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District heating assessment for University of Galway Campus. (Act!onHeat support facility)

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act!on heat

THERMOS

This work includes results from the THERMOS heat network model (https://www.thermos-project.eu).
For more information about THERMOS contact the Centre for Sustainable Energy (https://www.cse.org.uk).

University of Galway.ie

Summary

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1. DHC Ireland policy
2. DHC Options in Ireland
3. University of Galway DH Pilot
4. District Heating Plan EXCEED 2025/2026
5. Alice Perry Engineering Building / GEOFIT
6. THERMOS workflow
7. THERMOS demand estimation
8. Network Problem
9. DH Network Temperature Discussion
10. Conclusion and Next Steps

DHC Ireland policy

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- NATIONAL HEAT STUDY
- NET ZERO by 2050
- DISTRICT HEATING AND COOLING - Spatial Analysis of Infrastructure Costs and Potential in Ireland

- Policy Framework for the Development of District Heating in Ireland Submission 2020.pdf
- Policy Framework for the Development of District Heating in Ireland 2020 REI Submission.pdf
- The effect of Part L Building on the District Energy sector in Ireland 2020.pdf
- DH Can Supply the Heat for 10 % Ireland by 2030 and Save Almost 1 Mt CO2 per Year 2020.pdf
- Call for Expert Evidence Climate Action Plan 2021 2020.pdf
- Best Practice In Heat Network.pdf
- IrDEA Heat Atlas Overview.pdf
- Transition Roadmap for Developing District Heating in South Dublin 2019 Codema.pdf
- Eastern and Midland Regional Assembly Draft Regional Spatial and Economic Strategy Sub. 2019.pdf
- Developing District Heating in NorthcWest Europe 2019.pdf
- Initial Public Consultation National Energy and Climate Plan 2021 2030 2018.pdf
- IDEA Kick-off Workshop 26th January 2018.pdf

Source: https://districtenergy.ie/policy

DHC Options in Ireland

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- Option 1 – Heat extraction from power stations and industrial waste heat recovery (including data centres)
- Option 2 – Biomass boiler
- Option 3 – Biomass CHP with biomass boiler back-up
- Option 4 – Air source heat pump (ASHP)
- Option 5 – Ground source heat pump (GSHP)
- Option 6 – Low-carbon gas CHP
- Option 7 – Geothermal at depths up to 400 m

Source: DISTRICT HEATING AND COOLING - Spatial Analysis of Infrastructure Costs and Potential in Ireland

University of Galway DH pilot

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- **Develop** the University of Galway central campus case study in THERMOS;
- Compare the THERMOS **Demand Estimation** with other Estimation methods;
- Run the Network problem and **size the supply,** and Supply Problem in an iterative process;
- Compare of **Two Case Scenarios**: (1) Gas based system with 90-70 deg.C Delta T and (2) HP system with 60-40 deg.C Delta T;
- Academic value of Thermos as teaching tool for current MSc Energy modules;
- Support the EXCEED Grant application. (3M certified Grant Scheme);

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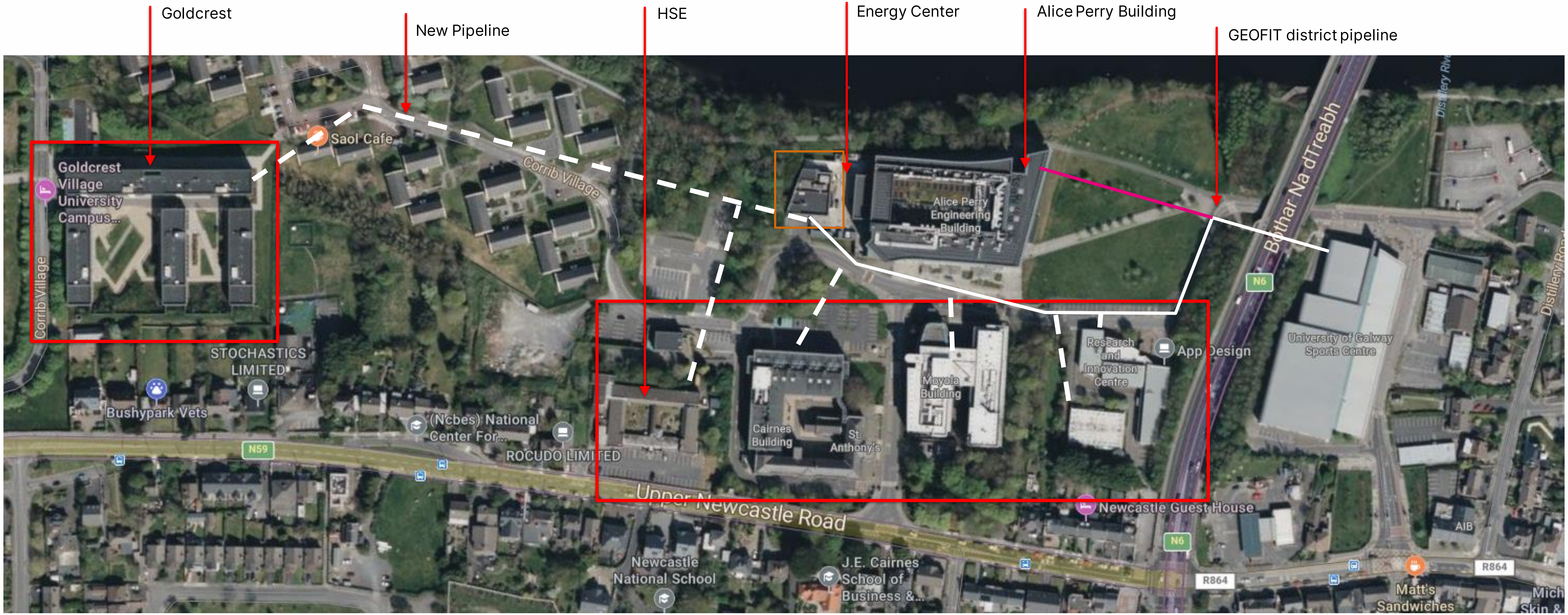
District Heating Plan EXCEED[(1)] 2025/2026



(1) Excellence in Energy Efficient Design

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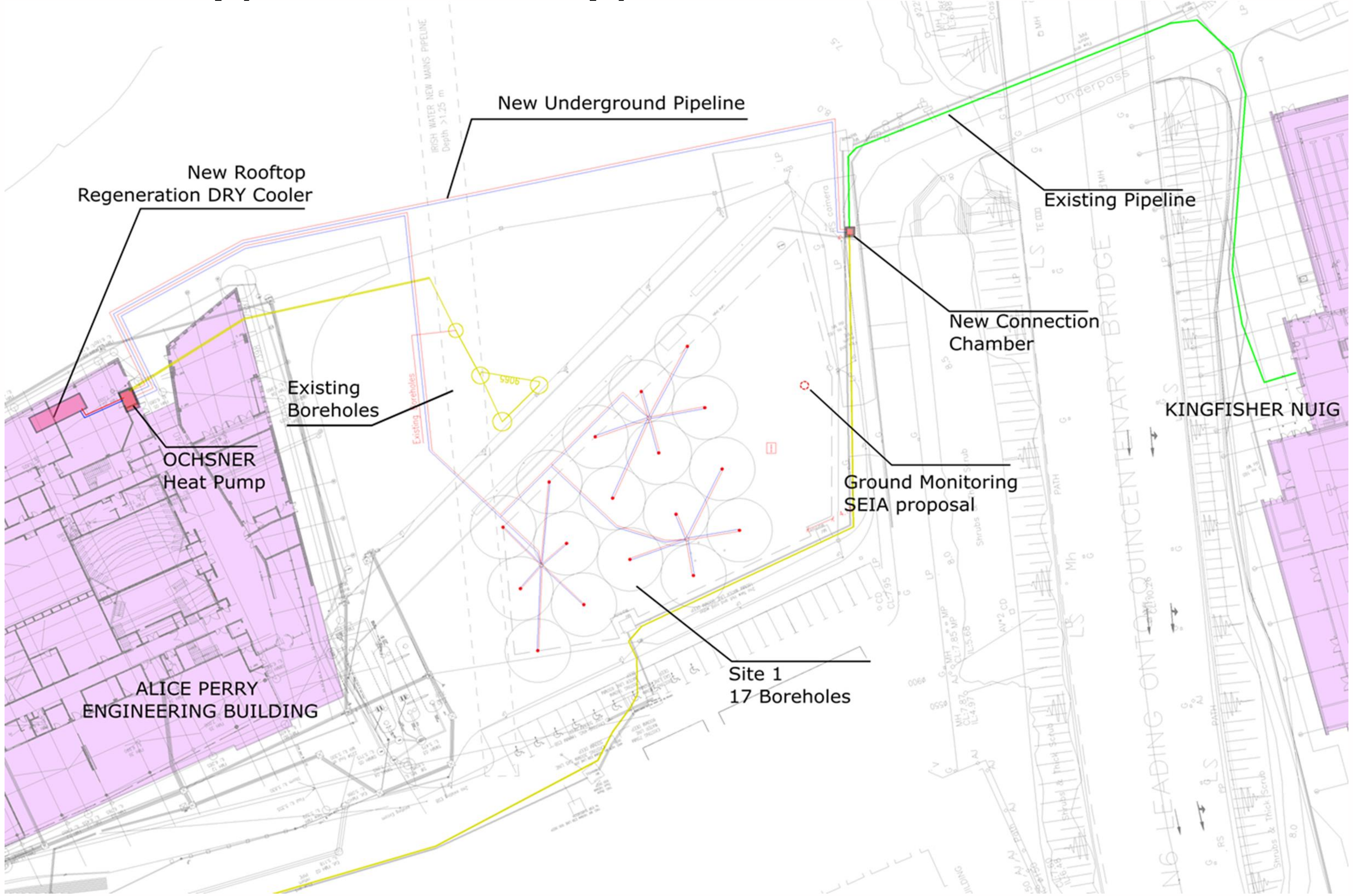
Adapted from: Geothermal Webinars 2023. Webinar 3: GEOFIT Heat Pump Pilot, University of Galway. https://youtu.be/oKyiiKr7Tvw?si=-vV1532TJYiK-Dlv

Alice Perry Engineering Building / GEOFIT

- 18 boreholes – 150 m. Depth
- Air/Ground source HP (2x50kW OCHSNER)
- Downhole equipment (DTS)
- District Heating pipeline
- IEA TCP-HPT ANNEX 52 instrumented
- IEA TCP-HPT ANNEX 60 case study
- SQL database
- Teaching demonstrator



THERMOS Workflow

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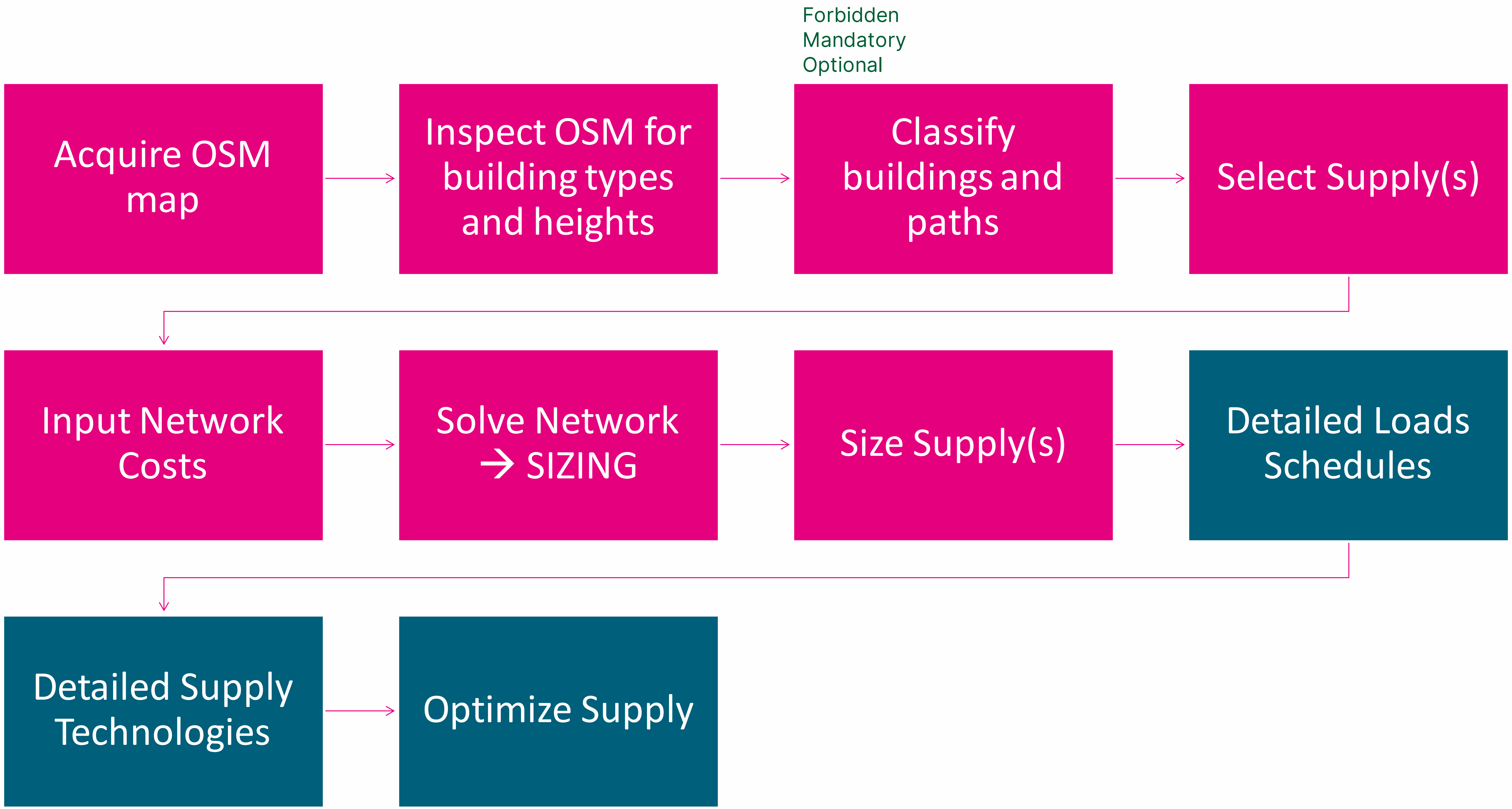

THERMOS Demand Estimator

Space Heat Demand

- Based on regression models (LM, SVM). Trained on Copenhangen dataset (polygons, metered demand, and others).
- A number of tested datasets depending on 3D and 2D data some models have better fits
- Better fit for urban areas, worse for rural areas

Peak demand :

- kWp=0.0004963×kWh/yr+21.84
- This relation is a regression fitted to a large sample of published UK half-hourly domestic gas consumption data.

Best is to have BER data, or even better metered data, as all buildings input can be overridden.

BUT what happens if we have 100s of buildings or lots different types of uses. ?

Demand Estimation

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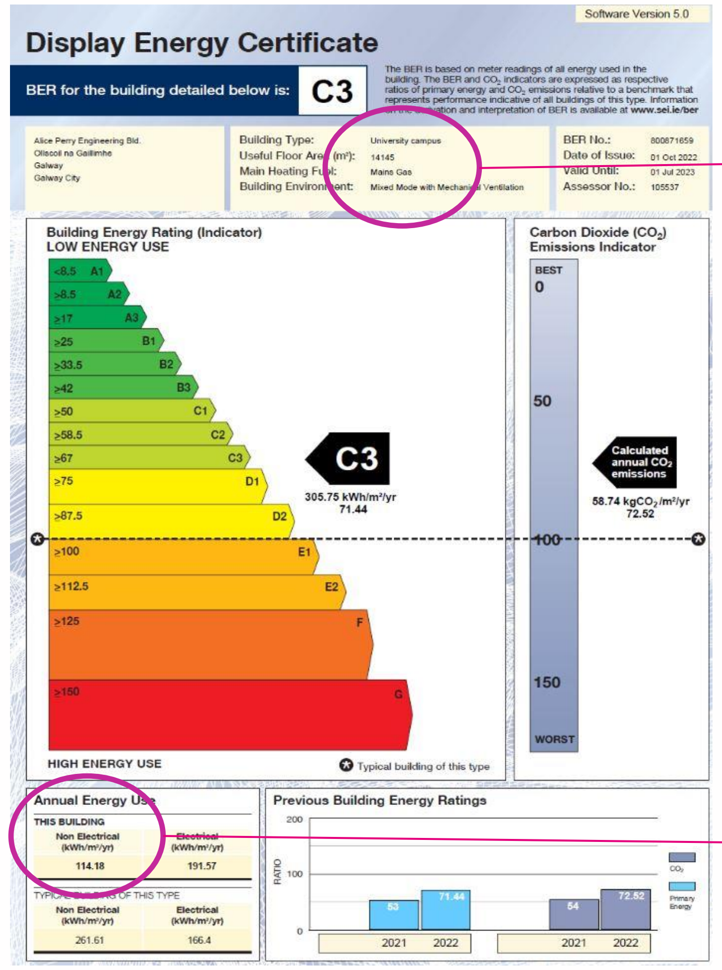
Building	height	Supply	Demand	m2	Archetype (B-C) (kwh/m2*annum)	BER-NonElec (kwh/m2*annum)	BER (MWh/year)	THERMOS (MWh/year)	THERMOS PEAK (kWp)
Energy Centre	5	Y	N	N/A					
Alice Perry Building	16	Y	Y	14,145.00		114.18	1,615.08	1002.25	528.84
Goldcrest Village	18		Y	13,050.00	80		1,044.00	897.25	532.67
HSE St. Francis	4		Y	1,400.00	150		210.00	384.76	218.80
Aras Cairnes	16		Y	7,213.00		39.11	282.10	402.94	221.82
St. Anthonys	12		Y	2,800.00		39.11	109.51	265.76	153.74
Aras Moyola	16		Y	9,500.00	150		1,425.00	576.07	307.74
Research & Innovation	8		Y	2,800.00	150		420.00	299.72	170.59
Business & Innovation	3		Y	600.00	150		90.00	124.48	83.62
							5,195.68	**3953.23**	



Usable floor area

Non-Electr. Consumption

- ➢ BER data uses usable floor area;
- ➢ BER cert. estimated from Non Electricity Consumption;
- ➢ OSM data discrepancies with height, number of levels and usable areas;
- ➢ Demand based on 1724 Degree-Days (Eurostat) at 17 Deg C but corrected to 2200 (Shannon Airport Meteo data). Sometimes it gives 2800 (error??)
- ➢ Some University buildings are used less intensively. Worth considering?;
- ➢ Higher figures considered;
- ➢ Peak demand considered by extrapolation.

Network Problem

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Option 1 - Maximize network NPV

In this mode, the goal is to choose which demands to connect to the network so as to maximize the NPV for the network operator. This is the **sum of the revenues** from demands **minus the sum of costs** for the network.

The impact of non-network factors (individual systems, insulation, and emissions costs) can be accounted for using the market tariff, which chooses a price to beat the best non-network system.

Option 2 - Maximize whole-system NPV

In this mode, the goal is to choose **how to supply heat to the buildings in the problem (or abate demand) at the minimum overall cost.** The internal transfer of money between buildings and network operator is not considered, so there are no network revenues and tariffs have no effect.

The whole system NPV will always be negative, because the model only displays costs - the benefit is in terms of delivered heat, which is assumed to be a non-negotiable good desirable at any price.

- Connection Cost – 75k € per building
- Civil Cost - 225 €/m
- Pipe Cost – 76 to 270 €/m
- Initial supply sizing results: **1.22 MW**
- Demand Coincidence: 66%
- Some connections are redundant and include unnecessary loops
- Maximum size 100 mm diam.

Packaged substation
source: https://www.danfoss.com/en/

Discussion: 90-70^0 C Vs. 60-40^0 C

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Gas Boilers

Cost summary | Network | Individual systems | Insulation | Emissions | Optimisation

Item	Capital cost (¤)	Operating cost (¤)	Operating revenue (¤)	LCH (c/kWh)	NPV (¤)
Pipework	524.25 k	--	--	--	-401.67 k
Heat supply	0	1.21 M	--	--	-721.4 k
Demands	2.25 M	--	7.63 M	--	3.2 M
Emissions	--	0	--	--	0
Network	**2.78 M**	**1.21 M**	**7.63 M**	**2.72**	**2.08 M**
Emissions	--	0			0
Individual Systems	--	**0**			**0**
Insulation	--	--			--
Whole system	**2.78 M**	**1.21 M**			**-2.46 M**

Cause	co2 t/yr
Network (heat)	825.18
Network (pumping)	0
Total	**825.18**
Counterfactual	**0**
Net	**825.18**

Total cost summary

Supply technologies							
Item	Capex ¤TOTAL	Opex ¤TOTAL	Fuel ¤TOTAL	Export ¤TOTAL	Emissions ¤TOTAL	Total ¤TOTAL	PC ¤PV
Gas Boiler 1.5 MW	100 k	120 M	5.11 M		0	125.21 M	69.23 M
Total	100 k	120 M	5.11 M		0	125.21 M	69.23 M

Average unit cost of production: 81.62 c/kWh

Water Source HP

Cost summary | Network | Individual systems | Insulation | Emissions | Optimisation

Item	Capital cost (¤)	Operating cost (¤)	Operating revenue (¤)	LCH (c/kWh)	NPV (¤)
Pipework	554.8 k	--	--	--	-425.09 k
Heat supply	1.47 M	1.18 M	--	--	-1.83 M
Demands	2.25 M	--	7.63 M	--	3.2 M
Emissions	--	0	--	--	0
Network	**4.28 M**	**1.18 M**	**7.63 M**	**3.97**	**940.53 k**
Emissions	--	0	--	--	0
Individual Systems	--	**0**			**0**
Insulation	--	--			--
Whole system	**4.28 M**	**1.18 M**			**-3.6 M**

Cause	co2 t/yr	¤
Network (heat)	412.67	0
Network (pumping)	0	0
Total	**412.67**	**0**
Counterfactual	**0**	**0**
Net	**412.67**	**0**

Total cost summary

Supply technologies							
Item	Capex ¤TOTAL	Opex ¤TOTAL	Fuel ¤TOTAL	Export ¤TOTAL	Emissions ¤TOTAL	Total ¤TOTAL	PC ¤PV
WSHP	1 M	120 M	7.49 M		0	128.49 M	71.45 M
Total	1 M	120 M	7.49 M		0	128.49 M	71.45 M

Average unit cost of production: 85.76 c/kWh

Conclusions and Next Steps

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- Do demand estimation from actual metered data whenever possible;
- OSM data good for perimeter and paths;
- OSM data used for demand estimation is uncertain (stories, height);
- Economics of heat generation is uncertain. Data based on heat studies does not usually match reality (higher construction costs). At a design stage cost of new supply is uncertain for the average practitioner;
- CAPEX and OPEX cost ratios are difficult to workout;

- Construction costs – in depth;
- Comparative with SEAI National Heat Study sources and levelized costs.
- Hydronic design and operation – in depth;
- Counterfactual for EXCEED application;

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