Master Thesis Sustainable Business & Innovation

How does the established sector influence the development and diffusion of clean technologies in developing countries? A case study about HVAC/R and heat pumps in Turkey

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Abstract: The development and diffusion of clean technologies, such as heat pumps, is crucial for mitigating CO2 emissions. Technological Innovation Systems (TIS) provide a framework for understanding the diffusion and development of clean technologies in developed countries. For developing countries, however, researchers suggest an extended version of the TIS framework accounting for their characteristics of developing countries. On the top of this, researchers claim that there is a need for exploring how established sectors may influence the development and diffusion of clean technologies. Prior research on developing country's TIS did not emphasize on how the established sector may influence the diffusion and development of technologies in formative phase. Accordingly, this paper studies how established sector (HVAC/R industry) influence the diffusion of heat pumps in Turkey. Through desktop research and 28 semi-structured interviews with relevant actors, the analysis examines the influence of the HVAC/R sector on the extended TIS framework for developing countries. The findings of study, shows that special emphasise should be given to creating conditions that create industrial space for the TIS in developing countries since the production activities found to be highly critical for their TISs. Furthermore, it is observed during the formative stage of clean technologies in a developing country, the structural overlaps between sector and focal TIS significantly impact TIS functions. The infrastructure overlap, network overlap and formal institutions positively influence the knowledge development and diffusion and these overlaps ease the path of diversifying from HVAC/R to HP. However, the overlapping actors influence the expectations and activities to legitimize the HPs negatively since there is a lack of commitment and misalignment inside the sector. Thus, this study shows that while the infrastructural overlaps created opportunities for TIS based in developing countries, these positive influences do not lead market growth or vision to diffuse a clean technology. To address these challenges and diffuse clean technologies in developing countries, this paper shed light on the importance of creating conditions that enables formation of industrial space to capitalize the market demand, even though there is no adequate domestic market size.

Keywords: Technological Innovations Systems (TIS) in developing countries, structural overlaps, established sector influences on TIS, heat pumps

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1. Introduction:

1.1 Research Problem and Question

Fifty years ago, scientists warned that the Earth would be pushed beyond its limits due to the exponential economic growth, human population, and resource consumption (Meadows, 1972). Today, according to the latest report by the Intergovernmental Panel on Climate Change, depending on the rate of global warming, after 2040 significant threats to natural and human systems will result from climate change (IPCC, 2022).

Climate change refers to altered climatic patterns caused by greenhouse gas (GHG) emissions like carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O) (Fawzy et al., 2020). Researchers have suggested drastic shifts in energy technologies are needed to limit climate change (Dechezleprétre et al., 2019). Environmental innovations, defined as clean technologies reducing environmental impact such as emissions (Li et al., 2021), not only sustain economic growth but also play a crucial role in mitigating GHG emissions and alleviating environmental stress (Weber & Rohracher, 2012; Dechezleprétre et al., 2019).

The building sector operations, responsible for 28% of global CO2 emissions, emits 3.7 Gton of indirect emissions from power and heat production and 1.9 Gton of direct emissions from fossil fuel burning for heating and hot water (Abergel & Delmastro, 2020). Decarbonising heating and cooling through clean technologies, such as heat pumps and district heating, is one of the promising options for reducing GHG emissions (EU Commission, 2016). Heat pumps (HP) are used for heating and cooling throughout the year by extracting heat from one place and transferring it to another by using thermal energy from heat sources such as water, air and ground and additional energy needed for compression to provide the heat (Carroll et al., 2020; Fischer & Madani, 2017). There are a variety of six types of heat pump designs: air source, water, ground sourced, sorption, solar and hybrid. Heat pumps use similar technology to refrigerators; the heat is transferred from one place to another via refrigerants (Gaur et al., 2018). However, compared to conventional heating alternatives, heat pumps are cleaner alternatives, reducing energy/fuel consumption, and emissions, and improving building efficiency, enabling the shift to renewable energy (Wang et al., 2021; Roy & Caird, 2013; Hedegaard, 2013). Thus, transitioning to heat pumps is a way to reduce CO2 concentration and mitigate climate change (IEA, 2022).

In Europe, there is a growing trend of switching to clean technologies for heating, such as heat pumps (Carroll et al., 2020). However, addressing climate change globally relies on successful clean technology transitions in emerging economies and developing countries, which account for two thirds of the world's population and increasing CO2 emissions (IEA, 2021a). Thus, understanding factors that drive clean technology diffusion in developing countries is essential to mitigate climate change.

The technical innovation system (TIS) approach is most frequently used in research on sustainability transitions for analysing a specific technology in particular countries, such as heat pumps (Bergek et al., 2008a; Markard & Truffer, 2008). This paper will also use the TIS framework since it provides a technology specific focus for understanding how the innovation system performs and enables to identify system, problems or blocking mechanisms (Bergek et al., 2015; Markard, 2012; Bergek et al., 2008a; Hekkert et al., 2007).

While the TIS approach is valuable for analysing technology diffusion, it is primarily based on developed countries (Blum et al., 2015; Gosens et al., 2015). However, it is important to note that circumstances differ between developing and developed countries, and the current TIS framework does not consider these territorial sensitivities or geographical variations (Coenen et al., 2012). Further research is suggested to explore TIS in unexplored geographical settings, such as Eastern Europe or Africa (Coenen et al., 2012). In developing countries, technology transfer primarily involves the adoption of ready to use and mature technologies from developed countries. Accordingly, some studies conceptualised the emergence of TIS in developing nations as a process of 'catching up' with the technologies dominated by developed countries (Gosens & Lu, 2013; Schmidt & Dabur, 2014) and adjusted the TIS approach according to the characteristics of geographical settings in developing countries (Esmailzadeh et al., 2020; Edsand, 2019). Studies have yet to be conducted in Turkey, a country between Eastern Europe and the Middle East, to analyse how TIS functions in developing countries.

With its emerging economy as the 19th largest economy globally and its membership in the G20, Turkey is considered a developing country due to economic and socioeconomic indicators (World Bank, 2023). Additionally, Turkey's unique geography and high CO2 emissions per capita, coupled with its growing economy (Bozkurt & Akan, 2014), make the country an interesting case for studying the diffusion of clean technologies in developing countries.

Besides the studies focusing on the TIS in developing countries, researchers give attention to the dynamics of the surrounding context factors that influence the TIS but are not typically accounted for in a traditional TIS analysis (Bergek et al., 2015; Markard et al., 2015). The innovation systems are not isolated (Van der Loos, 2021; De Oliveira & Simona, 2019). Bergek et al., 2015 claimed that contextual structures in which the TIS is embedded significantly influence the novel technology's diffusion, development and use. To understand the influence of context-TIS interactions Bergek et al., (2015) suggested four main context structures which are ' TISTIS', 'sectoral', 'geographic', and 'political'.

For analysing the sector influence, prior researchers showed that the established sectors, which has institutionalised and regulated system that follow specific technological trajectories and organisational patterns (Dolata, 2009), influences the emerging TIS (Mäkitie et al., 2018; Hanson, 2017; Haley,2015; Wirth & Markard, 2011). Established sectors can be the oil and gas or automotive industries, as they existed in a market for a long time and have a large market share with an established customer demand (Hanson, 2018). However, the literature so far did not elaborate on how the established sector influences the TIS in developing countries. Thus, to narrow the literature gap, the paper has mainly focused on analysing the established sector's influence on the diffusion of clean technologies in developing countries.

Turkey was chosen as a case study to examine the impact of the established HVAC/R sector on the development of heat pumps (HP) in developing countries. There are two main reasons for selecting Turkey. Firstly, it aligns with the suggestion by Coenen et al. (2012) to investigate unexplored countries within the Technological Innovation Systems (TIS) framework. While some TIS studies have been conducted in Turkey, there is a still scope to explore the boundaries of the framework, making it an intriguing subject for investigation. The second reason is Turkey's growing economy with a rapid increase in energy demand. In 2018, Turkey's energy related industries emitted 374 Mt CO2eq CO2, with the electricity and heat generation sector accounting for 39% of emissions (IEA, 2021b). Buildings, particularly residential heating, consume 70% of energy in the residential sector (IEA, 2021b). Therefore, investigating the diffusion, development, and use of heat pumps in Turkey is crucial in addressing these factors.

Besides, to analyse the influence of the established sector influence on heat pumps, the HVAC/R sector is chosen as a case study. This is because HP is already covered as a product category under the HVAC/R sector since there is a high technical similarity between HP and HVAC/R products (Gaur, 2018) (see Appendix A). HVAC/R is an established sector in Turkey since there are many well-established companies, including multinational, international or large or medium size domestic firms, there are sectoral associations and organisations, and it has emerged as a production hub for HVAC in Europe and Africa (Biyikoğlu, 2018). The HVAC/R sector started in the 1960s and became organised in 1993, has a significant export volume of 6.7 billion USD in 2022 (Hvac&r Turkey, 2023). With 13 associations and 6,697 active companies, the sector offers a range of products, including heat pumps, divided into four main groups (Biyikoğlu, 2018). These are for a group of sectors such as Heating equipment, Cooling, Ventilation & Air Conditioning and Utility (Biyikoglu, 2018). The Heat pumps are categorised under Ventilation and Air conditioning, which includes 26 products.

Accordingly, to understand how the established sectors influence the diffusion of clean technologies in developing countries, this paper will analyse the following research question:

- *How does the established sector influence the diffusion and development of clean technologies in developing countries? A case study about HVAC/R and heat pumps in Turkey.*

2. Theoretical Background

This research addresses the theoretical concept of Technological Innovation systems (TIS) which is widely used in literature for understanding the use, development and diffusion of new technologies (Kieft et al., 2021; Bergek et al., 2008a). However, to address the research question, the TIS framework does not cover emerging technologies in developing countries and the importance of sector context related factors. Therefore, the adjustments made regarding TIS in developing countries and the context-TIS literature will be analysed.

2.1 Innovation Systems

Technological change involves technical and social dimensions (Edquist, 2001). This multidimensionality of the transitions leads to the development of 'sociotechnical transitions' since social elements such as user practices, regulation, industrial networks, infrastructure, and economic

structures are inevitable in the technological transition process (Geels, 2002). For understanding technological change, which includes the interaction between innovation and surrounding social elements, the science and policy community accept the 'Innovation Systems Approach'.

Freeman (1987) defined innovation systems as the interactions and activities between a network of institutions, the public and private sectors. An innovation system consists of structural elements, referred to as dimensions of the innovation system, which include 4 main structural elements: actors, institutions, and networks, and some approaches use technology to include knowledge embodied in actors (Jacobsson & Bergek, 2011). Wieczorek and Hekkert (2012) propose framing the structure of technology through an infrastructure dimension, which encompasses; the knowledge infrastructure (universities and research centres) for distributing knowledge, the physical infrastructure (e.g., roads, grid systems) and financial infrastructures (e.g., grants or funds) (see Table 1).

There are several implications of the innovation system approach depending on the unit of analysis, which are National (NIS), Regional (RIS), Sectoral (SIS) and Technological (TIS) for explaining the systematic aspects of technological change. The National Innovation Systems (NIS) focused on the national boundaries and interaction among agents to identify the process of learning which promotes innovation (Nelson, 1992; Senker et al., 1988). Another approach is the Sectoral Innovation System (SIS), in which the main concern is the overall dynamics of firms active in a sector to develop technologies and sell sectoral products (Breschi & Malerba, 1997). However, the Technological Innovation System (TIS) approach is the most appropriate framework understanding the dynamics of technology use and diffusion as it focuses on technology specific factors (Hekkert et al., 2007). Compared to the other systemic aspects, the TIS framework giving main focus more on technology specific analysis and researches that focus on understanding what hampers or enables the development and diffusion of a heat pump (as a specific technology) often used in Technological Innovation Systems (TIS) (Kieft et al., 2021; Wessling et al.,2022).

2.2 Technological Innovation System (TIS) Framework

TIS contributes an analytical framework for understanding the complex nature of technology development and the factors that hamper or alleviate the development, diffusion and use of novel technologies (Bergek et al., 2015). TIS is "a network or networks of agents interacting in a specific technology area under a particular institutional infrastructure to generate, diffuse, and utilise technology." (Carlsson & Stankiewicz, 1991, p. 94). The interaction between these agents, conceptualised as system elements, forms structural actions such as forming social, political and learning networks, alignment of institutions and accumulation of knowledge (Jacobsson & Bergek, 2011). Bergek et al. (2008) and Hekkert et al. (2007) suggested that each function is examined from four structural elements to understand the interaction between the functions. Accordingly, to enhance the understanding of the key activities that influence the ultimate performance of the technology development, diffusion and use, TIS literature suggested adding "a second level of key processes in TIS development, bridging the gap between structure and performance" (Bergek et al., 2008b). To do so, the structural functional approach enabled an understanding of the interaction between the key process of actions that leads an effective innovation (Hekkert et al., 2007; Bergek et al., 2008b; Hekkert & Negro 2009). To map the activities that occur in the innovation system and understand the interactions, Hekkert et al. (2007) and Bergek et al. (2008a) suggested mapping these

activities that occur in the innovation system as “Functions of the Innovation System Approach”. The functions approach explains the system's work by suggesting the most related action processes. These so called functions take place in the system to understand the determinants of technological change (Hekkert et al., 2007). The paper uses the conceptualisation of functions suggested by Hekkert et al. (2007).

- (F1) Entrepreneurial activities: The presence of active entrepreneurs is a first and prime indication. Turning the potential new development into consecrated actions. The actions of agents, new entrants, or diversifiers accumulate knowledge for entrepreneurial activities.
- (F2) Knowledge development: Learning mechanisms can be done by ‘learning by doing or ‘learning by searching.’ A level of R&D or knowledge development is needed.
- (F3) Knowledge diffusion through networks: The exchange of information is needed to develop technology. Interaction between the agents or activities conducted in networks exchange of information.
- (F4) Guidance of research: A certain degree of legitimacy or expectation of agents can generate a momentum of change. To trigger this firms can be guided by some institutions.
- (F5) Market formation: Availability of the protected space for the new technology is needed since the technologies may need to compete with other technologies. Specific institutions, standards or targets are necessary for the market establishment.
- (F6) Resource mobilisation: Resources are needed to sustain activities. Basic inputs are financial, financial and physical. The absence of these can hamper the success or failure of the project.
- (F7) The creation of legitimacy: Provision of legitimacy by lobbying or putting the issue on the political agenda is needed to overcome the existing resistance to change or to avoid the negative influence of the incumbent technology parties. Advocacy of coalitions is needed to increase legitimacy through activities such as advantageous tax regimes and resource flow.

The defined TIS functions are independent but interrelated and build upon each other, and their positive or negative interactions affect overall system performance (Quitzow et al., 2015). The positive improvements in one function mutually reinforce functional dynamics and result in cumulative causation (Bergek et al., 2008a: Hekkert et al., 2007), which means that TIS grows cyclically and gradually through reciprocal reinforcement of its systemic activities (Suurs & Hekkert, 2009). This reinforcement may result in positive or negative cycles in the system. Suurs & HeKkert (2009) identified different types of loops for the formative phase of technologies, which they called “motors of innovation”. They suggested that the positive feedback loop ultimately results in the transition of TIS into the growth phase, and functions within a system can interact in ways that either support and enhance or hinder innovation (Suurs & Hekkert 2009). For example, they suggested that positive interactions between functions can impede innovation, while negative interactions can create barriers, such as inefficient innovation processes or conflicts among actors (Suurs and Hekkert, 2009). Thus, the availability of well-functioning actions to form emerging technology may accelerate innovation system growth (Hekkert & Negro, 2009). Accordingly, the TIS framework can analyse innovation systems performance (success or failure), identify the system's weaknesses and strengths and implement adequate incentives regarding the need for technological system dynamics (Jacobsson & Bergek 2011).

2.3 TIS in developing countries

Even though TIS could operate across national, geographical or sectoral boundaries (Markard & Truffer, 2008), some researchers criticised analysing the specific technologies in a selected country oversimplify the influence of foreign or geographical level of differences that can impact the TIS (Coenen et al., 2012; Coenen & Truffer, 2012; Binz et al., 2014; Edsand, 2019; Esmailzadeh et al., 2020). Developing countries mostly follow the technological trajectories of industrialised economies and seek to 'catch up' with the advanced technologies within these leading countries (Unruh & Hermosilla, 2006; Gosens et al., 2015; Binz et al., 2012). Thus, studies categorised the developing countries as 'latecomers' (Gosens et al., 2015), 'followers' (Bento & Fortes, 2015) or 'economies for leapfrogging' (Tukker, 2005). These "latecomer countries start to participate in a certain technological field when the global TIS has matured to a certain extent." (Gosens et al., 2015, p. 380). Accordingly, researchers to address the TIS framework in developing countries for analysing the TIS due to the differences in terms of localized resources, capabilities and institutions and/or access to global networks (Coenen, 2012). Thus, the boundaries of the TIS framework are an ongoing discussion, and multiple literature papers (Edsand, 2019; Esmailzadeh et al., 2020) address this research gap by expanding or adjusting the boundaries of TIS specific to the conditions in developing countries.

Edsand (2019), modified the (F2) knowledge development, (F5) resource mobilisation and (F7) creation of the *legitimacy* functions and suggested an 'extended version of TIS functions', which are TIS functions adjusted according to the circumstances of the developing countries (see Appendix E). Firstly, Edsand (2019) modified (F2) 'knowledge development' by adding the creating absorptive capacity' function. The national absorptive capacity defined as "the ability to learn and implement the technologies and associated practices of already developed countries" (Dahlman & Nelson, 1995, p.88). A developing country's ability to develop external knowledge is essential since emerging economies do not usually follow the same technology development steps which are engineering, development and research activities respectively (Kim & Lee, 2002). In general, they transfer the technology from abroad, and no change in technology happens first (Esmailzadeh et al., 2020). Thus, they add (F2A) 'creating absorption capacity' as one of the functions that explain the process of action for TIS in developing countries.

Secondly, for the (F6) 'resource mobilisation', Edsand (2019) and Esmailzadeh et al., (2020) highlighted the importance of both national and international resource mobilisation since the developing companies do not share the same advantages as developed countries (e.g., available grants and loans to finance the projects of clean tech) in terms of resource mobilisation. Accordingly, Edsand (2019) suggested dividing resource mobilisation into two and added function (F6A) for international resource mobilisations.

Third, the suggested function for the developing TIS is dividing the (F7) 'creation of legitimacy' into formal (F7) and informal lobbying (F7A) (Edsand, 2019). He claimed the lobbying can also occur from groups of individuals lacking initial structure, financial muscle, or economic and political influence, such as media platforms and informal lobbying (F7A) includes these smaller groups, associations or individuals (Edsand, 2019)

2.4 Context-TIS

Even though the TIS framework provides a valuable tool for understanding the success factor for technology diffusion, it is criticised for being inward oriented and overlooking the system's environment, such as the system that TIS is embedded in (Markard & Truffer, 2008). The conventional TIS framework overlooks the external factors since TIS can be influenced by the strategies of different actors, institutional structures and developments in a broader context (Wirth & Markard, 2011). To better understand the factor that influences the development of novel technologies, TIS scholars analysed the relationship between TIS and the dynamics of the surrounding contextual factors to fill in the gap in the literature (Coenen et al., 2012; Sanden & Hilman, 2011; Markard & Truffer, 2008). These critiques have been met by (Bergek et al., 2015) by conceptualising these interactions between TIS and its context under a concept called context-TIS factors (Bergek et al., 2015). They have identified four main context structures: TISTIS, geographical, sectoral and policy.

2.5 Sector TIS analysis

Numerous research has analysed the sector TIS interactions (Andersen et al., 2020; Bach et al., 2021; Ulmanen and Bergek, 2021; Hanson, 2018; Mäkitie et al., 2018). According to Dolata (2009), sectors can be characterised as stable, institutionalised, and regulated sociotechnical systems, specific organisational structures and technological trajectories influenced by the technologies employed and developed within them. Prior literature claimed that the established sectors provide a structural base for the emerging TIS since a sector can integrate multiple technologies in various degrees and sectors constructed from the same structural elements as a TIS noted above.

Bergek et al. (2015) claimed that the TIS is inextricably linked to the structure and dynamics of the sector in which it operates, and focal TIS can be embedded in one main sector, or it can be connected to sector level structures (actors, institutions, network and infrastructure) in a variety of degrees. In the analysis of sector influence, literature has primarily examined how the upstream and downstream sectors in the value chain affect the focal TIS (Ulmanen & Bergek, 2021; De Oliveira and Negro, 2019; Wesseling & Van der Vooren, 2017; Hanson, 2017). While existing literature has primarily focused on analysing the influence of the upstream and downstream sectors in the value chain on the focal TIS (Ulmanen & Bergek, 2021; De Oliveira and Negro, 2019; Wesseling & Van der Vooren, 2017; Hanson, 2018). However, this paper will analyse sector-TIS influence by analysing the overlapping structural elements between the established sector, as Makitie et al., (2018) have suggested.

For analysing the interaction between TIS and sector, Bergek et al. (2015), argue that the level of connection between the sector level structures and TIS can vary, as focal TIS may exhibit technology specific elements and elements coupled with sectoral structures. Thus, TIS scholars have identified two ways of analysing interactions depending on the level of interdependencies between the context and TIS (De Oliveira & Negro, 2019). The first is called close interactions, or structural overlaps or couplings, with shared structural elements between TIS and context. The second relationship refers to distant interactions, which are named external links and have one way influence.

Sectors are typically characterized by stable entities with established knowledge infrastructures, institutionalised social networks, and user practices (Markard & Truffer, 2008). The established structures, such as existing infrastructure, come from the established sector (Raven,2007) and these

existing structures from the established sector may influence the novel technology (Bach et al., 2021). Mäkitie et al. (2018) suggested that the share of structural elements between the established sector and TIS can influence the process of actions of TIS (e.g., through the flow of resources or knowledge from the sector to TIS). Thus, Mäkitie et al. (2018) have focused on the structural unit of analysis by identifying the structural couplings between TIS and the established sector and examined the impact of overlapping structural factors between sector-TIS on the TIS framework. They defined structural overlaps as components shared by the sector and the TIS (Mäkitie et al., 2018) (see table 2). Consequently, the paper will focus on the structural unit of analysis to see the influence of the shared structural elements between the sector and TIS.

Overlaping structures/ Strucuctural couplings	**Explanation**
Overlapping actors	Can be firms, research institutes, public organization shraed between focal TIS and sector. The diversifiers firms which play dual role
Institutional overlap	Shared of formal (regulatios, standards and policies) and informal (routines, norms and visions) instutions.
Network overlap	Network organizations that connects sector and the focal TIS
Infrastructure overlap	Physical, knowldged and financial artefacts used in both sector and TIS

Source: Mäkitie et al. (2018)

2.6 Conceptualising the two concepts

Previous literature on TIS framework based in developing countries Edsand (2019) and Esmailzadeh et al. (2020) emphasized that exogenous factors are important for developing countries. One example of these exogenous factors is the overlapping context influence such as the presence of structural couplings." (De Olivera & Negro, 2019). However, no researchers have yet analysed how the overlapping infrastructures between two sectors may influence the TIS based in developing countries. Thus, analysing how the overlaps of structural elements between the established sector and TIS influence the development of TIS in developing countries, the theories related to the sector-TIS context and developing countries' TIS will be used together.

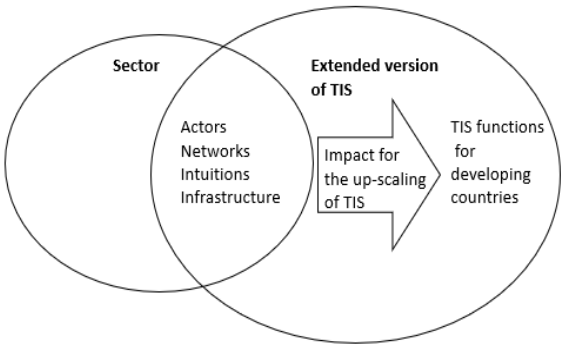


Figure 1: Extended version of the sector and developing countries TIS overlaps

3. Methodology

3.1 Research Design

To evaluate the influence of sectors on the development of TIS in developing countries, a qualitative method is adopted as the research will identify the influence by asking how questions. An industry level and single country case study design is a suitable approach for the research since the research has analysed context specific processes (Yin, 2009) and understands the dynamics in a single setting (Eisenhardt, 1989). By conducting desktop research and semi-structured interviews, the research aims to understand the diffusion and development of heat pumps innovation system and the role of the established sector in developing country. Selecting a critical case study which provides suitable conditions was critical. The selected case study in Turkey based on analysing diffusion of HPs fulfils all the necessary requirements for analysing the research question since Turkey is a developing country and has an established sector on HVAC/R which is a sectoral related to HPs. By conducting desktop research a semi-structured interview with Turkish and international heat pump companies, HVAC/R diversifiers, networking organizations, and government officials in Turkey, the research shed a light on established sector influence in a developing countries' TISs.

3.2 Data collection

The primary data collection method to map the structural elements of the TIS is desktop research. To analyse the structural elements of the heat pump and identify the overlaps between sector-TIS, the data from the industry reports, technical reports, sectoral organisations' websites and reports, company reports, news on media, related research and studies about HP, official statistics from the Ministry of Energy and Natural Resources and IEA, local and global policies and regulations will be collected. Also, through semi-structured interviews, the gathered information will be complemented to understand the sector-TIS overlaps better.

For the data collection of the second and third steps, the semi-structured interviews conducted with various experts will be the primary data collected. The research aimed to select relevant actors suitable for conducting structural and functional analyses of heat pumps. Thus, a selective sampling technique is used to interview individuals with extensive knowledge in the field. To minimize potential bias associated with selective sampling, the research conducted interviews with actors of varying experience, aiming to align with the structural aspects and actors within the Transition Innovation System (TIS). Selective sampling is followed by snowballing since the method can reveal added essential key employees involved in developing TIS, using the network of interviewees.

In total 28 semi-structured interviews involving 34 individuals to ensure an adequate number of actors (see Appendix B). The interviewees come from several types of corporations, networking organizations, information institutes, and government entities. The names of the interviewees were kept anonymous and therefore coded with specific letters. To see the overview of the interviewees and codes given to their name (see Appendix C).

An interview guide is prepared according to the indicators mentioned above to understand the sector's influence on the diffusion of HP (see Appendix D). The interview guide addressed the seven

functions and the influence of overlaps on the functions. According to the answers from the experts, the related data to analyse the sector's influence on the developing countries' TIS functions will be analysed. The interviews lasted between 45 and 60 minutes and were primarily conducted via Microsoft Teams. The interviewees were asked for permission to record and transcribe the audio.

3.4 Operationalization:

The research will follow three phases of investigation,

(1) In the first step, the structural mapping of the TIS will be established to understand the overlapping structures between TIS and the sector. Each structure will be explicitly distinguished to differentiate sources of the impact caused by different dimensions of structural overlap. Research has used the categorisation of structural elements suggested by Wieczorek & Hekkert, 2012 distinguish the structural elements (see Table 3). After that, the shared structures, which are actors (actors dedicated to both sector and TIS), institutional overlaps (shared regulations, norms, standards by sector and TIS), network overlaps (networks which connect sector-TIS) and institutional overlaps (the knowledge, artefacts and financials used in both sectors) are identified. The influence of overlapping structures will be discussed in the third step since the main goal is to analyse the influence of structural overlapping on the extended TIS functions.

Table 3: The structural dimension of TIS (Source: Wieczorek and Hekkert, 2012)

Structural elements/dimension	**Definition**	**Subcategories**
Actors	Firms and along with the other actors in the supply chain	•Civil society •Companies: startups, SMEs, large firms, multinational companies •Knowledge institutes: universities, technology institutes, research centres, schools •Government •NGOs •Other parties: legal organisations, financial organisations/banks, intermediaries, knowledge brokers, consultants
Institutions	shared concepts organised by rules (hard) or repetition situations (soft)	•Formal institutions (Hard): rules, laws, regulations, instructions •Informal institutions (Soft): customs, common habits, routines, established practices, traditions, ways of conduct, norms, expectations
Networks/ Interactions	Can be formal (orchestrated to solve specific task, policy regulated) or informal interactions (joint ventures)	•At level of networks •At level of individual contacts
Infrastructure	The availability of physical, knowledgebased and financial infrastructure	•Physical: artefacts, instruments, machines, roads, buildings, bridges, harbours •Knowledge: knowledge, expertise, knowhow, strategic information •Financial: subsidies, fin programs, grants etc.

(2) In the second step, to evaluate the diffusion of heat pumps in Turkey, the study mapped the TIS in developing countries according to the 'extended versions of TIS functions' by taking account the circumstances of the developing countries. One way to measure how to function X influences the technology is to map the `events' that influence the functioning of the innovation system positively or negatively and assigned them under the functions (Suurs & Hekkert, 2009; Hekkert et al., 2007). Edsand (2019) have suggested some additional functions while Esmailzadeh et al., (2020) reviewed and modified the indicators introduced for the functional analysis of TISs based on developing countries circumstances for better analyse the developing countries' TIS. According to the suggestions of Esmailzadeh et al., (2020) and Edsand (2019) on the top of seven main functions suggested by Hekkert et al., (2007) additional functions of TIS, which are (F2A), (F6A) and (F7A), are added and suggested indicators to analyse the evaluate the functions are assigned (see Appendix E column 1). For example, for evaluating the (F2A) `creating absorptive capacity`, Esmailzadeh et al. (2020) include indicators such as countries' ability to learn by copying, imitating or deploying the technology imported from outside. Also, for evaluating (F6B) 'international resource mobilisation', Edsand and Esmailzadeh et al. (2020) highlighted the importance of international donations and loans for developing countries. Also, for evaluating the (F7B) 'informal lobbying', they have suggested assessing the social networks in the media and their comments and support in the technology (see Appendix E).

(3) Lastly, after the adjustment of the TIS according to developing countries, to understand the influence of the sector on the diffusion of technology, the influence of overlapping structures on the developing countries' TISs are mapped according to the framework suggested by Mäkitie et al. (2018). Mäkitie et al. (2018) have suggested framework in two steps to assess influence of the sector-TIS overlaps on the TIS functions. First, they identify the structural overlaps between the sector-TIS and then they suggested set of indicators to assess the impact of such overlaps at the functional level. Each implication of the structural overlaps is classified into specific TIS functions to assess the sector-TIS influence on the TIS (see Table 4, column 3). The suggested indicators for evaluating the influence of overlapping structures at the functional level are classified into specific TIS functions to assess the sector-TIS relationship. It is essential to mention that Mäkitie et al. (2018) have adjusted TIS functions suggested by Bergek et al. (2008a). To adapt the adjusted sector-TIS functioning according to TIS functions suggested by Hekkert et al. (2007), minor changes have been made, and their suggested indicators are adjusted accordingly. Also, for the analysis of shared structural elements, different from Mäkitie et al. (2018) which used structural elements as actors, networks, institutions and infrastructure, the study used the structural mapping of Wieczorek & Hekkert 2012. Thus, for analyse the overlapping structures the technology element switched into the infrastructure element and the Mäkitie et al. (2018) indicators to evaluate the sectoral overlaps modified according to the changes mentioned above. For example, the available infrastructure of human capital and artefacts, which categorized as an technology overlap by Makitie et al., 2018 categorized under infrastructure overlap and delineated assigned as an evaluation criterion to analyse the function of (F7) 'creation of legitimacy' (see Appendix E).

3.4 Data analysis

Data from interviews and desktop research were analysed using Nvivo software, employing a deductive approach based since the prior literature already conducted analyses of TIS framework based in developing countries and established sector-TIS analysis. However, the thematic analysis method is used with axial and open coding techniques. In the initial coding phase, open coding technique with elements of axial coding. To accurately capture intricate nuances, sentence level tags were assigned during the coding process. The author coded, deriving categories from the structural elements, seven system functions, and systemic policy framework. The thematic analysis method is used to categorize the data. The interviews were recorded, transcribed, and coded in Turkish and English. Microsoft Word "transcribe function" for Turkish interviews, and an app called 'Descript' has been used for transcribes the interviews in English. However, each transcript was examined and reviewed to maintain nuances and details. Since 25 of the interviews were conducted in Turkish, the transcripts were not individually translated due to time constraints and the lack of advanced Turkish to English translation software. However, relevant interview quotes were translated into English (see Appendix F).

4. Structural Analysis:

In this section, the structural mapping for the Heat pump will be made according to Wieczorek and Hekkert 2012 (check Table 3). This will be followed by mapping the overlapping structure between the HP and HVAC/R sector.

4.1 Actors:

Table 4: *Structural mapping for the HP actors*

Civil Society and NGOs	TEMA Foundation, TÜRÇEV, Troya Environment Association, Antok, Kuzeydoga, Ekinoks, Greenpeace and WWF
Other parties: legal organisations, intermediaries, knowledge brokers,	Word BANK, EBRD The Turkey Technology Development Foundation The Scientific and Technological Research Council of Turkey (TÜBİTAK)
Financial organisations/banks,	Word Bank, EBRD
Consultants	54 DEEE authorized energy efficiency consultancy firms ESCOs and EVD
Firms	35 firms - 23 international diversifiers - 12 domestic firm 1 international, 4 large size and 4 SME from HVAC/R diversifiers, 3 SME firm established for HP production, 2 of them diversified from other sectors one only established for HP production. 9 firms in production (9 of them domestic based and 1 international firm) - 3 domestic firm producers within their facility - 2 domestic firms produce it in other facilities,

	- 3 domestic firms declared to start production end of year, - 1 international firm will start production next year, 1 supplier which only conduct production for mechanical aspect of HPs, 21 international firm that conduct only sales activities.
Governmental actors	- The Ministry of Environment, Urbanization, and Climate Change (MEUCC) The General Directorate of Construction Affairs, - The Ministry of Energy and Natural Resources (MENR) The Energy Efficiency and Environment Department (DEEE) - Ministry of Science, Industry, and Technology,
Universities	- 9 university research on cooling cycles, heating and cooling. - 6 universities which published the most papers and analyses on HP: Yildiz Teknik University, Marmara University, Gebze Technical University, Ege University, and Istanbul Technical University researched heat pumps. - 29 vocational schools of technical sciences also focus on climatization and cooling technologies
R&D centres	Only Istanbul Technical University has an R&D centre focused on HP and two entrepreneurial firms, and two firms have specific test labs and R&D centres for the heat pumps. The rest of the 19 R&D centres coming from HVAC/R based activities, and 7 interview firms declared that they could conduct tests on the industrial type of HP.

4.1.1 Society and NGO:

For the diffusion of heat pumps in Turkey's civil society, there is a growing consensus regarding climate change, and environmental nongovernmental organisations (ENGOs) are becoming particularly active in advocating environmental policies (Bey, 2022). However, no specific public figures or social media account highlights the importance of using heat pumps or heating electrification to reduce C02 emissions regularly (see Table 4).

4.1.2 Other parties: legal organisations, financial organisations/banks, intermediaries, knowledge brokers, and consultants

There is no specific Turkish Bank that offers incentives such as lower credit rates for individuals for heat pump purchases, and there is no support for the heat producers specifically for their investments in heat pumps. The only financial organisation is The Word Bank which provides Clean Technology Funds (CTF) to encourage sustainable energy resources and improve energy efficiency. Also, EBRD has subsidised nine Turkish banks to leverage green fund investments.

The Ministry of Industry and Technology and TÜBİTAK are Turkey's leading agencies coordinating and funding research. TÜBİTAK encourages academist research, particularly in the natural sciences, and supports young researchers. The Turkey Technology Development Foundation focuses on improving technology and innovation, prioritising sustainability projects and offering support and potential financing. The Energy Efficiency and Environment Department (DEEE) authorises universities, professional chambers, and energy efficiency consultancy firms which provide monitoring, auditing, and training services. 54 DEEE authorised energy efficiency consultancy firms, including Arcelik,

Alarko-Carrier, Vaillant, and Daikin, operate in the HVAC/R and heat pump sectors. These firms, including ESCOs and EVD Companies, contribute to promoting the use of heat pumps.

4.1.3 Companies: Multinational companies, Large size companies, SMEs and startups

The Turkish sector is dominated by international players from the heating and ventilation sector, such as Vaillant, Viessman, Hitachi, BDR Therma, Carrier, Daikin, Nibe, Samsung… Through desktop research, networking and exposition, 35 companies active in heat pump sales have been found. Only 21 of the firms are members of the ISKID (ISKID, 2020). According to the ISKID 2020 Turkey HVAC/R Industry Statistics, 20 firms in total (3 domestic, 2 partnership, and 15 international firms with large sizes) are involved in the heat pump market (ISKID, 2020).

Out of 35 firms 23 of them are domestic companies were fully acquired by international firms, couple of years ago. Besides to the international firms, there are 12 domestic companies and out of these 12 firms there are 5 large size firms and all of them has partnerships or collaborations with the international firms. Out 0f 35 firms, only 5 companies (which are all domestic) are currently involved in the production, 3 of them produce HP in their facilities while the other 2 make it produced in other facilities. However, through the research, it was revealed that 3 more domestic companies (3 domestic companies, 2 of them large size and one SME) have a goal to start HP production, however, there is no official declaration yet. Besides the domestic firms, only one international firm, Mitsubishi, has declared to open a heat pump production band in 2024 and invested in opening a Factory in 2023. Also, two large size and one SME domestic firms declared their projects to produce HP by the end of this year (see table 4).

4.1.4 Governmental Actors:

The government's involvement in heat pumps is currently limited, with only one expert assistant conducting research in a governmental body this year. This results in low government participation in heat pump diffusion.

The Ministry of Environment, Urbanization, and Climate Change (MEUCC) formulated climate change and environmental strategies, monitored compliance with environmental regulations, and oversaw building energy efficiency. Under this ministry, the General Directorate of Construction Affairs implements the KABEV project to renovate public buildings and improve energy efficiency. The project is funded by the World Bank, focusing on using heat pumps to enhance energy efficiency. The Ministry of Energy and Natural Resources (MENR) coordinates energy policies and conducts analyses to meet energy demand. The Department of Energy Efficiency and Environment, established in 2019, develops action plans and analyses legislation in line with EU standards. They monitor and direct the National Energy Efficiency Action Plan and maintain the EnVer Portal, an energy consumption database for buildings. However, there is no found governmental department that expertise in the energy efficiency in heating and cooling and heat pumps are generally covered under the renewable energy alternative.

Regarding building efficiency studies, the Ministry of Science, Industry, and Technology and the Ministry of Treasury and Finance play key roles in legislating and subsidising factories, research centres, and projects. The General Directorate of Incentive Implementation and Foreign Capital, under

the Ministry of Science, Industry, and Technology, develops mechanisms to encourage R&D and investments.

4.1.5 Knowledge Institutes: Universities, technology institutes, research centres and schools

Among 208 universities in Turkey, there are 9 universities with a specific focus on heating and cooling. Out of these 9 schools, Gazi Technical, ITU, and Yildiz Technical are the ones which also have R&D centres for heating and cooling but also have research on sustainability topics such as zero-energy buildings. Besides high education, there are 29 Vocational Schools of Technical Sciences, specifically educate practitioners for heating and cooling technologies (YOK, n.d.)

According to Scopus, for the search of heat pumps and heat pump systems in Turkey, 454 pieces of literature have been found. The desktop research showed that there no found of patent and the academic publishments was generally from technical universities, and most articles were published or supervised by similar academics and the content of the studies were mostly limited by the case studies to check COP level HPs, and the interviewed academic scholars also indicated this situation.

Despite general knowledge of cooling cycles and the mechanical side of the heat pumps, only one testing laboratory is dedicated explicitly to heat pumps at ITU. ITU has a ground based heat pump test and research laboratory supported by TUBITAK and one firm. TUBITAK has supported and encouraged university-industry relations through its projects, such as called Industry R&D Projects Support Program (TEYDEB). However, it was found that so far they have provided support for only one large-scale project in the field of water pumps. Additionally, two entrepreneurial companies mentioned in the interviews that they received support from TUBITAK.

Besides universities, only two firms, Coolaer and Solimpeks, in Turkey have established testing laboratories for residential types of heat pumps. However, besides the R&D centres focused on HP, there are 19 R&D centres in Turkey which have focused on heating and cooling.

4.2 Institutions:

4.2.1 Formal Institutions (hard rules):

Turkey is committed to being a party to 14 international agreements and treaties related to environmental protection, including Paris Climate Agreement, Kyoto Protocol and United Nations framework convention on climate change. Turkey ratified the Paris Agreement in 2021 after five years of holding it.

MENR's published energy policies ensure energy supply security, promote alternative and diverse energy resources, utilise domestic energy resources to enhance economic value, liberalised energy markets, and prioritise energy efficiency. The Turkish companies must adhere to, Eco-design and energy labels regulations for space heaters, which entered into operation in 2018, three years later from Europe (ISKID, 2021 b). The regulations must use energy labels and require minimum efficiency rates depending on the KW of products. Besides that, there are voluntary certificates such as ISO 14001(quality), Eurovent, ISO 9001(environment), and CE mark. These certifications are not

mandatory but are based on the principle of voluntarism.

4.2.2 Informal institutions (soft rules):

Turkish households prioritise energy efficient products however, their willingness to purchase environmentally friendly options is mainly driven by saving and efficiency factors rather than pollution concerns (Bülbül et al., 2020), and only 27% of individuals pay little attention to energy labels on white goods, according to a waste report found that about (Güzel et al., 2018). Thus, socioeconomic factors are critical criteria for the actors and (İpek & İpek, 2022; Karaaslan et al., 2022). However, economic challenges and the reluctance of financial institutions to lend money to households hinder energy efficiency changes (IEA, 2021b).

4.3 Networks/ Interactions

Since heat pumps are categorised under the HVAC/R sector in general network organisations, thus there is considerable overlap in the sectoral network, which will cover later in the overlapping network. The IPK committee is the only network committee focused on heat pumps. IPK committee aims to inform the Turkish market regarding heat pumps, discuss measures to promote the widespread use of HP, and align and harmonise European regulations and standards with Turkey (ISKID, n.d.). Commission's purpose is to encourage firms to work together in unity and solitary towards implementing practices to diffuse heat pumps in Turkey. They work on adapting European regulations and standards and coordinating efforts to create a standardised approach to heat pump implementation in Turkey (ISIB, 2022). The committee has made webinars, public events and training to increase public awareness.

4.4. Infrastructure

4.4.1 Physical:

Turkey ranks 5th in Europe and 12th in the world regarding installed capacity in renewable energy. Turkey’s renewable capacity has a growing trend (it grew by 50% between 2016-2021), and it is forecasted to grow by 53% between 2021 and 2026, with solar and wind accounting for 80% of the capacity increase, according to the International Energy Agency Country report 2021 (IEA, 2021b).Thus, there available renewable electricity generation and distribution potential to be used by heat pumps however the building insulation is an important criterion (Roy & Caird, 2018). However, 80% of buildings lack insulation (Eruslu, 2021), making it no favourable for the HPs efficiency.

Turkey is one of the most critical crossroads in the world (UAB, 2020) as it is a confluence of three continents and a crossroad of Europe and Asia, with a long coast on the Mediterranean and the Black Sea. European firms use it as a door to open Africa's eastern market, while Asian based firms are attracted to its closeness to Europe (BN10, BI22). Besides the geographical advantages, the country has carried out multibillion projects over the last two decades to expand its roads and ports (UAB, 2020).

4.4.2 Financial:

Under the NEAAP project, Turkey has determined that an investment of 1 billion 10 million US dollars in 2022 (MENR, 2023). Since the NEAAP program did not include direct action plans to increase the use of HP, there are no direct financial incentives specifically for the diffusion of a heat pump in Turkey.

Regarding foreign direct investment (FDI), Word Bank and EU/EBRD support Turkey's transition to renewable energy and energy efficiency. For example, Work Bank provided 200$ million as a fund to reduce energy use in public buildings to scale up the national program for energy efficiency in buildings with the flexibility of paying back in 1220 to incentives the use of heat pumps in public buildings. Besides that, Word Bank and EU/EBRD provided programs in past to improve energy efficiency and reduce consumption, namely, TUREFF, MIDEFF and TurSEFF, which funded €874 million. However, these investments were not specific to the heat pumps.

Government incentives for factory opening and R&D centres in Turkey through project based programs such as (Hamle Project), some tax and investment incentives depending on the project and production companies mainly benefit from the general tax advantages for production. Even some companies are funded by organisations such as TUBITAK subsidised two companies for R&D research. However, there is no specific funding or incentives from the government specific to heat pump investments.

Besides governmental and international funding, there are generally no large size firms' investments. The only international firm investment has been made by Mitsubishi Electric which invested around US$113m for facility expansion. While there are no other examples of foreign investments, through the interviews it is found that three more domestic firm will start production by the end of the year, however no financial information is available about their investments as there is no official declaration of their HP production.

4.4.3 Knowledge Infrastructure

The knowledge structure supporting the heat pumps encompasses knowledge, expertise, knowhow, and strategic information from companies, universities and their R&D centres (see universities and R&D centres under the actors). As discussed before numerous universities and R&D centres are coming from the HVAC/R. These existing R&D centres from HVAC/R are applicable to test the large size HPs for the industry since the working principal heat pumps are technically and theoretically similar to the ventilation and cooling sector. Thus, there are experienced practitioners and experts that have been experienced in the heating and cooling cycle. However, institutions give no specific education for the HPs except the workshops given by the ISKAV organisation to provide participants with basic information about heat pumps, recent developments, calculation and selection methods, and cost analysis (ISKAV, 2021).

5. Overlapping structure

5.1 Overlapping actors:

TIS actors encompass various entities, including companies, educational institutions, public agencies, and interest groups (Bergek et al., 2008). However, the focus will be given to firms and universities, and R&D centres and research organisations or public bodies will not be included since they are often involved in everything, and this would be complicating the examination of overlapping actors (Makitie et al., 2018).

For companies overlaps, 35 firms are active in the heat pump sector. The majority of heat pump firms have diversified from the HVAC/R sector. Of 35 firms, 31 (88,5% of the firms in the heat pump sector) diversified from HVAC/R. The remaining four firms, two of them diversified from other industries while other two mainly established to produce HPs. Currently only 5 out of 12 (41,6%) domestic companies officially producing and only 1 out of 5 the producer companies diversified from HVAC/R.

Besides firm actors, the universities and R&D centres are largely overlapping. The universities which have the highest research on heat pumps are the ones which have a specific focus on HVAC/R and have collaborations with the HVAC/R sector. Also, according to the interviewed HVAC/R diversifiers HVAC/R diversified firms share their existed researchers and employees for HP, thus it can be generalized that mostly the HVAC/R diversifiers companies does not have fulltime employees that only dedicated to HP in Turkey.

5.2 Overlapping Infrastructure:

5.2.1 Knowledge overlaps:

There is a high technical overlap between the heat pumps and HVAC/R products. “HP uses technology similar to refrigerator or an air conditioner” (IEA, 2022b, p. 18). Working principal of heat pumps, are technically and theoretically more similar to the A/C and refrigerants as they use the reversed version of the simple Carnot cycle (ISKID Dernegi, 2021b). However, this knowledge overlap varies between the subsectors under the HVAC/R. The HVAC/R diversifiers from the A/C based firms have higher technical and mechanical similarities between HP in comparison to the one which focused on producing boilers since the technical similarity between A/C and HP is significant. For example, due to their technical similarities, HVAC/R companies with R&D centres for chillers and VRF (ventilation based products) also test large HP for industrial use.

In addition to the technical knowledge, it is observed that acquiring strategic knowledge coming from existing service practices, such as understanding the market, building environment, application, and logistics, are also highly overlapping between HP and HVAC/R as both sectors provide service with their existence for the similar purpose with the use of similar components and theory.

5.2.2 Financial Overlaps:

The heat pump has no specific funding or tax incentives. Thus, there are no shared fundings between the sector and HP. However, since %88,5 of firms diversified from the HVAC/R, there is a considerable overlap of investors. According to the sector leader (BN20), 28 firms would cover 95% of the general HP sales in Turkey. Thus, the firms with a production capacity mostly depend on international HVAC/R diversifiers.

5.2.3 Physical overlaps

As mentioned before, there is a 1.260 R&D centres in Turkey, 19 of which belong to the HVAC/R sector. Through interview 4 large size A/C based firms (BN3, B16, BN20,BN16) mentioned that their existed test laboratories mostly used for chiller and VRF units are suitable for large size HP for industrial types. Besides R&D centres, numerous companies already have HVAC/R based production facilities in Turkey, such as Vaillant, BN17, Viessman, LG-Arcelik, Alarko-Carrier, Hitachi and BDR Therma… Due to similarities between HVAC/R and Heat Pumps, there is a significant overlap between the machinery needed to produce heat pumps and the HVAC/R sector. Some production machines are valid for heat pump production, such as sheet metal forming, condensers and pumps, are valid for heat pump production.

5.3 Overlapping institutions:

Firstly, for the formal institutions such as there is a high overlap between HVAC/R and HP as both sectors use similar technologies for heating and cooling. Thus, for the formal rules such as certifications and minimum efficiency requirements such as eco-design and energy labels which obliged companies to have minimum energy efficiency requirements transferred from HVAC/R to HPs.

For the informal overlaps, due to the overlap between knowledge, actors and customer actually, the old habits and traditions of doing business are transferred from HVAC/R and HP, resulting in overlapping institutions. Besides the firm's side also, customers' old habits for heating stayed valid for the HPs as they shared the same market.

5.4 Overlapping networks:

Turkey has an established organisational network for the HVAC/R as in 2006, the TOBB Union of Chamber and Commodity Exchanges of Turkey, the highest legal entity representing the private sector, established "Turkey's Climatization Chamber" under the TOBB umbrella to create a superstructure for sectoral cooperation and growth and to analyse and predict problems. There are 14 more associations active in the HVAC/R industry, and the organisation's focus ranges from export, education, and cooperation. This established networking provides a base for developing HP as the HVAC/R sector already conducted expositions and conferences. The IPK (heat pump committee) is committed under the ISKID (A/C and refrigeration manufacturers association) and has 28 members from 21 companies and also members of ISKID (ISKID, n.d.). Thus, there is a large share of network actors. Also, actors claimed, in general, that HVAC/R products such as boilers and A/C are assembled products due to improved collaboration between the suppliers. This existing collaboration between HVAC/R suppliers and manufacturers was also transferred to HP through the shared networking routes.

6. Functional Analysis:

6.1 F1: Entrepreneurial activities

There are up to 35 companies in the HP business, primarily diversified from HVAC/R based firms (88.5 % of firms) active in Turkey. Despite the presence of numerous experienced HP sellers and the involvement of several industrial actors, out of 35 companies, only five are currently engaged in HP production activities in Turkey. As a result, most HP firms in the country operates as service providers, focusing primarily on aftersales services.

Out of 5 HP producer companies(currently) 4 of them are small to medium size domestic companies, and all actors from 3 companies producing HP domestically in Turkey. Among them, there are three companies (B8, BN26, B27) producing heat pumps within their facilities in Turkey. These companies stated that their decision to enter the business was driven by the increasing market demand in Turkey. However, some business actors from incumbent firms argued that the producer companies in Turkey merely assembled components without adding value or engaging in independent product development (B3, BN7, BN17, BN21).

However, the sectoral leader from HVAC/R (BN20) mentioned *"Projects are happening in the sector to start HP productions. However, to produce HP, prototype testing, technical analyses and ensuring proper function takes time"*. In line with this statement, two of the interviewed companies and the SME company mentioned that they are currently conducting activities such as testing and ensuring proper function and component supply to produce HP by the end of the year (B4, B16). Besides the domestic firms, and international company, Mitsubishi, there are no found of firms have declared their efforts to increase their existing capacities for HP production in Turkey. Thus end of this year the number of production firms expected to be 9.

In addition to these manufacturing companies, one participant from the supply chain has been identified as a producer. The manager of one supplier firm that provide mechanical production for its client mentioned company stated that they "*solely focus on providing the mechanical aspect upon request… and their primary objective is to sell one more compressor"* (B15) . Consequently, there may be companies entering the market to achieve short term gains and lacking in product development effort.

Lastly, for the entrepreneur activities, involvement related actors such as actors from governmental, university and R&D centres are low. There was only one pilot heat pump related project conducted by one technical university ITU to test ground source heat pumps almost 10 years ago, and it stayed in the prototype stage.

Overall, despite the high involvement of diversifiers so far, the entrepreneurial activities are primarily limited to sales and after sales activities, while efforts for production and R&D projects are left to SMEs with limited financial and production capacity.

6.2 F2: Knowledge development

In Turkey, all interviewees agreed that technology is learned from outside through their efforts or through existing joint ventures or partnerships. As stated by one interviewee (AN34), *"Generally, knowledge transfer starts with copy paste or imitating, followed by product development, and then enters into universities"*. Business actors holding positions in network organizations (BN20, BN26, BN10) assert that the initial step in the production project involves. If companies possess an existing R&D laboratory, firms proceed to evaluate performance and identify the positive and negative sides of the futures and then prototype products are developed (BN20, BN26, BN10). After the prototype, the developments on product conducted through iterative learning from assembly and incorporating feedback into newly assembled products (B4, B8, B14, B15, B16, B19, BN26, BN27). As one actor from a domestic producer firm (B8) mentioned , *"HP is an open system, and you can improve it while designing it, and we build a system which works step by step".* Thus, in general companies technology learned through reverse engineering and imitating and the product developed is developed through the experience coming from assembling and use.

However, since production activities and product development associated with production are left to SME firms. Thus, there are not numerous R&D research activities conducting on HPs and a sales manager from a largescale domestic firm with international partnerships (BN21) mentioned that these SME firms which *"engage in production on their own scale and make R&D efforts based on what they have learned from European products but it is acknowledged that their R&D efforts are not sufficient".* Thus, all local actors from largescale or incumbent firms agreed that *"there is mostly no production by doing R&D; the current HP production in Turkey is based on assembling of products and lack of generating know-how"*(BN18).

Besides to knowledge development conducted in firms level, all interviewed academicians (AE32, AN33, AN34) mentioned that research activities primarily revolve around company specific challenges. Although there is a noticeable increase in published articles, documents, and project activities focused on pump systems in Turkey, An expert and academician (AE32) mentioned that "to produce ideal literature which is analytical, experimental and numerical resource flow from sectoral involvement is necessary". However, in Turkey, the private sector's knowledge production with universities is not as intensive as abroad (AE32, AN33). Thus, *"In Turkey, when we talk about R&D, it mostly refers to Product and Development activities"* (B11) and mostly there research would be about solving a sectoral problem or function of a product rather innovating or developing the existing literature (AE32, AN33).

Overall, the knowledge developed through reverse engineering and imitation and the level of research is limited to the product development rather than improving the existing technology or transformative breakthroughs.

6.3 F2A: Absorptive capacity

All interviewees agreed that Turkey possesses technical knowledge, capability and expertise for heat pump production. A VP of an international company (B3) claimed that "Turkey has been implementing HPs for about 30-40 years, with a modifications made to improve heating efficiency". In line with it, an academician and expert (AE32) mentioned Turkey, "there is a workforce capacity for *design and*

engineering to calculate the necessary information for production of a HP but also skilled workforce for assembly". Thus, Turkey already has a great base of technical and theoretical knowledge, skilled workers, education and experience to transfer the knowledge outside and implement. Even an HP company founder (B14) mentioned, "*Our engineers may actually know the technical specifications of the top 810 companies in the sector better than international companies engineers because they have to compete with those rival manufacturers every day"*.

Despite these positive comments, positive comments regarding the absorptive capacity of Turkey, two business actors mentioned (BN26, BN17,BN12, B15) that *"as you delve deeper into areas like air conditioning, large scale heat pumps, or even more complex systems like central cooling units, the number of experts or knowledgeable individuals in this field gradually decreases"(BN26).* Some actors and all interviewed academicians involved in HP research mentioned that unless firms are producing the main core of HPs, the compressor, there is not much input or output on the differential side (BN17, BN18, AN33). Therefore, knowing components and their production is crucial for HP production (AE32, AN33). Academician and expert on HP (AE32) mentioned that producing *compressors* requires expertise in various fields such as fluid dynamics, thermodynamics, chemistry, and physics however a country manager of an incumbent firm with HP production (B11) stated that *"basic sciences are not being produced in turkey, expert physicists chemists are not developing, there are no good institutes studies etc. and there are no R&D activities that enable them to be turned into technology what we call R&D*". In addition to this, sales manager in one of the main domestic A/C firms (B9) mentioned, *"the biggest challenge for Turks is that we have a bit of knowledge about everything, whereas firms abroad such as LG usually have a dedicated person responsible for a specific product, and they have the authority to make all the necessary changes on that product".* Accordingly, there is a lack of expertise in the basic science and basic knowhow for improving the existing technology.

Moreover, the practitioner's actors claimed that "everyone knows about natural gas installations and radiator systems" (BN26). There are skilled practitioners with expertise in the cooling cycle (B27, AN33, B3, B11, BN10, G28). Despite the knowledge coming from HVAC/R, two of the business actors (BN19, B8) from companies whose main purpose is heat pumps stated that the practitioner's knowledge is not enough since HP implementations require the inclusion of different criteria and require it is a relatively more complex product than A/C or boiler and requires.

Overall, it seems that Turkey has an established form of absorptive capacity in. However, expertise in basic science to create added value products and R&D hinder the capacity to improve the existing knowledge and innovate relatively lower.

6.4 F3: Diffusion of knowledge

In terms of knowledge sharing among actors, the extensive exchange of information by users is well-established, as all interviewed business actors from HVAC/R diversified companies already have a 'feedback system'. These companies improve internally by analyzing the problems and finding solutions received from users (BN21). Besides the companies with existing feedback systems, new entrant firms also mentioned depending on customer feedback; they have improved the applications.

While collaborative projects between universities and industries receive government support for research and development (R&D) initiatives and there are sectoral organizations such as ISKAV, all interviewed academicians agreed that there is a deficiency in establishing structured industry-university relationships similar to those observed in Europe. All interviewed academicians concurred, that existing industry-university collaborations are often based on individual introductions, where the industry seeks specific assistance from the university for key areas or projects specific problems are leading such collaborations. A product manager of an incumbent firm (BN18) explained the reason behind this one way of communication from sector to university due to universities lagging. He claimed, *"Universities should be one step ahead of the sector… so that companies keen to establish collaborations… However, in Turkey, companies are even two steps behind the sector"* (BN18). In the interviews conducted with six out of the top 10 leading companies in the sector, the industry's leaders and all academics mentioned that the university stayed theoretical and tended to have a more passive role. The sector mostly directs the universities according to their business or product related problems.

Apart from the limited number of sector- university knowledge transfers, an academician and HP expert (AN33) has claimed that companies are unwilling to publish the knowhow they have developed in partnership with the university due to competitive environments and the governance of knowledge. As a result, developments in this area are not effectively conveyed in the academic literature.

Network organizations like the heat pump community (IPK) under ISKID play a vital role in facilitating knowledge transfer through various means such as reference books, webinars, and conferences. These platforms encourage active knowledge sharing among different actors involved in the field. "There are fairs and symposiums, and the Chamber of Mechanical Engineers holds a congress once every two years and HP topic discussed in these congresses" (B16). However, a business actor (b15) mentioned *"Conferences and fairs are necessary for obtaining information in the sector as a whole. It helps you learn about the dynamics of the sector, but you may not gain technical benefits from it".* These grounds for disseminating versions do not lead to collaboration between rival firms or exchange of tacit knowledge but provide diffusion of knowledge between the supply chain.

Even though collaboration between rival firms is low since HP is an assembled product, "collaborative work is conducted with suppliers for components, especially for compressors, heat exchangers, evaporators, pumps, and software development" (BN20) and "if a component is missing in domestic firms, sometimes they collaborate and contribute to each other"(BN10). Besides to this, all business actors from firms with partnerships mentioned the importance of company mergers and partnerships with international firms since these enable knowhow transfers and sharing of knowledge. However, two actors (B5, B4) from one large size domestic firm claimed that the extent of knowledge transfer varies depending on the joint venture or partnership as they have suggested international firms that use Turkey only as a product assembly base may not have significant knowledge transfer. At the same time, those with R&D centres or exchange information can benefit from knowledge transfer. Also, two managers from incumbent firms (BN18, B11) mentioned that foreign partnerships imply that knowledge transfer is achieved only if partners have win-win situations. Thus, even though actors mentioned the importance of collaboration, international companies only share knowhow or R&D if there are win-win situations.

Overall, even though a network chain provides networking between the actors, the collaboration between firms and diffusion of tacit knowledge to produce the components which requires high initial investment and knowhow is not well established. Also limited number of sector university, limit the companies potential innovate or develop the products.

6.5 F4: Guidance of Research

Sector representatives of HP and governmental actors mentioned there are no short to medium term goals and a clear vision from the government regarding the widespread adoption of heat pumps. According to an assistant specialist in MENR(G29), support is limited to increasing the recognition of heat pumps, and it seems that future actions will focus only on raising awareness. Heat pumps are mentioned minimally in Turkey's National Energy Efficiency Action Plan (NEEAP) and the 11th Development Plan (see Appendix G and H). As the governmental actor(G30) mentioned, "*There are policy objectives and action items related to renewable energy, although there is no specific action item directly under the heat pump heading"*. Thus all business actors were in accord that "*there are good intentions, but overall, there is a lack of incentives"*(B3).

The energy policy of the Turkish government reflects a mixed approach, encompassing elements of renewable energy, energy efficiency in buildings, and support for fossil fuels. Actors mentioned that Turkey's commitment to reducing carbon emissions and *"decreasing the trend of the emission factor (EF) trend approaching 0.45-0.50 levels, heat pumps have gradually become a more viable option for discussion, especially in coastal regions with a mild climate where the duration of solar irradiation is long"* (BN2). However, despite the positive expectations due to the increasing levels of renewables and targets, the mixed energy policy stance reflects the diverse expectations for the diffusion of HP among stakeholders. All interviewed business actors have mentioned that the current energy policy of Turkey does not provide any specific guidance for the dissemination of heat pumps. However, product and marketing manager of international company (BN18) mentioned that even though there are no regulations to incentives rapid growth of HPs in turkey, as the market share grows and conditions change (exploration of new technology) in Europe, investors from developed companies may gradually shift their production to Turkey.

The governmental actors from the Ministry of Energy and Natural Resources (MENR) (G30, G31) have emphasized the importance of promoting renewable energy generation while ensuring energy supply security and gradually phasing out the use of fossil fuels in building environments. However, there is a lack of a solid foundation or clear roadmap outlining how Turkey intends to achieve this transition towards green energy in the building sector, particularly concerning heating and cooling systems (see appendix G and H). None of the governmental actors interviewed has provided specific targets or action-based plans for the transition from conventional heating alternatives to HP. Therefore, all actors agreed that there is *"no clear information on how long it will take Turkey to implement regulations" (BI22)*, there is only good wishes for the clean energy transition and need for regulation or incentive for firms to start production.

Besides the regulations and goals for HP and expectations from the firm side, business actors mentioned that due to the significant increase in coal prices, there is a transition from coal to heat pumps in regions where the gas is not available. *Thus, in general HP categorised as "a product*

alternative for regions without natural gas distribution" (B27). Once natural gas distributed to new locations, sales managers of these regions (BN21, BN1) observed that users switched from heating pumps (HP). They (BN21, BN1) claimed that by selling their HPs in second hand market and switching to boilers, consumers are saving money due to high inflation in recent years. This shows that the consumer's vision is driven by financial gains rather than reducing emissions, and there is no environmental awareness, as (Bülbül et al., 2020) suggested.

Overall, there is a lack of guidance of the search through regulations and targets especially from the government side. Even though all actors expect a gradual increase in activities and research on HP some actors claimed (BN17, B14, B16, B11) that it is not expected to have fast and rapid growth like in the EU (BN17) due to the current energy policies, regulations and socioeconomic factors.

6.6 F5: Market formation

According to the sectoral leads (BN20, BN2, B11) estimated, number of unit sold in 2022 was around 15,000 units including the industry type HPs, with an expected increase of 1,500 units per year. Despite the anticipation of stable growth, the annual market size of heat pumps in Turkey is limited compared to Europe since according to the 2022 data of EHPA European heat pump market broke a new record 21 markets with a sales around 3 million 34% grew compared to the previous year (EHPA, 2023). Considering Turkey population, HP sales stayed way below the average in comparison to EU market.

In Turkey numerous international companies is available due to their existed facilities mainly for A/C and boiler production. Thus, there are numerous international firm that conduct HP sales. Even though, there is a high number of firms with sales the production activities are low. The all-interviewed business actors from international companies agreed that the flow of resources from the international actors also depends on the market size and volume. Despite the low domestic market size, lead managers of large-scale companies *(BN20, B11)* claimed there are 3-4 large size Turkish companies which can produce HP for increasing demand for the EU. However, except one large size domestic company with an international partnership that have considered in this list, none of the other domestic firms have mentioned their plans about capitalizing on the growing heat pump market in Europe. A business actor from the largest domestic A/C producer (B9) mentioned that *"If the incentives of the state find their way from natural gas to electricity and product sales increase, there is a possibility that they will make a factory investment".* Regarding the diffusion and development of HP, an expert in HVAC/R and business actor (BN17) mentioned, *"For technological development to occur in a country, either it needs to be incentivised and its path cleared by the government, or there should be a demand in the market… Additionally, the domestically produced product should be competitive with* imported *products to compete".* Thus, even though there is market potential in the EU, it is observed that domestic large size companies are awaiting regulatory changes and incentives to create protective space for market formation. In this case to create a protective state, all business actors mentioned the need of regulation to make HP production economically feasible for the producer and this can be done via such as tax regimes, new environmental standards on production side on consumer to increase the demand and create economies of scale.

The only specific target in which the state incentives for using heat pumps (HP) is a requirement for buildings larger than 5,000 m2 to fulfil at least 5% of their energy consumption through renewable

energy sources and recognition HPs as a renewable resource. Besides, starting from 2025, this requirement will be raised to 10% for buildings measuring 2,500 m2 or larger. The vice president of a large domestic company which will start HP production in the upcoming year (B16) claimed, *"If this requirement expands to include 2000 m2 buildings, it will become a mandatory regulation rather than just an incentive. Especially in tall buildings, it is impossible to meet a specific percentage of energy demand solely through photovoltaic (PV) energy, and heat pumps offer a viable solution".* Besides that, there are eco-design and energy label standards. Eco-design and energy labels require minimum efficiency rates depending on the KW of products and labelling the products according to energy efficiency classification, respectively. Even though there is a requirement to have energy labels "*there is no organisation or mechanism to control the COP values of HP"* and most devices may not have energy labels, and anyone can attach them falsely (B27). This results in low-level COP products with low life expectancy in the HP market (AN33, B27). An academician (AE32) who conducted tests on the product claimed that their test results showed that *"we have obtained COP values within the industry and found that there are a few companies in the market that have managed to meet the demand in terms of performance and COP values".*

Despite a lack of policies or targets from the government, the IPK (heat pump network organization) set some numeric targets for annual heat pump sales, indicating short to medium term expectations. The IPK association conduct some activities to increase awareness through webinars and HP handbook. Member of IPK has made a conference with the Ministry of Energy about current EU heat pump regulations. Thus, sectoral actors in network organisations are putting efforts to improve the HP applications that existed in Turkey.

Overall, even though firm actors and networks are conducting some activities to increase HP sales, the market size of HP is small, and the government does not have incentives or regulations for creating protective space for market formation.

6.7 F6: Resource Mobilization

The International actor (BI22) claimed that "*Turkey has inherent advantages: knowledgeable and skilled workforce, large population, and abundant labour resources, both in quantity and quality due to emphasis on education".* Business actors (B25, B14, BN21) mentioned Turkish market can respond quickly to demand, which implies that other functions, such as knowledge development and entrepreneurial ventures, are also affected rapidly when demand exists. However, insufficient domestic market size deters companies' decision to invest on HP production. So far, except for the Mitsubishi, there is no official factory expansion for the HP production; thus, there is a limited resource flow for the HP production. Also, for the dedication of personnel on HPs, except for 2 companies that only produce and sell HPs as heating and cooling solutions, the diversifiers use existing personnel with general expertise in heating and cooling.

Past and recent leading managers of one of the largest domestic firms (B11, B9), which also conduct HP sales service, claimed that one of the challenge to not invest in HP production is also related to the lack of machinery and human resource to produce components , especially the compressor, which is framed as the "heart of HP" as it is considered as the main component that influence the COP levels of HPs by an academic (AN33). The sales manager of a prominent white goods producer in Turkey (B9)

mentioned that while a few companies attempted to produce compressors, they faced software related issues and found it more cost effective to purchase readymade solutions since to "*recover all these costs, including initial investment and research and development expenses, you need to achieve high production levels"* (B11). Thus, in addition to the lack of market size that can make production feasible, companies are short term and price-oriented perspectives limits the resource flow to HP.

Regarding funding and financial incentives, governmental actor (G30), *"In terms of government investment and public financing, it is limited, and there are no funding or credit advantages specific to heat pumps."* TUBITAK is also funding some HP producer companies for R&D research; there are no specific funding options for heat pump production. The government's investment and public financing in this area are limited, however governmental actor (G30) mentioned that a significant amount of international funds is available for renewable energy projects, and HP includes mostly under the category but some funds are being returned due to insufficient applications or incomplete procedures.

Overall, there is the availability of resources in Turkey; however, access to the resources has some criteria, such as market size, to make production feasible.

6.8 F6A: International Resource Mobilization

Most of the firms active in HP (65,6% of firms) are international firms and the rest out of 12 domestic firm only 4 of them can be considered as an large size firms and two of these companies are partially acquired by an international firms. Thus, Turkish companies are mostly reluctant the investment decisions of the international's actors.

Despite several international players in Turkey, no international investments are specifically dedicated to heat pump production, except for Mitsubishi, which plans to start HP production in 2024. Despite the Turkeys' low production cost advantages, with highly skilled labour as a business actor (BN17) from an international company claimed, "*no one would invest in it for a market as small as 15,000 units"* since for the international firms *"everything is about creating demand and market"* to invest in a developing country *(B11).* International actors (BI22, BI23, BI24) claimed mainly Turkey's geopolitical location, low production costs, skilled labour force, and compliance with regulations attracting international investors. However, actors mentioned that international investment choice is primarily driven by the proximity to large markets and their existing R&D centres. For example, a business actor of one the incumbent firm (BN2) mentioned that for the factory opening of HPs, HVAC/R diversifier, investors invested in Poland even though they were already having existed facility. Besides to that some business actors from incumbent firms (BN2, B3, B10, BN12) and all international actors mentioned that existence of energy policies, regulations or incentives that provide clear vision but also create an financial or market opportunity for the business is a factor that influence HVAC/R diversifiers invest decision redeploy resources from HVAC/R to HP.

"Due to the economic crisis, academia and the industry have focused on the West and European Union projects" (AE32). As mentioned before, there are some funding initiatives from organisations like the World Bank and EU/EBRD. However, there have been no direct investments specifically for heat pumps, with most relative investments focusing on public building renovations. The most relative investment was the Public Buildings) Project (KABEV), a governmental actor in the KABEV project

mentioned that World Bank provided 200$ million as a fund to reduce energy use in public buildings with “payment flexibility of up to 20 years for the implementation of heat pumps” (G28).

Lastly, regarding the return of human resources living abroad, (AN33) have mentioned only 10 to 20 per cent of experts have returned, and most of them have either established their firms or integrated into new companies in Turkey. However, he added that experts had no significant returns, specifically in heat pumps (AN33).

There are no sufficient funds or investments in HPs; there is a lack of access to financial resources from the incumbent or international firms.

6.9 F7: The creation of legitimacy (formal lobbying)

There are some associations, such as IPK under ISKID and the Mechanical Engineering community, which are working together for the diffusion of heat pumps and engage in lobbying activities through seminars, conferences and webinars and emphasising heat pumps as future of clean heating and cooling. ISKID organisation conducted conferences involving government representatives to increase the diffusion of heat pumps. However, when it comes to supporting heat pumps as an investment, companies face opposition from the natural gas lobby. The distribution of natural gas is large, and there are lobbying activities even though in 2021, Turkey's dependency on natural gas imports for its supply increased to 99.3%, compared to the previous year, according to the oil and energy sector report of Turkey (Türkiye Petrolleri, 2022). Besides, many international firms such as Hitachi, Vaillant and BDR Therma have acquired Turkish firms and shifted their boiler production centres to Turkey by making significant investments (B14, BN7, BN17, BN18), while the BOTAS (the state owned pipeline and oil transportation company in Turkey) has substantial investments to distribute natural gas (B11, B14). A member of the ISKID statistics community and IPK community (BN10)stated, *“in past HP was an economically viable investment option only if the Coefficient of Performance (COP) of the heat pump reaches levels of 4-4.5, but now with the recent suspension on natural gas COP level needs to be 6-6.5 to become an economically viable option in comparison to other alternatives” (*maximum COP value is 5 in lab conditions, see Appendix *A)*. Thus, actors claimed that besides a lack of awareness from the customer side, the natural gas electricity price gap is on the main barrier (BN21, BN1). This also shows the importance of activities to legitimize the diffusion of the HPs.

Despite the investments in natural gas and gas fired boilers in recent years, sectoral actors claimed that there are no lobbying activities from the actor's side to limit the diffusion of heat pumps. Business actor (B4) mentioned that “*I do not think such a barrier would be established by the manufacturers themselves because everyone is already prepared or almost ready. So, the industry does not need such a barrier”.* Besides, that some business actors (BN7, BN20, BN10) claimed they argued, due to carbon tax regulations, companies are encouraged to promote devices with low carbon emissions. According to the business actor (B14) *“firms are the only actors that direct their customers to HP”. However,* some actors argue that advertisements are just for the marketing (B11), without a commitment to sustainability (AN33). Under the suspensions on natural gas and price gap between natural gas and electricity, there is no even need of resistance from users or companies and the energy policies are enough to limit the diffusion of HP (B4, B14). In line with it some sectoral leaders in HVAC/R (BN20,

B11) claimed that if the regulations changed for the benefit of heat pumps, some lobbying activities might appear due to a conflict of interest.

On consumer side, some consumers may resist the widespread adoption of heat pumps if they are positioned as alternatives to natural gas in the future (B5). For example, as mentioned before, heat pumps were used until natural gas became available, resulting in a market for second-hand heat pumps (BN21, BN1). Even though some of the business actors (BN21, BN1) attribute the main causes of this second-hand market for HPs situation to hyperinflation and the affordability of boilers rather than resistance to clean technology, some business actors (B8, B4), suggested there might be a resistance from the consumer side since the issue of the slow heating process of heat pumps may create resistance from consumers accustomed to heating system, such as A/C or boilers, which gives heating comfort in short time, relatively. Thus, heat pumps' slow heating process and high prices compared to natural gas further contribute to potential resistance. However, a business actor from one of the producer firms (B8) mentioned that the current consumer awareness, coupled with incorrect usage behaviours, diminishes the efficiency of heat pumps. Consequently, this results in increased energy bills and a higher number of customer complaints.

Overall, there is a natural gas lobby in Turkey, and actors' efforts are insufficient to create lobbying for the diffusion of the HP.

6.10 F7A: Creation of Legitimacy (Informal lobbying)

There is no frequent support found from individuals, environmentalists or groups regarding promoting heat pumps. Companies primarily rely on advertisements published in sector magazines and participation in conferences and fairs, which predominantly reach individuals within the industry. Heat pump marketing activities related to heat pumps are relatively limited, with only a few advertisements appearing on social media platforms and television. Furthermore, some sales manager of incumbent and large size firms (BN21, BN1, BN18) mentioned that there is little engagement from citizens or environmental groups in actively promoting heat pumps. A Product manager of one incumbent firms in turkey (BN18) mentioned that *"only 5% of customers would have known the HPs".* A leading member in IPK (BN18) also mentioned that, in last year's even if the awareness in the suppliers and businesses have increased the efforts to reach end consumers were not adequate and there is a need for improvement in this sense.

7. Dynamics between the functions

In general, it is found that Turkey's numerous companies and knowledge institution created adequate absorptive capacity to transfer the knowledge and conduct some level product development on product functions. Also, the availability infrastructures and human resource potential to conduct HP production activities resulted adequate level of absorptive capacity (F2A). The level of absorptive capacity ease the learning by reverse engineering and imitating (F2). However, the level of expertise and current activities for research were not high enough to improve the existing technology. Through the network organisation there was general share of knowledge between actor however the share of tacit knowledge was not actualized and rivalry firms companies did not conduct collective entrepreneurship to create value-added product that requires high expertise (F3). Besides, since the diffusion of knowledge dhar between the universities and sector is low the knowledge development and diffusion (F2), (F3) was not highly positive

their performance was more than enough to create opportunity for companies to start entrepreneurial activities (F1). The involvement of firms for HP sales were high however the level of production and research was low despite the high involvement. Engagement of the HVAC/R firms and conducting projects or production is also essential to increase knowledge development since companies declare that they are learning by assembling and using. Thus there is a reciprocal relationship between F1 and F2/F3 (see chart 1).

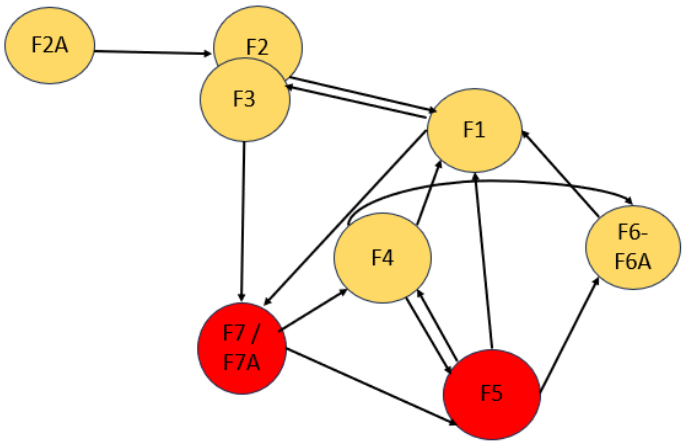
Despite high rates of involvement to HP activities reason behind moderate performance of entrepreneurial activities (F1) due to the lack of production activities is due to influence of guidance of search (F4), market formation (F5) and resource mobilization (F6). Firstly, there was no guidance of search (F4) from the governance since there is no clear and transparent energy policy to incentives companies to conduct HP activities. As a result, companies' expectations for the future of HP stayed moderate (F4). Thu,s this moderate rates of expectations also constrained the resource flow for HPs (F6/F6A). The availability of the financial resource flow especially from the international actors was highly critical since there was limited number firm domestic which has the financial sources to produce HP to capitalize the market demand in EU but also most of the firms were reluctant to financial decisions of international actors. It is found that the resource flow to invest in HP and start production was highly dependent in the adequate market size and volume to achieve 'feasible production' which defined by availability of adequate market size to recover the investment. Business actors indicated that with the expansion of the domestic market size or a regulations to create a business opportunities for firms both large domestic firms and international firms would be capable of commencing production. They emphasized their possession of adequate infrastructure, resources, and knowledge accumulation to facilitate this. This showed that the main reason for low rates of production activities was not related to knowledge development and diffusion, guidance of research or resource mobilization (F2, F3, F4 or F6). Bottleneck of the system that blocked the TIS performance was lack of regulation or incentive that can create an opportunity to increase market size and volume and make the production feasible as a result. Thus the main systemic barriers in TIS functions were related to the low performance in market formation (F5) and creation of legitimization (F7).

It is found that sufficient market size and volume is highly critical for large firms to enable resource flow for entrepreneurial activities, and this create a positive reinforcement mechanism between (F5-F1-F6) (see chart 1). Despite the market potential in Europe, it seems that for domestic companies' to capitalize the market demand in Europe availability regulations to create industrial space that incentives the production of clean technologies are essential. Thus, mainly lack of regulation and clear vision for the transition of HPs result low market size and volume (F5) to perform low (coloured in red) and this result low expectations from market (F4) and lack of commitment to invest in HP (F6) and conduct production activities(F1) (see chart 1).

As the availability of market size and volume or having regulation that creates opportunities(positive conditions that can create industrial space e.g. tax reduction or guidance of search) for firms to start HP production become a critical factor. This shows the importance of putting the diffusion of HP on the agenda of policymakers. Accordingly there is lack alliances or pressure groups to legitimise clean heat pumps blocked the possible market formation or guidance of search to develop and diffuse the HPs (F7). Despite the networking through the IPK, which increases the diffusion of knowledge between the supply chain (F3), their efforts to bring the regulations in the EU to Turkey, were not adequate for legitimising the HP. There is natural gas lobby and subsidies applied to natural gas eliminate the economic viability of heat pumps as an heating alternative. This low performance in lobbying negatively impacts both the low market size and volume (F5) and the expectations of the producer (F4). In addition to that, one founder of HP company

(B14), mentioned that government won't incentives tax regulations or incentives on consumer side unless there is production activities from domestic firms . Thus it shows that in order to put issues on government agenda also involvement of production from firms are important.

Chart 1: Dynamics of functions



Note: Since the lowest performed functions and main system problems were related F7/F7A and F5 these functions coloured in red. Also, arrows stands for showing the interactions and dynamics between the functions.

8. Established HVAC/R sector influence on developing country TIS

As discussed in the overlapping sectoral section, the HP and HVAC/R sector has numerous robust overlaps. In this section influence of the sectoral overlaps and this stimulation of the developing TIS, functions will be explained.

- "Structure overlap → Functions", such as (actors → F1), indicates that the sectoral overlap influences a TIS function positively, the green arrow in chart means positive influence.
- "Structure overlap --- > functions" such as (F2 --->F1) symbolises influence is negative the red arrows in chart means negative influence

The infrastructural overlap is one of the significant overlaps between HVAC/R and HP. Knowledge overlap between HP and HVAC/R. As an actor (BN21) claimed, *"The HVAC/R sector has a significant impact on the development of heat pumps… This is because the primary knowledge and expertise reside within this sector, and it is best to progress in collaboration with those knowledgeable about heat pumps and the industry"*. HP's technical, theoretical and process similarities and similarities for the physical infrastructure such as components, machineries increased the absorptive capacity for the HP and increased the number of projects and researchers on HPs **(physical and knowledge infrastructure overlap → F2A)**. Besides to this the availability of physical infrastructure (such as service network, R&D test labs, factory) and knowledge (expertise) mobilized to support the activities in HP **(physical and knowledge infrastructures →F6)**. Besides these, since HVAC/R products and HP are similar technologies that provide the same services, established formal rules from the HVAC/R sector, such as eco-design certificates, energy labels, and quality standards (e.g. ISO 14001), resulted in the transfer of these rules to HP either **(Formal institutions overlap → F2A)**.

The physical and knowledge similarities also the leads high overlap between firms and lead HPs to be covered under the HVAC/R sector. The lead member of HP committee in Turkey (BN2) mentioned, IPK established by member of HVAC/R associations (ISKID) firms which also sell HP. Thus there is a high rate of board interlock. Thus actually, leading member of IPK (BN2) suggested that the presence of an organizational structure like ISKID has eased the establishment of the Heat Pump Committee (IPK) The availability of networking coming from the established HVAC/R sector organisational structure enables guidance of research between firms and supply chains. Thus, the existing networks positively influence the diffusion of knowledge in the formative phase **(network overlap → F3)**. Also, existing network connections with customers and the supply chain of the HVAC/R diversifiers influence the (F1) and (F4). Firstly, the overlapping networks also influenced (F1) since firms have used their existing networks connection from their past HVAC/R activities; as one actor in that large size HVAC/R diversifier (B4) claimed, *"We have one trusted partner whom we have known for a long time, and we also have another partner whom we have just started getting to know for this project."* This ease the path of collaboration between the firms to conduct collective entrepreneurship to conduct HP production **(network overlap→ F1)**.

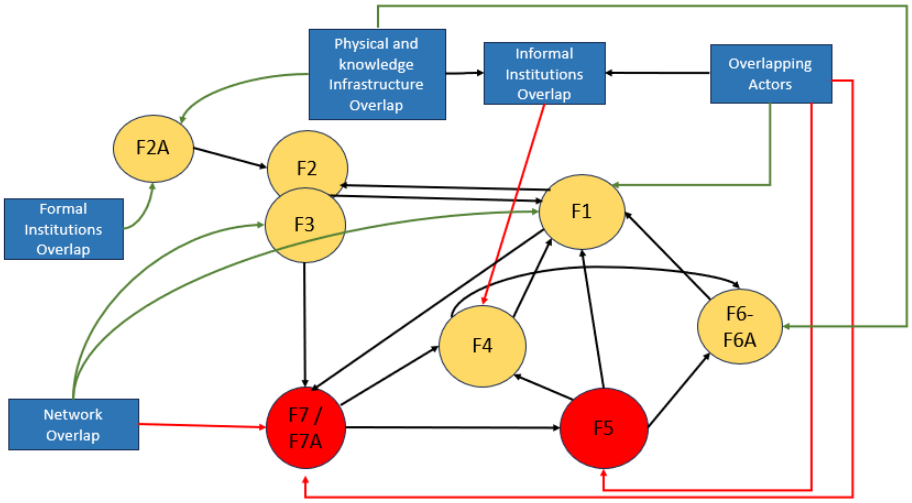
Besides to these positive overlaps coming from the overlapping infrastructure, formal institutions and network overlaps, there are negative influences of the overlapping sector-TIS structures. The HVAC/R sector includes subcategories and we can divide into two subcategories: firm which focused on cooling specialized in A/C products and heating based companies focused on boiler production. Despite infrastructural overlaps actually, actually HP itself is a new category of a product which however the infrastructural overlap which lead high diversifier involvement and this result some old routines and habits from HVAC/R to pass HP. One business actor from company with production activities (B8) mentioned that complex products that require specific expertise but HVAC/R sector perceived as a product group that has been caught in the middle of A/C and boiler. However, according to firms which established mainly for HP production, heat pumps requires specific expertise, understanding of components and how they function (B8, B14, BN19). Also, Academician (AN33) mentioned that the diversifier companies are lack of sustainability perspective for conducting the HP activities. Thus actually the overlapping infrastructure and actor which result transfer of old habits, actually restrict the generation new vision and way of conducting business specific for the case of HP diffusion and development **(Informal institutions overlap -- > F4).**

Furthermore, the presence of a wide range of product groups within the HVAC/R sector has led misalignment between the diversifiers restrict the activities to legitimize the diffusion HPs. For example, while the A/C based companies consider HP as an opportunity to expand their current business and product range rather than seeing it as a complementary product, companies mainly focused on boiler prediction of a heat pump is more like a strategy to reduce the future risk of natural gas-based heating solutions. Thus, actually HVAC/R diversifiers are not putting high efforts to put HP on the agenda of government, one business actor from large size domestic firm explained that (B3), HVAC/R diversifiers approach is more about avoiding a future risk and being able to capitalize the market under the scenario that heat pumps would incentives. This showed that high rates overlapping actors from HVAC/R and board interlock in network organisations with a limited commitment on HP negatively influenced the activities to legitimize the HP **(overlapping network and actor -- > F7).**

Lastly, HVAC/R diversifier and has control over the market since "*only 5% of the customer would purchase heat pumps by knowing, %90 of consumers is buying it without knowing the product they purchase what the seller gives"* (BN18). Thus, the HVAC/R diversifier's efforts and commitment to guide customers to sell HP and create a protective market space is critical as they have a customer base and network connection **(overlapping actor -- > F5**). Even though most of the HVAC/R diversifier

mentioned they are trying to lead customers for the clean alternatives, as the diversifiers firms also sell different product categories a business actor mentioned (B11) under the scenario that HP market size would increase this situation creates conflict of interest especially for companies focused on boiler production. Thus domination of existing heating sector dominated by the

Chart 2: Established sector-TIS influence



Note: the green arrows shows positive influence while the red one influence the negative influence

9. Discussion and theoretical contributions

9.1 Discussion and theoretical contributions to developing countries' TIS

Based on the results, it is evident that additional functions, namely absorptive capacity (F2A) and international resource mobilization (F6A), hold significant influence in the context of Turkey and research findings provide support for the recommendations and theories put forth in the literature regarding the role of technological innovation systems (TIS) in the development of developing countries. In line with this, studies by Edsand (2019) and Esmailzadeh et al., (2020), study shows that absorptive capacity (F2A) is essential to transfer the knowledge from outside. While access to resources (F6A) was one of the critical activities for the development of HP in Turkey as international actors' investment decision and their strategies were one of the main influences for the entrepreneurial activities (F1) and market formation(F5). However, these prior researches did not find insight related to the informal lobbying (F7A) as it did not influence the overall performance of TIS. Thus, in general, research supports that an extended version of TIS based on developing countries as suggested by prior researchers (Edsand, 2019; Esmailzadeh et al., 2020) is valid for as a developing country like Turkey.

Even though the developing countries TIS framework can be generalized for Turkey, it is essential to note that developing countries is a broad concept, and even among developing countries, there are specific differences (Edsand, 2019). However prior researches highlighted that process that,

important contributing factor for developing countries like China and India, might not be apply to smaller developing economies (Edsand, 2019). As Esmailzadeh et al., (2020) suggested, the sufficiency of market size and volume found to be important since price optimisation (or feasible production) is important for market formation. Therefore the level of small market size and volume and lack regulations for HPs (F5) is the main barrier that deterred companies from investing. While this study confirms the validity of the suggested criteria from past studies, such as the importance given to market size for large-scale production, absorptive capacity, and resources from international investors, it also introduces additional criteria that have not been emphasized in previous research. Insights gained from this research shows that the production activities to capitalize the market demand in other countries is essential. Firstly, since knowledge development achieve through assembling and mostly firms are approaching the universities to conduct R&D only for the product development, production is needed to enable product development and improvement in existed technology. Additionally, it is observed that policymakers need to perceive an active engagement in the production side to address specific issues in their agenda. This situation, in turn, brings about the potential for more regulations to be implemented. Therefore, outcomes of this investigation reveal that further research should focus on illuminating the role of production activities and the conditions that activate the production activities in developing country contexts. Accordingly, two criteria's that found to be important to conduct production activities are; 'proximity to market demand' and 'creation of market opportunities for the production activities'.

These findings were for the case of Turkey however these may be particularly relevant for developing countries with emerging economies, which possess the capacity for production, available human resources, education, and sectoral establishment but no clear vision or regulations to create opportunities for the increasing market size for clean technologies (e.g. Turkey, Mexico, Brazil, Egypt, Iran). This highlights the need for future studies to address this gap and explore strategies to foster the growth of clean technology markets in developing countries with emerging economies. Future research could analyse additional activities, namely, 'proximity to market demand' and 'creation of market opportunities for the production activities'. This could provide even deeper understanding of TIS in developing countries given these activities were seen to be integral to the framework in this study.

Overall, the findings from previous literature were found to be applicable for analyzing (TIS) in Turkey. However, to better understand the developing country TIS, further research may shed more light on developing countries with emerging economies like Turkey, Mexico, Brazil, Iran, Egypt (where there is a level of absorptive capacity and some level of resource mobilization to produce) and how they can capitalize on market demand, even in the absence of energy policies that provide a protective space for the diffusion of clean technologies. This highlights the importance vision to create industrial space domestic firms and favourable conditions to enable FDIs.

9.2 Discussion and theoretical contributions of established sector -TIS influence on functions of TIS

Researchers, focusing on the TIS in developing countries have highlighted the significance of exogenous factors Edsand, 2019; Esmailzadeh et al., 2020) such as overlapping structures between sector-TIS. In line with Mäkitie et al. (2018) findings which highlighted significance of structural

overlap influence between established sector-TIS on the focal TIS in developed country, the study confirmed that structural overlaps between sector-TIS also influential on the developing country TIS circumstances.

The overlapping infrastructure influences the absorptive capacity (F2A) and access to international resources activities(F6/F6A), which were mentioned as circumstances that creates differentiation between developing TIS and developed TIS (Edsand, 2019: Esmailzadeh et al., 2020). Thus, research shows that availability of an established sector narrowed the gap in technology learning and enabled sufficient level of knowledge to attract and exploit new knowledge (F2A). Also this overlap in machineries and expertise leads to some level of resource flow from HVAC/R to HP as the overlapping structures ease to diversify. Therefore study showed that the availability of the overlapping structures between established sector and TIS in developing countries may enable to bridge the gap between developed and developing countries related issues such as absorptive capacity and resource mobilization. In line with this, future researchers can also include the influence of overlapping structures between established sector and TIS to better understand the TIS in developing countries.

Moreover, the infrastructure overlap, network overlap and formal institutions positively influence the knowledge development and diffusion and lead high involvement of HVAC/R diversifiers. However, the overlapping actors between HVAC/R and HP negatively influence the expectations and activities to legitimize the HPs since there was a lack of commitment and misalignment of the expectations inside the sector. Thus, in line with the Mäkitie et al., (2018), the sectoral overlap influence found to be important but not adequate to create guidance of search or resource flow from HVAC/R to HP. The high overlapping structures result adaptation of the routines and habits from HVAC/R and restrict commitment to create an new vision specific for HPs. The lack of commitment and misalignment between of HVAC/R diversifiers, restricted the legitimizing activities but also result in a sales-oriented vision with no high expectations. In line with that, HVAC/R diversifiers low involvement in production activities indicates that the positive influences or opportunities coming from the overlapping infrastructure, knowledge and existed networking are not adequate for firms to conduct production activities. This finding is concurrent with that of Mäkitie et al., (2018), whose research also suggested that despite the positive influences overlapping structures may create, it does not leading high commitment and deployment of resources from established sector to TIS. This situation demonstrates that, in accordance with Hanson's assertions in 2018, established sector's ability to enable positive impact on emerging technologies depends on the "sector openness and ability to interpret opportunities linked to new technologies" Hanson (2018, p. 65). It is found that despite the positive advantages coming overlapping structure between HVAC/R sector and HP, domestic HVAC/R diversifier could not capitalize the demanding markets or attract FDI for production activities. Thus, the study reveals that despite the positive influences of overlapping infrastructures between sector - TIS on developing country TIS these advantages did not result in high rates of investment for the production or committed actors to put the issues on policy makers agenda regulations and establishing conditions for creating industrial spaces that can activate the production.

10. Recommendations

Firstly, the research shows the importance of clear and transparent vision and regulations to increase the diffusion heat pumps. The most critical action to be taken is redirecting subsidies from natural gas

to electricity and placing greater emphasis on energy efficiency for heating and cooling in the built environment. This should be prioritized on the political agenda. In line with this, the research demonstrates that although Turkey has signed numerous environmental regulations and agreements, these did not result in creating vision for diffusing clean technologies. It shows that, the existing regulations and funding mechanisms are not creating adequate push for developing countries to legitimize HPs and create guidance of search.

Secondly, to establish favourable conditions for production in Turkey it is imperative for them to utilize their existing knowledge and expertise resources to capitalize the market demand in abroad, even if the domestic market size is not adequate for feasible production. In line with it, study finds that vision for creating conditions that may lead formation of industrial space or favourable conditions to enable foreign direct investments (FDIs) is essential. The creation of industrial space secure may secure FDIs before international firms decide to invest in alternative countries with low cost production alternatives. Moreover, beyond attracting FDIs, policymakers can create opportunities and industrial space for their domestic firms by fostering collective entrepreneurship among domestic companies and research institutes. This may allow companies and research institutes to unify their forces to start production and capitalize the demanding market.

11. Research Limitations

Firstly, the research presented in this study also had some limitations due to the scope and availability of the respondents. Even though 28 interviews with 34 actors were consulted, a large size of the actors were from the business side; thus, the ratio of the actors from government and universities was lower. The limited research with universities and government institutions is also due to their low participation in TIS in general. Also, even though interviews were conducted with the members of the IPK, the network organisations only replied via mail and their answers were not sufficient or detailed to identify sector-TIS analysis. The diversity imbalance in conducted interviews may not provide a reliable representation of the HVAC/R and HP sectors.

Secondly, it is important to consider that the main data in these studies consisted of semi-structured interviews, which means that the results were highly influenced by the researcher's interpretation. Although many interviews were conducted to ensure saturated data, which reduced the level of interpretation by the researcher, it is still necessary to acknowledge that the interpretation of the results is ultimately subject to the researcher's perception.

The last limitation is related to the scope of the research. The research is limited to the influence of the context factor by sector; however, including the other context structure, such as geographical context and TISTIS context, would provide a better provision for developing TIS understanding. Incorporating geographical boundaries would have enhanced the TIS analysis, as it is a crucial factor in sectoral system analyses due to concentration of machinery in specialized regions Malerba (2002). For example, for the case of heat pumps, the actors suggested that a couple of countries dominate the component production of heat pumps since it requires sizeable first investment costs. Also, geographical proximity of countries to the market should be highlighted. Especially, analyzing the

influence of geographical context for a country like Turkey, which bridges Europe and Asia, might lead to interesting results.

Accordingly, further research analysis on the influence of the geographical context on TIS based in Turkey can be a topic for further research. Besides this, since the study has found that Turkey provided an empirical case study to understand the TIS framework, future researchers can also analyse the generalisability of the suggested criteria and importance of the production also in other countries.

12. Conclusion

This study analysed the influence of the structural overlaps between TIS in the established sector on clean technologies in a developing countries' TIS. Firstly, the results confirmed that an extended TIS framework for developing countries helps to understand diffusion and development of HPs in Turkey. However, on the top of the suggested framework this research suggest to shed light on extra criteria and activities. Since there is no regulations and clear vision to increase the volume of HP market, study emphasizes the importance of capitalizing the demanding markets abroad. To better highlight the importance of market capitalization two additional indicators are suggested for increasing the understanding of TIS in developing country are suggested; 'proximity to market demand' and 'creation of market opportunities for the production activities'.

Furthermore, it is observed that, the structural overlaps between sector and focal TIS has important influence on the developing country TIS. The overlapping infrastructure, network and formal institutions, positively influence the knowledge development and diffusion (F2, F3) and lead high involvement of HVAC/R diversifiers (F1). These overlaps ease the redeployment of resource flow from HVAC/R to HP (F6/F6A) and result high rates of diversification from HVAC.R to HP. Study shows that structural overlaps positively influence additional functions suggested for developing country TIS such as absorptive capacity (F2A) and access to resources (F6A). Thus, availability of the established sector in developing countries may enable to bridge the gap in terms of absorptive capacity and resource mobilization between developed and developing countries. However despite this positive influence, the sectoral overlaps also had negative influence on the focal TIS. Overlapping actors influence the expectations(F4) and activities to legitimize (F7) the HPs negatively since there was a lack of commitment and misalignment of the expectations inside the sector. HVAC/R diversifiers keep a sales-oriented vision and leave tasks like production and product development to small size firms with limited resource and know-how. This leads entrepreneurial activities to be sales oriented and restrict the production activities. Thus, this study shows that while the infrastructural overlaps created positive influences for TIS based in developing countries, the influence is insufficient to facilitate the market formation and production due to lack of commitment and misalignment of vision between actors.

Overall, although it is important for developing countries to participate in green technology transfer to combat the climate crisis, the research shows that Turkey lacks clear an transparent vision and regulations to achieve clean technology transition. This lack of regulation and vision leads an limited market size and volume and results low rates of production activities. Accordingly, capitalizing the demanding markets found to be important for developing countries where there is a lack of regulations or vision that can contribute to market growth and size. For enabling developing countries

to capitalize the demanding markets this research suggest policymakers for creating a conditions to enable formation industrial space for clean technologies and fostering collective entrepreneurship within the country. Through this approach, creation of industrial space can lead a positive feedback loop for the diffusion of clean technologies since production activities leads technology development and puts the issues on policy makers agenda. These findings found for Turkey might be generalised into other countries which has capacity produce and level of resource mobilization and sectoral establishments such as Mexico, Brazil, Iran and Egypt. In line with these suggestions, further research can test the applicability and significance of these suggestions for other developing countries.

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Appendix A: Technical background about HP:

Heat pumps utilise similar technology as refrigerators by transferring the heat from the colder body to the heated body (Gaur, 2018). There are six categories of heat pumps, including air-to-air sourced, air-to-water sourced, water sourced, ground sourced, sorption, solar and hybrid. The heat pumps can also be categorised according to the buildings, such as “residential type” (individual use for households) or “industrial type”(for large size public buildings, factories). In Turkey, primarily split air-to-air models, consisting of outdoor and indoor units, are used. The indoor unit is almost the same as the A/C; however, the main technical difference comes from the outdoor unit. There are also monobloc heat pumps that combine indoor and outdoor units in a single unit.

The heat pump technology is saturated (Kieft et al., 2021), and there have been no significant improvements for the last 1015 years except the minor improvements for increasing efficiency and software improvements (B14). HP has twelve components: a compressor, condenser, expansion valve, refrigerant, expansion valve, reversing valve, fan, defrost control, thermostat, air filter, cabinet and control board. Heat pumps transfer heat from the cold body to the refrigerant in the evaporator, which is then converted from a liquid phase to a gas phase due to heat transfer. The gas is then passed to the compressor, where additional energy is used to increase the temperature of the refrigerant, and then to the condenser, where the heat is transferred to the hot body. The refrigerant then turns into a liquid form and passes through the expansion valve, and the cycle continues.

The performance of the HP is essential for heat pumps to be classified as a low carbon technology since it affects how effectively they use primary energy (Gaur, 2018; Roy & Caird,2013). The efficiency of heat pumps is named as a coefficient of performance (COP), which is the ratio of the system's heat output to the electricity used in a given time. Heat pumps have efficiency levels for energy use since every kWh fed to the system generates between 35 kWh of heat in lab conditions. However, the heat pumps strongly depend on the seasons and using the Seasonal Performance Factor (SPF) is a more meaningful measure (Roy and Caird, 2013).

Due to the reliance on numerous parameters, HP efficiency might vary greatly (Gaur,2018; Roy & Caird,2013; Fischer & Madani, 2017). According to the findings obtained from the interviews conducted with experts in the field, it was revealed that the compressor, refrigerants, and software were identified as the most salient technical factors affecting the efficiency and operational quality of heat pumps (AN33, B11, B9, B8, B11). Besides these, internal also outside factors affect HP efficiency. The primary variable that affects the efficiency of the HPs is the difference in temperature between the heat source and sink (Fischer & Madani, 2017). In addition, various factors, including the

subsystem's technical characteristics and application and design based variations, might influence the efficiency rates (Gaur et al., 2018; Roy & Caird,2013). Ideally, well insulated housings have relatively high heat sources with a low temperature heating system. Integrating solar panels to generate electricity would be the perfect condition to use HP (Kieft et al., 2021).

Lastly, there are factors in the system which would influence the diffusion of heat pumps since the transition toward a heating system is challenging and interaction between HP with the rest of the energy systems, such as availability of grid system and smart grid system integration, electricity generated from renewables, insulating measures (Liu et al., 2019). For example, The clean energy ratio owned by the country (Roy and Caird, 2013), thermal insulation in buildings, the energy efficiency of buildings (Gaur, 2018), the presence of supportive systems that prevent voltage or similar fluctuations, and the existence of control systems, all affect the heat pump applications (Fischer and Madini, 2017).

Appendix B: Data selection

#	**Organisation type**	**Description of the interviewee's**	**Code**
1	Business International firm Network organisation	Section manager and active actor in sector and university collaborations in incumbent firms leading the market, member of IPK	BN 1
2	Business International firms Network organisation	Sectoral leader for the HP researcher and manager in an incumbent firm leading the market	BN2
3	Business Incumbent firm	Vice president	B3
4	Business large size domestic firms	R&D manager	B4
5	Business large size domestic firms	R&D project manager	B5
6	Business large size domestic firms	Sales manager, member of IPK	BN6
7	Business Large size firm organisation member	Product engineer and member of the sectoral network	BN7
8	Business SME	Sales manager	B8
9	Business international domestic firm network organisation	Sales manager	B 9
10	Business – SME, network organisation member	Sales manager, active in HVAC/R statictics commitee under ISKID and also IPK	BN10
11	Business International firm	Country manager	B11
12	Business International firm network organisation member	Product Manager , member of IPK	B N12
13	Business domestic firm network organisation member	Sales Manager, member of IPK	BN13
14	Business domestic firm Researcher	Owner	B14
15	Supplier	General Manager	B15
16	Business large size domestic firm	Vice President Marketing	B16
17	Business International firm network organisation member	Technical Director with an expertise in HP and working experience abroad, member of IPK	BN17
18	Business International firm network organisation member	Marketing Product Management Manager, member of IPK	BN18
19	Business SML network organisation	Sales Manager, member of IPK	BN19

20	Business large size domestic firm network organisation	Chairman of the board, sectoral leder of HVAC/R	BN20
21	Business large size domestic firm network organisation	Heat pump Product Director, member of IPK	BN21
22	Business International firm, international investor	Sales manager of International company	BI22
23	Business International firm international investor	Sales Director of EMEA region of an international company	BI23
24	Business International firm, international investor	Sales Manager of international company	BI24
25	Business Domestic firm acquired by International firm	Managing Director of HVAC/R based company	B25
26	Business Domestic Medium size firm	Business Development Manager and leading member of the IPK	BN26
27	Business Large size firm	Engineering Department Manager	B27
28	Governmental actor	Certified Energy Manager, Energy Efficiency Expert in The Ministry of Environment, Urbanization, and Climate Change	G28
29	Governmental actor	Assistant manager in Ministry of Environment and Urbanization Department	G29
30	Governmental actor	Branch manager	G30
31	Governmental actor	Assistant Specialist	G31
32	Academician expert	Assistant Professor	AE 32
33	Academician network organisation	Assistant Professor	AN 33
34	Academician network organisation	Research Assistant	A N34

Appendix C: Overview of Interviews

Category	**Number of interviews**
Firms/ diversifiers/ network members	21 firms with 26 individuals
1.1 Actors involved in international trade chains and sector associations	• 16 of these interviewees was a member of associations
1.2 Experts from abroad, international investors	• 2 interviews with 3 individual
1.3 Multinational firms	• 7 interviews
1.4 SME companies in the HVAC/R sector with the heat pump category (domestic firms)	• 3 interviews
1.5 Medium to Large size domestic firms with international partnerships	• 10 interviews with 13 individuals
1.6 Managers of startups', entrepreneurs or recently established companies	• 3 interviews
1.7 Suppliers and under the stairs manufacturer	• 1 interview
Actors working in governmental bodies	4 interviews with 5 individuals
R&D research centres, academia	3 interviews

Appendix D: Interview guidelines

Guiding Theme	Interview questions Prompts (P), Follow-up (F), Specifying (S), Interpretation (I)
Introductory Phase	**Could you tell me a little bit more about yourself and your role in the HVAC/R industry**? (S) How long have you been working IN HVAC/R sector and Heat pumps and what are your responsibilities? (S) Are you involved with associations or organizations regarding HVAC/R?
Entrepreneurial activities	**What are your projects or R&D activities for producing or testing heat pumps. How do you test new technologies regarding heat pumps?** (F) How and why do you choose to diversify (If you are member of company and invest in different product categories)? Are there enough diversifying firms and new entrants for heat pumps? (S) Do you have pilot projects, collaborations or projects with different parties such as joint ventures with companies, universities or research centres **Is there growth in the projects for the heat pumps?** (S)Is there attention to largescale production?
Knowledge development and absorptive capacity (capability transfer the knowledge from outside and utilize or improve it)	**How is the heat pump technology emerged and grow in Turkey or in your company?** - (S) What is your R&D activities, projects or investments for development of Heat Pump technology? **What the activities, projects you are doing for developing knowledge about heat pumps?** - (S) Do you think Turkey has a ability learn the technology from abroad and improve or utilize that technology internally? For example, can turkey copy or imitate technology from abroad and even improve the existed technology? - (S) Does technical and higher education, infrastructure(factories) and R&D centres enables a suitable location for improving or using the technology learned from abroad. **How the existed business activities of HVAC/R sector influence the projects, R&D research or actions for creating economies of scale or achieving technical advances for heat pump technology?** - (S) For example, does existed external collaborations or networking activities such as company visits, factory openings of international firms, fairs or existed collaboration, projects or JV's influence the development of the growth of knowledge regarding to the heat pump does.
Knowledge diffusion through networks	**How does the knowledge is shared between the parties for the development of knowledge?** (P) How the exchange of information between universities and industry (P) How the knowledge diffuses between companies or joint ventures (S) Also does conferences, meetings, exhibitions, governance practices, sectoral standards, sector meetings etc. made by HVAC/R among actors leads share of knowledge for Heat Pumps?

Guidance of research	**Is there a clear and common vision about the diffusion of Heat Pumps from government and sector?** (P) Policy goals (etc. programs and policies) or supporting goals (S) Does this vision for HP fit into the existing legislation **How do the diversifier's engagements and level of expectations influence the HP diffusion?** (S) Visions, forecast and technology expectations from the HVAC/R sector
Market formation	**Are there targets to reach for the size and volume of HP? What are the actions they are taking to achieve these targets for the HP diffusion?** (P) institutional incentives and barriers (such as tax regimes, international or domestic green labels and environmental standards) to increase the market volume? (F) Are there supportive policies to protect the domestic market against international firms?
Resources mobilization	**How the domestics investments from firms, governments on the Heat pumps are distributed?** (S) Are there enough investments in human capital and skilled labour, physical infrastructure R&D (S) Are there government investments such as public funding for the heat pumps **How the HVAC/R sector influence the access to the resources? Is there a flow of resources from sector the HP?**
International Resource Mobilization	**For which purposes the international companies, organisations or institutions invest in Turkey? How they prefer to invest for example** do they build factories, or do they incentives R&D and skilled labour? (S) How the human capital abroad outside of Turkey or in Turkey is used? (S) Grants and loans for technical assistance for example human capacity building or green energy investments) (F) Do existing international collaborations influence the investments for HP?
Creation legitimacy **-formal lobbying** **-informal lobbying**	**Is there support or resistance for the distribution of HPs? If so, how it's manifests itself? For example, what are the activities for the legitimisation of technology?** (P) Are there interested groups or alliances that incentives or disincentive the technology? (S) Are there actions for coordinated advocacy which aligns or misaligns with the needs of heat pumps? Or are there lobbying activities for the technology competes against the heat pumps? **How the platforms such as social media react to HP technology?** (S) The advertisement of technology in scientific or industrial meetings, social networks and new media

Final question	**Do you have any other thoughts about the diffusion of heat pumps in Turkey and how the established HVAC/R sector influenced this process?** Thank you for taking the time for the interview

Appendix E: Extended version TIS functions and indicators for evaluating TIS and TIS from overlap sector

Extended version of TIS Functions	**Extended version of TIS indicators: Indicators for assessing the TIS in developing countries from (Esmailzadeh et al., 2020)**	**Indicators for TIS from overlap sector (Mäkitie et al., 2018) A=actors, I=institutions, N=networks, T=technology.**
F1 Entrepreneurial activities	•Related actors in the innovation system •The presence of a sufficient number of industrial actors in the innovation system •Provide enough innovation from industrial actors •Attention to largescale production by industrial actors •The amount of abandonment by entrepreneurs •The rate of entry of new entrepreneurs into the innovation system	•Entrance of diversified firms (A) •TIS utilizing technological concept from sector (T) •Level of collective Entrepreneurship (I)
F2 Knowledge development (technological learning)	•Number of projects, documents, and papers in this field •The conformity between supplying technical knowledge (qualitatively and quantitatively) by universities and R&D centres with the demand of industry •Learning and knowledge acquisition from the use of technology (such as assembling and deploying it) •Acquiring sufficient knowledge of imported technology to copy, imitate, and reverseengineering •Acquiring enough knowledge to improve existing technology (ability to improve existing technology inside the country) at research and development centres and universities	•TIS actors prior using prior experience and technology from sector (A, T) •Patents developed by diversified firms (A)

F2 a Creating Absorptive capacity	•Enough skilled staff, in the R&D department, to develop knowledge •Enough investment in human resource development for knowledge development •Sufficient physical infrastructure, such as R&D centres, laboratories, raw materials, etc., to develop knowledge •Sufficient budget and expenditure on R&D in the private and public sectors •number of papersand publications	
F3 Knowledge diffusion through networks	•An adequate exchange of knowledge between universities and industry •An adequate exchange of information between the users of the technology and its manufacturers (industry) •The amount, quality, and space for the dissemination and exchange of knowledge (conferences, meetings, etc.) among actors	•Transfer of governance practices from sector to TIS (I) •TIS standards cite sector standards (I) •Interlocking directorates and other networks between sector and TIS (N)
F4 Guidance of the search	•Visions, clear forecasts, and expectations about how technology is developed • Policy goals (clear encouragement policies) related to this area (such as renewable energy incentives) •Supporting goals with specific programs and policies that guide the system •Transparency of specific objectives and regulations determined by government and industry	• Diversification of firms from sector to TIS(A) •The ease of transferability of diversifiers experiences from sector to TIS (T) •Existed customer networks from sector (N) •Diversifiers' level of expectations (I) •Diversifier' engagement
F5 Market formation	•Sufficiency in the size and volume of the market •The existence of legal incentives and barriers to the formation of a new technology market •The existence of supportive policies to protect the market for domestic firms against the influence of international companies •Positive and adequate forecast for the future	•Engagement of diversifiers in advocacy for market formation (A, I)
F6 Resources mobilization	•The existence of sufficient human resources (in complementary and managerial fields) within the country • The existence of sufficient funds (joint ventures, government credits, etc.) inside the country •The amount of access to these resources for actors • The existence of sufficient physical infrastructures (such as roads, water, electricity, gas, automobiles, complementary infrastructure, etc.)	•Sector investments in TIS (N) •Access to artefacts and infrastructure (T) •Access to human capital of sector (A)
F6a International Resource Mobilization	•The use of international financial resources, including international donations and loans •Use of human resources living abroad	
F7 The creation of legitimacy(formal lobbying)	•The quantity and the quality of alliances or pressure groups (such as environmentalists) to legitimize and support technology	•Media attention on diversifiers' TIS activities (A)

	•Resistance to change and use of new technologies	•Coordinated advocacy for TIS (A, I)
F7 a Informal lobbying	•The extent to which there are supportive comments about the use of new technology in the media • The extent and manner of support, and the introduction of technology in social networks and the Internet • The amount of media support and advertising for investment in new technology in social networks and scientific and industrial meetings	

Appendix F: Quotes translated from Turkish

Section	Interviewee code	Turkish quote	Translation to English
6.1	B20	"Sektörde HP üretimine başlamak için projeler yapılıyor. Ancak HP üretmek için prototip testleri, teknik analizler ve uygun işlevin sağlanması zaman alıyor."	"Projects are happening in the sector to start HP productions. However, to produce HP, prototype testing, technical analyses and ensuring proper function takes time."
6.1	B15	"Amacimiz gelen talep uzerine mekanik tarafini vermek.. Amac bir compressor daha satmak isi pompasi uretimi gibi bir amacim yok."	"Solely focus on providing the mechanical aspect upon request… and their primary objective is to sell one more compressor."
6.2	AN34	"Genelde copy paste arti urun gelistirme oluyor ardindan unioversiteler sin icine geliyor."	"Generally, knowledge transfer starts with copypaste or imitating, followed by product development, and then enters into universities."
6.2	B8	"HP acik bir sistem gelisrtirebilirsin tasarlarkende gelistirebilirsin. Tabiki bizde litereaturu takip ediyoruz."	"HP is an open system, and you can improve it while designing it, and we build a system which works step by step."
6.2	B20	"Türkiye de kendi çapında üretim yapanlar bunlarda kendi arge'siyle, Avrupadaki ürünlerden kendilerince öğrendikleriyle burada bir şeyler üretmeye çalışıyorlar. Ancak tabii yeterli bu yeterli degil."	"Engage in production on their own scale and make R&D efforts based on what they have learned from European products. However, it is acknowledged that their R&D efforts are not sufficient."
6.2	BN18	"Türkiye'de de üretim diyen de hem uretim anlamda arge yapıp üretip daha	"There is mostly no production by doing R&D; the current HP production in Turkey is based on assembling of

		çok malzemeleri toplayıp birleştirerek şey bir knowhow yok yani.”	products and lack of generating knowhow.”
6.2	B11	“Türkiye'de ar ge dediğimiz daha cok urge ürün geliştirme yani.”	“In Turkey, when we talk about R&D, it mostly refers to URGE (Product and Development) activities.”
6.2	AE32	“En ideal literatür analitik deneysel ve numeriktir üçünü kapsamasını istedi dir yani”	“To produce ideal literature which is analytical, experimental and numerical resource flow from sectoral involvement is necessary.”
6.3	B3	“Bundan 30 40 sene öncede HP kullaniliyordur türkiye'de... modifikasyon yapildi bundan 30 sene önce yapıldı.”	“Turkey has been implementing HPs for about 30-40 years, with a modifications made to improve heating efficiency.”
6.3	AE32	“Bizde isi pompasi uretimi icin aynı dizayn tasarımcımız da var hesaplama yapacak mühendisimiz var ve onun montajini yapacak insan kaynağı var.”	“There is a workforce capacity for design and engineering to calculate the necessary information for production of a HP but also skilled workforce for assembly.”
6.3	B14	“Bizim muhendizlerimiz sektorde en iyi 810 firmanin teknik ozelliklerini daha iyi bile biliyor olabilir kendi o firmlarin muhendislerinden cunku her gun o rakip ureticilerle bogusmak zorunda.”	“Our engineers may actually know the technical specifications of the top 810 companies in the sector better than international companies engineers because they have to compete with those rival manufacturers every day.”
6.3	BN26	“Işin içine işte biraz daha böyle işte klima veya seri daha büyük işte ısı pompası veya bundan daha büyük işte klima santrali vesaire gibi cihazlar girdiğinde bu konuda hani uzman kişi sayısı veya bilen kişi sayısı git gide azalır.”	“as you delve deeper into areas like air conditioning, largerscale heat pumps, or even more complex systems like central cooling units, the number of experts or knowledgeable individuals in this field gradually decreases.”
6.3	B11	“Türkiye'de temel bilimler uretilmiyoe temel bilimler türkiye'de iyi fizikçiler kimyacilar gelismiyor iyi enstituler çalışmalar vesaire yok ve bunların teknolojiye döndürülmesini sağlayan arge faaliyetleri yok.”	“Basic sciences are not being produced in turkey, expert physicists chemists are not developing, there are no good institutes studies etc. and there are no R&D activities that enable them to be turned into technology what we call R&D”
6.3	B9	“Türklerin en büyük sıkıntısı biz her şeyden biraz biraz anliyoruz onlar da ornegin LG de öyle değil yani sadece bir üründen sorumlu arkadaş ve sadece o biliyor.”	“The biggest challenge for Turks is that we have a bit of knowledge about everything, whereas firms abroad such as LG usually have a dedicated person responsible for a specific product, and they have the authority to make all the necessary changes on that product.”
6.3	BN26	“Herkes dogal gaz uygulamalari ve radyator sistemlerini biliyor.”	“Everyone knows about natural gas installations and radiator systems.”

6.4	BN18	“Bizim universiteler yada ogretim ksiminin bir adim once olmasi gerkiyor ki sirketlerin universitler ile diyolog icine girebilmesi icin.. ama bir adim ileride olmayip 2 adim geride olunca hicbir zaman is birligi saglanmiyor.”	“Universities should be one step ahead of the sector… so that companies keen to establish collaborations… However, in Turkey, companies are even two steps behind the sector.”
6.4	B16	“Fuarlar sempozyomlari oluyor makina muhendisligi odasi congereleri var 2 yilda bir her yil ikisinden biri oluyor.”	“There are fairs and symposiums, and the Chamber of Mechanical Engineers holds a congress once every two years and HP topic discussed in these congresses.”
6.4	BN20	“Tedarikçilerle birlikte ortak çalışmalar yapılıyor örneğin ısı pompası noktasında bakıldığı zaman ısı pompasının ana komponentleri kompresörler, ısı eşanjörleri, buharlaştırıcılar, pompalar ve yazılım geliştirme."	“Collaborative work is conducted with suppliers for components, especially for compressors, heat exchangers, evaporators, pumps, and software development.”
6.4	BN10	“Domestik firmalarda eger bir komponent yoksa beraber calisip birbirlerine katkida bulunabiliyorlar. Ortak bir cihaz cikarabiliyorlar.”	“If a component is missing in domestic firms, sometimes they collaborate and contribute to each other.”
6.5	G30	“Ozel bir araştırmaya yönlendirici politika hedefleri yanı destek İyice hedefler direk ısı pompası başlığı altında değil ama yenilenebilir enerji konusunda politika hedefleri var eylem maddeleri var.”	“There are policy objectives and action items related to renewable energy, although there is no specific action item directly under the heat pump heading.”
6.5	B3	“Iyi niyetler var sadece teşvik yok genel olarak.”	“There are good intentions, but overall, there is a lack of incentives.”
6.5	BN2	“Hem EF faktörü çok önemli şu anda mesela sıfır 0.50 lerde falan galiba veya 0. 45 0. 49 lara geldi oralara kadar düştü dolayısıyla birazdan konuşabilir hale geldik.”	“Decreasing the trend of the emission factor (EF) trend approaching 0.45 0.50 levels, heat pumps have gradually become a more viable option for discussion, especially in coastal regions with a mild climate where the duration of solar irradiation is long.”
6.5	BN18	“Kömür fiyatları çok arttığı için kömürden gaza geçiş var gazın olmadığı yerde kömürden ısı pompasına geçiş var.”	“Due to the significant increase in coal prices, there is a transition from coal to gas where gas is not available, and a transition from coal to heat pumps.”
6.5	B27	“Isı pompası doğalgazın olmadığı bölgelerde de bir ürün alternatifidir.”	“HP is a product alternative for regions without natural gas distribution.”
6.6	B9	“Devletin teşvikleri doğalgazdan elektriğe doğru bulursa ve ürün satışları artarsa bunların bir ihtimal fabrika yatırımı bizimkiler yaparlar.”	“If the incentives of the state find their way from natural gas to electricity and product sales increase, there is a possibility that they will make a factory investment.”

6.6	B16	“Isı pompalari yenilenebilir enerji olaraka kabule diliyor daha sonra bu 2000 m2 lare giderse bu bir tesvik degil zorunluluk haline gelmeye basliycak ozellikle yuksek binlarda sadcee catuya koydugunuz PV enerjinin belli oranini karsilamakmumkun degil bunun bir yoluda isi pompalari tabiki.”	“If this requirement expands to include 2000 m2 buildings, it will become a mandatory regulation rather than just an incentive. Especially in tall buildings, it is impossible to meet a specific percentage of energy demand solely through photovoltaic (PV) energy, and heat pumps offer a viable solution.”
6.6	BN17	“Yani bir tek teknolojik ülkede gelişmesi için ya devlet tarafından teşvik edilmesi lazım önü açılması lazım ya da pazarın bir talep olması lazım yada türkiye'de ürettiği üründe ithal üründe rekabet edebilecek durumda olması lazım.”	“For technological development to occur in a country, either it needs to be incentivised and its path cleared by the government, or there should be a demand in the market… Additionally, the domestically produced product should be competitive with imported products to compete.”
6.6	B27	“Enerji sertifikasini kontrol edecek bir kurum yada bunun önünde bir engel çıkacak bir yapı yok türkiye'de.”	“There is no mechanism to control the energy efficiency rates… most devices may not have energy labels, and anyone can attach them falsely.”
6.6	AE32	“COP degerleri elde edildi ve baktik ki piyasada bu işi kurtarabilmis birkaç firma var geri kalanlar oldukca bu performans COP degeleri anlamında talebi karşılıyamiyor.”	“We have obtained COP values within the industry and found that there are a few companies in the market that have managed to meet the demand in terms of performance and COP values.”
6.7	AN33	“Isi pompasinin kalbi kompressordur.”	“Heart of HP.”
6.7	B11	“İlk yatirim maaliyetlerin arastirma gelistirme maliyetlerin yuksek olan isler sonrasinda tum bu maaliyetleri cikarabilmen icin yuksek uretim yapman gerekir.”	“Recover all these costs, including initial investment and research and development expenses, you need to achieve high production levels.”
6.7	G30	“Yani kaynak yeterli değil peki devlet yatırımı kamu finansmanı yok aynen yahut bir kredi avantaji direk devletten gelen bir fonlama yok.”	“In terms of government investment and public financing, it is limited, and there are no funding or credit advantages specific to heat pumps.”
6.8	B11	“Her sey market ve talep yaratmak ile ilgili.”	“Everything is about creating demand and market.”
6.8	BN17	“Kimse 15.000 lik bir Pazar icin yatirim yapmaz.”	“No one would invest in it for a market as small as 15,000 units.”
6.8	AE32	“Ekonomik krizden dolayı akademide sektörde buna yüzünü batıya ve Avrupa Birliği projede çağırmış durumda.”	“Due to the economic crisis, academia and the industry have focused on the West and European Union projects.”
6.8	G28	“Geri dönüş süresiyle ilgili bize çok büyük esneklik sağladılar işte 20 yıllara kadar çıkabilir.”	“Payment flexibility of up to 20 years dfor the implementation of heat pumps.”

6.9	BN10	“Eskiden COP degerlerinin 44.5 olmasi yetiyordu. Fakat suan dogal gaza gelen susbansiyonla isi pompalarinin ekonimik acidan diger sistemlere yetisebilmesi icin 6 6.5 olmasi gerekiyor.”	“In past HP was an economically viable investment option only if the Coefficient of Performance (COP) of the heat pump reaches levels of 44.5, but now with the recent susbension on natural gas COP level needs to be 66.5 to become a viable option.”
6.9	B4	“Ben böyle bir bariyeri üreticilerin kuracağını düşünmüyorum çünkü herkes yer hazır ya da hemen hemen hazır olmak üzere. Yani böyle bir bariyer dedi bence sektöre ihtiyacı yok gibi duruyor açıkçası.”	“I do not think such a barrier would be established by the manufacturers themselves because everyone is already prepared or almost ready. So, the industry does not need such a barrier.”
6.9	BN20	“Şuan lobilesme yok ama karbon emisyonu dusuk cihazlari yonlendirmeye calsiyoruz.”	“Due to carbon tax regulations, companies are encouraged to promote devices with low carbon emissions.”
6.9	B14	“Sadece firmalar musterileri yonlendiriyor.”	“Firms are the only actors that direct their customers to HP.”
6.10	BN18	“Yani %5 isi pompasını müşterisi ne almaya gittiğini bilerek alır.”	“Only 5% of customers would have known the HPs.”
8	BN21	“HVAC/R sektörünün isi pompasi gelisimi uzerine de çok büyük etkisi var. Çünkü asıl bilgi birikimi bu sektörde, isi pompasi isini bilenler ve bu sektörü bilenlerle beraber ilerlemesi en doğrusu olur.”	“The HVAC/R sector has a significant impact on the development of heat pumps… This is because the primary knowledge and expertise reside within this sector, and it is best to progress in collaboration with those knowledgeable about heat pumps and the industry.”
8	B15	“Konferans fuarlar sektor genelinde bilgi almak icin gerekli oluyor... Bu bilgileri almak ve sektor dinamigini ogrenmenize yariyor fakat teknik faydayi alamiyorsunuz.”	**“**Conferences and fairs are necessary for obtaining information in the sector as a whole. It helps you learn about the dynamics of the sector, but you may not gain technical benefits from it.”
8	B4	“Biz bir tanesi yıllardır yanımızda olan karşılıklı güvendiğimiz bir tanesi bu yola çıkarken yanımıza 2 ay partnerle işi böyle hiç bir şekilde yürütüyoruz.”	“We have one trusted partner whom we have known for a long time, and we also have another partner whom we have just started getting to know for this project.”
8	BN18	“Yani %5 isi pompasını müşterisi ne almaya gittiğini bilerek alır geri kalan %90 i müşteri doğal olarak ne alacağını bilmeden HP adinda bir urun alir.”	“Only 5% of the customer would purchase heat pumps by knowing, %90 of consumers are buying it without knowing the product they purchase what the seller gives.”
8	B9	“Çünkü hazır alip satmak piyasa açısından daha ucuz ve uygun oluyor.”	“Buying the component from outside is cheaper and favourable for the market.”

Appendix G : National Energy Efficiency Action Plan (NEEAP) (20172023) selected items indirectly influencing heat pumps

Goal	Target and Actions
1. Setting energysaving targets for public buildings based on energy efficiency audits	Goal to save a minimum %15 of energy by 2023
2. Promoting renovations of existing buildings and energy efficiency improvement in heating and appliances (including through the creation of a new financial support system),	The "World Bank Energy Efficiency in Public Buildings Project", with an the budget of $200 million. Regarding thermal insulation in buildings, which will increase the energy consumption of heat pumps, insulation material thickness from an average of 5 cm to 78 cm in Istanbul and from 6 cm to 89 cm in Ankara, as well as improve the insulation values of windows. In 2022, the Turkish government gave a thermal insulation loan package supporting energy efficiency in buildings incentives loans up to 50 thousand Tl with 60month maturity and 0.99 interest rate for each house. The insulation has to be made by practitioners with professional competence certificates.
3. Promoting central and district heating and cooling systems	Also, Through NEAAP, the heating and cooling demand of the building sector has been determined, and the most suitable areas for implementing the district heating systems are calculated through Copernicus Monitoring Program. The program divided regions and calculated the costeffectiveness of district heating systems. Also, there are supporting mechanisms for the industrial buildings, heat market legislations prepared for district heating and cooling, and energy efficiency projects will be supported by efficiency–enhancing project implementation process. Some voluntary support has been given to firms which achieve %10 energy efficiency, and ISO 50001 certification became mandatory to apply for these voluntary agreements.
4. Promoting energy efficiency upgrades in new buildings from C class to A or B	The Buildings bigger than 5000 m2 have an energy performance class of "B" and a 5% energy consumption requirement from renewables.
5. Increase the use of renewable energy and cogeneration of systems in buildings.	According to these government roadmaps, several actions have been taken. Under the goal of the "2053 net zero emissions buildings" target from 2023, buildings bigger than 5000 m2 need to meet %5 renewable energy sources(solar panels, wind power, heat pumps etc.). The regulations counted heat pumps as a renewable energy source, and this is the only positive discrimination been made to promote HP according to a governmental actor.
6. Promote sustainable green buildings through certifications	Energyefficient and renewable energy technologies were incorporated into the Construction and Installation Unit Prices Book. Also, the national Green Certification System (YesTR) process started in 2022.

Source: National Energy Efficiency Action Plan (NEEAP). (2018). National Energy Efficiency Action Plan (NEEAP) 20172023. Republic of Turkey Ministry of Energy and Natural Resources, Ankara. Retrieved from https://www.yegm.gov.tr

Appendix H: Eleventh Development Plan (20172023) selected items indirectly influencing heat pumps

2.2.1.1.5. Logistics and Energy Infrastructure	341.4. Heat market legislation will be established to expand energyefficient district heating and cooling systems throughout the country and to enable heat trade.
2.2.1.2.4. Machinery and Electrical Equipment	492.1 Domestic production in the sector will be improved by promoting energy efficiency in the electrical equipment and domestic appliances sector
2.2.3.6. Energy	492. Buildings that are more efficient and produce their energy will be expanded. 492.1. Energy efficiency in existing buildings will be promoted through support systems. 492.2. National Green Building Certificate System will be established. 492.4. Energy Efficiency in Public Buildings Project will be implemented (KABEV project)

Source: Presidency of Strategy and Budget (2019). 100th year Turkey plan: Eleventh Development Plan (20192023). Presidency of Strategy and Budget, Ankara. Retrieved from https://www.sbb.gov.tr