Decarbonising Heat,

Local Area Energy Plans & GeoEnergy

Housing Executive

Northern Ireland Housing Executive

NIHE: A UK social housing landlord with 84,000 homes.
30,000 of these are heated with fossil heating oil

The Regional Strategic Housing authority for 780,000 homes.
Northern Ireland Home Energy Conservation Authority role

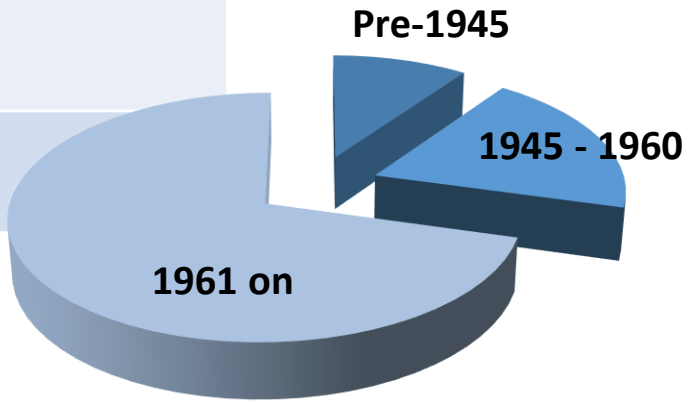
Approximately 500,000 of NI homes use heating oil.
Homes in rural areas are dependent on heating oil.
50% of private oil heated homes lack temperature controls.

Housing Executive

Where we are now

Main Fuel	%	number	on gas
Gas	56.0%	48,000	> 60%
Oil	36.9%	30,000	
Electricity	3.6%	3,100	
Coal/other	3.5%	2,900	
Total	ca	84,000	

+ “Gas to the West”



Northern Ireland Housing Executive

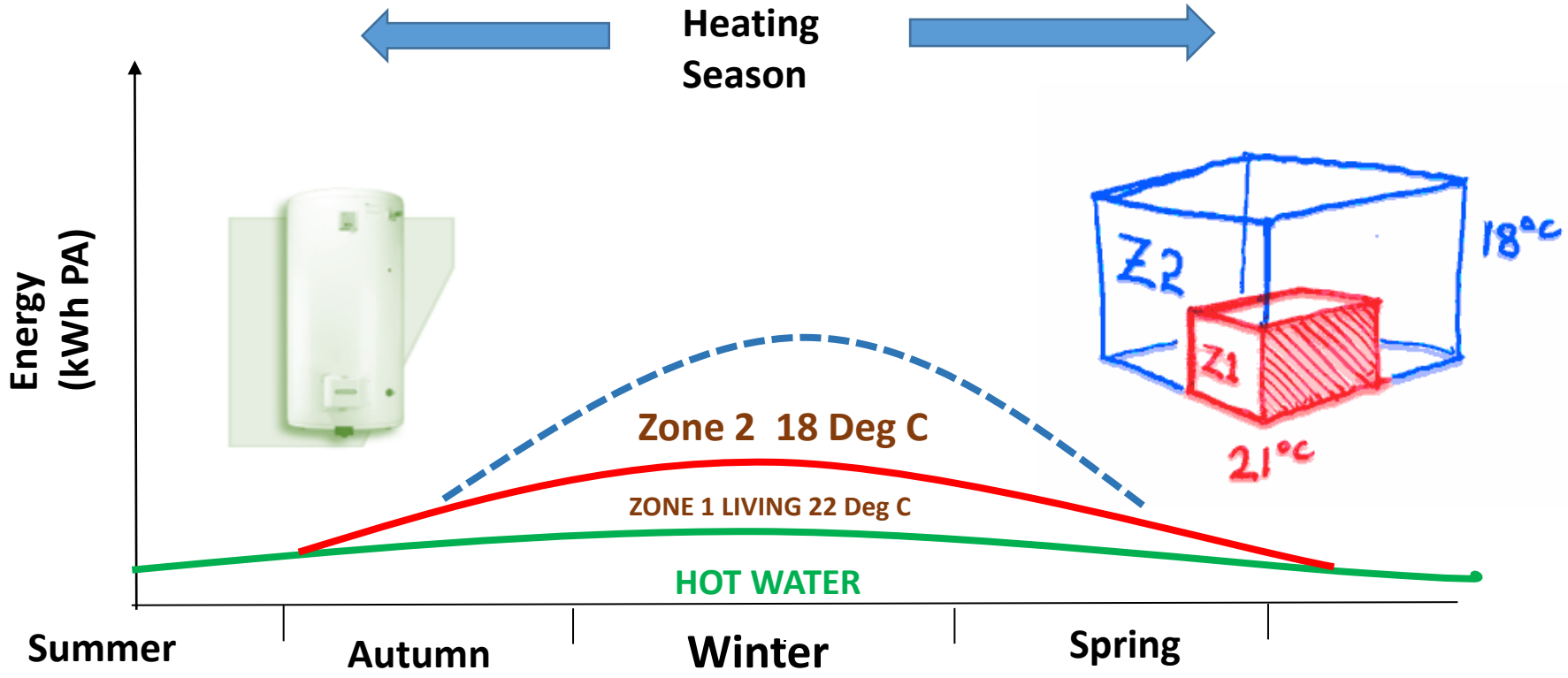
Urban and rural low carbon energy systems
Storing heat produced by renewable electricity
Durable Pay As You Go Systems
Remote diagnostics, low life costs

Supply & Demand - managing the time dimension
Just Stop (Using) Oil (when we can)

Renewable Electricity > Store hydrogen > Electricity > Heat?
Renewable Electricity > Store Heat > Heating and Hot Water

Housing Executive

Annual Heat Demands: Living & Bed Zones



NIHE monitoring: Upstairs heating zone on only ca 20% of time. Saves between 6-24%. Safer for moderately insulated homes.

Reducing Heat Demands

Housing Executive

"Fabric First"

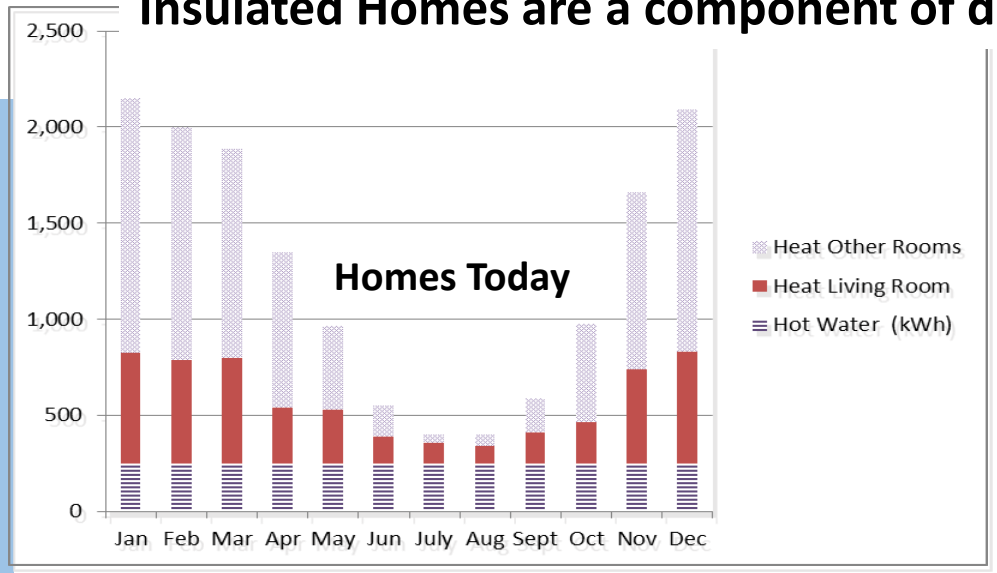
- Loanda Crescent Newry
- External Wall Insulation EWI onto outside of cavity walls
- Shortened heating season
- Smart controls, gas boilers, solar inputs
- Constant ventilation system

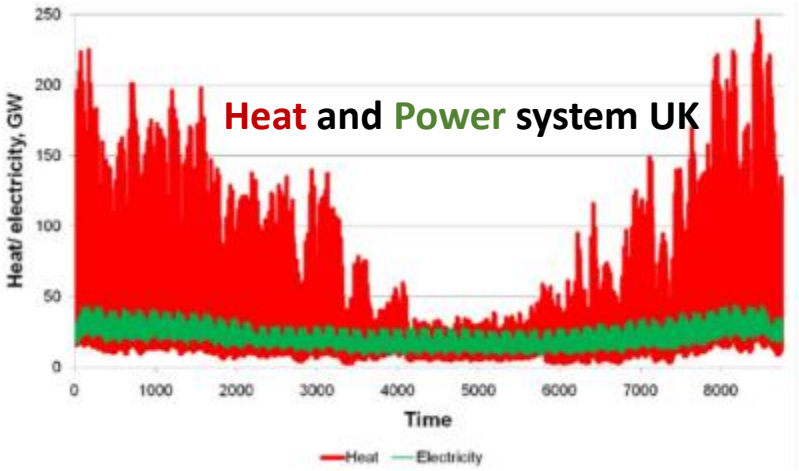
Project Architect Caroline Best NIHE

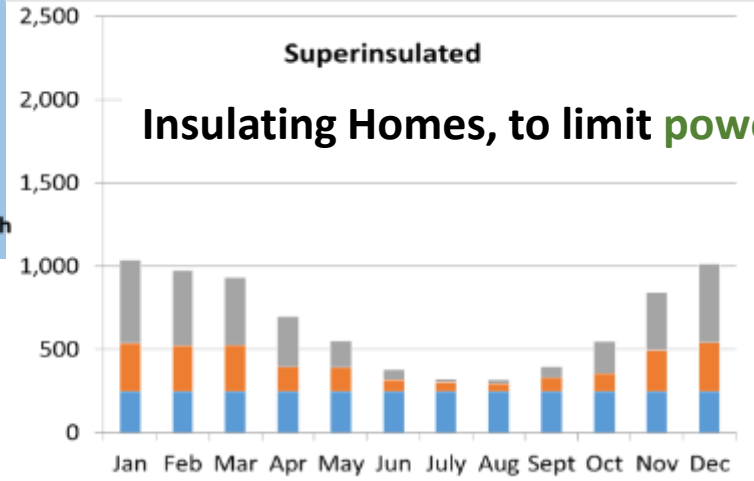
EWI: Enhanced heat storage capacity, compatible with heat pumps.

“Fabric First”

Insulated Homes are a component of decarbonised Energy Infrastructure

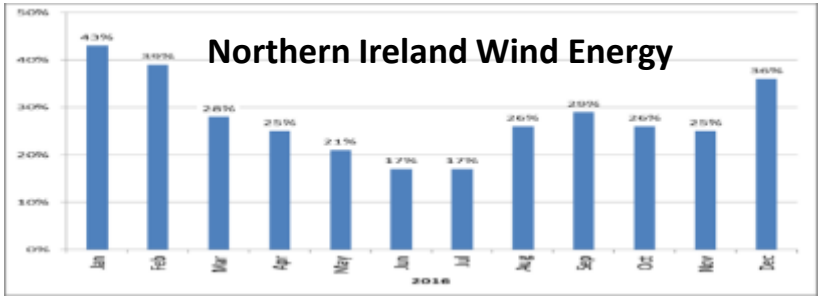




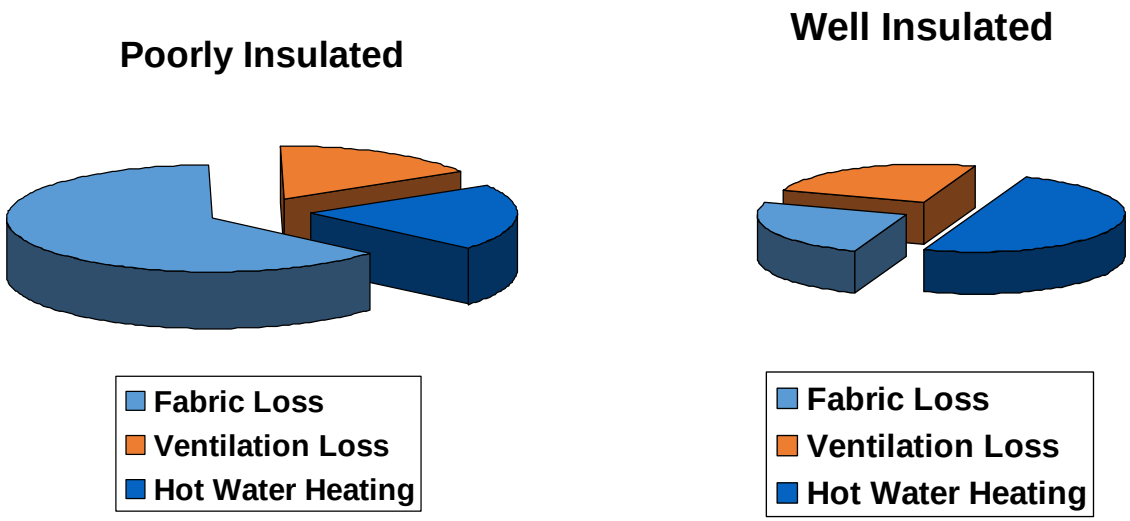


Insulating Homes, to limit power investments & to match renewable energy supply

kWh

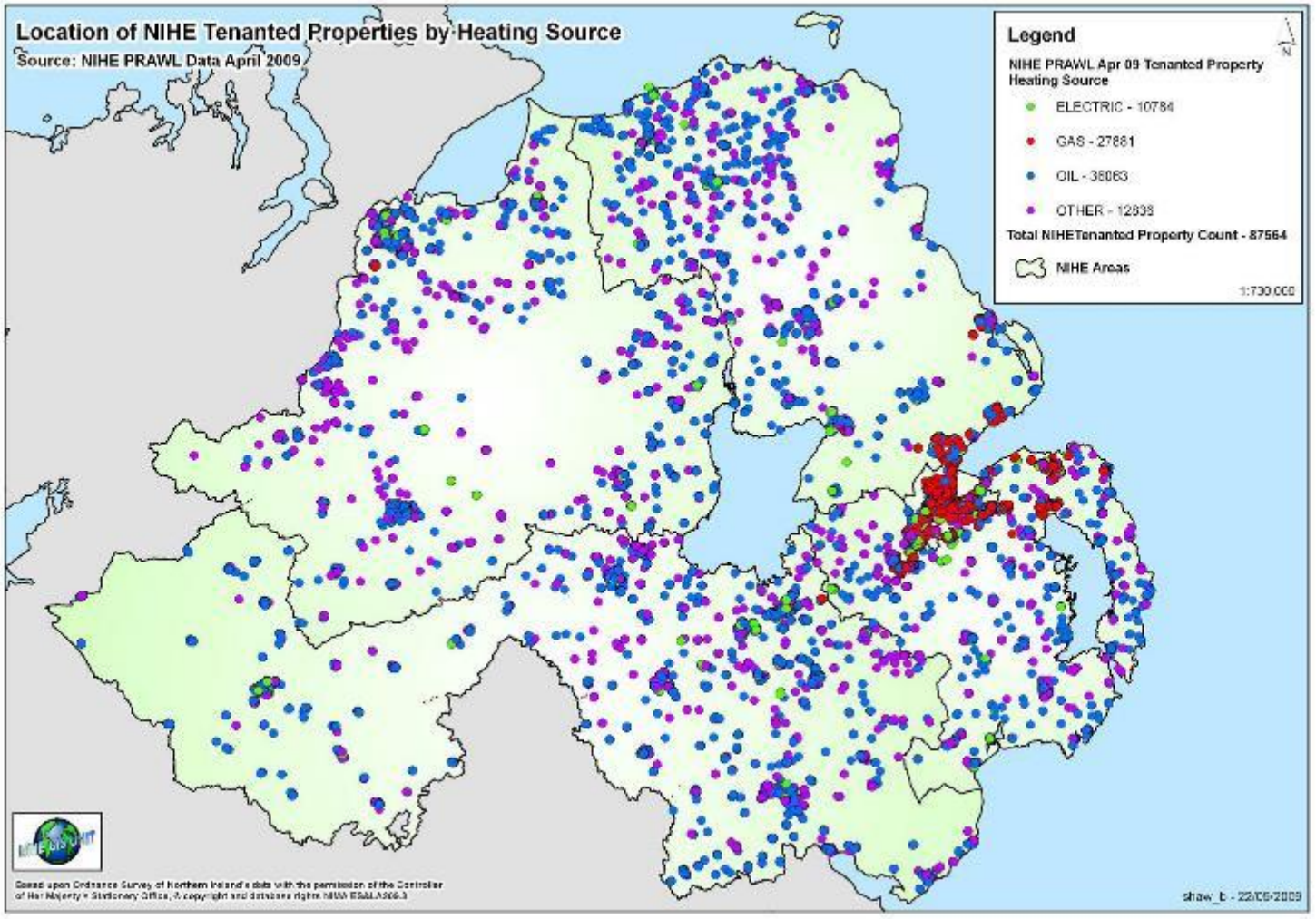


Heated ventilation air carries away moisture, pollutants: ventilation measures improve health

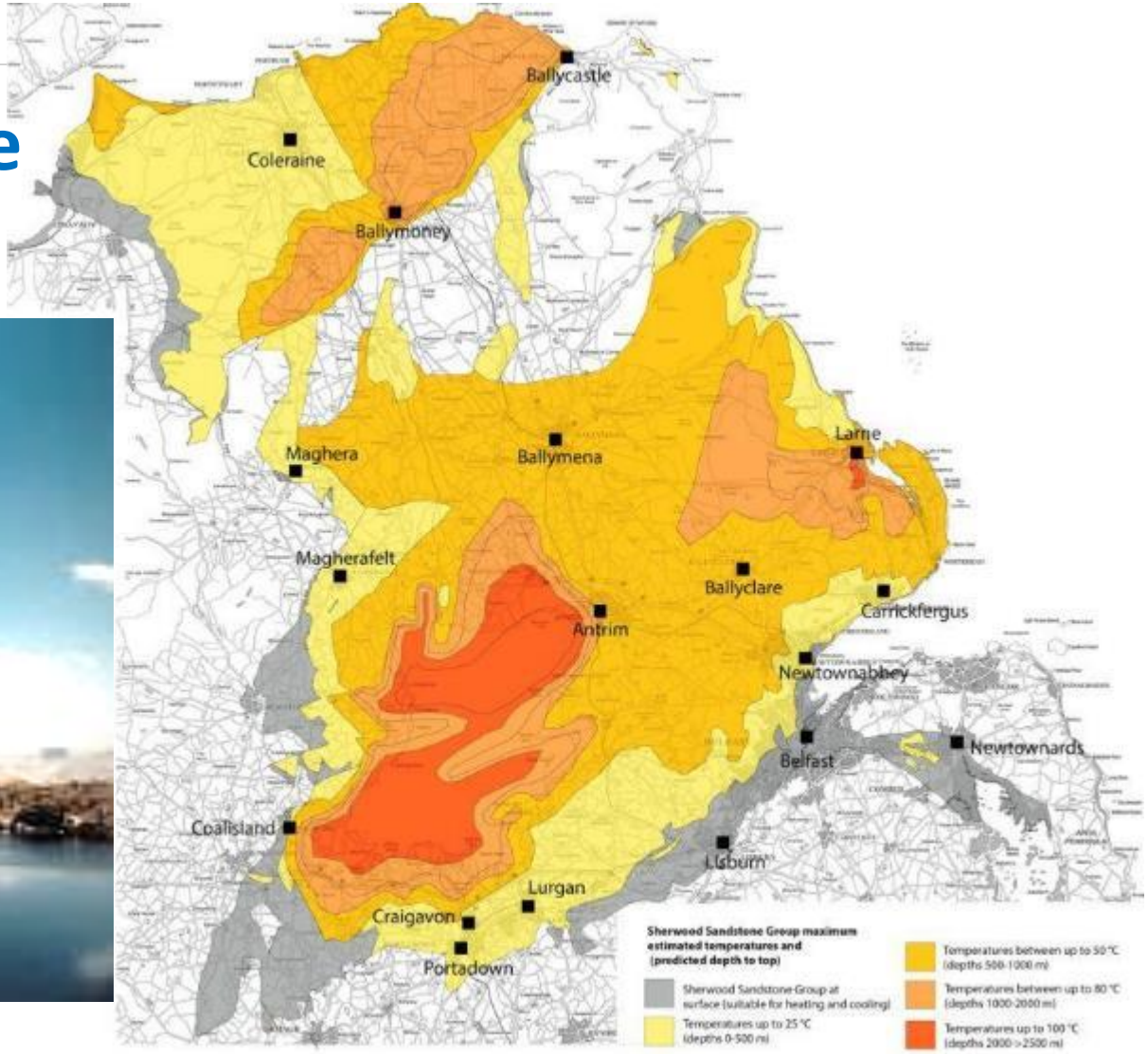


After insulation, heat is still required to heat hot water & ventilation air> Decarbonise heat supply.

NIHE homes Urban & Rural Energy Options

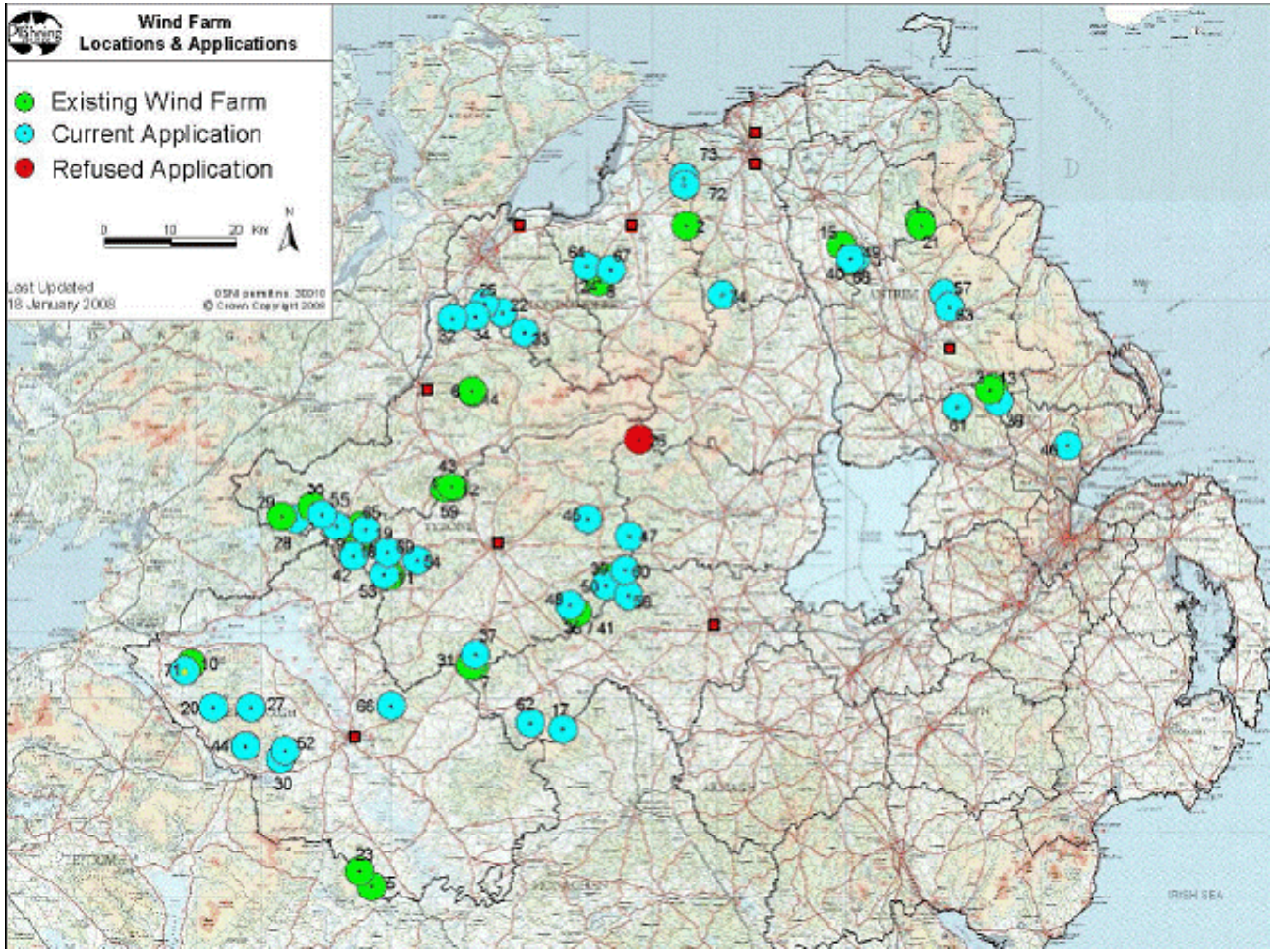


Renewable Energies



Geoenergy/ Wind

Renewable Energy: Wind Farms(2008)



Historic City Streets

Villages

NIHE estates

Suburbs

Isolated Rural Homes

Low Carbon Heat

Seasonal Thermal Storage

Hot Pipe Networks

Shared heat sources, deep water, boreholes

Cold Pipe Networks

Solar, heat pumps, EV's, superinsulation

Waste Heat, Combined Heat and Power

Hot geothermal

Massive heat pumps

H2 Fuel Cells

Biogas

Wind Energy

Rural Heating Solutions

Air Source Heat Pumps

Paul Kenny 'Superhomes' heat pumps + retrofitting expert:

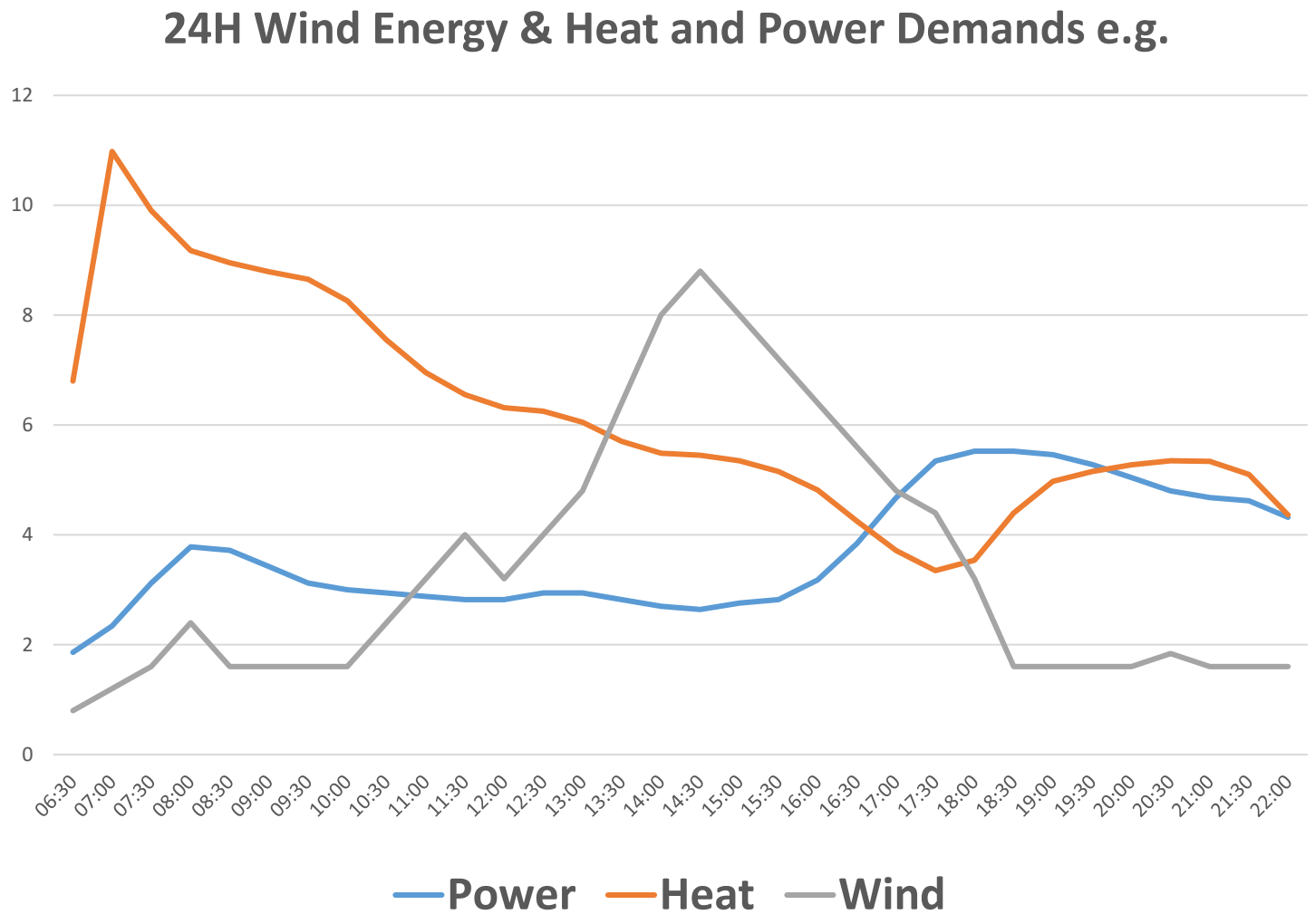
- "Good heating circuit plus ordinary heat pump = OK"
- "Bad heating circuit plus good heat pump: Not OK"

Need bigger radiators for low running costs. – (+add PV for power, hot water.)

Water flows in radiators need to be balanced: (usually not done well)
> Similar low temperatures returning to the heat pump.
e.g. Radiators operating at e.g. 50C

Some pipe sizes may need increased to keep flow below one meter per second to limit noise, whistling etc.

Using hot water storage to use the cheapest power?


24H Wind Energy & Heat and Power Demands e.g.
12
10
8
6
4
2
0
06:30
07:00
07:30
08:00
08:30
09:00
09:30
10:00
10:30
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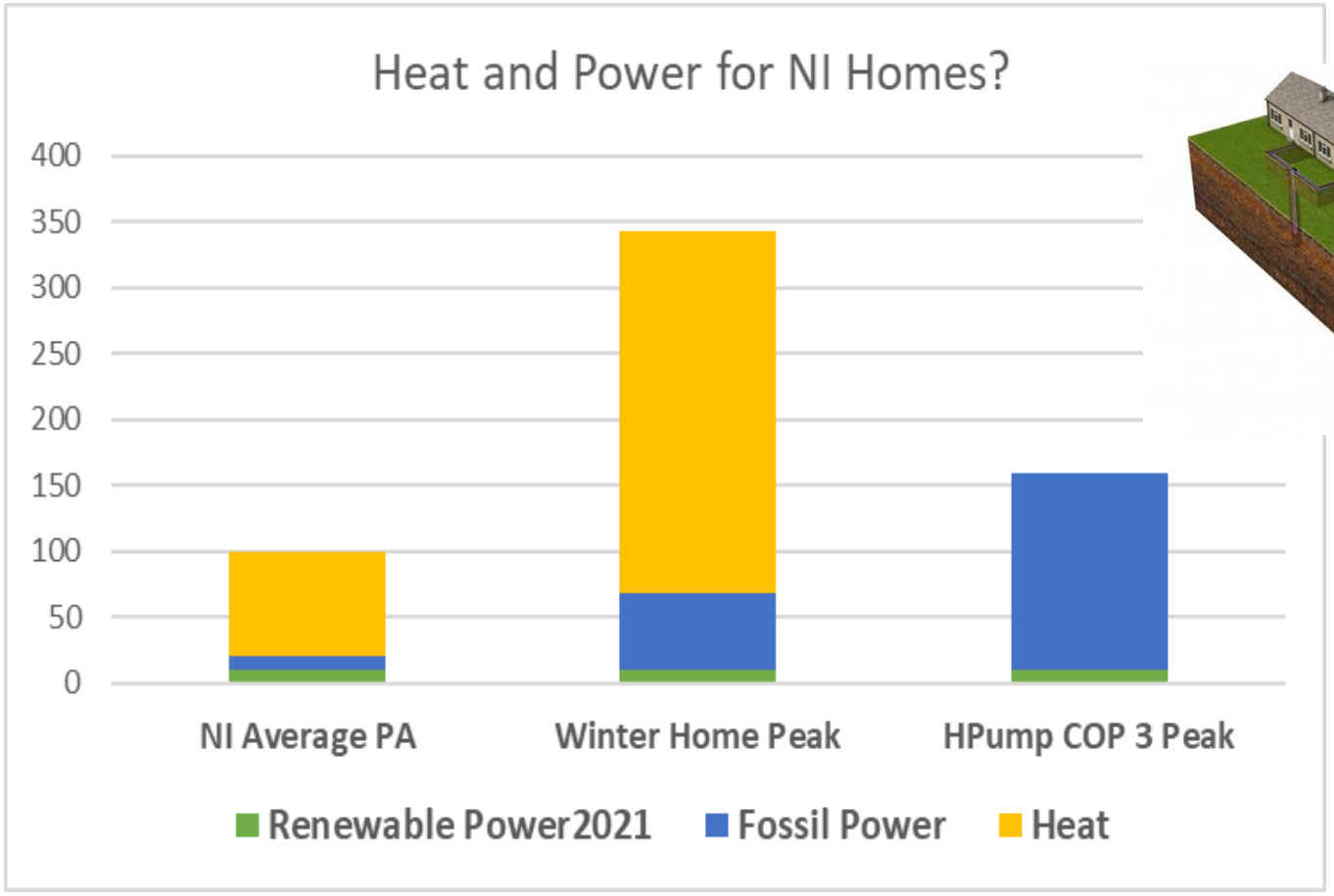
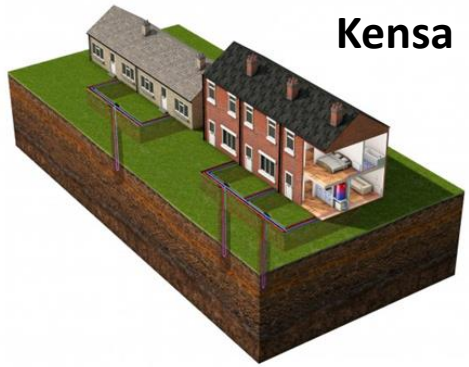
Power
Heat
Wind

Dealing with Peak Winter Heat & Power Demand?



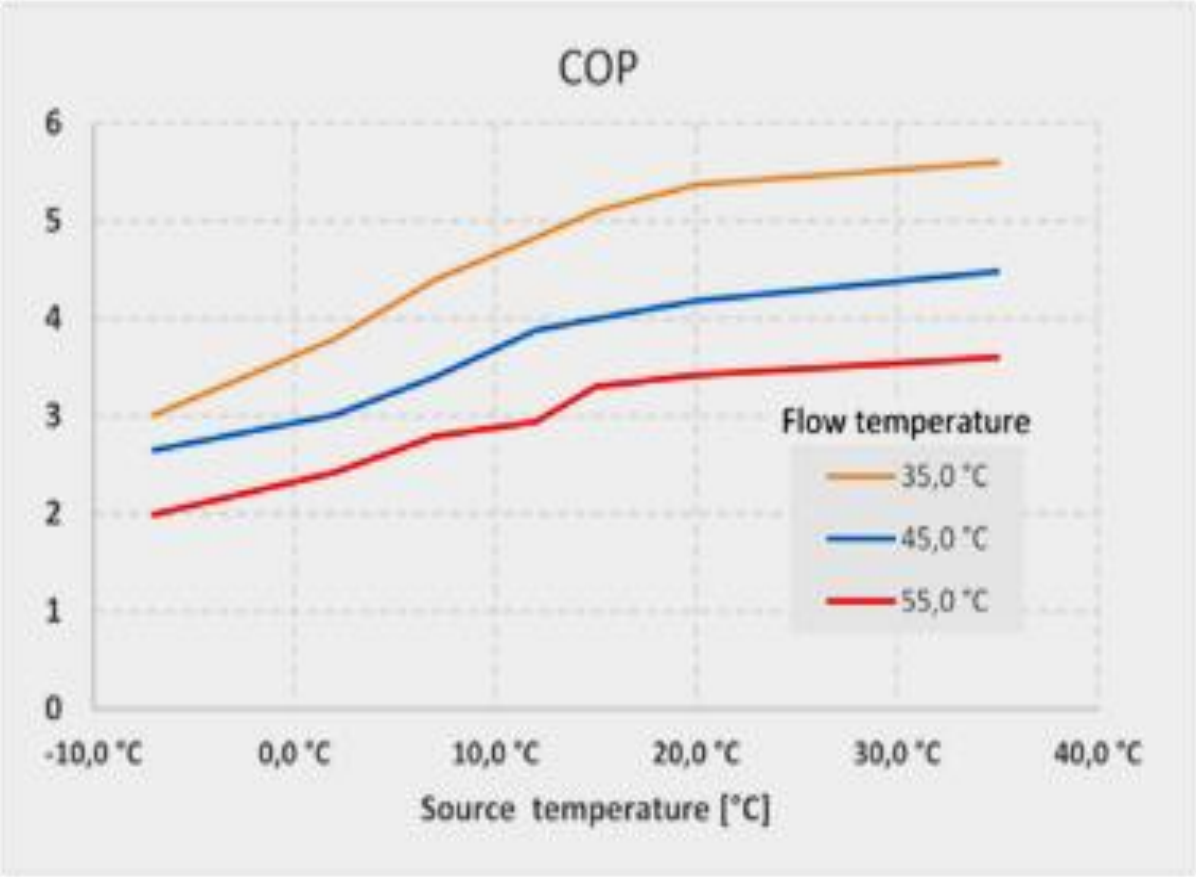
GSHP
Kensa



ASHP?

Providing heat to off-gas homes. ASHPs increase system size & use OCGT generation

Geothermal Heat pump outputs rise with the source temperature.
E.g. At depth. **And fall with any rise in radiator or output temperature.**

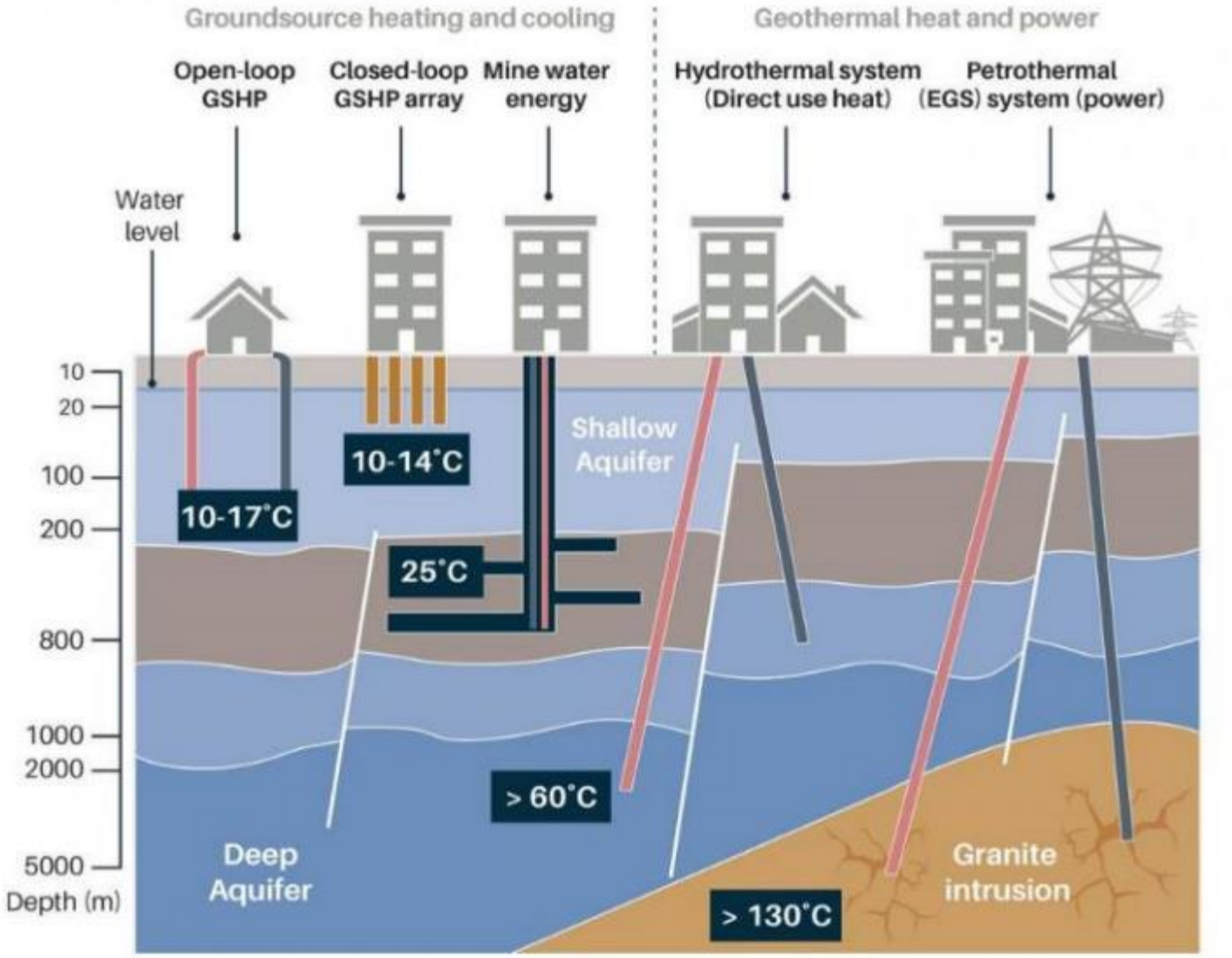


To beat oil/ gas costs?

Pre-heat GSHP inputs with solar thermal or geoenergy <20C?

Or heat stored underground?

COP =Coefficient of Performance/ efficiency. 300%-I kWh in, 3 heat units out.



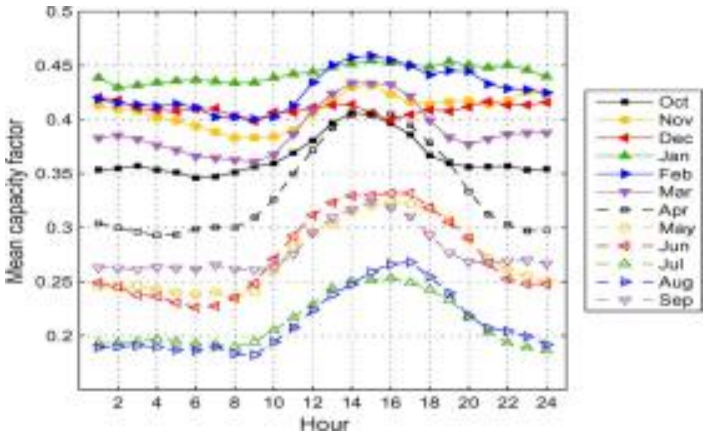
Belfast &
Co Antrim
B.Castle
Larne
Ref. GSNI

Pic: British Geological Survey/UKRI

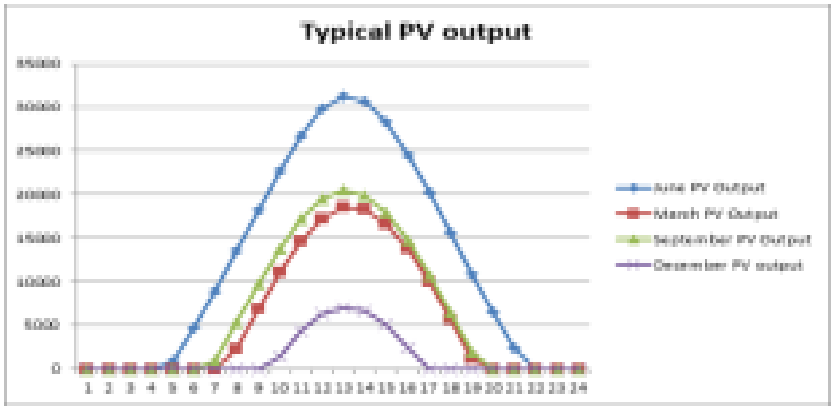
NI. Geothermal Energy/LongTerm Heat Storage

Using renewable electricity for heat:

More solar and wind energy is available in afternoons, BUT: Wind energy correlates better with winter heat demands



Winter wind outputs are high



Solar outputs are lowest in December

Rural (or suburban, or heating for insulated newbuild) "Ambient" shared heat loops serving single heat pumps:

- **Electric "Pay As You Go" system. Flats etc.**
- Shared pipes bringing water from "ambient" heat sources to homes with their own heat pumps.
- Water in the system is cool, usually below 20C
- Boreholes may also provide some summer cooling
- Or Solar thermal can re-heat boreholes.
- To cut running costs, accepts geothermal heat, to use existing radiators, or to reduce the need to upgrade the rural power grid.
- **No 'fan box' outside, QUIET (PlanningOK).**
- **Good for adjoining flats, terrace homes.**
- Private network& borehole finance?
- Use boreholes, the sea, lakes, geothermal sources.

- *Treatment of renewables for heat metering?*

Images: Kensa Heat Pumps

Choosing the best new system to cut carbon??

Mains Gas	**100%**
Mains gas and insulation	**60%**
Heating oil	**142%**
Air Source Heat Pump & Oil	**58%**
Heating oil & wind for hot water	**105%**

Air Source Heat Pump	**22%**
Geothermal Heat Pump	**14%**
Street heat networks	**5-10%**

NIHE are doing pilots, final decisions in about 3 years

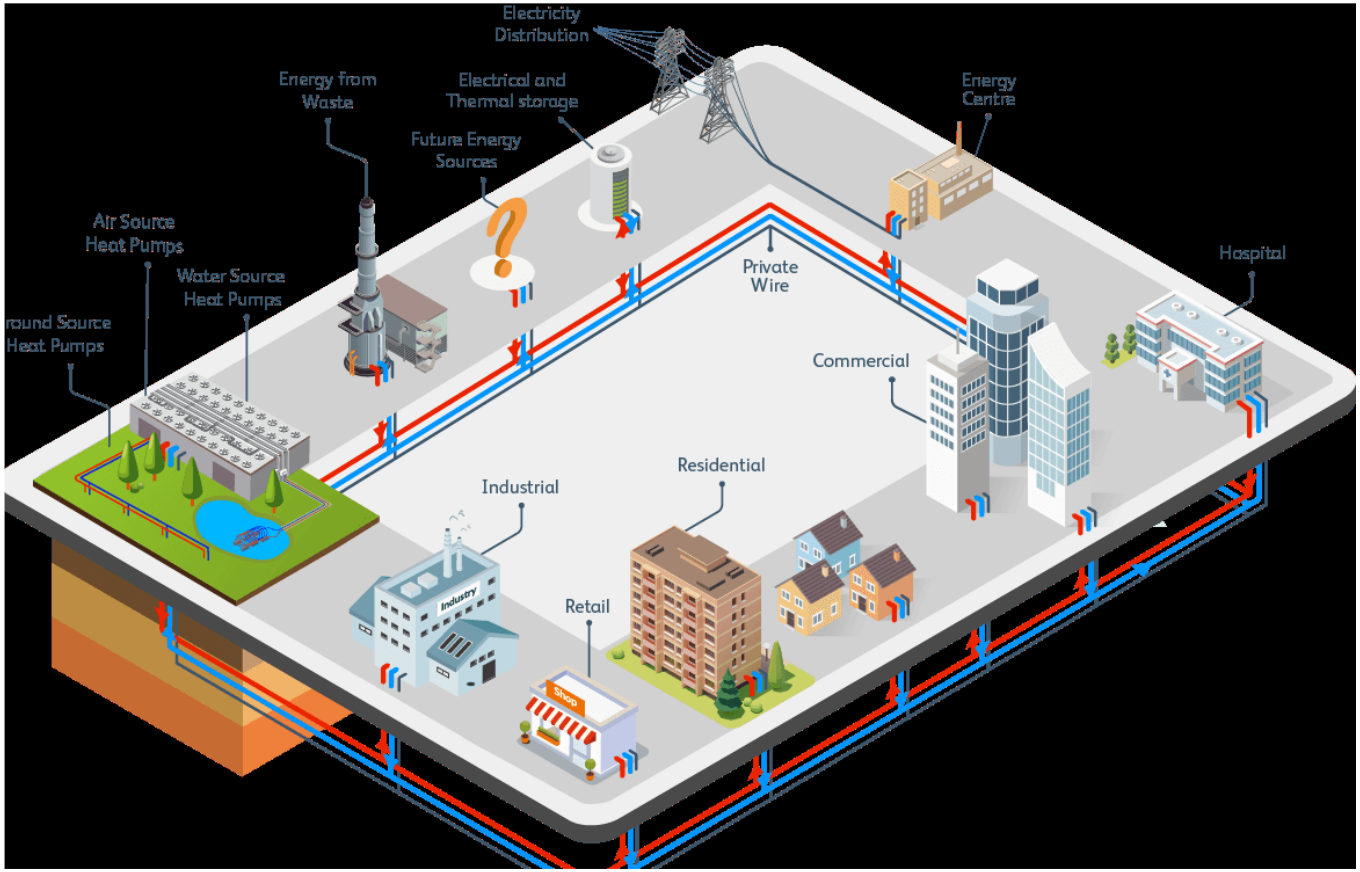
*Community hot pipe heat networks are more suitable in towns, but free up electricity system & grid winter peak capacity for rural heat pumps.

Urban Heat Networks

Issue	Status	Risks	Benefit
Community Heat Networks.  Local Geothermal resources for heat extraction or storage?	Are now reliable, have ultra low carbon potential by using central heat pumps. Hot heat networks can include very large thermal storage tanks or pits to input and output heat flexibly.	Likely to be promoted, grant funded.	Avoided insulation? V. low carbon & low maintenance. Can use mostly renewable electricity to produce heat if thermal storage is included.

Urban heat pumps can use power when rural HPs do not, resulting in a smaller power system, lower bills.

Urban Heat Networks



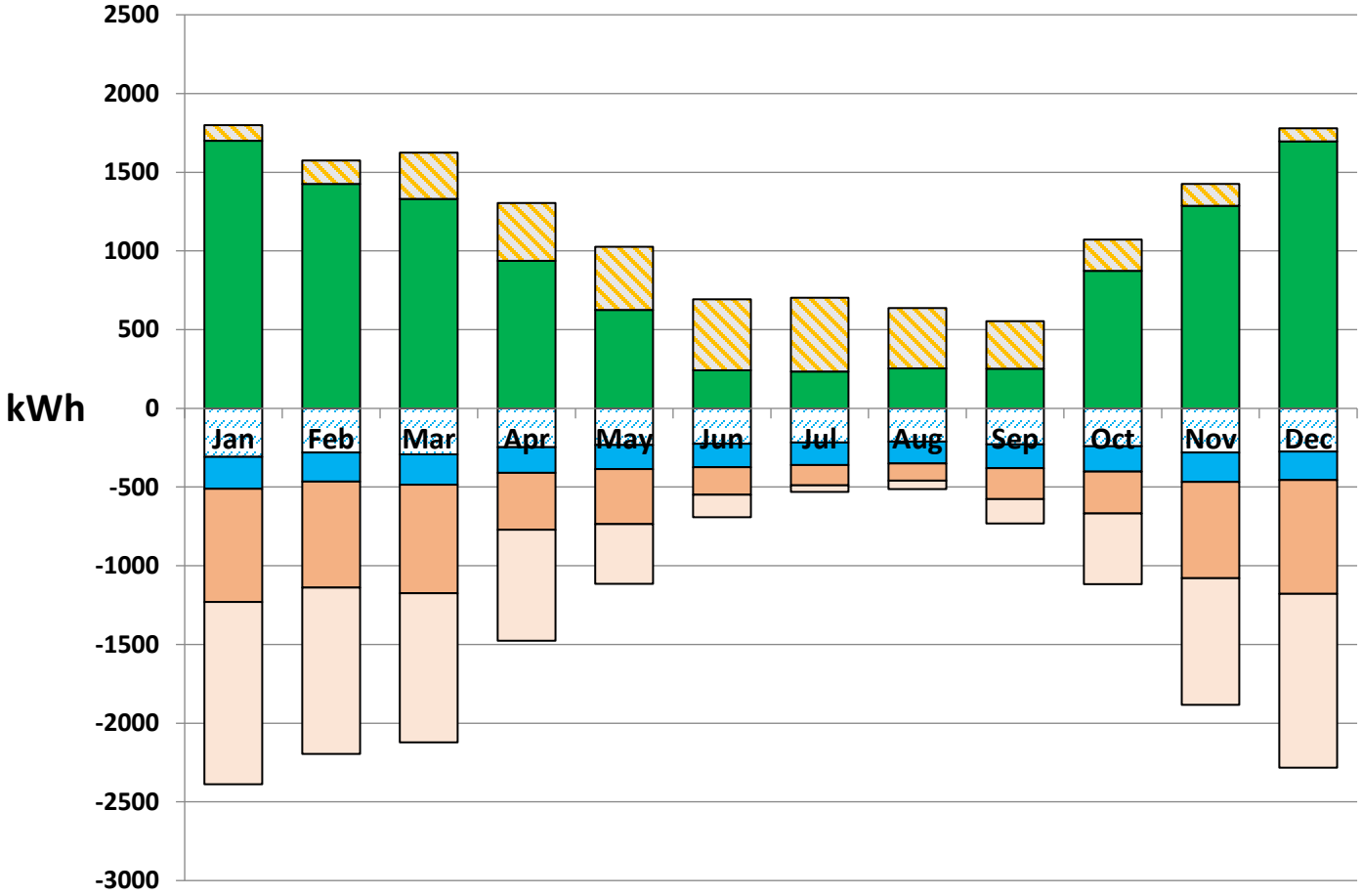
e.g. Codema Dublin: Amazon data centre waste heat

Urban Heat Networks

XXL heat pumps, thermal stores

Renewable Electricity & Monthly Heat Demands

For total home energy demands, wind is more abundant than solar.
The living room radiator/ zone/ downstairs needs heat more often.
Hot water tanks can accept heat inputs at most times and in summer.



Monthly Renewable Energy availability and Home Energy Demands

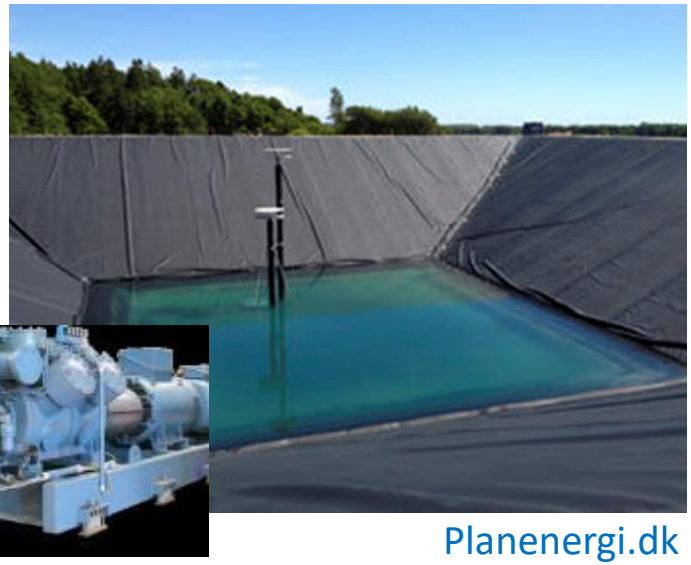
- PV Output
- Wind O/P
- Upstairs Heat
- Living Heat
- Hot Water
- *Electricity*

Making use of variable wind energy for heat, while it is available/ cheap:

Low Carbon Street Heat Networks

Very large community heating systems with large heat pumps can use large heat storage tanks as heat reservoirs for many weeks to ensure that heat is always available.

- Can use power when rural heat pumps are not running.
- **Also compatible with CHP.**



Planenergi.dk

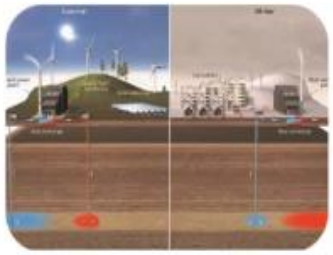
Heat supply can be decarbonised 90%+ using wind energy, PV, & heat pumps.

Example EU Project:

heatstore
High Temperature Underground Thermal Energy Storage

GEOTHERMICA

THE UTES TECHNOLOGIES IN HEATSTORE



Aquifer Thermal Energy Storage

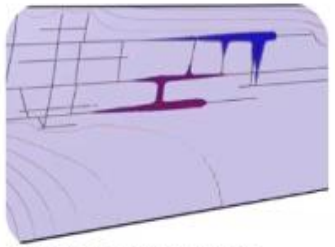
- Injection and later re-production of hot water in aquifers in both shallow and deep geological formations. T
- the aquifers can be both unconsolidated sand units, porous rocks like sandstones or limestone or e.g. fractured rock formations.
- It is an open system using geothermal or water wells and storing the heat in the groundwater and in the formation around it.

Pit Thermal Energy Storage

- Hot water is stored in very large (multiple) excavated basins with an insulated lid.
- Sides and bottom are typically covered by a polymer-liner, but can also be made of concrete.

Borehole Thermal Energy Storage

- The natural heat capacity in a large volume of underground (unconsolidated) soil or rock is used to store thermal energy with or without groundwater as the storage medium.
- It typically has several closely spaced boreholes, between 50 and 200 m deep; they act as heat exchangers to the



Mine Thermal Energy Storage

- Mine water of abandoned and flooded mines is used as a storage medium for high temperature storage.
- The mine water can also be used as an ambient energy source in combination with heat pumps.

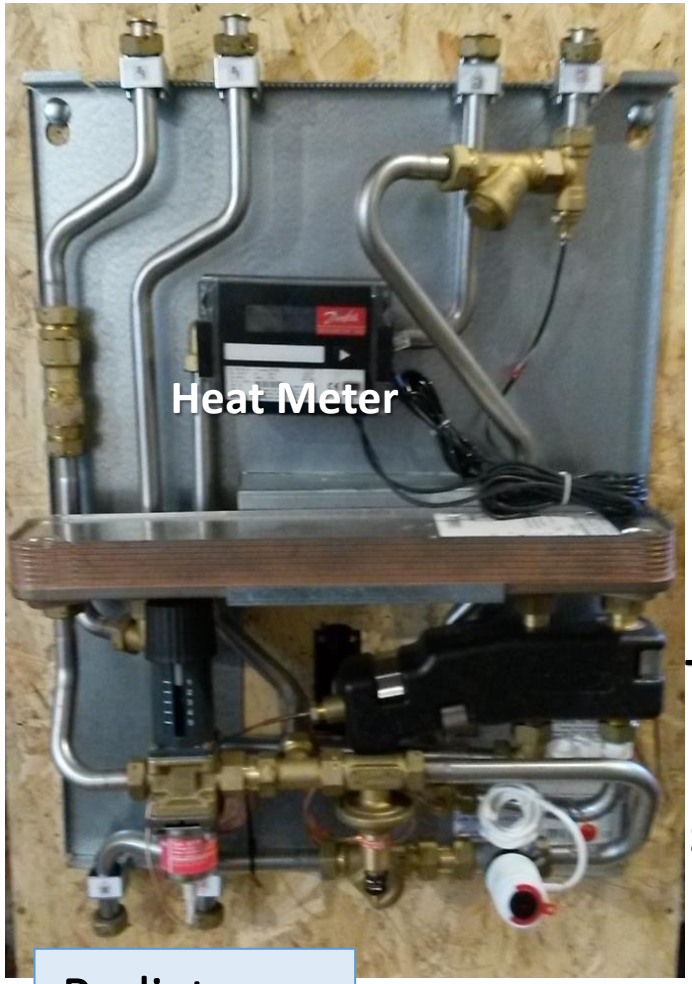
Heat Interface Unit Insides

- Like a boiler
- but no flue

Cold in

Hot out

Community Heat out in



Heat exchanger for domestic hot water

Temperature sensor

Shut Off Valve

Radiators in out

Domestic hot water flow and temperature controls

Historic City Streets

Villages

NIHE estates

Suburbs

Isolated Rural Homes

Low Carbon Heat

Seasonal Thermal Storage

Hot Pipe Networks

Shared heat sources, deep water, boreholes

Cold Pipe Networks

Solar, heat pumps, EV's, superinsulation

Waste Heat, Combined Heat and Power

Hot geothermal

Massive heat pumps

H2 Fuel Cells

Biogas

Wind Energy

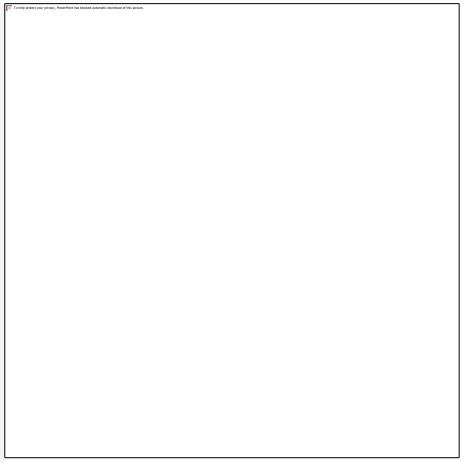
NIHE Small Business Research Initiative: 3 Smart remote sensor R&D contractors.

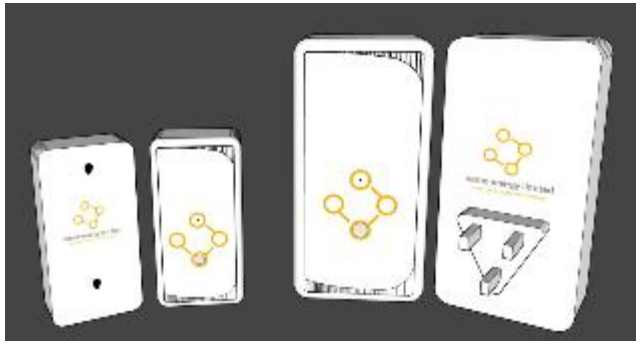
To chose the right heating systems, we need to know:

- **How much are households spending? (fuels, CO2)**
- **When do they need heat? (electricity market)**
- **How warm are homes? (insulation level)**
- **How humid are homes inside? (any damp risk)**

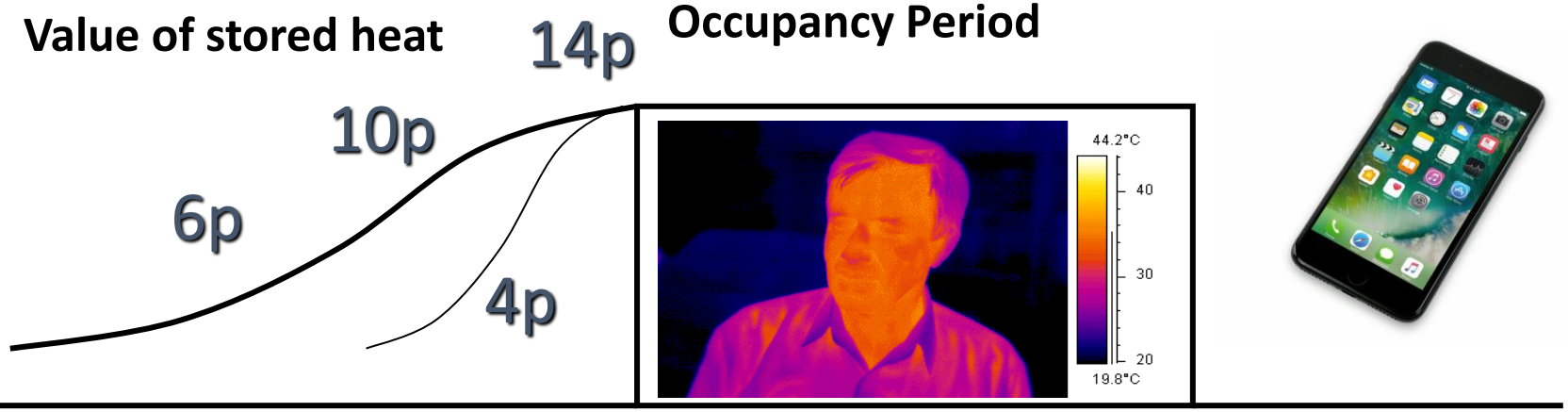
Sensors and communications are now more affordable

SBRI New energy products and services





Value of stored heat



Occupancy Period

Time

Housing Executive

Possible SBRI results (2024?)

1. **Remote control of heating times and pre-heating to have the home warm when you come in or wake up, using more wind and solar energy.**
2. **Automatic advice on how to keep a home warm and dry**
3. **What your heat is costing is visible via mobile phone**
4. **Indications of when oil could run out, current prices**
5. **Automated control of electric heat pumps to minimise costs, especially if the boiler is kept for the coldest days.**

This is <u>your</u> data, how should it be used?

Housing Executive

Possible SBRI results (2024?)

Purrmetrix:
NIHE are working with Purrmetrix to develop a new tool to manage oil consumption and heating. Over the winter, selected residents will be given a chance to trial the heating monitor and its app, aiming to reduce the cost of heating and to help residents keep their homes warm and dry.

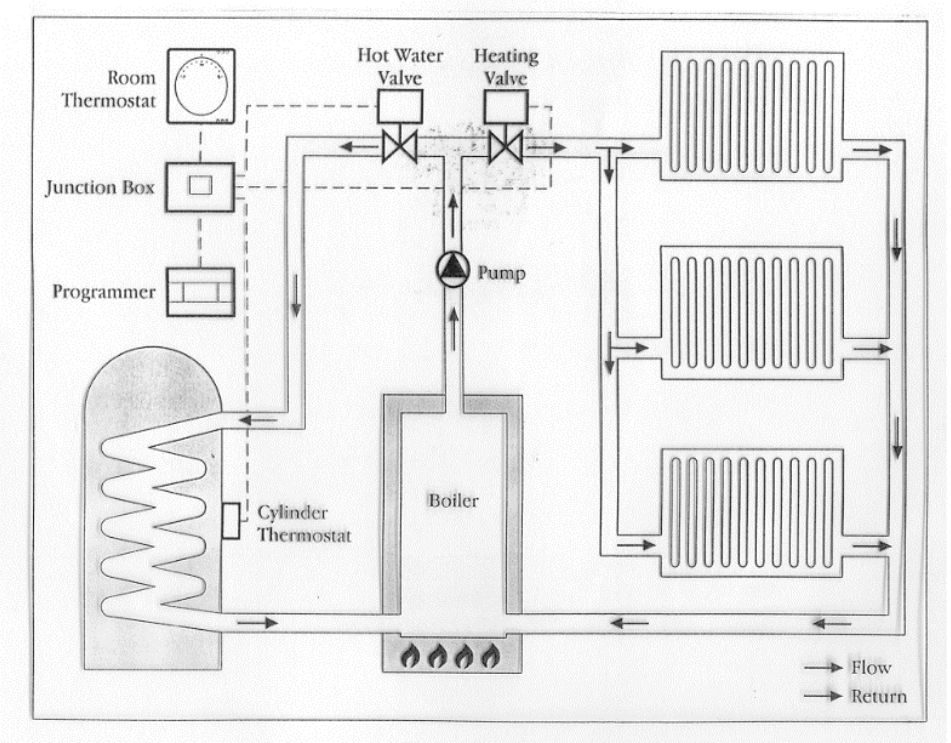
NEMO:
Are developing advanced home monitoring and user control systems, preparing to install heat pumps.

Passiv:
Will demonstrate the use of new cost-effective home heat pump controls that are easy to use and which reduce electricity bills.

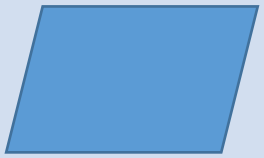
Housing Executive

SBRI Results: Potential with existing boiler systems?

- Adding some economic mass-produced electronics to existing small more pipe and radiator systems, to use a % of wind energy for hot water and heat. Ref “EnergyCloud” using “spare” wind energy to heat hot water.
- All boiler systems with radiators can pass some heat from an immersion heater to radiators.
  - Can pre-heat home ahead of heating/ peak demands
- Preparing for economic heat pump operation using existing condensing boilers?



Electric Systems

Issue	Status	Risks	Benefit
Photovoltaic Panels 	No ROCS, so self-use is critical for economy. Potential for heating hot water, use with heat pumps.	Asbestos in roofs. Price falls for batteries.	**Widely applicable and effective with different orientations.**
Electric Storage Heaters 	Often overheated at night or underused.	**High power prices in future**	**PAYGO, can be made Smarter.** **Add Air to Air Heat Pump with summer cooling?**
Prepayment Meters	Most NIHE tenants use these.	Running out of power with shops shut	Affordable

Solar Orientation & Time Of Use pm/am ?

	Orientation from North						
	W			S			E
Tilt	270°	240°	210°	180°	150°	120°	90°
0°	84	84	84	84	84	84	84
10°	84	87	90	91	90	87	84
20°	82	89	94	96	94	89	82
30°	81	90	97	100	97	90	81
40°	78	89	97	100	97	89	78
50°	74	87	95	98	95	87	74
60°	69	82	92	95	92	82	69
70°	64	77	86	89	86	77	64
80°	57	69	78	81	78	69	57
90°	50	61	68	71	68	61	50

East and West orientations can match actual power demands.
Diversion of solar PV to water & heating is now cost-effective

Renewable electricity is getting even cheaper

Insulated housing allows more renewable electricity to be used as it is produced, reduces the cost of new energy infrastructure.

But to achieve Nett Zero emissions at least cost over a region, balancing a constantly changing renewable energy supply, heat supply must be changed:

Individual systems using a percentage of renewable electricity for heat and hot water can save carbon affordably. E.g. Hybrids

Urban community heating systems with thermal storage can use electricity at different times from the heat pumps in rural areas.

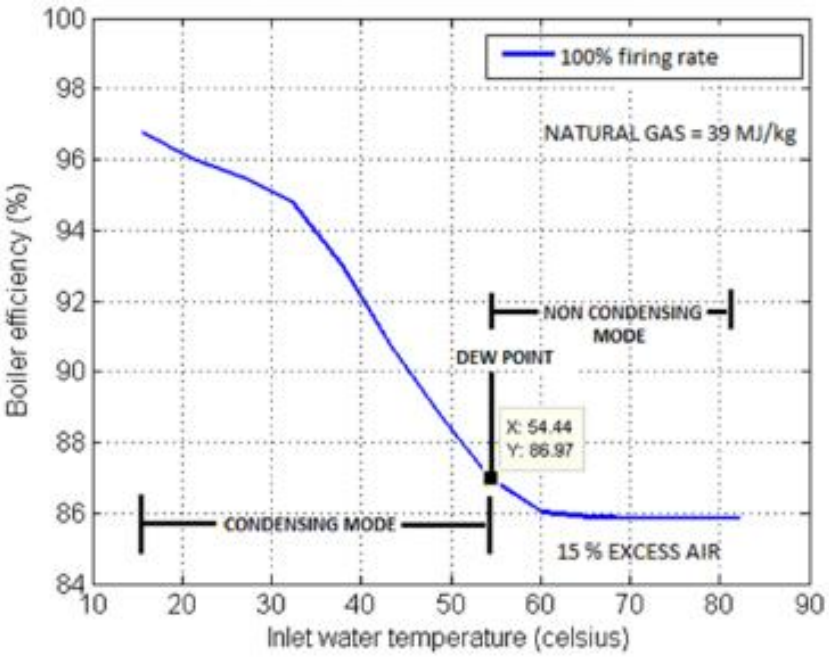
Thank You

Getting more from oil and gas (esp Combi) boilers now:

5C reduction in flow Temp saves ca 2% (more from heat pumps later)

Balancing radiator flows and adding ErP Class V room thermostats/ controls reduce the radiator output temperature according to the actual room temperature:

- Radiant radiator temperatures are boosted when the room is cold.
- Boiler output is then ‘modulated’, limited to maximize more efficient condensing boiler operation.
- Installing bigger radiators now heats rooms OK with lower water temperatures, and prepares the way for savings with heat pumps.



Getting more from oil boilers now:

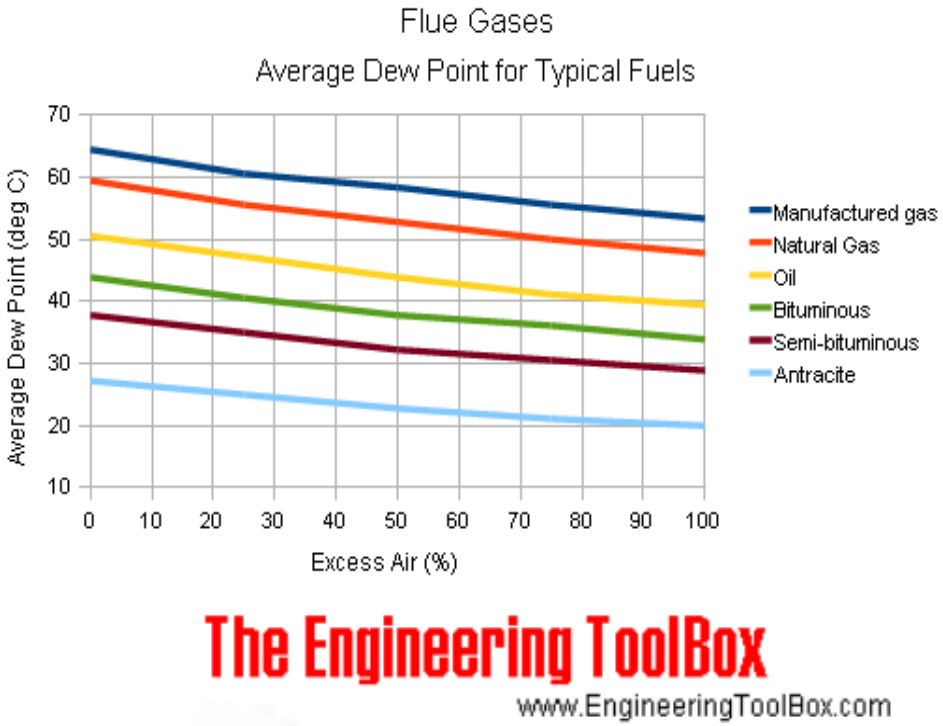
Steady Heat Demand ca 3kW, fixed output 14 kW Min?

Oil boilers' condensation temperature is lower than 50C with gas, e.g. With larger radiators sized for later installation of a heat pump. 5C lower saves ca 2% Oil. ErP controls save another 3-4%; TPI electronic control ca 2%

- ErP Class VII controls start& stop the boiler to reach the target room temperature.
- TPI Time Proportional Integral controls also provide savings

- The larger mass of water in bigger radiators or hot water cylinders can reduce boiler cycling losses.

- Priority Domestic Hot Water [PDHW] controls can ensure Hi. Temp. legionella protection



END

Andrew.frew@nihe.gov.uk

Send details of your interests, also anything I should see please.

References 1:

NI Geoenergy: GeoEnergy NI - Unearthing The Heat Beneath Our Feet

University of Ulster 2023 Chicago IEA Heat Pump Technologies conference paper published, covers Rulet, Air Source Heat Pumps, 'State of the Art'.
(search "460") ASHPs & Thermal Storage for homes

Publications Archive - HPT - Heat Pumping Technologies

https://www.gov.uk/government/publications/evidence-gathering-high-temperature-heat-pumps-hybrid-heat-pumps-and-gas-driven-heat-pumps

https://www.gov.uk/government/collections/heat-pump-research

QUB Geothermal Report:
https://nora.nerc.ac.uk/id/eprint/531393/33/GSNI-%20NI%20Geothermal%20Energy%20Summary%20for%20GAC%202021_report.pdf

https://www.escubed.org/articles/10.3389/esss.2022.10047/full "Heat Battery"

References 2:

Drakes landing solar community _____https://www.dlsc.ca/

http://www.sdewes.org/jsdewes/pid8.0340 National power system synergies

"decarbonisation of the example district's power and heating energy can be reached even without the availability of biomass, if sufficient Power to Heat (XXL Hpumps) and Power to Gas capacity is integrated to the District Heating grid, and sufficiently more wind- and solar power is installed" e.g. Using existing power connections.

Consultant shared interesting 'SEEMS' paper on meshed heat networks, using solar thermal in France, (but wind powered ASHPs could be better here): interseasonal BTES storage. "We are still far away from this, due to our prevalent and (not optimal) techno-economic systems. I have recently written a paper on this topic":
https://drive.google.com/open?id=10KEFutLzlX5uo4M3BYwxXir18KNI7LKk&authuser=davidbourguignon.net%40gmail.com&usp=drive_fs

References 3:

Lots of documentation relevant to Ireland (ROI)

https://www.seai.ie/data-and-insights/national-heat-study/

Geothermal Heat Storage potential:

https://www.heatstore.eu/documents/HEATSTORE_UTES%20State%20of%20the%20Art_WP1_D1.1_Final_2019.04.26.pdf

(NI also has above average heat at depth, potential in the porous sandstone aquifer under Belfast)

Minewater

https://iea-gia.org/areas-of-activity/geothermal-heating-and-cooling/mine-water-geothermal-energy-group/