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INTERNATIONAL POST DOCTORAL RESEARCH FELLOWSHIP PROGRAMME

FINAL REPORT

TITLE OF THE RESEARCH :

Developing Renewable Electricity Generation in the Global Economy:

Co –evolution of Renewable Energy Technological Innovation System and Global Values Chains

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DIRECTOR NAME: Prof. Dr. Antonio HIDALGO NUCHERA

GENERAL INFORMATION

RESEARCH TITLE	Developing Renewable Electricity Generation in the Global Economy: Co –evolution of Renewable Energy Technological Innovation System and Global Values Chains
RESEARCHER NAME	Yelda Erden Topal
RESEARCH FIELD	Economics and Politics of Technology Development in Renewable Energy Technologies
RESEARCH DURATION	12 months

1. Introduction

To meet increasing energy demand with fossil fuels causes the problems of import dependency and energy insecurity. Deployment of emerging technologies for renewable electricity generation is supposed to be an alternative for solving these problems. Using renewable sources and increasing the role of these clean sources in energy bundle are supported to decrease the amount of fossil fuels in energy production.

However, energy insecurity and import dependency problems cannot be solved only by decreasing the amount of fossil fuel used. Additionally, development of technological capabilities in emerging low carbon technologies must be motivated. For this purpose, public policies should be designed to support development of technological capabilities in emerging renewable energy technologies (as Concentrated Solar Thermal Technologies-CST) and hence to fasten deployment and manufacture of low carbon technologies. To enhance the supporting efforts, the policy design process should be engaged to international policy framework and global economics circumstances. Therefore, we investigated the development of technological capabilities in emerging low carbon technologies in global sustainable energy transitions.

In this scope, motivations for development of technological capabilities in emerging low carbon technologies are examined. Investigation of governance and policy making for enabling frameworks to transfer and to diffuse low carbon and climate resilient technologies would be the main theme of the research. For this purpose, a comparative analysis is conducted for defining Turkish and Spanish Renewable Energy Sectors. In this context, we can examine the way of strengthening Turkey's synergistic integration into European Sustainable Energy Transitions (through EU-SOLARIS), and strengthening Turkey's low carbon technologies (especially CST) research & innovation activities, industrial capacities, and markets by identifying Spanish best practices, and adapting these to the unique conditions of Turkey.

By using the quantitative *method of bibliometric analysis* and *qualitative methods of interviews and comparative analysis,* it is aimed to understand the current situation of Turkish CST Sector, and then compare it with Spanish Renewable Energy Systems and Policy Frameworks.

Using these two methods together for Turkish case is the other original contribution of this study. The outputs of this research are expected to be two journal articles, one policy document and a graduate level course design. For this purpose, I attended conferences, sent full articles and had feedback, gave seminars, engaged to network activities and prepared project proposal in these postdoctoral research. After introduction, in second part I reported the studies in two reporting periods of six months. In section 3, I presented the overall research results of the postdoctoral research. In fourth section, I briefly mentioned the conclusions of the research and then in last part I put the outputs mentioned and described in this report.

2. Studies in report terms:

For this post-doctoral research the duration is planned to be March 02, 2020 to March 02, 2021. The first term (I. Term) is the first six months from March 02- September 02, 2020. The second terms (II. Term) is the last six months from September 02, 2020- March 02, 2021. There are four work packages (WP) for this research and six deliverables (D) related to these work packages:

- **WP1**: Comparative Case Study
  - **D1**: Working Paper about comparative analysis and Renewable Energy (RE) Sector in Turkey
    - ✓ **D.1.1** The paper on Market Formation in Turkish RE Sector (Attachment 1)
    - ✓ **D.1.2.** Analysis for Diffusion of Concentrated Solar Thermal Technologies in Turkey-Turkey-CSP Country Report (Attachment 2)
    - ✓ **D.1.3** Comparative analysis of Spain & Turkey (Attachment 12) + (Attachment 13)
- **WP2**: Data Analysis – Qualitative and Quantitative Data Collection Analysis,
  - **D2:** Journal article about the data analysis
    - ✓ **D.2.1:** CSP/STE Bibliometric Analysis -Turkey *embedded in* (Attachment 3)
    - ✓ **D.2.2:** CSP/STE Bibliometric Analysis -Turkey & Spain Comparison (in preparation)
- **WP3:** Education Abilities - Course Design and Lecturing
  - **D3:** Course syllabus and Teaching Design
    - ✓ **D.3.1.** Syllabus Design-First Draft (Attachment 14)
    - ✓ **D.3.2.** Seminar at UPM (Attachment 12)
    - ✓ **D.3.3.** Seminar at ODAKTr Seminar Series (Attachment 13)
- **WP4:** Policy Analysis.
  - **D4:** Policy document- Journal article.
    - ✓ **D.4.1.** EAPE Conference Paper 1 (Attachment 3)
    - ✓ **D.4.2.** EAPE Conference Paper 2 (Attachment 4)

I prepared deliverables to complete work packages as the outputs of this postdoctoral research. I presented the studies in each term under the headings of **the research results & outputs**, **collaboration and networking** during this post-doctoral stay, the **dissemination and communication activities**, and **future research and new connections** after post-doctoral process.

I. Term

The first term is the first six months from March 02 to September 02, 2020. The studies completed in this term are presented above:

A. Research Results and Outputs:

In this first term, for WP1 I completed two parts of Deliverable 1. D1.1 is *the Paper on Market Formation* (Attachment 1). It was submitted ICEEE 2020 Conference and presented in June 2020. Then the full paper is submitted to "Energy Sources, Part B: Economics, Planning, and Policy" Journal "Special Issue-ICEEE in May 30, 2020 and it was not accepted. It will be submitted again on May 15, 2021 to Environmental Science and Societal Transitions Journal-Special Issue-Markets in Sustainability Transitions. D.1.2. is the *Analysis for Diffusion of Concentrated Solar Thermal Technologies in Turkey.* For this purpose we prepared. *Turkey-CSP Country Report*. It is submitted in May 8, 2020 to EC. It is accepted and will be available public in project website when approved by EC (Attachment 2). Also a paper derived from this report is submitted to European Association for Evolutionary Political Economy (EAEPE) 2020 Conference as full paper on May 15, 2021 and accepted for presentation (Attachment 3). Hence, with attachment 3, D.4.1 is completed. For WP3, the background study for D3 also completed. In this term, another paper as the policy analysis is completed and it is submitted to EAEPE 2020 Conference as full paper submission and presentation (Attachment 4). Then it will be submitted to a journal (most probably Energy Policy) in 2021. Hence, with attachment 4, D.4.2 is completed.

The outputs in these term are D.1.1. Market Formation Paper (Attachment) 1) D.1.2. Turkey Country Report (Attachment 2), D.4.1. EAPE Conference Paper 1 (Attachment 3) and D.4.2. EAPE Conference Paper 2 (Attachment 4).

B. Collaboration and Networking:

My post-doctoral stay in Technical University of Madrid (UPM), Madrid/ Spain officially started on March 02, 2020. We came here on March 01, 2020 and met with Post Doc Advisor Prof. Dr. Antonio Hidalgo on March 06, 2020 to talk about the details of the post-doctoral project and to plan the details of the works we would do together and collaboration opportunities. I made a presentation about my research proposal, I saw my office

space and I planned to start on March 10, 2020 to work in the office. However due to the total lockdown started on March 11, 2020 in Madrid/Spain, I could not started to go to office and worked online since then. I have been reporting my progress for the previous week and my plans for the next week on bi-weekly bases to my advisor, and we were keeping contact via mails.

C. Dissemination and Communication activities

During the first term, dissemination and communication activities are:

- On June 2020, I attended *online* **ICEEE'2020 International Conference on Economics, Energy and Environment** and made a presentation (Attachment 5) on June 27, 2020 (can be seen in the certificate (Attachment 6). Professor Hidalgo rewieved this paper once in April 2020, and then I will send it to him again before submitting on "Environmental Innovation and Societal Transitions"- Special Issue May 15, 2021.
- With my co-authors I submitted two papers to **European Association for Evolutionary Political Economy 2020 Conference** that was held on September 2-4, 2020. One of these paper is "Development of CSP / STE Sector in Turkey: Local integration to Global Value Chains through International Channels" (Attachment 3) by Prof. Dr Erkan Erdil, Asst. Prof. Dr Arsev Umur Aydinoglu and me. We made the presentation on September 3, 2021 (Attachment 7). This paper is the enlarged version of Turkey CSP /STE Country Report. The other one was "A Policy Design Model for Market Formation of Solar and Wind Electricity Generation in Turkey" by Prof. Dr Erkan Erdil, Prof.Dr Antonio Hidalgo and me (Attachment 4). We made the presentation on September 04, 2020 (Attachment 8).
- With Prof. Erdil and Assoc. Prof. Dr Pınar Derin Gure (Middle East Technical University) we planned to submit an abstract to "PV CON 2020, 2nd International Conference on Photovoltaic Science and Technologies".
- I sent abstracts and applied to "**EUROLICS** (The European network for the economics of learning, innovation, and competence building systems)", "**The fifth Energy and Society Conference** and midterm conference of the European Sociological Association's Research Network 12 Environment and Society, Energy transition: Does the mountain give birth to a mouse?" and "**9th Mannheim Energy Conference**". However, they are postponed and were not held in 2020.

D. Future research opportunities and new connections:

In the first term of post-doctoral process, I could accomplish some connections and develop following pieces of works for future research opportunities in my research field. These opportunities and connections were:

- **SolarTwins Joint Research Line for Social Sciences:** For SolarTwins Project "Communication, Outreach, Dissemination and Exploitation (CODE) Plan" submitted in July 15, 2020; Strategic Research and Innovation Agenda (SRIA) for GUNAM ODAK was prepared by the project coordinator Prof. Dr. D. Baker. Each researcher at METU Project Team (including me) described and prepared their own research line documents in collaboration with the project partners of CIEMAT (Spain) and DLR (Germany). The goal in developing these JRLs was "to elaborate the content that results in useful outcomes by guiding, thinking and triggering collaborative actions"[1]. As a part of this SRIA, I prepared "JRL 9. Social Aspects of Sustainable Energy Transitions (CIEMAT – METU)" (Attachment 9).Following the JRL, now I am searching for new research and funding opportunities to exploit in renewable energy and sustainable transitions for Turkey in European Union Context.
- **Newton Katip Celebi Fund- Project Application:** In June 2020, Assoc. Prof. Dr. Ismail Solmaz (Ataturk University, Turkey) submitted a proposal entitled as "Integration of Novel MOF Adsorption System with Highly Concentrated Advanced Multi-Junction Solar PV/Thermal System for Clean Cooling and Electricity Production in Turkey" in collaboration with Dr. Raya AL-Dadah (Birmingham University, UK) and Prof. Dr Derek Baker (METU Mech. Eng.). I contributed to the proposal to carry out techno-economic and environmental analysis of the proposed technology in Turkey and I am included to the project proposal as researcher. The results were announced in February, 2021. Despite passing the threshold and accepted by the national funding authority (TUBITAK), unfortunately, it was not accepted for total funding. We are

[1] This part is taken from related SolarTwins Deliverable that is not a public deliverable (only for consortium members) and now under evaluation by European Commission. After the evaluation completed, a public version will be available.

planning to re-evaluate and re-submit it for another funding sources. (You can see the application form in Turkish in Attachment 10. The abstract is in English).

- **Turkish Photovoltaic Technology Platform (TFTP) Research Programme Social and Economic Impact (funded by TUBITAK**): METU GUNAM is awarded as the holder of The Center of Excellence Support Program "Call for High Technology Platforms" Grant for the "Turkish Photovoltaic Technologies Platform" Project in June 2020. The main aim of this platform is developed and produce domestic photovoltaic technologies to contribute to a sustainable energy supply based on domestic and renewable resources in Turkey. The project coordinator Prof. Dr. Rasit Turan (Director of METU GUNAM) has started a collaboration with the METU Faculty Members Prof. Dr. Ramazan Sari and Prof. Dr. Erkan Erdil for measuring the social and economic impacts of this platform and preparing a project proposal for this platform. I contributed to proposal writing and I am included to the project as researcher (You can see the application form in Turkish in Attachment 11).

II. Term:

The second term is the second six months from September 02 to March 01, 2020. The studies completed in this term are presented above:

A. <u>Research Results and Outputs:</u>

In this second term, for WP1 I completed the last part D.1.3 which is the *Comparative analysis of Spain & Turkey*. For this part, D.1.3 is the collection of two presentations. First presentation is the one I prepared for the seminar at UPM (Attachment 12). Second Presentation is the one I prepared for *Winter 2020/2021 ODAKTR Concentrating Solar Thermal (CST) Webinar Series* (Attachment 13). For WP2: Quantitative Data Collection and Analysis, I could complete the bibliometric part of the CST Technologies in Turkey as quantitative study in addition to qualitative study of interviews. I submitted D2.1. as a part of full paper presented it in EAEPE 2020 Conference with my colleagues from Turkey. I am planning to develop this analysis by including Spain to this data and develop the comparative analysis by the quantitative approach to finalize D.2.2 in 2021. This will also contribute WP1. For WP3, I prepared a very basics syllabus for the course given at UPM entitled as "Developing Renewable Energy Generation in the Global Economy (Attachment 14). For WP 4, the first draft of **D.4**. Policy analysis is completed and it is submitted to EAEPE 2020 Conference as full paper. It will be submitted to a journal (most probably Energy Policy) in 2021.

In III. Research Results part, second term's research results are reported under the heading of (3) Comparative Analysis of Turkey and Spain and (2) Discussion and Policy Implications. The outputs are D.1.3. made up of Presentation for ODAKTR Seminar and UPM Course (Attachment 12+Attachment 13). D.2: Two full paper articled submitted to EAEPE 2020 Conference (Attachment 3 and Attachment 4). D3: Course Syllabus Draft (Attachment 14) D4: Policy Article Draft for Comparative Analysis will be drafted and submitted to Gazi University Journal of Sciences.

B. <u>Collaboration and Networking:</u>

In the second term of the post doc research, I worked online and contacted with my supervisor via mails. Every two/three weeks I reported my progress for the previous week and my plans for the next week to my advisor, and we were keeping contact via mails.

C. <u>Dissemination and Communication activities of Conferences:</u>

During the second term, dissemination and communication activities are:

- **On November 27, 2021** I lectured one hour course in "Interuniversity Master in Economics and Innovation Management (MEGIN)" Programme at UPM My postdoctoral research advisor Prof. Hidalgo gave a certificate for approval of the participation (Attachment 14). The presentation title was "Developing Renewable Energy Generation in the Global Economy: Co evolution of Renewable Energy Technological Innovation System and Global Values Chains". The audience was a group of graduate students (27 students) who enrolled to MEGIN. It is a joint degree that is taught at the Faculty of Economics at the Universidad Complutense de Madrid (UCM), the Faculty of Economics at the Autonomous University of Madrid, and the School of Industrial Engineering at the Polytechnic University of Madrid. (Attachment 12).

- **On December 02, 2021** I made a presentation in **PVCON 2020: 2nd International Conference on Photovoltaic Science and Technologies** entitled as "Review of Socio-Economic Impacts of PV Technology Development TFTP Research Programme and Social Impact Assessment". In November, we submitted an abstract. It is accepted and I made a presentation in the name of the group (Attachment 16). With the group of SolarSOS Project (mentioned below), we are now working on the submission of full paper to the PVCon2020 Special issue in the international journal "Renewable Energy" in April 2021.
- **On January 08, 2021** I gave one hour seminar about "CST in Turkey: Current State and National Strategies to Exploit Opportunities" in comparison to Spain in **Winter 2020/2021 ODAKTR Concentrating Solar Thermal (CST) Webinar Series** (Announcement is Attachment 17).This Seminar Series is organized as a part of H2020 SolarTwins Project (Grant Agreement No: 856619). I am a researcher in this project for whole duration of the project (01.2020-01.2022). I am also included in the organization team of this Seminar Series as to program this series and I attended all the seminars. The details of all seminars are given in a booklet (Attachment 18).

D. <u>Future research opportunities and new connections:</u>

- **September 2020-SOLARSOS Project:** This project is the Social and Economic Impact Assessment (SEIA) of Turkish Photovoltaic Technology Platform (TFTP) Research Programme funded by TUBITAK 1004 Programme for 4 years between 2021-2025. I am a member of interdisciplinary research team. I am co-leading one of three work packages in the project to make the SEIA of the scientific research programme of TFTP and impose science and technology policy implications for improving the platform towards increasing the skills and abilities for domestic technology development in solar energy (Attachment 11).
- **September 25, 2020- EUSOLARIS ERIC National Application:** In the name of METU Solar Energy Research and Application Center (GUNAM), with Prof. Dr. Derek Baker we prepared the application document to TUBITAK for METU GUNAM to be the national node for EUSOLARIS ERIC (European Research Infrastructures Consortium for Concentrated Solar Thermal Technologies). It is approved, and now METU GUNAM is the scientific national node of EUSOLARIS. (Attachment 19).
- **On October 19, 2020,** in the name of H2020 Project Horizon STE (Grant agreement ID: 838514), with Prof. Dr. Derek K. Baker , we attended the "SET-PLAN Joint Action (JA) 2 Workshop 2020- Deep Geothermal Implementation Working Group Support Unit" and represented Project team, made a presentation about Horizon STE Project among 10 H2020 JA projects supporting the implementation of the SET-Plan (Strategic Energy Technology Plan as the technology pillar of the EU's energy and climate policy. For this presentation we gathered all the green energy projects of five consortium members (DLR_Germany, CIEMAT_Spain, METU_Turkey, ENE_Altaly and ESTELA_Belgium).
- **On November 2020,** I was included in the preparation of two COST (European Cooperation in Science and Technology) Project Proposals. The first one is "ACET2US: Actions for Circular Economy Transitions to Urban Sustainability". The coordinator is the United Nations University - Maastricht Economic and Social Research Institute on Innovation and Technology (Netherlands). METU TEKPOL is the consortium member and I am researcher. The other COST Project Proposal is "PV2ROAD: System analysis of photovoltaic application in road transport sector". The coordinator is Forschungszentrum Jülich GmbH (Germany). METU GUNAM ais the Consortium Member and I am researcher.
- **January 26, 2021- LPinSHIP Project:** TUBITAK announced a joint research programme between Turkey and Germany on September 2020. In collaboration with Prof. Dr. Derek Baker (METU, Mech.. Engineering, Turkey), LL.M. Onur Çağdaş Artantaş (Hacettepe University, Faculty of Law), Asst. Prof. Dr. Semih Sırrı Özdemir (Hacettepe University, Faculty of Law),Msc. Sevgi Deniz Akdemir (METU, Earth Systems Sciences) we formed an interdisciplinary research team. The Principle Investigator from Germany is Prof. Dr. Michael Fehling (Bucerius Law School, Germany), and from Turkey is me. The title of the project is "Promotion of Solar Heat in Industrial Processes (SHIP): Policy and Law Analysis with Focus on Turkey and Germany" The proposed project aims to discover potential approaches to promote SHIP in Turkey and Germany with a comparative analysis: (1) The current status of SHIP in both countries will be examined and compared. (2) The current status of the SHIP policy and law in both countries will be examined and compared. (3) SHIP Policy proposals for both countries will be made. The proposal is still under review. The project is one year proposed project and the total budget is 140.000 TL.

3. Research results:

The research results are presented under four complementary parts. 1) Introduction: The Snapshot of the Current Situation in Turkish Renewable Energy Sector and CST Technologies, (2) Analysis of Concentrated Solar Thermal Technologies in Turkey – Quantitative and Qualitative Analysis, and (3) Comparative Analysis of Turkey and Spain.

3.1. Introduction:

A snapshot for Turkey Energy Sector

In the growth phase of globalized economies, meeting energy demand is emerging as an important problem (Asif and Muneer 2007; Holdren 1991). With this problem, the debate on sustainable and clean energy supply comes to the fore (UNFCCC 2015). Especially, the dominance of fossil fuels in primary energy consumption and carbon intensive electricity generation technologies using fossil fuels increase the concerns about environment and climate change (UNFCCC 2015). In Turkey, fossil fuels are also the main source of electricity generation and most of these sources are imported since Turkey is not self-sufficient for supplying fossil fuels. This makes import dependency for fossil fuel a critical problem for Turkey (Ozcan 2019). According to the Turkish General Energy Equilibrium Table 2018, the rates of fossil fuels (natural gas, petroleum and solid fuels) in total imported amount of energy sources are 38%, 43% and 21% respectively (ETKB 2018). In electricity generation, the share of natural gas is 30%, the share of solid fuels is 37%, and the share of petroleum is 0.1 %. Hence in 2018, 67% of electricity is generated from fossil fuels which are mostly imported (ETKB 2018). This energy scheme shows that Turkey generates its electricity by using carbon intensive energy technologies using fossil fuels and, imports most of these energy sources.

To meet the increasing energy demand in sustainable manner, the rate of environmentally clean sources in energy bundle must increase[2] (Keleş and Bilgen 2012; Yuksel 2010; Erden-Topal 2016). For this purpose, by considering environmental, social and economic aspects of sustainability, as a solution it is proposed to balance energy sources bundle by improving the role of clean energy sources in electricity generation (World Economic Forum 2016; Yuksel and Kaygusuz 2011). There are three major clean energy options: carbon neutral energy (fossil fuel in conjunction with carbon sequestration), nuclear power, and renewable energy (Kamat 2007). Besides other alternatives, renewable energy is generated from available and domestic resources such as hydroelectric resource, geothermal land area, wind power, tidal energy, biomass and solar energy striking the earth (Kamat 2007). Increasing the role of renewable sources is advantageous as compared to other clean sources in terms of sustainability (World Economic Forum 2016). Especially the countries where the dominant energy sources are imported fossil fuels, like Turkey, energy production from domestic and clean renewable sources becomes a promising solution for energy problems (Toklu 2013; Asif and Muneer 2007; Yuksel 2010; Yuksel and Kaygusuz 2011). Renewable energy sources are used in heating, electricity production and lighting. Electricity generation from renewable sources is an accepted alternative for solving energy problem.

When Turkey's electricity consumption covering the period 2000-2016 is examined, it shows that electricity consumption has increased an average of 6% over a 16-year period. According to Turkish Electricity Transmission Company (TEIAS) data, electricity consumption increased by 4.3% in 2016 compared to the previous year. In 2017, it increased by 5.6% compared to the previous year. When Ministry of Energy and Natural Resources (ETKB, 2018) energy statistics report is examined, electricity consumption in April 2018 increased by 6.6% compared to the electricity consumption in April 2017. This increase, which can be normalized to an average of 6% per year, is quite high.

Moreover, electricity prices follow a high upward trend. Since 2008, the rate of increase in electricity prices is calculated to be 3.2% annually for residential consumers and 2% for industrial consumers. Using the Tariff Tables Based on Electricity Bills provided by Electricity Market Regulatory Authority (EMRA) on its website, the average increase in electricity prices used in industrial, commercial and residential areas in 2012-2018 was 4.6%, 5.2% and 5.8%, respectively (EMRA, 2018). In fact, in April, August and September 2018, electricity prices have increased three times. In the first quarter of 2018, the price of industrial electricity, which was 31.3 cents/kwh, increased by 33% to 41.9 cents. In the same period, the price of residential electricity, which was 36.1 cents/kwh, increased by 22% to 44 cents.

[2] According to ETKB (ETKB 2018), in 2018, the rate of renewable sources in electricity generation is app. 33 % (including hydropower (20%), solar (2.5%), wind (7%), biomass (1%), geothermal energy (2.5 %).) This rate was 29 % 2017.

In short, the energy scheme summarized above shows that; increasing electricity consumption and increased electricity prices in Turkey, with heavy use of imported fossil fuels in electricity production and abundant renewable energy resources in the country promote the use of low carbon electricity generation technologies. **This indicates a structural change in energy generation and resulting transition in energy sector**, and Turkey will increase using low carbon energy production as a part of this structural change. Moreover, the development of domestic renewable energy technologies is recognized as a pillar of this structural change. This acceptance is one of the main starting points of the study. **Producing renewable energy technologies based on country's own skills and knowledge accumulation and the processes of building these skills** will be the main issues examined in this research. To identify the main factors affecting development of technological capabilities in emerging low carbon technologies and hence development of domestic renewable energy technologies in the context of developing countries as compared to a best practice will be the main contribution of this study.

Renewable Energy in Turkey

Development of the Renewable Energy (RE) Sector in Turkey has not a long but a fast-moving history. Since the beginning of 1990s, with the investments in emerging renewable energy generation technologies the sector started crawling. In early 1990, the first wind turbine installments started. First, in 1998 the total installed wind power was reported as 8.7 MW (EMO, 2015). Afterwards, the installed power capacities had increased very slowly until the 2000s. Especially after 2013 with the establishment of the new legislative framework and new initiatives (such as Solar Tenders, Unlicensed Electricity Generation Legislation and its amendments, Renewable Energy Development Zones, New tariff rates and implications), decreasing costs, and groundbreaking technological developments; the renewable energy sector has started running without walking in-between in Turkey. First large-scale wind power plant installments started after 2007 and large-scale solar power plant applications, using photovoltaic energy generation technologies, started lately in 2015. Nowadays, the installed capacities have reached impressive levels in such a short time. According to Turkish Electricity Transmission Company (TEIAS) last report on June 2020 (Table 1), total installed power reached to 93,951 MW that includes hydropower of 29,916 MW (31.8%), wind power of 8,330 MW (8.9%), solar energy of 6,487 MW (6.9%), geothermal power of 1,579 MW (1.6%) and biomass of 1,391 MW (1.4%). This means today approximately 50% (47,703 MW) of all installed power plants generate electricity from renewable energy sources (TEİAŞ 2020). On the other hand, in 2013 Turkey's total installed power was 64,044 MW and only 39.6 % (25,330 MW) of this power was renewable energy. In total, hydropower was 22,744 MW, wind power was 2896 MW of geothermal power was 311 MW and solar power did not exist. (EMO, 2015). This means the total installed power of renewable sources increased approximately 88% in the last seven years. However, this growth trend is unique to emerging renewable energy technologies of wind turbines and solar PV applications. In this time period, wind energy has grown more than triple and solar power (of PV applications) has grown from 0 to 6500 MW. On the other hand, another type of solar power, concentrated solar power / solar thermal energy (CSP / STE) segment that has cross-cutting and solid grounds in mature energy generation technologies, practices and transdisciplinary research, is moving cautiously and safely, hence slowly since the beginnings of the 1980s. Still in 2020, there are no installed electricity generation power plants using concentrated solar thermal technologies.

Table 1: Turkey's Energy Installed Capacities

	2013	**2020**	**Increase**
Total Installed Capacity	64,044 MW	93,951 MW	47%
Renewable Energy	25,330 MW (39.6 %)	47,703 MW(50,7%)	88%
Hydropower	22,744 MW (35.5%)	29,916 MW (31.8%)	32%
Wind power	2896 MW (4.52%)	8330 MW (8.9%)	187%
Solar energy	0 MW	6487 MW (6.9%)	∞ (NO CSP)
Geothermal power	311 MW (0.48%)	1,579 MW (1.6%)	407%
Biomass	0 MW	1391 MW (1,4%)	∞

Renewable energy sectoral development in Turkey originates mainly in search of solving the society-based energy challenges. Today, in Turkey, we are experiencing specific and inherent energy problems such as *import dependency* for energy sources and energy generation equipment, and *governance of the energy sector* rooted in standardization of the sector wide applications, changing role of government, regulatory issues, trust relationship and legitimation and structural transformations (Erden Topal, 2016). In such an energy context, renewable energy is seen and flourishing as an important alternative for solution. Among the other renewable energy technology alternatives; specifically, we propose that Concentrating Solar Thermal (CST) Energy technologies promise global as well as local impacts and solutions to these energy problems through various applications of Solar Thermal Electricity (STE), Solar Heat for Industrial Processes (SHIP), Solar Fuels, and Clean and Fresh Water technologies. In such circumstances, we aim at understanding the current situation in this segment of the Renewable Energy Sector in Turkey, since we observed that CSP Research in Turkey has a transformative nature in knowledge generation in renewable energy and decision-making process of producers and policy makers. To include wider perspectives to analyze, we included inputs from different stakeholder groups; included different aspects of knowledge generation beyond problem solving and put emphasis on collaborative action among the actors. Therefore, to examine CSP Activities in Turkey, we made a qualitative analysis of 14 semi-structured interviews with various actors of industrial partners, university researchers, bureaucrats and NGOs between September 2019-January 2020. Also, we benefited from the quantitative analysis of bibliometric data by scanning the research networks through 483 publications derived from Web of Science (WOS). Each publication has at least one co-author that is affiliated with a Turkish university. By using and combining these two analyses we derive conclusions for the current situation and CSP Sector in Turkey.

3.2. Data Collection Methods:

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 (Table 2).

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 14 semi-structured interviews in Turkish with the researchers and professors at universities and research centers (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 based in Istanbul and Ankara, and via phone calls & video conferences. We completed interviews between November 2019 - January 2020. Also, as a consortium member of the EU H2020 Programme funded project "Implementation of the Initiative for Global Leadership in Solar Thermal Electricity' — HORIZON-STE (No: 838514), we accompanied Horizon STE research team's meetings in Ankara conducted for preparing Turkey CSP/STE Country Report, and exploited the opportunity of benefiting from the discussion in these meetings. We used a general interview guide which included six sections:

- 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 analyzed, 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 the CSP/STE Research Field. Bibliometrics, by OECD Glossary of Statistical Terms[3], is defined as the "statistical analysis of books, articles, or other publications". The bibliometric analysis[4] includes

- 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 the Middle East Technical University (METU) H2020 Programme 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[5]. We scanned the Web of Science (WOS) Database by searching our keywords in the TOPIC Area[6] 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 coauthor 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).

Table 2: Details of the Methods used in the study.

Background research (June October 2019)
Aim: 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 and to define and determine the main actors and stakeholders in the sector for stakeholder mapping and interviews.
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, 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.
Visits & Interviews (November 2019-January 2020)

[3] You can have detailed information from: https://stats.oecd.org/glossary/detail.asp?ID=198
[4] You can have detailed information about bibliometrics as a research method from https://instr.iastate.libguides.com/c.php?g=49332&p=318077
[5] You can reach detailed information about Web of Science from https://clarivate.com/webofsciencegroup/solutions/web-of-science/
[6] You can make article search from WOS Database by using Topic, Title, Author, Publication Name, Year Published, Funding Agency etc.

Aim: (i) To generate data through expert interviews to determine needs in the renewable energy sector in Turkey and to have feedback on scientific, political, economic and social factors affecting development and diffusion of CSP/STE Technologies in Turkey (ii) to understand the current and future energy strategies regarding energy security and renewable energy sector in relevant framework conditions

Description of the Stakeholders:

Researchers:

- Prof. Dr. H. Ö. P. 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. U.C. from Istanbul Technical University, Institute of Energy, Head of Renewable Energy Division.
- Prof. Dr. H. E., Bogazici University, Dep. of Mechanical Engineering, Head of Thermal Energy Systems Laboratory.
- Prof. Dr. İ. G., TUBITAK 2232 Leader Researchers Grant Programme holder, hosted by METU Mechanical Engineering Dep. And Emeritus Professor of French National Centre for Scientific Research/CNRS.
- Prof. Dr. P. M. 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)
- S. E., Entrepreneur of the First CSP Plant in Turkey (Greenway Co. And NYU)
- GKE Energy (having R&D Center for Energy Solutions in Turkey, Consultant and service provider for energy investments in Turkey and MENR Region)

NGOs:

SHURA Transition Center (An NGO directly involved in Transition of Energy Sector and Sustainable Solutions to Energy Problems in Turkey in the international context)

Bibliometric Analysis (February 2020-June 2020)

Aim: To collect data for scientific research base in CSP/STE by measurement of research performance through publication search.

Description:

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, 483 publications are found).

3.3. Analysis of the Data:

3.3.1 Interview Analysis

In qualitative analysis we conducted fourteen interviews with *industrial stakeholders* such as company owners, investors in technology development activities for SHIP applications, service supplier and entrepreneurs; *researcher*s 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 (Transmission System Operator) and a civil society representative. We look for the 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:

- Technology Development & Domestic Production
- Industrialization of the research
- Implications of CSP / STE Technologies (Hybridization and SHIP)
- Storage and Integration of CSP to Energy Sector
- Supports & Incentives for Development & Diffusion
- Political & Legislative Framework
- Problems and Threats
- 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 a 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 implications 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 locations for such SHIP investment (both in terms of DNI and region of production). Energy costs are 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 neighboring 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 continues. 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 the 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 the future of the technology, Energy Mix including Renewable Energy and SHIP implications would be the 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.

3.3.2. Bibliometric Analysis

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 coauthor 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 more than 50 publications per year (Figure 1).

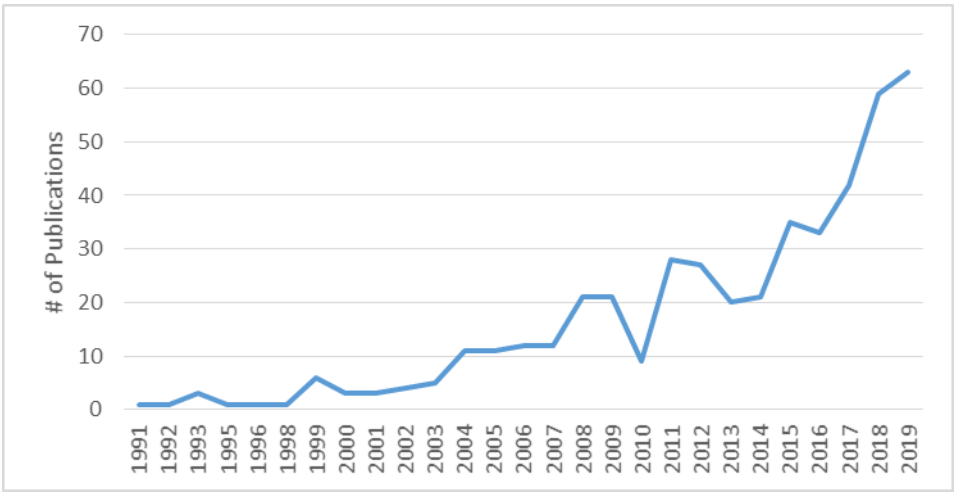

Figure 1 The number of publications annually.

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 color. As communicated by Figure 7, the most active authors (Halime Paksoy, Ahmet Sari, Cemil Alkan, Kamil Kaygusuz) are at the center 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.

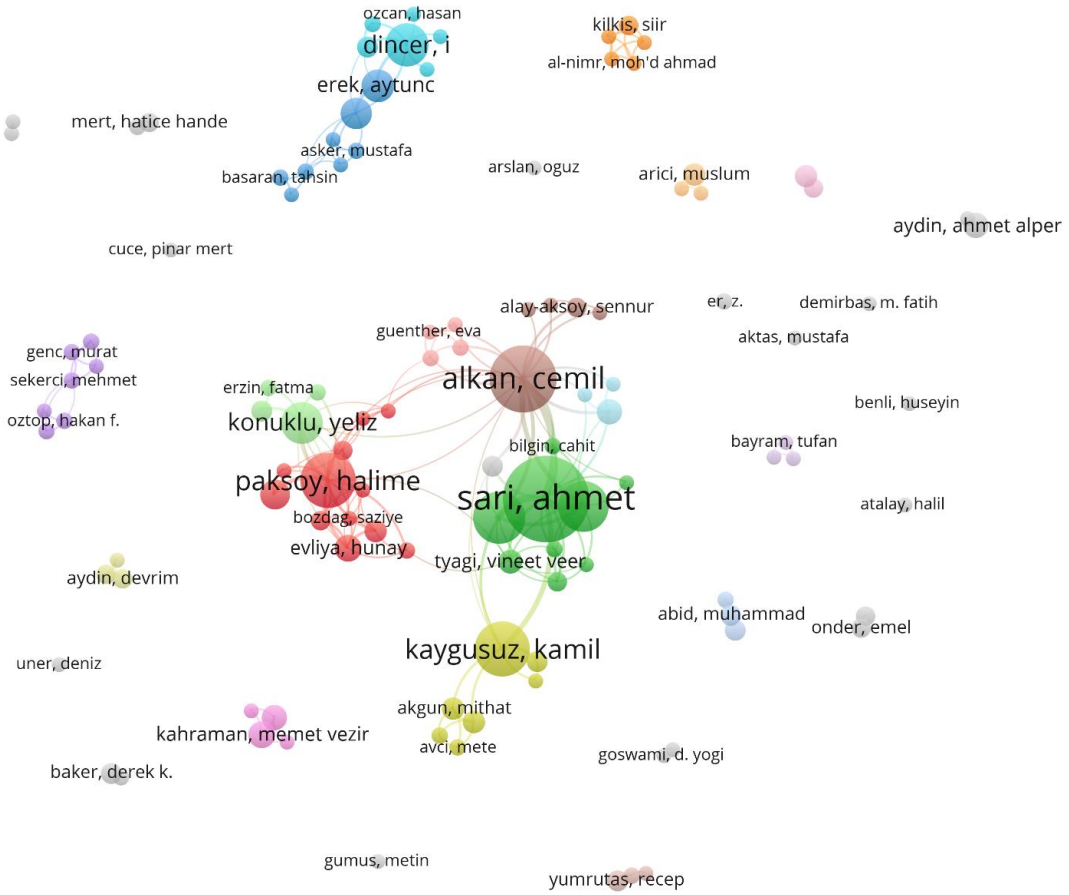

Figure 3 – Coauthorship network (coauthors with a minimum of three publications, 113 nodes out of 768).

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 coauthors. One thing here is clear though, all of these scholars work are on the technical side of CSP research, there are almost no studies on the policy or the market side of things.

Table 2 – Co-authorship network

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

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 8 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.

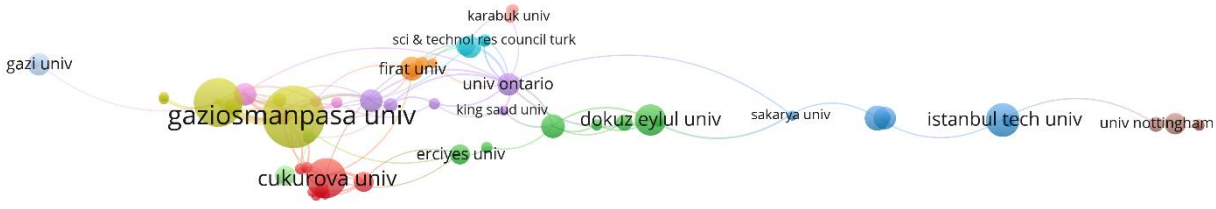

Figure 4 – Organization network (organizations with a minimum of three publications, 59 nodes out of 236).

The collaboration at the country level can be seen in 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.

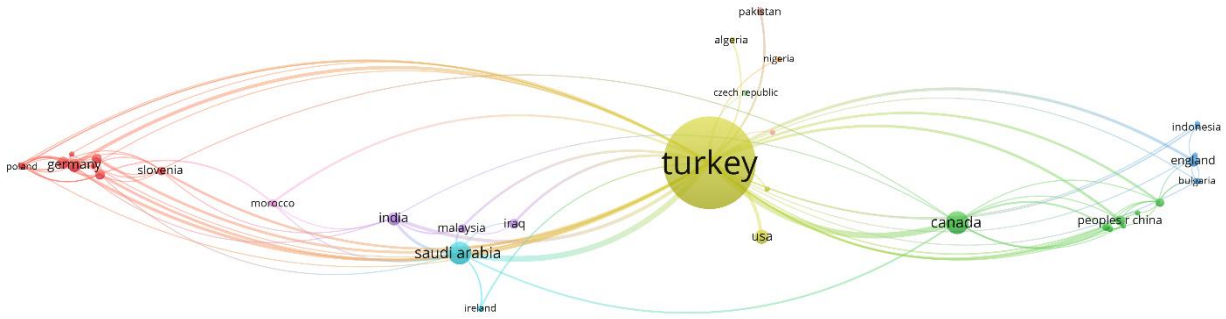

Figure 5 – Collaboration at the country level (a minimum of one publication, 40 countries in total)

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 identified.

A keyword map of CSP research (Figure 8) can also provide an insight to the interdisciplinary nature of the research. The co-occurrence network map provided below. There are eight clusters (each color 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. Findings from the interviews highlights the interdisciplinary perspective as reported earlier in our study.

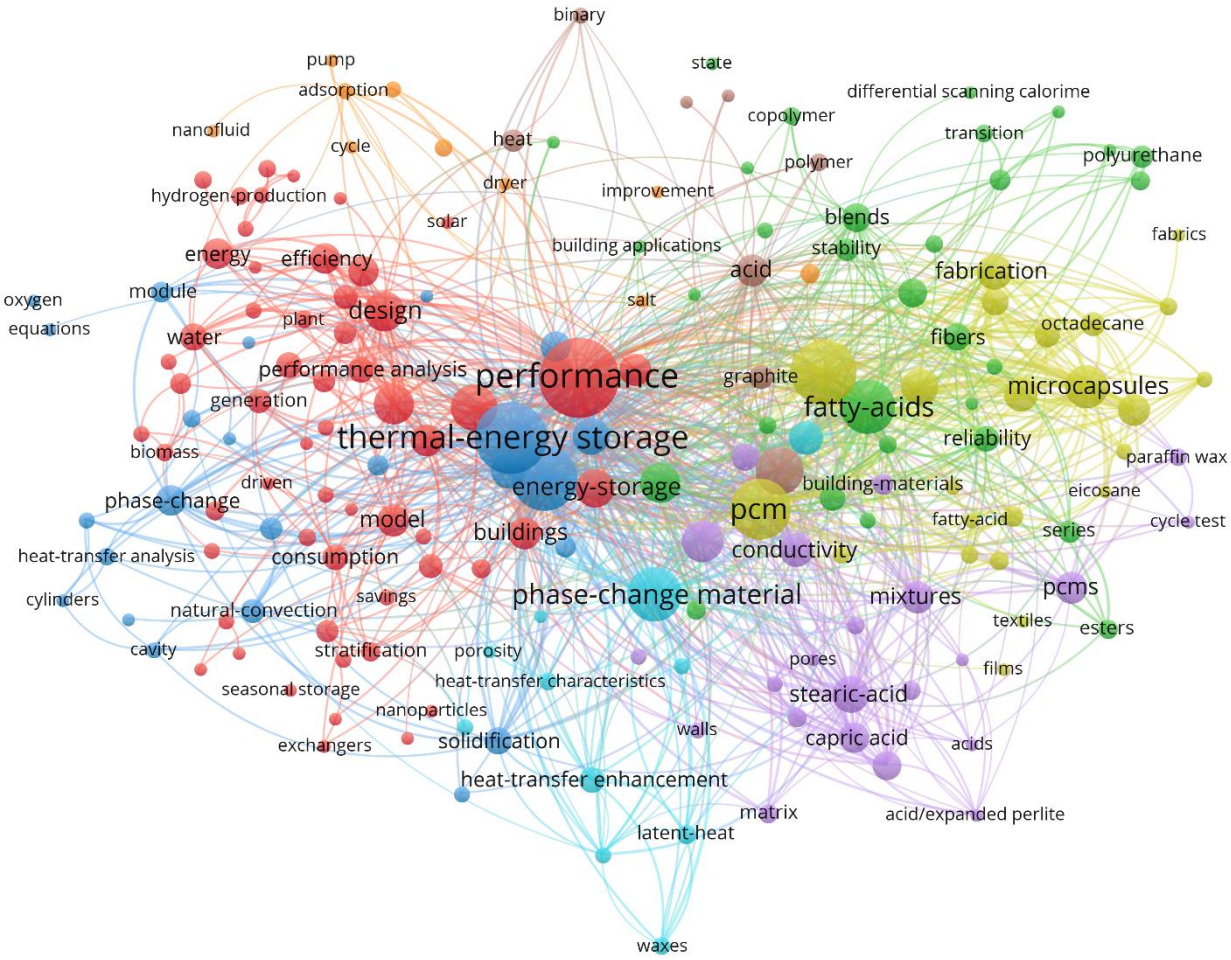

Figure 8 – Keyword map (minimum three times, 187 keywords out of 812).

3.4. Comparative Analysis: Energy Transition & CST in Spain & Turkey (Preliminary Findings)

Turkey and Spain in EU Context- Basic Statistics & Demographics

Turkey, with 15.9 B USD) has the largest Research and Development (R&D) expenditures in the Eastern Mediterranean Region and the 7th largest in European Research Area (ERA) behind Germany (110 B USD), France (60.6 B USD), UK (43.8 B USD), Italy (29.5 USD), Spain (19.4 B USD), and the Netherlands (16.4 B USD)[7]. Turkey's GDP[8] (0.74 Trillion USD) is the Largest in the Eastern Mediterranean Region; 7th largest in ERA, behind Germany (3.86 T USD), UK (2.83 T USD), France (2.71 T USD), Italy (1.99 Trillion USD), Spain (1.4 T USD), and the Netherlands (0.90 T USD); 19th largest globally. Turkey's population (84.3 M) recently surpassed Germany (83.8 M) to become the largest in ERA and 17th largest globally.[9] Spain's population is (46,7 M). Turkey (428 MtCO2/yr.) is the 2nd largest GHG emitter in ERA behind Germany (759 MtCO2/yr.) and 17th largest globally[10]. Spain's GHG Emission in 268 MtCO2/yr. Therefore, in terms of geographical and demographic features Turkey has an important place in EU Region, and is very similar to Spain for deriving lessons learnt for renewable energy sector from Spanish Case to adapt and implement in Turkish Case.

Recent Trends in Energy Sector in Spain (2019)[11]

In 2019, The PV has increased its production by more than 18 points (it has covered 3.5% of peninsular demand) in Spain. The thermosolar has also grown a lot, 16.8% over 2018 and 3.8% compared to the average for the last 5 years; thus, it has covered 2% of the energy demand. However there is no installation in 2019. On the other hand, in 2019, coal use declined resulted in falling CO2 emissions associated with electricity generation, which have marked an all-time low since registrations (1990): 40.6 million tonnes of CO2, 25.5% less than in 2018. 52% of the power of the national generation park (55,195 MWs) is renewable power, while conventional power - fossil fuels and uranium - would add up to 48%, (51,000 MW) of power. The Spanish installed capacity grew by 5.9% in 2019. In particular, 6,539 green MW entered service this past year. 47% of renewable power is wind; 16%, photovoltaic; and 37% is other green technologies (alluding to biomass, undyrm and thermosolar).

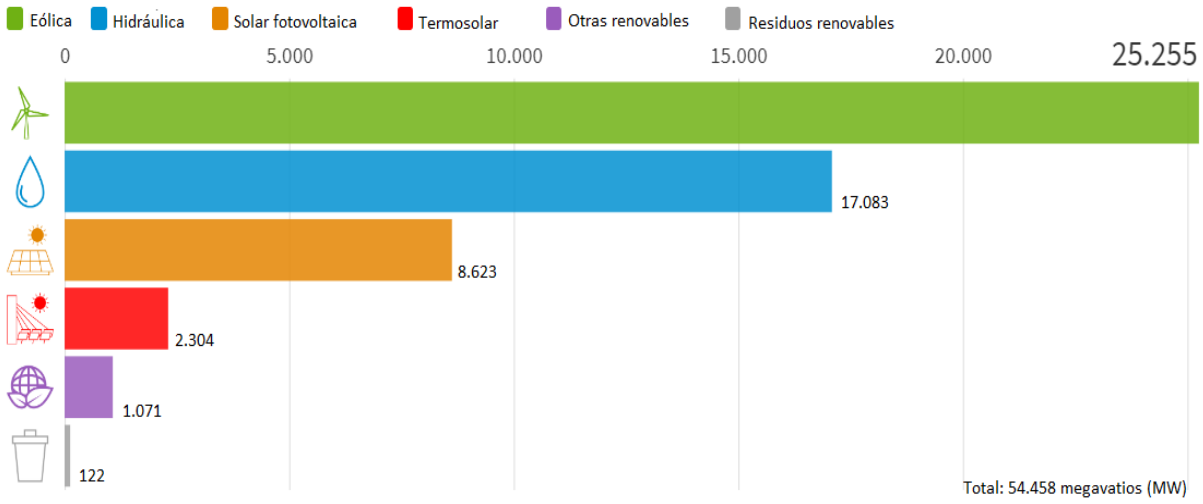

Figure 9 – Total installed capacity of renewable energy sources in Spain (2019)

Lessons Learnt from CST Sector in Spain

In Solarthermal Electricity, Spain operates a third of the world's capacity - just over 6 GW. New solar thermal plants were built 7 years ago, since then there is no building. On the other hand in Turkey, there is still no CSP Power Plant. Energy Transitions shaped by National Integrated Energy and Climate Plan (PNIEC) for 2021-2030 released in June 2020 by Spanish Ministry Transition Ecological and Demographic Challenge. First calls relased

[7] http://uis.unesco.org/apps/visualisations/research-and-development-spending/
[8] https://www.investopedia.com/insights/worlds-top-economies/
[9] https://www.worldometers.info/world-population/population-by-country/
[10] http://www.globalcarbonatlas.org/en/CO2-emissions
[11] The statistics and evaluations in this section is gathered from ProtermaSolar Website (https://www.protermosolar.com/)

specific for CST Power Plants Projects and as a result, new Capacities are targetted to reach 10 GW in 2030. Additionally the target is to improve existing facilities, thus increasing manageable renewable generation by leveraging the infrastructures that are in operation.

- In Spain, implementation and diffusion strategies for CST are clearly defined by the policy documents. Technology specific solutions to energy problems such as specific calls for CST are used for energy transition.
- Hence, **clear policies and regulations**, and **technology specific solutions** to energy problems can be adopted in Turkey for including CST in Energy transition.

The mode of operation for CST power plants are complementary to photovoltaics. The main aim is preventing prices from deflating when the sun shines and reducing the need for fossil backing at night.

- **Hybrid and complementary energy generation methods** can be implemented to integrate CST in power system effectively..

In Spain, the autions for CST are announced recently and wil be accrued in Summer 2021. Expected Impact of Auction until 2030 are: (i) 200,000 equivalent one-year jobs (distributed according to the capacity of each auction until 2030) (ii) 5,000 indefinite and skilled jobs would be created for the operation and maintenance of the new plants. (iii) Regional Development of *Spain Empty (the regions in Spain where the areas are not urbanized and are empty)*, during construction of new power plants, but also the rest of its useful life. (iv) To strenthen daytime storage capacity and exclusive overnight dispatch (v) Implicitly there are technology specific implications & solutions in auctions that makes the thermosolar to be in the best position for new energy installations:

- Due to the appropriate geographical regions for CST are similar in Turkey and Spain, **Spain's CST diffusion and implementation strategy targeting regional development** can be a model for Turkey's CST diffusion.

Advantages of CST Technologies in Spain:

- ***Operation and maintenance are the key to success***. Operators of Spanish solar thermal power plants are increasingly experienced. They can build domestic and local skills and abilities to construct and sustain the power plants, that bring advantage of cost reductions in operation of CST power plants.
- ***Gurantee in supply*** *is another advantage of CST Technologies.* The thermosolar can operate as a guarantee of supply (such as gas) when the photovoltaic does not.
- ***Storable power is*** one of the important ***advantages of*** CST Technologies. Thermal energy storage is a strong solution for energy storage that can be integrated to any kind of energy generation when the physical conditions for solar radiation is appropriate.
- ***Capable to answer declining electricity demand.*** Since the demand for electricity on the Iberian peninsula during 2019 slightly lower than in 2018 (2.7% less), CST power plants can suply the needed energy in line with green energy transition.
- **Answers the Green Economic Development Targets** in terms of operational capabilities, technology development skills, industrialization motivations, export potential promoted, new job creation.
- ***Regional Disparities are taking into account*** for the implementation plans for energy invesments. This makes CST Policies are also beneficial for regional development**.**
- Support to decrease carbon emission by **declining the authorization new fossil energy projects.**

4. Conclusion and Comments:

In Turkey, we analyzed the CSP Energy Technologies Sector by collecting data through qualitative and quantitative techniques, and then making a comparative analysis with Spain.

In the data analysis part, we found that there are robust research infrastructure and qualified cutting-edge research in this area in Turkey. However, the links between companies and the research conducted in universities are loose. On the other hand, there is an established political and regulatory framework in Turkish Renewable Energy Sector. Policymakers can regulate the industry with close relations and continuous updating. 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, some loose interventions to provide systemic sustainability. Yet this is still experimentation. This would be turned to an advantage for CST /STE to exploit the new opportunities in the energy sector with changing consumption, production and regulation patterns. Another important phenomenon observed in data analysis is the integration of both industry and university to EU Research Networks. EU Research networks in this area are secure, and Turkey's inclusion in these networks are successful. This brings natural boundaries (and also 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. CSP, with different methods of energy harvesting from electricity generation to process heat production, is seen as a solution for the problems of RE storage and supply security. Diffusion of technology and increasing awareness about the benefits of this technology are very critical. One of the spots highlighted is that the complementary and hybrid solutions that include CSP /STE Technologies.

Hybridization rather than the individual CSP power plants are the key for this technology to diffuse in Turkey. Bibliometric analysis that investigates the scholarly work on the topic supports the framework described by qualitative analysis as well. The scientific research areas included in CSP / STE Research are diverse, and the picture of the research network seems to be transdisciplinary. Moreover, when we analyze 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 CSP /STE sector in Turkey, we infer that in Turkey there is a cutting-edge research base related to these technologies and the industrialization of the sector with loose relations to industry. Development and diffusion of this new technology can be analyzed through local integration to global value chains through the mediation of international channels. In the paper, we will propose policy implications to support sectoral development.

From comparative analysis of Spain and Turkey in CST Sector, we derived preliminary findings than can be used for policy analysis in this sector. Since Turkey and Spain are very similar to each other in terms of geographical and demographic features those pave the way for CST implementation and diffusion, Spanish model for CST Diffusion in EU Region can be exploited as an appropriate model for deriving lessons learnt for renewable energy sector in Turkey. The main pillars of Spain's CST diffusion strategy are clear policies and regulations, technology specific solutions and hybrid and complementary energy generation methods including CST. Therefore, these main pillars can be examined as lessons learnt for Turkey's CST case. CST Diffusion in Spain generates many advantages such as *building operation and maintenance skills; gurantee in power supply; generation of storable power; ability to answer declining electricity demand and green Economic Development Targets; and declining authorization new fossil energy projects by taking into account the regional disparities for the implementation plans for energy invesments*. These preliminary results can be elaborated and delienated in designing specific policies for CST technolodgy development and difusion in Turkey.

5. Outputs

The output of the postdoctoral research are given below (*Paper on Market Formation (Attachment 1) and EAEPE Paper 2- Policy Paper (Attachment 4) are drafted as full paper and now under preparation for submission. These papers will be co-authored by Prof. Dr. Antonio Hidalgo.*)

1. Paper on Market Formation (Market Formation in Solar and Wind Electricity Generation in Turkey: Technological Innovation System Approach) – Attachment 1
2. Turkey-CSP Country Report (Horizon STE Integrated Country Report- Turkey) - Not public yet- Attachment 2
3. EAEPE Paper 1 –CSP Paper (Development of CSP / STE Sector in Turkey: Local integration to Global Value Chains through International Channels) Attachment 3

4. EAEPE Paper 2- Policy Paper (A Policy Design Model for Market Formation of Solar and Wind Electricity Generation in Turkey) Attachment 4
5. Participation to ICEEE Conference –ICEEE Presentation (MARKET FORMATION in SOLAR and WIND ELECTRICITY GENERATION in TURKEY: TECHNOLOGICAL INNOVATION SYSTEM APPROACH)- 27.06.2021-Attachment 5
6. Participation to ICEEE Conference –Certificate - Attachment 6
7. Presentation for EAEPE Paper 1- CSP Paper -03.09.2021-Attachment 7
8. Presentation for EAEPE Paper 2 -Policy Paper -04.09.2021- Attachment 8
9. H2020 Programme SolarTwins Project Joint Research Lines 9 (Submitted JRL9)- Social Aspects of Sustainable Energy Transitions- Attachment 9
10. Newton Katip Celebi Programme- Project Application Form (in Turkish) - Attachment 10
11. TUBITAK 1004 Programme-Socio-Economic Impact Assessment of Turkish PV Technology Platform (SOLARSOS) Project Application Form (in Turkish) - Attachment 11
12. MSc Programme Seminar Presentation at UPM- 27.11.2020 -Attachment 12
13. ODAKTr Presentation-08.01.2021 (Winter 2020/2021 ODAKTR Concentrating Solar Thermal (CST) Webinar Series- 2021-CST in Turkey: Current State and National Strategies to Exploit Opportunities)-Attachment 13
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15. YET Certificate by Prof. Dr. A. Hidalgo- Nov. 27, 2020 Seminar- Attachment 15
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18. OdakTr Seminar/Webinar Series Final Booklet- Attachment 18
19. EUSOLARIS Eric METU Application Folder- 28.09.2020 - Attachment 19

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