TECHNOLOGICAL UNIVERSITY OF THE SHANNON: MIDWEST (TUS)

With over 14,000 students on six campuses in Ireland’s Midwest and Midlands

We offer undergraduate, postgraduate, vocational, and professional training from Level 6 undergraduate courses right up to Level 10 PhDs.

THE DU TEAM

The Development Unit

Dedicated to implementing our vision of supporting individuals, companies and industries to achieve social, economic and environmental changes through applying its expertise in a collaborative manner.

We pride ourselves on working with people to solve real problems and challenges.

TUS

HP4ALL

Increasing Heat pump Skills
Increasing Demand for those skills

ABOUT THE PROJECT

HP4ALL will enhance, develop and promote the skills required for high quality, optimised Heat Pump installations within residential/non-residential buildings bringing Europe to the forefront of the climatization sector.

IMPACTS

Primary energy savings
2 GWh/year

Renewables production
1.95 GWh/year

Reduction of
628 tCO2 /year

400
People trained

Heat pump benchmarking tool

1
Heat pump knowledge hub

Horizon 2020
European Union Funding
for Research & Innovation

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 891775

OBJECTIVES

Design Heat Pumps competency & excellence skills framework

Increase the number of skilled workers

Enable end users/clients to demand high quality solutions

Replicate the project at national and EU-level

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Pilot Activities:

HP4ALL

Event Name	Descriptions	Target
Homeowner events	To increase the knowledge of people who live with Heat pumps.	100
Installer Events	To increase the knowledge of those installing Heat Pumps in residential and non-residential settings.	150 RESI, 15 Non-RESI
Specifier/Designer Events	Boosting the knowledge of those who are precuring heat pumps and designing heat pump installations	10 RESI, 5 Non-RESI

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Homeowner Events:

Estate Events / Heat Pump Roadshow will include:

1. Heat Pumps: Basics
2. Heat Pumps: The Irish Context
3. Heat Pumps: Components
4. Heat pump ready home
5. HP performance Monitoring
6. Manufacturer guest speaker

A unit from Manufacturers will be available to show homeowners how to control their unit.

There is huge interest in this venture by County Councils

Source: Gannon Homes

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Installer Events:

Contractors events will consist of learning units created in collaboration with Superhomes2030, Grant, Unitherm, RVR.

1. Heat pump ready home
2. Flow rates, pipe sizing and dTs of Heat Pumps
3. Emitter systems
4. System Balancing
5. Optimisation
6. SEAI Grant Inspection points
7. Heat Loss Calculations

This training will consist of 10 minute toolbox talks live online, at lunchtime held via zoom as to access the poll functionality.

To avoid crossing the work/learn dichotomy line!

Source: Irish Times

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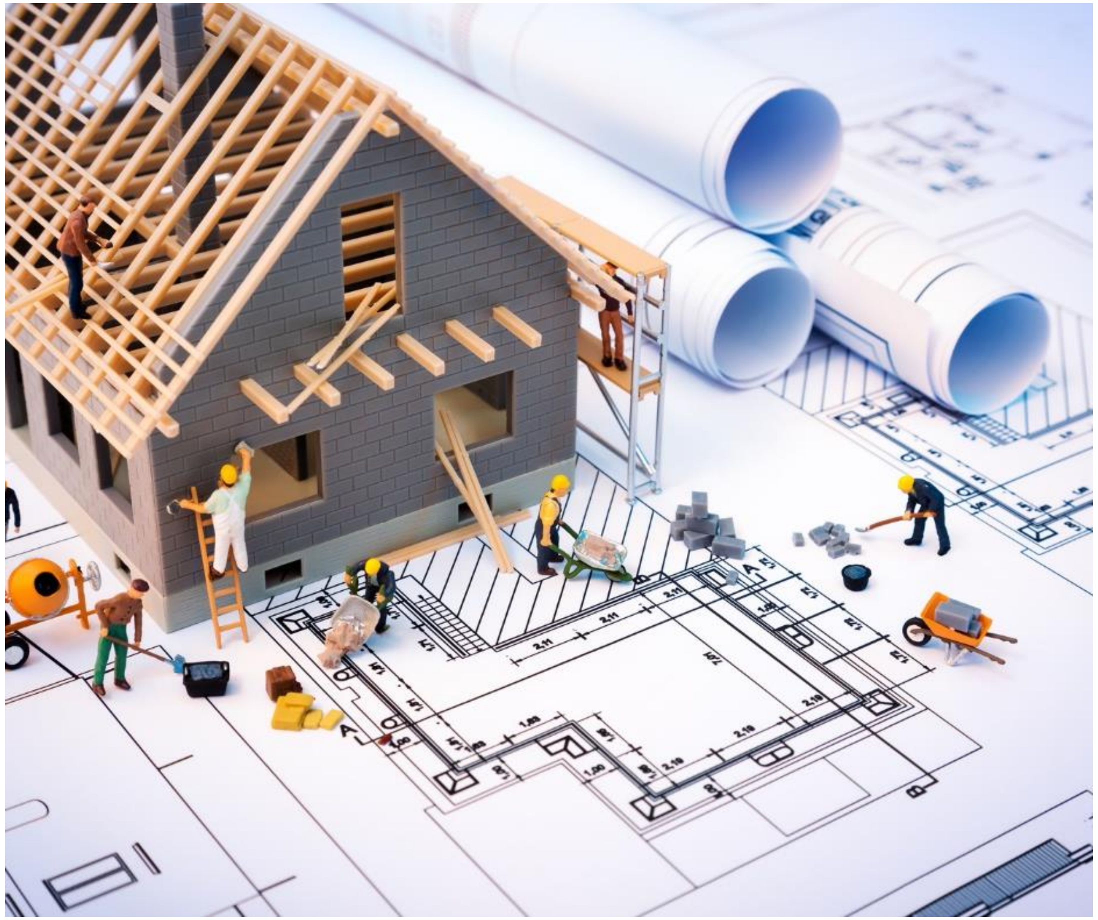
Specifier/Designer Events:

Specifier/Designer events will consist of CoCo in-house engineers and procurement officers, learning units will consist of all units:

1. Heat Pumps: Basics
2. Heat Pumps: The Irish Context
3. Heat Pumps: Components
4. Refrigerant
5. Heat pump ready home
6. HP performance Monitoring
7. Flow rates, pipe sizing and dTs of Heat Pumps
8. Emitter systems
9. System Balancing
10. Optimisation
11. SEAI Grant Inspection points
12. Heat Loss Calculations
13. Manufacturer guest speaker

Aim to upskill the entire heat pump value chain!



Source: Reliant Construction

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PARTNERS

ehpa european heat pump association

CTA

LIT ACTIVE LEADERSHIP IN EDUCATION, ENTERPRISE AND ENGAGEMENT

iERC International Energy Research Centre

RINA

OÖENERGIESPARVERBAND

Sustainable INNOVATIONS®

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HP4ALL

hp4all

heatpumps4all

www.hp4all.eu

LU1 Heat Pumps: The Irish Context

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Join at slido.com
#711043

ⓘ Start presenting to display the joining instructions on this slide.

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NATIONAL CLIMATE LAW

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Climate Action Plan (IE) 2019

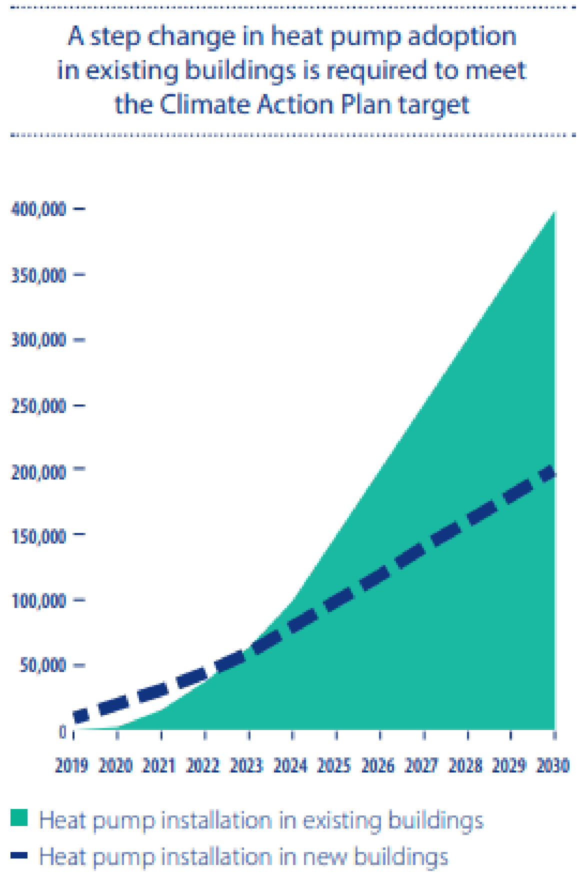
- The Irish Government have plans for a huge increase in Heat Pumps installations! 600,000 to be installed by 2030! of which 400,000 will be in existing buildings.

- Government's Housing for All policy, which commits to the retrofitting of 36,500 local authority houses by 2030."

- 55,870 heat pumps installed as of 2020 (Statista.com)

- There are some risks that come to mind… surrounding the installation of this many units which includes quality of installation, and performance…

- In **Action 66 of the climate action plan** that specifically mentions upskilling approx. 300-500 heat pump installers. This is important as installers are a factor that can affects Heat Pumps performance.



Source SEAI

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Could you describe these targets using one word?

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Climate Action Plan 2019 Action 66

Action 66: Roadmap to develop supply chain to support the phase out of fossil fuel boilers in new dwellings			
Steps Necessary for Delivery	**Timeline by Quarter**	**Lead**	**Other Key Stakeholders**
Introduce NZEB Dwellings in Building Regulations to facilitate phasing out the installation of oil boilers in new dwellings where practical	Q2 2019	DHPLG	
Develop National Standards for the design and installation of Heat Pumps in New Dwellings	Q1 2021	NSAI	DBEI, DCCAE, SEAI, DHPLG
Coordinate the Development of Training specification for the design and installation of heat pumps	Q4 2021	DCCAE	DES, SOLAS, ETBs, SEAI, DHPLG
Put in place a registration scheme for competent heat pump installers	Q4 2021	DCCAE	SEAI
Complete 2023 Cost Optimal study to identify cost optimal performance for NZEB Dwellings to take account of developments in supply chain	Q1 2023	DHPLG	SEAI
Coordinate the roll out of a training programme to up skill approximately 300-500 heat pump installers	Q4 2023	DCCAE	DES, SOLAS, ETBs, DHPLG
Subject to completion of the above actions and results of 2023 cost optimal study, advance the building regulations requirements for new dwellings to a performance requirement based on the use of heat pumps	Q4 2025	DHPLG	

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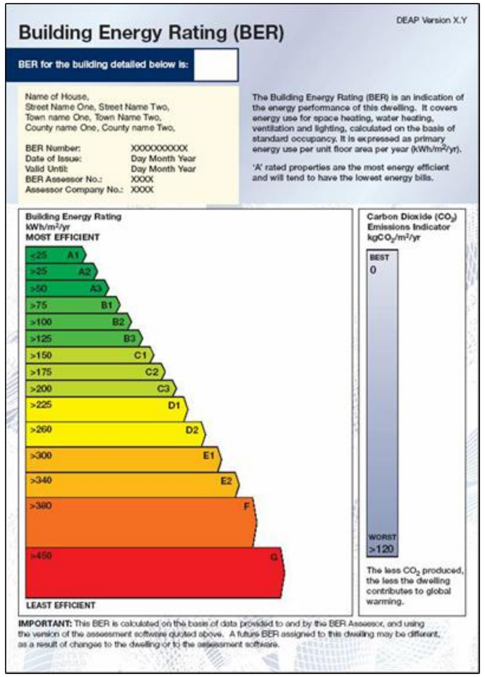
Building Energy Rating

A Building Energy Rating (BER) certificate rates your home's energy performance on a scale between A1 (<25 W/m^2/ year) and G (>450 W/m^2/ year).

A-rated homes are the most energy efficient while G-rated are the least energy efficient.



Building Energy Rating (BER)

DEAP Version X.Y

BER for the building detailed below is:

Name of House,
Street Name One, Street Name Two,
Town name One, Town Name Two,
County name One, County name Two,

BER Number: XXXXXXXXXX
Date of Issue: Day Month Year
Valid Until: Day Month Year
BER Assessor No.: XXXX
Assessor Company No.: XXXX

The Building Energy Rating (BER) is an indication of the energy performance of this dwelling. It covers energy use for space heating, water heating, ventilation and lighting, calculated on the basis of standard occupancy. It is expressed as primary energy use per unit floor area per year (kWh/m^2/yr).

'A' rated properties are the most energy efficient and will tend to have the lowest energy bills.

Building Energy Rating
kWh/m^2/yr
MOST EFFICIENT

<25 A1
>25 A2
>50 A3
>75 B1
>100 B2
>125 B3
>150 C1
>175 C2
>200 C3
>225 D1
>260 D2
>300 E1
>340 E2
>380 F
>450 G

LEAST EFFICIENT

Carbon Dioxide (CO_2) Emissions Indicator
kgCO_2/m^2/yr

BEST
0

WORST
>120

The less CO_2 produced, the less the dwelling contributes to global warming.

IMPORTANT: This BER is calculated on the basis of data provided to and by the BER Assessor, and using the version of the assessment software quoted above. A future BER assigned to this dwelling may be different, as a result of changes to the dwelling or to the assessment software.

Passive haus	2-10 W/m²
Eco/low carbon homes	10-20 W/m²
Recent new build (post 2006)	20-40 W/m²
Pre 2006 new build or recent renovation	30-50 W/m²
Renovated properties with cavity wall insulation and over 75mm loft insulation	40-65 W/m²
Victorian houses, perhaps a mix of single/double glazing with 55-75mm loft insulation	65-85 W/m²
Victorian or older, single glazed, no loft insulation	95-110 W/m²
If the property is going to be on/off	Add 10%
If intermittently heated, i.e. a holiday home	Add 20%

https://www.seai.ie/home-energy/building-energy-rating-ber/

Source: Heat Geek.com

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What BER is your house/apartment?

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TGD Part L

HPALL

Title: Conservation of Fuel and Energy – Dwellings

Sets out of minimum energy performance requirements for buildings and application of these requirements to new buildings to achieve Nearly Zero Energy Buildings

L1 A building shall be designed and constructed so as to ensure that the energy performance of the building is such as to limit the amount of energy required for the operation of the building and the amount of carbon dioxide (CO_2) emissions associated with this energy use insofar as is reasonably practicable.

L2 For existing dwellings, the requirements of L1 shall be met by:

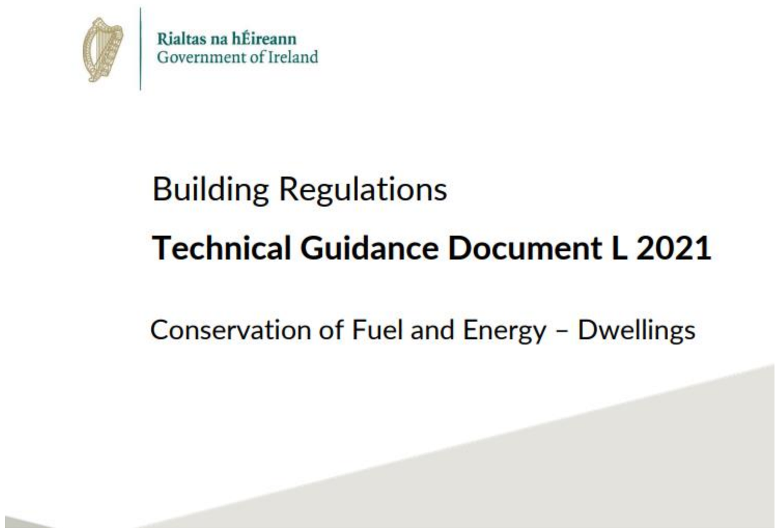
(a) limiting heat loss and, where appropriate, availing of heat gain through the fabric of the building;

(b) controlling, as appropriate, the output of the space heating and hot water systems;

(c) limiting the heat loss from pipes, ducts and vessels used for the transport or storage of heated water or air;

(d) providing that all oil and gas fired boilers installed as replacements in existing dwellings shall meet a minimum seasonal efficiency of 90 % where practicable.

L6 Energy performance of buildings requirements as set out in the European Union (Energy Performance of Buildings) Regulations 2019.



Rialtas na hÉireann
Government of Ireland

Building Regulations

Technical Guidance Document L 2021

Conservation of Fuel and Energy – Dwellings

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Nearly Zero Energy Building - Summary

Nearly Zero Energy Building has a very high energy performance

Or

A building that uses very low amounts of energy

Or

A building which produces more or less the same amount of energy per year as it uses.

Or

The building can generate this renewable energy on site or feed back to the electricity grid

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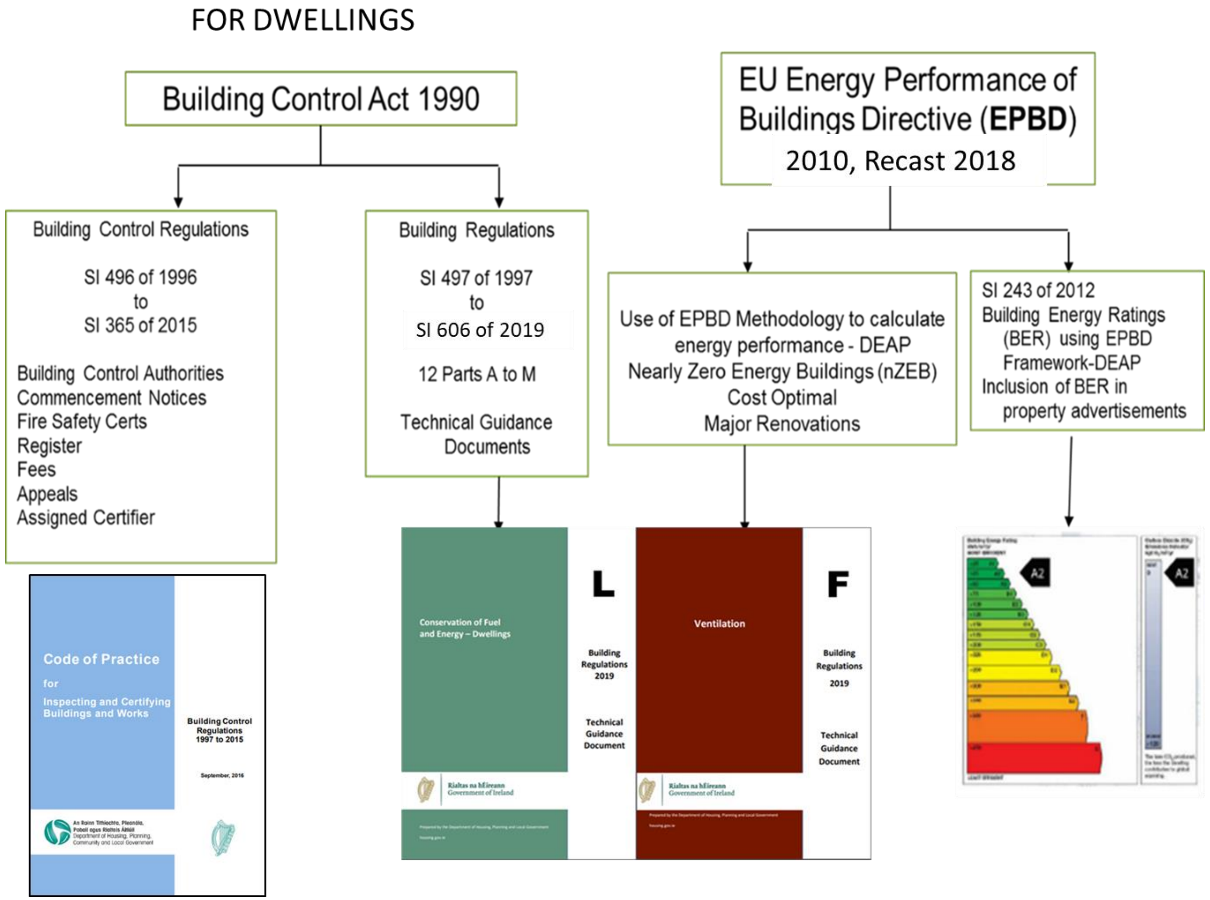
Nearly Zero Energy Building - Ireland

- **NZEB is Mandatory**

- NZEB and TGD L Dwellings 2019 to apply to all **new Dwellings** from 1st November 2019 subject to transition.

- Also applies to **Dwellings with deep renovation** (major renovation) means the renovation of a building where more than 25 % of the surface of the building envelope undergoes renovation.



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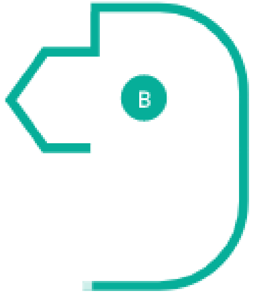
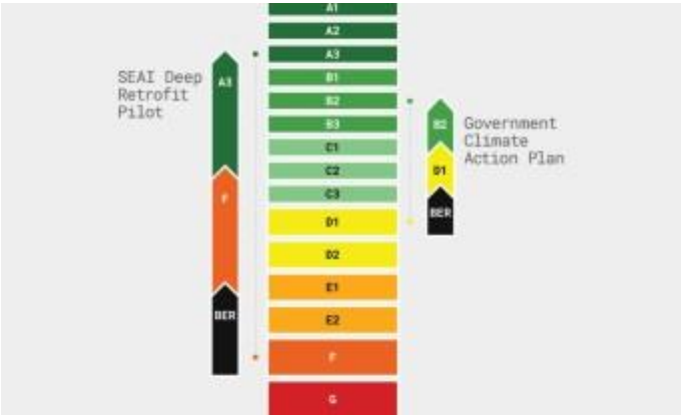
Public Sector Buildings targets

In addition, the Climate Action Plan requires a new Public Sector Decarbonisation Strategy to be put in place 'to deliver 30% CO_2 emissions reduction by 2030 and to develop a roadmap to carbon neutrality by 2050.'



Under 'Project Ireland 2040', Ireland has committed to an energy performance improvement programme to upgrade all public buildings to BER 'B' level

National initiatives include developing a detailed roadmap for the deep retrofitting of school buildings to bring them to a minimum standard of Building Energy Rating (BER) B2



Large Scale heat pumps can be an option for Public Body buildings reaching a B level or higher.

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Non-Domestic Heat pump Installations

Heat pumps are considered large if they exceed capacities of 100 kW.

They can easily reach the one to several megawatt range with the largest units providing 35 MW in a single machine.

Currently available heat pump technology can provide heat up to 100°C with a spread between source and sink temperature of approx. 50K per stage

HP4ALL are looking for Non-Domestic Case studies to write about!

More information available at:

https://www.seai.ie/publications/Heat-Pump-Technology-Guide.pdf

https://www.ehpa.org/fileadmin/red/03._Media/03.02_Studies_and_reports/Large_heat_pumps_in_Europe_MDN_II_final4_small.pdf

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If you have a Non-domestic heat pump project in mind, please let us know. Even if only in planning stage. (The answers will not be shown on screen).

ⓘ Start presenting to display the poll results on this slide.

SEAI Obligations and Targets

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EXEMPLAR ENERGY MANAGEMENT ROADMAP

seai

	MICRO BUSINESS Energy Cost < €25k	SCHOOLS	ORGANISATIONS with Energy Cost < €250k	ORGANISATIONS with Energy Cost €250k - €5M	ORGANISATIONS with Energy Cost > €5M
ASSESS USING	SEAI Home energy assessment or small business tool	Energy in Education EM assessment	Energy MAP basic diagnostic	Energy MAP advanced diagnostic	ISO 50001
HOW TO ASSESS	Self assess*	Self assess*	Self assess*	Independent assesment*‡	3rd party certification
HOW OFTEN	Annually	Annually	Annually	1 - 1.5 years	Annually
SEAI SUPPORT	Home EM guide, Small business training & pack	EinE training & programme	Energy MAP training/partnership	Energy MAP training/partnership	Tailored support programme

* Annual DEC can also be used for assessment. If the organisation has just one building/campus location then a DEC could be used as a self-assessment tool; but a DEC from one building only cannot be used if the organisation has more than one building.
Under SI 426 of 2014, as well as to be exemplar in energy management, all public bodies must report annually to SEAI, and must consider energy efficiency as part of purchasing criteria, amongst other requirements. More information at Obligations and Targets.
‡ The Energy MAP Advanced Diagnostic should be carried out by a Registered Energy Auditor.

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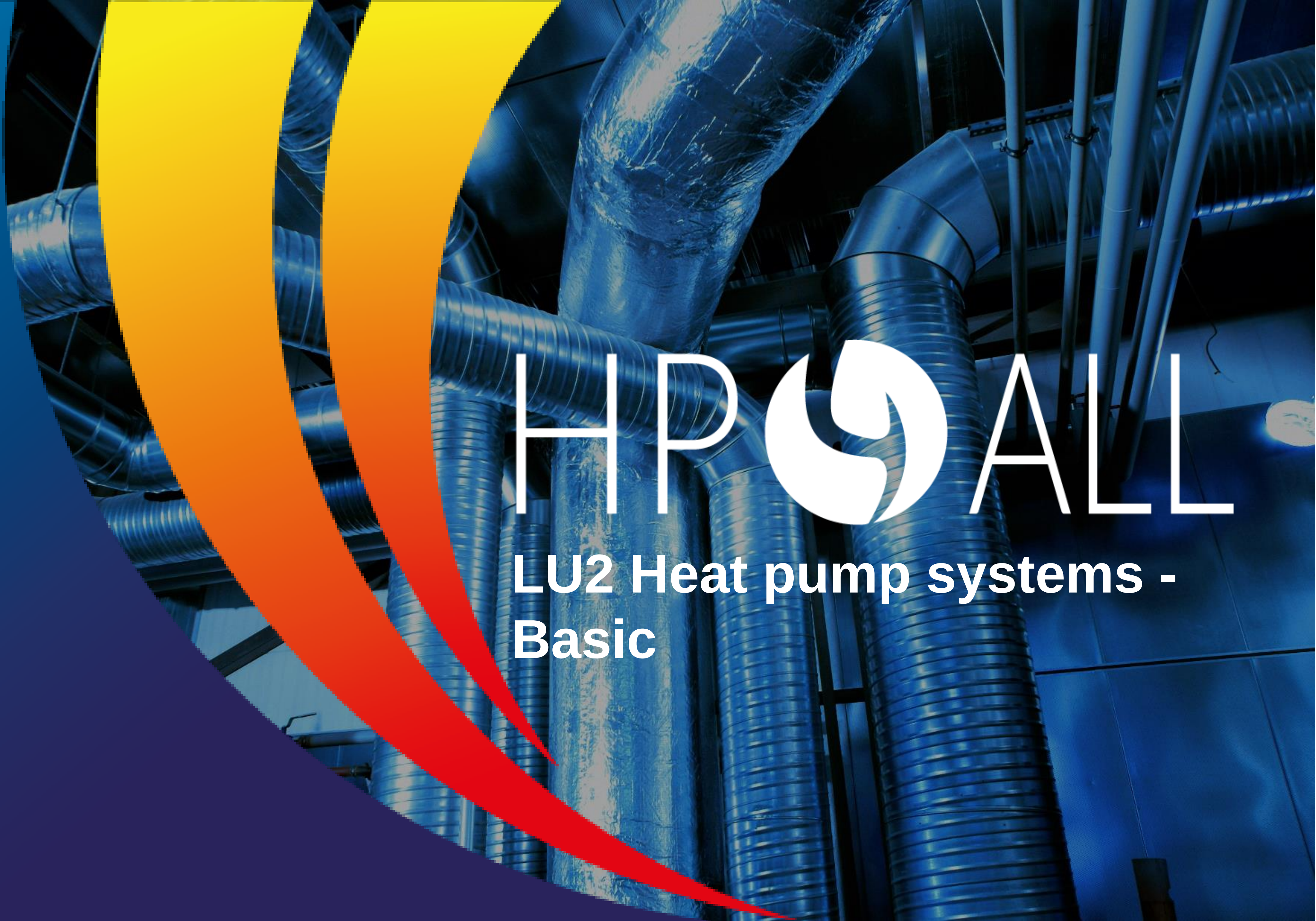


LU2 Heat pump systems - Basic

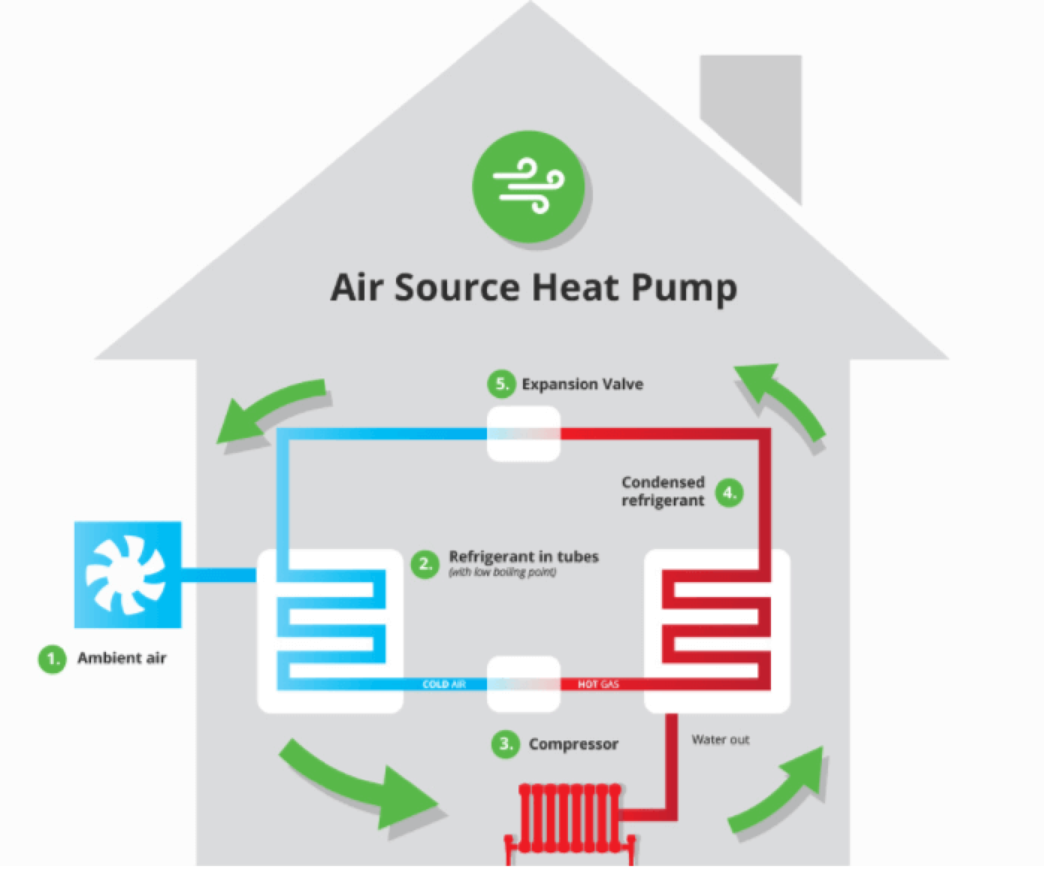
What is a HP?

Heat pumps are similar to refrigerators and air-conditioning systems

They use a refrigerant cycle to extract very low grade heat (usually under 25 °C) and upgrade it to a higher Temperature. A heat pump gets 75% of its energy from Air.

A Heat Pump refrigerant Cycle consists of:

1. **Evaporating phase:**
    a) heat energy is taken from the ambient air by the outdoor unit via Heat Exchanger
    b) and compressed using a compressor converting the refrigerant into a gas.
2. **Condensing phase:**
    a) The heat is then extracted from the gas in the indoor unit for use via Heat Exchanger.
    b) This liquifies the gas so an expansion valve is used to remove pressure.



Source: Remodelling Calculator

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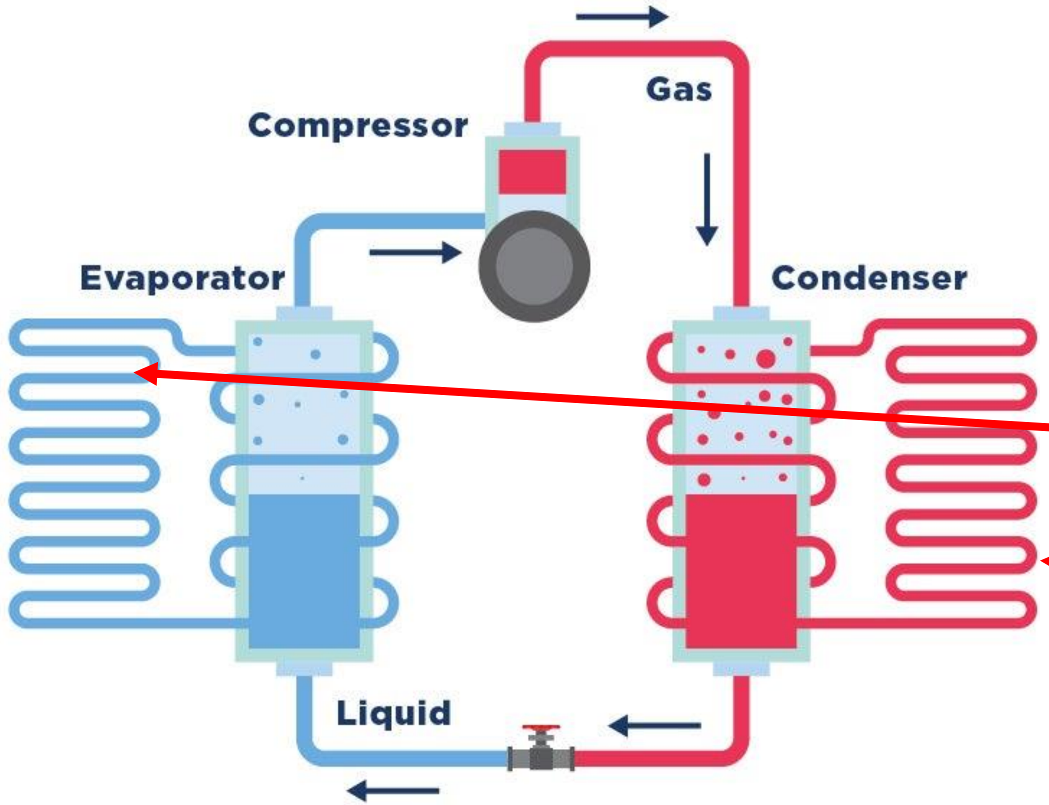
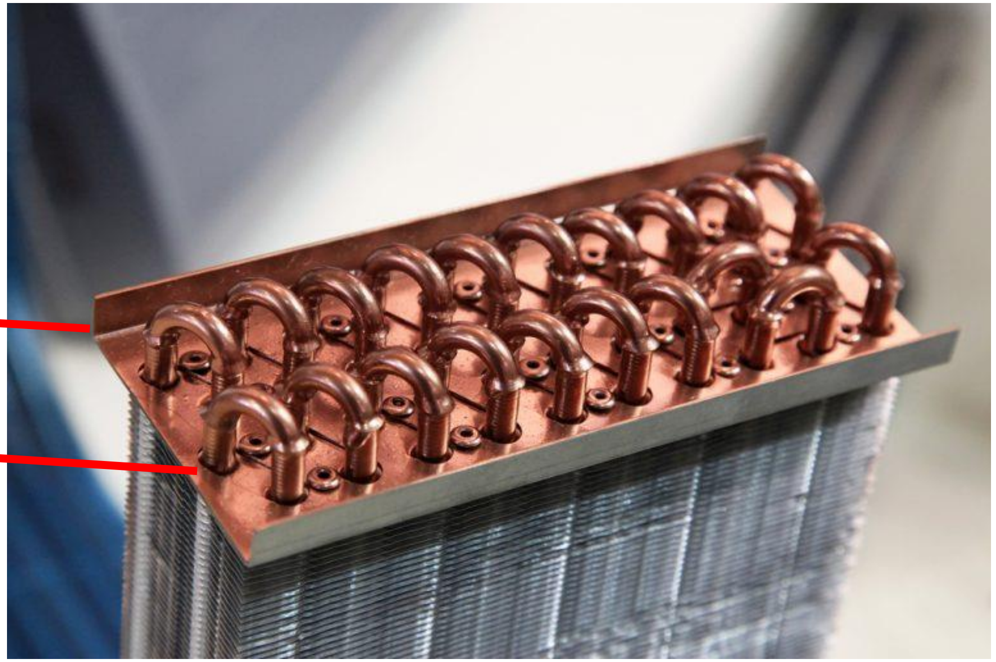
What is a Heat Exchanger?

In a heat pump it is a coil of tubing filled with refrigerant.



Source: Bord Gais



Source: Long Refrigeration

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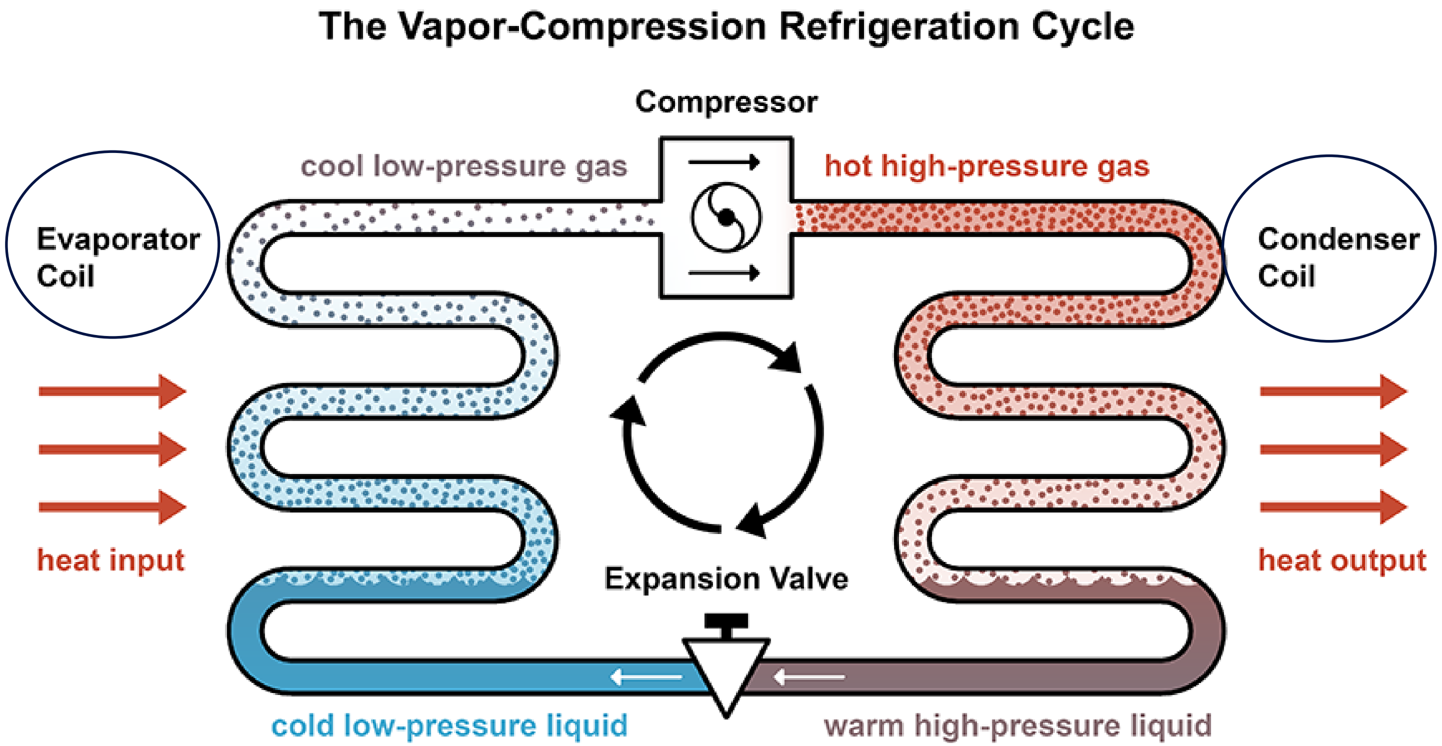
Refrigerant Cycle – Heat Pump

Source: RVR Technology



Source: Building Enclosure

Source: SEAI

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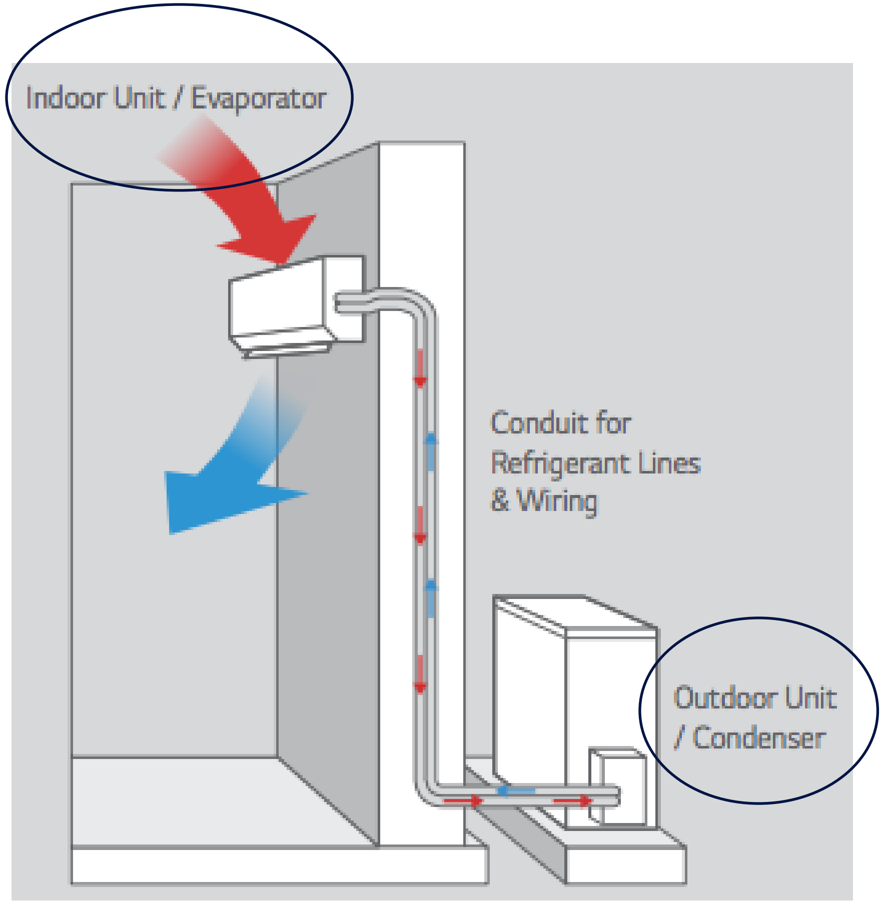
Refrigerant Cycle - Air Con

Evaporator and Condenser roles are reversed (compared to a Heat Pump)

The Evaporator unit pulls the heat out of the air inside

The Heat from cycle is expelled to the outside air

Also can act in heating mode as a Heat pump



Source: Acsis air conditioning warehouse

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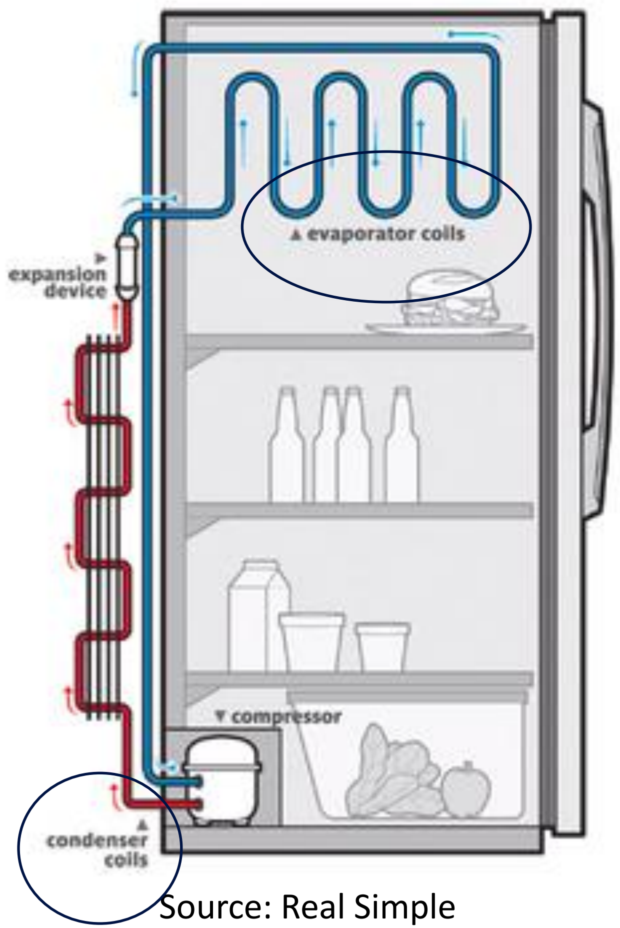
Refrigerant Cycle - Refrigerator

Evaporator and Condenser roles are reversed (compared to a Heat Pump)

The Evaporator unit pulls the heat out of the Refrigerator

The Heat from the cycle is expelled to the outside air / back of the refrigerator



Source: Real Simple

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One word to describe the training so far?

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LU3 Heat Pump Components

Heat Pump Type

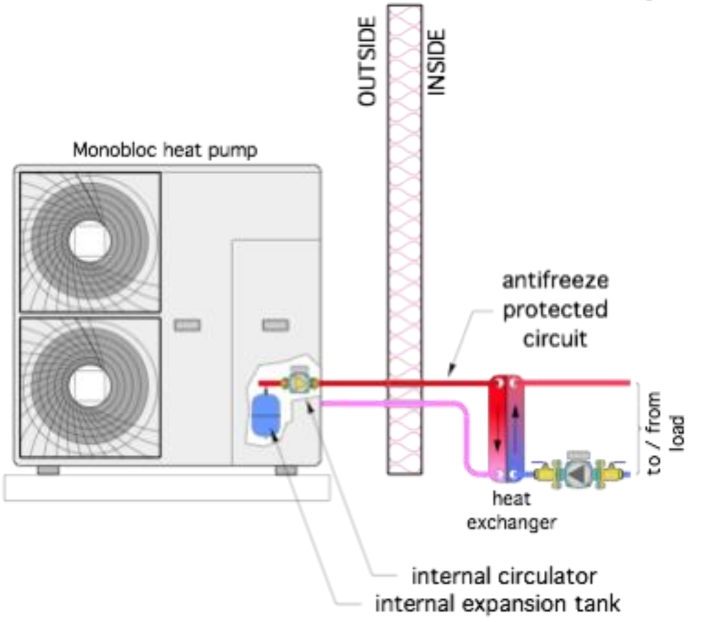
Monobloc:

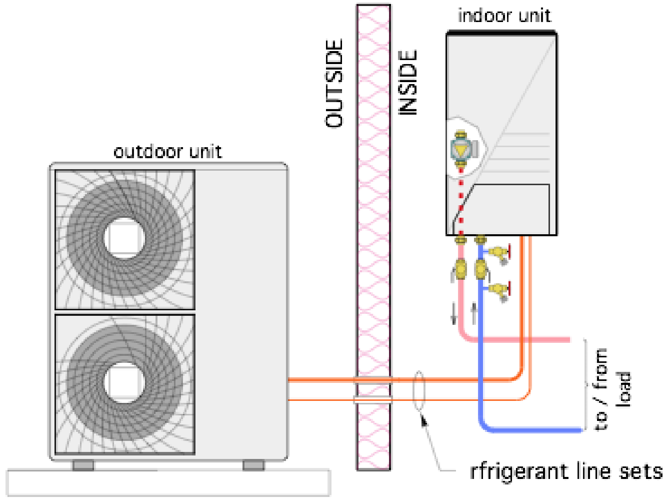
Like a combi boiler and is literally a 'single block' system, where the heat pump and all of its components (except hot water tank) are all in one packaged unit and is situated outside the home. Packaged systems (with DHW) are neater, quicker installation, at a higher cost.

Split System:

Is split into an outside unit (evaporator) and an internal heat exchanger unit (condenser) connected by a refrigerant line. Benefit is the Outdoor unit can be placed anywhere outside.

Mono or Split is site specific. (Packaged systems are neater, quicker installation, higher cost, mostly picked for New Build)





Source: Heatspring Mag

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Which type of heat pump do you mostly install in your county council?

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Heat Source

There are 3 heat sources for a Heat pump system:

1. **Air Source:** The most common heat pump systems extract heat from external air, typically using an outside unit
2. **Water Source:** Water source heat pump systems use open water (lakes, rivers or streams) as a heat source.
3. **Geothermal:** A ground source heat pump system, also known as a geothermal heat pump system, uses the earth as a source of renewable heat.

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Heat Source and Heat Sink

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Heat Source (IN)

Source	Max Temp	Min Temp
Outside Air	20 > 30 °C	-5 > -2 °C
Exhaust Air	24 > 26 °C	20 > 22 °C
Ground Loop	12 > 14 °C	10 > 12 °C
Borehole	14 > 16 °C	12 > 14 °C
Surface Water	0 °C	18 °C
Effluent	14 > 16 °C	24 > 26 °C

Heat Sink (OUT)

Sink	Heating Range	Cooling Range
Radiators	45 > 55 °C	-
Underfloor	30 > 40 °C	-
Fan Coil Unit	50 > 70 °C	6 > 8 °C
Condenser Coil	50 °C	-

The Higher the Heat source temperature the less compression required to reach heat sink temperatures

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Air Source Heat pump

Air source is the most common heat pump type, can come in 3 combinations:

1. **Air to Water:** Most commonly used. Heat is distributed through radiators and underfloor heating and they can also produce hot water.
2. **Air to Air:** heat is provided through air units, Air conditioning unit. Air to air heat pump systems do not provide hot water.
3. **Exhaust Air to Water:** mechanical extract ventilation and recover heat from air drawn from the dwelling

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Evaporator

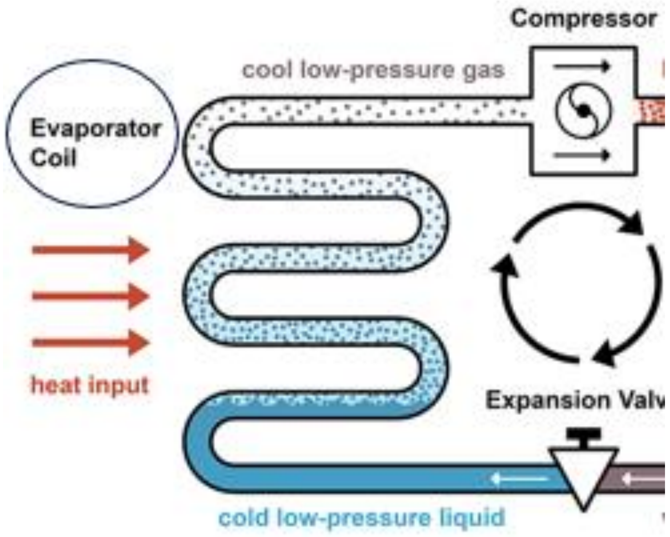
An evaporator is a device in a process used to turn the liquid form of a chemical substance such as water into its gaseous-form/vapor.

The liquid is evaporated, or vaporized, into a gas form of the targeted substance in that process.

This is the outdoor unit for a Heat pump and contains within the shell

1. The Fan
2. The circulating pump
3. Compressor

Source: Daikin



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Outdoor Unit Installation - Location

Manufacturers provide location parameters in their installation manuals:

2.1. Choosing the outdoor unit installation location

- Avoid locations where the unit is exposed to direct sunlight or other sources of heat.
- Select a location where noise emitted by the unit does not disturb neighbors.
- Select a location where easy wiring and pipe access to the power source is available.
- Avoid locations where combustible gases may leak, be produced, flow, or accumulate.
- Note that condensate water may be produced by the unit during operation.
- Select a level location that can bear the weight and vibration of the unit.
- Avoid locations where the unit can be covered with snow. In areas where heavy snow fall is anticipated, special precautions must be taken to prevent the snow from blocking the air intake such as to install the unit at higher position or installing a hood on the air intake. This can reduce the airflow and the unit may not operate properly.
- Avoid locations where the unit is exposed to oil, steam, or sulfuric gas.
- Make sure to hold the handles to transport the unit. Do not hold the base of the unit, as there is a risk that hands or fingers may be pinched.

2.3. Windy location installation

When installing the outdoor unit on a rooftop or other location where the unit is exposed to strong wind, do not face the air outlet of the unit directly into the winds. Strong wind entering the air outlet may impede the normal airflow and it may result in a malfunction.

Mitsubishi EcoDan R32 Zubadan

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Outdoor Unit Installation - Location

Manufacturers provide location parameters in their installation manuals:

Precautions for Selecting the Location

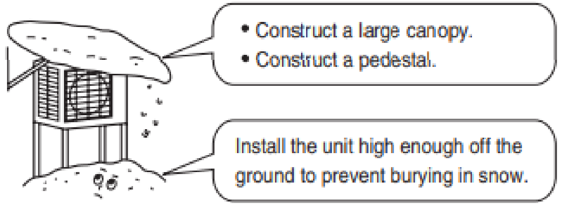
1) Choose a place solid enough to bear the weight and vibration of the unit, where the operation noise will not be amplified.
2) Choose a location where the hot air discharged from the unit or the operation noise will not cause a nuisance to the neighbors of the user.
3) Avoid places near a bedroom and the like, so that the operation noise will cause no trouble.
4) There must be sufficient spaces for carrying the unit into and out of the site.
5) There must be sufficient space for air passage and no obstructions around the air inlet and the air outlet.
6) The site must be free from the possibility of flammable gas leakage in a nearby place.
7) Install units, power cords and inter-unit cables at least 3 meter away from television and radio sets. This is to prevent interference to images and sounds. (Noises may be heard even if they are more than 3 meter away depending on radio wave conditions.)
8) In coastal areas or other places with salty atmosphere of sulfate gas, corrosion may shorten the life of the air conditioner.
9) Since drain flows out of the outdoor unit, do not place under the unit anything which must be kept away from moisture.

NOTE
Cannot be installed hanging from ceiling or stacked.

⚠ CAUTION

When operating the air conditioner in a low outdoor ambient temperature, be sure to follow the instructions described below.

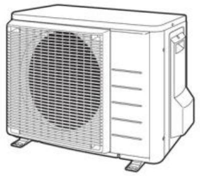
1) To prevent exposure to wind, install the outdoor unit with its suction side facing the wall.
2) Never install the outdoor unit at a site where the suction side may be exposed directly to wind.
3) To prevent exposure to wind, it is recommended to install a baffle plate on the air discharge side of the outdoor unit.
4) In heavy snowfall areas, select an installation site where the snow will not affect the unit.



DAIKIN

OUTDOOR UNIT INVERTER R410A Split Series

INSTALLATION MANUAL



MODEL

RXL25M2V1B	RXLS25M2V1B
RXL35M2V1B	RXLS35M2V1B
RXL25M3V1B	ARXL25M2V1B
RXL35M3V1B	ARXL35M2V1B
RXLG25M2V1B	
RXLG35M2V1B	

Daikin Installation Manual

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Outdoor Unit Installation - Location

Manufacturers provide location parameters in their installation manuals:

3.4 Heat Pump Location

3.4.1 Selection of position

- Consider a place where the noise and the air discharged will not affect neighbours.
- Consider a position protected from the wind.
- Consider an area that reflects the minimum spaces recommended.
- Consider a place that does not obstruct the access to doors or paths.
- The surfaces of the floor must be solid enough to support the weight of the heat pump and minimise the transmission of noise and vibration.
- Take preventive measures so that children cannot reach the unit.
- Install the heat pump in a place where it will not be inclined more than 5°.
- When installing the heat pump where it may exposed to strong wind, brace it securely.
- If the Aerona³ heat pump is to be installed within 1km of the coast, avoid siting facing the sea.
- If the Aerona³ heat pump is to be installed within 10km of the coast, the evaporator must be sprayed with AFC50 and this must be repeated on each annual service.
- For heat pumps fitted within 5km of the coast, Grant recommend the unit is pretreated with Blygold, which is done during the manufacturing process.

Grant Installation Manual

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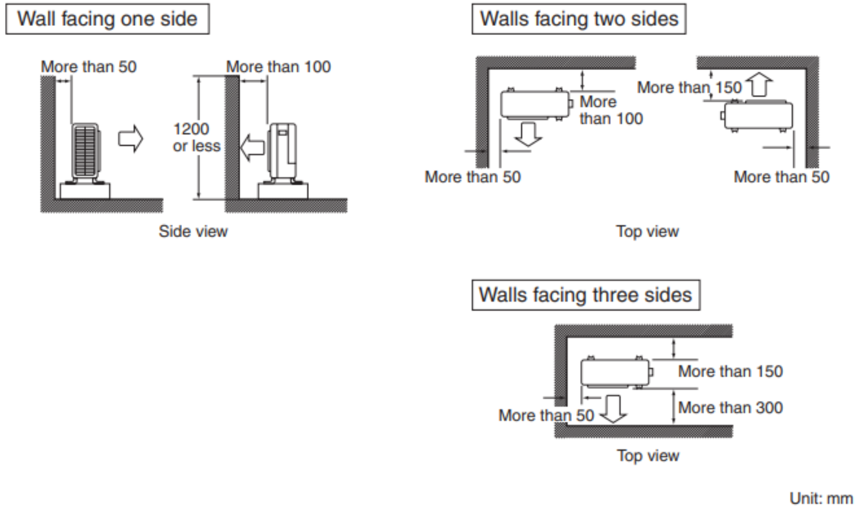
Outdoor Unit Installation - Clearances

Clearances are manufacturer Specific but usually 100 – 1,000mm spacings around the unit



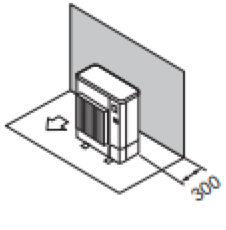


Fig. 2-5

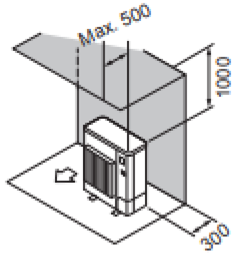


Fig. 2-6

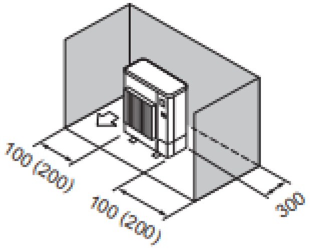


Fig. 2-7

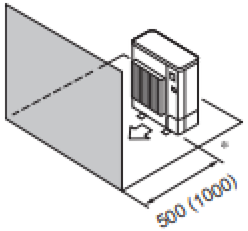


Fig. 2-8

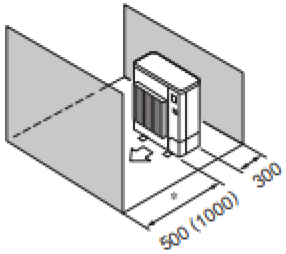


Fig. 2-9

UNIT : mm
( ) : HW140

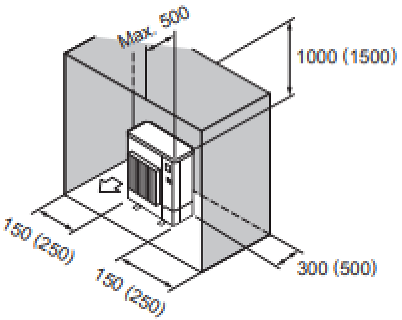


Fig. 2-10

from
20 resear

HPID10R32

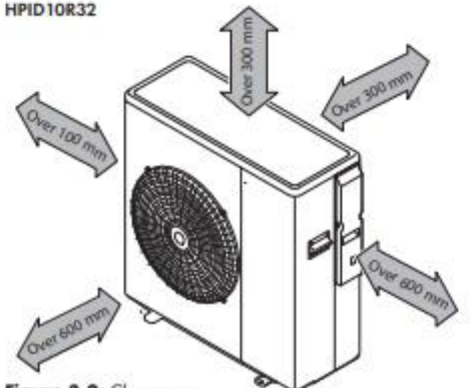


Figure 3-2: Clearances

HPID13R32 & HPID17R32

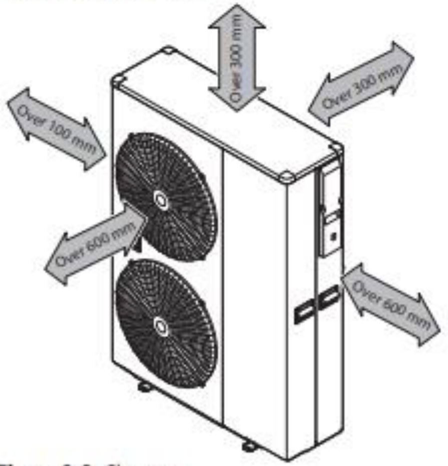


Figure 3-3: Clearances

Outdoor Unit Installation - Noise

Manufacturers should provide a noise level of the unit in operation in product fiche

Power consumption in modes other than active mode				Supplementary Heater			
Off Mode	P_{OFF}	0.10	kW	Rate heat output	P_{sup}	0	kW
Thermostat-off mode	P_{TO}	0.04	kW				
Standby mode	P_{SB}	0.10	kW	Type of energy input			
Crankcase heater mode	P_{CK}	0.00	kW				
Other items							
Capacity control	Variable			Rated airflow rate, outdoors	-	2082	m^3/h
Sound power level indoors/outdoors	L_{WA}	44/65	dBA				
Annual Energy consumption	Q_{HE}	2755	kWh				
For heat pump combination heater				Water heating energy efficiency	ηwh	**114**	%
Declared load profile		L		Reference Hot Water Temperature	θ'_{WH}	**49.04**	°C
Daily electricity consumption	*Qelec*	4.23	kWh	Actual Volume of cylinder under test		**206.8**	Litres
Annual electricity consumption	*AEC*	897.77	kWh/a	Standby Cylinder Heat Loss		**1.76**	kWh

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Outdoor Unit Installation – Condensate Build Up

- Condensate from defrosted coils or from condensation against the evaporator coils will gather at the bottom of the unit unless there is a drain. This is not toxic, just water!

- Provision must be made to safely collect and dispose of the condensate.

- It is essential that the condensate is able to drain away and not allowed to run onto any adjacent paths or driveways where, in winter, this will result in icing and a potential hazard for anyone walking near the heat pump.

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Can you name 1 consideration for installing a heat pump evaporator unit?

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Compressor

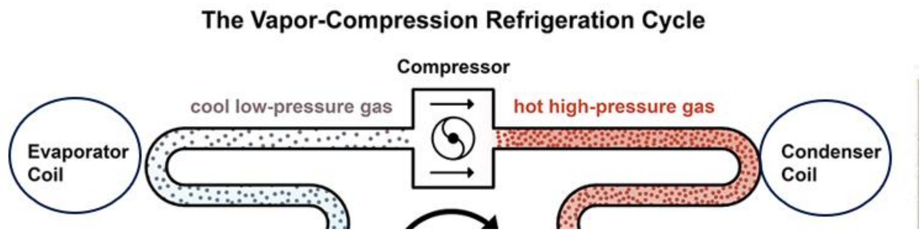
A compressor is a mechanical device that increases the pressure of a gas by reducing its volume.

Compressor also maintains the refrigerant flowing inside the heat pump.

There are different types of compressor control in chillers and heat pumps:

1. Single-stage compressor
2. Two-Stage compressor
3. Variable Speed compressor

Source: Heat Pumps HQ



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Condenser

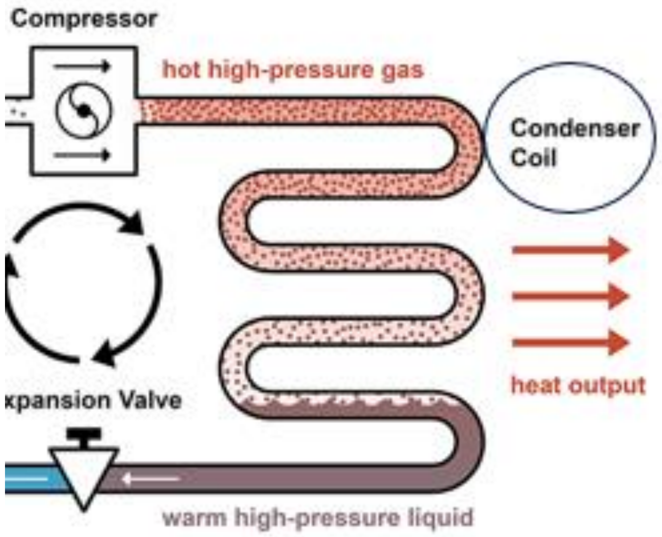
A device or unit used to condense a gaseous substance into a liquid state through cooling is called a condenser.

The latent heat is released by the substance and transferred to the surrounding environment or to the heating system.

For Heat pumps this is the indoor unit.

Manufacturers have guides on indoor installation and spacing requirements

Source: Daikin



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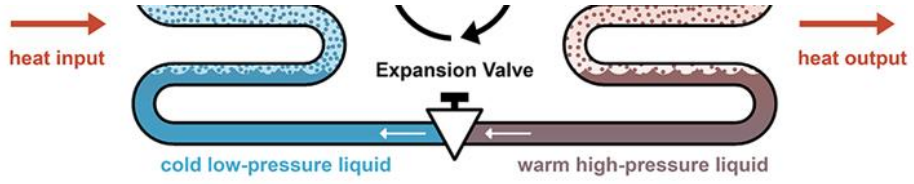
Expansion Valve

A thermal expansion valve reduces the pressure in the refrigerant cycle.

The warm high pressure liquid refrigerant enters the expansion valve; reducing the pressure and temperature of the refrigerant

Some newer systems use electronic expansion valves.

Source: Trade Wheel



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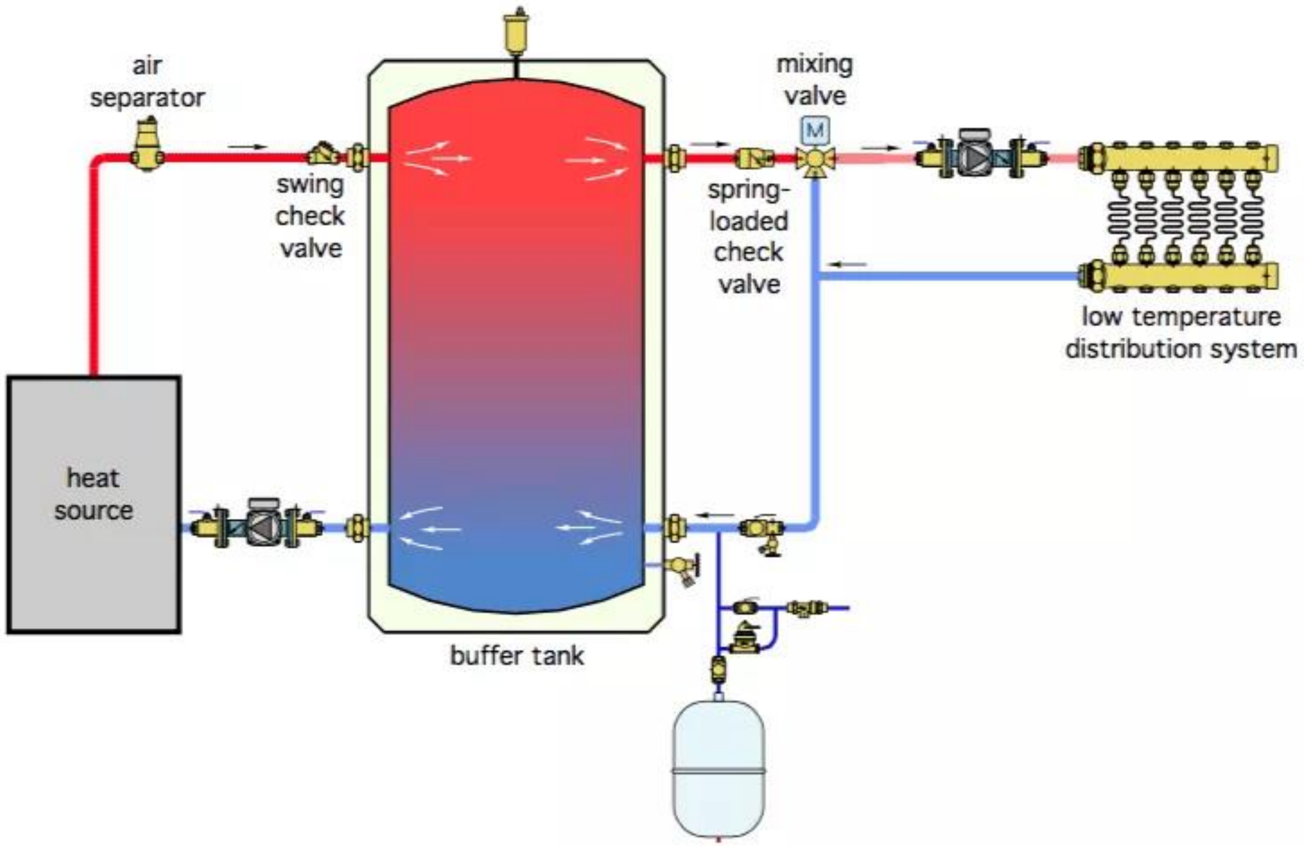
Buffer Tank



A Buffer Tank is designed to help reduce cycling of a heat pump or to reduce the compressor switching off/on (no more than 3 times per hour)

A buffer tank is used to hold a volume of hot ‘black’ water typically 15 litres (per Heat pump kW rating) to be used in the heating circuit.

A buffer tank provides a bypass route to maintain the minimum flow rate through the heat pump.

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Buffer Tank

An added benefit of adding a buffer tank is it provides a store of warm water and can be **used in reverse** for when a Heat pump is undergoing a de-frost cycle

- Not needed usually with invertor
- Some units have internal buffer
- Often to ensure flow rate through heat exchanger
- Consider for small zoned UFCH
- Careful to ensure no mixing,

Source: Joule

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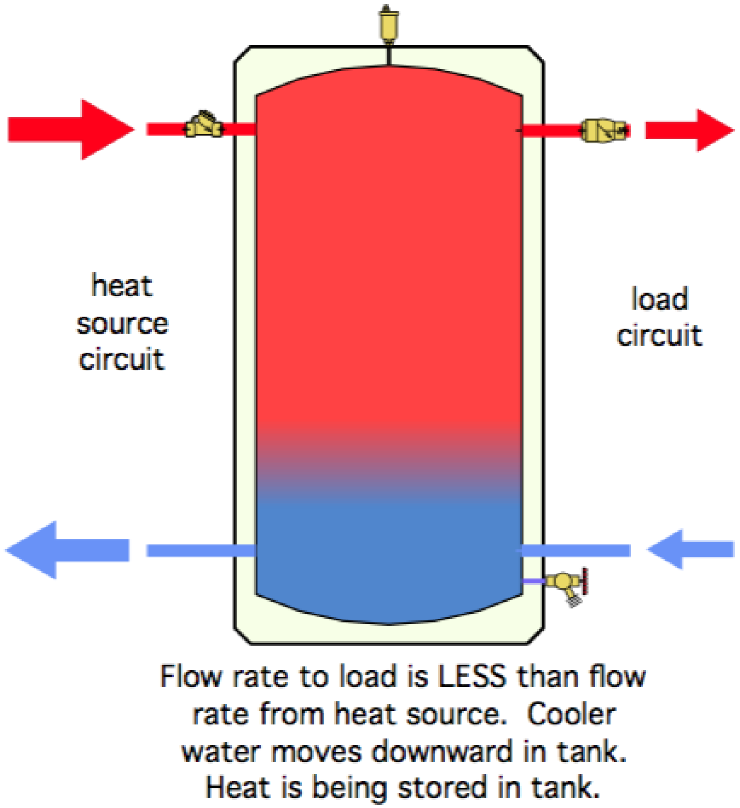
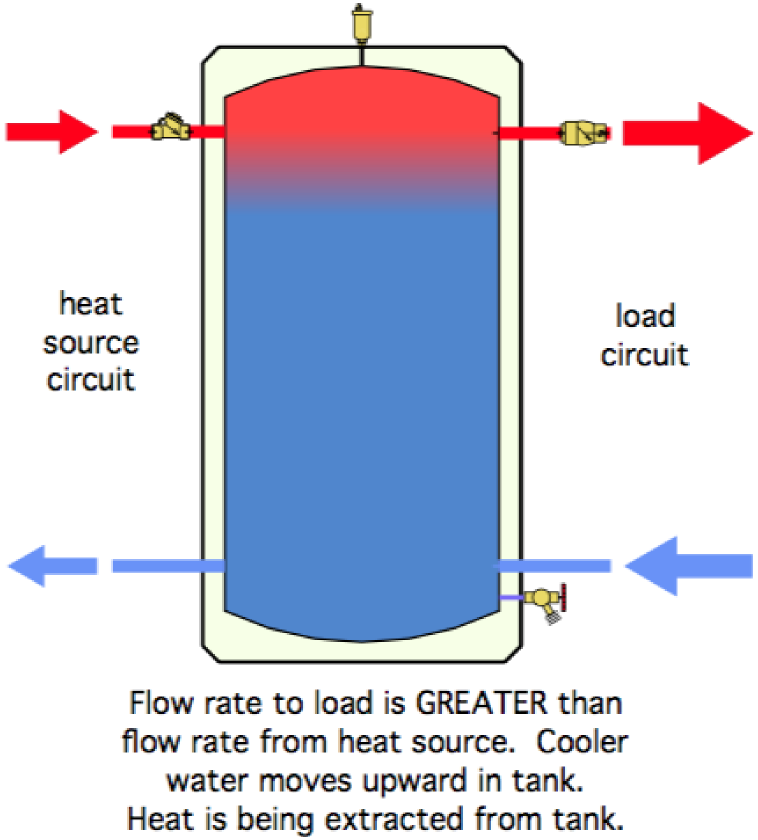
Buffer Tank



Source: Heatspring Mag



Source: Heatspring Mag

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Do you use a buffer tank in your installations? or are considering using buffer tanks?

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HP4ALL

LU4 Refrigerant

Refrigerant

A refrigerant is a substance or mixture, usually a fluid, used in a heat pump and refrigeration cycle.

In most cycles it undergoes phase transitions from a liquid to a gas and back again.

Many working fluids have been used for such purposes.

A Very important feature of refrigerants is the ability to transfer energy.

Another important aspect of Refrigerants is the GWP or the Global Warming potential

Refrigerant should be handled by competent and accredited workers

Source: Aspirationenergy.com

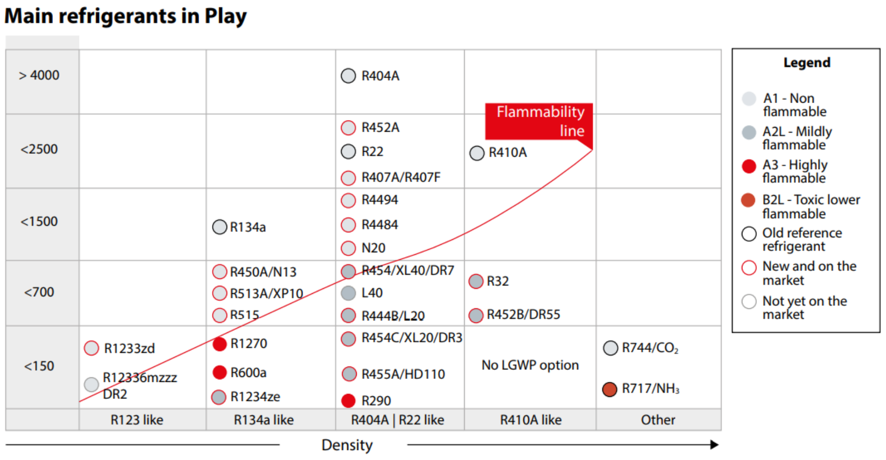

Figure 6: Carbon Chain Based Refrigerants (HCs, HFCs, HCFCs)

Source: Danfoss, 2017, Refrigerant options now and in the future

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THE GREENHOUSE EFFECT: GASES

HP ALL

CO_2	CH_4	N_2O	HFCs
Carbon dioxide	Methane	Nitrous oxide	Hydro-fluoro-carbons
Fossil Fuels Deforestation Land change Waste Manufacturing	Production/Transport of fossil fuels Agricultural practices and Livestock Landfill wastes	Intensive agriculture Industrial activities	Refrigeration Aerosols

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The Greenhouse Effect: Global Warming Potential

HPOALL

CO_2

Carbon Dioxide

- Has a GWP of 1 regardless of the time period
- Cause increases in atmospheric concentrations of CO_2 that will last thousands of years.

CH_4

Methane

- GWP of 28–36 over 100 years
- CH_4 emitted today lasts about a decade on average
- Absorbs much more energy than CO_2

N_2O

Nitrous oxide

- GWP 265–298 times that of CO_2
- N_2O emitted today remains in the atmosphere for more than 100 years

HFC

Hydro-fluoro-carbons

- High-GWP gases because, for a given amount of mass, they trap substantially more heat than CO_2.
- **GWPs in the 1000s or 10,000s**

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The Greenhouse Effect: Refrigerants

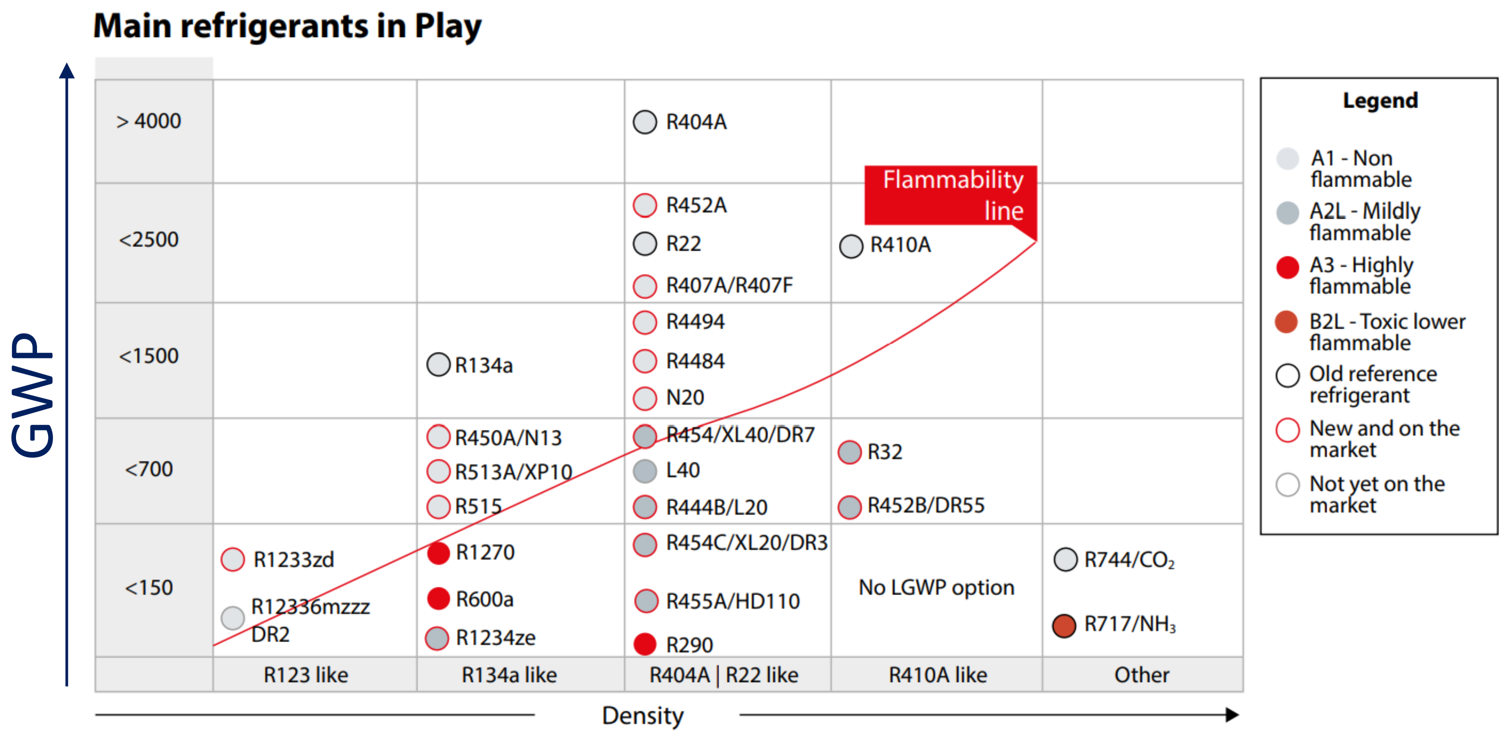

Figure 6: Carbon Chain Based Refrigerants (HCs, HFCs, HCFCs)

A person handling F-gases is required **under European and Irish law** to be appropriately certified in order to ensure that F-gases are not emitted to the atmosphere while working on F-gas containing equipment.

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Refrigerant / R32 Transition Phase

R 32 is the most used refrigerant for Heat pumps…

Heat pumps are rapidly transitioning from R410A to R32. As R32 has a GWP of 675, roughly 30% lower than that of R410A.

"The whole of F-Gas, which effectively polices the change in refrigerants, also refers to the changes as a 'phase down' rather than a phase out.

This is exactly why manufacturers offer comprehensive training on how to install, commission and maintain equipment using refrigerants." - Ben Bartle-Ross, Mitsubishi

Newer refrigerants with lower GWP are coming online,

Source: Cooling solutions.net

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Why do some refrigerants have a capital "A" and some have "a"?

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Refrigerant Metrics

Refrigerant	Name (Scientific or trade)	Type	ODP	GWP	Comments
R12	R12 Freon	CFC	1 (high)	10000	Phased Out
R22	R22 Freon	HCFC	0.05	1810	Phased Out
R125	Pentaflouroethane	HFC	0	3500	A main component of blended refrigerants
R124a	Tetrafluoroethane	HFC	0	1430	Non Flammable
R32	Difluoromethane	HFC	0	675	Slightly Flammable due to methane
R410A	Puron, Forane, Genetron	HFC	0	2088	50% R32, 50% R125
R407C	Floron	HFC	0	1300	23% R32, 25% R125, 52% R134a
R290	Propane	Natural	0	3.3	LP Gas, highly flammable
R744	Carbon Dioxide	Natural	0	1	Higher Operating temperatures and pressures
R717	Ammonia	Natural	0	0	Toxic and reacts to copper
R1234yf	Tetrafluoropropane (Opteon YF or Solstice YF)	HFOI	0	4	R134a replacement. Expensive and flammable
R454C	Opteon XL20	HFOI	0	148	78.5% R1234yf, 21.5% R32. Flammable
R452B	Opteon XL55	HFOI	0	698	67% R32, 7% R125, 26% R1234yf. Cheaper than R1234yf but still flammable

ODP: is O-ZONE Depletion Potential

Capital Letter at end of refrigerant means it is a mixture of other refrigerants.

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The Ideal Refrigerant

1. Does not damage the environment, low ODP and GWP
2. Is a natural gas (not mixed or a combination)
3. Not flammable, toxic or corrosive
4. Efficient (low boiling point, high latent heat of vaporisation, low specific heat capacity)
5. Chemically Stable
6. Easily detectable (if leaks)
7. Low cost
8. Is easily available

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Refrigerant Handling

Must be Compliant with F-Gas regulations on fluorinated greenhouse gases:

- Qualified for refrigerant handling

- Exact requirement for maintenance including checking for leaks and record keeping depend on the amount of refrigerant held in the system

- Only persons who are competent to do so should carry out heat pump installations, testing or maintenance.

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Refrigerants / F-Gas Handling

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For RAC personnel, the European Commission Regulation 303/2008 refers to four different levels of certification, which allow personnel to carry out different activities.

Category I certificate holders may carry out all refrigerant handling activities for any size of RAC systems containing HFC refrigerants.

This includes leakage checking, refrigerant recovery, installation, maintenance and servicing.

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Refrigerants / F-Gas Handling

HP4ALL

Category II certificate holders may carry out **refrigerant recovery, installation, maintenance** and servicing, in relation to RAC systems containing **less than 3 kg of fluorinated greenhouse gases** (or less than 6 kg for systems that are hermetically sealed).

Also carry out leak checks on any plant provided that it does not **entail breaking into the refrigeration** circuit containing fluorinated greenhouse gases.

Category III certificate holders may carry out **refrigerant recovery i**n relation to RAC systems containing less than **3 kg of fluorinated greenhouse gases** (or less than 6 kg for systems that are hermetically sealed).

Category IV certificate holders may carry out leak checks on any plant provided that it does not entail breaking into the refrigeration circuit containing fluorinated greenhouse gases.

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Refrigerants / F-Gas Handling Courses

F-gas training is available in Ireland:

1. ECAC: Category 1 F-gas training, intensive F-Gas, HVAC and Safe handling courses. Available at ECAC.ie.

2. ESS: Intensive f-gas refrigeration training, available at: essltd.ie

3. Diagnostic Solutions: F-gas refrigerant handling IMI awards certification course, available at: diagnosticsolutions.ie

4. Limerick Clare ETB are starting up an NZEB centre of excellence with specialists in F-Gas and refrigeration

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If you see a refrigerant line leaking at your home, what should you do?

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LU5 Heat Pump Ready Home

Nearly Zero Energy Building - EU POLICIES & LEGISLATION

1997 – Kyoto Agreement
EU Directive to improve energy efficiency and reduce GHG emissions

2002 – Energy Performance of Buildings Directive (EPBD)
Improve energy performance for new and existing buildings

2010 – EPBD Recast
To achieve nearly zero energy buildings NZEB, mainly using renewable energies by 2020.

2012 – Energy Efficiency Directive (EED)
To use energy more efficiently at all stages of the energy chain from its production to its final consumption

National Building Codes

2018 – EPBD Recast
Decarbonise building stock by 2050, smart technologies and the mobilisation of investments

2020 – The European Green Deal
Circular Economy Action Plan, Renovation Wave Inititiative and smart sector integration

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Nearly Zero Energy Building - Summary

Nearly Zero Energy Building has a very high energy performance

Or

A building that uses very low amounts of energy

Or

A building which produces more or less the same amount of energy per year as it uses.

Or

The building can generate this renewable energy on site or feed back to the electricity grid

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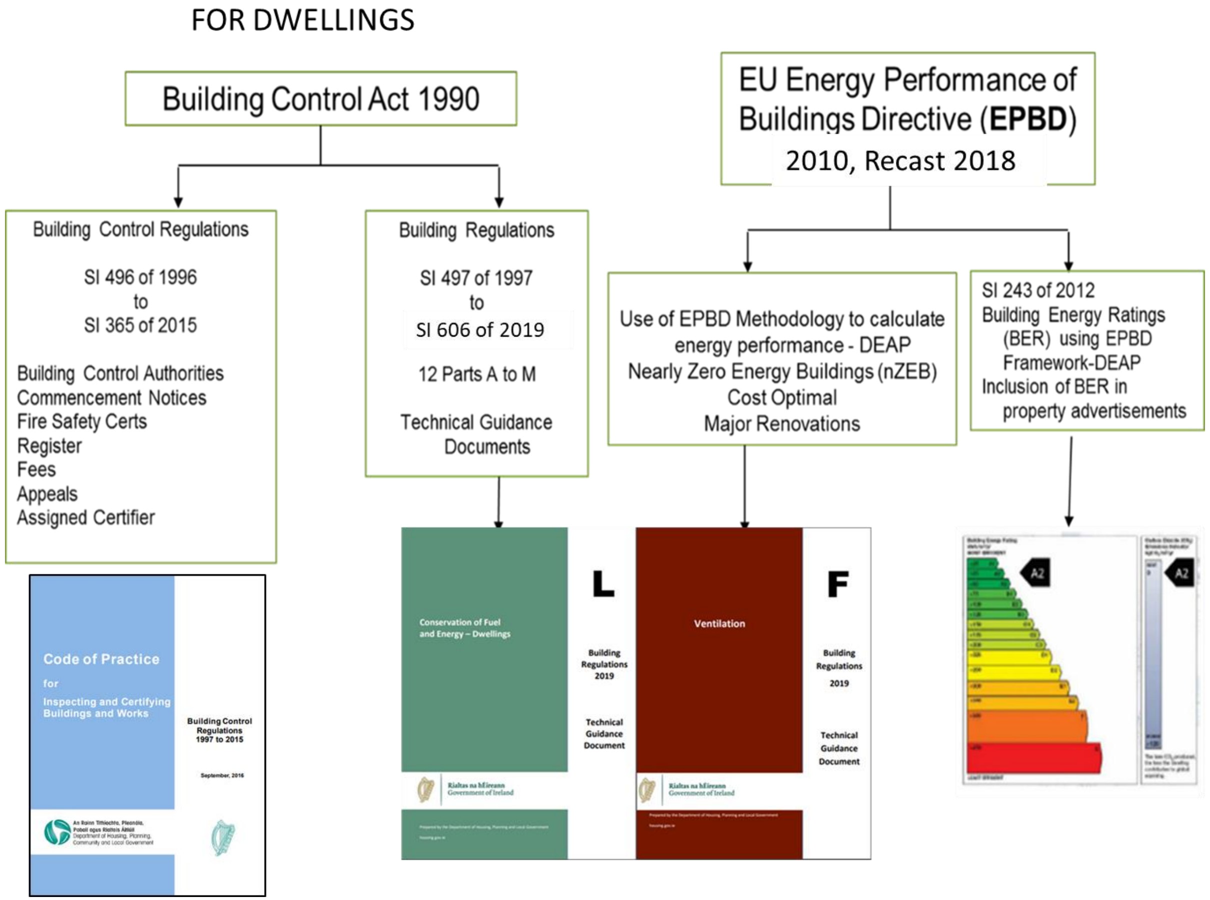
Nearly Zero Energy Building - Ireland

- **NZEB is Mandatory**

- NZEB and TGD L Dwellings 2019 to apply to all **new Dwellings** from 1st November 2019 subject to transition.

- Also applies to **Dwellings with deep renovation** (major renovation) means the renovation of a building where more than 25 % of the surface of the building envelope undergoes renovation.



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Heat Pump Ready Home - Insulation

- The heat losses through a standard building component (i.e., Wall) are defined by the **heat transfer coefficient (U-value).**
- The lower the U-value, the lower the rate of heat transfer and the higher the thermal resistance (R-Value).
- Resistance = Thickness (d) / Thermal conductivity (λ)
- U-Value = 1 / R-Value = 1 / (d/ λ)

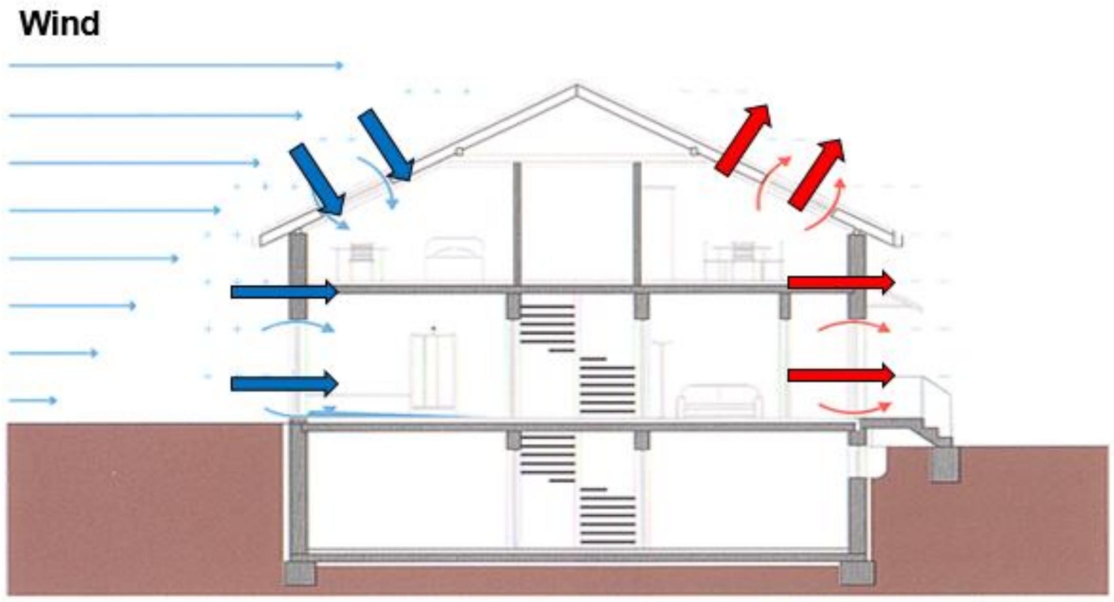
Part L U-Values

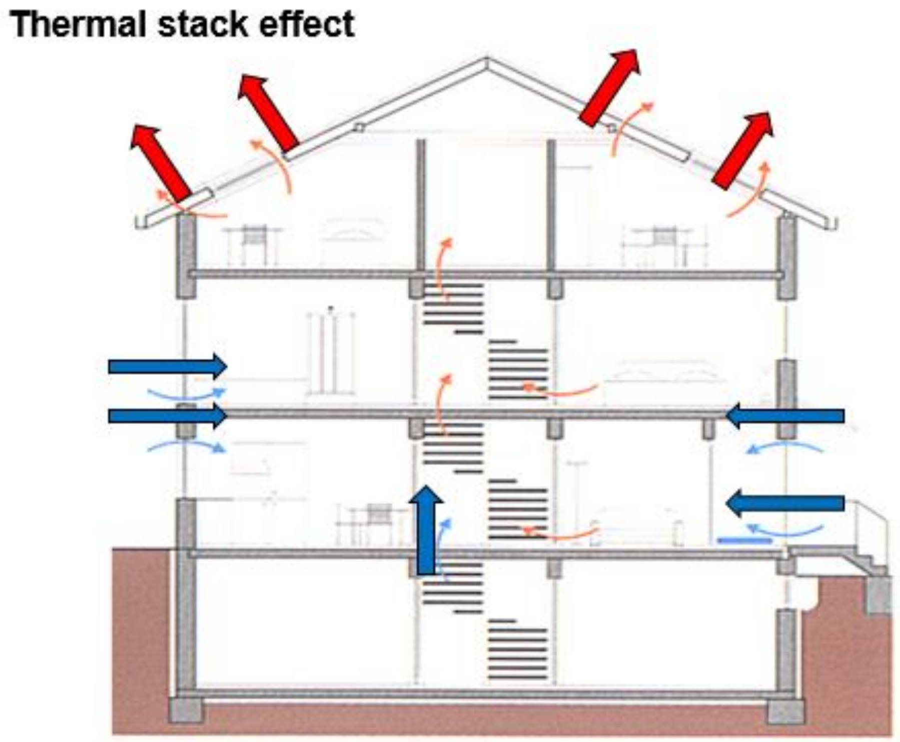
Building Element	Minimum U-Value
Ground Floow (Underfloor Heating)	0.15 W/m²k
External Walls	0.18 W/m²k
Flat Roof	0.20 W/m²k
Pitched Roof	0.16 W/m²k

Material	Thermal Conductivity (W / (mK))	Thickness required for U = 0.18
Re-inforced Concrete (1% Steel)	2.3	23.95
Solid Brick	0.8	8.33
SoftWood	0.13	1.36
Porous Brick / Concrete	0.11	1.15
Straw	0.055	0.57
Typical Insulation Material	0.04	0.41
Vacuum Insulation Material	0.002	0.020

Heat Pump Ready Home - Airtightness

Airtightness reduces the Infiltration and exfiltration via leakages in the building fabric





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Heat Pump Ready Home - Airtightness

HP ALL

Why to build airtight?

Avoids structural damage (condensate within the fabric build-up)

Air quality: directed air circulation becomes possible, precondition for controllable demand-oriented ventilation

Enhances living comfort: no draughts or cold air accumulation (ground floor)

Energy conservation through reduced ex- and infiltration (ventilation losses)

Avoids pollutants (e.g., Radon) entering the room air

Enhances noise protection

Source: BIMzeED

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Heat Pump Ready Home - Ventilation

There are 2 types of ventilation that can be incorporated:

1. Passive Ventilation: Natural Cooling, FREE (i.e., Opened Windows, Vents)

2. Mechanical Ventilation: Mechanical fan, a machine for producing airflow and often for cooling (i.e., vent fan for Cooking)

Keeping the heat within the building during the heating season is not the only goal… overheating in the summer needs to be addressed in the design.

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CIBSE Guide A – Environmental Design

Building/room type	Winter operative temp. range for stated activity and clothing levels*			Summer operative temp. range (air conditioned buildings†) for stated activity and clothing levels*			Suggested air supply rate / (L.s^{-1} per person) unless stated otherwise	Filtration grade‡	Maintained illuminance¶ / lux	Noise rating§ (NR)
	Temp. / °C	Activity / met	Clothing / clo	Temp. / °C	Activity / met	Clothing / clo				
Airport terminals:										
— baggage reclaim	12–19[1]	1.8	1.15	21–25[1]	1.8	0.65	10[2]	F6–F7	200	45
— check-in areas[3]	18–20	1.4	1.15	21–23	1.4	0.65	10[2]	F6–F7	500[4]	45
— concourse (no seats)	19–24[1]	1.8	1.15	21–25[1]	1.8	0.65	10[2]	F6–F7	200	45
— customs area	18–20	1.4	1.15	21–23	1.4	0.65	10[2]	F6–F7	500	45
— departure lounge	19–21	1.3	1.15	22–24	1.3	0.65	10[2]	F6–F7	200	40
Art galleries — see *Museums and art galleries*										
Banks, building societies, post offices:										
— counters	19–21	1.4	1.0	21–23	1.4	0.65	10[2]	F6–F7	500	35–40
— public areas	19–21	1.4	1.0	21–23	1.4	0.65	10[2]	F5–F7	300	35–45
Bars/lounges	20–22	1.3	1.0	22–24	1.3	0.65	10[2]	F5–F7	100–200[5]	30–40
Bus/coach stations — see *Railway/coach stations*										
Churches	19–21	1.3	1.15	22–24	1.3	0.65	10[2]	G4–F6	100–200	25–30
Computer rooms[6]	19–21	1.4	1.0	21–23	1.4	0.65	10[2]	F7–F9	300	35–45
Conference/board rooms	22–23	1.1	1.0	23–25	1.1	0.65	10[2]	F6–F7	300/500[7]	25–30
Drawing offices	19–21	1.4	1.0	21–23	1.4	0.65	10[2]	F7	750	35–45
Dwellings:										
— bathrooms	20–22	1.2	0.25	23–25	1.2	0.25	15 L·s^{-1}	G2–G4 (extract)[8]	150[4]	—
— bedrooms	17–19	0.9	2.5	23–25	0.9	1.2	0.4 –1 ACH to control moisture[8]	G2–G4	100[4]	25
— hall/stairs/landings	19–24[1]	1.8	0.75	21–25[1]	1.8	0.65	—	—	100	—
— kitchen	17–19	1.6	1.0	21–23	1.6	0.65	60 L·s^{-1}	G2–G4 (extract)[8]	150–300	40–45
— living rooms	22–23	1.1	1.0	23–25	1.1	0.65	0.4 –1 ACH to control moisture[8]	G2–G4	50–300	30
— toilets	19–21	1.4	1.0	21–23	1.4	0.65	> 5 ACH	G2–G4	100[4]	—
Educational buildings:										
— lecture halls[9]	19–21	1.4	1.0	21–23	1.4	0.65	10[2]	G4–G5	500[10]	25–35
— seminar rooms	19–21	1.4	1.0	21–23	1.4	0.65	10[2]	G4–G5	300[10]	25–35
— teaching spaces[9]	19–21	1.4	1.0	21–23	1.4	0.65	10[2]	G4–G5	300[10]	25–35

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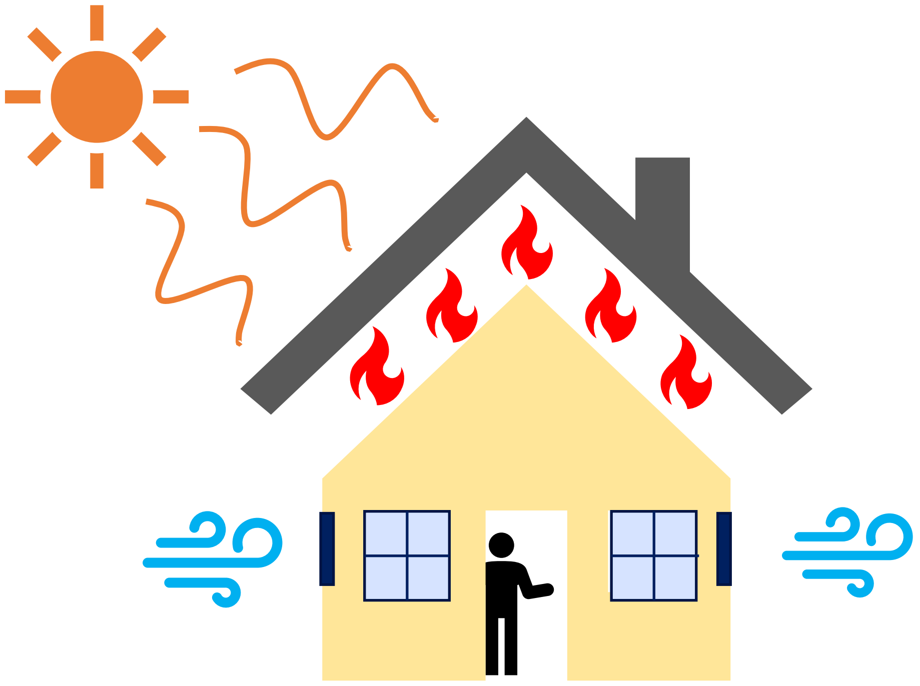
Heat Pump Ready Home - Overheating

Some ideas for avoiding overheated homes:

Won’t affect the BER:
- Internal and external shading options
- night-time natural ventilation strategy.
- Reflective glazing options

Will affect the BER:
- Mechanical Ventilation
- Heat recovery systems
- Air Conditioning units



Article by RTE for homeowners: https://www.rte.ie/lifestyle/living/2021/0630/1232180-8-simple-ways-to-cool-your-house-down-on-hot-days/

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Name one retrofit measure?

ⓘ Start presenting to display the poll results on this slide.

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LU6 Heat Pump Performance Monitoring

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What word would you use to describe heat pump performance?

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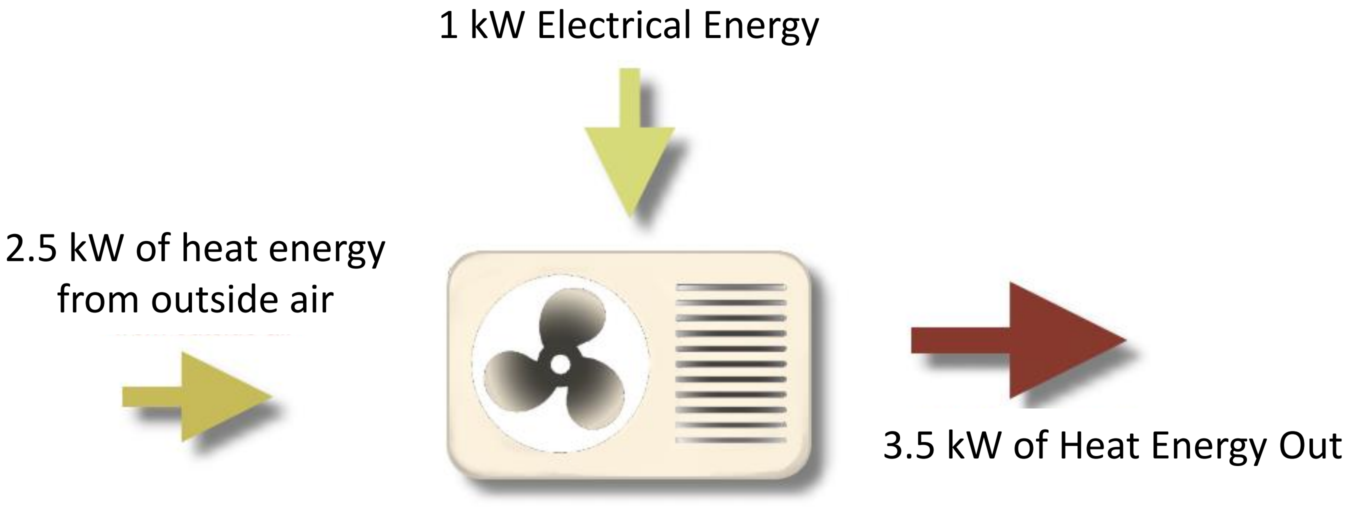
Refrigerant Cycle - Efficiency

The efficiency of heat pump, refrigerator or air conditioning system is often described in the form of “COP” or the coefficient of performance

It is a ratio of useful heating (or cooling) and electrical energy required.



Heat Energy Out / Electrical Energy = COP

3.5kW / 1 kW = 3.5 COP

Source: Green Business Watch

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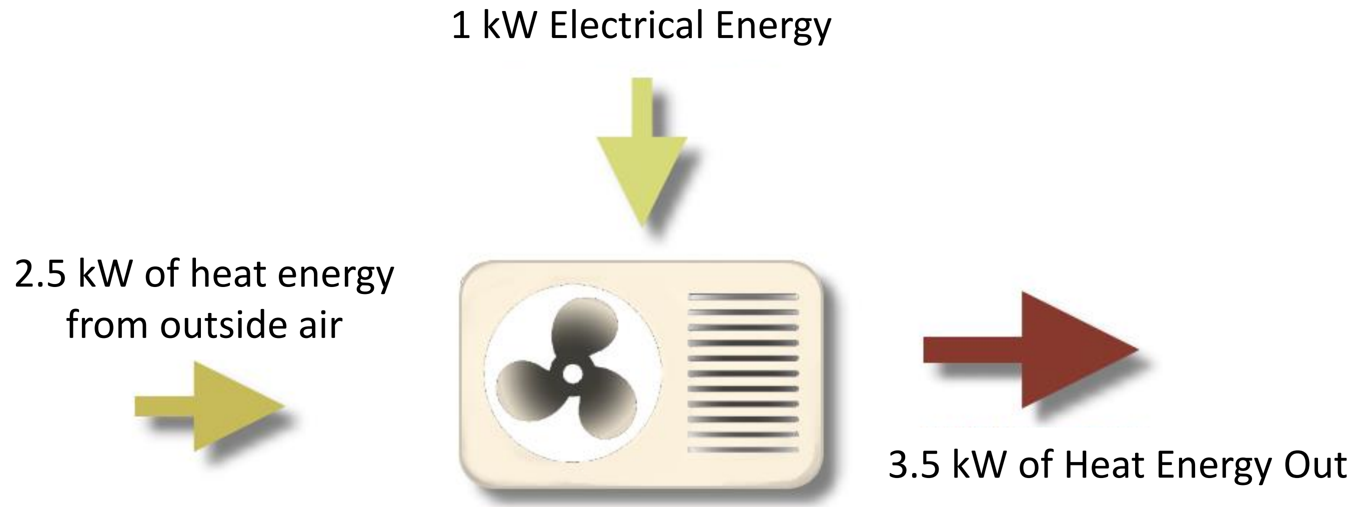
Efficiency Comparison

Compared to Conventional Heating systems…



Heat Energy Out / Electrical Energy = COP

3.5kW / 1 kW = 3.5 COP **Or 350% Efficiency**

Source: Green Business Watch

Boiler Efficiency and Ratings

A	90% +
B	86% - 90%
C	82% - 86%
D	78% - 82%
E	74% - 78%
F	70% - 74%
G	below 70%

Source: My Plumber.co.uk

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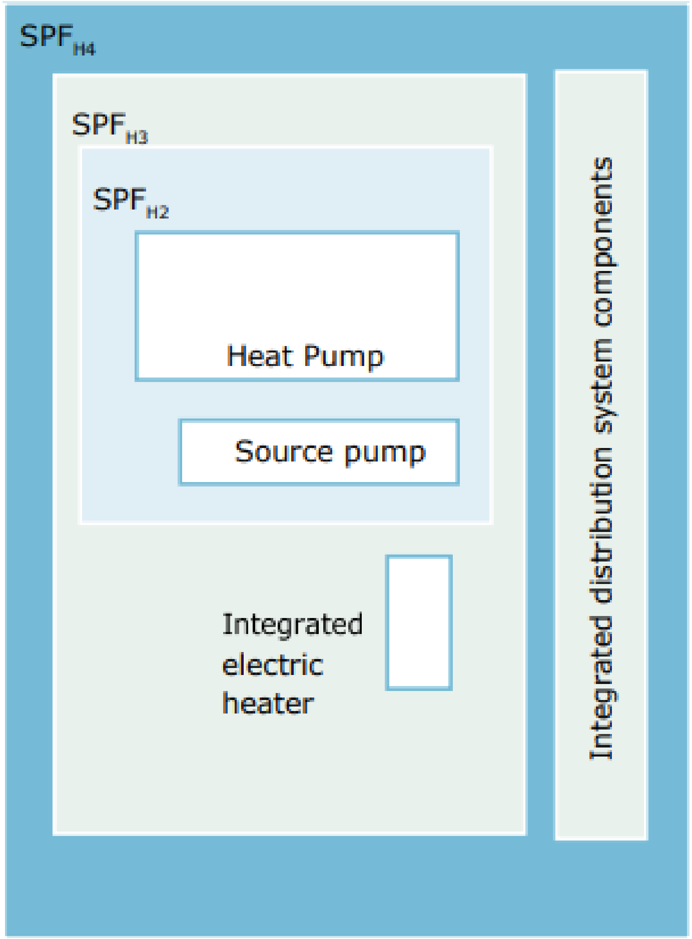
Seasonal Performance Factor SPF

SPF or Seasonal Performance Factor is the average COP over a full heating season! Or over the course of a year. There are 4 SPFs in a Heat pump home:

- SPFH1: is the COP, Heat output over electrical input to Heat pump only
- SPFH2: The Heat pump unit (including a fan/ circulating pump)
- SPFH3: Heat pump unit + pumps + integrated immersion
- SPFH4: Entire Heating System (incl. Domestic Hot Water)

This requires a monitoring of Electrical input to the heat pump and the heat output of the heat pump (Heat meters and Electrical Meters are required!)

SPF can help identify problems in design or in operation



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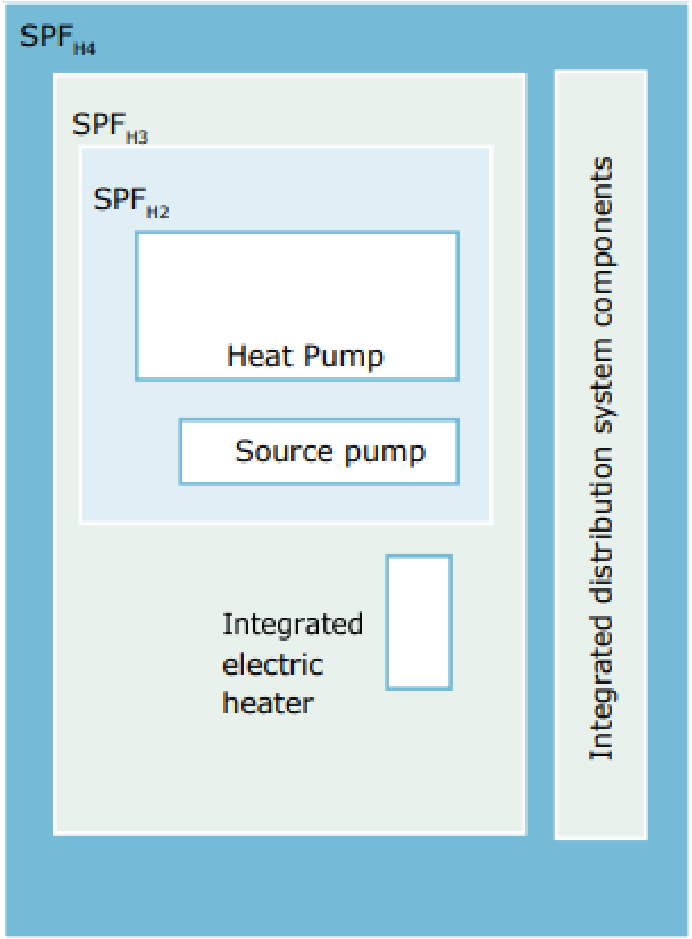
EN15450 –SPF TARGETS

EN15450 sets a target SPF (Space Heating + DHW) of 2.8 and a minimum SPF of 2.5 for Retrofits.

And minimum SPFs of 3.0 and 2.7 for new Builds

It should be noted the SPF figures in EN15450 are for continental Europe, and so with Ireland’s milder climate, it would be reasonable to expect to achieve higher target and minimum SPF.



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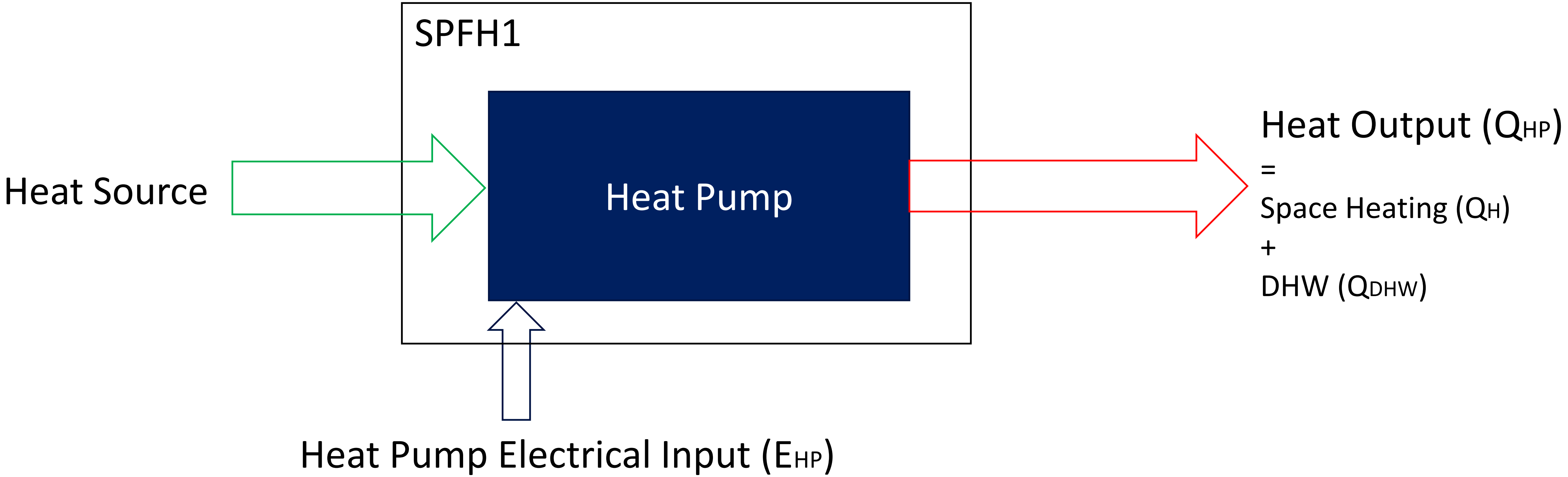
Monitoring SPFH1



$$\mathbf{SPFH1 = Q_{HP} / E_{HP}}$$

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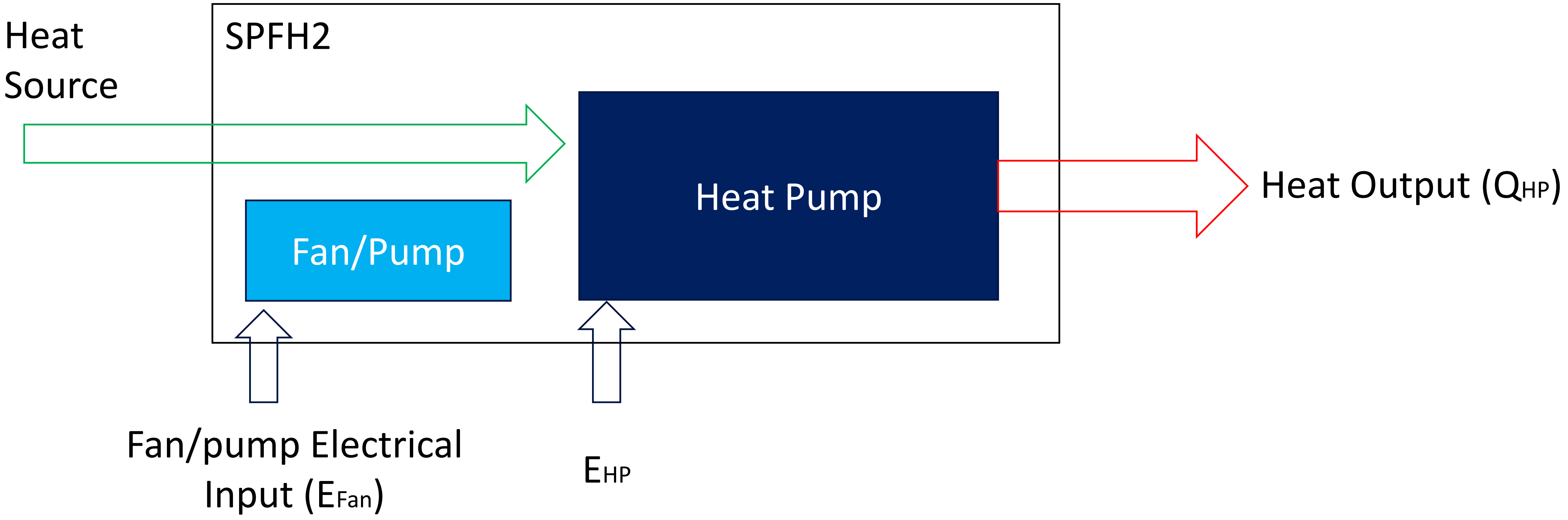
Monitoring SPFH2



SPFH2 = Q_{HP} / E_{HP} + E_{Fan}

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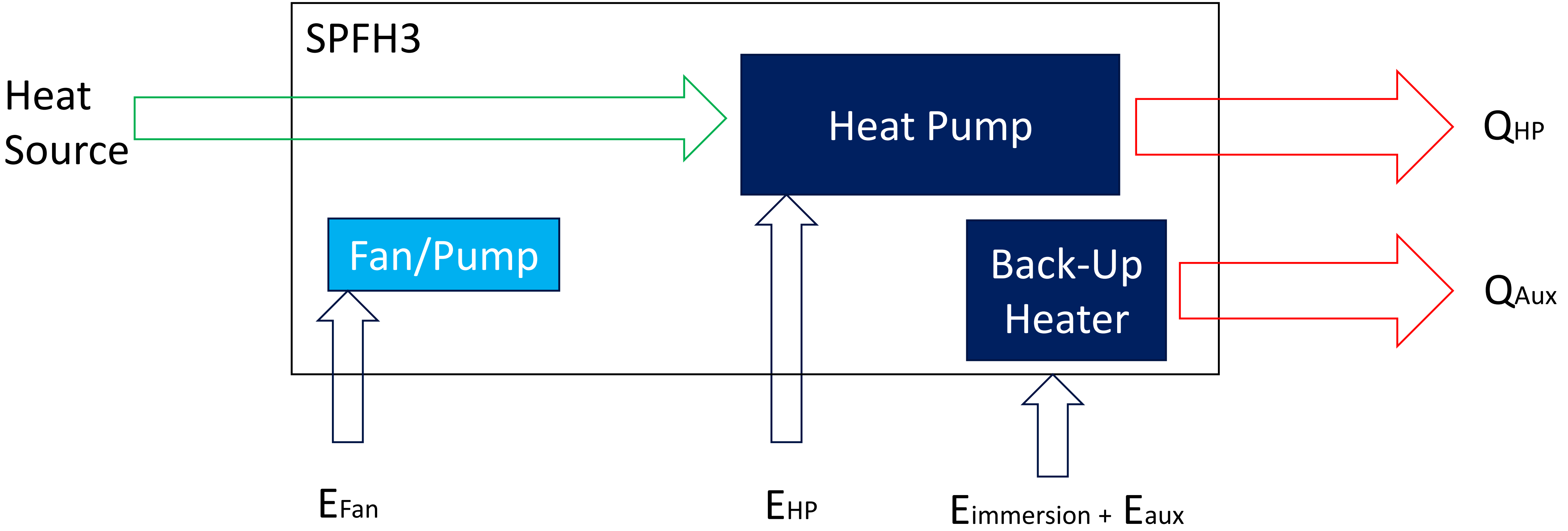
Monitoring SPFH3



$$\mathbf{SPFH3 = Q_{HP} + Q_{Aux} \,/\, E_{HP} + E_{Fan} + E_{immersion} + E_{Aux}}$$

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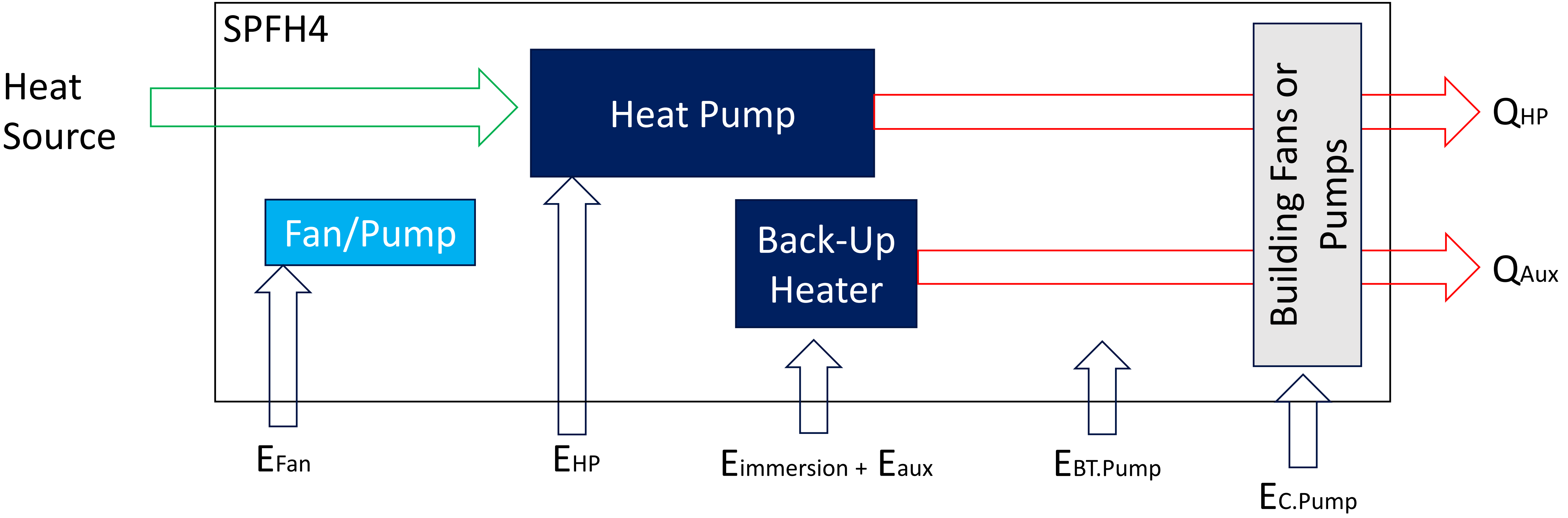
Monitoring SPFH4



SPFH3 = Q_{HP} + Q_{Aux} / E_{HP} + E_{Fan} + $E_{immersion}$ + E_{aux} + $E_{BT.Pump}$ + $E_{C.Pump}$

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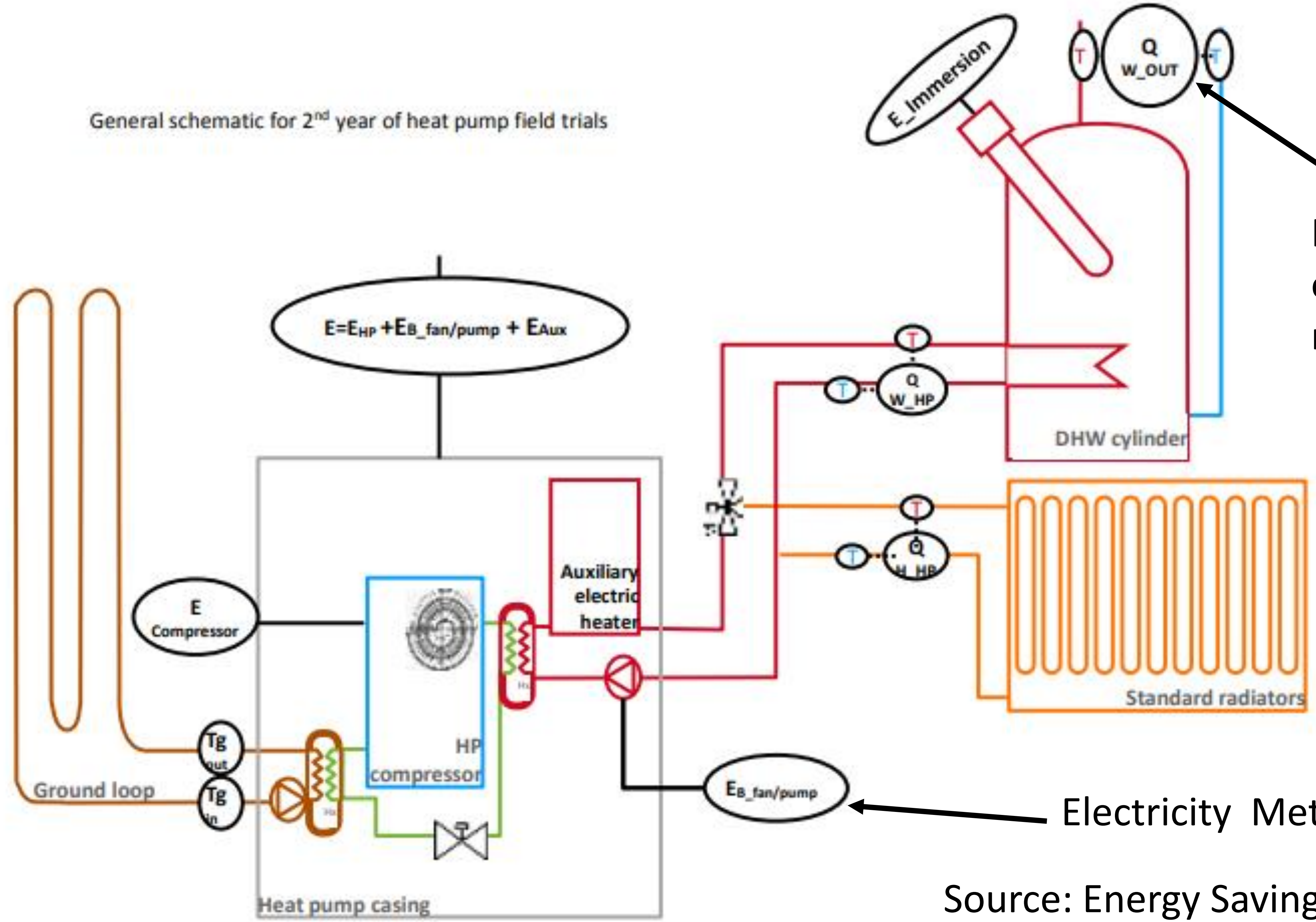
HP4ALL



Heat Meter (Q) on flow and return for ΔT

Electricity Meter (E)

Source: Energy Savings Trust

Previous Projects

UCL Energy Institute in the UK analysed the performance of 318 Air Source Heat Pump installations showed that the median

- SPFH2 for space heating output was 2.74
- SPFH4 for the whole system (incl. Domestic Hot Water) was 2.44.

SEAI Funded FactHP project used 2018 tariffs and estimated the SPFs that must be exceeded for the systems to make

a) CO2 savings and
b) b) Energy Bill Savings.

Fuel	System Efficiency	SPF_{H4} needed For reduction in CO_2 emissions	SPF_{H4} needed For reduction in Cost reduction
Coal	60%	0.53	2.11
Oil	84%	1.02	3.25
LPG	85%	1.30	1.77
Natural Gas	85%	1.50	2.82

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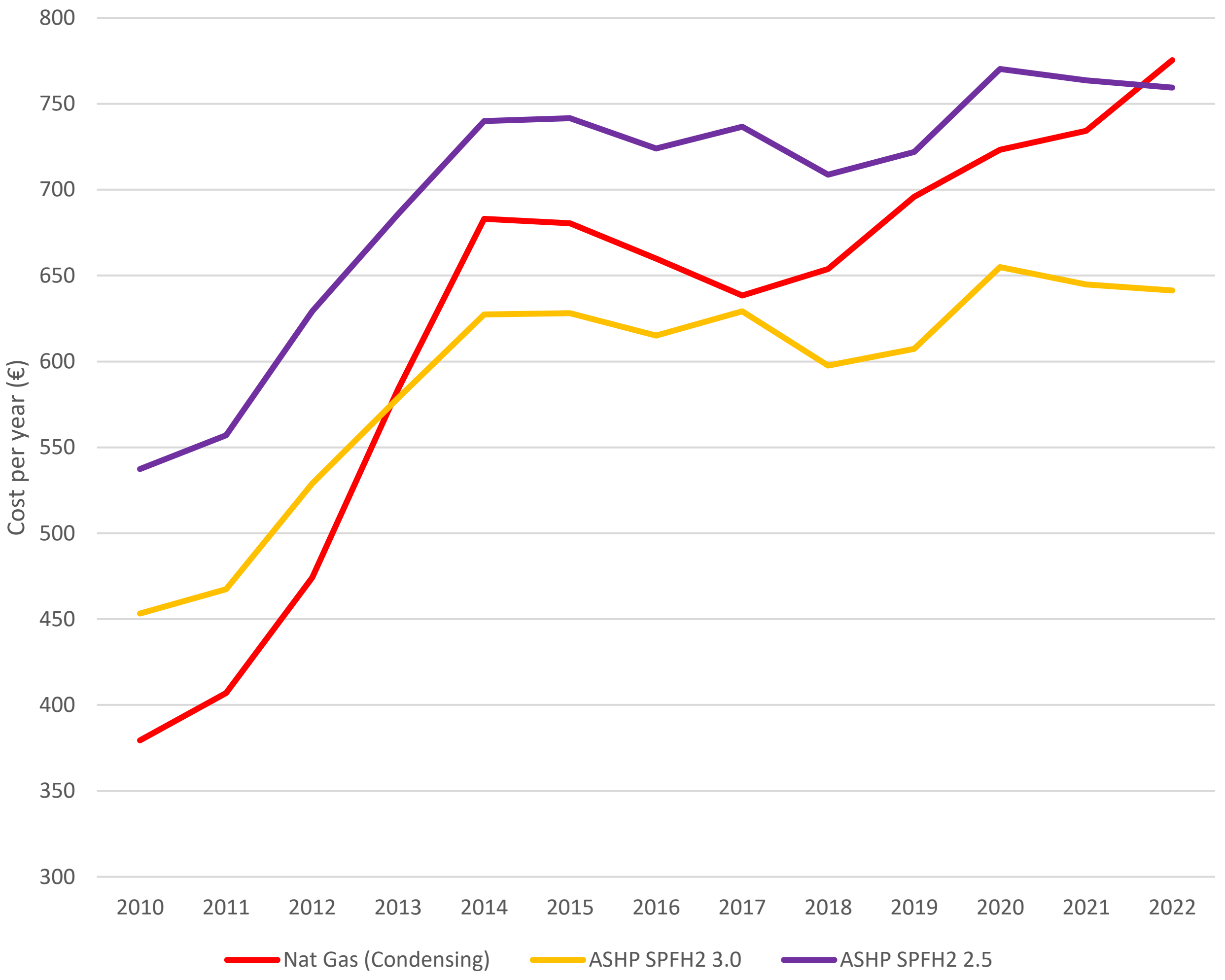
SPF comparison to Condensing Gas Boiler

From our Own analysis on cost comparisons (includes Carbon tax, latest fuel unit costs, and PSO Levy) since 2010:

For a Irish-Average sized (81m2) B2 House with approx. 78% of energy being used for heating and domestic hot water (SEAI, Energy Statistics in Ireland, residential report).

Only as of 2022 is an ASHP with SPFH2 of 2.5 more economical than a new Gas boiler by €15.99 / annum.

Compared to an ASHP with SPFH2 of 3.0 which is €187.35 / annum cheaper!



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SPF comparison to New Oil Boiler

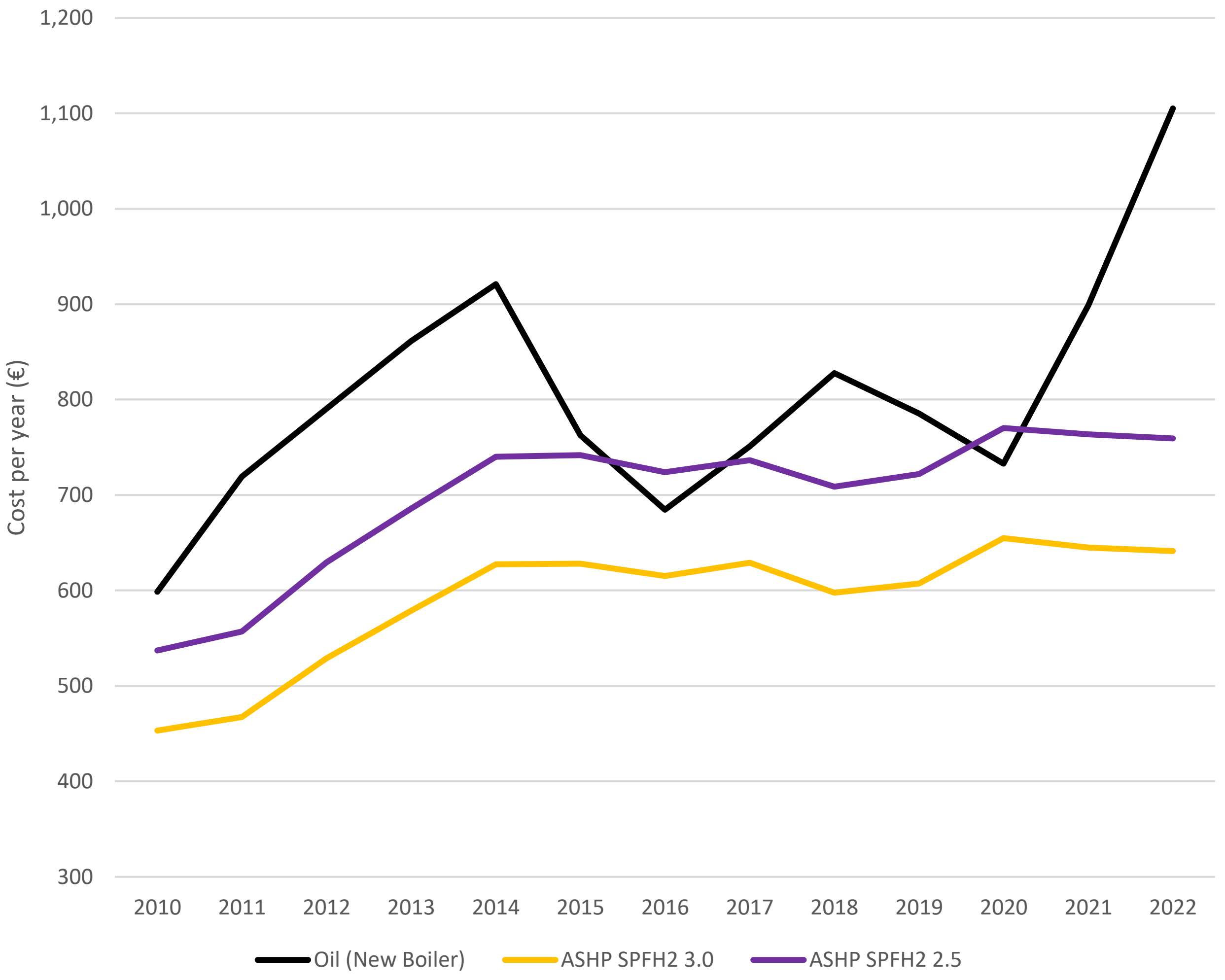
From our Own analysis on cost comparisons (includes Carbon tax, latest fuel unit costs, and PSO Levy) since 2010:

For a Irish-Average sized (81m2) B2 House with approx. 78% of energy being used for heating and domestic hot water (SEAI, Energy Statistics in Ireland, residential report).

Oil prices are problematic to predict as the global market can shift and change based on releasing of reserves.

In Jan 2022, an oil boiler compared to an ASHP with SPFH2 of 3.0

€464 / annum more expensive



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SPF comparison to Condensing LPG Boiler

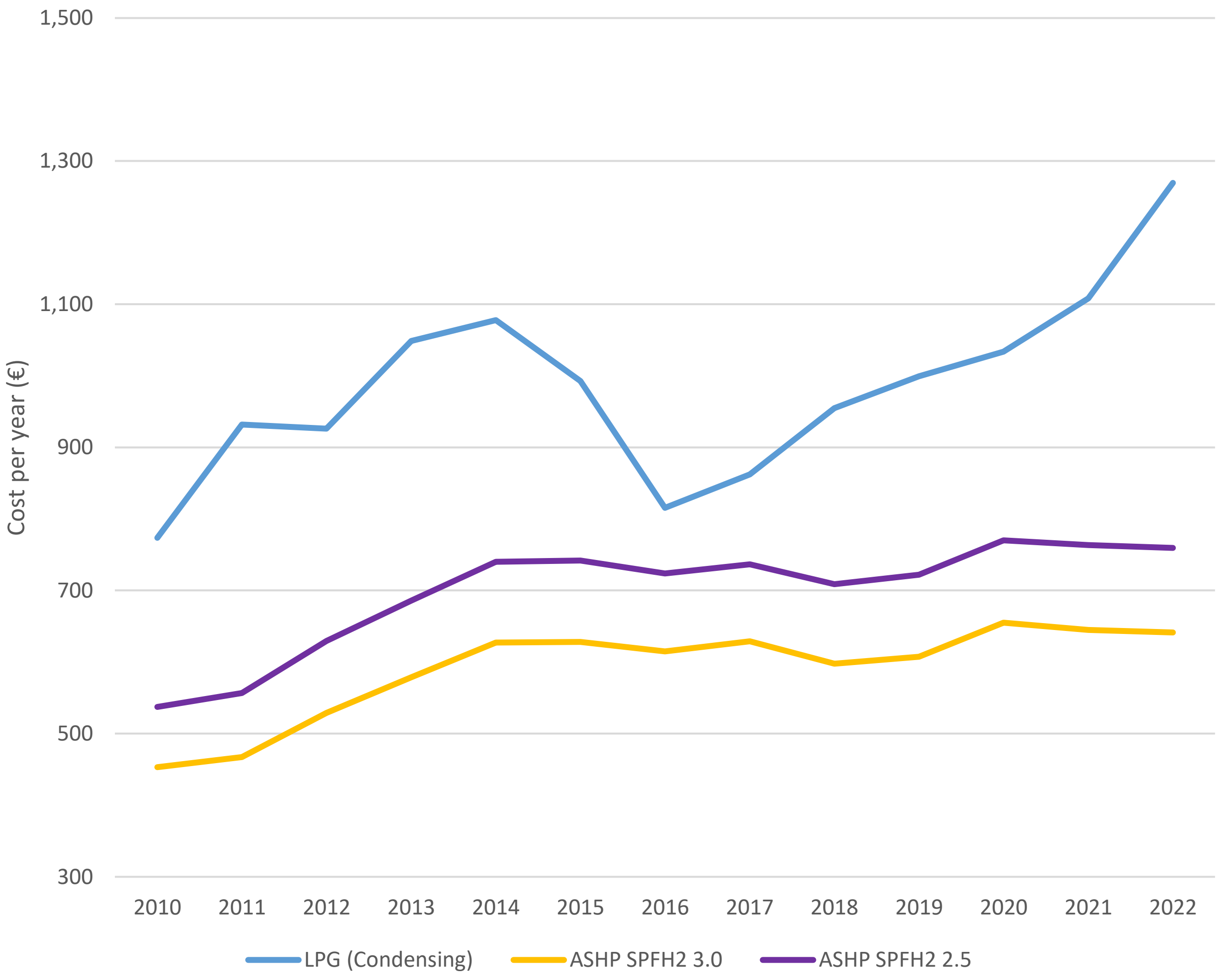
From our Own analysis on cost comparisons (includes Carbon tax, latest fuel unit costs, and PSO Levy) since 2010:

For a Irish-Average sized (81m2) B2 House with approx. 78% of energy being used for heating and domestic hot water (SEAI, Energy Statistics in Ireland, residential report).

LPG is cleaner than oil and as clean as gas but it costs a lot more. Condensing boilers are more efficient than older boilers but the price per unit of LPG means it is never going to be cost effective.

In Jan 2022, a condensing LPG boiler compared to an ASHP with SPFH2 of 3.0

€628 / annum more expensive



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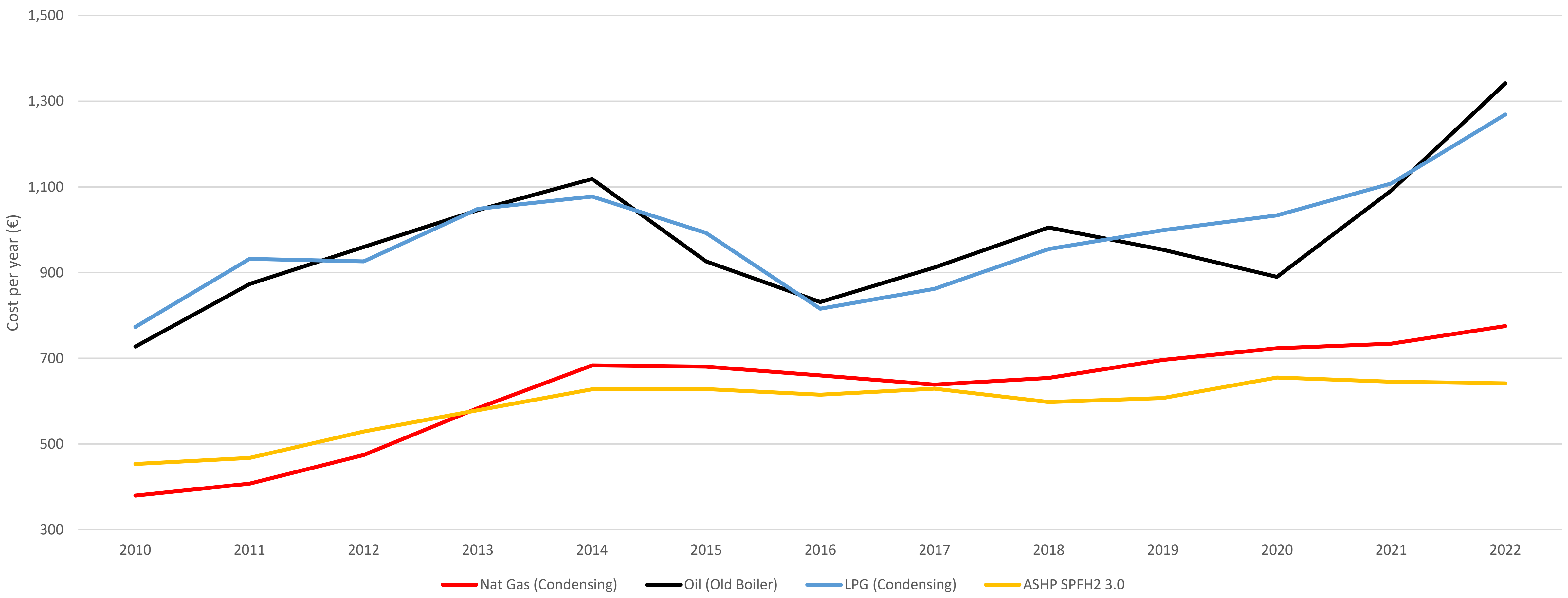
Old Oil Boiler compared to other heating systems



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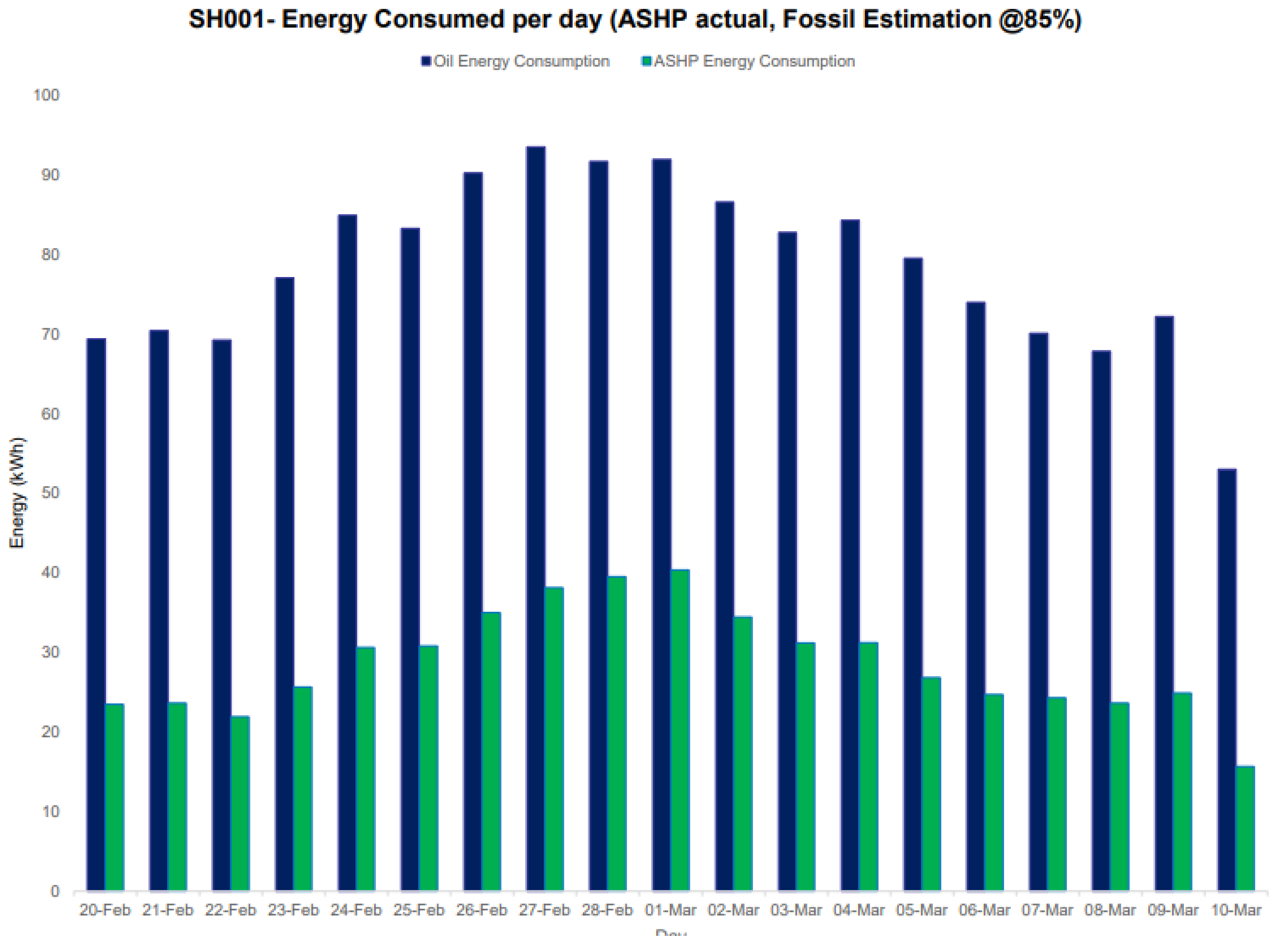
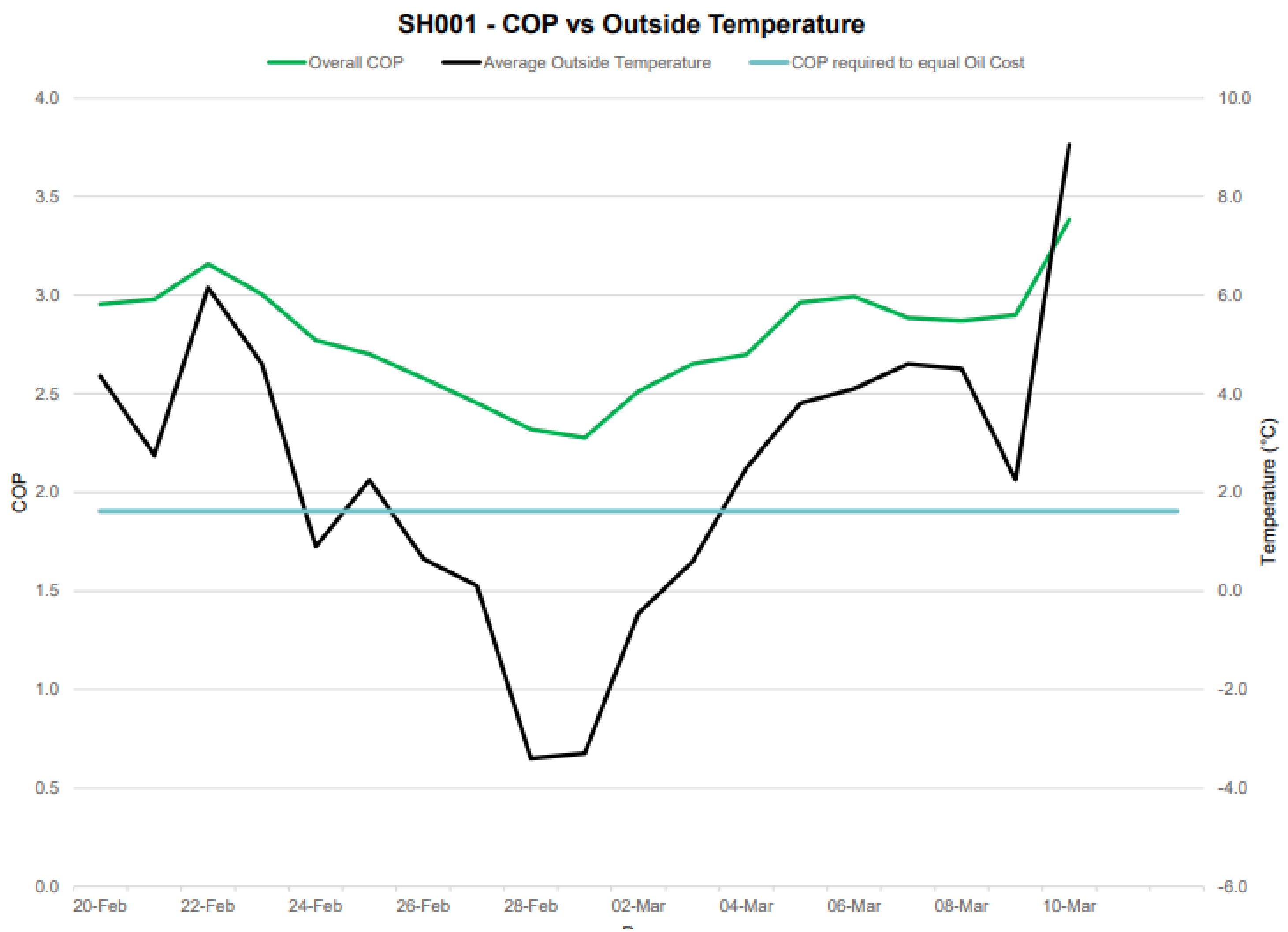
Superhomes 2.0



Superhomes 2.0



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Please provide comments and feedback on LU 1 to LU 6. (This will not be shown on screen)

ⓘ Start presenting to display the poll results on this slide.

LU7 Heat Loss Calculations

Steps for Heat Pump Installations

HP ALL

Step 1 Heat Loss Calculations

- Fabric Heat loss & Ventilation Losses
- Room by Room

Step 2 Heat pump Selection

- Design Parameters
- SCOP and COP

Step 3 Emitters Selection

- Sizing
- System Balancing

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How is your knowledge of heat loss calculations?

ⓘ Start presenting to display the poll results on this slide.

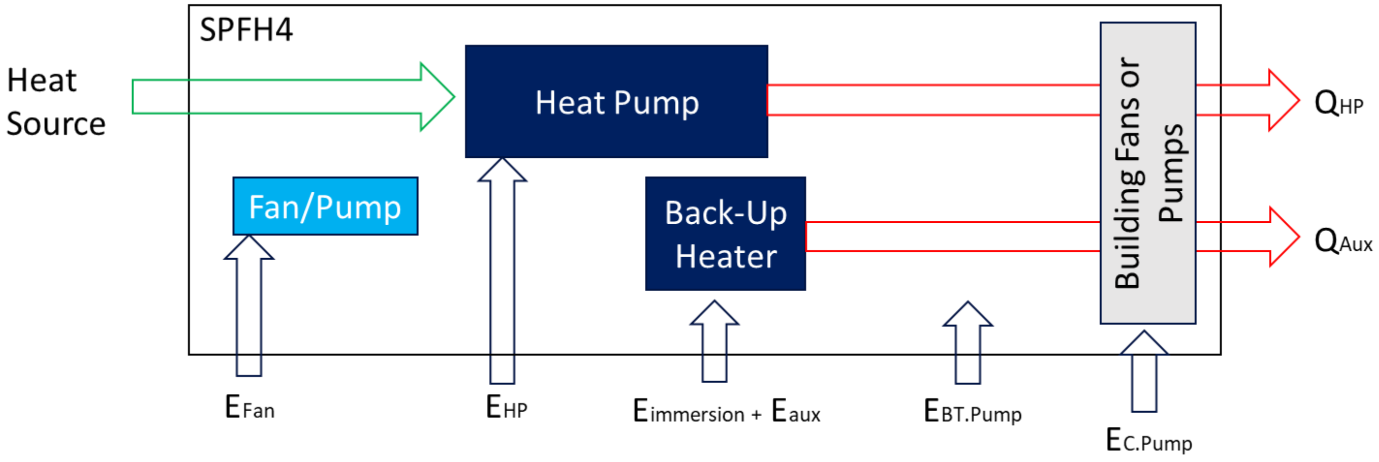
Affects of Heat Pump Sizing

Boilers for heating systems are usually oversized relative to the design heating and hot water load!! Heat pumps are different.

1. **Bigger Heat pumps are more expensive**, Cost proportional to capacity.

2. **An oversized heat pump will**:
   a) Low COP
   b) High compressor Cycling (shorter life)

3. **An undersized Heat pump will**:
   a) Not be able to heat the home
   b) Not be able to provide DHW



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Heat Pump Capacity Sizing

Carefully consider for domestic buildings:

- Room by room heat loss calculations (SEAI Tool or BER assessor Tool)
- Background ventilation (not purge)
- Interior temperature
- allowance for DHW
- Design flow temperature 45 to 55.
- Split Vs Mono is site specific. Mono is easier to install, and neater, splits offer versatility.

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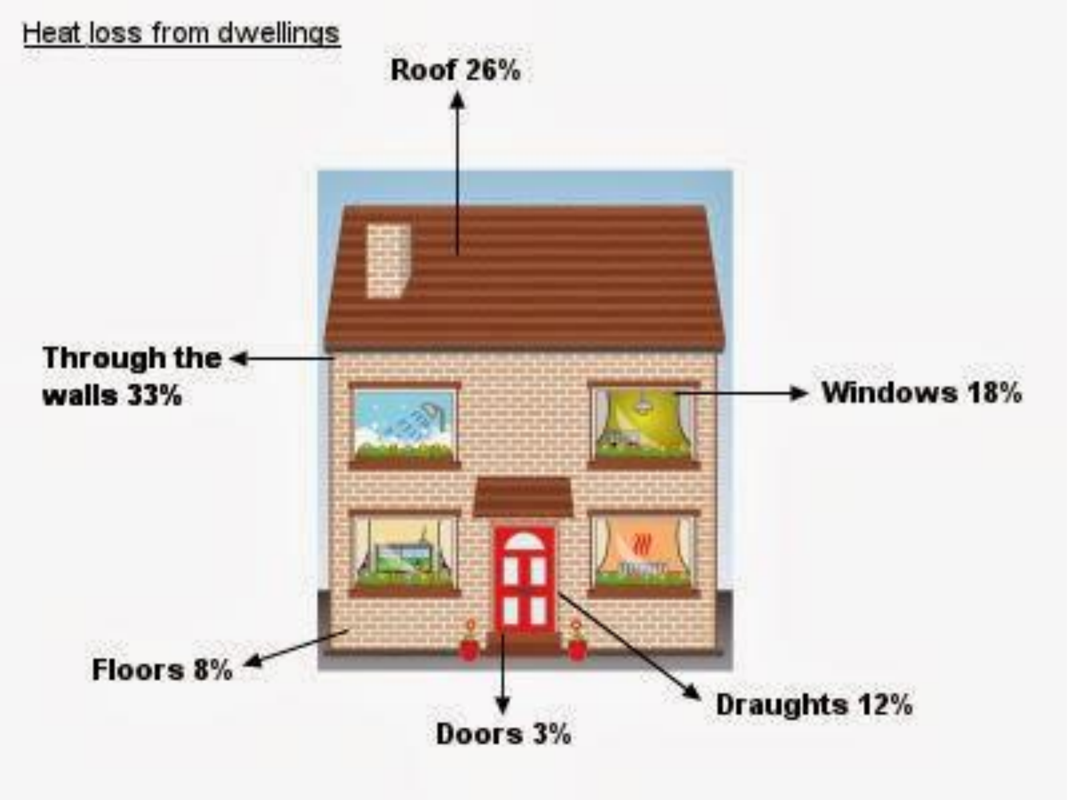
Fabric Heat Loss Calculations

Fabric heat losses are losses directly through the walls, windows, doors, floors and ceiling of the room (assumed that these losses are at a uniform rate).

Fabric Heat Loss (Watts) =
[Area (m^2)] x [‘U’ Value ($W/m^2x°C$)] x [ΔT (°C)]

The ‘U’ value of a material can be found from the manufacturer or from tables such as that **TGD Part L Appendix B**

Fabric First Approach is important as you can lower the heat loss of the building to levels that suit a heat pump



Source: Architectural Technology

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TGD Part L Appendix B (p76 – p94)

Table D1	Section 1 - Cavity Wall Insulation	Target U-values		
Junction detail Identifier 2011 Edition	Junction detail	U-value = 0.18 W/m²K, 150mm full-fill or partial fill cavity[1, 3] (roof U = 0.16) (floor U = 0.18)	U-value = 0.15 W/m²K, 150mm full-fill or partial fill cavity and internal insulation[2, 3] (roof U = 0.14) (floor U = 0.15)	U-value = 0.15 W/m²K, 200mm full-fill or partial fill cavity[2, 3] (roof U = 0.14) (floor U = 0.15)
		ψ-value (W/mK)	ψ-value (W/mK)	ψ-value (W/mK)
Section 1	**Details**			
1.01a	Ground Floor - Insulation above slab	0.170	0.072	0.196
1.01b	Ground Floor - Insulation above slab plus lightweight block	0.080	0.042	0.093
1.02a	Ground Floor - Insulation below slab	0.163	0.108	0.191
1.02b	Ground Floor - Insulation below slab plus lightweight block	0.070	0.061	0.083
1.03	Timber Suspended Ground Floor	0.219	0.102	0.227
1.04	Concrete Intermediate Floor within a dwelling	0.000	0.039	0.000
1.04a	Concrete Separating Floor between dwellings[6]	0.064	0.087	0.045
1.05	Timber Intermediate Floor within a dwelling	-0.001	0.020	-0.001
1.05a	Timber Separating Floor between dwellings[6]	0.041	0.051	0.029
1.06.1	Masonry Solid Separating Wall (plan)[6]	0.045	0.066	0.032
1.06.2	Masonry Cavity Separating Wall (plan)[6]	0.051	0.072	0.036
1.07	Masonry Partition Wall	0.000	0.000	0.000
1.08	Stud Partition Wall	0.000	0.000	0.000

Table D4	Section 4 - Timber Frame Construction	Target U-values	
Junction detail Identifier 2011 Edition	Junction detail	U-value = 0.18 Wm²K. Insulation between studs[1, 3] (roof U = 0.16) (floor U = 0.18)	U-value = 0.15 Wm²K. Insulation between studs and internal Insulation[2, 3] (roof U = 0.14) (floor U = 0.15)
		ψ-value (W/mK)	ψ-value (W/mK)
Section 4	**Details**		
4.01	Ground Floor - Insulation above slab	0.051	0.021
4.02	Ground Floor - Insulation below slab	0.205	0.125
4.03	Timber Suspended Ground Floor	0.063	0.046
4.04.1	Corner	0.062	0.030
4.04.2	Inverted corner	-0.004	-0.015
4.05	Timber Intermediate Floor within a dwelling	0.130	0.080
4.05a	Timber Separating floor between dwellings[6]	0.193	0.132
4.06	Separating Wall (plan)[6]	0.087	0.079
4.07	Separating Wall (section)[6]	0.236	0.236
4.08	Partition Wall	0.000	0.000
4.09/4.10	Eaves – Unventilated/Ventilated roof space	0.082	0.044

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Fabric heat loss calculation (An example using the SEAI Heat Loss Tool)

https://berassessors.com/wp-content/uploads/2020/05/MIKE-TEAHAN-VER.-SR50-Heat-Loss-Calculations.xlsx

https://www.seai.ie/publications/HPAI%20Heat%20Pump%20Code%20of%20Practice

https://www.seai.ie/tools/SEAI-Room-Heat-Loss-and-Radiator-Sizing-Guidance.xlsx

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Heat loss calculation (Room by Room)

We will start with the design parameters for a living area

Living areas i.e. – sitting room, dining room, play room: 18-21°C

Other areas i.e. – kitchen, hall, toilet, bedrooms: 16-18°C

Bathrooms (with shower): 22°C. [Due to high ventilation rates]

Design Room Temp	21
External Design Temp	-3
Design Temp Difference	24

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Fabric heat loss calculation (Room by Room)

Fabric Heat Loss	Length (m)	Width (m)	Height (m)		Area (m^2)	U-Value ($W/m^2.K$)	Design Temp Diff °C	Heat Loss (Watts)
External Floor	4.9	2.7			13.23	0.77	24	244.4904
External Wall (Gross area)	7.6		2.4		18.24			
Window		1.1	1.05		1.155	1.6	24	44.352
Window		1.1	1.05		1.155	1.6	24	44.352
External Door		1.75	2.1		3.675	1.6	24	141.12
External Wall (Nett area)	(Subtract glazing and door areas from gross external wall area)				12.255	0.27	24	79.4124
External Roof (Gross area)	0	0			0			
Rooflights		0		0	0	0	24	0
External Roof (Nett area)	(Subtract roof glazing area from gross roof area)				0	0	24	0.000
Party Wall Adjoining unheated space	2.7			2.4	6.48	1.02	11	72.706
Total	-	-		-	-	-	-	**626.432**

Ventilation Loss calculation

Ventilation Heat Loss	No. of air changes per hour ac/h	Room Volume (meters)			Amount of air to be heated per hour m^3/h	Air change factor $W/m^3.K$	Design Temp Diff ºC	Heat Loss Watts
		Length (m)	Width (m)	Height (m)				
	1.5	4.9	2.7	2.4	47.628	0.33	24	377.21376
Additional air changes due to Chimneys or Flues	3	For additional air changes see table in section 2.2. Ventilation Heat Loss			95.256	0.33	24	754.42752
TOTAL								

The difference between the inside temperature and OAT and the rate at which the air enters and leaves the building will affect the ventilation heat loss.

Rate of Heat Loss = V * N * ΔT * 0.33

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CIBSE Guide A – Environmental Design

Building/room type	Winter operative temp. range for stated activity and clothing levels*			Summer operative temp. range (air conditioned buildings†) for stated activity and clothing levels*			Suggested air supply rate / (L.s^{-1} per person) unless stated otherwise	Filtration grade‡	Maintained illuminance¶ / lux	Noise rating§ (NR)
	Temp. / °C	Activity / met	Clothing / clo	Temp. / °C	Activity / met	Clothing / clo				
Airport terminals:										
— baggage reclaim	12–19[1]	1.8	1.15	21–25[1]	1.8	0.65	10[2]	F6–F7	200	45
— check-in areas[3]	18–20	1.4	1.15	21–23	1.4	0.65	10[2]	F6–F7	500[4]	45
— concourse (no seats)	19–24[1]	1.8	1.15	21–25[1]	1.8	0.65	10[2]	F6–F7	200	45
— customs area	18–20	1.4	1.15	21–23	1.4	0.65	10[2]	F6–F7	500	45
— departure lounge	19–21	1.3	1.15	22–24	1.3	0.65	10[2]	F6–F7	200	40
Art galleries — see *Museums and art galleries*										
Banks, building societies, post offices:										
— counters	19–21	1.4	1.0	21–23	1.4	0.65	10[2]	F6–F7	500	35–40
— public areas	19–21	1.4	1.0	21–23	1.4	0.65	10[2]	F5–F7	300	35–45
Bars/lounges	20–22	1.3	1.0	22–24	1.3	0.65	10[2]	F5–F7	100–200[5]	30–40
Bus/coach stations — see *Railway/coach stations*										
Churches	19–21	1.3	1.15	22–24	1.3	0.65	10[2]	G4–F6	100–200	25–30
Computer rooms[6]	19–21	1.4	1.0	21–23	1.4	0.65	10[2]	F7–F9	300	35–45
Conference/board rooms	22–23	1.1	1.0	23–25	1.1	0.65	10[2]	F6–F7	300/500[7]	25–30
Drawing offices	19–21	1.4	1.0	21–23	1.4	0.65	10[2]	F7	750	35–45
Dwellings:										
— bathrooms	20–22	1.2	0.25	23–25	1.2	0.25	15 L·s^{-1}	G2–G4 (extract)[8]	150[4]	—
— bedrooms	17–19	0.9	2.5	23–25	0.9	1.2	0.4–1 ACH to control moisture[8]	G2–G4	100[4]	25
— hall/stairs/landings	19–24[1]	1.8	0.75	21–25[1]	1.8	0.65	—	—	100	—
— kitchen	17–19	1.6	1.0	21–23	1.6	0.65	60 L·s^{-1}	G2–G4 (extract)[8]	150–300	40–45
— living rooms	22–23	1.1	1.0	23–25	1.1	0.65	0.4–1 ACH to control moisture[8]	G2–G4	50–300	30
— toilets	19–21	1.4	1.0	21–23	1.4	0.65	> 5 ACH	G2–G4	100[4]	—
Educational buildings:										
— lecture halls[9]	19–21	1.4	1.0	21–23	1.4	0.65	10[2]	G4–G5	500[10]	25–35
— seminar rooms	19–21	1.4	1.0	21–23	1.4	0.65	10[2]	G4–G5	300[10]	25–35
— teaching spaces[9]	19–21	1.4	1.0	21–23	1.4	0.65	10[2]	G4–G5	300[10]	25–35

For a Kitchen with Volume 100m3
[1 m3 of Air = 1000 L of Air]
[1 seconds = 1/3600 Hours]

Equation 1: (60 L/s) / (1000 L / m3) = 0.06 m3 / s

Equation 2: 0.06 x 3600 (hours / seconds) = 216 m3 / h

Equation 3: 216 / 100 = 2.16 Air Changes per hour

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LU8 Heat Pump Design Parameters & Pipe Sizing

Steps for Heat Pump Installations

HP ALL

Step 1 Heat Loss Calculations

- Fabric Heat loss & Ventilation Losses
- Room by Room

Step 2 Heat pump Selection

- Design Parameters
- SCOP and COP

Step 3 Emitters Selection

- Sizing
- System Balancing

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Affects of Heat Pump Sizing

Boilers for heating systems are usually oversized relative to the design heating and hot water load!! Heat pumps are different.

1. **Bigger Heat pumps are more expensive**, Cost proportional to capacity.

2. **When dT is too low the heat pump may be oversized and will lead to:**
   a) Reduced COP
   b) High compressor Cycling (EN15450 suggest a target maximum of three compressor starts per hour.)
   c) Burn out, reduced lifespan

3. **When dT is too High the heat pump may be undersized and will lead to:**
   a) may not maintain the required comfort levels in the building during cold weather
   b) Not be able to provide DHW
   c) Increased Defrost events

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Heat Pump vs Traditional Boiler

HP ALL

Heat Pump	Traditional Boiler	Comments
Operates on Electricity	Operates on Fossil Fuel	A heat pump isn't reliant on Oil/LPG deliveries, nor does it need to be on the Gas network.
Low Flow Temperature	High Flow Temperature	Heat Pumps usually Operate around 45°C for heating only and 55°C for DHW production. Boilers operate above 65°C
Low Temperature difference (45/40°C)	High Temperature difference (75/65°C)	A heat pump operates at ΔT5 (ΔT8 in England). i.e. manufacturer's requirement is a nominal 5°C ΔT across the condenser A boiler will operate above ΔT8 (usually ΔT10 or ΔT15) which works for radiators very well.
300% - 500% Efficient	90%-95% efficient	For every 1 unit of electricity, the heat pump will produce 3 to 5 units of heat.
€8,000 - €18,000	€3000 on average	There is a SEAI grant of €6,000 for heat pumps available. The prices include installation fees. All depends on the level of works required to create a heat pump friendly system.

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Design Flow & OAT Temperatures

HP4ALL

When designing an air source heat pump it is important to consider:

1. The output of the system will vary with the OAT (colder heat source, higher thermal lift)
2. Lowest OAT (design conditions)
3. SCOP = Seasonal COP is the Average COP over a year at a design flow temperature.
4. Heat Pump operation range: Manufacturer specific (Daikin Altherma, -20°C)

ASHP design heating outputs are usually given by ‘A2/W35’ or ‘A7/W35’ meaning air at 2 °C or 7 °C, water flow temperature at 35 °C

OUTDOOR UNIT		PUZ-WM60VAA(-BS)
HEAT PUMP SPACE HEATER - 55˚C	ErP Rating	A++
	η_s	142%
	SCOP (MCS)	3.56
HEAT PUMP SPACE HEATER - 35˚C	ErP Rating	A+++
	η_s	190%
	SCOP (MCS)	4.76
HEAT PUMP COMBINATION HEATER - Large Profile*1	ErP Rating	A+
	η_{wh}	145%
HEATING*2 (A-7/W35)	Capacity (kW)	6.0
	Power Input (kW)	1.88
	COP	3.20

Source: Mitsubishi ECODAN

Item	Symbol	Value	Unit	Item	Symbol	Value	Unit
Rated Heat Output (*)	Prated	4.5	kW	Seasonal space heating energy efficiency	ηs	132	%
Declared capacity for heating for part load at indoor Temperature 20°C and outdoor temperature Tj				Declared coefficient of performance or primary energy ratio for part load at indoor temperature 20°C and outdoor temperature Tj			
Tj = -7°C	*Pdh*	5.03	kW	Tj = -7°C	*COPd*	2.11	-
Degradation co-efficient (**)	*Cdh*	0.99	-				
Tj = +2°C	*Pdh*	3.21	kW	Tj = +2°C	*COPd*	4.03	-
Degradation co-efficient (**)	*Cdh*	0.99	-				
Tj = +7°C	*Pdh*	2.20	kW	Tj = +7°C	*COPd*	5.10	-
Degradation co-efficient (**)	*Cdh*	0.98	-				

Source: Grant Aerona, 55 Deg C. Flow temp

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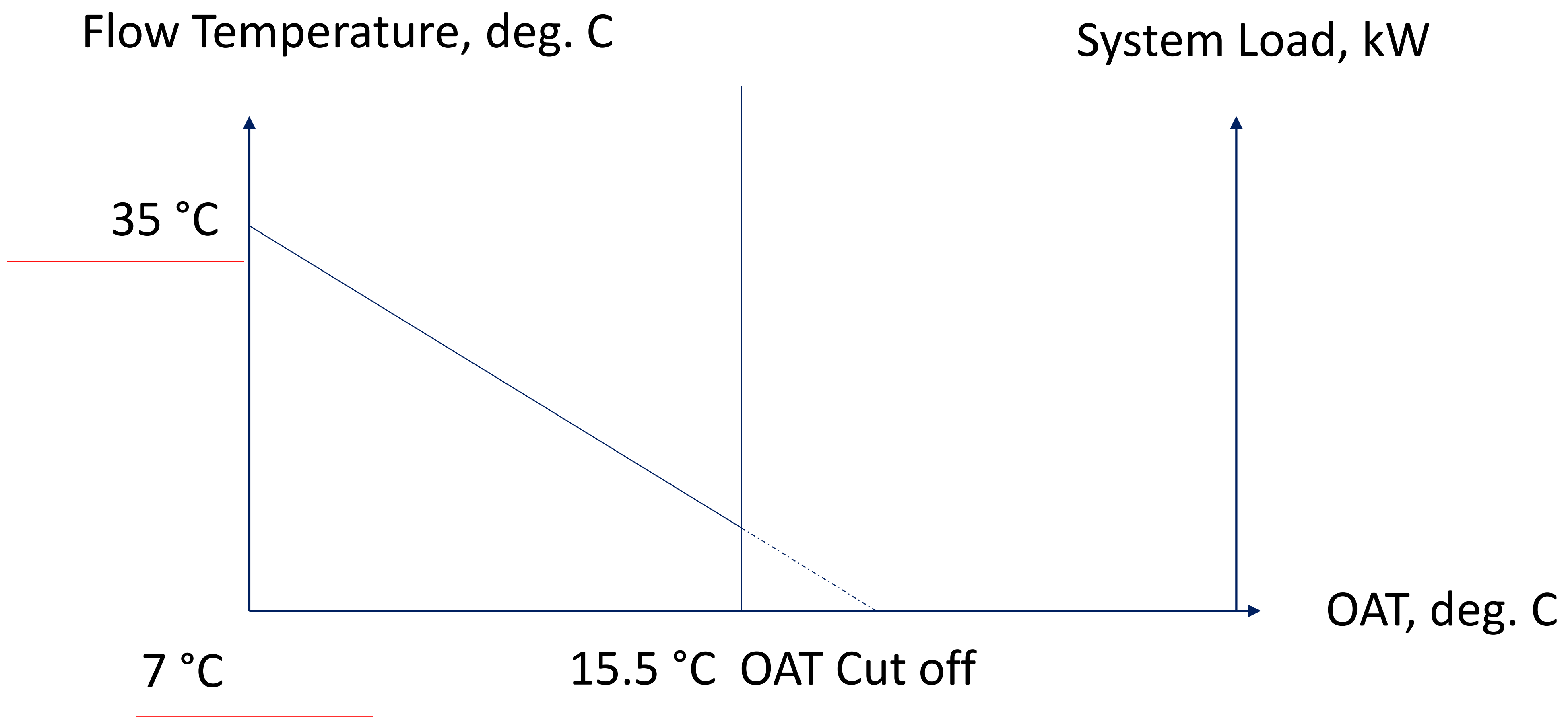
Demand Curve (flow temperature)



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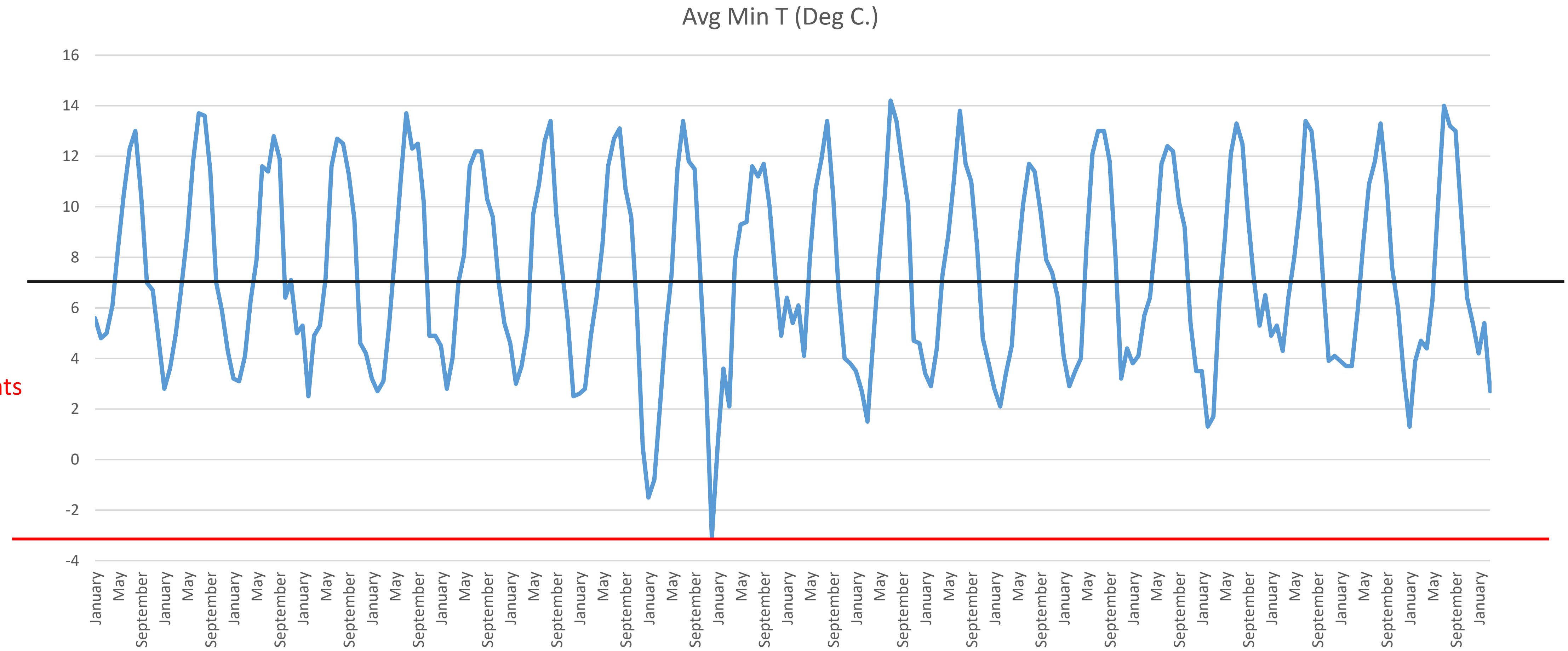
Outside Air Temperature – Avg. Minimum

Say we take the Average Minimum Temperature of each month for 2002 to 2022 for Shannon Airport…

7 °C

48% Datapoints under 7 °C.

-3 °C December 2010



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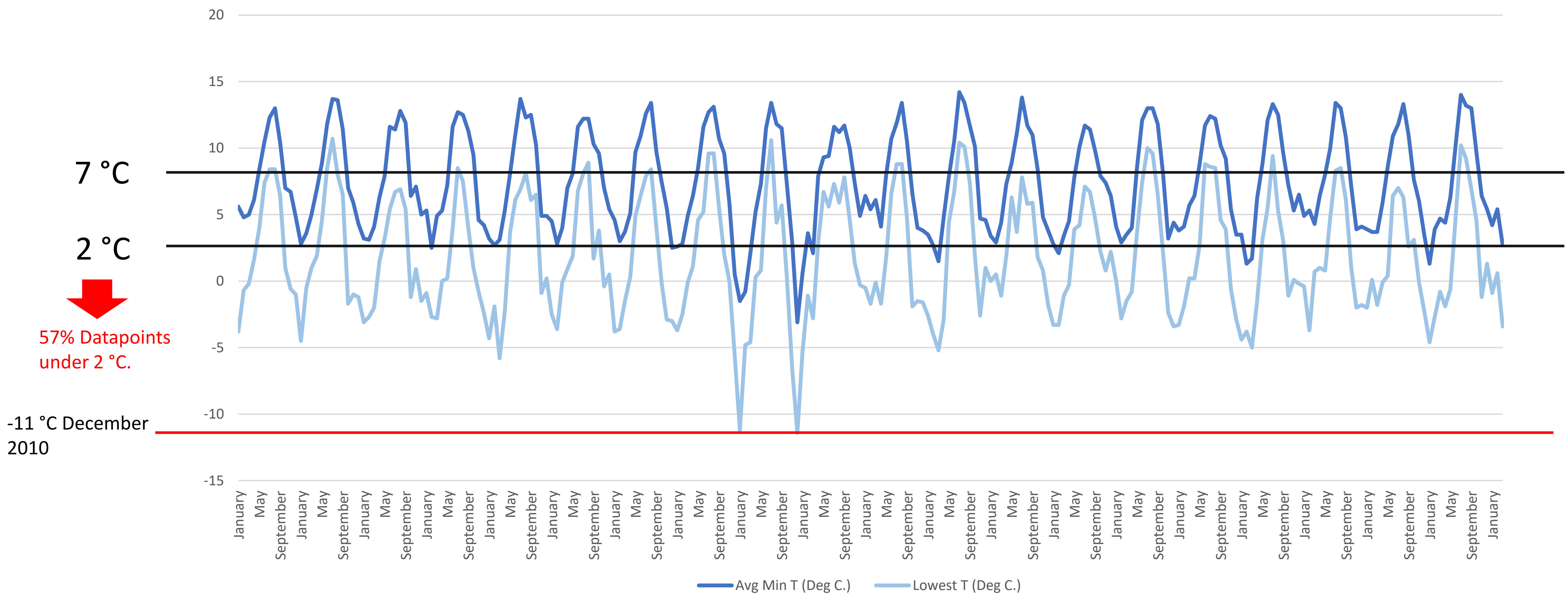
Outside Air Temperature – Lowest Recorded temperatures

Say we take the lowest Temperature of each month for 2002 to 2022 for Shannon Airport…



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Design Outside Temperature – Check

Option 1: CISBSE Guide A provides a method that uses either a 24-hour or a 48-hour mean temperature and then carrying out a risk analysis of the likelihood of the design outside temperature being exceeded. (Section 2.3 Winter Design Temperatures)

Option 2: Check using Heating Degree Days (degreedays.net), and use design temperature as base temperature.

Example:

In the last 12 months, there have been no heating degree days with a base temperature of -4°C

There have been 156.6 heating degree days, at base temperature 7°C, in the last 12 months

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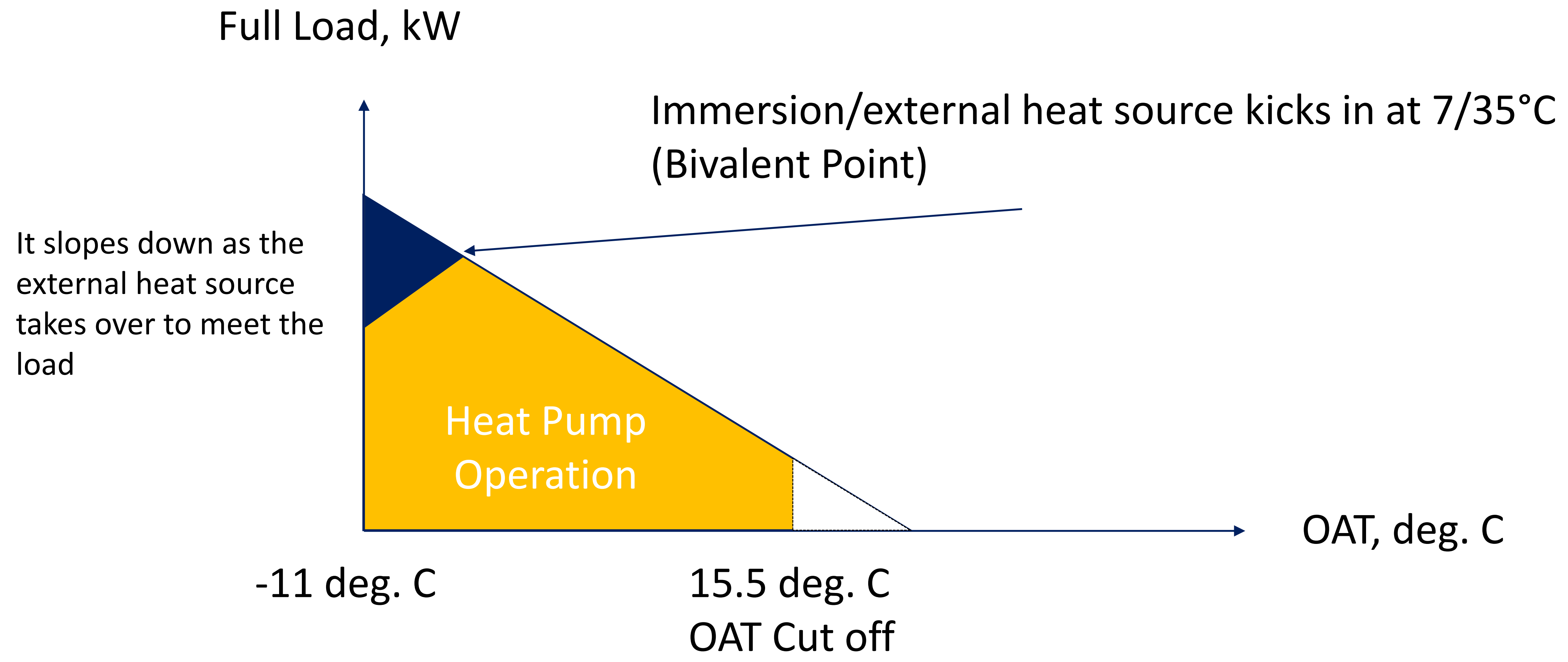
Heat Pump and Immersion



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Immersion vs Heat Pump Cost

HP ALL

They are a bit like giant kettles in that a conductive element is used to heat the water and an electric Kettle is ~80% efficient.

So say for 50L of water to be heated to 45°C from the Cold water feed (5 °C)

50L x 4.2 x (45-5) = 8.4 kW of heat required

Heat Pump @ COP 2.1 (very poor COP)
4 kW electrical input @ 28c per kWh = €1.12 after an hour

Immersion @ 90% efficiency
9.3 kW electrical input @ 28c per kWh = €2.6 after an hour

We want to reduce or remove the amount of time the immersion is used

When your Mam realises you've left the immersion on

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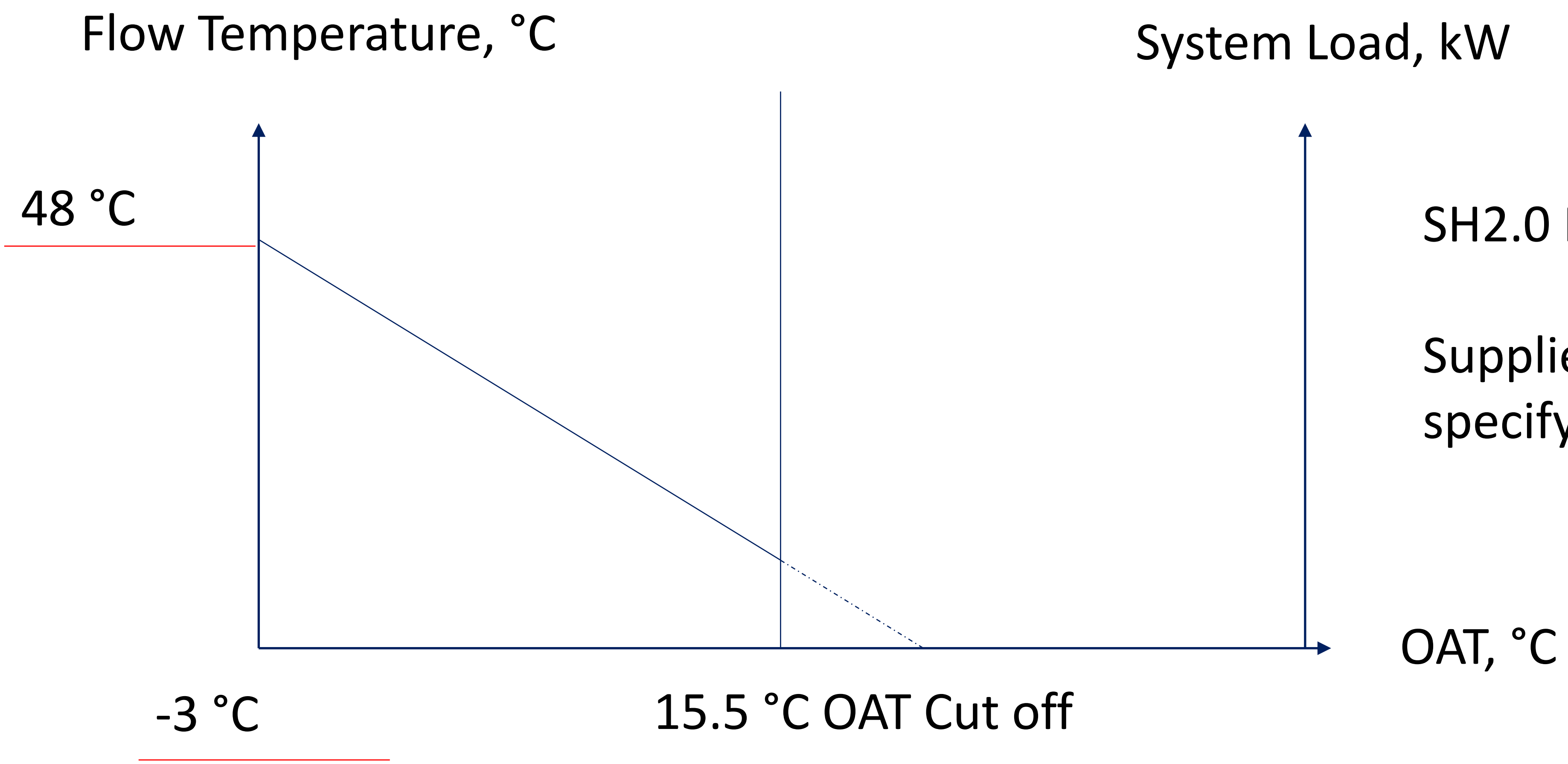
Optimal Design Flow & OAT Temperatures



SH2.0 Project: Suggest -3/48

Supplier or Designer will specify

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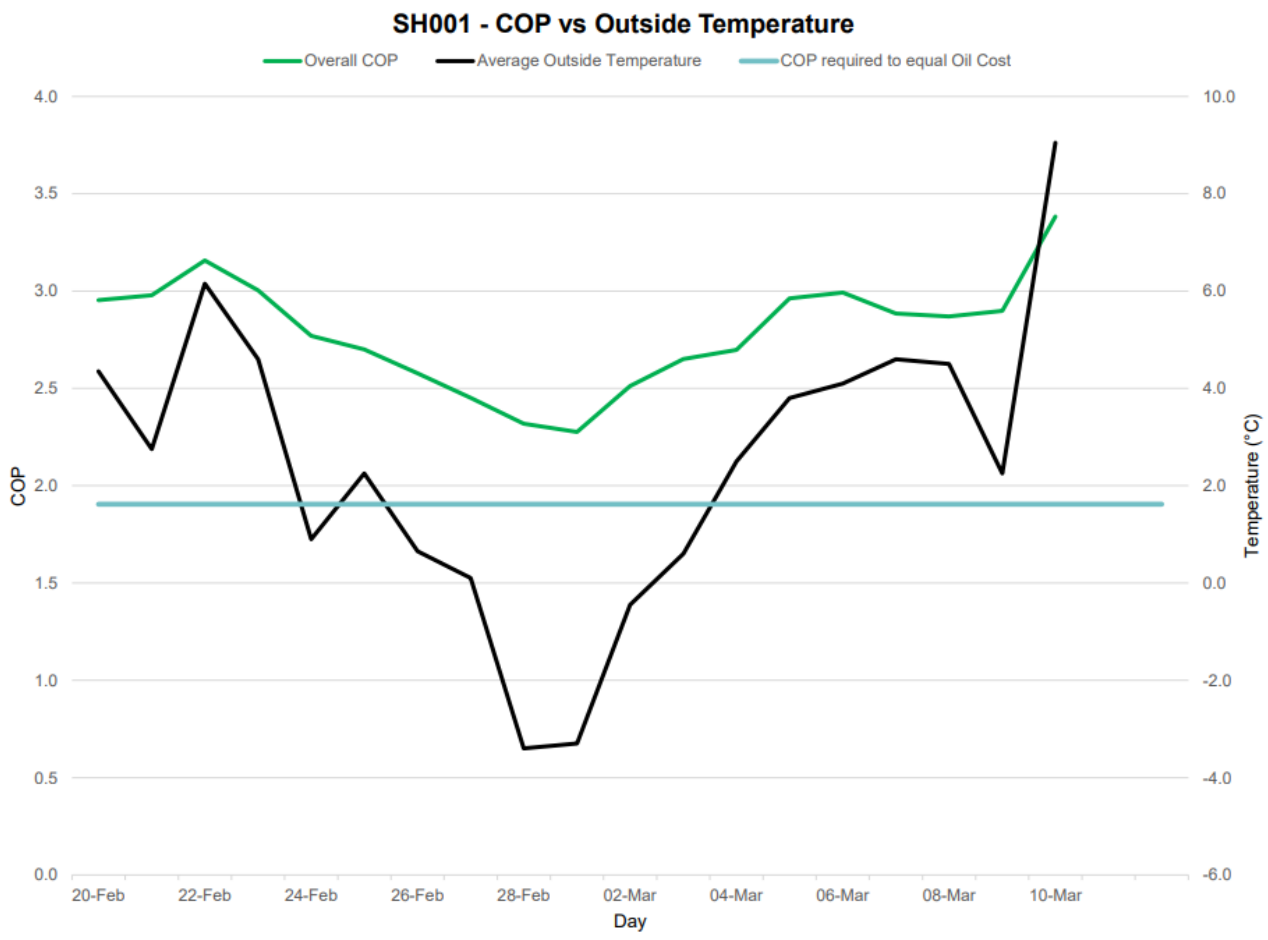
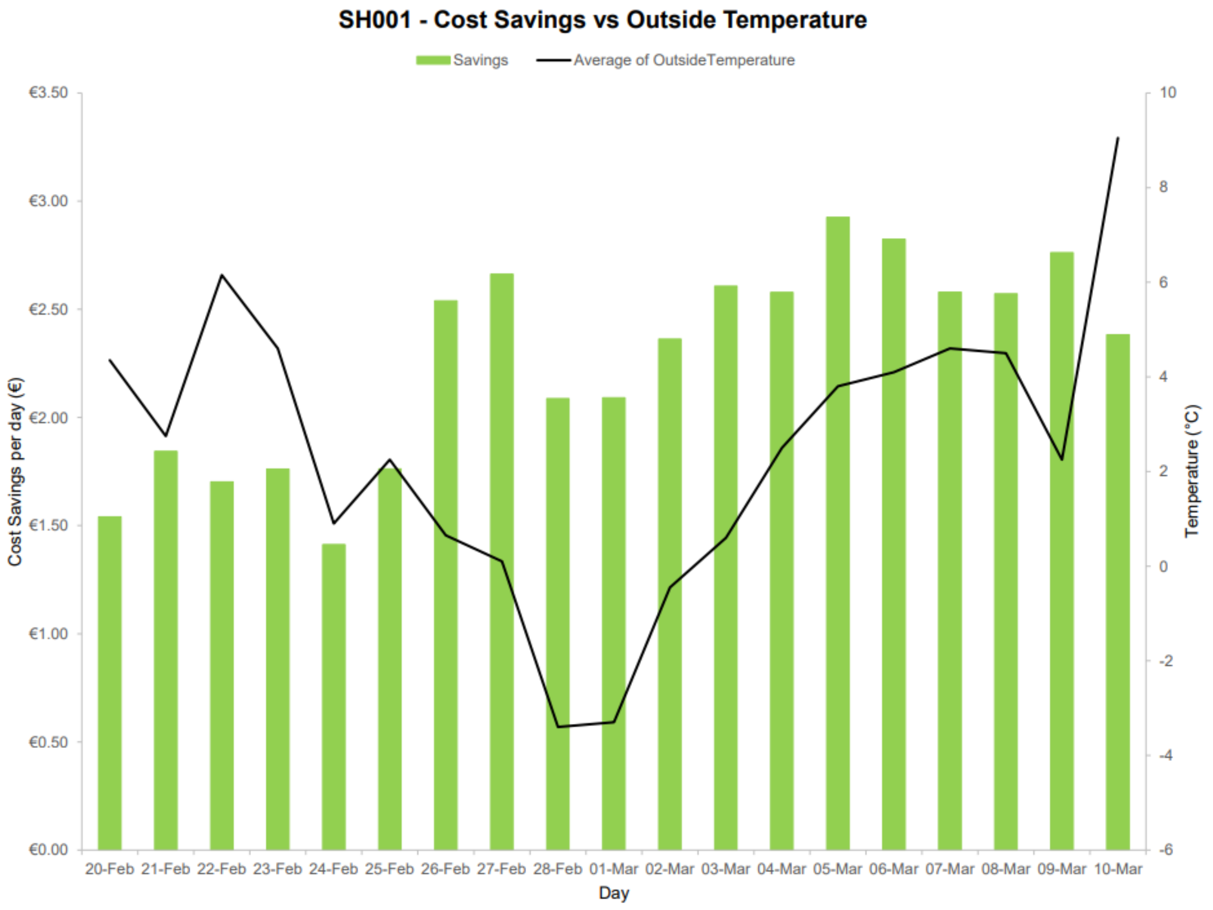
OAT vs COP





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Nominal Flow rate and ΔT

The nominal heat pump flow rate varies but the main goal is to have a ΔT at the condenser of 5°C meanwhile the designed ΔT for radiators is 10°C.

Meaning the flowrate through the condenser will be double that of the radiator circuit.

Manufacturers suggests that designers allow for systems to operate with condenser ΔT in the range 5-8°C.

There is some evidence that suggests ΔT above 5-10°C will lead to lower heating system mean water temperature (MWT) that will lead to lower emission system's output, increasing cycling and unable to reach room target temperature.

If flow rate through the heat pump is too high leading to ΔT <5°C, a reduction in potential COP can be expected

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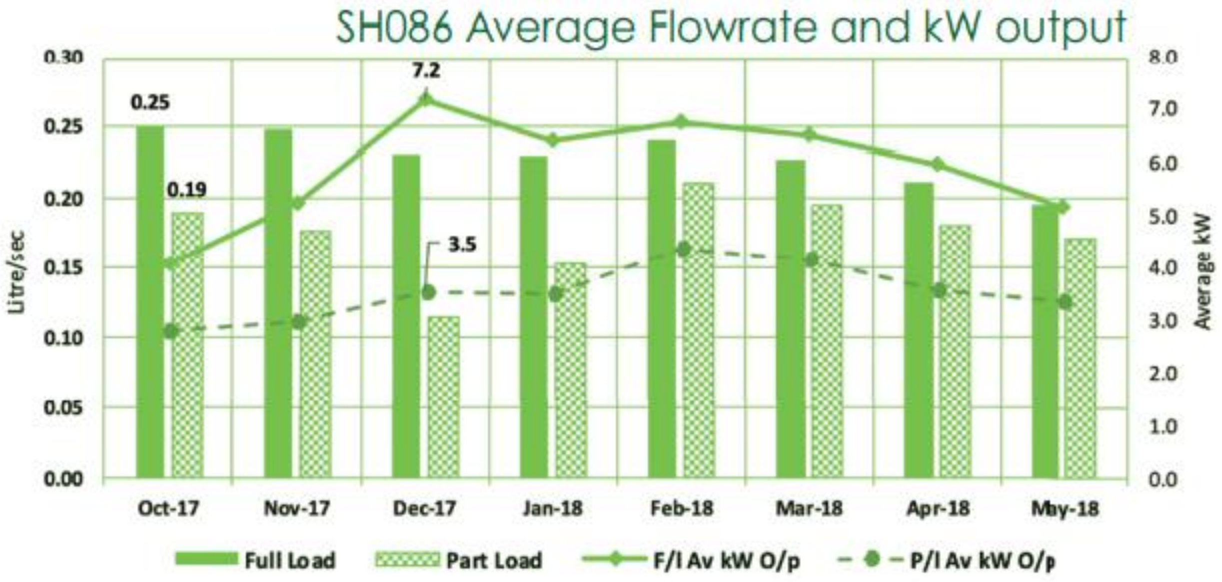
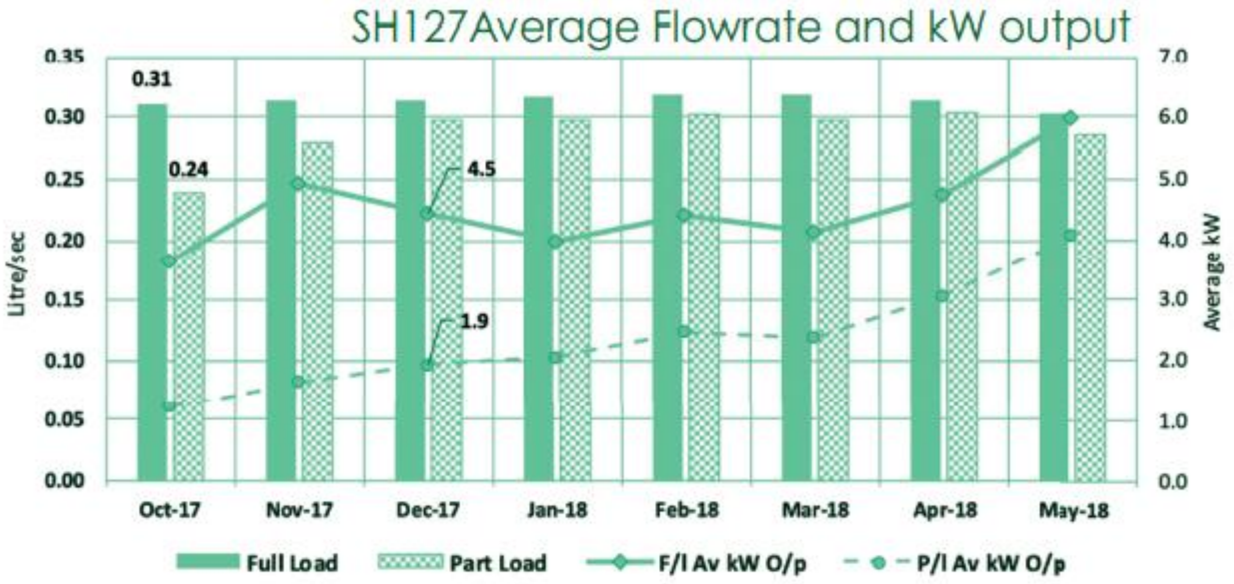
Average Flow Rate and kW Output





This is the Heat Pump flowrates for full and part load.

For the radiator systems, the ideal flow rates would be half the heat pump flow rates as the ideal radiator flow/return ΔT is 10°C as opposed to 5°C for the heat pump.

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ΔT & COP

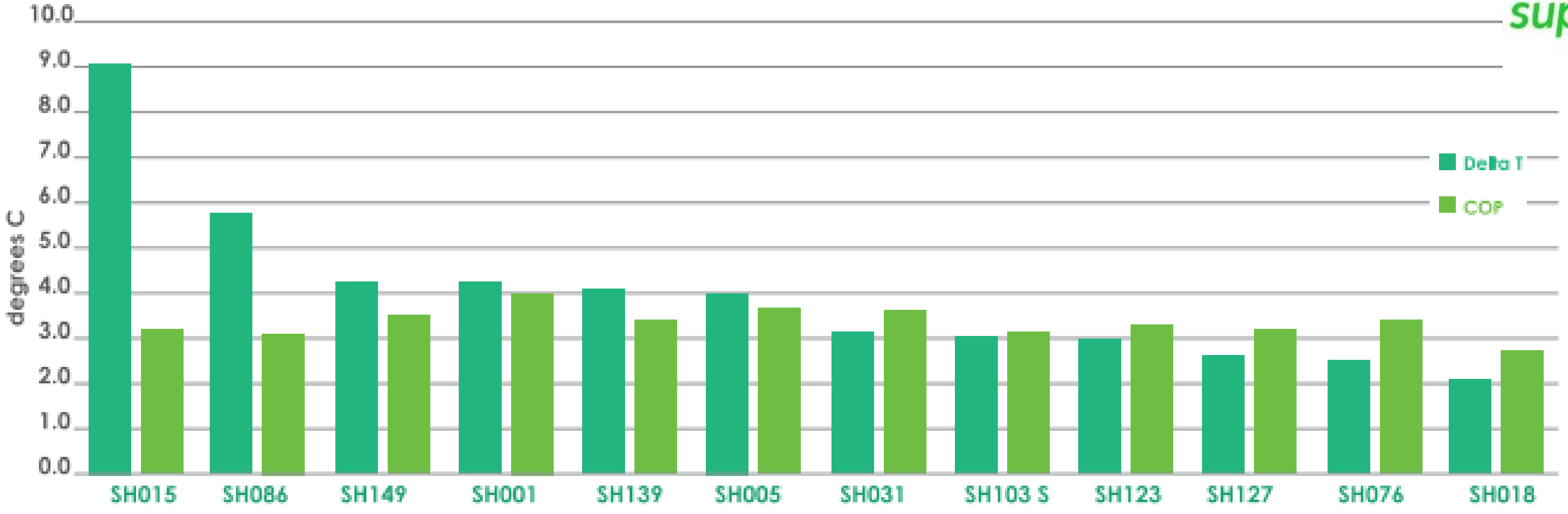

Figure 32: Average flow/return ΔT for SH2.0 systems

5 of the 12 systems have average ΔT within +/- 1°C of ΔT 5 °C requirement.

Comparing the COP of these 5 systems to the average space heating COP for all systems in November 2018 (3.35), 4 of the 5 had higher than average COP.

Of the 6 systems with ΔT between 2.1 and 3.1°C , 5 of the 6 recorded COP below the average.

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Pipe Sizing

Pipe sizing and circulation pumps **are critical** for the correct operation of the heat pump and the heating system.

The nominal heat pump flow rate is such that the ΔT at the condenser is 5°C while design ΔT for radiators is 10°C.

This means that at full load, the flow rate through the heat pump should be twice that through the radiator system.

Under sizing the pipe work will have a knock-on effect: the building will not reach the desired comfort temperature and as a result will have frequent cycling of the compressor, reducing its life time.

Higher flow rate will cause a reduction in flow/return ΔT across the radiator and lead to a higher MWT.

The increase in MWT does not lead to a significant increase in output once flow rate exceeds the standard water flow rate.

Source: Sigman Heating & Air Conditioning

Piping Limitations - Min Flow rate = 16L/min			
Unit	Delta T	1" Copper (Internal dia. = 25.4mm)	PEX DN32 (Internal dia. = 26mm)
		Max Pipe Length (m)	
EPGA11DV	5	26	
EPGA14DV	5	18	
EPGA16DV	5	12	
Notes:	• If your pipe run exceeds the values listed below please contact the Daikin Ireland Engineering Team • For each fitting, reduce pipe run by 1m		

Source: Daikin Schematic Book

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Existing Pipe work

- Pipework in older systems from pre 2005, boilers were designed for DT11. That's 2 x faster flow rate than current boilers use, this gets them much closer to the DT (or temperature drop) of 5 to 7 for heat pumps.
- Insulation has improved since pipework was installed.
- Most installers historically install based on these old outdated rules of thumb rather than calculating.
- A small increase in pipe bore allows much higher volume, in fact if you double the diameter the volume is 8 times higher. This gives a lot of wiggle room with existing pipework.
- For retrofits try to use existing pipework and emitters where possible, lower the cost of the installation. Removal is not required as long as design is done right.

kW/s of power the pipe can carry in the centre.				
Pipe Size	**Heat output (0.9 mps @DT5)**	**Heat output (0.9 mps @DT7)**	**Heat output (0.9 mps @DT10)**	**Heat output (0.9 mps @DT15)**
mm	**kW**	**kW**	**kW**	**kW**
8	0.75	1.05	1.5	2.25
10	1.15	1.61	2.3	3.45
12	1.72	2.41	3.4	5.16
15	2.75	3.85	5.5	8.25
22	6	8.46	12	18
28	10	14.2	20	30
35	15.75	22	30.15	45.9

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Water Velocity & Pressure Drop

HP ALL

CIBSE Guide A provide considerations when selecting the appropriate pipe size for a given design flow rate:

- Pipework noise - If velocity is high enough it will cause vibration (noise) or erosion of the pipe material.
- Erosion of relatively soft metals such as copper can occur at elbows if the water velocity is excessive.
- Pipes must be sized such that the energy consumed by the pump is not excessive. Smaller pipes will have a greater resistance to flow and will therefore incur a greater pump energy consumption compared to larger pipes.
- Pipes should be sized based on a criterion of not exceeding 200 Pa/m.

Table 1.A1.4: Recommended range of maximum water velocities.

Pipe diameter (mm)	**Copper**	**Steel**
15-50mm	1.0 m/s	1.5 m/s
Over 50mm	1.5 m/s	3 m/s

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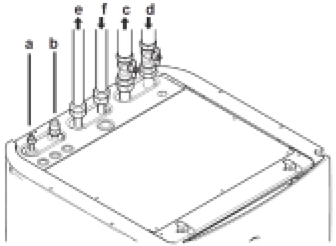
Example Air source Heat Pump

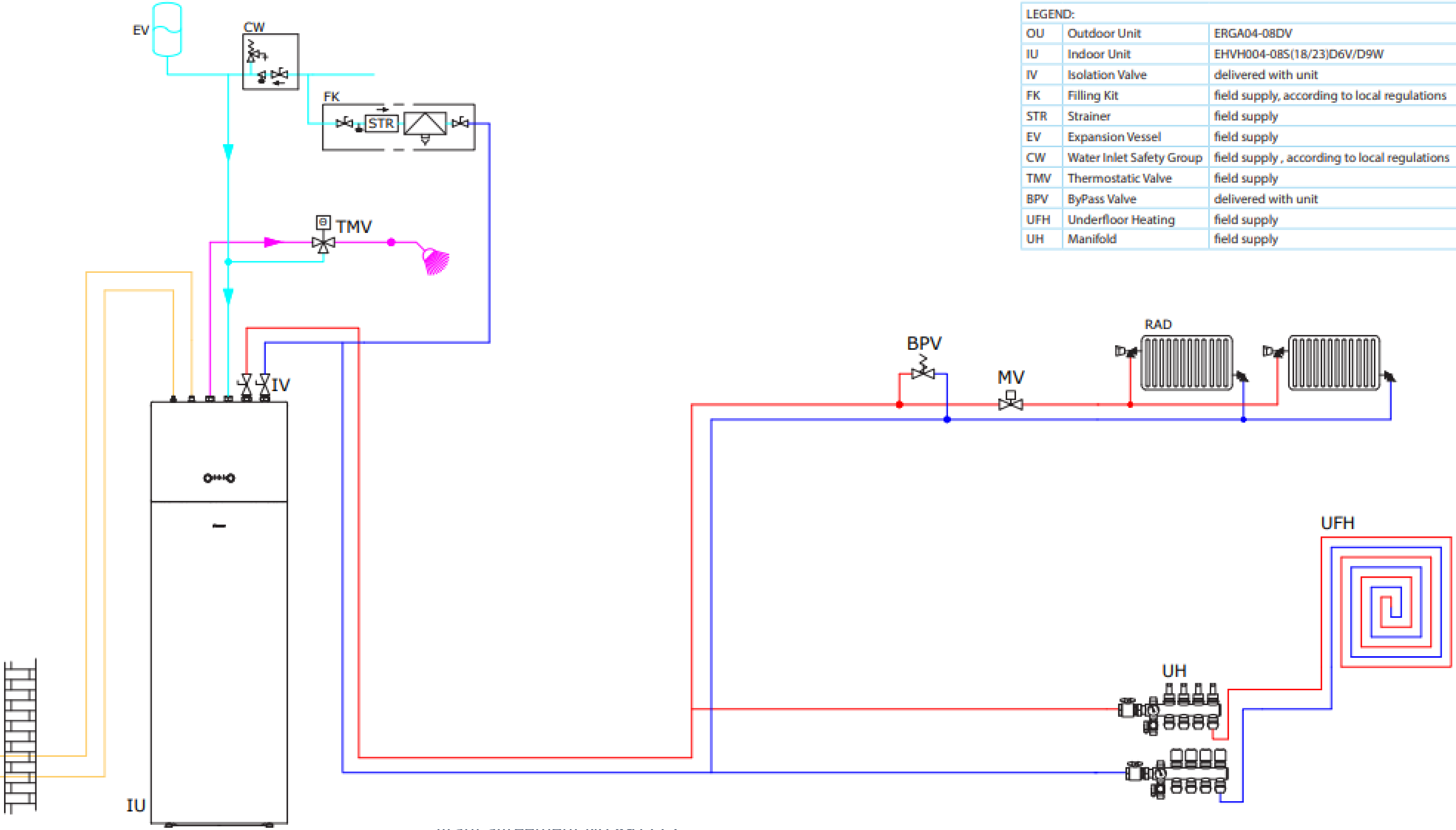
Piping Connections

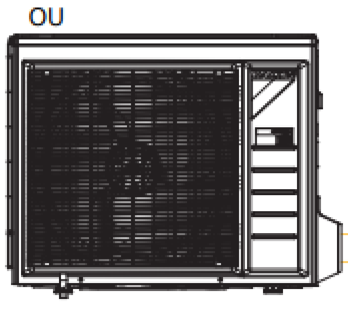
A) Refrigeration Liquid Connection - 5/8"
B) Refrigeration Gas Connection - 1/4"
C) Space Heating out - 1"
D) Space Heating in - 1"
E) Domestic Hot Water out - 3/4"
F) Cold Water Supply - 3/4"



Piping Guidelines

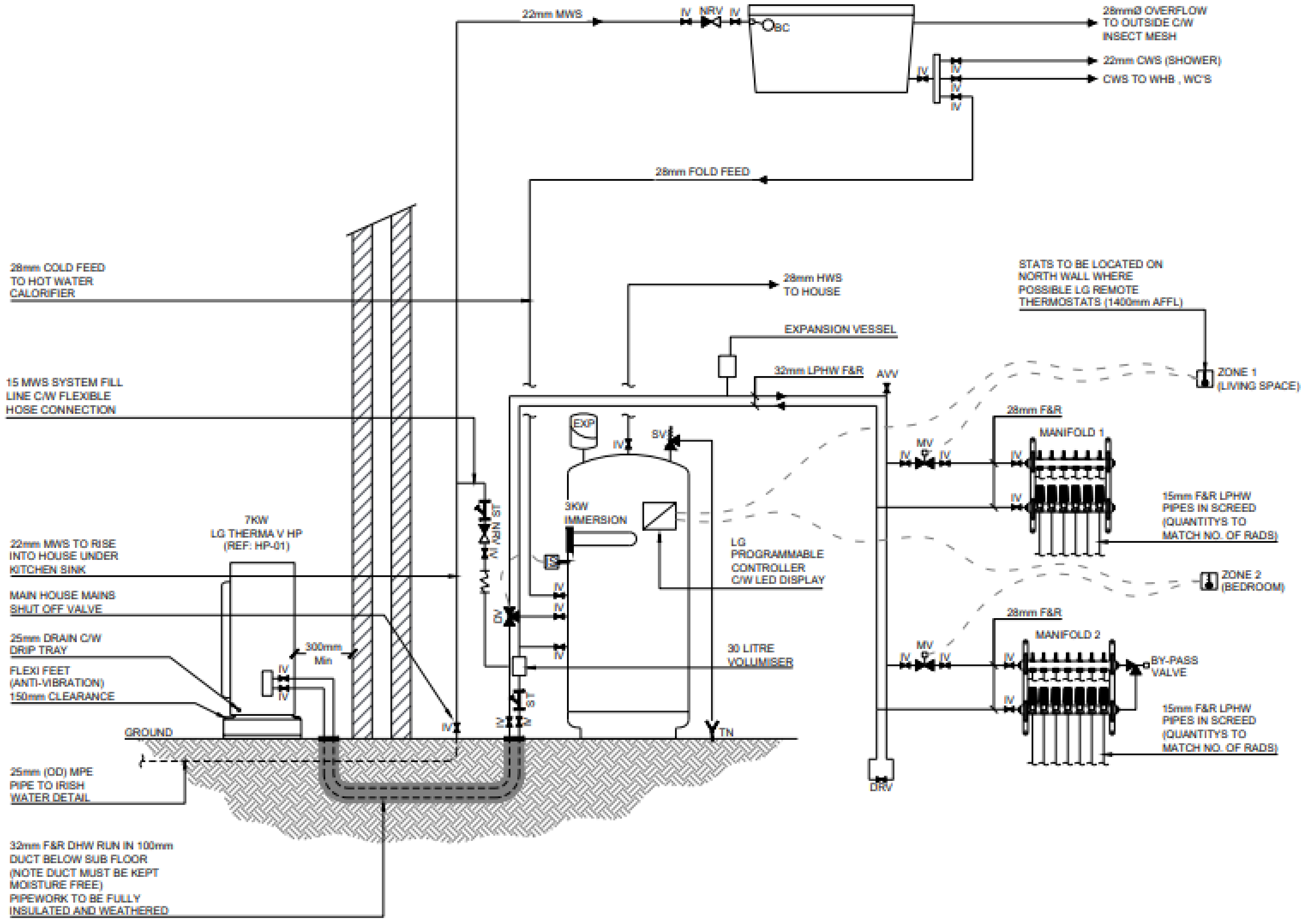
Minimum: 3m
Maximum: 30m (ventilation required if 27m+)
Height Difference: 20m
Min Flow Rate: 12L/min



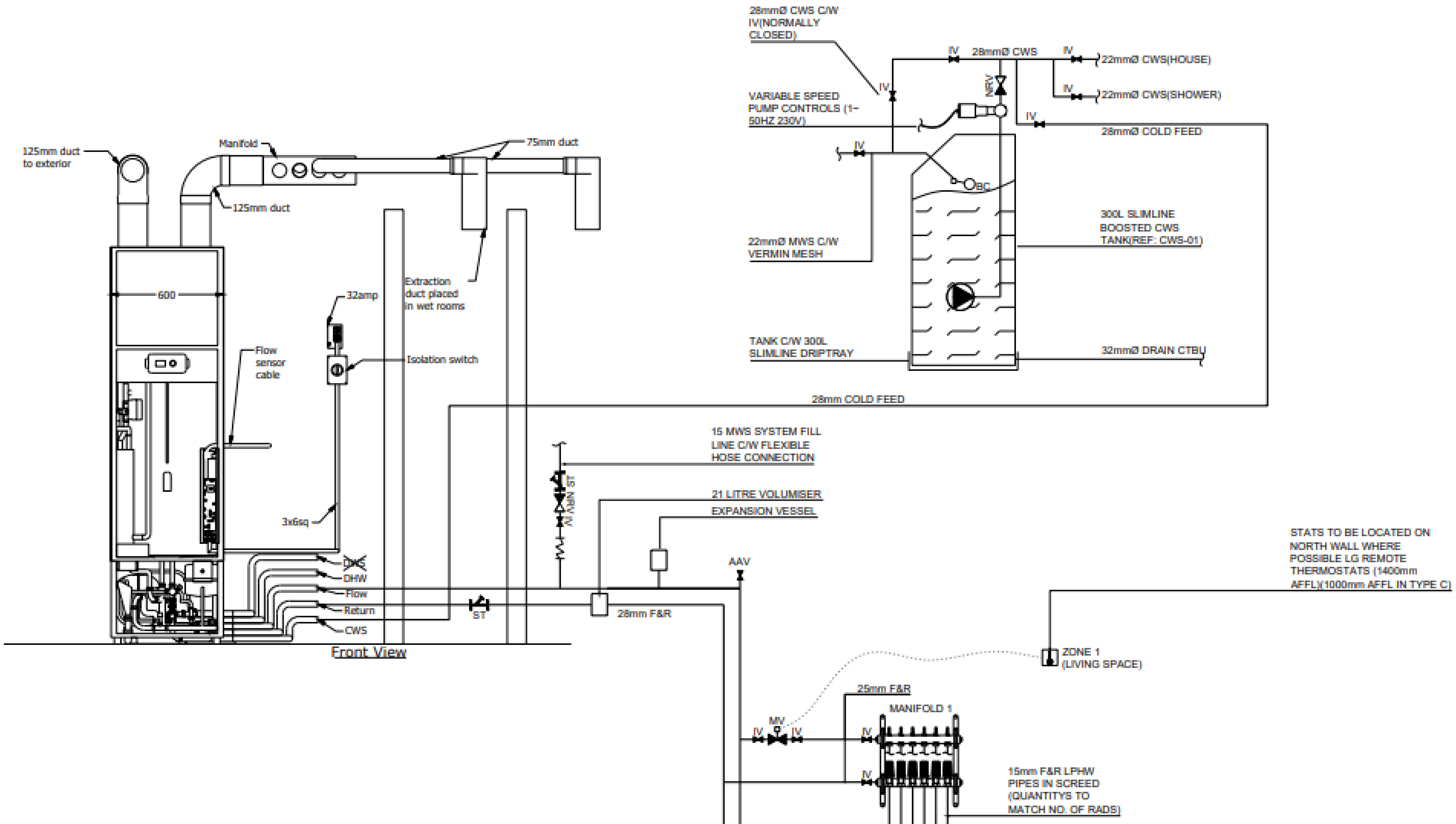


LEGEND:		
OU	Outdoor Unit	ERGA04-08DV
IU	Indoor Unit	EHVH004-08S(18/23)D6V/D9W
IV	Isolation Valve	delivered with unit
FK	Filling Kit	field supply, according to local regulations
STR	Strainer	field supply
EV	Expansion Vessel	field supply
CW	Water Inlet Safety Group	field supply , according to local regulations
TMV	Thermostatic Valve	field supply
BPV	ByPass Valve	delivered with unit
UFH	Underfloor Heating	field supply
UH	Manifold	field supply

Example Air source Heat Pump



Example Exhaust Air



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Audience Q&A Session

ⓘ Start presenting to display the audience questions on this slide.

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Please provide comments and feedback on LU 7 TO LU 12. (This will not be shown on screen).

ⓘ Start presenting to display the poll results on this slide.

LU9 Emitters

Heating System Design

Heat Emission & Operating Temperature

- Emission system heat output depends on emitter size and temperature
- Design the emission system for lowest practical flow temperature to maximise Space Heating COP

Water Flow Rate – Emission System

Set for each emitter/underfloor circuit

- Too low – insufficient heat to room and can cause high cycling
- Too high – artificially reduces heat pump return temperature, generates radiator valve noise

Water Flow Rate – Heat Pump

- Too low – forces downward modulation and can cause high cycling
- Too high – reduces COP

Emitter	Heating Range	Cooling Range
Radiators	45 > 55 °C	-
Underfloor	30 > 40 °C	-
Fan Coil Unit	50 > 70 °C	6 > 8 °C
Condenser Coil	50 °C	-

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slido

What are the typical emitters being installed in your county?

ⓘ Start presenting to display the poll results on this slide.

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Room Temperature Requirement

Living areas i.e. – sitting room, dining room, play room: 18-21°C

Other areas i.e. – kitchen, hall, toilet, bedrooms: 16-18°C

Bathrooms (with shower): 22°C. [Due to high ventilation rates]

Heat loss calculations are used to size the radiators/emitters effectively against these desired temperatures.

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Underfloor heating (UFH) - Overview

To increase Underfloor heating efficiency:

1. Narrow pipe spacing/increasing the number of pipes (traditionally 200 mm)
2. High conductivity screed / floor covering

Typically 100 W/m2 for screeded floors, ~70W/m2 for timber finish flooring

Underfloor systems designed for use with heat pumps generally have pipes spaced 100-150mm apart

greater pipe density allows the screed to operate at lower temperatures.

Source: Energywise Ireland

underfloor heating has the advantage of having a far greater thermal inertia compared to radiator systems.

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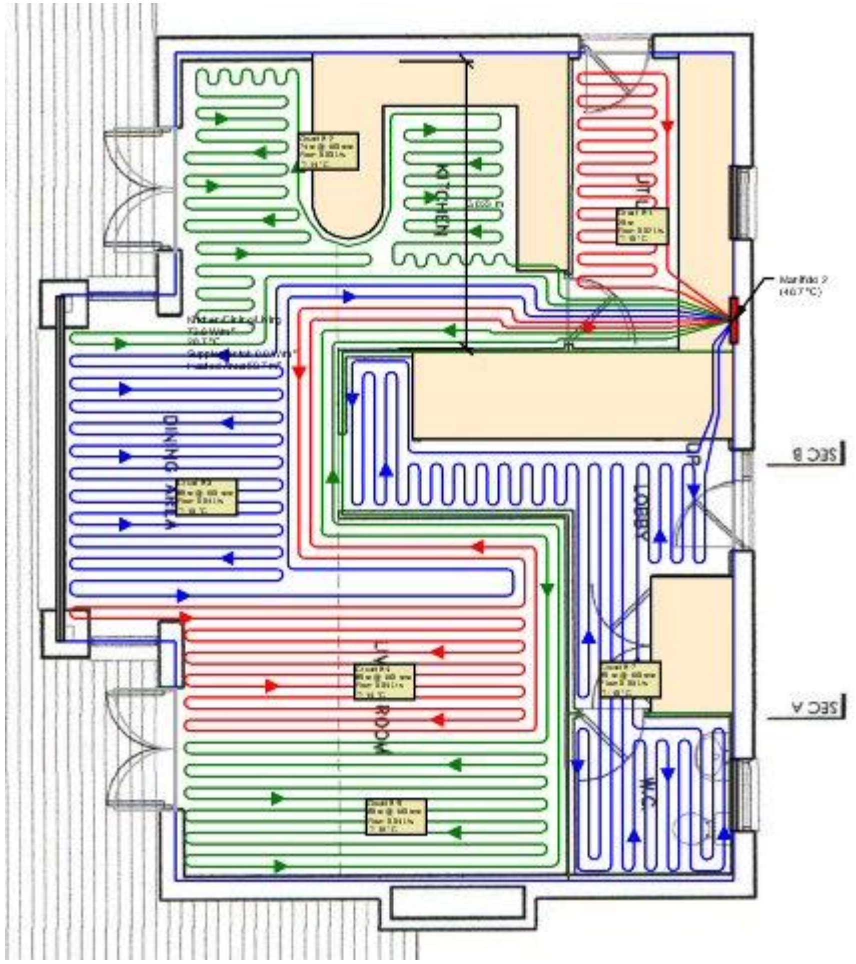
Underfloor - Considerations

- Underfloor shouldn't be installed under showers / baths / cupboards / permanent fixtures.
- Screed needs to be Dried without the use of the underfloor heating! Check with supplier drying times.
- Insulation under the underfloor heating loops can increase the heat output (upwards)
- Thermostat – Air temperature or Floor probe temperature?
- If using carpet, ensure adhesive is suitable up to 40°C
- Concrete takes longer to heat up from cold start, but can retain heat better
- Max Floor surface Temp should never exceeded for Wood Floor, Vinyl, Carpet 27°C
- Comfort levels lower after 27°C to 29°C floor surface temperature
- It is important to purge the pipework, to avoid air and dirt blocks



Source: Underfloor Heating Express

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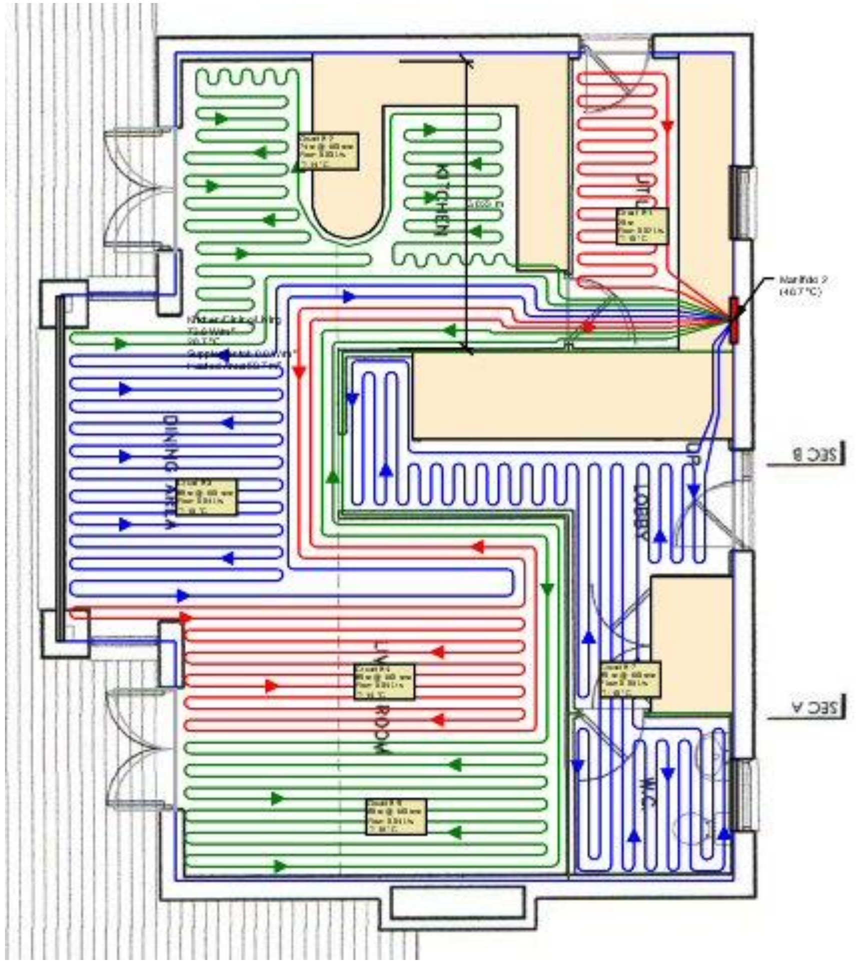
Underfloor - Calculations

- To calculate the flow rate for each underfloor heating loop, take the loop length and divide by 40.
- For example, 100 m loop length/40 = 2.5 l/min flow for the underfloor heating loop.
- To calculate the water content in our underfloor heating system use 0.12l of water per m pipe.
- For example, 500 m of 16 x 2 mm underfloor heating pipework will have 0.12 x 500 = 60 l of water in the underfloor heating pipework.



Source: Underfloor Heating Express

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Radiators

- Traditionally, DT 50 radiators used for traditional boilers at the EN442 standard which governs the rating of thermal output of radiators.

- The rated thermal output is given for the standard operating conditions of 75/65/20, i.e. flow temperature 75°C, return temperature 65°C and room temperature 20°C. This is presented as ΔT50

- DT 30 radiator for condensing boiler at flow temperature of 55/45 (if not done correctly condensation won't occur, lower efficiency)

- DT 23 for heat pumps at flow/return temperature of 48/38

- Meaning you will require 1.25x DT 30 condensing boiler radiator area and 2.5x DT50 traditional boiler radiator area.

- EN442 also provides guidelines for a standard low temperature output at ΔT30.

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Delta T (Δt) Radiator

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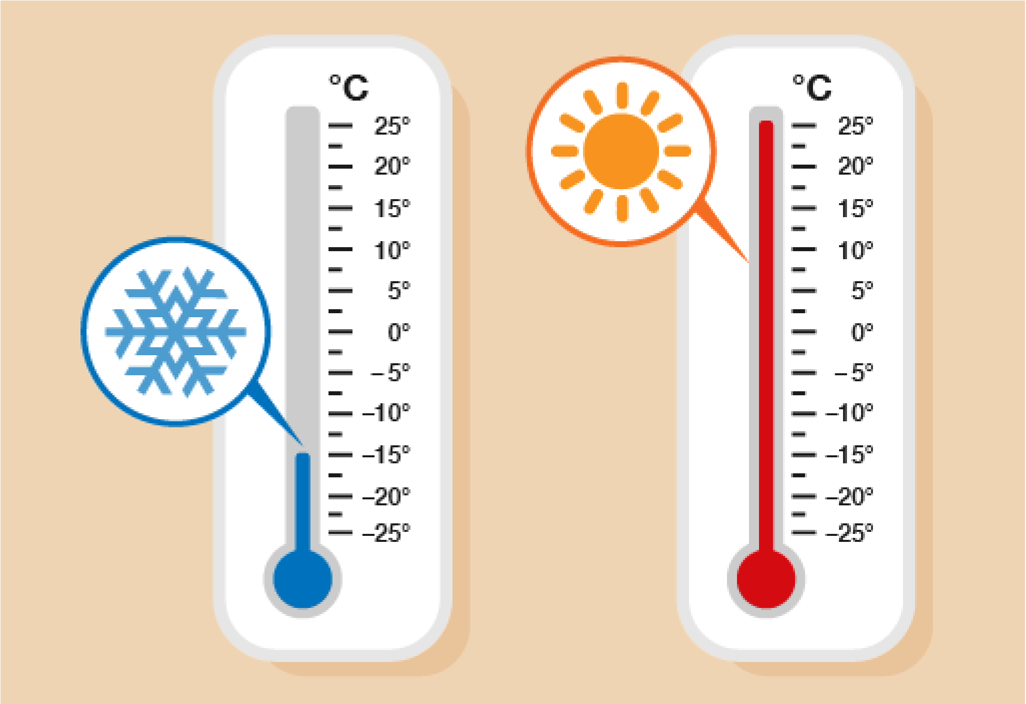
Delta T refers to the difference in average temperature between the water circulating throughout your central heating system and the room temperature.

Room Temp - (Flow Temp – Return Temp / 2) = Delta T (Δt)

Delta T can help correctly size emitters and heating requirements

Design Parameters for Heat Pump Installations:

1. Optimal Heat pump flow = 45°C - 55°C
2. Optimal Living Room Temp = 18-21°C
3. Optimal ΔT across radiator is 5°C - 10°C



Source: Open University

Note that the nominal ΔT across the heat pump's condenser should be 5°C, system needs to be balanced

Add radiator or increase size = more volume = lower dT

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Radiators – Rad Sizing

In order to size to another flow temperature HPAI have published conversion factors in the Heat Pump code of Practice:

- Δ50 radiator output x [0.7482] = Δ40 radiator output
- Δ50 radiator output x [0.8720] = Δ45 radiator output
- Δ50 radiator output x [1.2675] = Δ60 radiator output

- $F = (\Delta T/50)n$ where n is 1.3 for steel rads and aluminium rads

For retrofits not every radiator needs to be replaced if the condition of the radiator is good and the proper heat calculation and balancing is done.

- Finned = 1.8 times flat panel
- Double panel finned = 3.6 output of flat panel.
- Triple panel 700 high = 2.1 times 500mm double panel

Add radiator or increase size = more volume = lower dT

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Radiators – Steel vs Al

- Aluminium conducts up to 5 times more efficiently than steel so faster heat up times
- Steel can ‘store’ heat longer than Al rads, Al rads cool quicker
- Aluminium Rads are much lighter than Steel rads but can be damaged more easily.

Aluminium

Steel

under

Radiator TRVs

Pro:

Thermostatic Radiator Valves (TRVs) control the heat output from individual radiators automatically. Often TRVs are used in every room except one (usually the lounge or the hall) which contains a zone thermostat.

Con:

As each room reaches its desired temperature, the TRV closes down, reducing both the capability of the system to reject heat and the volume of water being circulated around the system and increase the tendency for the heat pump to short cycle.

Source: PlumbNation

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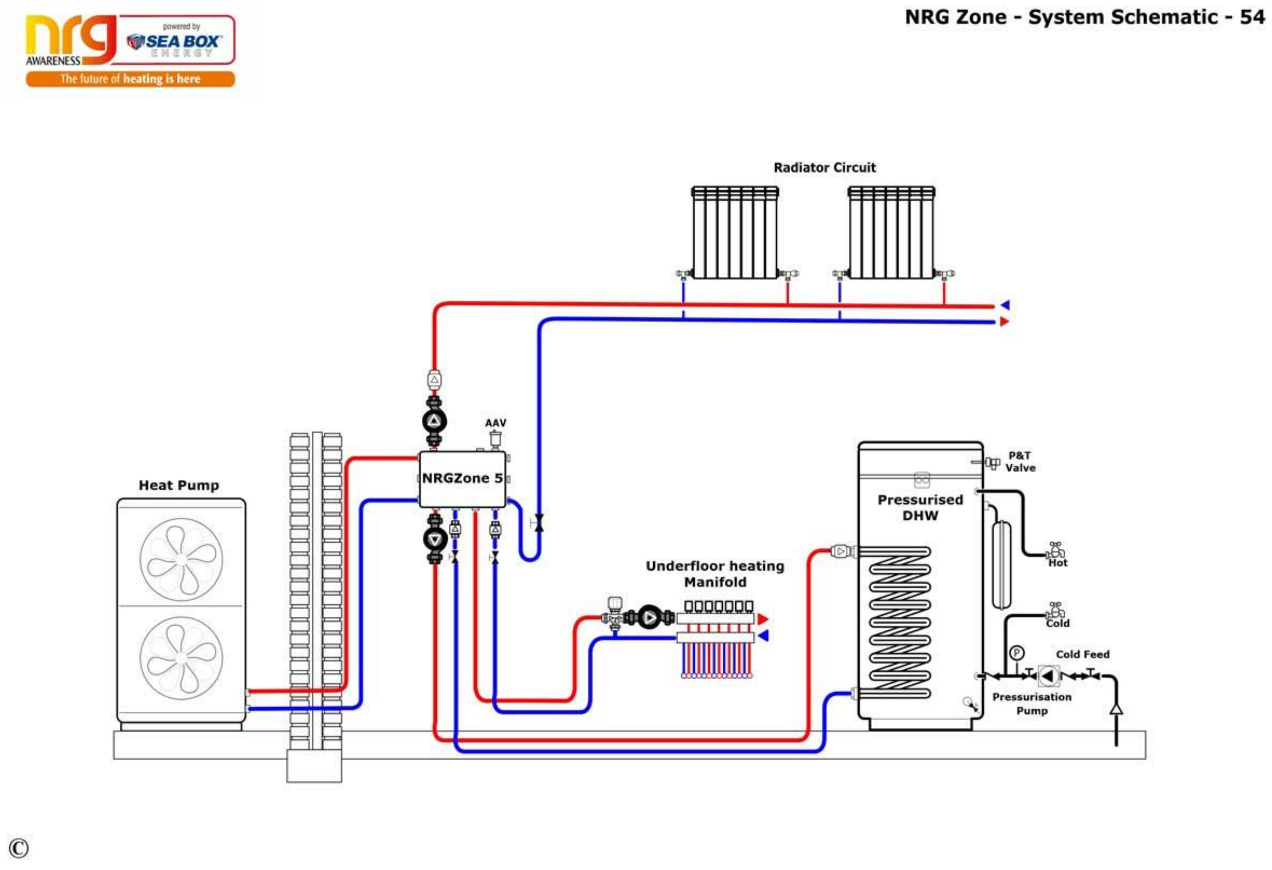
Radiators + Underfloor systems (Mixed)

Underfloor heating systems are designed to operate at lower temperatures than radiator systems (30-40°C vs 40-55°C) so are expected to deliver higher SPFs

For mixed systems (UFH + radiators) are used in a two storey dwelling:



Source: NRG Awareness

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Radiators + Underfloor systems (Mixed)

It is advisable that radiators are only used in first floor sleeping areas (lower target temperature), so the heat pump can take full advantage of the lower operating temperature afforded by good underfloor design.

Problems can arise if mixed systems involve radiators in core living areas of the house. Radiators HAVE TO work more, so higher flow temperatures than the underfloor design requires which will impact COP.

Install a mixing valve in the installation that will lower temperature in the UFH circuit, to lower temperature.

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Zoning

Space and hot water heating should be zoned separately, a supplemental guidance document to Part L of the 2011 building regulations technical guidance document (TGD) also mentions that:

- The water distribution system should be arranged for reverse return operation to maximise efficiency
- Constant water flow should be maintained through the heat pump
- Pipe sizes should be in accordance with the manufacturer's recommendations
- Isolation 'Zone' for and ease commissioning and future maintenance

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Audience Q&A Session

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LU10 System Balancing

Heating System Design

Heat Emission & Operating Temperature

- Emission system heat output depends on emitter size and temperature
- Design the emission system for lowest practical flow temperature to maximise Space Heating COP

Water Flow Rate – Emission System

Set for each emitter/underfloor circuit

- Too low – insufficient heat to room and can cause high cycling
- Too high – artificially reduces heat pump return temperature, generates radiator valve noise

Water Flow Rate – Heat Pump

- Too low – forces downward modulation and can cause high cycling
- Too high – reduces COP

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Heating System Design

Parameter	Heat Pump System	Traditional Boiler	Radiators	UFH
Operating Flow Temperature	40 > 45°C	65 > 75°C	45 > 60 °C	35 > 45 °C
ΔT (Flow/Return)	5°C > 8°C	10°C > 15°C	10°C > 15°C	5°C > 8°C

The conflict between the flow rate required by the heat pump and the emission system causes the following issues:

- Unacceptably high water-noise levels in the distribution and emission systems, (aluminium radiators amplify noise more than steel radiators)
- Difficulty in balancing radiators leading to uncertain heat output
- Compromised flow rate causing sub-optimal operation in terms of heat output and COP.

Two solutions exist to help with this situation:

- Buffer in parallel
- Automatic bypass valve

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Pressure, Flow and Power

The relationship between flow, pressure and power consumption.

1. If you double the flow rate but keep the pressure loss the same (by increasing pipework size for example), you will double pump power consumption.
2. If you double the pressure loss (aka differential pressure or DP) but keep the flow rate the same (by closing a valve for example), you will again double the power consumption.
3. If you double the flow and double the pressure you increase power consumption by 4x.

However, the real exponential increase in power consumption comes from the square rule:

The 'square rule' states that the system resistance is proportional to the flow rate squared. It’s a quadratic relationship.

If you double your flow rate through fixed size pipework, you double your velocity (speed the water moves through the pipe).

Doubling of speed, Quadruple the frictional resistance against the flow (Which requires an exponential increase in pump power.)

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Pressure Differential Balance

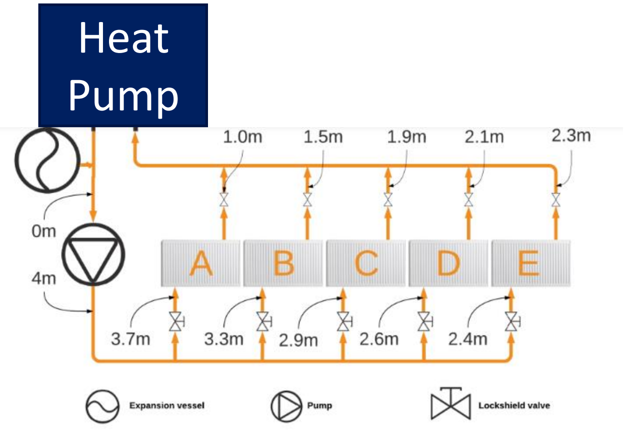
Pressure differential refers to the difference in pressure between any two points in the heating system.

Pressure Differential of Rad A is 2.7 m head A (and a high flow rate!)

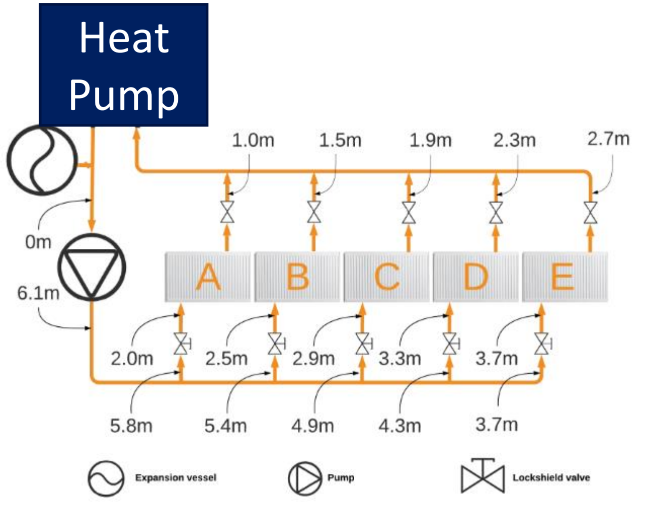
There is less resistance to flow through Radiator A so more water passes through that circuit until the pressure difference builds to match 4m head.

Radiators have been balanced at the lock shield and the new DP across the system is 6.1 metres head.

However, the resistance across each radiator is now exactly the same (1m) and so flow is evenly distributed.



Source: Heat Geek in-Balanced System



Source: Heat Geek Balanced System

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Balanced Radiators

Achieving a high DT across radiators AND Radiator balancing IS CRITICAL

Designers should aim for 5-8 °C at a design minimum (i.e., A7/W35), this would mean 3-4°C at 39/35 at average winter temperature.

Radiator balancing is ensuring all radiators **heat up at the same speed/ in the same time.**

If rads aren't balanced then the hot water returns to HP, gives the heat pump a false sense of the house and decreases compressor invertor leading to cold spot in the house.

There is a 10% - 20% difference in running costs for balanced and unbalanced radiators

Domestic radiator balancing is poor in Ireland, commercial is better, but should be supervised.

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How to Balance Radiators at Home

You Will Need:

1. Radiator bleed key
2. Lock shield valve key
3. Screwdriver
4. Digital thermometer/multimeter with thermometer
5. Adjustable spanner

How To Balance Radiators

1. Turn off your heating
2. Open all radiator valves fully
3. Note the speed/time of each radiator takes to heat up (first on the circuit will heat up first)
4. Allow your heating to cool down
5. Turn your heating back on
6. Adjust the fastest radiator
7. Repeat for other radiators.

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Balanced Underfloor Heating

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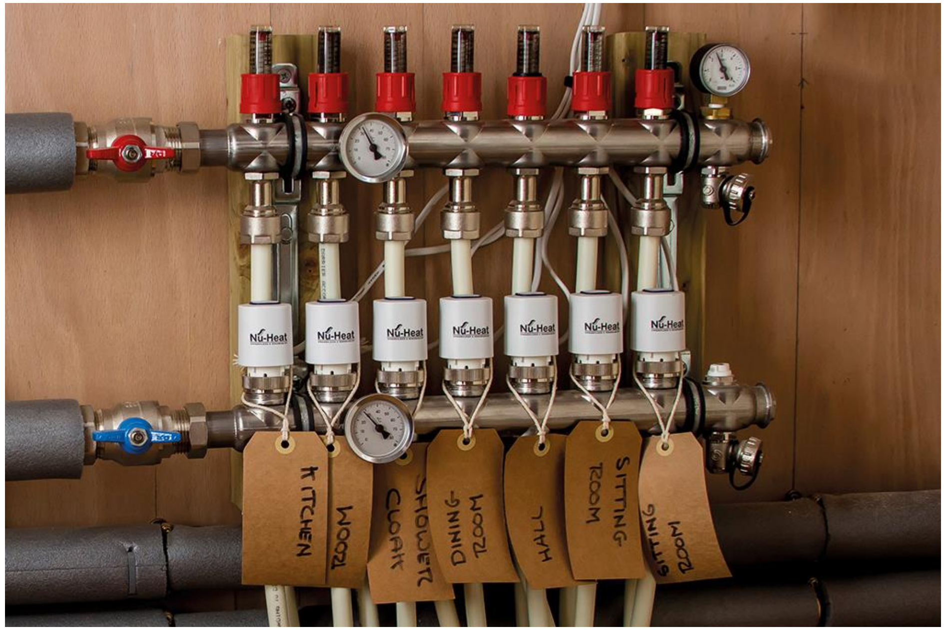
To manually balance the system, the installer needs to:

1. adjust the flow meters on the manifold
2. determine what is the correct flow level of the water supplied to each zone or room.

The physical task is not complicated as the flow metres simply need opening to the desired amount.

To ensure maximum efficiency, UFH systems need to be balanced.

Installers need to create artificial resistance within short pipe circuits and less resistance in the longer circuits to ensure that every circuit has the correct volume of water flowing through it.



Source: Nu-Heat

https://www.youtube.com/watch?v=4X5iKXwOOxY&ab_channel=GreenlightSolutions

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Audience Q&A Session

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LU11 Optimisation

Default Controls

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- Most HP units come with:
  - Integrated weather compensation
  - Timers
  - Backup
  - Legionnaires control
  - DHW controls often allow economy/ normal/ luxury.
  - Integrated (almost) always better than start stop

- Careful to not use fossil controls if not appropriate.
- Wireless has saved a fortune in rewiring.
- Avoid over-zoning and low loading.

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Variable Speed Pump

- In order for a constant ΔT to exist across the condenser, the condenser pump should vary its speed in conjunction with the compressor.

- This would require the pump to be capable of speed control under the command of the heat pump's controller, which is not always the case!

- Some Split units contain a variable speed condenser pump which can be controlled by the heat pump controller.

- As a result, there are opportunities for greater control of the condenser pump to match demands and improve efficiency

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Room Temperature Controls

- Technical Guidance Document part L, 2011 – Conservation of Fuel and Energy, Dwellings, Section 1.4.3 stipulates a requirement for the "automatic control of space heating on the basis of room temperature"

- ASHP performs best when TRVs do not introduce interruptions to the heat emission system.

- Advise to set the TRVs to their maximum setting so that they would not close down, ensuring that the thermostat dictates the heat output.

- The position of the thermostat is very important. The thermostat should not be in direct sunlight or near heat emitters, so it doesn't switch off too soon.

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Time of Use Scheduling

- Night electricity usually c. 50% of day rate, we can utilize this price drop for:
- Domestic hot water production
- Pre-heating buildings (works very well with UFH)
- New Smart metering will allow for Heat pump tariff (Electric Ireland have 2-4am)

- You might also run the heat pump during the day to absorb solar PV if present (particularly shoulder season), to avoid spilling to the grid.

- Ensure that there are no pay as you go meters / pay as you go services for Heat pump. If the heat pump turns off when credit runs out the heat pump will turn off. Running a heat pump from cold will incur more costs over continuous top ups.

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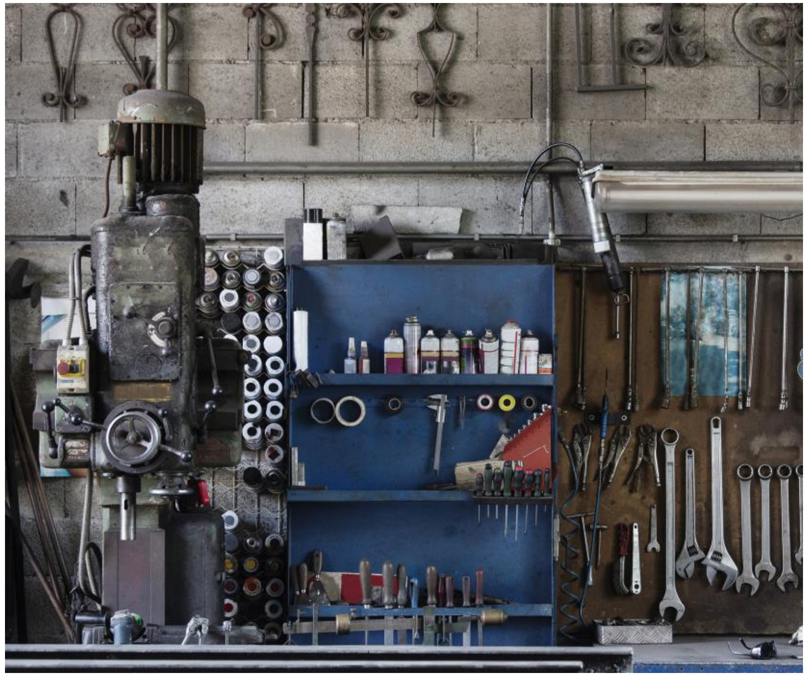
Servicing & Maintenance

- A service engineer may cost up to €200 for a heat pump, while only up to €100 for a boiler.

- More equipment that can be damaged in a boiler, so more replacements of equipment leads to higher cost overall.

- Annual Servicing should include:
  - Check the filter / replace the filter as filtration is more important than in a fossil system.
    - Strainer
    - Magnetic filter
  - Cleaning evaporator & check for oil / gas leaks
  - Visual inspection pipework & wiring
  - Expansion vessel pressure check; Temp relief valves check;
  - Operation of motorised valves & ELCB
  - Gas pressure in refrigerant cycle – depends on manufacturer - several years warranty



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Weather Compensation Controls

The Heating Compensation Curve (HCC) is a control strategy which aims to reduce the flow temperature required by the heat pump in line with increasing outside air temperature and heating load.

Auto Adapt is a form of HCC control method that sets Flow temperature based on internal as well as external temperatures.

This reduces the thermodynamic lift between the evaporator and condenser and so there is an expected increase in COP when compared to systems operating at a fixed SET Flow Temperature.

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Weather Compensation Controls

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Example: a house in SH2.0 was changed from Auto-Adapt to HCC an analysis of the 10 days before and after changing from Auto Adapt to HCC.

While there was a 31% reduction in HDD for the 10 days after the change, when normalised for HDD, energy consumption reduced by 20%.

It had been observed that Auto Adapt created conditions that led to long operating hours, high CC and poor attainment of zone target temperatures.

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Are there any other energy/cost saving control strategies that come to mind?

ⓘ Start presenting to display the poll results on this slide.

LU12 SEAI Grant Inspection Points

SEAI Grant requirements - Funding

A homeowner must select an independent, SEAI Registered Technical Advisor.

They will carry out a technical assessment of your home, and will advise you on what steps you need to take to make your **home heat pump ready**.

There is a **€200 grant available for the assessment**.

Air to Water heat pump system: The most common heat pump system extracts heat from external air using an outside unit.

Apartment (Any) **€4,500** or

Semi-Detached/End of Terrace/Detached/Mid **Terrace €6,500**

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SEAI Grant requirements – Heating System

Heat pump systems must be installed by suitably qualified personnel.

Personnel nominated to supervise and inspect the works, and to sign off the Declaration of Works must be competent in the different aspects of the works.

The minimum qualification and training requirements that must be met to sign the Declaration of Works for grant purposes:

1. Fetac/QQI Level 6 Advanced Craft in Plumbing, including a module on minor electrical works, or equivalent

2. Certificate of competence from the specific manufacturer of the heat pumps installed, based on an adequate training programme

3. Fetac/QQI Level 6 Heat Pump Systems (Course Code C30263) and supplemental Domestic Heat Pump Installation (Code 700606) or equivalent


FETAC
UASTEASTAS LEIBHÉAL 6
LEVEL 6 ADVANCED CERTIFICATE
Ceird - Pluiméireacht
Craft - Plumbing
Tuillteanas
Merit
Bronnta ar
Awarded to
Joe Bloggs
02/02/2022

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SEAI Grant requirements – Heating System

A Registered Electrical Contractor (REC) **is required to supervise and sign off** the electrical installation of a heat pump system, in accordance with the definition of "Controlled Works and Restricted Works" by the CRU.

A copy of the RECI certificate must be left with the homeowner and available for inspection.

An F-Gas engineer **is required** to carry out and certify heat pump system installations involving **refrigerant pipework** and charging as per the F-Gas Regulation3

Certified F-Gas engineer
find us on the Fgasregister.com

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HOT WATER SYSTEM

- Reheat Time needs to be considered and agreed with customer
- Domestic Hot Water Heat Exchanger specification shall meet heat pump manufacturers recommendations
- Minimum insulation as per Part L (50 mm factory applied)
- Incorporate means and set up to prevent Legionella
- Efficiency calculated in accordance with EN 16147 at 55ºC.

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LOCATION OF HEAT PUMP

- Follow the manufacturer’s instructions and guidance
- Agreed with the homeowner
- Avoid noise next to sleeping areas and neighbours
- In accordance with applicable regulations and planning requirements
- Allow the system to be safely maintained
- Consider distance between inside and outside units

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KEY SUCCESS FACTORS

- Domestic Hot Water
  - Hot water cylinder – size of heat exchanger,
  - Cylinder insulation
  - Legionella prevention

- Documentation

- Electrical – Registered Electrical Contractor
  - Load
  - Wiring
  - Earthing and bonding
  - RECI Certificate

- Refrigerant Volume

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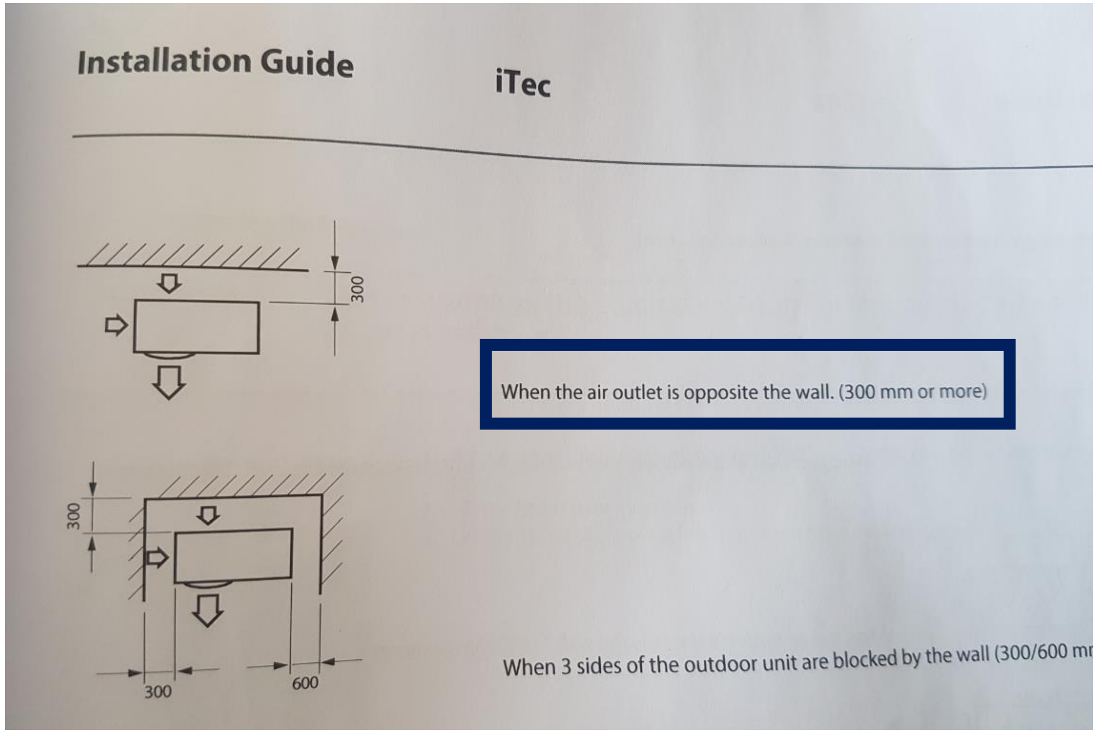
COMMON REWORKS - OUTDOOR UNIT SITED INCORRECTLY

Unit sited too close to the wall

- Not as per manufacturer's instructions



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COMMON REWORKS - CONDENSATE PIPEWORK

- Should be piped to
  - Drain
  - Soakaway
  - Gully

- Potential for
  - Ice
  - Staining
  - Slips

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COMMON REWORKS - UNIT NOT LEVEL

- Bearing Damage
- Excessive Noise
- Potential Warranty Issues
- Shortens Unit Life Span

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COMMON REWORKS – ELECTRICIAL

Earthing/Bonding not to required standard

- Electrical regulations
- All metallic services

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COMMON REWORKS – ELECTRICIAL

Cables poorly secured

- Trip hazard
- Risk of accidental damage

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COMMON REWORKS – WATER PIPEWORK

Incorrect pipe lagging

- Must be refringent grade
- Protection from Vermin

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COMMON REWORKS – WATER PIPEWORK

Incorrect pipe lagging

- Not UV Protected
- Degrading Insulation
- Exposed Pipework

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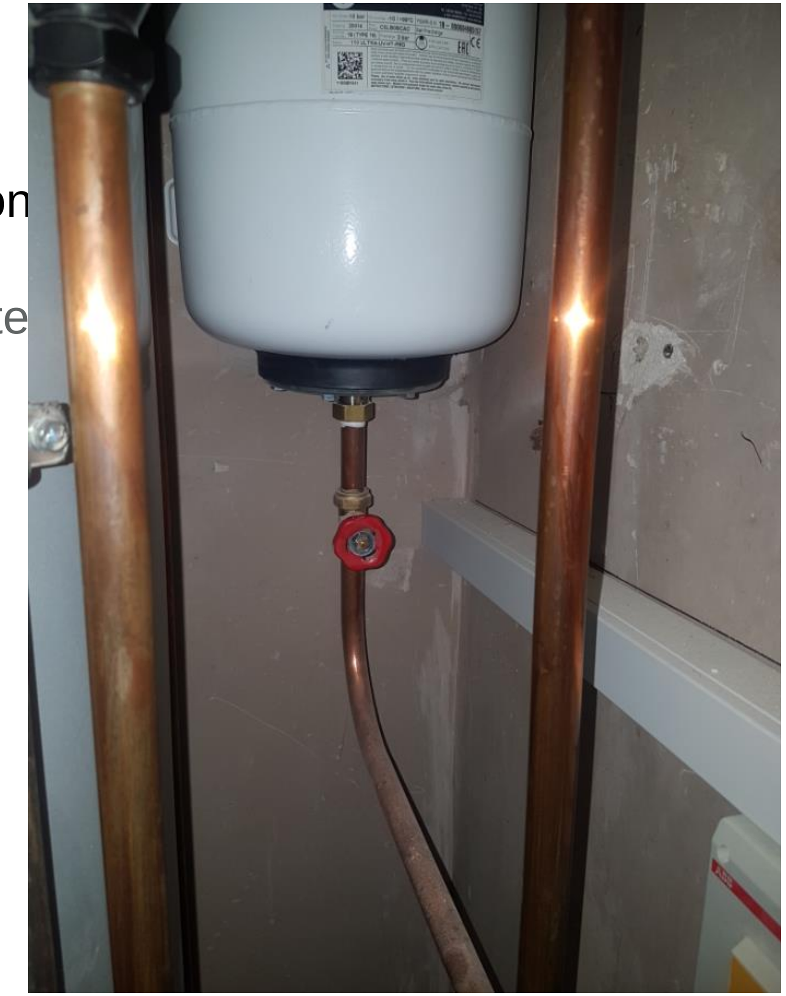
COMMON REWORKS – WATER PIPEWORK

Isolation valve on expansion pipework

- Potential of accedental Isolation
- Potential for no facillity for syste expansion



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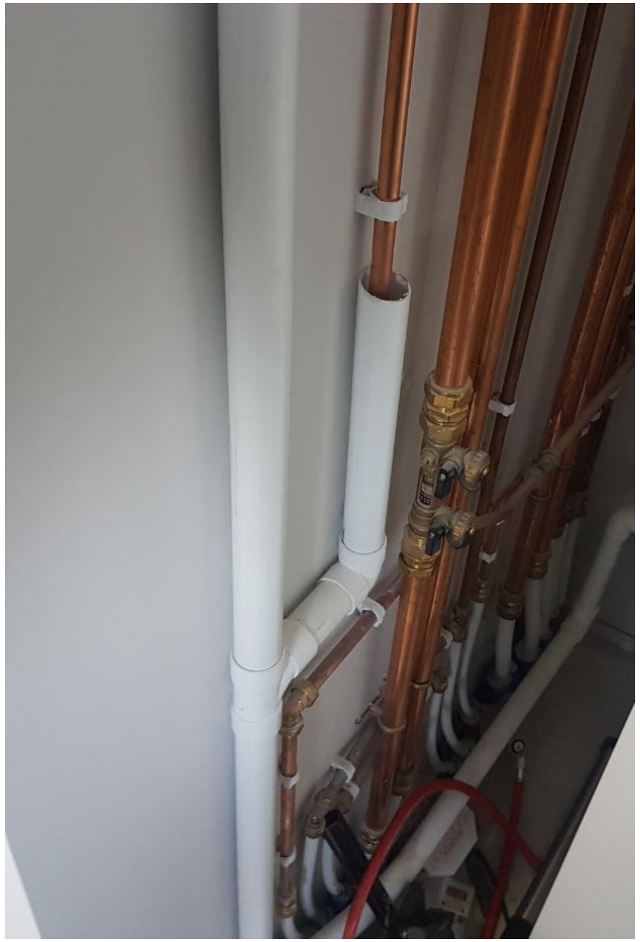
COMMON REWORKS – WATER PIPEWORK

Pressure relief valve not piped to safe and visible area

- Piped direct to drain (not visible)



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COMMON REWORKS – WATER PIPEWORK

Pressure relief valve not piped to safe and visible area

- Piped direct to drain (not visible)

- Not piped to outside (water damage)

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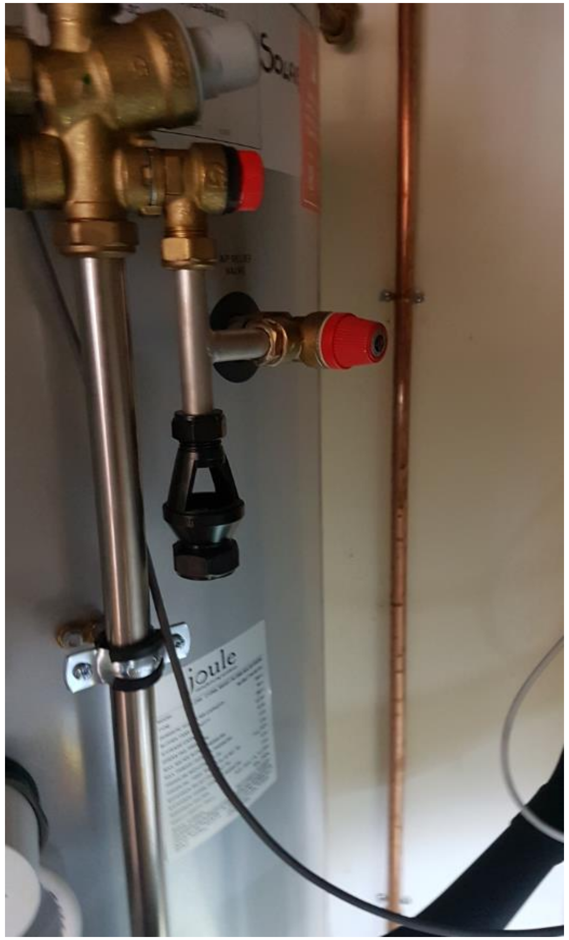
COMMON REWORKS – WATER PIPEWORK

Pressure relief valve not piped to safe and visible area

- Piped direct to drain (not visible)
- Not piped to outside (water damage)
- Not discharging in a safe direction (injury)



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COMMON REWORKS – WATER PIPEWORK

Pipework untidy/unsecured

- Incorrect pipe insulation
- No pipework brackets
- No pipework protection

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COMMON REWORKS – ROOM STAT/SENSOR(S)

Poor Location

- Room stat close to Convection currents
- TRV in the same room

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for Research & Innovation

This project has received funding from
the European Union's Horizon 2020 research and innovation programme under
grant agreement No 891775

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Feedback on LU7 - LU2? (Answers will not be shown on screen).

ⓘ Start presenting to display the poll results on this slide.

Target Groups

- Public Authorities,
- Public procurement staff
- Construction sector
- Policy makers

Green Handbook
GPP Training building program
GUPP Web Platform, e-training & e-learning tool

Discuss training Clause.

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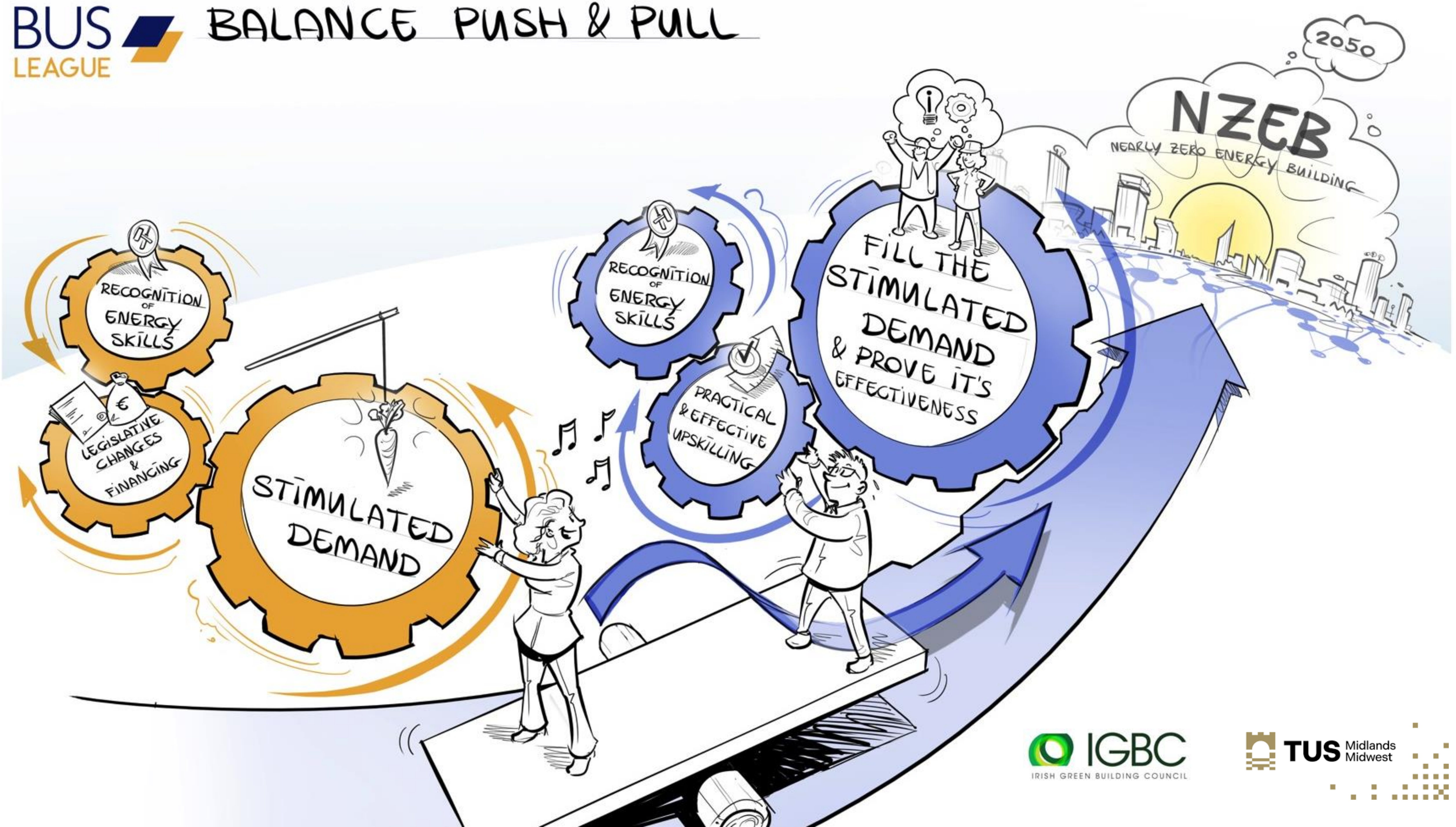
BUS LEAGUE

BALANCE PUSH & PULL



IGBC
IRISH GREEN BUILDING COUNCIL

TUS Midlands Midwest

ABOUT THE TRAINING CLAUSE

- Training clauses allow public procurers to **require companies winning nZEB projects (renovation and new built) to train their staff in energy efficiency**.
- Training clause is currently in-use in the **Hauts-de-France region (France)**, where the **companies winning these projects must train staff working on a project** (construction workers and site supervisors) in **energy efficiency**.
- In Ireland, a version of the clause was used by Dublin City Council on St Bricin's Retrofit Project.

E

Please note D.C.C. will arrange training for the successful contractor so that at a minimum 2 no. personnel employed on the project successfully complete the Certified Passive House Tradespersons training for a minimum of 2 days. As well as this t he Contractors electrical and mechanical subcontractors must also undertake the training.

Bedsit Amalgamation St. Bricins Block 2
Volume C - Pricing Document **19**

BUS LEAGUE

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For Further training info on NZEB (Near Zero Energy Building)
email: Benny.McDonagh@lit.ie

Also for other NZEB courses, check out:
http://nzeb.wwetbtraining.ie/

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Overall Feedback on today's session? (This will not be shown on screen).

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