conducted with the key experts in the sector since the primary sources of data were the key actors' perspectives, experiences, approaches, beliefs and functions (Patton, 2002). The sampling strategy was "purposeful sampling" to pick the information rich cases in the population, and snowball sampling to go to the corresponding experts referred by the former informant (Patton, 2002; Flyvbjerg, 2006).

We conducted (in Turkish) 14 semi-structured interviews with the researchers and professors at universities and research centres (5 interviews); company owners, entrepreneurs, consultants and service providers from industry (5); bureaucrats and regulators in public sector (3), and non-profit organization (1) on face-to-face base in Istanbul and Ankara, and via phone calls & video conferences. We completed interviews between November 2019 - January 2020. Also, we accompanied ESTELA Team's meetings in Ankara and exploited the opportunity of benefiting from the discussion in these meetings. We used a general interview guide which included six sections of

- Introduction and Actor Profile (understanding of the global energy and renewable energy situation per stakeholder)
- Current Situation (to understand the global landscape of Turkey regarding energy policy)
- Opportunities and Threats for Diffusion of CSP/ STE Technologies (to understand the diffusion process)
- Market (to understand the marketization and industrial dynamics)
- Policy (to determine the potential needs for manageable RES and the strategy developed by the government and the main stakeholders regarding energy and renewable energy)
- Future Expectations & Foresights (Potential challenges and foresight about the CSP/STE technology development & deployment).

Each interview is recorded and verbatim transcribed by the project assistants. The raw data text is analysed, the findings are presented by grouping the quotations and derivation in eight different categories, and the main findings are reported by referring to these categories.

In **quantitative analysis**, the motivation is to measure the research performance in CSP/STE Research Field. Bibliometrics, by OECD Glossary of Statistical Terms[1], is defined as the "statistical analysis of books, articles, or other publications". The bibliometric analysis includes[2]

- collecting data on scientific articles and publications classified by authors and/or by institutions, fields of science, country, topics, keywords, titles etc., to construct indicators for measuring academic research,
- to identify & understand the dynamics of research networks, and to map the development of new research field. Bibliometric research is performed through the uses of indexes like Web of Science or Scopus.

In this study, a small panel that consisted of METU Horizon STE Project Team identified keywords that were relevant for Concentrated Solar Power and Solar Thermal Energy Research. The keywords to grasp the main frame in the Turkish Case are "concentrated solar power", “concentrating solar power”, “solar thermal electricity”, “solar thermal”, “thermal energy storage”, and “solar heat for industrial process”. Using these keywords, we conducted a search in the Web of Science™ Core Collection database to create our data set of Turkish Researchers.

Web of Science is a website and research engine that delivers publication and research measurement indicators (such as citations) data from different disciplines[3]. We scanned Web of Science (WOS) Database by searching our keywords in the TOPIC Area[4] for Turkish Case. By this search, you can find the articles which have the specific keywords in "Keywords", "Title" and "Abstract" sections of the article. As of May 2020, our search retrieved 483 publications indexed in the Web of Science ™ Core Collection that had at list one co-author affiliated with a Turkish university or research institute. Of the 483 publications, 429 were tagged as articles and 57 as proceedings.

Visualization of connections between authors, institutions and countries are constructed using VosViewer (http://www.vosviewer.com) and CiteSpace (http://cluster.cis.drexel.edu/~cchen/citespace) visualization tools, which are freely available software for bibliometric studies. The results of the bibliometric study are described by using these graphs and visual maps (Aydınoglu & Taskin, 2018).

[1] *You can have detailed information from: https://stats.oecd.org/glossary/detail.asp?ID=198 (Last access: May 05, 2020)*

[2] *You can have detailed information about bibliometrics as a research method from https://instr.iastate.libguides.com/c.php?g=49332&p=318077 (Last access: May 05, 2020)*

[3] You can reach detailed information about Web of Science from https://clarivate.com/webofsciencegroup/solutions/web-of-science/ (Last access: May 05, 2020)

[4] *You can make article search from WOS Database by using Topic, Title, Author, Publication Name, Year Published, Funding Agency etc.*

<table>
<tr><th>List of activities</th><th>Timeline</th></tr>
<tr><td>Background research</td><td>Phase 1
June- October 2019</td></tr>
<tr><td colspan="2"><u>Aim:</u> To collect relevant information to understand better CSP/STE Landscape in Turkey, the current situation, potential development paths and challenges for the development of CST & to define and determine the main actors and stakeholders in the sector for stakeholder mapping and country report interviews.</td></tr>
<tr><td colspan="2"><u>Description</u>

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, direct contacts with the experts

Identification of Contacts for Stakeholder mapping: Analysis of the specific relevant departments and actors for each identified target group to gather information and contact details of the stakeholders, listing the stakeholders and gathering contact information and consent to be interviewed.</td></tr>
<tr><td>visits</td><td>Phase 2:
November 2019 – January 2020</td></tr>
<tr><td colspan="2"><u>Aim:</u> To generate data through expert interviews
• to determine needs in the renewable energy sector in Turkey
• to have feedback on scientific, political, economic and social factors affecting development and diffusion of CSP/STE Technologies in Turkey
• to understand the current and future energy strategies regarding energy security and renewable energy sector in relevant framework conditions</td></tr>
<tr><td colspan="2"><u>Description of the Stakeholders:</u>

Researchers
• Prof. Dr. Halime Ömür Paksoy from Cukurova University, Dep. of Chemistry, Turkish Delegate& Representative of International Energy Agency Energy Conservation through Energy Storage Technology Collaboration Program (IEA ECES TCP).
• Prof. Dr. Uner Colak from Istanbul Technical University, Institute of Energy, Head of Renewable Energy Division.
• Prof. Dr. Hakan Erturk, Bogazici University, Dep. of Mechanical Engineering, Head of Thermal Energy Systems Laboratory.
• Prof. Dr. İskender Gökalp, TUBITAK 2232 Leader Researchers Grant Programme holder, hosted by METU</td></tr>
</table>

	Mechanical Engineering Dep. And Emeritus Professor of French National Centre for Scientific Research/CNRS. • Prof. Dr. Pınar Menguc from Ozyegin University, Center for Energy, Environment and Economy
Public Sector.	• Head of Planning and Investment Department of TEIAŞ (TSO of Turkey) • Head of Department of Energy Efficiency and Environment / Energy Advisor to the Minister, MENER • Head of Renewable Energy Department of Energy Market Regulatory Authority
Private Sector/ Companies	• TEKFEN Co (investors in CSP /STE Energy Solution and SHIP R&D activities, project team member of H2020 Projects in CSP / STE) • Zorlu Holding (investors in CSP/STE Energy Solution and SHIP R& D activities, investors in a geothermal power plant in Turkey) • Emerson Co. (International Co. for Automation Solutions of Power Plants including CSP / STE & enter Turkey to exploit the opportunities in CSP Sector in Turkey and MENR Region) • Serdar Erturan, Entrepreneur of the First CSP Plant in Turkey (Greenway Co. And NYU) • GKE Energy (having R&D Centre for Energy Solutions in Turkey, Consultant and service provider for energy investments in Turkey and MENR Region)
NGOs	• SHURA Transition Centre (An NGO directly involved in Transition of Energy Sector and Sustainable Solutions to Energy Problems in Turkey in the international context)

BIBLIOMETRIC ANALYSIS	**Phase 3:** February 2020-May 2020
<u>Aim:</u> To collect data for scientific research base in CSP/STE by measurement of research performance through publication search.	
<u>Description:</u> By using relevant keywords (approved by the experts), full-text article search in the Web of Science™ Core Collection and reporting the data by using visualization and graphical tools. Data Set: Publication search by using "concentrated solar power", “concentrating solar power”, “solar thermal electricity”, “solar thermal”, “thermal energy storage”, and “solar heat for industrial process” keywords to understand Turkey’s research performance (as of May 2020, app. 500 publications are found).	

Further Step: Publication search in European Context which provides current situation analysis and comparative analysis for research performance of EU countries involved in the project & CSP / STE Research by using a set of keyword encompassing a wide range of research activities in CSP / STE (such as Solar Thermal Storage and Thermal Energy Storage)

1.2.2 Industry

1.2.2.1 Foreseen activities and implementation challenges

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

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

1.2.2.2 Carried out activities

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

<u>Aim:</u> 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.

<u>Description</u>

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

<u>Aim:</u> 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.

<u>Description</u>

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 First observations

1.3.1 R&I landscape:

<u>In qualitative analysis,</u> we conducted fourteen interviews with *industrial stakeholders* such as company owners, investors in technology development activities for SHIP applications, service supplier and entrepreneurs; *researchers* conducting cutting edge research in the CSP / STE Research and Sustainable Transitions in Energy Sector; high

level bureaucrats from the public sector at Ministry of Energy & TSO and a civil society representative. We try to understand existing political, legislative, institutional, scientific, social and economic environment in Turkey for development, diffusion, industrialization, commercialization and implementation of CSP/STE Technologies. For this purpose, we examined the interview transcriptions and grouped quotations and derivations under six headings to describe and report the main findings. These groups are:

1. Technology Development & Domestic Production
2. Industrialization of the research
3. Implications of CSP / STE Technologies (Hybridization and SHIP)
4. Storage and Integration of CSP to Energy Sector
5. Supports & Incentives for Development & Diffusion
6. Political & Legislative Framework
7. Problems and Threats
8. Future of the Technology & Foresights

For current situation of Turkish Energy Sector and CSP/STE Technologies and Implications in the sector, referring to above mentioned categories, we can derive following main findings by using the briefs of information given by the interviews:

- ✓ *There is robust research infrastructure & qualified cutting-edge research in the area for technology development and domestic production of the equipment*

In Turkey, the research capabilities and skills in basic science (such as Physics and Chemistry) and Engineering Departments (Mechanical, Electrical & Electronics, Environmental and Chemistry Engineering) are very strong, the researchers are experienced, and well-integrated to global and European context via strong link. Also, Turkish Industry has long history in energy technologies and has capabilities to make domestic production. Domestic production and in-house technology development and implementation are very critical for Turkish Energy Sector as being targeted by the National Energy Strategy based on “domestic production, energy security, decreasing import dependency and foreseeable markets”.

- ✓ *Commercialisation and industrialisation of the research*

The links between companies and the research conducted in universities are loose. Most probably, this is due to Turkey’s R&I eco-system especially in CSP /STE Research being weak. A new trend in the Turkish energy landscape started approximately in the 2000s due to increasing energy demand, increasing import dependency for fossil fuels, debates about energy security and self-sufficiency, and a desire to supply energy needs quickly. This trend brought motivations towards using renewable energy sources in energy generation more than before. As the saturation in wind energy and PV solar is experienced, new technologies and sources will come to fore (as geothermal, concentrated solar thermal, biomass….). If this new trend can be absorbed by the private sector (the leading investors in energy generation in Turkey) as in case of PV after 2015; CSP /STE would be a new rising trend in Turkey. Here commercialisation of the research is significant since this is a new sector and directing it in the right direction with robust and reliable grounds would be the key to success. For this purpose, university-industry relationship and its nature would be one of the critical points in R&I part of the report.

- ✓ For companies Solar Heat for Industrial Processes (SHIP) is promising and variation of i*mplications for CSP / STE Technologies including hybrid solutions and power plants are the promising areas for development and diffusion of CSP / STE Technologies.*

Here the main emphasis is on go small and supply the energy needs of companies by their facilities and sources. SHIP is crucial for the companies who can integrate it into their production facilities, and which have available and appropriate location for such SHIP investment (both in terms of DNI and region of production). Energy cost is increasing day by day in Turkey. Electricity is becoming more expensive even in industrial production, which was subsidized at high levels in the past, but not anymore.

- ✓ CSP is a solution for the problems of renewable energy storage and supply security

Being a solution to storage and supply security problems is an essential advantage of concentrated solar power technologies and not very well known or appreciated. This is mainly because of not knowing the technology completely. Diffusion of technology and increasing awareness about the benefits of this technology are very critical. New suggestions should be made, and new models should be built to promote this diffusion. Complementary and hybrid solutions to the energy problem are preferred. Hybridization rather than the individual CSP power plants are the key for diffusion.

- ✓ Integration of both industry and university to EU Research Networks

EU Research networks are secure, and Turkey's inclusion in these networks are becoming stronger. This brings natural boundaries (and also constraints) for Turkey's research activities. Again, this well-structured integration can be exploited to build the concentrated solar power sector in Turkey and transfer the knowledge, technology and industrialization base to neighbour countries through Turkey. Also, industrial integration is very critical, and companies in Turkey have that vision to integrate into European networks.

- ✓ There is an established Political and Regulatory framework for Renewable Energy in Turkey. However, the Support Mechanisms such as YEKA and YEKDEM should be updated to support diffusion. Additionally, for secure and progressive technology development and implementation, there is a Need for political stability for investment decision

In Turkey, political structure and the regulatory documents are established, following the new trends and needs in the sector. Politicians can regulate the industry with close relations and continuous updating after following the links. This is a result of structural change in the role of the state in the energy sector. This brings flexibility in connections. On the other hand, policy makers cannot respond quickly to urgent needs to provide sustainability of the system. However, this is still an experimentation period and structural change still continuous. This would be turned to an advantage for CSP/STE to exploit the new opportunities in the energy sector with changing consumption, production and regulation patterns.

For the energy investments in Turkey (especially coming from abroad) political stability in the country is seen very important. This can be promoted by the direct motivation of political landscape towards RE and CSP/STE. The investors (both foreign and domestic) are looking for support for this new technology. We are also trying to build this support via networking, lobbying, being a strong participant to EU Research Networks (both funding programs and EUSOLARIS ERIC).

- ✓ For future of the technology, Energy Mix including Renewable Energy and SHIP implications would be main focus.

Energy Mix is directly related to Turkey's primary energy policy of energy security and decreasing import dependency. To exploit domestic renewable energy sources, hence decreasing import dependency energy mixing solution and SHIP implications in local industrial production facilities would be the main focus. Since Turkey has a robust research base and high application and implication potential for this technology, CSP is a low hanging fruit for both researchers and industrial partners.

In quantitative analysis part, namely "the bibliometric analysis of Turkish scholarly research on CSP", we generated data to understand the general landscape in CSP research in Turkey. A small panel that consisted of the METU Horizon STE Project Team identified keywords that were relevant to the project: "concentrated solar power", "concentrating solar power", "solar thermal electricity", "solar thermal", "thermal energy storage", and "solar heat for industrial process". On May 6, 2020 we conducted a search in the Web of Science ™ Core Collection database to create our dataset. Our search retrieved 483 publications indexed in the Web of Science ™ Core Collection that had at list one co-author affiliated with a Turkish university or research institute. Of the 483 publications, 429 were tagged as articles and 57 as proceedings. The CSP / STE research started to take off in the early 2000s and even though there were some setbacks, the overall trend demonstrates that Turkish researchers are publishing more CSP related research – in two decades it reached to more than 50 publications per year (Figure 1).

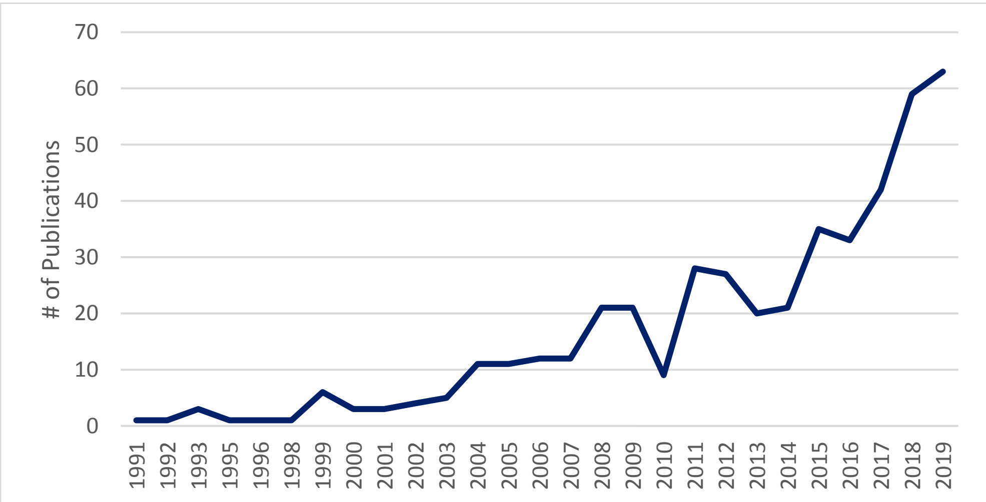

Figure 1: Annual number of publications

Figure 2 provides the name of the most scholarly productive researchers in Turkey. Here the indicator is the number of publications per author[5]. Ahmet Sari (Karadeniz Technical University & King Fahd University of Petroleum Minerals) with 99 publications on top of the list. Cemil Alkan (Gaziosmanpasa University) with 58, Kamil Kaygusuz (Karadeniz Technical University) with 40, Ali Karaipekli (Cankiri Karatekin University) with 35, Alper Bicer (Gaziosmanpasa University) with 34, and Halime Paksoy (Cukurova University) with 25, and Yeliz Konuklu (Omer Halisdemir University) with 24 publications are among the other researchers in the list. There is one name that is not affiliated with Turkish organizations, Ibrahim Dincer of Ontario Technical University; however, as he is listed as a coauthor in 25 of the 483 publications, his name pops up in the treemap.

Figure 2: The top-25 co-authorship Treemap

In Figure 3 the co-authorship collaboration networks are visualized, with each network being identified with a different colour. As communicated by Figure 3, the most active authors (Halime Paksoy, Ahmet Sari, Cemil Alkan, Kamil Kaygusuz) are at the centre of a small network, and these smaller networks are linked to form a larger and dominant network. The authors outside this dominant network work in smaller and independent networks. In conclusion, the co-author collaboration networks can be described as consisting of a main network containing the most active authors, and a series of smaller networks that are both independent from the main network and from one another.

[5] *The impact of the paper is not evaluated here in this analysis.*

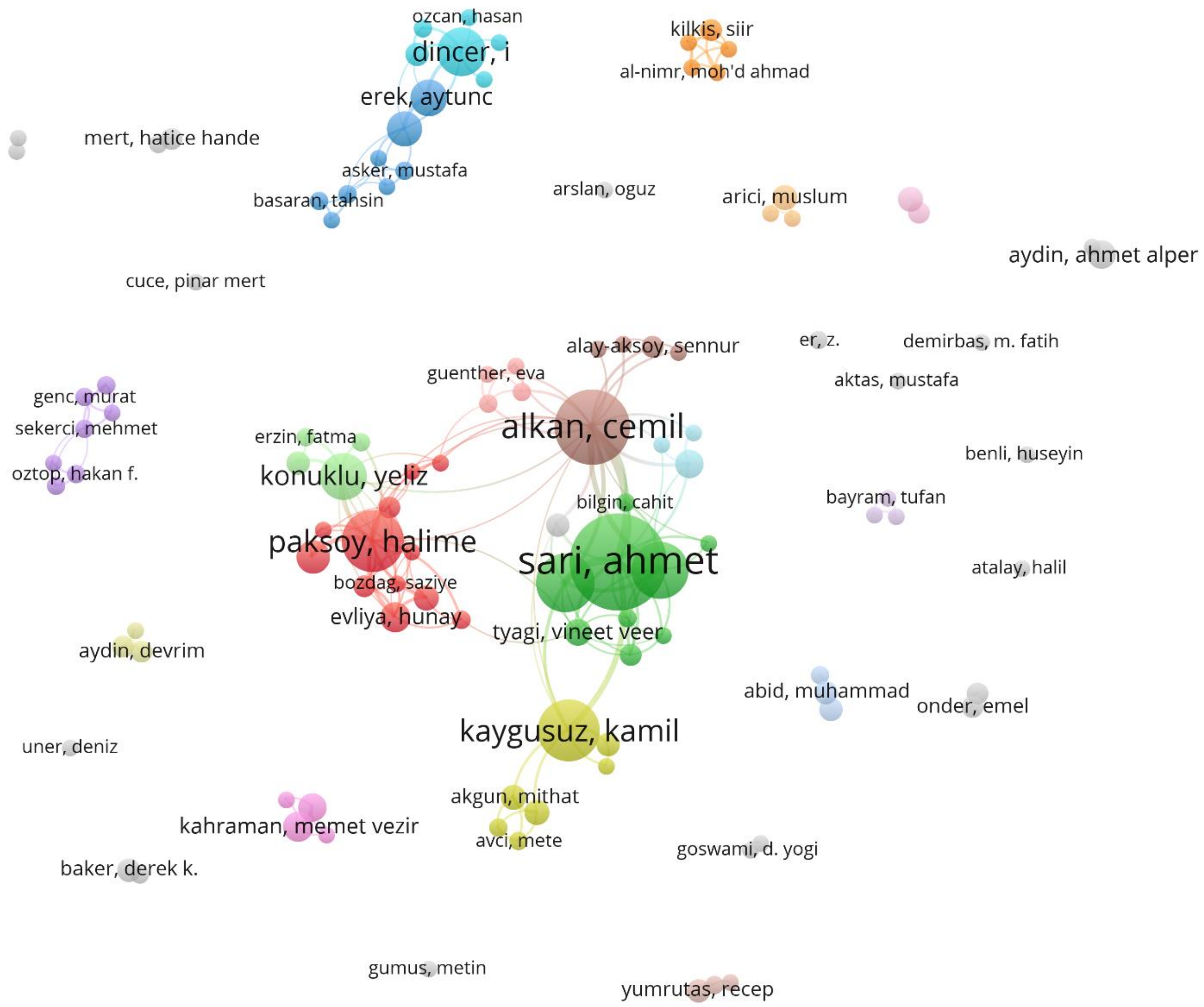

Figure 3: Coauthorship network (coauthors with a minimum of three publications, 113 nodes out of 768)

The number of publications or citations does not necessarily correlate with the total link strength of a node in the network. Here is the table for number of co-authored publications, citations received, and total link strength of the top 25 co-authors.

Author	Documents	Citations	Total Link Strength
Sari, Ahmet	99	6718	164
Alkan, Cemil	58	2947	121
Bicer, Alper	34	1491	80
Paksoy, Halime	40	1256	73
Karaipekli, Ali	36	3938	69
Kaygusuz, Kamil	40	1499	44

Konuklu, Yeliz	24	541	37
Evliya, Hunay	10	481	30
Dincer, Ibrahim	25	578	24
Ezan, Mehmet Akif	13	174	22
Turgut, Bekir	7	137	22
Al-Sulaiman, Fahad A.	5	104	19
Tyagi, Vineet Veer	8	369	19
Doguscu, Derya Kahraman	9	176	18
Erek, Aytunc	15	494	18
Mazman, Muhsin	5	349	18
Akgun, Mithat	7	321	17
Aydin, Orhan	7	321	17
Cabeza, Luisa F.	5	265	16
Sahan, Nurten	12	299	16
Uzun, Orhan	6	680	16
Basturk, Emre	9	25	14
Kahraman, Memet Vezir	10	25	14
Bozdag, Saziye	3	26	13
Hekimoglu, Gokhan	4	16	13

Table 1: Co-authorship network

As for the institutional collaboration, the affiliations of the most scholarly productive researchers are in the network. However, it is also possible to track their international collaborations in the network. Figure 4 below shows 59 organizations out of 236. In addition to Ontario Technical University and King Fahd University of Petroleum Minerals, Shri Mata Vaishno Devi University, University of Nottingham, Technical University of Munich, Universitat de Lleida, and University of Barcelona are among the important international nodes for Turkish Scholars in CSP/STE Research.

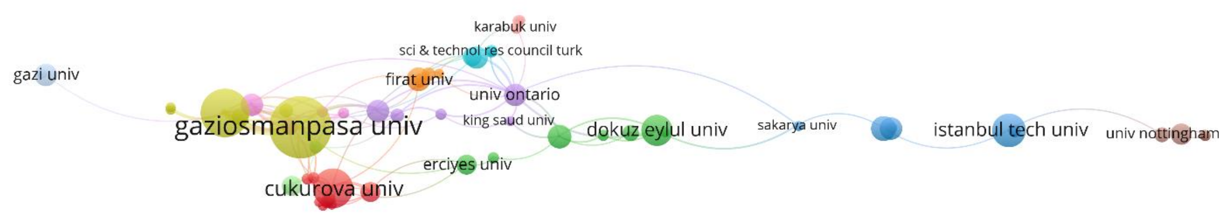

Figure 4: Organization network (organisations with a minimum of three publications, 59 nodes out of 236)

The collaboration at the country level can be seen in the Figure 5. Turkish researchers are collaborating with researchers from 39 different countries. Canada, Saudi Arabia, Germany, and Spain are among the most frequently collaborated countries where researchers are affiliated with.

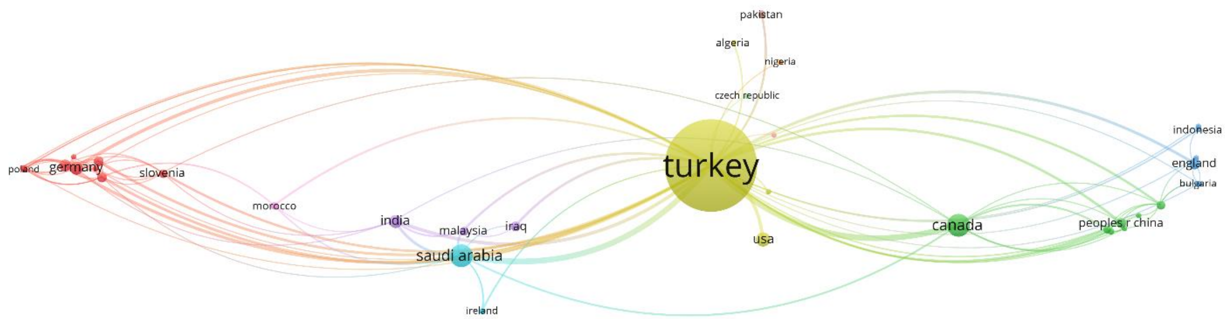

Figure 5: Collaboration at the country level (a minimum of one publication, 40 countries in total)

The funding for these researches comes from different sources as shown in Figure 6. The Science and Research Council of Turkey (TUBITAK) is the leading national funding source. Scientific Research Projects (BAP) are also important; however, as they are provided by the respective universities of the researchers, they are listed here with the university names. There is also international funding for some of the research conducted. European Union (6), Spanish Government (5), COST (4), Federal Ministry of Education Research – Germany (3), National Science Foundation – USA (3), Department of Energy – USA (3) and Natural Sciences and Engineering Research Council – Canada (3) are the other international funders.

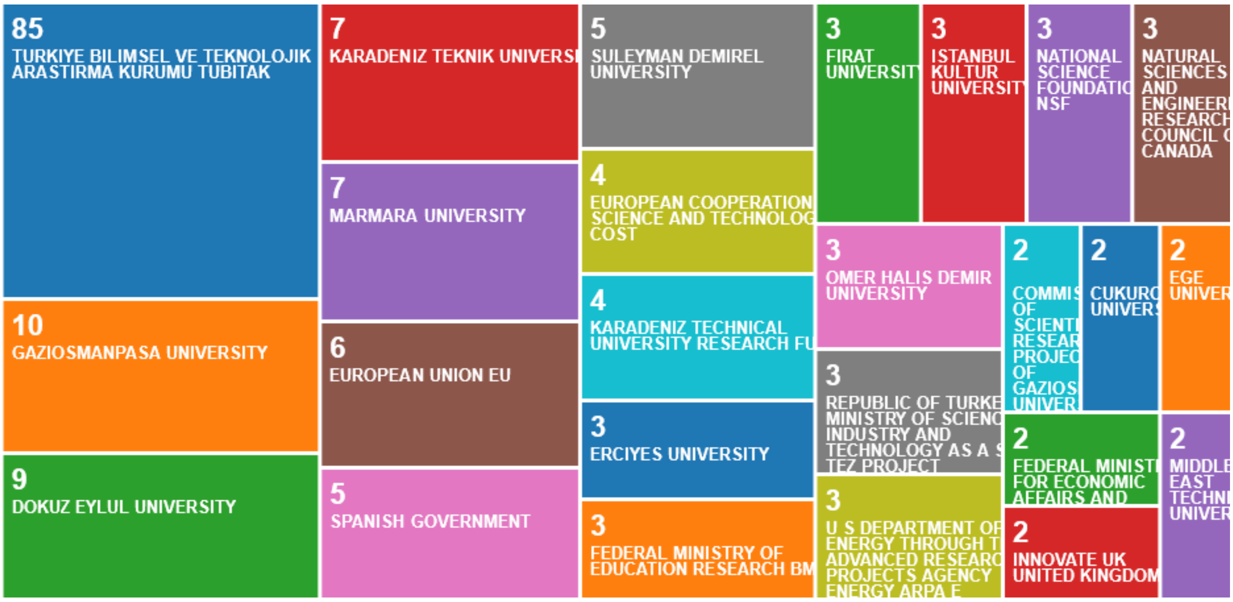

Figure 6: Top 25 funding sources

Figure 7 shows the research areas identified in our article search of CSP. It is apparently seen that the CSP research is quite interdisciplinary. Energy, chemistry, physics, chemical engineering, sustainability science, mechanical engineering, and environmental sciences are to name a few of these areas.

Figure 7: Research Areas related to CSP

A keyword map of CSP research (Figure 8) can also provide an insight to the interdisciplinary of the research. The co-occurrence network map provided below. There are eight clusters (each colour represents a cluster). As it is evident from the map, the keywords have been intertwined with each other. These keywords or phrases come from the titles, abstracts, and keywords of the 483 articles in our dataset.

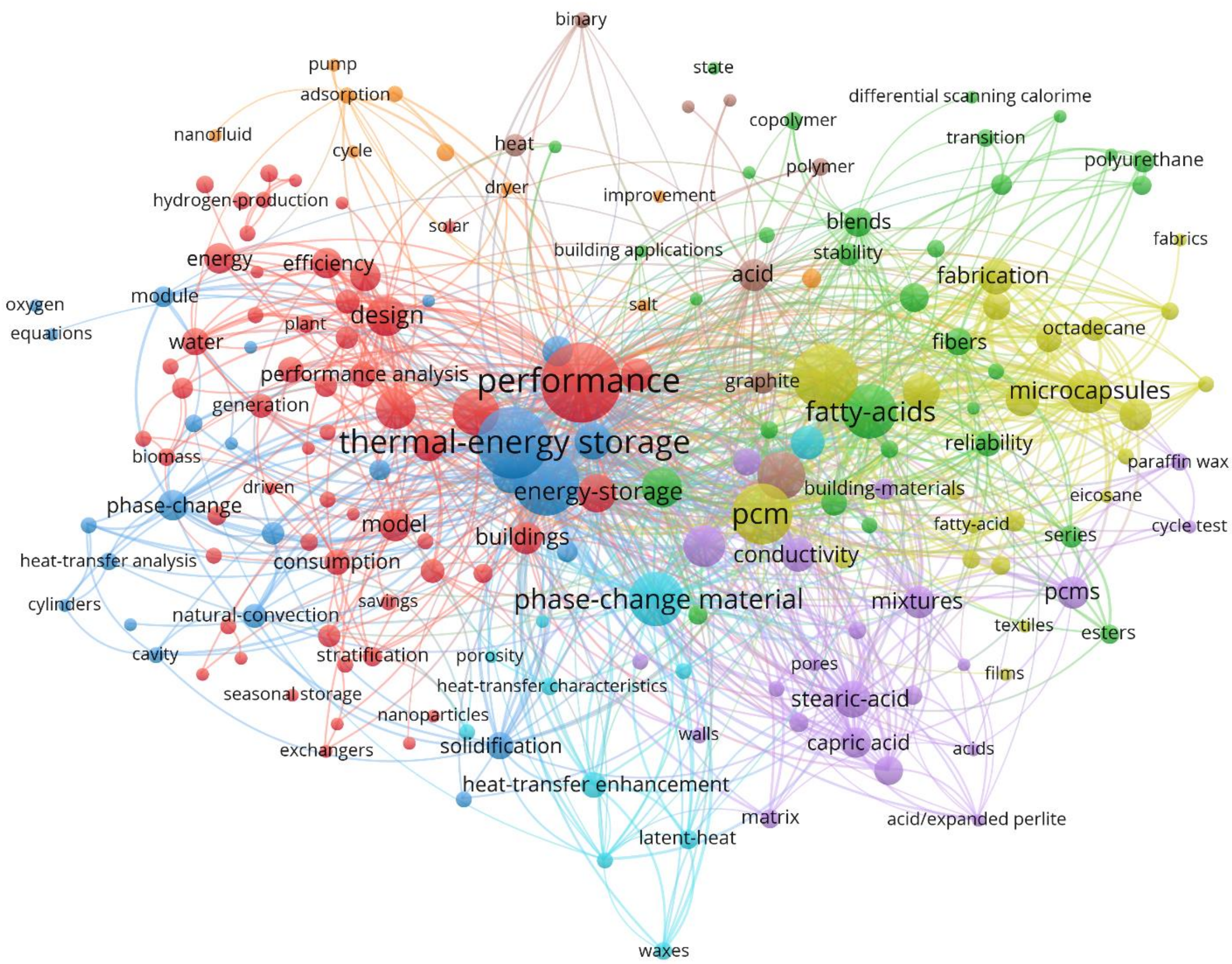

Figure 8: Keyword map (minimum three times, 187 keywords out of 812)

1.3.2 Overview of the context for industry

1.3.2.1 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[6]), of which 43.9GW of renewables[7]:

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

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

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

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 2: 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[8]:

- 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

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

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.

1.3.2.2 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 3. 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 3 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 3: 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[9] " 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."[10] "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

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

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

allowed. With the upcoming new hybridisation regulation[11], 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[12]. 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.

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[11] *See below for further description*

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

1.3.2.3 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.

1.3.2.4 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[13]:

- $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.

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

1.3.2.5 A big industry potential 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"[14], 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 an estimate of about 20-30 million dollars investment. In addition, the versatility of STE,

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

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

1.4.1 R&I

- There is robust research infrastructure & qualified cutting-edge research in Turkey for technology development and domestic production of the equipment.
- Commercialization and industrialization of the research in one of the most important aspects of the realization of the R&I activities.
- For companies, Solar Heat for Industrial Processes (SHIP) is promising, and variation of implications for CSP/STE Technologies including hybrid solutions and power plants are promising areas for development and diffusion of CSP / STE Technologies.
- Integration of both industry and university to EU Research Networks is seen as a critical gateway for local integration to global value chains and diffusion of technology.
- There is an established Political and Regulatory framework for Renewable Energy in Turkey. However, the Support Mechanisms specific to CSP /STE technologies and implementation should be designed.
- For the future of the technology, Energy Mix, including Renewable Energy and SHIP implications would be the main focus.
- The CSP / STE in Turkey started to take off in the early 2000s, and Turkish researchers are publishing more CSP related research. In the last two decades, it reached to more 50 publications per year.
- More than half of (63%) of CSP / STE related publications addressed Turkey is affiliated to 6 most productive scholars. Each of these scholars has more than 40 papers in the field. These researchers are affiliated to the Engineering Faculty and Arts& Sciences Faculty, and they have secure international and national networks that link them the nodes of most productive networks in the Country.
- The CSP / STE Researchers are tightly integrated to European networks via their collaboration with universities and research organizations in European Countries

(such as the University of Nottingham, Technical University of Munich, Universitat de Lleida, and the University of Barcelona) and funding resources of their published research (such as European Union, Spanish Government, COST, Federal Ministry of Education Research – Germany).

- CSP research in Turkey is quite interdisciplinary. Our bibliometric analysis pointed out that Energy, chemistry, physics, chemical engineering, sustainability science, mechanical engineering, and environmental sciences are to name a few of the research areas that contribute CSP / STE Research. This interdisciplinary can be seen in the keyword map that encompasses various keywords that are studied by different disciplines.

1.4.2 Industry

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.

1.4.2.1 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 4: First list of potential companies to actively contribute to the deployment of STE[15]

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

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

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 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.

1.4.2.2 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 unfolded 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 represent 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.

1.4.2.2.1 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 **Error! Reference source not found.** of this report), the use of STE a nd 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.

1.4.2.2.2 Heat as a primary need in Turkey

However, the short-term potential for CST to unfold in Turkey at the moment relies mainly 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), which 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[16] 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.

1.4.2.2.3 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 possibility of adding an additional source of power generation to an existing power plant without going through the licensing procedure.

[16] *See Error! Reference source not found. of this report*

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.

1.4.2.3 The general context indirectly influences the industrial canvas

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.

1.4.2.3.1 Fostering investment

The macroeconomic instability resulting from the global Covid-19 pandemic 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[17]:

- 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.

1.4.2.3.2 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 the previous section. The lack of investment triggers no further development of projects, the lack of project development does not influence a drop in the

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

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.

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.

1.4.2.3.3 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[18]. 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.

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

Turkey is still relying heavily on coal and shows interest in attracting foreign investors to further develop national coal exploitation [19]. Coal is still one of the prominent sources of fuel that can decrease the import dependency in Turkey's energy production, since 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. However, its existence can be seen as an opportunity for STE technologies: hybrid plants can be thought 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[20]. 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[21]. 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[22]. 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[23].

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.

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

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

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

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

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

1.4.3 Integrated findings

Following a close monitoring of the situation in Turkey from both the research and the industry sides, key integrated observations can already be seen as pillars for joint conclusions and recommendations.

1.4.3.1 Turkey is favourable to renewables, but further consistency in energy policy should be sought for

- Two important dimensions must be accounted for when designing a RES project: opportunities for domestic production (including national production of components), and the use of national resources (aka existing technological and academic knowledge). However, the domestic/local production is not yet at the desired levels in energy technologies: this leaves an open door for future RES development, in particular for STE, as academic research is already well advanced.
- There is a lack of interdisciplinary and transdisciplinary studies. The development of a sustainable energy policy could be favoured by a co-benefit strategy that should be implemented for decreasing carbon footprint and global climate crisis.
- YEKDEM is a correct policy initiative for renewables, but the regulation should be more flexible to allow further diversified penetration.
- There is a problem with a system which does not favour any technology: by choosing to try and develop all, problems are caused and can hinder the development of adapted renewable technologies.

1.4.3.2 Contradictions in the market system do not favour sustainable investment

- Market formation is important in terms of liberal free markets: it influences the volume of investment in specific areas.
- In addition to financial crises, macroeconomic instability, and external factors such as a global pandemic, Turkey is also sending mixed signals to investors. By promoting investment at the same time in coal and in renewables, Turkey lacks systemic concepts in renewable investments. Renewables are treated as minor energy producing technologies as compared to coal for instance, which diverts potential investments and does not reassure investors.
- Subsequently, compact and shortened investment processes for investments in renewables also question the sustainability of investments after public incentives are ceased to exist.

1.4.3.3 However, the overall energy policy in Turkey is not opposing the development of renewable energies

- There is a bright future for all renewable technologies thanks to the YEKDEM system.
- The opportunities for hybridization and possibilities for incentives also participate in this opportunity window.

- Turkey experiences problems with the base load and is yearning for energy security. Renewable energies are local resources and offer minimum load problems. However, the balance of electricity supply is problematic, as well as productivity problems in renewables when mostly based on variable renewable energy sources.
- Hence the need to diversify the RES and turn towards dispatchable systems with storage.

1.4.3.4 The gap between research and industry should be closed

- Problems regarding commercialisation of research findings in universities have been observed: more interactions with the industry and demonstration studies are needed, to follow the needs of the industry to further develop
- Glass/Mirror production competencies are important for CSP, together with nano fluid competencies: this knowledge and research basis are already developed in Turkey and could give way to industrial know-how of the country.

1.4.3.5 A sound potential for the development of STE if necessary measures are implemented

- Storage technologies are very critical for the Turkish energy system. STE technologies should thus always be introduced with thermal energy storage applications.
- However, costs remain the main obstacle for the development of the technology, particularly when comparing to the decreasing cost of PV and the absence of specific STE incentives. As long as LCOEs remain the main comparator, STE will need specific support to emerge in electricity production.
- Hence, CST applications should be more industry-oriented at the beginning, because of cost advantages of other electricity-producing technologies. The sole concern should not be producing electricity. Demand by industries would attract investors and cut the shortage of demand for these technologies. The advantages regarding industrial heating, and cooling applications should thereby be put forward and call for proposal for industrial applications of STE.

1.5 Aligned conclusions and recommendations

All the conditions, both on the industry and the R&I sides, show already a strong coherence as a fertile basis for the CST sector to unfold in Turkey: there is no reason for it not to happen. All aspects that have been surveyed allow the following overarching comments and suggestions.

1. Turkey is favourable to renewables, but further consistency in energy policy should be sought for

In countries where a market for a given technology does not yet exist, the deployment of a new technology primarily depends on industry and STI policy decisions which are subsequently embedded in a specific regulatory framework and operational targets. The basis for such policy discussions is the political assessment of what lies in the national interest of the country:

- National economies have built their largest industrial corporations around clearly defined industrial programmes and priorities to serve the national interest. However, some countries can choose, on the contrary, to develop multiple energy policy alternatives, instead of a core industry focusing on a core resource. They will then be more of a "**test field" for export-oriented corporations, rather than providers of solutions to a national problem**. This may become a potential obstacle or a brake to the development of renewable technologies with a very high added value on the mid- or long-term
- There is therefore **a problem with a system which does not favour any technology**: by choosing to try and develop all, problems are caused and can hinder the development of adapted renewable technologies
- The trigger for **establishing a market** for a new technology is therefore **neither its technological performance nor its costs**. Technology performance and costs turn out to be triggers for the further development/higher efficiency, namely within an already existing market featuring a larger number of competing actors

This is also the case for Turkey, which has assessed that **three conditions must be met** to receive substantial support

- **opportunities for domestic industries** (such as national production of components) but also export opportunities
- **use of national resources** (besides natural resources, existing technological and academic knowledge), and
- **almost implicitly, meeting national needs** (such as the need to ensure system reliability and security of supply of the power system in the context of a strong demand increase)

Regarding the **local industries,** which would be engaged in a larger deployment of STE in Turkey, they do **not appear yet at the desired technology level**, compared to international competitors, **to establish alone an efficient national STE market**. This might also be linked to a **lack of interdisciplinary and transdisciplinary studies** demonstrating the national benefits and the sustainability of decreasing the carbon footprint. This would contribute to both the Turkish national economy and the global fight against climate change

However, this leaves an **open door for future RES development**, in particular for STE. **Academic research** has best international reputation and references. **Industry platforms** also play a role, where joint ventures with other companies could be considered and result in balanced setups of industry consortia, some technology transfer, and other shared benefits.

1. Contradictions in the market system do not favour sustainable investment

In addition to the effects of financial crises, macroeconomic instability, and external factors such as a global pandemic, **Turkey is also sending mixed signals to investors** by promoting investment at the same time in coal and in renewables, in particular since its main goals are to reach security of supply, decrease foreign dependency by using domestic sources (including solar and coal at the same time) and develop its own technology (indigenisation).

Turkey lacks systemic concepts for renewable investments, even though following a structured marketisation in renewable energy.

Renewables are treated as a secondary energy producing technologies, as compared to coal for instance, which diverts potential investments and does not reassure investors. However, hydro has a special role and is one of the major source of renewable energy in various policy documents.

Subsequently, compact and shortened investment processes for investments in renewables also question the sustainability of investments after public incentives ceased to exist.

2. However, the overall energy policy in Turkey keeps the door open to the development of renewable energies

Turkey experiences problems with base load and is yearning for energy security. **Renewable energies** are sometimes seen only as **local resources** with minimum impact on load problems.

Therefore, it appears that a **strong support to balancing the power system** cannot be based on variable renewable energy sources, but should be **complemented by sustainable storage solutions**, for which STE could play a decisive role

The **YEKDEM** system represents a **good opportunity for all renewable technologies** in Turkey. Even though the policy initiative for renewables goes in the right decision, the **regulation should be even more flexible to allow further diversification** of various complementary technologies

The **opportunities for hybridisation** and possible new incentives also provide **new business opportunity windows**

Unsuspectedly, **STE can also play a role in tourism**, as this is already the case in some countries[24], which is a distinctive asset which is not shared by many renewable energy sources

3. The gap between research and industry should be closed

There is still a **challenge to improve the commercialisation of research** findings in universities: **more interactions with the industry and demonstration studies** are needed, to follow the needs of the industry, for it to further develop.

Glass/Mirror production are a key component for STE and **premium know-how** about it as well as about **nanofluid is a strong asset**: the **knowledge and research basis are already well developed in Turkey** and could pave the way to better use this industrial know-how in the country

4. A sound potential for the development of STE if necessary measures are implemented

Storage was reported as a critical issue for the Turkish power system over the next decade. **A deployment of STE** (plants with storage) in Turkey would make sense along other thermal energy storage applications.

[24] *An example: In France, there is a touristic path in the South which shows all STE installations in the region, including the Four d'Odeillo.*

However, **the argument of costs** remains the **main obstacle** for the development of the technology, particularly when comparing to the decreasing cost of PV and the absence of specific STE incentives

To overcome this while strengthening the planning of a higher penetration of renewables in the power system of sunny countries, **a fair comparison between technologies is needed**. Assuming a firm commitment to a real energy transition is made, the question of the **cheapest renewable technology** able to compensate the loss of PV production **after sunset** should be addressed. This would avoid putting more pressure on market prices for PV power generated during daytime which would further pull down their already very low value

Solar thermal power plants are a valid answer: they capture solar radiation during the day, store it in their tanks to produce electricity on demand during the night, slightly overlapping with PV generation at sunset to improve the ramping of the "duck" curve.

Using batteries with variable renewable technologies may in the future add some value for specific system needs at transmission and distribution levels. However, it will only make sense if batteries inject all their capacity into the system when the wind stops, or at sunset. Otherwise, they would deliver power at much higher prices than the variable sources during their operation. This would therefore not be sustainable since it would contribute to a so-called "price channelling". This does not correspond to the real backup needs of electrical systems, namely the ability to replace variable sources when these are no longer available, in various timeframes

Introducing such considerations in the planning of the Turkish system may **need some time**. Therefore, **CST applications** should, at the beginning, be **more industry-oriente**d because of cost advantages of other electricity-producing technologies.

Producing electricity is not the sole perspective for STE in Turkey. The demand for **industry heat** by various local industries may first attract investors so that industrial heating, and heating and cooling applications, should thereby be considered in calls for proposals for industrial applications of STE. This could be the best channel to introduce STE in the country.

5. Create a common advocacy platform and think political

To maximise the impact of a **global coherence between research and industry**, both should gather in a **common advocacy platform**, in which they would work together.

By uniting **representatives from the R&I and industry sectors**, the platform would embody the sector in its full spectrum and thus favour the consistency of its message. It would also facilitate the discussion between the two pillars of the sector.

Such a common advocacy platform would **help structure and give more weight to bring research results to market**, by offering a bigger weight in the political negotiations regarding energy policies and, most important, with the Ministry, which is the most influential entity.

It would therefore make it easier for research entities to have an **impact on financial institutions** and unlock potential funds for the industry: **having small projects**, adapted to the industry needs, funded in a consistent and sustainable way would attract investors and thereby open the possibility to have larger commercial projects.

The **risk-sharing of spin-offs** – if supported by the government – would drag more funds into a sector which shows good dynamic, and which is solidly aware of what it can bring to a complex societal ecosystem

The multiplication of opportunities for (small) STE and/or CST projects offers the chance to tackle the LCOE issue.

If, politically speaking, **the LCOEs** are the reference value for allocating funds and favouring technologies, it is of major importance for the CST sector to prove that this **cannot be the only criterion**. By showing the assets of STE in projects and by building a Turkish CST narrative through the advocacy platform, it should be possible t**o build a strong case for reference criteria** which **go beyond LCOEs** and encompass **more complex and essential concepts**, such as flexibility for instance.

To call for a **strong and reshaped support mechanism**, not to a priori discard STE, is thus a key political mission for the stakeholder platform. **Political certainties must be acquired**, in order to thwart economic uncertainties and favour economic diversity, dynamism and competitiveness. STE can reinforce all of these aspects.

This platform could work along the following advocacy main lines:

A. WHAT CAN CST DELIVER TO THE ELECTRICITY SECTOR?

The European solar thermal industry can provide **power on demand at utility scale**, without further delay, and at lower costs than renewable electricity stored in batteries or hydrogen. This is the timely **answer to the challenge of intermittency of PV and wind at sustainable costs**. This is possible via:

- **Complementing PV generation after sunset** which will contribute to achieve a more ambitious overall deployment of renewables with a higher impact on decarbonisation and prevent overinvestments in non-dispatchable technologies.
- **Constructing new innovative CSP plants with large thermal storage capacity** in Southern Europe and EU neighbouring countries with the best solar resources.
- **Revamping not only existing CSP plants**, but also fossil-fired installations with thermal storage facilities allowing a further use of existing generation and grid connection infrastructures, including fossil-fired plant sites.
- All this will **result in substantially reduced PV curtailments**, with an optimised use of natural resources across the continent, allowing shared benefits of bulk storage capacities and new strategic reserves amongst more Member States.

B. WHAT CAN CST DELIVER FOR THE DECARBONISATION OF THE INDUSTRY SECTOR?

The decarbonisation of the industrial sector will need more time and efforts than for the power system. Major contributions by renewable energy must be achieved through **high temperature process heat, sustainable fuels, and reducing agents**. This goes far beyond the potential that can be covered by biomass alone. This role and potential of CSP is particularly important for Southern Europe:

- **CSP can provide and store high temperature heat** (up to 900°C) at costs clearly below renewable fuels or electricity-based options.
- **CSP can provide power and high temperature heat with a very high capacity factor** (7000h/year) to enable the decarbonisation of industrial processes
- Due to these characteristics, it also allows an **efficient operation of renewable fuel production facilities at constant load and at high capacity factors** – both essential to reduce the fuel costs.
- **It has the potential to decarbonise heat grids,** as it can provide and store heat more efficiently at suitable temperature levels (120°), compared to non-concentrating collectors, even in central European climate zones

C. WHY?

- Because **CSP is the cheapest renewable technology to avoid fossil energy backup**, making the energy transition easier in Southern European countries.
- To **reap the benefits of the complementarity** between PV and CSP especially, but also between wind and CSP, to make a larger penetration of renewables into the EU electricity sector possible.
- To **reflect the currently non-considered value of storage in upcoming auctions** for new renewable capacities and the full system costs
- **To foster European innovation and keep the European technological leadership in the field of CST**, which is just at the beginning of its learning curve. **Substantial cost reductions are expected** if backed by strong R&I resources and a proven track record for industrial implementation.

D. WHEN?

- CST can make a sustainable energy transition happen **right now, without waiting for "hoped-for-viability"** of other solutions. It will help match the upcoming bulk storage needs in the electricity and process heat sectors that could be used for harder-to-decarbonise industries.
- **CST is a mature solar technology** with a track record of over more than three decades that **has already 'pulled' the development phase of a "solar industry" in Europe**.

E. HOW?

- **Include CSP** and its characteristics **into national regulatory framework conditions and tendering schemes** for renewables electricity projects. The design of future auctions should include a **market-based valuation of the flexibility added to the system by new capacity** - under consideration of shifted or hidden costs of other generation sources ("cost channelling").
- **Adapt the current "least cost" system planning models** that was supportive to the deployment of fossil energy sources in the past but turns out to no longer be adequate for planning systems with a high share of renewables.
- **Provide access to comparable financial conditions** – as available to non-EU competitors on world markets.
- **Finalise the features of currently prepared new financial support mechanisms** (CEF, IF) to allow CST to fairly compete for eligibility.
- **Extend the concept of "sector coupling**" to be understood as optimising assets and resources of all renewables where there is a win in efficiency compared to "decarbonised gas" or biogas
- Support **large scale CST demonstration** projects for high **temperature process heat** and **industrial decarbonisation** projects within a more ambitious European innovation ecosystem.
- **Improve funding to the R&I initiatives along the full CST value chain** to defend and consolidate the unique worldwide technology leadership of European companies

F. WHAT IS THE REAL COST/BENEFIT RATIO OF A LARGER USE OF CST?

When confronting the two-fold objective of a "Green recovery", **the use of LCOEs as only metric for investment decisions is no longer suitable** for guiding investments since:

- **CST technologies are just at the beginning of the learning curve with significant further cost reductions expected**. **The real ratio** between incurred costs and benefits must go beyond LCOE and **include a correct valuation of:**
  - **the added flexibility to the electricity systems** via thermal storage
  - **the environmental impact for each sector** (reduction of CO_2 and GHG)
  - **the part of hidden or externalised costs** of single technology choices in the total system costs
  - **geopolitical effects on world markets and support to the European Union's Neighbourhood Instrument policies**
  - **societal and macroeconomic impacts on national economies** due to new business cases for European companies with more sustainable jobs (local engineering, construction, and component supply chain as well as related services) that can not only substitute but also create jobs in the fossil energy sector

- the recognised excellency of European research that brought to Europe a still undisputed technology and innovation leadership in CST.

2 Glossary

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
IFIs	International Financial Institutions
IMF	The International Monetary fund
IRENA	The International Renewable Energy Agency
KfW	KfW Development Bank
kWh	Kilo Watt hour
kWp	Kilo Watt peak
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
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
RES Certificate	Renewable Energy Source Certificates
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

3 Appendices

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3.2 Meeting guidelines

3.2.1 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? …*]

3.2.2 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? ...]*

3.2.3 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.: ?]

3.2.4 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)...]*

3.3 Interview guidelines

3.3.1 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

3.3.2 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

3.3.3 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