TRI-HP PROJECT | Trigeneration systems based on heat pumps with natural refrigerants and multiple renewable sources

Enhancing stakeholders' acceptance of trigeneration heating and cooling systems: Recommendations from the TRI-HP stakeholder process

Deliverable number: D2.3

Version 1.0

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CONTENTS

List of acronyms

H/C	heating and cooling
HP	heat pump(s)
HVAC	heating, ventilation, air conditioning
MFB	multi-family building(s)
NR	natural refrigerant(s)
RE	renewable energy
RE H/C	renewable heating and cooling
SWS	stakeholder workshop(s)

Executive Summary

Deliverable D2.3 presents results on expert knowledge and stakeholder acceptance of trigeneration heating and cooling systems. This task has the overall objective to explore potential social implications of TRI-HP systems and improve stakeholders' acceptance towards these systems. Particular emphasis is given to market acceptance in order to understand potential barriers and hindrances for the adoption of TRI-HP by market participants.

Stakeholder workshops in Germany, Switzerland, Spain and Norway were carried out to understand and determine barriers and drivers that influence the acceptance of renewable heating and cooling systems. The focus of the workshops held in June 2021 was on market participants who can be considered as key stakeholders for the implementation of such innovative systems. The following groups were considered important stakeholders for this purpose, as they have a direct influence on their dissemination, planning, construction or maintenance:

- decision makers (e.g. investors or building owners who make investment decisions for a building);
- planners and technical consultants for the design and technical functionality of renewable heating and cooling systems in residential buildings (architects, HVAC consultants, building engineers, etc.);
- experts for the successful installation of renewable heating and cooling systems (installers, tradesmen, plumbers, etc.);
- manufacturers and distributors (e.g. of heat pump systems);
- building or facility managers in charge of operating and maintenance of renewable heating and cooling systems.

Carefully selected representatives of these or similar groups were invited to the stakeholder workshops in order to represent a broad spectrum of different perspectives and interests and to be able to capture and discuss barriers and drivers in a most inclusive way.

It can be concluded from the four stakeholder workshops that the barriers and drivers of stakeholder acceptance, which were already elaborated and described in Deliverable D2.2[1], could be fundamentally validated and affirmed in the workshops. This refers both to the cross-country results and to the country-specific contexts. Especially in the action steps jointly developed by the stakeholders to overcome key challenges, the different country-specific framework conditions became evident.

Furthermore, it also became clear how interdependent the numerous challenges associated with the introduction of innovative trigeneration heating and cooling systems are. In order to enhance the acceptance of such systems by the relevant stakeholders, it is therefore recommended to develop solutions with a holistic and long-term perspective and consider a wide range of non-technological factors in addition to technological and economic ones. Building on Deliverable D2.2, this Deliverable D2.3 offers numerous ideas, suggestions and proposals on how to better align acceptance of TRI-HP systems with the needs and expectations of key stakeholders and better address primary national challenges. These recommendations for action include, for example, that heat pump manufacturers should align themselves more closely with the needs of heating installers to ensure that

[1] Friedrich, T. and Stieß, I. (2021): Social acceptance of innovative RE H/C systems: barriers, hindrances, drivers and incentives, https://www.tri-hp.eu/fileadmin/downloads/Deliverables/D2.2_-_Social_acceptance_of_innovative_RE_HC_systems_.pdf

heat pumps become more standardised and easier to install, or that the funding of innovative heating and cooling systems that combine several renewable energy sources should be improved. The proposed actions indicate that a systemic view that takes into account the different perspectives of the relevant stakeholders is needed to achieve an improved framework and thus more market acceptance for TRI-HP systems.

1. INTRODUCTION

The aim of the TRI-HP project is to develop flexible, energy-efficient and affordable trigeneration systems based on heat pumps (HP) with natural refrigerants (NR) and an on-site renewable share of 80 per cent. These systems can be coupled with multiple renewable energy (RE) sources and storages to provide environmentally friendly heating, cooling (H/C) and electricity for multi-family buildings (MFB) with high efficiency. The flexibility will be achieved by allowing the use of three heat sources: solar (with ice/water as storage medium), ground and ambient air.

As part of the TRI-HP project, the social acceptance of renewable heating and cooling (RE H/C) systems is investigated. The focus is on the views and perspectives of key stakeholders on the diffusion and deployment of RE technologies, such as trigeneration systems in residential buildings.

As a first step, a literature review was carried out exploring key social and contextual factors which could promote or impede the further development and upscaling of innovative RE H/C systems. As a result of this review, key barriers, hindrances, drivers and incentives that could affect market acceptance of RE H/C systems were identified.[2]

These topics were further explored in greater detail in an international survey. Interviews with different stakeholders in Germany, Switzerland, Spain and Norway were carried out to understand and determine barriers and drivers that influence the acceptance of RE H/C systems in these countries.

The stakeholder interviews yielded a wealth of insights into barriers and drivers that impede or foster a market uptake of RE H/C systems in the four countries. Key issues were systematically identified and then evaluated and refined in a subsequent stakeholder process. This process encompassed four national stakeholder workshops (SWS) in Germany, Switzerland, Spain and Norway and will be concluded with an EU level workshop.

This report is structured as follows: first, the overall objective and relevant stakeholder groups of the TRI-HP stakeholder process are presented in Sections 2 and 3. Section 4 provides a description of the SWS concept and its methodological approach. Section 5 presents the main SWS results in all countries, while Section 6 provides a brief summary of the recommendations from the SWS process.

2. OVERALL OBJECTIVE OF THE TRI-HP STAKEHOLDER PROCESS

At the heart of the stakeholder process was the advanced identification and exploration of the needs of key stakeholders in regard to TRI-HP systems. Social barriers and benefits that can influence the acceptance of TRI-HP systems have been further elaborated, taking into account differences between countries and stakeholders.

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[2] see TRI-HP Deliverable D2.1: Friedrich, T. and Stieß, I. (2019): Social issues of novel renewable energy heating/cooling systems, http://doi.org/10.5281/zenodo.3763715

This overall objective of the stakeholder process can be subdivided into the following secondary objectives:

- A first goal was to **validate the barriers and drivers** which have been elaborated from the expert interviews with a particular focus on the national context. In the SWS, key topics that have been identified in the interviews were subsequently assessed by national stakeholders and experts from the point of view of their professional expertise and the specific conditions in their country. Particular emphasis was given to national framework conditions (regulatory framework, funding policies, energy markets, building industry etc.).
- A second goal was to assess and **refine potential incentives and ideas** which were raised in the stakeholder interviews. Ideas and suggestions from the stakeholder interviews were evaluated by representatives of key stakeholder groups with regard to the national context in the respective country. Selected topics were elaborated in greater detail and conclusions for measures and actions to improve market uptake of TRI-HP systems were identified in the four countries.
- As a third goal, recommendations to **improve market uptake** of TRI-HP systems were developed. As a result of the discussions in the national SWS, recommendations were derived regarding:
    - measures and actions improving framework conditions for market uptake of TRI-HP systems;
    - topics, target groups and activities for further dissemination and communication activities.
- Last but not least, the SWS also fulfilled an important **communication function**, as the latest TRI-HP technical developments were presented to different audiences and key stakeholders as well as to obtain valuable feedback from them already during the development phase.

3. KEY STAKEHOLDERS OF THE TRI-HP STAKEHOLDER PROCESS

The focus of the TRI-HP stakeholder process is on market participants that can be considered as key stakeholders for the adoption of RE H/C systems. According to Freeman et al. (2010), we understand stakeholders as any individual or group who can affect or is affected by the achievement of the objectives of a project or organisation.[3] In the case of RE H/C systems, the following groups were considered important stakeholders for this purpose, as they have a direct influence on the dissemination, planning, construction or maintenance of innovative RE H/C systems:

- decision makers (e.g. investors or building owners who make investment decisions for a building);
- planners and technical consultants for the design and technical functionality of RE H/C systems in residential buildings (architects, HVAC consultants, building engineers, etc.);
- experts for the successful installation of RE H/C systems (installers, tradesmen, plumbers, etc.);
- manufacturers and distributors (e.g. of HP systems);
- building or facility managers in charge of operating and maintenance of RE H/C systems.

Carefully selected representatives of these or similar groups were invited to the SWS in order to represent a broad spectrum of different perspectives and interests and to be able to capture and discuss barriers and drivers in a most inclusive way. The organisations, associations and enterprises that have contributed to the SWS are presented in Table 3.1:

[3] Freeman, R.E.; Harrison, J.S.; Wicks, A.C.; Parmar, B.L. and de Colle, S. (2010): Stakeholder Theory – The State of the Art. Cambridge University Press, New York

Table 3.1: Representatives of stakeholder categories that participated in the four TRI-HP SWS.

Categories	Germany	Switzerland	Spain	Norway
HP associations	Bundesverband Wärmepumpe (BWP)		Asociación de Fabricantes de Equipos de Climatización (AFEC)	Norsk Varmepumpeforening
RE H/C system (components) manufacturer	Emerson Commercial & Residential Solutions	Heim AG; Hoval; Energy Solair; Solarcampus GmbH	Airlan; Carrier; Domusa; Ecoforest; INTARCON; Keyter; Koxka/Groupo K; Sedical; Shrieve; Mitsubishi Electric Europe	Technoblock Sinop AS; ptg
HVAC planners / energy counselling	EnergieAgentur.NRW	anex ingenieure ag	Satys; Telur	VKE
Installing / tradesmen associations	Fachverband SHK Baden-Württemberg; Handwerkskammer Hannover			Polar Kuldeservice AS
Investors / housing company	Frank ECOenergy GmbH	Genossenschaft Migros Ostschweiz		TOBB
Facility management / energy contracting	Frank ECOenergy GmbH	Engie Services AG	Veolia	TOBB
Architects / building engineers	Arbeitsgemeinschaft Energetische Sanierung	Bearth & Deplazes Architekten AG	Comsa	
Other		Wärmepumpen-Testzentrum Buchs (WPZ)	ACA; Tellus Ignis	SINTEF

4. Stakeholder workshop concept and methodology

4.1 Concept

The concept of the SWS was developed by ISOE. Minor country-specific adjustments were incorporated in collaboration with the national organisers.

ISOE also prepared a short synopsis of the most important results from the stakeholder interviews in German and English (see Appendix). This was made available to the SWS organisers and aimed to be sent to the invitees as preparation for the SWS, thus creating a common basis for discussion. The synopsis contained cross-country results as well as country-specific topics. To ensure comparability of results, each of the SWS covered a number of core topics, with an option to add new topics according to the specific conditions of each country.

All SWS were held as virtual events due to the COVID-19 pandemic. In addition to the conference software, virtual whiteboards and an online voting tool were used. The languages in which the workshops were conducted were German in Switzerland and Germany, English in Norway and Spanish in Spain.

Each SWS was organised by a national partner of the TRI-HP project consortium and supported by project partners in terms of moderation and documentation (see Table 4.1). At least 7 carefully selected stakeholders from different sectors participated in each SWS, including relevant associations, organisations, companies or practitioners (see Table 3.1).

The main results and conclusions of each SWS were summarised in condensed documentations, which were then subjected to a comparative analysis. For this purpose, ISOE has provided a documentation template to the national partners. In addition, the information from the whiteboards and the votes were evaluated.

Table 4.1: Comparative overview of the four TRI-HP SWS and number of attendees.

	Germany	Switzerland	Spain	Norway
Date and time	09.06.2021 09:30-12:30	24.06.2021 09:30-12:30	23.06.2021 09:00-11:00	16.06.2021 09:30-12:30
SWS organiser	ISOE	SPF	Tecnalia	NTNU
Moderation and support	ISOE, SPF	ISOE, SPF	SPF, Tecnalia, NTNU, IREC	ISOE, SPF
Participants total	20	19	37	23
Stakeholders	7	9	26	7

4.2 Schedule

The basic structure of the workshop schedule is shown in Table 4.2. It has been slightly adapted by the national organisers when necessary.

Table 4.2: Basic schedule of SWS in all countries.

Time	Activity	Objective	Methods	Who
09:30-10:00	Reception and virtual get together	Login, technical check		SWS organiser
10:00-10:05	Welcome	Introduction of workshop objectives, present project members and moderators		SWS organiser
10:05-10:10	Course of the workshop	Presenting SWS agenda and digital rules	PowerPoint presentation	SWS organiser
10:10-10:20	Presentation of the participants	Becoming acquainted to the workshop	Brief introduction	SWS organiser, participants
10:20-10:25	"TRI-HP in a nutshell"	Introduction of the overall project, role of SWS in the TRI-PH project	PowerPoint presentation	SPF in English
10:25-11:10	TRI-HP: fresh results from research	Short presentations of key TRI-HP topics (see below)	PowerPoint presentations, 3x10min + 5min Q&A	Experts from TRI-HP project team, moderated by SWS organiser or project partner
11:10-11:20	Coffee break			
11:20-11:35	Key findings from stakeholder interviews	Feedback on and evaluation of results from expert interviews	Short presentation of vision canvas @Miro Voting challenges for group discussion @MS Forms	SWS organiser, ISOE
11:35-12:05	Taking action to accelerate market acceptance of RE H/C systems	Developing steps of actions and identification of stakeholders to activate	In-depth discussion of challenges in one or more working groups (breakout rooms) using the vision canvas approach @Miro	SWS organiser or moderating project partner, participants

12:05-12:15	Presenting of results by each small group	Summary of discussion results	3 min for each small group, moderated plenary session	Participants, SWS organiser or moderating partner
12:15-12:25	Final plenary discussion	Summary and outlook		SWS organiser, participants
12:25-12:30	Wrap-up and goodbye	Concluding remarks		SWS organiser

4.3 THEMATIC INPUT

In all SWS, the TRI-HP project members provided a thematic input in the first half of the SWS. They presented some of the innovative developments of the project to the stakeholders. The topics presented by the TRI-HP project members for each SWS country are listed in Table 4.3.

Table 4.3: Titles of the presentations given by TRI-HP project team members.

Topic	Presenter/country
"Heat pumps with natural refrigerants"	HKA/Germany, HEIM/Switzerland, Tecnalia/Spain, NTNU/Norway
"Solar-ice systems for heating and cooling apartment buildings"	SPF/Germany, SPF/Switzerland
"Ice slurry production through water supercooling"	HKA/Germany, SPF/Switzerland
"CO_2 heat pumps with tri-partite gas cooler"	NTNU/Spain, NTNU/Norway
"Propane dual source heat pump"	Tecnalia/Spain, Tecnalia/Norway

4.4 GROUP DISCUSSIONS

The thematic inputs were followed by group discussions of key challenges in terms of improving the uptake of trigeneration H/C systems among stakeholders. These challenges and thus the actual subjects of discussion were selected by the stakeholders themselves in a voting process prior to the discussion. Depending on the country and the voting results, the participants of the SWS then were divided into moderated small groups in which different challenges were discussed and action steps were developed.

The presentation of the key challenges during the SWS was done via Miro[4] in the form of a vision canvas (see Figure 4.1). The centre of the canvas shows the vision, which provided the scope and direction for discussion. Arranged around the vision are central themes that emerged in the interviews in all countries as important in one way or another for supporting and realising the vision. For example, it was mentioned multiple times in the interviews that RE H/C systems should be easy to understand, install and maintain, and that this requires different skills and cross-stakeholder collaboration.

Figure 4.1: Vision Canvas used in all TRI-HP SWS.

The left side of the canvas shows the supports that enable to reach the vision. They largely correspond to the drivers and incentives that were elaborated in the interviews. "TRI-HP innovations" had been added as a support, which refers to the thematic inputs presented in the first half of the SWS.

It was explicitly pointed out that this list was not exhaustive, but a pre-selection of topics mentioned frequently in all interviews. As the focus of the SWS was not on the supports but on the challenges, no discussion was intended for this part of the canvas. However, the supports could be referred to later when action steps were being developed.

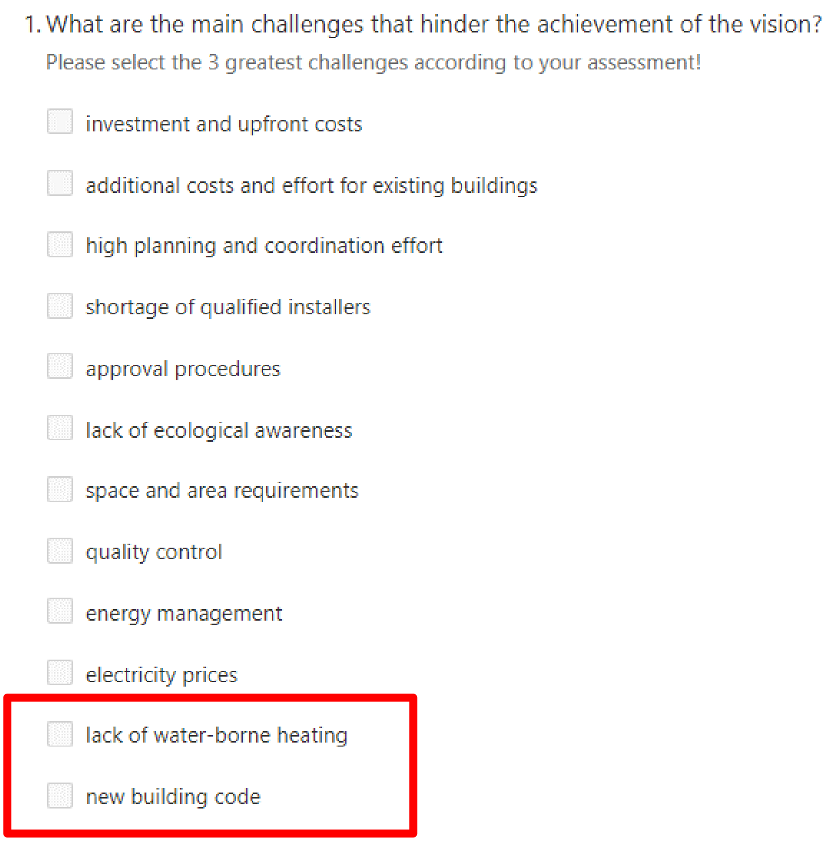
On the right-hand side of the canvas is a list of key challenges that corresponded to the major barriers and obstacles that were identified in the interviews. The SWS focused on this side of the canvas.

After presenting some of the most important issues that were frequently mentioned in all interviews, stakeholders were given the opportunity to add challenges if they missed any, or they could change or even delete existing

[4] www.miro.com

ones. In this way, they were able to bring in and include in the discussion certain aspects specific to certain stakeholder groups or countries. After the list of key challenges was deemed complete, a voting process followed. Each stakeholder could cast a vote on which challenges he or she thought were most important. The voting tool Microsoft Forms[5] was used for this purpose. The top results of this voting process in all four countries can be found in Section 5.

An example of this voting process for the Norwegian workshop is shown in Figure 4.2. The first 10 challenges correspond to those listed on the right-hand side of the canvas and were equally available in all countries. Two further options were added before the voting process in Norway, which had already been identified as being specific to the country in the interviews (see Section 6).



1. What are the main challenges that hinder the achievement of the vision?

Please select the 3 greatest challenges according to your assessment!

- [ ] investment and upfront costs
- [ ] additional costs and effort for existing buildings
- [ ] high planning and coordination effort
- [ ] shortage of qualified installers
- [ ] approval procedures
- [ ] lack of ecological awareness
- [ ] space and area requirements
- [ ] quality control
- [ ] energy management
- [ ] electricity prices
- [ ] lack of water-borne heating
- [ ] new building code

Figure 4.2: Respond options for the main challenges (red frame = new challenges added before voting).

After agreeing on the response options, stakeholders were given the opportunity to cast up to 3 votes depending on how they assessed the challenges. For example, in Norway, the main challenges selected are shown in Figure 4.3. Based on this, it was decided which challenge would be discussed in the next step.

[5] www.microsoft.com/de-de/microsoft-365/online-surveys-polls-quizzes

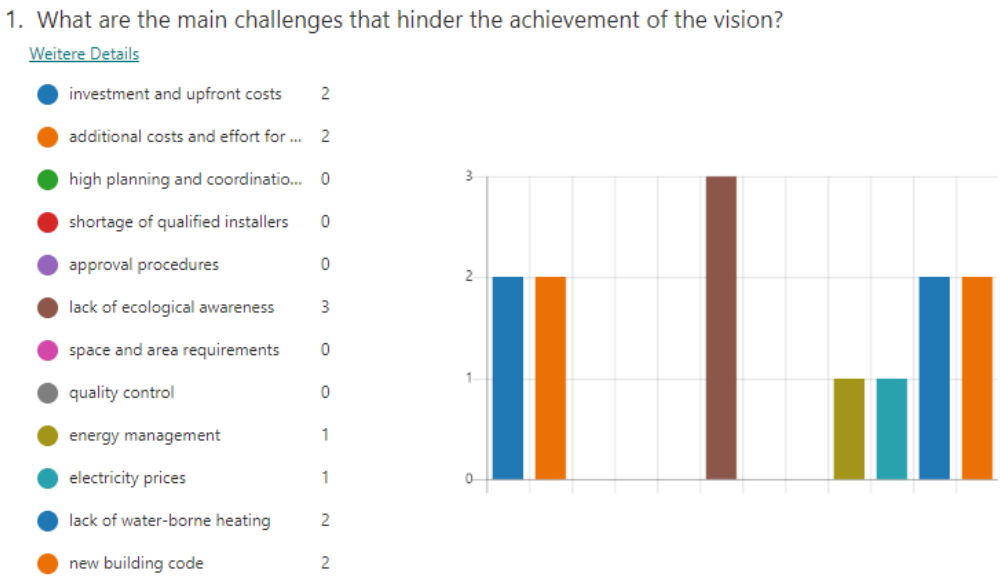


Figure 4.3: Voting result of the main challenges in Norway.

Once one or more challenges had been agreed upon by the participants, they were discussed in one or more groups. The Miro whiteboard was used again to structure the discussion and record its results. At the beginning of the discussion, the moderator asked the initial question "What exactly is the challenge?" in order to clarify the subject and to obtain a shared understanding from all stakeholders. The answers were noted on the canvas in parallel to the discussion to help facilitate and structure it (see Figure 4.1).

The next step was to ask for "3 concrete action steps" that can help to overcome the discussed challenge and achieve the vision (Figure 4.4). Here, too, the answers were noted down transparently for everyone in parallel to the discussion.

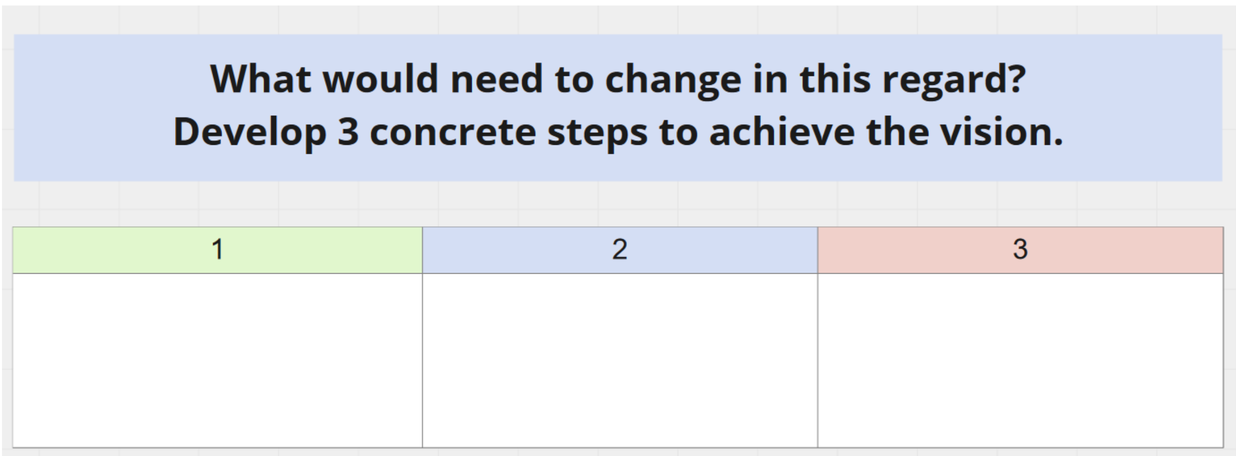


Figure 4.4: Table on the Miro Whiteboard for noting the action steps.

The last part of the discussion was initiated by a question about the key stakeholders or professional groups that need to be activated for the realisation of the action steps just developed (Figure 4.5). Depending on whether a division into small groups had taken place, the participants were regrouped in the plenary at the end of the discussion. There, they briefly presented their results to each other using their filled-out canvases before a final summary concluded the SWS.

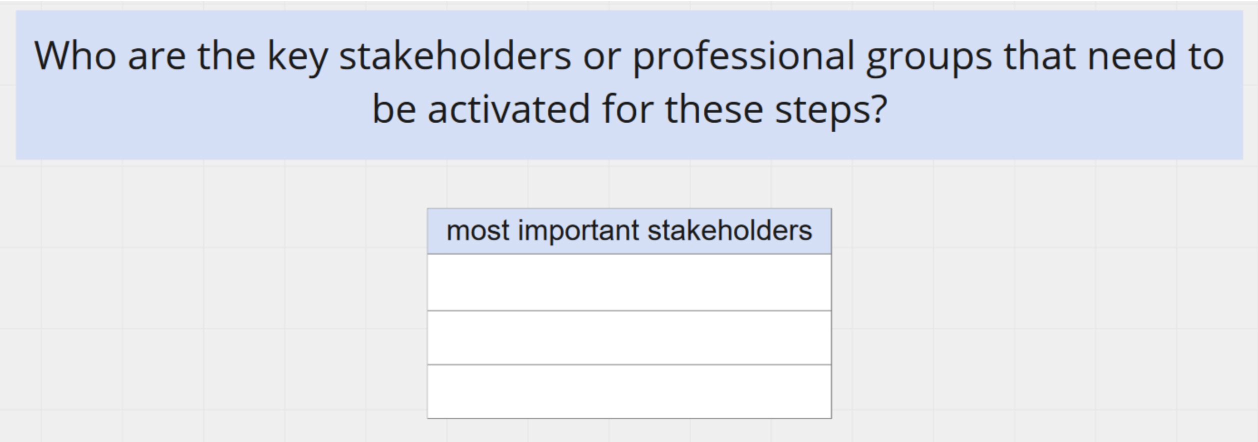


Figure 4.5: Table on the Miro Whiteboard for noting the main actors to be activated.

5. STAKEHOLDER WORKSHOP OUTCOMES

In addition to the Miro whiteboard and the vision canvas, all the SWS were thoroughly documented along a template provided in advance by ISOE to all organisers. This ensured that both country-specific characteristics and the best possible comparability of the results were captured. Hereafter, the most important results that were developed jointly by the stakeholders are presented for each country, following the methodology outlined before.

5.1 GERMANY

Prior to the voting, the following additional response options were added: “noise insulation”, “user behaviour”, and “complexity for investors and building owners”. Two existing response options were changed to: “shortage of skilled workers, training and deployment of skilled workers”, and “electricity prices and electricity market”. The German stakeholders assigned their votes for what they considered to be the main challenges as follows:

	Challenges	Votes
1.	“High planning and coordination effort“	5
2.	“High investment and upfront costs”	4
3.	“Shortage of skilled workers, training and deployment of skilled workers“	3
	“Electricity price and electricity market“	3
	“Complexity for investors and developers”	3

Two small groups were formed to discuss the first two topics.

With regard to the high planning and coordination effort, it was emphasised that for proper planning, an understanding of the overall system is required. Especially when installing HP in existing buildings, proper dimensioning is important. This requires an exact and elaborate calculation of the heat demand of the building.

The following action steps on how to best tackle the challenge were worked out by the small group:

Proposed action steps
A training offensive should be launched to enable professional associations and manufacturers to better understand HP systems and acquire the knowledge they need to install HP.
Manufacturers should align HP more with the needs of installers and design them to be more standardised and easy to install.
Installers should be provided with a planning manual with detailed operating steps, including a catalogue of building types and suitable HP systems.

The group agreed that the use of RE systems must become a matter of course and implementation must be made as easy as possible. This requires mediation by professional associations and manufacturers. In the long run, policymakers are called upon to secure this change in thinking by setting clear targets for the future development of the H/C sector.

With regard to high investment and upfront costs, it was pointed out that the installation costs must be considered holistically by taking into account the entire life cycle of H/C systems. In the case of refurbishment, not only additional radiators or adding an underfloor heating, but also the insulation of the building envelope are a significant cost factor from an investor's point of view. However, this can decrease on the other hand the HP cost: better insulation will reduce the energy demand, thus a smaller, less expensive HP will be required.

The following action steps on how to best tackle the challenge were worked out by the small group:

Proposed action steps
Adequate planning for the entire building must be carried out, whereby the heat demand of the building must be determined individually in order to be able to calculate the appropriate dimensioning of the HP and potential additional costs.
Planning should be carried out by an independent energy consultant, who furnishes a manufacturer-independent expert opinion and calculates the life-cycle costs for different scenarios, including future price increases for fossil fuels.
Builders owners' awareness should be raised that good planning saves money rather than being a cost factor.

Stakeholders who should be addressed for this are heating installers, energy consultants and building owners.

5.2 Switzerland

In Switzerland, the deployment of heat pumps is larger compared to many other countries, which is why the discussion of the challenges focused more on the specific case of solar-ice systems – the concept of TRI-HP that applies to this climate. Prior to the voting, the following additional response option was added: "adjusted funding for larger systems". The Swiss stakeholders assigned their votes as follows:

	Challenges	Votes
1.	"High planning and coordination effort"	6
2.	"Investment and upfront costs"	5
3.	"Shortage of skilled workers"	4

Two small groups were formed to discuss the first two topics.

With regard to the high planning and coordination effort, the group opted to discuss this challenge with focus on solar-ice systems. It was emphasised that building owners and architects need practical examples so that they can build confidence in the technology. Further, they need comparative offers from which they can choose. Another problem is, that architects are not remunerated for the extra work and prior research they have to do on such innovative systems.

The following action steps on how to best tackle the challenge were worked out by the small group:

Proposed action steps
More demonstration sites need to be built to enhance confidence in the technology.
Where such demonstration sites already exist, they need to be better promoted in order to significantly increase the awareness of such systems across relevant stakeholder groups.
Extra work done by the construction management, architects or planners must be remunerated.

Building owners, planners, architects and installers were identified as key stakeholders who need to be activated with regard to this challenge. The latter in particular are of great importance, as they are the ones who decide which heating system is ultimately installed in smaller MFB (e.g. with 10 residential units). Usually, planners are not yet consulted in these cases.

With regard to the investment and upfront costs, it was pointed out that the installation costs must be considered holistically by taking into account the entire life cycle of H/C systems but also buildings. Opinions differed on the time horizons for which life cycle costs should be calculated. Periods of more than 50 years remain not very attractive for investors. Another challenge is the tenant-landlord dilemma, which will not be resolved by a life cycle assessment alone.

The following action steps on how to best tackle the challenge were worked out by the small group:

Proposed action steps
Change in tenancy law is needed to adequately take into account investment costs for H/C systems and clear regulation under which conditions landlords can pass on costs of investments to tenants.

Proposed action steps
Depreciation and tax breaks for large investments in energy efficiency and heat supply should be extended, e.g. by staggering tax deductions over several years.
Funding for innovative H/C systems that combine several RE technologies should be increased, as well as support for business models such as energy contracting.

Stakeholders who should be involved in this context are political decision-makers, building owners, funding bodies and financing or pension funds.

5.3 Spain

Prior to the voting, the following additional response options were added according to stakeholder input: "gas natural price", "adding TEWI (total equivalent warming impact) in public tenders or in regulatory mandates to be considered in projects", and "regulatory and administrative barriers". The Spanish stakeholders assigned their votes for what they considered to be the main challenges as follows:

	Challenges	Votes
1.	"Investment and upfront costs"	9
2.	"Regulatory and administrative barriers"	4
	"Shortage of skilled workers"	4
	"Lack of space"	4

As there was a clear majority for the most important topic, it was decided to discuss the first topic in one group.

There was general agreement that the overall investment costs associated with RE H/C systems are a key barrier to their implementation. Decision-makers are primarily guided by upfront costs when evaluating different alternatives for HVAC solutions.

The following action steps on how to best tackle the challenge were worked out by the group:

Proposed action steps
Proposals for RE H/C systems should include detailed life cycle assessment, including operating costs, to allow a fairer comparison of systems and avoid an undue focus on investment costs.
Life cycle assessments should also include refrigerants, e.g. their global warming potential.
Awareness raising of all relevant stakeholders should be done as well as improved dissemination of knowledge about the benefits and opportunities of RE H/C systems to enable better decision making.

System developers, planners and manufacturers were identified as the most important stakeholders or professional groups to be activated for these steps.

5.4 NORWAY

Prior to the voting, the following additional response options were added: “missing water-borne systems” and “new building code”. The Norwegian stakeholders assigned their votes for what they considered to be the main challenges as follows:

	Challenges	Votes
1.	”Lack of ecological awareness"	3
2.	”Investment and upfront costs”	2
	”High planning and coordination effort”	2
	”Missing water-borne heating”	2
	”New building code”	2

It was decided to discuss the first topic in one group.

The lack of ecological awareness was highlighted as a major challenge, as many homeowners do not care what heating technology they use or which refrigerant it contains as long as it is legal and cost-effective. In Norway, heating is predominantly powered by electricity, which is commonly understood as “green”. Therefore, for the Norwegian population heating is not an environmental issue, which means that there is no incentive to switch to renewable and more environmentally-friendly heating systems.

The following action steps on how to best tackle the challenge were worked out by the group:

Proposed action steps
A labelling system should be introduced that transparently maps the environmental impact of heating systems and thus that of houses, so that HP systems (with NR) receive a better rating.
Before building a house, owners should declare which heating system they choose and why not a more environmentally-friendly one.
For better awareness raising and to demonstrate that it works, public actors such as schools should step forward.
Not only positive incentives should be set but also penalties introduced.

Stakeholders who should be activated for these steps are political decision-makers (government), public actors, building developers and building owners.

6. CONCLUSIONS AND RECOMMENDATIONS

In terms of the overall objectives, it can be summarised that the **drivers and barriers identified in the stakeholder interviews could be validated and affirmed** in many ways during the four country-specific SWS. This applies both to the ten pre-selected challenges, none of which was considered irrelevant by the stakeholders or even suggested for removal, and to the modified or added answer options. Aspects from all three categories of barriers and drivers identified in Deliverable D2.2 (see Appendix for a summary) were vividly discussed in all SWS.

For example, "investment and upfront costs" were found among the key challenges in three out of the four country workshops as well as "shortage of skilled workers" and "high planning and coordination effort". As already shown in the interviews, very similar challenges were discussed in Germany and Switzerland, although the proposed solutions varied due to different market situations and stakeholder constellations. The important role of upfront costs, already evident for Spain in the interviews, was likewise confirmed in the SWS. And the Norwegian SWS could also reaffirm that the lack of environmental awareness is a major challenge in the country.

Another validation of the interview results are the changes and additions to the answer options, as they are a **clear indication of country specificity**. This applies in particular to the issues of "shortage of skilled workers, training and deployment of skilled workers", and "electricity prices and electricity market" in Germany, "regulatory and administrative barriers" in Spain, and "lack of water-borne systems" in Norway.

With the joint elaboration of the action steps and the stakeholders to be activated for this purpose, numerous ideas and practical **suggestions for improvement** were developed in all SWS. In many cases, these corroborate the incentives elaborated from the interviews. This includes, for example, the frequently made argument that the economic efficiency of H/C systems should be considered over the entire life cycle, or the proposal to support new business models such as energy contracting. It was also suggested that the complexity of such systems and their components should be reduced and that they should be easier to install. Especially in Germany and Switzerland, the significance of heating installers became evident once again. Further qualification for the installation of HP but also awareness raising across all stakeholder groups were frequently mentioned aspects in the SWS.

With regard to the third objective of the workshops, it became clear during the entire stakeholder process, including interviews and workshops, that the **country-specific framework conditions are very different.** This concerns various (future) market developments, political legislations, funding availability, geographical and weather conditions as well as cultural contexts. For TRI-HP systems, it is therefore recommended to consider these non-technical aspects at an early stage of development.

Even though the number of participants in the SWS does not allow for representative conclusions, each of the suggestions for improvement and recommendations for action from the national workshops can be checked for plausibility and transferability. As this shows, none of the action steps seem to be categorically valid only for the country in which they were developed. For example, the idea that the time and effort required to adequately plan an energy-efficient and cost-efficient RE H/C system should be remunerated was mentioned in one way or another in several interviews and workshops. Addressing this apparent need, e.g. by **simplifying the systems and providing easy-to-use planning tools** that significantly reduce planning effort and thus planning costs, should be considered in the development of trigeneration systems. Moreover, topics and challenges such as raising awareness or better qualification of installers were recurrently discussed in SWS even if they were not selected as major challenges in the voting before. This reflects the **complex interdependencies that exist between the challenges** and why it is problematic to look at them in isolation from each other.

Approaching the challenges "holistically" was a view that was put forward repeatedly by many stakeholders in both interviews and workshops. Ultimately, this could explain why the action steps, which were all discussed and evaluated against the background of different challenges regarding the common vision, seem to be largely compatible with each other.

We conclude that all results developed in the SWS can be understood as stimulating contributions for **enhancing stakeholder' acceptance of trigeneration H/C systems**. Any measures and actions to improve the framework conditions for market acceptance of TRI-HP systems – such as new funding instruments, qualification offers or communication activities – should therefore take this **holistic perspective** into account. To enhance the acceptance of TRI-HP systems among key stakeholders, their different needs and expectations as well as key national challenges should be included in communication and dissemination approaches.

Appendix: Barriers and drivers of renewable heat pump adoption – Key findings from stakeholder interviews in Germany, Switzerland, Spain and Norway

The following synopsis of Deliverable D2.2 was sent to the invited participants of the stakeholder workshops as background information on the TRI-HP project and in preparation for the workshop.

A1. The TRI-HP Stakeholder Workshops

Climate change is one of the most urgent environmental challenges of our times. A transition towards a post-carbon society requires a far-reaching decarbonisation of the energy system. In addition to an increase in energy efficiency of buildings, a broader market introduction of renewable heating and cooling systems is an important contribution in this regard.

The TRI-HP project is to develop **flexible, energy-efficient** and **affordable trigeneration systems** based on heat pumps with **natural refrigerants** and an **on-site renewable share of 80 per cent**. These systems can be coupled with multiple renewable energy sources and storages to provide environmentally friendly heating, cooling and electricity for multi-family buildings with high efficiency. The flexibility will be achieved by allowing the use of three heat sources: **solar** (with **ice/water** as **storage** medium), **ground** and **ambient air**.

As part of the TRI HP project, the social acceptance of renewable heating and cooling systems is investigated. The focus is on the views and perspectives of actors which are considered as **key stakeholders** playing a critical role for **adopting renewable energy technologies,** such as **trigeneration systems** in buildings:

Building owners	Investors or building owners making investment decisions for a building
Planners and technical consultants	Planners and technical consultants for the design and technical functionality of H/C systems in buildings (architects, HVAC consultants, building engineers, etc.)
Installers	Experts for the installation of H/C systems (Installers, tradesmen, plumbers etc.)
Manufacturers	Manufacturers and distributors of heat pump systems
Facility Managers	Building or facility managers in charge of operating and maintenance of H/C systems

In a series of **stakeholder workshops** (SWS), the TRI-HP project team wants to discuss how a broader market acceptance of innovative renewable heating and cooling systems in multi-family buildings can be achieved. Four **national SWS** will be held in **Germany**, **Switzerland**, **Spain** and **Norway**. The workshops will focus on recommendations on a national level. Overarching recommendations on an **EU-level** will be formulated in a final **workshop**.

- The national SWS will **validate** the findings from interviews with key stakeholders on barriers, hindrances, drivers and incentives promoting or impeding the acceptance of innovative heat pump systems. In the SWS, stakeholders are invited to assess key topics identified in the expert interviews from the point of view of their **professional expertise**.
- The SWS will also **evaluate** the suggestions for promoting market acceptance innovative heat pump systems. The suggestions which were raised in the stakeholder interviews will be assessed with regard

to the **national context and framework**. Selected topics will be elaborated in greater detail and conclusions for actions to improve market uptake of TRI-HP systems in the four countries are formulated.

– Finally, the SWS will **develop recommendations** to improve market uptake of TRI-HP systems regarding **actions** improving **framework conditions** for market uptake as well as **dissemination and communication activities** regarding the adoption of these systems.

A2. Barriers, drivers and incentives towards the adoption of trigeneration systems – Cross-country results from the expert interviews

In the last years, the use of heat pumps for heating, cooling and hot water generation increased steadily in most European countries. However, the market share of heat pumps still varies strongly between market segments and countries. In new constructions heat pumps are well established: According to a market analysis in 2017, the market share of heat pumps in newly constructed single-family houses was above 90 % in Norway, Sweden and Finland and around 35 % in Austria and France. In the renovation market with multi-family buildings, the share of heat pumps is much lower, reaching only around 10 % in Germany, Austria and France.[6]

To better understand the conditions of market uptake of trigeneration systems, the project team investigated key social and contextual factors that influence the social and market acceptance of renewable heating and cooling systems. The analysis included a comprehensive **literature review** and in-depth **expert interviews** with representatives from key stakeholder groups in Germany, Switzerland, Spain and Norway.[7]

As a result, **barriers**, **hindrances**, **drivers** and **incentives** for the **adoption of trigeneration systems** could be identified. These factors can be divided into three categories:

– **Economic–financial barriers and drivers**, including investment, operating and maintenance costs are included, but also economic viability or the distribution of costs and benefit.

– **Barriers and drivers towards practical implementation and feasibility**, related to technical components of heating and cooling systems or to building characteristics.

– **Non-monetary and non-technical barriers and drivers,** including psychological, socio-cultural and organisational factors, as for example, the understanding or handling of complex technical systems, the cooperation between different trades on the construction site, or country-specific heating cultures.

It should be noted that the categories are not necessarily mutually exclusive, since barriers or drivers in one category may affect other categories. For example, the planning and installation of a renewable heating and cooling system can detract from the technical performance and thus also curtail the economic viability of the system.

In the following sections, main barriers and drivers towards the adoption of renewable heating and cooling technologies are presented. While barriers and hindrances refer to the adoption of heat pumps more generally, **drivers and incentives** point to aspects that might help overcome these challenges. These aspects include specific

[6] EurObserv'ER (2018): Heat Pumps Barometer https://www.eurobserv-er.org/heat-pumps-barometer-2018/

[7] Friedrich and Stieß (2021): Social acceptance of innovative renewable heating and cooling systems: Barriers, hindrances, drivers and incentives https://www.tri-hp.eu/fileadmin/downloads/Deliverables/D2.2_-_Social_acceptance_of_innovative_RE_HC_systems_.pdf

advantages of **trigeneration technology** as well as **external factors,** such as political framework conditions, funding schemes or new business models that support the market introduction of trigeneration systems. They also include **suggestions** from stakeholders **for further action** that could improve social and market acceptance of these systems.

Topics that were raised in several countries are presented in the next section. Country-specific findings are presented in an additional section.

A2.1. Economic-financial aspects

A2.1.1. Economic-financial barriers and hindrances

High investment, **upfront costs** and **additional costs**, especially for refurbishment measures that may be required if heat pumps are to be installed in existing buildings, were the most frequently mentioned financial hurdle for renewable heating and cooling systems such as TRI-HP. Additional efforts for drilling in the case of ground source heat pumps, result in further increase of installation costs.

High electricity prices were seen as another barrier, because they increase operating costs and reduce the system's cost effectiveness. This risk increases when heat pumps are not properly installed and configured.

The **uneven distribution of costs and gains** can pose another barrier when an investor is unable to reap personal benefit from low operating costs (landlord–tenant dilemma).

Since complex systems such as TRI-HP require **enhanced planning and coordination effort**, it is necessary to factor in additional costs for quality control, maintenance, etc.

A2.1.2. Economic-financial drivers and incentives

The **low operating costs** of renewable heating and cooling systems and their reliance on basically **inexhaustible energy sources** were emphasised by many interviewees. Maximising **self-consumption of renewable energy generated on site** – as is the case with TRI-HP – is considered a very effective means of keeping operating costs low and becoming largely independent of the electricity market.

Operating costs can be reduced further through **intelligent system control** that can make use of flexible electricity tariffs.

Carbon taxation and ongoing **changes in the regulatory framework** of energy markets are expected to further increase the competitiveness of renewables. **Public subsidies** were highlighted as a main lever with which to ease the burden of the high upfront cost of renewable heating and cooling systems and increase social acceptance of this technology.

Innovative business models, like energy contracting, based on the investment of a third party who is paid for the heat or cooling production can overcome the hurdle of high upfront costs and reduce financial risks for property owners.

Novel forms of cooperation, for example housing cooperatives or energy networks, can also help renewable heating and cooling systems achieve wider market acceptance, as they support a long-term perspective, rather than seeking a rapid return of investment.

A2.2. Practical implementation and feasibility

A2.2.1. Barriers and hindrances regarding practical implementation and feasibility

Poor energy efficiency standards of **existing multi-family buildings** have often been mentioned as a practical barrier that impedes a broader adoption of renewable heating and cooling systems in this segment of the building market. In many cases, the efficient operation of heat pump systems requires expensive and disruptive measures such as insulation of the building façade or the installation of underfloor heating.

The **technological complexity** of advanced renewable heating and cooling systems and the need to adapt these systems to different energy consumption profiles were seen as another challenge, especially with regard to configuration, coordinated interplay between the individual components, and quality control.

Other barriers to feasibility relate to a **lack of space** required for the technological components and boreholes, plus the **noise emissions** of air source heat pumps, which amplify, when the installation is not done properly.

A2.2.2. Drivers and incentives regarding practical implementation and feasibility

A **higher standardisation of heat pump manufacturing** could take the pressure off installers, who would no longer have to grapple with a variety of barely compatible systems from different suppliers. **Compact, space-saving systems or modules** that come **off the shelf** and can be installed and replaced via plug-and-play increase feasibility for both new and existing buildings. Ready-made and simple solutions such as combined packages of, for example, a heat pump with photovoltaic and electrical storage would be appreciated by investors and installers.

Refurbishment measures are considered important to achieve a high performance from a heat pump in existing buildings. A new generation of **high temperature heat pumps** can meet the needs of older buildings, having a modest insulation standard. Disruptive changes to the heat distribution system can be avoided, if technological components such as **low-temperature radiators** are used as an alternative to underfloor heating.

The individual thermal needs and the social structure of residents lead to a variety of **heat consumption profiles** of individual residential buildings. These profiles should be **assessed accurately** in order to determine the ideal sizes of heat pumps, photovoltaic panels, heat storages and other technological components. In multi-family buildings, **intelligent control systems** that automatically adapt to individual user behaviour can help boost the efficiency of the system.

The use of **natural refrigerants** such as propane or CO_2 instead of fluorinated gases further reduces environmental risks. **Technical risks and safety concerns** linked to the use of natural refrigerants in trigeneration systems were **considered to be very low** as installation and maintenance rules were observed. Existing regulations, for example regarding safety measures in the maintenance of heat pumps so that no leakage or contamination can occur, were evaluated positively. There were a few suggestions, however, that called for **permissible maximum levels** when filling a device with natural refrigerants to be **increased** for larger heat pumps installed **in multi-family buildings**.

Due to technical development, air source heat pumps **have become significantly quieter** in the last years. Nevertheless, they should be set and programmed in such a way that noise levels remain constant. **Noise protection equipment** should be considered and **night and quiet times respected**. Complaints from neighbours can thus be minimised.

A2.3. Psychological, socio-cultural and organisational aspects

A2.3.1. Psychological, socio-cultural and organisational barriers and hindrances

Lack of awareness of the ecological impacts of fossil heating and cooling systems, **knowledge deficits** and **preconceptions** about renewable energy technologies, and ignorance about available funding opportunities by many professionals and stakeholders in the heating and cooling sector were seen as an important obstacle to social acceptance of heat pump systems.

A **shortage of qualified installers** for renewable heating and cooling systems was described as a "bottleneck" in many countries. Qualification and training paths as well as the business model of many heating installers are still rooted in fossil technologies, hampering a swift decarbonisation of the heating sector. The **extensive technical and practical knowledge** required for planning, implementation, operation and maintenance of renewable heating and cooling systems was identified as a major **challenge**.

The **increasing demand for information** on a multitude of funding opportunities, regulations, and other framework conditions was seen as another factor that limits broader acceptance of renewable heating and cooling systems among heating installers. **Fragmented responsibility** and **difficulties in coordination** between planners and craftsmen on the construction site can make quality assurance more difficult which in turn means a higher risk for investors.

The prevailing **heating cultures** of end users can clash with the need to adapt heating routines to low temperature heating systems, thus impairing the operation of heat pump systems.

A2.3.2. Psychological, socio-cultural and organisational drivers and incentives

Awareness raising and **trust building** among end users and professional actors are key to increasing social and market acceptance of renewable heating and cooling systems. Prevailing prejudices and rumours among end users, heating installers and architects must be countered with **transparent information** on the advantagtes and benefits of renewable heating and cooling systems.

Close and trusted cooperation between **manufacturers and installation companies** were seen as particular important. Heat pump manufacturers should insist on quality control to guarantee proper installation, offer savings guarantees and maintenance contracts. The appointment of a single responsible overall coordinator for complex projects would improve stakeholder cooperation and enhance customer satisfaction.

Further training for **heating installers** should be targeted to technological issues as well as to communication and skills that are helpful for advising clients or marketing HPs more effectively. **Monetary incentives** for vocational training and further qualification could help address the quantitative and qualitative shortage of skilled workers in the field of heating installation, especially if such incentives are linked to **certification**.

Public communication should not only focus on **technical aspects** and **financial benefits**, but also address **environmental values** that intrinsically motivate stakeholders and end users to invest in renewable technologies and systems. These include, for example, the desire to lead a more **environmentally friendly life**, to practice **energy self-sufficiency**, or to participate in the decarbonisation of the energy system.

A3. Country specific findings

This section highlights differences and particularities that emerged in the country comparison and that have shown to be potentially relevant to increase the acceptance of renewable heating and cooling systems.

A3.1. Germany

In Germany**, existing laws, regulations and funding conditions** relevant for the market diffusion of renewable heating and cooling were assessed as **basically favourable**. The possibilities to receive financial subsidies are numerous. Funding should be **more focused** on **ground source heat pumps** and combined systems. Financial incentives for accompanying **quality assurance measures** were also recommended.

A critical bottleneck is seen in the **lack of sufficiently qualified installers**. Existing offers for vocational training and further qualification are hardly used by tradesmen and installation businesses. A **reform of the traditional SHAC training path** was therefore suggested by some experts. Special emphasis should be placed on renewable heating and cooling systems in order to train **more specialists for these systems**.

Low energy efficiency of the **building stock** is considered a major challenge for heat pump installation. A much discussed topic concerns the **renovation** of existing buildings and when it is reasonable (and under which circumstances) to replace an old (fossil) heating system with a heat pump.

The **high level of electricity prices** in Germany was considered by most of the experts to have a detrimental effect on acceptance of renewable heating and cooling systems. Systems, like trigeneration heat pumps, with a **high share of on-site generated electricity** can ease the burden of high operating costs. **More flexible and intelligent electricity tariffs** for heat pumps could further increase market acceptance.

A3.2. Switzerland

Efforts to harmonise the different legislations in the cantons, for example with regard to energy laws, are considered to impact positively on the social and market acceptance of renewable heating and cooling systems. Funding opportunities for renewable energy were assessed as well developed. Certification schemes are successfully introduced into the market.

The **Heat Pump System Module** was highlighted as a successful quality standard which could serve as a best practice example for other countries as well. The Module includes a **standard** for the planning, construction and commissioning of heat pumps (<15kW), **certification**, **binding procedures**, and **performance guarantees**, easy-to-understand documentation and regular quality checks. The adoption of the Heat Pump System Module is supported by specific funding conditions.

As in Germany, the **shortage of qualified heating installers** was also raised as an issue in Switzerland. The separation of the sanitary and heating trades, which is already taking place, was addressed by Swiss experts. **Tradesmen** in Switzerland have a very **influential position**, also in multi-family buildings, which is partly due to the ownership structure of these buildings. **Advice** of heating installers is often **biased towards fossil heating systems**. Alternatives such as heat pumps are rarely discussed. The pressure for further training for this stakeholder group was estimated to be very low.

A3.3. Spain

In Spain, the **climatic conditions** are very different within the country, creating **very different heating and cooling needs** from region to region. In regions with high summer temperatures, the cooling demand is very high. The development, dissemination and deployment of trigeneration systems in Spain should take account of these specific conditions, as they are associated with different user needs and user behaviour.

In the **building sector** there is a strong **dependence on fossil paths**, and it is only recently that political frameworks have changed in favour of promoting renewable energy technologies. But still, **renewable energy funding policy** is **less elaborated** compared to Germany or Switzerland.

Due to the high level of independence in Spanish autonomous regions, the **regional** implementation of national **building regulations** and **funding policies lacks coherence**. Inhibitive regulations for renewable heating and cooling aggravate the installation of heat pumps in some regions (e.g. "waste water tax" for water used by ground source heat pumps). Better harmonisation of ordinances and regulations with regard to renewable heating and cooling systems would improve the market of these systems.

Compared to other EU countries, building and apartment owners have only **little economic capacity**, and so the **upfront costs** play a **major role** for many residents. Direct savings on investments are seen as more important than long-term savings through lower operating costs.

Central heating and cooling systems are generally **not yet very widespread**. A reason for this is a very **individualistic heating and cooling culture**, with a strong desire for individual heating and cooling solutions for each flat. Being able to consume as much heat or cold as personally desired without thinking about the immediate costs is seen as an expression of "quality of life". hampering the change to larger centralized heating and cooling systems in multi-family buildings.

A3.4. Norway

Norway abounds in electricity from hydropower, and **electricity prices** are **very low**. The country has a huge potential for heat pumps due to cheap electricity. The dominant perception of Norwegians is that they already consume **renewable electricity**, even though the country also purchases non-renewable electricity from neighbouring countries. **Heating systems** are predominantly **based on electricity**, for example via radiant heaters on the walls or electric underfloor heating. Since electricity costs are low, a heating culture prevails in which it is **not very common to save energy**.

Low cost of electricity offers a great advantage and a huge potential for heat pump deployment in Norway. But residents are accustomed to cheap electricity and the **willingness to pay for alternative heating systems is rather low**. Water-based heating systems, as used in Germany and Switzerland, are the exception. The introduction of trigeneration systems requires a shift in heating distribution systems. Home-owners should be encouraged to use more water-based systems.

As the market share of water-based systems is only small, there is a **shortage** of **qualified and well-trained professionals** who can **install** heat pump systems in residential buildings. This poses the need for training and further education.

E-Mobility is widespread in Norway. Advanced **sector coupling using** e-vehicles as electricity storages offers new opportunities to integrate trigeneration systems in the energy grid.

A4. Summary of barriers and drivers

The main barriers, hindrances, drivers and incentives are summarised in the table below. To each category, barriers and hindrances are listed in the left column of the table. Drivers and incentives that might help overcome these barriers are presented in the right column.

Economic-financial aspects	
Barriers and hindrances	**Drivers and incentives**
• high investment and upfront costs • additional costs, e.g. for drilling or refurbishment measures • uneven distribution of costs and gains between investor and buyers/tenants (landlord–tenant dilemma) • high operating costs due to high electricity prices	• low operating costs due to high self-consumption of electricity generated on-site • higher taxation of fossil fuels • public funding and subsidies • new business models, such as energy contracting or housing cooperatives • flexible electricity tariffs for heat pumps • promoting an assessment of total costs and revenues over the entire lifetime of a system
Practical implementation and feasibility	
Barriers and hindrances	**Drivers and incentives**
• high heating demand in existing buildings • additional effort for refurbishment measures in existing buildings • challenging on-site composition of various technological components • high space requirements inside and outside the building (especially in densely populated areas) • lack of understanding of complex renewable heating and cooling systems • complicated approval procedures and funding applications	• new generation of high-temperature heat pumps • low temperature radiators instead of underfloor heating in refurbished buildings • standardised, simple solutions (off-the-shelf modules, plug'n'play sub-systems) • ensuring compatibility of components from different manufacturers by standaridisation • offer compact heat pump systems to avoid work on the refrigeration circuit for installers • certification schemes for installers or tradesmen • closer and trusted cooperation between planners, tradesmen and manufacturers • easy-to-use manuals for installation and operation • cooperation with local planning authorities • making funding applications simple, low-threshold (digital) but also accessible for all ages

Psychological, socio-cultural, and organisational aspects	
Barriers and hindrances	**Drivers and incentives**
• lack of expertise and skilled workers • prevailing fossil business model of heating installers • existing heating routines and heating cultures • noise emissions from air source heat pumps • high level of planning outlay (and investors deterred by complexity and associated uncertainties) • lack of awareness of ecological impacts of fossil heating systems	• further qualification training for heat pump installation • financial incentives for heating installers to take up existing qualification training offers • remunerate additional effort for proper designs and installation of heat pumps • easy-to-use smart control that also adapts to user behaviour • use of quieter air source heat pump equipment and noise control reduction measures • public relation and better marketing for renewable energy systems, for example via social media • awareness raising for non-monetary benefits (thermal comfort, energy self-sufficiency, etc.)

TRI-HP PROJECT | Trigeneration systems based on heat pumps with natural refrigerants and multiple renewable sources

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