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

Prifysgol Bangor University

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

Delivering Solutions for the Sustainability of the Water-Energy Nexus

Final Event

Trinity Business School, Trinity College Dublin
7th March 2023

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Agenda

Time	Event
10.00 – 10.30	**Registration, Coffee/Tea & Networking** (location The Foyer)
10.30 – 10.40	**Choral Introduction** *Dublin Welsh Male Voice Choir*
10.40 - 10.50	**Welcome** *Brian Broderick, Associate Dean of Research, Trinity College Dublin*
10.50 – 11.10	**Welsh Assembly Perspective** *Lee Waters MS, Deputy Minister for Climate Change*
11.10 – 11.40	**Delivering Engineering Solutions** *Aonghus McNabola, Trinity College Dublin*
11.40 – 12.10	**Environmental insights for industry and policy** *Prysor Williams, Bangor University*
12.10 – 12.20	**Leveraging Transdisciplinary Research Collaboration for Impact** *Paul Coughlan, Trinity College Dublin*
12.20 – 12.40	**Acknowledgements, Next Steps & Panel Discussion** *Aonghus McNabola, Prysor Williams & Paul Coughlan*
12.40 – 13.00	**Choral Closure** *Dublin Welsh Male Voice Choir*
13.00 – 14:00	**Networking, Poster & Lunch** *The Foyer*

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Choral Introduction ♪♫

The Dublin Welsh Male Voice Choir

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Welcome

Prof. Brian Broderick, Associate Dean of Research (STEM),
Trinity College Dublin

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Welsh Government Perspective

Lee Waters MS, Deputy Minister for Climate Change

Welsh Government

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Delivering Engineering Solutions

Prof. Aonghus McNabola, Trinity College Dublin

Introduction to Dŵr Uisce

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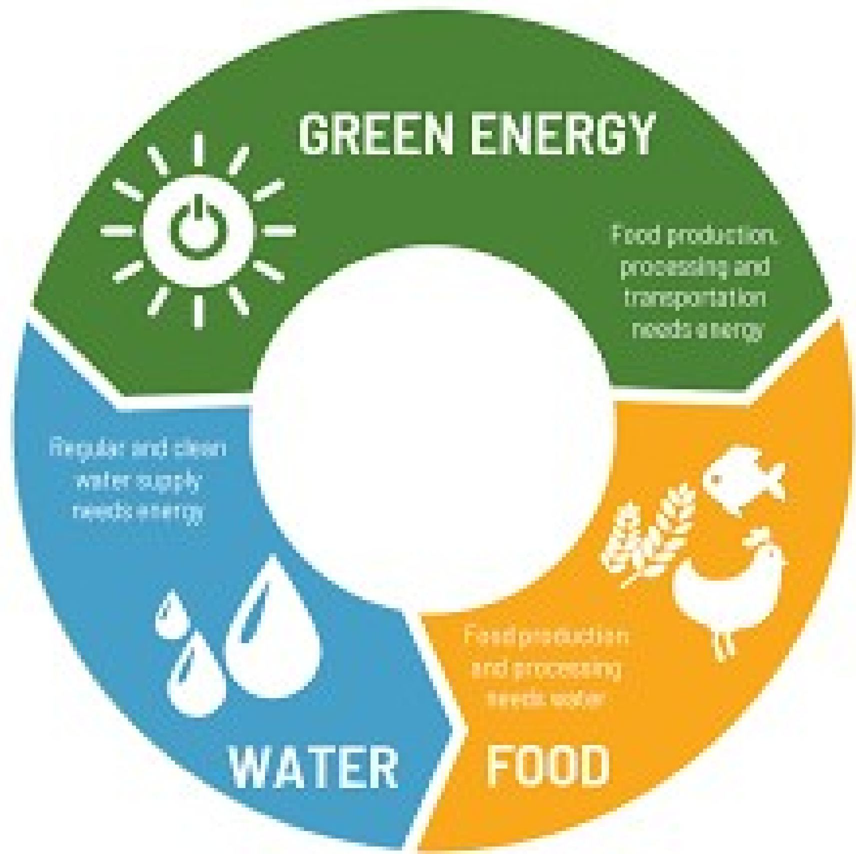
The Dŵr Uisce project aimed to address the water-energy-food nexus using:

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 stakeholder groups: **water suppliers** and **water consumers**

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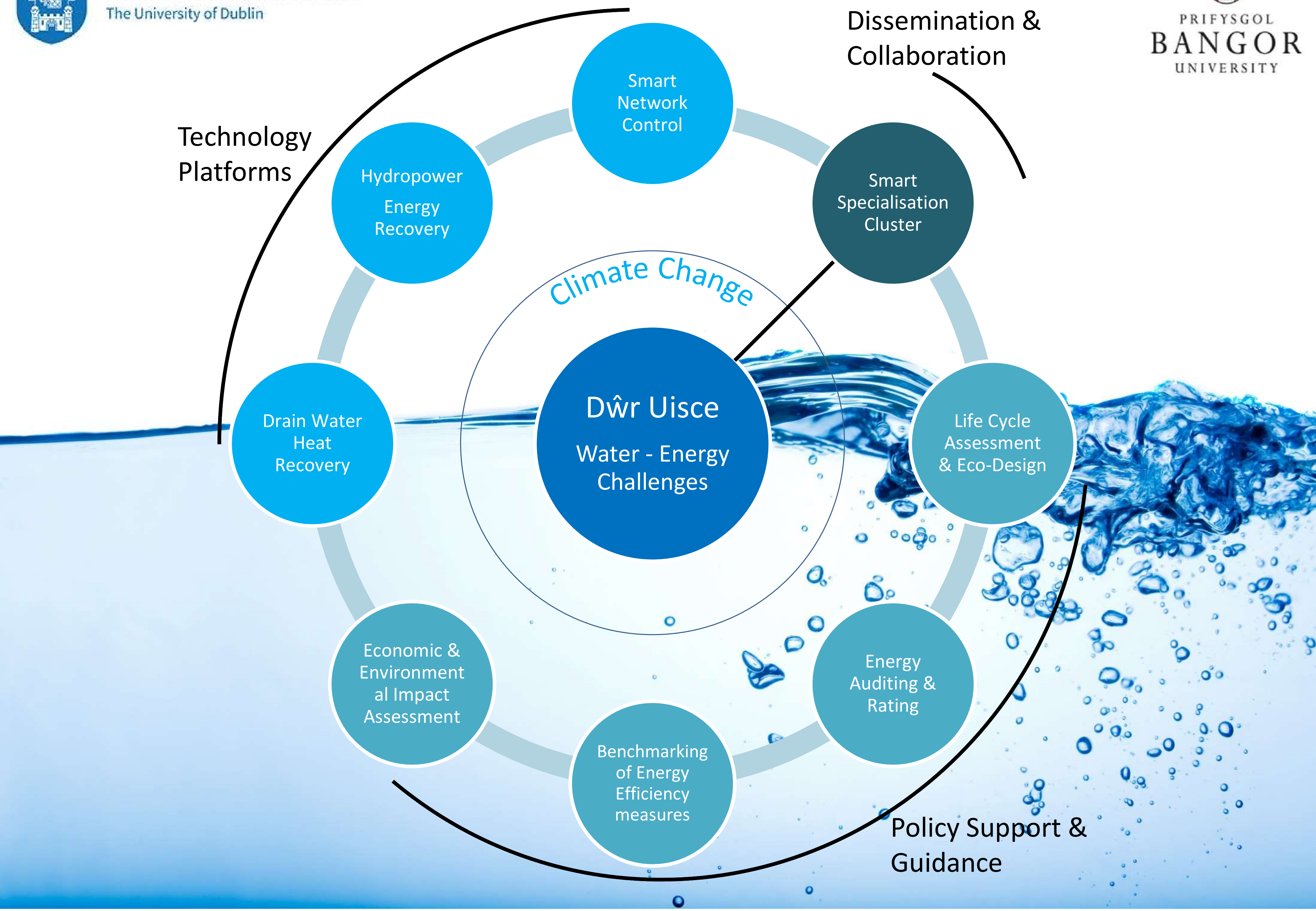

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Wastewater Heat Recovery

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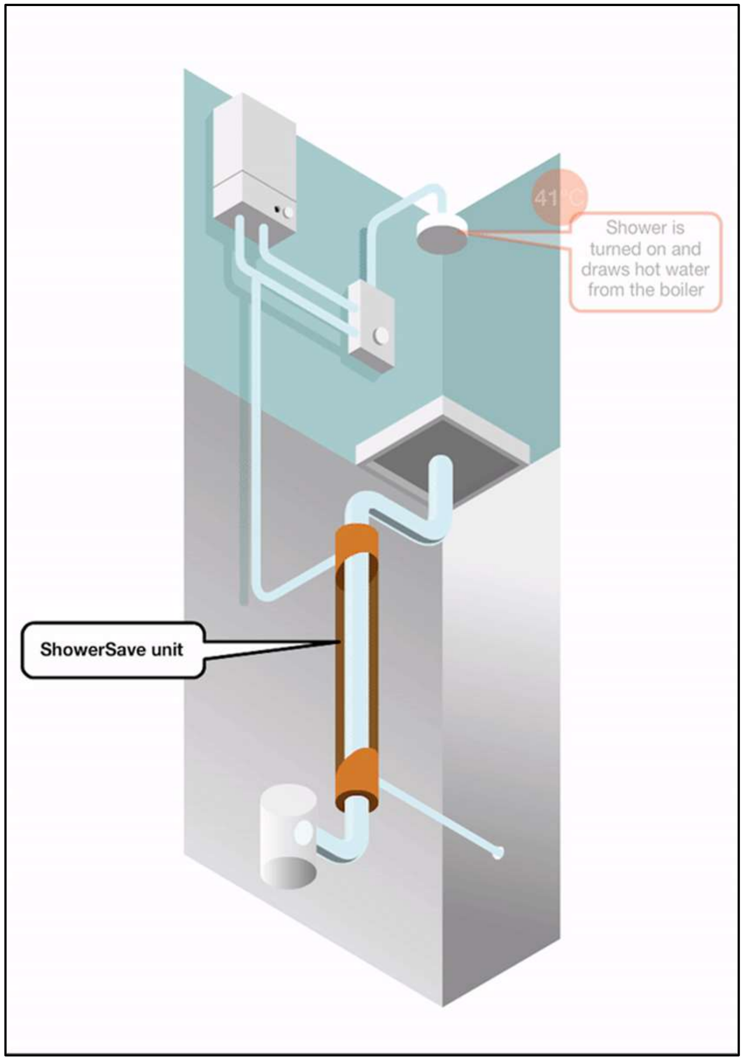
- Heating/cooling account for ~50% of energy consumption in the EU
- 15-30% of a buildings thermal energy is embedded in wastewater
- Water from a typical 40°C shower enters the drain at 30°C
- In 2016 the Dwr Uisce project faced the following challenges:
    - The magnitude of heat resources available in the sewer systems is unknown
    - The spatial and temporal variation of waste heat resources is unknown
    - Technical solutions for heat recovery outside of showers or single domestic/commercial appliances are lacking

DWHR at Penrhyn Castle

Heat recovery concept in wastewater



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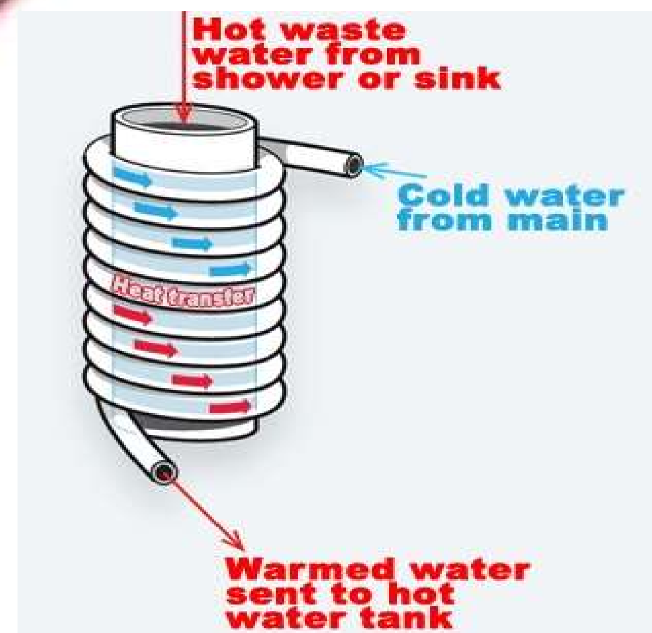

[1] https://showersave.com/wp-content/uploads/2016/08/A-System-1.mp4
[2] https://showersave.com/vertical-wwhrs/

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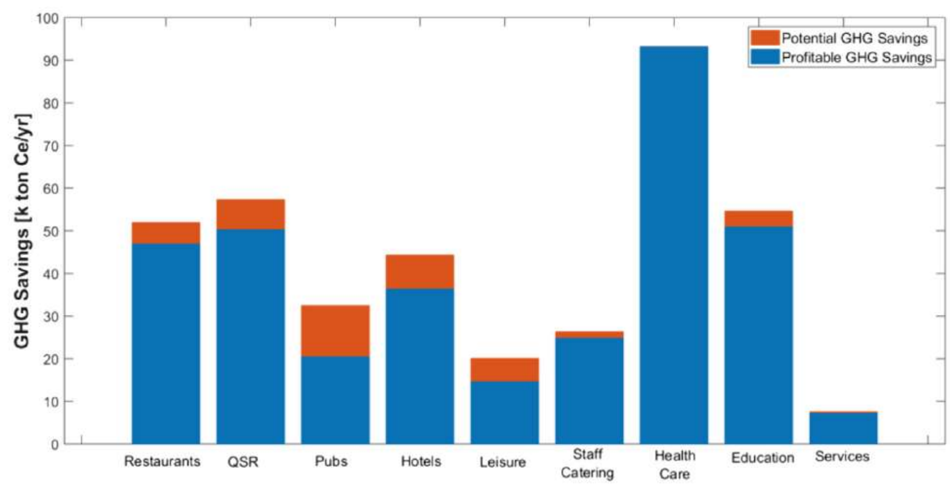
Wastewater Heat Resource Estimation

- Wastewater heat measured in:
  - 10 domestic residences
  - 1 nursing home
  - 5 hotels
  - 5 cafes
  - 3 leisure centres
  - 3 industrial food producers
  - 1 Wastewater treatment plant

- Estimated 1.4 TWh/yr of waste heat be discharged from commercial kitchens in the UK



- Showed wastewater heat in the domestic sector in Ireland has the potential to reduce greenhouse gas emissions related to domestic hot water- and space heating by up to 22%

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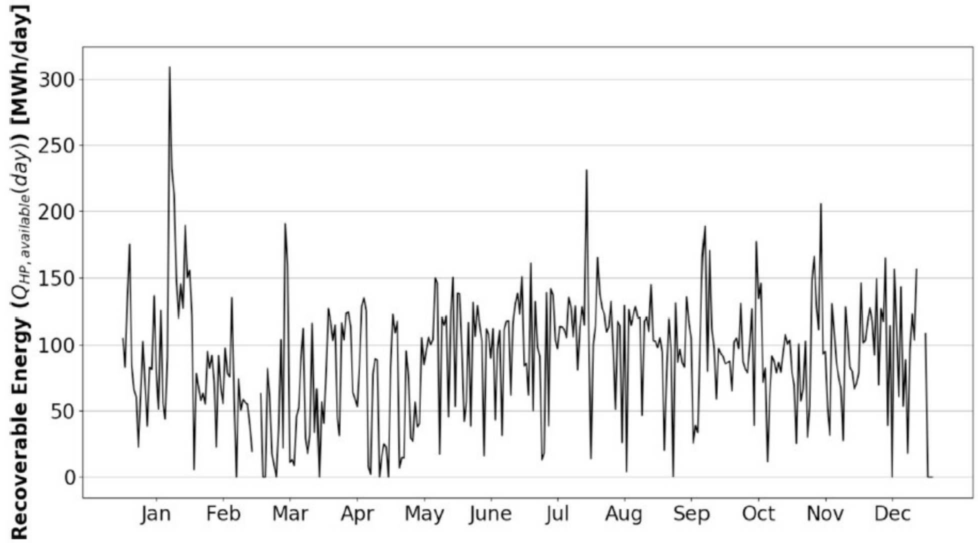
Wastewater Heat Resource Estimation

- Estimated a total 26 GWh/yr of available wastewater heat at Tullamore wastewater treatment plant in Ireland

- Established a picture of the size and spread of wastewater heat resources

- This led to new questions and opportunities for WWHR technology



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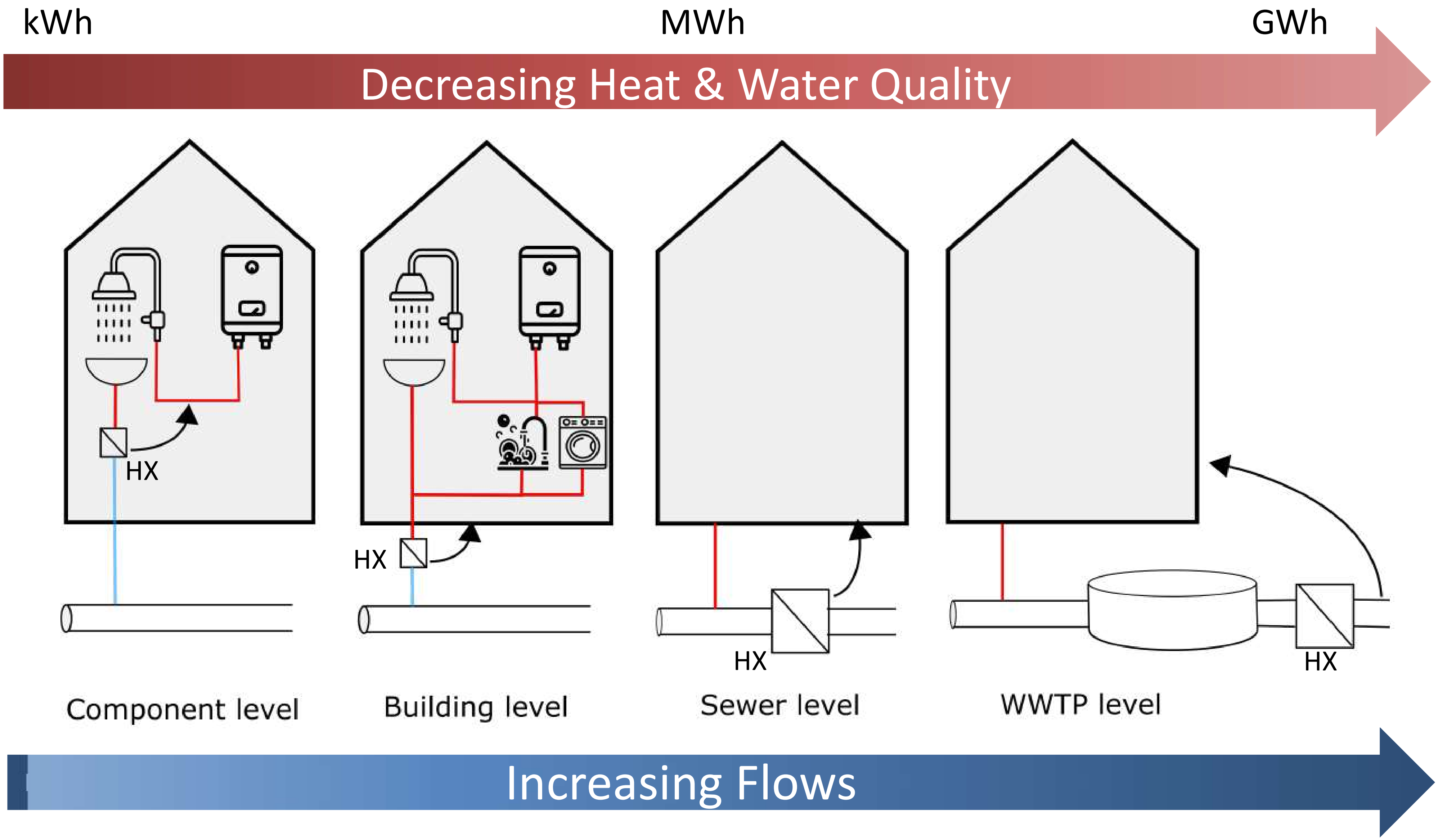
Wastewater Heat Resource Estimation



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Wastewater Heat Recovery Demonstration

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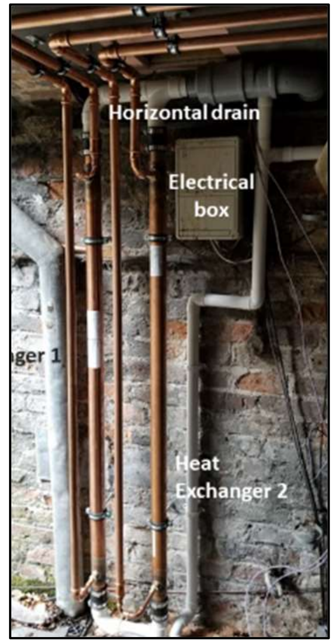
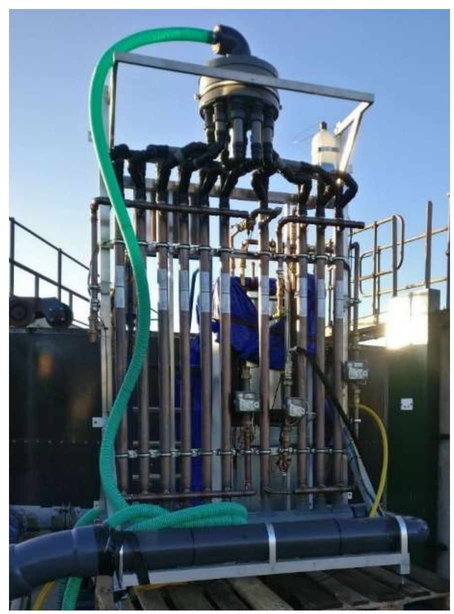
- Pilot demonstration of WWHR at Penrhyn Castle Café
  - Saved 1510 kWh during 2022 tourist season (233 kWh / month on average)
  - £1815 system cost with 1-7 year payback (depending on fuel price)

Ymddiriedolaeth Genedlaethol National Trust

abp Food Group



- Pilot demonstration of WWHR at ABP Food Cahir
  - Recovered 48-168 kWh/day from treatment works inlet
  - Recovered 38-140 kWh/day from treatment works outlet
  - MWh available onsite but more HX development required



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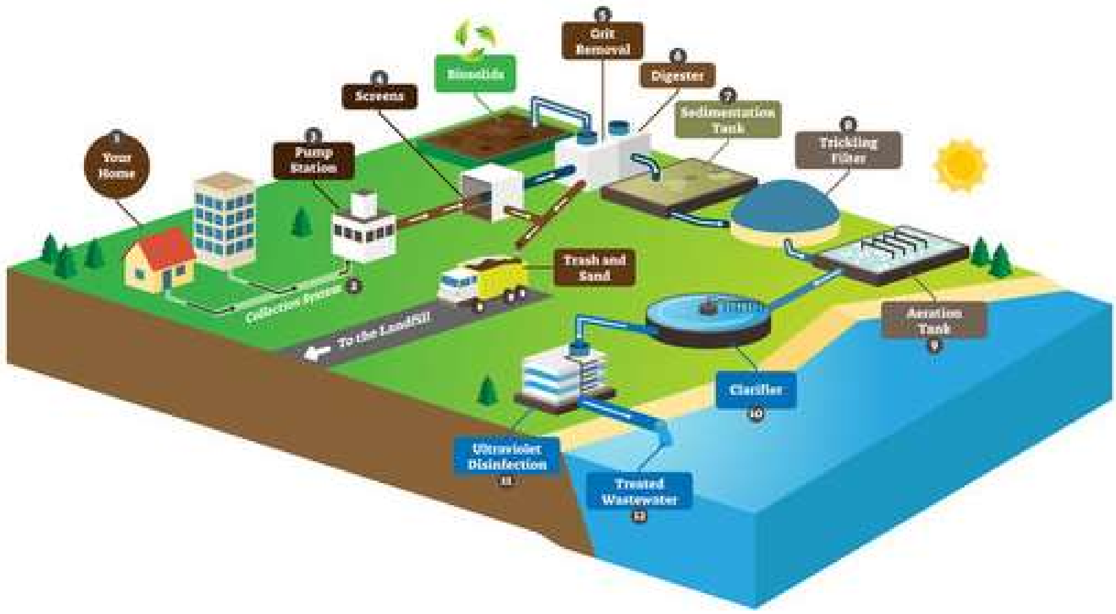
Key learnings & Future Developments

Very significant renewable heat resources available in wastewater systems:

- Key sectors include water-intensive industry/commerce & municipal treatment plants

- Key factors include ambient temperature and cold-water temperature
- Key unknown: impacts of WWHR on wastewater treatment and sewer system



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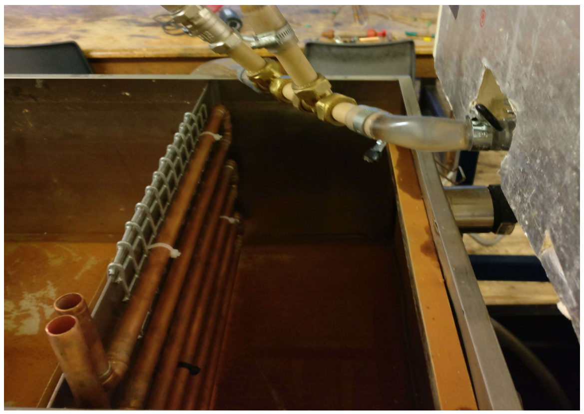
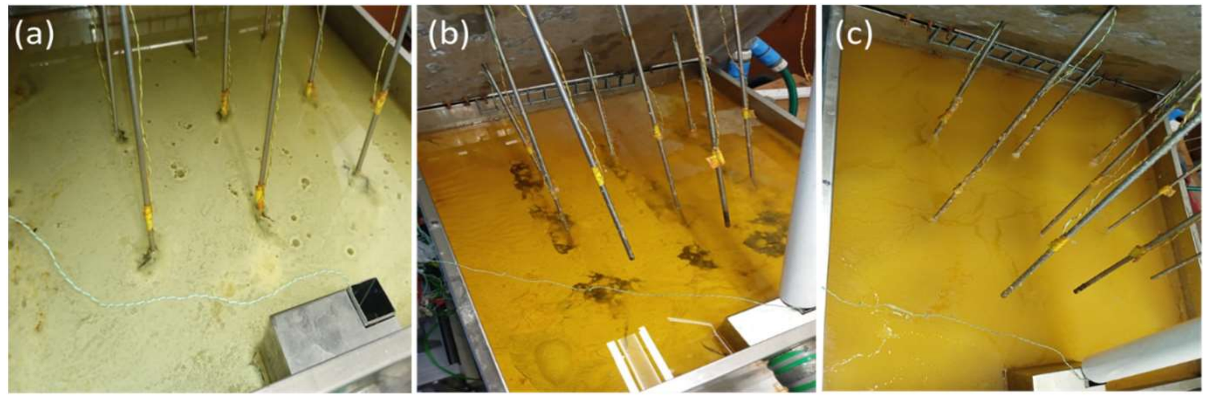
Key learnings & Future Developments

- Key research question: how can we integrate WWHR into existing wastewater treatment processes?





Vegetable oil *Vegetable oil + Butter* *Vegetable oil + Butter + Goose fat*

- New research projects examining the integration 3D printed thermally conductive composite materials for WWHR in existing treatment tanks

Recycling Energy Hidden in Existing Wastewater Treatment Systems (REHEATS)

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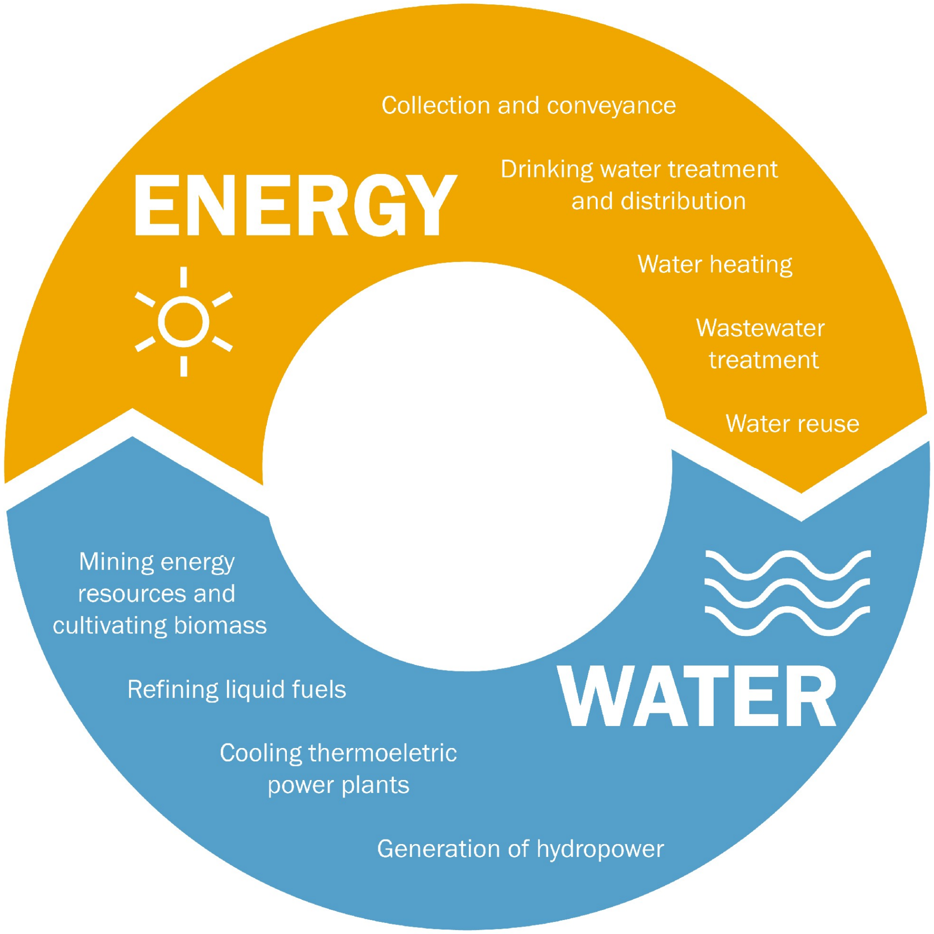
Micro Hydropower Recovery

- Globally, 2-3% of energy usage is reported to be associated with the production, distribution and treatment of water.

- Water Industry in the Ireland is the **4th most energy intensive sector** and contributes heavily to CO_2 emissions.

- In 2016 the Dwr Uisce tried to improve the sustainability of W-E nexus using micro-hydropower

- The project addressed the following challenges:
    - The cost of MHP to not economic under 20-50 kW
    - Pump-as-turbines offer a low-cost solution but their performance prediction is unreliable
    - PATs are not well regarded in the water industry



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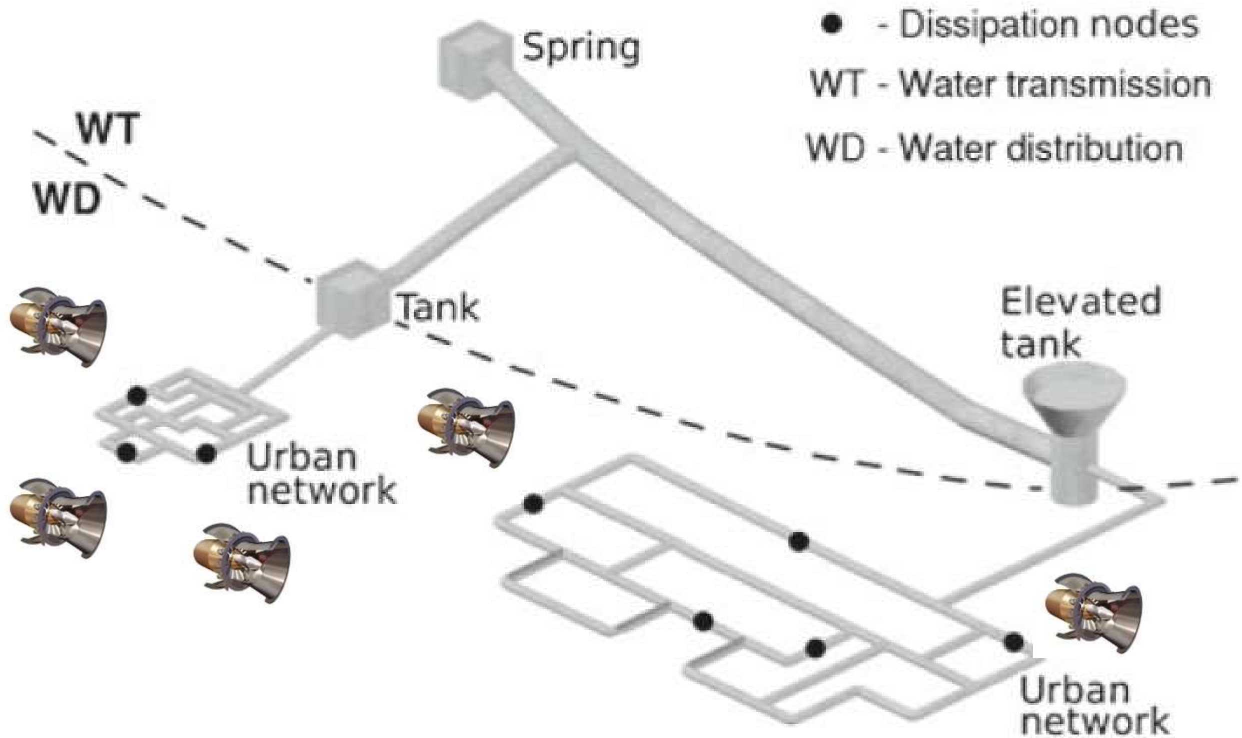
Micro Hydropower Recovery

Recovering energy from flowing water in network infrastructure at points of excess pressure:



- Building on work of the Hydro-BPT project (ERDF Interreg Ireland-Wales 2007-2013)
- Starting at TRL3-4 and finishing at TRL7-8

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Pump-As-Turbines (PATs)

PUMP MODE

- Compact dimensions
- Mass manufactured
- Short delivery time
- Easy maintenance
- Low cost (5-15 times less expensive)

TURBINE MODE

- Poor part-load efficiency
- Lower peak efficiency
- Lack of information on characteristic curves
- Perceived risk to investment
- Low accuracy in existing methods of performance prediction (±30%)

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PATs Decision Support System

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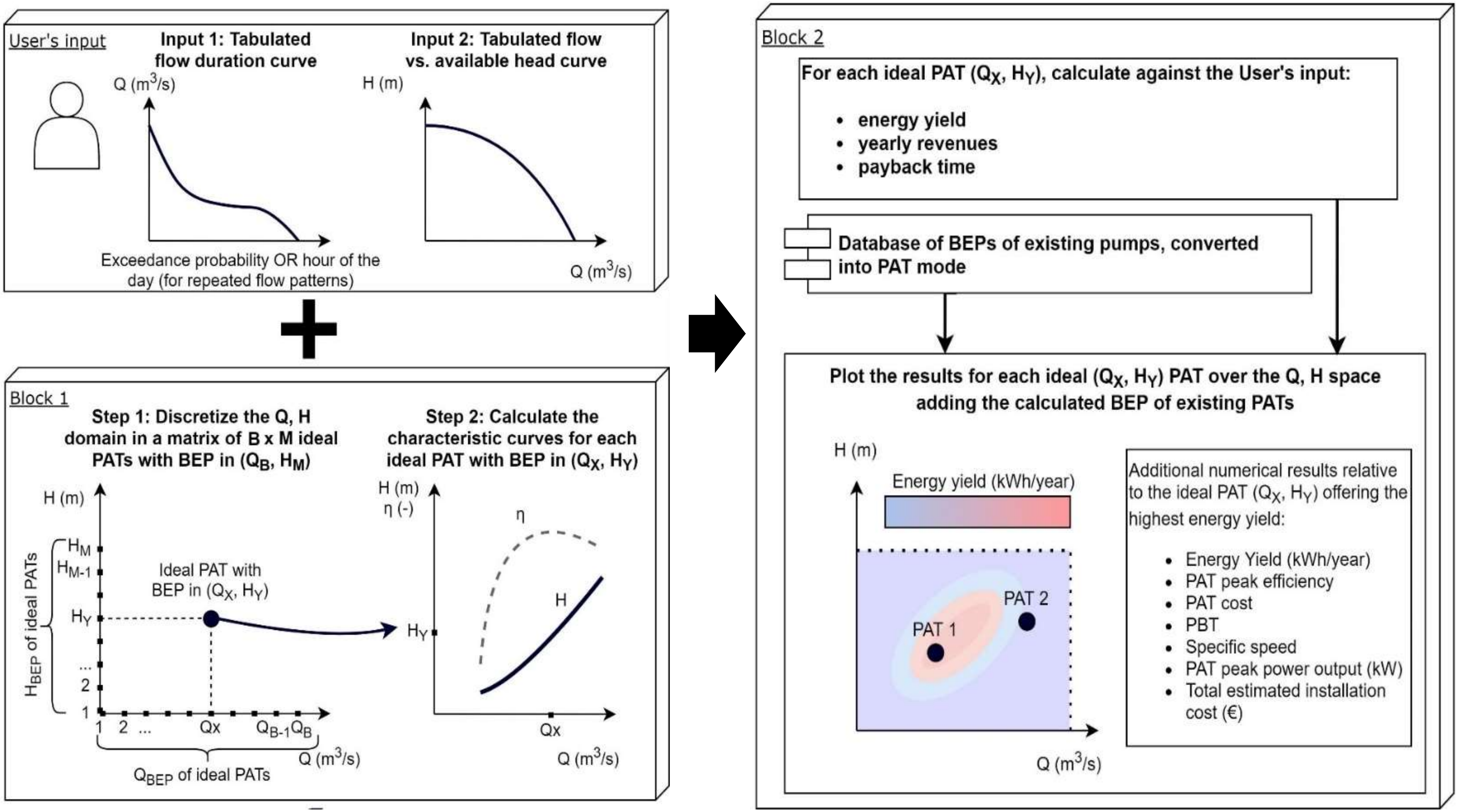

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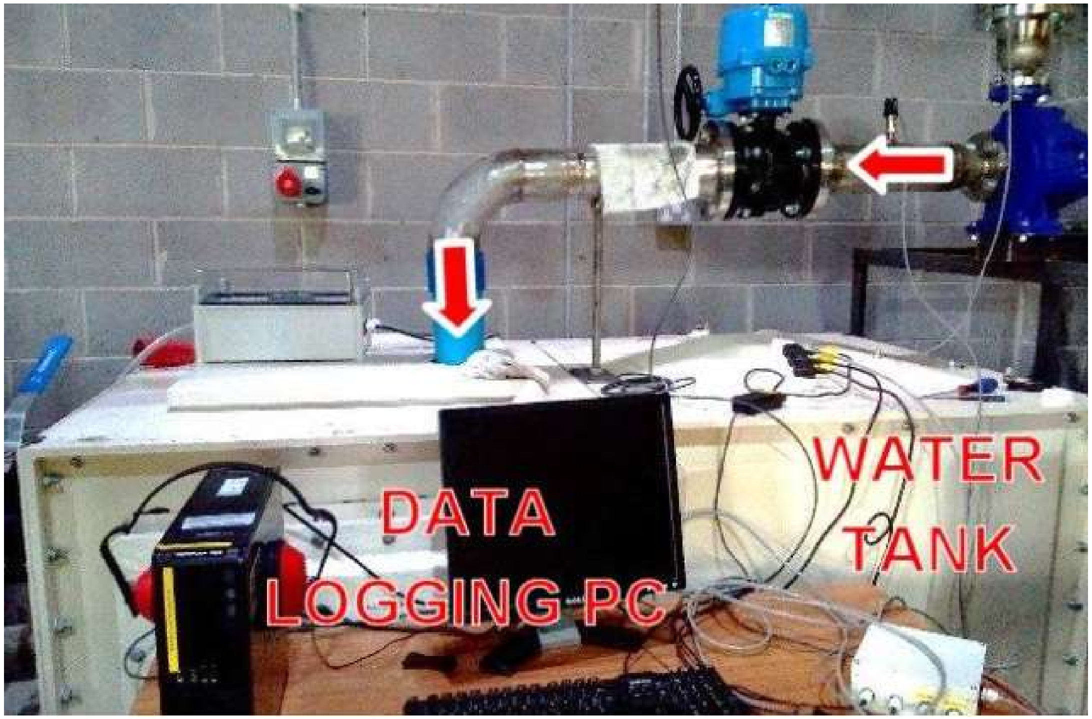
PATs Decision Support System

Decision support system developed to enable pump selection for turbine design

- Based on cost and performance data of 343 pumps, 286 generators and 113 experimentally determined PAT curves.
- Provides optimum PAT choice for maximum energy yield or lowest payback period



Lab-scale PAT test apparatus

Development and validation of PAT design software

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PATs Decision Support System

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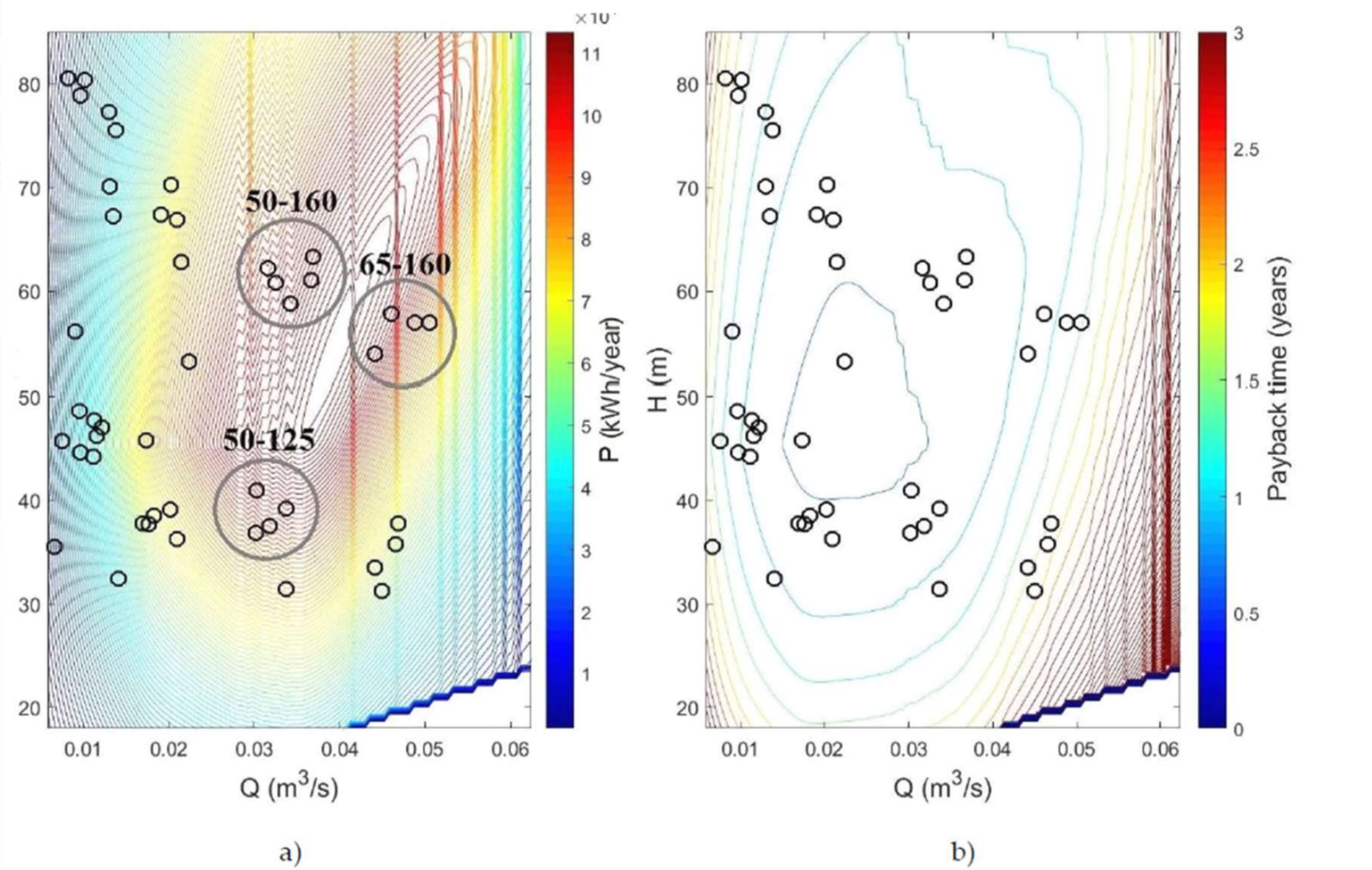

Figure 4. Algorithm results for the PAT downstream of Merano aqueduct: (**a**) yearly energy yield; (**b**)

NS

Fig. 7. Relative flow and power characteristic curves according to the Ns of all the 113 analyzed PATs, displayed together with the proposed interpolating 3D

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PATs Decision Support System

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- Pilot demonstration of MHP energy recovery at blackstairs water treatment works using a PAT:
  - 3.4 kW from 40m head and 17 l/s raw water flow
  - Yearly generation capacity: 37,000 kWh
  - 20-25% saving of energy requirements for water

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Delivering Solutions for the Sustainability of the Water-Energy Nexus

Environmental Insights for Industry & Policy

Dr. Prysor Williams
School of Natural Sciences
Bangor University

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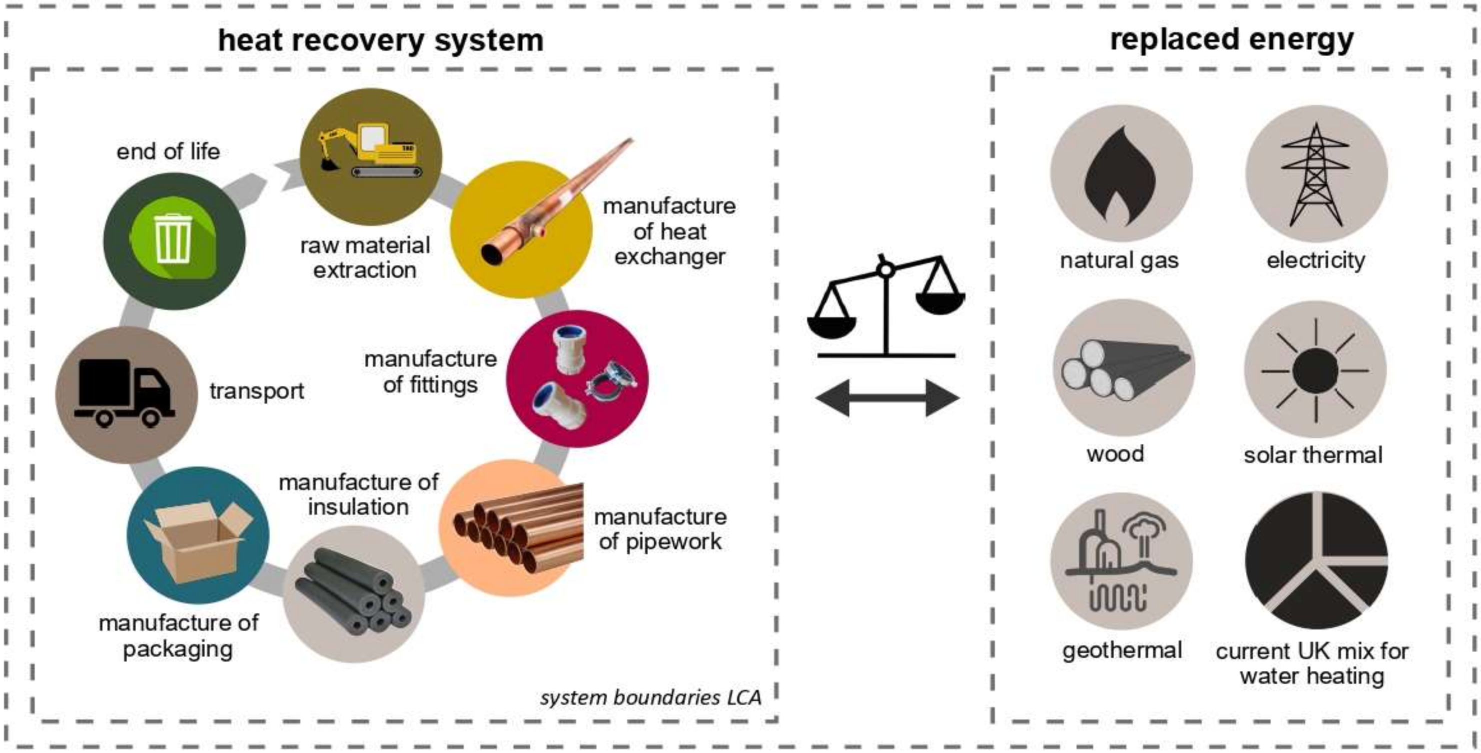
Environmental Insights

Through Life Cycle Assessment

Environmental benefits from kitchen drain water heat recovery

Heat recovery comes with environmental footprint through equipment manufacture and installation:

- Determine footprint of heat recovery installations (Life cycle assessment)
- Compare to environmental savings when retro-fitted to commercial kitchens



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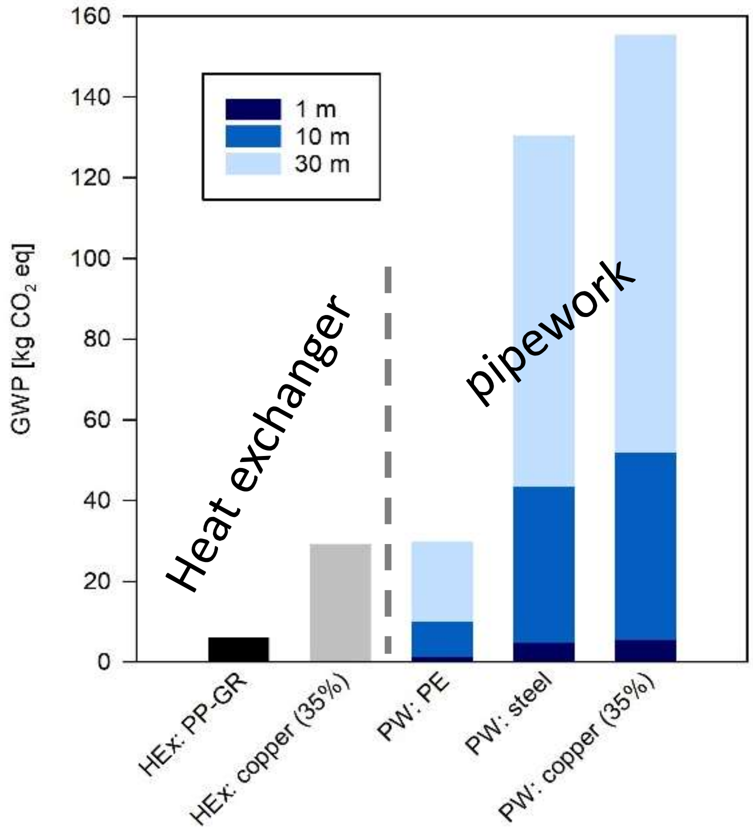
Environmental Insights

Through Life Cycle Assessment

Environmental benefits from kitchen drain water heat recovery

- Results (I)
  - Most environmental burdens from mining operations and energy for manufacture and finishing of copper parts
  - But: emission reduction possible through use of recycled copper
  - Material choice and length of pipework greatly influences footprint (polyethylene lower footprint than steel or copper)

➡ Smart and compact design important to lower footprint of installation and decrease environmental payback time



Environmental Insights

Through Life Cycle Assessment

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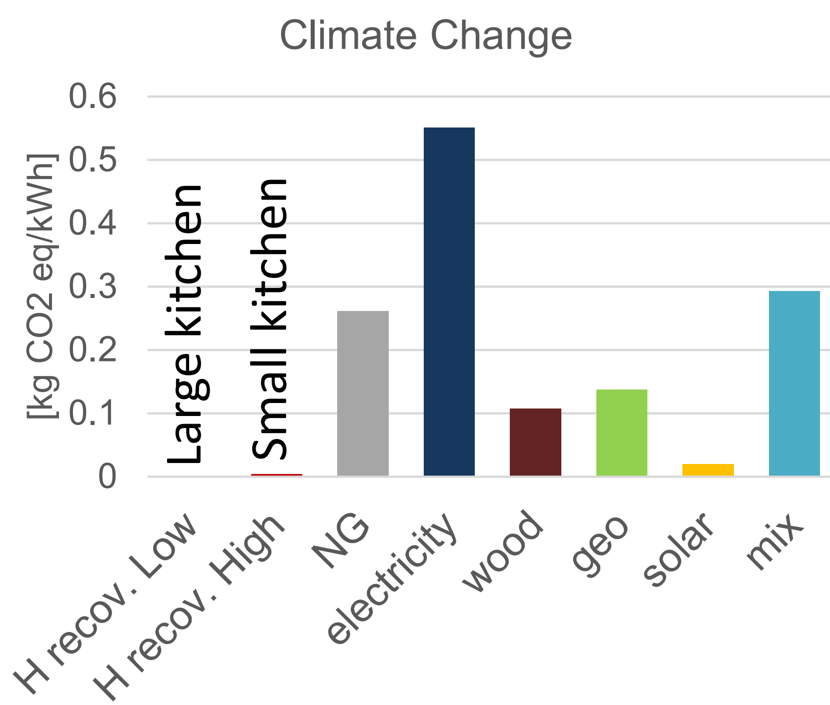
Environmental benefits from kitchen drain water heat recovery

- Results (II)
  - Recovering heat reduces environmental impacts even when replacing renewable heat, especially for climate change mitigation
  - Sustainable from ~ 200 m^3 per year water consumption, with the current water heating energy mix: i.e. environmental (resource depletion) trade-offs only for the smallest 10% of kitchens in UK



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

Emission savings: 500,000 tonnes CO_2 e/year = or taking 260,000 cars of the road

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Environmental Insights

Through Life Cycle Assessment

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Development of a heat recovery tool/calculator

- Purpose: Facilitate decision-making for commercial kitchens towards heat recovery: financially and environmentally viable?

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

User data: Water consumption, Energy price and type

Is heat recovery sustainable for my kitchen?

Heat recovery potential

Financial savings and payback time

Environmental savings and payback time

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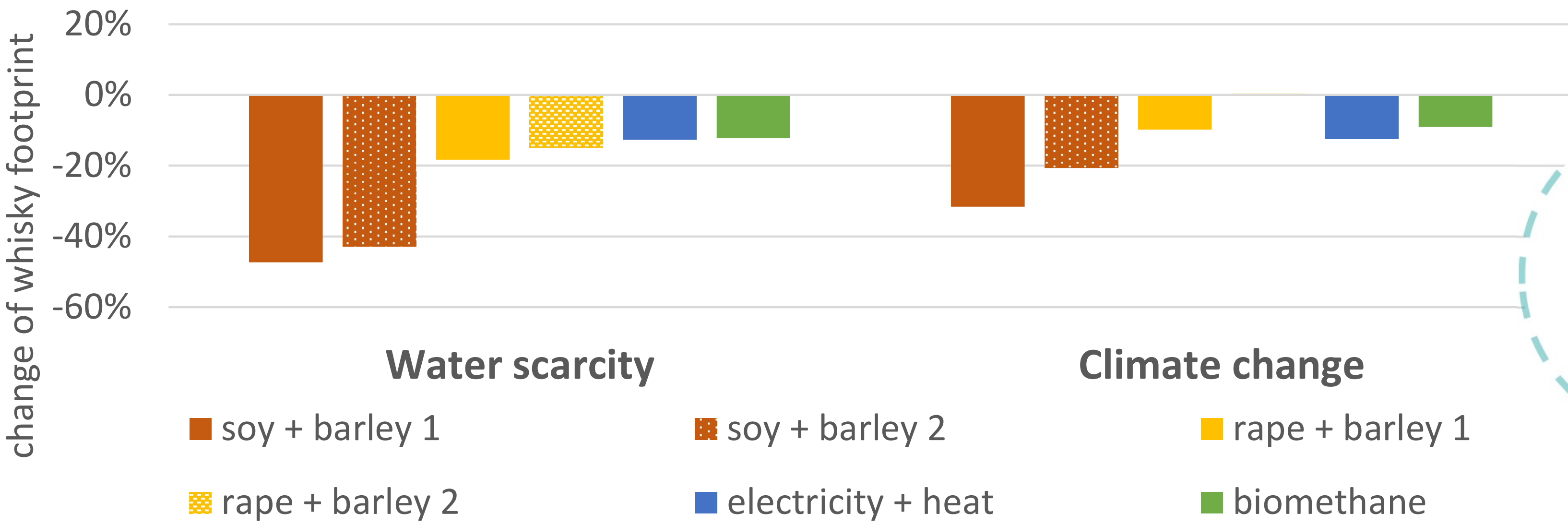
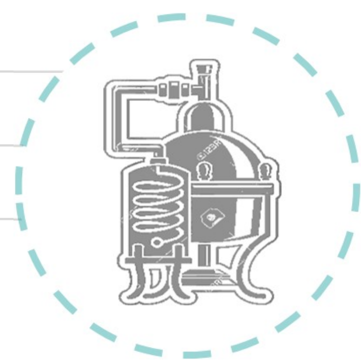
Environmental Insights

Through Life Cycle Assessment

Water use in distilleries (I): By-product use pathways

- What water and carbon footprint can be avoided through by-product use?
- Scenarios compared: cattle feed vs. bioenergy (car fuel, or gas+electricity)
- **Highest offset of water and carbon footprint when pot ale and spent grain used for feed, replacing imported soy and domestic barley;** as opposed to bio-energy use
- If all by-products from UK potable alcohol production used as feed: avoidance of 37% of imported soy water-scarcity footprint





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Environmental Insights

Through Life Cycle Assessment

Water use in distilleries (II): Heat recovery from process and by-product streams

- **Background:**
  - Over 400 spirit producers in the UK, predominantly small-scale craft distilleries
  - Majority of energy sources: fossil
  - Study takes into account environmental footprint of required installations and capital costs
- **Results:**
  - **Up to 25% fuel and 13% electricity savings**, up to 60% reduction of water evaporation through avoidance of cooling tower use
  - Carbon emission reduction: 8-23% depending on heat recovery configuration
  - UK potential 47 kt of CO_2 eq per year when applied in all malt whisky distilleries
  - **Financial payback time: under 2 years**

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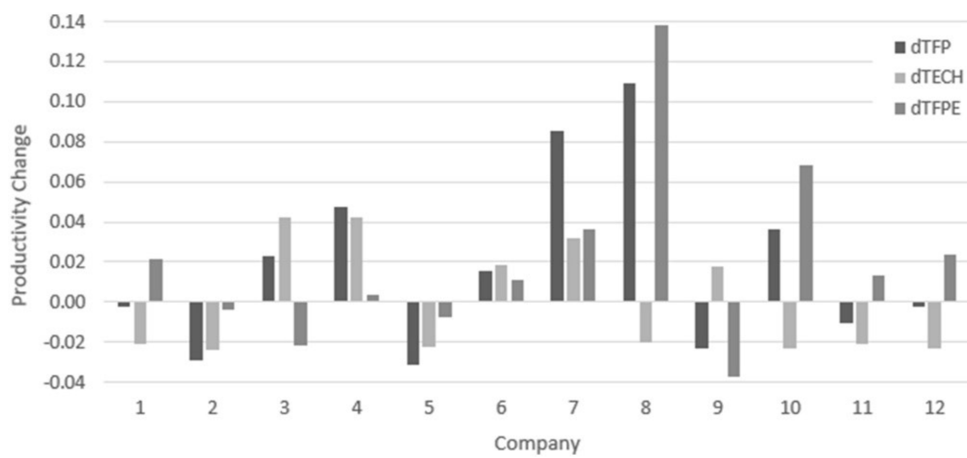
Environmental Insights

Benchmarking UK & Ireland water sectors

- Benchmarking can be useful to improve efficiency, expose areas for improvement, and identifying best practice
- To improve benchmarking methodologies, conducting efficiency comparisons and determine key variables
    - Between 12-17 companies were evaluated from 2014 onwards using environmental and economic indicators
- Companies could reduce economic inputs by 19% and carbon outputs by 16%
- The UK water sector has improved in productivity by 1.8% on average



Environmental Insights

Benchmarking UK & Ireland COVID-19 Response

	Percentage change
Post-tax return on regulated equity (%)	-20.6%
Adjusted Gearing (%)	2.3%
Interest Cover Ratio	-21.2%
Credit rating*	2.7%
Operational expenditure (£m)	-2.7%
Capital expenditure (£m)	-3.5%
Operating profit (£m)	-18.1%
Leakage (Ml/day)	-3.9%
Consumption per capita (Ml/d)	2.1%
Volume delivered (Ml/d)	4%
Water quality compliance**	-26.7%
Treatment works compliance (%)	0.0%
GHG emissions*** (kgCO2e/Ml)	-9.2%
Pollution incidents (per 10,000km)	2.2%
Supply interruptions (mins/properties)	-7.6%
Risk of sewer storm flooding (%)	-32.1%
Unplanned outage (%)	-36.8%
Customer satisfaction****	4.4%

* Credit rating based on Fitch and Moody's rating scales and converted to numbers for ease of comparison

** Based on compliance risk index figures (lower values = less risk and more compliance)

*** Location based carbon calculations for water production and wastewater treatment

**** From C-mex and D-mex surveys by OFWAT

- We evaluated how the water sectors in the UK and Ireland responded to COVID-19, using 18 indicators
- Financial indicators significantly negatively affected, with *interest cover ratio* and *operating profit* exhibiting the largest declines of 21% and 18%
- Service and environmental indicators improved, exemplified by *unplanned outage and sewer storm flooding risk* decreasing by 37% and 32%
- Specific advice to reduce non-critical spending, such as shareholder payments, during fiscal downturn to implement essential capital projects

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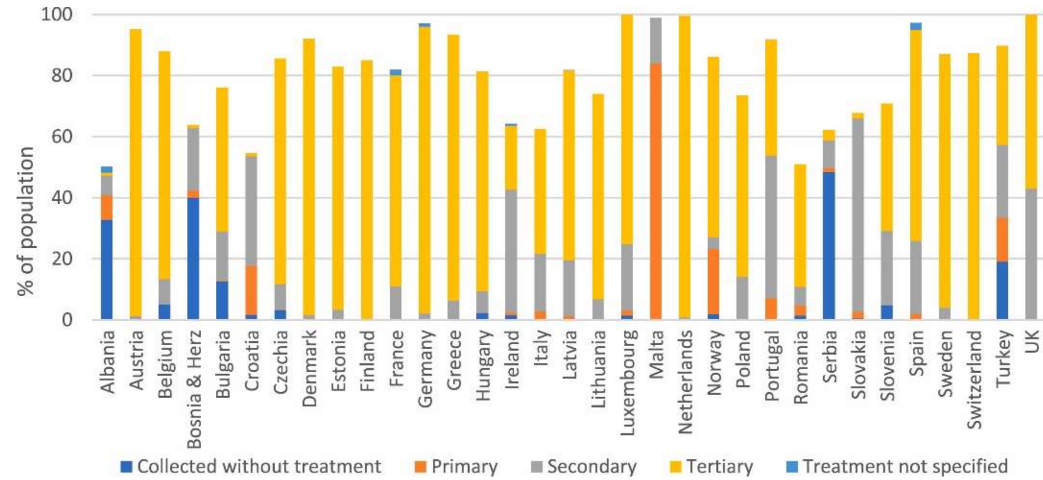
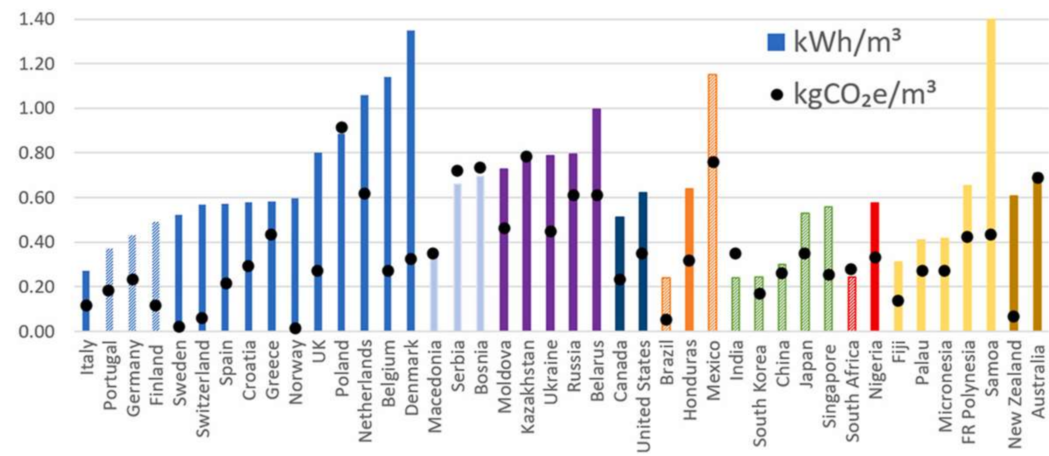
Environmental Insights

International energy efficiency benchmarking

- Wastewater treatment energy intensity benchmarking was undertaken on 321 companies from 31 countries
- EU states had the largest average kWh/m^3 with 1.18, which appeared a result of higher wastewater effluent standards
- Associated emissions showed a clean electricity grid can mitigate wastewater treatment inefficiencies, exemplified by Norway who emit just 0.013 kgCO$_2$ e/m^3 treated, despite consuming 0.60 kWh/m^3
- Treatment plant renewable technologies and a clean grid can deliver the highest effluent standards with much reduced environmental impacts





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Environmental Insights

Cross-sector benchmarking

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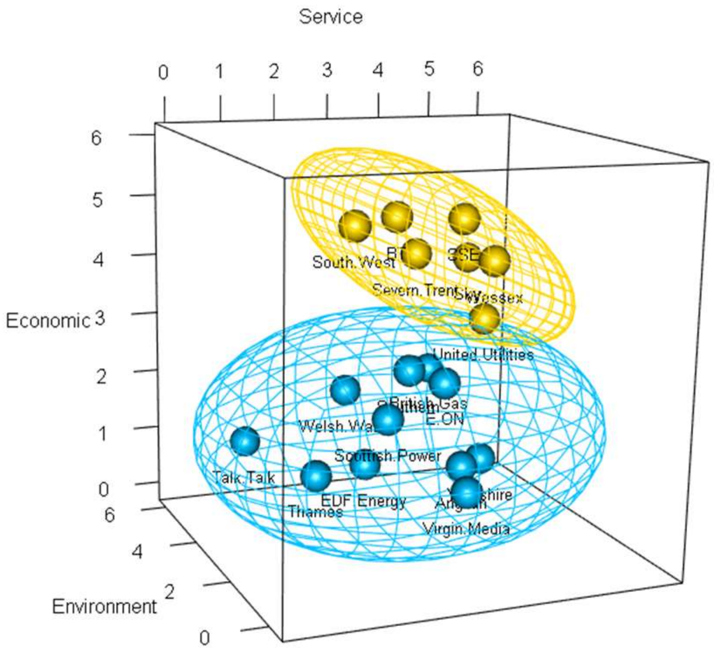

- We developed a methodology to compare companies across sectors, using 18 companies across the water and sewage, energy, and communications sectors as an example
- Based on 21 metrics covering service, environmental and economic data, we generated performance scores relative to sector peers
- Results showed two distinct clusters, one of 7 sector leaders and the other of 11 lower performers
- Top performers can assess top performers in other sectors to identify how they can continue improving, lower performers can look within and across sectors to identify best practices

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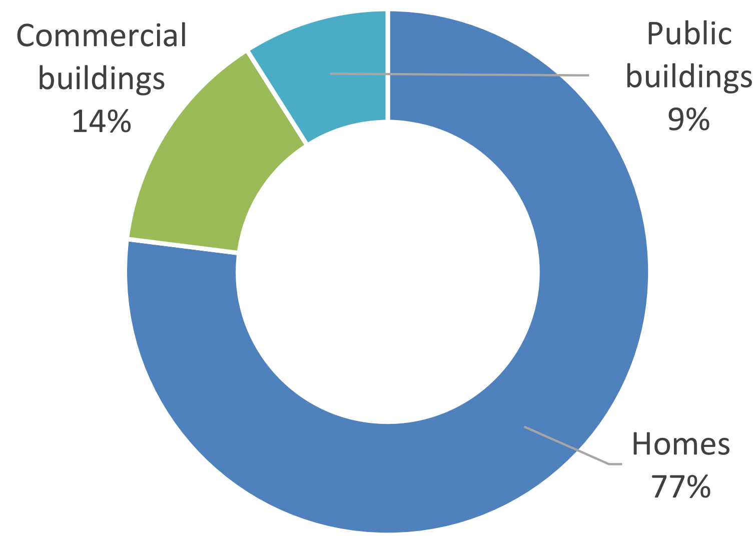
Energy auditing and rating

Water-energy efficiency in the built environment

Citizen science project in Irish homes

- Much scope for climate action through water use efficiency in the built environment
- Up to 90% of sector energy use is on water demand – mostly in the built environment
- Key objective: Energy efficiency through household water-use efficiency
- Crowd-sourced research – raising awareness of the linkages



CCC building sector summary from CCC's Sixth Carbon Budget Advice, Methodology and Policy reports.

Citizen science project in Irish homes

- Project in two parts:
  - Cross-sectional survey on perception of household water-energy use
  - Longitudinal study to collect data on water use
- Engaged with > 60 organisations, community groups, universities, LAs cross Ireland
- Over 300 households responded
- Representative result in terms of geographical coverage, population and other demographic factors

Key survey findings

- Less than a third of respondents knew if they had a water meter – household metering coverage is ca. 20%
  - Metering encourages water efficiency, and by extension - energy efficiency
- Almost 40% of respondents had no idea of current household water use
- 53% of respondents were not at all aware that their energy bills relate to their water use
  - Of those that did, 88% think there is a moderate to little relationship between energy bills and water use

- *Much work remains to be done to raise awareness of this link and the ways to reduce costs and emissions through water use*

Researching leisure centres

- Public leisure is facing significant and compounding challenges
  - Many face imminent and permanent threat of closure
  - Compounded by ageing infrastructure = inefficient
- Audited water-energy use of 7 centres in Wales

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Leisure centres – example interventions

- Optimising evaporation of a standard 25 m indoor leisure pool at typical operating pool and pool hall temperatures and humidity control can save up to £2,000 / year
- Case study of heat recovery potential in the wet-side of community-run leisure centre can potentially displace around 4,000 kgCO_2e per year with a payback of just over a year at current energy prices
- *Targeted investment is desperately needed*

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Environmental Insights

Climate change, water resources and hydropower

Research context

- Across the British Isles, climate change is expected to bring:
  - Milder, wetter winters; hotter, drier summers; more extreme events
- Clear implications for streamflows:
  - Greater flow seasonality, more frequent droughts and flood events
- Implications for public water supply, hydropower, agriculture, leisure & tourism, and the environment
- Hydropower contributed 5% of UK renewable electricity generation in 2021[1] and 6.5% in Ireland[2]
- Relatively small contributions, but important for various other reasons:
  - Adding resilience to the energy grid; making up deficiencies from other renewables (e.g. solar), particularly in winter, balancing the grid
  - Role in meeting Net Zero emissions targets
  - Often local community benefit – profits re-invested in local area

[1] DBEIS, 2022. Digest of UK energy statistics annual data for UK, 2021. [2] SEAI, 2022. Energy in Ireland: 2022 report.

Environmental Insights

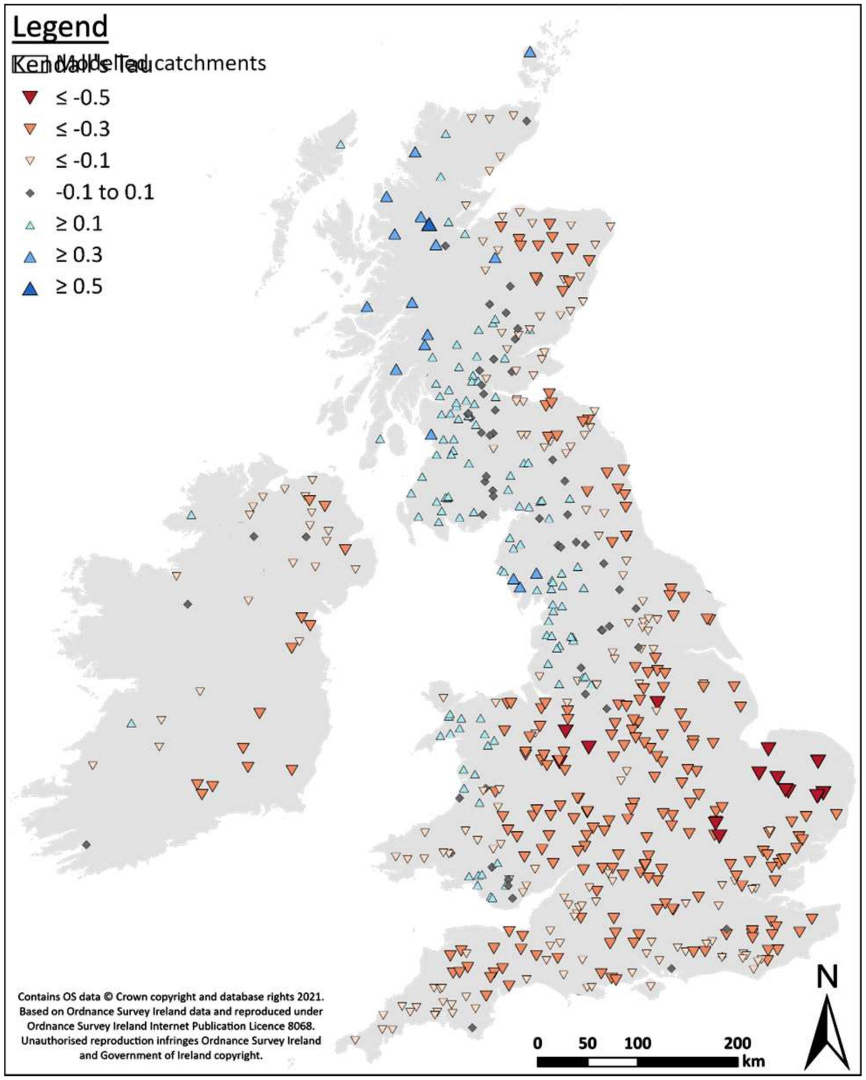
Climate change, water resources and hydropower

Streamflow modelling

- Daily future streamflow projections (2021-2080) for 585 catchments
- EXP-HYDRO model under worst-case RCP8.5 future climate scenario
- Clear northwest/southeast divide for Great Britain, and smaller west/east gradient for the island of Ireland
- Overall, annual average streamflows generally declining, except in Scotland

Change in annual average streamflow under RCP8.5 future climate scenario conditions when comparing 2021-29 to 2072-80 averages

England	Wales	Scotland	N. Ireland	Ireland
-7.2%	-1.5%	+1.1%	-5.3%	-4.7%



Modelled catchments across the UK and Ireland.
Trends in annual average streamflow (2021-2080) under RCP8.5 future climate scenario conditions.

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Climate change, water resources and hydropower

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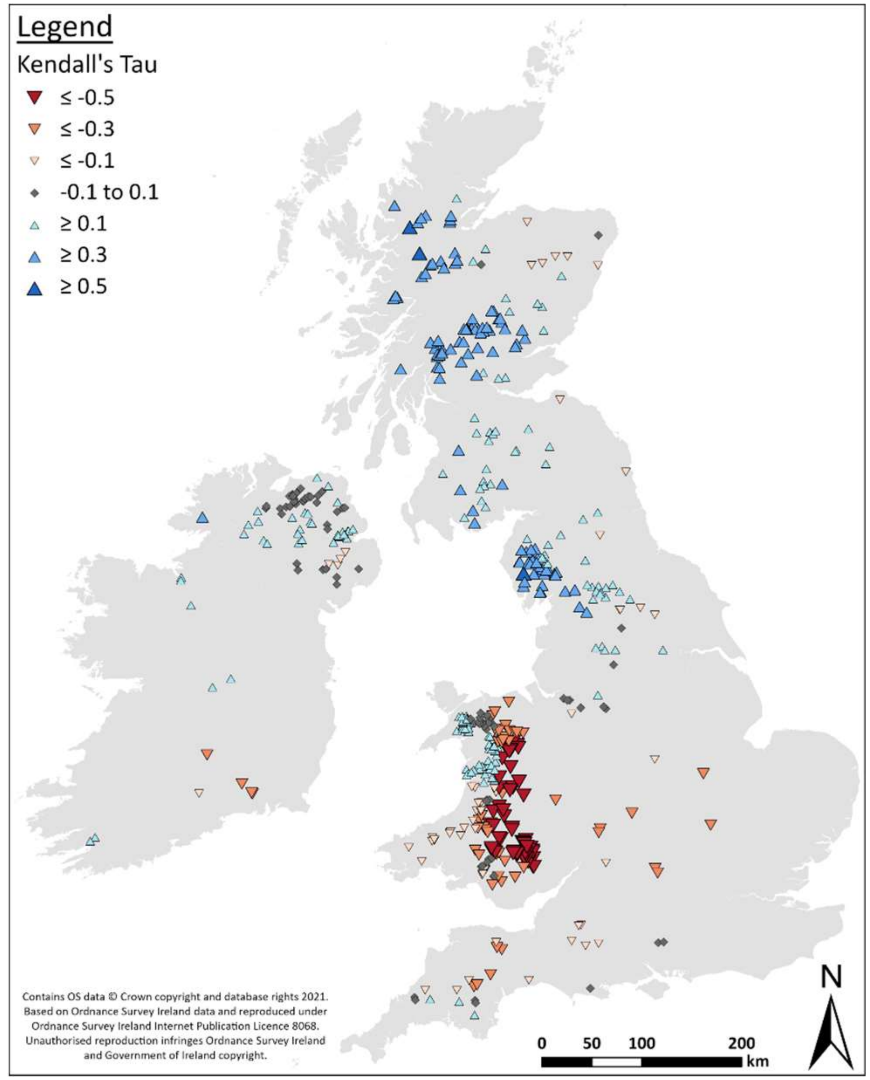
Hydropower abstraction & generation

- 531 run-of-river (RoR) schemes studied
- Abstraction calculated using nation-specific abstraction licence conditions (ALCs)
- Spatial variation due to differing ALCs and varied climate forcing impacts
- Power generation, linked to abstraction, shows much greater seasonality, with a net gain for Great Britain, and decline for Ireland

Change in power generation under RCP8.5 climate scenario conditions when comparing 2021-29 to 2072-80 averages

	Great Britain	Island of Ireland
Winter	+12.4%	+8.7%
Summer	-63.6%	-76.8%
Annual	**+6.2%**	**-1.4%**



Trends in annual average abstraction (2021-2080) under RCP8.5 future climate scenario conditions

Modelled hydropower catchments and locations in the UK and Ireland

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Environmental Insights

Climate change, water resources and hydropower

Research implications

- Greater seasonality and extremes of streamflows likely, linked to changes in precipitation patterns
    - Implications for available water resources, particularly for those sectors dependent on instantaneous flows
- Seasonality and timing of RoR hydropower abstraction and power generation will be impacted – varying spatially
- New RoR schemes should be being designed with future streamflows in mind, to optimise generation across scheme lifespan
- Maintenance of protection for environmentally or otherwise streamflow-sensitive catchments is also important – a tricky balance to get right!

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Delivering Solutions for the Sustainability of the Water-Energy Nexus

Leveraging Transdisciplinary Research Collaboration for Impact

Prof. Paul Coughlan, Trinity Business School

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Our Challenge

How can researchers design and implement a research initiative and produce quality research-based green process innovation?

Our Response

Ní Neart Go Cur Le Chéile

Mewn Undod Mae Nerth

There’s No Strength Without Unity

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Positioning the Challenge

- Enquiring into complex phenomena of societal interest requires new research designs and methods of knowledge production

- Research associated with green process innovation can engage with society, cross geographical borders and transcend disciplinary and practice boundaries.

- Such research is of increasing relevance to addressing the UN Sustainable Development Goals (SDGs).

Illustration: Getty Images

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What was our opportunity?

- **Green process innovation…**
  - Mitigate environmental impacts
  - Commercial and environmental performance
  - Complex and collaborative process
- **…through transdisciplinary research**

"Innovation for environmental sustainability requires firms to engage with external stakeholders to access expertise, solve complex problems, and gain social legitimacy"

Transdisciplinary research…

…can vary widely along six key dimensions:

- **breadth/diversity** of interdisciplinarity;
- **depth** of disciplinary integration;
- degree/quality of **interaction** with non-academic participants;
- **composition** of non-academic partnerships;
- **timing** of participatory engagement;
- and **types of knowledge** being emphasised.

OECD (2020). Addressing societal challenges using transdisciplinary research, *OECD Science, Technology and Industry Policy Papers*, No. 88.

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The Team spanned five disciplines

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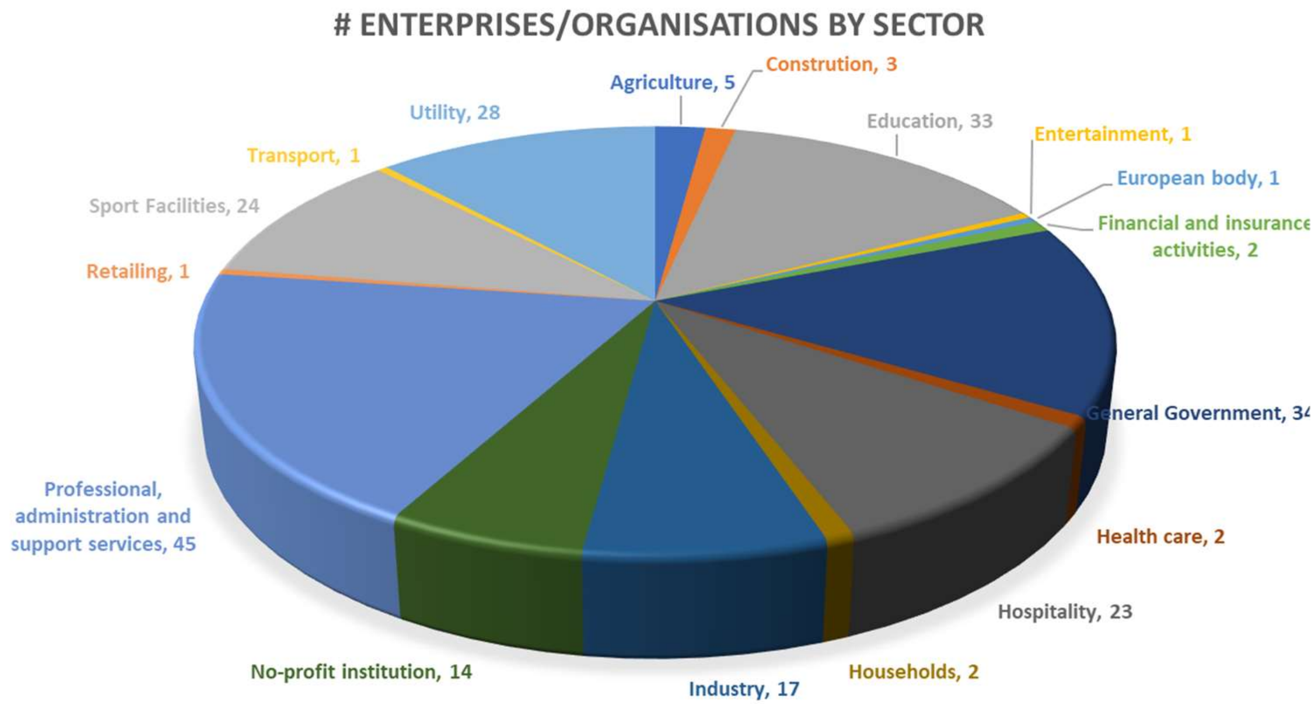
Collaborators came from the cross-border Water-Energy Network

National Federation of Group Water Schemes
Ymddiriedolaeth Genedlaethol National Trust
Dŵr Cymru Welsh Water
abp
BGWS Blackstairs Group Water Scheme
CALON TYSUL
ARBIKIE
POOLSENTRY
Co-operative housing Ireland
ST MARY'S VILLAGE
PRIFYSGOL BANGOR UNIVERSITY
Scoil Náisiúnta Rath an Iubhair
Ballinabranna Water Co-Operative Society Ltd
PO Box 133, Carlow
Email: info@ballinabrannawater.ie Tel: 086 0448166
Newpark Comprehensive School
Scoil Chuimsitheach Na Páirce Nua
Gibney's of Malahide
The ROYAL VICTORIA HOTEL Snowdonia
REDISCOVERY CENTRE



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Some collaborators came from surprising areas and offer us hope

Newpark Comprehensive School
Scoil Chuimsitheach Na Páirce Nua

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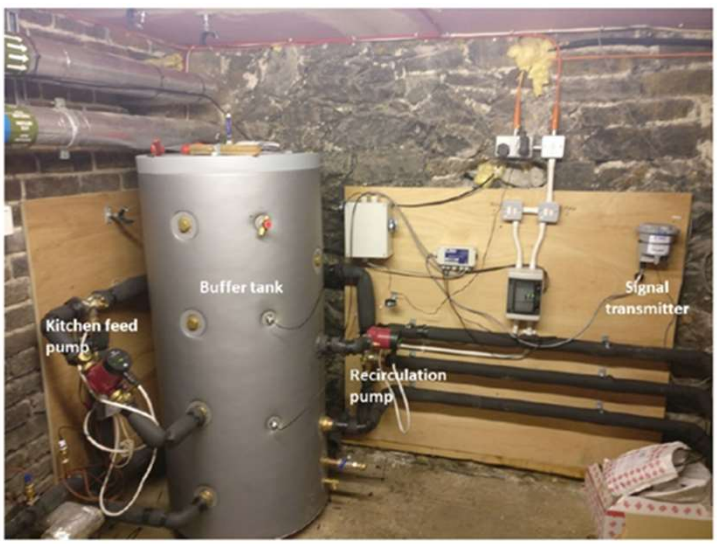
Working together, the research evolved towards developing & demonstrating energy recovery. For example…

National Trust

❖ Penrhyn Castle

- Tourist attraction in North Wales
- A pilot site for the installation of a system
- A practical demonstration of design and implementation of Drain Water Heat Recovery at the Tearooms



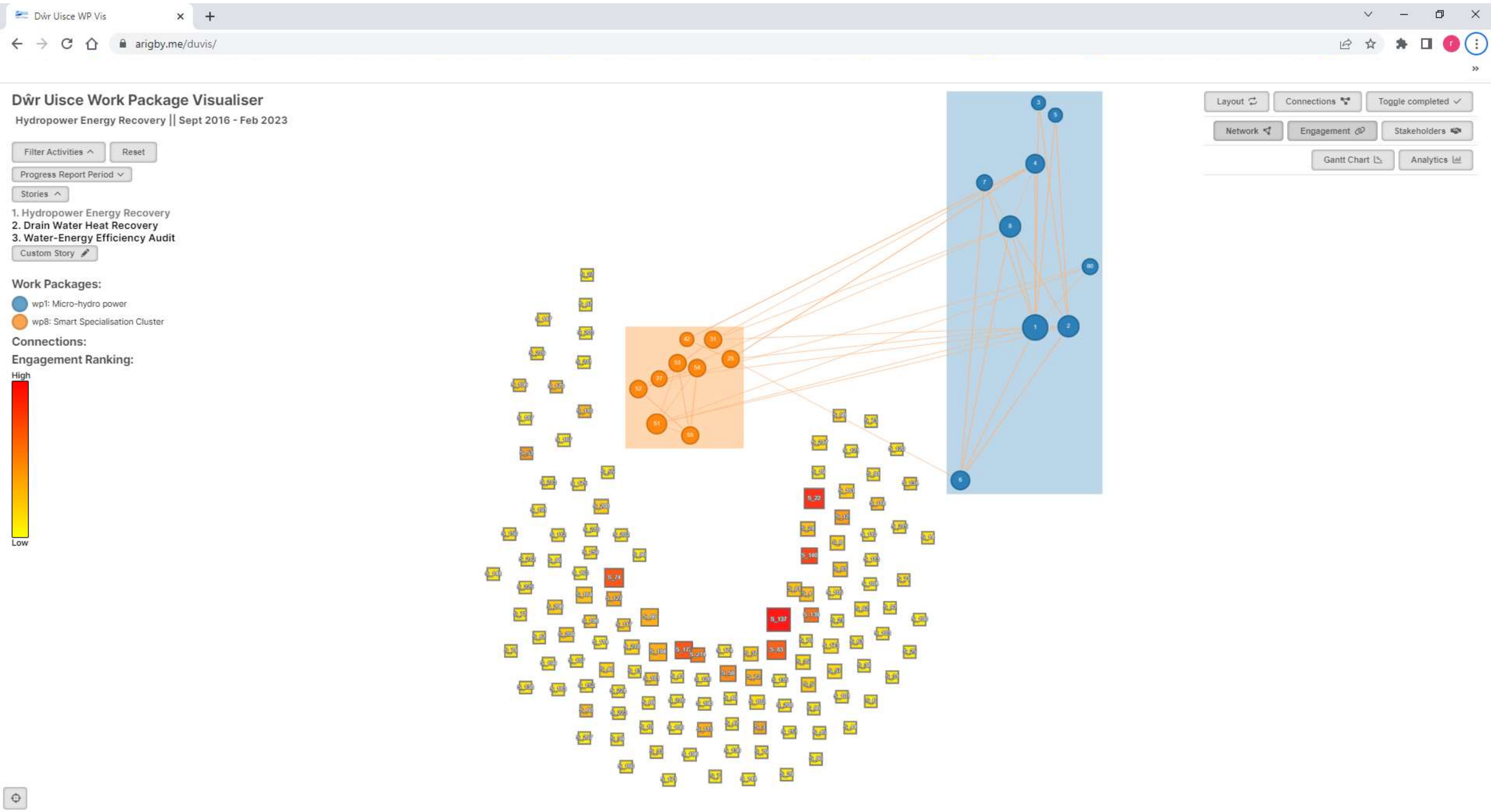
❖ Toolkit for commercial kitchens

- Unique opportunity to evaluate the environmental potential, performance, burden and benefits of DWHR
- Developed a *Heat Recovery Toolkit* to guide commercial kitchens on heat recovery estimates, technology selection, financial and environmental savings, and payback

So, who did what, with whom and when?

Story	WP Lead	Activity Phase	Timing of participatory engagement	Diversity of disciplines engaged	Depth of interaction across disciplines	Degree/quality of interaction with non-academic participants	Composition of non-academic partnerships	Types of knowledge being emphasised
DWHR Development	2	Laboratory/ Monitoring	None	Engineering	Limited	N/A	N/A	Generalised knowledge; specific engineering theoretical knowledge
		Installation	Throughout	Engineering	Limited	High	Conservation charity, meat producer, government bodies, equipment suppliers	Context specific actionable knowledge
		Demonstration	Throughout	Environmental science, operations management, communication	High	High	Conservation charity, government bodies, equipment suppliers, hospitality sector, community.	Context specific, generalised and practical/actionable.
Toolkit for commercial kitchens	4	Design and development	None	Environmental science and engineering	High	N/A	N/A	Context specific based on engineering theory
		Dissemination and feedback	Throughout	Environmental Sciences, Communication, Management	High	High	Facilities managers in hospitality sector & conservation charity	Context specific, practical/actionable

Our interactions were dynamic



As we engaged in action, we learned that…

- The five discipline groups generated disciplinary knowledge **and** **combined** that with other researchers and practitioners in the context of application.
- We **integrated** the knowledge produced through hardware, software and humanware.
- We engaged in **collective decision making** supported by open communication and information sharing across discipline and practice boundaries.
- Finally, through periodic real and virtual co-location, mutual respect and patience, we **shared, communicated and exchanged** our evolving ideas in a non-confrontational manner.

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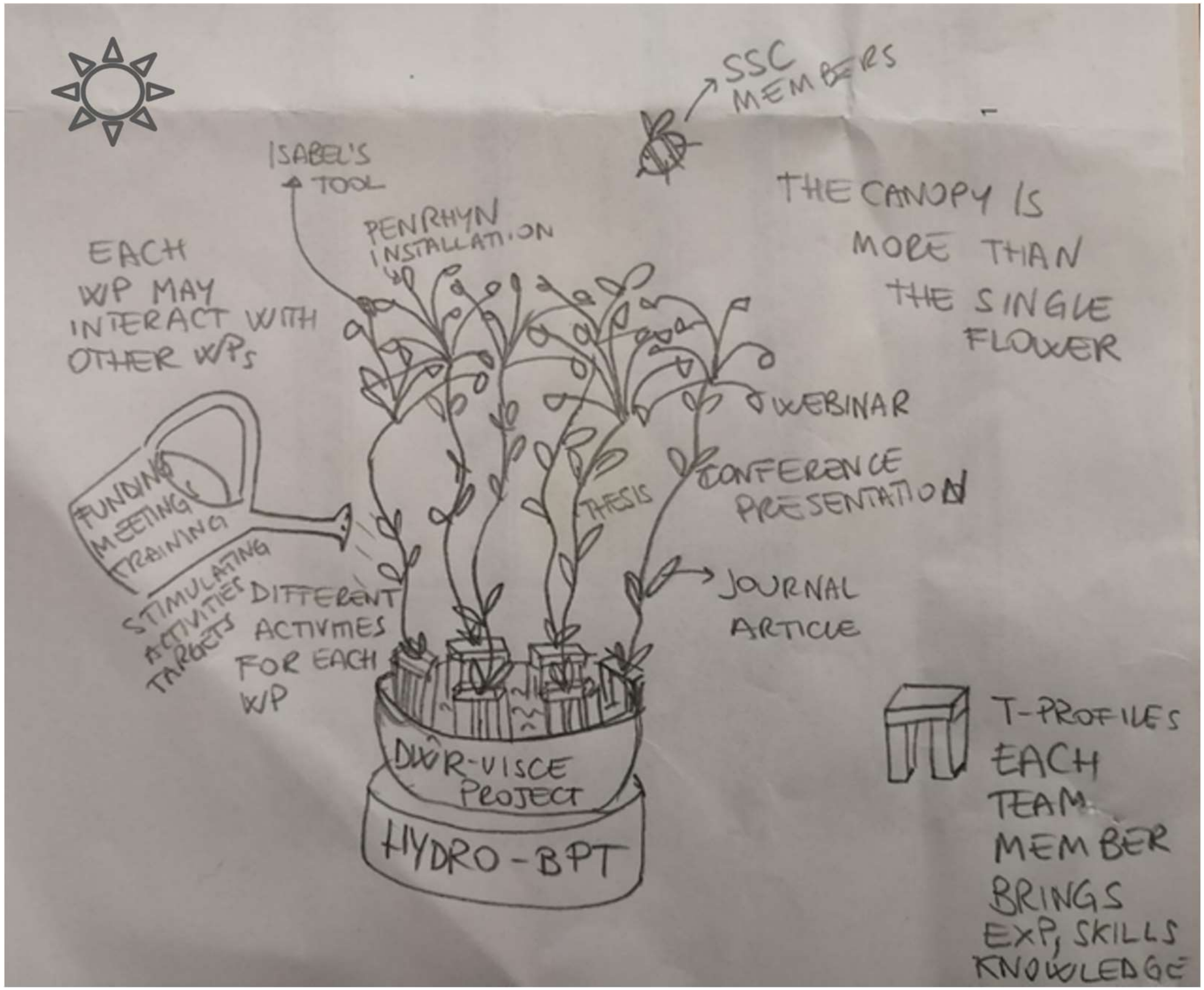
We were like an ecosystem!



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So, on reflection…

- Managing this kind of research requires **a climate** which enables collaboration, interdisciplinarity, integration, interaction with practitioners, the formation of non-academic partnerships.
- **Interaction** needs to be frequent, data-driven, reflective and respectful in an atmosphere of collaboration and trust where stakeholders can be open, curious, and willing to explain and to listen.
- **Timing** of interaction needs to be driven both by project activities and the emergent opportunities to share insights at research team meetings, project webinars and academic conferences.
- …

and…

- Publications, presentations and citizen science outreach help to generate awareness and debate.
- The **continuing involvement** of the collaborators in further initiatives provides learning opportunities for researchers to advance theoretical knowledge and for practitioners to advance practical knowledge.
- And, we are now looking to the future...

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We are planning to launch a new cross-border venture

WE-HEAT

CONSULTANCY

- Auditing and Benchmarking
- Feasibility studies of drain water heat recovery
- Carbon footprint of industrial processes from a water-energy perspective
- Climate change and future streamflow water resources assessment
- Science Engagement and Communication

EXPERT TRAINING AND EDUCATION

- Training courses on water-energy efficiency
- School and Community Education programmes
- Awareness raising programme for community/businesses
- Webinars with up to date findings from innovative research

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I began with a saying…

- …Ní Neart Go Cur Le Chéile
- I finish with a quote from Hansen & Madsen (2019):

  "In order for (knowledge production) to be successful, it has to be picked up by the community, and further developed through communal efforts"

- So, on to the next challenge - together!

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Panel Discussion, Acknowledgements & Next Steps

Aonghus McNabola, Prysor Williams & Paul Coughlan

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People & Organisations

Cyngor sir ddinbych denbighshire County Council

Dŵr Cymru Welsh Water

National Federation of Group Water Schemes

Ymddiriedolaeth Genedlaethol National Trust

eps WATER

BGWS Blackstairs Group Water Scheme

abp

ARBIKIE HIGHLAND ESTATE

Dublin City Baile Átha Cliath

Cwrw Llŷn

POOLSENTRY

ST MARY'S VILLAGE

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Scoil Náisiúnta Rath an Iubhair

The ROYAL VICTORIA HOTEL Snowdonia

Newpark Comprehensive School
Scoil Chuimsitheach Na Páirce Nua

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Email: info@ballinabrannawater.ie Tel: 086 0448166

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Comhairle Contae Thiobraid Árann
Tipperary County Council

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Choral Closure

The Dublin Welsh Male Voice Choir

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Thank you for your attention

Diolch am eich sylw

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