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Distributing our Water Resources: Utilising Integrated Smart & low-Carbon Energy.

Penrhyn Castle Drain Water Heat Recovery Project

Demonstration Event

Penrhyn Castle, Bangor, North Wales
11th October 2022

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Penrhyn Castle DWHR Demonstration Plant

Mr Paul Southall, National Trust

In collaboration with:

Ymddiriedolaeth Genedlaethol
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Penrhyn Castle DWHR Demonstration Plant

Dr. Prysor Williams, Bangor University

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Dŵr Uisce

Energy Recovery in Water Services
Adennill Ynni yn y Diwydiant Dŵr

From Concept to Operation

Time	Event
10.00 – 10.30	Registration, Coffee/Tea & Networking (location The Stables)
10.30 – 10.40	Welcome & National Trust Motivation Paul Southall, National Trust
10.40 - 10.50	Dwr Uisce Project Overview & Welcome Prysor William, Bangor University
10.50 – 11.10	Drain Water Heat Recovery at Penrhyn Castle – Design & Performance Aonghus McNabola, Trinity College Dublin
11.10 – 11.30	Environmental Impacts & Benefits of Drain Water Heat Recovery Isabel Schestak, Bangor University
11.30 – 11.40	Open Discussion & Emerging Opportunities Paul Coughlan, Trinity College Dublin
11.40 – 12.40	DWHR Site Demonstration & Historical Tour of Penrhyn Castle Tea rooms, Coal yard & general castle tour
11.40 – 12.10	DWHR Site Virtual Tour & Online Q&A 3D online virtual tour of Team Rooms & Coal yard
12.40 – 13.40	Lunch & Networking Penrhyn Tearooms
13.40pm	Departure

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Penrhyn Castle DWHR Demonstration Plant

From Concept to Operation

A day for Celebration !

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Introduction to Dŵr Uisce

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- Significant scope to improve the energy efficiency of the distribution of water resources.

- The Dŵr Uisce project aims to <u>quantify</u> and <u>demonstrate</u> this scope using:
  1. Smart and low-carbon technology.
  2. Cross-sectoral & cross-border benchmarking, and economical and environmental impact assessment
  3. Networking, dissemination, knowledge exchange, brokerage events, demonstrations.

- The project will deliver improved efficiency of the water-energy nexus, benefitting two key stakeholders groups: **water suppliers** and **water consumers**

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DWHR System Design & Performance

Prof. Aonghus McNabola, Trinity College Dublin

In collaboration with:

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The challenge today

Energy, Environment, Economy

- Heating/cooling account for ~50% of energy consumption in the EU and 75% of Heating is delivered by fossil fuels.
- 15-30% of a buildings thermal energy is embedded in wastewater
- Water from a typical 40^{o}C shower enters the drain at 30^{o}C
- Yearly embedded heat in commercial kitchen wastewater in UK estimated at 1.24 TWh/yr
- This waste heat is present in:
  - The domestic sector
  - Commercial buildings
  - Industrial water users (brewing, food production, etc)
  - Wastewater treatment works

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DWHR at Penrhyn Castle

The journey from concept to installation

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- Measuring wastewater heat resources
  - Various building types
  - Various locations within historical buildings / tourist facilities
- Identifying heat demands
- System design & installation
- Performance monitoring

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Introduction to heat recovery concept in wastewater

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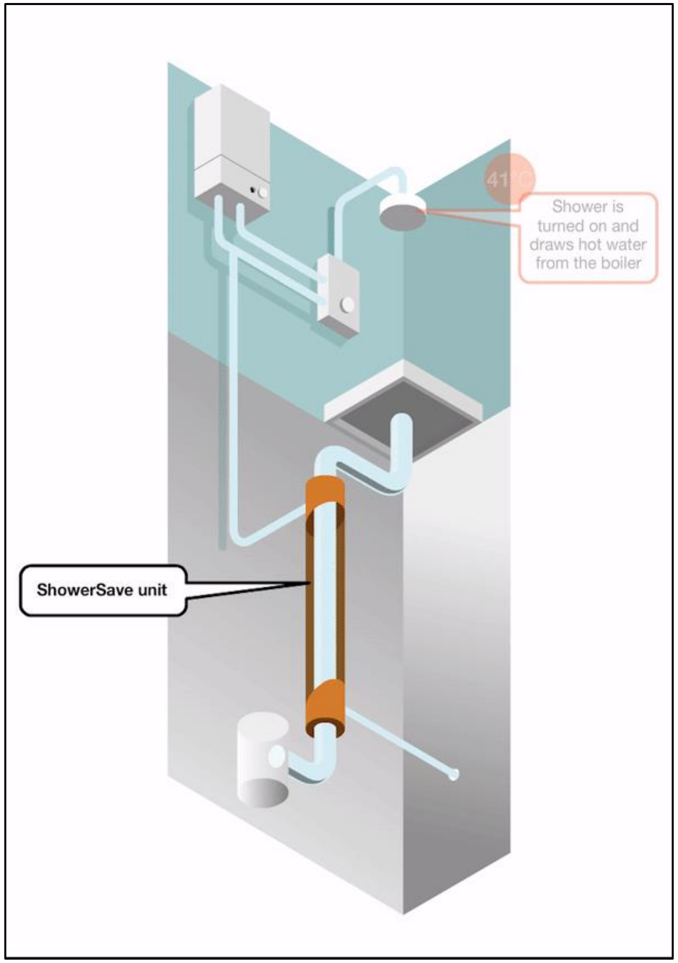
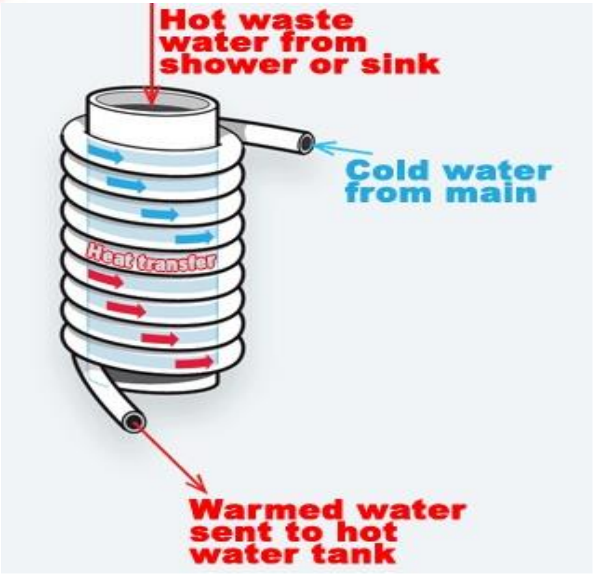


[1]

[2]



[1] https://showersave.com/wp-content/uploads/2016/08/A-System-1.mp4
[2] https://showersave.com/vertical-wwhrs/

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DWHR at Penrhyn Castle

Measuring wastewater heat at the castle

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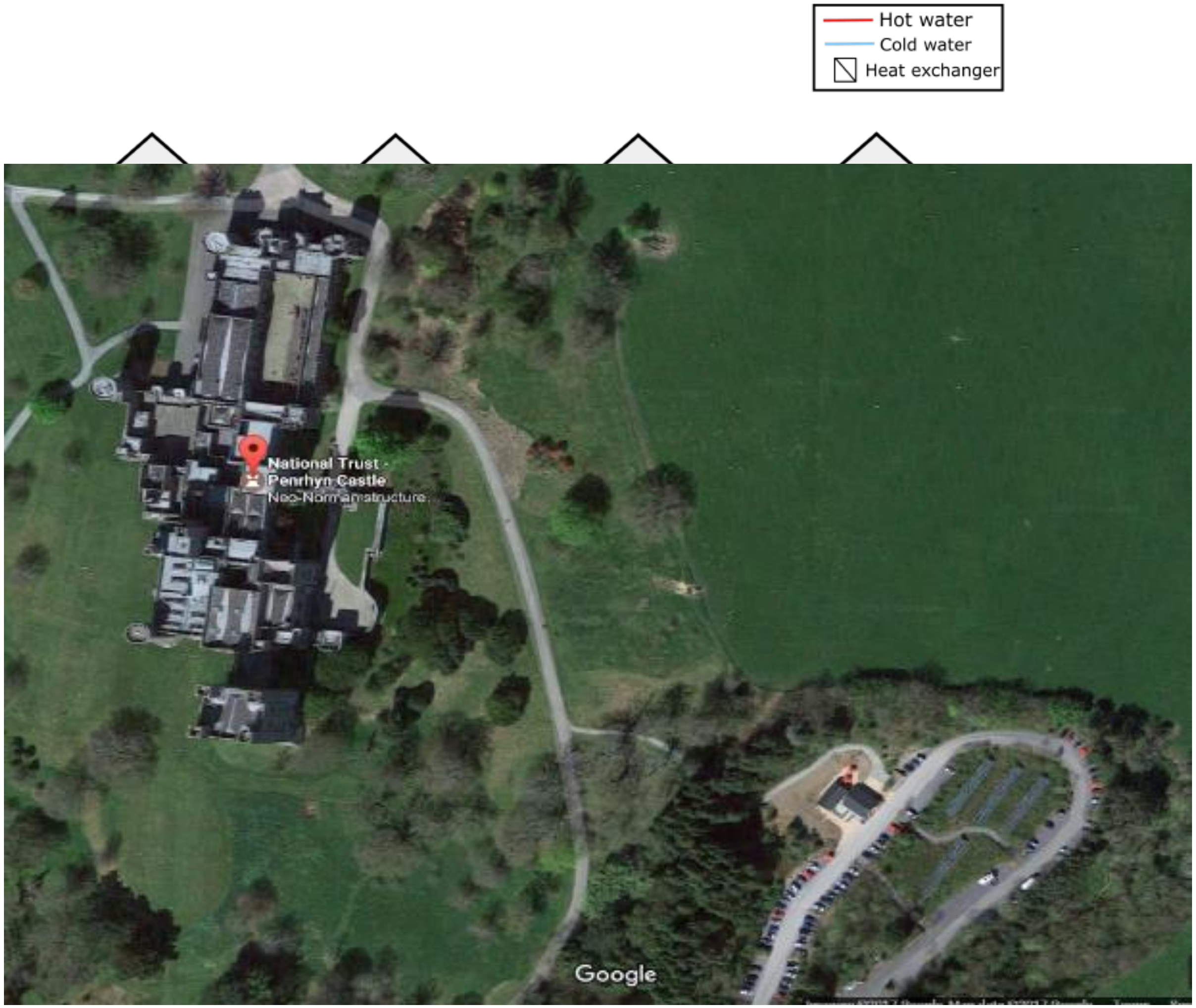

Measuring waste heat in:

- Septic tanks
- Sewer network
- Within the castle

Measurements of water use and wastewater temperatures over an extended period

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DWHR at Penrhyn Castle

System Design at the Tea Rooms / Coal Yard

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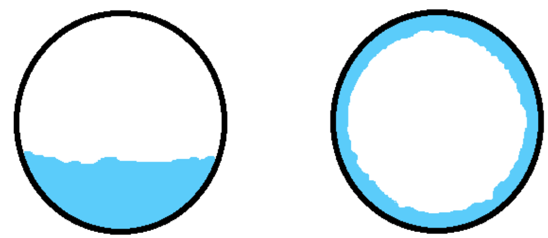
Recovering waste heat from the Tea Rooms due to:

- High energy density
- Proximity to heating demand system
- Vertical space for conventional heat exchanger



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System Design at the Tea Rooms / Coal Yard

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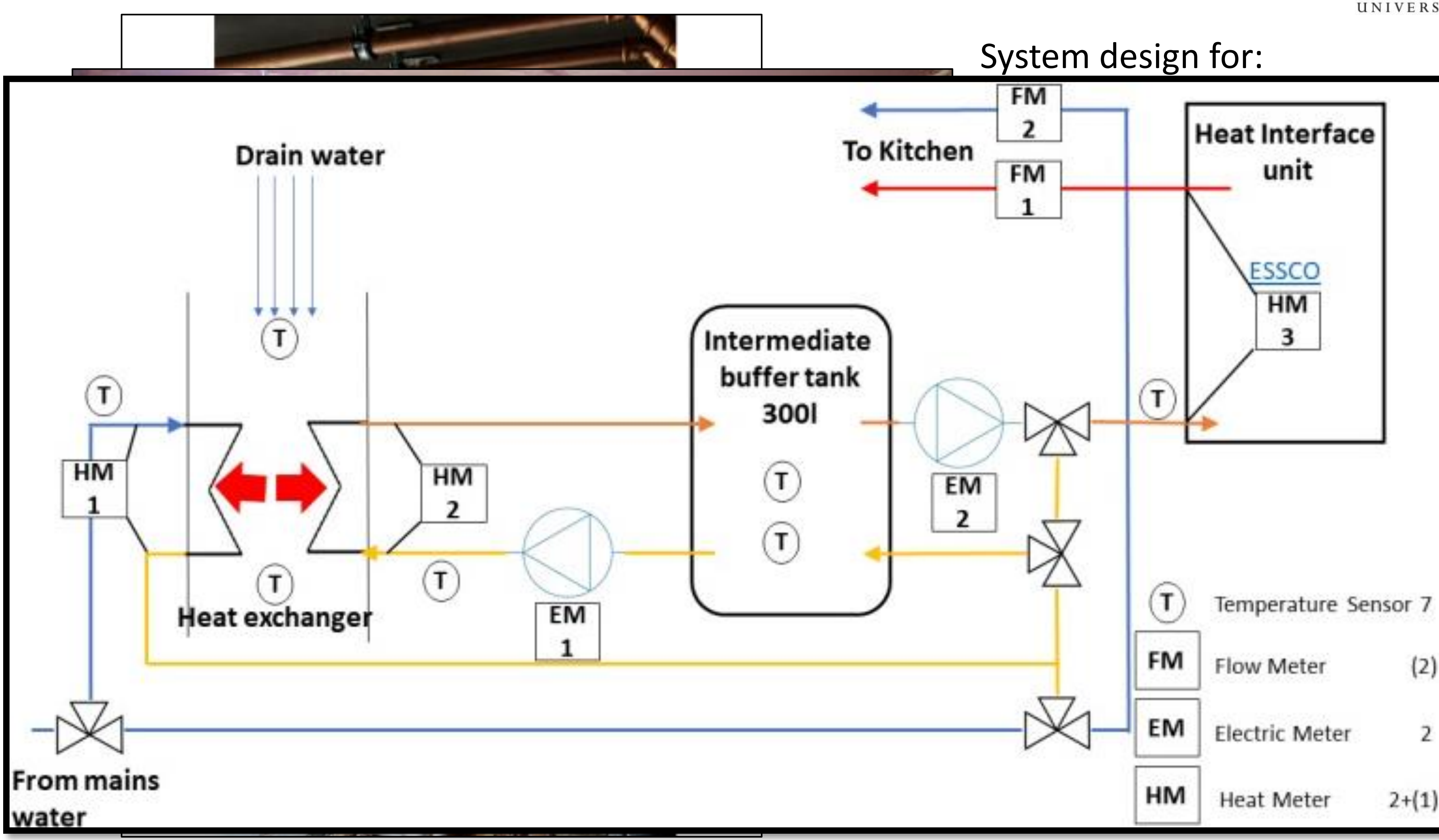
System design for:



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DWHR at Penrhyn Castle

System Performance over Tourist Season

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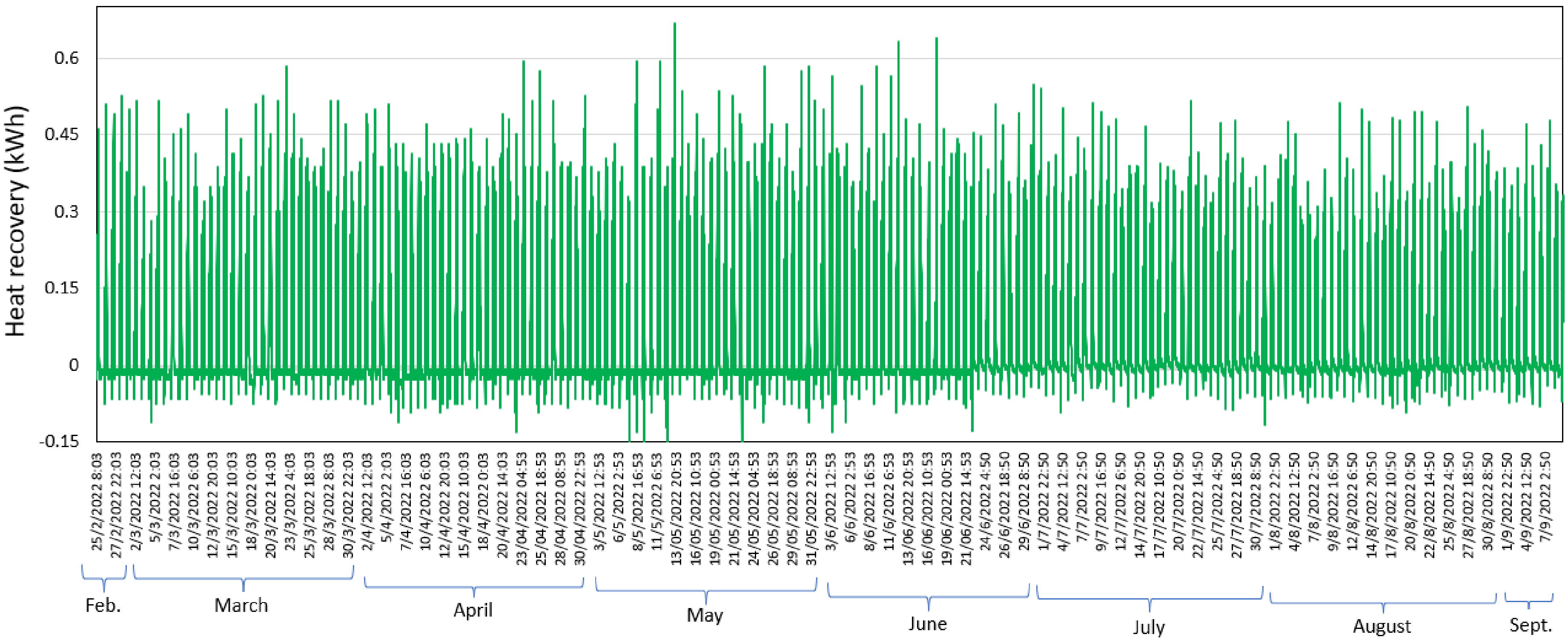
- Commissioned in Feb 2020 (good timing.....); operation since Feb 2022

25 Feb - 9 Sept 2022



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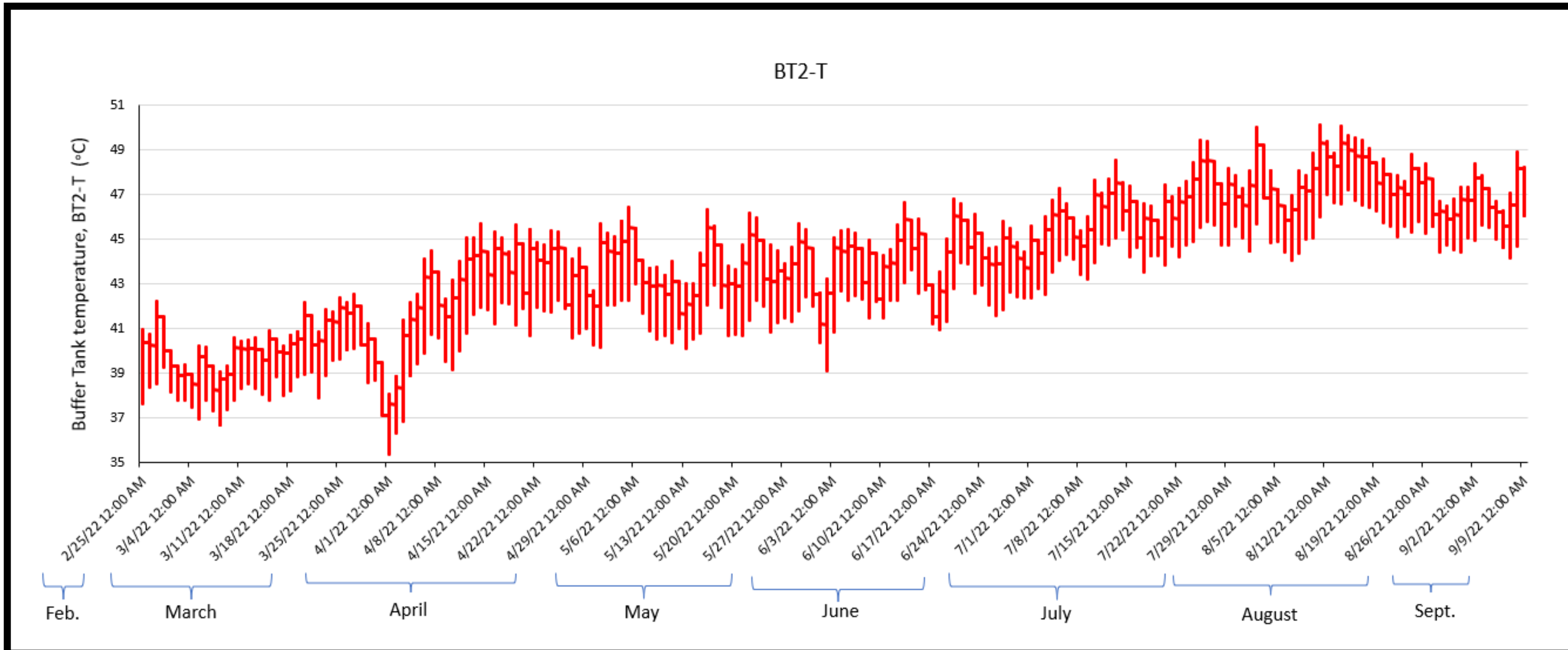
DWHR at Penrhyn Castle

System Performance over Tourist Season

- Temperature maintained in the buffer tank & interactions with Heating interface unit



Heating interface unit to reheat preheated supply water

Mixing of preheated water with hot water from biomass boiler

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DWHR at Penrhyn Castle

System Performance over Tourist Season

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- Operating period 25th Feb to 9th Sept 2022 (197 days)

- Heating energy save due to pilot heat recovery installation = 1510 kWh (233 kWh / month on average)

- Cost saving*:
  - Wood chips = 9p / kWh (2022) 4.2p / kWh (2021)
  - Gas = 20.9p / kWh (2022) 7p / kWh (2021)
  - Electricity = 63.4p / kWh (2022) 28p / kWh (2021)

- System Costs = £1885 Pump costs savings = 3.1 kWh / month

- Payback period:

  (considering heat savings only)

Year	2021	2022
Biomass	16.1 years	7.5 years
Gas	9.6 years	3.1 years
Electricity	2.4 years	1 year

- Note: experimental system (not every component necessary in every scenario); performance could be improved with some HX flow controller. *excluding taxes & standing charges

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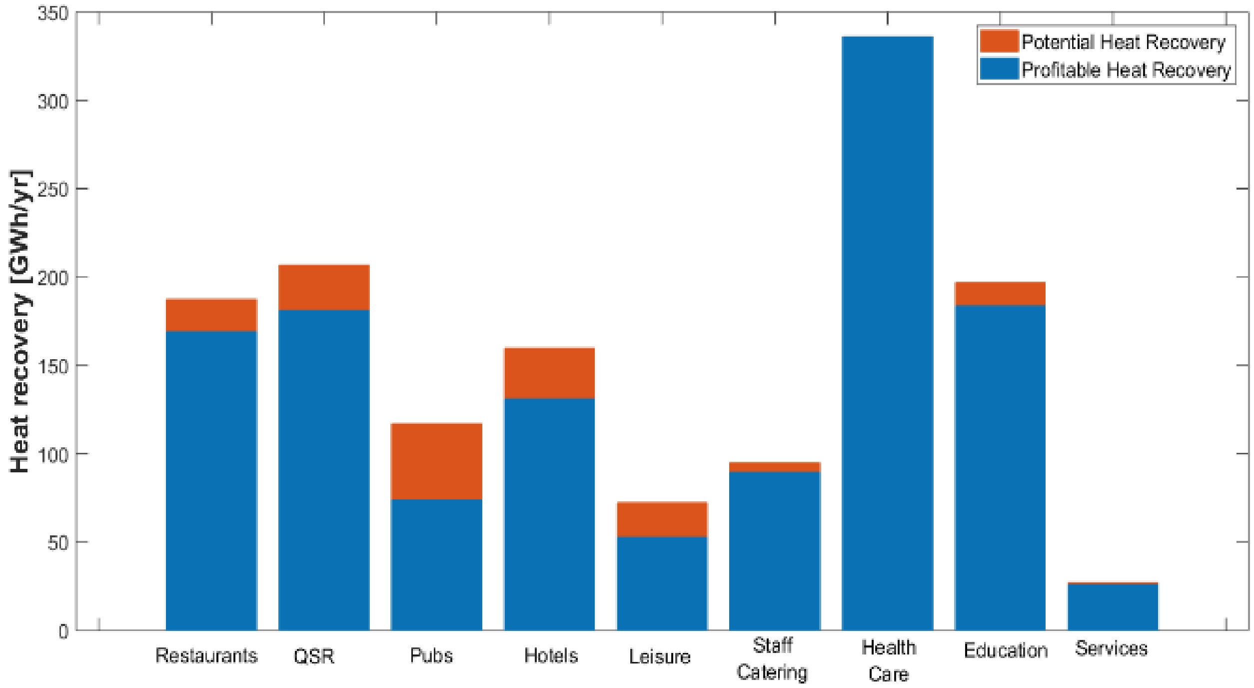
Heat recovery potential in Ireland & Wales

- **1.4 TWh/yr** could be saved annually in the UK food & hospitality sector using DWHR



- Potential to reduce heating related greenhouse gas emissions by 7.6% to 22% from the domestic sector in Ireland.

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Environmental Impacts & Benefits of DWHR

Dr. Isabel Schestak, Bangor University

In collaboration with:

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Environmental costs of heat recovery: equipment

Resources from nature, energy

emissions to air, water, soil

Different sorts of damages…
e.g.
Climate Change,
Eutrophication,
Ecotoxicity,
Resource depletion
…

[1] https://showersave.com/vertical-wwhrs/

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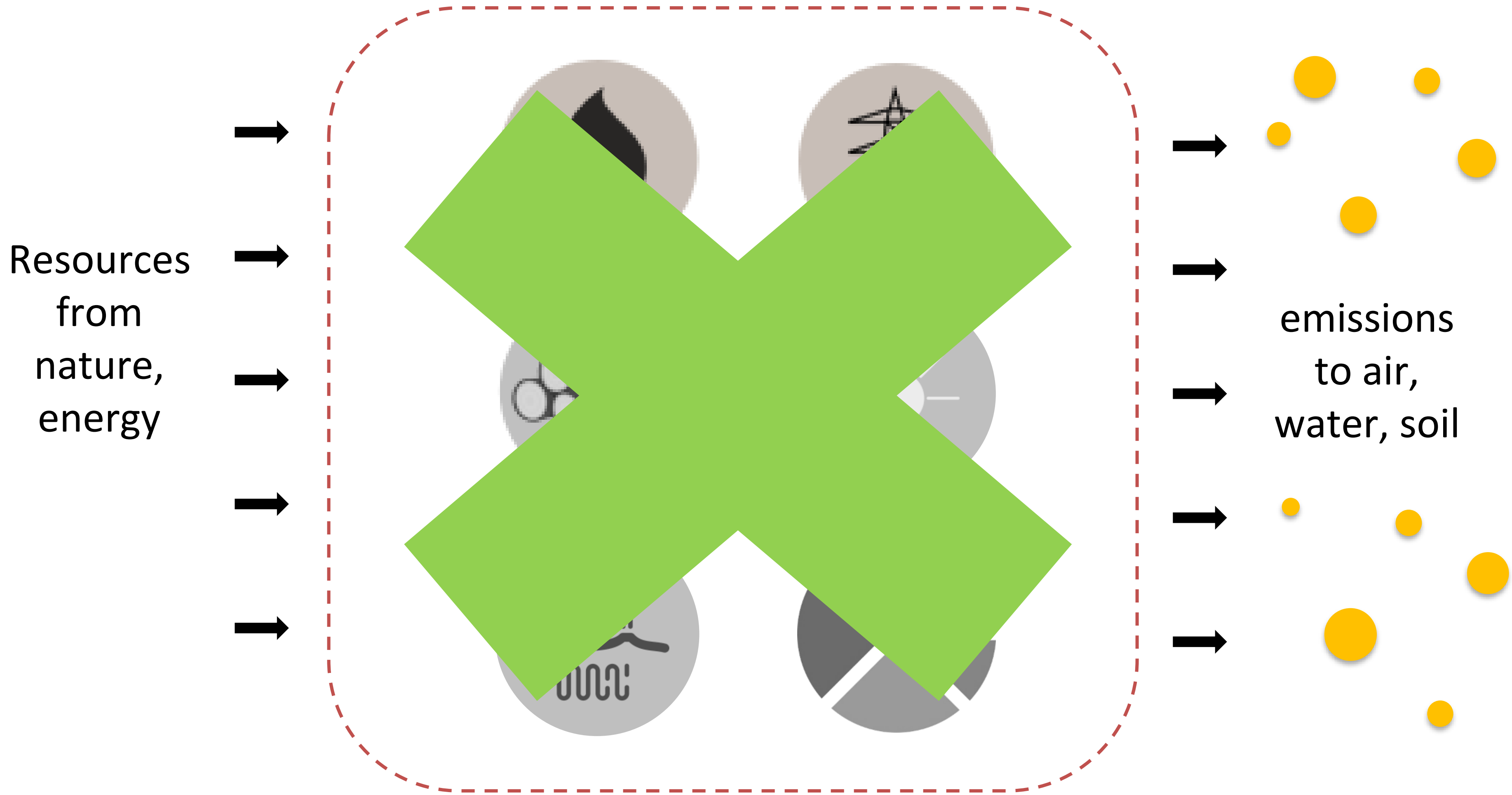
Environmental benefits from heat recovery: saved energy



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The environmental footprint depends on…

Material of the heat exchanger

Copper?
Recycled?
Alternative material?

Material and amount of pipework

Copper?
Steel?
Polyethylene?
How many meters?

Amount of heat recovered
=
How much water goes down the drain?

The environmental savings depend on…

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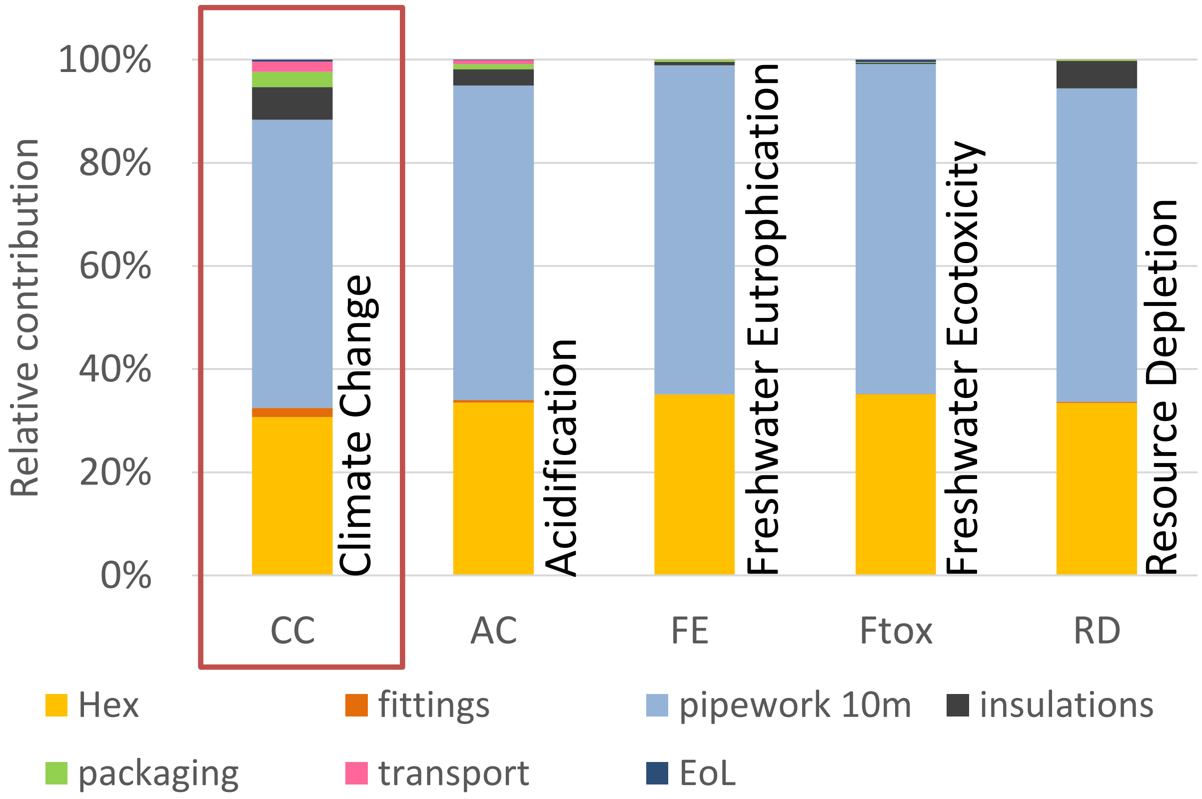
Result 1: Environmental footprint of the equipment



- Heat exchanger and pipework from 35% recycled copper
- 10m pipework
- Most emissions: mining operations and energy for manufacture and finishing of copper parts

Schestak, I., Spriet, J., Styles, D., Williams, A.P., 2020. Emissions down the drain: Balancing life cycle energy and greenhouse gas savings with resource use for heat recovery from kitchen drains. J. Environ. Manage. 271, 110988. https://doi.org/10.1016/j.jenvman.2020.110988

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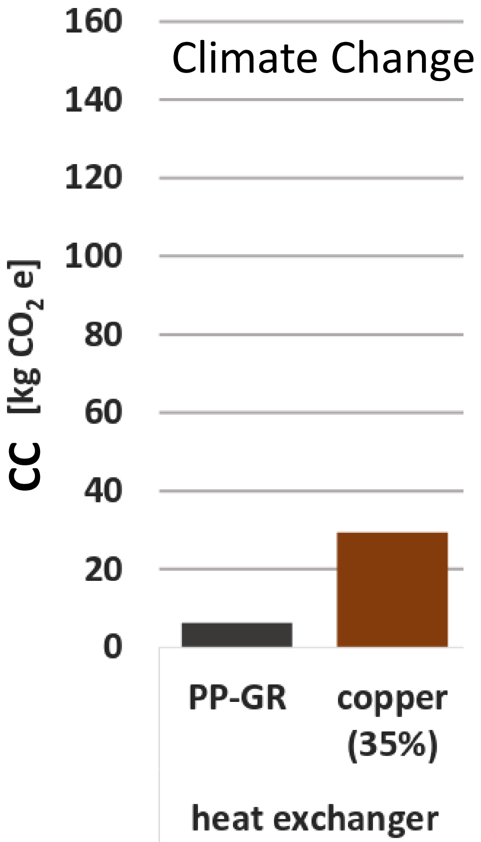
Result 2: Environmental footprint of the equipment



Benefits through smart material choice and compact design.

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Result 3: Savings and payback time: Penrhyn case

Assumption: heat savings of 230 kWh/month, 2760 kWh/year

Annual carbon savings: Penrhyn case and other replaced energy sources:

[kg CO_2 eq]	Penrhyn (wood+electr.)	NG	UK electr.	wood	geo	solar	UK mix
CC	308	721	777	297	379	54	706

Payback times: Penrhyn case and other replaced energy sources:

[Years]	Penrhyn (wood + electr.)	NG	UK electr.	wood	geo	solar	UK mix
CC	0.3	0.1	0.1	0.3	0.2	1.5	0.1
AP	1.1	1.7	0.6	1.1	0.6	1.8	1.1
FEP	8.2	11.6	5.6	8.3	1.0	3.1	9.1
FEtoxP	10.8	13.4	4.2	11.2	1.6	3.3	9.8
RDP	30.5	13.6	10.5	31.8	8.0	3.4	12.8

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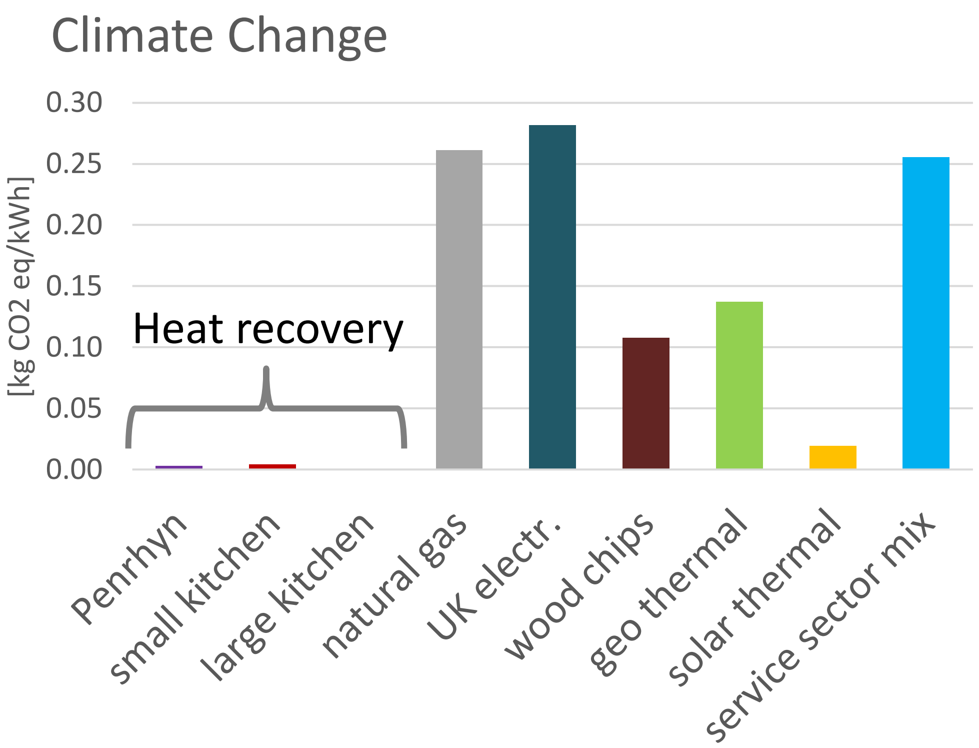
Result 4: Footprint per kWh: heat recov. vs other energy sources

Dependency on flowrate and type of avoided energy:



Recovering heat reduces environmental impacts even when replacing renewable heat, especially for climate change mitigation.

Large kitchen: low impacts/high use scenario (12,500 L/day);

Small kitchen = high impacts/low use scenario (360 L/day); Heat exchanger from copper, 35% recycled and 10 m pipework from PE.

Schestak, I., Spriet, J., Styles, D., Williams, A.P., 2020. Emissions down the drain: Balancing life cycle energy and greenhouse gas savings with resource use for heat recovery from kitchen drains. J. Environ. Manage. 271, 110988. https://doi.org/10.1016/j.jenvman.2020.110988

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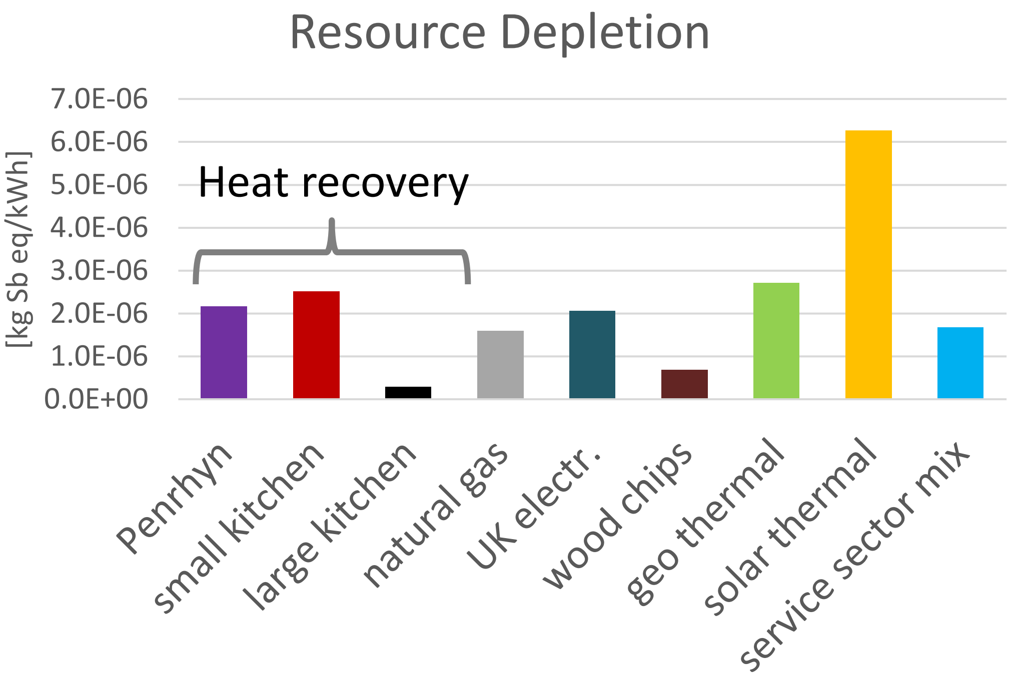
Result 5: Footprint per kWh: heat recov. vs other energy sources

Dependency on flowrate and type of avoided energy:



Resource depletion: possible trade-offs for small kitchens.

Sustainable from ~ 170 m^3 per year water consumption, with the current water heating energy mix (UK)

Schestak, I., Spriet, J., Styles, D., Williams, A.P., 2020. Emissions down the drain: Balancing life cycle energy and greenhouse gas savings with resource use for heat recovery from kitchen drains. J. Environ. Manage. 271, 110988. https://doi.org/10.1016/j.jenvman.2020.110988

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National savings potential for the UK

If heat recovery systems were installed in every UK food outlet…

Emission savings: 500,000 tons CO_2 e/year

… or taking 260,000 cars of the road.

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Free heat recovery calculator

- Purpose: Facilitate decision making for commercial kitchens towards heat recovery, taking into account individual conditions.
- Excel based
- Available for free

Is heat recovery sustainable and financially viable for my kitchen?

Download for free: https://www.dwr-uisce.eu/heat-recovery-tool

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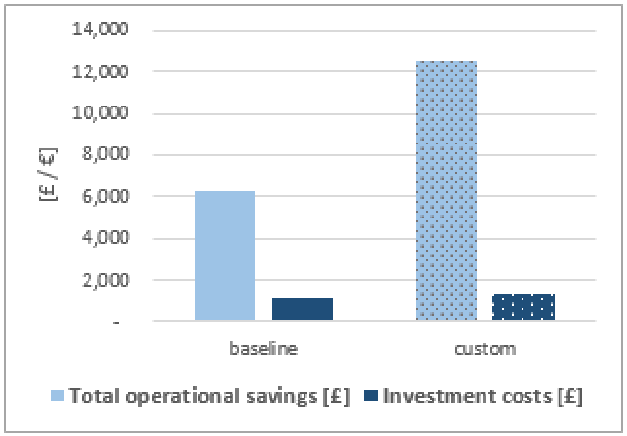
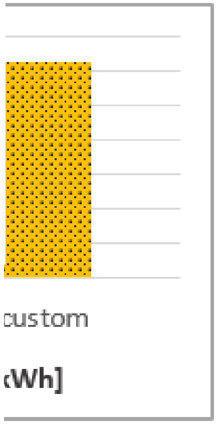
Financial assessment

	baseline:	custom:
Annual savings [£] These are the costs you save per year as the heat recovered replaces your usual energy source.	627	627
Total operational savings [£] The costs you save over the whole service life.	6,273	12,547
Investment costs [£] The investment costs include initial spends for heat exchanger, pipework with insulation and fittings.	1,112	1,292
Simple payback period [years] Time of service life after which your installation costs are paid back through the annual savings above.	1.8	2.1





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The University of Dublin

Dŵr Uisce | Energy Recovery in Water Services
Adennill Ynni yn y Diwydiant Dŵr

Prifysgol Bangor University

Open Discussion & Emerging Opportunities

Prof. Paul Coughlan, Trinity College Dublin

In collaboration with:

Ymddiriedolaeth Genedlaethol
National Trust

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Tionól Réigiúnach an Deiscirt
Southern Regional Assembly

EU Funds: Ireland Wales Programme 2014-2020

Project funding & context

- Funded for 6.5 years (€4.4M) by the ERDF Interreg Ireland-Wales Programme 2014-2020
- Cross border innovation theme
- Increasing innovation within SMEs
- Encouraging collaboration between Higher Education, Public Sector organisations & SMEs.
- Improve innovation performance and productivity within SMEs
- Create new/improved products, services or processes.

Dissemination

Website: www.Dŵr-uisce.eu

Twitter: @Dwr_Uisce

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Dŵr Uisce

Energy Recovery in Water Services
Adennill Ynni yn y Diwydiant Dŵr

From Concept to Operation

Time	Event
10.00 – 10.30	Registration, Coffee/Tea & Networking (location The Stables)
10.30 – 10.40	Welcome & National Trust Motivation Paul Southall, National Trust
10.40 - 10.50	Dwr Uisce Project Overview & Welcome Prysor William, Bangor University
10.50 – 11.10	Drain Water Heat Recovery at Penrhyn Castle – Design & Performance Aonghus McNabola, Trinity College Dublin
11.10 – 11.30	Environmental Impacts & Benefits of Drain Water Heat Recovery Isabel Schestak, Bangor University
11.30 – 11.40	Open Discussion & Emerging Opportunities Paul Coughlan, Trinity College Dublin
11.40 – 12.40	DWHR Site Demonstration & Historical Tour of Penrhyn Castle Tea rooms, Coal yard & general castle tour
11.40 – 12.10	DWHR Site Virtual Tour & Online Q&A 3D online virtual tour of Team Rooms & Coal yard
12.40 – 13.40	Lunch & Networking Penrhyn Tearooms
13.40pm	Departure

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Thank you for your attention

Diolch am eich sylw

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