Alternative Pathways to the Deployment of Concentrated Solar Thermal Technologies in Turkey

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Yelda Erden Topal

Middle East Technical University (METU/ ODTÜ)
Department of Economics and
Science and Technology Policies Research Center (METU TEKPOL)
Ankara/Turkey

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Alternative Pathways to the Deployment of Concentrated Solar Thermal Technologies in Turkey[1]

Yelda Erden Topal[1], Ayşe Ayda Gerçek[2], Ilgın İrem Gündüz[3]

1. Post-Doc. Researcher, Middle East Technical University, Dep. of Economics and Science and Technology Policies Research Center, yeldae@metu.edu.tr
2. MSc Student, Middle East Technical University, Science and Technology Policies Research Center
3. MSc Student, Middle East Technical University, Science and Technology Policies Research Center

1. INTRODUCTION

The path to a prosperous, sustainable, and secure Turkey includes a Clean Energy Transition (CET) and Green Economy Transition (GET). Many of the largest challenges to be solved to realize these transitions lie at the intersection of technology, policy and society. Here, the role of governance is critical in bringing about transitions in societal systems such as energy. Taking the Concentrating Solar Thermal (CST) Technologies as the case study for the energy transition in Turkey, we aim to conduct a detailed case study of the German and Spanish CST Sectors separately, and the Current Turkish situation in this sector.

The development of the Renewable Energy Sector in Turkey has not long but a fast-moving history. Since the beginning of the 1990s, with the investments in emerging renewable energy generation technologies of wind turbines and then photovoltaics (PV), the sector started crawling and especially after 2013 with the establishment of the new legislative framework and new initiatives such as Solar Tenders in 2015, the first release of Unlicensed Electricity Generation Legislation in 2013 and its amendments, and Renewable Energy Development Zones, the renewable energy sector has started running without walking in-between. However, this experience is unique to emerging renewable energy technologies such as solar photovoltaics or harvesting energy by wind turbines. The market segment of more mature renewable energy technologies, such as Concentrated Solar Thermal Technologies (CST), has cross-cutting and solid grounds in incumbent energy generation technologies, practices and transdisciplinary research, and hence has been moving cautiously, safely and slowly since the beginning of the 1980s.

Today, Turkey is experiencing specific and inherent socio-technical problems (such as import dependency and governance problems) and structural transformation (such as in changing institutional role of government) in the energy sector; CST technologies promise global impacts and solutions to these energy problems through different applications of Solar Thermal Technologies such as Solar Heat for Industrial Processes (SHIP), Solar Fuels, and Clean and Fresh Water technologies. These technologies provide a rich environment for designing industrial policies to respond to the global challenges related to the interplay of local creation and diffusion of knowledge in Turkey and its integration in global value chains through exploiting these international channels (Chang and Andreoni 2020; Oldekop et al. 2020; Gräbner and Hafele 2020; Lee J-D et al 2020; Pianta et al 2020; Andreoni and Chang 2019; Wade 2018; Mazzucato 2018, Lee and Malerba 2017).

In this study, we search for how Turkey, as an emerging country, can take advantage of green transition by developing and diffusing CST Technologies and integration to global value chains via EU Networks. For this purpose, we examine the current situation in the CST market segment of the renewable energy sector in Turkey from a comparative perspective with its European strategic partners, Spain and Germany.

First of all, we present the Turkish Case with the inputs from

- CST Stakeholder Analysis made in 2020 (and the research paper was presented in EAEPE 2020) and Updated status of the integrated country report of Turkey in CST

[1] This paper is benefitted from the bibliometric analysis made for updating the Turkey CST Country Report by Asst. Prof. Dr. Arsev. U Aydınoglu's data generation and analysis co-work with the authors. We would like to thank H-STE Project (No: 838514).

- Joint National Event entitled “Pathways to the Deployment of Solar Technologies in Turkey: Concentrated Solar Thermal Energy and Photovoltaic Energy Technologies”, held on April 7, 2022 in SolarEx International Solar Energy Fair (Turkey), and organized by Turkey’s CST Network of ODTÜ-GÜNAM- Center for Solar Energy Research and Application in Turkey, ODAKTR-Turkish Concentrating Solar Thermal Initiative, EU H2020 Project: HORIZON-STE - Implementation of the Initiative for Global Leadership in Solar Thermal Electricity (GA ID: 838514), and EU H2020 Project: SolarTwins- Solar Twinning to Create Solar Research Twins (GA ID: 856619)

Following the detailed analysis of Turkey, we examine Spain and Germany in detail from the main headings of (i) industry perspective - EU and global, (ii) applications and research perspective - EU and global, (iii) policy & legal perspective in at national level (Turkey) and (iv) industry perspective - national level (Turkey). For the leading countries of Europe in CST Technology development and diffusion, Spain and Germany, we elaborate on the conceptualization of technological change and innovation in CST Sector, the role of the CST market and competition, collaboration dynamics in renewable energy systems and governance and policies in CST Area in Germany and Spain. Here the research question is how to stimulate the technological change and industrial development in CST Technologies Implications.

To derive the lessons learnt from Germany and Spain and to examine alternative pathways for modelling the energy transition in the Turkish CST Sector, this study aims to understand for Spanish and German CST Sectors by a detailed analysis of

- the processes and mechanisms that drive CST technology development the methods followed in R&D Activities and industrialization
- the policies (best) put in place to support the transition
- the co-evolution of demand and supply for CST technologies in the market
- behavioral and institutional changes in the society for CST Technologies use
- the specificities of transition pathways, competition among firms and other actors in the market that these two countries followed,
- drivers of diffusion and adoption of CST technologies

In parallel, to set the theoretical framework of these cases studies, a detailed literature review will be presented for the multi-level perspective, transition management, strategic niche management and adaptive governance. The concluding aim is to impose policy proposals for the deployment of Concentrated Solar Thermal Technologies in Turkey, using the lessons learnt from German and Spanish Cases.

The first section introduces the background and main motivations of the research. The second section gives a brief theoretical background on “Clean Energy and Green Economy Transition”. The following section of methods and materials describes the data and the tools to collect the data. In the fourth section, the results of the empirical analysis are presented. The paper is concluded with a summary of the data analysis and further discussion for implications of industrial policy measures for the green transition of Turkey as integrated into global value channels.

2. THEORETICAL FRAMEWORK: Clean Energy and Green Economy Transition

To analyze the clean energy and green economy transition we mainly examine the theoretical approaches of multi-level perspective (Geels, 2002; Smith et al. 2010), transition management (Loorbach 2010; Rotmans et al 2001), strategic niche management (Geels and Raven 2006; Schot and Geels 2008) and adaptive governance. These analysis items are

(i) processes and mechanisms that drive new technology development *(Drivers of New Tech Development)*
(ii) the methods followed in R&D Activities and industrialization (*R&D and Industry Dynamics)*
(iii) the policies (best) put in place to support the transition (*Transition Policies*)

(iv) behavioral and institutional changes in the society for new Technologies use *(Behavioral and Institutional Changes)*

(v) the specificities of transition pathways, competition among firms and other actors in the markets *(Transition Pathways)*

(vi) drivers of diffusion and adoption of new technologies *(Drivers of New Tech. Diffusion).*

i) The processes and mechanisms that drive new technology development (DRIVERS of NEW TECH DEVELOPMENT)

Looking from an evolutionary economic perspective, Geels (2002) takes technological developments as "**evolutionary reconfiguration processes**". This viewpoint assumes that the developments are creating "**new combinations**" that result in paths and trajectories, therefore contributing the proceeding evolution. He accepts **the main processes as the process of variation, selection and retention**. In terms of the mechanisms that drive technology development, Geels states that even though the firms and engineers share similar routines in order to create stability, "the **Socio-technical landscape"** (an external structure or contest for interactions of actors) causes the changes to occur slowly. Furthermore, he indicates that **niches** are crucial for the evolution of technology because they provide the seeds for change.

ii) The methods followed in R&D Activities and industrialization (R&D AND INDUSTRY DYNAMICS)

Smith et al. (2010) summarize two main dimensions of the innovation studies, which are the "**Broadening of the problem framing**" and "**Broadening the analytical framing".** Geels & Raven (2006) indicate that, technical search activities in different locations are focused in a similar direction, they add up to a **technical trajectory.** Technological trajectories are stable patterns in technological development that exist at the global level of community of actors. **Expectations and visions** are special set of cognitive rules that are oriented to the future and related to action, in the sense that they give direction to search and development activities

iii) The policies (best) put in place to support the transition (TRANSITION POLICIES)

According to Smith et al. (2010), **regimes** are forms of governance. They structure and order the **interaction of material artifacts and social processes** (Rip, 2006). For transition, we need a **purposeful governance** and analysis for deliberate policy aiming to transform regimes. **Rules** not only constraint but also enable participation. For policies to gain support, they need to be capable of assuring desired re-configurations. It is claimed that it is their strength **to be more flexible** and to allow various changes and even imaginations when necessary. It is stated that, the boundaries of socio-technical regimes are not necessarily identical with those of a geographical landscape, a nation-state or a social community, it is mostly determined by the area that the technology diffused. According to Geels & Raven (2006), there are "**technological frames**" that are consist of the goals, problem agendas, problem-solving strategies, current theories, tacit knowledge, design methods and criteria.

iv) Behavioral and institutional changes in the society for new technologies use (BEHAVIORAL AND INSTITUTIONAL CHANGES)

According to Smith et al. (2010), in the conceptual understanding of transitions, academia (Rip and Kemp 1998, Schot 1998, Geels 2002) combines a micro-level processes of constructing new technologies, with a view on emerging macro and meso-level patterns of culture, organization, markets, regulation and infrastructure. Additionally, social movements engage with socio-technical systems and seek to transform them. According to Geels (2002), "socio-technical regimes" are semi-coherent set of rules carried by different social groups. As it is mentioned in various parts of this paper, the importance carried by the regimes comes from **the features and perspectives of social groups.**

v) The specificities of transition pathways, competition among firms and other actors in the markets (TRANSITION PATHWAYS)

Smith et al. (2010) indicates that **the way niches, regimes and landscapes (wider external factors) interact**, determines the characteristics of a transition. Cohen's article suggests that we should not consider niche dynamics only in the context of current regime, but also in competition with unsustainable practices in niches more closely aligned with interests of the regime. There is a contest between various niches, each positioned differently in relation to regimes. According to this paper, this idea suggests that the various transition pathways can carry various meanings according to its location in a regime. In fact, this can give a power to ensure competition even within the same regime. According to Smith et al. (2010), the role of places and special scales in these transition processes has not been an explicit issue of concern. If they have been, they would require transformations to multiple regimes (regional vs. local level visions).

vi) Drivers of diffusion and adoption of new technologies (DRIVERS of NEW TECH DIFFUSION)

Geels (2002) suggests seven dimensions of the socio-technical regime (which are also the drivers of transition): 1. technology itself, 2. User practices and application domains (markets), 3. Symbolic meaning of technology, 4. Infrastructure, 5. Industry structure, 6. Policy, 7. Techno-scientific knowledge. It is stated by Smith et al. (2010) that Pearce et al. (1989) indicates that environmental considerations are poorly served by markets.

3. METHODS and MATERIALS:

In this paper, we are using the data collected for and the analyses made in updated 'Updated status of the integrated country report of Turkey in CST, CST Stakeholder Analysis made in 2020 (and the research paper was presented in EAEPE 2020)' and 'The proceedings Joint National Event' titled "Pathways to the Deployment of Solar Technologies in Turkey: Concentrated Solar Thermal Energy and Photovoltaic Energy Technologies", held on April 7, 2022 in SolarEx International Solar Energy Fair (Turkey), and organized by Turkey's CST Network of ODTÜ-GÜNAM- Center for Solar Energy Research and Application in Turkey, ODAKTR-Turkish Concentrating Solar Thermal Initiative, EU H2020 Project: HORIZON-STE - Implementation of the Initiative for Global Leadership in Solar Thermal Electricity (GA ID: 838514), and EU H2020 Project: SolarTwins- Solar Twinning to Create Solar Research Twins (GA ID: 856619)

In the "CST Stakeholder Analysis" the aim is to grasp the network and collaboration dynamics in this European context. For this purpose, we conducted a stakeholder analysis and benefitted from qualitative and quantitative data collection and analysis methods. In the quantitative part, we made a bibliometric analysis by scanning the research networks through the approximately 4485 publications[2] (644 From Turkey, 2064 from Spain and 1777 from Germany) derived from the Web of Science Database. To further investigate the current situation to propose a new generation of industrial policy implications in Turkey, we completed the analysis of Turkish Stakeholders with a qualitative data collection of 14 semi-structured interviews with industrial partners, university researchers, bureaucrats and NGOs between October 2019-January 2020 in Turkey.

In the proceeding of Joint event, we reported the the Joint Event on April 7, 2022. As a part of H2020 HORIZON-STE (GA ID: 838514) Project in collaboration with H2020 SOLARTWINS Project (GA ID: 856619), ODTÜ GÜNAM-Center for Solar Energy Research and Applications, Middle East Technical University (METU) and ODAKTR (Turkish Concentrated Solar Energy Initiative) organized a seven-part conference at the International Istanbul Solar Energy and Technologies Fair (SOLAREX), which was held at Istanbul Expo Center between 7-9 April 2022. This mini-conference, called Joint National Event of "Pathways to the Deployment of Solar Technologies in Turkey: Concentrated Solar Thermal Energy and Photovoltaic Energy Technologies" was held on April 7 at GOLD HALL, includes content within the fields of Concentrated Solar Thermal Technologies and Photovoltaics, and research and development in accordance with the scope of the fair. 113 people representing universities, companies, researchers, and R&D Institutes and Centers attended this conference and signed the registration form. Conference participants discussed solar energy from the perspectives of industry, government and research centers. The proceeding is to report the main description of the event and the main discussions made about CST Technologies in Turkey at EU Context.

[2] Double counting is possible since one publication may be counted in both countries' account if it is a product of international collaboration.

4. RESULTS and CONCLUSIONS:

4.1 Updated Country Report by New Bibliometric Analysis (Turkey in comparison to Spain and Germany)

In the quantitative analysis part, namely “the bibliometric analysis of Turkish scholarly research on CST in comparison to Germany (DE) and Spain (ES)”, we generated data to understand the general landscape in CSP research in Turkey. Moreover, we collected the same type of data for Germany and Spain to make a comparative analysis to understand how Turkey integrates to global value chains in CSP Research through EU Networks.

A small expert panel that consisted of the H-STE Project Team approved the 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 January 07, 2022, we searched the Web of Science ™ Core Collection database to create our dataset. Our search retrieved 644 publications indexed in the Web of Science ™ Core Collection with at least one co-author affiliated with a Turkish organization, 2064 with a Spanish Organization and 1777 with a German Organization (Table 1). For these countries, “article” is the dominant research output in this research area. However, Germany and Spain, as compared to Turkey, disseminate the research results with (article) proceedings paper and Turkey is not very active in producing such output. This shows Turkey may benefit more from conference gatherings and networking outputs as to integrate to global knowledge generation channels in EU Context. Another sing to support more of Turkish organizations' internationalization activities is the number of number of single-authored documents. As compared to low number of publication in Turkey, single-authored documents number is high (82) as compared to Spain (46) and Germany (103) and the number of “Co-Authors per Documents” is low (3.29) as compared to Spain (4.89) and Germany (4.68). This shows Spain and Germany prefer to collaborate more in preparing CST research output as compared to Turkey. The numbers of “Authors of multi-authored documents” support this finding too (Table 2).

Of the 644 publications, the first article was published in 1991 in Turkey (1989 in Spain and 1990 in Germany). The CST research started to take off in the early 2000s, and even though there were some setbacks, the overall trend demonstrates that Turkish, as well and German and Spanish, researchers are publishing more CSP related research – in last two decades. It reached more than 50 publications per year in last five years (Figure 1).

Table 1: The table reports the main bibliometric information derived from Web of Science Database about the publications in Turkey, Spain and Germany.

MAIN INFORMATION ABOUT DATA	**TURKEY**	**SPAIN**	**GERMANY**
Timespan*	1991:2022	1989:2022	1990:2022
Sources (Journals, Books, etc.)	183	421	456
Documents	644	2064	1777
Average citations per documents	34.61	25.51	21.75
DOCUMENT TYPES**			
article	530	1368	974
article; book chapter	5	44	35
article; proceedings paper	33	78	123
proceedings paper	30	425	564
review	37	138	69
AUTHORS			
Authors	958	3945	4369
Authors of single-authored documents	53	34	77
Authors of multi-authored documents	905	3911	4292
AUTHORS COLLABORATION			
Single-authored documents	82	46	103
Authors per Document	1.49	1.91	2.46
Co-Authors per Documents	3.29	4.89	4.68
Collaboration Index	1.61	1.94	2.56

**The data is collected for the time period of 1945-2022 however the first publication was released in 1991 in Turkey, 1989 in Spain and 1990 in Germany. The time-span starting date shows the first publication.*

***Document types of editorial material; book chapter, review; early access, review; book chapter are excluded from the table due to low number of count.*

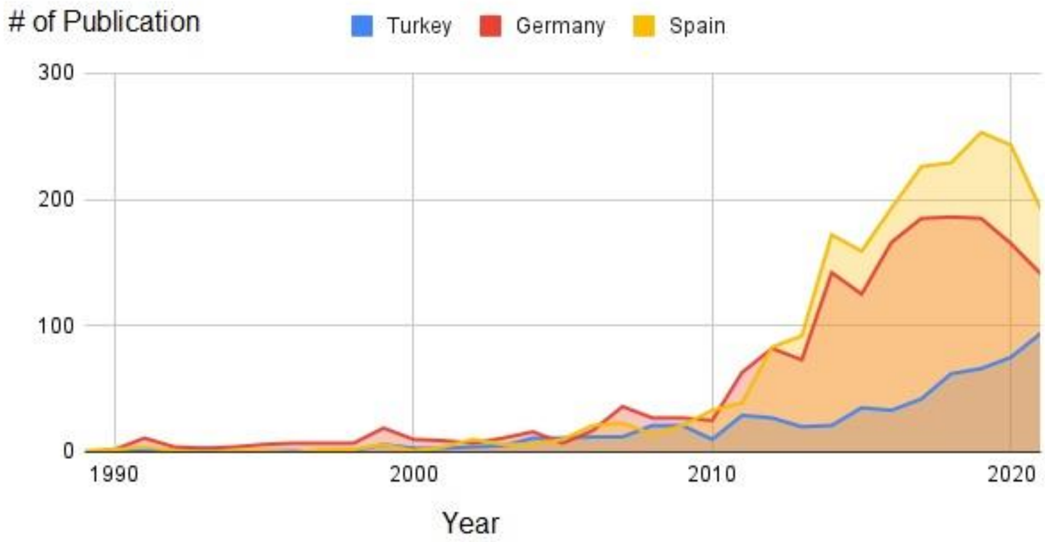

Fig 1 The number of publications annually

In Figure 2, the co-authorship collaboration networks are visualised, with each network being identified with a different colour. The co-author collaboration networks can be described as the primary network containing the most active authors and a series of smaller networks independent of the main network and from one another. With the help of the statistics derived from data, this figure provides the name of the most scholarly productive researchers in Turkey. Here the indicator is the number of publications per author. Ahmet Sari (Karadeniz Technical University and King Fahd University of Petroleum Minerals) with 121 publications on top of the list. Cemil Alkan (Gaziosmanpasa University) with 62, Kamil Kaygusuz (Karadeniz Technical University) with 42, and Halime Paksoy (Cukurova University) with 33 publications are among the other researchers in the list. Ibrahim Dincer is affiliated with Yildiz Technical University (Turkey) and Ontario Technical University (Canada), and he is listed as a co-author in 31 of the 644 publications. These most active authors (Halime Paksoy, Ahmet Sari, Cemil Alkan, Kamil Kaygusuz and İbrahim Dinçer) are also at the centre of a small network. These smaller networks are linked to form a more extensive and dominant network. The authors work in smaller and independent networks with their co-authors outside this dominant network. One thing here is clear though, all of these scholars' work is on the technical side of CST research; there are almost no studies on the policy or the market side of the technology and industrialisation strategies to support technology development and diffusion.

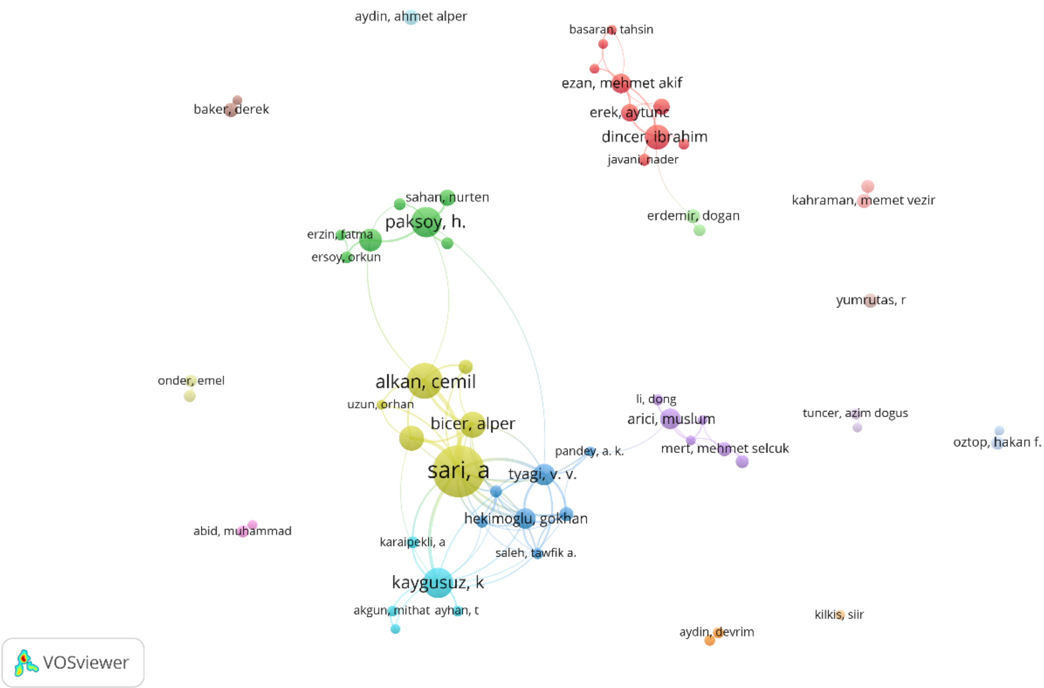

Fig 2 Co-authorship network (co-authors with a minimum of three publications)

Figure 3 below shows the organization network in Turkey. As for the institutional collaboration, the affiliations of the most scholarly productive researchers are in the network, and most of them are local research organizations of Turkey. It is also possible to track their international collaborations in the network despite not too much. 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 the University of Barcelona are among the critical international nodes for Turkish Scholars in CST Research. However, the Turkish network seems to be a close network mostly dominated by Turkish institutions. This is another reason to support the internalization of Turkish CST Research activities and integration of this strong knowledge development network to global channels.

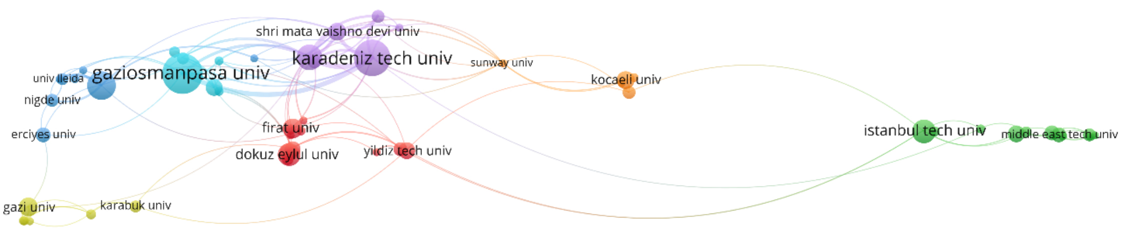

Fig 3 Organization network (organizations with a minimum of three publications)

The collaboration at the country level can be seen in Figure 4-5-6. Turkish researchers are collaborating with researchers from 39 different countries. Canada, Saudi Arabia, India, the USA and Spain are among the most frequently collaborated countries affiliated researchers (Figure 4). Both Germany's (Figure 5) and Spain's (Figure 6) Country Collaboration Networks show that CST research networks seem to integrate European Countries well (for the technology and knowledge development) and are closely connected with Middle Eastern Countries of Jordon, Morocco, Algeria, Tunisia and Egypt (for industrialization of the knowledge in the regions where the solar energy sources are profound). This shows great potential for Turkey to integrate CSP knowledge generation and application of the knowledge as a bridge to Europe and the Middle East.

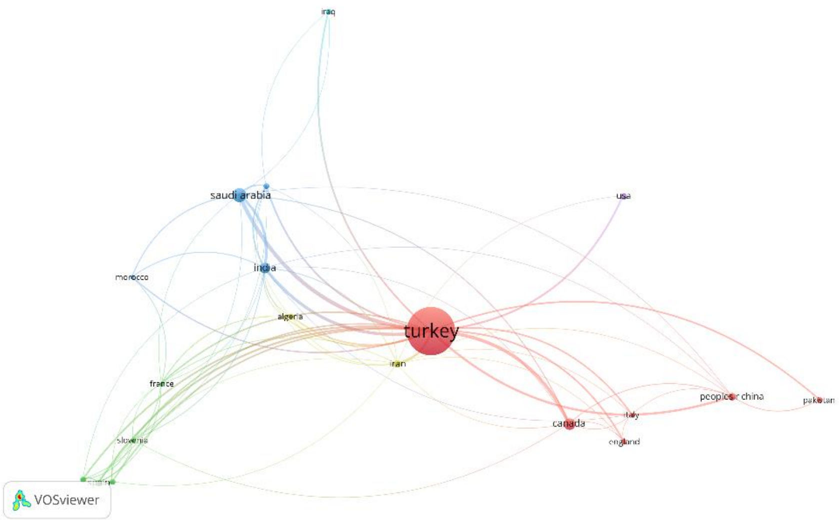

Fig 4 Collaboration at the country level (a minimum of one publication)

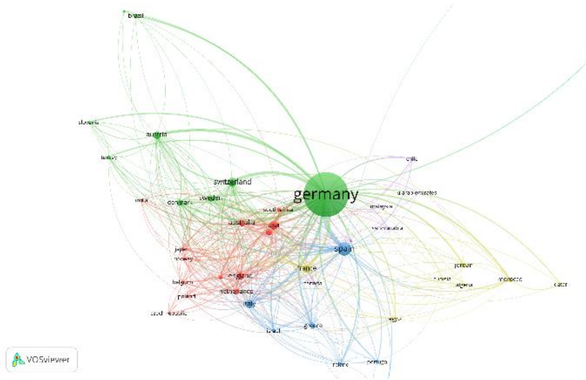

Fig 5 Collaboration at the country level (Germany)

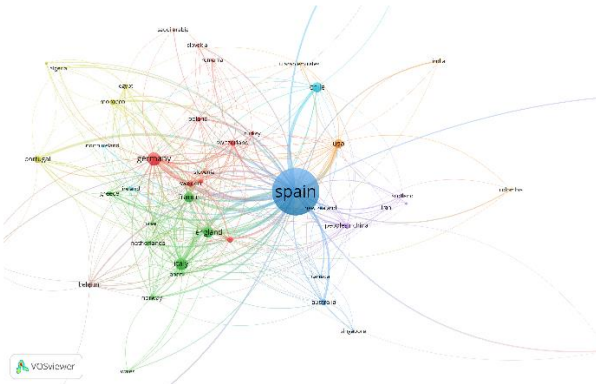

Fig 6 Collaboration at the country level (Spain)

A keyword co-occurrence network map of CSP research (Figure 7) can also provide an insight into the research's interdisciplinary nature. There are four clusters (each colour represents a cluster). As evident from the map, the keywords have been intertwined. These keywords or phrases come from the titles, abstracts, and keywords of the 644 articles of Turkey in our dataset. Turkey has an active and diverse research base in Thermal Energy Storage (TES) technologies (blue), or equivalently storage (red) with a particular focus on latent heat storage (green) that includes phase change, solidification, and melting processes (blue), and Phase Change Materials (PCMs) (green) including paraffin (blue), and various acids (e.g., fatty, capric, and stearic) (green) as heat storage media, and technologies to package PCMs such as microcapsules and microencapsulation (yellow). There is also significant research on performance (green) that includes heat transfer, heat transfer enhancement, and natural convection (blue), conductivity and thermal conductivity (green) and performance analyses that includes exergy and thermodynamic analysis (red). Research at the system (red) level also includes simulation.

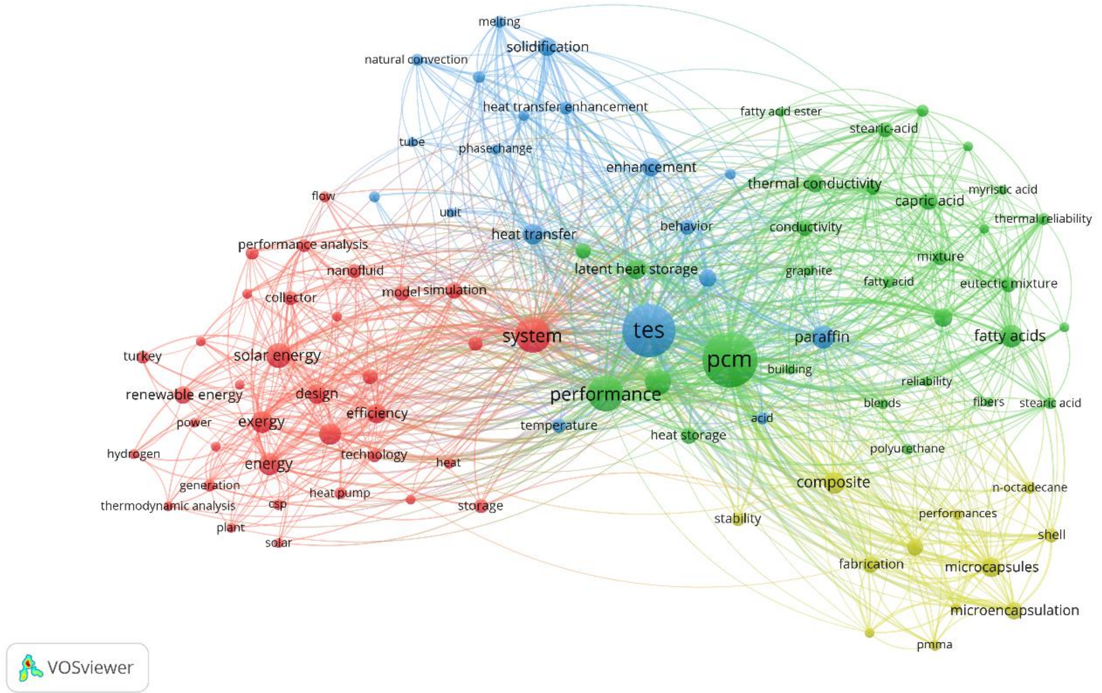

Fig 7 Keyword map (minimum three times)

In Turkey, we analyzed the CSP Technologies sector using transdisciplinary research. We found robust research infrastructure and qualified cutting-edge research in this area. However, the links between companies and the research conducted in universities are loose. This necessitates the design of industrial policies to integrate the local creation and diffusion of knowledge and its integration in global value chains. Here, the key is developing production structures and embedded learning processes of collective capabilities and 'capability domains' at the national and global contexts.

On the one hand, there is an established political and regulatory framework in the Turkish Renewable Energy Sector. Policymakers can regulate the industry with close relations and continuous updating. This results from the structural change in the state's role in the energy sector. This brings flexibility in connections; on the other hand, some loose interventions to provide systemic sustainability. However, this is still experimentation. This would be an advantage for CST to exploit the new opportunities in the energy sector with changing consumption, production and regulation patterns. These opportunities can be exploited by providing industrial policy measures that have long-term perspectives and outcomes incompatible with sustainable development goals, SDG 7: Affordable and Clean Energy, SDG 9: Industry, Innovation and Infrastructure and SDG 13: Climate Action[3]

Another important phenomenon observed in data analysis is integrating both industry and university to EU Research Networks. EU Research networks in this area are secure, and Turkey's inclusion in these networks have great potential. This brings natural boundaries (and constraints) for Turkey's research activities. Again, this well-structured integration can be exploited to build the CST sector in Turkey and transfer the knowledge, technology and industrialization base to neighboring countries through Turkey (mainly the middle eastern countries). This potential can be explicitly seen in the collaboration dynamics at the country level. Germany and well Spain are well integrated into EU research networks and using European Commission funds to finance research, technology development and innovation activities, and closely collaborating with Middle Eastern Countries where CST Technologies have great potential for application, that results in the industrialization of the knowledge produced in EU Countries in these sunny regions of Middle East. Turkey, both being in the crossroads of these two regions of the EU and the Middle East in terms of knowledge production and implication of this knowledge, has great potential for designing industrial policies for its green transition and the region.

Another significant result we derived from the data analysis points out that with different energy harvesting methods from electricity generation to process heat production, CST is seen as a solution for the problems of renewable energy storage and energy supply security. Diffusion of technology and increasing awareness about the benefits of this technology are very critical. One of the spots highlighted is the complementary and hybrid solutions

[3] For the details of all SDGs, see: https://sdgs.un.org/goals (Last access: Jan. 05, 2022).

that include CST Technologies. Here, hybridisation and energy storage comes to the fore as the main areas for Turkey to respond to the global challenges of energy and climate change with industrial policy measures.

Hybridisation rather than the individual CSP power plants are essential for this technology to diffuse in Turkey as integrated into global value chains in the context of the European Union. Bibliometric analysis that investigates the scholarly work on the topic also supports the framework described by qualitative analysis. The scientific research areas included in CST Research are diverse, and the picture of the research network seems to be transdisciplinary. Moreover, when we analyse the country network in CSP research, we see that European countries, especially Spain and Germany (which are the strategic partners of Turkey in different EU Networks and EU funded Projects), are one of the critical research nodes in the world. By moving from this picture of the CST technologies in Turkey compared to Germany and Spain, we infer that there is a cutting-edge research base related to these technologies and the high potential of the industrialisation policies for green transition in its region in Turkey integrated to global value chains. The development and diffusion of this new technology can be analysed through local integration to global value chains through the mediation of international knowledge and technology development channels.

4.2. Joint National Event Report (of Turkey) with highlights from Spain and Germany

Turkey's 2nd Joint Industry-R&I Event for the HORIZON-STE project was held as the mini-conference *Pathways to the Deployment of Solar Technologies in Turkey: Concentrated Solar Thermal Energy and Photovoltaic Energy Technologies* at the 2022 Solar Energy and Technologies Fair in Istanbul (*SolarEx Istanbul*). SolarEx Istanbul was held on 06-08 April 2022 at Istanbul's Expo Center with an estimated daily attendance exceeding 2500 participants[4]. The mini-conference was co-organized by the aligned European Union (EU) Horizon 2020 (H2020) Concentrating Solar Thermal (CST) projects HORIZON-STE and SolarTwins, Turkey's national center of excellence on solar energy *ODTÜ-GÜNAM*, and the national $ODAK_{TR}$ Concentrating Solar Thermal initiative on April 07, 2022. The agenda for the mini-conference as presented in the SolarEx programme is given below.

Germany's National Event is organized by DLR and ESTELA in collaboration with Deutsche-CSP on June 30, 2022 in Berlin/ Germany with the aim of discussing the contribution of CST Technologies for the realization of the "heat transition" ("Wärmewende" in German).

Spain's National Event is organized by CIEMAT and ESTELA in collaboration with PROTERMOSOLAR on July 06, 2022 in Madrid/ Spain with the aim of making a general introduction of solar energy in the strategic framework of energy and climate and the solar applications to industrial process heat and the development programs that the Spanish government is promoting. Presentation sessions are followed by discussion roundtables about institutional vision of concentrated solar thermal technologies (Panel 1), highlight the vision of the industry (Panel 2) and Spanish research institutions with interest in concentrating solar thermal technologies (Panel 3).

[4] https://solarexistanbul.com/en/

GOLD HALL — 7 APRIL 2022

FİRMA İSMİ	KONUŞMACI	KONU	SAAT
ODTÜ GUNAM	Presentation: Marcel Bial (Secretary General) European Solar Thermal Electricity Association - ESTELA / Belgium	INDUSTRY PERSPECTIVE - EU and GLOBAL	11:00-11:30
ODTÜ GUNAM	Moderation: Prof. Dr. Derek K. Baker (METU and ODTU GÜNAM) Presentations: Eduardo Zarza Moya (CIEMAT-PSA*): CST Applications and Spanish Experience Ricardo Sánchez (CIEMAT-PSA* and Coordinator of the EERA JP CSP**): EU and Global Research Perspective CIEMAT-PSA*: The Center for Energy, Environmental and Technological Research/ Spain EERA JP CSP**: European Energy Research Area- Joint Programme on Concentrated Solar Power	APPLICATIONS AND RESEARCH PERSPECTIVE - EU and GLOBAL	11:30-12:30 15 minutes for Coffee break
ODTÜ GUNAM	Moderation: Tayfun Hız- ODTÜ-GÜNAM Director Presentations: Mustafa ÇALIŞKAN General Directorate of Energy Affairs / Head of Renewable Energy Project Development and Monitoring Dept. Bilal DÜZGÜN Republic of Turkey Ministry of Energy and Natural Resources/ Head of Planning and Regulation Department	POLICY & LEGAL PERSPECTIVE in at NATIONAL LEVEL (TURKEY)	12:45-13:45
ODTÜ GUNAM	Moderation: Tayfun Hız- ODTÜ-GÜNAM Director Presentations and Discussions: Industrial Partners and Companies of • Mrs. Derya Gunvaran Soyler - Dow Chemicals Turkey • Mr. Ahmet Lokurlu, Solterm Group (Aachen/Germany) • Mr. Gazi Kalkan-AKUO Energy / Turkey • Mr. Fatih Can- TEKFEN Engineering • Mr. Haluk Erdem, SISECAM Co., Atmospheric Coating Tech. Department • Mr. Serdar Erturan, City University of New York and Greenway CSP • Mr. Sinan Akmandor - Pars Makina Co.	INDUSTRY PERSPECTIVE - NATIONAL (PITCHES AND ROUNDTABLES)	13:45-14:45 15 minutes for Coffee break
ODTÜ GUNAM	Prof. Dr. Raşit Turan, Chairman of the Board of Directors of ODTÜ-GÜNAM, Coordinator of the Si-PV Division 20 minutes for Presentations & Discussion in Turkish	NEW GENERATION CRYSTALLINE Si SOLAR CELLS DEVELOPED BY ODTÜ-GÜNAM: TOPCon, IBC, n-PERT, SHJ	15:00-15:20
ODTÜ GUNAM	Assoc. Prof. Dr. Görkem Günbaş, Middle East Technical University, Dep. of Chemistry and ODTÜ GÜNAM, Coordinator of Emerging PV Division 20 minutes Slot for Presentations & Discussion in Turkish	EMERGING PHOTOVOLTAICS TECHNOLOGIES AT EXPANDING ODTÜ-GÜNAM: GENERAL OVERVIEW, PEROVSKITE SOLAR CELLS AND STRIKING OPPORTUNITIES	15:20-15:40
ODTÜ GUNAM	Dr. Talat Özden, ODTÜ-GÜNAM, Coordinator of Module Technologies Division	PV INTEGRATION TO AGRICULTURE (AGRI-PV), VEICHLES (VIPV) AND BUILDINGS (BIPV)	15:40-16:00

The invited international presentations (11:00-12:30) and industrial perspectives (13:45-14:45) were devoted to CST. The Policy and Legal Perspectives (12:45-13:45) addressed both CST and PV, while the last presentations (15:00-16:00) were devoted to PV. ODTÜ-GÜNAM also had a booth at the fair, which allowed one-to-one engagement with key CST stakeholders.

A summary of the participant profile is as follows:

Sector	Number of Participants
Industry	81 (74.3%)
Research and Innovation	15 (13.8%)
Public Authorities	5 (4.6%)
Other / Not Specified	8 (7.3%)
Total	**109**

In total, 109 participants attended the whole-day meeting and signed the attendance list. The industrial stakeholders were highly interested in the event and 74.3% of all participants were coming from manufacturing, consultancy, and engineering companies in the energy sector and renewable energy solutions. The remaining part of participants was from mainly universities (8), research institutes (7), public institutions (5) and associations (1). Based on the number and sectors of participants, the event was successful at engaging both the Turkish industry and Research and Innovation (R&I) communities.

In German event, in total 79 participants attended the whole-day meeting. The largest fraction came from German industry (32) which confirms the capabilities and interest of the industry. The other participants are equal number of participants from research institutions (15) and associations (15), and consultants and other types of organizations (9) and National decision makers and authorities (9).

In Spanish Event, in total 56 participants attended the whole-day meeting. The largest fraction came from Spanish industry (30) which confirms the capabilities and interest of the industry. The other participants are from research institutions (21) and National decision makers and authorities (5).

Highlights and Conclusions: The main highlights of the event in Turkey and conclusions are:

- **INCREASE AWARENESS about CST in TURKISH INDUSTRY**

  Marcel Bial opened the session with a presentation on the EU and Global- Industry Perspective. While indicating that the CSP is not an established industry in Turkey, there are sufficient R&D potential and application opportunities. Financial problems can only be solved embedded in a supportive political environment for CST in Turkey in the context of the EU Green Energy and Sustainable Transition. The key to success to benefit from these technologies in the economy at large is to motivate the industry to invest in this area and to explain how to use these technologies in their own processes.

- **SPANISH R&D and INDUSTRIAL APPLICATION EXPERIENCE in CST CAN BE a GUIDE FOR TURKEY**

  Eduardo Zarza Moya (CIEMAT-PSA) made a presentation on CST applications and Spanish experience. He emphasized thermal storage as the main benefit of CST applications. Spain, as the EU CST Leader, is the home for EU's largest R&D center in collaboration with the industry since the 1980s. This collaboration model and the lessons learned from the Spanish experience may be used to guide the Turkish CST sectoral development.

- **EU-SOLARIS ERIC: A POWERFUL ALLIANCE FOR TURKEY's DEVELOPMENT and ITS INTEGRATION INTO THE GLOBAL CST SECTOR**

  Ricardo Sánchez (EERA JP CSP and CIEMAT-PSA) reported about both the EU and the global R&I perspectives. He emphasized the prioritization in the R&D Strategy of the countries to reach the targets, and gave details about EU-SOLARIS ERIC. Despite Turkey being one of the group members of EU-SOLARIS since its establishment in 2012, it has not been included in the submitted EU-SOLARIS proposal. Still it appears possible for Turkey to be part of EU-SOLARIS, but this will need time and regulatory changes to fully align with ERIC requirements. A participation in EU-SOLARIS via an observer status is possible and would be beneficial for the CST development in Turkey.

- **THERE ARE NO FORMAL LEGAL or POLITICAL BARRIERS to FULFILL CST REQUIREMENTS IN TURKEY**.

  H. Esad Yılmaz, Energy Systems Engineer from the Ministry of Energy and Natural Resources of Turkey, presented the national energy policy and explained the renewable energy policies & strategies. He talked about the solar energy potential of Turkey, the targets of increasing solar energy supply, and ensuring system integration for renewable energy. Even without formal barrier to CST Technologies, there is no installed CST capacity. The demand should come from the private sector, which would lead the public sector to adapt.

- **SOLAR HEATING and COOLING AS A PROMISING CST APPLICATION AREA for TURKEY.**

  Fatma Dilek Öznur, from the Directorate of Energy Efficiency and Environment, Ministry of Energy and Natural Resources of Turkey, presented the important developments achieved in the district heating and cooling area in Turkey. She indicated that the involved Ministries are harmonizing the regulation on energy performance in buildings.

- **INDUSTRIAL ROUNDTABLE: AWARENESS RAISING; DECREASING MANUFACTURING COSTS, and COOPERATION**

  Participants were key stakeholders in the sector such as Haluk Erdem (SISECAM); Fatih Can (TEKFEN Engineering); Sinan Akmandor (Pars Makina Co.); Serdar Erturan (City University of New York & Greenway CSP); Derya Gunvaran Soyler (Dow Chemicals Turkiye); Tayfun Hiz (Moderator: ODTU-GUNAM). The discussion topics were on cost and manufacturing issues for CST systems and components, the increasing role and importance of R&D investments in industrial CST applications, and research-industry cooperation in the area. In the discussion, which especially drew attention to the issue of R&D, it was agreed that cooperation should be emphasized by all stakeholders at the national and international level.

Highlights and conclusions for Germany:

- A mix of different renewable energy technologies combined with efficiency measures are needed.
- The various technology options for providing heat from renewable sources should be examined, combined and promoted in parallel.
- CST represents an important part of the hybrid supply portfolio.

→This requires

- The definition of a development target with accompanying measures
- Ensuring consistent remuneration schemes, Create suitable framework conditions and incentives
- The promotion of concentrating solar thermal reference projects, Promote innovation and create awareness
- The launch of an information campaign for heat consumers (Consulting & concept creation)

Highlights and conclusions for Spain:

For national decision makers and authorities

- Update of Integrated National Energy and Climate Plan imposed by current energy situation with more realistic figures
- clear desire to promote applications for industrial process heat
- The auction mechanism implemented to new solar thermal power plants is necessary to develop the market, but the current mechanism separating the auctioning of new capacities and the access point must be modified
- The Next Generation funds make it possible to expand the storage capacity of the Spanish solar thermal power plant park
- The idea of Germany: “relaunching the concept pursued by the DESERTEC project” should be used by Spain to join forces and promote a wide network of solar thermal power plants in southern Europe and North Africa.

For industry:

- A significant loss of “talent and know-how” is taking place in the industrial sector because the lack of new solar thermal power plant projects. If new solar thermal power plants are not promoted quickly, this loss of talent will worsen.
- Solar thermal power plants do not compete with but complement photovoltaic plants
- A fundamental problem is that the benefits of various technology options for Spain including the full supply chain, beyond the sole cost of electricity
  produced, is not valued in the procurement mechanisms for new RES capacity. Spain can produce all the necessary components for a solar thermal power plant (except the turbo machinery), while for photovoltaic plants depend on supplies from non-European countries.

For Research Institutions:

- A significant R&D effort is also needed from companies
- Innovative ideas exist to further reduce costs and increase the efficiency of solar thermal power plants. However, the necessary public support to develop these innovative ideas is missing. The curent aid programs, both at national and European level, appear insufficient.
- The Spanish industrial sector has developed new components in recent years (rotary joints, heliostats, parabolic trough collectors...) that reduce costs and increase efficiency, but these innovations have not yet been implemented due to the lack of new commercial projects.

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