HEAT PUMPS SKILLS FOR NZEB CONSTRUCTION (HP4ALL)

Monitoring & Evaluation Plan report

Lead Contractor: Technological University of the Shannon: Midlands, Midwest (TUS)

Author(s): Stephen Murphy

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This report presents the plan for monitoring and evaluating the HP4ALL project pilot region awareness raising and training activities.

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Project details			
Project acronym		Start / Duration	**November 26, 2021**
Contact persons	Padraic O'Reilly (Padraic.OReilly@tus.ie)		
Website	**www.hp4all.eu**		

Report Contributors				
	Name	Organisation	Role / Title	**E-mail**
Report leader	Technological University of the Shannon: Midlands, Midwest	TUS	Project Leader	**Stephen.Murphy@tus.ie** **Padraic.OReilly@tus.ie**
Contributing Author(s)	Megan Gignac	ESV	Project Partner	**megan.gignac@esv.or.at**
	Carlos Garcia Delgado	CTA	Project Partner	**carlos.garcia@corporaciontecnologica.com**
Reviewer(s)				
Final review and quality approval	Padraic O'Reilly	TUS	Project Coordinator	**Padraic.OReilly@tus.ie**
	Stephen Murphy	TUS	Project Leader	Stephen.Murphy@tus.ie

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1 Executive Summary

This document outlines the monitoring and evaluation plan that will be used to calculate the impact of the HP4ALL project. HP4ALL has focused on heat pump skills and the demand for heat pump skills, this led to training of installers, designers, and specifiers of heat pump installations. From an analysis of heat pump performance, improvements from training, behavioural change, and performance gap improvements, the HP4ALL project estimates that an increase in heat pump seasonal performance factor (SPF) of 6.88% will be realised after attending HP4ALL training sessions. The assumptions used in the calculations used in the grant agreement and in this evaluation are shown in Appendix A.

From the calculations conducted by each pilot region the preliminary project impact analysis is shown below vs the grant agreement targets showing that the targets have been surpassed.

Table 1 Overview of Targets and Impact Analysis

Project Performance Indicator	***Target within Project Duration***	***Preliminary Impact Analysis (Dec-22)***	**Measurement unit**
Primary energy savings triggered by the project	2.00	3.04	GWh/year
Renewables production resulting from improved skills	1.95	2.89	GWh/year
Reduction of the greenhouse gases emissions	628	847	tCO_2/year

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2 Introduction

The overarching objective of the HP4ALL project is to enhance, develop and promote the skills required for high quality, optimised Heat Pump (HP) installations within residential/non-residential buildings. In order to achieve this awareness raising activities and training activities were undertaken in the 3 pilot regions.

Awareness raising activities include any events, conferences or workshops that aim to increase end user awareness of heat pumps. Training Activities include training sessions, training courses, capacity building events, conferences and events that aim to increase the knowledge and competency on heat pump system designers and installers.

Due to the varying target audiences and the different stages of maturity of the heat pump market in each pilot region, different approaches were used in order to raise awareness and provide training. This report outlines the evaluating and monitoring techniques that will be used by each pilot region to quantify the impact of these activities in terms of energy savings (final and primary), carbon emission savings.

3 Grant Agreement Target

The grant agreement lays out a preliminary plan of activities and targets for pilot regions to pursue during the lifetime of the project and after the project.

a. Energy related Targets

These targets relate to the impact training and capacity building for installers and designers. The overall targets for the project are outlined within the HP4ALL grant agreement and shown below:

Table 2 Grant Agreement Energy Targets

Project Performance Indicator	Quantification		Measurement unit
	Within the project duration	To 2030	
Primary energy savings triggered by the project	2.00	1,969	GWh/year
Renewables production resulting from improved skills	1.95	1,871	GWh/year
Reduction of the greenhouse gases emissions	628	686,583	tCO_2/year

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The assumptions, references and calculations used to produce these figures is outlined in the HP4ALL grant agreement and shown in Appendix A – Grant Agreement Energy Targets. This calculation sections also provides a target set for each pilot region (AT, ES, IE) outlined below:

Table 3 Overview of Pilot Region Energy Targets

Impact of Project Target	*Upper Austria*	*Republic of Ireland*	*Andalusia, Spain*
Final Energy savings (GWh/year)	0.30	0.43	0.25
Primary Energy Savings (GWh/year)	0.64	0.84	0.53
Carbon emissions saved (tCO_2/year)	108	367	153
Additional RES Production	0.59	0.85	0.49

b. Awareness Raising Targets

These targets relate to the activities taken by pilot leaders to increase awareness of heat pumps, heat pump innovation and good practice in heat pump installation in each of their respective pilot regions. The grant agreement outlines the awareness raising targets for each pilot activity, some of these targets were changed as the project progressed.

The following is an overview of the awareness raising targets for each pilot from the grant agreement, with targets that have been changed highlighted.

Table 4 Overview of Non-energy related Targets

Upper Austria	*Republic of Ireland*	*Andalusia, Spain*
5,000 leaflets distributed	5,000 HP Skills Leaflet for End Users distributed	1 Webinar about the project for policy makers
1 Detailed Planning Guide: (16-24 pages, 3,000 copies)	Promotional Campaigns for End Users in 10 DIY Stores (Changed)	1 webinar about the project for the private sector
10 Best Practice Studies	10 Case Studies of Exemplar Installations/Knowledge Hub Resources	Event for all stakeholders present project results, promote resources in the hub
~200 people attending training courses	Capacity Training for HP Installers and SMES on Innovations (150 Attendees)	Event for policy makers, professional associations, VET schools to discuss public policies assessment and recommendations, discussions between policy makers and education sector

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5 Information events / site visits	3 Webinars on Technical Innovations (50 attendees)	Event for private sector capacity building: universities/ researchers present trends
-	Workshop with Training and Education Providers on Competency Framework (10 Training Providers)	-
-	Training Programme for Designers/Specification/Procurement of HPs (20 Designers/Specifiers)	-

Changes to Targets

In Ireland the target of 10 DIY stores for a promotional campaign was changed due to a few reasons:

1. Some DIY stores had already completed a promotional campaign of heat pumps;
2. The focus was placed on local authorities in the Irish pilot, and educating the Local authorities staff, contractors and tenants was seen as more impactful than another DIY store campaign.

Local authorities own and manage 140,000 homes in the Republic of Ireland. They are responsible for planning permission of new builds and extensions. The Programme for Government (PfG) commits to retrofitting 500,000 homes to a B2/Cost Optimal Equivalent BER standard by 2030. It is expected that approximately 36,500 of those homes, will be local authority owned homes and a total of 88,400 new build social homes are to be introduced in the period 2022-2030[1].

TUS recognise that Local authorities will play a vital role for the procurement and installation of heat pumps, the quality and competency of installers and designers, as well as increasing awareness of heat pumps

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4 Monitoring Plan

a. Andalusia, Spain

As provided for in the Grant Agreement, the following events have been conducted in Andalusia:

ISVIS Congress (10/11/21)

The I Congress on Innovation and Sustainability in Social Housing (ISViS 2021) was organized by the Housing and Rehabilitation Agency of Andalusia (AVRA) with the following objectives:

- Explore new or alternative design, technology and management ways to improve energy efficiency and sustainability in the publicly promoted housing stock.

- Exchanging experiences, knowledge and good practices amongst administrations, companies and professionals in this field.

- Highlight the leading role of public administrations in this process, as well as in promoting technological innovation, knowledge transfer and awareness raising amongst citizens.

HP4ALL was presented at ISVIS 2021 with a *dedicated session*, stressing the importance of HPs as a key and cost-effective technology in this context, as well as of having an adequate professional reference framework and related information, training and enabling schemes for all the parties involved in the value chain.

A specific, more detailed communication on HP4ALL was also submitted and was included in the Congress Proceedings. Finally, three interviews were held to highlight HP4ALL essentials, two of them orally and one in writing, all of which were uploaded in the Congress website.

Figure 1 HP4ALL representation at ISVIS Congress

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Efficient energy supply in buildings. Needs and opportunities (25/05/22)

This event was specifically organized by CTA with a view to bring together representatives from the whole HP value chain as well as public administrations to be briefed on the technological challenges and opportunities offered by HPs. The event focused on two aspects:

- Technical requirements and objectives to be met by HP installations

- *Best* available technologies and equipment, and how to have a reliable first idea among possible alternatives to demand or install, especially the most innovative and effective.

Figure 2 Panel at Efficient energy supply in buildings. Needs and opportunities

Cleaner heating & cooling technologies in non-residential applications (02/06/22)

CTA, together with the utility IBERDROLA and the Andalusian Association of heating & cooling equipment manufacturers (AFAR) convened this event to highlight the advancement of more energy efficient, decarbonized, solutions for non- residential applications (incl. tertiary), notably heat pumps, including synergies thereof with other alternatives (e.g. biomass) in cases of difficult electrification -including thermally driven heat pumps- , as well as various case studies in industry, tertiary buildings and public services.

Figure 3 HP4AAL at Cleaner heating & cooling technologies in non-residential applications

Rehabiliving Forum (06/10/22)

REHABILIVING is the most important annual forum on energy efficient rehabilitation and installations in Andalusia. It aims to bring together, the most advanced technologies for building heating, cooling, and renovation

REHABILIVING counts on the sponsorship and support of the most important regional sectoral associations and organizations and the Regional Government of Andalusia, including CTA Again, HP4ALL featured high therein within a dedicated session on renewable building heating and cooling.

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II Spanish Heat Pump Forum (20/10/22)

CTA has co-organized with the Andalusian (AFAR) and national (AFEC) heating & cooling equipment manufacturers associations the event II Heat Pump Forum: Opportunity for training and employment. HP4ALL had once more a specific session to highlight its contribution to employment & skills.

Summary data on the attendance to these events and specific sessions can be found in the table hereunder:

Figure 4 HP4ALL representation at Spanish Heat Pump Forum

Table 5 Spanish Pilot Attendance Overview

			Attendees					
Event	Admin.	Manufact.	Designers		Installers		Customers[1]	Total
			Res.	Non-Res.	Res.	Non-Res.		
10/11/21	12	-	23	-	10	-	6	51
25/05/22	7	4	9	8	17	5	2	52
02/06/22	4	5	6	8	14	9	15	61
06/10/22	6	10	10	3	20	4	6	59
20/10/22	10	12	6	2	21	6	8	65
TOTAL	39	31	54	21	82	24	37	288

[1] Promoters, constructors, industry

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b. Republic of Ireland

Heat Pump Register

TUS have been working with Local Authorities and a list of homes with heat pumps that are in planning or currently controlled by the Local authorities is shown below. TUS has also provided heat pump and procurement training to local authority staff and ran promotional events at local authorities. The full description of events is shown in another output of the HP4ALL project D5.2 Regional Development Reports. The full breakdown of the heat pump register is shown below:

Table 6 Irish Pilot Heat Pump Register

County Council Name	*Number of in-house staff to be trained*	*Number of Contractor companies*	*Number of Heat Pump Installations current planned up until end-2023*
Carlow	11	4	355
Kilkenny	12	3	519
Cork	20	-	-
Roscommon	21	-	192
Offaly	-	-	-
Galway	-	10	148
Laois	21	3	35
Tipperary	19	4	63
Clare	16	6	74
SUM	**120**	**30**	**1386**

Attendance Sheets

Local Authority in-person Training

TUS has provided heat pump training and heat pump procurement training with 7 county councils, each of the participants were provided a certificate saying that they had completed the training. The certificate of the training can be found in Appendix B – Local Authority in-person Training.

Figure 5 Local Authority Training

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Installer Capacity Building / Training

TUS organised multiple webinar series that were aimed at various stakeholders. By involving leading experts in heat pumps and construction, the most up to date and relevant information was presented. At each of the events the attendance was taken and also the number of participants that registered for the events. The names and emails were taken and were informed of any new webinars or webinar series TUS were organising. The webinars are also readily available online on YouTube and on the HP4ALL website. The views on the YouTube channel are not part of the monitoring plan.

c. Upper Austria

ESV organised numerous awareness raising and training activities with the aim of increasing knowledge and skills along the HP value chain. In addition to adding HP content to its current information services, ESV developed new events (e.g., in its Energy Academy), cooperated with organisations in the HP sector, and looked for and utilised synergies with already existing events. The initial targets of the pilot activities (5 events and 200 people trained) were significantly surpassed. Over 780 people (mostly professionals along the HP value chain, and end-users in companies) attended the events organised by the ESV, of which 285 people were trained. Additionally, over 10,000 private building owners received information on sustainable heating systems at the ESV's stands at 3 tradeshows.

The full breakdown of events is shown below:

Trainings held:

Table 7 Upper Austria Training provision overview

Description of event	***Attendees***	***Date***
Multi-day training course to become a certified HP planner and installer (together with AIT and Wärmepumpe Austria)	planners, installers, providers of building technology, property developers; 40 participants in total	3 courses: Nov.-Dec. 2020, Nov. 2020 - Jan. 2021, Nov. 2022
Training on larger-scale HPs for professionals: a session organised by ESV in the context of a conference for the DACH region (Germany/Austria/ Switzerland) by Wärmepumpe Austria	manufacturers, planners, public bodies; 150 participants	16 Sept. 2021
Training course on climate-friendly heating systems for residential buildings, with a focus on HPs	planers, installers, property developers, providers of building technologies, architects, energy advisers; 16 participants	11 Nov. 2021

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Training course on HPs for professionals in the construction sector	planers, installers, property developers, providers of building technologies, architects, energy advisers; 28 participants	1 Feb. 2022
Training course on renewable process heat for industry	energy managers in companies, facility managers, energy auditors, planers, installers, suppliers of energy products and services for industry; 19 participants	17 May 2022
Multi-day training of energy advisers (including a heat pump training session)	person interested in becoming energy advisers; 20 participants	June-July 2022
Training course on climate-friendly heating systems for residential buildings, with a focus on HPs	planers, installers, property developers, providers of building technologies, architects, energy advisers; 12 participants	22 Sept. 2022

Awareness raising activities:

Table 8 Upper Austria Awareness Events overview

Description of event	***Attendees***	***Date***
Workshop for companies on process heat and cold including presentations and interactive exchange	companies that already use or are potential users of HPs for process heat and cold; 15 participants	23 March 2021
Innovation forum on renewable heat	All stakeholders along the HP value chain; 178 participants	1 June 2022
Participation in tradeshows: dissemination of material and information, technical presentations	mainly for residential end-users and building owners; very high number of visitors, energy advice sessions carried out, and information brochures distributed: • overall, 10,700 private building owners received information on sustainable heating systems at the ESV stands • over 300 people attended the 8 technical presentations on heating and cooling with HPs, organised by ESV at the tradeshow from 6-10 April 2022	3 tradeshows: 5-7 Nov. 2021, 6-10 April 2022, 4-6 Nov. 2022

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Figure 6 Photos from ESV training and events

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5 Evaluation Plan

Following analysis of the impact of education/training on the abilities of professionals and the impact on energy savings. From Multiple sources and from this projects experience after multiple capacity building / training events, trainees are impacted positively. As training reinforces good behaviours and leads to increased knowledge of the trainee leading to an improved professional and positively affecting the performance of their work thereafter. The key is to have multiple training sessions or events in order to allow for proper transfer of knowledge. From the analysis conducted by the HP4ALL project an estimated increase in heat pump seasonal performance factor (SPF) of 6.88%. can be achieved after training. This figure will be used to evaluate the impact on all heat pumps by the HP4ALL project.

The following table shows the sources used, the efficiency increase associated to that study and the text that confirms the efficiency increase.

Table 9 Overview of sources of information for Performance increase of 6.88%

Source	***Keywords mentioned***	***Efficiency Boost from Training Installers***	***Text confirming increase in savings***
Verallgemeinerte Methoden zur Bewertung von Energieeffizienzmaßnahmen,	Commercial Vehicles training, Fuel Saving training	6.50%	A savings potential is derived from the results after a fuel-saving group training (8 teaching units) of 10% and after a fuel-saving individual coaching (1 teaching unit) of 5% accepted. In the field of commercial vehicles, there is a legal obligation as part of the C95 / D95 training to complete a training course on "economical driving style" for professional drivers in the truck categories and bus. However, there is no requirement here to complete a practical part of the training. A sustainable savings potential of 6.5% is derived from the results after fuel-saving training of energy consumption for commercial vehicles.[2]

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Greener HGV Programme	Commercial Vehicles training, Fuel Saving training, Continuous feedback, telematics and monitoring,	10.00%	This technology coupled with the development of a professional driving culture of HGVs will result in a reduction of the business' carbon footprint. It will bring fuel savings of at least 10% and reduce the annual fuel bill by €000s.[3]
SEAI 'Changing energy behaviour – what works?'	Behavioural Change, Behavioural vs technical savings, Residential, Public buildings, Industry, Transport	5.00%	Providing businesses with eco-driving programmes can reduce fuel use by between 3.5% and 7%. [4]

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Interreg: TRAINING MATERIAL ON ENERGY EFFICIENCY IN PUBLIC BUILDINGS	Public Buildings, Energy consumption reduction, Technical investments vs better organisation	7.50%	Most of public buildings, above all older ones, have a great potential for the efficient use of energy. The reduction of energy consumption by 10% could be achieved without bigger investments, with a more rational use of energy and better organisation. This mostly means the energy needed for space heating, electrical energy, and water. Further 5% of energy consumption could be saved by better organisation of work and better awareness of end-users. According to the estimates appropriate technical investment measures could bring the potential of efficient use of energy up to 30%. [5]
Frontiers Article	Performance Gap, Occupant Behaviour, poor operational performance	10.00%	In their review of the performance gap in non-domestic buildings, Van Dronkelaar et al. offer a very rough quantification of the factors contributing to the performance gap, namely: • specification uncertainty in modelling = 20 to 60%; • occupant behaviour = 10 to 80 percent; • poor operational practices = 15 to 80% [6]
Climacheck	Chillers and Heat pump savings from Refrigerant cycle control improvement	10%-30%	Today there are many manufacturers of high performing chillers and heat pumps. However, there is a huge difference in buying an efficient unit and making it perform at optimal rate all the time. Ensuring that it always runs optimally, will ensure efficient energy usage also known as “energy efficiency”. Based on thousands of optimised system ClimaCheck can conclude that most systems have a saving potential on 10-30%, making it one of the most cost-efficient areas to focus optimisation

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			action on. Considering that many of the optimisation measures are low cost to implement, and the savings are “instant” the ROI is often very short (less than one year is not unusual). [7]
SH2.0	Performance Gap, Occupant Behaviour, poor operational performance	5.18%	After much digging we found a % savings that we can stand over in the DU from SH2.0. Of the 20 Superhomes, minus SH202, SH76 and SH18 the average increase in efficiency from heating season 2017/18 to heating season 2018/2019 was 5.18% The increase in efficiency was small changes to the Heating system such as heating curve adjustment to reduce cycling, and emitter flow rate adjustments, and as a result of Superhomes2.0 a HP checklist based on the outputs of this project was introduced to increase heating curve to reduce cycling (we can say that Superhomes was informed by SH2.0 (Training)). Hot water was not included as we thought it is very house specific and was not tampered with during the project (but can be done).
HP4ALL figure for Heat pump savings based on above sources.		6.88%	

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a. Evaluation Methodologies

Heat Pump register Evaluation

Where possible the number of heat pumps, type of heat pump and size of heat pump will be logged in a heat pump register by partners. In Ireland, from the existing heat pump register a 9kW output heat pump is the most commonly used heat pump in domestic settings, therefore for all domestic heat pumps that are used in the evaluation of this project will be considered to be 9kW. For non-domestic heat pumps, heat pump experts have provided a range of typical unit output being 100 kW – 300 kW depending on the application (process heat, large building heating, etc) so a conservative figure of 150kW will be used (as seen in appendix A under assumptions) for any non-domestic heat pump applications that is being evaluated in this project.

The assumed Seasonal Coefficient of Performance (SCOP) for domestic heat pumps will be 2.8 derived from work previously done by TUS in Superhomes2.0 (SH2.0) and the assumed SCOP or Seasonal Performance Factor (SPF) for Non-domestic heat pumps (based on conversations with experts) was decided to be 2.8.

As stated above a figure of 6.88% boost in efficiency is applied to the electrical input of a heat pump installation, therefore the new SCOP will be 3.00687. The calculations (Equations 1-3) showcase where the figure 3.00687 SCOP is calculated. This figure will be applied to the annual heat output to calculate the renewable energy production claimed by this project (Equation 4).

$$\frac{9\ kW\ output}{2.8\ scop} = 3.214\ kW\ input$$

Equation 1 Business as Usual (BAU) Electrical Input

$$3.214\ kW\ \times (100\% - 6.88\%) = 2.99\ kW\ input$$

Equation 2 Savings applied to BAU Electrical Input

$$\frac{9\ kW\ output}{2.99\ kW\ input} = 3.00687\ SCOP$$

Equation 3 New SCOP

$$\left[Annual\ Heat\ Output\ (AHO) - \left(\frac{AHO}{New\ SCOP}\right)\right] - \left[AHO - \left(\frac{AHO}{BAU\ SCOP}\right)\right] = RES\ Production$$

Equation 4 RES Production Calculation

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Domestic Heat pump installation Example:

- 9kW output / 2.8 COP = 3.21 kW Electrical Input
- 3.21 kW Electrical Input x 6.88% = 0.2211 kW saved
- 1568 Equivalent Full Load Hours for residential systems, the figure 1,568 is derived from SH2.0, average full load equivalent hours for 5 systems.
- Savings per Domestic heat pump installation: 0.2211 x 1568 = 346.68 kWh / year
- We consider that 50% of the energy savings can be reclaimed due to the actions of the HP4ALL project.

Non-Domestic Heat pump installation savings Example:

- 150kW / 2.8 COP = 53.57 kW Electrical Input
- 53.57kW x 6.88% = 3.68 kW Electrical Input
- 2667 Equivalent Full Load Hours for Non-Domestic systems (based on conversations with experts)
- Savings per Non-Domestic heat pump installation: 3.68kW x 2667 = 9,830 kWh / year
- We consider that 50% of the energy savings can be reclaimed due to the actions of the HP4ALL project.

Attendance Sheet Evaluation

As stated in the grant agreement, an assumed 60% of participant of capacity building/training events will be impacted by the capacity building/training. Each impacted installer that works primarily in the domestic market is assumed to be responsible for 20 heat pump installations for the duration of the project (this figure was further backed up from information gathered throughout the project) whether it be through maintenance and servicing or for installation and commissioning of heat pumps as per the grant agreement and non-domestic installers are expected to carry out the same functions for 2 heat pump systems. For Specifiers/Designers that primarily work in the domestic heat pump installations are assumed to be responsible for 10 heat pump installations for the duration of the project again whether it be through maintenance and servicing or for installation and commissioning of the heat pump system, and for non-residential heat pump system specifiers/designers they are expected to carry the same function in the same time period to 1 installation. The assumptions used in the heat pump register evaluation section will be applied to each of the effected heat pumps.

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6 Preliminary Evaluation of Project

This section is the first step to evaluating the impact of the project and will take into consideration any activities and training that has taken place up until December 31st, 2022. Further events and training are planned in 2023 that will not be included in this preliminary evaluation.

a. Andalusia, Spain

Using the methodology stated in section 6.a the following is the calculated impact of the Andalusian pilot region:

Table 10 Spanish Pilot Impact Analysis

Descriptor	Residential	Non-Residential	Residential	Non-Residential
Professional type	Installers		Specifiers /Designers	
Number of Professionals Engaged	82	24	54	21
% Impacted by HP4ALL	60%	60%	60%	60%
Number of Heat pumps per professional	20	2	10	1
Equivalent Full Load Hours	1568	2667	1568	2667
Annual Heat Output	13.89 GWh	11.52 GWh	4.57 GWh	5.04 GWh
Electrical Input (2.8 SPF)	4.96 GWh	4.11 GWh	1.63 GWh	1.80 GWh
Final Energy Savings per year (6.88%)	0.34 GWh	0.28 GWh	0.11 GWh	0.12 GWh
50% of Final Energy Savings reclaimed due to the actions of the HP4ALL project.	0.17 GWh	0.14 GWh	0.06 GWh	0.06 GWh
Pilot Final Energy Savings	**0.43 GWh / year**			
Pilot Primary Energy Savings (TPER Factor 2.12)	**0.91 GWh / year**			
Pilot Carbon Emissions Savings (Carbon Intensity of 0.29 t/MWh)	**264 tCO_2**			
RES Production	**0.86 GWh / year**			

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b. Ireland

For the Irish pilot, a heat pump register and attendance to training were both being monitored for evaluation. The heat pump register is a list of heat pumps that are installed or planned to be installed up until end of 2023 by the Local Authorities that TUS have provided training to the housing departments of the listed local authorities below and provided learning materials for their staff, their installers, and their tenants. The register is shown in section 5.b. Taking the total number of planned and installed local authorities heat pumps the following analysis showcases the energy savings that the HP4ALL project will reclaim.

Table 11 Irish Pilot Heat Pump register Impact Analysis

Description	**Figure**
Number of Local Authority Heat Pumps	1386
Equivalent Full Load Hours	1568
Average Heat Pump Output	9 kW
Annual Heat Output	19.56 GWh
Annual Electrical Input (SCOP 2.8)	6.99 GWh
Annual Final Energy Savings (6.88%)	0.48 GWh
Final Energy Savings reclaimed due to the actions of the HP4ALL project. (50%)	**0.24 GWh / year**
Primary Energy Savings (TPER Factor 1.952 as of Dec-22)[8]	**0.47 GWh / year**
Carbon Emissions Savings (Carbon Intensity of 0.35 t/MWh, Dec-22)	**164 tCO_2 /year**
RES Production	**0.48 GWh / year**

A 14 half hour sessions/webinars were conducted to help raise the base level of knowledge of understanding of installers and professionals working with heat pumps in Ireland. The 7 hours training was presented by various experts in the field of retrofit, building physics, and heat pumps to give the trainees the most up to date and relevant information available. Those who registered for the training, received the slides, contacts and link to recordings of the training that is openly available on YouTube. There were 282 registrations for the training who were all working in the domestic heat pump market and can be further categorised as:

Table 12 Irish Pilot Overview of Domestic Application Training attendees

Student	***Educator***	***Installer***	***Designer***	***Local Authority Staff***
6	13	154	75	34

TUS ran non-domestic heat pump-oriented events presented by leading experts in hydronic systems, multifunctional heat pumps, district heating and large-scale heat pump application

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that gathered 66 attendees, these events are planned to continue after the life of the project. The Attendees of the event can be categorised by the following:

Table 13 Irish Pilot Overview of Non-domestic Application training attendees

Educator	*Installer*	*Designer*	*Local Authority Staff*
3	35	20	8

Using the methodology described in section 6.a the following calculation can be made to calculate the potential energy savings of the HP4ALL training:

Table 14 Irish Pilot Training impact analysis

Descriptor	*Residential*	*Non-Residential*	*Residential*	*Non-Residential*
Professional type	Installers		Specifiers /Designers	
Installers	154	35	75	20
% Impacted by HP4ALL	60%	60%	60%	60%
Number of Heat pumps per professional	20	2	10	1
Equivalent Full Load Hours	1568	2667	1568	2667
Assumed Heat Pump Output	9 kW	150 kW	9 kW	150 kW
Annual Heat Output	26.1 GWh	16.8 GWh	6.4 GWh	4.8 GWh
Electrical Input (2.8 SPF)	9.3 GWh	6.0 GWh	2.3 GWh	1.7 GWh
Estimated Electrical Savings (6.88%) per heat pump	0.64 GWh	0.41 GWh	0.16 GWh	0.12 GWh
50% of Final Energy Savings reclaimed due to the actions of the HP4ALL project.	0.32 GWh	0.21 GWh	0.08 GWh	0.06 GWh
Final Energy Savings	**0.66 GWh / year**			
Primary Energy Savings (TPER Factor 1.952)	**1.30 GWh / year**			
Carbon Emissions Savings (Carbon Intensity of 0.35 t/MWh)	**454 tCO_2 / year**			
RES Production	**1.33 GWh / year**			

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The total savings from the Irish pilot are shown below:

Table 15 Irish Pilot overview of Impact analysis

Final Energy Savings	**0.90 GWh / year**
Primary Energy Savings (TPER Factor 1.952)	**1.76 GWh / year**
Carbon Emissions Savings (Carbon Intensity of 0.35 t/MWh)	**617.70 TCO_2 / year**
RES Production	**1.81 GWh /year**

c. Upper Austria

In Upper Austria, the specification, design, and installation of HP systems are typically carried out by the same professional. Therefore, the distinction between "installer" and "specifier/designer" (as explained in the appendix) does not apply.

For the Upper Austrian pilot, the number of designers/installers who took part in trainings was monitored through registration and attendance keeping. The overview of the Upper Austrian pilot impact is detailed below.

Table 16 Upper Austria pilot Impact analysis

Descriptor	***Residential***	***Non-Residential***
Designer/Installers trained	116	19
% Impacted by HP4ALL	60%	60%
Number of Heat pumps per professional	20	2
Number of heat pumps affected by the training	1392	23
Equivalent Full Load Hours	1568 hours	2667 hours
Assumed Average Heat Pump Output	9 kW	150 kW
Annual Heat Output	19.64 GWh	9.20 GWh
Annual Electrical Input (2.8 SPF)	7.02 GWh	3.29 GWh
Estimated Electrical Savings (6.88%)	0.48 GWh	0.23 GWh

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50% of Final Energy Savings reclaimed due to the actions of the HP4ALL project.	0.24 GWh	0.11 GWh
Final Energy Savings	**0.35 GWh / year**	
Primary Energy Savings (Primary Energy Factor of 2.12)[9]	**0.75 GWh / year**	
Carbon Emissions Savings (Carbon Intensity of 170 t/GWh)[10]	**128 tCO_2 / year**	
RES Production	**0.70 GWh / year**	

d. Project Impact Summary

Below is a summary of the impact that is to be claimed by the HP4ALL project.

Table 17 Overview of Project Impact analysis

Pilot Region	***Andalucia, Spain***	***Ireland***	***Upper Austria***	***TOTAL***
Persons receiving Training	288	348	135	771
Annual Final Energy Savings	0.25 GWh	0.90 GWh	0.35 GWh	1.5 GWh
Annual Primary Energy Savings	0.53 GWh	1.76 GWh	0.75 GWh	3.04 GWh
Annual Carbon Emissions Saved	265 tCO_2	454 tCO_2	128 tCO_2	847 tCO_2
RES Production	0.86 GWh	1.33 GWh	0.70 GWh	2.89 GWh

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8 Appendices

a. Appendix A – Grant Agreement Energy Targets

Assumptions and References

Capacity Building Target Groups

- For the Impact Calculations Capacity Building activities will be focused on two main target groups. Firstly, those involved in the design, installation, and commissioning of systems for both residential and non-residential sectors. Secondly, for those involved in the specification or procurement of HP system (again for residential and non-residential systems).
- In Austria, capacity building activities will target to engage with 100 individuals for residential HP systems and 10 individuals for non-residential systems. These numbers will increase to 150 and 15 in Ireland and Spain due to the perceived bigger needs in those countries. It is anticipated that the success rate will be 60%, i.e., 60% of those involved will receive new knowledge and will put it into practice.
- In all countries, it is assumed that those receiving capacity building will implement 20 residential installations of 9kW average thermal output and the non-residential ones will implement 2 systems of 150kW average thermal output.
- A similar approach is taken for Specifier/Designers with reduced number of projects per individual. However, a 100% relevance is applied as the project members will seek out professionals who are actively involved in actual projects.

Energy and CO_2 Calculations

- Equivalent Full Loan Hours (EFLH) is a measure of the total thermal output delivered to the building divided by the number of hours of operation. For residential systems, the figure 1,568 is derived from SH2.0, average full load equivalent hours for 5 systems. For non-residential systems, the figure 2,667 was provided by a study carried out by Pennsylvania Public Utility Commission August 2019, average for Lodging type buildings for 9 cities in that state in the USA.
- Business as usual (BAU) COP of 2.8 is the o/a average SPF for 2018/2019 from SH2.0
- SH2.0 found that the average increase in COP arising from improvements to commissioning settings was 6.7%. This % applied as an Energy Performance Gap (EPG) to the BAU COP sees HP4ALL predicting a COP of 3.0 arising from the increased skills of trainees.
- HP4All assumes that 50% of the EPG will be reclaimed due to the actions of the project.
- PEF for Austria and Spain is taken from a report by Esser, A & Sensuss, F (2016), Evaluation of Primary Energy Factor Calculation options for electricity, Fraunhofer ISI, Karlsruhe, Germany.
- PEF for Ireland is taken from the 2017 SEAI publication https://www.seai.ie/data-and-insights/seai-statistics/conversion-factors/

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- Austrian CO_2 emission intensity factor is taken from Joint Research Centre of the European Commission, (2017) CoM Default
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- Irish CO_2 emission intensity factor is taken from the 2017 SEAI publication https://www.seai.ie/data-and-insights/seaistatistics/conversion-factors/
- Spanish CO_2 emission intensity factor is taken from a report by RED Electricia de Espana, (2018) The Spanish Electrical System 2017, RED Madrid Spain
- Delivered energy savings are the savings realised if the EPG is reduced by 50%.

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Calculations

Target Group	Country	Building Type	# People Engaged	Impact	Projects /Person	Project capacity	Total Installed Capacity	EFLH	Annual heat o/p	SPF BAU	Predicted SPF HP4All	HP4All reduction of SPF EPG	PEF	Delivered Energy Saved	Primary Energy Saved	Add RES prod	CO2 Saved
			#	%		kW	MW	hours	GWh	COP	COP	%	PEF	GWh/y	GWh/yr	GWh/yr	tonnes
Installer	AT	Res	100	60%	20	9	10.8	1568	16.9	2.8	3.0	50%	2.12	0.20	0.43	0.40	72.7
		Non Res	10	60%	2	150	1.8	2667	4.8	2.8	3.0	50%	2.12	0.06	0.12	0.11	20.6
	IRL	Res	150	60%	20	9	16.2	1568	25.4	2.8	3.0	50%	1.96	0.30	0.59	0.60	259.0
		Non Res	15	60%	2	150	2.7	2667	7.2	2.8	3.0	50%	1.96	0.09	0.17	0.17	73.4
	ES	Res	75	60%	20	9	8.1	1568	12.7	2.8	3.0	50%	2.12	0.15	0.32	0.30	93.0
		Non Res	10	60%	2	150	1.8	2667	4.8	2.8	3.0	50%	2.12	0.06	0.12	0.11	35.1
Sub Total			**360**				**50.4**		**87**					**0.85**	**1.75**	**1.71**	**554**
Specifier/Designer	AT	Res	10	100%	10	9	0.9	1568	1.4	2.8	3.0	50%	2.12	0.02	0.04	0.03	6.05
		Non Res	5	100%	1	150	0.75	2667	2.0	2.8	3.0	50%	2.12	0.02	0.05	0.05	8.58
	IRL	Res	10	100%	10	9	0.9	1568	1.4	2.8	3.0	50%	1.96	0.02	0.03	0.03	14.39
		Non Res	5	100%	1	150	0.75	2667	2.0	2.8	3.0	50%	1.96	0.02	0.05	0.05	20.40
	ES	Res	10	100%	10	9	0.9	1568	1.4	2.8	3.0	50%	2.12	0.02	0.04	0.03	10.33
		Non Res	5	100%	1	150	0.75	2667	2.0	2.8	3.0	50%	2.12	0.02	0.05	0.05	14.64
Sub Total			**45**				**4.95**		**10**					**0.12**	**0.25**	**0.24**	**74**
Total			**405**				**55.95**		**97**					**0.97**	**2.00**	**1.95**	**628**

Table 6: Detailed calculations of HP4All Impact

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b. Appendix B – Local Authority In-person training

Certificate

Certificate

This is to certify that:

Joe Bloggs

of Roscommon County Council

Successfully completed the 4-hour training session:

Heat Pump Specifier/Designer

As part of the HP4ALL project.

Date: 28/06/2021

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