Rialtas na hÉireann
Government of Ireland

Geological Survey
Suirbhéireacht Gheolaíochta
Ireland | Éireann

Overcoming barriers and raising awareness

The role of Geological Survey Ireland

Dr Sarah Blake

Groundwater & Geothermal Unit

National Geothermal Energy Summit 2022, 9 November 2022

Who are we?

- Geological Survey Ireland is Ireland’s public earth science knowledge centre founded in 1845. It is a division of the Department of the Environment, Climate Action and Communications

- We provide free, open and accurate data and maps on Ireland’s subsurface to landowners, the public, industry, and all other stakeholders, within Ireland and internationally; all of our data and maps are available online at www.gsi.ie

- We collect and collate geothermal data to produce maps, reports, and user guides on Irish geothermal resources, and provide impartial scientific advice to policy makers and the public.

What is geothermal energy?

- Commercially proven renewable energy that can be used for heating and/or cooling, and electricity production.
- EU definition: “energy stored in the form of heat beneath the surface of solid Earth”.
- Heat flows outwards from the centre of the Earth, and the temperature (and the amount of available energy) increases with depth at an average rate of 25 to 30 °C per kilometre for most places in the world.
- Whilst not a ‘traditional’ geothermal setting (i.e., far from active volcanoes), geothermal energy could be a viable, significant source of energy in Ireland.

Always on

Local and secure

Carbon-free at source

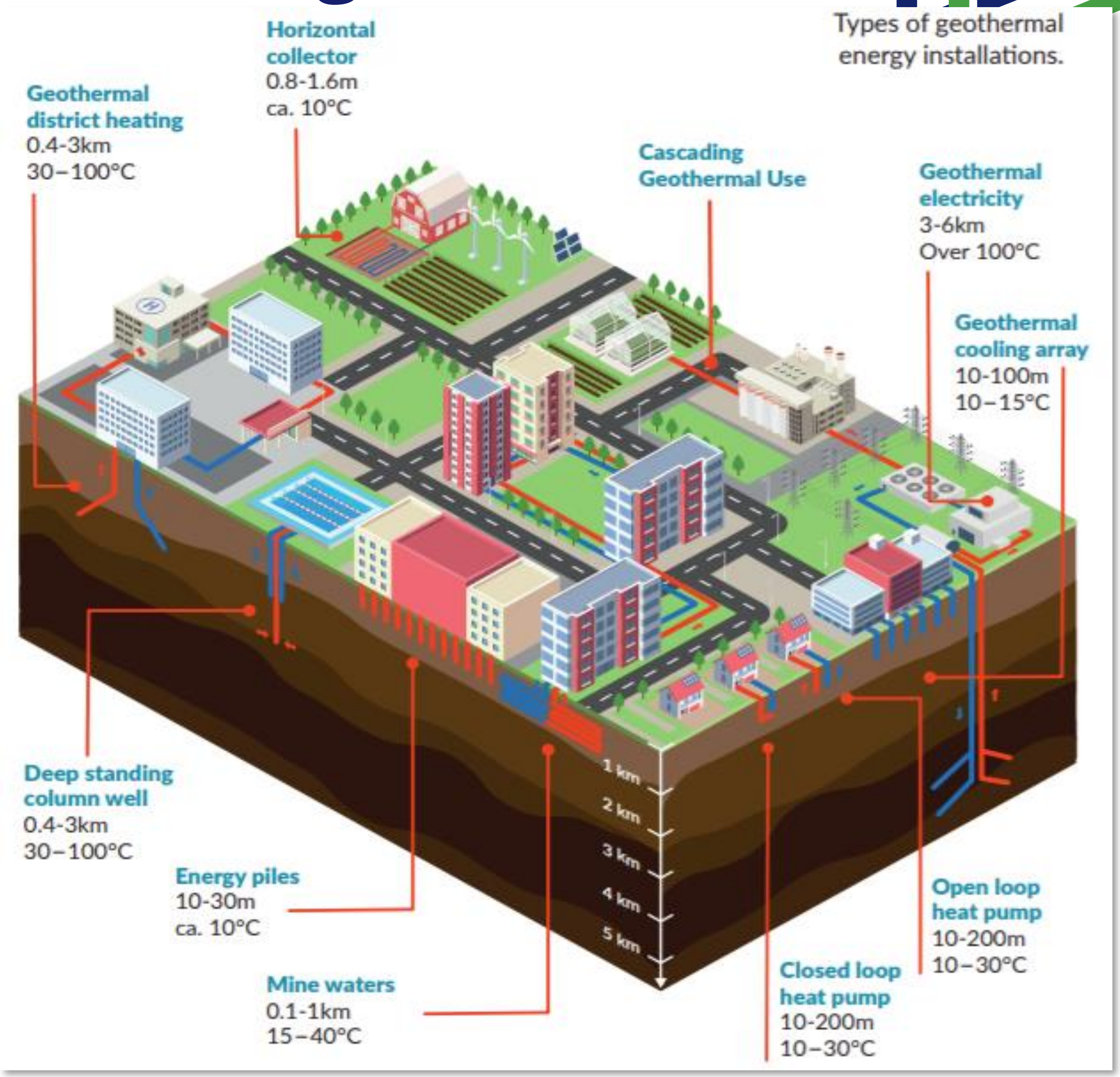
Improved air quality

Small land footprint

How do we get energy out of the ground?

- Geothermal energy is everywhere at depth.
- Geothermal solutions are not one-size fits all.
- Can provide heating, cooling and heat storage.
- Required temperatures, heating/cooling load and site specific geology all influence technology choice.
- Ideal for DH applications.
- Integration possible with other renewable sources.

GSI, 2021



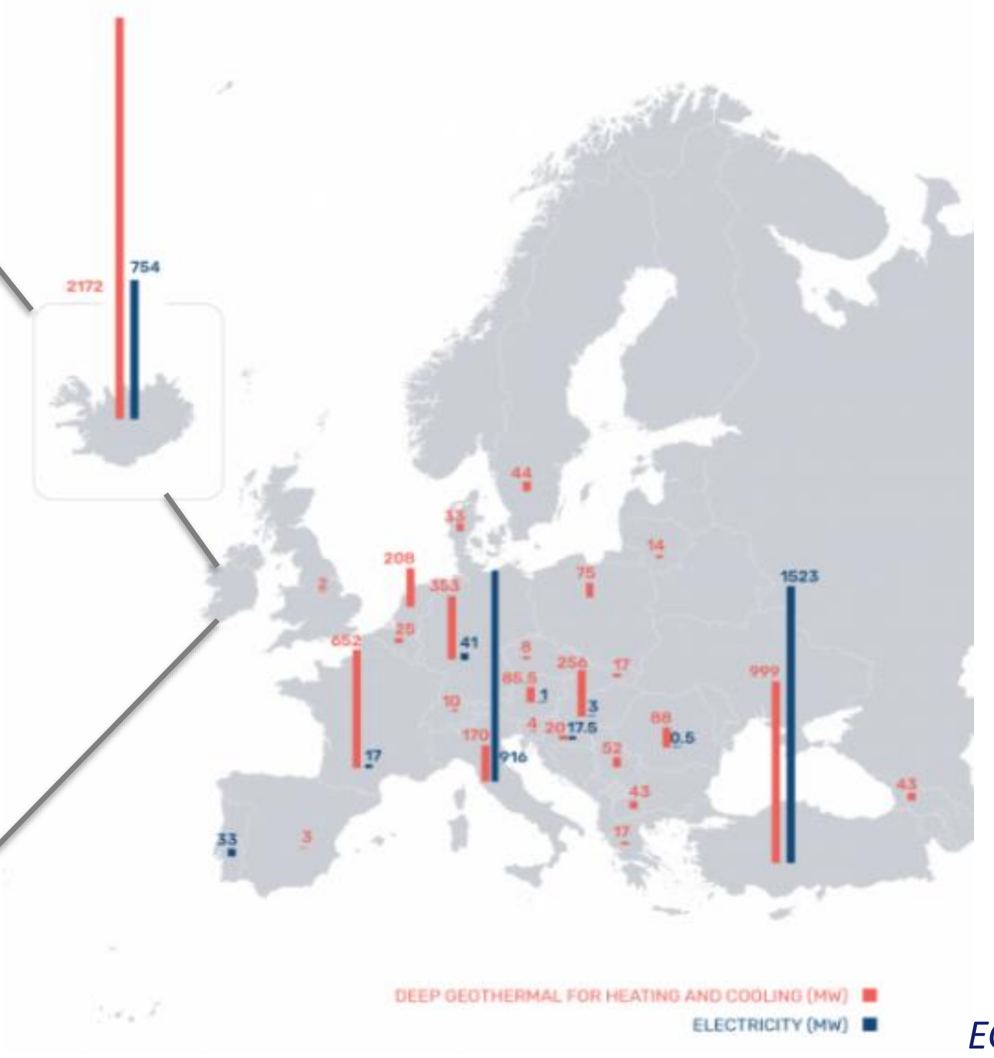
What are the main barriers?

94% of Ireland suitable for shallow geothermal (GSHP) yet has failed to gain traction. Why?

- Lack of **Awareness**
- Lack of **Policy**

Deep geothermal remains an untapped source of always-on, low carbon renewable energy in Ireland. Why?

- Lack of **Awareness**
- Lack of **Policy**
- Lack of **Data** (high geological uncertainty)



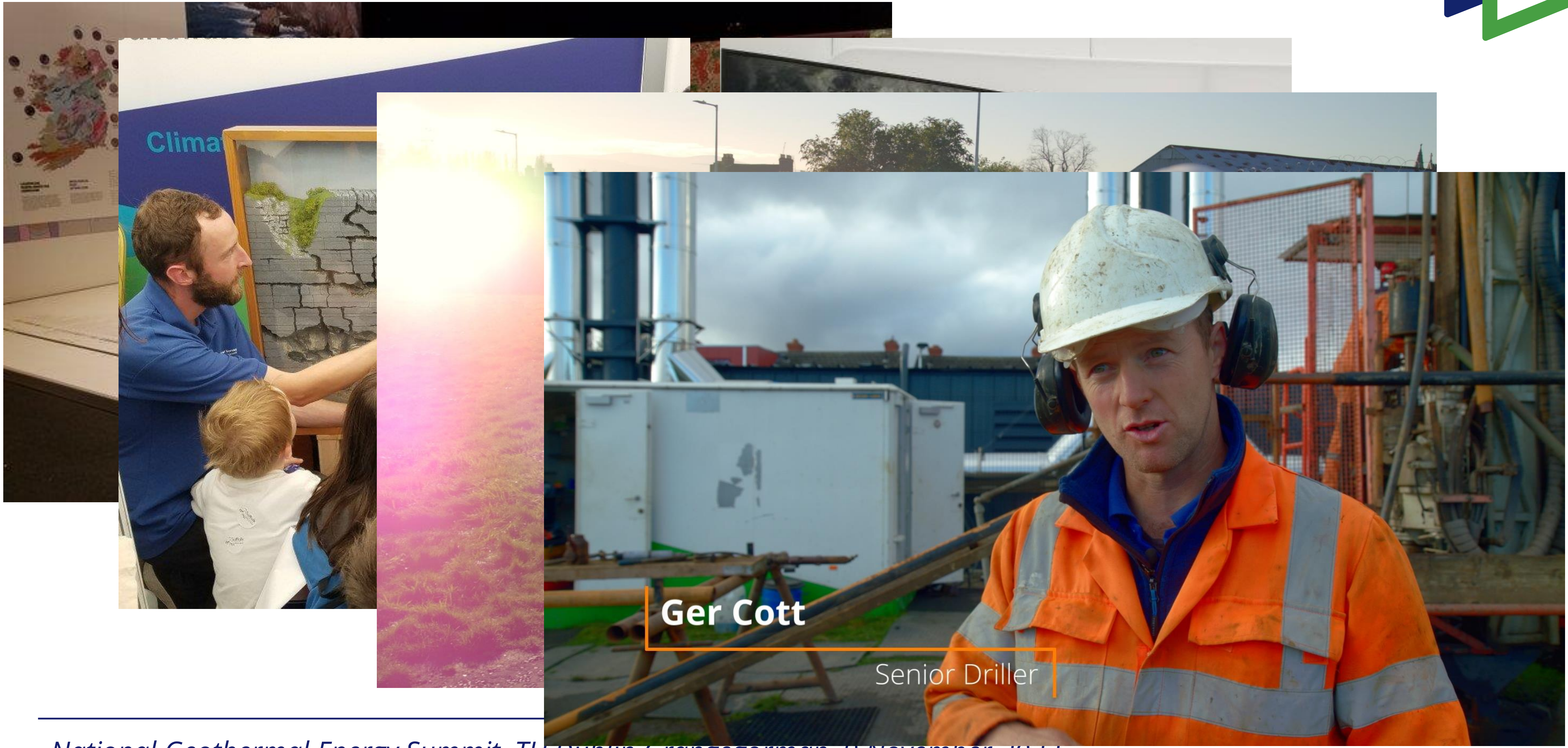
EGEC, 2020

Raising awareness

Raising awareness

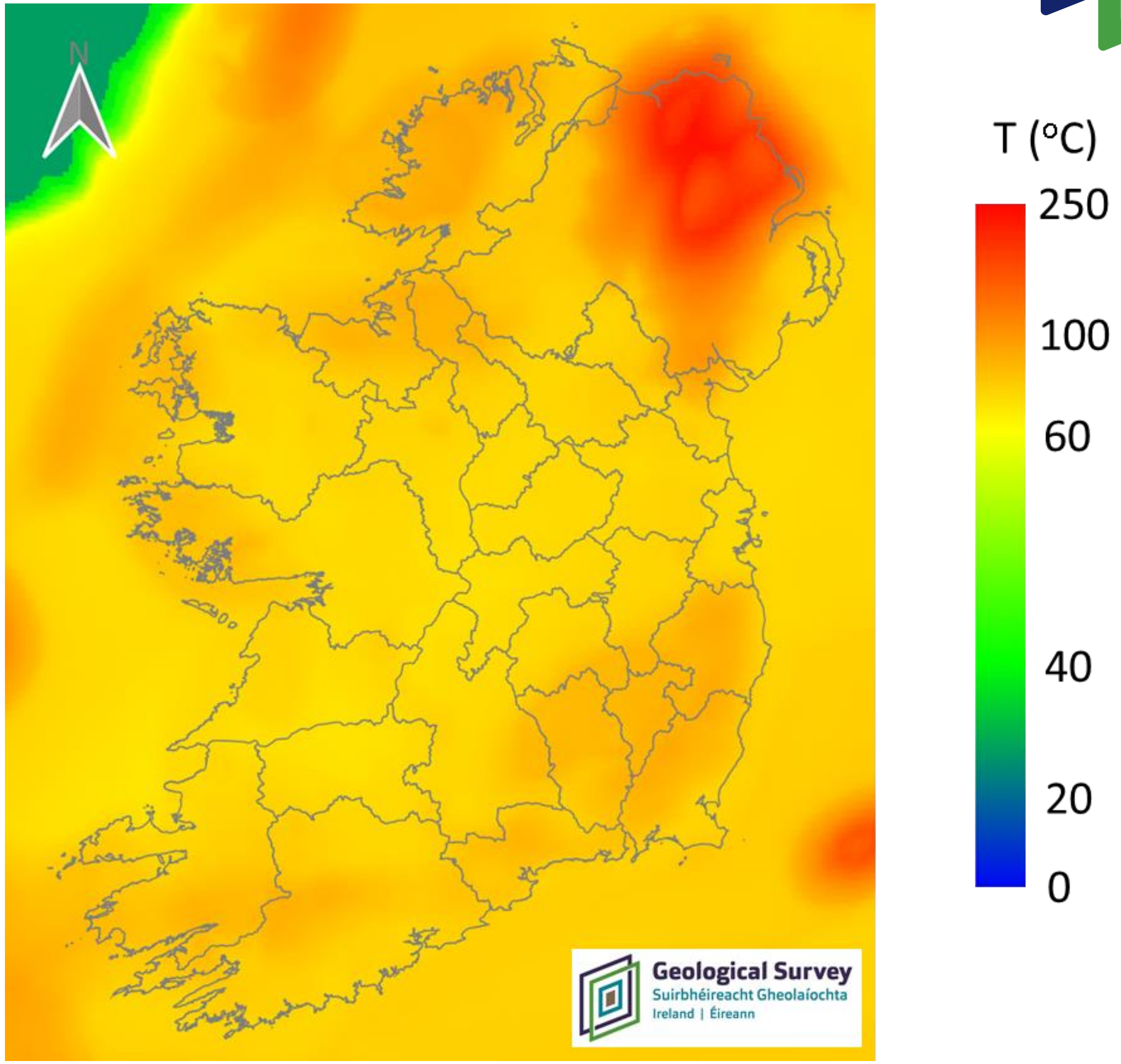
Raising awareness

Raising awareness



Raising awareness

Raising awareness



Geothermal policy development

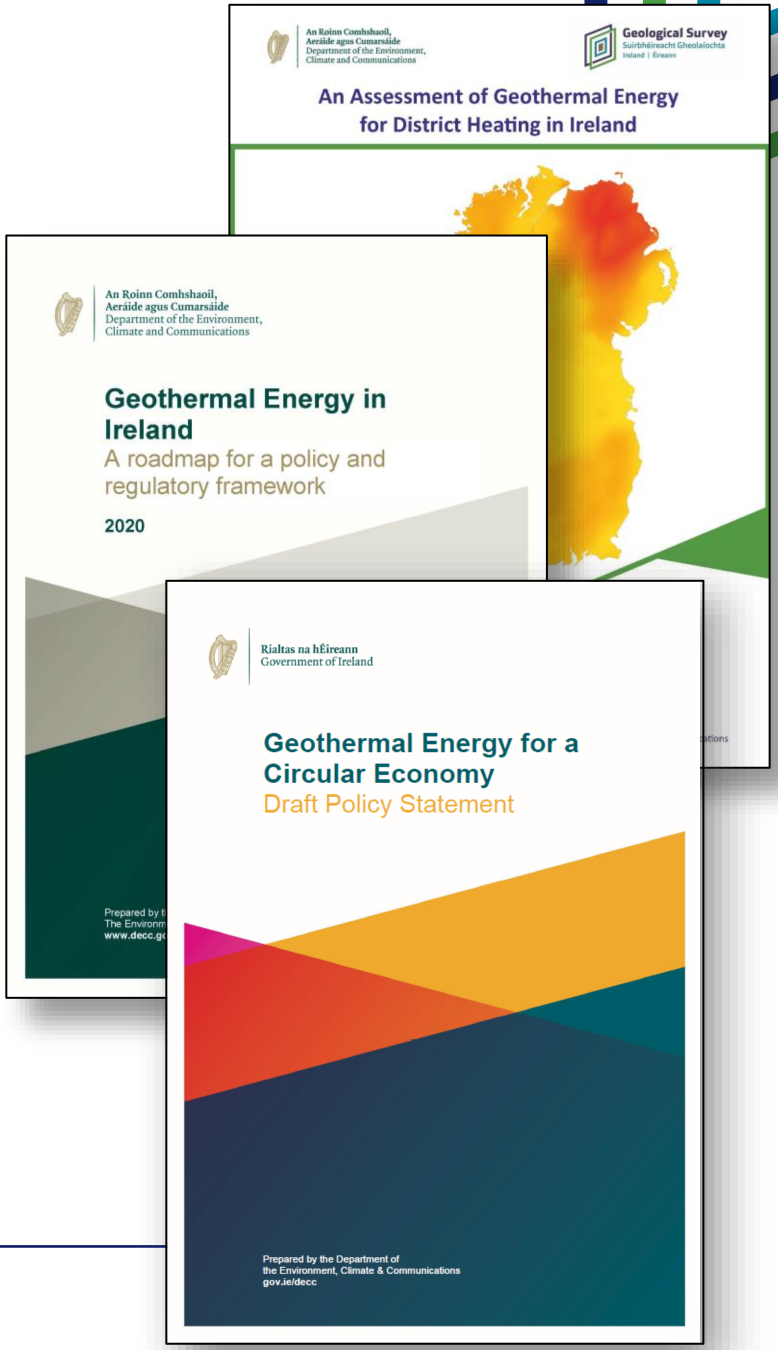
Published in November 2020:

- GSI Assessment of Geothermal Energy for District Heating in Ireland
- 2020 Non-Technical Roadmap for a Policy and Regulatory Framework

Under current Climate Action Plan:

- DECC published Draft Policy Statement end 2021
- Propose to Government in Q4 2022
- Legislation first draft by end 2023

Geological Survey Ireland provides technical support to the Working Group (DECC GeoScience Policy Division) and sits on the Advisory Group



Data: de-risking the subsurface

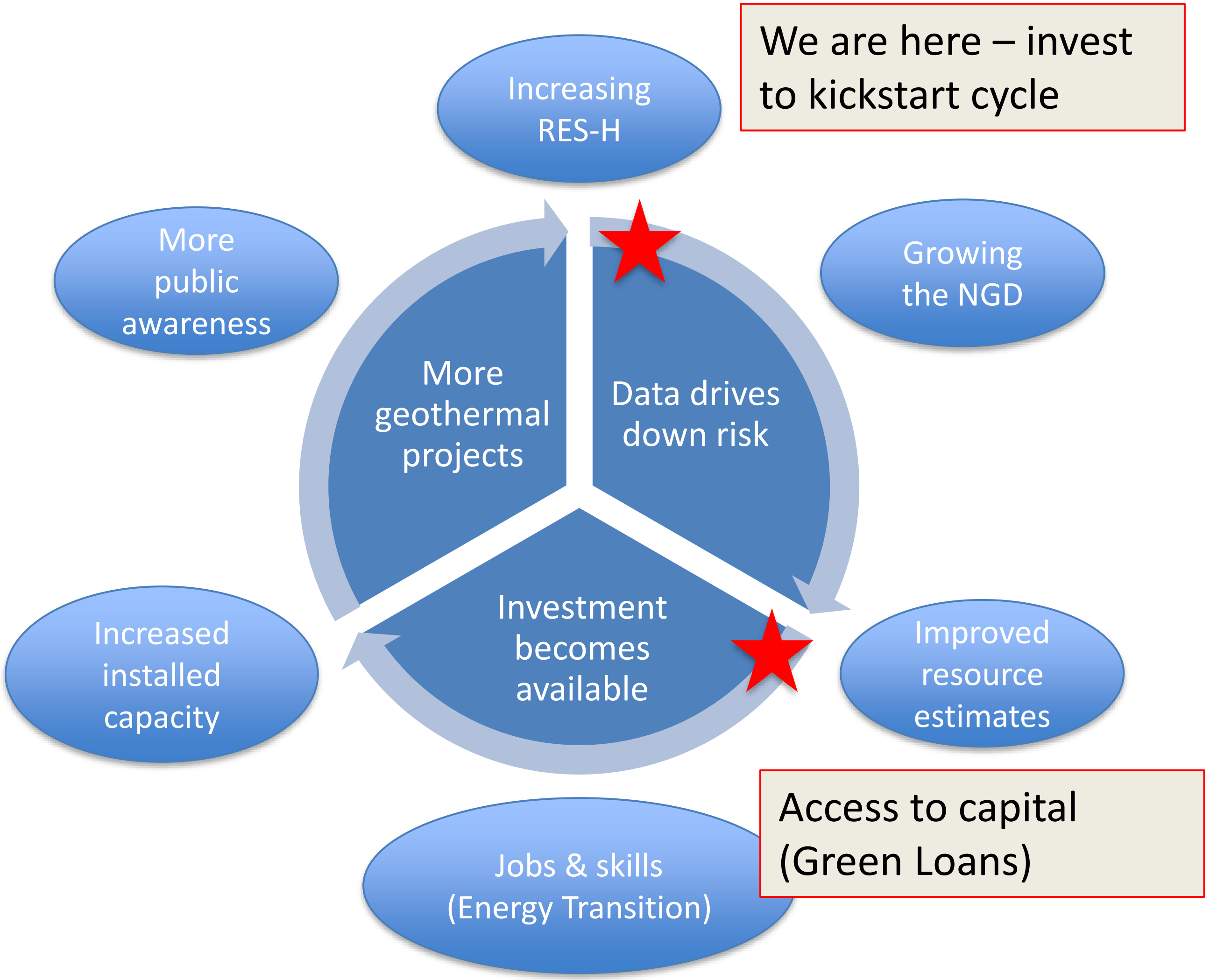
Geothermal economics

- High geological risk for geothermal projects can impact comparative economic metrics such as LCOE/H.
- At the moment, it is hard to directly compare geothermal with other renewable solutions.
- The perceived risk translates into a larger return demanded by equity investors.

- Public investment needed to remove this barrier by:
  1. Financing **low-cost green loans** for geothermal projects.
  2. Investing in **data (drilling and geophysics)** to reduce geological uncertainty.
  3. **Establishing true LCOH** through demonstration projects.

- **Geothermal energy for a circular economy**
- **Reducing our reliance on finite fossil fuels**

Data: de-risking the subsurface



- **Geothermal energy for a circular economy**
- **Reducing our reliance on finite fossil fuels**

Data: de-risking the subsurface

GSI hosts the National Geothermal Database but this needs to scale up to bring us into line with more advanced EU counterparts

- Seismic surveys
- Deep boreholes
- Pilot geothermal DH projects

Policy considerations

- National Geothermal Development Plan
- Long-term view

- **Geothermal energy for a circular economy**
- **Reducing our reliance on finite fossil fuels**

Data: de-risking the subsurface

GSI hosts the National Geothermal Database but this needs to scale up to bring us into line with more advanced EU counterparts

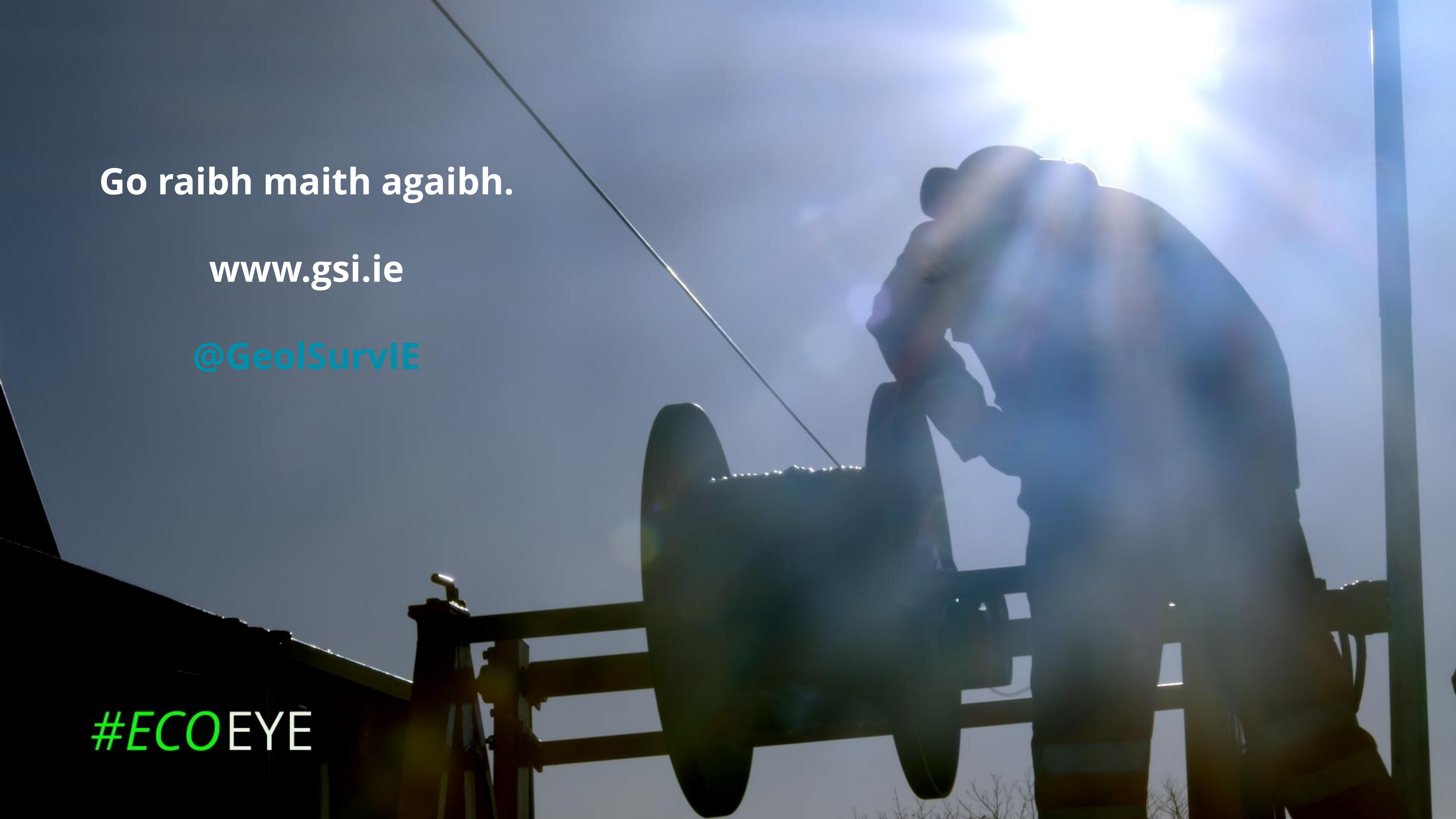
- Seismic surveys
- Deep boreholes
- Pilot geothermal DH projects

Policy considerations

- National Geothermal Development Plan
- Long-term view

How can different bodies come together to define funding, resources and supports needed to set the goals and grow into our geothermal potential?

- **Geothermal energy for a circular economy**
- **Reducing our reliance on finite fossil fuels**


Go raibh maith agaibh.
www.gsi.ie
@GeolSurvIE
#ECOEYE

An Roinn Comhshaoil,
Aeráide agus Cumarsáide
Department of the Environment,
Climate and Communications

Policy Statement on Geothermal Energy For a Circular Economy

National Geothermal Energy Summit 2022

Ian Devlin, Geoscience Policy Division

9 November 2022

An Roinn Comhshaoil,
Aeráide agus Cumarsáide
Department of the Environment,
Climate and Communications

Policy Statement Submissions - Regulation

- Licencing of exploration and utilisation leases only for deep systems (below 500m)
- Threshold to define small and large shallow systems
- Effort to treat residential ground source and air source heat pumps equally
- Large shallow systems subject to design verification, permitting and reporting
- More research needed on potential cumulative environmental impacts of small systems
- Geothermal Energy Advisory Group established to advise on finalisation of the policy statement

Policy Statement Submissions - Strategy

- Strategy to develop the sector
- Recognise more immediate potential of shallow systems to decarbonise heating and cooling
- Subsurface data collection programme
- Economic research and analysis to establish case for subsidies/incentives

Implementation - Regulation

- Bill brought before Oireachtas at earliest in late 2023
- Research needed in drafting general scheme of Bill:
  - Potential cumulative environmental impacts of small shallow systems
  - Contract and environmental law governing interdependencies in integrated geothermal networks
  - Ownership of and access to resources below 500m
  - Regulation of traded prices to avoid monopoly and monopsony
  - Testing regulatory thresholds and licencing processes
  - Consultation on data to be provided by permit, licence and lease holders

An Roinn Comhshaoil,
Aeráide agus Cumarsáide
Department of the Environment,
Climate and Communications

Submissions on Strategy Development

- Further development of National Geothermal Database
- Scope for developing a GIS Planning Tool to place and size systems
- Communications and engagement strategy
- Guidance for sponsors, planners and regulators
- Identify preferred approach to a Registration system
- Targets:
  - Ground source heat pumps (NECP 21-30)
  - Contribution to RES-H for residential, commercial and industrial sectors
  - Uptake by industrial sector
- Economic research and analysis on incentives

Geothermal lessons from Europe

National Geothermal Summit

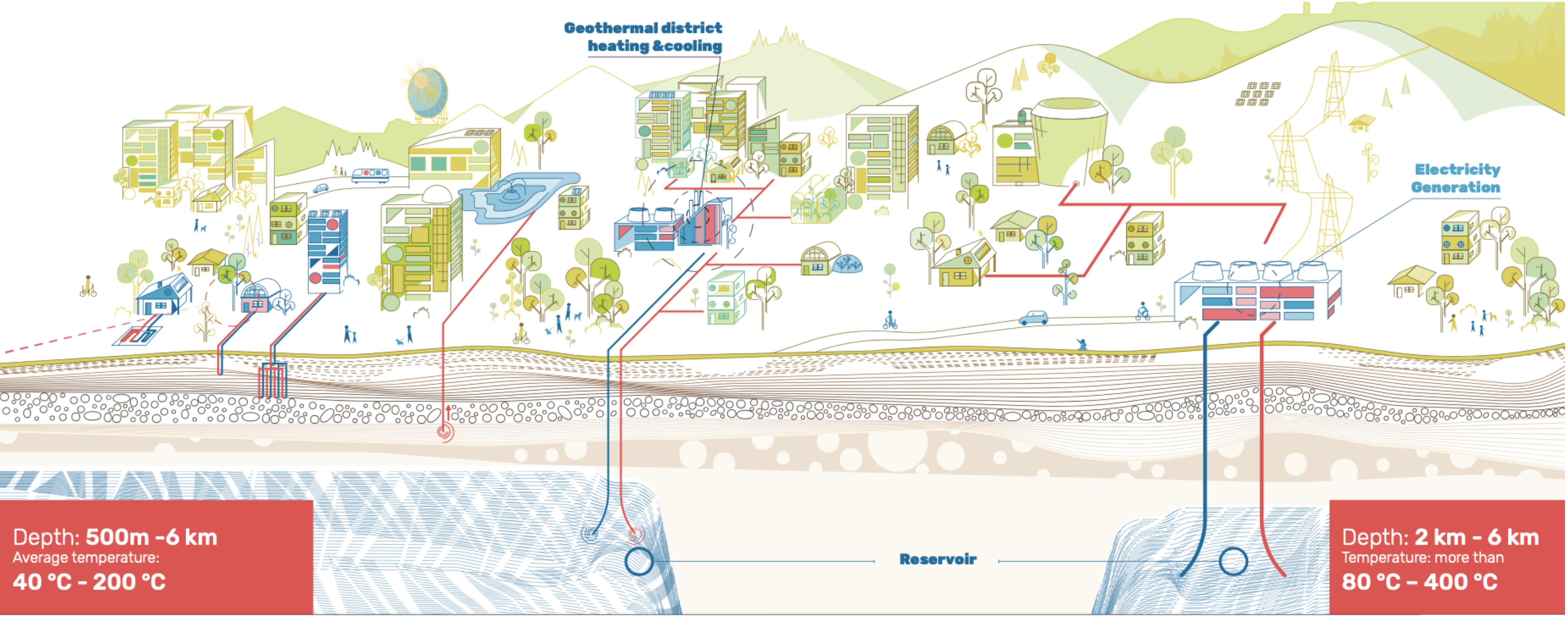
Dublin, 9 November 2022

Sanjeev Kumar
Head of Policy, EGEC
s.kumar@egec.org | +32 499 539731

EGEC GEOTHERMAL

SAPHEA
INTEGRATING GEOTHERMAL HEATING AND COOLING NETWORKS IN EUROPE

The many forms of geothermal energy

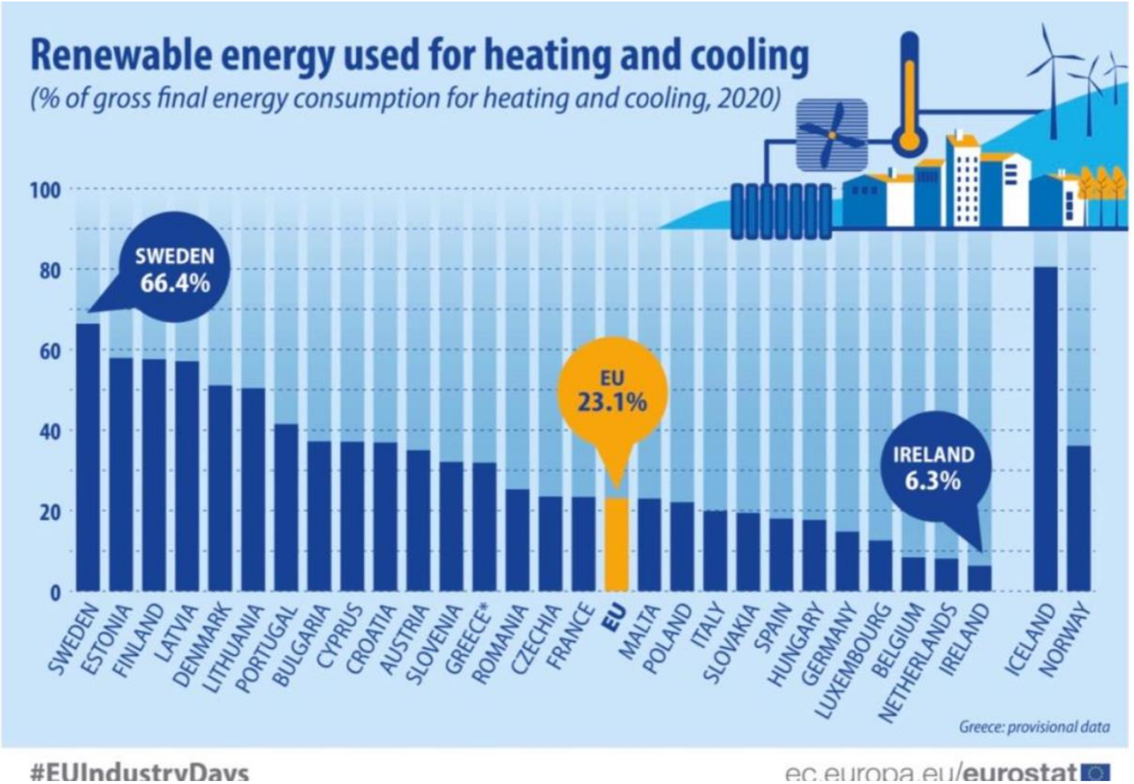


"I would like to reassure the industry and investors in Ireland and internationally that the Government is committed to introducing a proportionate and robust regulatory framework at the **earliest possible opportunity**".

Conor Lenihan
Minister of State
(2009)

In those 13 years……..

Ireland end up with the lowest share of RES heating & cooling use in 2020



Meanwhile:

Croatia developed a legal base for geothermal and support mechanisms to launch its first geothermal power and heat plant in 2019.

The Netherlands installed nearly 300 MWth of geothermal district heating capacity since 2010. It had zero beforehand.

Geothermal Heat Pumps

Geothermal Heat Pumps

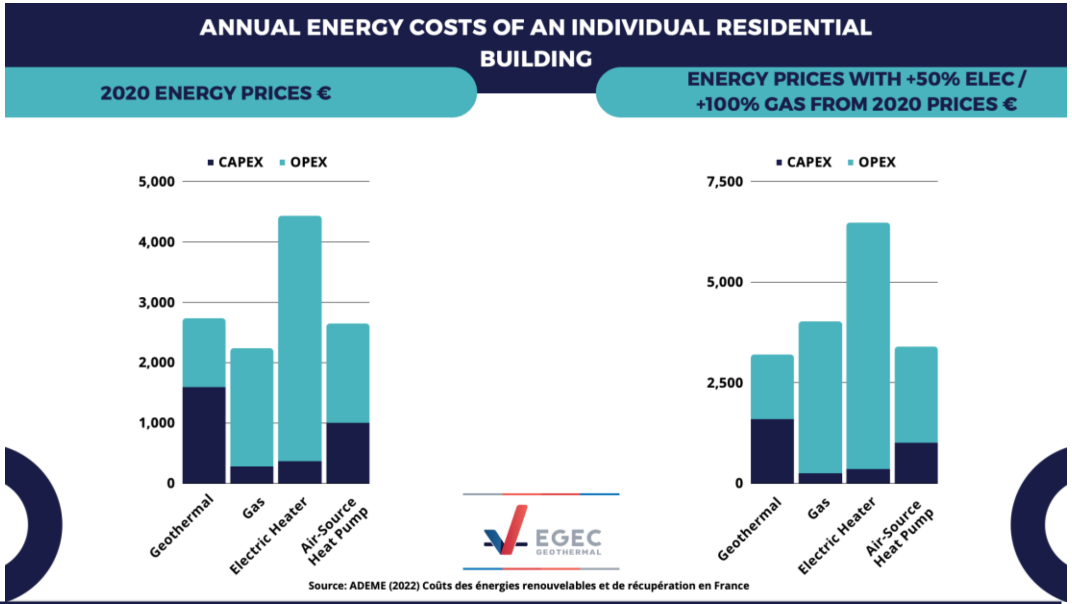
- **Geographical coverage:** Geothermal Heat Pumps can be applied in almost all locations and for different types of buildings. The larger the building, the more appropriate geothermal becomes.
- **Good for property values:** In Sweden, household retail agencies found houses with Geothermal Heat Pumps increased property prices by about €10-12,000.
- **Multiple uses:** GHPs can provide space heating, cooling and hot water.
- **Large public & commercial buildings:** The NATO headquarters; Budnestag; Maltese Parliament; Elsyee Palace (announced by President Macron on 14 July 2022); IKEA stores in Sweden & Poland; Churches; university campuses, etc converting using geothermal.
- Three types of GHP:
    - Closed loop – can be horizontal, vertical (higher temperature & efficiency);
    - Open loop – linked to an aquifer (higher temperature & efficiency).
- Over 2 million heat pumps installed in Europe. Sweden, France & Germany largest markets. Poland and Netherlands fastest growing.

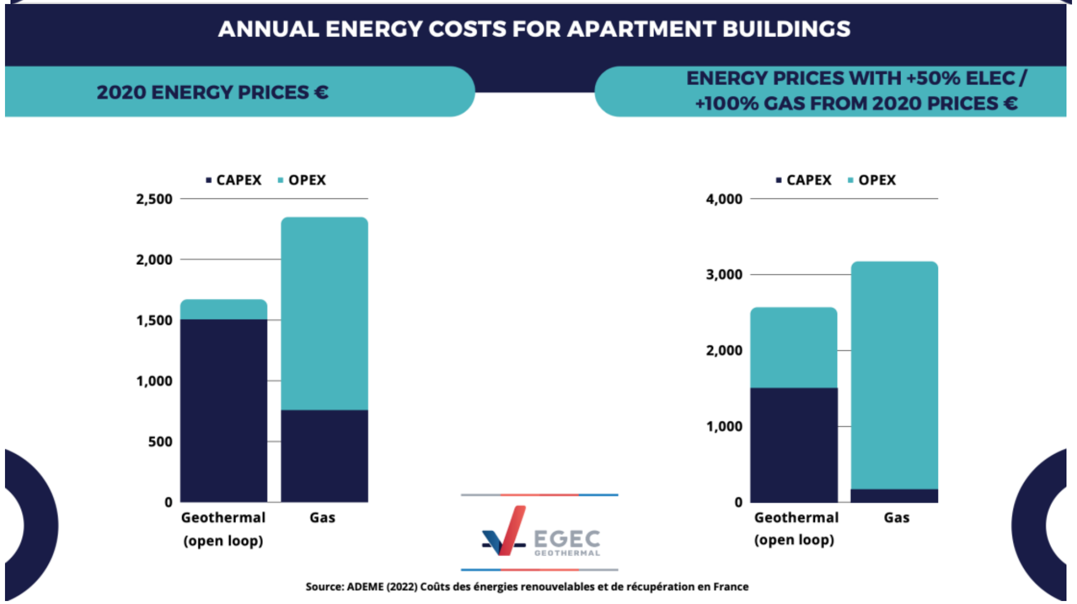
NATO headquarters, Brussels

Bundestag, Berlin

Saint Patrick's Church, New York

Costs, environment and power sector impacts

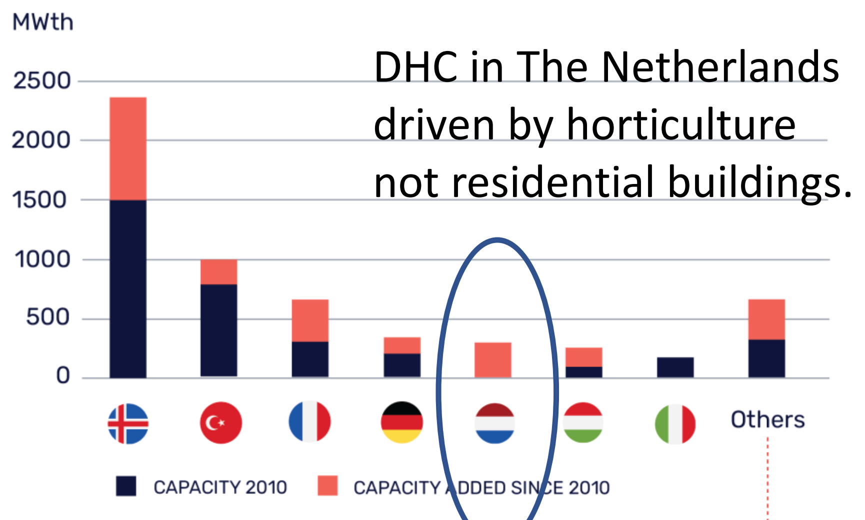


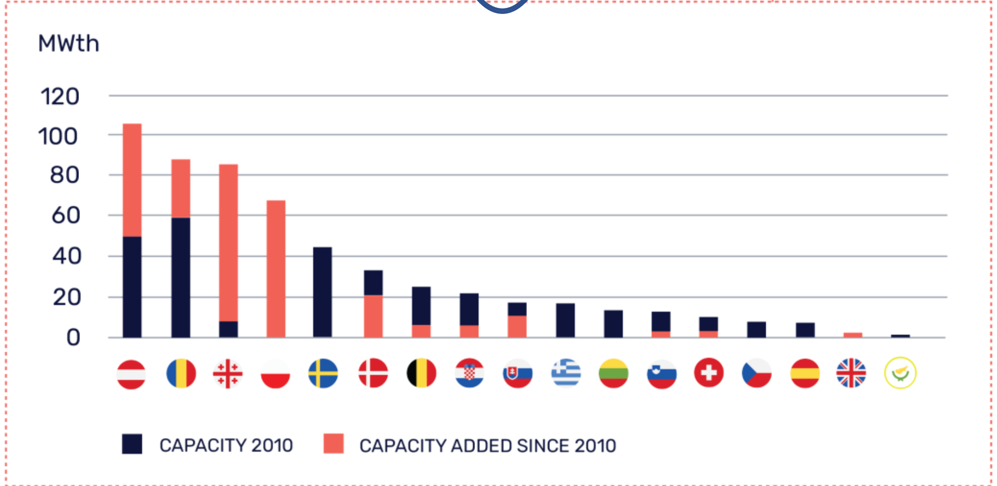


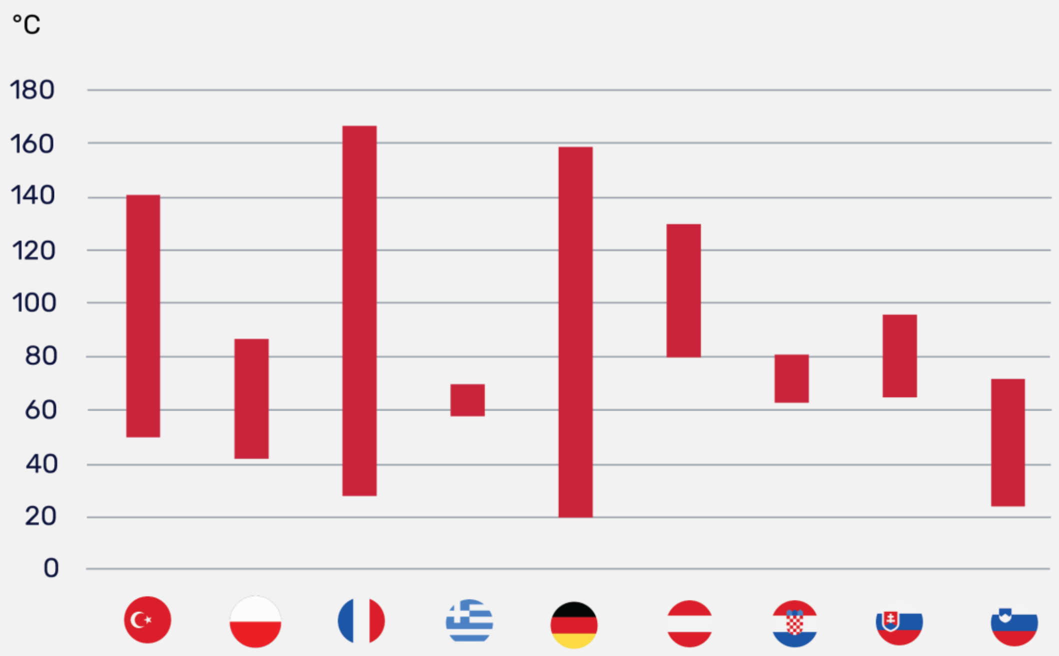
- **Cost effectiveness:** Geothermal Heat Pumps have a very long timespan making the one-off cost of installation cheaper. Policy solutions and business models required to reduce this upfront capital cost.
- **Impact on the power sector:** GHPs are the most efficient heat pump available. ADEME, the French energy agency, compared different renewable and fossil heating systems pre and post the invasion of Ukraine. They found GHP to have the lowest electricity consumption and therefore the least
- **Environmental impacts:** GHPs have the least visible environmental impact. Key conservation NGOs EuroNatur; Birdlife Europe and the European Environmental Bureau came out in support of their use, especially in the context of the EU's new streamlined permitting rules for renewable energy. See https://www.euractiv.com/section/energy/opinion/a-bonfire-of-environmental-standards-wont-accelerate-renewables-deployment-in-go-to-areas/

Geothermal District Heating

Geothermal district heating 2010-2020







Range temperature of systems

Geothermal DHC in France

- **Cheaper than fossil and other renewable heat sources** ADEME, found that the levelised cost of geothermal district heating was €15 MWh compared to €51 MWh for gas in 2019.
  France has highest share of geothermal DHC in the EU. Iceland has more than 90% coverage from geothermal.
  Vélizy-Villacoublay geothermal project in France, by Engie, used innovative multi-drain drilling techniques which increased the geothermal output by 30%.
  SAS RENEWABLE – Allows Special Purchase Vehicle established with the energy supplier, service provider and local government. Prices, social controls, etc agreed continually. Allows the supplier (ENGIE) to take the full risk for geothermal development on its balance sheet.

- New business models: *délégation de service public'* (DSP) law allows private companies to build public infrastructure on behalf of local authorities.
- 4 Parisian regional local authorities have teamed up to jointly develop geothermal projects using the DSP model. It allowed Engie to take the risk for the entire project on its balance sheet. 60-80 degree temperature of the systems being developed. Consumers in Sipperec include 20,000 social housing units. Costs €1,5 million for Sipperec, €600,000 for Pantin, €200,000 for Les Lilas and €200,000 Le Pré-Saint-Gervais.
- National de-risking scheme combined with local authority planning key to development in France.

Aarhus in Denmark:

- Heat grid already exists. 95% of the population is connected to these heat grids.
- Innargi will replace existing fuels in the system with geothermal. Because the infrastructure already exists there is a strong business model to convert to geothermal.
- 30 year agreement between the city and the project developer.
- Geothermal to cover 20% of the heat grid. To be operational in 2029.

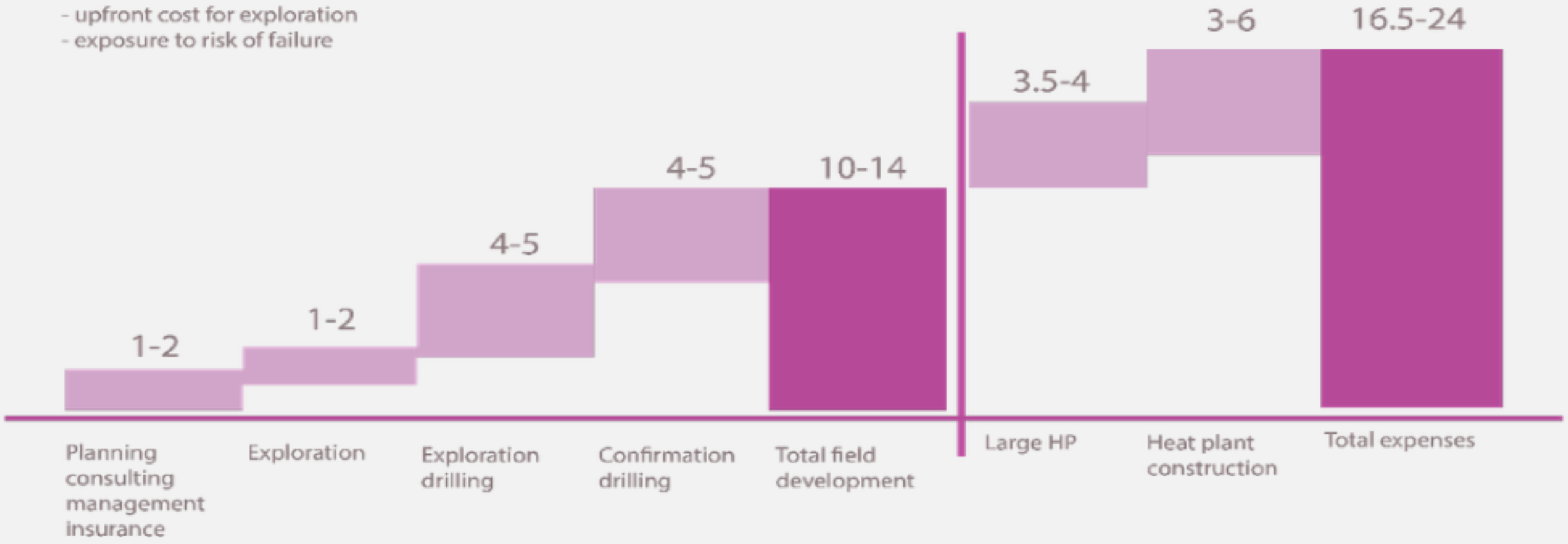
Munich, Germany

- Stadtwerke model. Local governments own the DHC systems. Established public interest companies to manage network. Stadtwerker's are often politically and financially powerful.
- Munich operates 6 geothermal plants. 7th to go online in 2029 adding additional 75,000 buildings to the network.
- A cooling network being added to the system in Sendling (southern part of the region) at a cost of €80,000. This is also to manage the electricity load factor as more cooling appliances being used due to climate change.
- **Grunwald heat plant:** Stadtwerke München (SWM) and Erdwärme Grünwald (EWG) signed contracts in June 2022 to build geothermal DHC system that provides additional balancing to both DHC systems. This is the first of kind project but can be replicated, at scale, across Europe.

Ferrara, Italy

- Geothermal covers only 40% of the DHC system but has stable price.
- Local authority and Gruppo Herra (DHC company) reduced heat tariffs by 20-30% for 2022/2023 even though gas is 50-70% costlier.

PROJECT DEVELOPMENT PHASE



10 MWth heating plant: example of some plants installed in Paris region Ile-de-france, France. In Million €

Source: Financing Geothermal Energy. EGEC (2020). Link https://www.egec.org/wp-content/uploads/media_publication/financing-paper-final.pdf

Key first steps for development in Ireland

An effective policy framework for geothermal

Demand creation

EU target: Binding target to increase RES Heating & Cooling by 1.1 percentage points per year

Planning: EU law will require local authorities to plan renewable heating & cooling systems based on local resources.

Visibility: Pilot programme for specific sectors eg. Horticulture, Aquaculture, DHC, public buildings.

Corporate purchases: Heat Purchase Agreements (Letters of Intent in The Netherlands) using Heat As A Service model

Ownership: Establish a geothermal authority to develop GHP and DHC market, promote the technologies and engage regulators & consumers.

Supply support

Drilling costs: Subsidies need to cover the total cost of installation, not just a heat pump

Financial de-risking: Some countries have national schemes. Should there be an EU scheme?

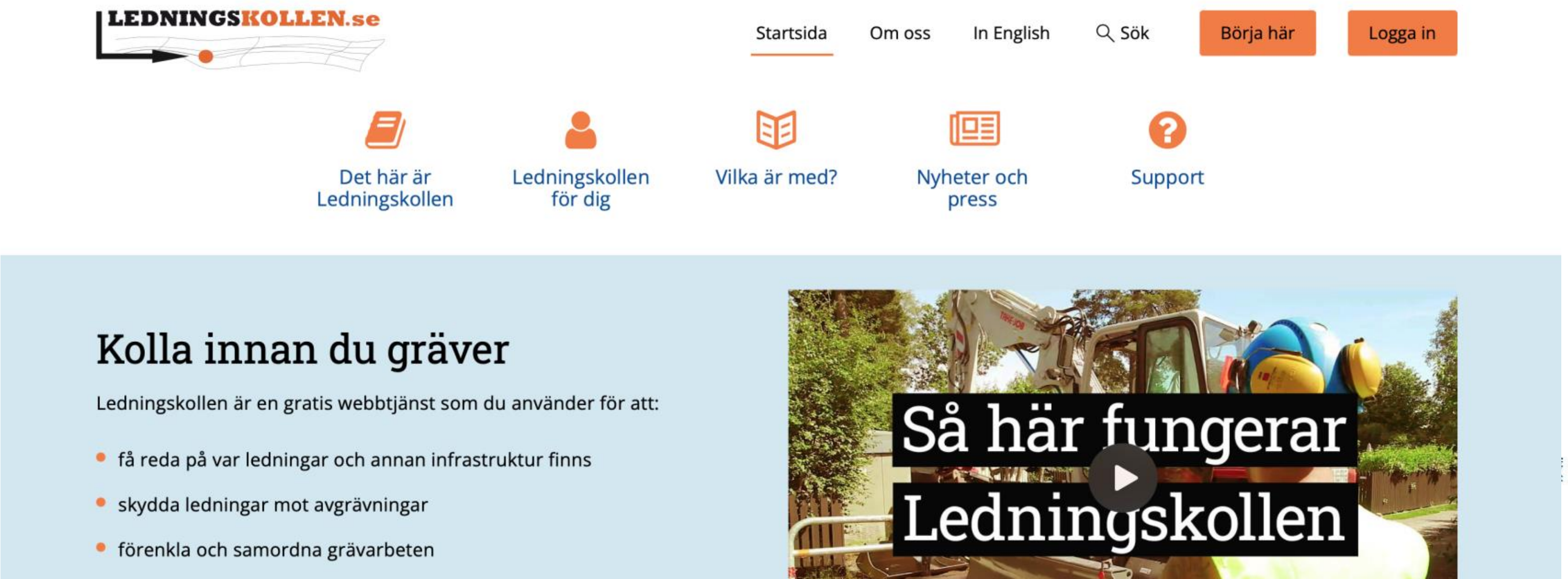
Certification scheme and legal requirement for GHP drillers: Reduced project risk /cost.

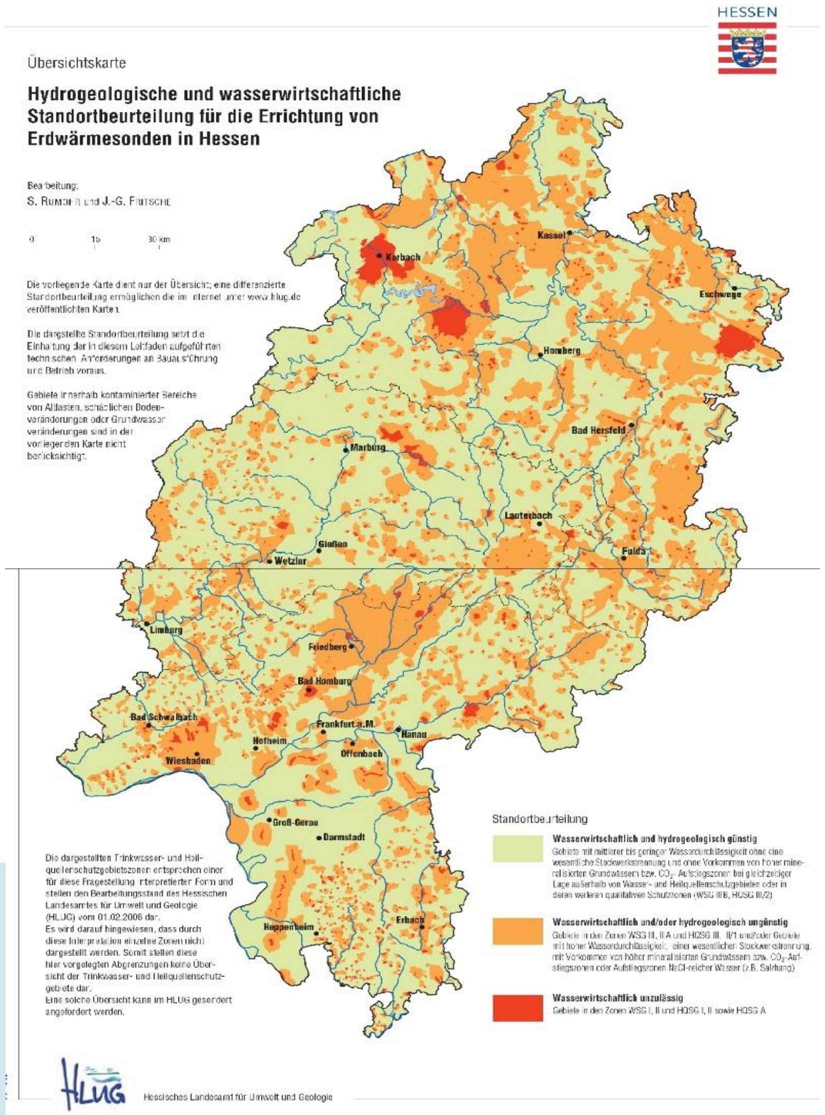
Streamlined permitting: Online notification processes like Stockholm City.

National target? Many countries have targets for wind and PV deployment. Needed to create pipeline of projects.

1. A ”traffic light” systems for permits

- Mature GHPs markets use a traffic light system to accelerate permitting - simple administrative notification (Green); where a permit is required (Orange); and where GHPs are not permitted. See map from Hessen in Germany.
- The Geological Survey of Ireland will be tasked with producing something similar for all renewables from the coming REPowerEU permitting rules. It’s key that that mapping includes subsurface areas for renewables.
- Online notification and simplified permitting procedures should be outlining in the upcoming legislation





2. Targeted action for key sectors


Fossil fuel divestment

This article is more than **4 years old**

Ireland becomes world's first country to divest from fossil fuels

Bill passed by parliament means more than €300m shares in coal, oil, peat and gas will be sold 'as soon as practicable'

Damian Carrington
Environment editor
@dpcarrington
Thu 12 Jul 2018 16.12 BST

A message to the Irish government to divest from fossil fuels is spelled out in lights in front of the lower house of parliament. Photograph: Sasko Lazarov/Photocall Ireland/Trócaire/350.org

- **Heat Purchase Agreements** mainly for agriculture, food, beverages and local authorities. Legal instruments should be introduced in the Irish legal base for geothermal.
- Facilitates long-term supply contracts (about 10 years or more). This is a guaranteed income to allow for geothermal development to occur eg 21 horticultural consumers signed **Letter of Intent** to purchase heat from energy company Tulip Energy (the Netherlands) in February 2022. Helps to de-risk geothermal system development.
- Targeted subsidies for a series of pilot projects to install geothermal heating in **horticulture** and **aquaculture** to build up the local supply-chains.
- **Public buildings** (government offices, swimming pools, hospitals, etc) should have publicly funded feasibility studies for geothermal applications. **Estonia's NECP** seeks geothermal pilots for national and local government buildings.

3. Ballingarry Coal Mine redevelopment

- **Heerelen in Limbourg, The Netherlands**, reflooded an abandoned coal-mine and used this for a 4th generation geothermal district heating and cooling system for the local community.
- The scheme is called Mijnwater
- Last coalmine closed in 1974. 2003 exploratory drilling. 2005 geothermal drilling and 8 km piping system installed. 2008 geothermal plant fully operational supplying nearby offices. Extended to residential houses and other offices.
- Ballingarry coal mine had maximum depth of 210 meters (700 feet).
- Could support local villages and large population centres in Killenaule and New Birmingham using the experiences learned from Heerlen.

4. Financial products

- **De-risking scheme is essential:** Must evaluate whether this is a national scheme, participation in another countries scheme eg Fonds Chaleur in France, or an EU-wide scheme. Geothermal authority should investigate this.
- Subsidies
- **Targeted subsidy schemes** for key industrial, agriculture, property developers and/or public buildings to pilot geothermal heat pumps. Could support development of low-medium temperature DHC system so multiple uses for GHP programme.
- **Electricity & gas Distribution System Operators** (DSOs) could be tasked with assessing the **electricity load** and **fuel consumption costs** of heating solutions into their infrastructure planning. This would allow geothermal heat networks to be classed as infrastructure projects rather than energy. Lower cost of capital and becomes attractive for private capital markets (pension funds).

Unlocking the geothermal decade

#geothermaldecade

EGEC GEOTHERMAL

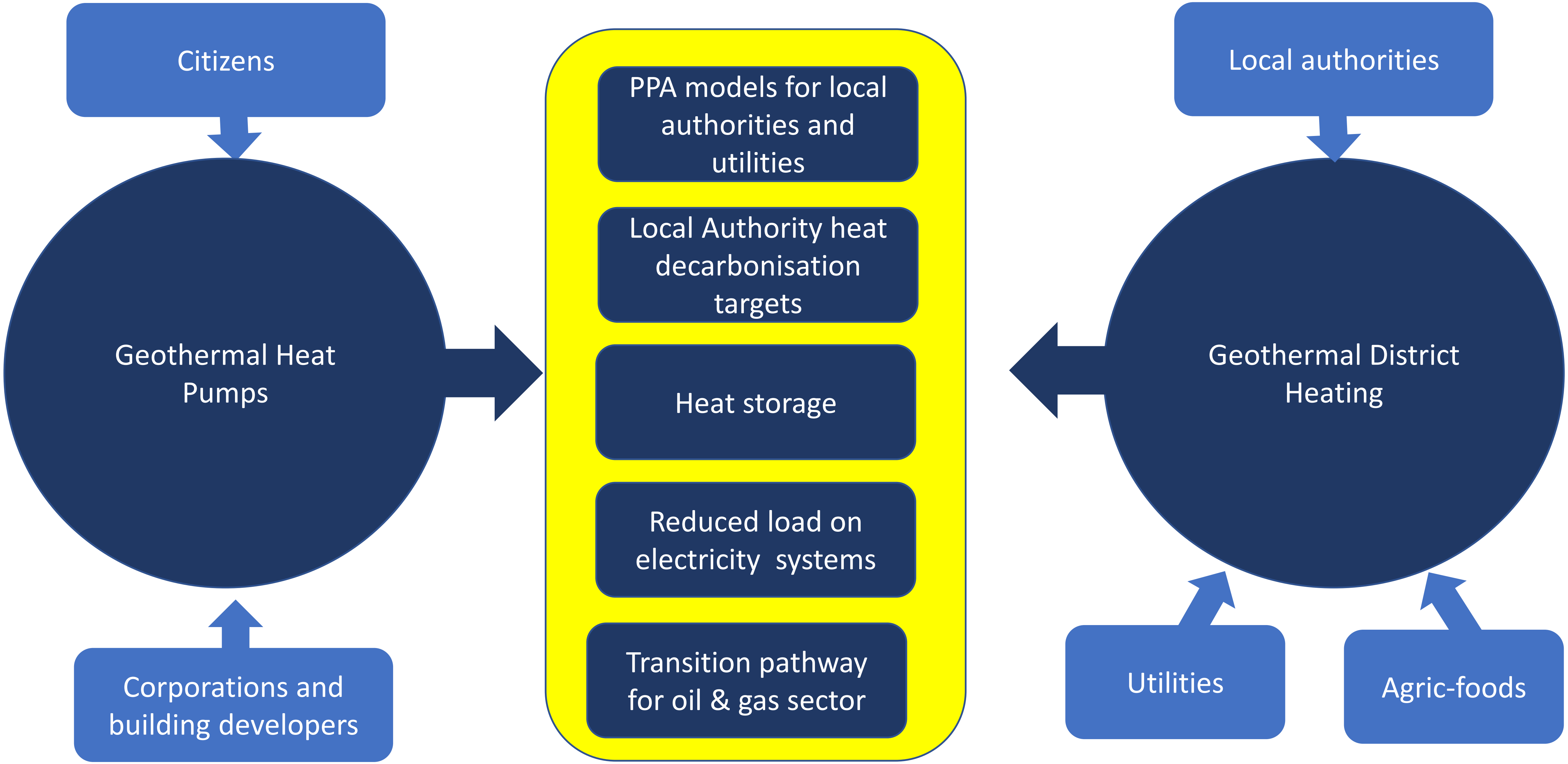
www.egec.org

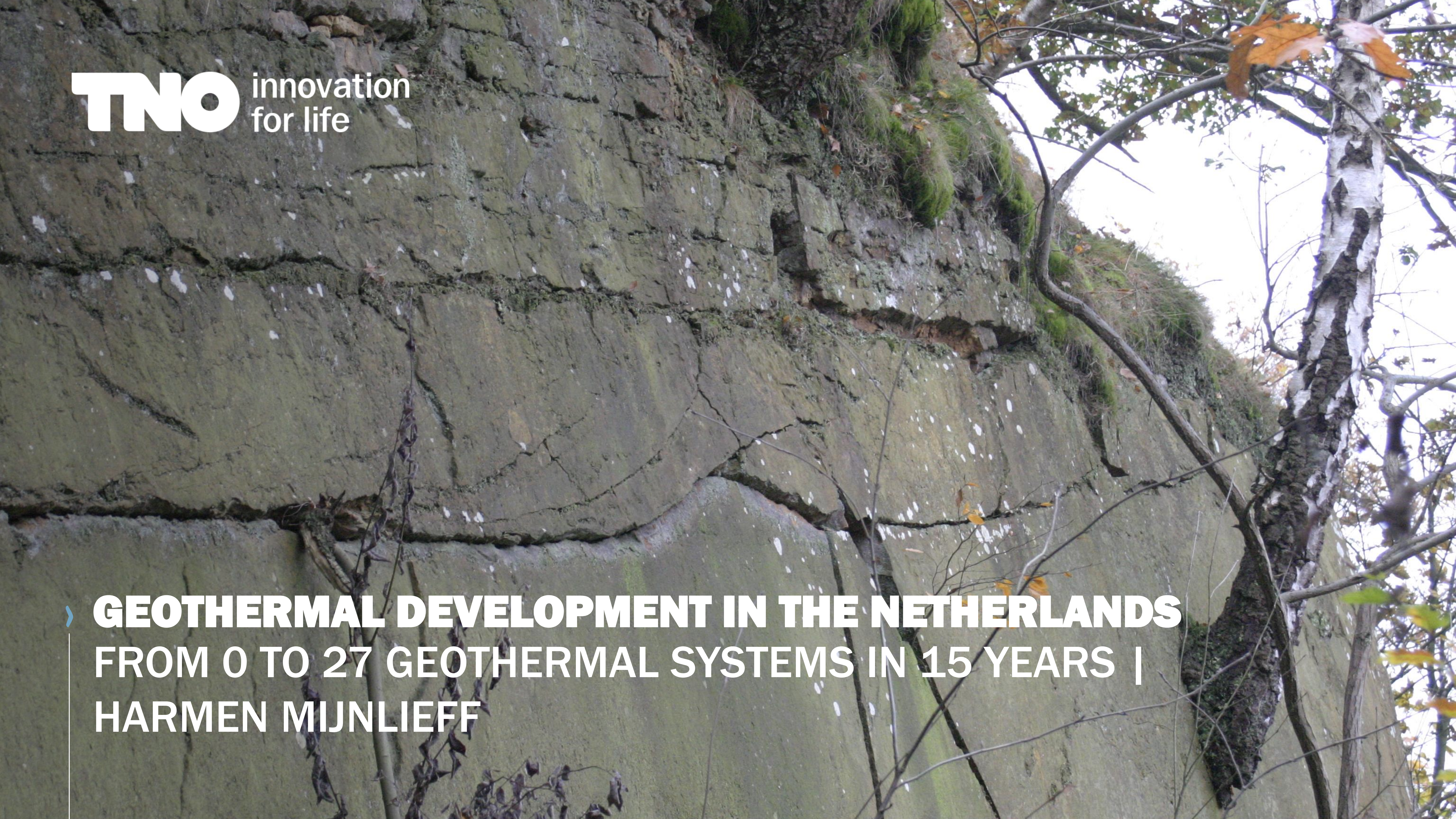
Support measures must focus on efficiency and total costs

- 80-90% of the total cost of a project is in the upfront capital expenditure - drilling, installing the heat exchanger, building or connecting to a heat network or installing a heat pump where appropriate.

- Recommendations:
  - Subsides should be distributed dependent on Seasonal Performance Factor (SPF) rather than Coefficiency of Performance (COP). SPF is an average efficiency over 12 months. COP is a factory testing system.
  - Subsidies should favour an SPF outlined in the Annex VII of the Renewable Energy Directive 2018/2001 and Commission Decision 2013/114/EU for heating and cooling systems over a 30 year lifetime in renovations of large public, residential and commercial buildings as well as any new builds. This ensure the least public subsidy is used for the maximum societal benefit.
  - **Feasibility studies** should assess the total cost of ownership or heating and cooling systems over a 30 year timescale, where public subsidy is required for project development.
  - **Total cost of installation** is preferred over the purchase subsidies. In Germany, the subsidy applies to the total cost of installation, not just the purchase of the heat pump. An additional 5% subsidy is given to a GHP that replaces a fossil heating system. The subsidy provides up to 40% of the total cost of installation of a GHP.

Trends in heating and cooling service provision





TNO innovation for life

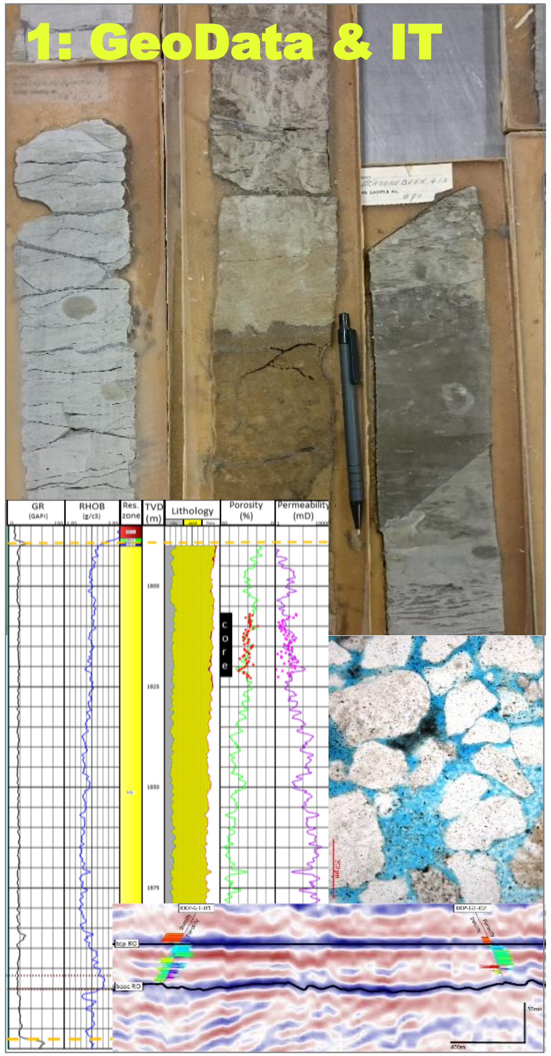
GEOTHERMAL DEVELOPMENT IN THE NETHERLANDS

FROM 0 TO 27 GEOTHERMAL SYSTEMS IN 15 YEARS | HARMEN MIJNLIEFF

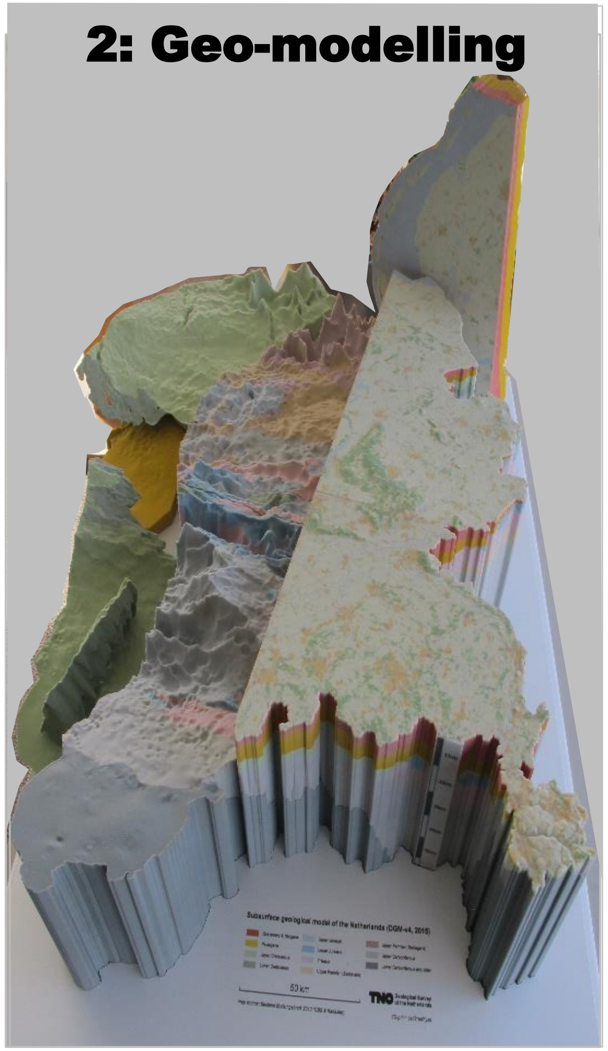
GEOLOGICAL SURVEY OF THE NETHERLANDS - TNO

DATA, MAPPING, RESEARCH AND POLICY ADVICE

1: GeoData & IT



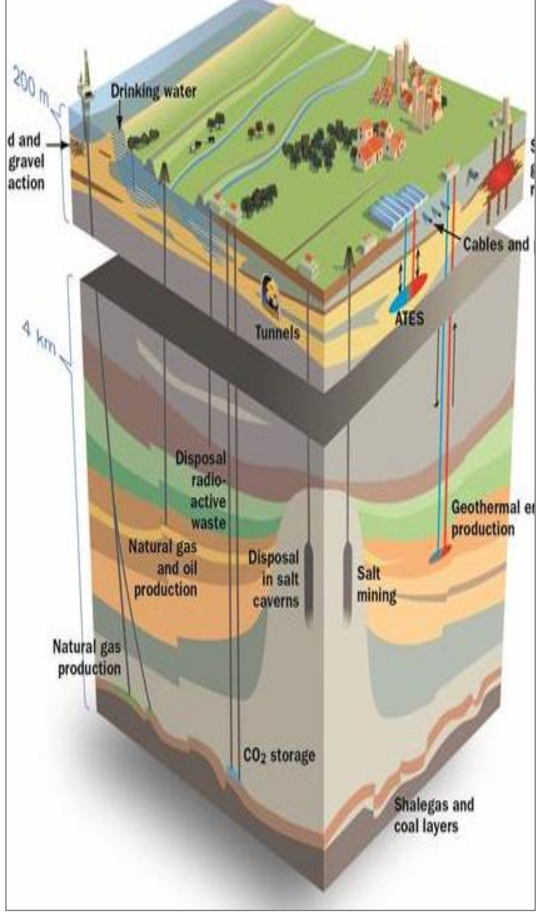
2: Geo-modelling



3: Applied Geosciences

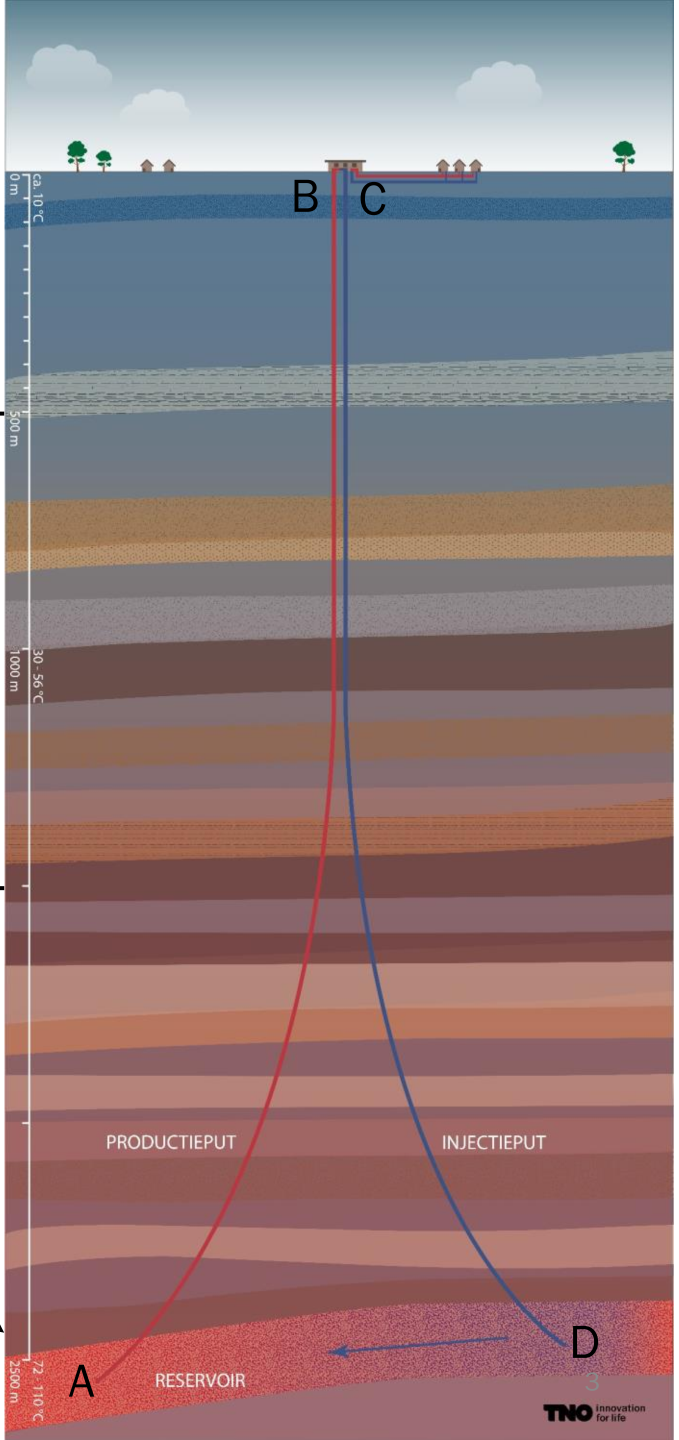
GeoWell
DESTRESS
GEISER
IMAGE
GEOTHERMICA
GEOELEC
ThermoGIS
GEMex
SURE
cato2
WARMINGUP
MiReCOL
THE VALUE OF SMARTNESS ISAPP
TKIgas

4: Advisory Group MEA&C



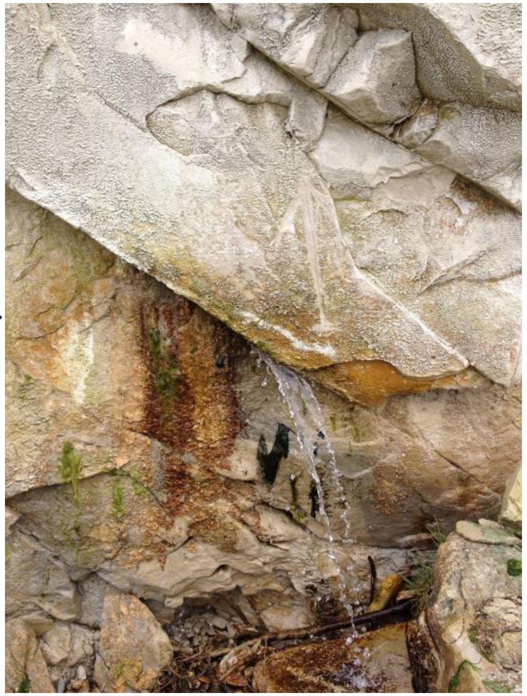
DUTCH GEOTHERMAL SYSTEMS
SOME KEY NOTES

- Reservoir => most aquifers are sandstones in the deep subsurface
- Geothermal gradient of 31 °C/km => Geothermal play = Hot Sedimentary Aquifer
- Permeability type => matrix permeability
- Doublet systems have an injection and a production borehole / well
- Geothermal brine is circulated from:
  - A => B=> heat exchanger => C=> D=> A
- Geothermal depth domains:
  - Very shallow / ground heat 0-500 m => mining law boundary
  - ***Shallow 500-1500 m => practical boundary temperature generally needs heat pump***
  - ***Deep 1500-4000 m porous reservoirs; can be used for direct application***
  - Ultra deep >4000 m tight reservoirs; fracture perm or EGS
- A geothermal borehole is only a **well** if it performs *well*;
  - So we need to know all about reservoir properties



PERMEABILITY TYPE; BRINE PROPERTIES

MATRIX ⇔ FAULT; SALINITY

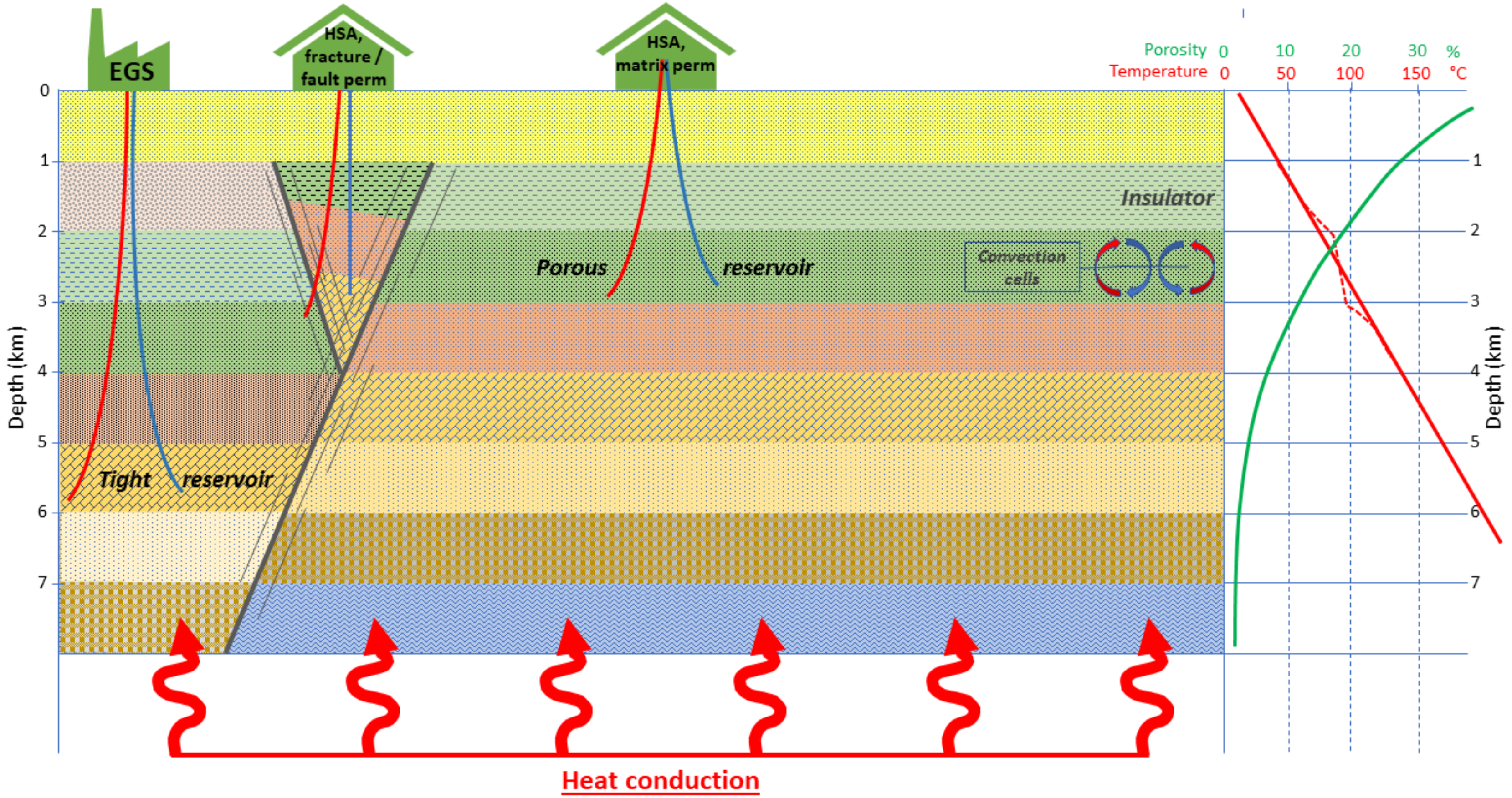


Important for hazard assessment e.g.:

- seismicity potential!
- Leakage / well integrity

GEOTHERMAL PLAYS
CLASSIFICATION TO COMPARE

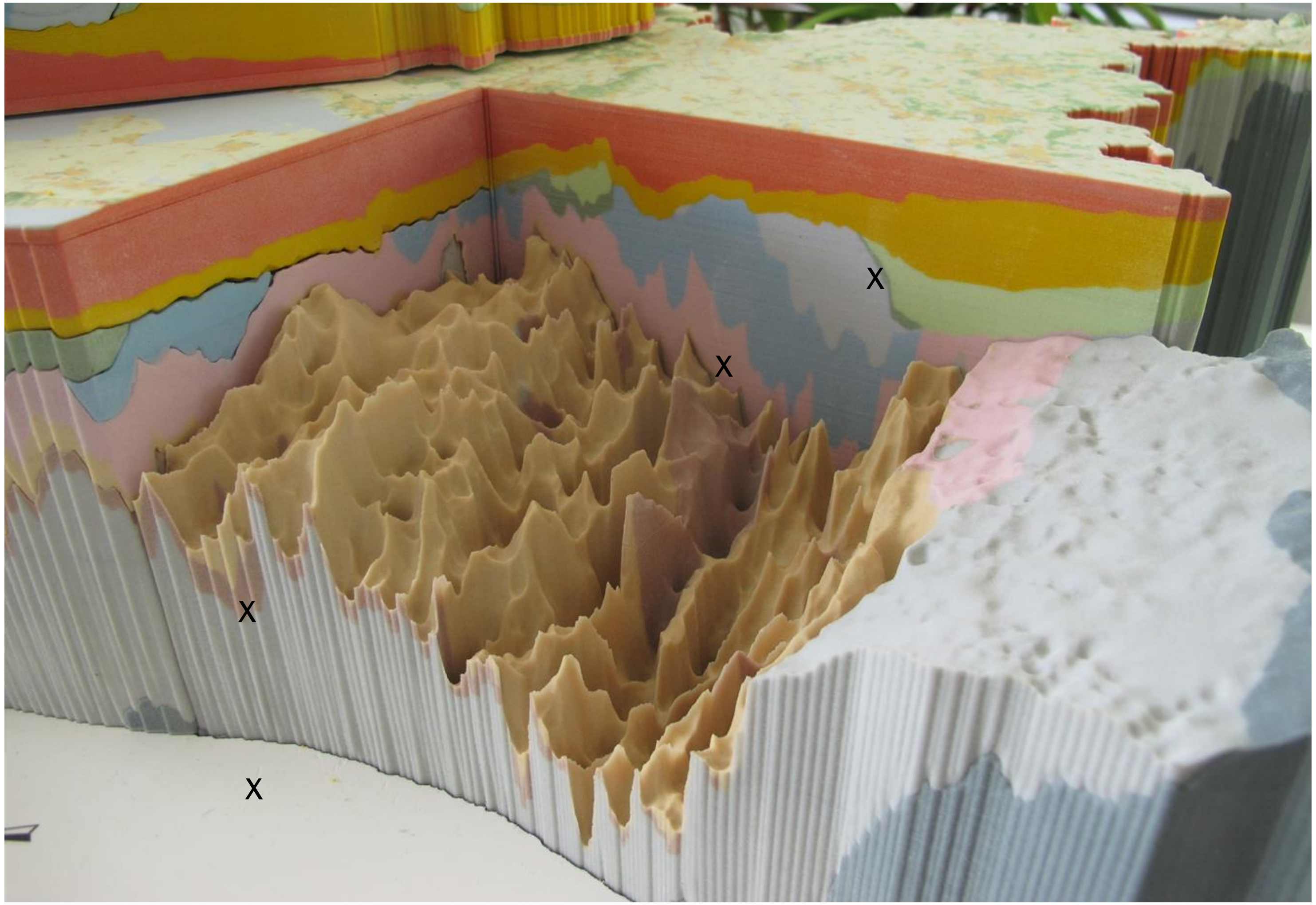
- <u>Geothermal Play jargon</u>:
  - Intra-cratonic basin,
  - Conductive,
  - Hydrothermal,
  - **Hot Sedimentary Aquifer,**
  - **Low temperature / enthalpy**
- <u>Permeability type</u>
  - **Matrix**
  - Fracture/Fault
  - Artificial

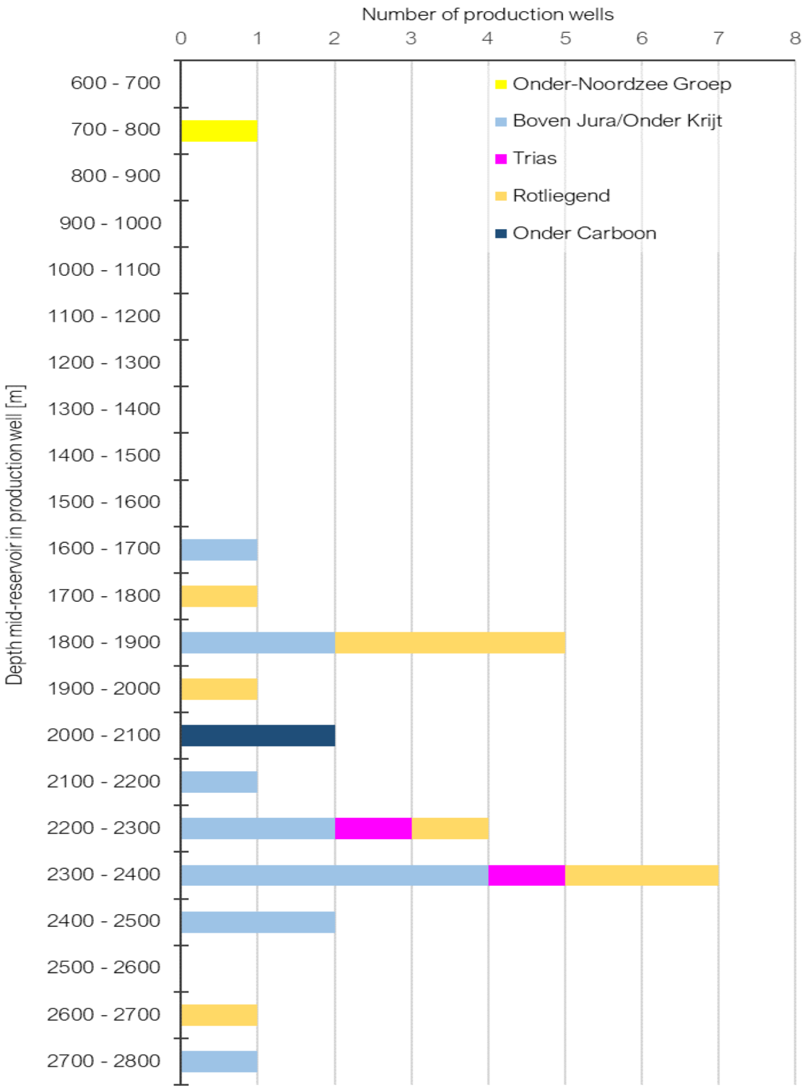


- <u>In the Netherlands</u>:
  - Predominantly matrix perm. sandstones; Hot Sedimentary Aquifers; relatively low enthalphy
  - Generally low seismicity hazard

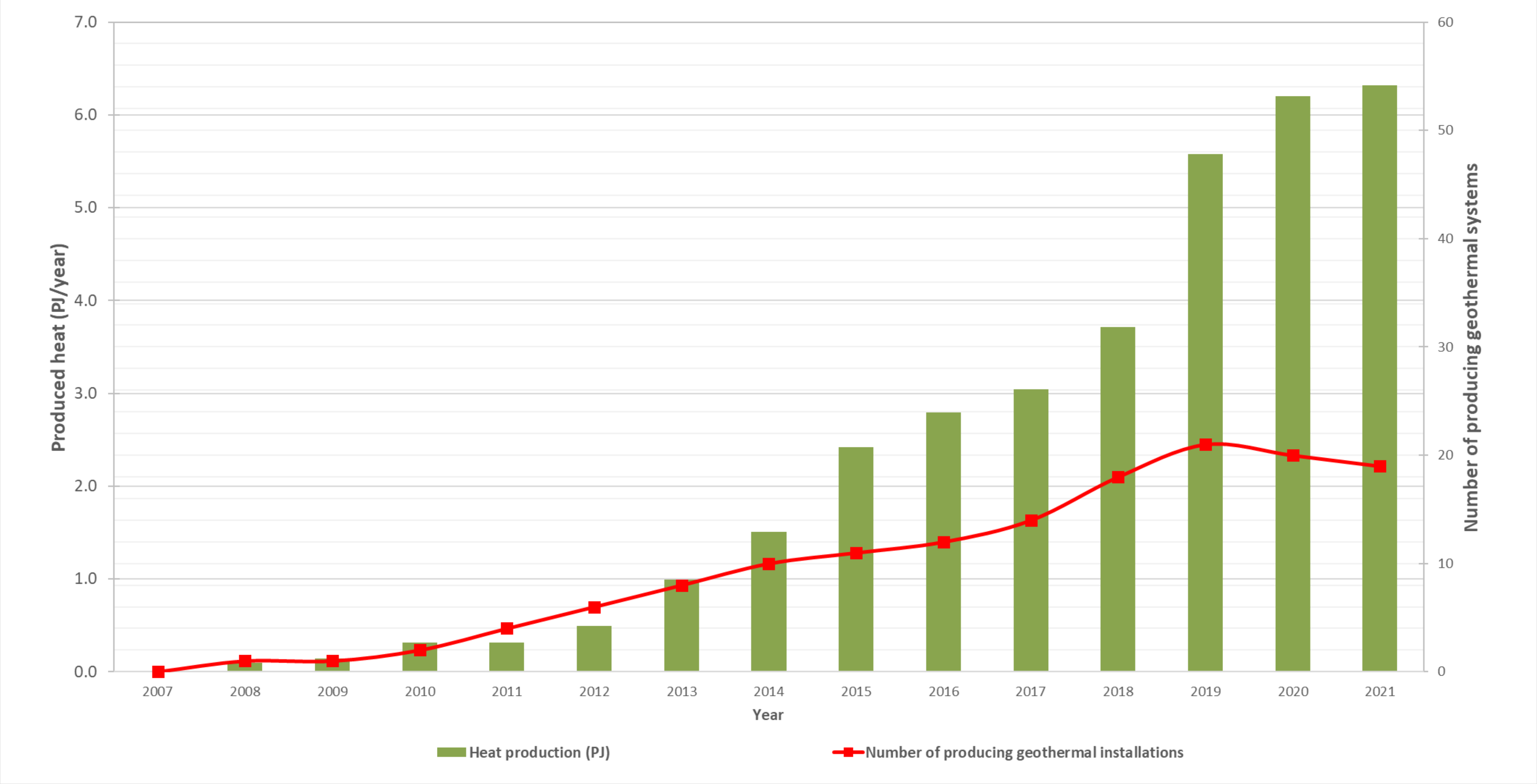
NL = FLAT AT SURFACE => MOUNTAINOUS IN THE SUBSURFACE

DUTCH SUBSURFACE => GEOTHERMAL RESERVOIRS





YEARLY GEOTHERMAL PRODUCTION
& NUMBER OF PRODUCING SYSTEMS

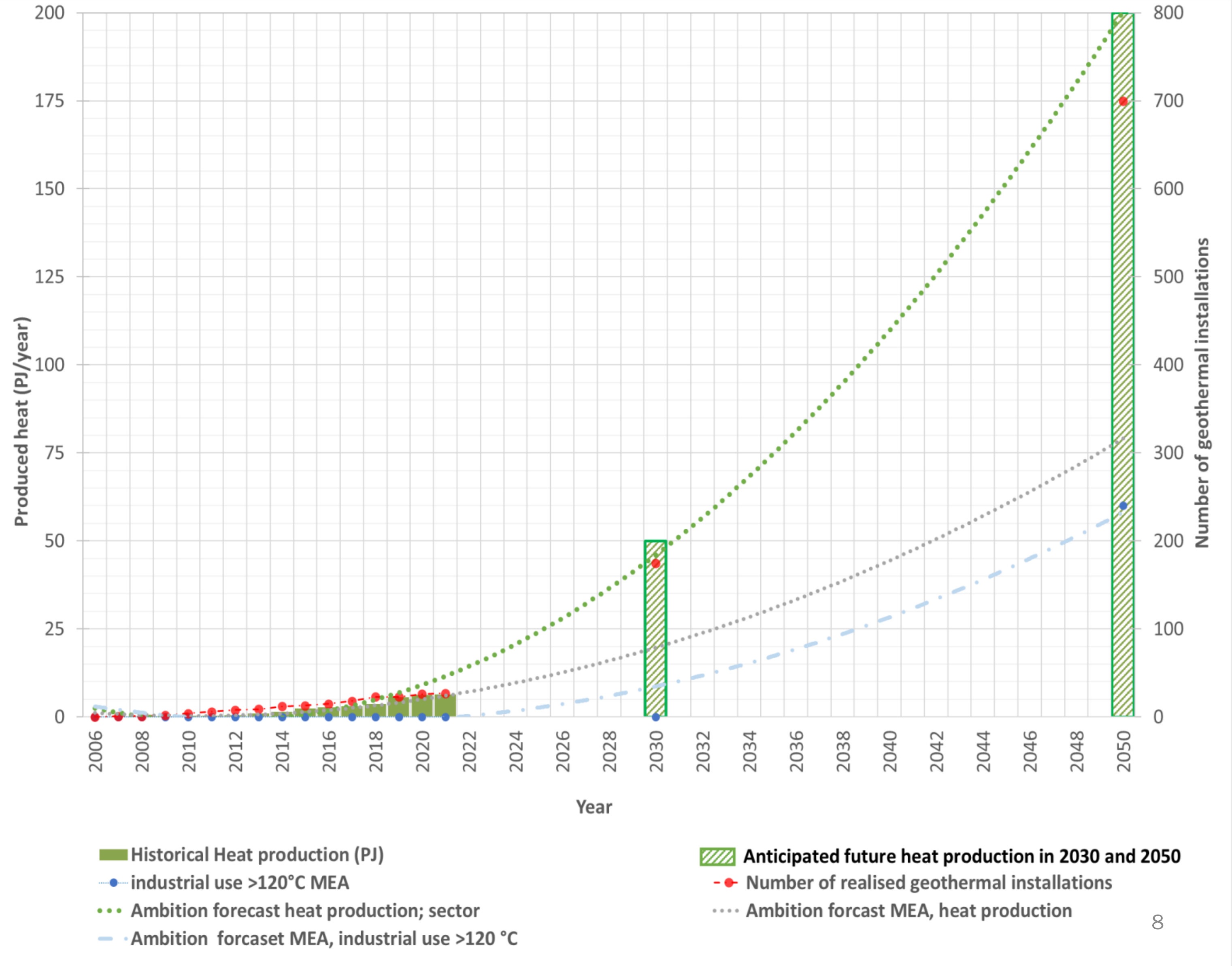


SETTING THE SCENE: DUTCH GEOTHERMAL AMBITION'S

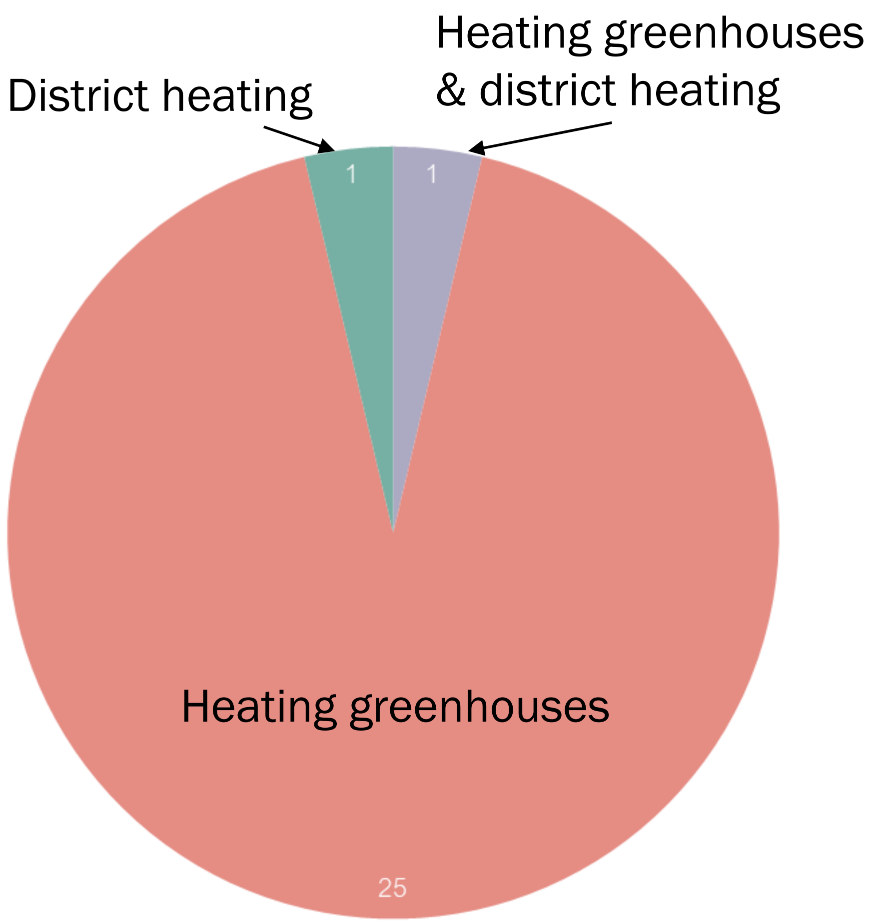
- Policy & Ambition:

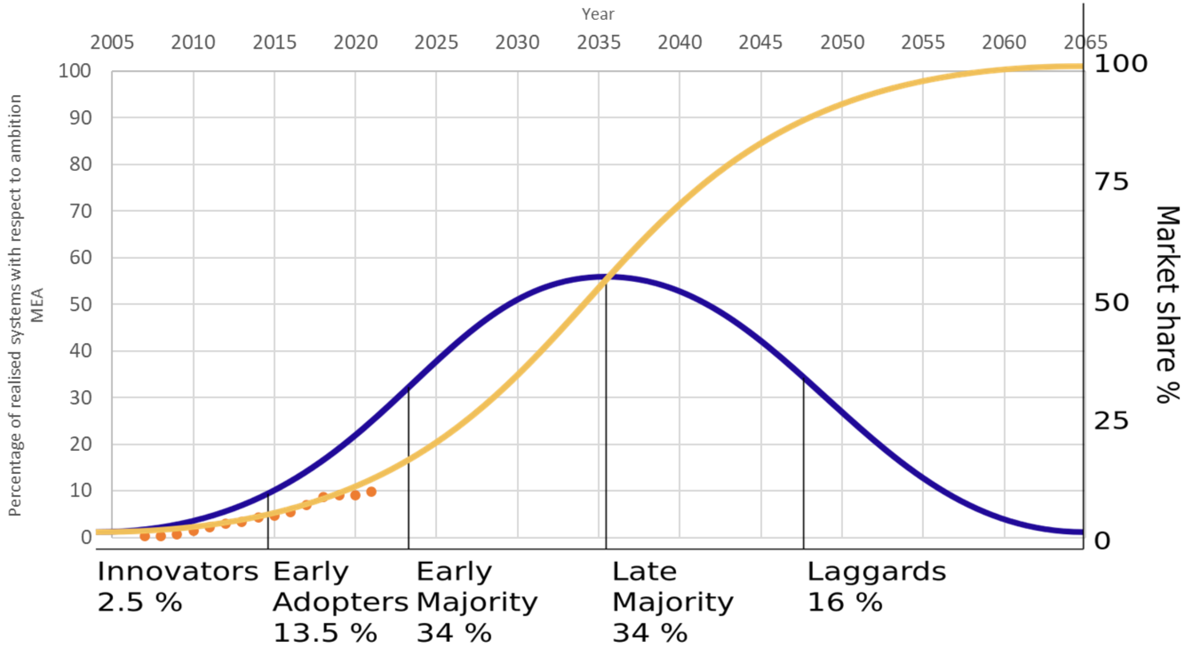
- Ministry of Economic Affairs and Climate
  - 15 PJ in 2030 &
  - 80 + 60 PJ in 2050

- Geothermal sector =>
  - 50 PJ in 2030 &
  - 200 PJ in 2050



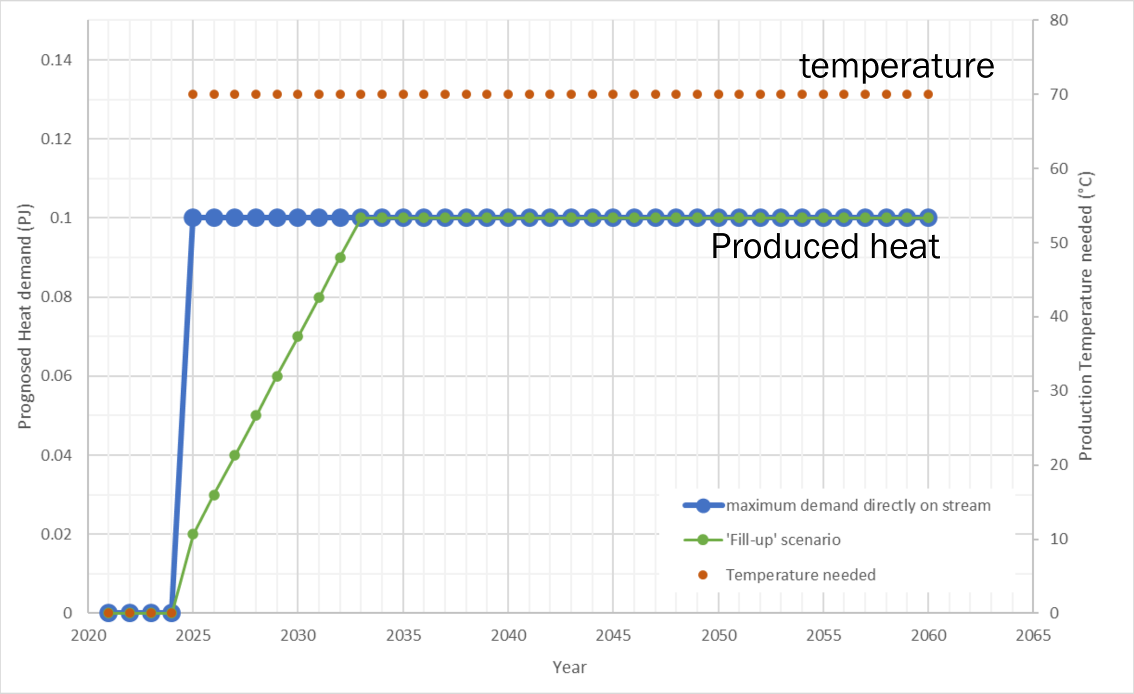
GEOTHERMAL USE; DEVELOPMENT PHASE

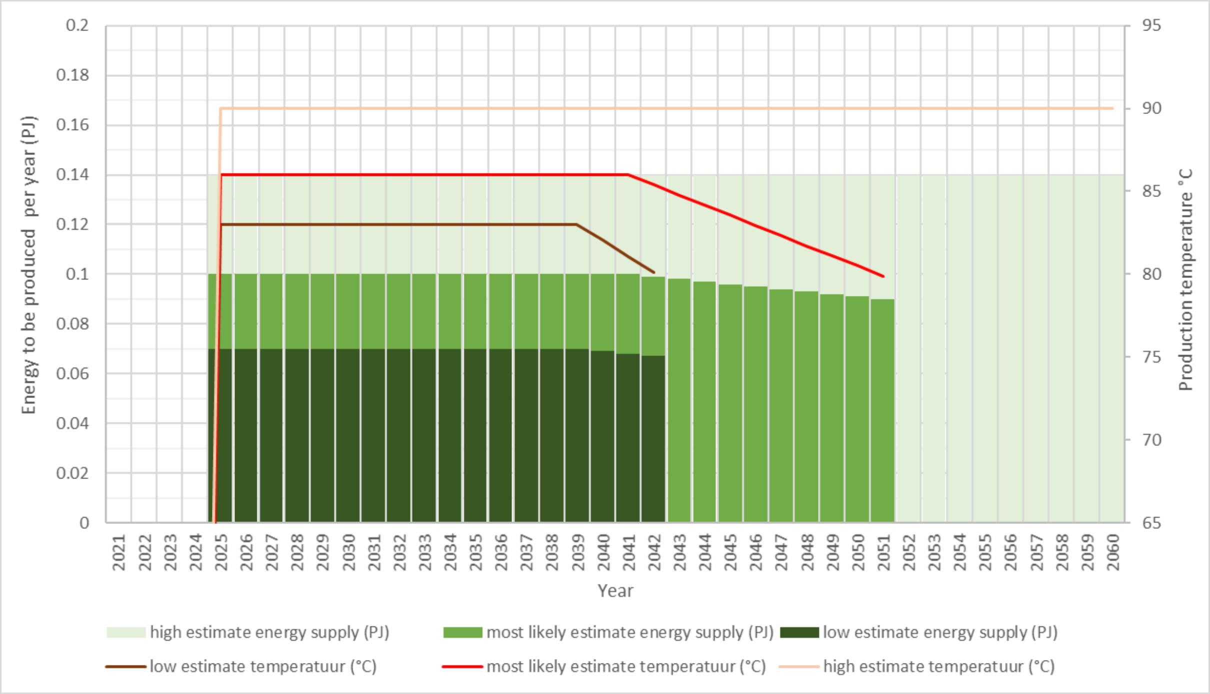


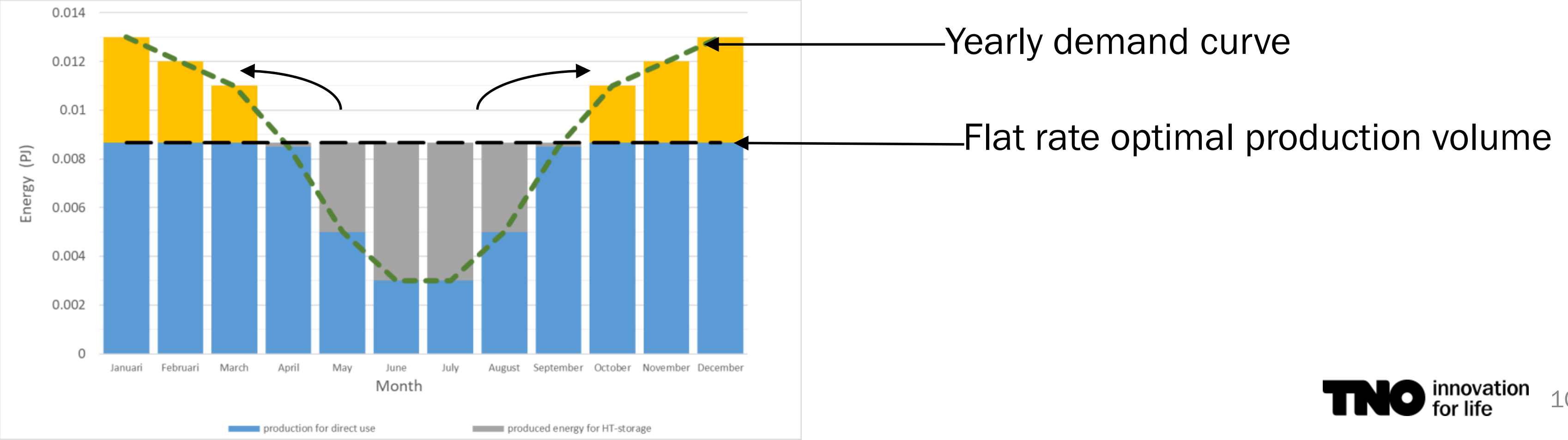


Presently, we see change in operators from single system operators to portfolio operators including the entrance of oil & gas companies

DEMAND ⇔ SUPPLY ⇔ BUFFERING

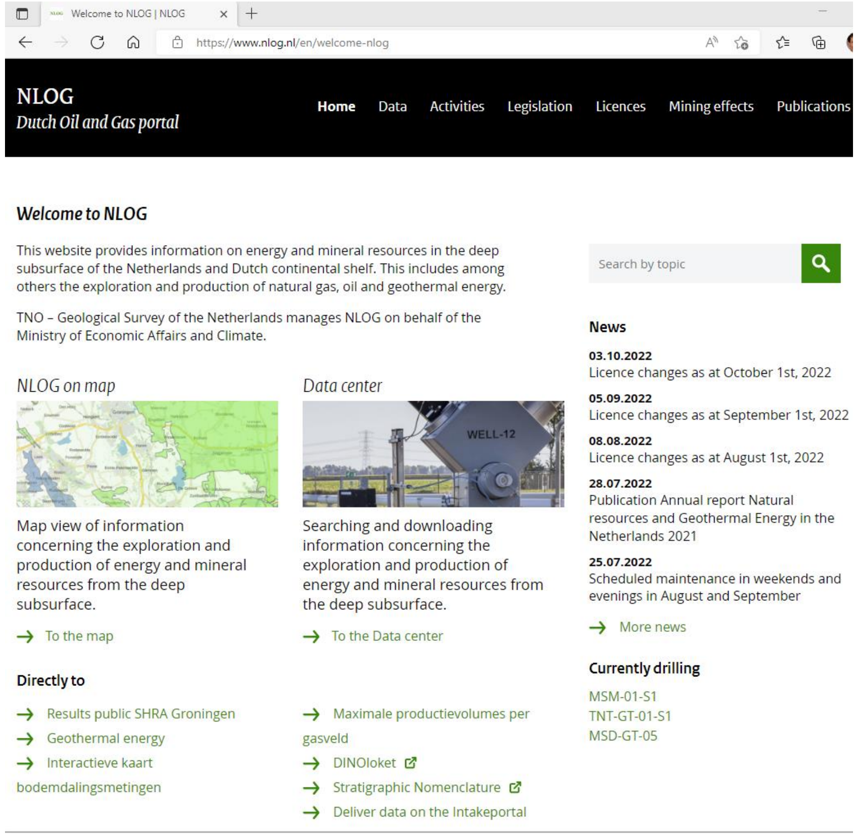






KEY ELEMENTS FOR THE GEOTHERMAL DEVELOPMENTS
JUST A FEW FROM THE NETHERLANDS

- *Availability of subsurface data and information in public domain* => *www.nlog.nl*
- Decisive entrepreneurship in horticultural sector
- Local, secure, high heat demand ⇔ relatively low risk geothermal supply
- Supportive attitude MEA and Ministry of agriculture
- Temporarily legal measures implemented preceding changes in the mining law
- Timely installation of support measures:
  - Investment subsidy
  - Research support with first systems
  - Exploration risk guarantee fund
  - Feed-inn premium scheme
  - Research grants: Kas als Energiebron; MMIP, Multiple year - Mission driven – Innovation Program; KEM; TKI; UDG; etc
  - Data acquisition: 2D-seismic & research boreholes (SCAN)
  - State participation in geothermal projects through EBN



FINANCIAL SUPPORT SCHEMES:

- **Market introduction Energy Innovation (MEI)**
  - Investment subsidy; Phased out

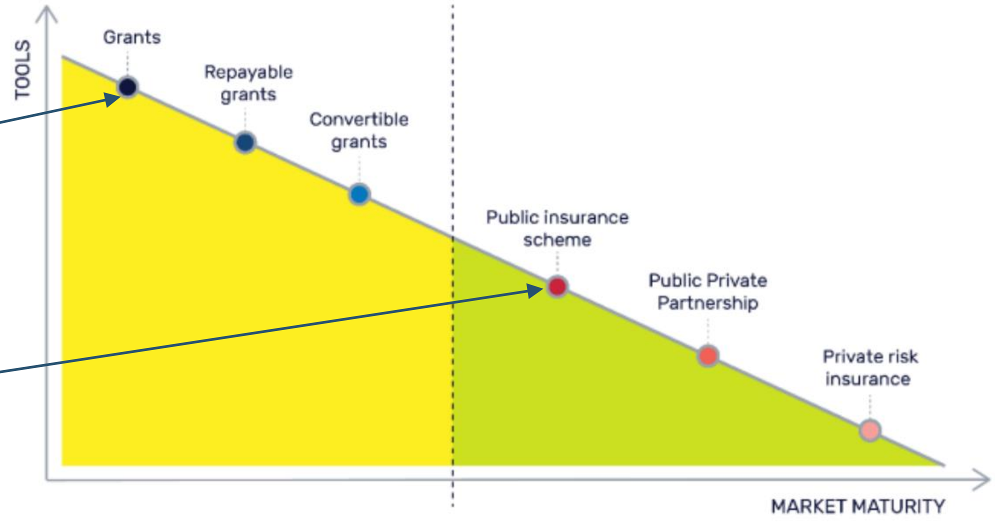
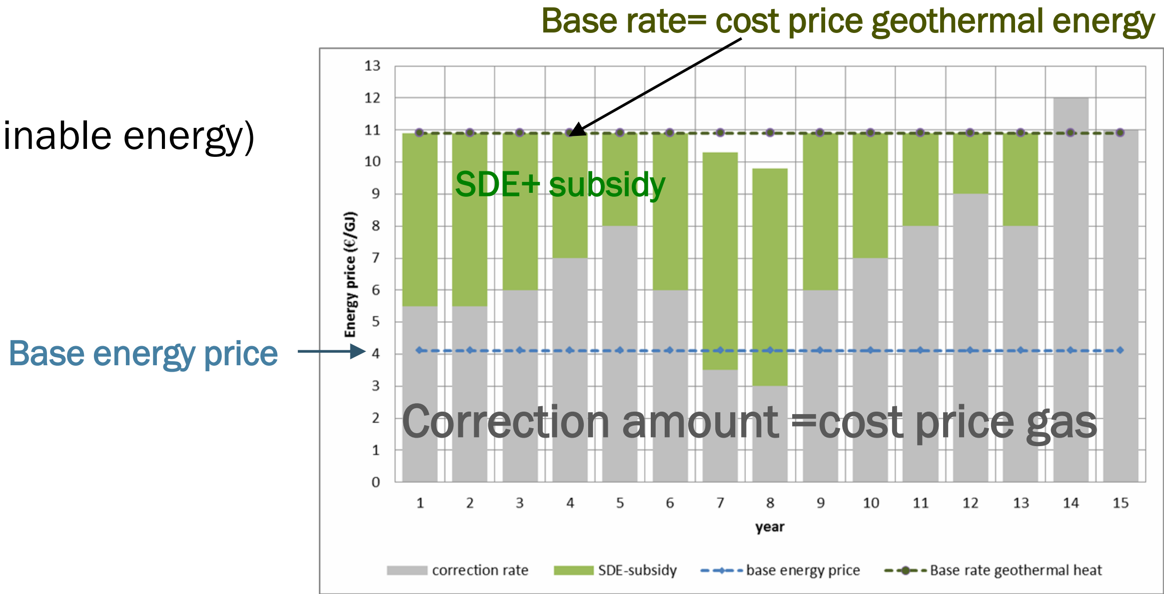


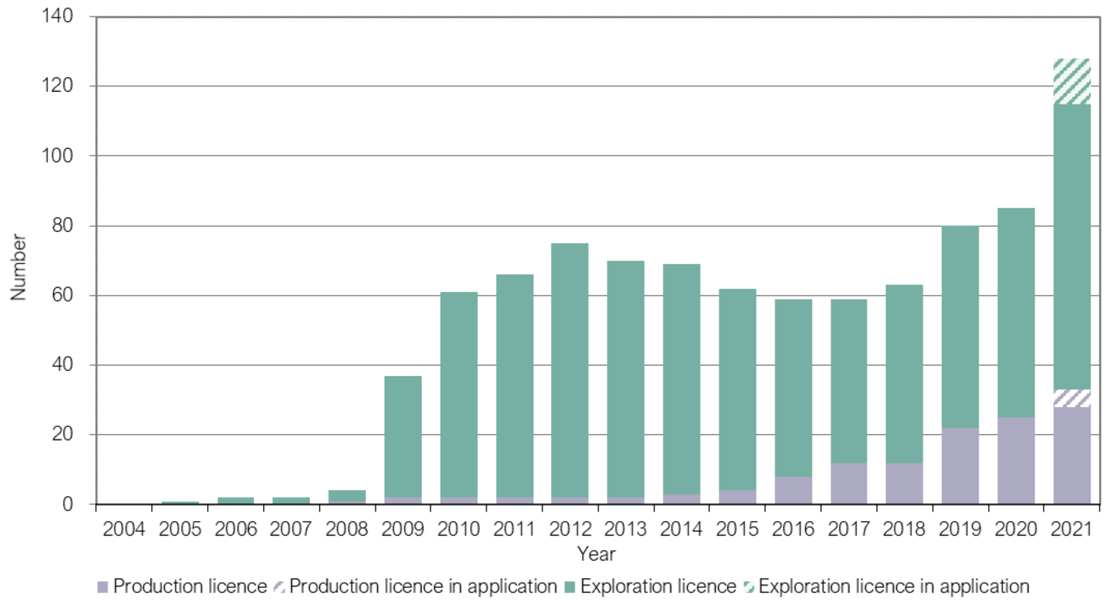
Figure 8:Original RMS Market Maturity Relationship (EGEC)

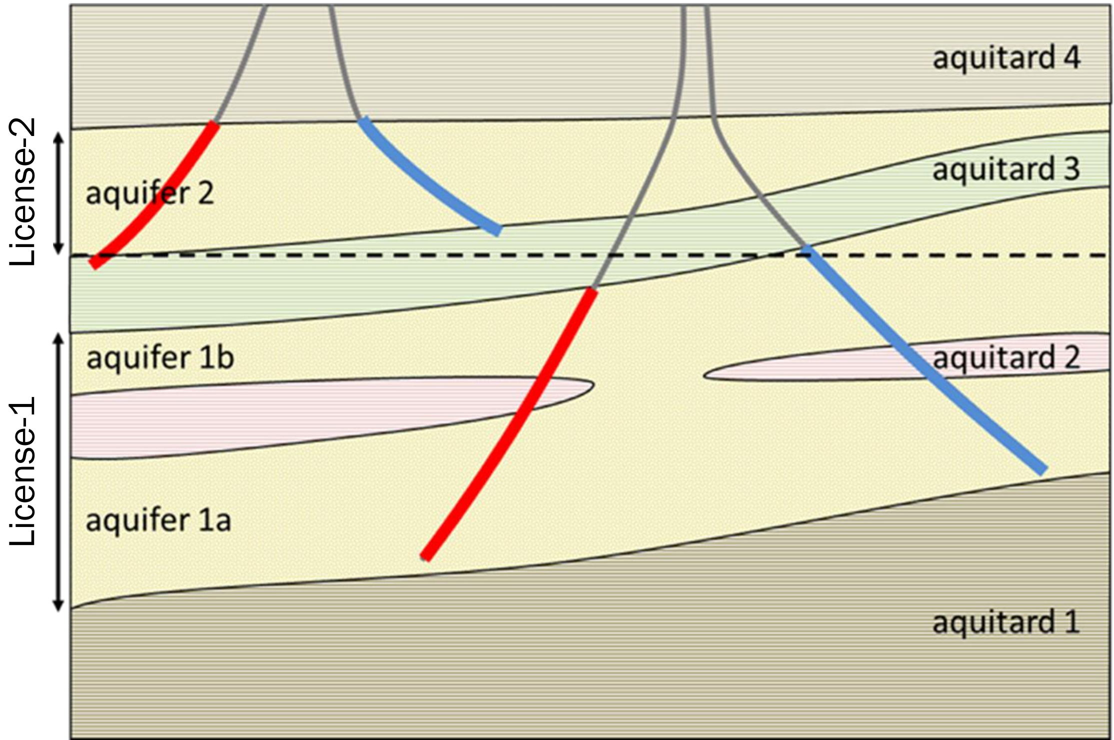
- **Exploration Guarantee Fund (RNES)**
  - Risk-mitigation scheme for geothermal projects (since ca 2010)
  - Insurance on disappointing realised performance of a geothermal doublet due to geological risks
  - Insurance on difference: pre-drill $P_{estimated/insured}$ (max. P90 estimated GT power) vs. $P_{realised}$ (realised GT power)
  - $P_{realised}$ based on well test results

- **Exploitation subsidy: SDE+/ ++** (feed in premium scheme for sustainable energy)
  - Levelling cost-price of sustainable energy vs grey energy
  - one pot + auction
  - renewable heat included since 2012
- *For information on SDE and Exploration Guarantee Fund see www.rvo.nl*

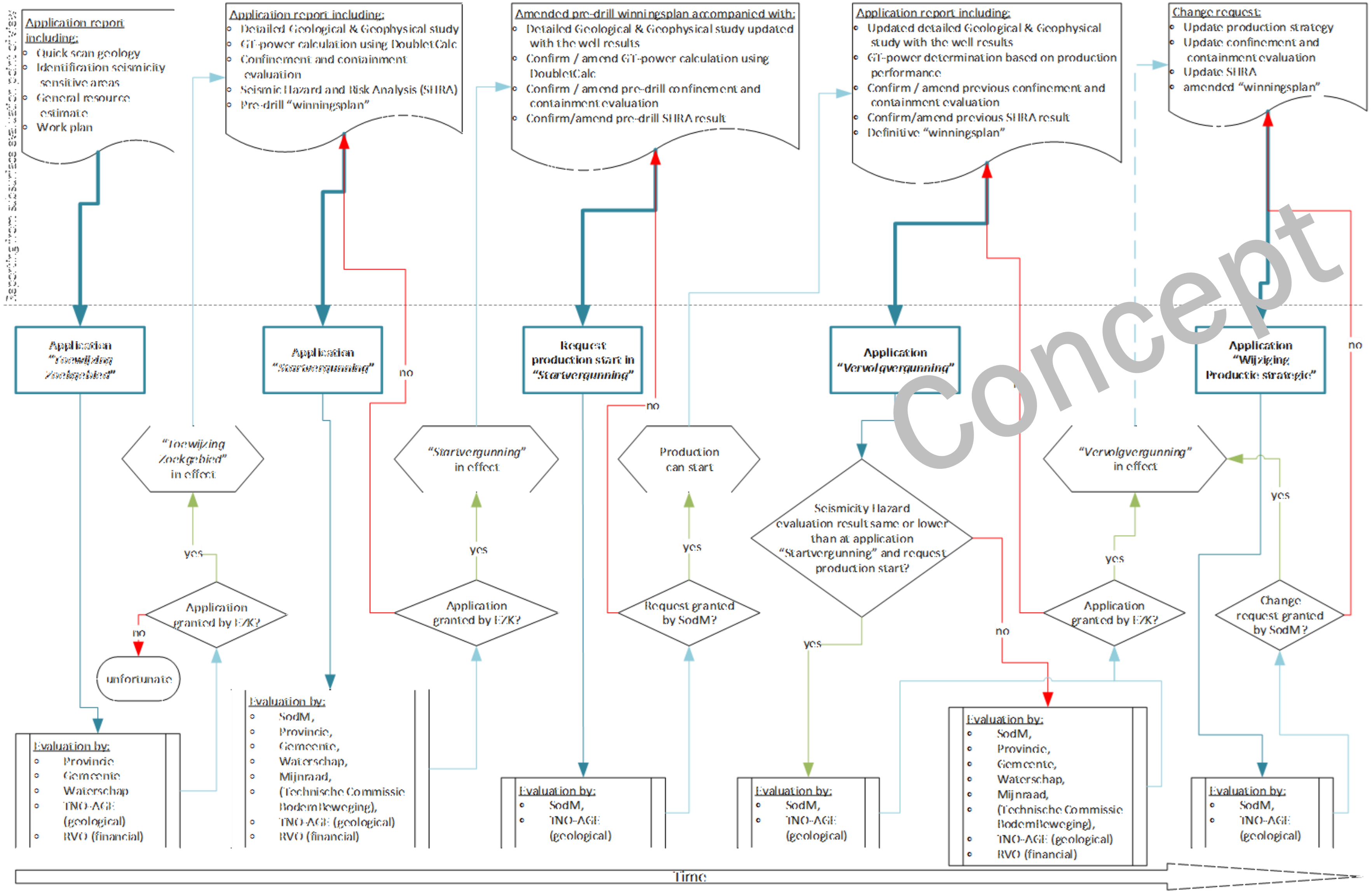


DUTCH GEOTHERMAL LICENSES
FOR EXPLORATION & PRODUCTION





LICENSE STEPS UNDER NEW MINING LAW DUE EARLY 2023



PRESENT DAY TOPICS

- The grass is always greener at the neighbours:
  - we look at Denmark for district heating development
  - we look at Germany and Belgium for fault related geothermal systems and seismicity

- Seismicity => modernise the Seismic Hazard and Risk Analysis
- Seal and well integrity
- Subsurface interference of Geothermal systems
- Project economy with high energy prices vs sustainable energy goals

THANK YOU FOR YOUR TIME

innovation for life

From Geoscience to Market Vision: Policymaking a Geothermal Community Marketplace

Professor Mark Palmer, Queen's University Belfast
&
Joseph Ireland, Queen's University Belfast

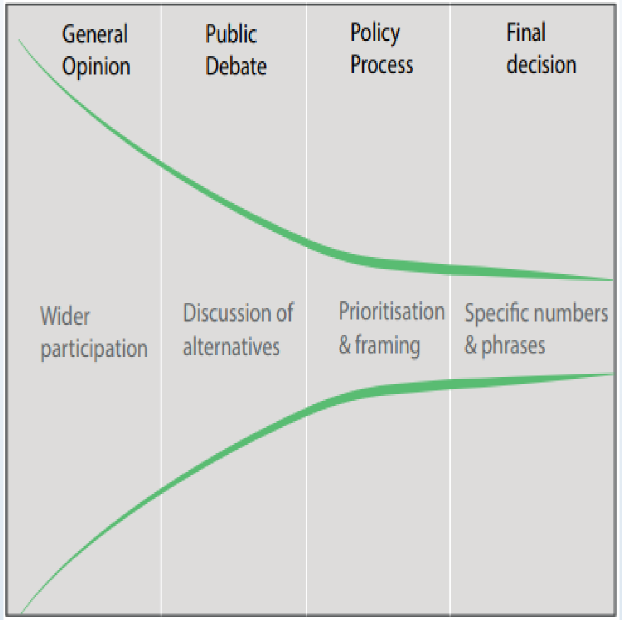
Presentation at the Geothermal Summit, Dublin

Geological Survey Ireland

9th of November 2022

QUEEN'S UNIVERSITY BELFAST

Green Energy Transitions and Policy Responses



Monks (2021)

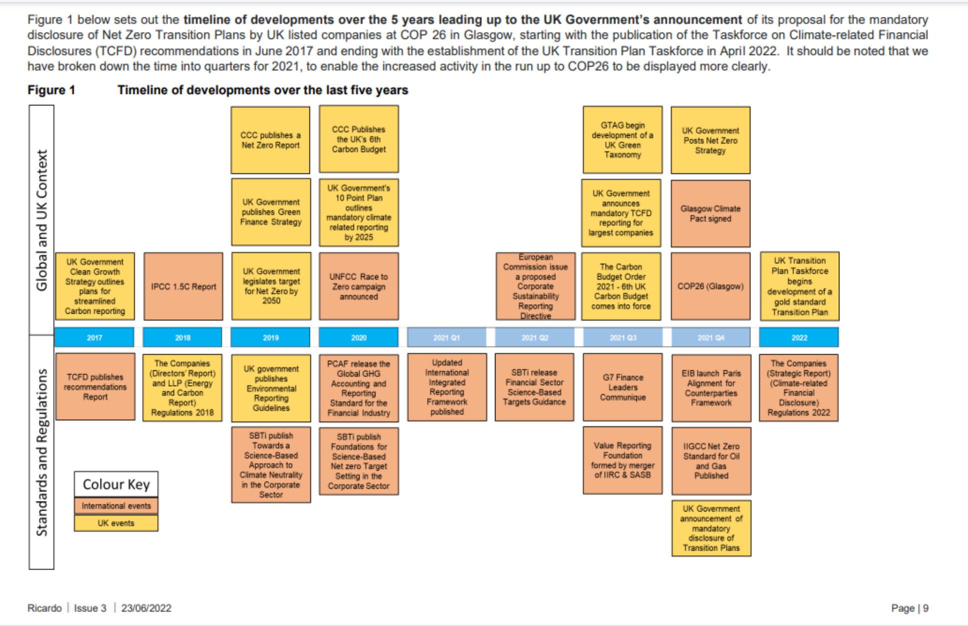


Figure 1 below sets out the **timeline of developments over the 5 years leading up to the UK Government's announcement** of its proposal for the mandatory disclosure of Net Zero Transition Plans by UK listed companies at COP 26 in Glasgow, starting with the publication of the Taskforce on Climate-related Financial Disclosures (TCFD) recommendations in June 2017 and ending with the establishment of the UK Transition Plan Taskforce in April 2022. It should be noted that we have broken down the time into quarters for 2021, to enable the increased activity in the run up to COP26 to be displayed more clearly.

Figure 1 Timeline of developments over the last five years

Ricardo | Issue 3 | 23/06/2022 Page | 9

Ricardo Energy (2022)

(1) Alignment of institutions - policy, problem and politics

(2) Policy portfolio-driven opportunity for market-making

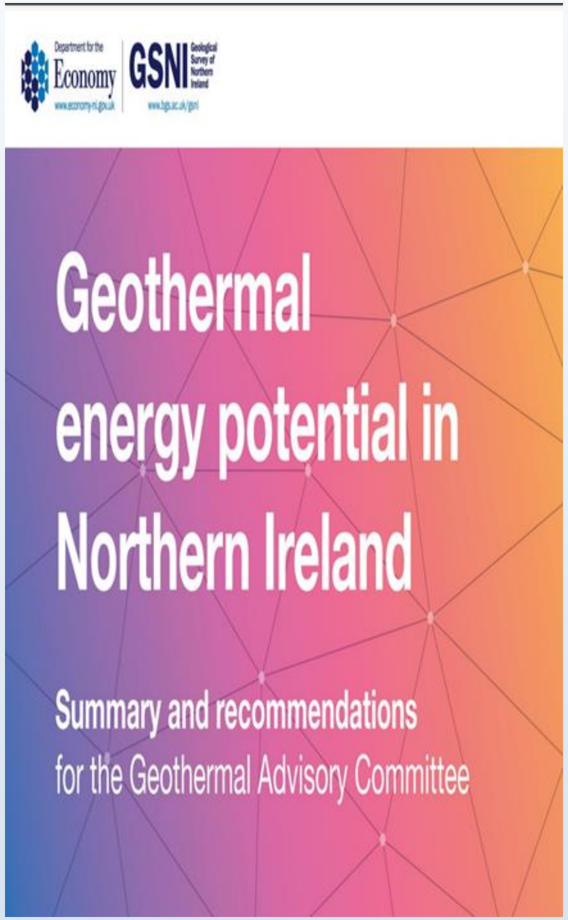
(3)Circular Policy Methodology

(4) Geothermal reports – support and flanking policy

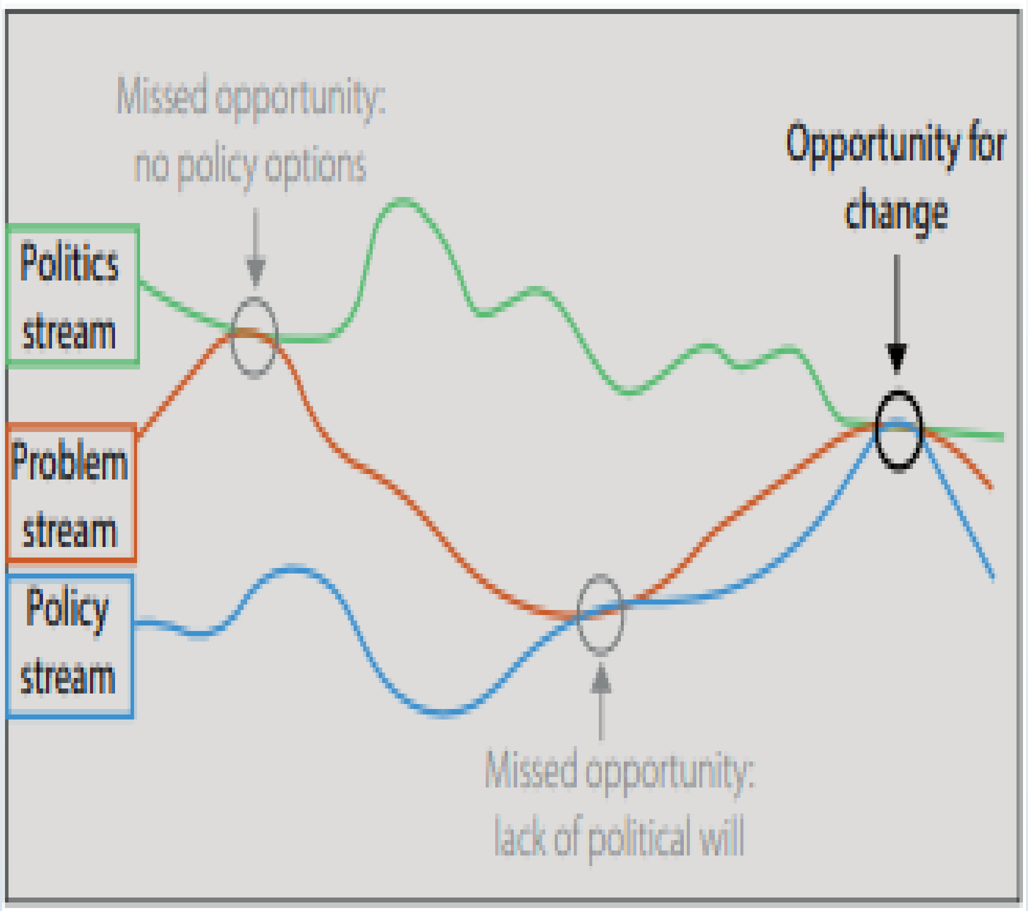
"Obligatory institutional passages" Bruno Latour

QUEEN'S UNIVERSITY BELFAST

(1) Alignment of geoscience and institutional work within green transition energy ecosystems (GTEs)



Source: Raine & Reay, 2021



Source: Monks (2021)

Planning system needs urgent reform for climate emergency, says Minister

KEVIN O'SULLIVAN

There is an urgent need to overhaul the planning system so as to allow for a more effective response to the current climate and energy crises, according to Ossian Smyth, Minister of State with responsibility for Public Procurement and eGovernment.

The current system is seen as "an obstruction; something that makes it harder to do things", he told a conference on accelerating progress towards an Ireland of net-zero carbon emissions.

The planning system was "sometimes seen as being too discretionary, as not being objective, and therefore arbitrary", which introduced an element of risk, Mr Smyth added.

In contrast, planning should be about making plans, he said — "county development plans, energy plans, strategic plans", and not be primarily about granting planning permission or not, he told a conference hosted by the Institute of International and European Affairs and the ESB.

Rules-based

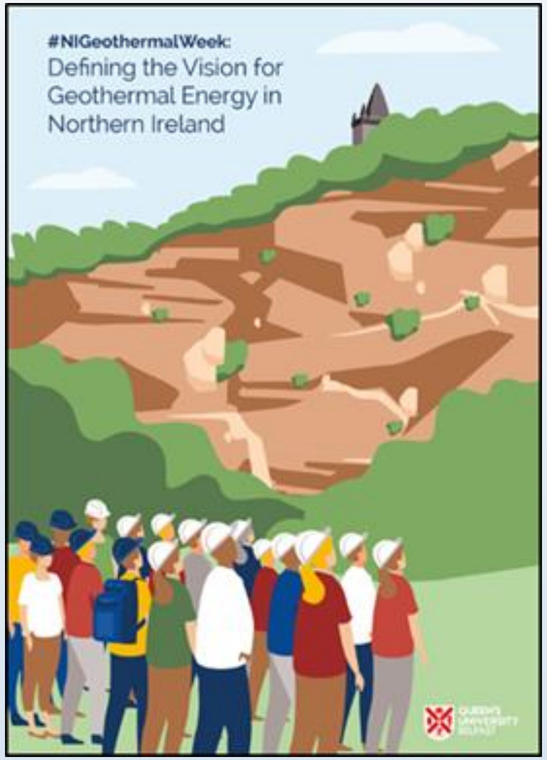
The Minister said he favoured a rules-based rather than a discretionary system — one that removes randomness and unpredictability while retaining fairness and due process. Attorney General Paul Gallagher is examining possible planning reforms and is expected to submit a report to Cabinet in coming months.

Mr Smyth said the case for reform had to be seen in the context of "a climate emergency requiring an emergency response", where critical processes were speeded up. People wanted "a speed-up" on renewable energy, especially in light of the Ukraine war.

"There's a feeling we cannot rely on Russia and on the Middle East to keep our country running; we need our offshore wind farms, we need our solar farms, we need anaerobic digesters — and why have we not got them already," he noted.

(1) Alignment through institutional field events and visions (Cont.)

As part of #NIGeothermalWeek, the below Steering Wheel Vision and associated vision statements for the sector were agreed upon by attending stakeholders



Source: Palmer, Ireland, Ofterdinger & Zhang (2022)

https://www.economy-ni.gov.uk/publications/net-zero-pathways-building-geothermal-energy-sector-northern-ireland

Communities
To deliver geothermal energy to all communities.

People
To build talent to drive geothermal excellence, capacity development and policy engagement.

Customers
To grow and facilitate geothermal customers in a sustainable way.

Environment
To protect and preserve the environment for all communities.

Operations
To build administrative, operational, and policy support.

Investment
To nurture, shield and protect sector investment funding.

QUEEN'S UNIVERSITY BELFAST

(1) Portfolio policy-driven alignment (cont.)

- Energy portfolio – strategic portfolio-led and driven approach
- Decarbonisation of the built environment
- Policy alignment of carbon in use and carbon in build

UK Climate Change Committee (June 2022 update)

Policy landing zone

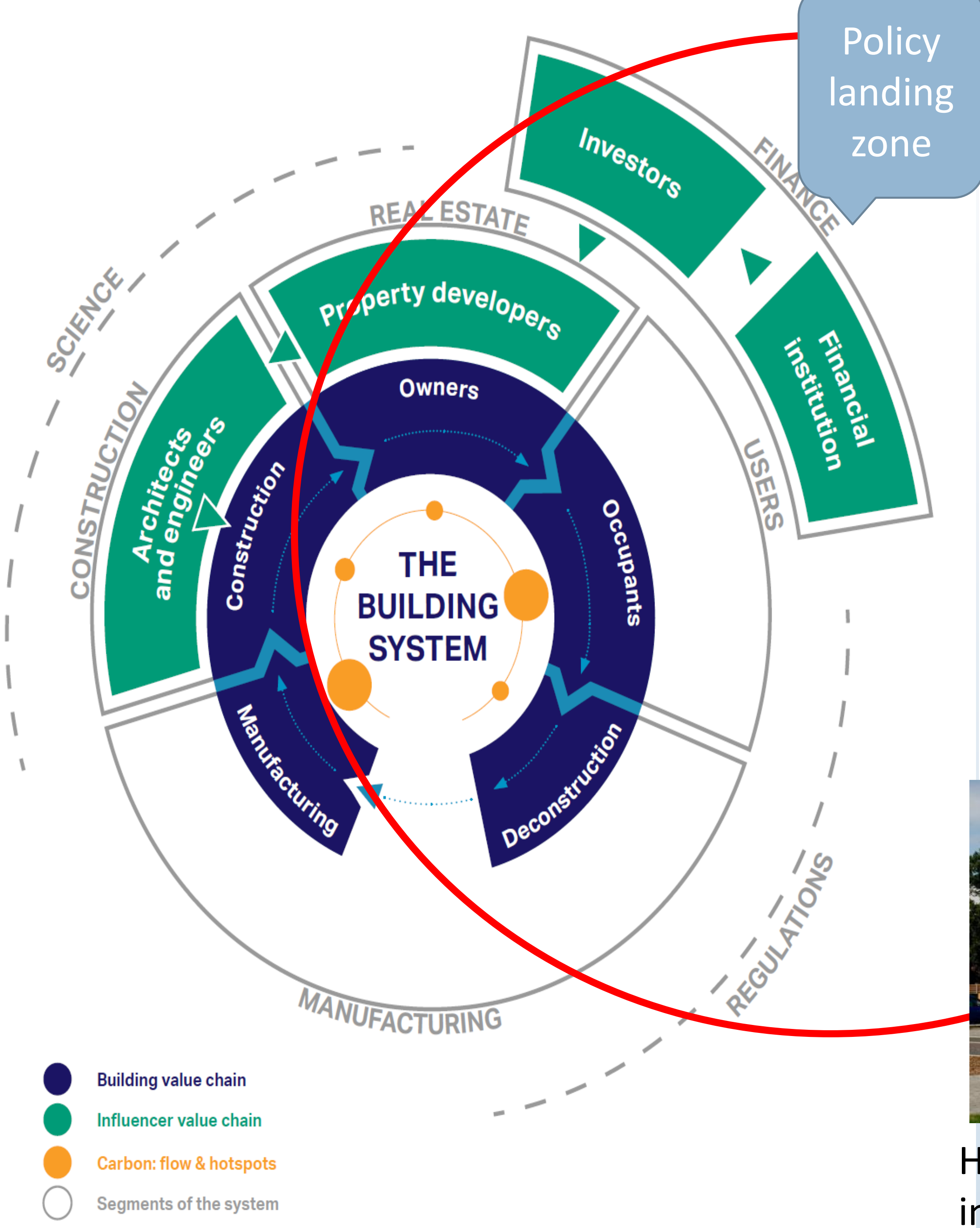
Table 1
Summary of progress against key indicators

Surface transport	Electricity supply	Buildings	Manufacturing and construction	Agriculture and land use
BEV car sales	Offshore wind, installed	Energy demand	Sector territorial emissions	Agriculture CH_4
EV cars sales	Onshore wind, installed	Energy efficiency retrofits	Sector consumption emissions	Agriculture N_2O
BEV van sales	Solar PV, installed	Non-res buildings energy intensity	Carbon intensity of energy	New woodland
EV van sales	Grid emissions intensity	Low-carbon heat supply	Material and product use	Woodland management
ICE car intensity	Unabated gas generation	Heat pump installations	Steel: energy efficiency	Peat restoration
ICE van intensity	Low-carbon flexible capacity	Heat pump costs	Paper: energy efficiency	Energy crops
Charge points	Nuclear	Electricity to gas price ratio	Low-carbon energy use	Farmer action
Car km	Flexible demand	Heat networks	Industrial hydrogen project pipeline	Crop yields
Van km	Onshore networks	Retrofit coordinators	Industrial CCS project pipeline	Livestock numbers
HGV km	Offshore networks	Willingness to replace boiler	Average embodied carbon of buildings	Meat consumption

Key:
- On track
- Slightly off track
- Significantly off track
- Too early to say
- Data not reported
- No benchmark or target

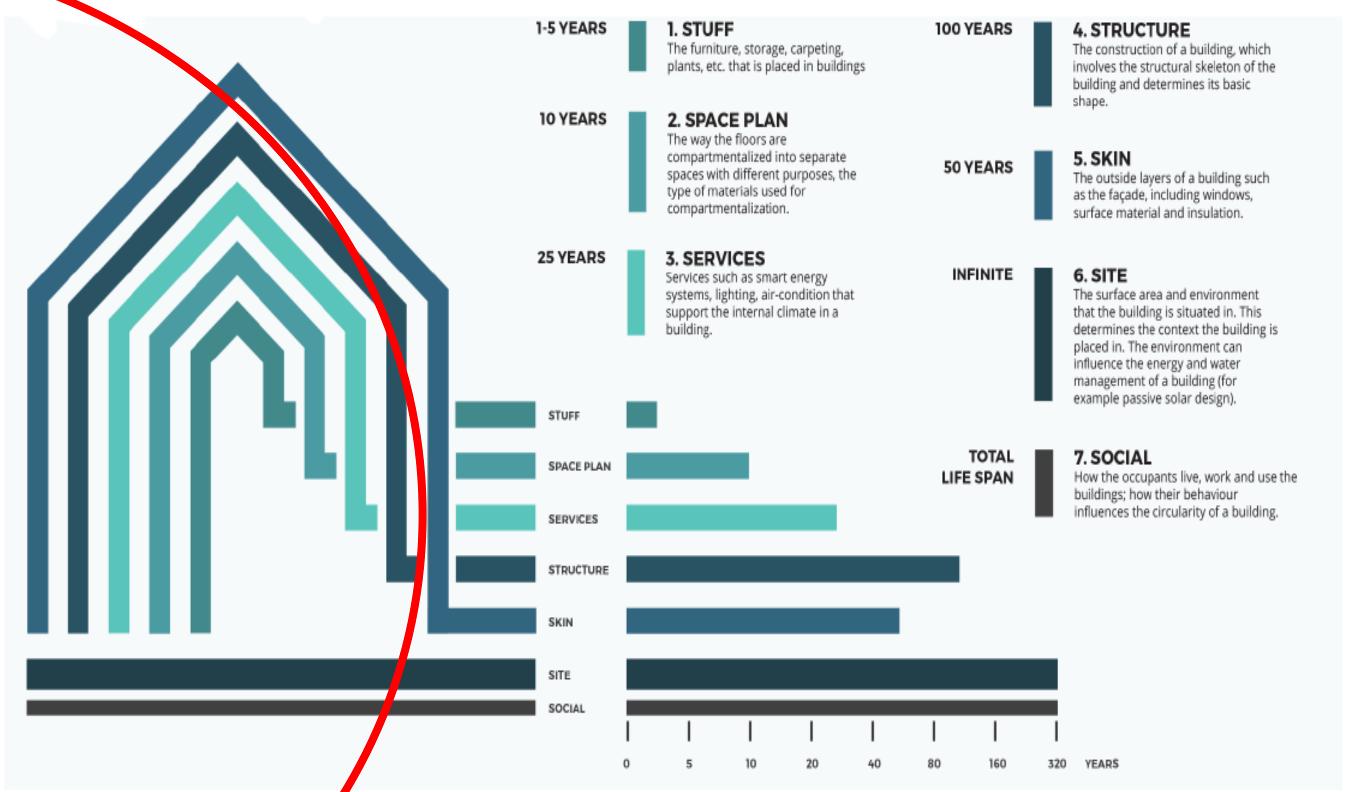
Notes: An indicator is on track if it is going in the right direction at an appropriate rate. This is determined either by comparing to a quantified pathway/benchmarks using data from 2019, 2020 and 2021, where available.
EV = electric vehicle, BEV = battery-electric vehicle, ICE = internal combustion engine.

Figure 2: The value chains of the building and construction system



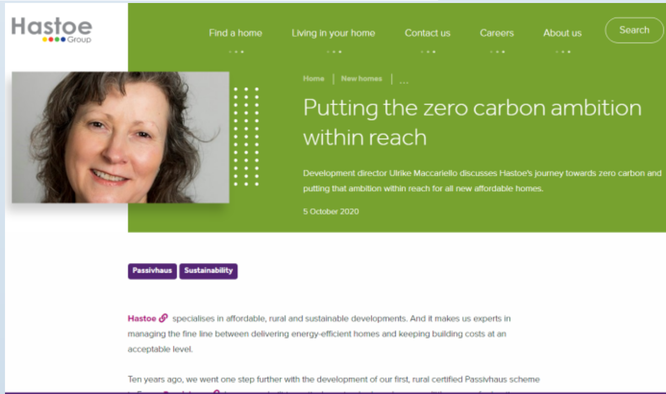
Policy landing zone

Figure 5: Building model consisting of the building related layers based on the sharing layers[9]



Source: WBCSD, 2021

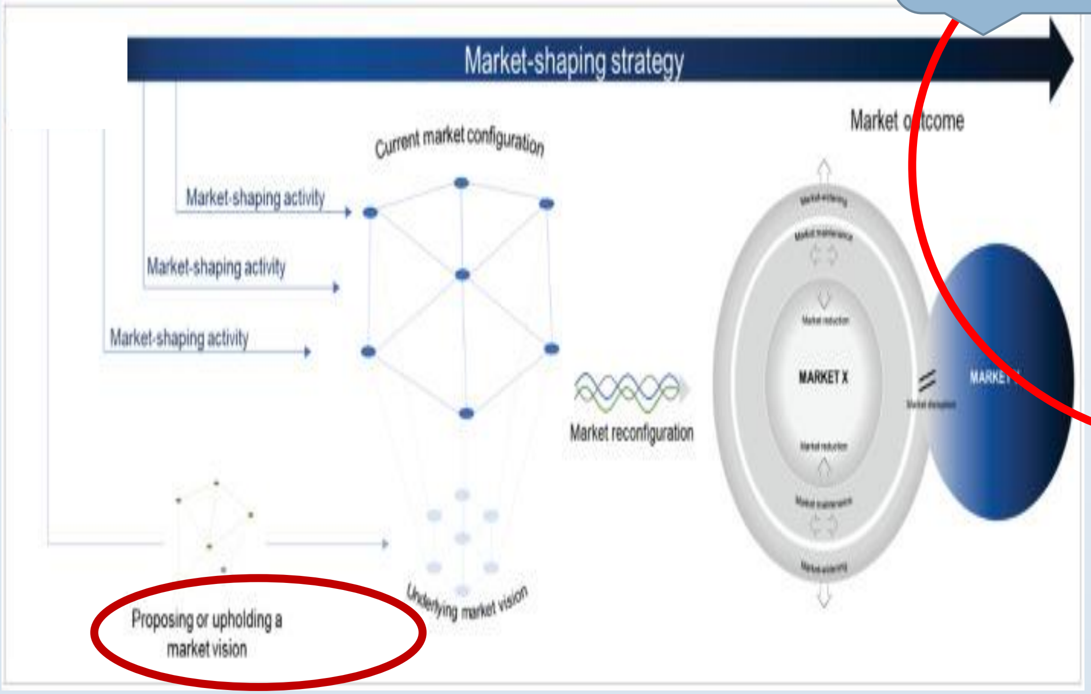
Hastoe's first Passivhaus development in Uttlesford, Essex



(2) Policy-driven opportunity for market-making

"No country has managed to make retrofit mainstream: it remains the preserve of enthusiastic practitioners, programme designers and customers. Retrofit is an immature market compared with the dominant sector of repair, maintenance and improvement (RMI)."

Policy landing zone



Flaig, Kindström & Ottosson (2021), IMM

Monks (2021)

Domestic retrofit supply chain initiatives and business innovations: an international review

BUILDINGS & CITIES

SPECIAL COLLECTION: RETROFIT AT SCALE: ACCELERATING CAPABILITIES FOR DOMESTIC BUILDING STOCKS

RESEARCH

]u[ubiquity press

FIONA BROCKLEHURST
ELIZABETH MORGAN
KELLY GREER
JOANNE WADE
GAVIN KILLIP

*Author affiliations can be found in the back matter of this article

ABSTRACT

A systematic review of international evidence on housing retrofit supply chains was undertaken for the UK government: a Rapid Evidence Assessment (REA) summarised the most relevant research from outside the UK; key emerging themes were examined via analysis of 10 expert interviews with European and UK stakeholders, selected for the depth and breadth of their experience in developing retrofit business models. Market development requires concerted efforts from industry and policy, including the regulation of minimum standards. Conservatism in the industry means that opportunities for retrofit will be ignored in preference for the less risky, more familiar repair, maintenance and improvement (RMI) market. Successful retrofit involves customer engagement and after-care, which is outside customary practice. Financing mechanisms are important for firms' cashflow and for customer acceptance. Skills governance needs to take account of national vocational education systems, and is more complex than simply providing a few new courses. Local partnerships are needed to mobilise and organise the supply chain, whether through local government involvement or new business models enshrining collaborative quality assurance. More formal quality assurance implies some consolidation of supply chains. All these elements must be integrated into a service package, whose overall purpose is to minimise the risks of retrofit for supply chains and customers.

POLICY RELEVANCE

A functioning, large-scale energy-efficiency retrofit market needs to have some of the attributes of the existing RMI market, with energy performance grafted on. When compared with the ideal requirements for effective policy, existing policy support is inadequate, being too short-lived, too inconsistent and too easily sidelined by market realities. Retrofit requires high-quality outcomes achieved through integrated service, but construction industry business culture is focused on inputs (not outcomes) and the service is fragmented. Policy must help deliver a cultural shift, which no country has yet succeeded in bringing about. The task may be slow as it entails coordination and change across policy, education and vocational training, and industry practices.

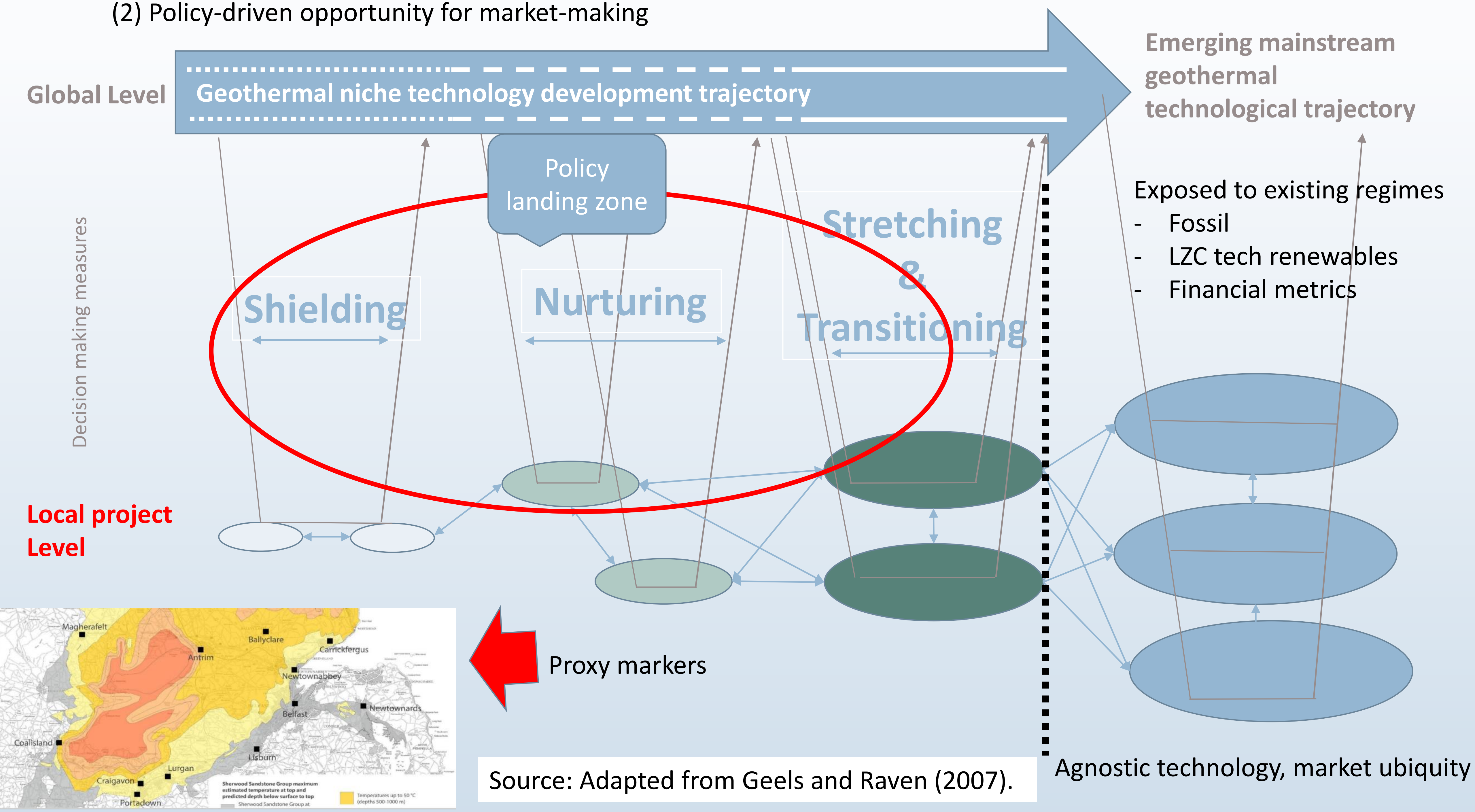
CORRESPONDING AUTHOR:
Fiona Brocklehurst
Ballarat Consulting, Oxford, UK
fiona@ballaratconsulting.co.uk

KEYWORDS:
capability; construction industry; energy efficiency; innovation; retrofit; supply chain

TO CITE THIS ARTICLE:
Brocklehurst, F., Morgan, E., Greer, K., Wade, J., & Killip, G. (2021). Domestic retrofit supply chain initiatives and business innovations: an international review. *Buildings and Cities*, 2(1), pp. 533–549. DOI: https://doi.org/10.5334/bc.95

Brocklehurst et al. (2021)

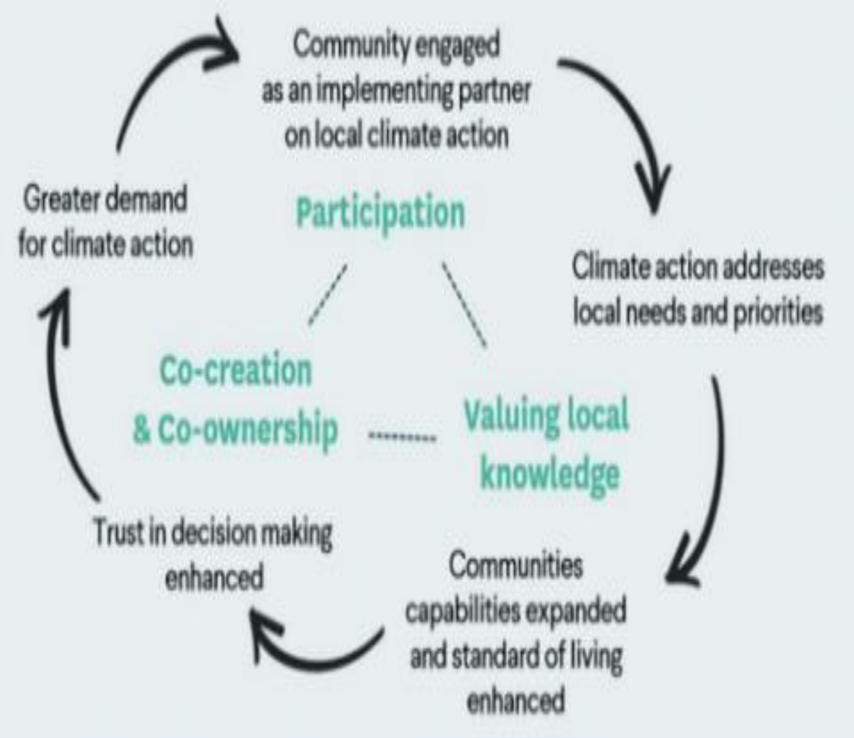
(2) Policy-driven opportunity for market-making



Source: Adapted from Geels and Raven (2007).

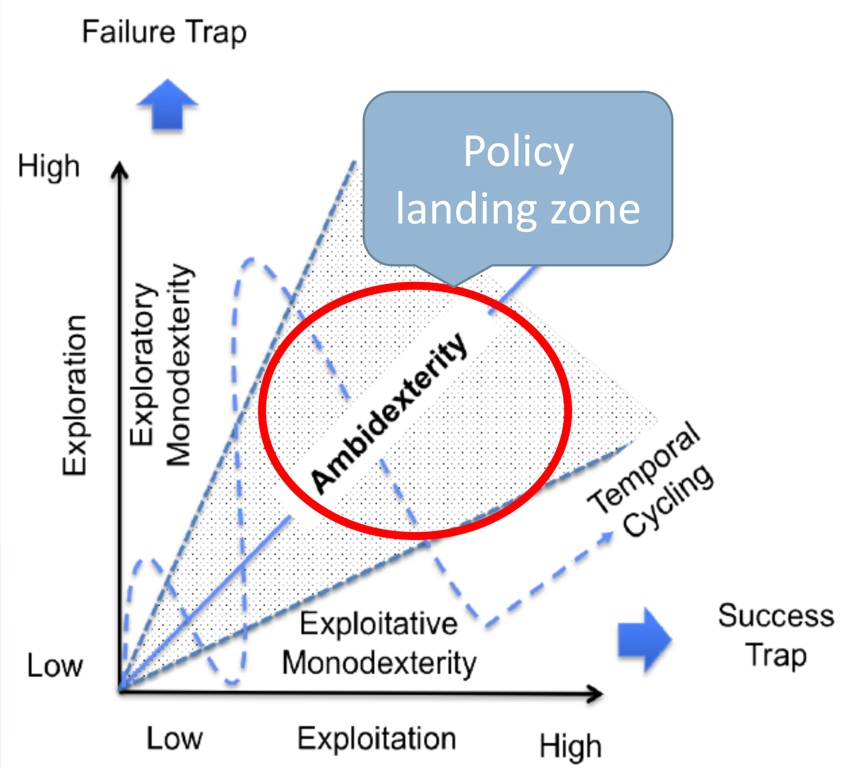
(3) Circular policy methodology – geoscience/social science-led process of arriving at the policy zones and practice

Department for the Economy, NI, 2022



TASC Climate Justice Centre

Academic geothermal projects



Source: Güttel et al., (2011)

(3) Circular policy methodology (cont.)

Feedback practice

DfE approval

#NIgeothermalweek

DfE approval

Dec 2021

GAC Meeting
25th February
Reported started

GAC Meeting
1st April 2022
Feedback

GAC Meeting
29th April 2022
Feedback

QUB report
hand over to
DfE & GAC
23rd May 22

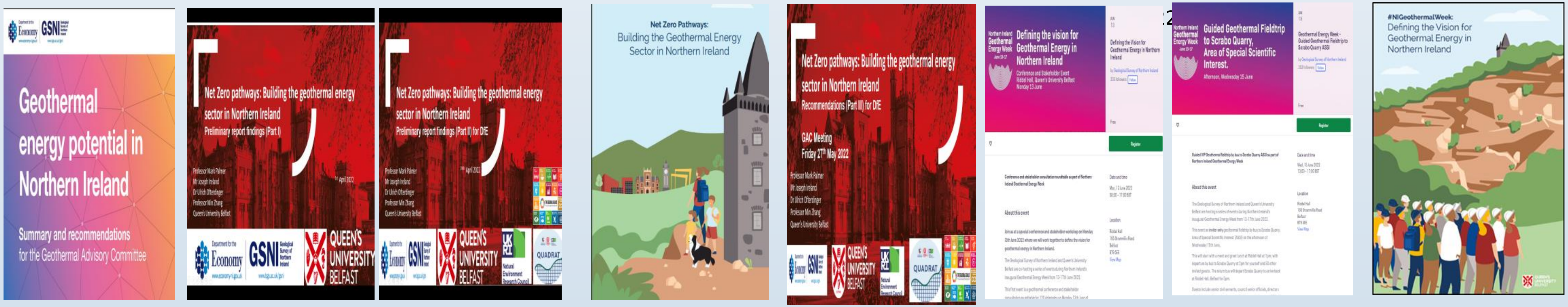
GAC Meeting
27th May 22
Presentation

Monday 13th – Friday 17th June 2022

Thursday 29th Sept 2022

DfE Report
Geothermal
Sector Vision

Process



Webinar Series, reports, presentations, roundtables, fieldtrip practice, public engagement panel session, site visits of cases

(3) Community acceptance: Conveying knowledge about the *physical world* is secondary to the *social world*

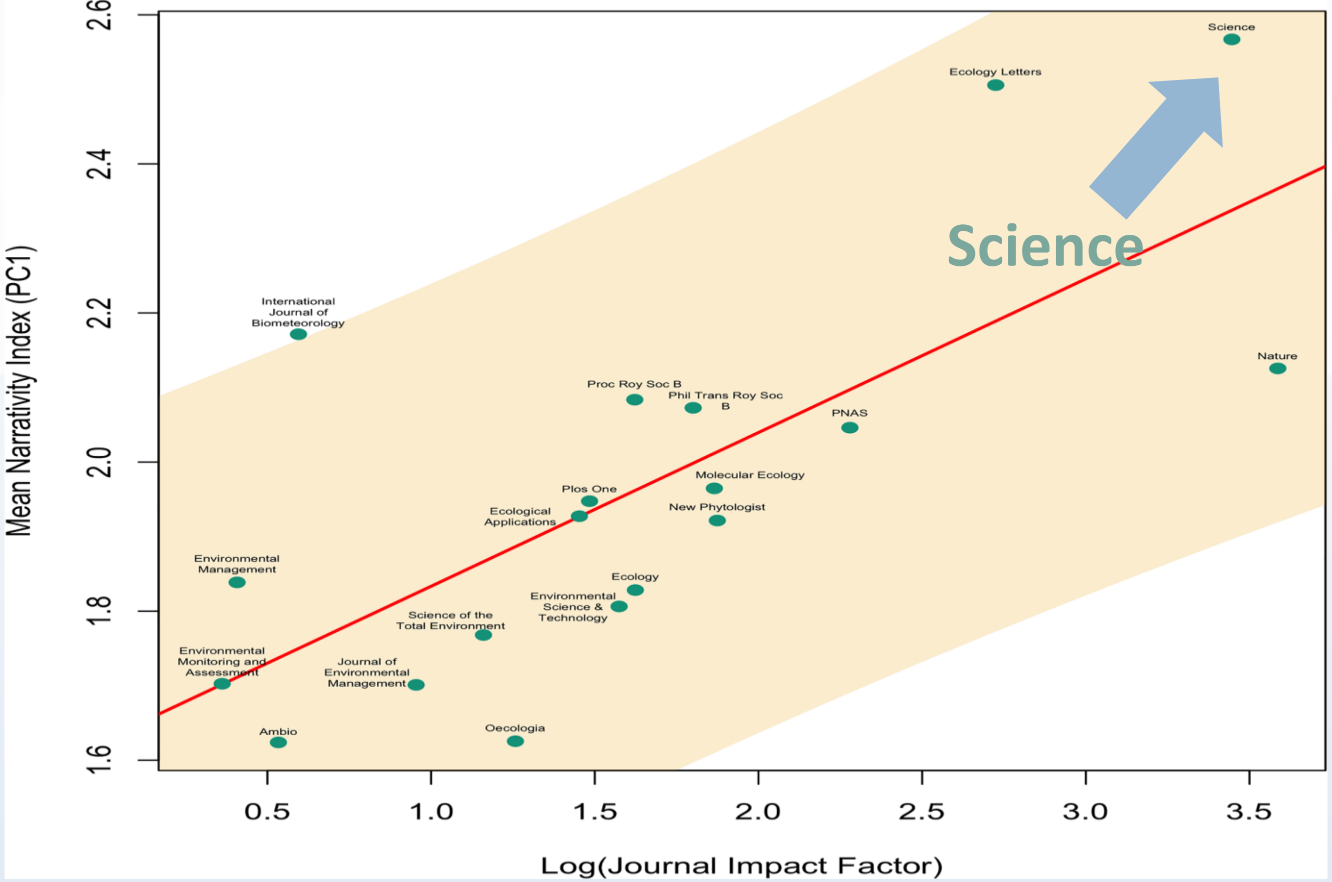
Policy landing zone

Policy landing zone

Residential and non-residential
Shallow
Closed loop
Individual and community (geothermal co-operatives, mutualisation)
Slim rigs – shallow between 125 metres - 400 metres for the GSHP (increase Coefficient of Performance over the life-cycle of the GSHP)
Thermal response test unit

Narrative isn’t just for ‘lay audiences’ or ‘just marketing’

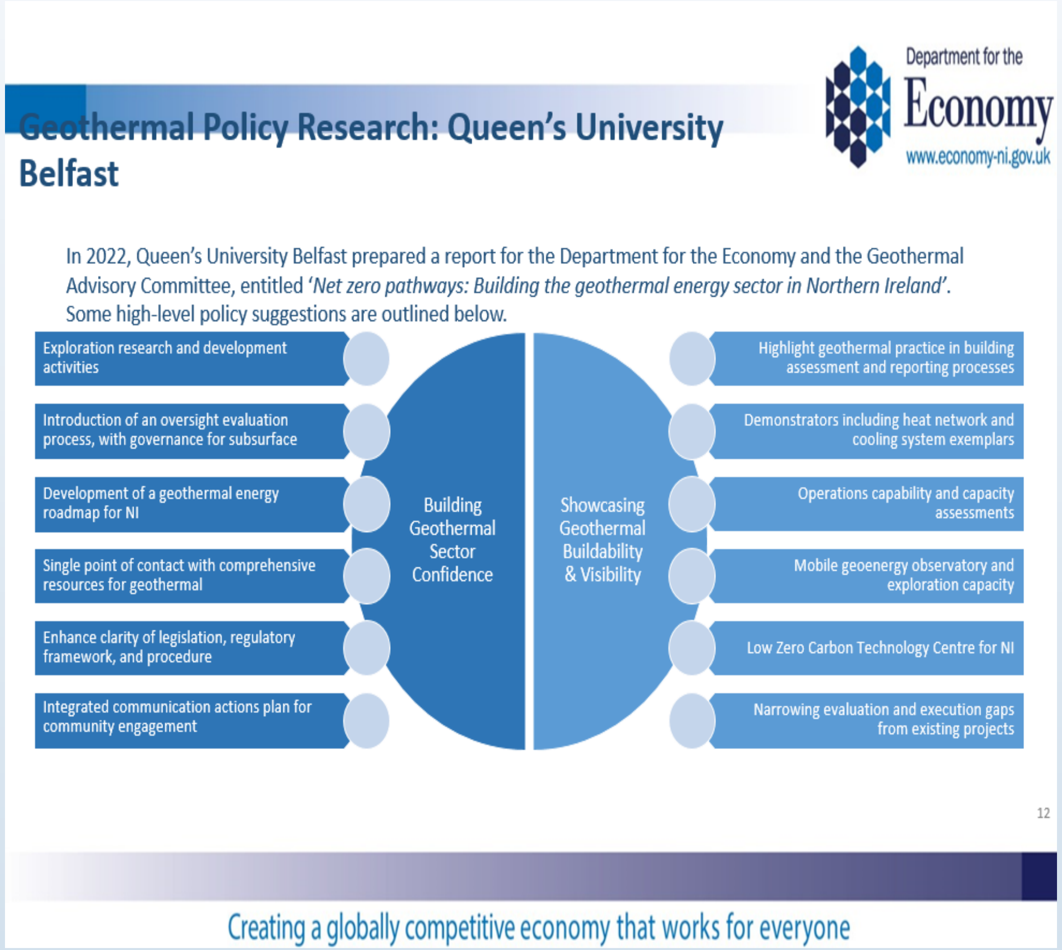
- Narrative style increases as *journal impact factor* goes up
- Articles that use narrative are *more highly cited*



Sherwood

Hillier, A., Kelly, R. P., & Klinger, T. (2016). Narrative style influences citation frequency in climate change science. PLOS ONE, 11(12), e0167983.

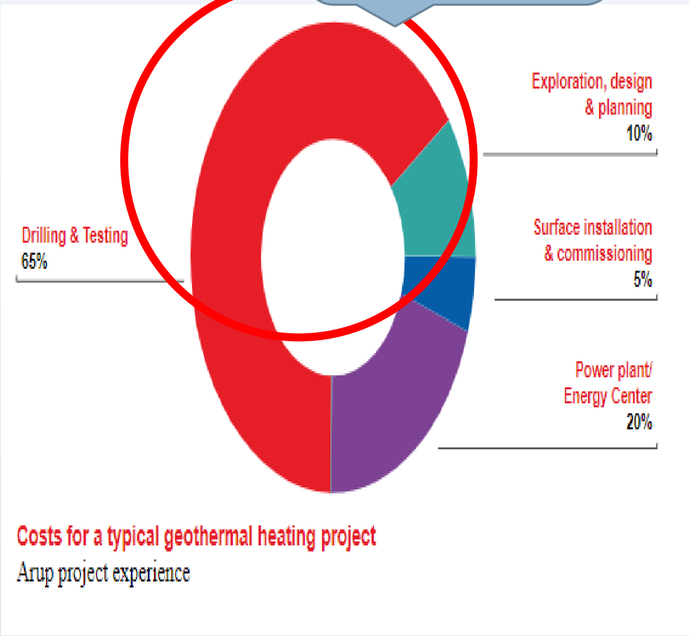
(4) Geothermal sector building scoping report (June 2022)



Source: Department for the Economy, NI, 2022

Palmer, Ireland, Ofterdinger & Zhang (2022)

Policy landing zone

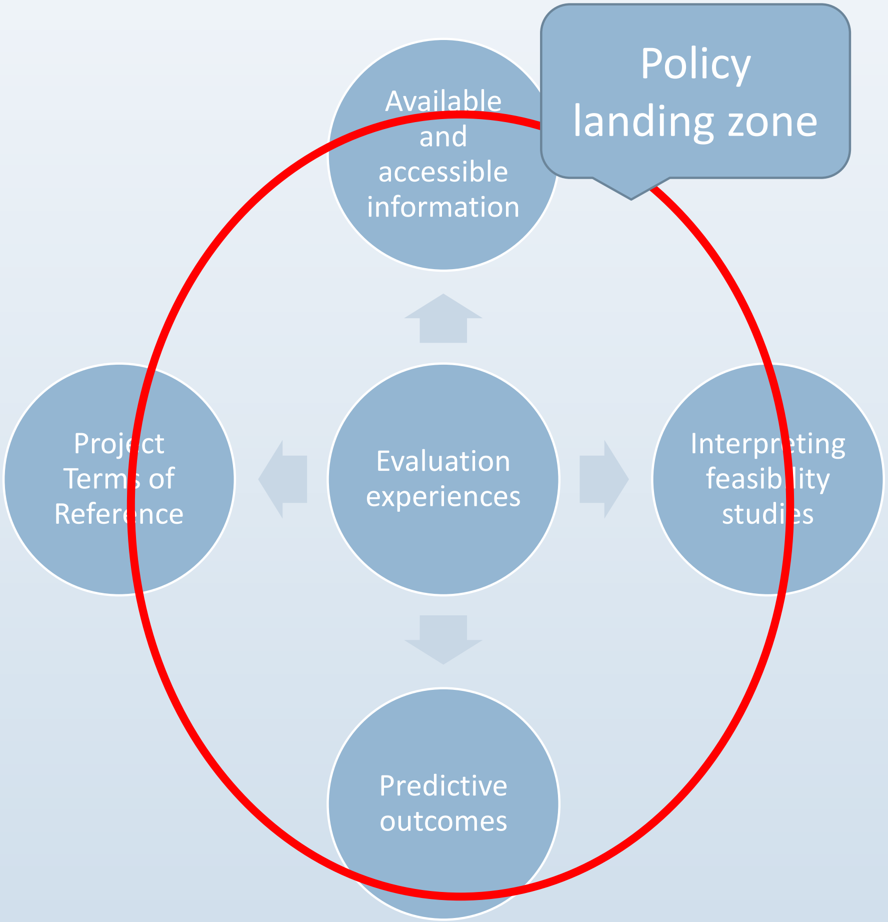


Arup, 2021

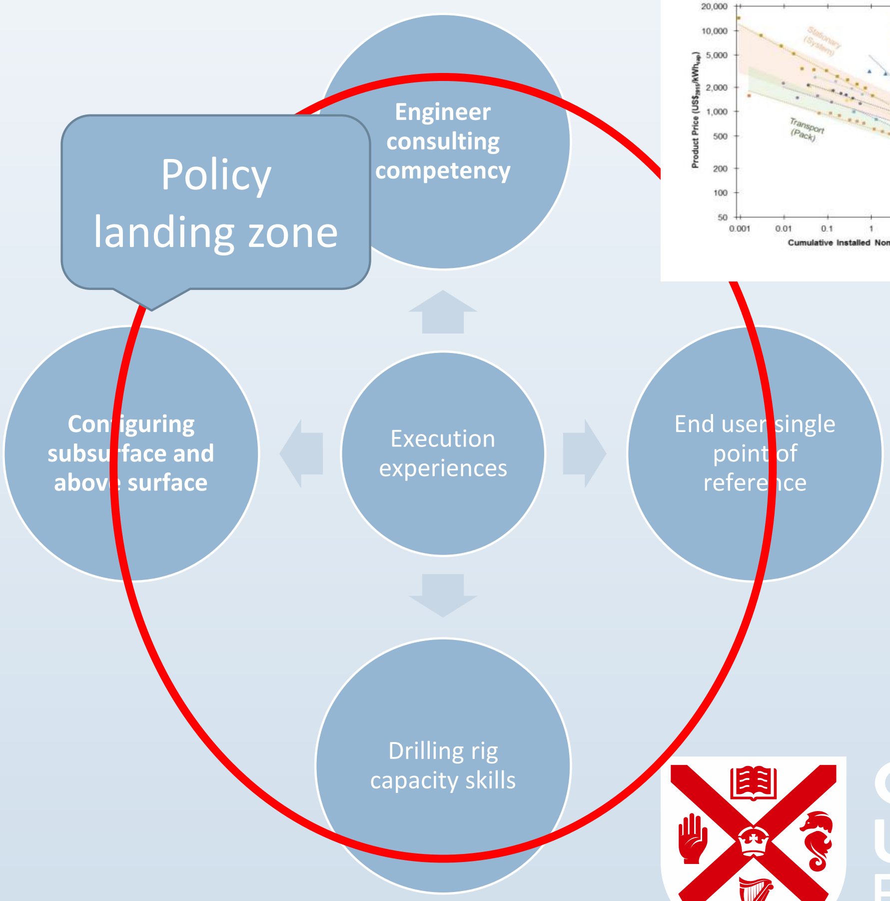
Driving & moving down technology and cost curves

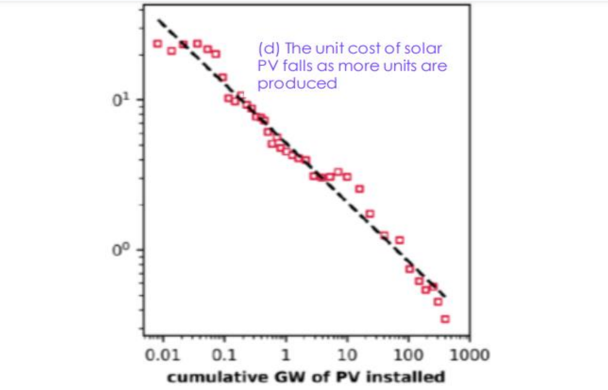
(4) Narrowing and closing the gaps with policy (cont.)

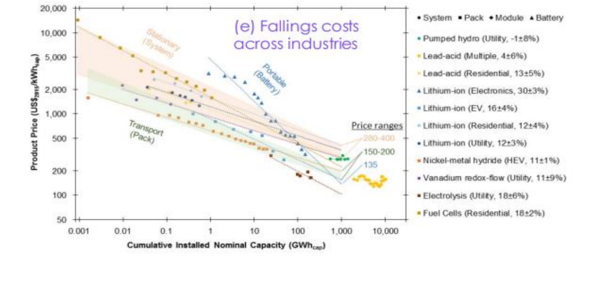
Evaluation practice



Executing operations

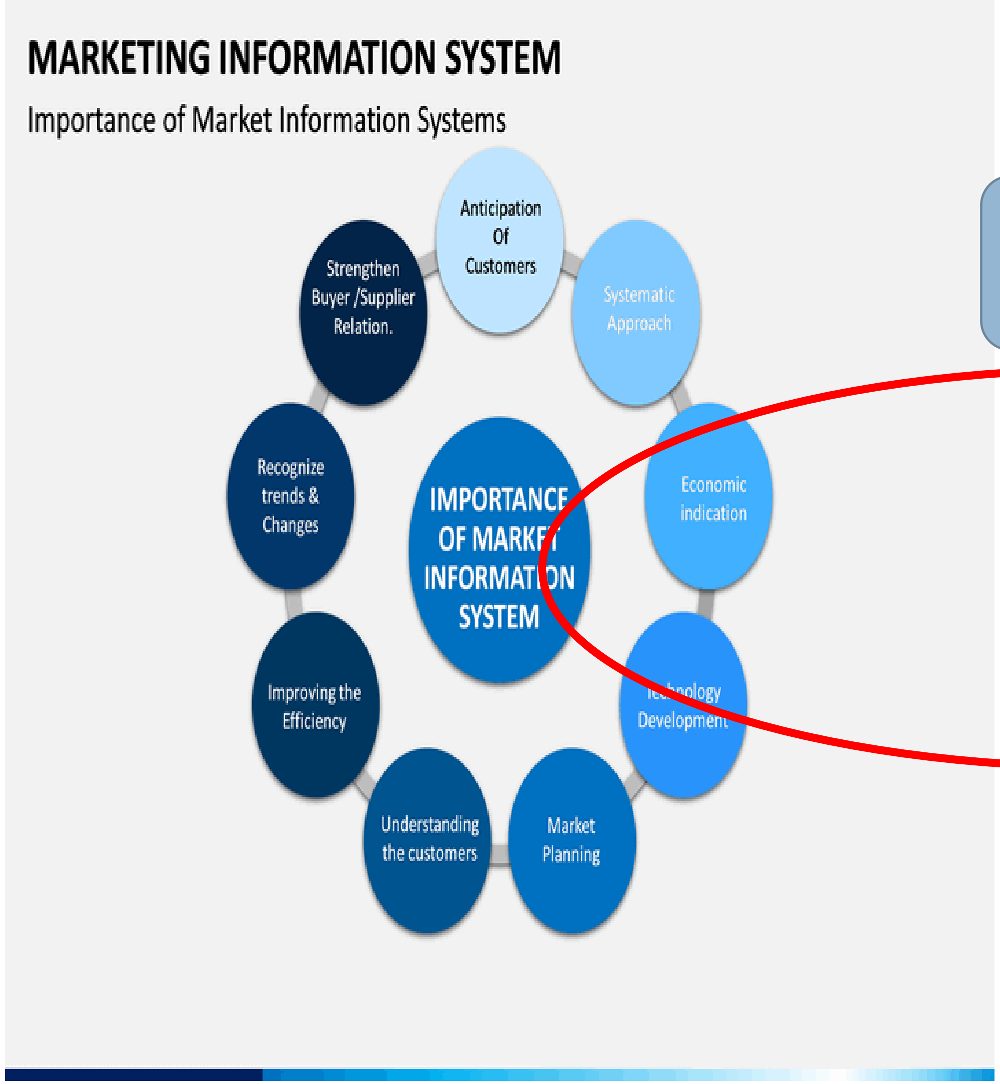




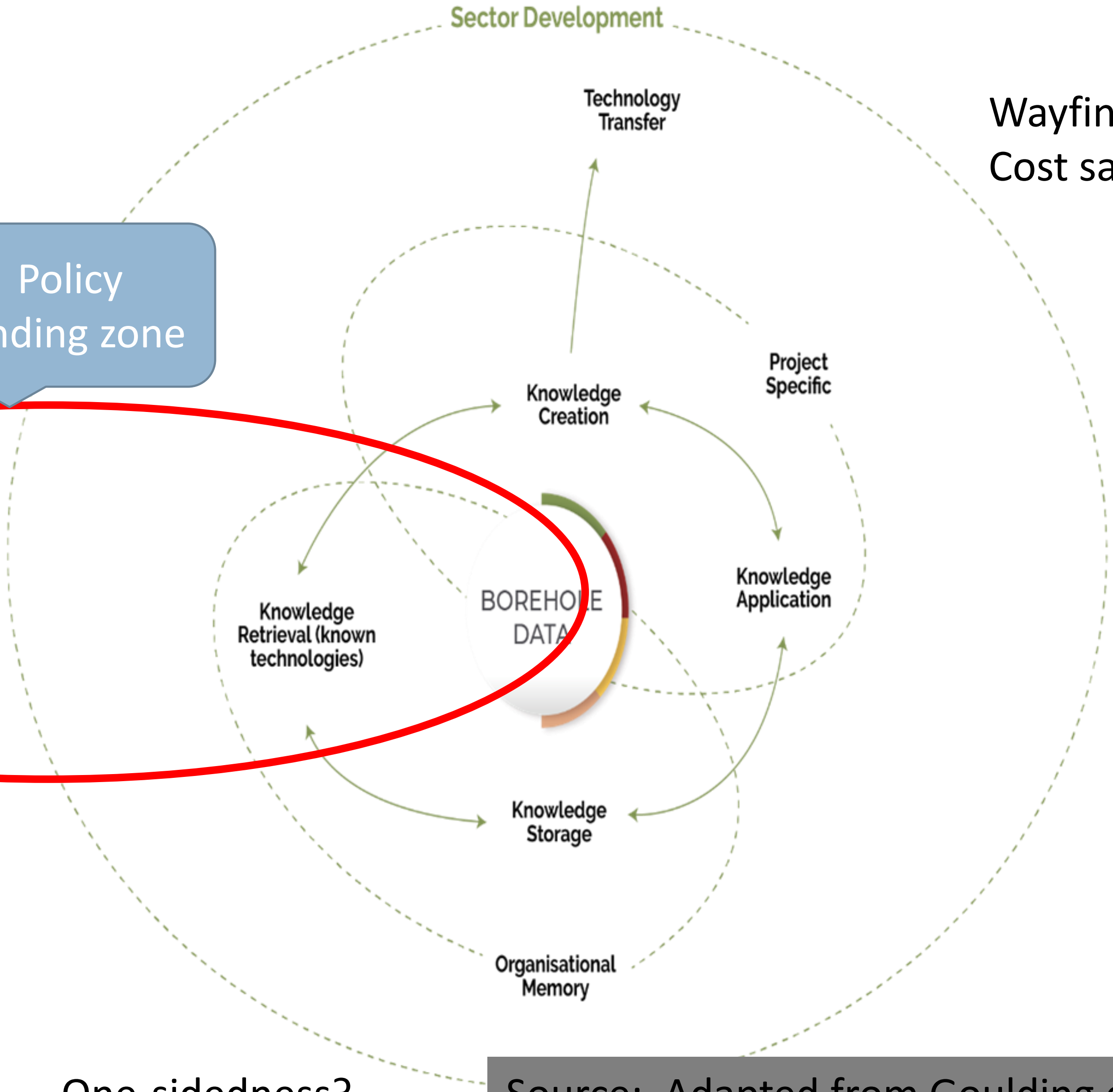


Chater, 2020

(4) R&D policy bridging (cont.)



Policy landing zone

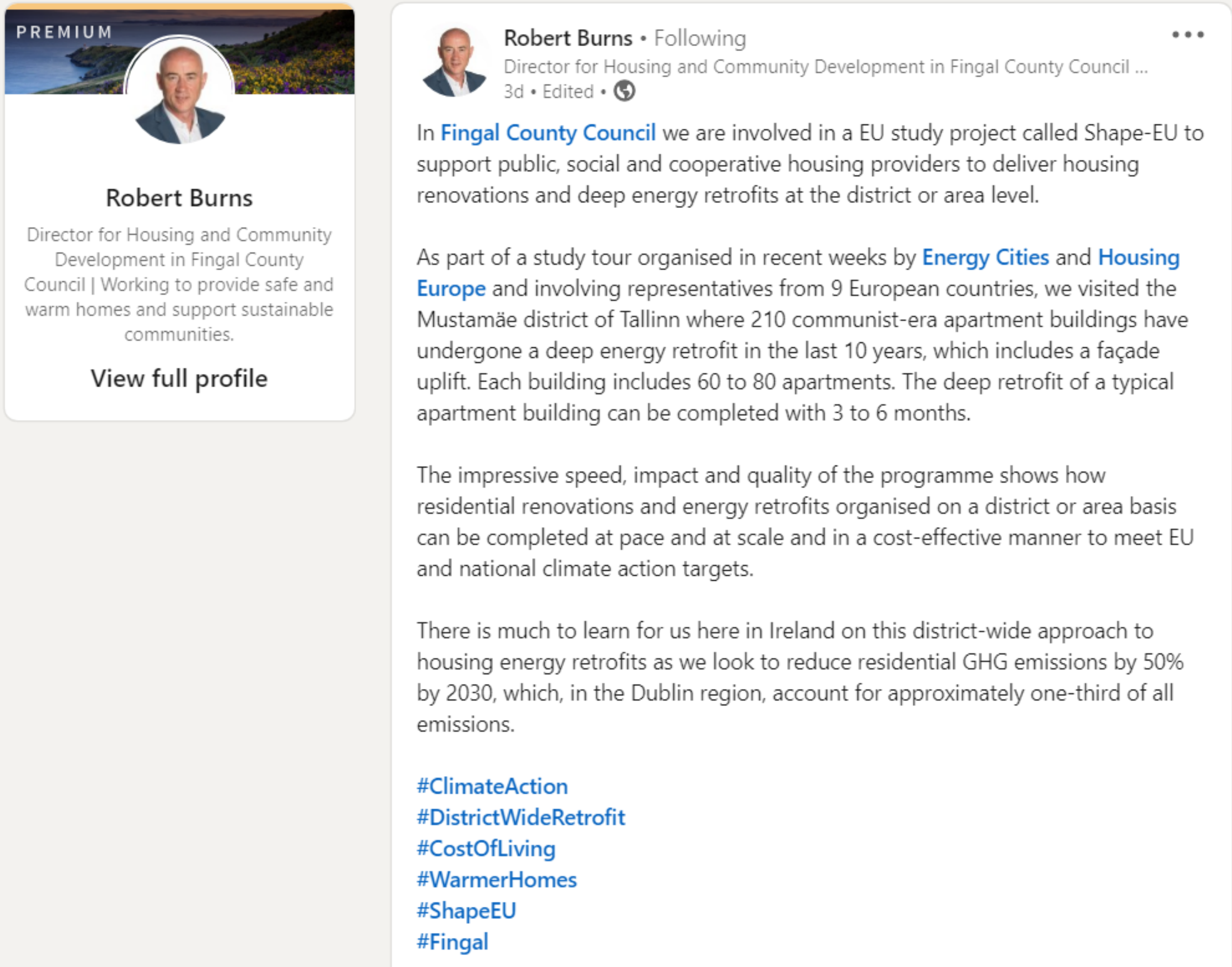


Wayfinding tools
Cost saving

One-sidedness?

Source: Adapted from Goulding et al. (2007)

(4) Policy to enable ‘show and tell’ R&D market intelligence (cont.)



PREMIUM

Robert Burns

Director for Housing and Community Development in Fingal County Council | Working to provide safe and warm homes and support sustainable communities.

View full profile

Robert Burns • Following

Director for Housing and Community Development in Fingal County Council ...

3d • Edited •

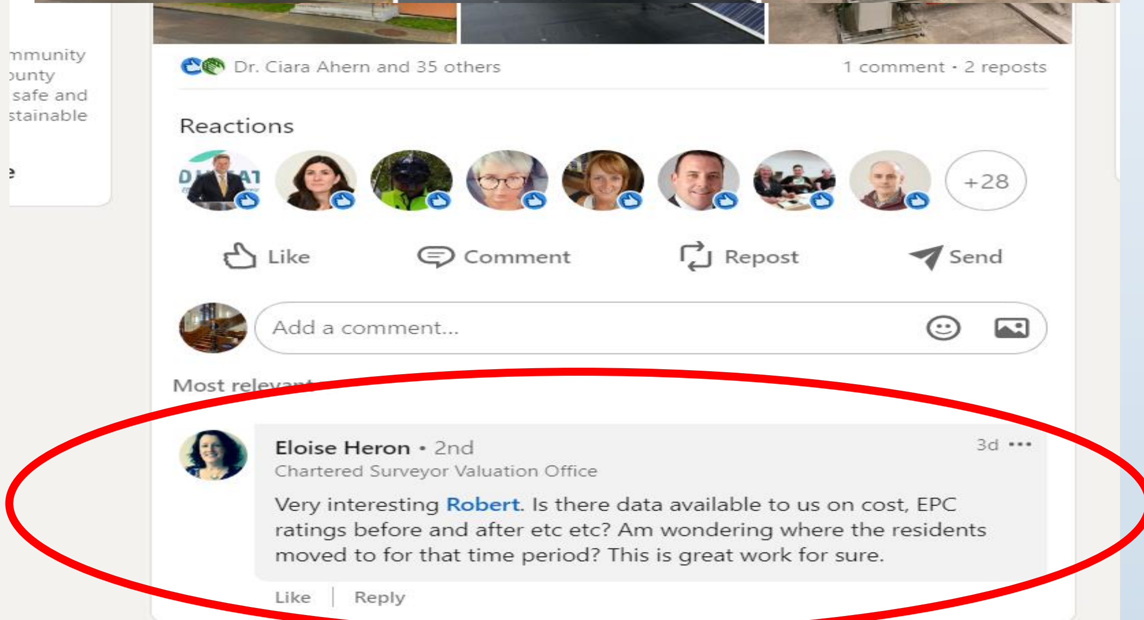
In Fingal County Council we are involved in a EU study project called Shape-EU to support public, social and cooperative housing providers to deliver housing renovations and deep energy retrofits at the district or area level.

As part of a study tour organised in recent weeks by Energy Cities and Housing Europe and involving representatives from 9 European countries, we visited the Mustamäe district of Tallinn where 210 communist-era apartment buildings have undergone a deep energy retrofit in the last 10 years, which includes a façade uplift. Each building includes 60 to 80 apartments. The deep retrofit of a typical apartment building can be completed with 3 to 6 months.

The impressive speed, impact and quality of the programme shows how residential renovations and energy retrofits organised on a district or area basis can be completed at pace and at scale and in a cost-effective manner to meet EU and national climate action targets.

There is much to learn for us here in Ireland on this district-wide approach to housing energy retrofits as we look to reduce residential GHG emissions by 50% by 2030, which, in the Dublin region, account for approximately one-third of all emissions.

#ClimateAction
#DistrictWideRetrofit
#CostOfLiving
#WarmerHomes
#ShapeEU
#Fingal



Dr. Ciara Ahern and 35 others

1 comment • 2 reposts

Reactions

+28

Like Comment Repost Send

Add a comment...

Most relevant

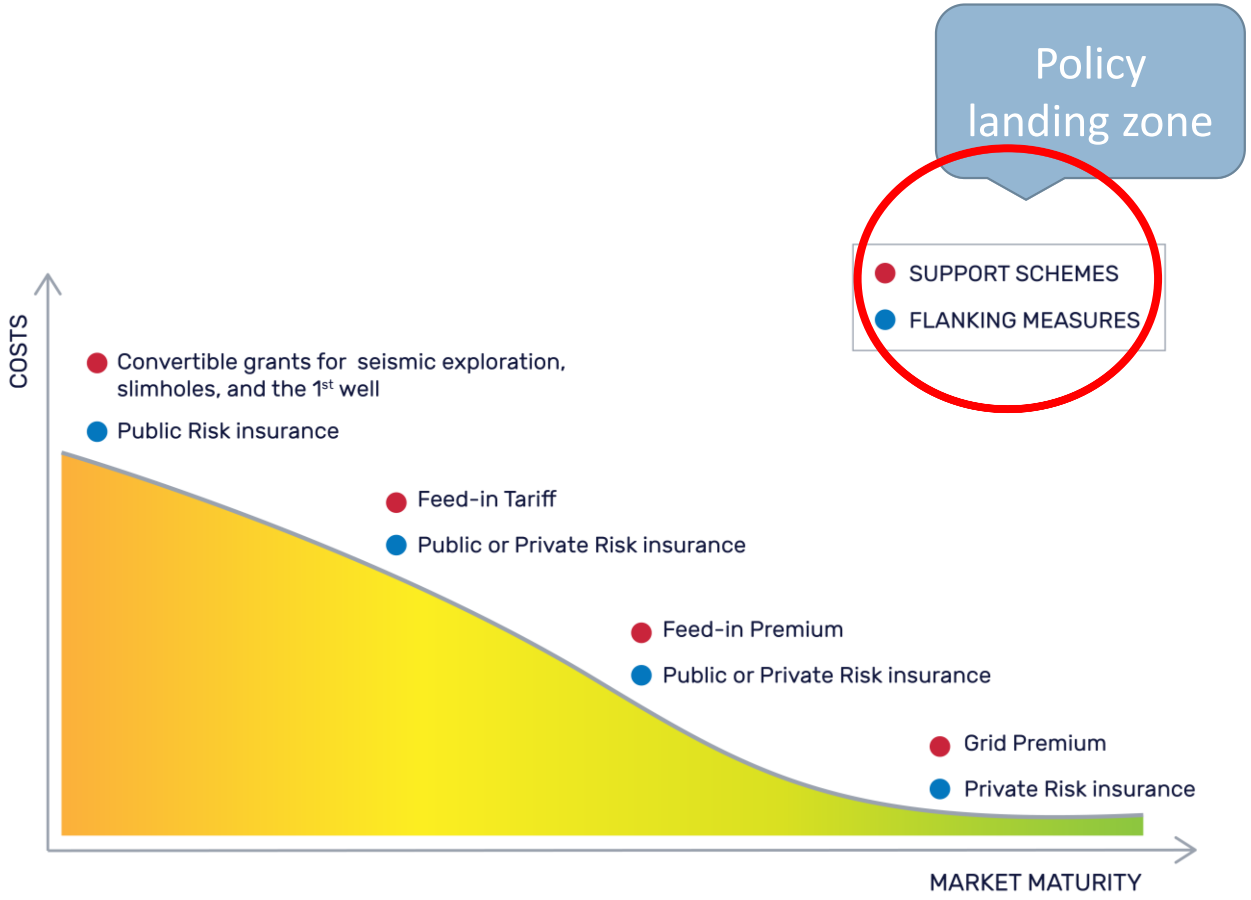
Eloise Heron • 2nd 3d

Chartered Surveyor Valuation Office

Very interesting Robert. Is there data available to us on cost, EPC ratings before and after etc etc? Am wondering where the residents moved to for that time period? This is great work for sure.

Like | Reply

(4) Policy *for nudging geothermal activity (cont.)*



Summary of NI geothermal activity progress, 2022		Analysis stage	Planning stage	Implementation stage
Strategy	Energy pathway alignment	Energy Strategy		Action 15 & 16
	Governance structure	GSNI/DfE	GSNI/DfE	GAC
	Vision	#NIGeothermalweek		
	Roadmap			
	Demostration resources	Depart for Economy	DfE Procurement	
	Business model development			
	Upstream TSCs	#NIGeothermalweek		Riddel Hall demo workshop
	Downstream TSCs			
	KPIs			
R&D	Geothermal Potential			
	Proof of concept demo	Stormont		
	Public engagement activity			
	R&D geothermal energy production			
	R&D geothermal energy storage			
	R&D carbon storage			
	Decision making tools			
	Data sharing obligations			
	Data access and available tool			
	Technology innovation and cost curves			
Policy & Regs Upstream	Heat as a resource			
	Deep & Shallow definitions			
	Feasability survey			
	Insurance schemes			
	Non-residental heat networks			
Policy & Regs Downstream	Grants & loans			
	Residental heat networks			
	Retrofit whole houses & streets			
	Air Condition Installations			
	Oil Pump Replacements			
	Heat Pump Installations			

Key:

	On course		Too early to say
	Some initial progress but not visible		No reported data
	Some initial progress but not significant		No benchmark or target
	Significant progress yet to be made		Significant progress made

(4)Policy sector-building approaches (cont.)

Different configurations:
Community residential,
Each with GSHP

Implementation/timeline ↑

	Small load cost/com acceptance	Med load cost/com acceptance	Large load cost/com acceptance
Long term	Hard to abate		Hard to abate
Medium term	Non residential (new) Shallow closed loop		Deep geothermal
Short term	Community residential (new) Shallow closed loop		Non residential (new)

End user relative costs/community acceptance →

Ridell Hall, QUB

https://edenderryvillage-energy.com

Concluding comments

Obligatory institutional passages for geothermal sector building – must go through the niche phases and institutions

Build sector institutions for geothermal technology readiness

Institutional work at the policy landing zones

Step 1 Demonstrators "show and tell"

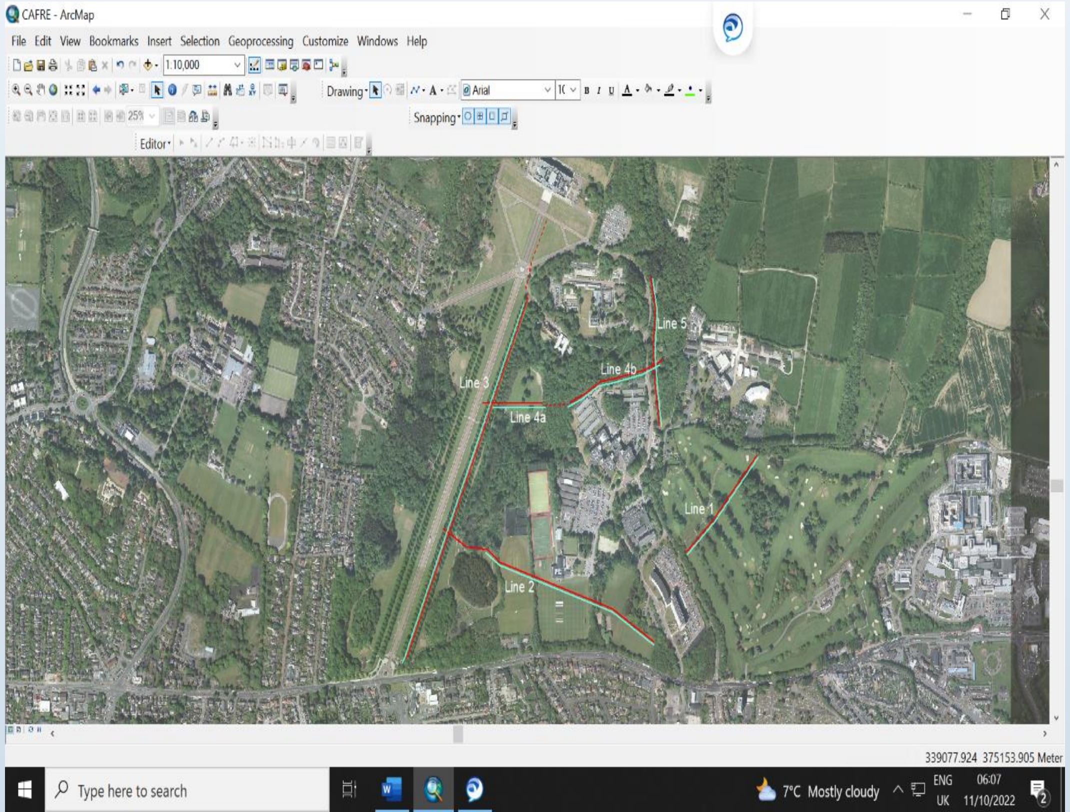
Value proposition offering

KPIs

Step 2 Geothermal Roadmap

Instructions for primary and secondary legislation

- Support geothermal entrepreneurs



OLLSCOIL NA GAILLIMHE
UNIVERSITY OF GALWAY

In partnership with iCRAG SFI Research Centre in Applied Geosciences · Ryan Institute · MaREI Centre for Marine and Renewable Energy

Shallow Geothermal for District Heating: University of Galway GEOFIT pilot experience.

Dr Marcus M. Keane (Civil Engineering)
Luis M. Blanes Restoy (Civil Engineering)
Dr Tiernan Henry (Earth & Ocean Sciences)

National Geothermal Energy Summit
November 9, 2022 TUD Grangegorman. Dublin

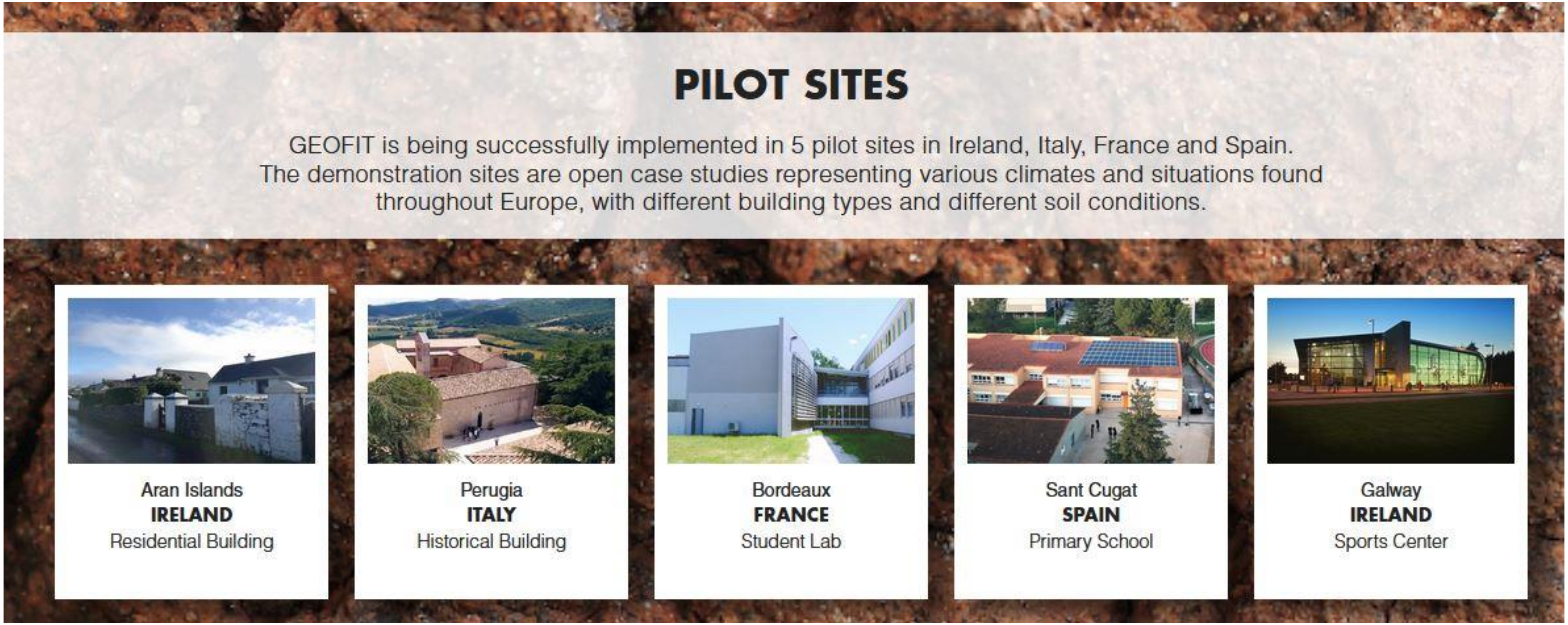
This project has received funding from the European Union's H2020 programme under Grant Agreement No. 792210

GEOFIT SMART GEOTHERMAL

University ofGalway.ie

GEOFIT EU (H2020 Project)

OLLSCOIL NA GAILLIMHE
UNIVERSITY OF GALWAY



geofit-project.eu/ geofit-project.eu/trainings/

Pilot Funding: **>€1M** from (1) EU-H2020 & (2) University of Galway Capital Investment

GALWAY Pilot: Key Facts

Thermal Energy Production : **400 MWh/year**

User: **University Swimming Pool Hot Water Heating**

Energy Use Reduction: **62%**

Energy Savings: **317 MWh/Year**

CO_2 Emissions Avoided: **24 TCOe²/year**

Equipment: **2 Dual Source (Air-Ground) Heat Pumps (50+50 kW)**

GSHEX: **17 closed loop vertical boreholes (150m depth, Ø 165 mm, 11 m separation)**

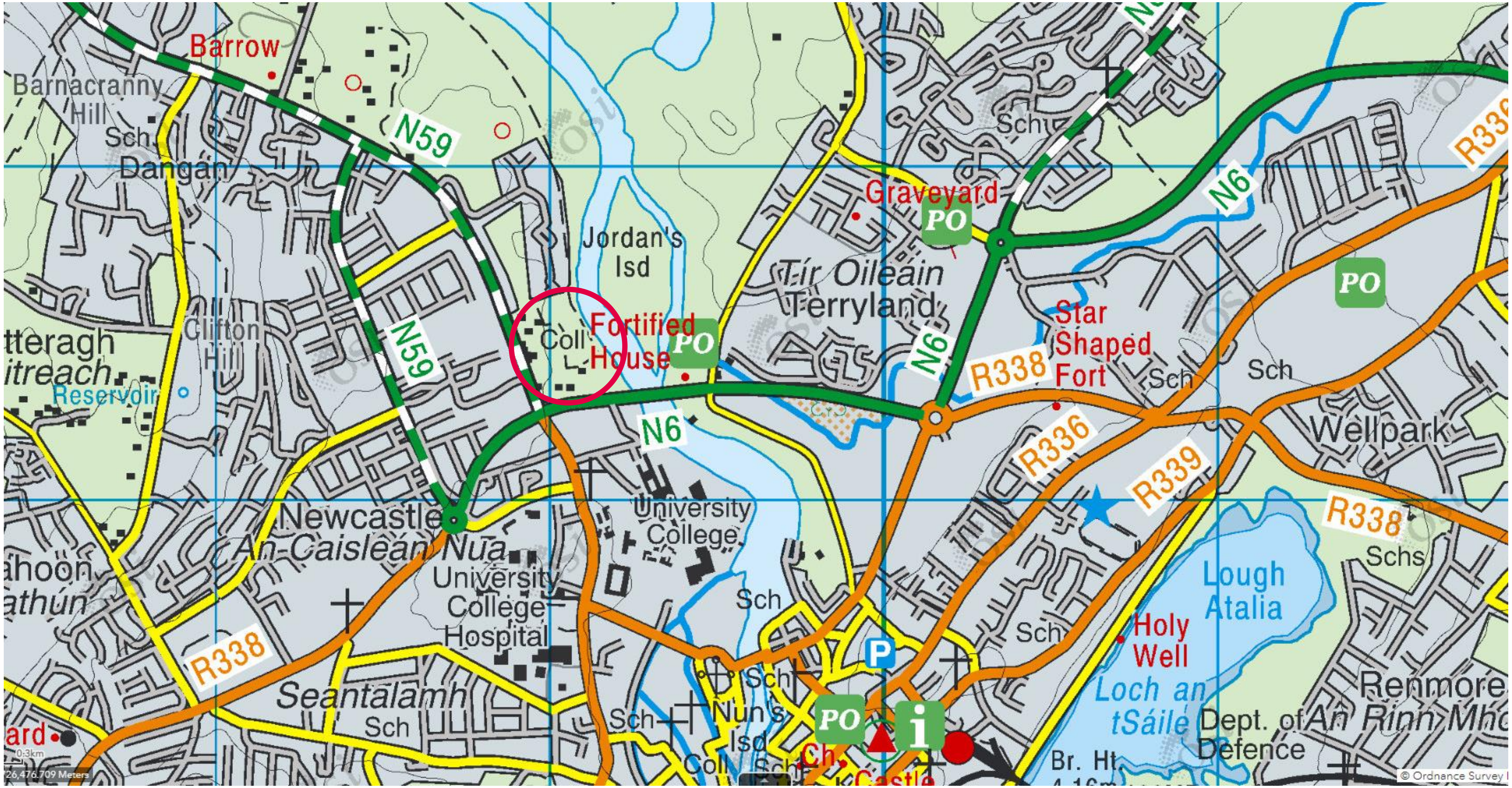
Equipment Phase Out: **2 Gas Fired Boilers**

Key Innovations

- Long Term Monitoring of Ground Temperatures with Distributed Temperature Sensing (DTS) system;
- Dual source switch cloud control optimization;
- Fully instrumented & monitored (*IEA TCP HPT Annex 52*);
- Academic Living Laboratory Open Data for Research.

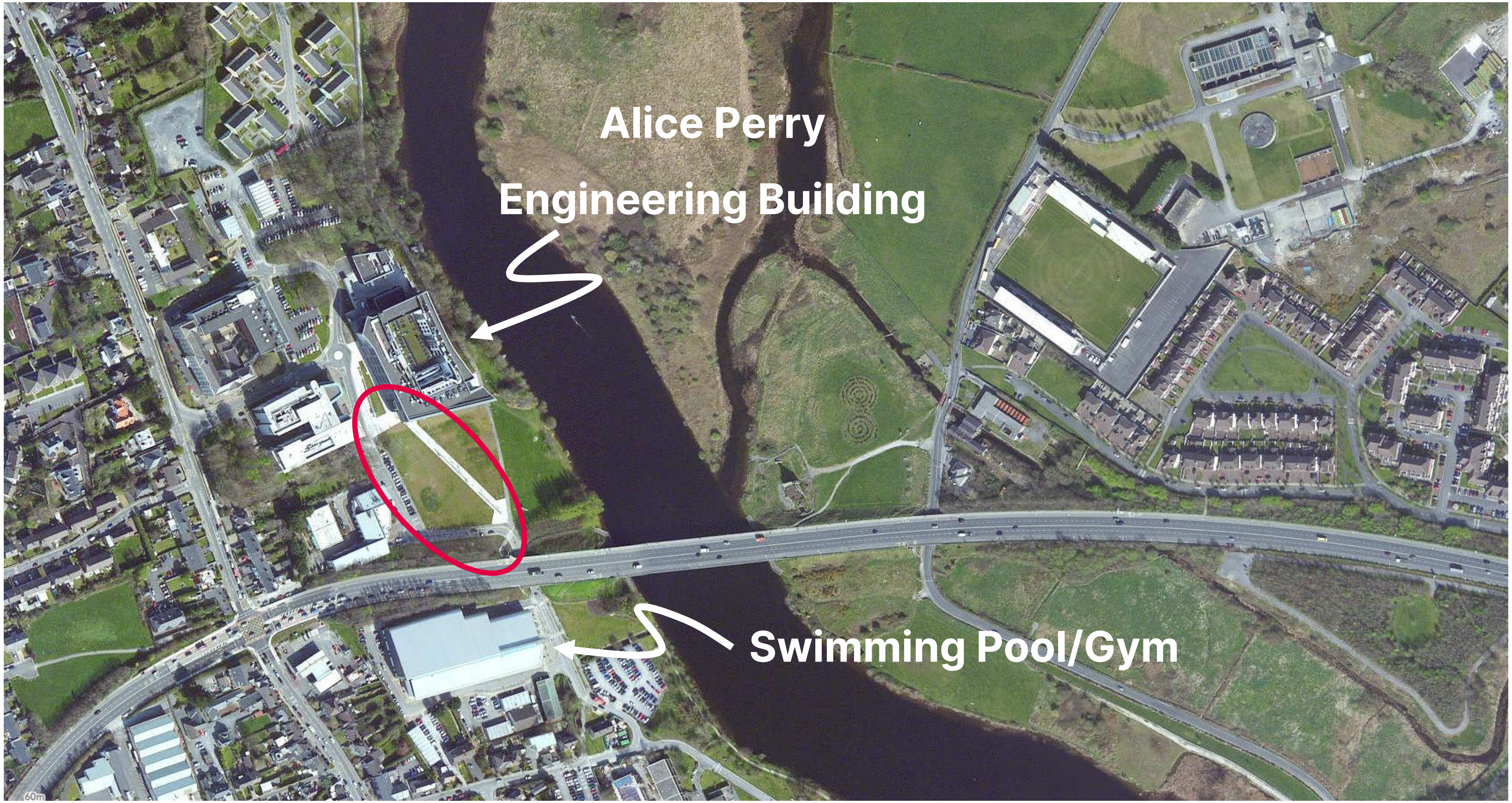
SITE LOCATION

OLLSCOIL NA GAILLIMHE
UNIVERSITY OF GALWAY

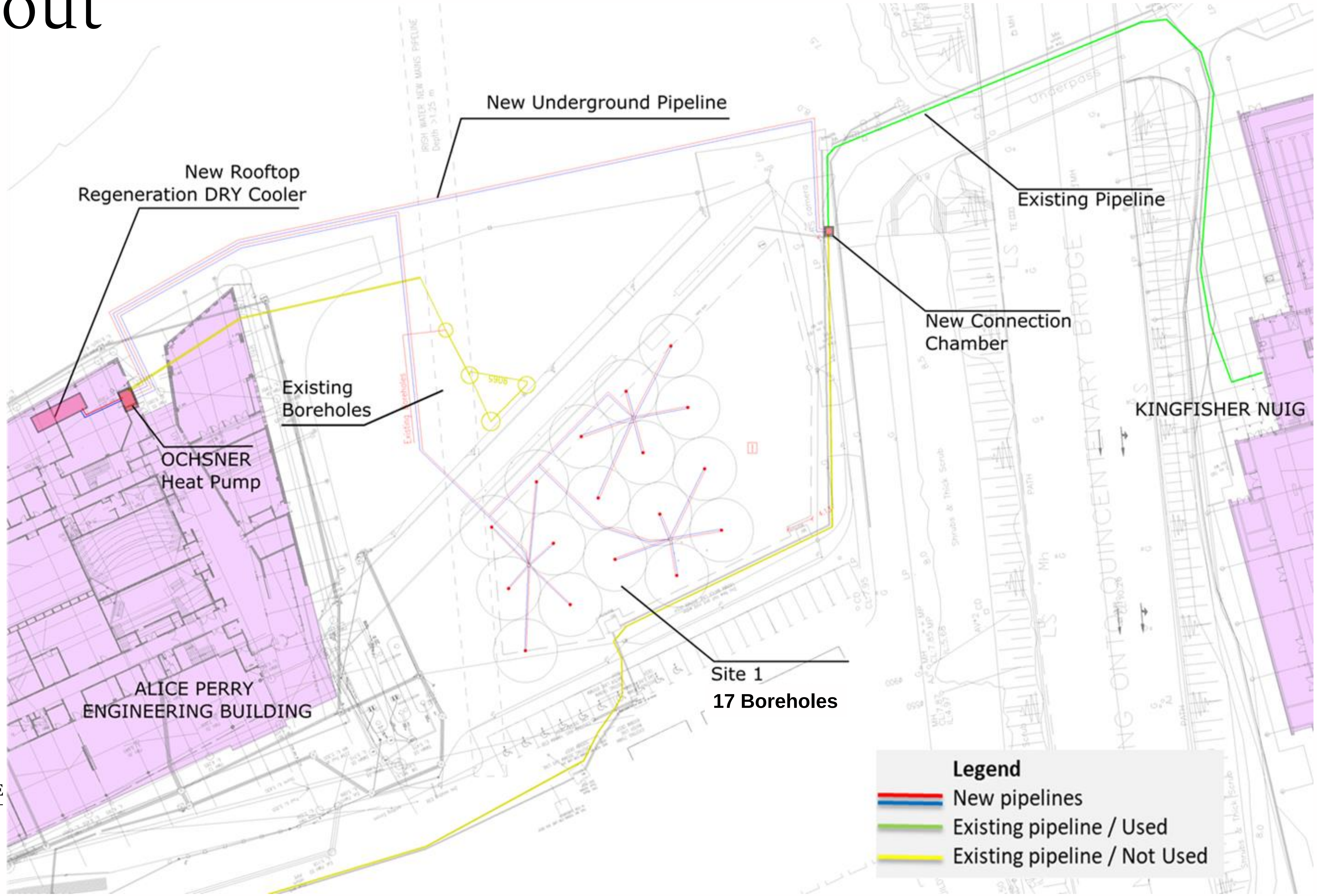


SITE LOCATION

Ollscoil na Gaillimhe
University of Galway

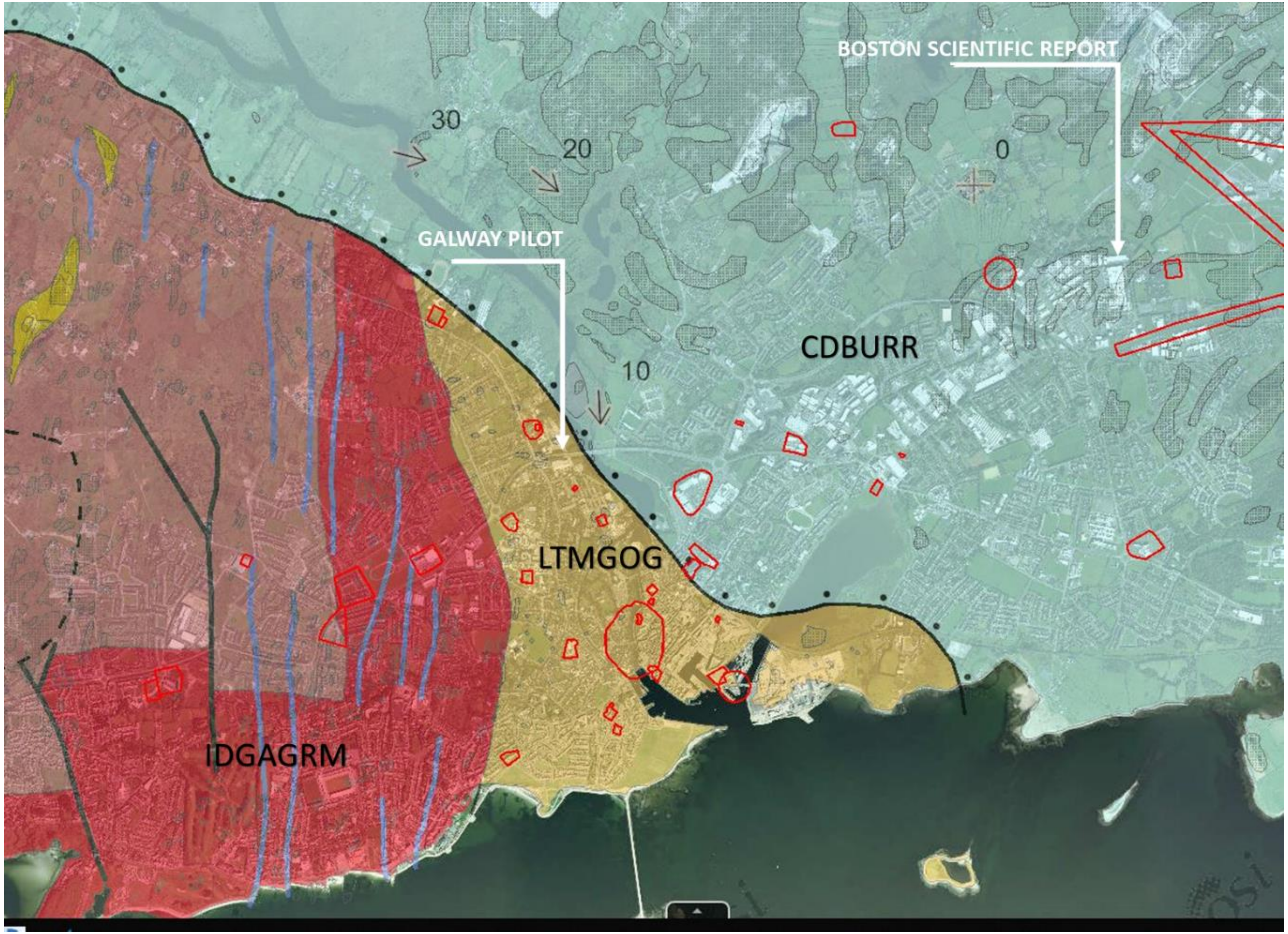


Project Layout



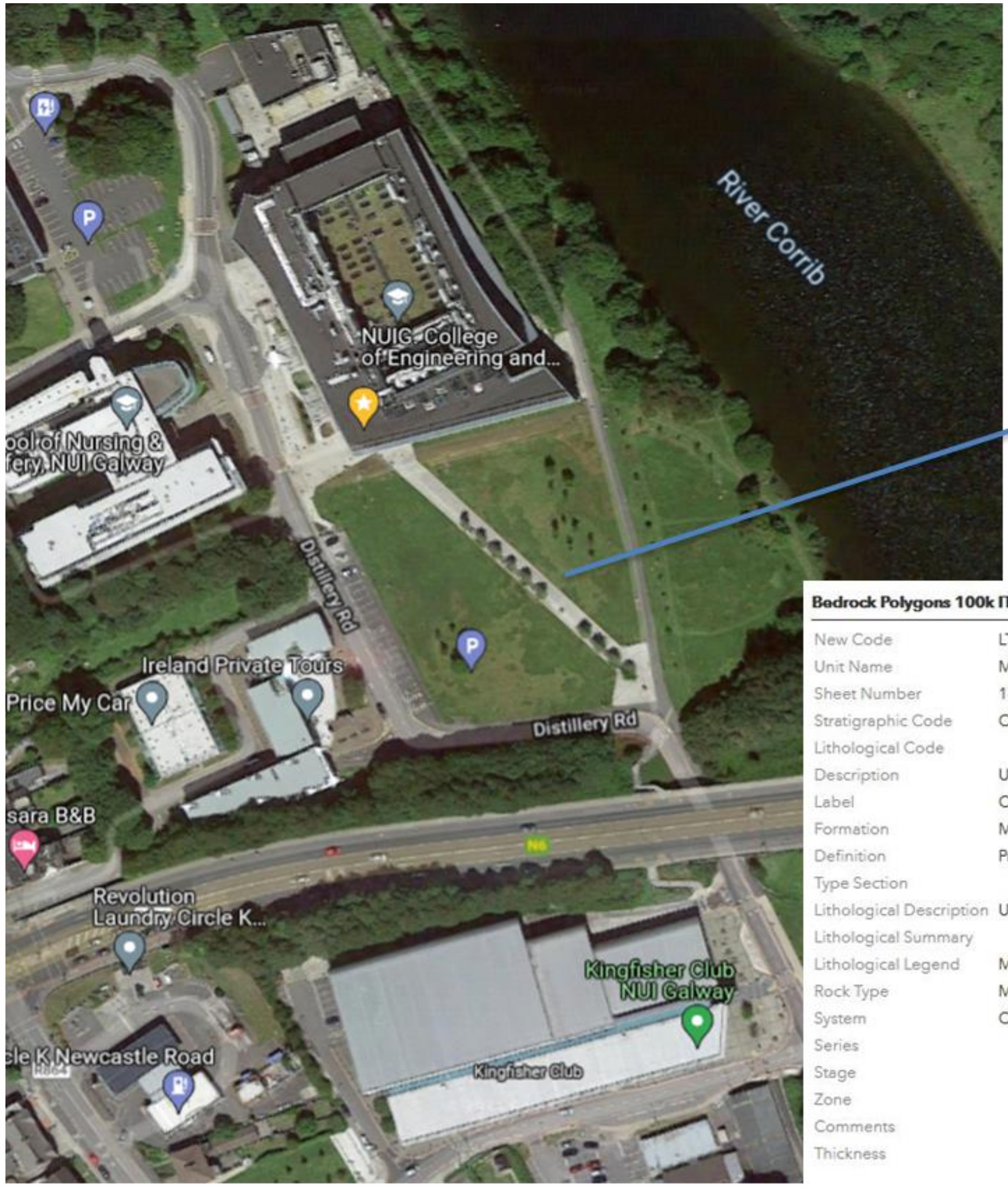
OLLSCOIL NA GAILLIMHE
UNIVERSITY OF GALWAY

SITE GEOLOGY



SITE GEOLOGY

Ollscoil na Gaillimhe
University of Galway



Bedrock Polygons 100k ITM 2018: Metagabbro & orthogneiss suite

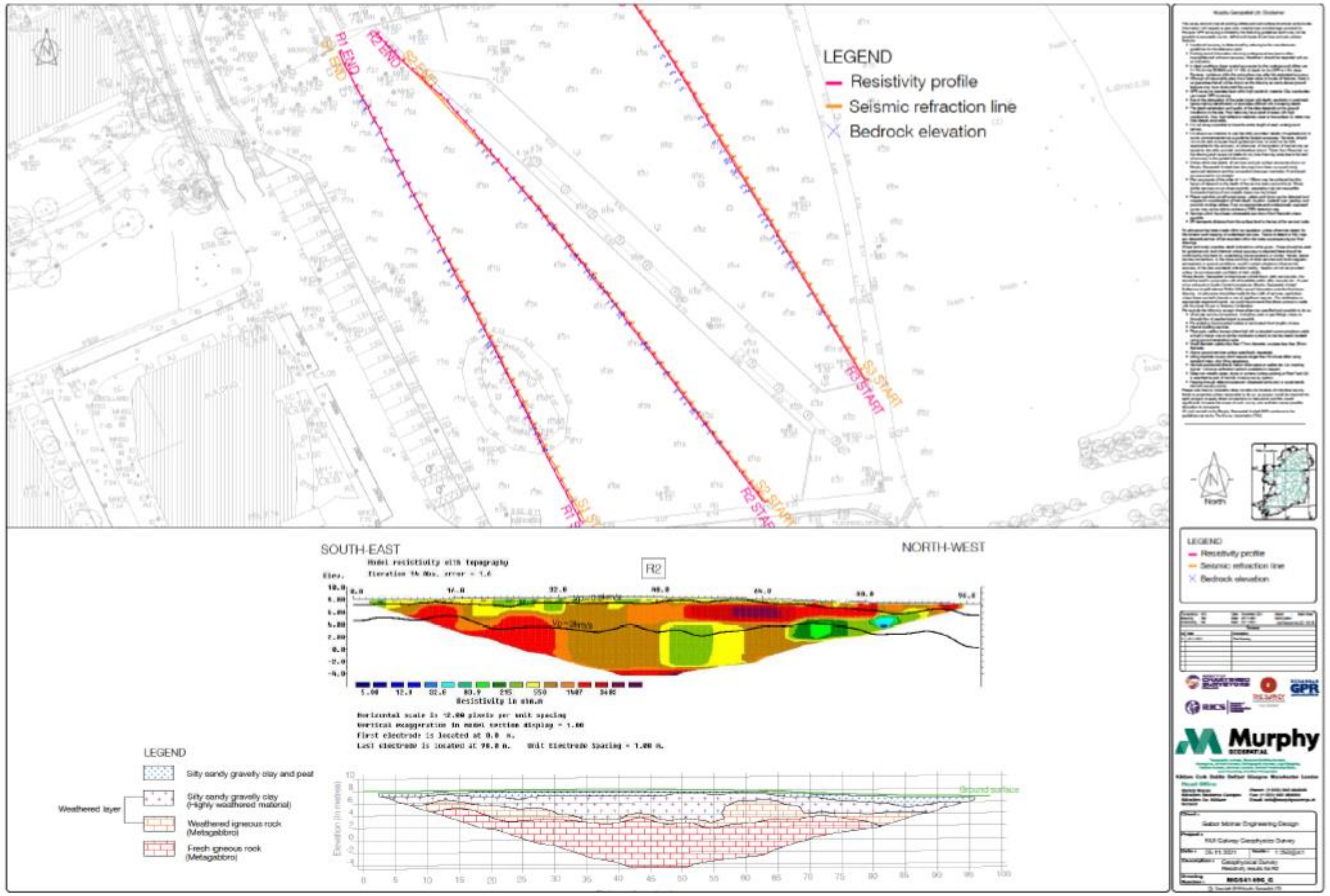
New Code	LTMGOG
Unit Name	Metagabbro & orthogneiss suite
Sheet Number	14
Stratigraphic Code	Om
Lithological Code	
Description	Undifferentiated
Label	Om
Formation	Metagabbro and Orthogneiss Suite (Undifferentiated)
Definition	Pracht et al (2004)
Type Section	
Lithological Description	Undifferentiated Quartz-Diorite Gneiss (Qd), Quartz Diorite Gneiss & Granitic Gneiss (Qg) and Metagabbro and Related Lithologies (Mg)
Lithological Summary	
Lithological Legend	Metagabbro and Orthogneiss
Rock Type	Metagabbro and Orthogneiss
System	Ordovician
Series	
Stage	
Zone	
Comments	
Thickness	

Related tables:

Bedrock100k_Seamless_2018 - BEDROCK.Lexicon_Polygons_2018

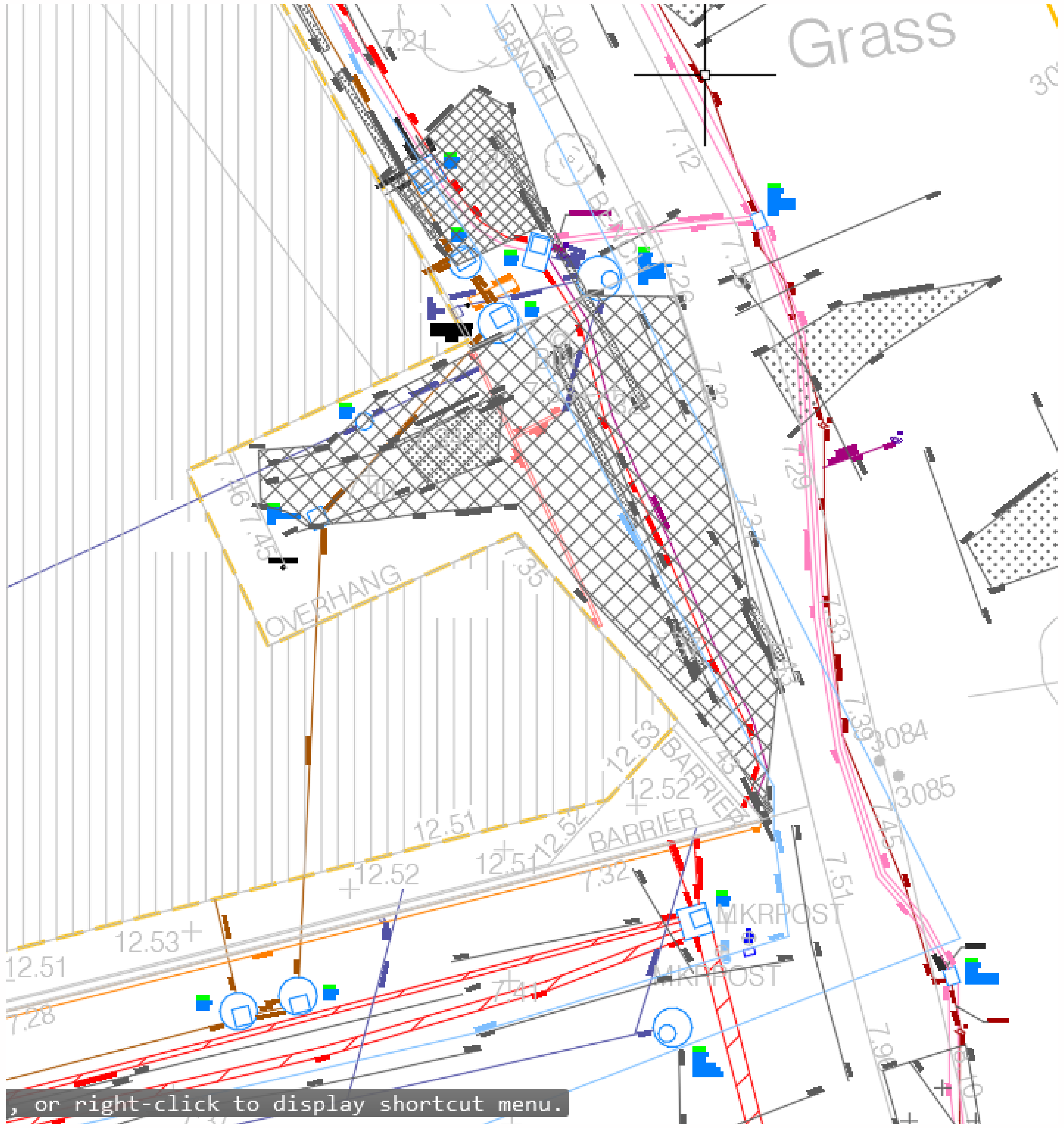
Preliminary Works – Geophysical Survey

- Geophysical investigation
- Hydrogeological investigation
- NATURA impact assessment
- Planning granted April 2022
- Site work started Sept 2022



Ollscoil na Gaillimhe
University of Galway

Preliminary Works – Municipal Services



Ollscoil na Gaillimhe
University of Galway

Site Progress

How it started...

Ollscoil na Gaillimhe
University of Galway

Site Progress

Busiest Moment with no. 3 drill rigs and borehole filling

OLLSCOIL NA GAILLIMHE
UNIVERSITY OF GALWAY

Site Progress

Single loop DN 32 probe installation

Circulating fluid: water & mono-ethylene glycol (-17°C)

OLLSCOIL NA GAILLIMHE
UNIVERSITY OF GALWAY

Site Progress

Drilling completed. Pipe connection.

OLLSCOIL NA GAILLIMHE
UNIVERSITY OF GALWAY

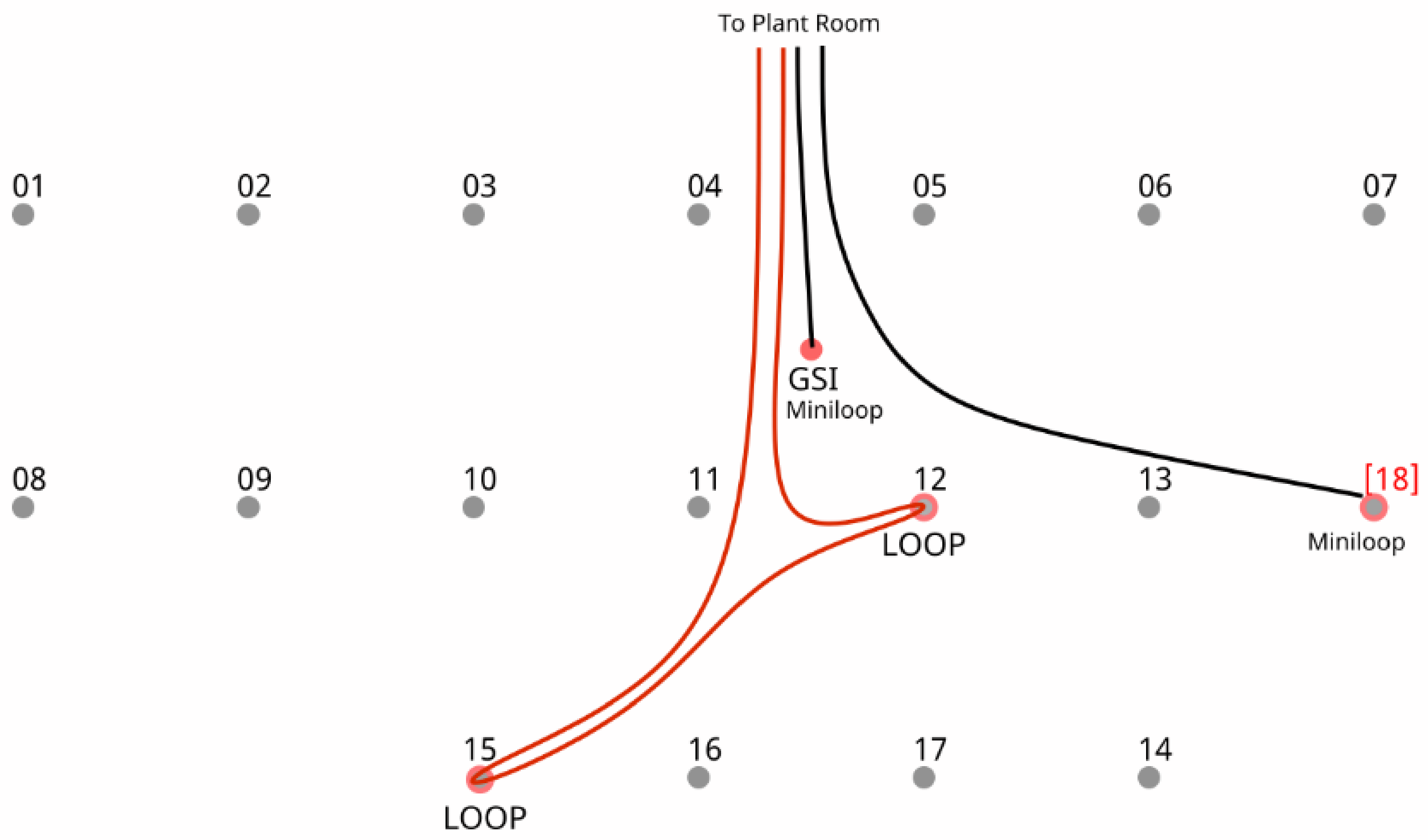
Site Progress

Downhole instrumentation (DTS cable)

Ollscoil na Gaillimhe
University of Galway

Project Layout

GEOFIT - Fibre Optic Layout
22-09-2022



Ollscoil na Gaillimhe
University of Galway

Core Exhibition (GSI)

Geological Survey
Suirbhéireacht Gheolaíochta
Ireland | Éireann

Ollscoil na Gaillimhe
University of Galway

Core Extraction

Geological Survey
Suirbhéireacht Gheolaíochta
Ireland | Éireann

Lessons Learned

- **Pre-Tender** surveys & geological characterization for due diligence and info packs (**trial** borehole for TRT & geological characterization effective for securing funding, real data for planning & engineering at early stage;
- Supply chain & bottlenecks (not only electronics);
- Think Long-Term/Big Picture for large scale projects:
  - Limitations of what geothermal can do, sometimes small is better than nothing;
  - Sometimes it is better to retrofit with a Coefficient of Performance =3 system than no retrofit at all (*ratio of useful heating or cooling provided to work (energy) required*);
  - Do size all parts of the system holistically… but think also on modularity and expansion;
  - Use experienced M&E consultants (HPs, GSHEX and are able to detail-engineer)

Plan for future R&D Activities

- Address the three unknowns:
  - DTS calibration & first measurement of the **Undisturbed Ground Temperature** (GSI);
  - Thermal Response Testing (TRT) – Heat Extraction: **Borehole Thermal Resistance**;
  - Bedrock **Thermal Conductivity** (Direct Measurement from Sample – Geoserv);
- Commissioning & Handover;
- Dual Source Switch: *Cloud Based Machine Learning Service* (iLECO);
- Long Term Performance of Ground Source Heat Exchanger;
- Potential for Ground Storage Seasonal Balancing (Direct – Indirect);
- Local Flexibility Markets (De-Risk) EU-H2020 project - Storage – PV Integration.

Thank You

Contact:
luismiguel.blanesrestoy@universityofgalway.ie
tiernan.henry@universityofgalway.ie

Ollscoil na Gaillimhe
University of Galway

In partnership with

iCRAG SFI Research Centre in Applied Geosciences
Ryan Institute
MaREI Centre for Marine and Renewable Energy

EDEN GEOTHERMAL PROJECT

Progress Update & Future Plans

National Geothermal Energy Summit 2022
TUD Grangegorman

Wednesday 9th November, 2022

Robbie Bilsland
Drilling Engineer
Eden Geothermal Ltd

Agenda

1. **Introduction to Eden**
   - Project Phase Breakdown
2. **Phase 1 Execution**
   - Geological Targeting
   - Site Selection & Preparation
   - Drilling Planning & Execution
   - Reservoir Characterisation
3. **Phase 1 Conclusion**
   - Coaxial Completion & Heat Main
   - Heat Demonstration
4. **Future Plans**
5. **Closing Statements**

Who's Involved

Eden Geothermal Limited is a partnership between the Eden Project and geothermal specialists EGS Energy and Bestec UK. The company was set up to drill the first geothermal well at Eden.

We're working with the University of Exeter as academic research partner, and specialist contractors selected via a competitive tender process, to deliver the Eden Geothermal Project.

Phase One – Drill & Test EG-1:

- Industrial research project
- Co-funded by the ERDF, Cornwall Council, and Gravis Capital Management.
- Demonstrate a GHG emission saving from a single well

Phase Two – Drill & Test EG-2

Phase Three – Power Plant

- Design, Build & Commission the power and heat plant

Eden Project

What is Eden?

- A regenerated former China Clay pit
- Designed to showcase the worlds most important plants and humans dependence on them
- These plants are housed in worlds biggest greenhouses; the Rainforest and Mediterranean Biomes

Carbon Saving Opportunity:

- Heating the biomes is currently dependent on gas and biomass
- Could the heat resource from Cornwall's granites be used to reduce the greenhouse gas emissions?

Eden Geothermal Project Objective:

To develop a deep geothermal energy system that provides sustainable heat and power at the Eden Project.

Geological Target

Elevated heat gradient in Cornwall:

- St Austell granite has one of the highest heat flows in the UK
- Expected heat gradient of 37-39°C/km

Indication of a major fault system:

- NNW-SSE Fault Zone called the Great Crosscourse
- Crosscourse structures aligned perpendicular to Minimum horizontal stress
- Identified in local mining records
- Surface Outcrop
- Permeability likely in the form of this fault structure

The Geothermal Opportunity:

Can we intersect the GXC fault at sufficient depth to provide the heat and permeability required to support an Enhanced Geothermal System

Fault trace inferred from pre-Eden mapping

Mueller, S., Scott, P.W. and Evans, M.J. (1999). Kaolinisation, mineralisation and structures in biotite granite at Bodelva, St. Austell, Cornwall. *Geoscience in south-west England*, **9**, 310-317.

Site Planning & Preparation

Selection Criteria:

- Within reach of subsurface target
- Proximity to heat demand
- Large, level site

Planning Consent :

- Access & traffic management
- Noise constraints
- Environmental Impact

Key Considerations:

- Engagement with Local Community
- Reinforced pad to support Bentec 450 rig
- Seismic Network Deployment
- Water availability & storage

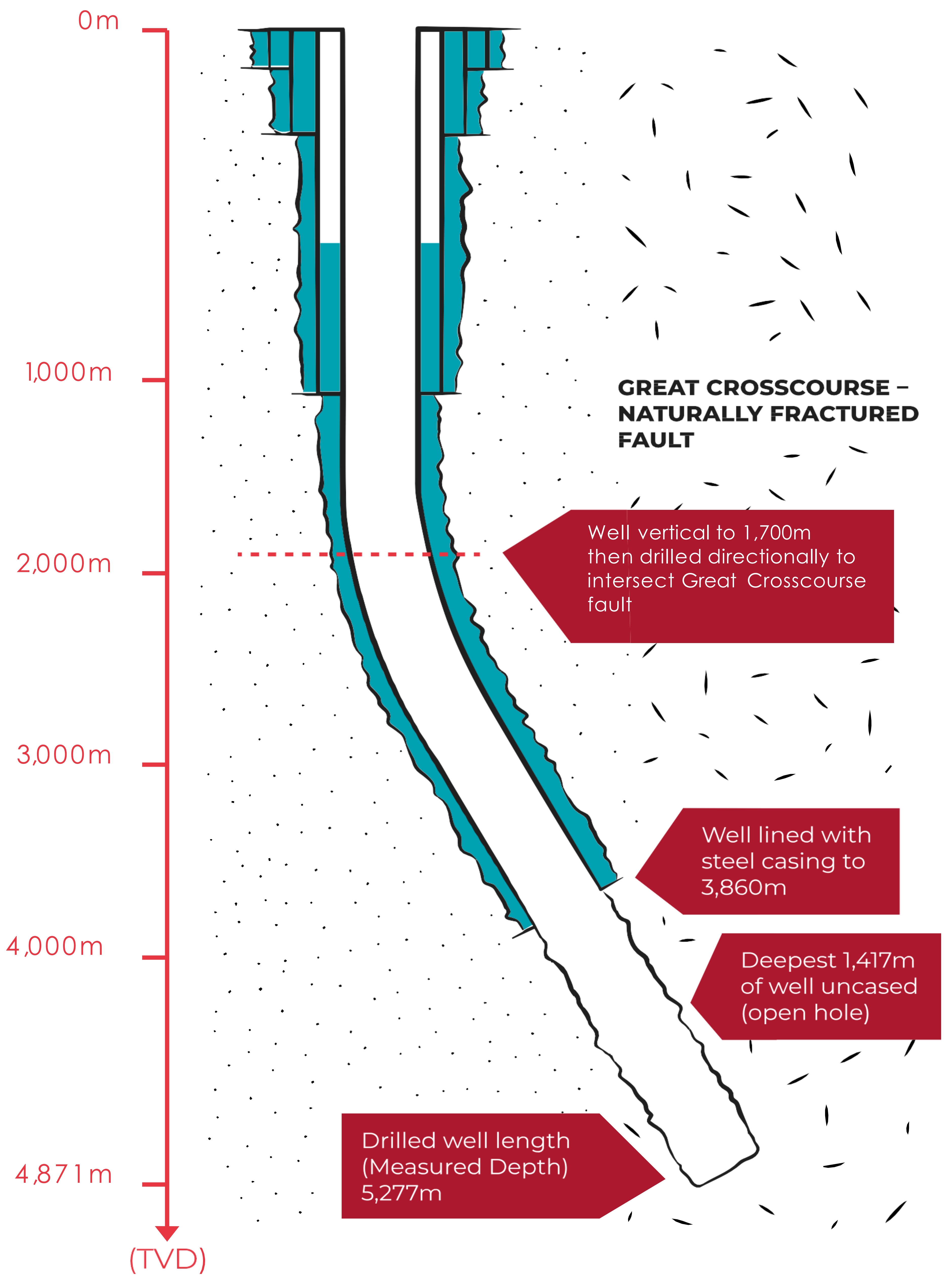
Drilling Programme

Well Design Requirements:

- J-Type well building to ~40° inclination
- Approaching the GXC from the footwall
- 8 ½" Section to be left open hole

Key Observations:

- Successful drilling operation, entirely in Granite!
  - Well TD = **5,276.67m MD** / **4,871m TVD**
  - Drilling duration = **164 days**
- Significant loss zone encountered at 3,950m MD during 12 ¼" Section
  - Balance plug required to run 9 5/8" casing
  - Not yet certain if it is the GXC
  - Complex fault system with fines production
- Multiple fracture zones encountered during 8 ½" section



Reservoir Characterisation

Wireline Operations:

- After each drilling section
- During well testing

Well Testing Operations:

- Injection & Production Testing

Seismic Monitoring Data:

- Continuously throughout drilling & well testing
- Ground motion sensors to give PGV

Well Cleaning Program with MEET:

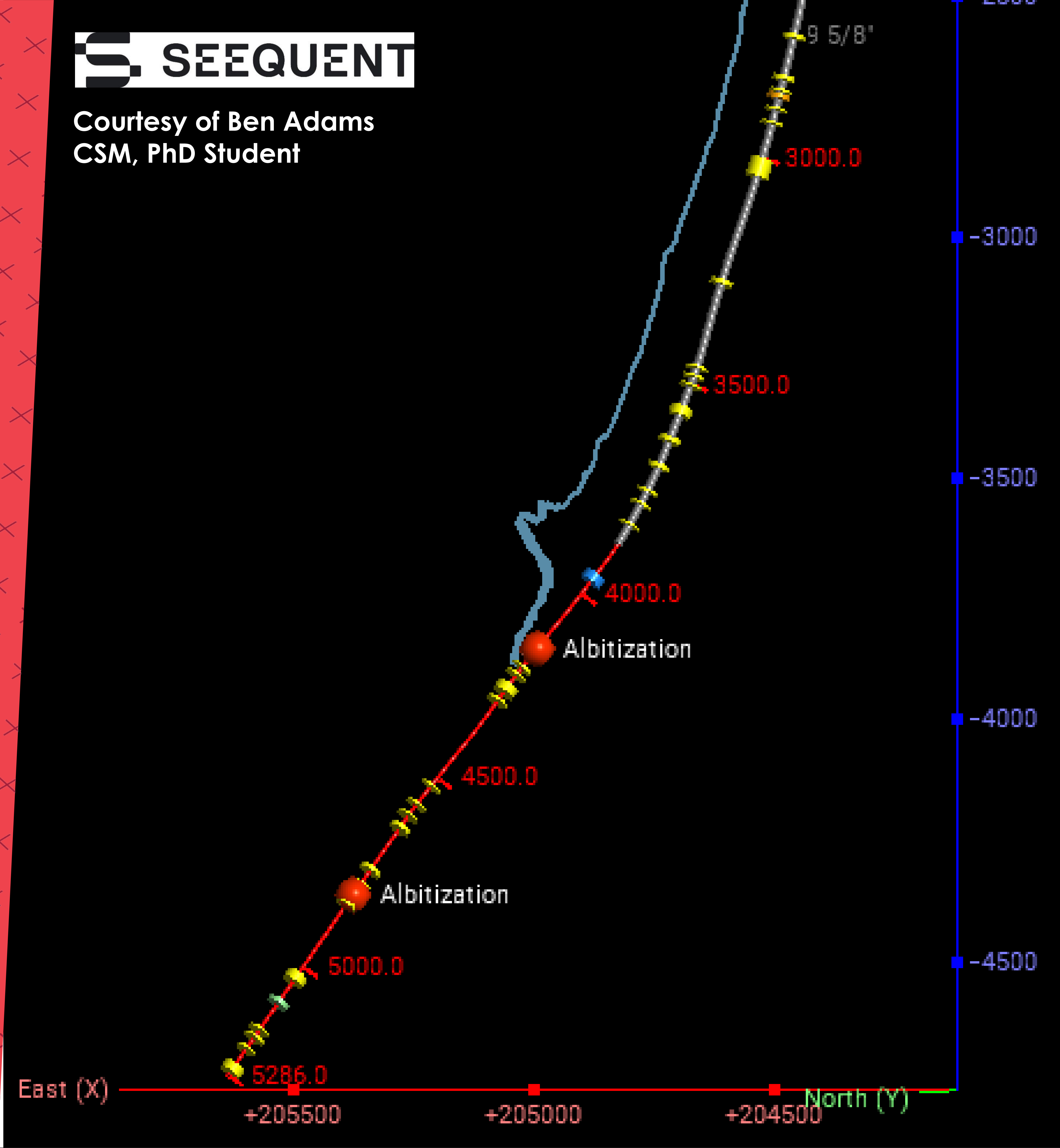
- Chemical stimulation to target balance plug
- An attempt to reinstate or improve permeability observed while drilling
- Clear sign of improvement, analysis ongoing

Further testing planned

MEET Multi-sites EGS Demonstration

SEEQUENT

Courtesy of Ben Adams
CSM, PhD Student



Heat Demonstration

Single well heat exchanger proposed to close out Phase 1 to demonstrate heat provision to Eden.

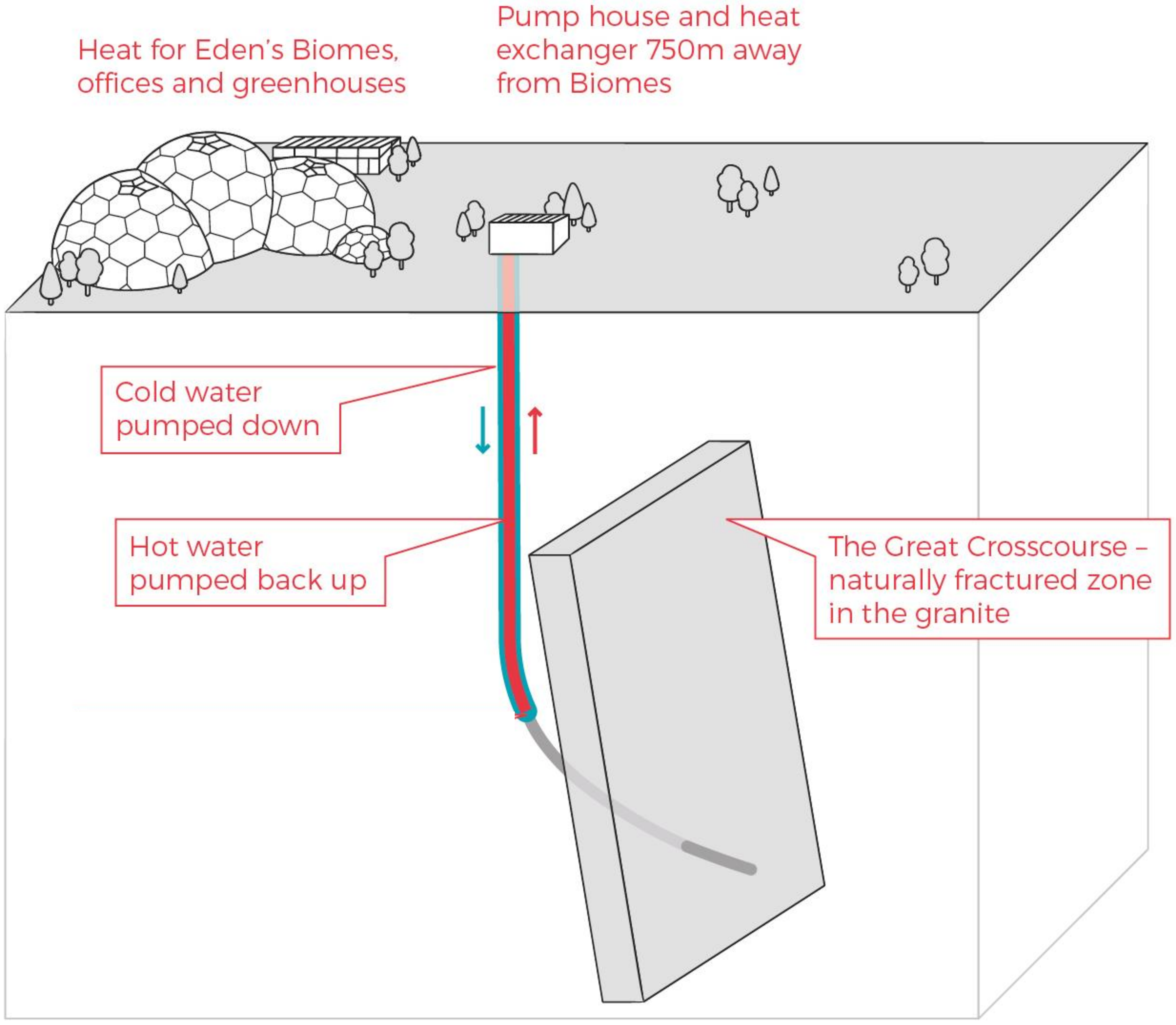
Eden Heat Demand:

- Eden Biomes = 800kWth
- Greenhouses = 200kWth
- Spa & Hotel Complex (TBC)

Operational Requirements:

- Coaxial completion in EG-1
- Heat Main Installation
- MEP Modifications

Key Validation step for ERDF funding is to prove GHG emission reduction.



Coaxial Completion

Temporary completion to prove a GHG saving for Eden.

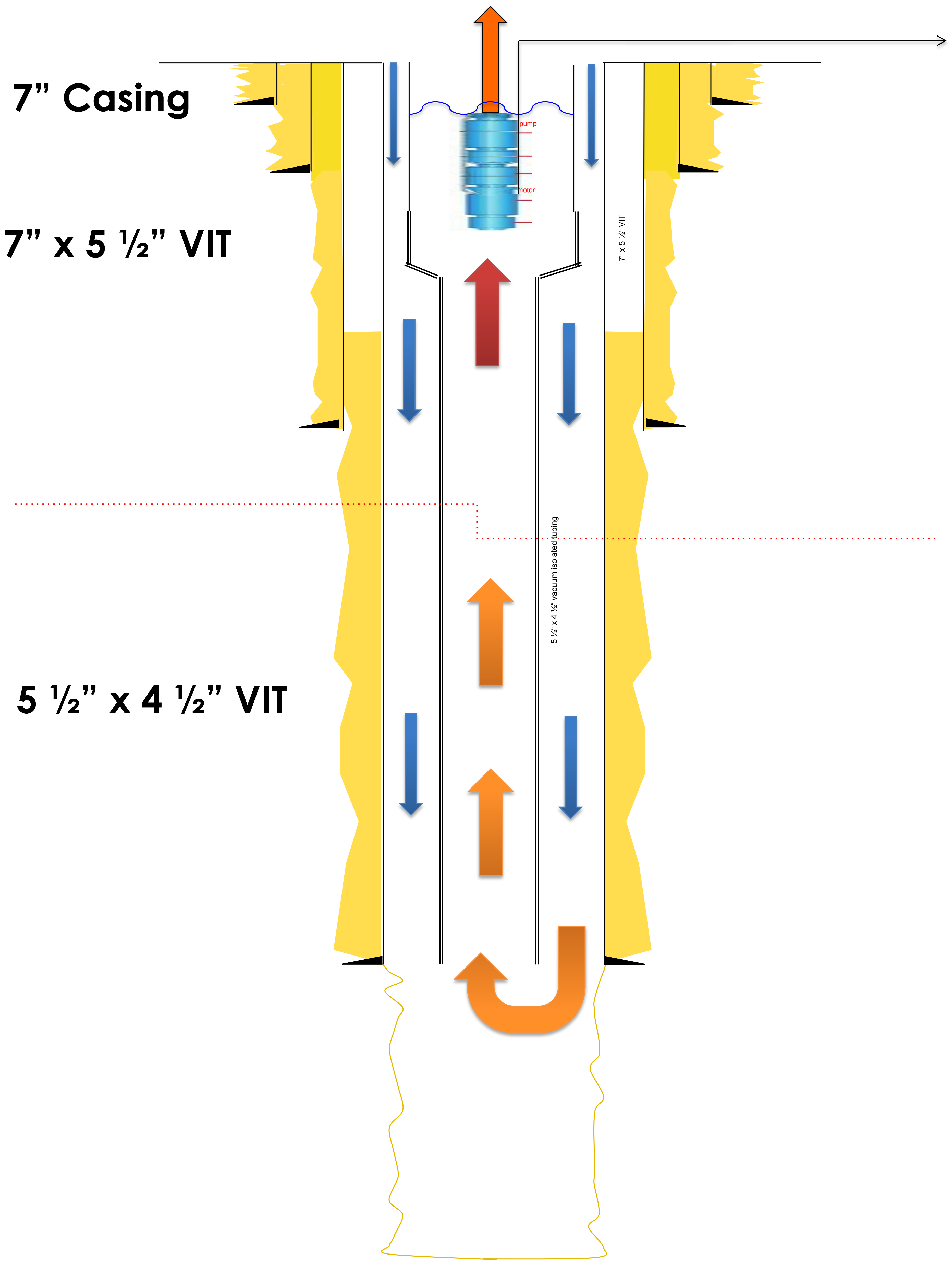
Key Metrics:

- Setting depth = ~3,850m MD
- Temperature at setting depth = ~150°C
- Flowrate = up to 5 l/s
- Injection temperature = ~20°C
- Surface temperature = ~90°C

Objectives:

- Case study of a functioning deep single well heat exchanger
- Define optimal parameters for most efficient heat extraction over time

During the heat demonstration, attention will switch to planning EG-2.



Heat Main

- Follows 1.4km route from EG-1 to Eden Energy Centre
- 6” pipe with Polyurethane insulation
- Max Operating Pressure = 25 bar
- Max Flowrate = 30 l/s
- Anticipated temperature loss = <1°C

Closing Statements

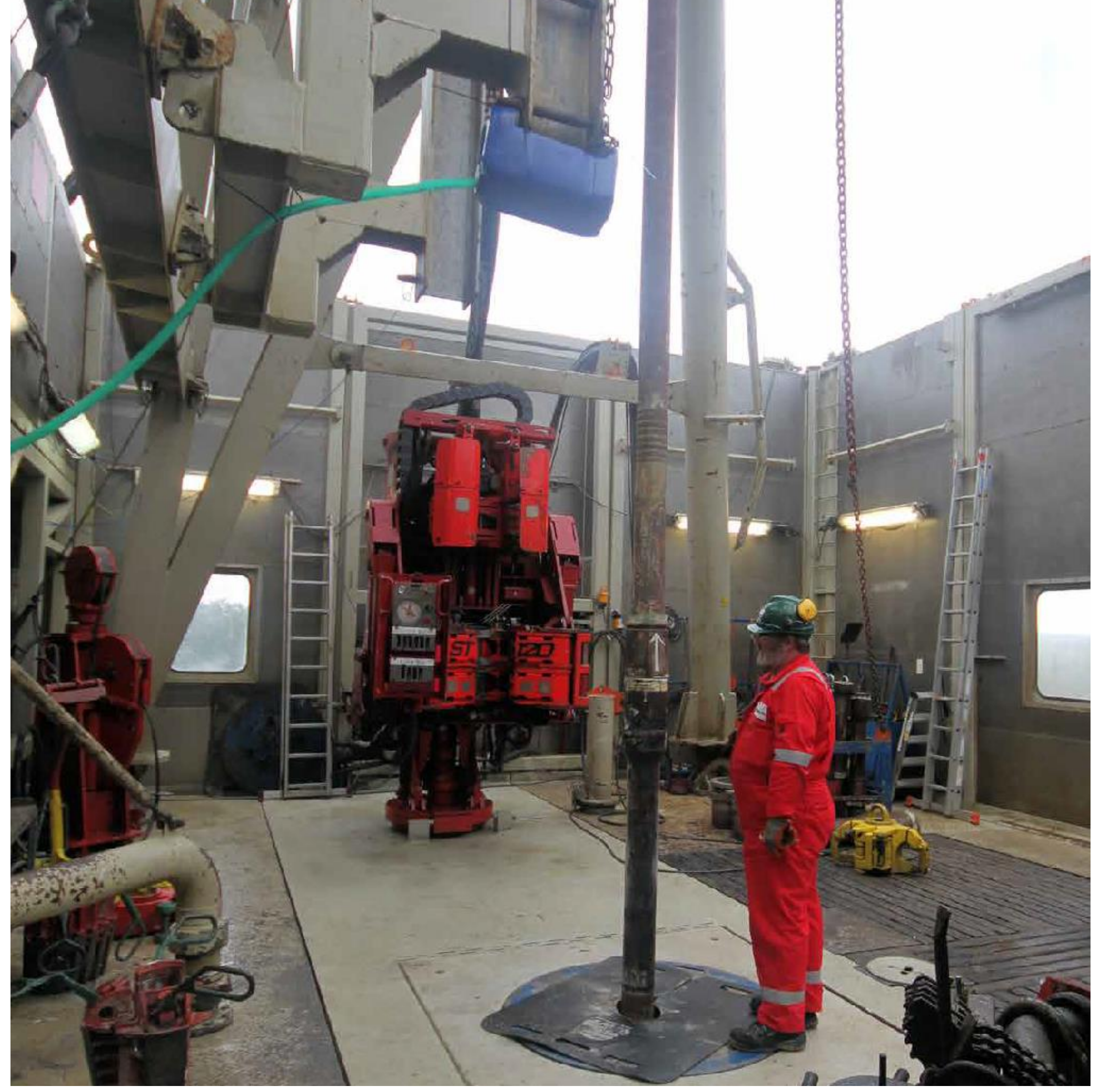
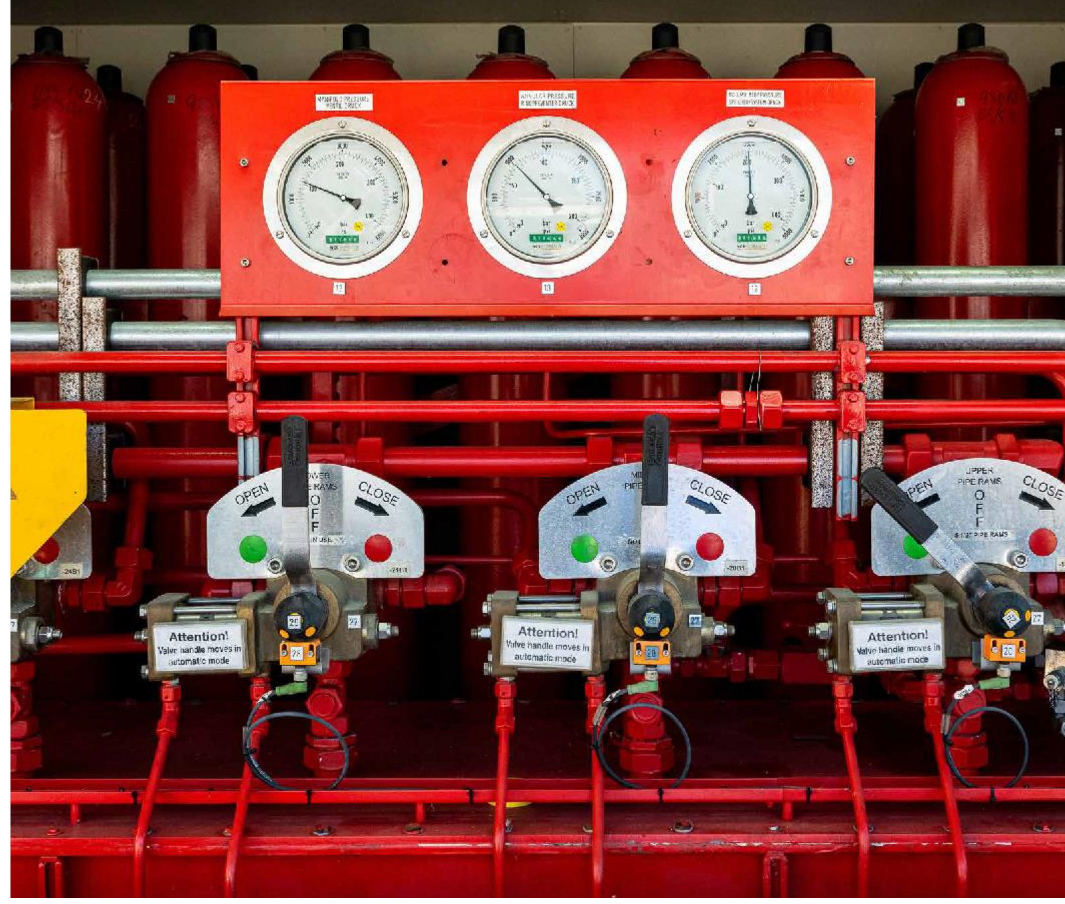
Progress So Far:

- Successful Drilling Campaign
- Dealing with a complex fault system which is not fully understood
- Focus turns to closing out Phase 1, need to validate ERDF funding

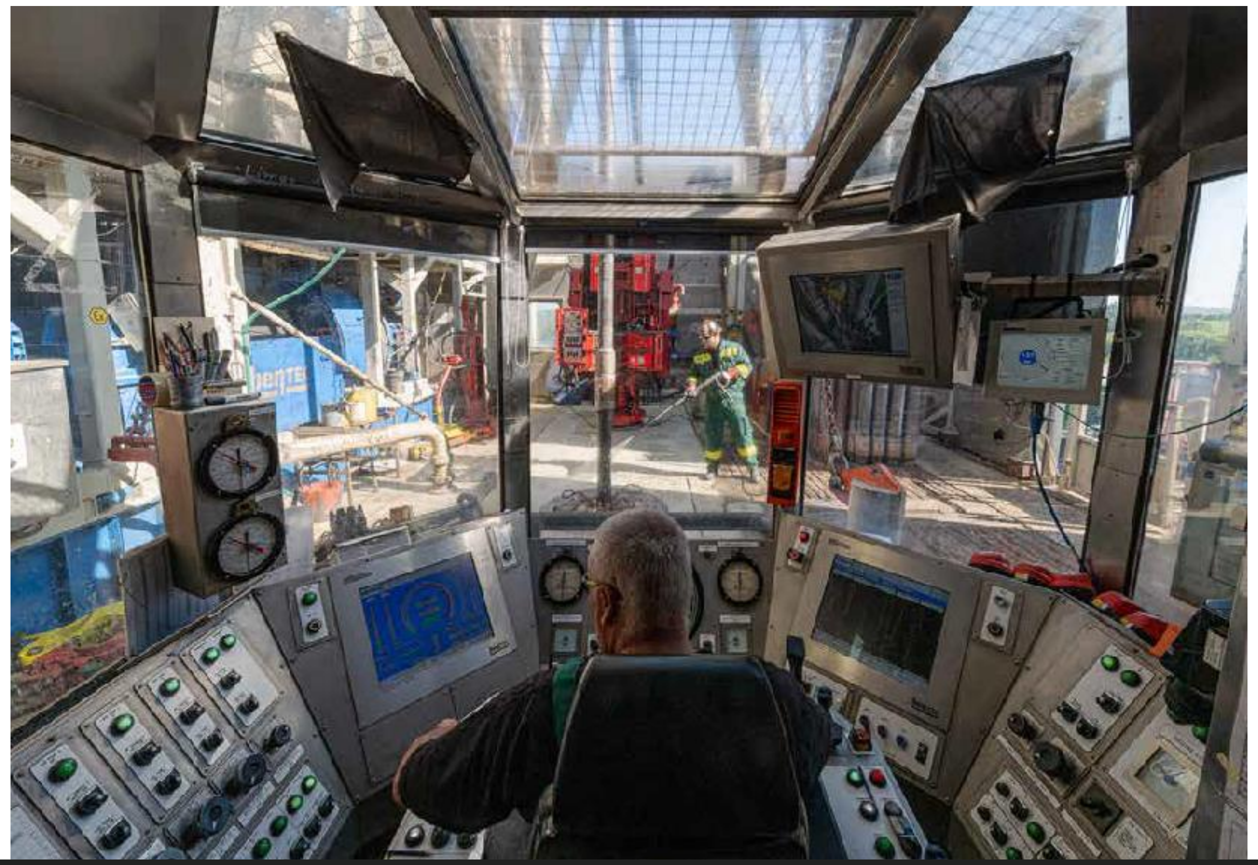
Future Plans:

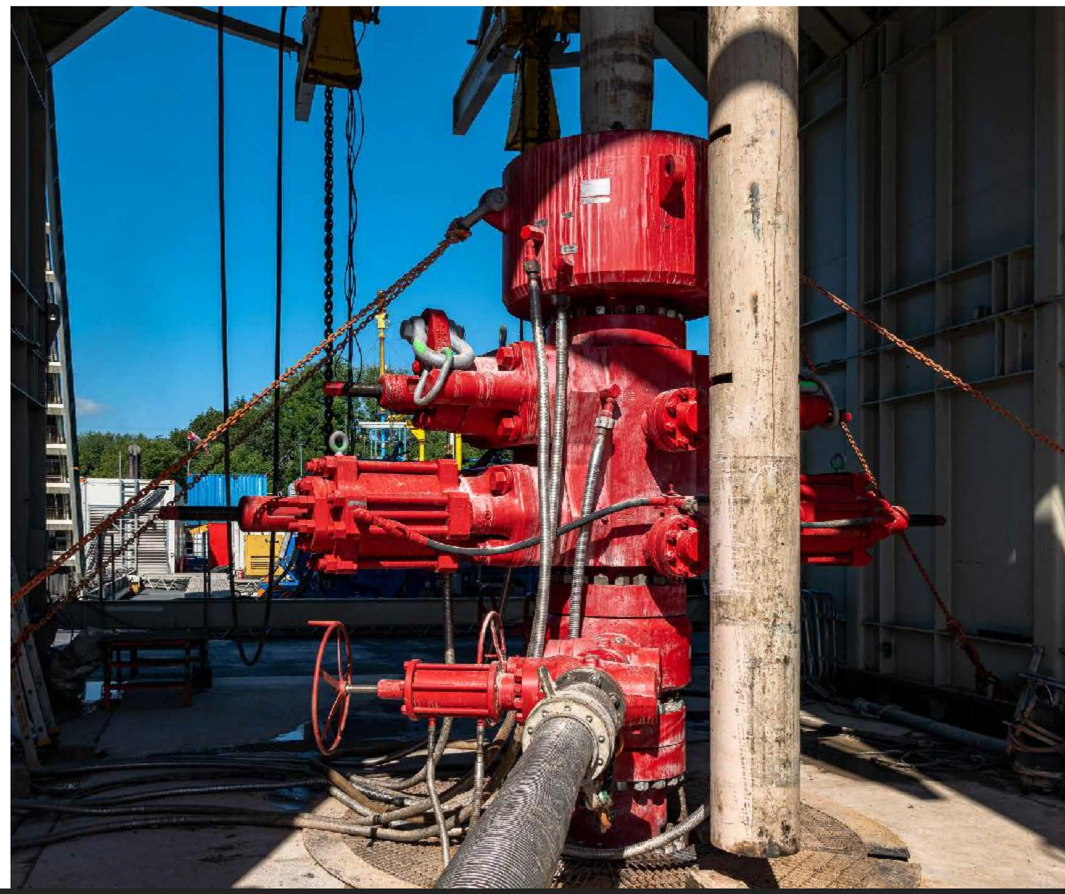
- Injection Testing - Q4 2022
- Phase 1 Completion - Q1 2023
  - Coaxial Completion / ESP / MEP
  - Heat Demonstration
- **Phase 2 Planning - EG-2**
  - MT Survey - March 2023
  - Well Design & Costing




Thank You For Listening

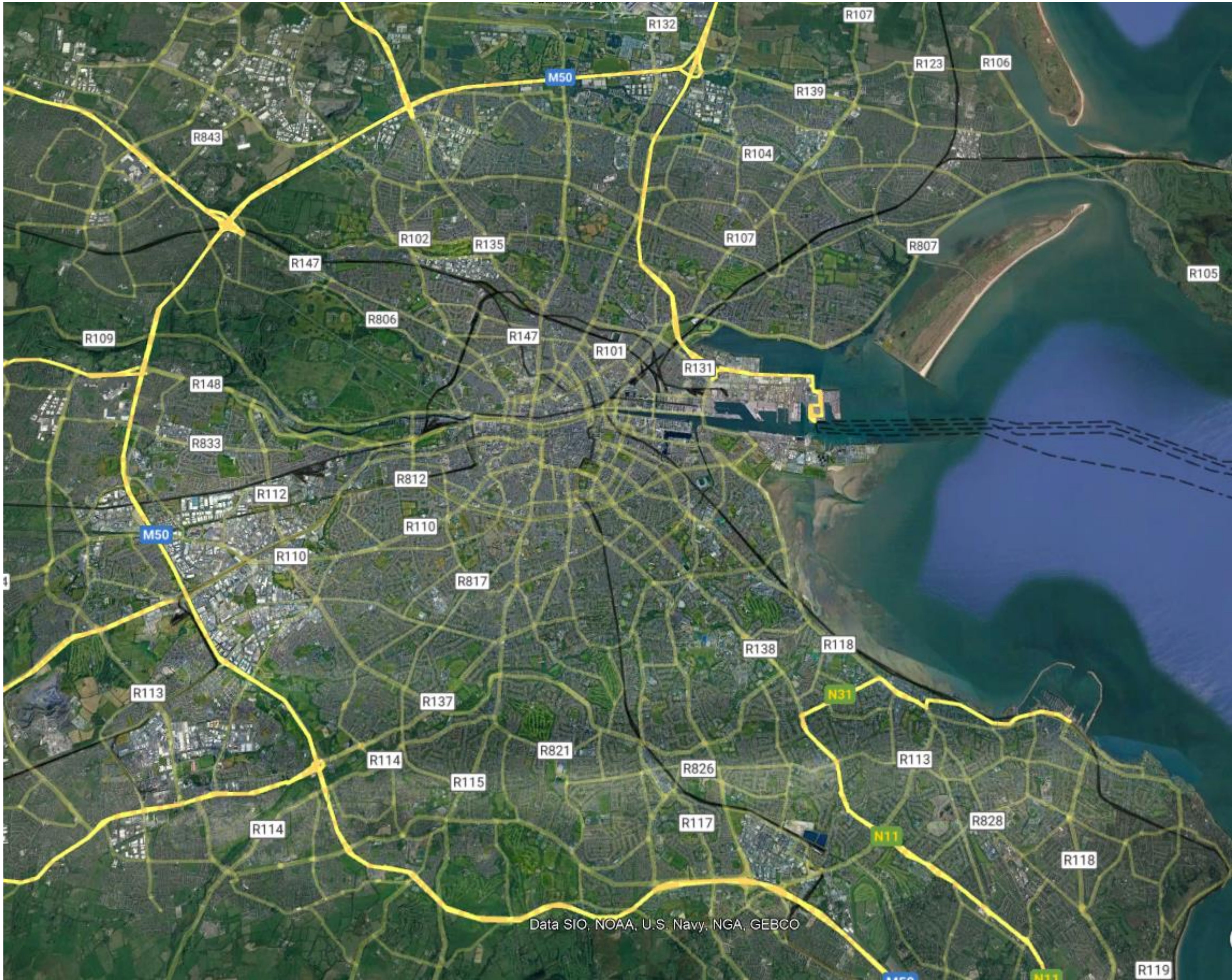


District Heating & Geothermal

in an Urban Context

Technological University Dublin
Grangegorman Campus

Technological University Dublin Grangegorman Dublin



Grangegorman History

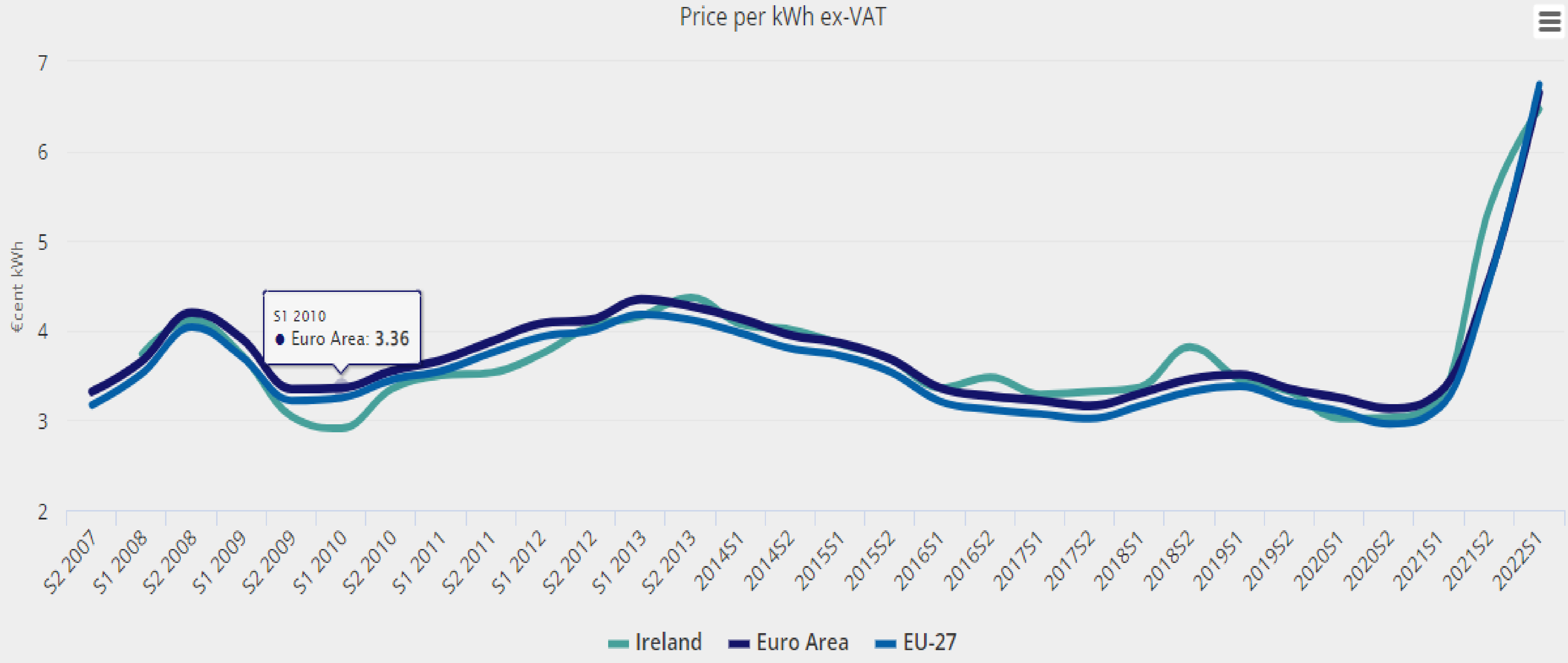
- 1814 The Richmond Asylum
- 1816 The Richmond General Penitentiary.
- 1840 – 1880’s transportation depot to Van Diemen's Land.
- 1890’s became the Richmond District Lunatic Asylum
- 1925 Grangegorman Mental Hospital
- 2014 Dublin Institute of Technology (Now TU Dublin)

Grangegorman District Heating

- 2km of new district heating installed
- 9 buildings on campus connected to the DH
- Central Energy Centre
- Gas fired
- 4 Megawatt current heat load

Average gas price to business

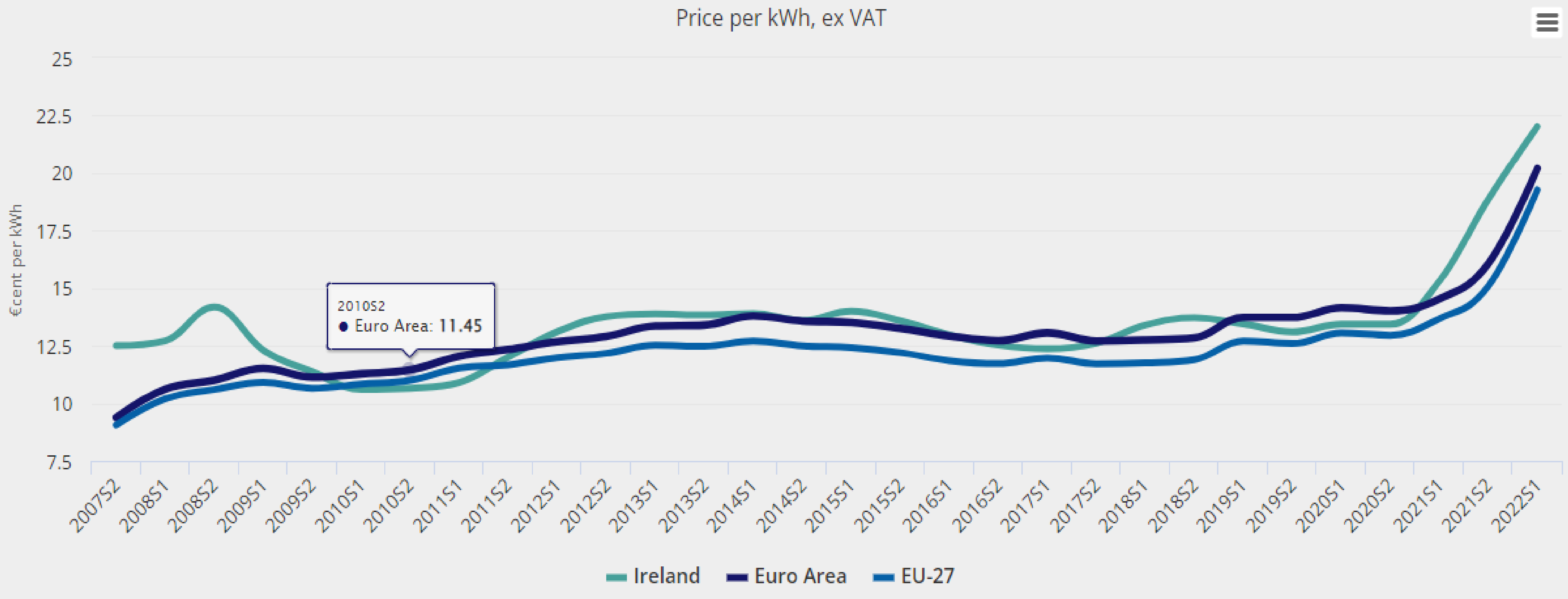
Download average gas price for business data



Source: SEAI based on Eurostat data

Average electricity price to business

Download electricity prices for businesses data



Source: SEAI based on Eurostat data

The weighted* average price of electricity to business consumers in Ireland has been above the European average since the second half of 2011 and has fluctuated above and below the Euro Area since the end of 2016. The latest data available, for the January to June 2022 period is shown above. See EPR Price note above for further details.

Conventional Energy Supply Market

- The price of Gas has risen exponentially over the past 2 years
- In the Irish market this had a knock on effect on electrical supply costs
- Advice and soundings from the market are advising companies to budget for a 300% increase in energy cost versus the existing OGP rate available to public sector clients.

District Heating Fuel Source Options

- 4 Mw of PV

approx. 4000 panels per Mw. 20 acres required. (rugby/soccer pitch is 2 acres)

- 4 Mw of Biomass

At 1MW, a standard heating season of 1,314 hours supplying a suitable load will require 375 tonnes of wood chips or 270 tonnes of wood pellets a year. Burning biomass can also emits more CO_2 than fossil fuels per unit energy

- 4 Mw Air Source Heat Pumps

1 MW ASHP requires 275 Kw of electricity (4 MW requires 1 MW of electrical supply)

District Heating Fuel Source Options

- 4 Mw CHP

CHP requires approx. 5000 annual run hours to be efficient with the University only operating 3700 hours. Challenges with dumping/storing surplus return hot water.

- 4 Mw Wind turbine

A 4Mw wind turbine is 130 meters high with 65m rotor blades

- 4 Mw Geothermal

Requires 2.5 Km deep bore doublet and aquifer for best results. Coupled with GSHP where required. Very small surface footprint

Thermal Efficiency

Fuel	Minimum Size	Thermal Efficiency
Biomass Woodchip CHP	1000 Kw	50%
Low-carbon gas CHP	1000 Kw	52%
Biomass Woodchip	1000 Kw	84%
Air Source Heat Pump	1000 Kw	270%
Ground Source Heat Pump	1000 Kw	510%

The Challenges / Opportunities

- Central Urban Environment
- Pedestrianised Campus
- 50 acre campus with a 3,000sqm plot for the Energy Centre
- Compliance with emissions targets
- Legislation / Regulation
- Funding
- The unknown
- First on the Island of Ireland
- Meets the alignment criteria of Geothermal & District heating
- University, Research, Data, collaboration with GSI & CODEMA

Land Use
Based on Acres/1GW

Solar PV

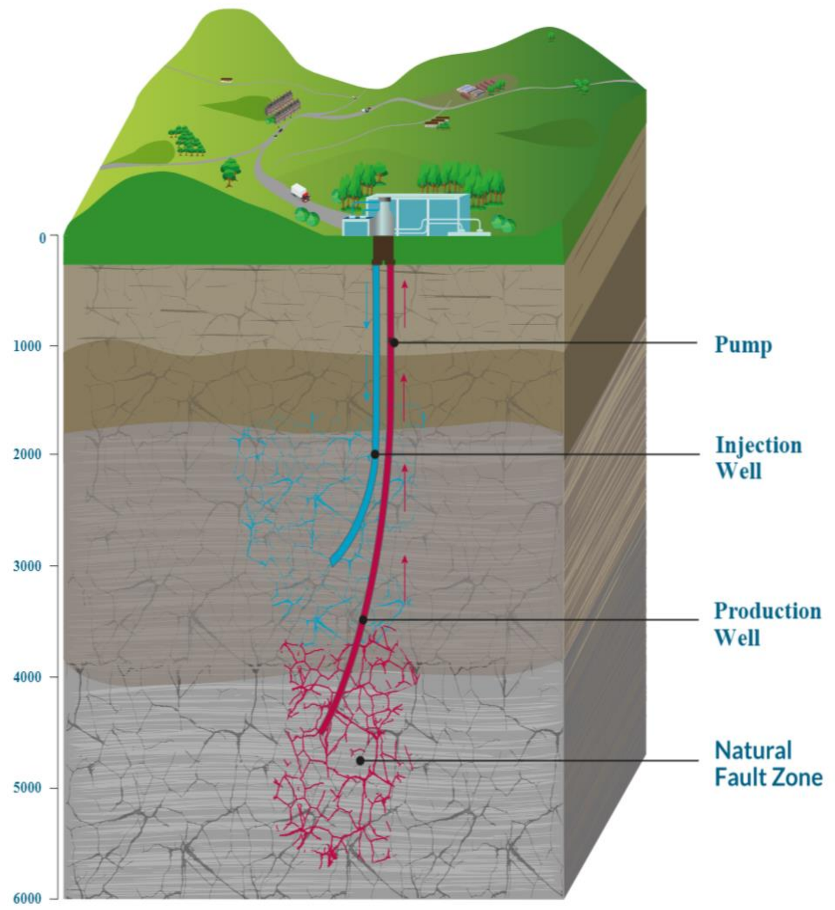
Solar Concent rating

Wind Onshore

Coal

Geothermal

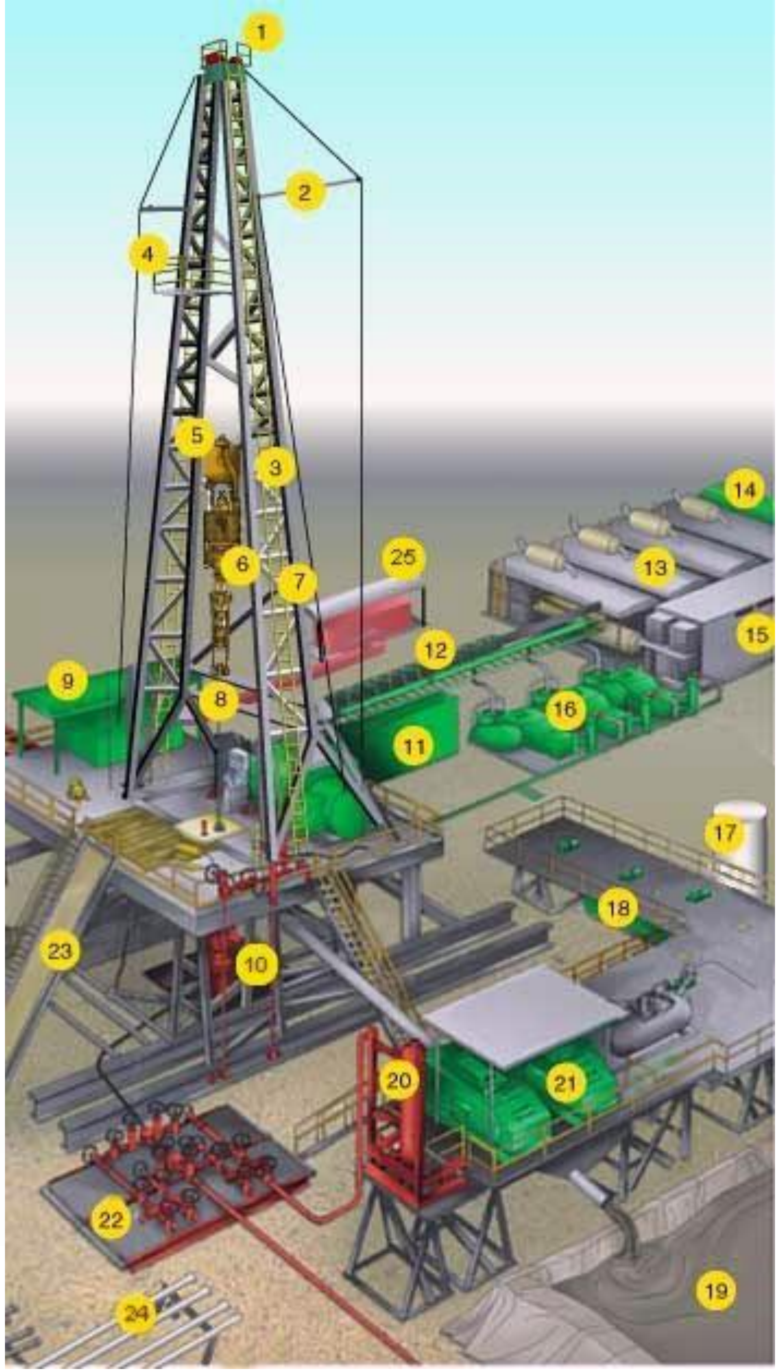
Geothermal has the smallest surface footprint of any land-based energy source and generates minimal waste products.



Project GEMINI

Geological Survey Ireland - GSI
Technological University Dublin – TU Dublin
City of Dublin Energy Management Agency – CODEMA

- 1Km trial hole drilled on site.
- Aligned to a new district heating system.
- Potential to deliver a working geothermal heat source in a short timeframe.
- Exemplar reference project for other potential projects, including geophysical, operational and research data.
- FUNDING €


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25

National Heat Study

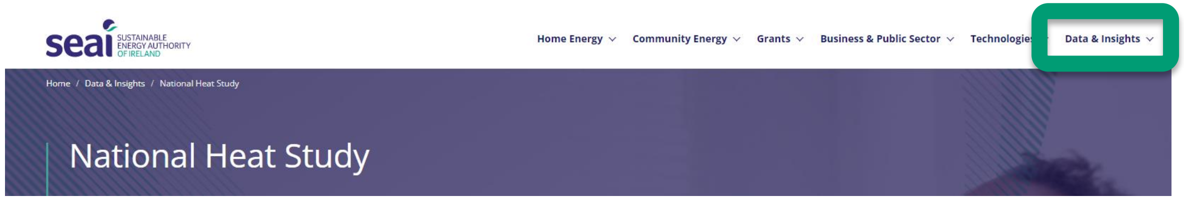
Key insights, Evidence and Actions

Geothermal Summit 9th November 2022

Dr. Niamh O'Sullivan

SUSTAINABLE ENERGY AUTHORITY OF IRELAND

SEAI National Heat Study



SUSTAINABLE ENERGY AUTHORITY OF IRELAND

94%

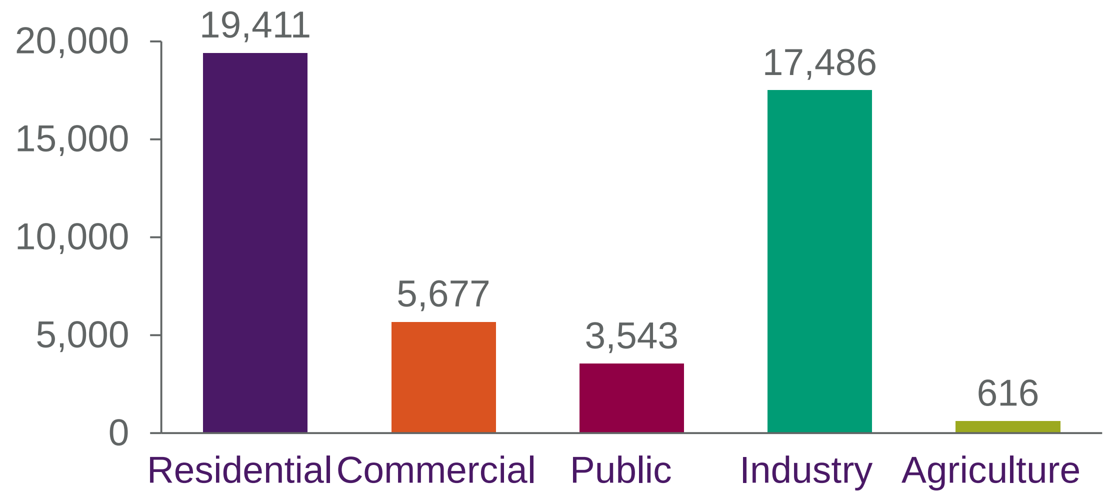
24%

Last

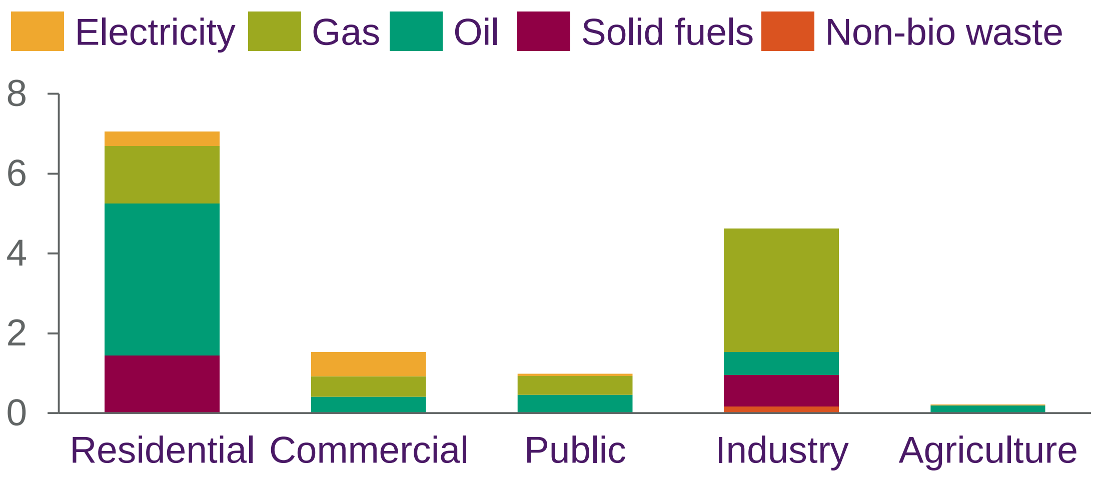
Key insights

- Heat related CO2 **emissions are rising**

Total heating demand (GWh) by sector

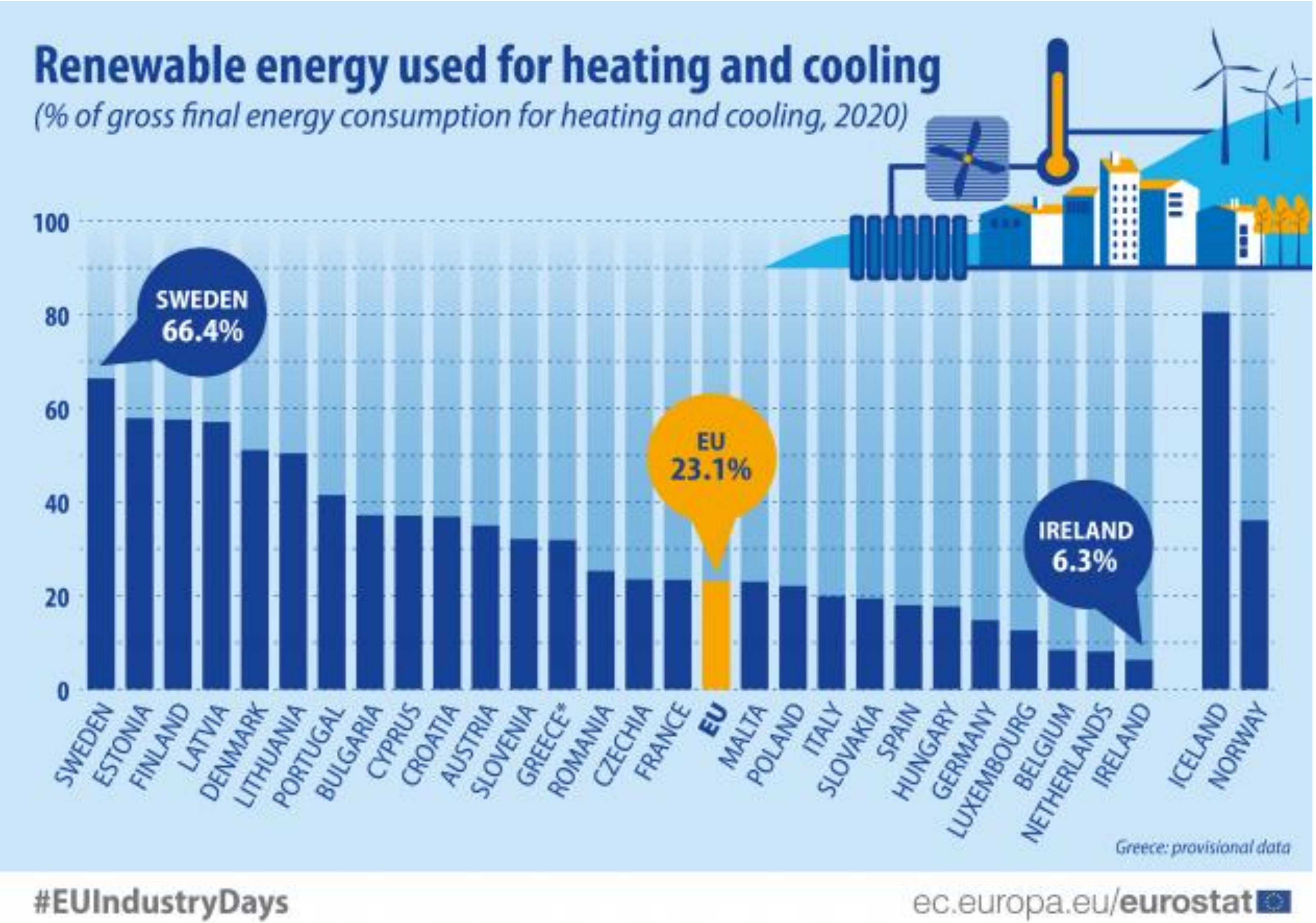


Total emissions ($MtCO_2$) from fuel use for heating by sector, broken down by fuel type



Heat related emissions are **38%** of energy related emissions and **24%** of total national GHGs.

Since the low in 2014, CO_2 emissions are up **13%,** growing at the historical rate. (excl. Electricity)


Renewable energy used for heating and cooling
(% of gross final energy consumption for heating and cooling, 2020)
100
80
60
40
20
0
SWEDEN 66.4%
EU 23.1%
IRELAND 6.3%
SWEDEN
ESTONIA
FINLAND
LATVIA
DENMARK
LITHUANIA
PORTUGAL
BULGARIA
CYPRUS
CROATIA
AUSTRIA
SLOVENIA
GREECE*
ROMANIA
CZECHIA
FRANCE
EU
MALTA
POLAND
ITALY
SLOVAKIA
SPAIN
HUNGARY
GERMANY
LUXEMBOURG
BELGIUM
NETHERLANDS
IRELAND
ICELAND
NORWAY
Greece: provisional data
#EUIndustryDays
ec.europa.eu/eurostat

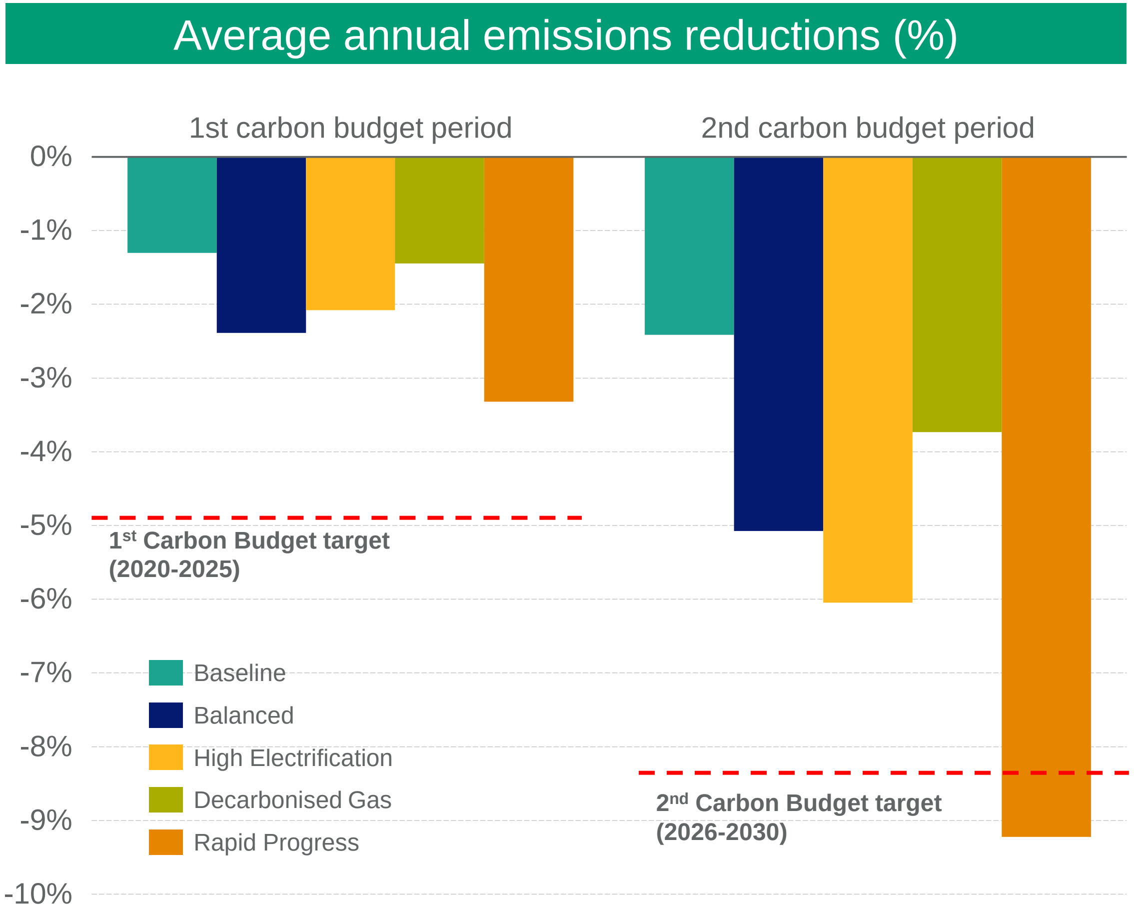
National Energy Modelling Framework

Trigger → Factors in the consumer's financial decision making process → Decision

Scenario Options on how we get to Zero?

Baseline	Decarbonised Gas	High Electrification	Balanced	Rapid Progress

Only Rapid Progress Scenario meets the annual average reduction and only in the 2nd period.



* Carbon budgets as recommended by the CCAC: 4.8% 1st period 8.3% 2nd period(October 2021)

This scenario implies an **unprecedented level of policy effort** such as:

- Phase out of fossil fuels starting in the mid-2020s
- Retiring fossil fuel technologies early
- Immediate and diverse policy supports
- Electrification in the near-term alongside the increased use of biomethane in the gas grid
- Implementation of CCS/BECCS in power and industry
- Maximising AD resources.
- District heating limit of 30%.

SEAI SUSTAINABLE ENERGY AUTHORITY OF IRELAND

Study shows excessive dependence on fossil fuels for heating as emissions continue to rise.

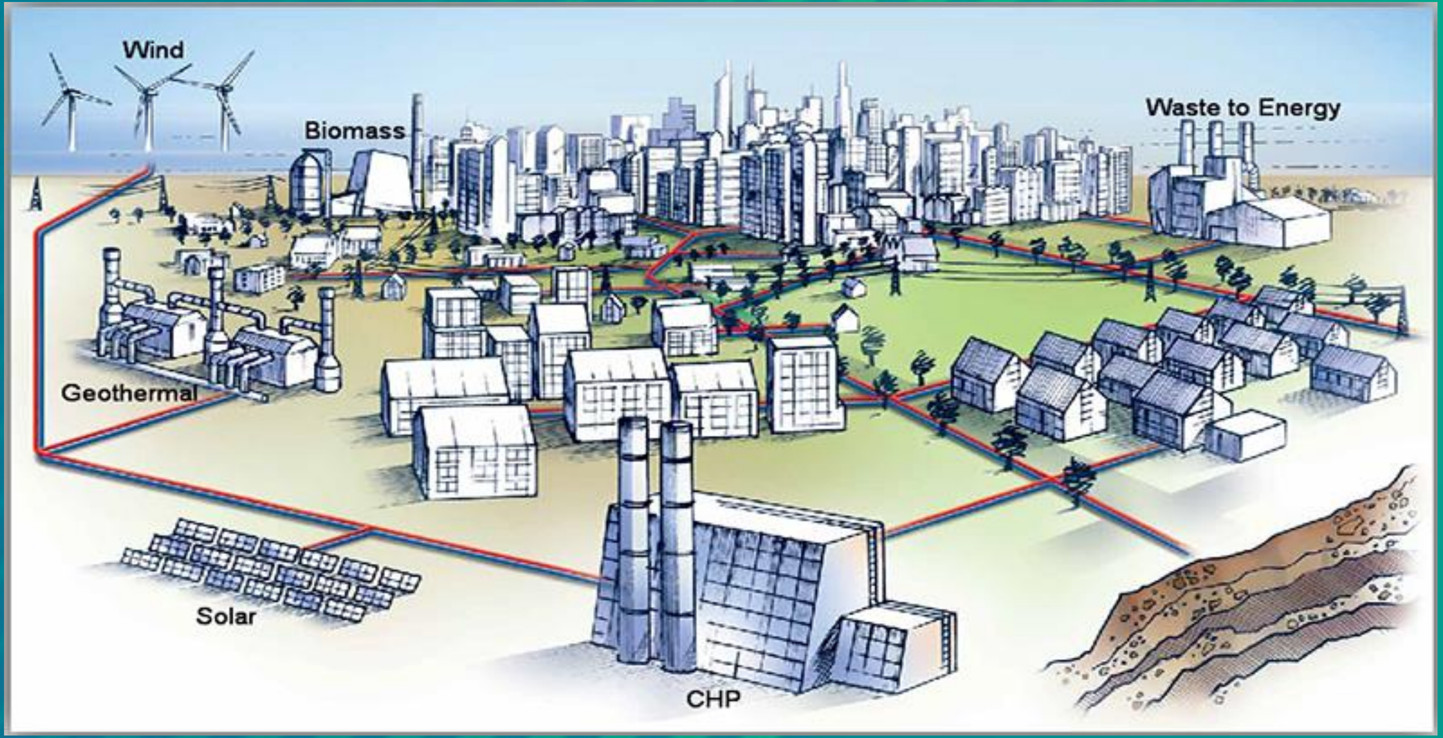
Urgency to deliver climate targets for heating necessitates fast deployment of technologies available today.

A combination of district heating and heat pumps in homes, businesses and industry will play a vital role in fast decarbonisation.

Key insights

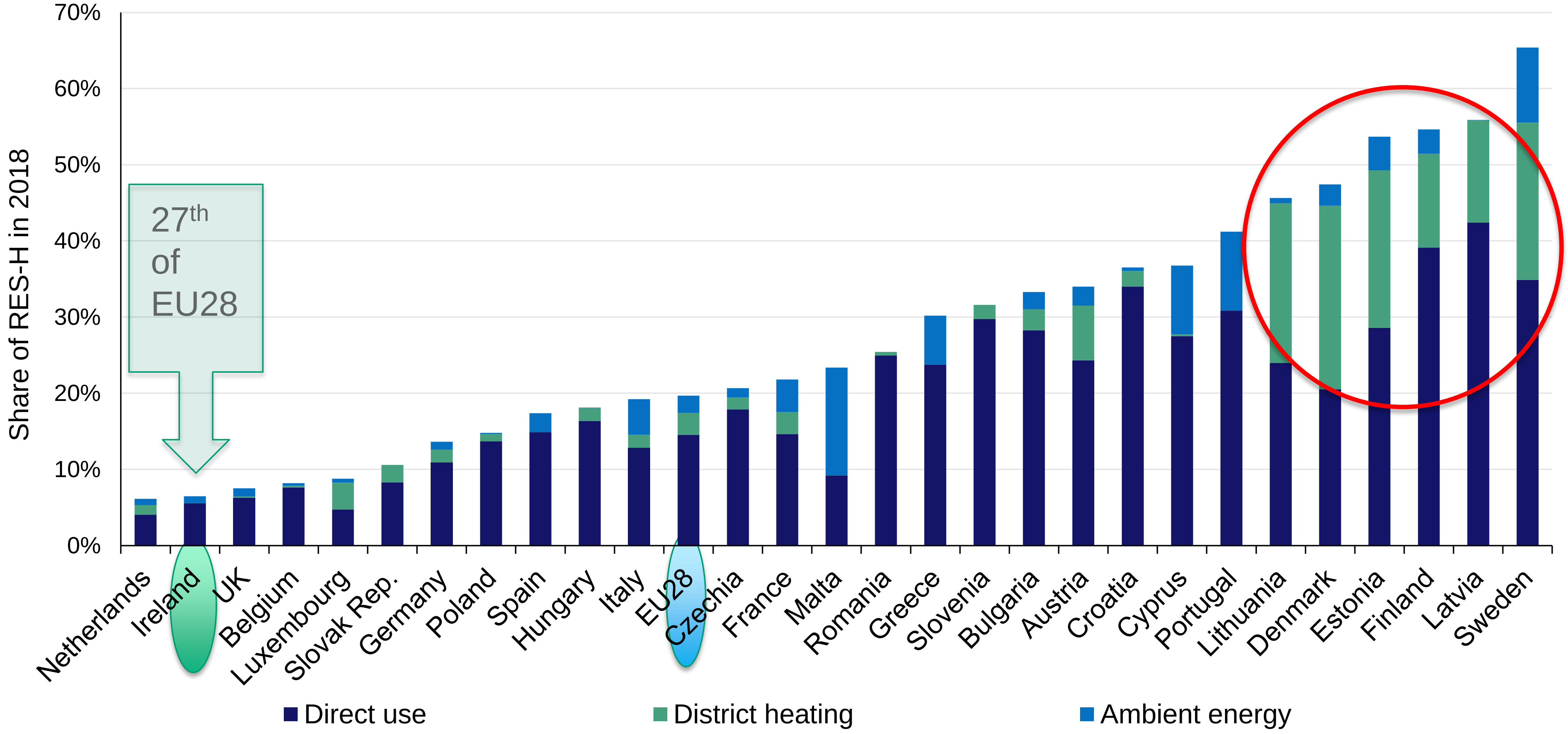
- District heating is a technology that offers additional potential.

- It is **proven and available** now. It could provide as much as around **50% of building heating** demand in Ireland.

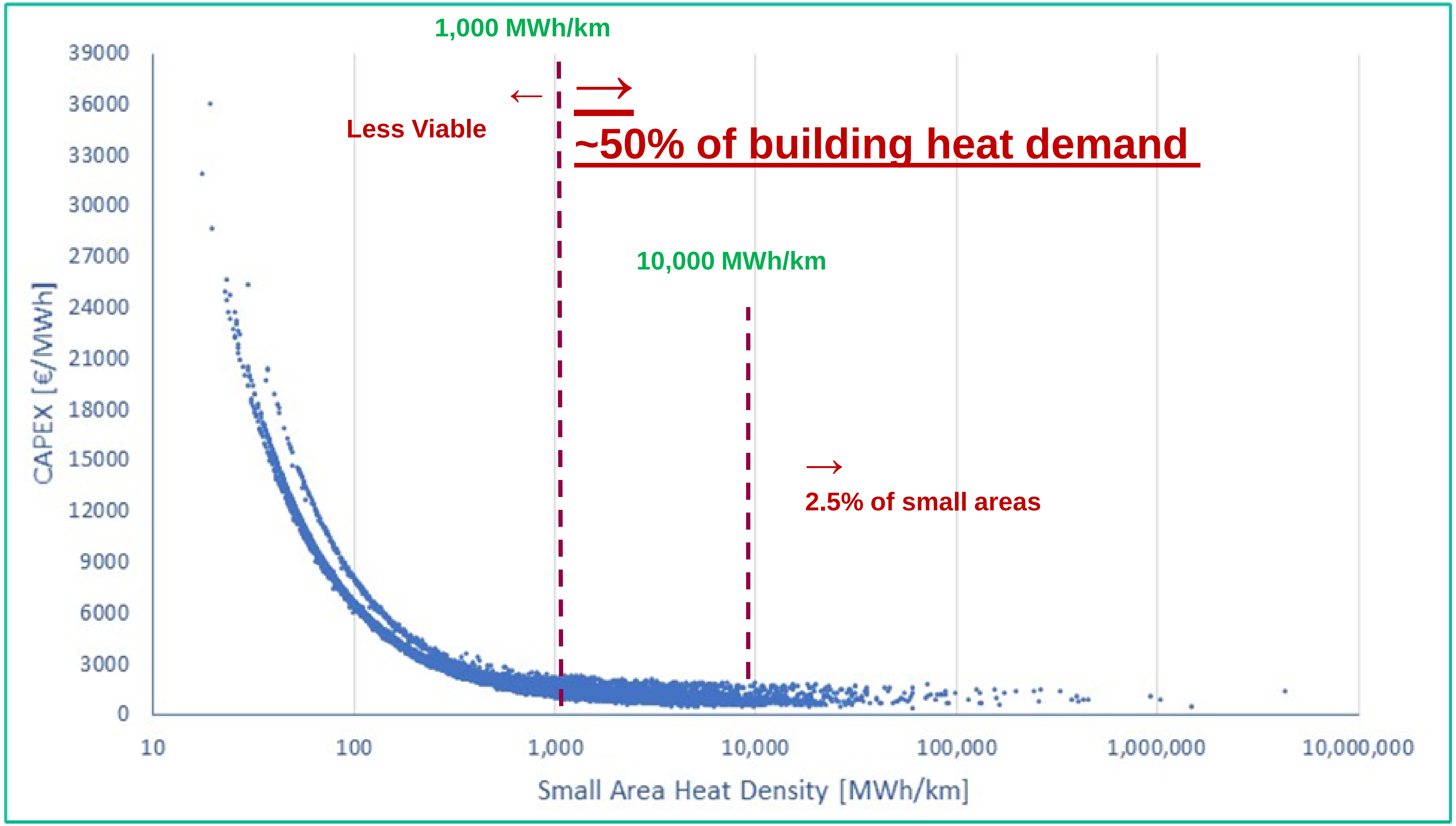


SUSTAINABLE ENERGY AUTHORITY OF IRELAND

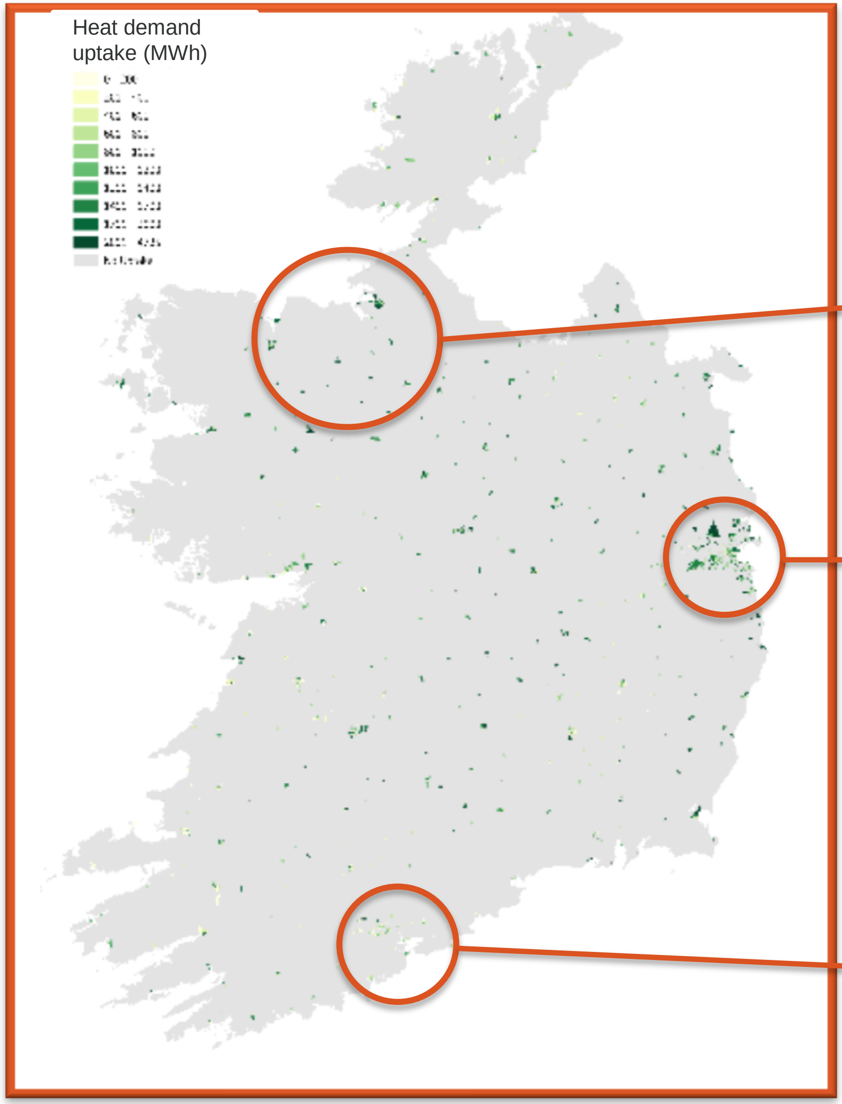
Renewable heat in EU

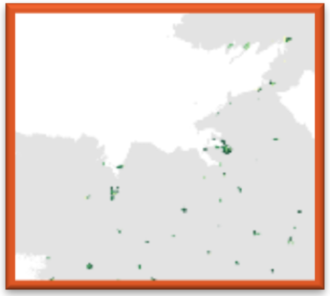


The detailed high resolution spatial analysis shows that more small areas are viable than in previous more high-level analyses



District heating is a mature technology available now. Strong district heating potential both in cities but also large towns, particularly those reliant on oil

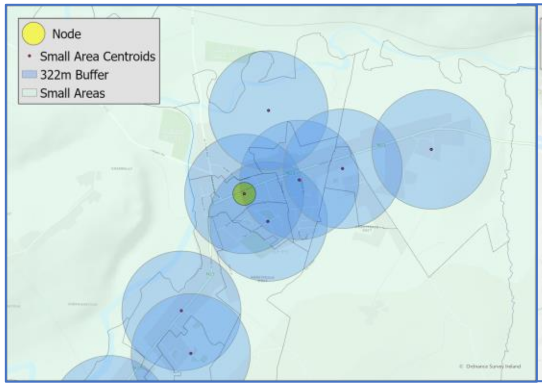


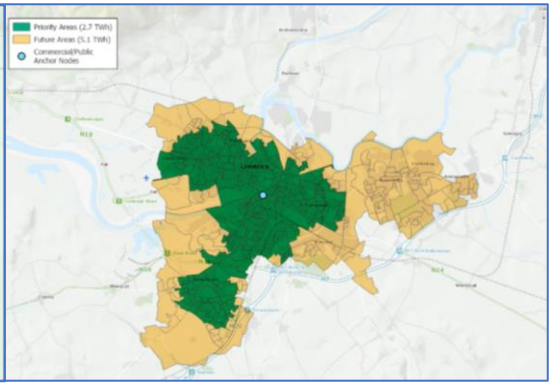


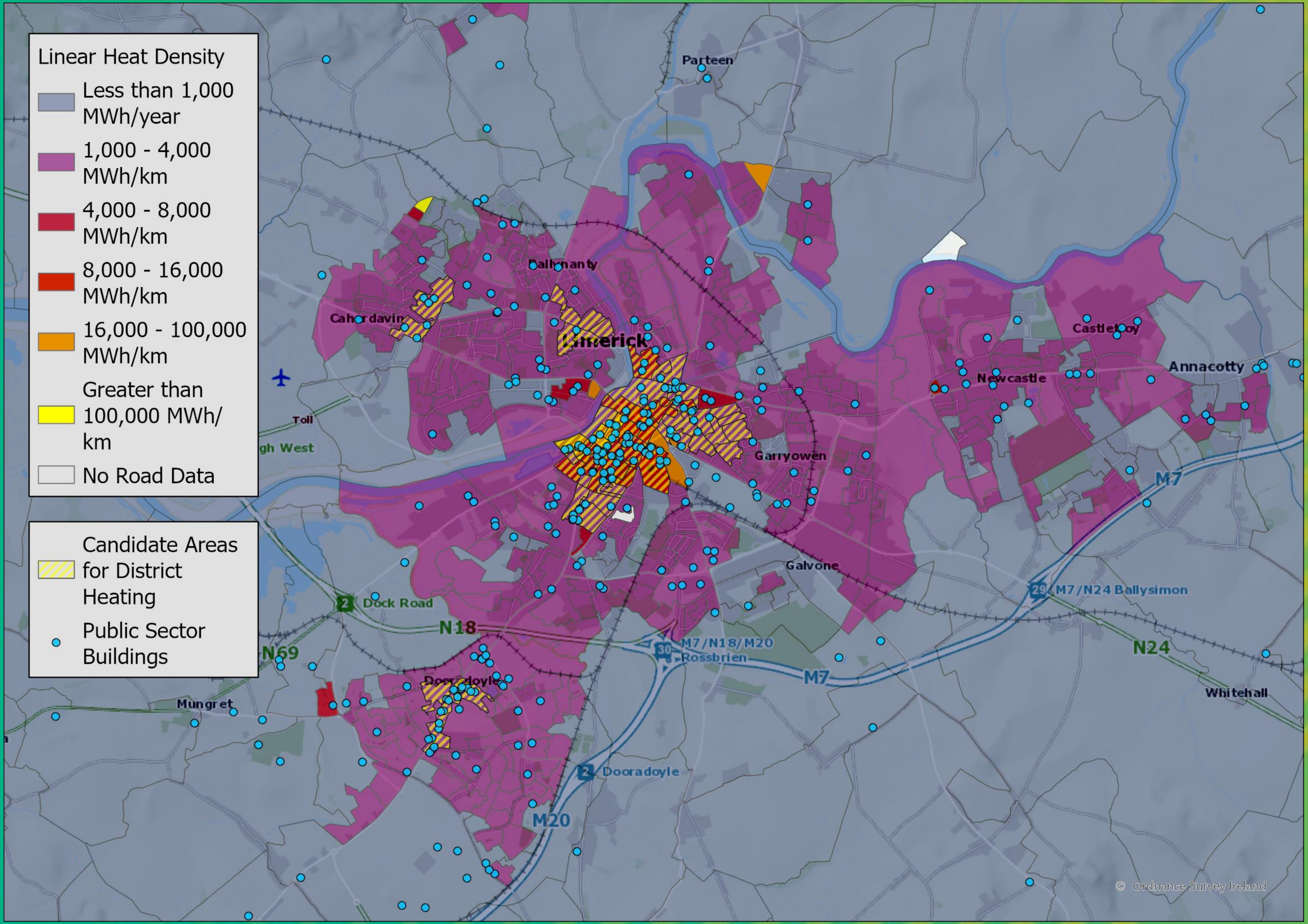
Castlebar, Westport, Ballina, Sligo, Carrick-on-Shannon, Bundoran

Dublin area

Cork area







Linear Heat Density
Less than 1,000 MWh/year
1,000 - 4,000 MWh/km
4,000 - 8,000 MWh/km
8,000 - 16,000 MWh/km
16,000 - 100,000 MWh/km
Greater than 100,000 MWh/km
No Road Data
Candidate Areas for District Heating
Public Sector Buildings
Parteen
Ballynanty
Caherdavin
Castletroy
Annacotty
Newcastle
Garryowen
Galvone
Toll
M7
M7/N24 Ballysimon
N24
Whitehall
Dock Road
N18
N69
M7/N18/M20
Rossbrien
M7
Mungret
Dooradoyle
M20
© Ordnance Survey Ireland

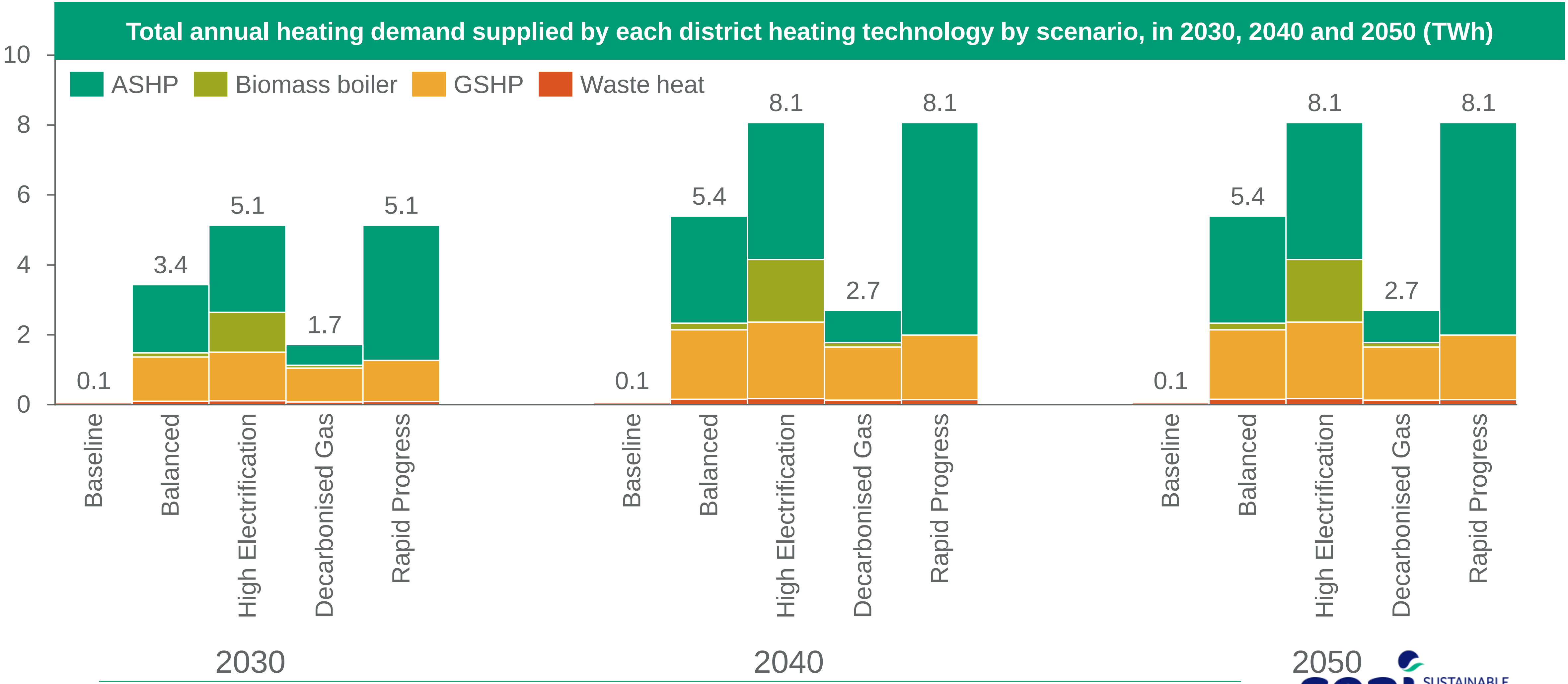
Key insights

- Heat related CO_2 **emissions are rising**

- District heating is a technology that offers additional potential. It is **proven and available** now. It could provide as much as around **50% of building heating** demand in Ireland.

- **Heat pumps are a prominent technology** in all scenarios and in all sectors.

Heat pumps supply 12-20% of heating demand in 2030, 33-38% in 2050. Heat pumps have a prominent role, including those using geothermal resource. More potential for deep geothermal and waste heat possible.



Key insights

- **Decarbonising the electricity grid** is essential to cutting heat-related emissions
- A **timetable for fossil fuel phase-out** in all sectors is needed as soon as possible to meet net zero by 2050
- Scenarios focused on a hydrogen gas grid have more cumulative emissions.
- Evolving existing policy supports **to focus on replacing fossil fuels** in buildings can have a more significant and immediate emissions reduction impact than a purely fabric-first approach.

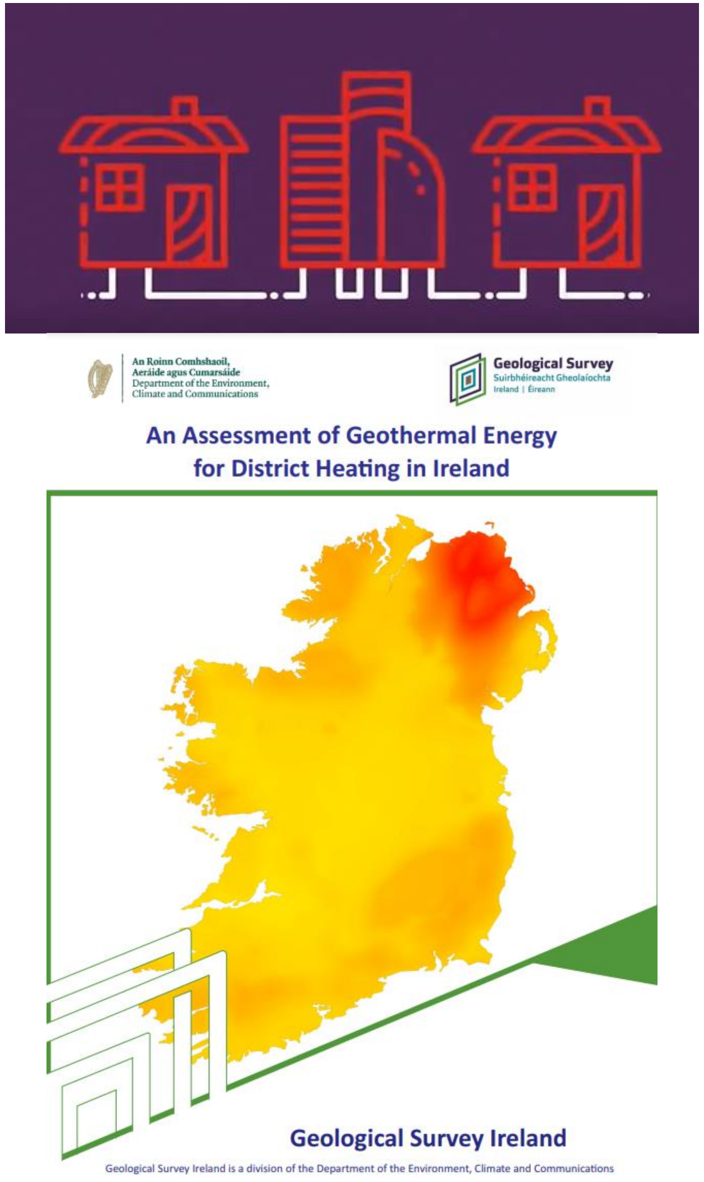
Geothermal Energy in the Heat Study

- Geothermal energy has **significant potential** in Ireland.
  - Heat study includes geothermal potential (GSHP) up to 400 m.
  - The results show that most areas suitable for district heating also have high suitability for geothermal resources.

- Further characterisation and analysis is needed in order to **fully investigate the potential of geothermal energy** across Ireland.

- **Welcome and encourage any further data or physical measurements to validate the models.**

- Support a range of ongoing **research.**



SUSTAINABLE ENERGY AUTHORITY OF IRELAND

SEAI National Energy RD&D Funding Programme Objectives

Accelerate

Accelerate the development and deployment in the Irish marketplace of competitive energy-related products, processes and systems

Support

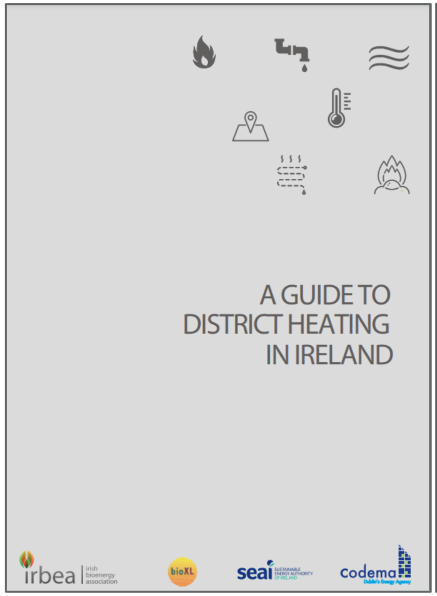
Support solutions that enable technical and other barriers to market uptake to be overcome

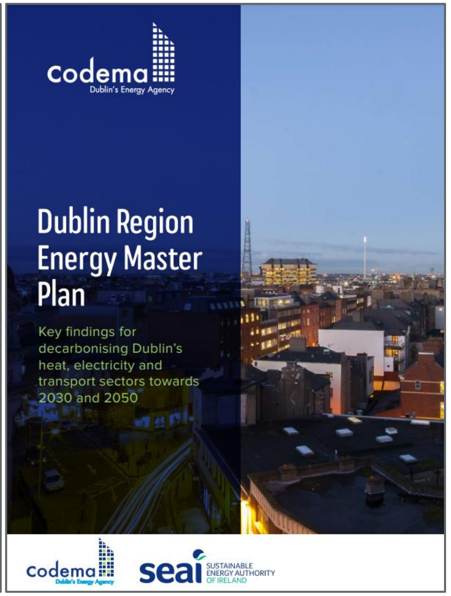
Grow

Grow Ireland's national capacity to access, develop and apply international class RD&D

Inform

Provide guidance and support to policy makers and public bodies through results, outcomes and learning from supported energy projects





DECARBONISING HEAT

District heating and high grade heat pumps for industrial use

GEOTHERMAL ENERGY

Economic evaluation and investigation for industrial applications. (Co-funded with GSI)

Geothermal Energy | Gavin and Doherty Geosolutions Ltd. (GDG) | SEAI; Geological Survey Ireland (GSI) | 2019

ThermoWell: Thermal Resource Extraction from a Standing Column Well

Ongoing

Geothermal Energy | GeoServ Solutions | SEAI; Geological Survey Ireland (GSI) | 2019

ShallowTHERM

Ongoing

Geothermal Energy | **Heat Sector** | Dublin Institute for Advanced Studies (DIAS) | SEAI; Geological Survey Ireland (GSI) | 2019

DIG: De-risking Ireland's Geothermal Energy Potential

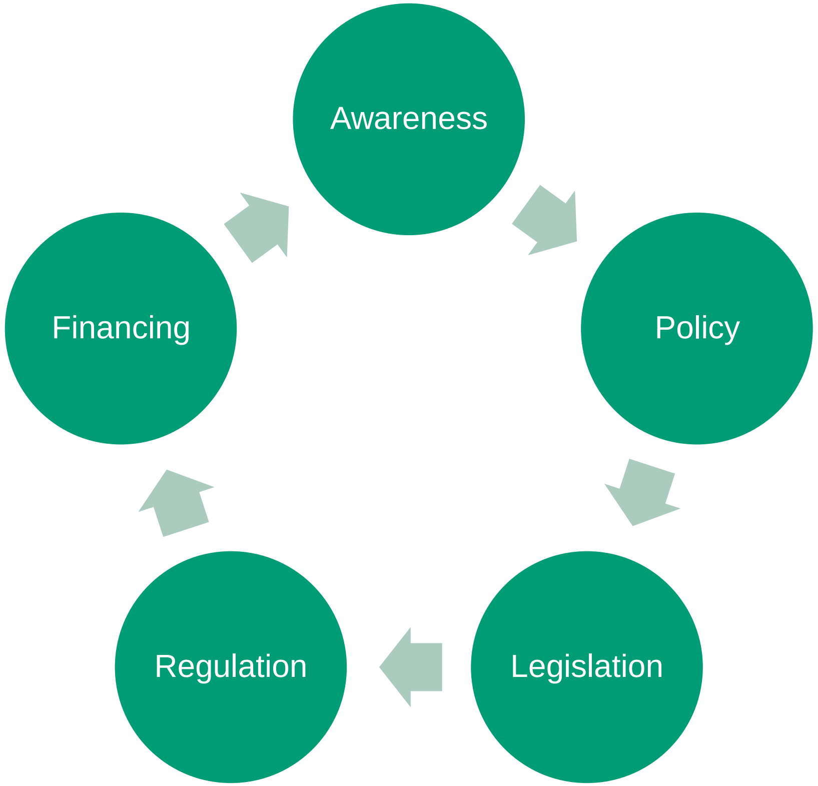
Takeaway Messages

*Plan and prioritise district heating deployment – target the **regulatory, planning and financing barriers.***

***Heat Pumps** are a prominent technology in all scenarios*

***Data and analysis** to inform evidence-based decisions to accelerate our energy transition.*

***Unprecedented** level of effort*



Thank you

@ seai_ie

Ireland's European Structural and Investment Funds Programmes 2014-2020

Co-funded by the Irish Government and the European Union

SUSTAINABLE ENERGY AUTHORITY OF IRELAND

An Roinn Comhshaoil,
Aeráide agus Cumarsáide
Department of the Environment,
Climate and Communications

Turning policy into action: the District Heating Steering Group

Danielle McCormack
danielle.mccormack@decc.gov.ie
8 Nov 2022

An Roinn Comhshaoil,
Aeráide agus Cumarsáide
Department of the Environment,
Climate and Communications

Climate Action Plan 2021

- Focus on addressing barriers to District Heating rollout in Ireland
- Decision to establish a Steering Group to advise Government

An Roinn Comhshaoil,
Aeráide agus Cumarsáide
Department of the Environment,
Climate and Communications

Steering Group Membership

- Government Departments
- Local Authorities
- Government Agencies

Working Groups

- Planning
- Regulation and Technical Standards
- Finance
- Research and Policy Insights

An Roinn Comhshaoil,
Aeráide agus Cumarsáide
Department of the Environment,
Climate and Communications

Progress to date

- Initiation of feasibility studies to move group heating schemes to a renewable energy source
- Emerging roadmap for regulatory framework
- Robust research recommendations
- Recommendations to strengthen position of district heating in the planning system
- Clarity as to areas of investigation for financing options

An Roinn Comhshaoil,
Aeráide agus Cumarsáide
Department of the Environment,
Climate and Communications

Benefits of Steering Group

- Draws together multiple organisations with similar aims
- Focus for expertise and knowledge
- Networking and reduction of ‘silos’

An Roinn Comhshaoil,
Aeráide agus Cumarsáide
Department of the Environment,
Climate and Communications

Report to Government

Due end 2022

An Roinn Comhshaoil,
Aeráide agus Cumarsáide
Department of the Environment,
Climate and Communications

Ambition for district heating

- Solutions-based approach of Steering Group
- Importance of evidence basis for policy decisions
- Requirement for public consultation

An Roinn Comhshaoil,
Aeráide agus Cumarsáide
Department of the Environment,
Climate and Communications

Context

- Decarbonisation of buildings
- Security of Supply
- Increased ambition for district heating within ‘Fit for 55’ package

Rialtas na hÉireann
Government of Ireland

Geological Survey
Suirbhéireacht Gheolaíochta
Ireland | Éireann

Designing the National Geothermal Database

Rory Dunphy

Completions Geoscience Consulting

COMPLETIONS GEOSCIENCE

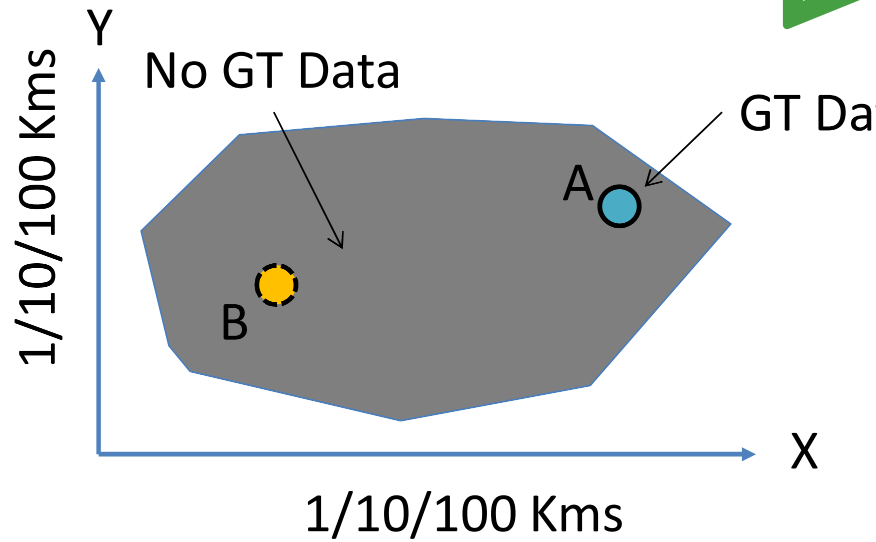
www.completionsgeo.com GEOTHERMAL | GEOMECHANICS.

What is the Purpose of the NGD?

- Need to understand the resource we are seeking to regulate, promote & communicate value of
- Geothermal is broad, one size does not fit all!
- National Geothermal Database: Policy Initiative to **collect, collate and analysis data** to:
  - Define the geothermal play types present
  - Quantify the resource
  - Inform economic assessment of GT projects
  - Create an information system to drive awareness & assist regulation

How can we best leverage geoscience data to help people choose geothermal?

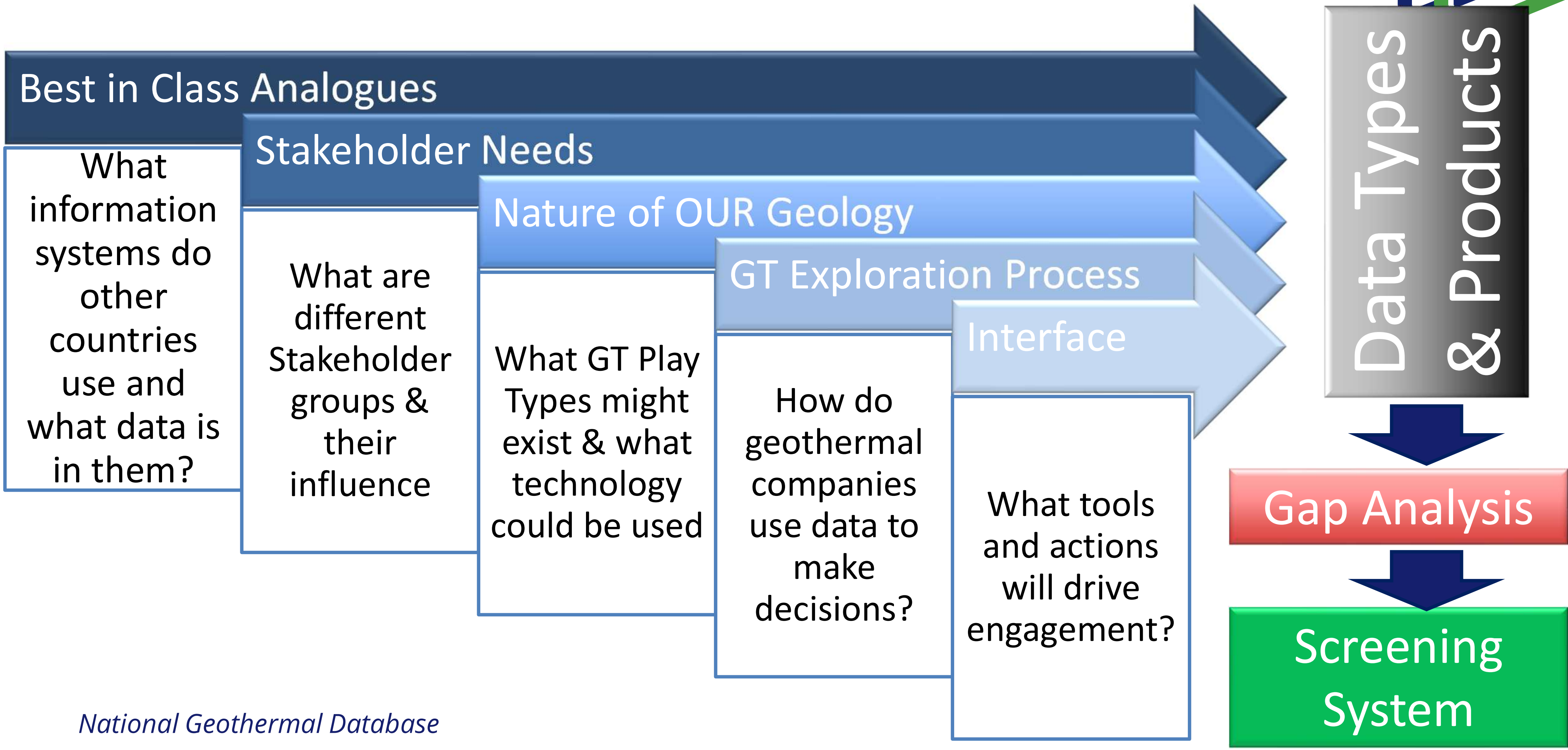
National Geothermal Database



Variables

- Nature of the Demand (End-use)
- Geology (Geothermal reservoir)
- Extraction Technology (Engineering)
- People & Place (Stakeholders)

Stakeholder Focused Design Process



Analogues Outcomes: Go Beyond Data

Data	Tools	Purpose
Temp Data	User Interface	"Guided Access to Data"
Database	Targeted Products	"Enabling Exploration & Education"
	Geothermal Knowledge Management "System"	"Scientific Leadership, Ownership & Influence"

Temperature Maps

Publishing Resource Estimates

Identifying Impactful Research
Share Methodology
Shaping Policy

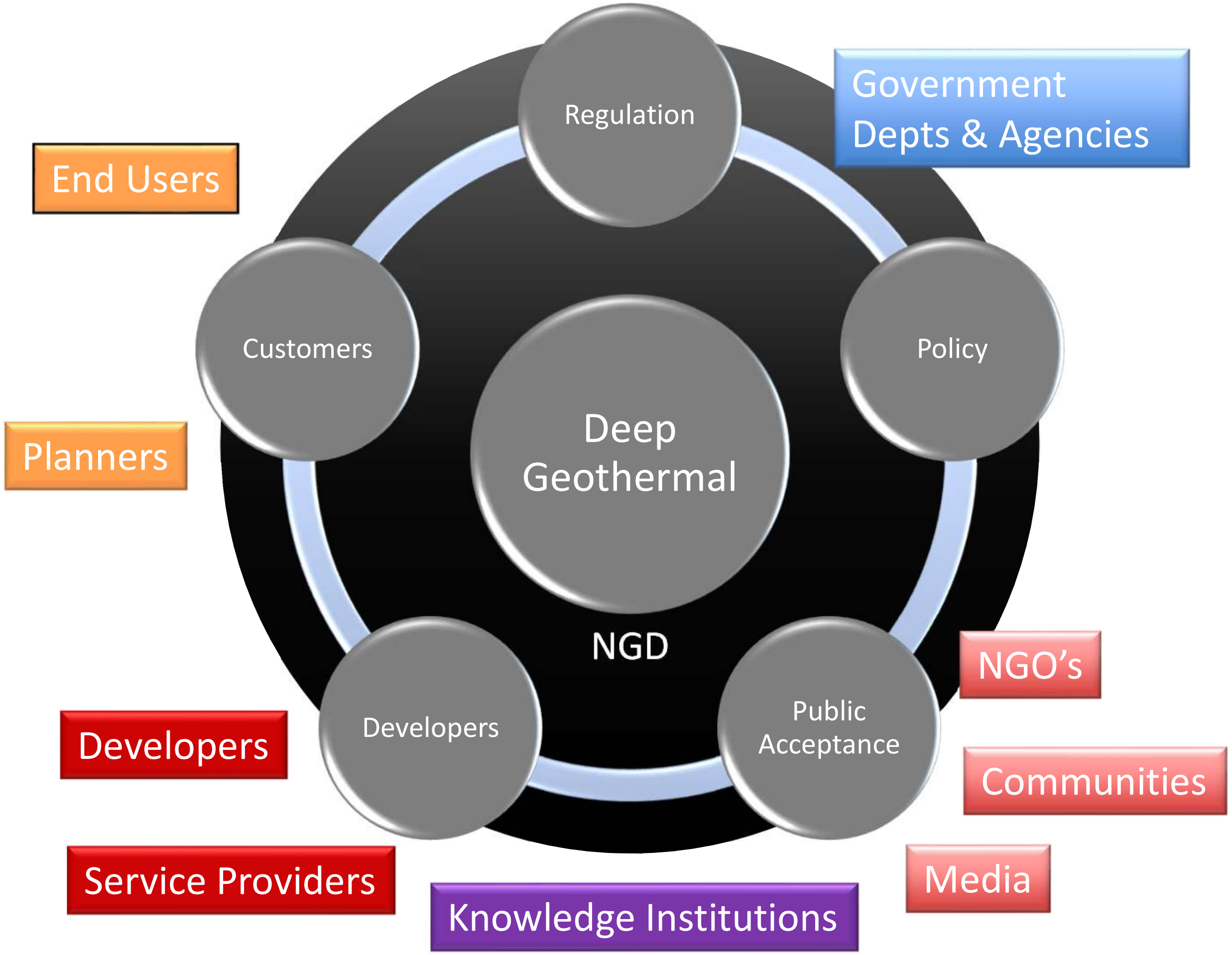
Database Project

National Geothermal Database

Key Design Principle:

- Design for the data you want, not what you currently have!

Stakeholder Outcomes – Who Influences Geothermal?

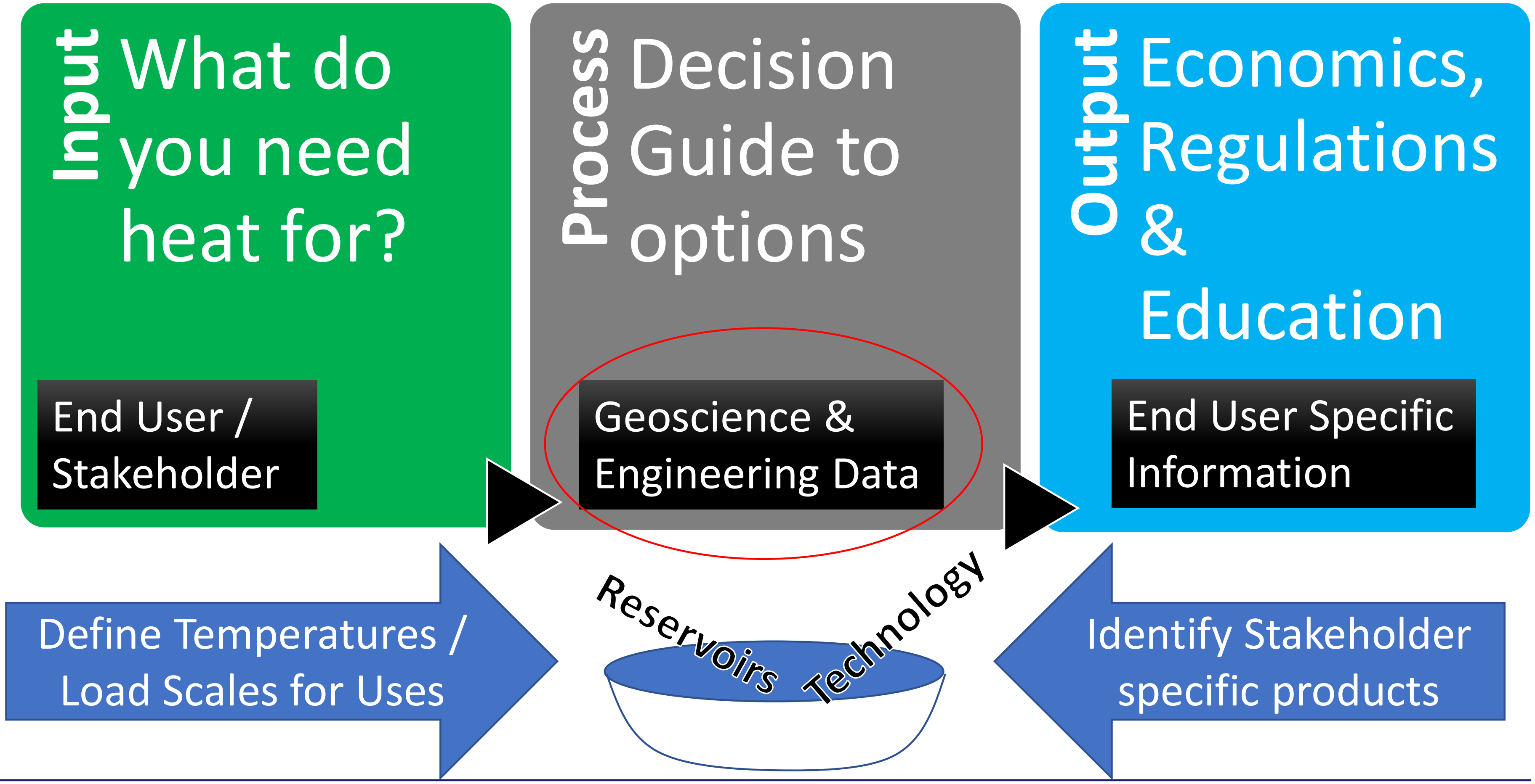


All of these elements need to be in place for Deep Geothermal Projects to succeed

Developed a set of stakeholder objectives, strategies and tactics

Identified list stakeholder specific "Products" e.g €/MWh map for milk processing

NGD Interface: A Geothermal Matchmaker

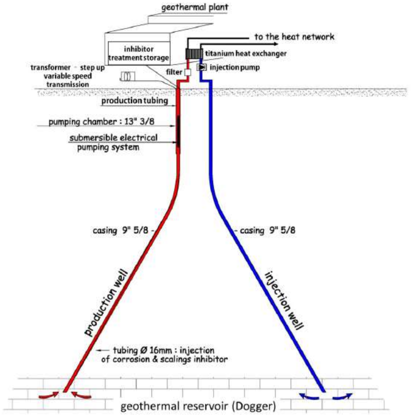


GT Play Types = Reservoir + Technology

Shallow Systems

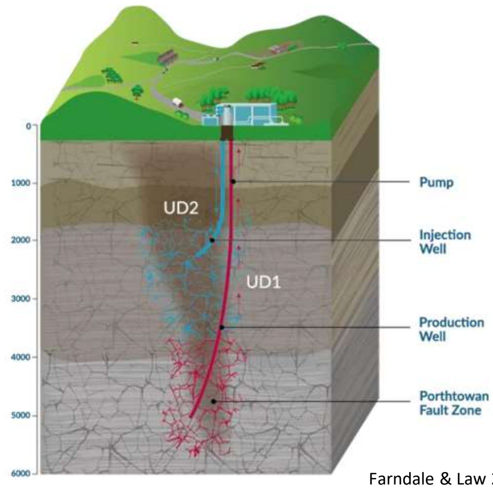
Hybrid / Large Heat Pump

Hydrothermal (HSA) Doublets



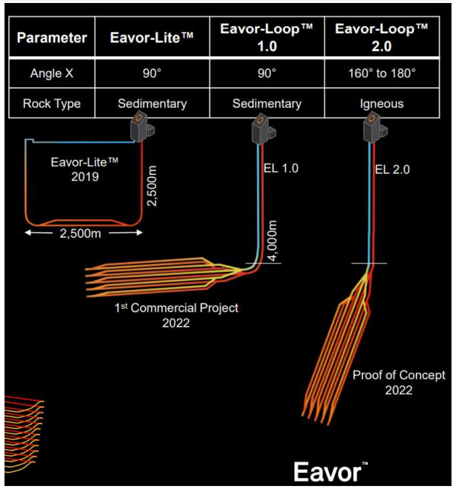
Kervevan et al 2014

Engineered Geothermal Systems



Farndale & Law 2022

Advanced Geothermal Systems / DBHE



Nature of Geology = Lack of primary porosity

- Low porosity/high perm carbonate plays are likely Irish hydrothermal plays
- Tight sandstones, fractured basement and fractured carbonates could be EGS hydrothermal plays
- Buried granites indicates potential for EGS Petrothermal
- Deep Borehole Heat Exchange / Deep Closed Loop

Data Types Needed

- ❑ Lithological/Structural Framework
- ❑ Fault & Fracture Characterization
- ❑ Geomechanics
- ❑ Heat Production
- ❑ Thermal Conductivity

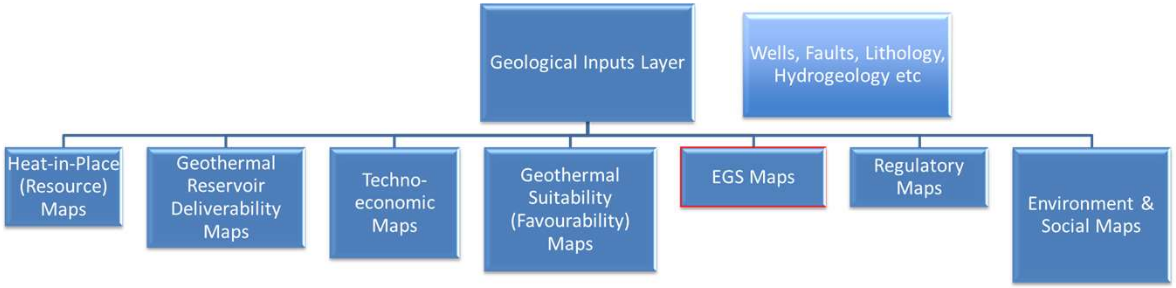
Exploration Process: Work Plan

- What work is needed to deliver the products and organise data?
- There are 5 Work Packages (WP) or "Spokes" in the Project
  - Heat in Place
  - Deliverability
  - Technoeconomic (incl operations & commercial factors)
  - **Environment & Regulatory**
  - **Stakeholder Engagement**
- Work Plan built for each
- Data collation & Mapping
  - Temperature Gradient
  - Thermal Conductivity
  - Depth to Temperature

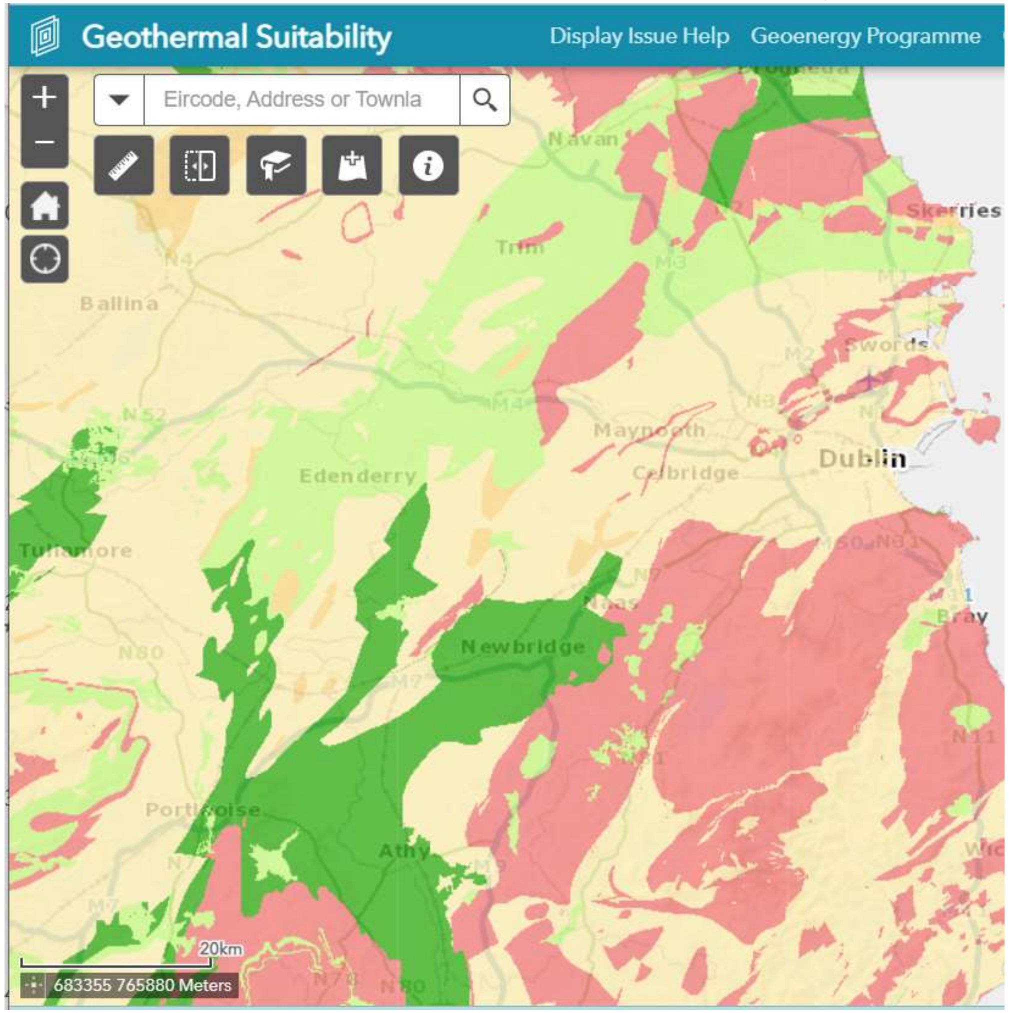
National Geothermal Database

Interface: GIS Based Suitability Mapping

- Depth to temperature
- Lithology (Thermal Conductivity)
- Lithology (Likelihood of karst/ fracture development
- Proximity to certain faults (FSP)
- €/MWth bands
- Links to relevant products/guides



National Geothermal Database



Gap Analysis: Key Themes

Developing 3D Geological Framework
- Surfaces
- Facies
- Faults

Mapping & Understanding of Temperature Variation
- Crustal Heatflow Variation
- Thermal Conductivity Heterogeneity
- Advection Influence
- 1D Modelling

Mapping & Understanding of Fault Perm & Flow
- Stress Mapping
- Fault Characterization & Flow Correlation
- FSP
- Mech Strat

Techno economic
- Do to learn
- More in-depth economic studies

Social
- Seismicity workshop

New research proposals, publications & interest!!

What we have:
- Track record turning funding into progress
- Strong geoscience expertise to leverage
- Mix of old and new industry expertise

What we need:
- Seismic , core & temp data
- Applied Geoscience & Engineering Resources
- Integrated Economic Studies

Applied Multidisciplinary Approach

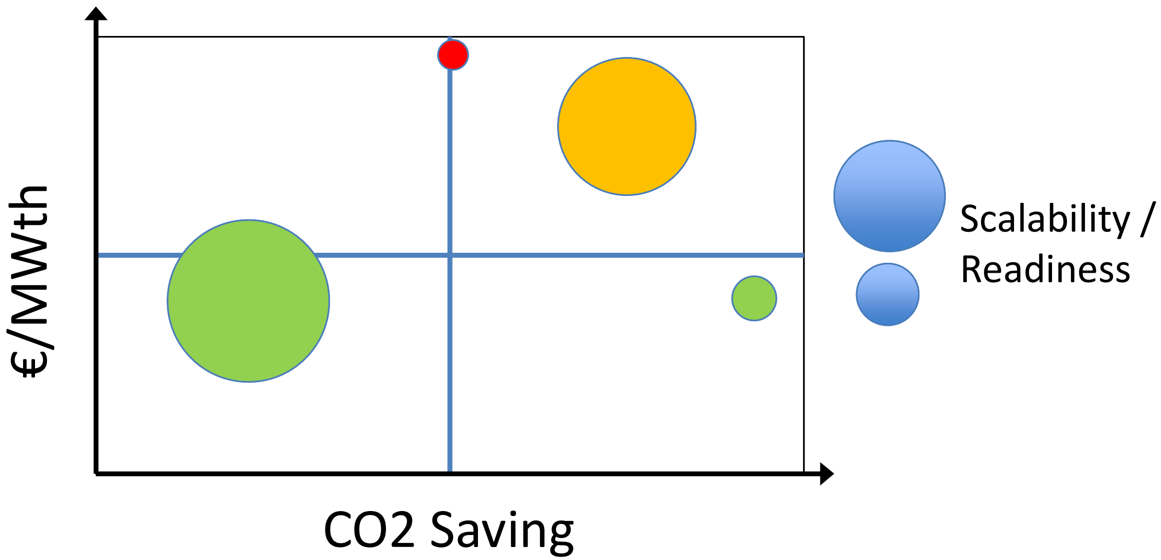
- Define Geothermal Opportunity Type (GTOT)
- Build a Database of GTOTs not just Data
- Define economics (supply cost), potential Carbon savings, ease of deployment/ability to scale up rate etc
- Pilots are key to getting the necessary data

<u>GTOT Definition</u>
Output (Temp & MW)
Cost (Depth)
Play Type

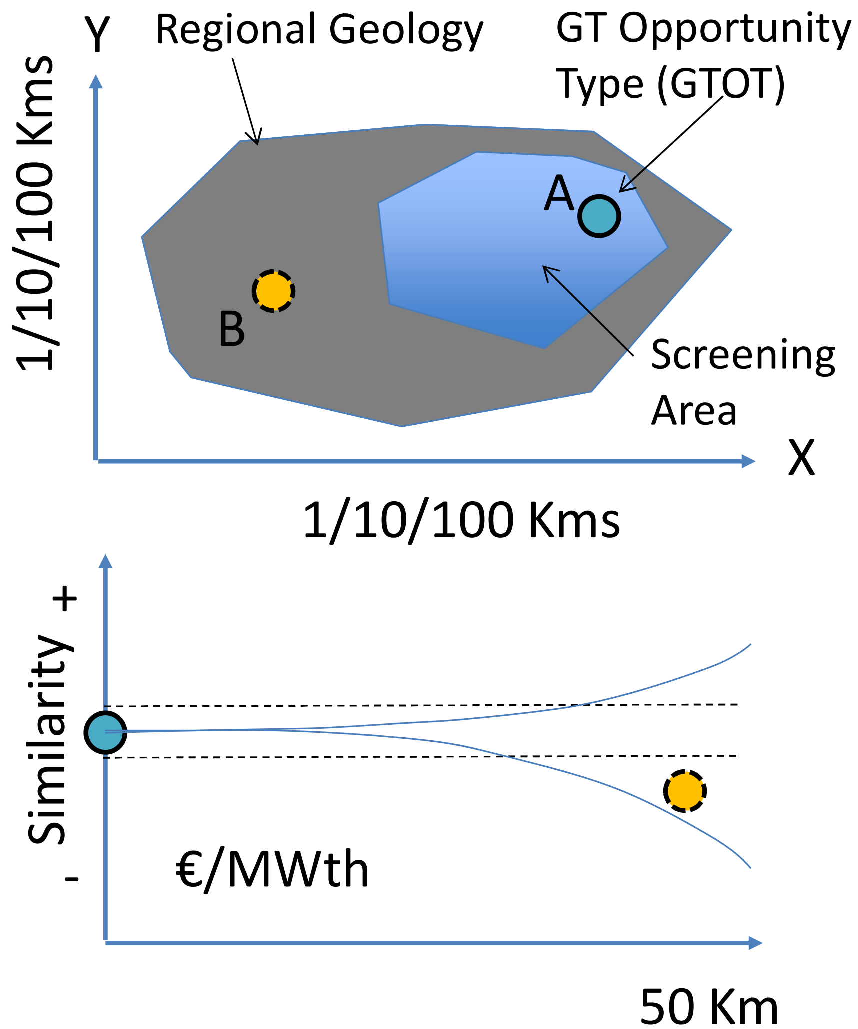
Example Only, Not a Real Assessment

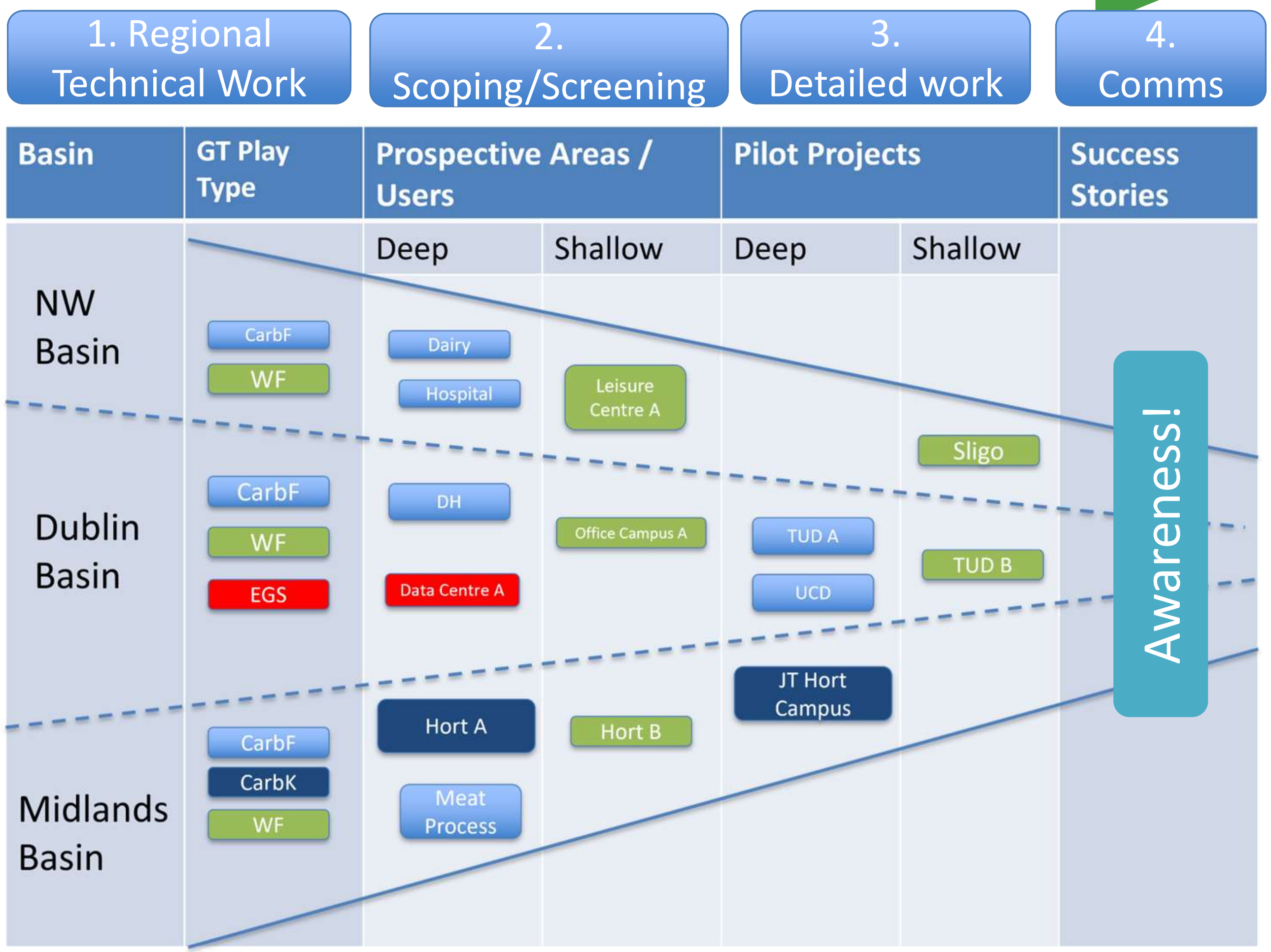
GTOT	Description	Pilot Project	€/MWth	CO2 Saved	Scalability
CarbK	Carboniferous Palaeokarst	Energy Campus	Low	Med	Low
CarbF	Carboniferous Fault Zone	TUD	Med	High	Med
Gran	Granite EGS	Newcastle	High	Med	Low
WF	Shallow Well Field	Sligo	Low	Med	High

National Geothermal Database



Screening System Interface - Ph. 1 GTOT based





Screening System Interface: Ph. 2 Map Based

What do you need the heat for?

End-use will determine temperature required and heat capacity/load

- Home Heating
- Large-Scale Heating
- District Heating
- Industrial Process
- Food Processing
- Horticulture
- Power

End-User

What temperature range is required?

End-use selection will guide to a temperature range

- 0-30°C
- 30-60°C
- 60-90°C
- 90-120°C
- 120-150°C
- 150°C+

How deep will you need to go to reach it?

Depth to that range will be function of temp gradient*

- Surface – 1000m
- 1000-2000m
- 2000-3000m
- 3000-4000m
- 4000-5000m
- 5000m+

*Depending on heat required & input temperature heat pumps are a variable that will affect this

What play type / reservoir exists at depth range?

What stratigraphy (and therefore reservoirs) will be encountered at the required isotherm range?

- Quaternary
- Shaley LST
- Clean LST
- Dolomitised LST
- Porous SST
- Tight SST
- LP Basement
- Proterozoic Basement
- Granite
- Other Igneous

Heat Extraction Technology Options

The reservoir type will determine the potential heat extraction methods suitable

- Shallow Open Loop
- Shallow Closed Loop
- Hydrothermal Doublet
- Hydrothermal EGS
- Petrothermal EGS
- Deep Closed Loop/AGS

Technical information required

Different heat extraction methods will require different additional geological understanding

- Fault & Fracture Characterization
- Stress Field
- Rock Mechanical Properties
- Thermal Conductivity
- Fluid Chemistry

Map based decision guide to lead potential-users to the information they need

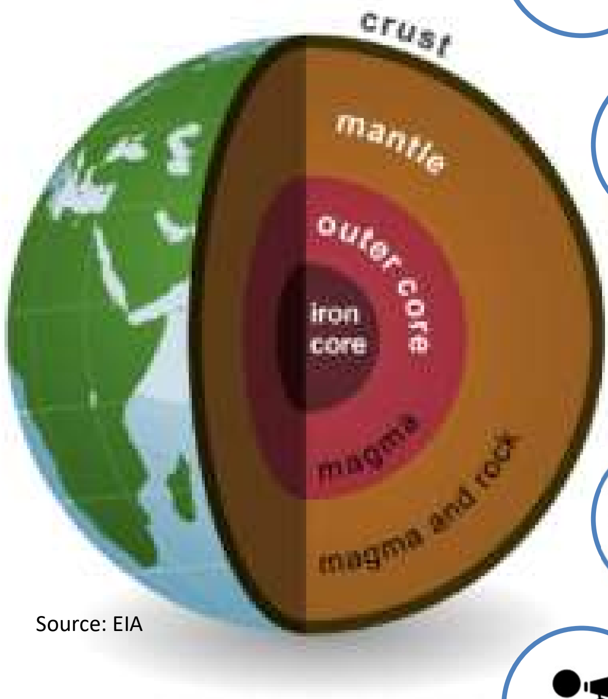
Output Factors

The depth, play type and technology option will combine to govern cost, regulatory requirements, environmental considerations, operation factors such as space required, facility type, monitoring etc

- Cost - €/MWth
- Seismicity assessment & Monitoring
- Exploration Licence
- Permits
- Surface Constraints
- Environmental Regulations

End-User Specific Info

Key Takeaways



Source: EIA

- Geothermal Direct Use Heat is a big prize- we need to quantify the size
- NGD goes beyond data – systematic plan to address risk & uncertainty
- There are several ways to get heat from the same geothermal reservoir. Need to define the economic hierarchy and pilot the options
- All deep play types will involve thermal conductivity, fault permeability &/or geomechanics: Seismic and well data key focus for new acquisition
- Awareness is everything. Goal is to create an accessible tool to guide users.

Thank You

Geological Survey
Suirbhéireacht Gheolaíochta
Ireland | Éireann

https://www.gsi.ie/en-ie/programmes-and-projects/geothermal

COMPLETIONS
GEOSCIENCE

rbd@completionsgeo.com

www.completionsgeo.com GEOTHERMAL | GEOMECHANICS.

Leveraging our existing data to understand geothermal resources

Dr Koen Torremans

@koentorremans

/in/koentorremans

koen.torremans@ucd.ie
koen.torremans@icrag-centre.org

UCD DUBLIN

iCRAG
SFI RESEARCH CENTRE
IN APPLIED GEOSCIENCES

With support from:

This presentation has emanated from research supported in part by:

- a research grant to **iCRAG** from Science Foundation Ireland (SFI) under Grant Number 13/RC/2092 and co-funded under the European Regional Development Fund and by iCRAG industry partners
- a research grant to **iCRAG2** from Science Foundation Ireland (SRI) under Grant Number 13/RC/2092_2
- the Horizon 2020 research and innovation programme under the **Marie Skłodowska-Curie Individual Fellowship** grant agreement No. 745945,
- a **research professorship** grant to UCD from Science Foundation Ireland (SFI) under Grant Number 16/SP/4319,
- an **SFI Industry Fellowship** research grant from Science Foundation Ireland (SFI) under Grant Number 18/IF/6330 and co-funded by Teck,
- a grant to contribute to the **Blue Book project** from Geological Survey Ireland through a Memorandum of Understanding with UCD.

The authors would like to thank the Geological Survey Ireland (GSI), Exploration and Mining Division (EMD), and Petroleum Affairs Division (PAD) of the Department of Communications, Climate Action and Environment (DCCAE), Ireland, for providing access to released well, seismic and potential field datasets.

Academic Software licences

Derisking deep geothermal is derisking the subsurface:

Identify the presence of reservoirs in suitable temperature windows and with sufficient flow rates

We need a reservoir:

- What geothermal reservoir units do we have?
- What are target depths?
- How thick are these units? What is their relationship with other units?

Derisking deep geothermal is derisking the subsurface:

Identify the presence of reservoirs in suitable temperature windows and with sufficient flow rates

<u>We need reservoirs to flow:</u>

- Rock properties of the reservoir units?
- Where are fault zones?
- What orientation and size are the fault zones?

iCRAG IRISH CENTRE FOR RESEARCH IN APPLIED GEOSCIENCES

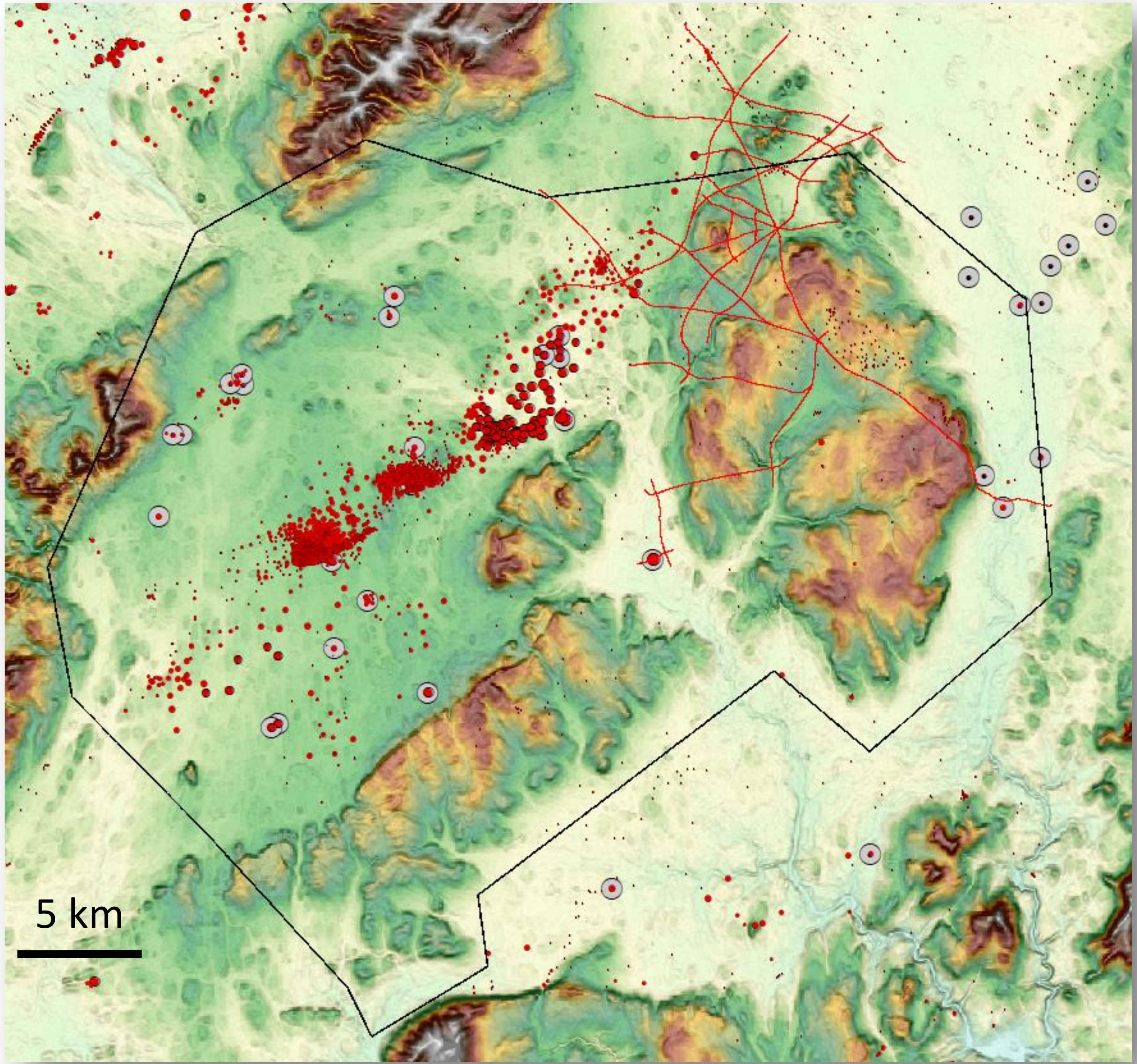
Derisking deep geothermal is derisking the subsurface:

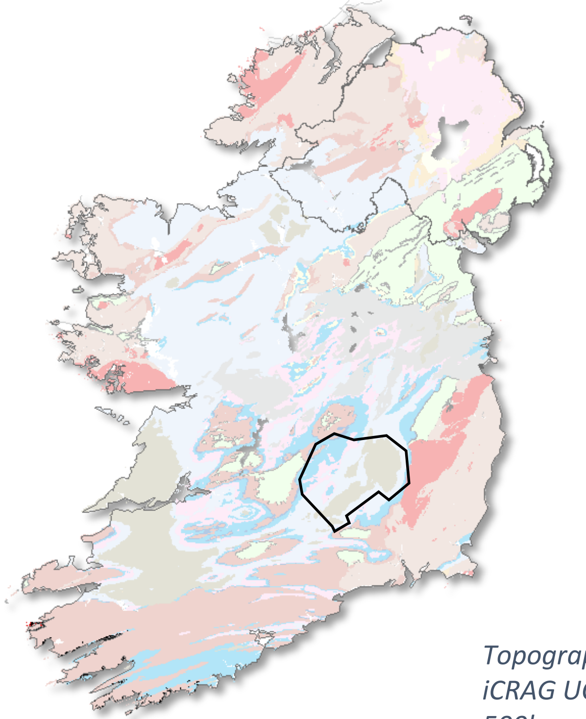
Identify the presence of reservoirs in suitable temperature windows and with sufficient flow rates

<u>Stepping stones to de-risk:</u>

- ✓ Robust subsurface models of reservoir units and faults
- ✓ Volumetric resource and flow estimates for depth intervals
- ✓ where temperatures exist in the ranges defined by sectoral uses.

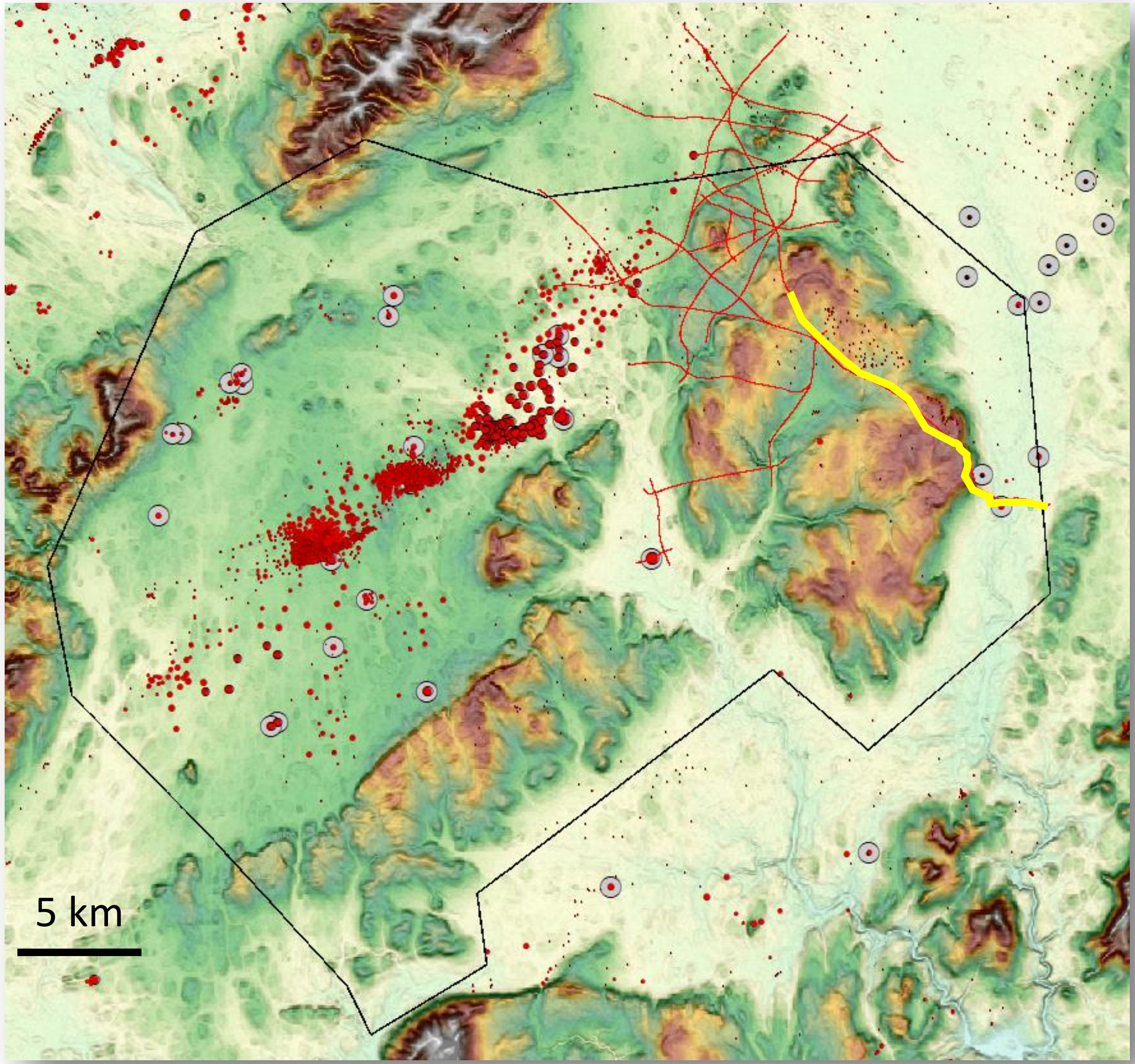
Local and regional scale subsurface modelling





Topography: JPL SRTM / Seismic from GSRO, DECC
iCRAG UCD drillhole database, and Vedanta Ltd database
500k geology modified from Geological Survey Ireland, 2017

Local and regional scale subsurface modelling



✓Mineral exploration & survey **drilling**

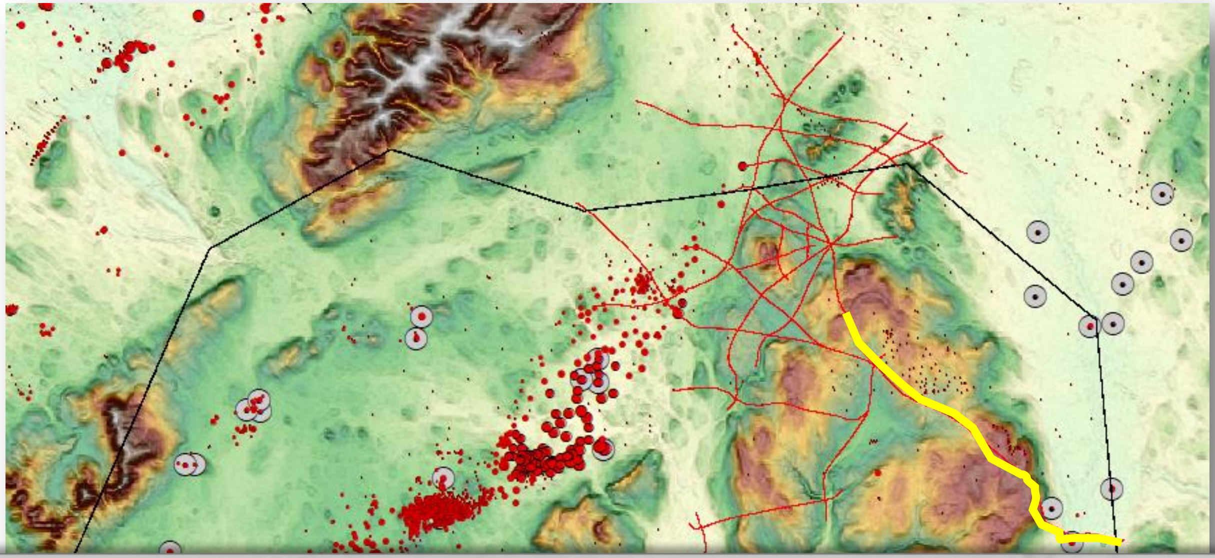
- 5 million meters – 7 decades of mineral exploration
- Uneven distribution

✓**Reflection seismic data**

- Hydrocarbon exploration
- Minerals exploration
- ~ 800+ line-km of ‘open’ 2D onshore, some 3D

2D reflection seismic
10 m deep drill hole
1000 m deep drill hole
Reference Borehole

Local and regional scale subsurface modelling

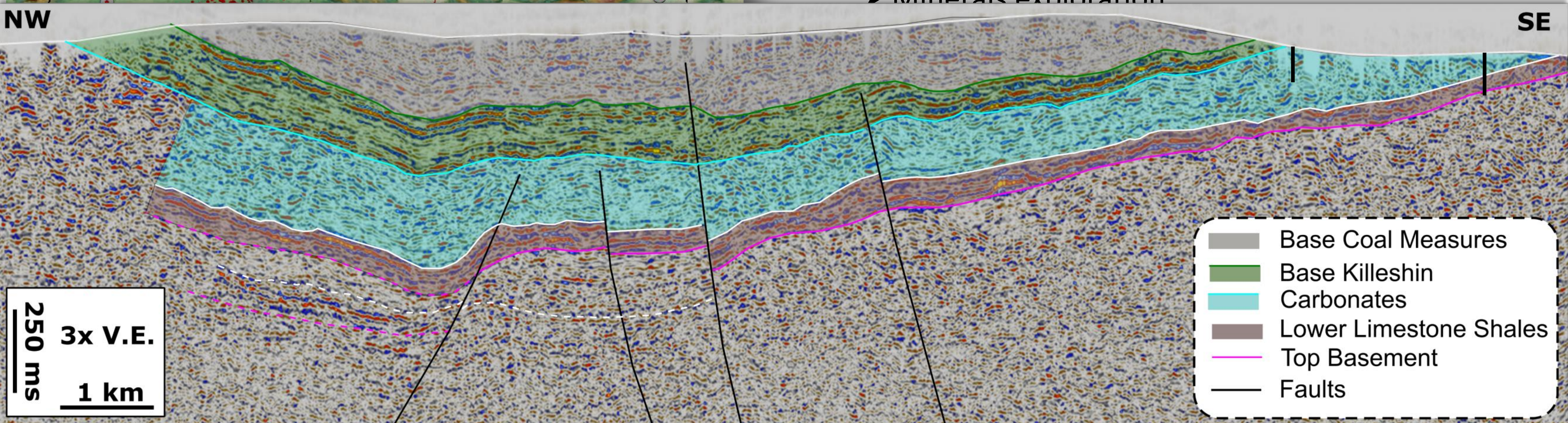


✓Mineral exploration & survey **drilling**

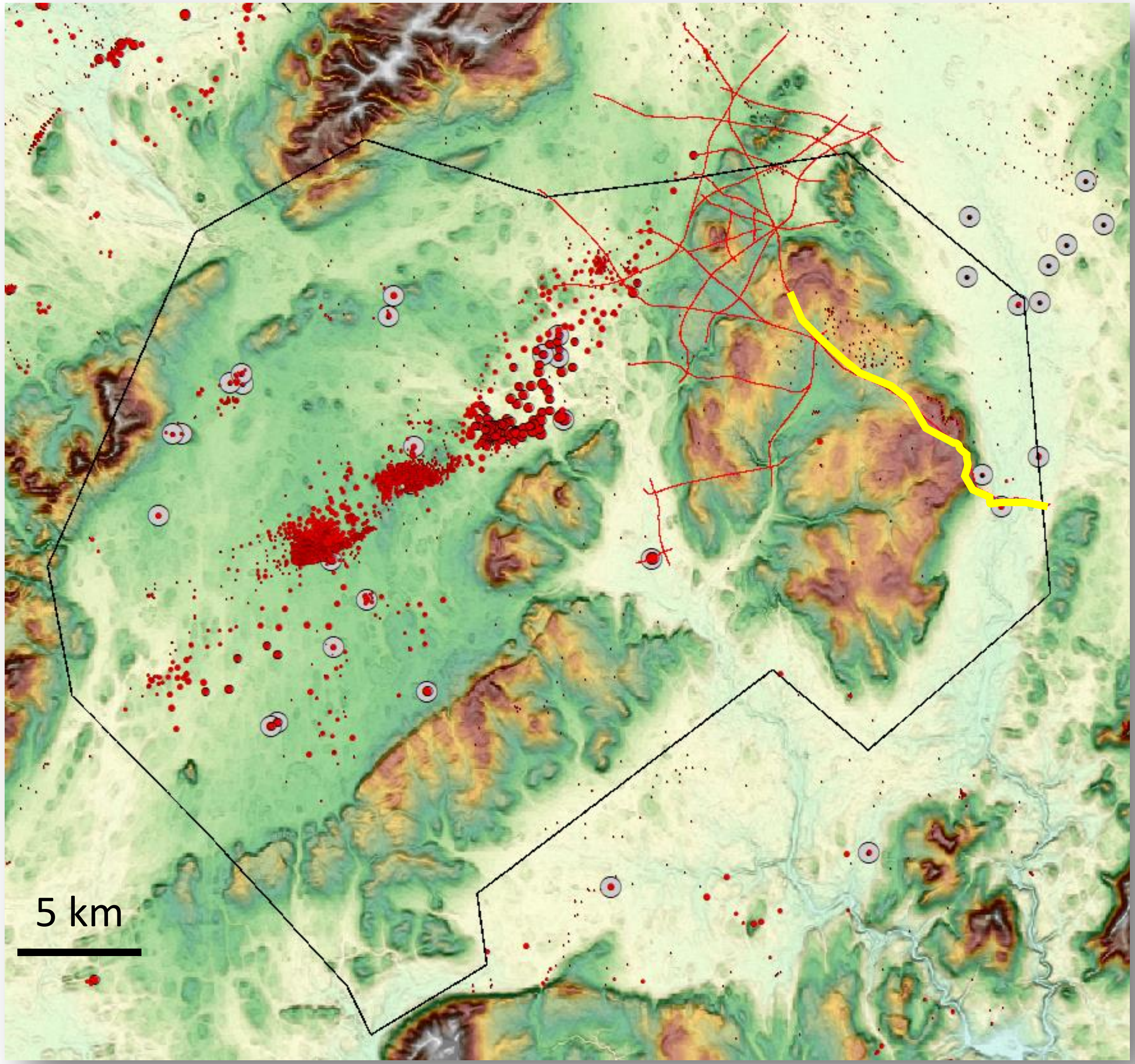
- 5 million meters – 7 decades of mineral exploration
- Uneven distribution

✓**Reflection seismic data**

- Hydrocarbon exploration
- Minerals exploration



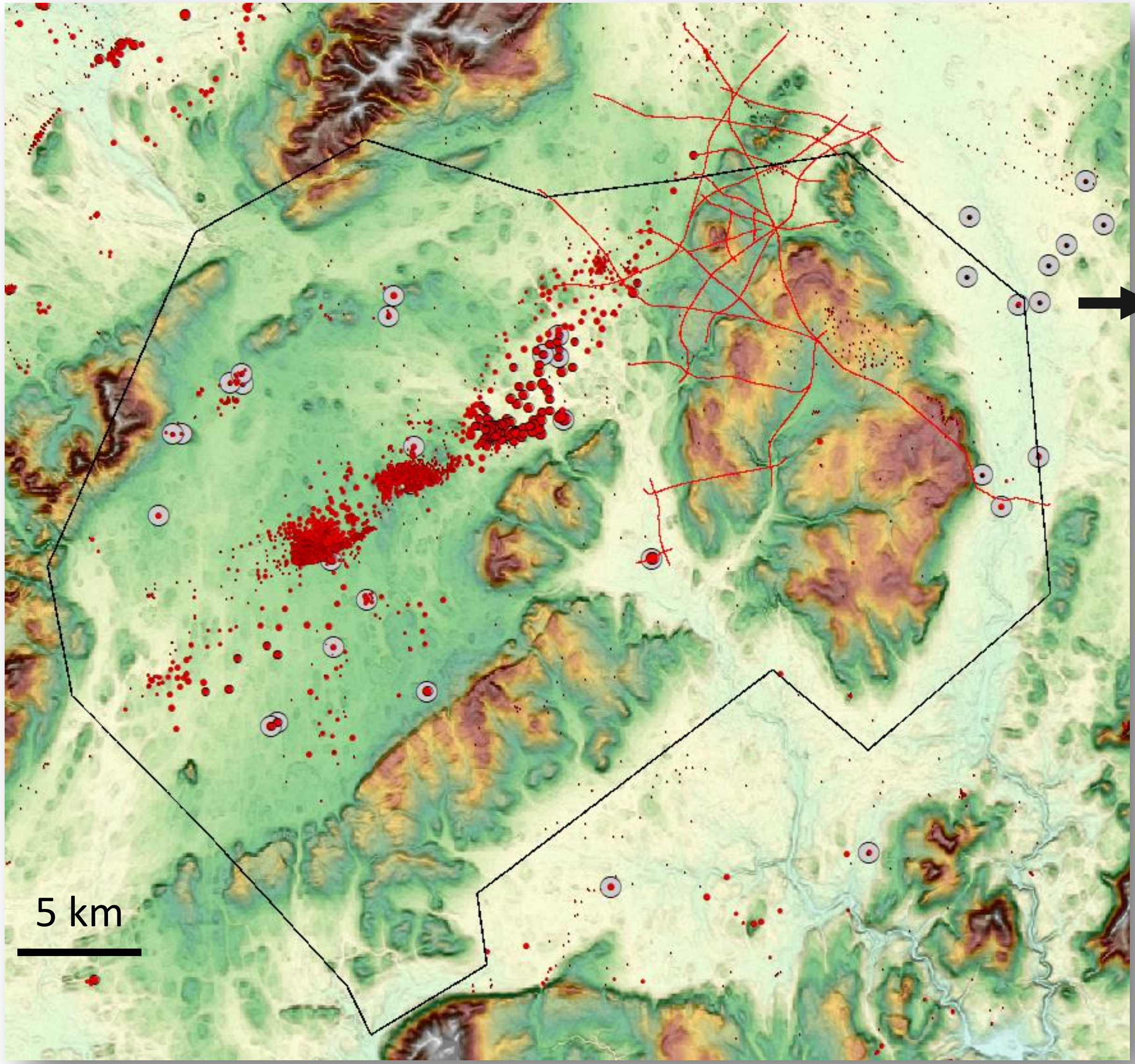
Local and regional scale subsurface modelling

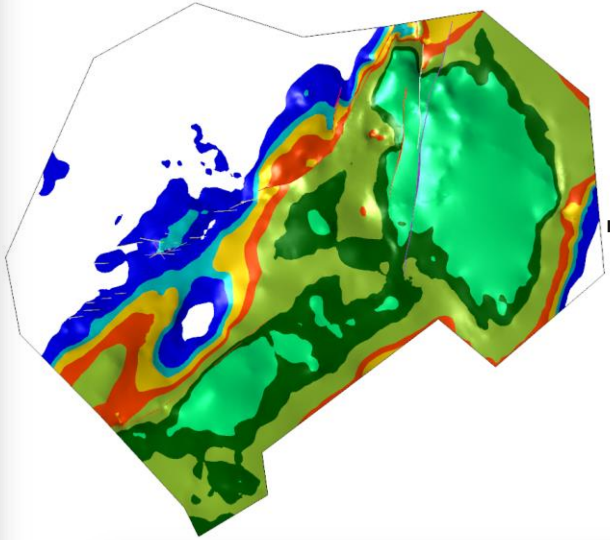


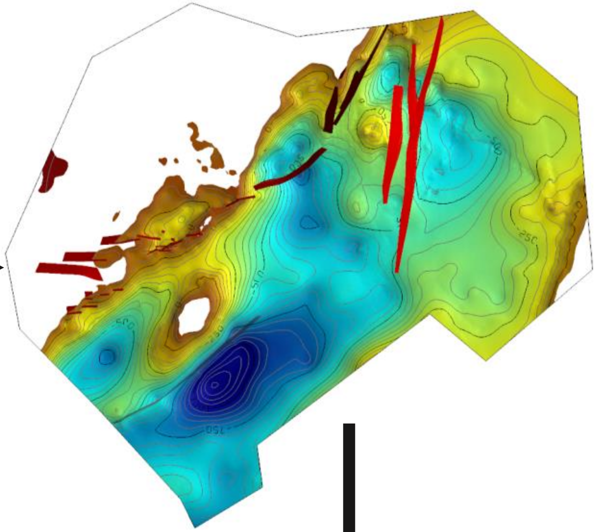
- ✓Mineral exploration & survey **drilling**
  - 5 million meters – 7 decades of mineral exploration
  - Uneven distribution
- ✓**Reflection seismic data**
  - Hydrocarbon exploration
  - Minerals exploration
  - ~ 800+ line-km of 'open' 2D onshore, some 3D
- ✓**Mine data** historic and present
- ✓**Geophysics** (e.g. Tellus):
  - Shallow: Electromagnetics
  - Deeper: airborne magnetics, magnetotelluricss
  - Deep: Gravity

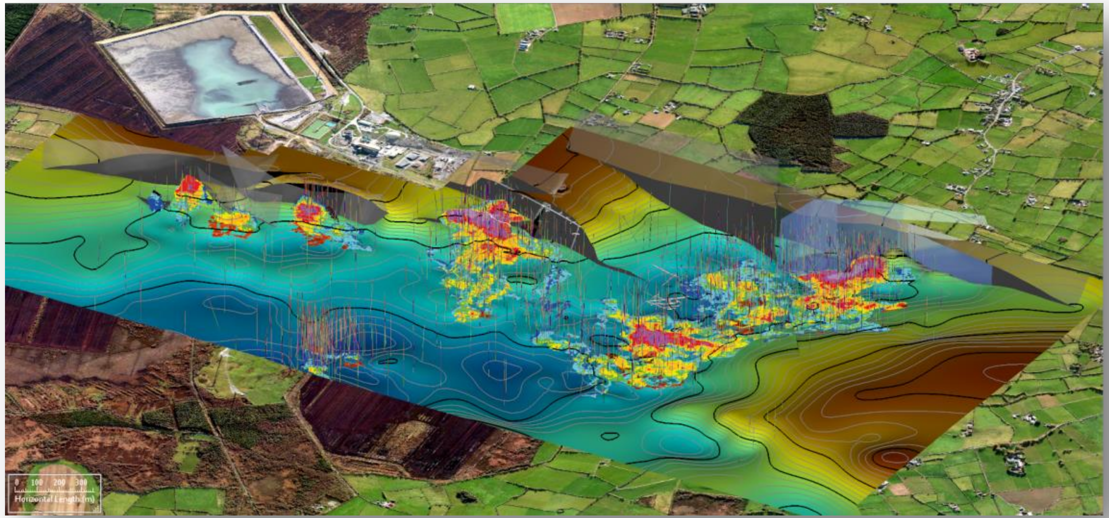
Kyne et al 2019; Torremans et al 2018; and Koen Torremans, Roisin Kyne, Robert Doyle, Nick Vafeas, John Guven, John Walsh

Local and regional scale subsurface modelling



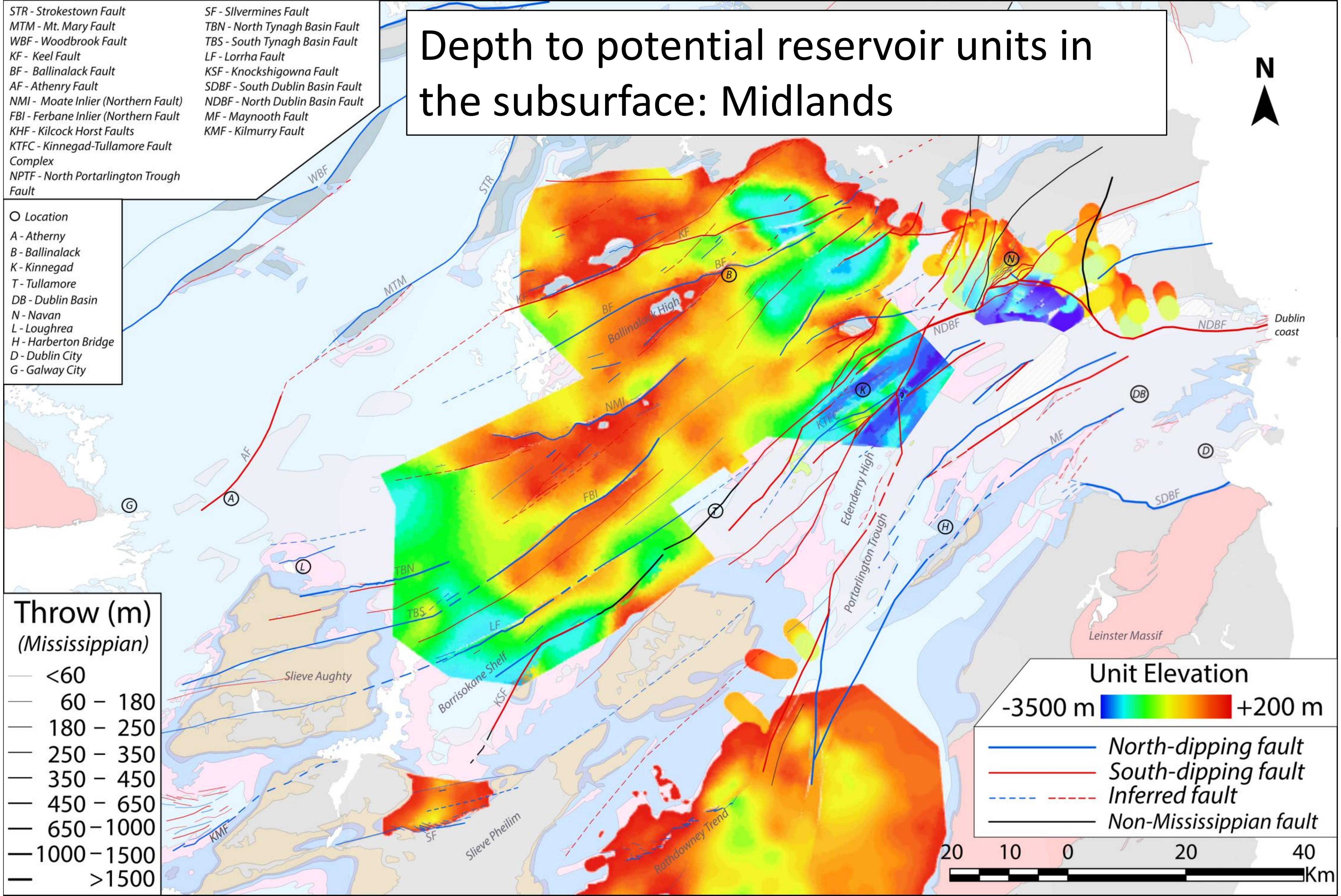




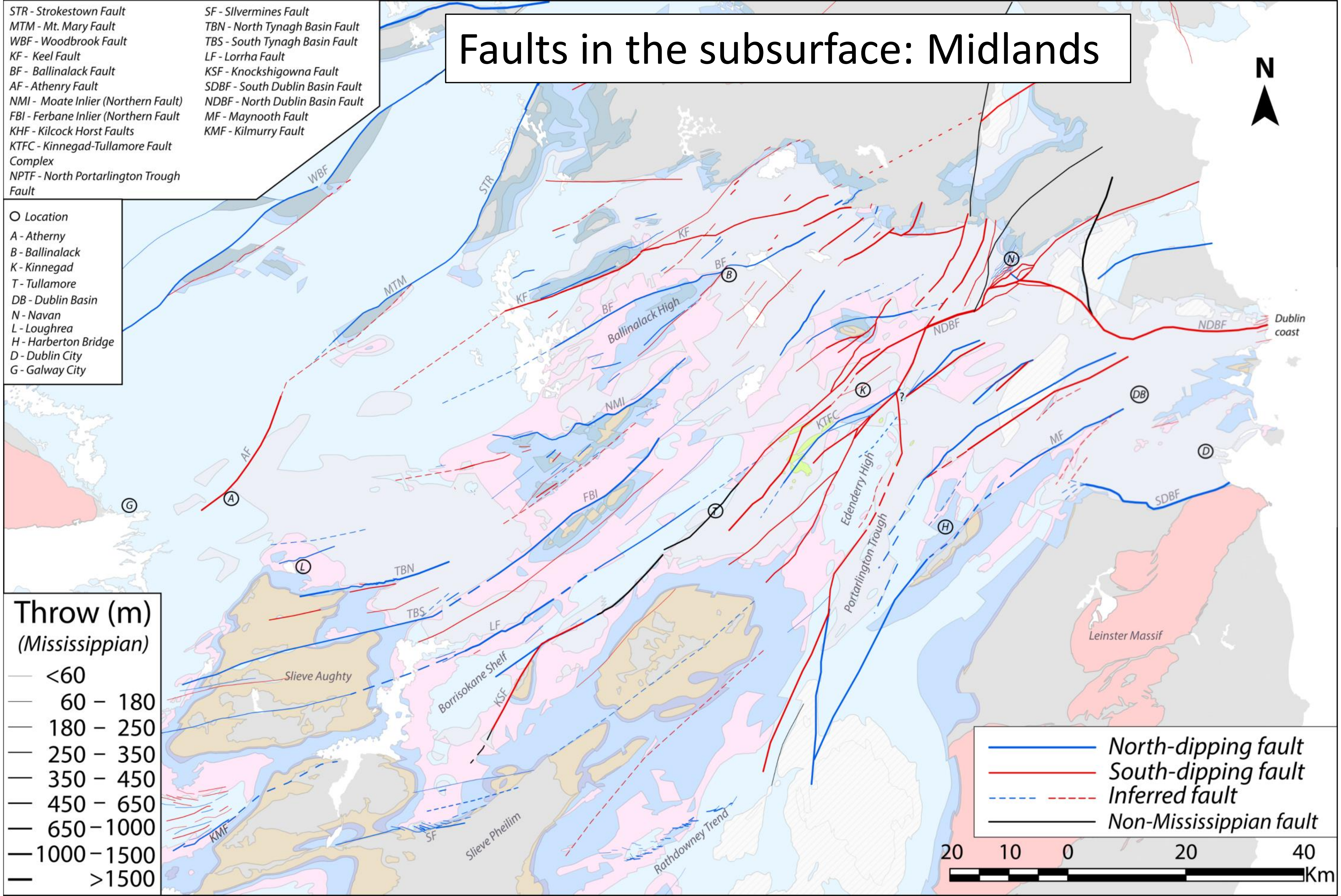


Kyne et al 2019; Torremans et al 2018; and Koen Torremans, Roisin Kyne, Robert Doyle, Nick Vafeas, John Guven, John Walsh

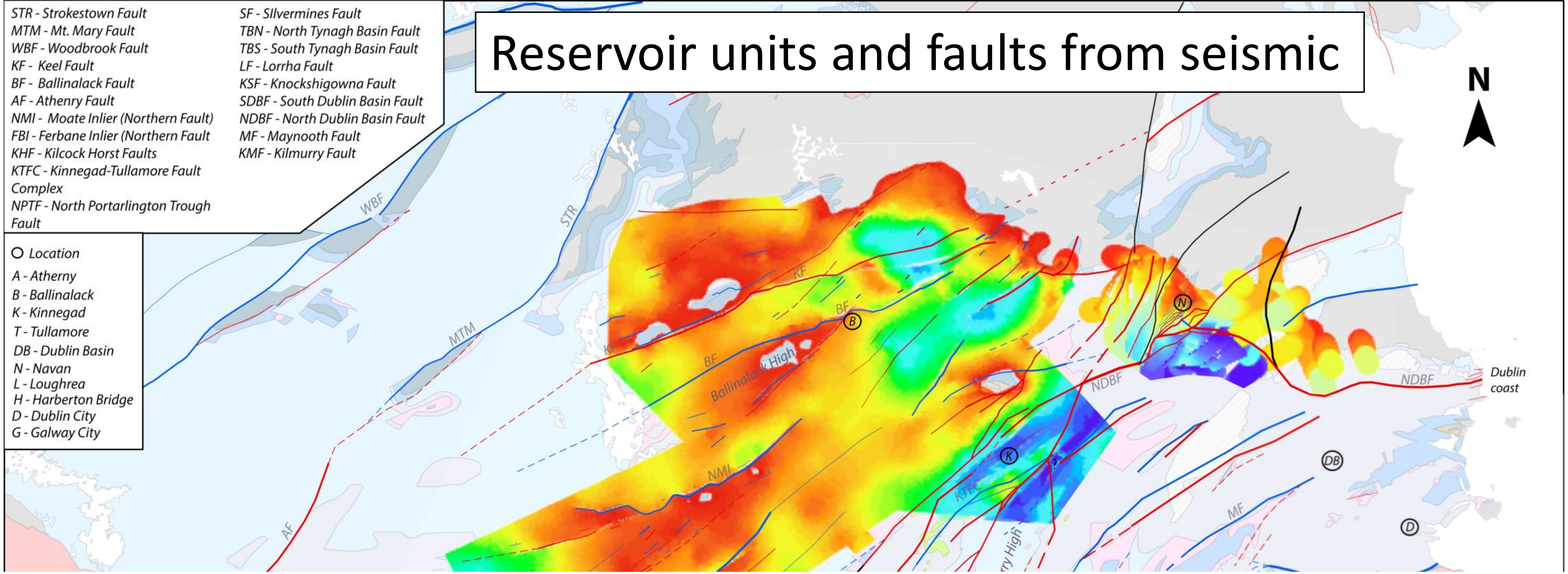
Depth to potential reservoir units in the subsurface: Midlands

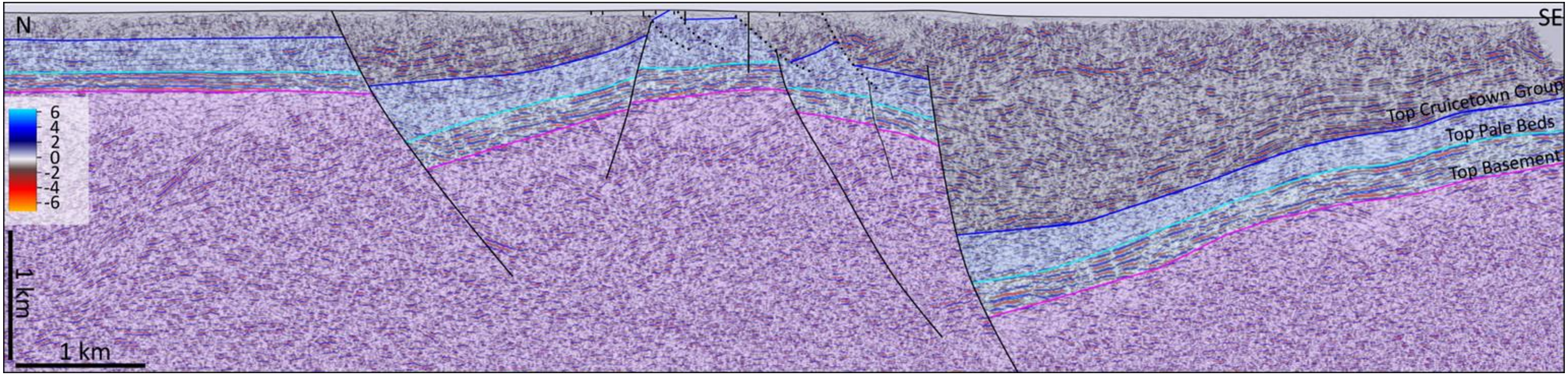


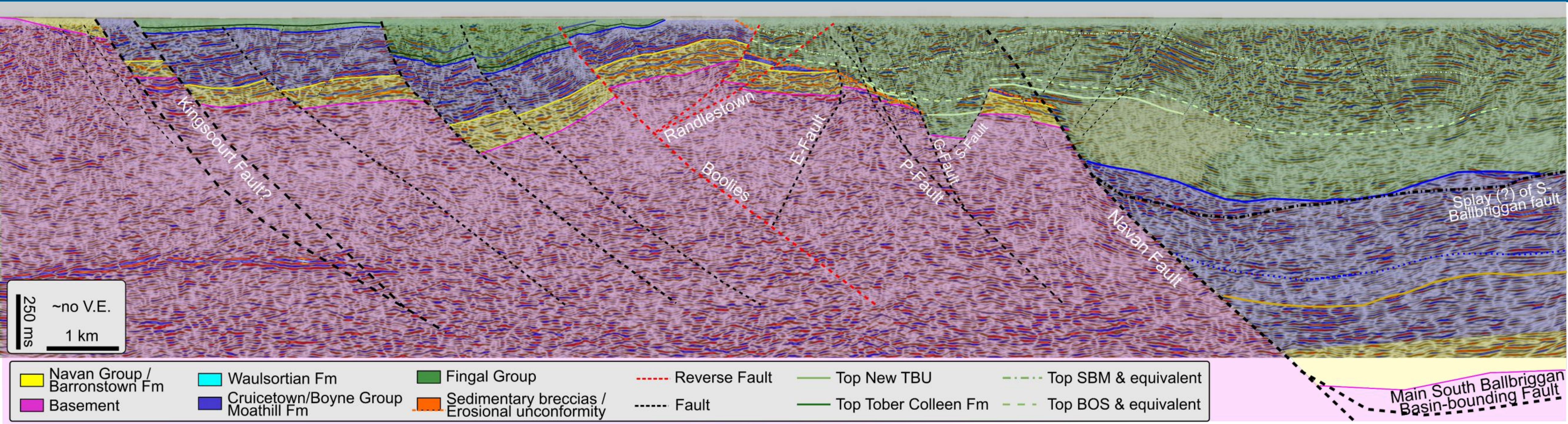
Faults in the subsurface: Midlands



Reservoir units and faults from seismic

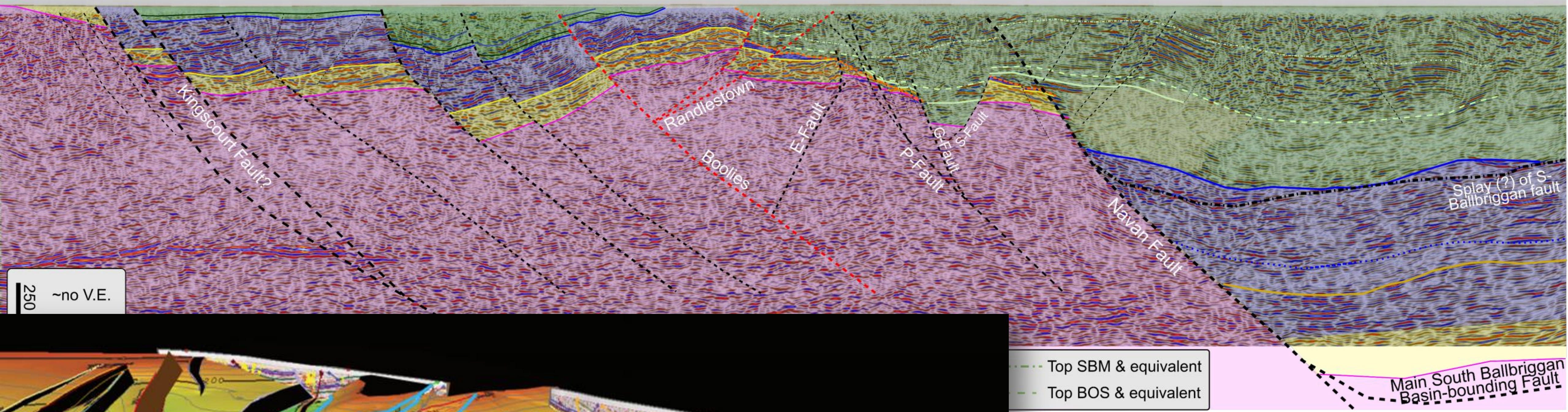


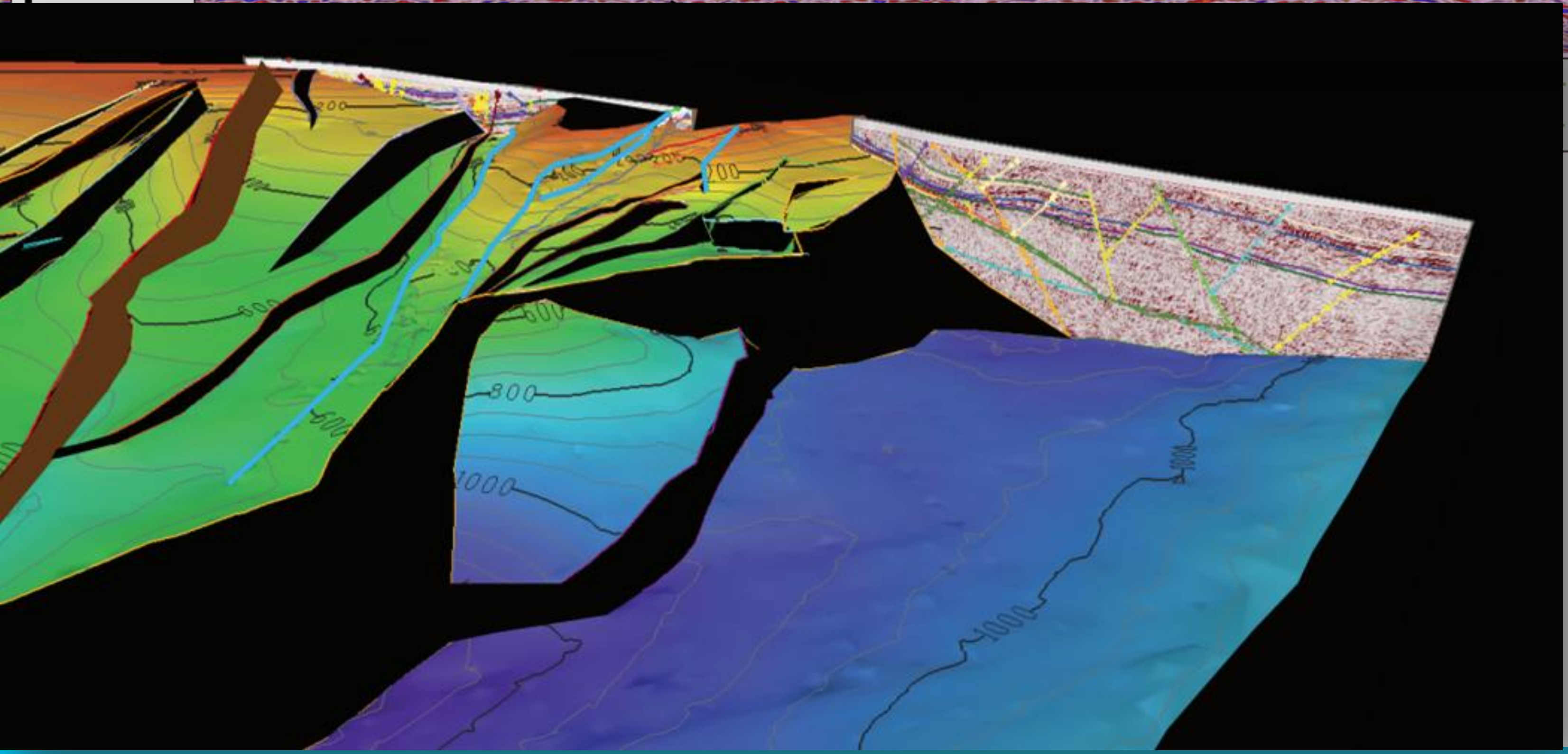




- Seismic line across the world-class Navan Zn-Pb deposit (see e.g. Ashton et al. 2018)
- Depths to target horizons: Different play types
- Major fault zones: Flow and depth = heat

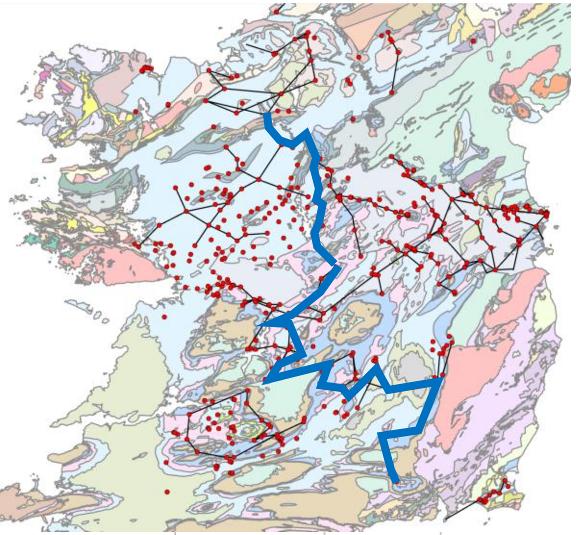
Leveraging seismic data

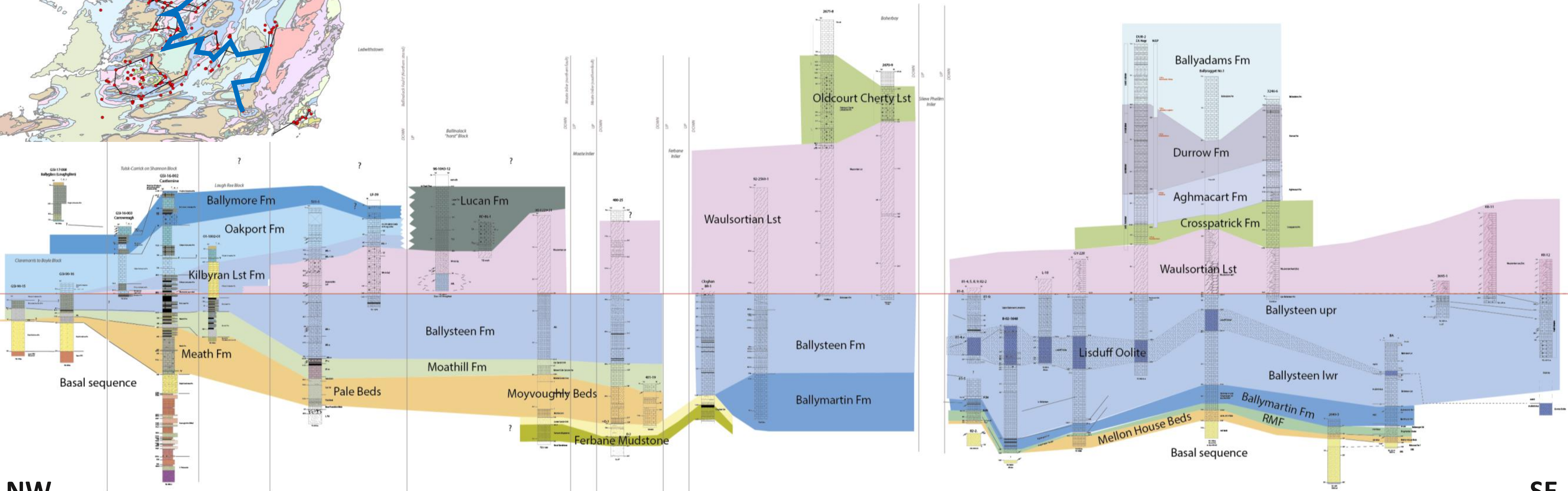


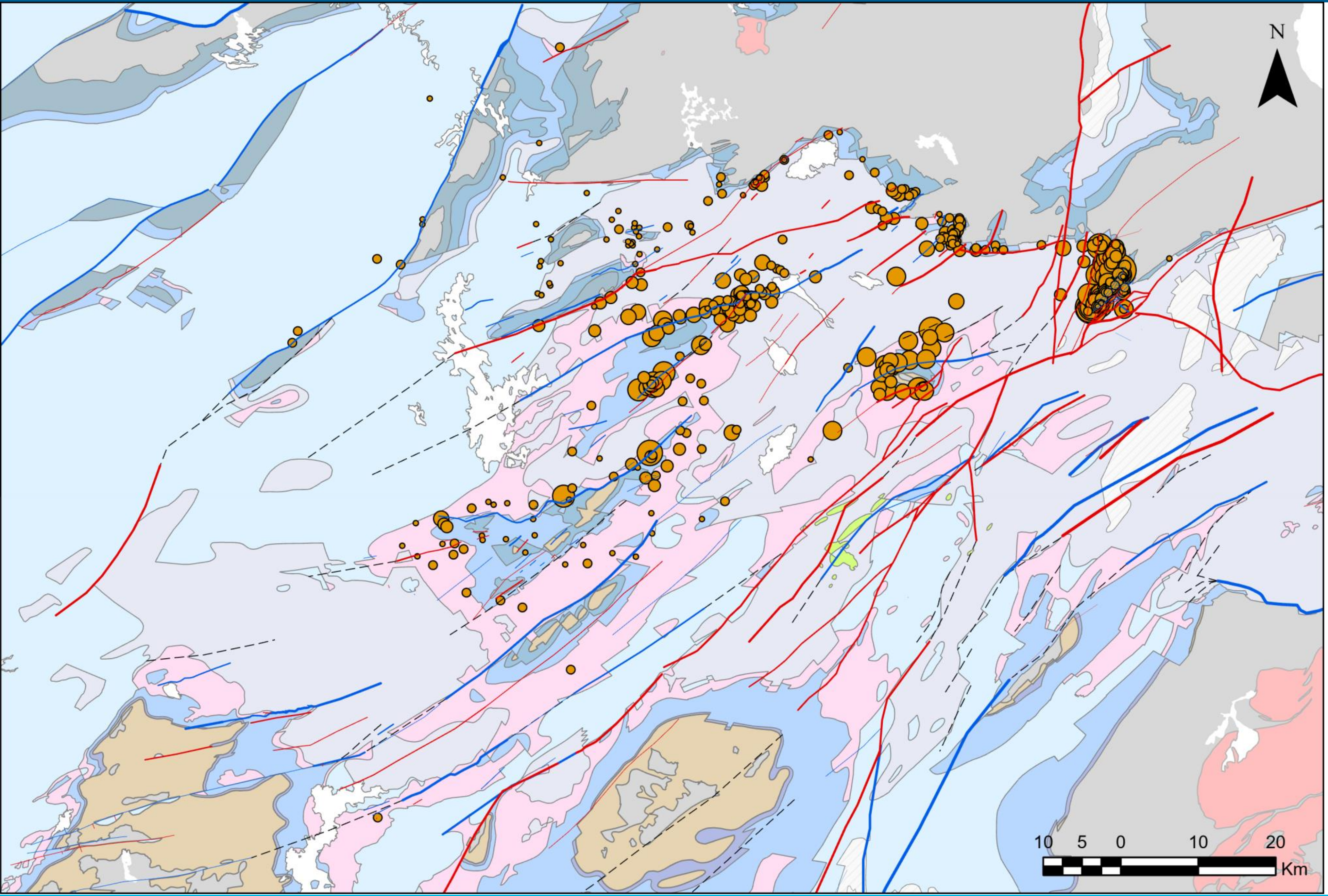


Identifying, characterising and correlating potential reservoir units

- ✓ Stratigraphic correlation and facies distributions of Carboniferous rocks of Ireland: iCRAG – GSI collaboration
- ✓ Ever-increasing amount of hyperspectral data
- ✓ In dire need for geothermal: *petrophysics*, *mechanical stratigraphy*







Thickness (m)

Moathill Fm/

SP

- 0.1 - 25
- 25 - 50
- 50- 75
- 75 - 100
- 100 - 125
- 125 - 150
- 150 - 200
- 200 - 300

Moathill Fm extent

Upper Sandstone extent

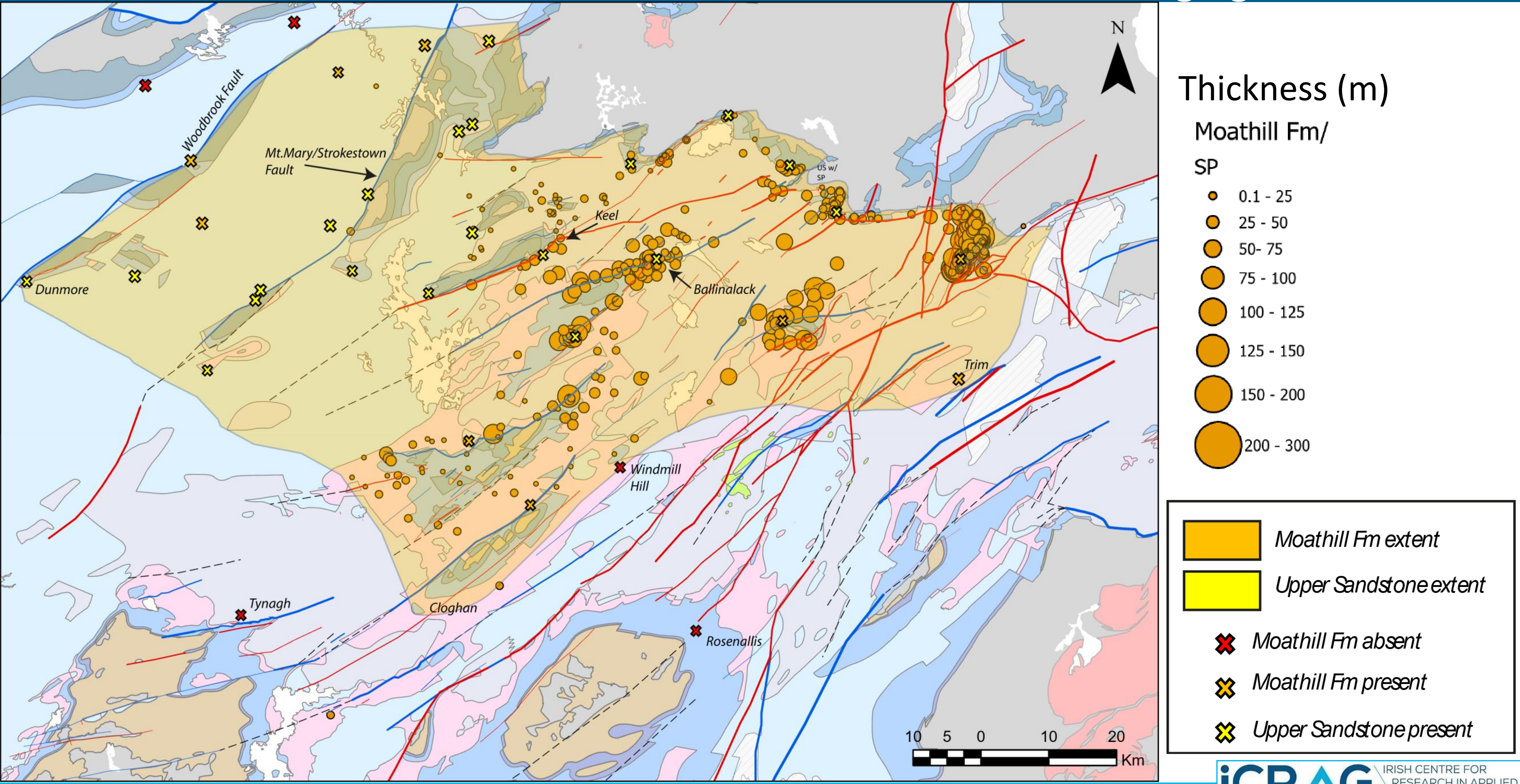
Moathill Fm absent

Moathill Fm present

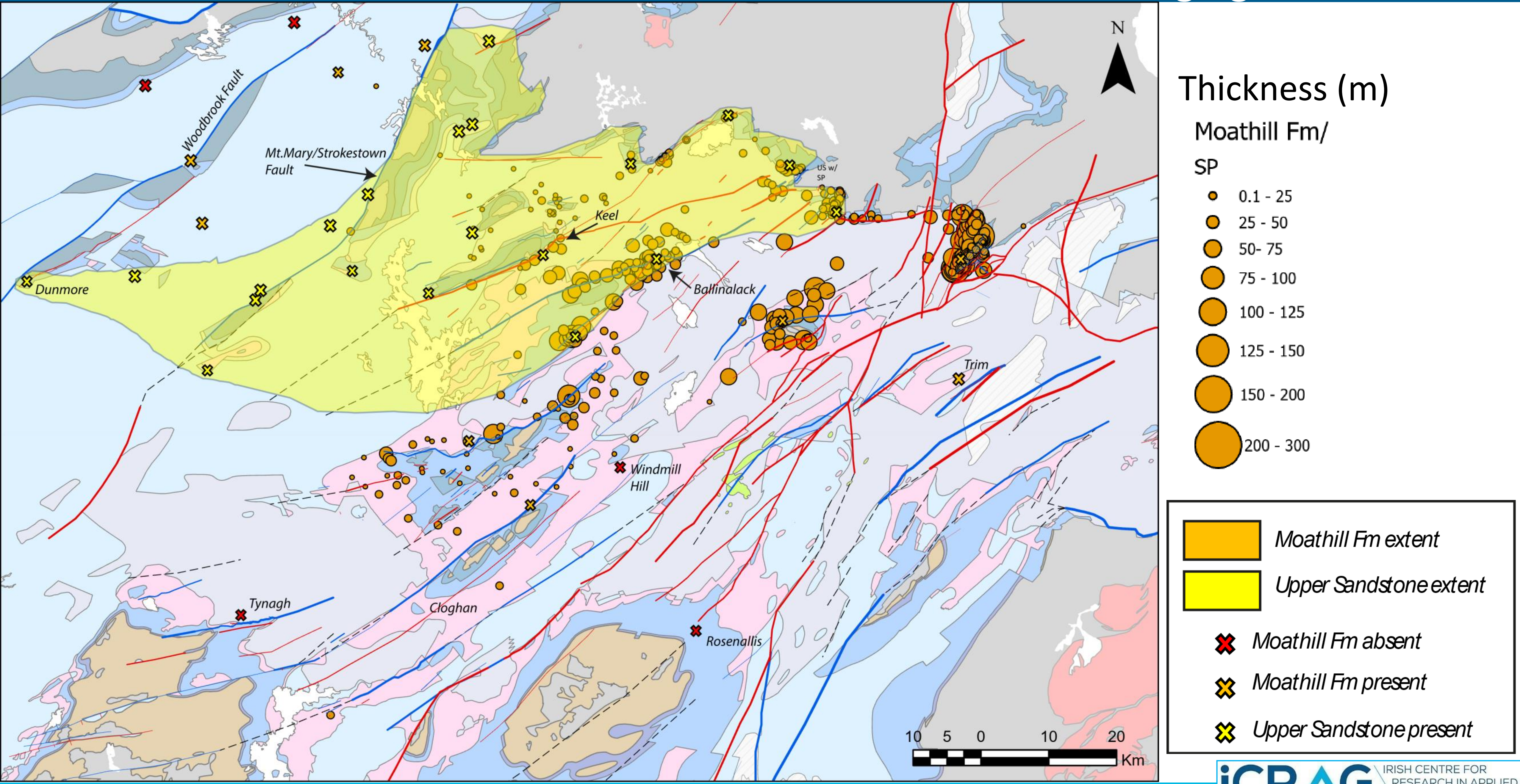
Upper Sandstone present

iCRAG IRISH CENTRE FOR RESEARCH IN APPLIED GEOSCIENCES

Leveraging borehole data



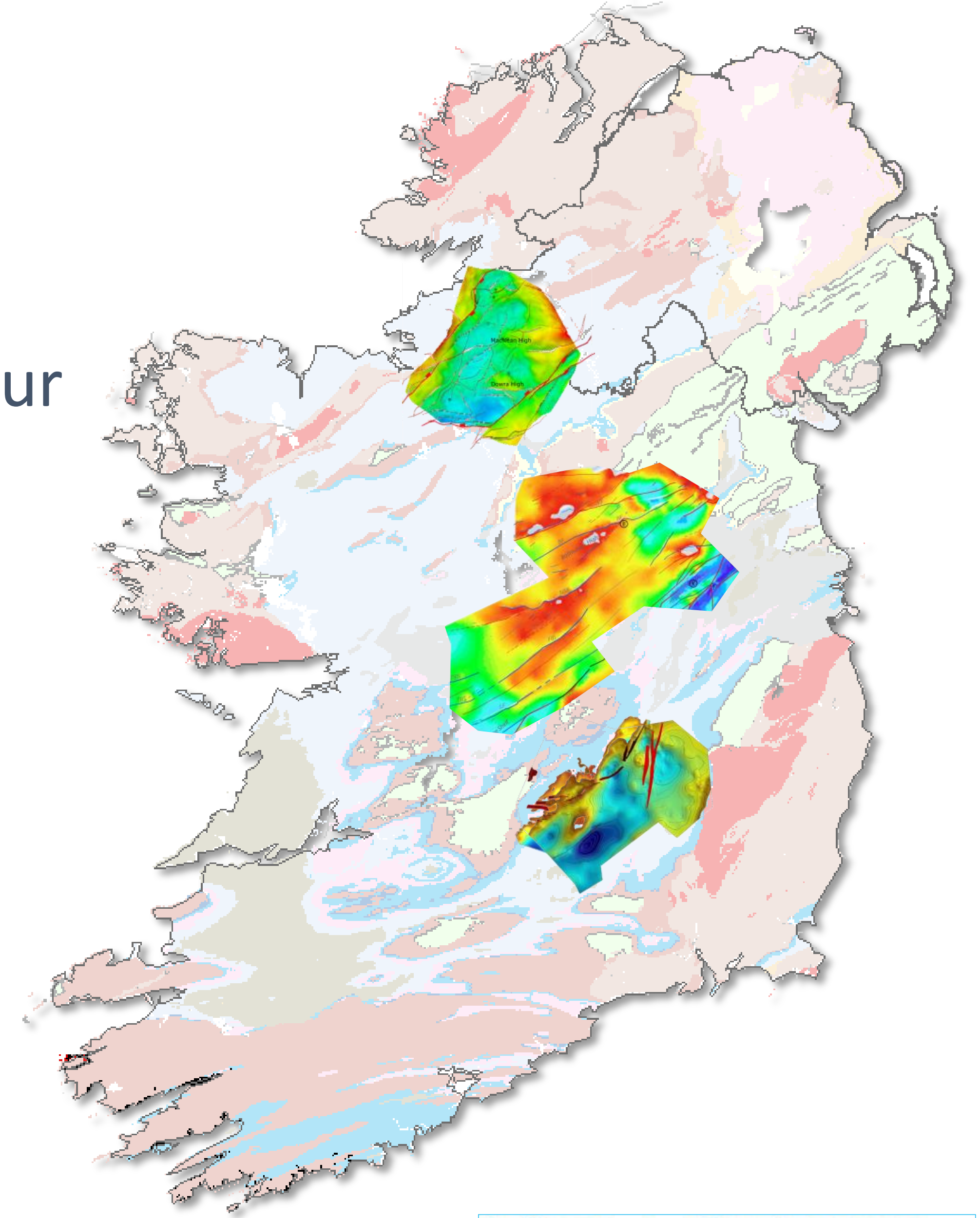
Leveraging borehole data



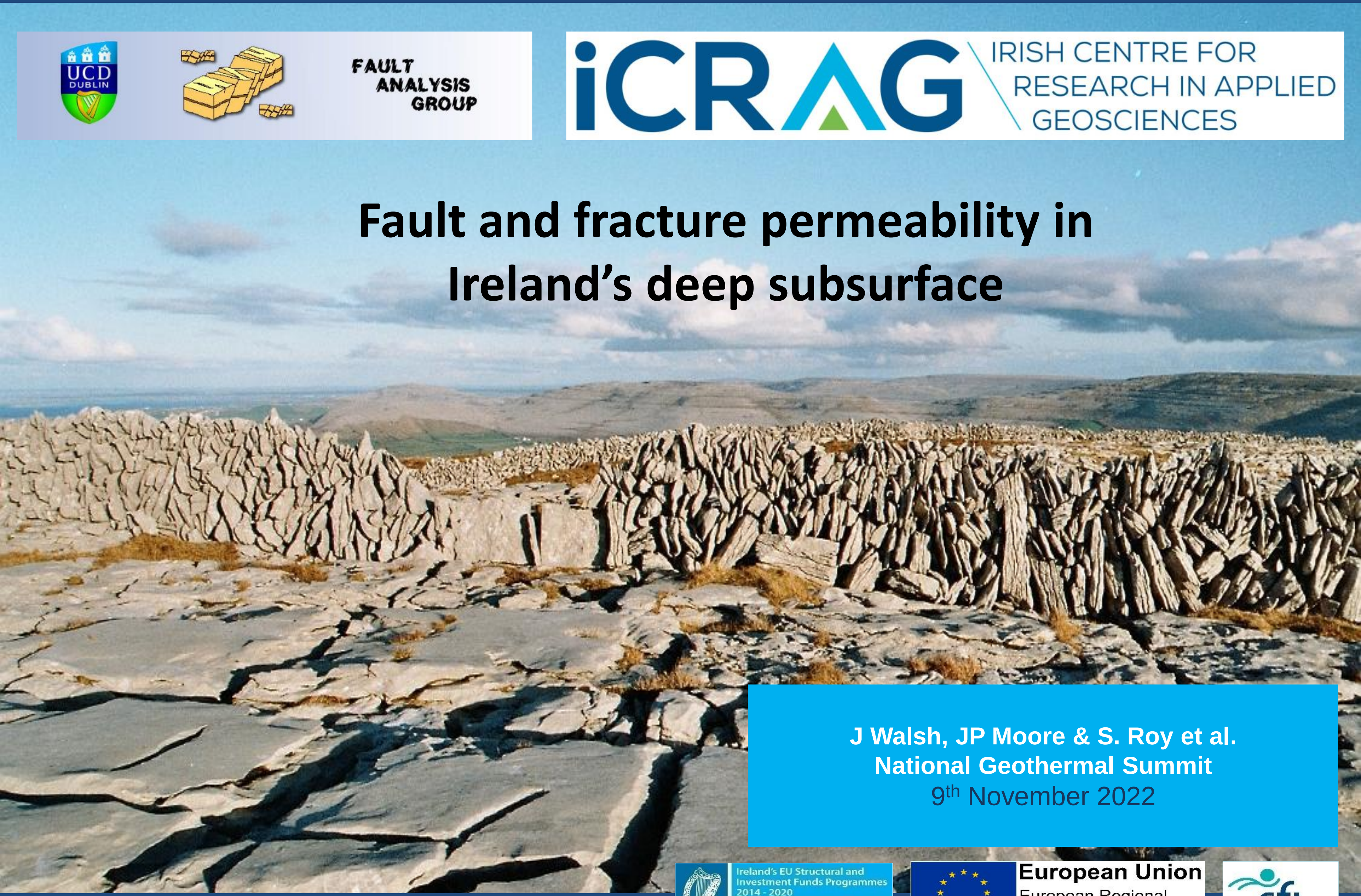
- Leveraged existing data to constrain basin architecture, faults and target depths.

- Reflection seismic data is essential to de-risk our subsurface efficiently

- Clear potential for:
  - Extending subsurface models to strategic and high-demand areas
  - Application of know-how and expertise to deep geothermal assessment in Ireland
  - Cross-sector collaborations



Geological map after Geological Survey Ireland 2018



IRISH CENTRE FOR RESEARCH IN APPLIED GEOSCIENCES

FAULT ANALYSIS GROUP

Fault and fracture permeability in Ireland's deep subsurface

J Walsh, JP Moore & S. Roy et al.

National Geothermal Summit

9th November 2022

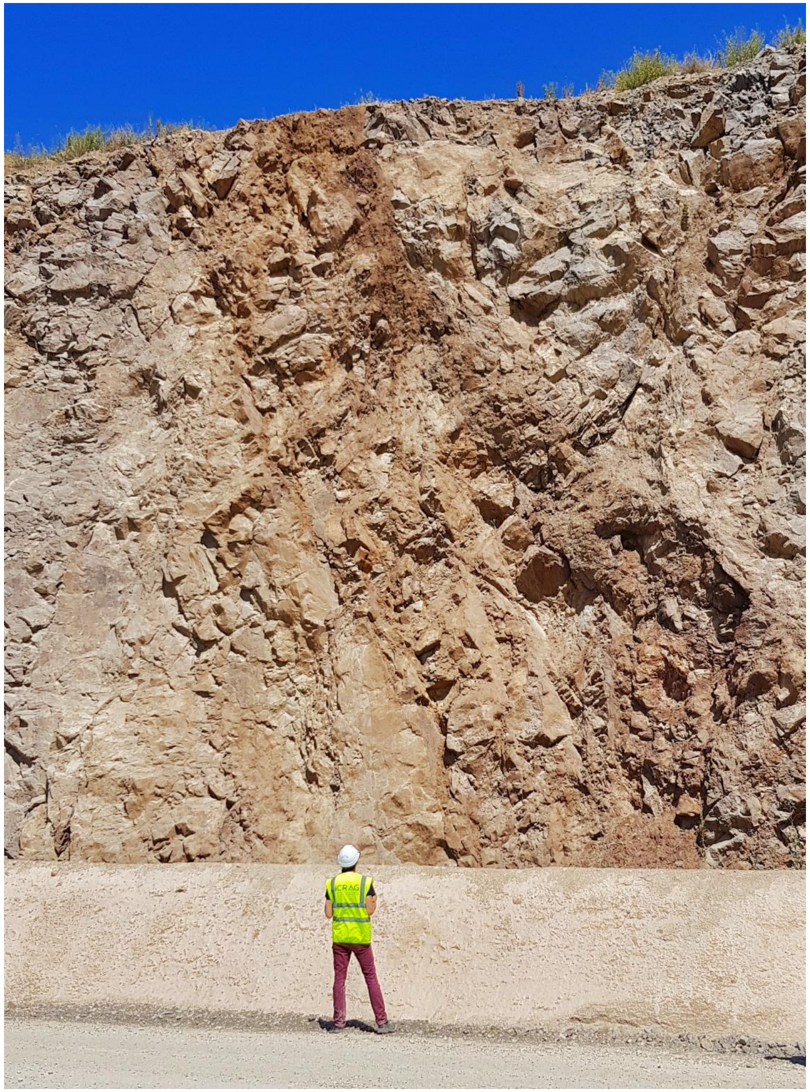
Ireland's EU Structural and Investment Funds Programmes 2014 - 2020
Co-funded by the Irish Government and the European Union
European Union European Regional Development Fund

De-risking deep geothermal is de-risking the subsurface:

Identify the presence of reservoirs in suitable temperature windows and with sufficient flow rates

<u>We need flow rates:</u>

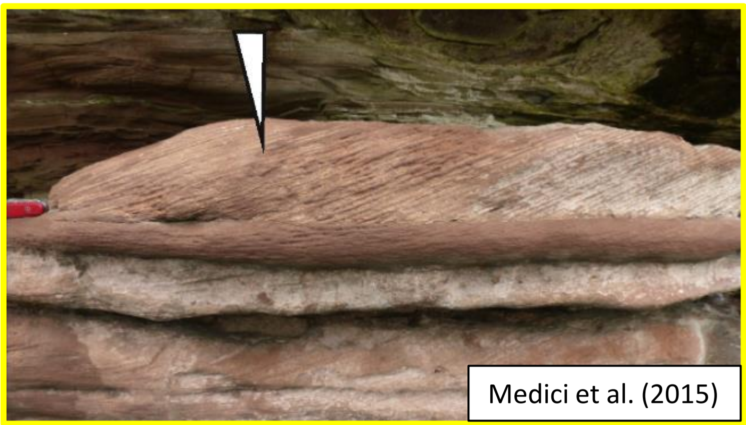
- What geothermal reservoir units do we have?
- Rock properties of the reservoir units?
- Where are fault/fracture zones?
- What orientation and size are the fault/fracture zones?



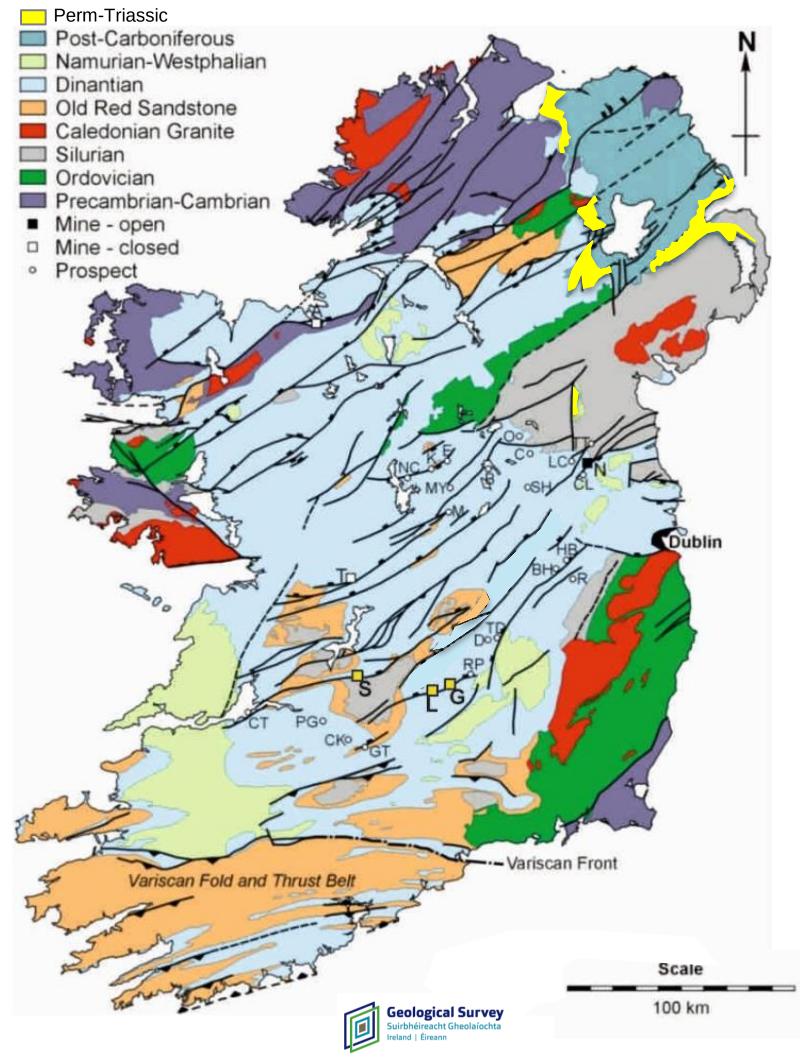
Why are faults/fractures important?

Geothermal systems benefit from advective flow

Sandstones contain faults that baffle flow



Limestones are tight without fractures

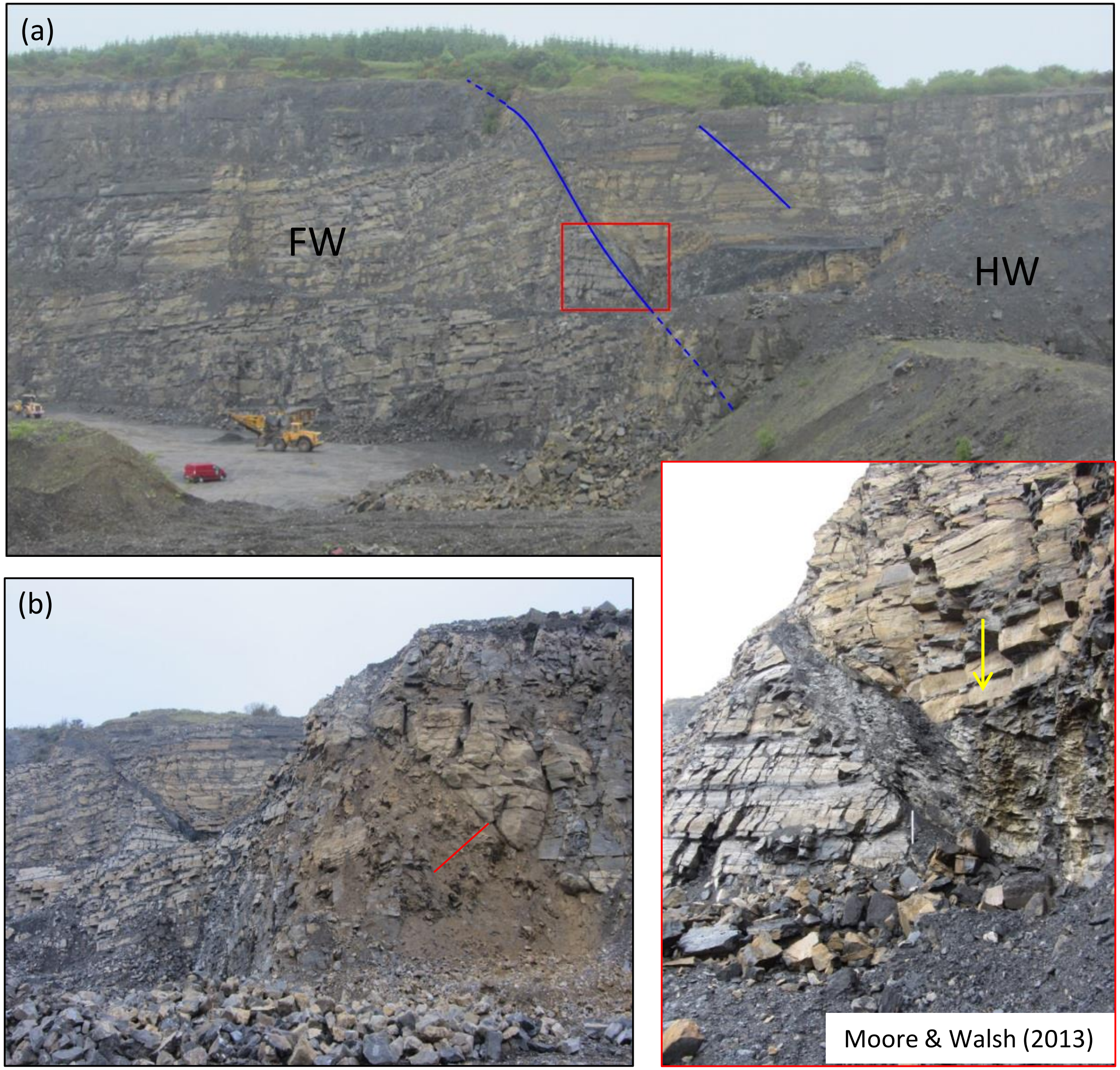


Carboniferous normal faults

BUT normal faults comprise shaley fault gouges, stylobreccias and veins.

Low permeability fault rocks providing fault seals.

These faults can, however, localize adjacent dolomite and along-fault karst.



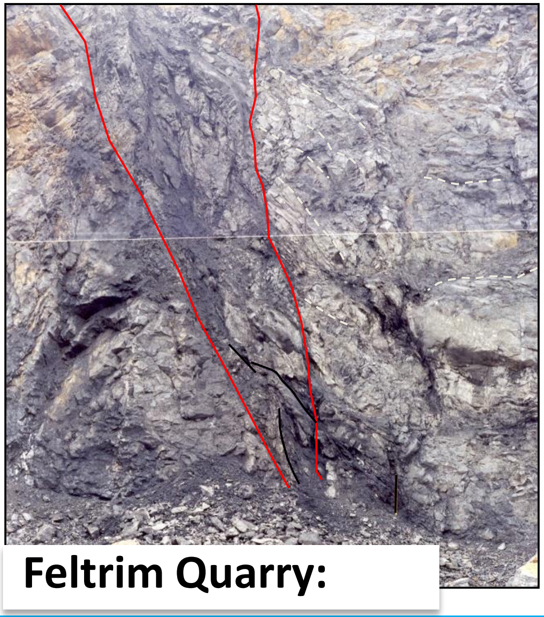
Dunaree Quarry, Fermanagh

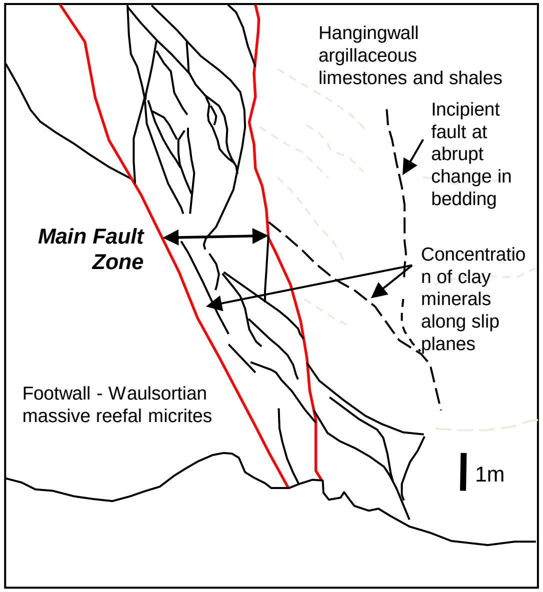
Carboniferous normal faults

BUT normal faults comprise shaley fault gouges, stylobreccias and veins.

Low permeability fault rocks providing fault seals.

These faults can, however, localize adjacent dolomite and along-fault karst.



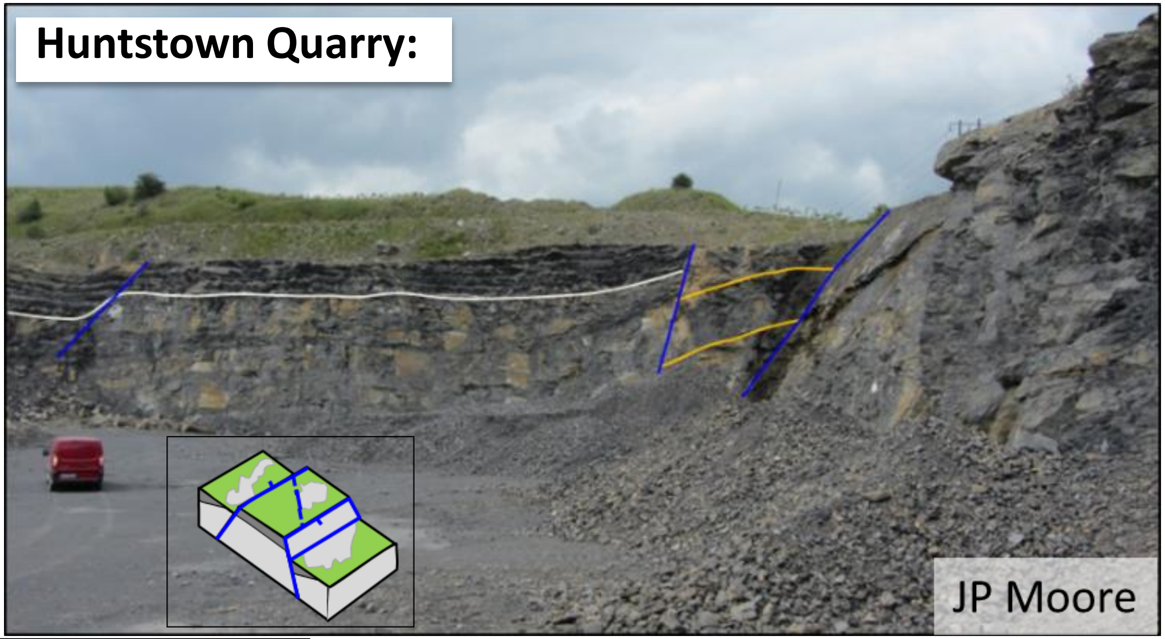


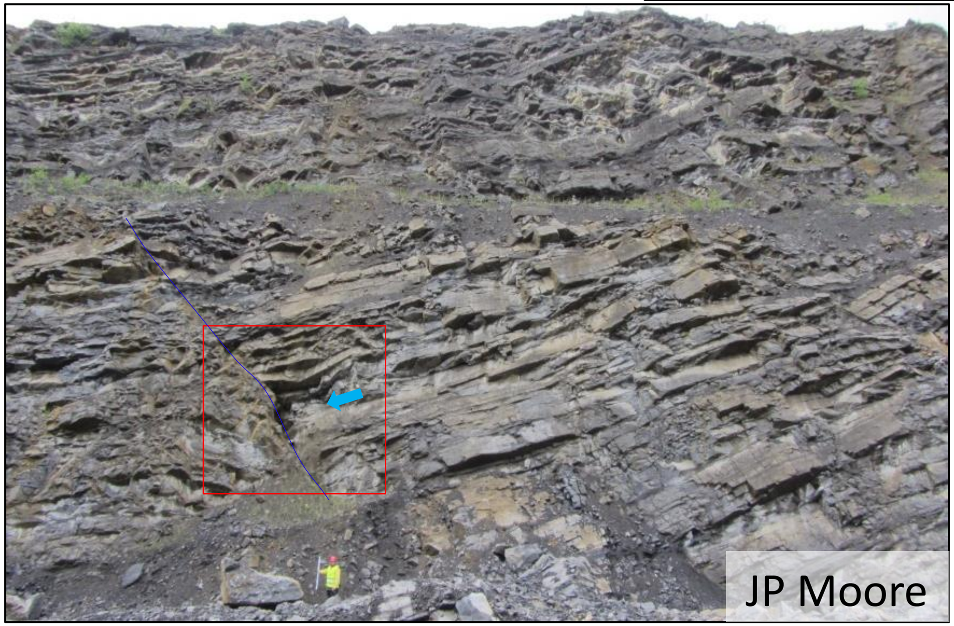
Carboniferous normal faults

BUT normal faults comprise shaley fault gouges, stylobreccias and veins.

Low permeability fault rocks providing fault seals.

These faults can, however, localize adjacent dolomite and along-fault karst.





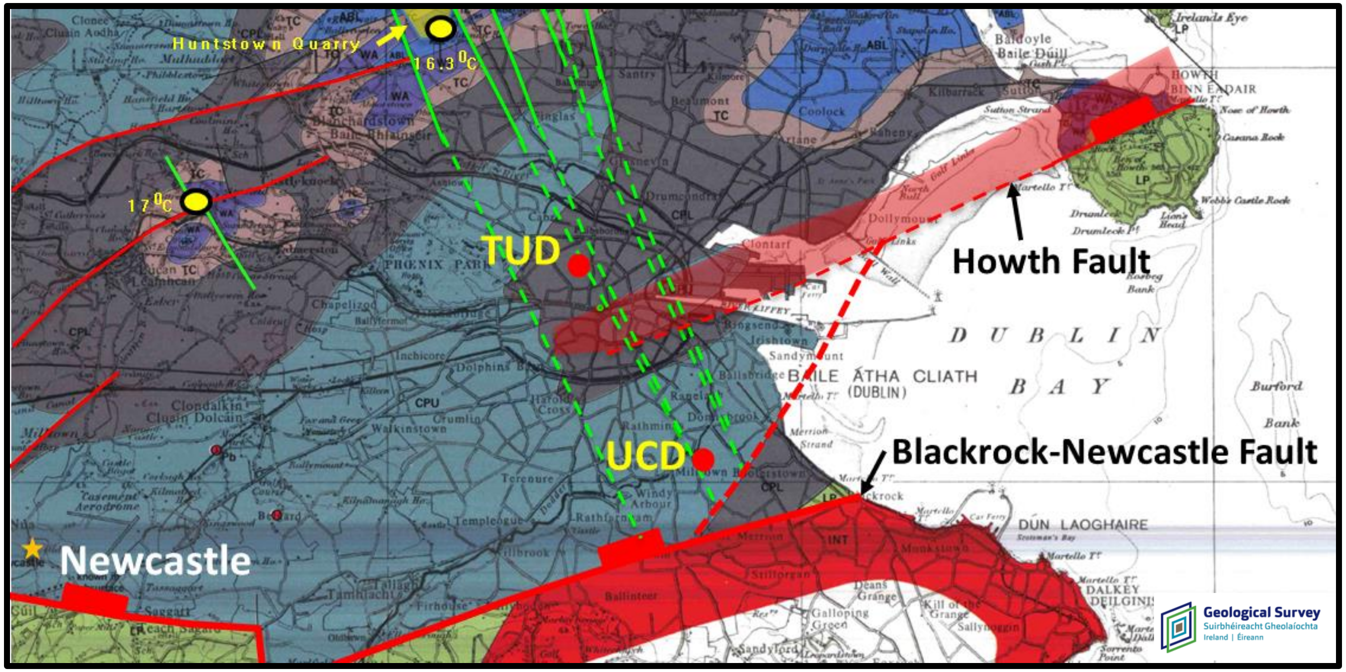
Carboniferous normal faults

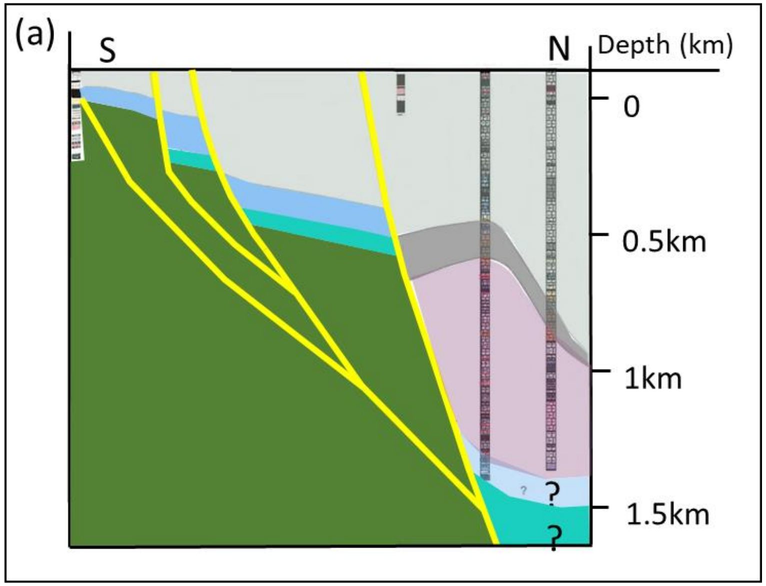
Carboniferous Dublin Basin is transected by normal faults (red).

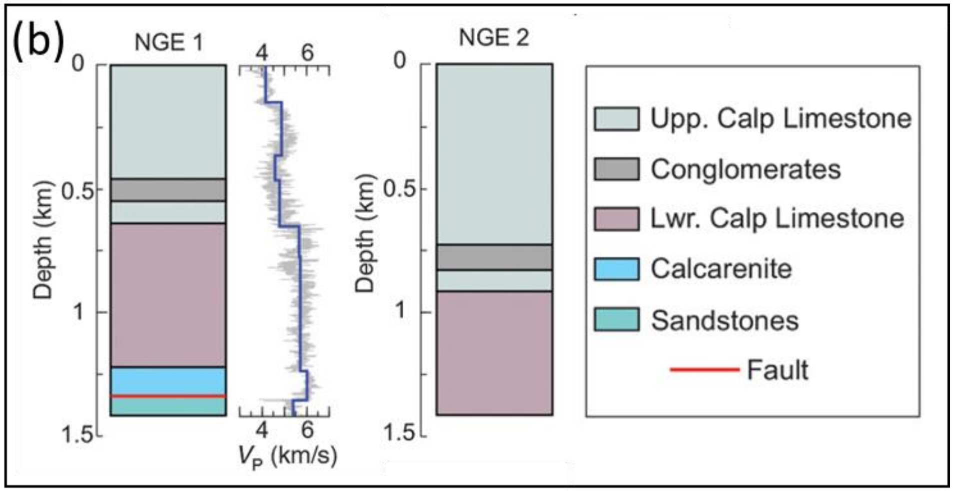
But there are also other younger faults (green).

Related Projects:

- Geo-Urban Project
- TUD Grangegorman
- UCD Campus



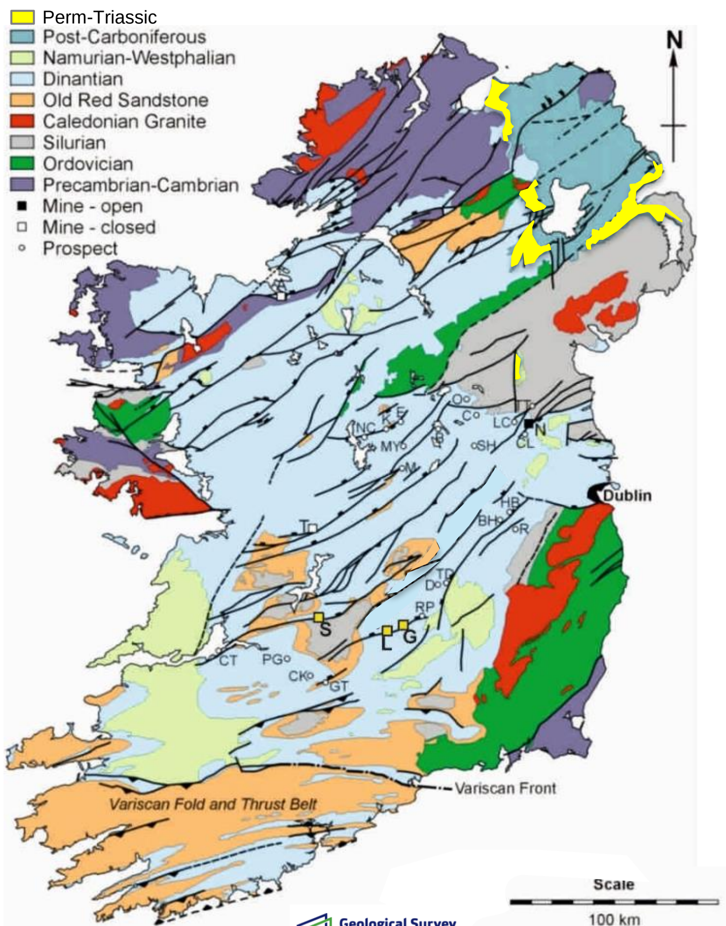




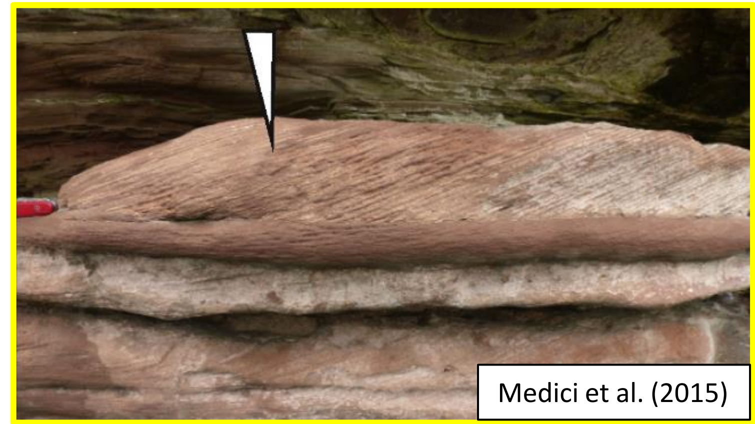
Modified from Licciardi & Agostinetti (2017) and Pasquali & Hanly (2018)

Why are faults/fractures important?

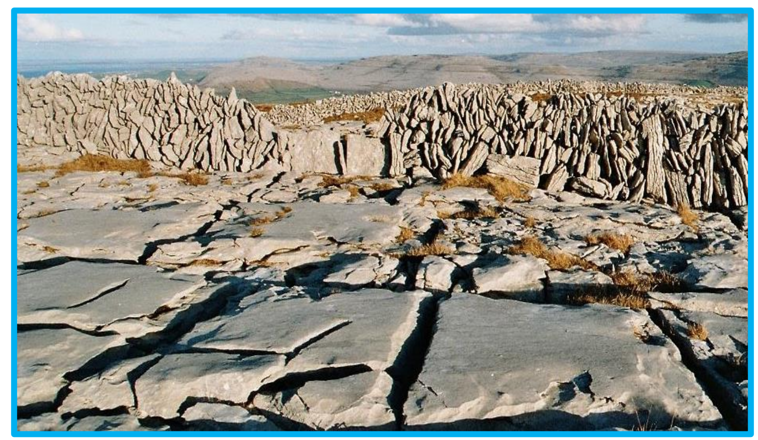
- Sherwood sandstone (up to 650m thick)
- Porous and permeable sandstones



Sandstones contain faults that baffle flow

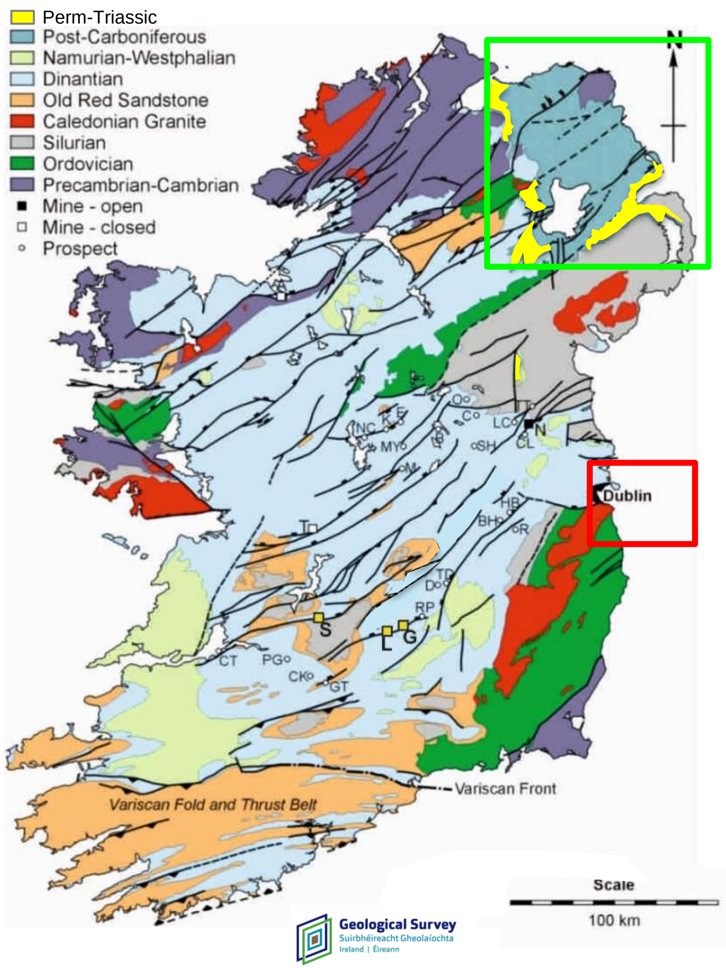


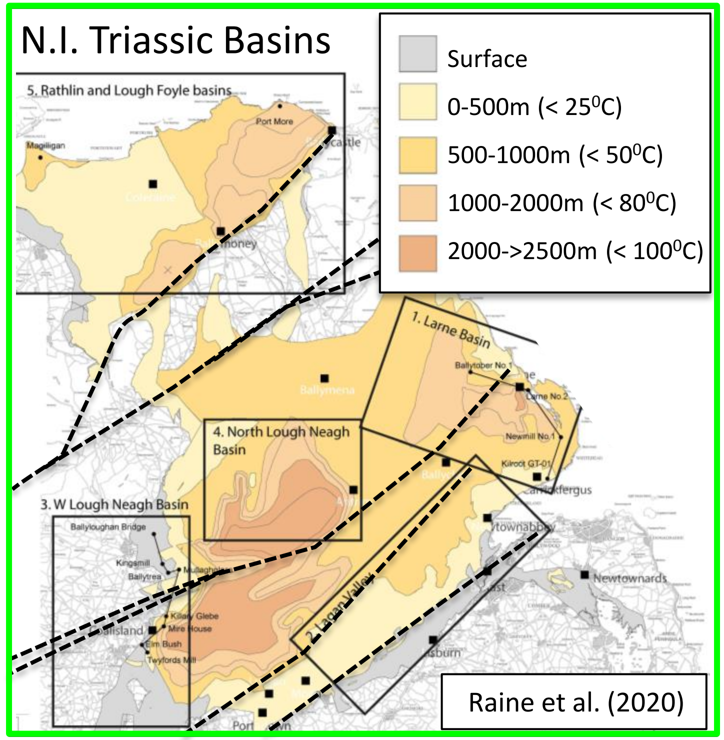
Limestones are tight without fractures

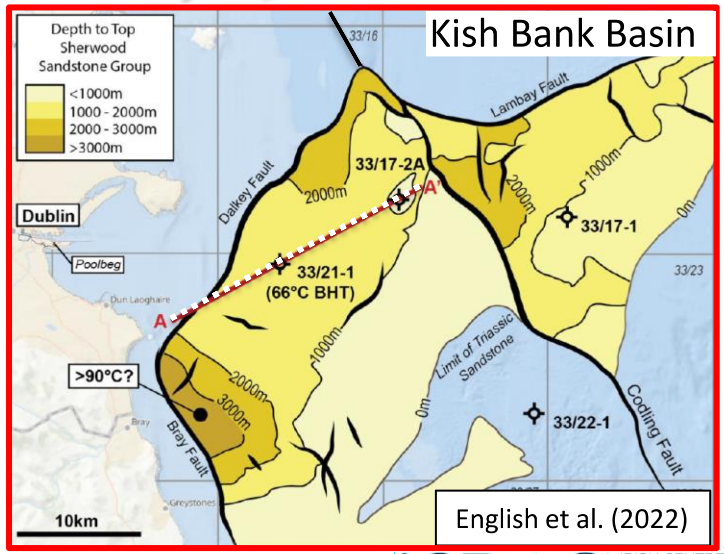


Sherwood Sandstone Basins

- Sherwood sandstone (up to 650m thick)
  – Northern Ireland and offshore Ireland
- Porous and permeable sandstones
- Normal faults, often parallel to older faults

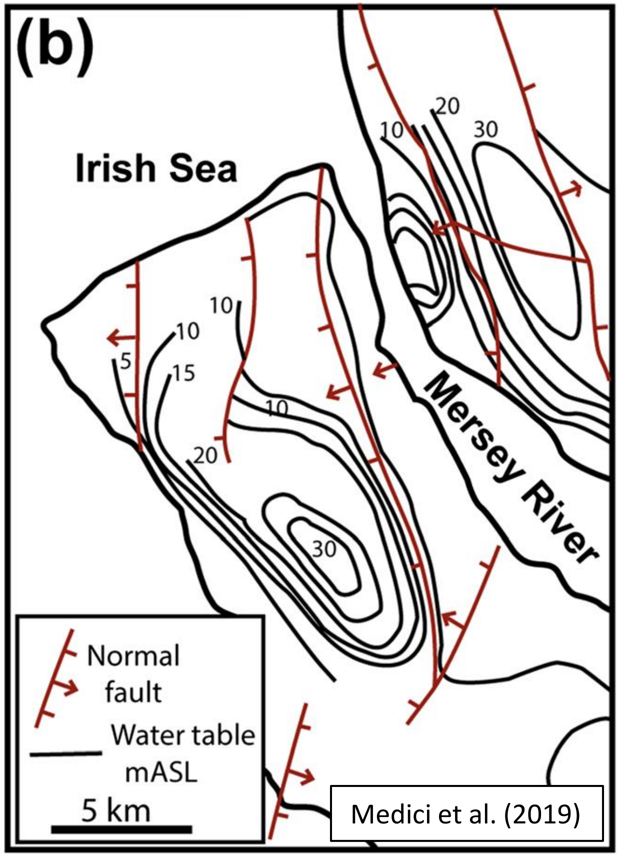




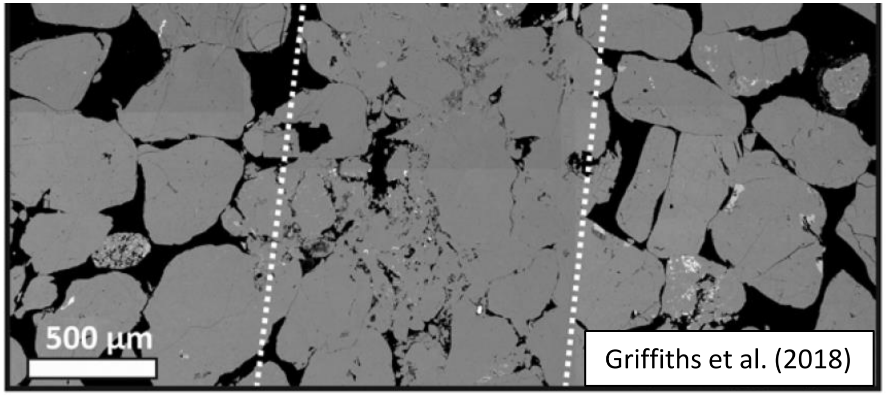


Sherwood Sandstone: Cheshire Basin – outcrop

- Sherwood sandstone reservoirs – Northern Ireland and offshore Ireland
- Porous and permeable sandstones
- BUT faults can act as baffles/barriers!



Medici et al. (2019)

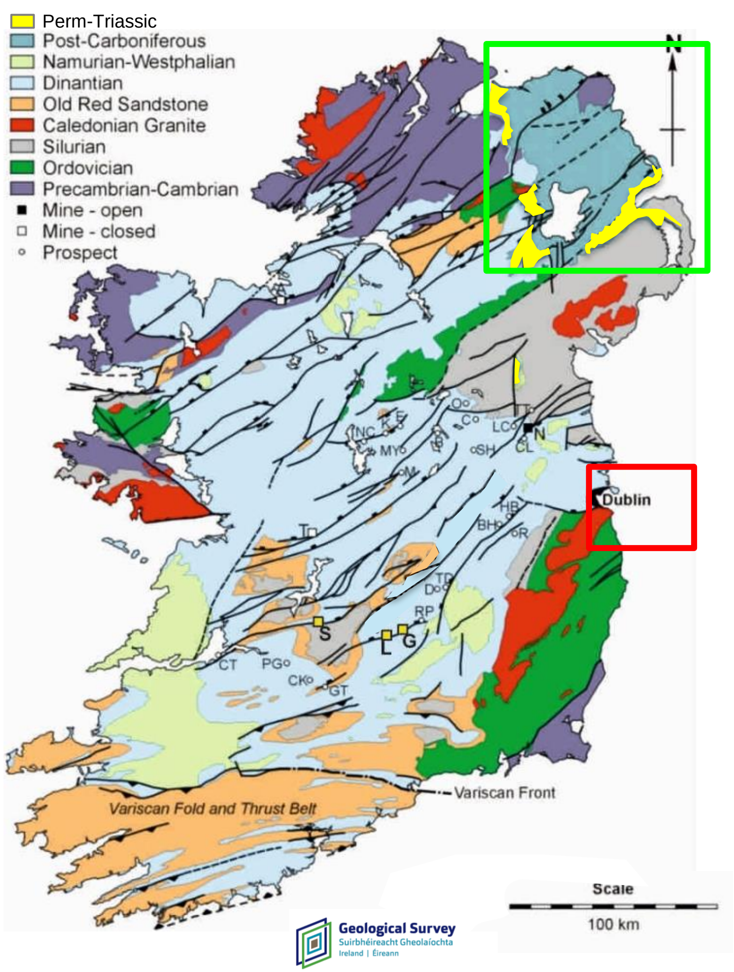


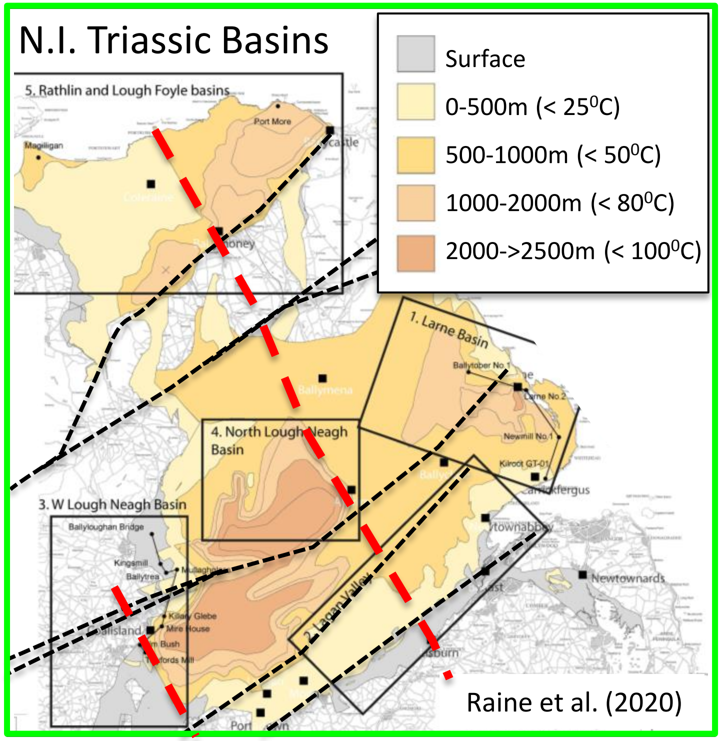
Griffiths et al. (2018)

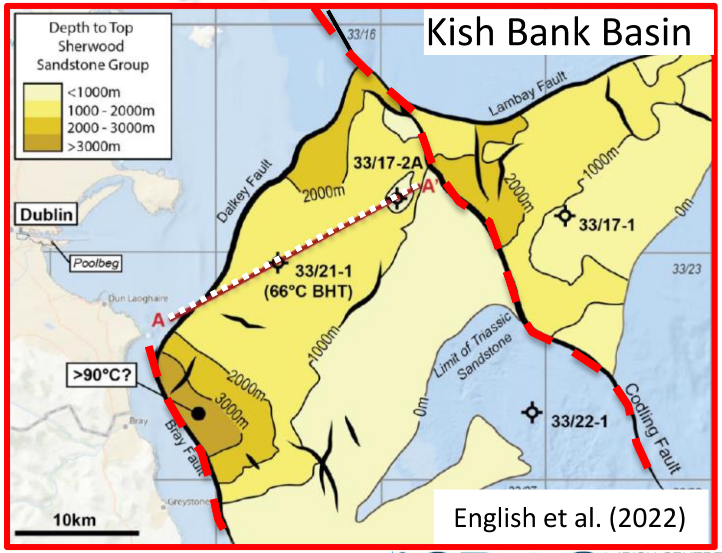
Medici et al. (2019)

Cenozoic strike-slip faults

- NE-SW striking basins are cross-cut by NNW-trending strike-slip faults
- Significance only recently recognised





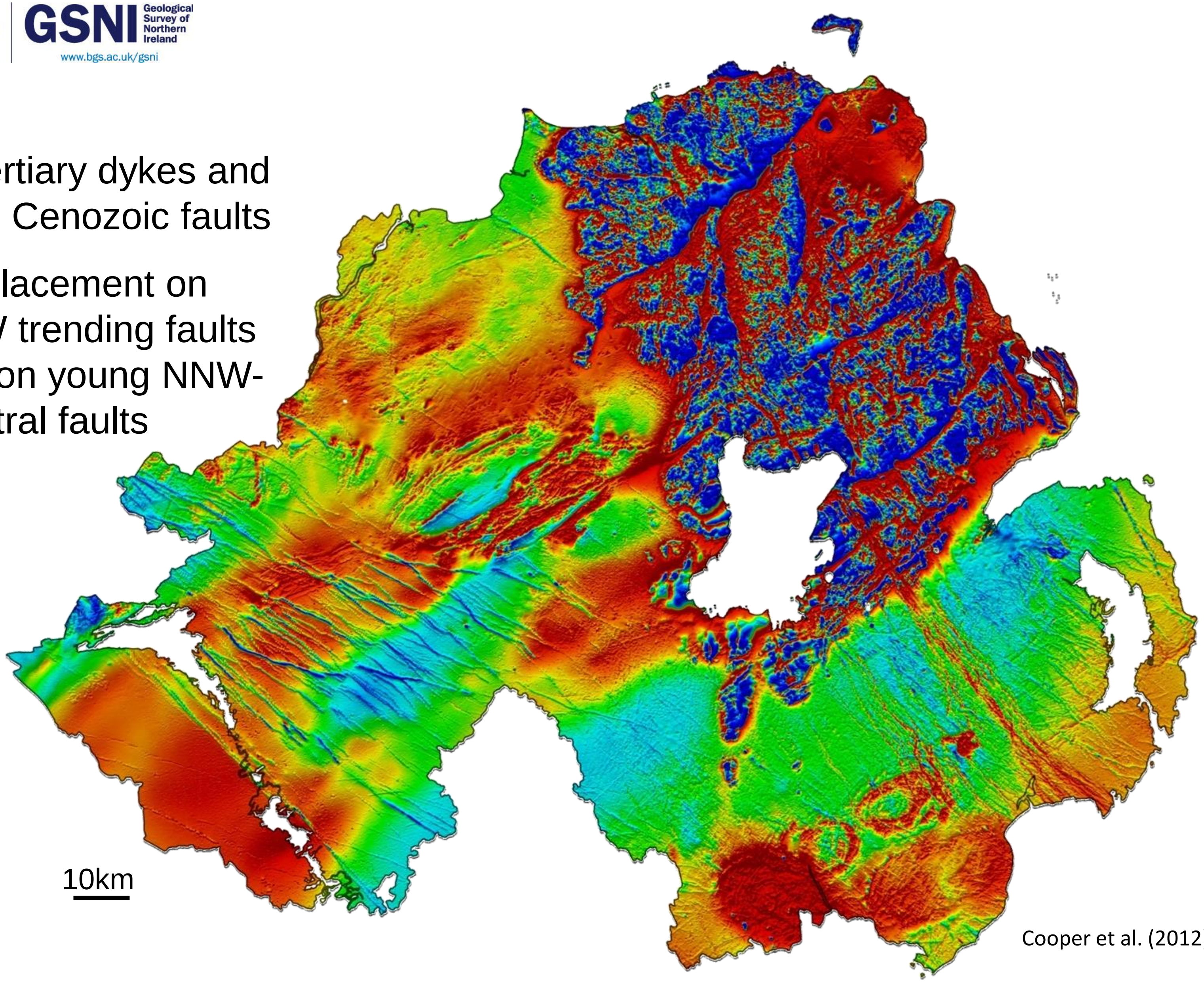


Tellus aeromagnetic data indicates 'recent faults'

Department for the Economy www.economy-ni.gov.uk | GSNI Geological Survey of Northern Ireland www.bgs.ac.uk/gsni

Highlights Tertiary dykes and cross-cutting Cenozoic faults

Sinistral displacement on older NE-SW trending faults and dextrak on young NNW-trending dextral faults

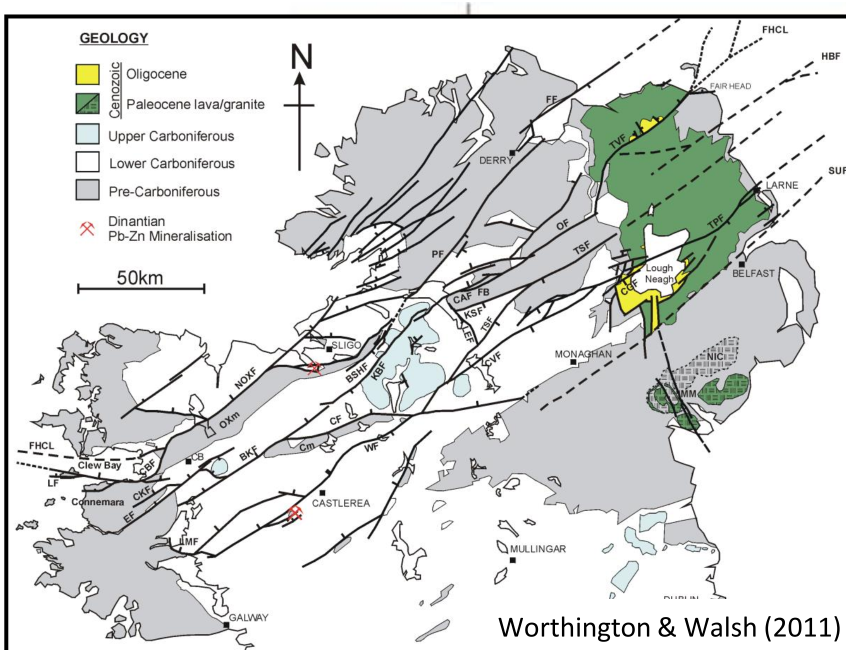


Cooper et al. (2012)

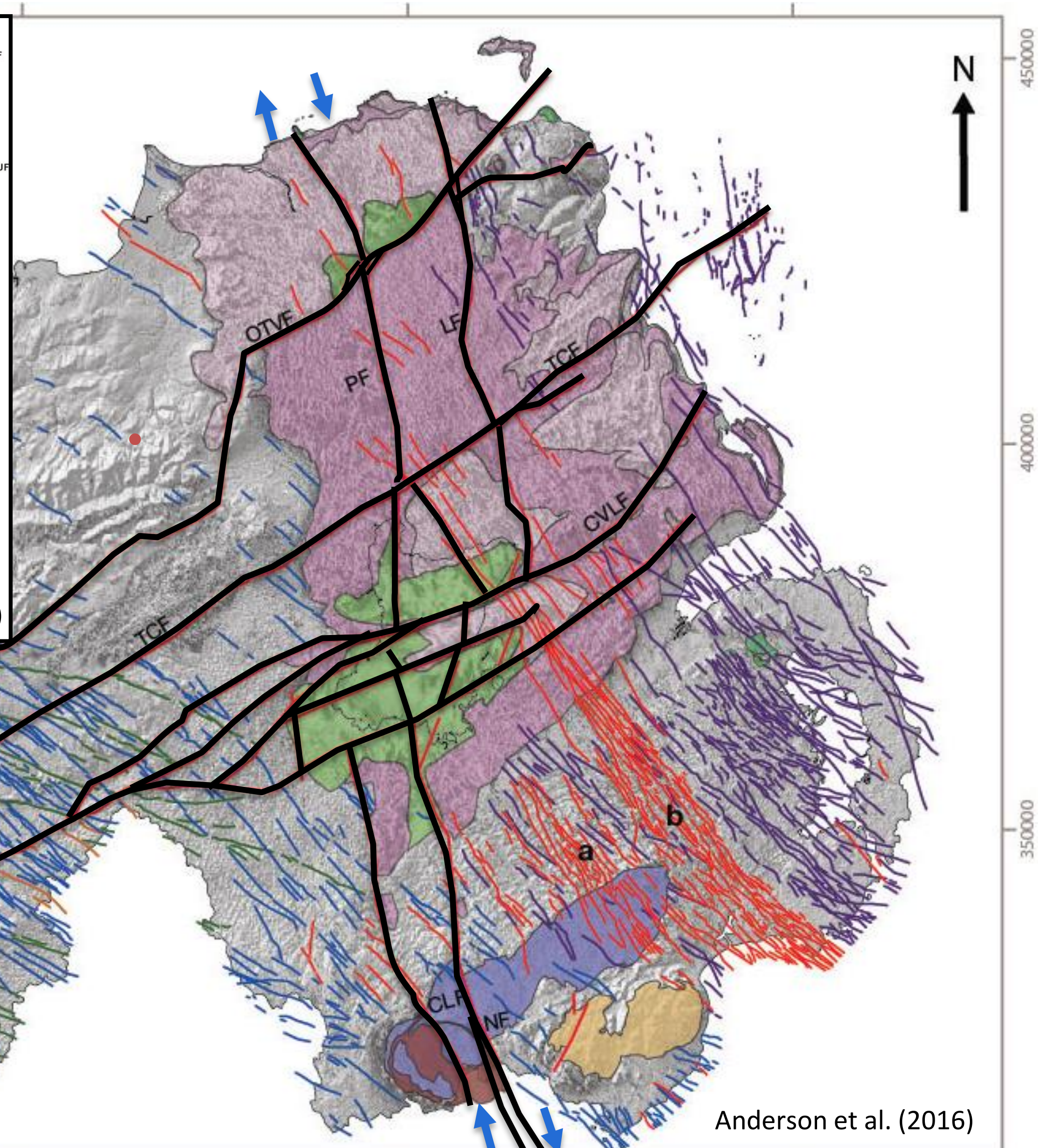
Cenozoic conjugate strike-slip faulting

Older Carboniferous normal faults

Cenozoic dykes and cross-cutting faults

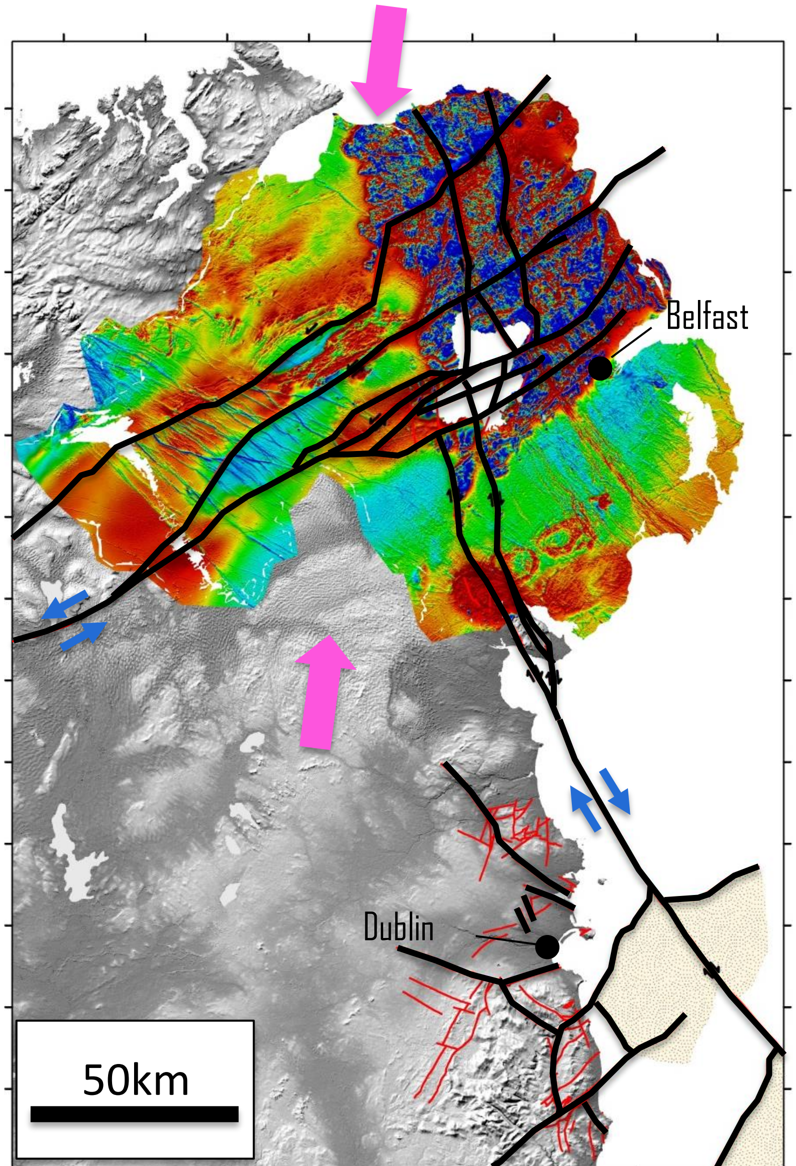


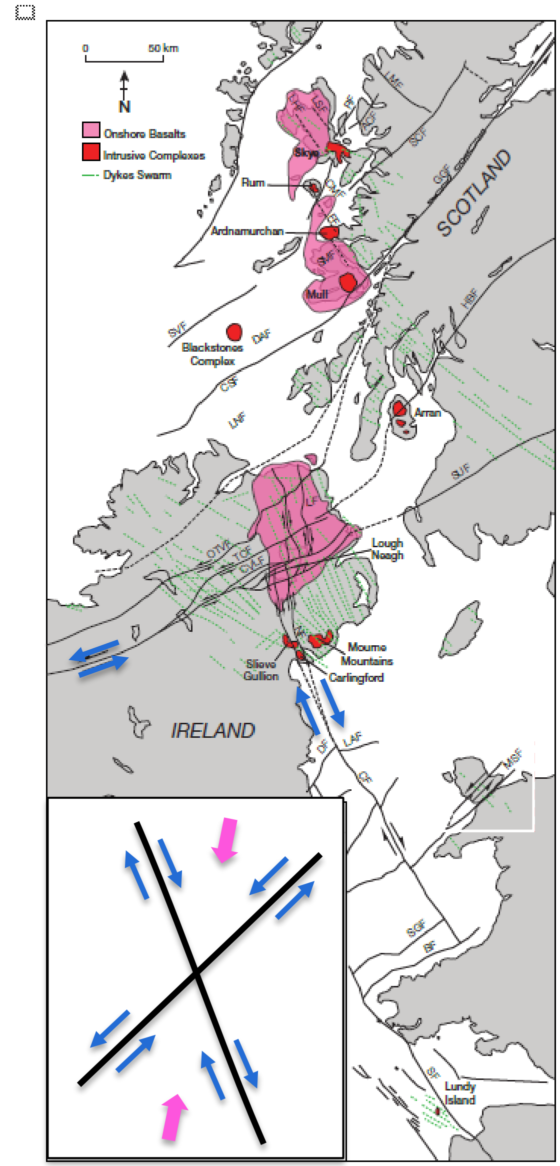
Worthington & Walsh (2011)



Anderson et al. (2016)

Alpine strike-slip faulting (< 60My)

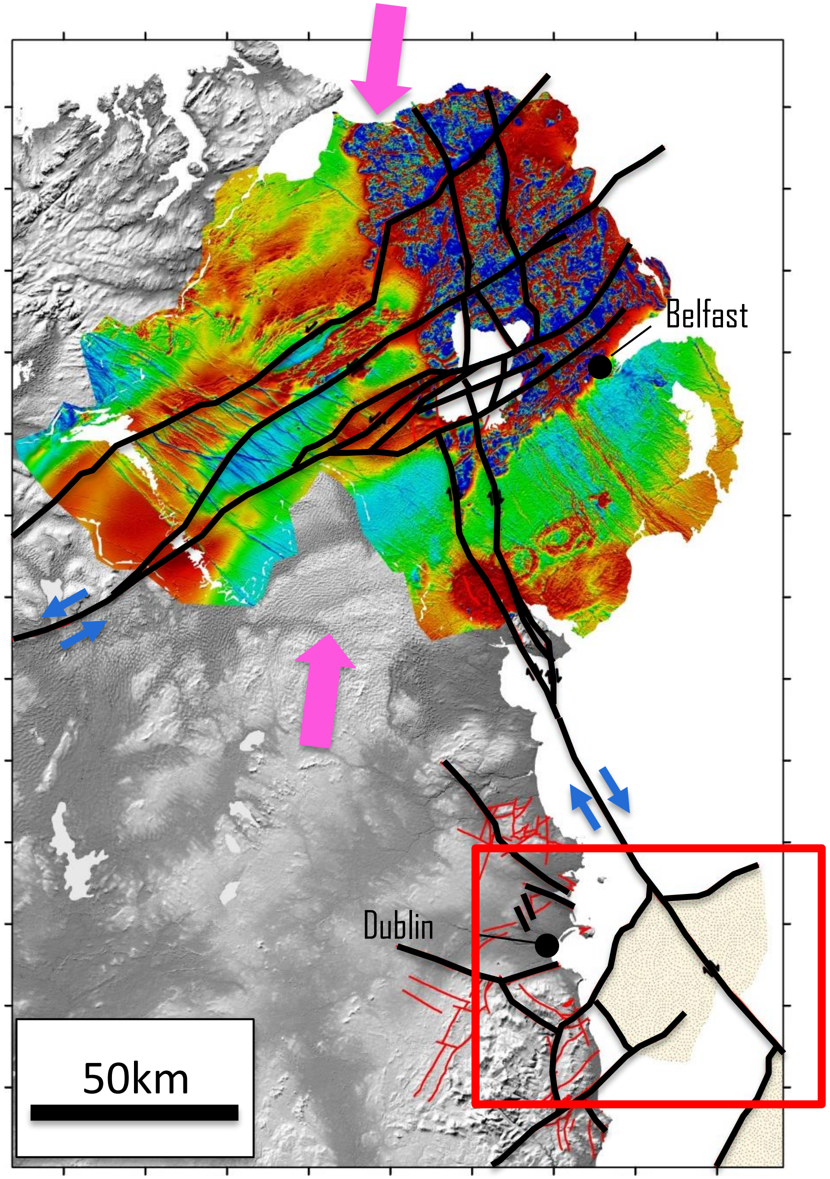




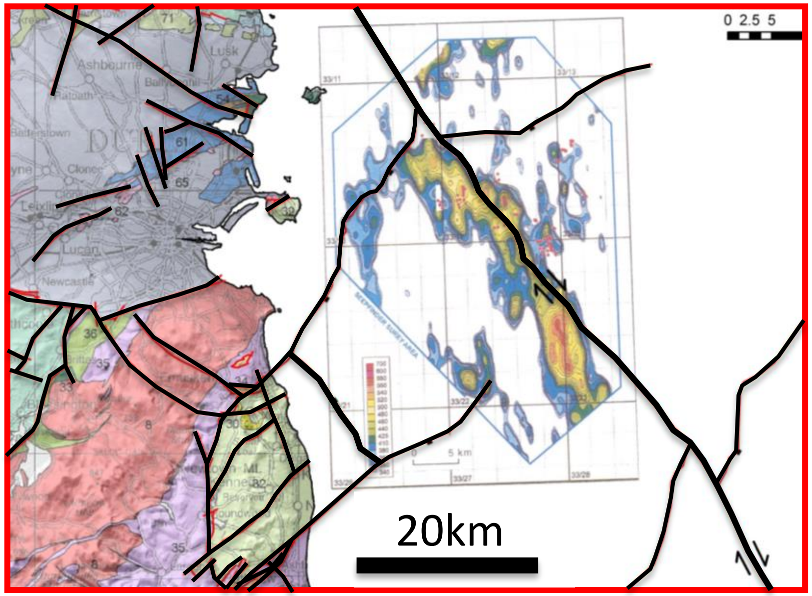
ENE and NNW conjugate strike-slip faults – N-S Alpine compression

Cooper et al. (2012); Anderson et al. (2016 & 2018)

Alpine strike-slip faulting (< 60My)



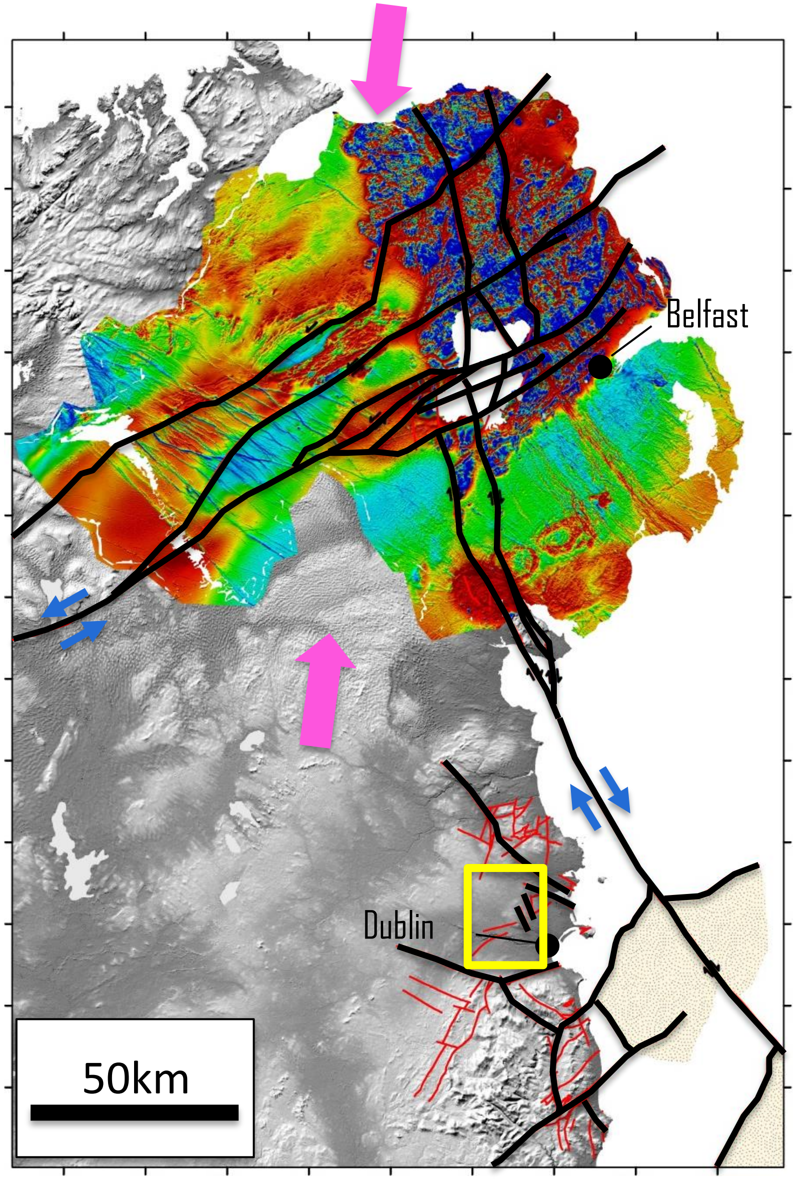
Hydrocarbon sniffer data – fault leakage

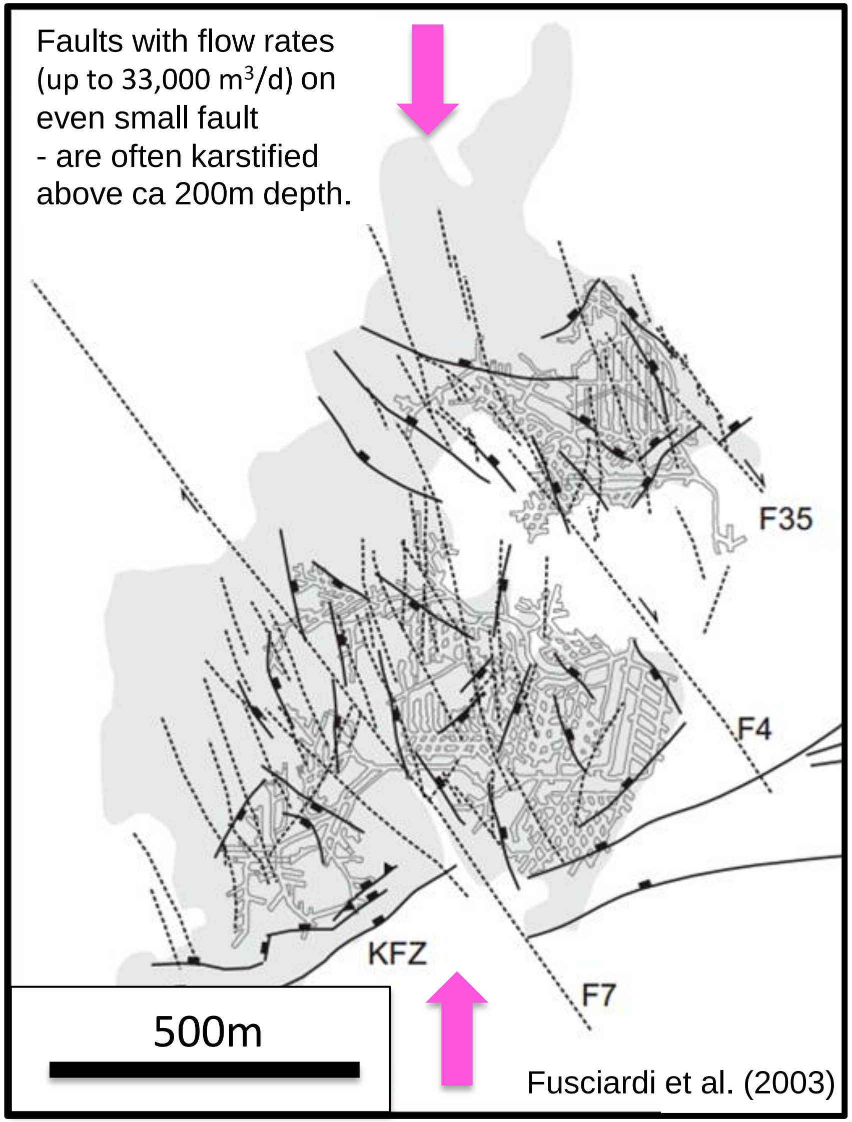


Anderson (2013); Peter Croker, pers comm.

ENE and NNW conjugate strike-slip faults – N-S Alpine compression

Alpine strike-slip faulting (< 60My)



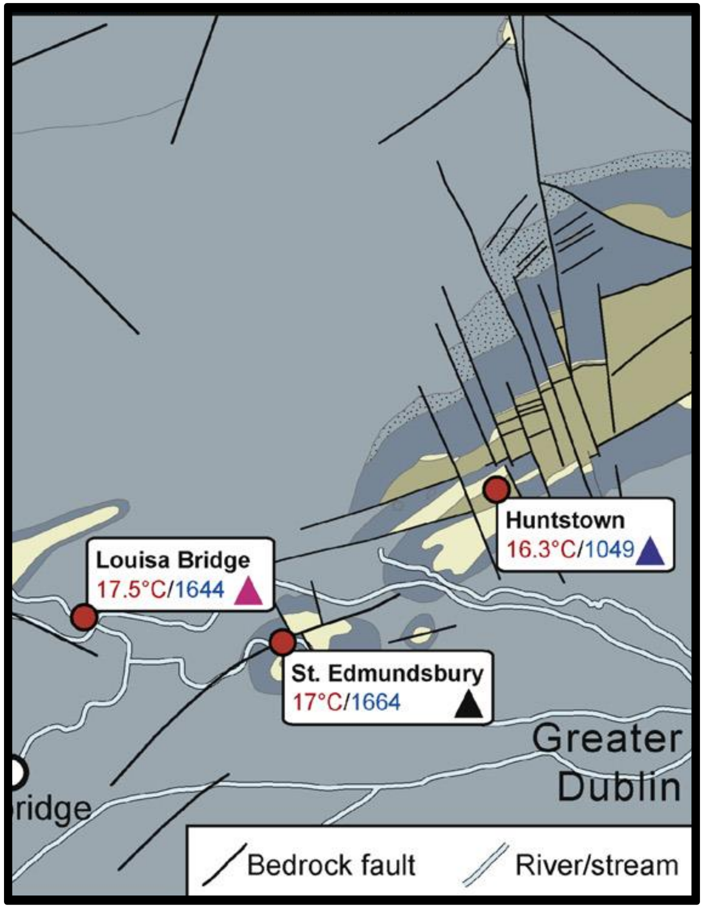


Lisheen and Galmoy mines – N-S Alpine compression

Groundwater/geothermal flow

- NNW strike-slip faults - newly formed and ubiquitous.
- Huntstown Quarry high flow rates (5,000 m^3/d) and slightly elevated temperatures.
- Flow rates vary rapidly over fault surfaces, arising from complexities and karst.

Moore & Walsh (2013, 2021)

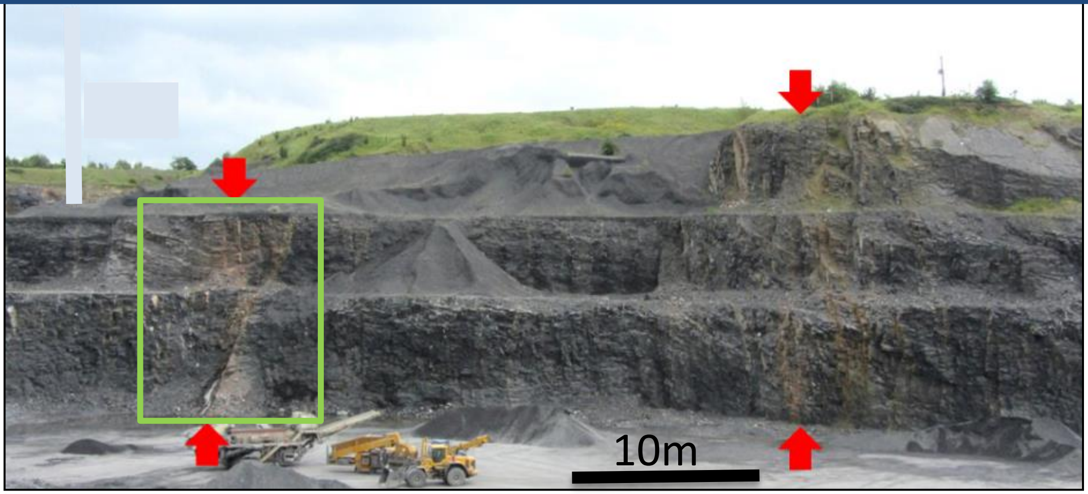


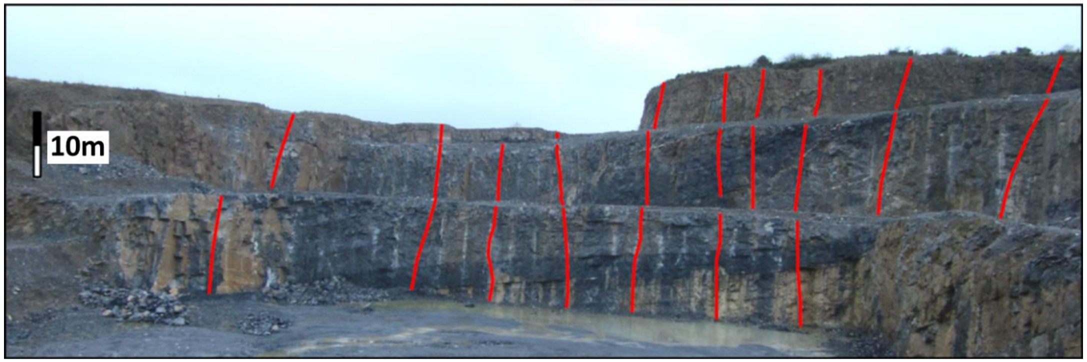
Blake et al. (2016)

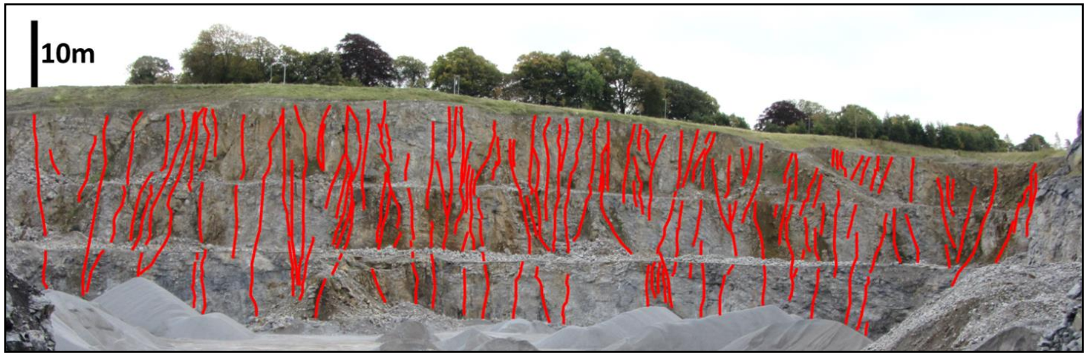
Groundwater/geothermal flow

Expression of faults and the frequency of related fractures has two principal controls.

- Lithological – increasing within massive limestone units.
- Spatial – decreasing towards the west.



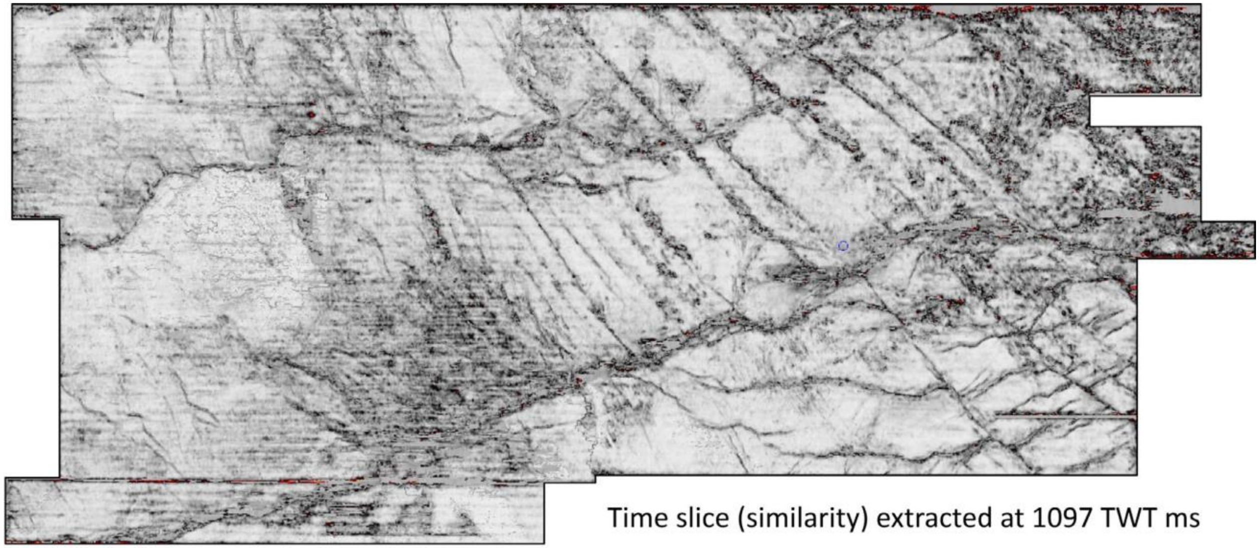




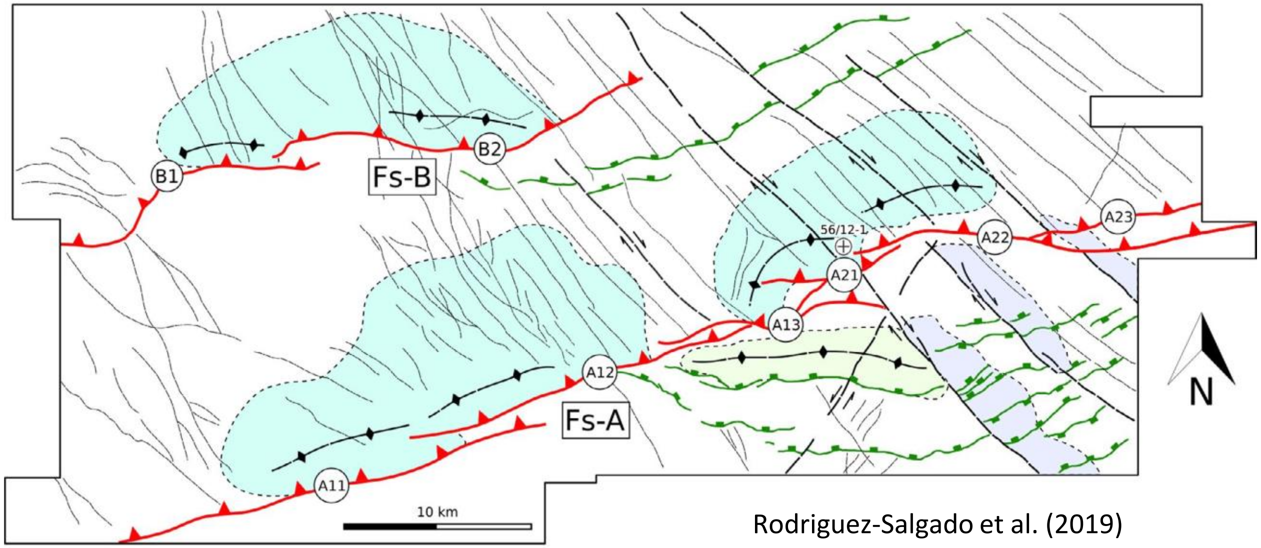
Moore and Walsh (2021)

Celtic Sea Basin – 3D seismic data

Alpine conjugate strike-slip faults are ubiquitous

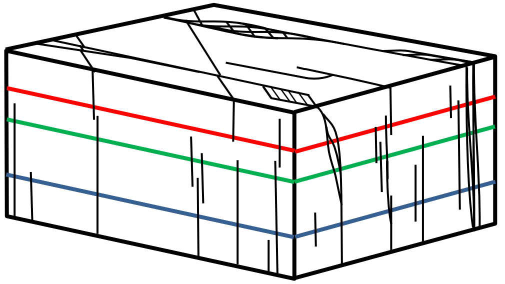


Time slice (similarity) extracted at 1097 TWT ms



Rodriguez-Salgado et al. (2019)

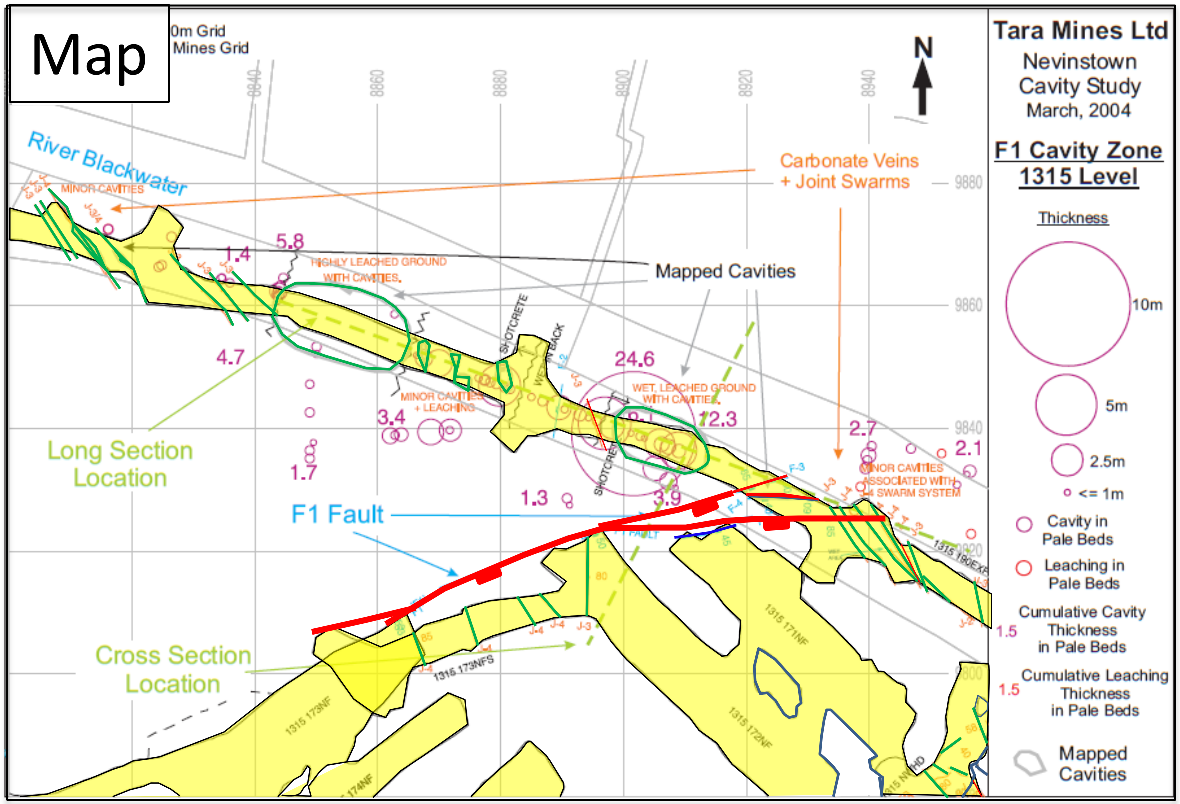
No characteristic scale – heterogeneous flow

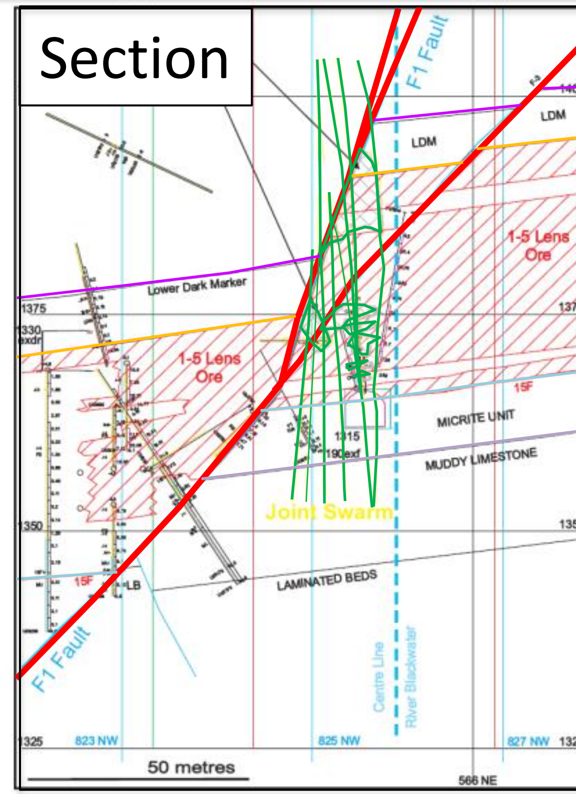


Must define structure in particular areas

Fault-related flow – Cenozoic strike-slip faults

Groundwater mine data – Navan mine



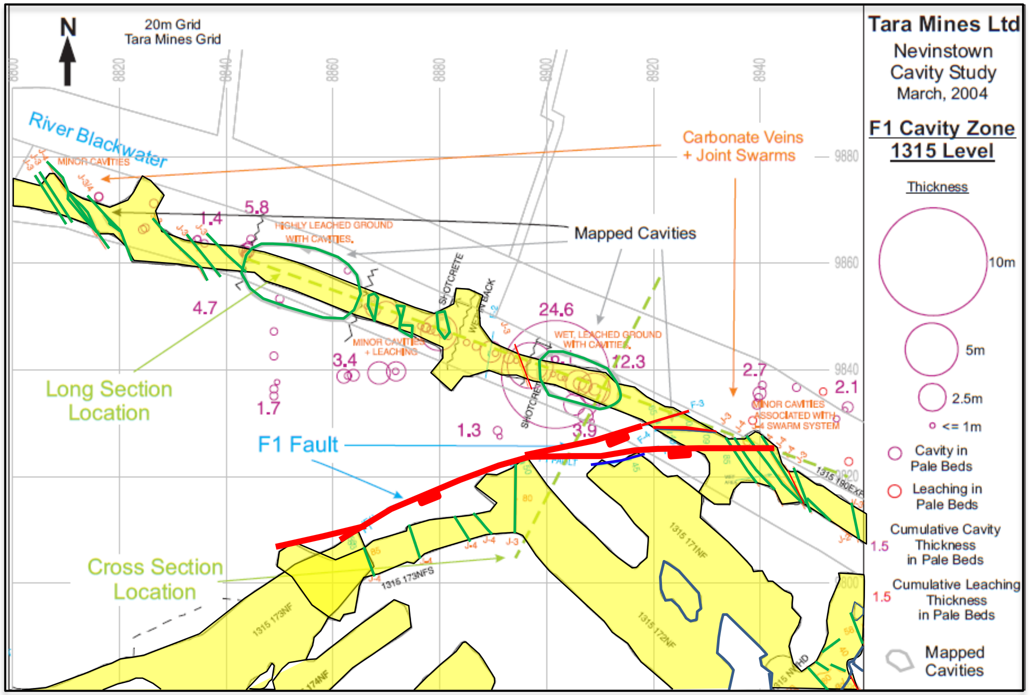


Tara Mines and JP Moore

Intersection between Cenozoic faults and normal faults are particularly kastified.

Karst in mines and hot springs

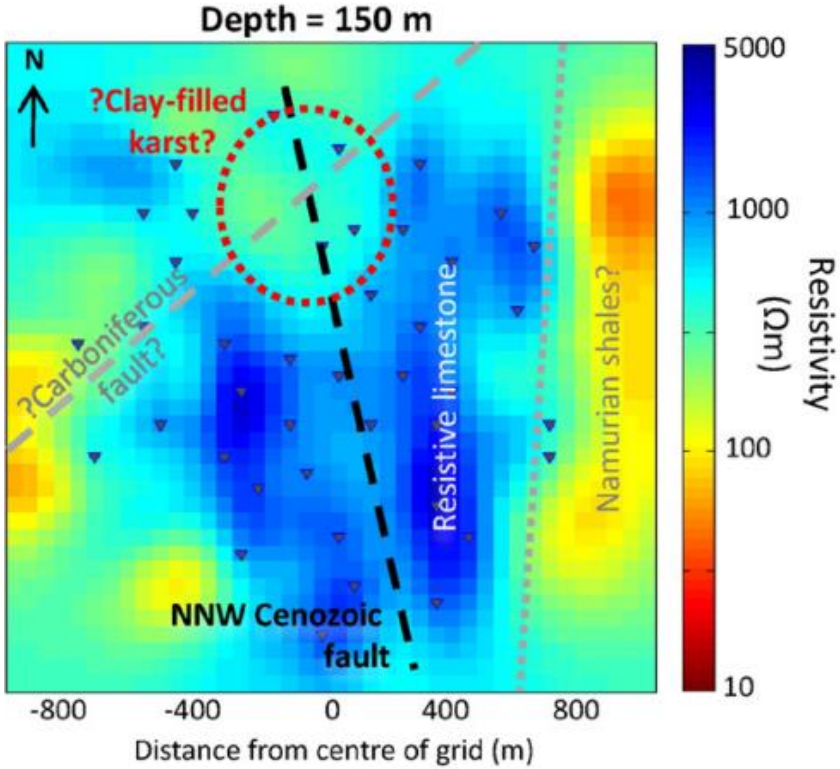
Mine Data



Intersection between Cenozoic faults and normal faults are particularly karstified.

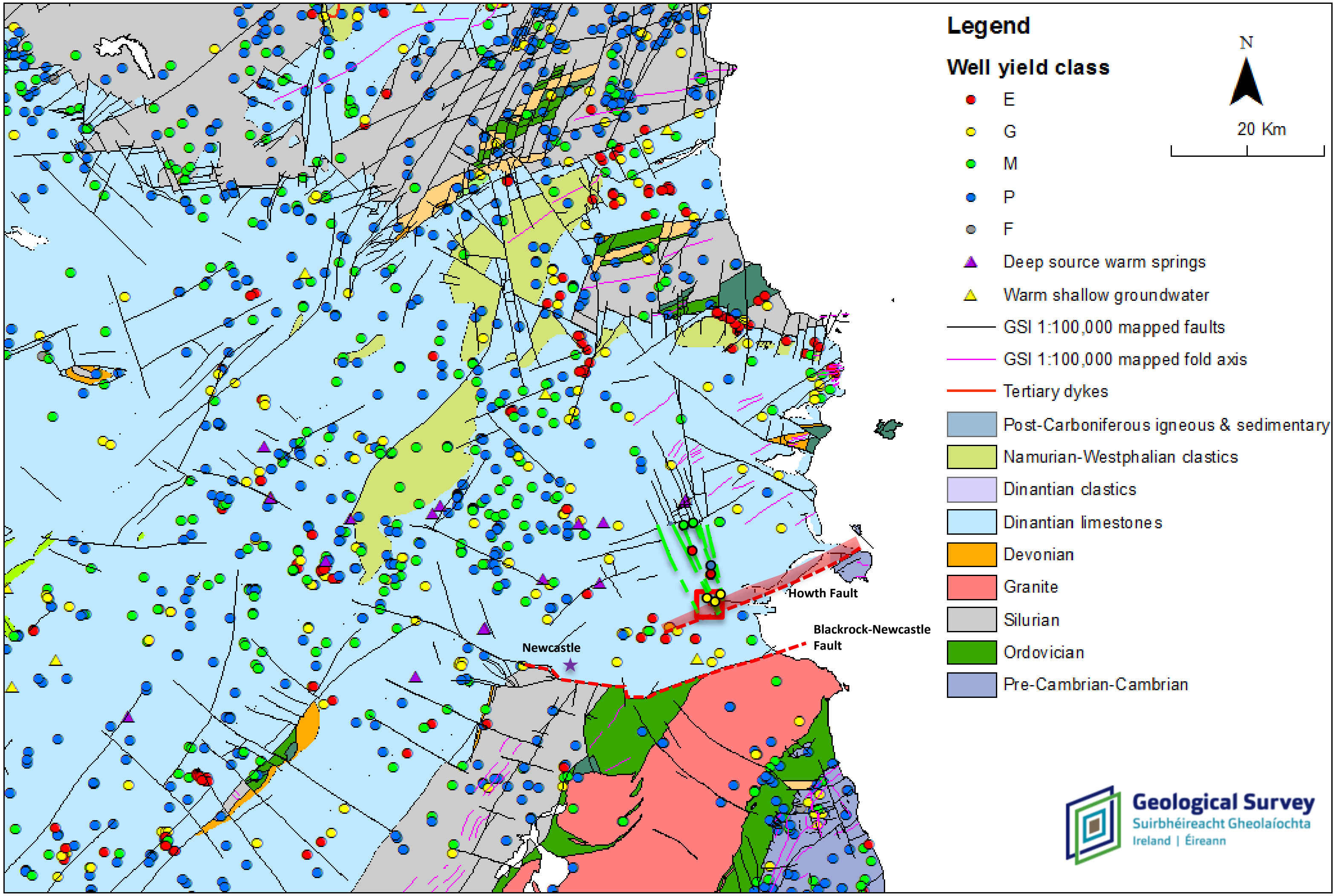
Magneto-Telluric Data: Blake et al. (2016)

Kilbrook Spring – 24.9^{0}C



Heterogenous nature of groundwater flow

GSI Groundwater Data – indicates heterogeneous flow

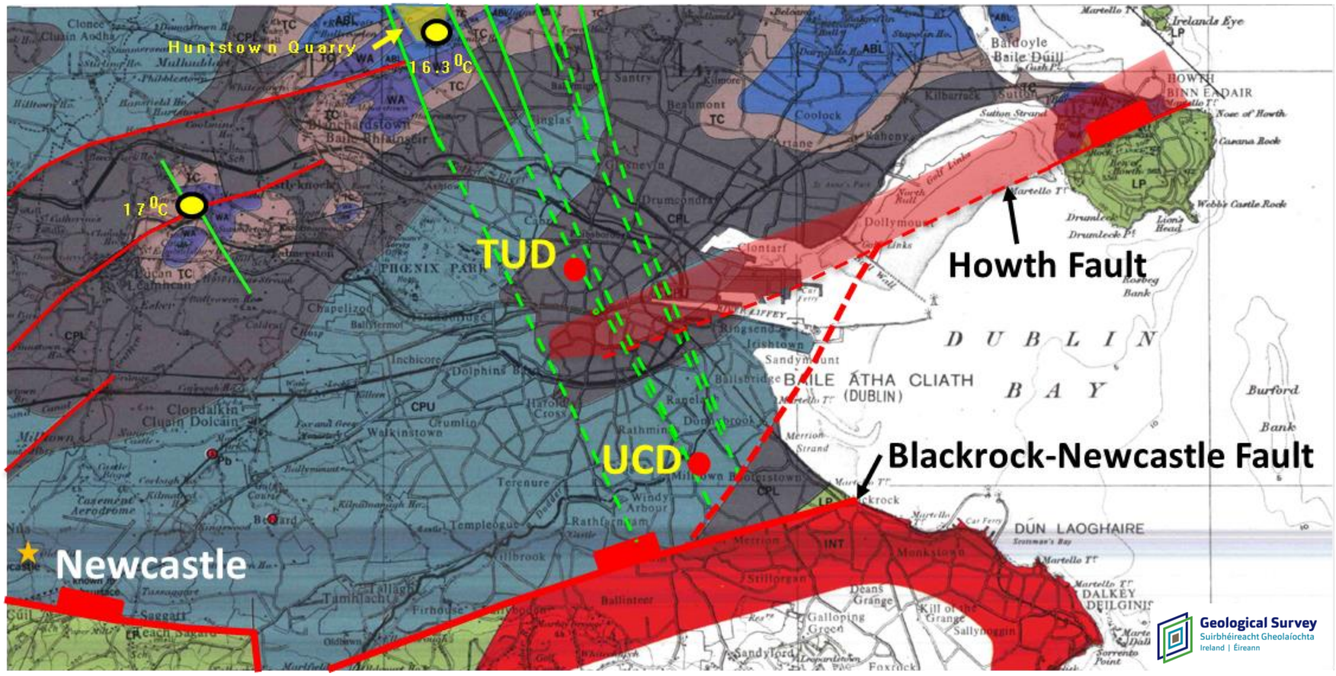


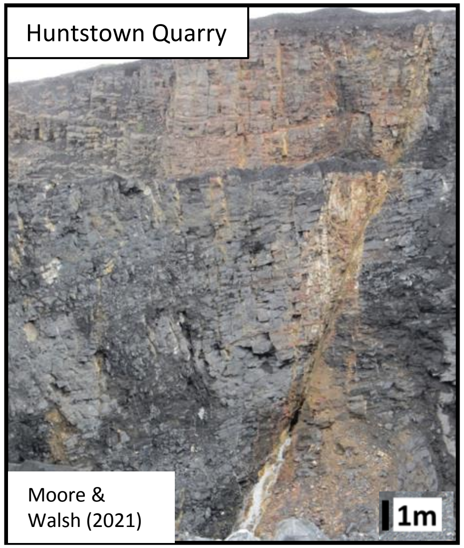
Faults and Fractures

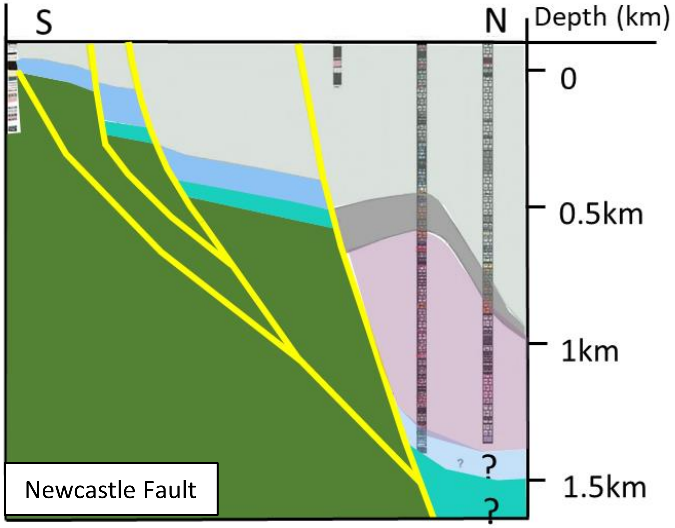
Limestones/shales:
The combined effects of normal faults and later Alpine faults/fractures, together with dolomite and karst, can provide significant fault-related flows on large scale.

Triassic Sandstones:
Faults, fractures and dykes can have significant impact on flow within clastic reservoirs.

Faults/Fractures are an important component of geothermal systems – existing constraints provide good conceptual basis for improved assessments of their impact on the scale and nature of flow in sites.







Pasquali & Hanly (2018)

Improving Existing Temperature and Heat Flow Models in Ireland

Emma L. Chambers, Duygu Kiyan, Javier Fullea, Raffaele Bonadio, Sergei Lebedev, Brian O'Reilly, Christopher Bean, Patrick Meere, Tao Ye, Meysam Rezaeifar, Gaurav Tomar and the DIG Team*

echambers@cp.dias.ie

De-risking Ireland's Geothermal energy potential

dig

DIAS
Institiúid Ard-Léinn Bhaile Átha Cliath | Dublin Institute for Advanced Studies

UNIVERSITY OF CAMBRIDGE

UNIVERSIDAD COMPLUTENSE MADRID

UCC
Coláiste na hOllscoile Corcaigh, Éire
University College Cork, Ireland

seai SUSTAINABLE ENERGY AUTHORITY OF IRELAND

Geological Survey
Suirbhéireacht Gheolaíochta
Ireland | Éireann

Rialtas na hÉireann
Government of Ireland

Current State of the Art

- Temperature Maps Mather & Fullea 2021
- Range from 2 – 5 km Depth (6 full maps)
- Moho and Lithosphere Asthenosphere Boundary depth (seismic - active source, receiver function, gravity)
- Surface Heat Flow – Mather & Fullea 2018
- Fixed Thermal Property data

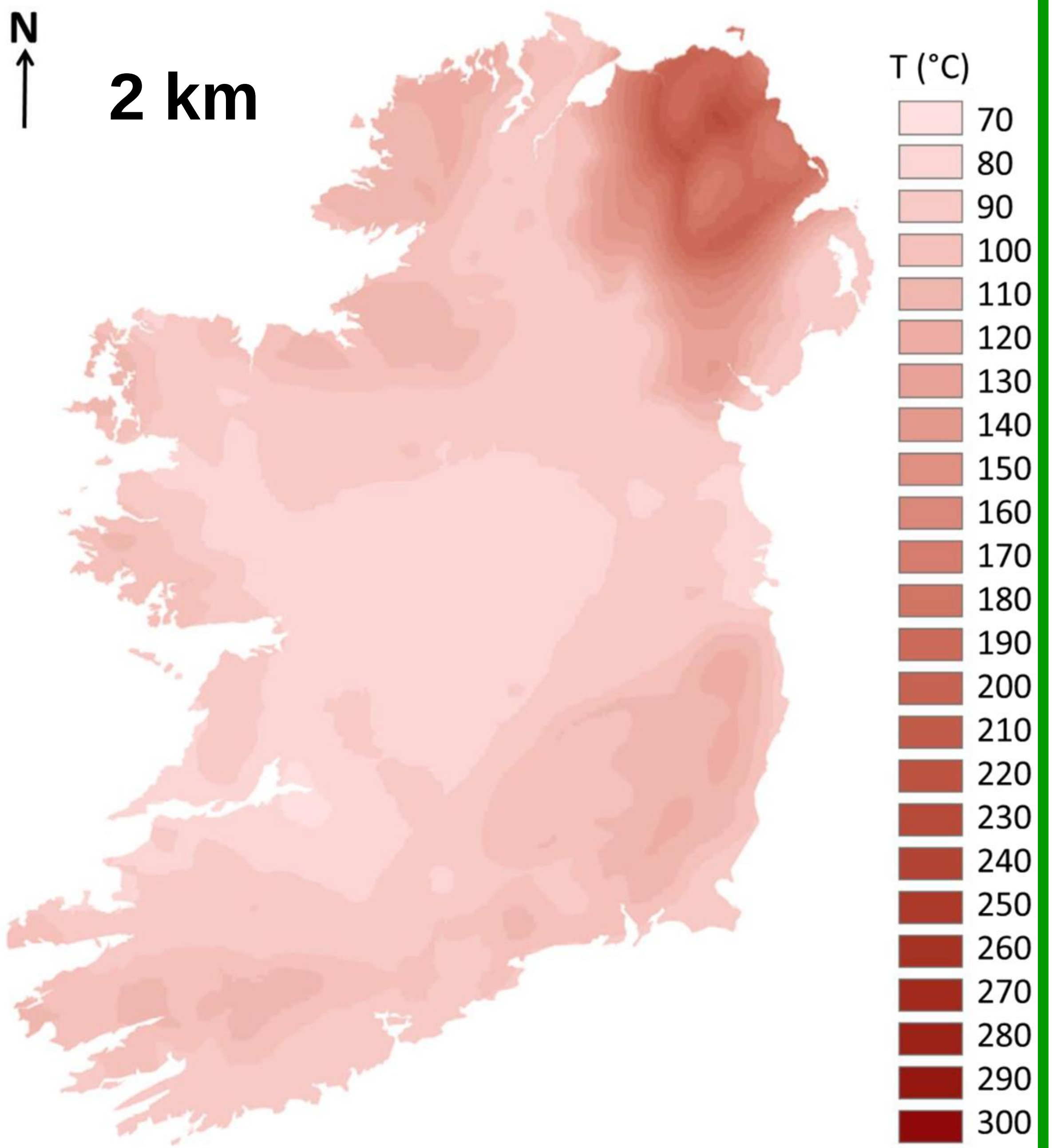
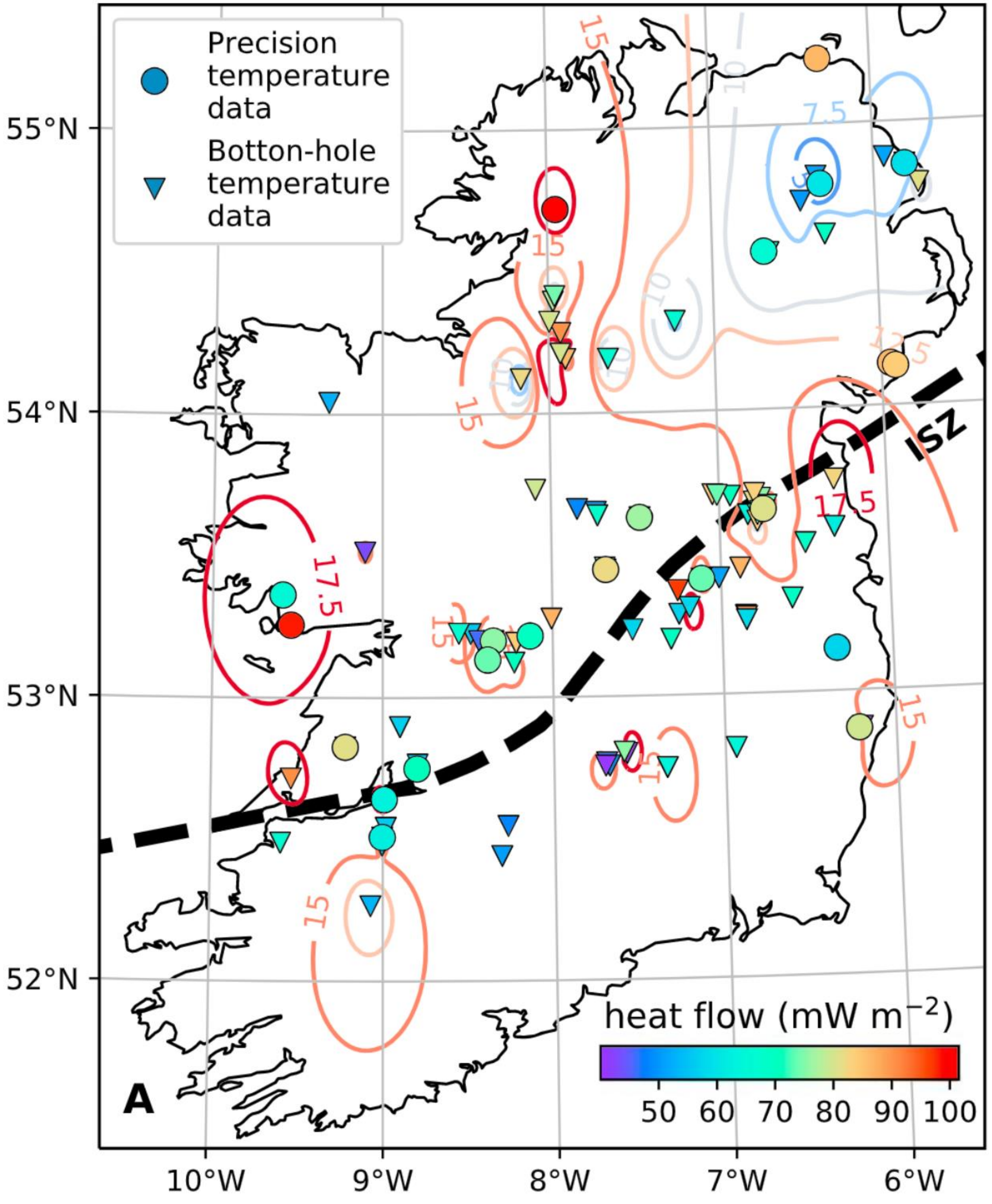


Figure 1 Deep temperature map at 2.0 km. Temperatures in degrees Celsius. Scale approx. 1:2,000,000. Values range from 70°C to 230°C.

C… Art

- Te… 20…
- Ra… ma…
- M… re Bc… so…
- Su… n 20…
- Fix…



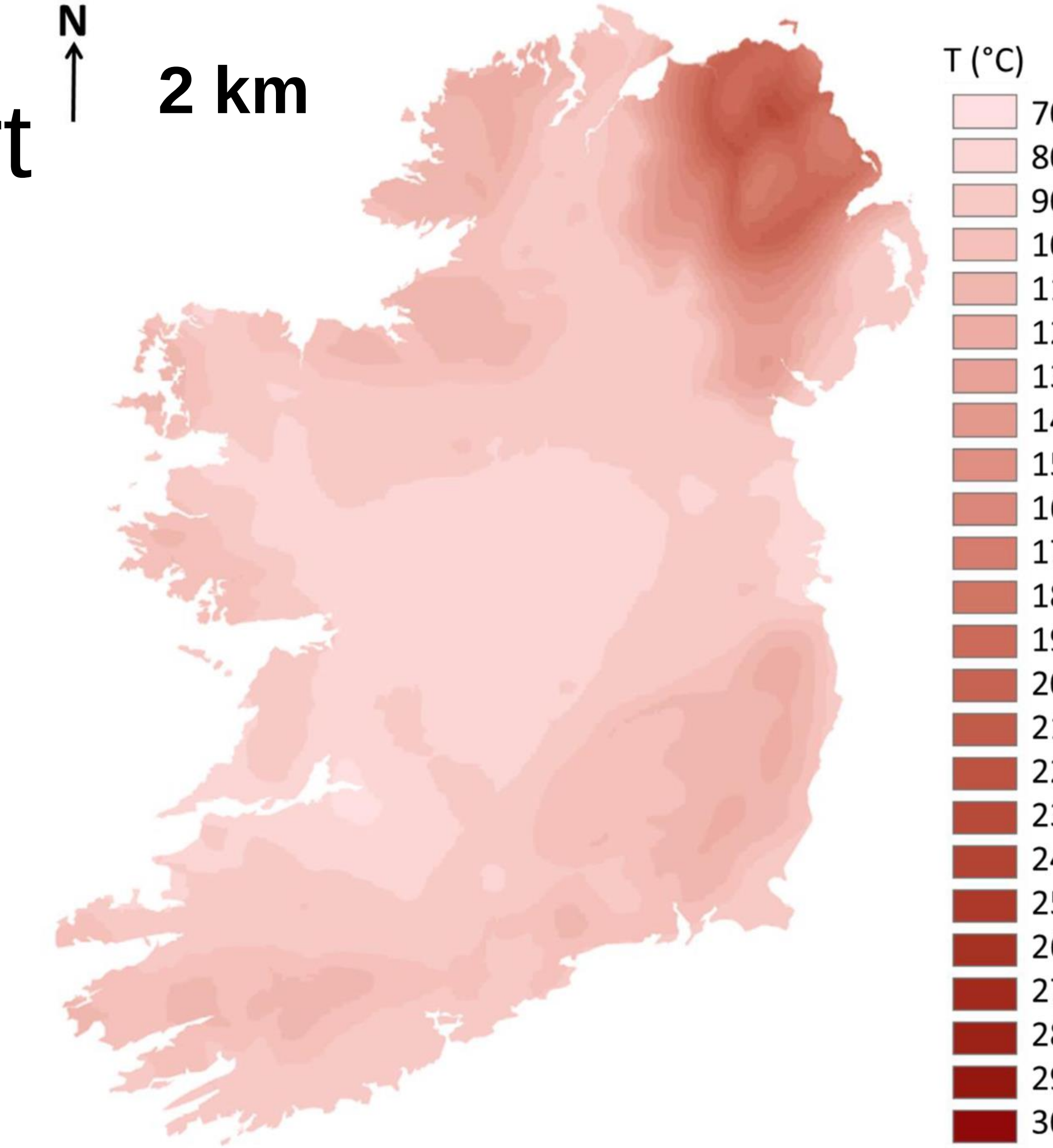
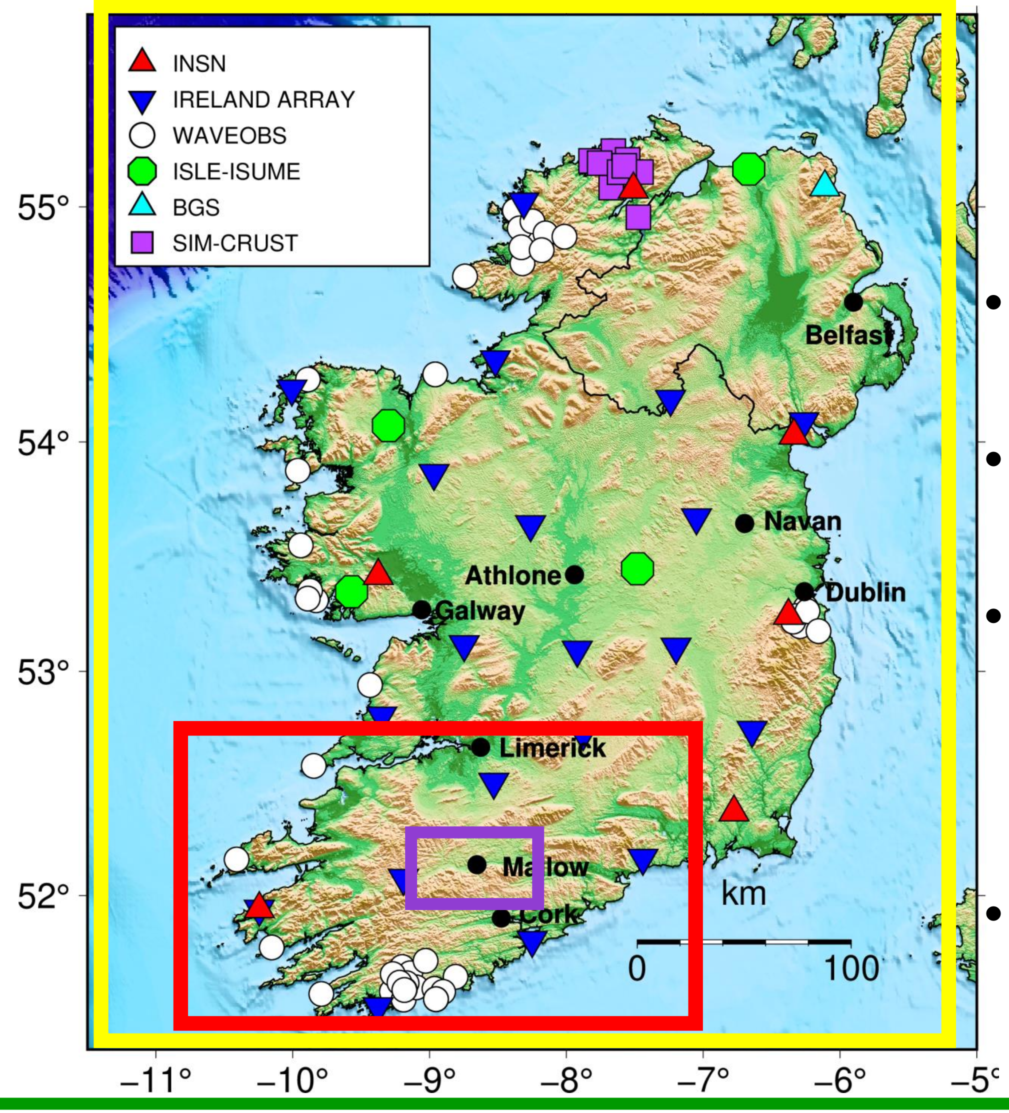


Figure 1 Deep temperature map at 2.0 km. Temperatures in degrees Celsius. Scale approx. 1:2,000,000. Values range from 70°C to 230°C.

De-Risking **I**reland’s **G**eothermal Potential **DIG**



Primary Objective - De-risk borehole drilling costs to promote geothermal energy in Ireland.

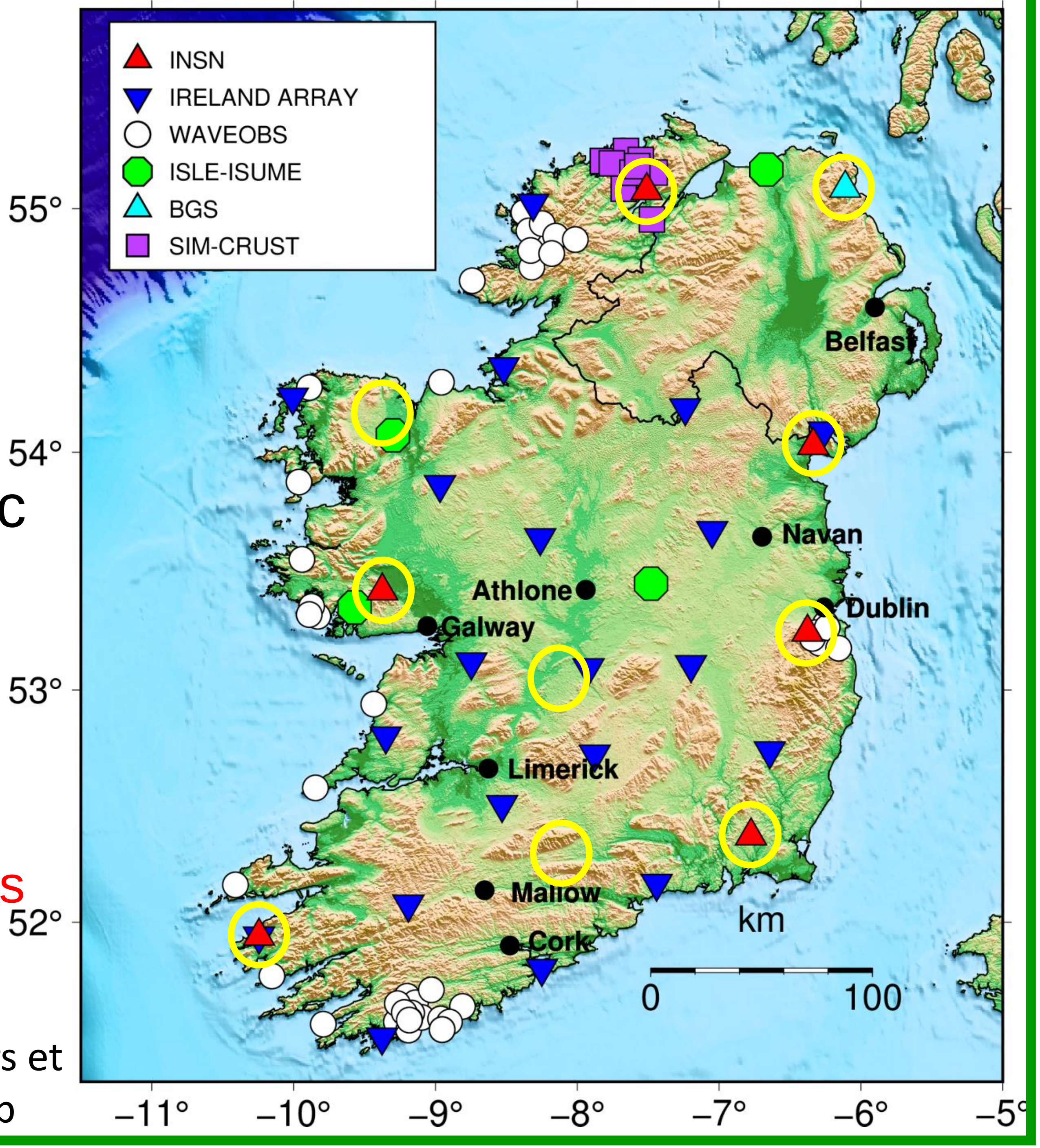
- **Creation of an improved resource map of Ireland**
- **(Island-scale approach) -** Determine the regional geothermal gradient in Ireland
- **(Regional-scale approach) -** Investigate the thermo-chemical crustal structure and secondary fracture porosity within the Upper Devonian Munster Basin
- **(Local-scale approach) -** Identify and assess the available low-enthalpy geothermal resources at reservoir scale in the Munster Basin

Seismic Data

- Primary objective is to improve the temperature maps of Mather and Fullea 2021.
- Add seismic – Constrain lithospheric thickness
- Large lateral coverage
- Lithospheric thickness is a control on geothermal gradient.

  Thinner lithosphere = warmer geotherms

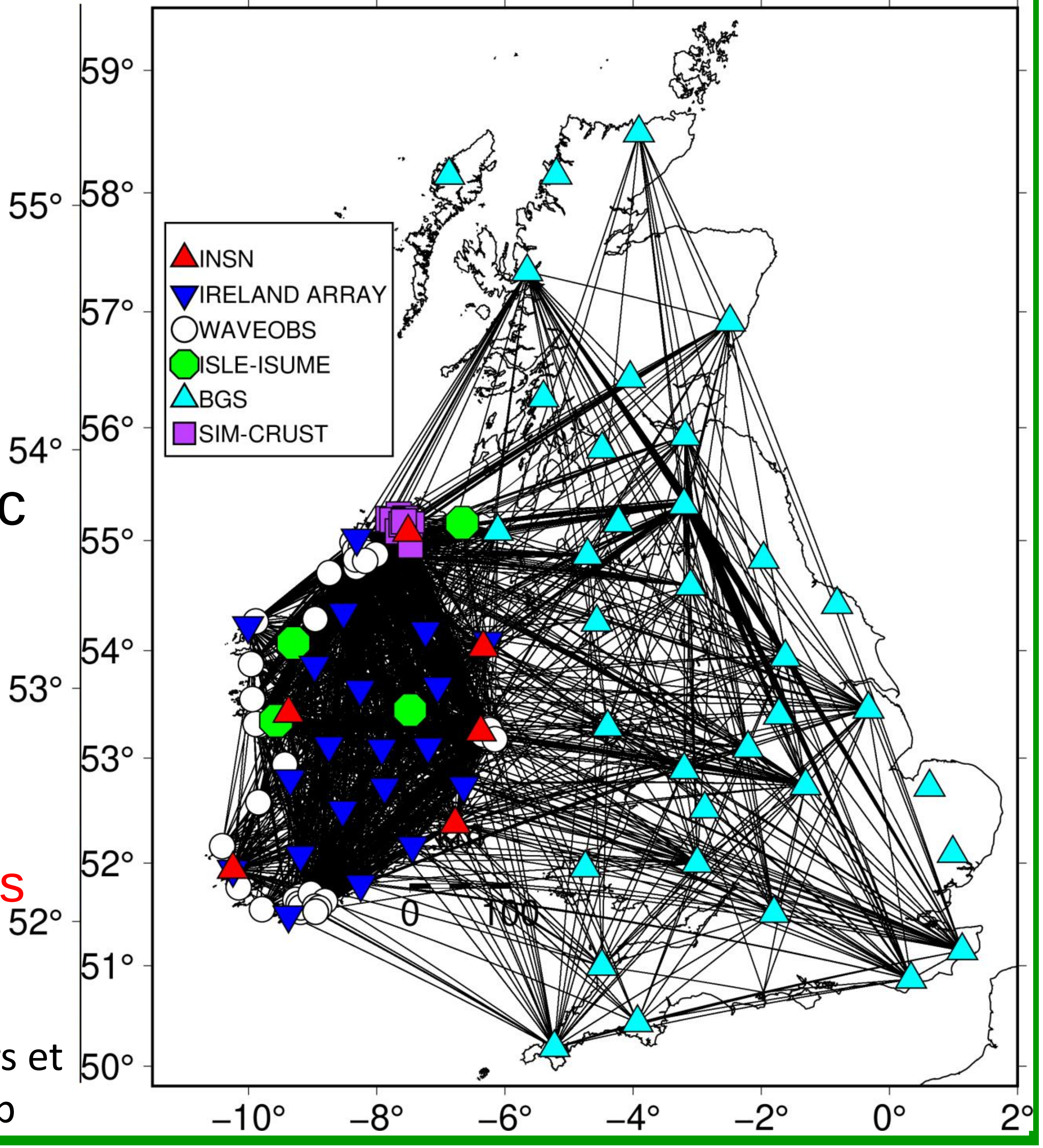
  Thicker lithosphere = cooler geotherms



Chambers et al. in prep

Seismic Data

- Primary objective is to improve the temperature maps of Mather and Fullea 2021.
- Add seismic – Constrain lithospheric thickness
- Large lateral coverage
- Lithospheric thickness is a control on geothermal gradient.
  - Thinner lithosphere = warmer geotherms
  - Thicker lithosphere = cooler geotherms



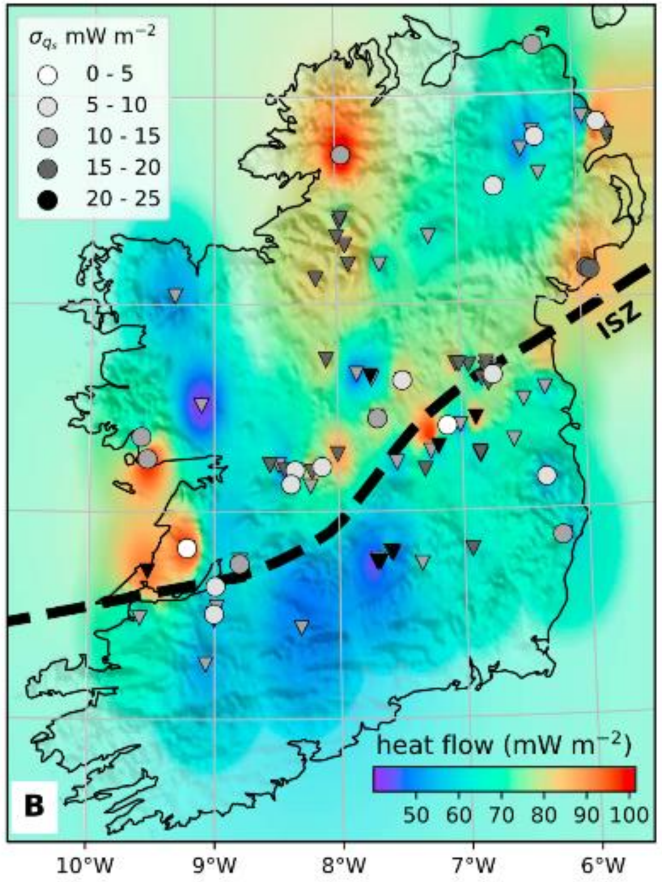
Chambers et al. in prep

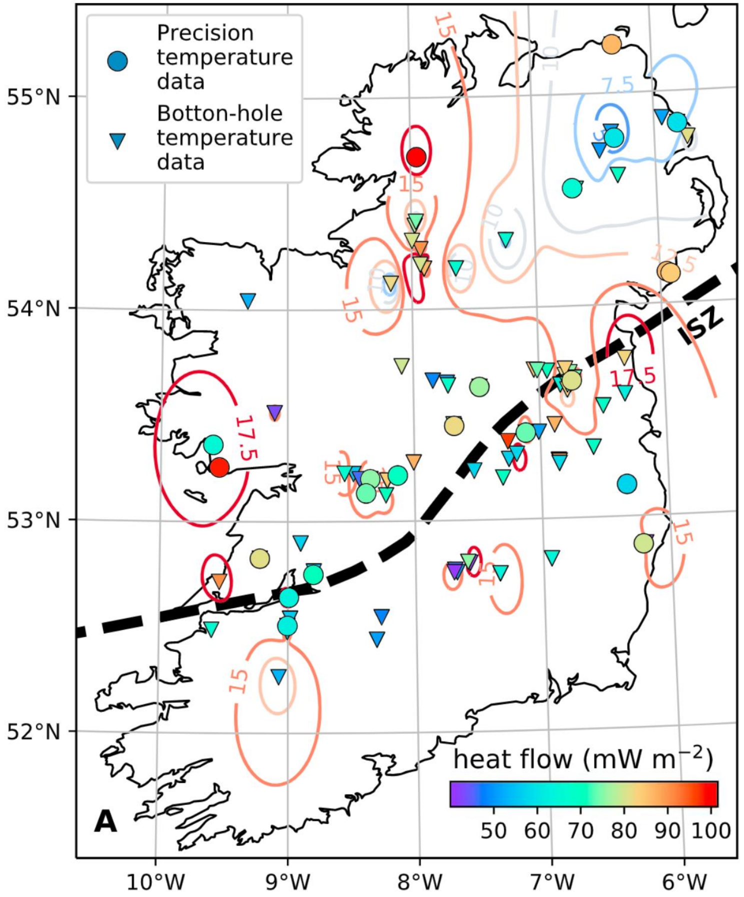
Thermal Properties

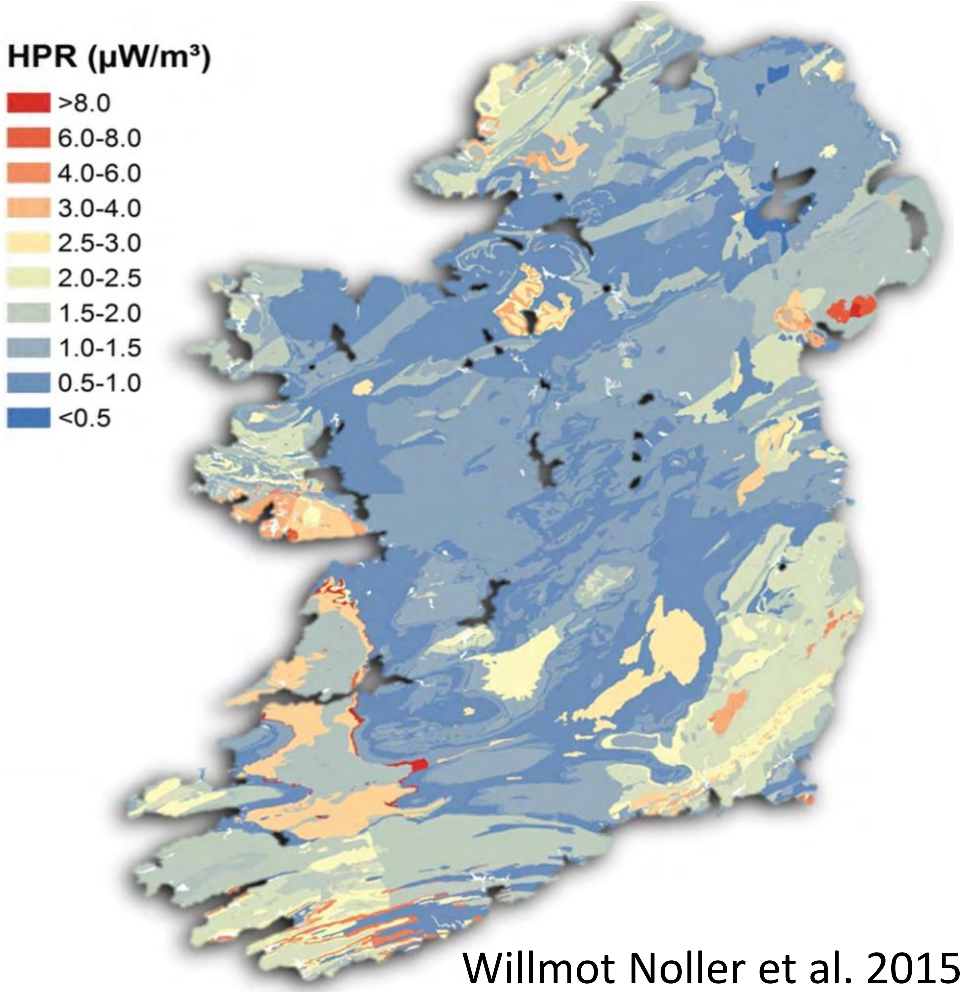
Surface Heat Flow

Radiogenic Heat Production

Mather et al. 2018



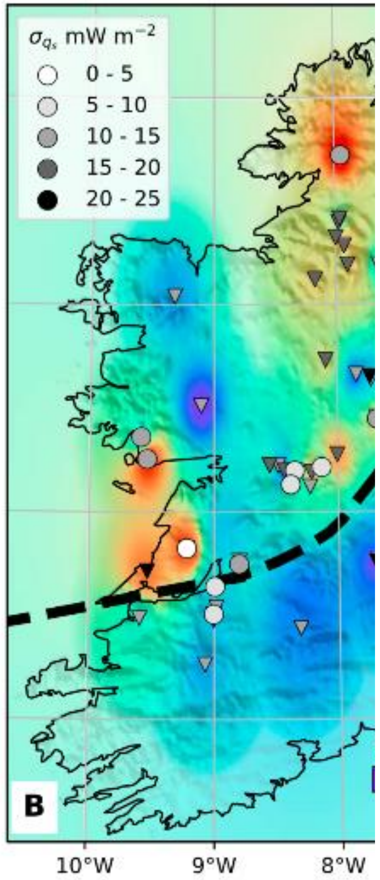


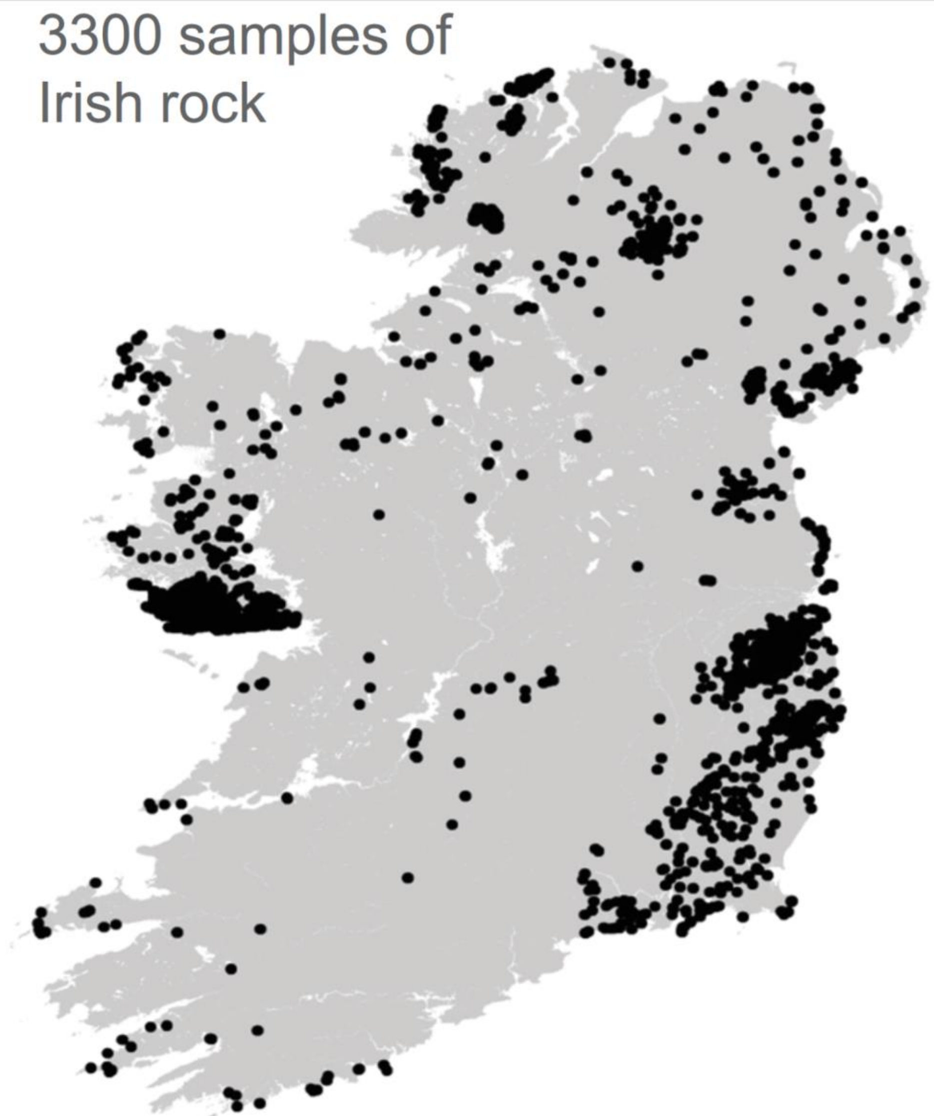


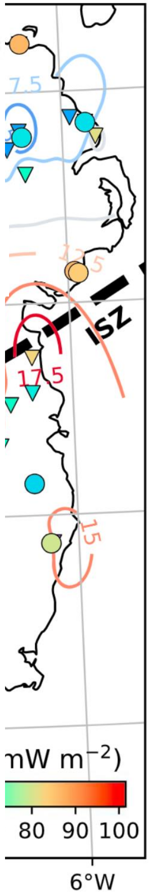
Willmot Noller et al. 2015

Thermal Properties

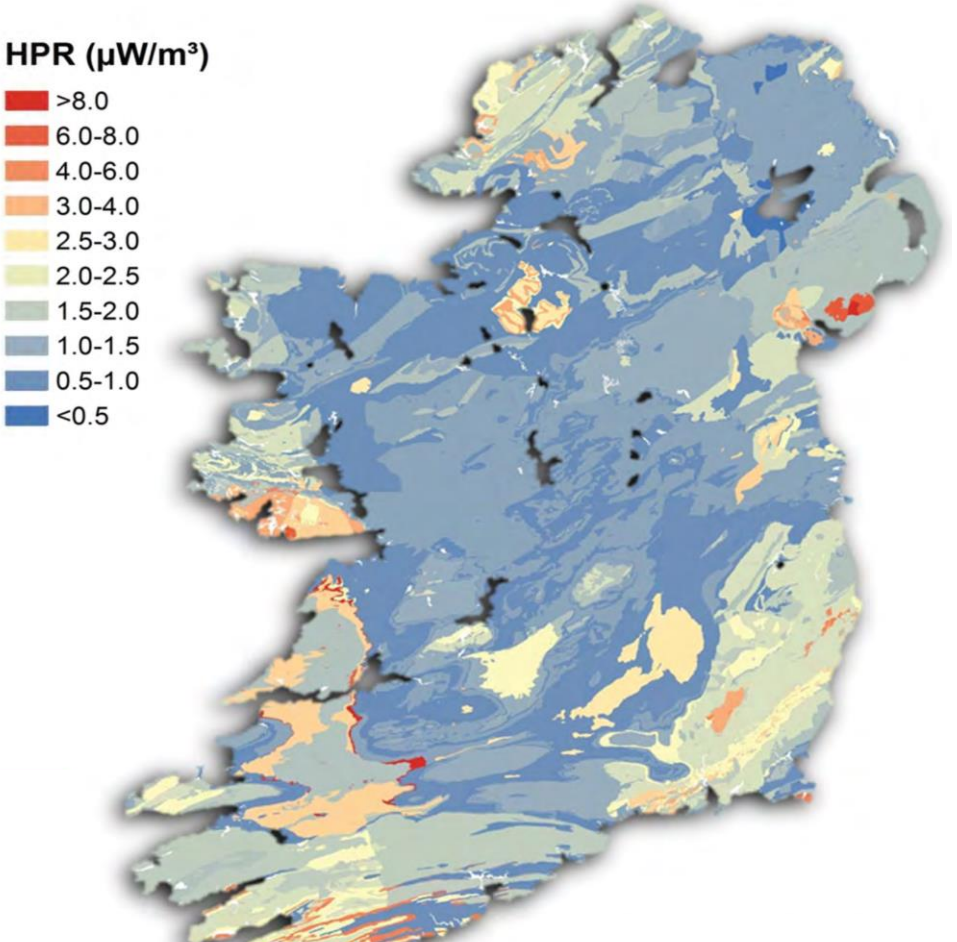
Mather et al. 20







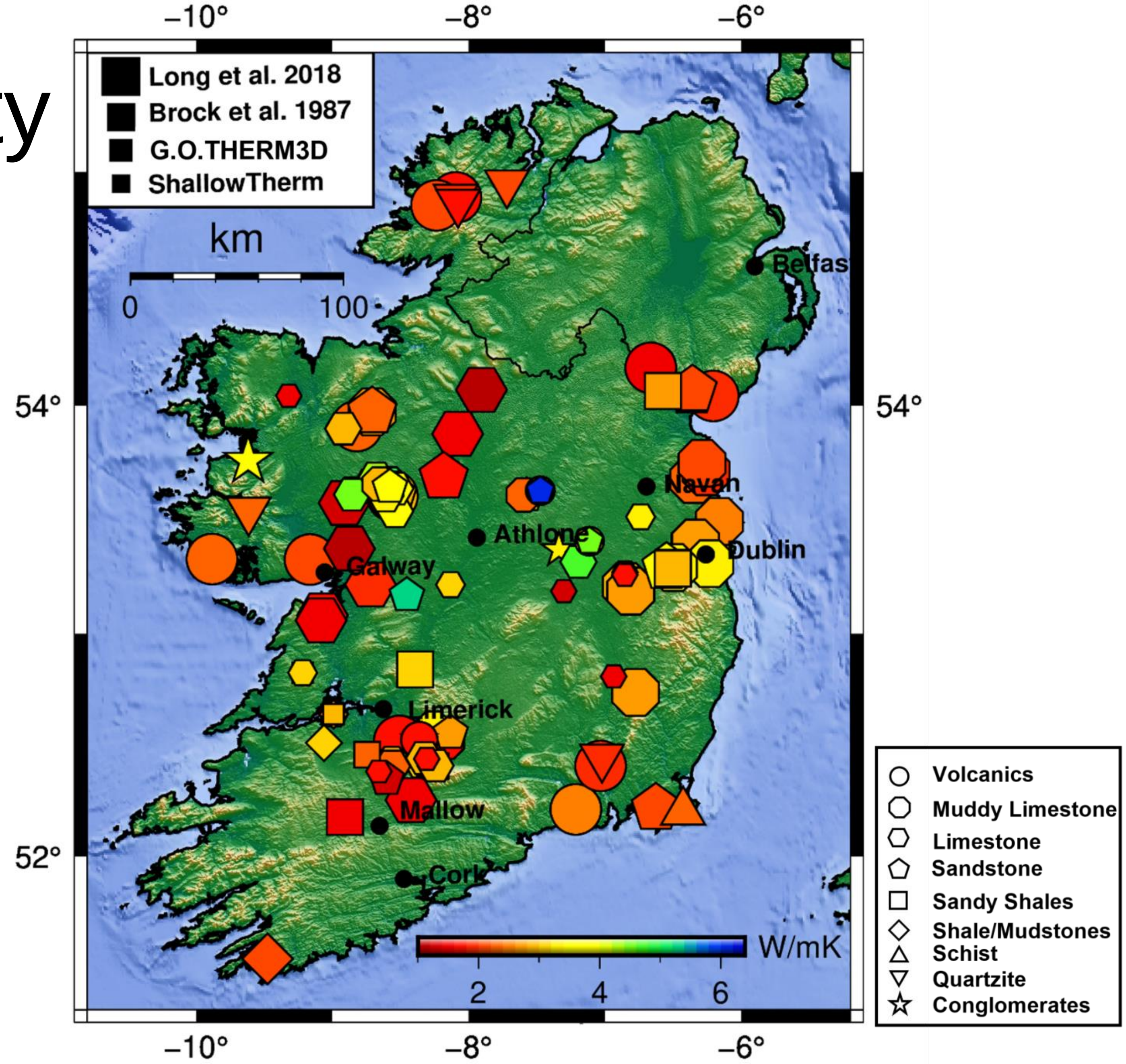
Radiogenic Heat Production



Willmot Noller et al. 2015

Thermal Conductivity

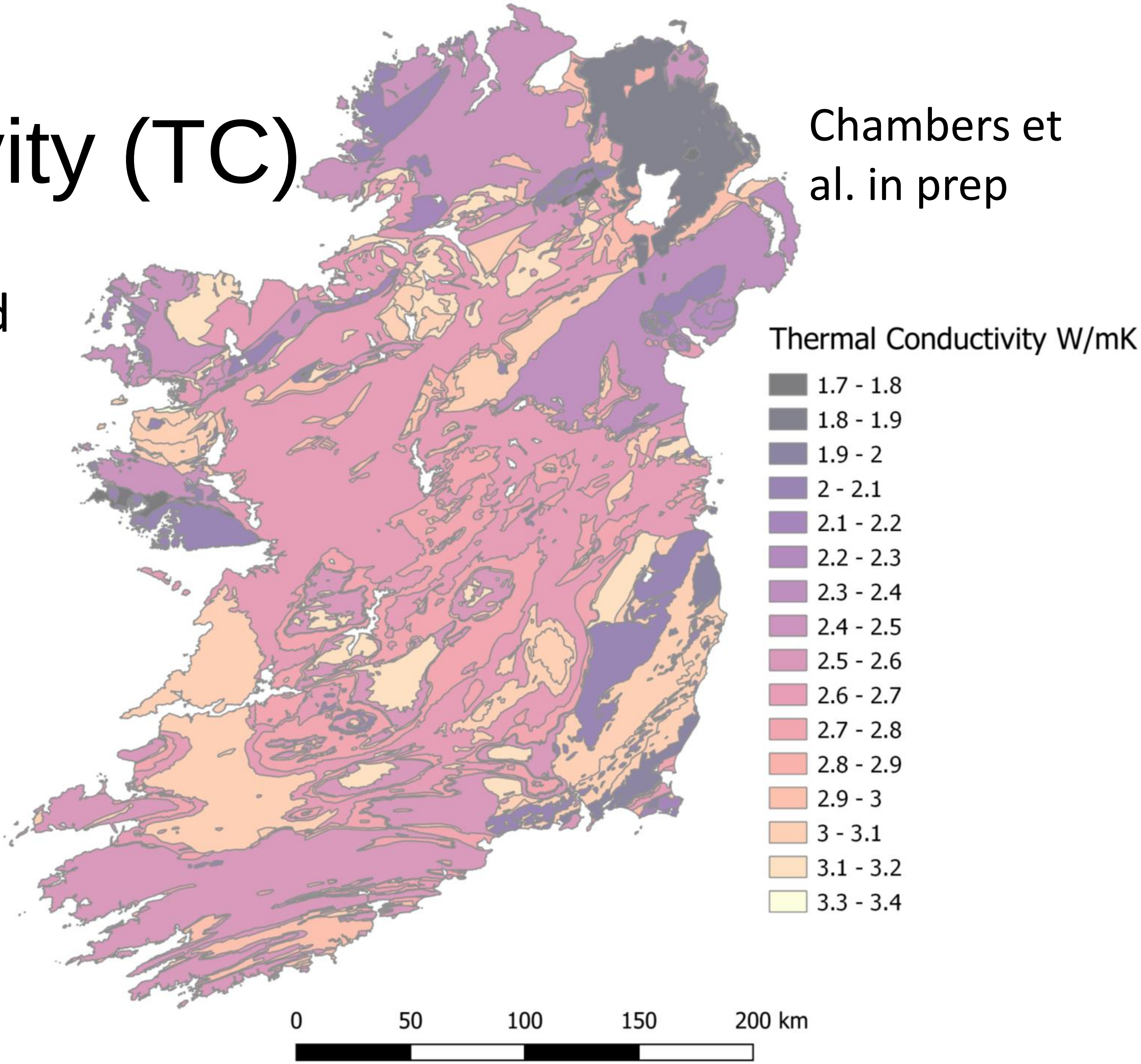
- Thermal conductivity measurements in Ireland
- Large variation between rock types
- Large variation within similar rock types – mud?



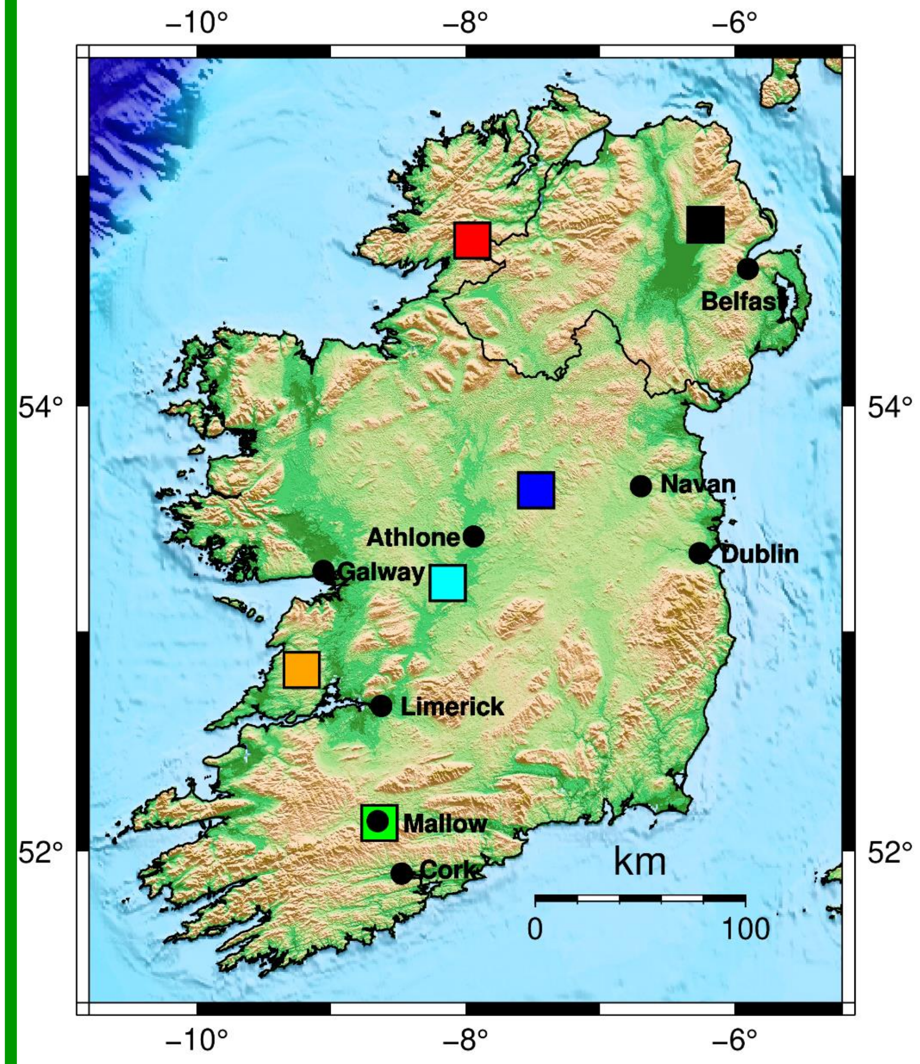
Thermal Conductivity (TC)

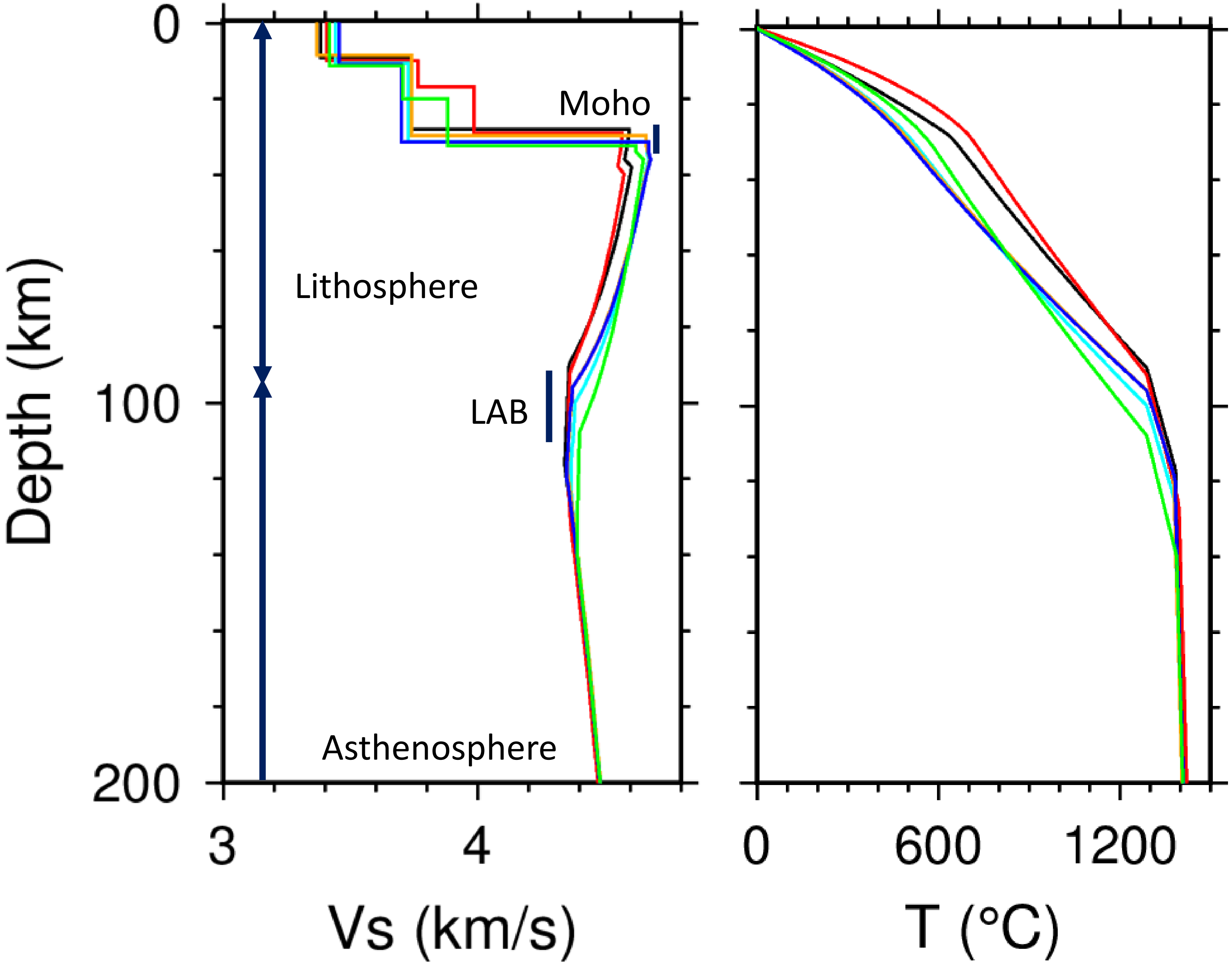
Chambers et al. in prep

- Took point measurements and assigned TC to lithology
- Based on surface bedrock geology
- NI is unsampled as is much of SW Ireland – where we have warm springs and high geothermal gradients



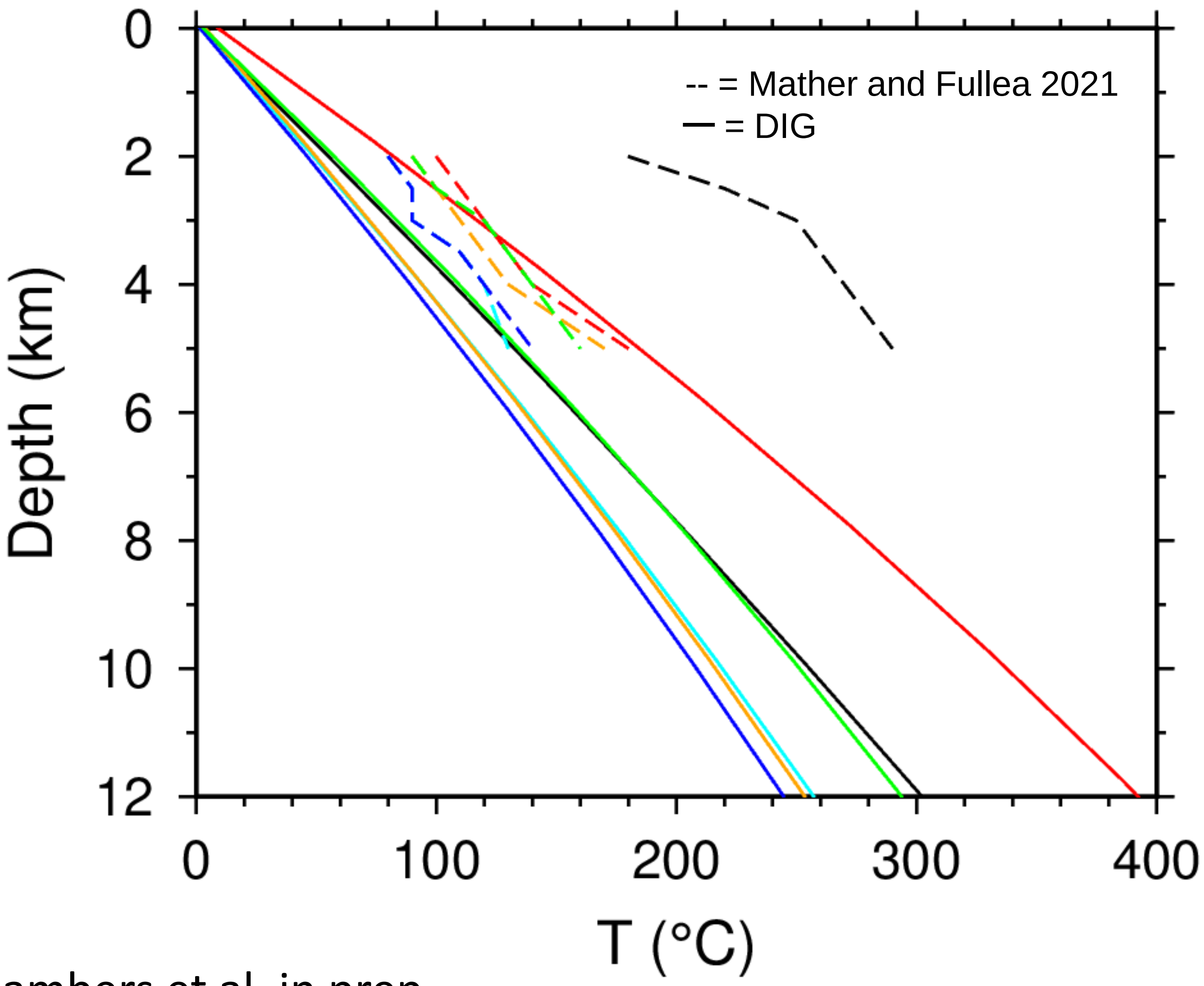
Joint geophysical-petrological inversion

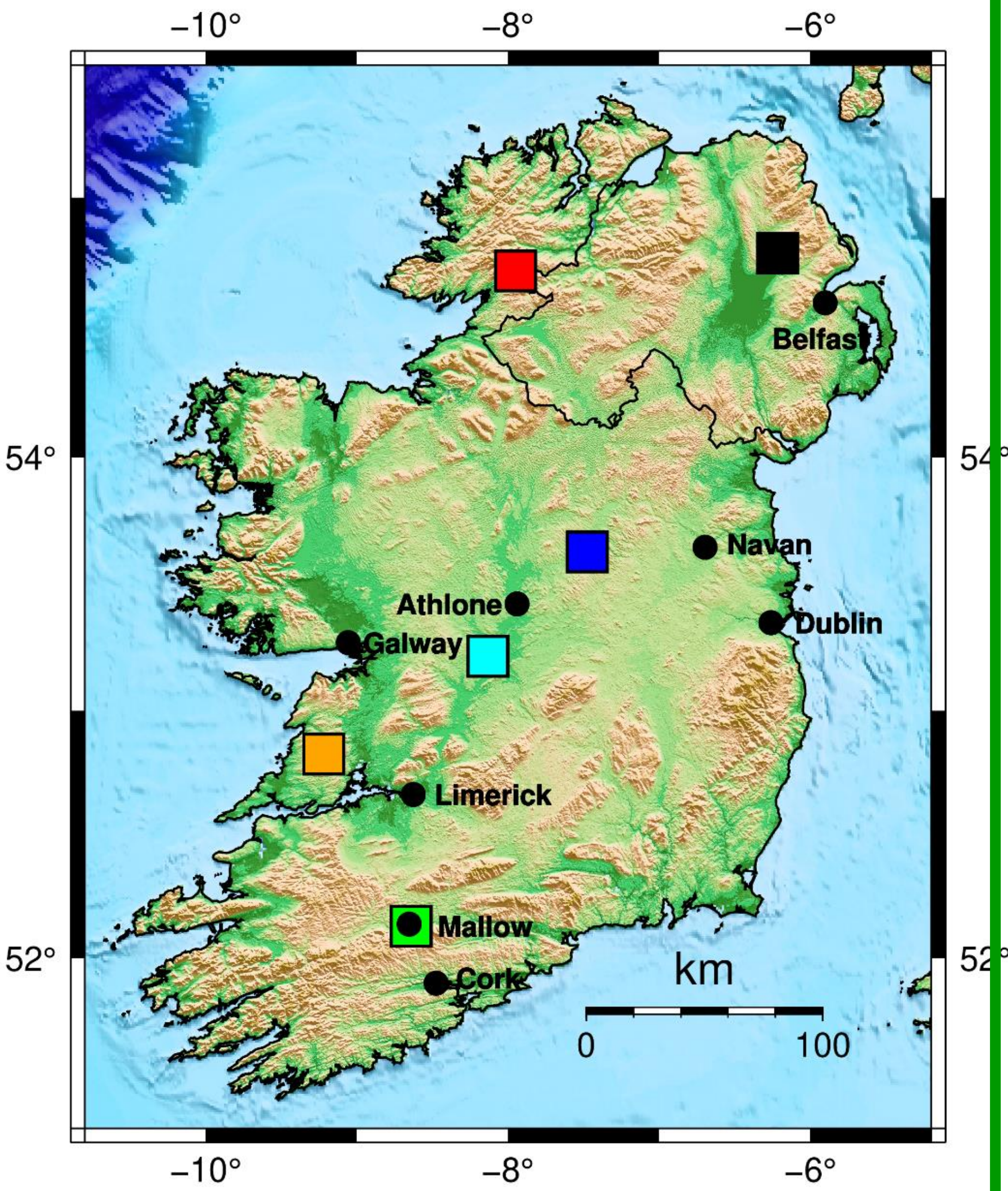




Chambers et al. in prep

Temperature comparison

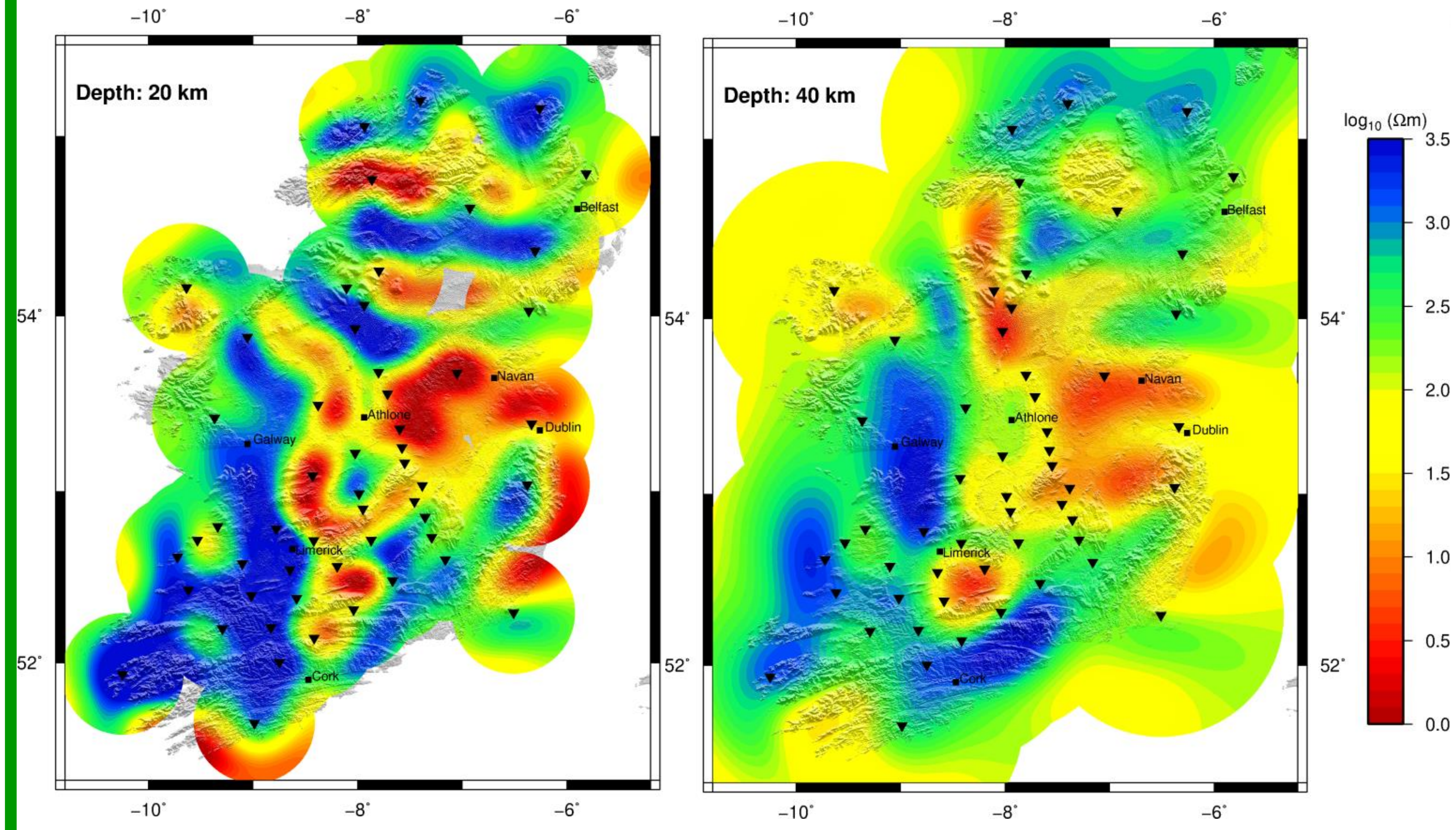


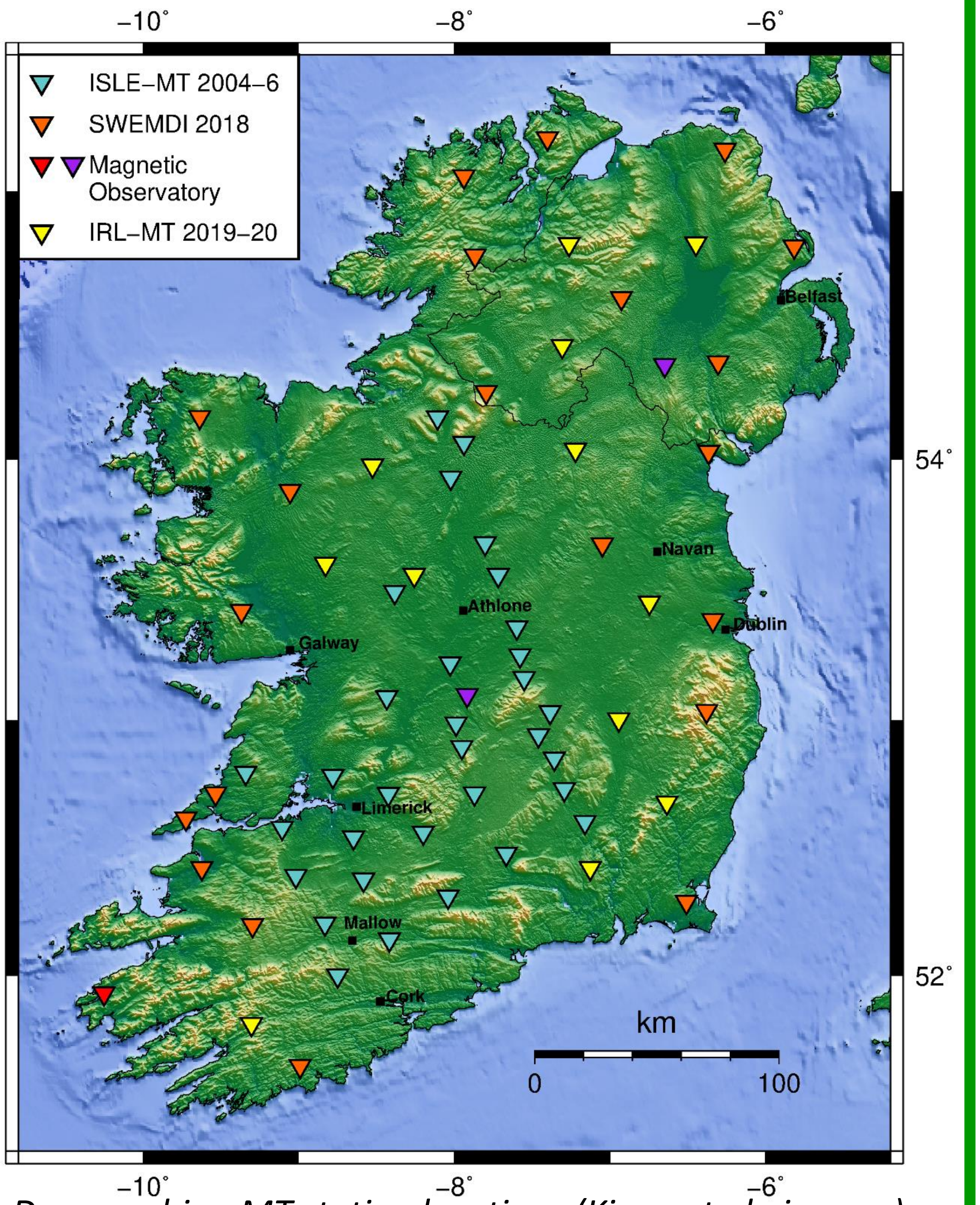


Chambers et al. in prep

Magnetotelluric data

Horizontal Slices of the 3-D MT Inversion Model

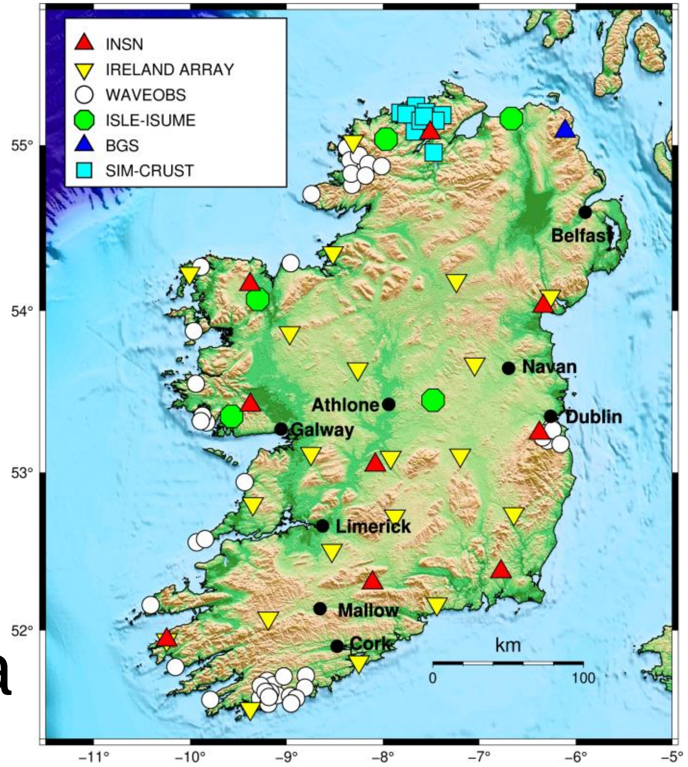


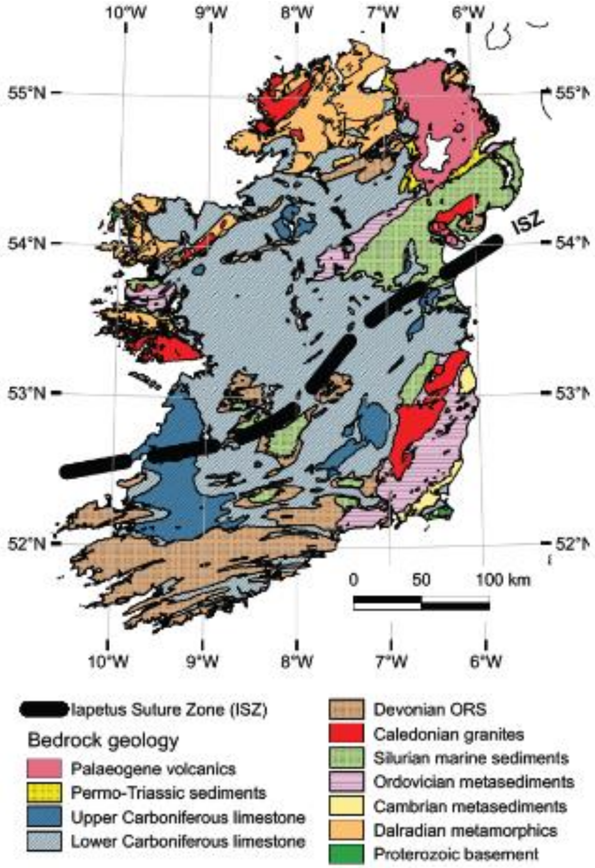


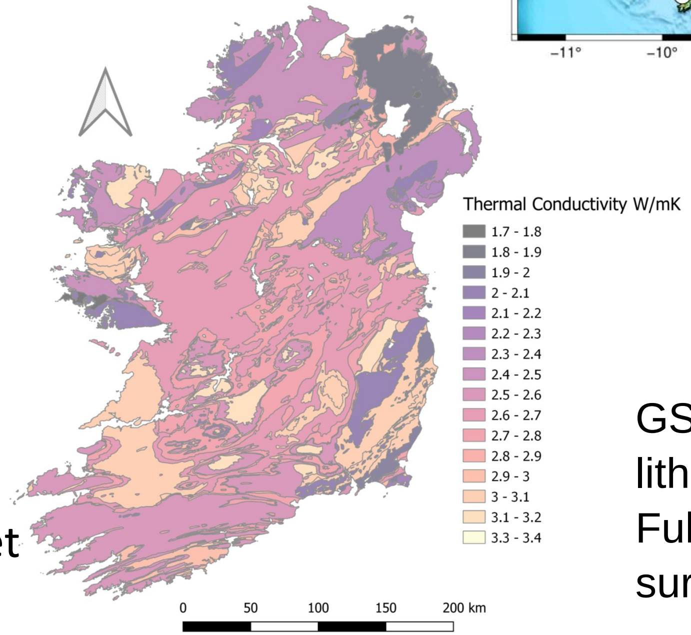
Deep-probing MT station locations (Kiyan et al., in prep)

Beyond DIG

- Lithology
- Workflow
- Seismic Data
- Other sources of seismic data
- Boreholes
- TC database

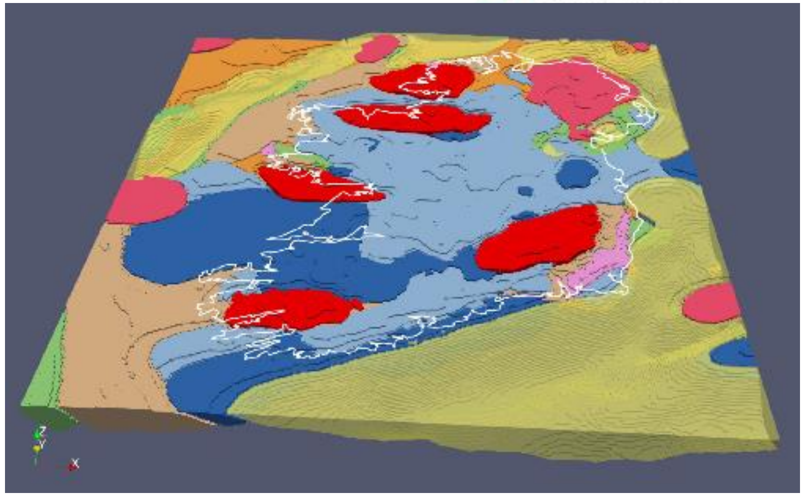






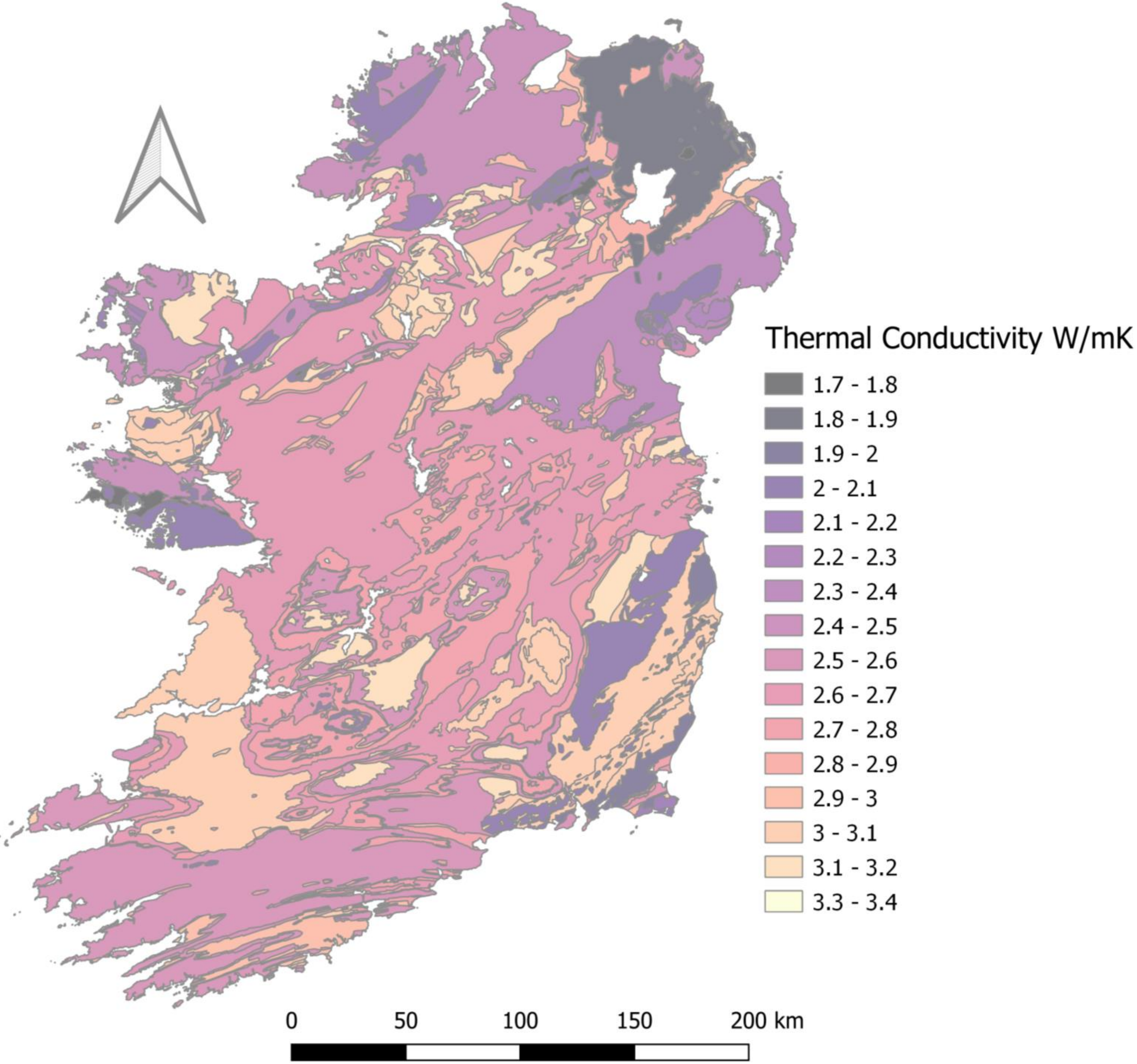
Chambers et al. in prep

GSI – G.O.THERM.3D lithospheric model: Fullea et al. (2014) + surface geology



Conclusions

- Current state-of-the-art = Mather & Fullea 2021
- Improving on these maps = DIG
- Future
  - Additional TC – Part of DIG
  - Additional seismic
  - Lithology
  - Boreholes
  - Update Workflow



Email: echambers@cp.dias.ie

Acknowledgements

DIG is financially supported by the Sustainable Energy Authority of Ireland and Geological Survey Ireland under Grant No. 19/RDD/522.

Thank you to GSI for the use of their online geological map viewer and resources and the DIG team* for information for this presentation.

*The named authors of this presentation and Stephen Daly, Colin Hogg, Ben Mather, Huda Mohamed, Mark Muller, Riccardo Pasquali, Nicola Piana-Agostinetti, Jan Vozar, John Weatherill

De-risking Ireland's Geothermal energy potential

dig

For the latest project updates visit:

www.dig-geothermal.ie

UNIVERSITY OF CAMBRIDGE

UNIVERSIDAD COMPLUTENSE MADRID

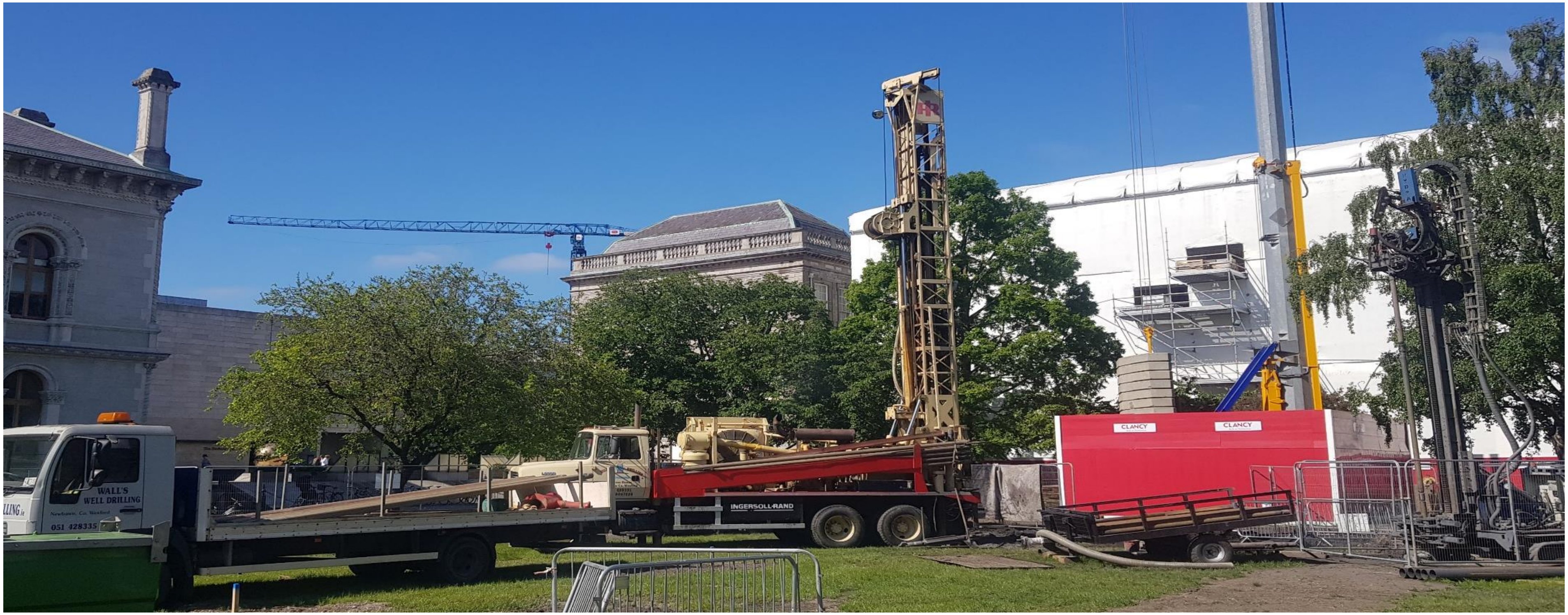
DIAS Institiúid Ard-Léinn Bhaile Átha Cliath | Dublin Institute for Advanced Studies

UCC Coláiste na hOllscoile Corcaigh, Éire University College Cork, Ireland

seai SUSTAINABLE ENERGY AUTHORITY OF IRELAND

Geological Survey Suirbhéireacht Gheolaíochta Ireland | Éireann

Rialtas na hÉireann Government of Ireland



Geothermal in Ireland – sector progress and barriers to development

9th November 2022

National Geothermal Energy Summit
TU Dublin, Grangegorman

www.geoservsolutions.com

Content

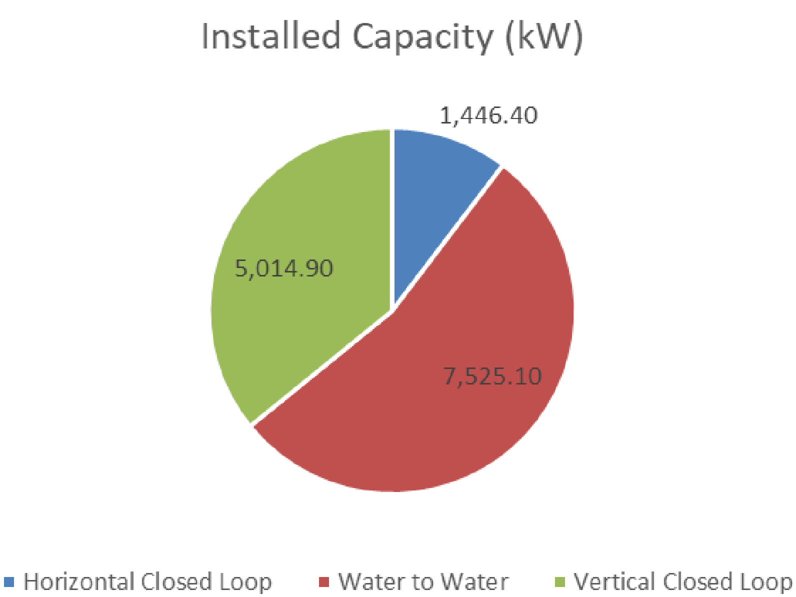
Topics covered

- Current status in Ireland
- Project Workflow considerations for GSHPs
- Barriers to development based on project experience

Geothermal in Ireland

Progress to date

- Estimated **208 MW_{th}** installed capacity
  - Est. 1.4 MW_{th} under development (Q4 2022)
- **GSHP Dominated**
  - **c. 194 MW_{th} - domestic installations**
  - **c. 14 MW_{th} - commercial/industrial installations**
  - **260.2 GWh of heating energy produced**
  - **10.3 GWh of cooling energy produced**
- Deep Geothermal
  - Limited Exploration 2007-2010
  - Increased research on potential available
  - No commercial development



Data sources: GAI, 2022 – EHPA, 2021

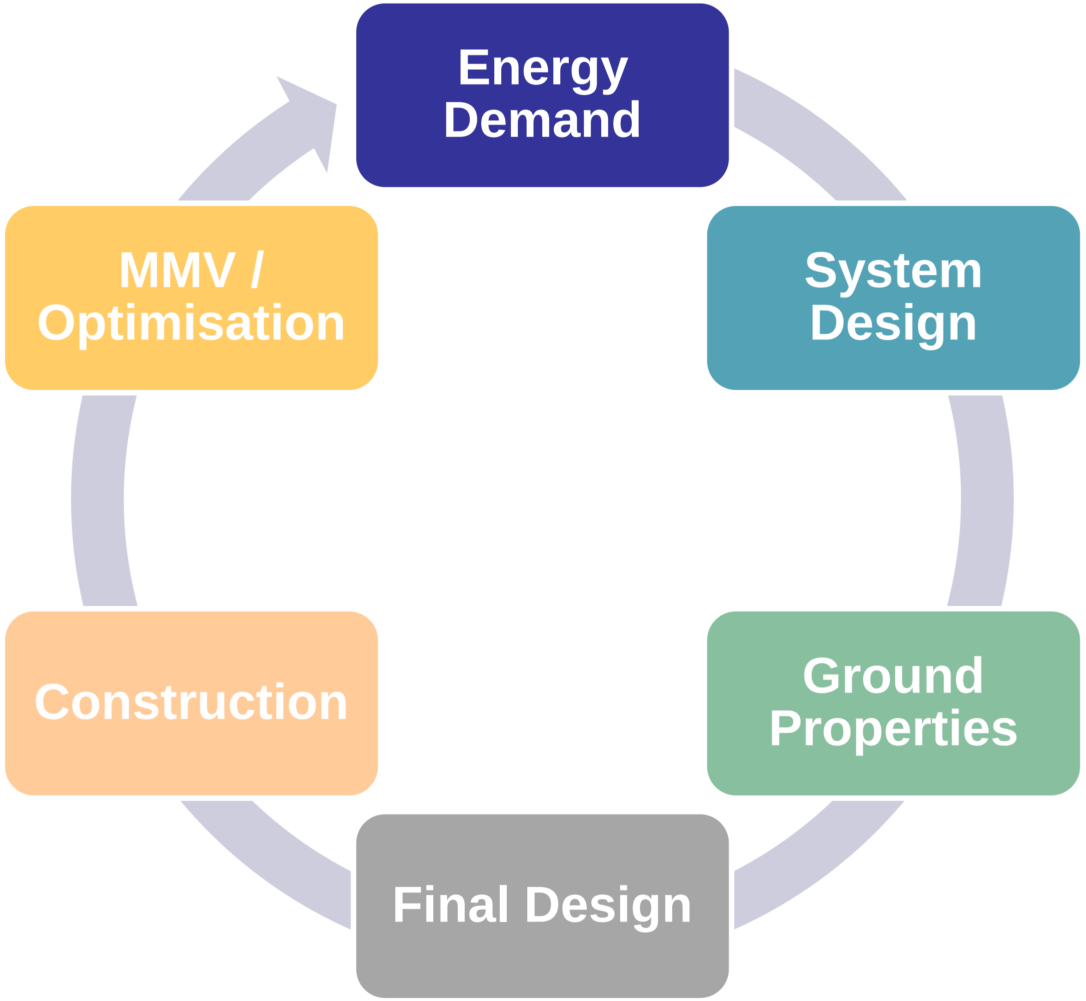
Geothermal in Ireland

Some Examples

Project Development

Typical Project Workflow

- Why do GSHPs stand out?
  - Heating & Cooling (simultaneous)
  - High SPF
- Interactions of Multiple Disciplines required
- Holistic Design Approach required for successful delivery



Shallow Geothermal

Geoserv

System Design

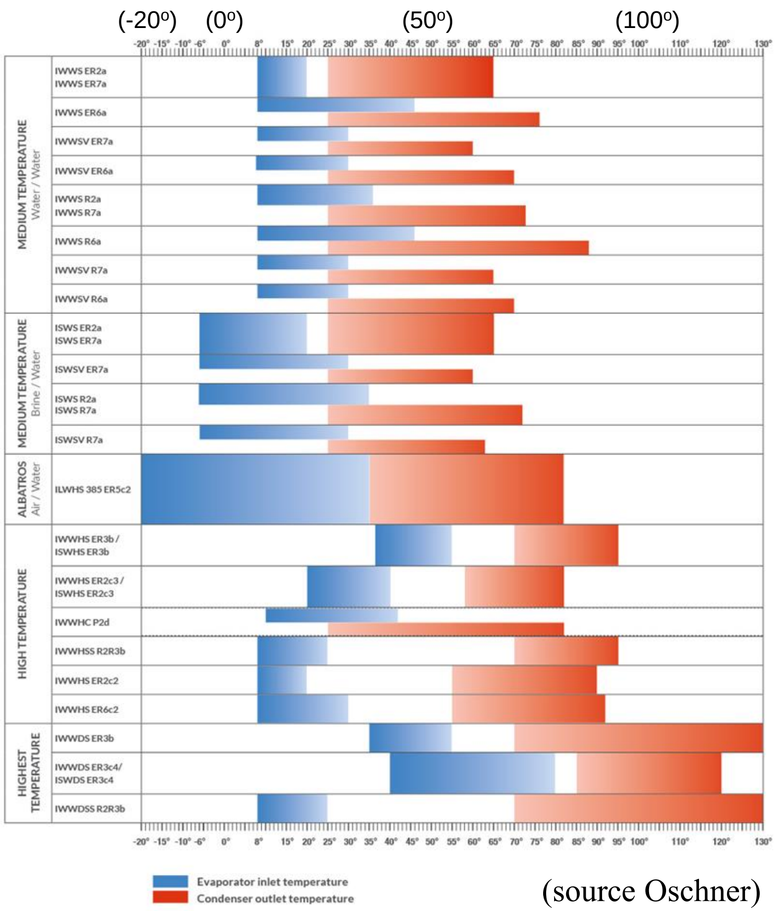
Barriers	Solutions
• Technology Perception	• What is available to end users & where? • Highlighting the benefits
• Design Strategy • *Integrated Heating & Cooling*	• Collector sizing based on demand & ground condition (Part L compliance)
• Standards & Guidance vs rules of thumb	• NSAI SR 50-4:2021 – EN17628:2015 • (pr) EN17522 (to be published Q1 2023) • UKGSHPA; CIBSE
• Planning & Permits	• Clear guidance on permitting requirements • Centralised application process
• Maximising the Opportunity	• GSHP solution integrated to the building or process fabric
• Competing Technologies	• Collector Infrastructure part of the building fabric cannot be compared to a plant room

Shallow Geothermal

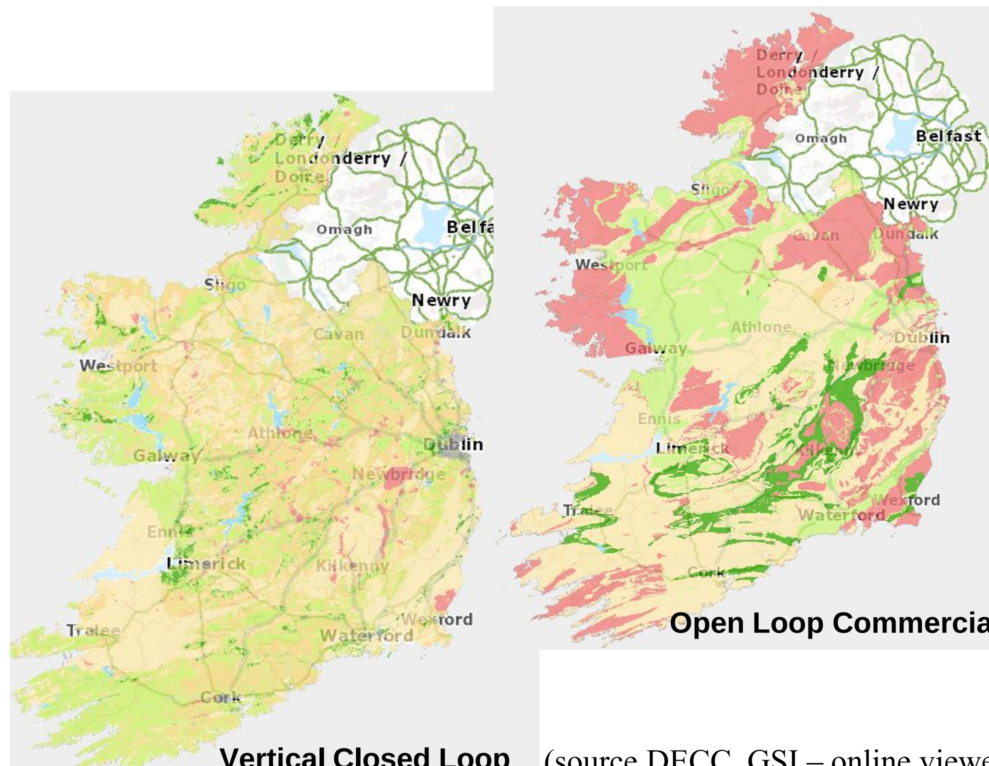
Technology Perception

- Heat Pump Temperatures

Collector Suitability Maps



(source Oschner)



(source DECC, GSI – online viewer)

Shallow Geothermal

Ground Properties

Barriers	Solutions
• Understanding of Geological Conditions	• Site Specific Solutions – GSHP solution integrate to the building or process fabric
• Verification of design – lack of testing	• Perform TRT and Pumping Tests at early project development stage

(source ENECRET, 2022)

Shallow Geothermal

Geoserv

Construction

Barriers	Solutions
• Procurement process	• Integrated – design to completion • Interface with M&E Disciplines

• Unexpected Ground conditions	• Early design RA & mitigation measures:
	  • Make up boreholes
	  • Alternatives
	  • Partial Load

• Material Selection & Piping	• Piping and completion guidance • Mechanical Testing Procedures & Certification

Shallow Geothermal

MMV & Optimisation

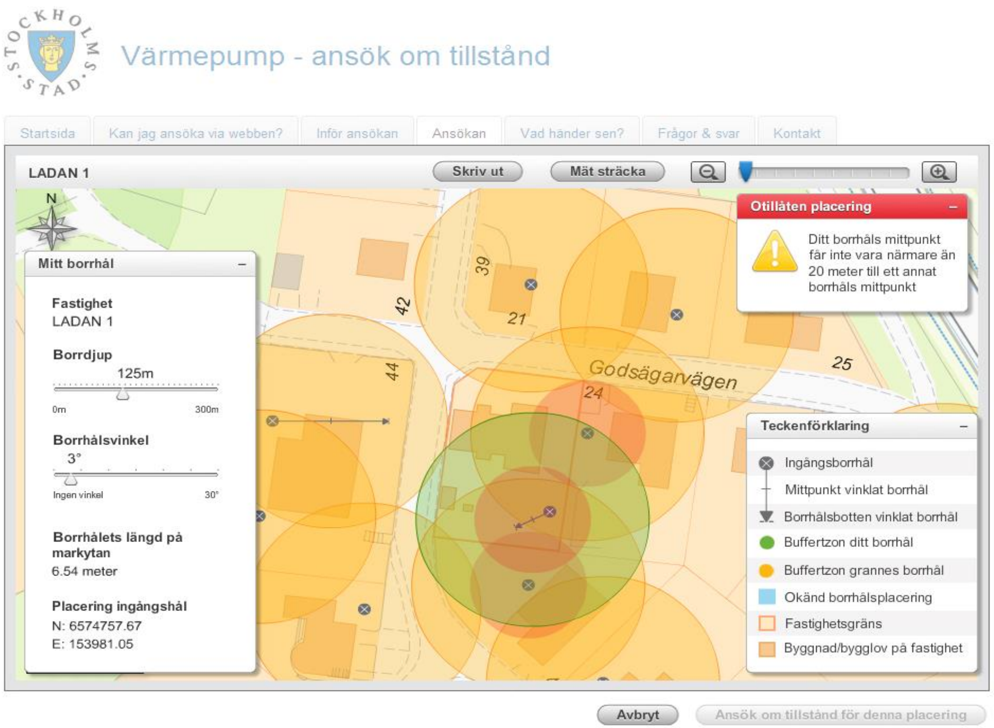
Barriers	Solutions
• Performance Data not available	• Monitoring & reporting of larger systems to understand performance • SPF vs COP approach
• System optimisation generally limited	• System optimisation & follow up generally limited
• Ground Energy exchange data not known	• Guidance on neighbouring systems to designers
• System proximity interactions	• Database/register of systems
• Resource & Energy master planning not possible	• System data to inform sustainable development

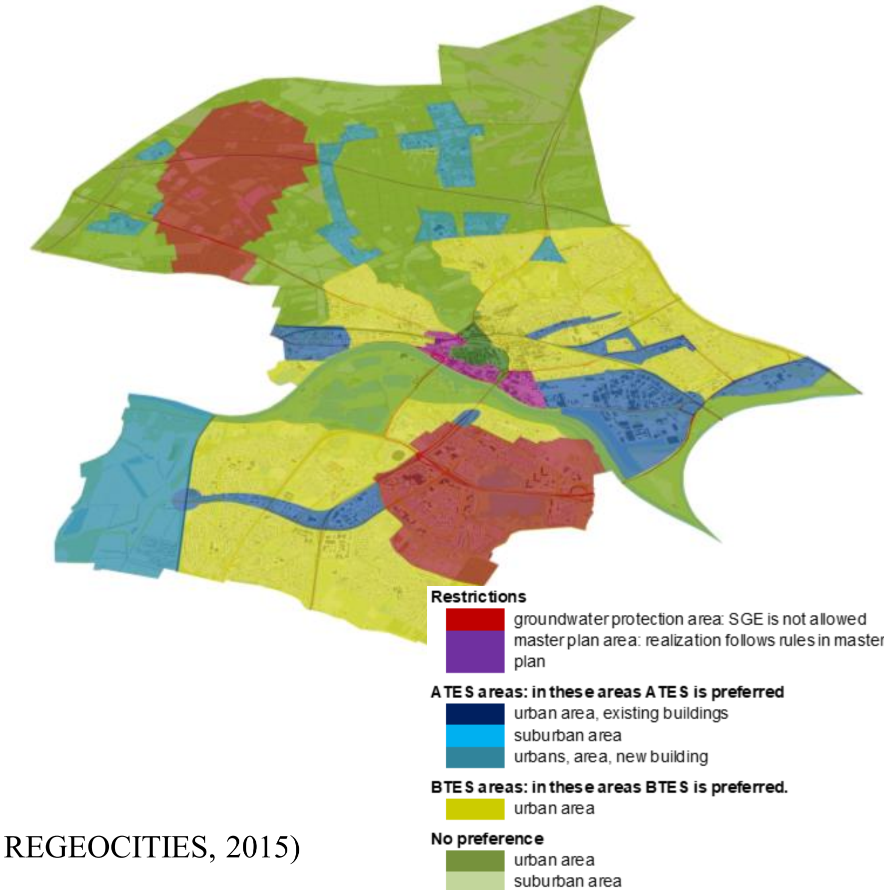
Shallow Geothermal

MMV & Optimisation

- Stockholm, Sweden

Arnhem, The Netherlands





(source REGEOCITIES, 2015)

Thank you

rpasquali@geoservsolutions.com

Geothermal Association of Ireland

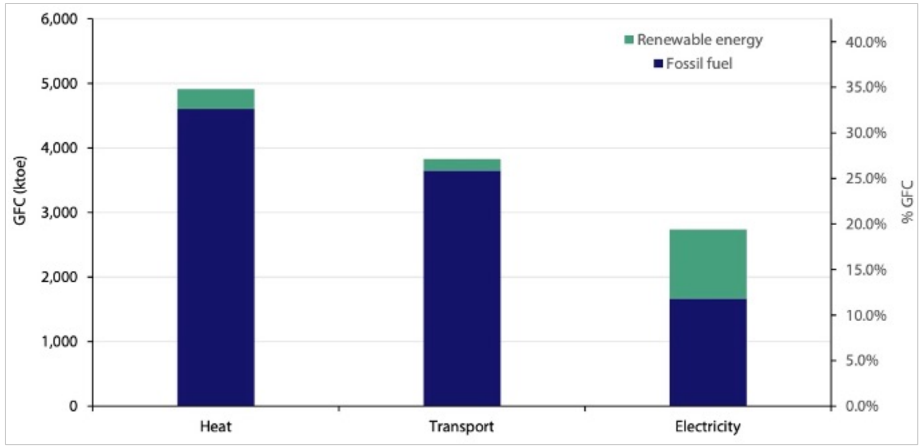
What needs to be in-place to promote the use of geothermal in Ireland?

Why does it matter? Geothermal can play a material role in decarbonizing heat, Ireland's largest energy decarbonization issue

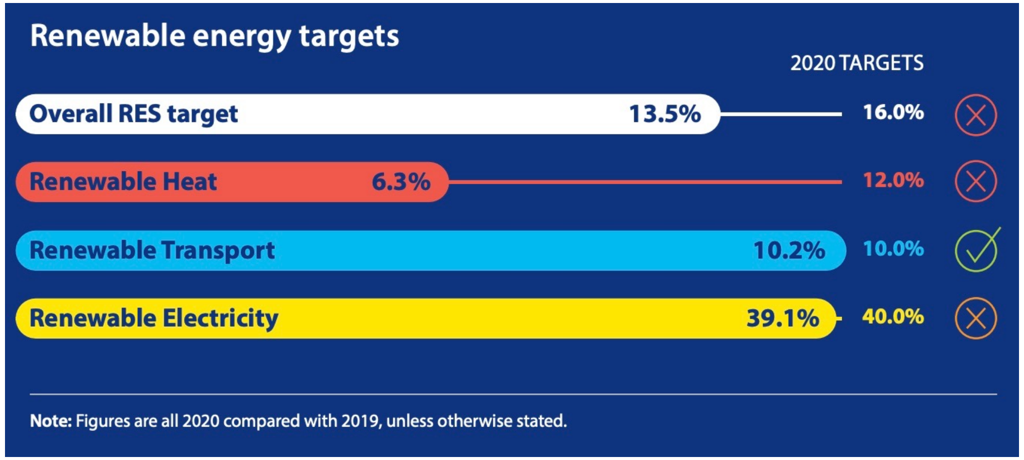
Geothermal Association of Ireland

Heat is the largest energy issue for Ireland

94% of Ireland's heating/cooling is supplied by fossil fuels

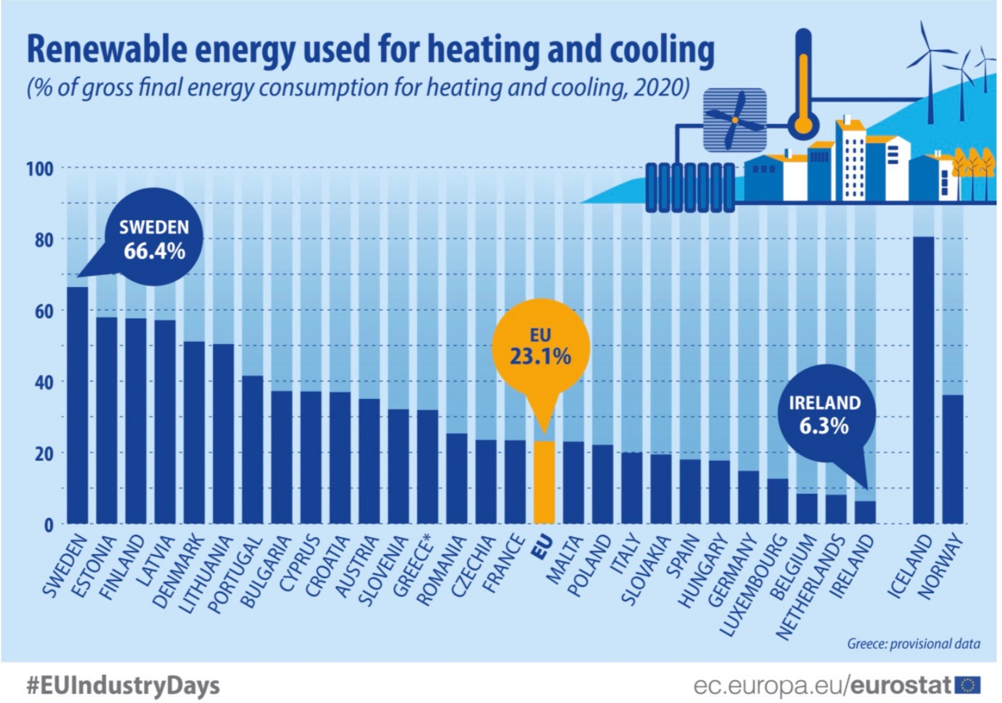


We missed our 2020 target by a long way



ENERGY IN IRELAND 2021 Report; December 2021 Sustainable Energy Authority of Ireland (SEAI)
https://www.seai.ie/data-and-insights/seai-statistics/key-publications/energy-in-ireland/

- The best in Europe use similar low enthalpy geothermal resources to support decarbonisation of their heating & cooling
- Sweden has 6.8 GW capacity (approx. 1/3rd of their renewable heat, >90% from shallow systems) to our 200 MW installed for geothermal energy than Ireland and it plays a big role in making it a leader renewable energy

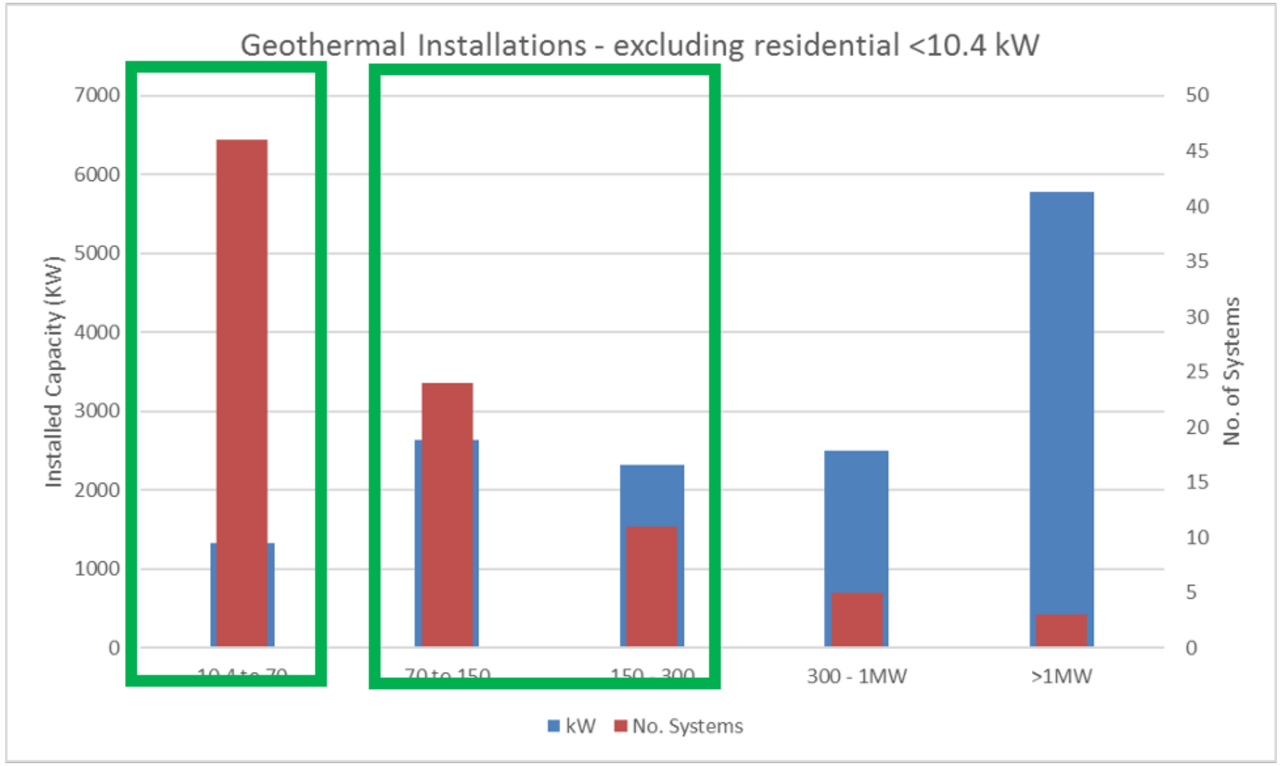


The Geothermal industry is a nescient industry, but with significant potential to support the energy transition in Ireland

Geothermal Association of Ireland

Ireland: used for heating/cooling and heat storage

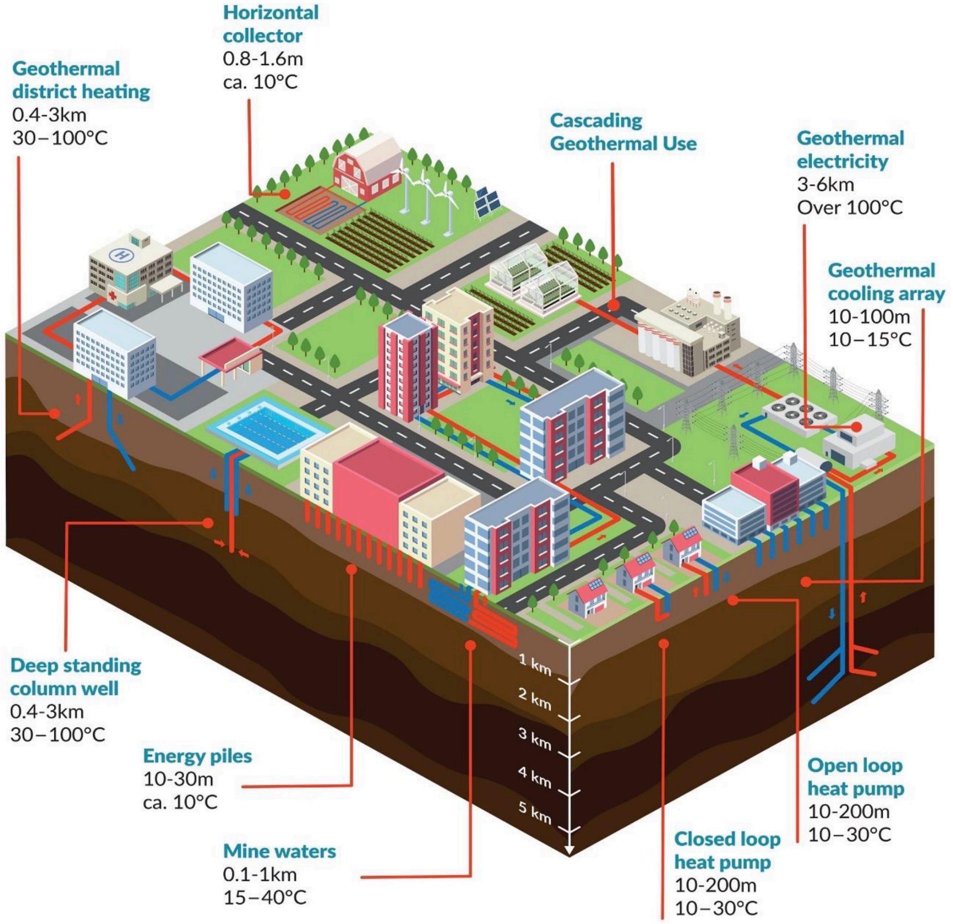
- **Total** of >**200 MW installed** capacity[1]
- **18,000 domestic systems** with an average **10 kW** capacity
- **90%** of commercial installations under 300KW capacity.



[1] Pasquali et al 2021. This is from the GAI database which does not include all installations in Ireland

What characteristics do we need to consider from the systems? Shallow v Deep

Geothermal Association of Ireland



After: Geological Survey of Ireland

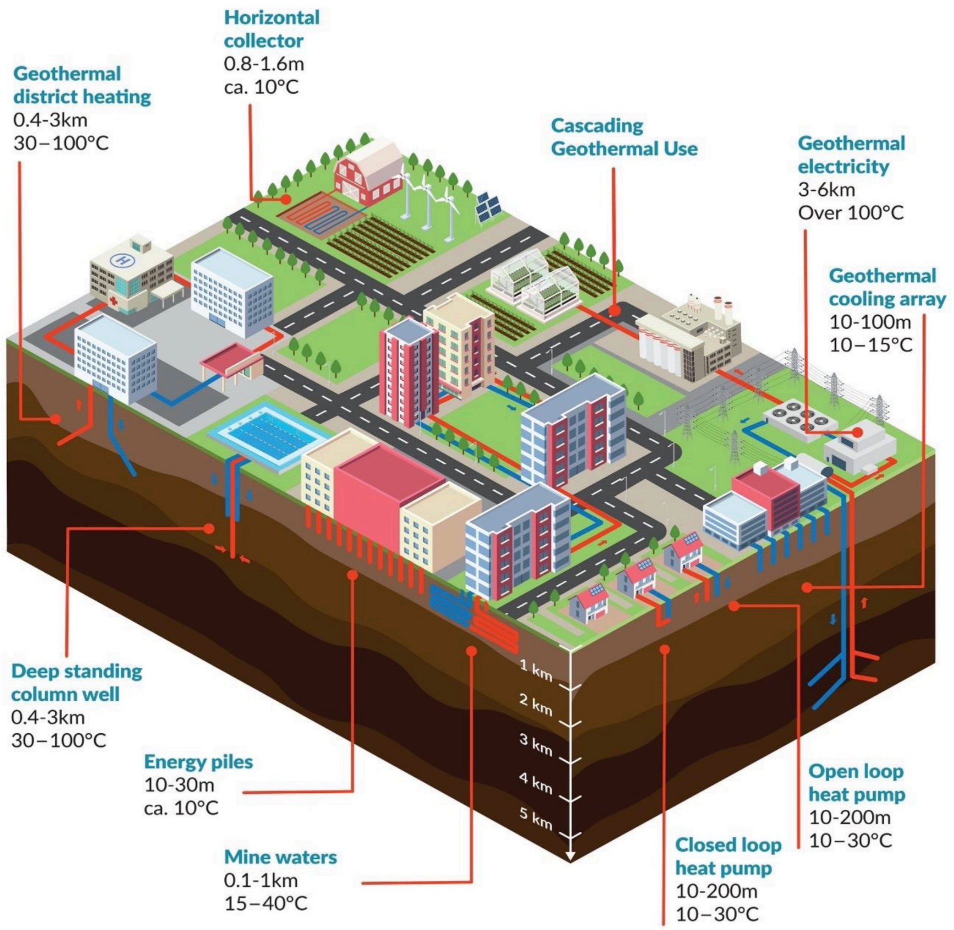
Shallow system

- Down to 400m
- Used for space heating/cooling, domestic and commercial
- >95% of Irish deployments
- Can be deployed from a house to multi-MW capacity
- Dependent on heat pumps
- Likely to dominate Ireland's geothermal deployments for at least a decade if not longer
- Lower cost, Low investment uncertainty,
- Deployed on-site or locally

Deep systems

- Greater than 400m, commonly much deeper
- In Ireland used for heating/cooling, as in most of Europe, however some areas in Europe use for electricity, less likely in the medium term in Ireland
- MW scale minimum
- Can be with or without heat pumps
- High cost, greater uncertainty
- Can be more remote from user
- Significant data gap in deep geology in Ireland

What characteristics do we need to consider from the systems? Closed v Open



Closed system

- No fluid is produced from the ground, system is self-contained and works on conducting heat.
- **Incudes custom boreholes, thermally active buildings, energy piles etc.**
- Heating and cooling applications, commonly integrated with heat pumps
- ‘Shallow or Deep’
- Very low environmental impact.

Open System

- Water/Fluid is abstracted from an aquifer.
- Direct heat common, electricity where temperatures are high enough & can be integrated with heat pumps
- Generally low environmental impact
- More geological uncertainty

After: Geological Survey of Ireland

What needs to be in a strong geothermal policy to support development?

Geothermal Association of Ireland

- **Targets:** Clear numerical **targets** for geothermal adoption (different targets for Shallow and Deep) aligned to Ireland and EU targets for heating and cooling

- **Incentives** for adoption of geothermal (Shallow and Deep different); capital cost is a barrier, evening if the economics in the long term are attractive

- **Capabilities:** Clear policy statement on the building of **capabilities** to deliver policy targets, including engineering, planning, drilling, geoscience

- **Shallow** (<4-500m) and **Deep** (>4-500m) Geothermal have different characteristics and are a different levels of technical maturity involving different requirements for how they are treated in policy and regulation

Resource Ownership & Development

- Shallow Systems that have **low impact should be Permitted**.
  - The landowner should have the right to develop automatically if the impact is small
  - The permit to develop should be assessed if the development is of a scale that it may impact outside the boundaries of the plot

- Deep geothermal is of a larger scale and the resource should be **licensed:**
  - Resource **licensing of the resource is appropriate**, and permit the subsequent development of the resource

What needs to be in-place to promote the sustainable development of different styles of geothermal for different types of development?

Geothermal Association of Ireland

Geothermal Systems

		Registration	Energy Exchange Based Permitting & licensing	Planning Permission & EIS	Water Abstraction License	Water disposal /IPCC
Closed Loop	Domestic	✓		✓ (highlighted)		
Closed Loop	Commercial Small	✓		✓ (highlighted)		
Closed Loop	Commercial Large	✓	✓	✓		
Closed Loop	Industrial	✓	✓	✓		
Open Loop	Domestic (<25m³/d)	✓		✓ (highlighted)		
Open Loop	Commercial Small or >25m³/d	✓	✓	✓ (highlighted)	✓	✓
Open Loop	Commercial Large	✓	✓	✓	✓	✓
Open Loop	Industrial	✓	✓	✓	✓	✓

✓ (highlighted) Included in Planning Applications for new developments

Macro considerations: Why have other countries accelerated in their transition to alternative supply?

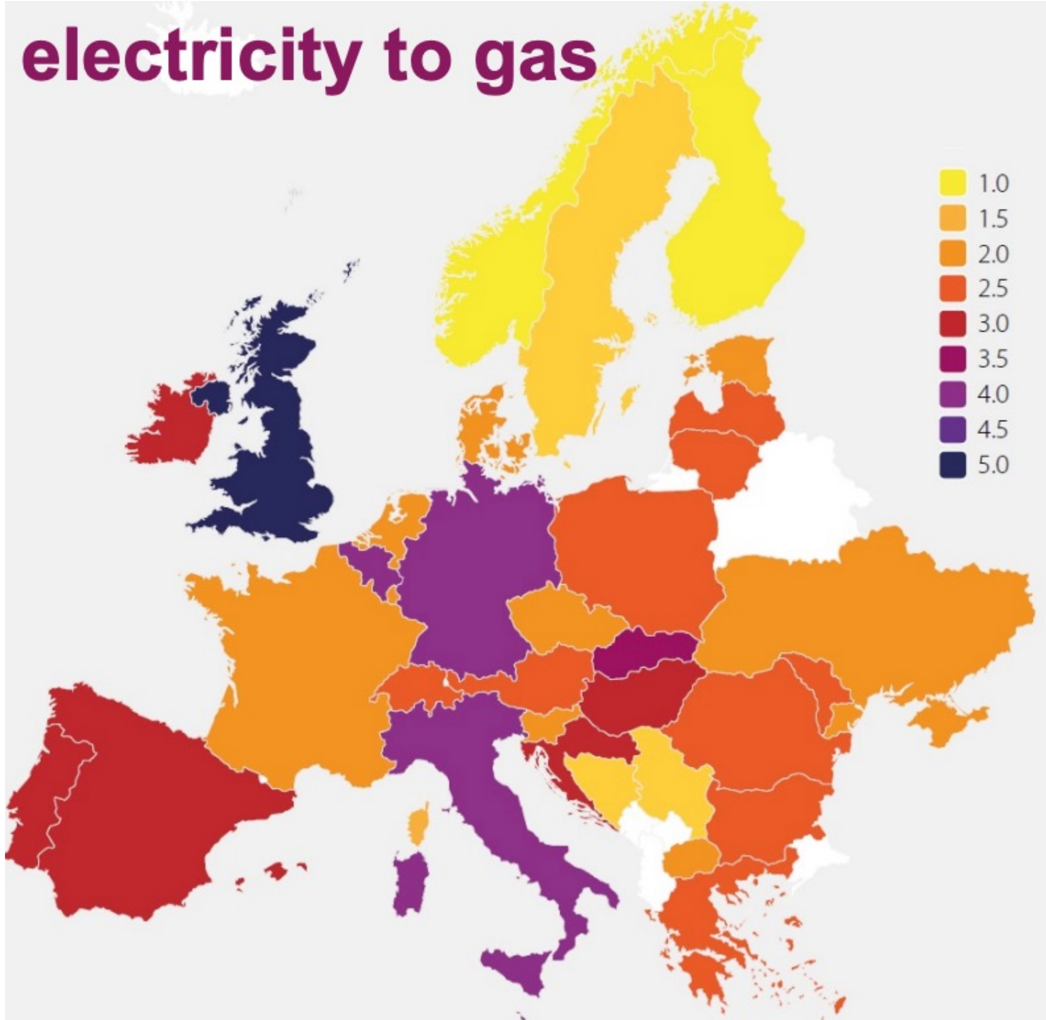
Geothermal Association of Ireland

Most geothermal applications in Ireland will use a heat pump.

Electricity price is key to the attractiveness of electrifying heat

Electricity Price to Gas price ratio

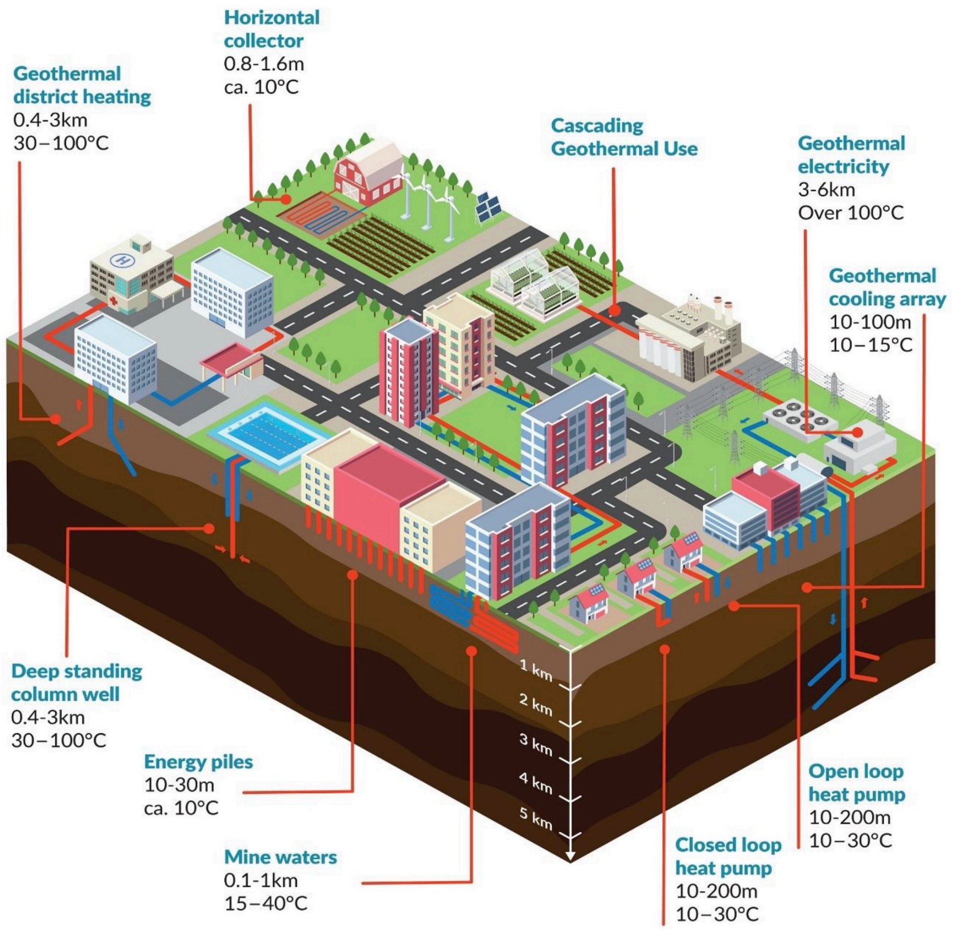
- Strong correlation,
  - where electricity is comparably priced to gas – heat is electrified (Nordics).
  - where electricity is significantly higher price than gas, people use gas…



Arpagaus 2021

What role will geothermal play if we get our policy right?

Geothermal Association of Ireland



After: Geological Survey of Ireland

Shallow system: short term

- Could deliver >30% of our heating and cooling needs
- Can be impact commercial, industrial and domestic today.
- Needs a strong policy framework

Deep systems: longer term

- Could deliver significantly more of our higher temperature heating requirements.
- Requires a strong policy framework supported by resource licensing to support investment
- Needs significantly more data to support de-risking our deeper resources.

Geological guarantee schemes: strategic tools for the development of deep geothermal energy in France

Christian BOISSAVY

Geothermal expert - GEODEEP

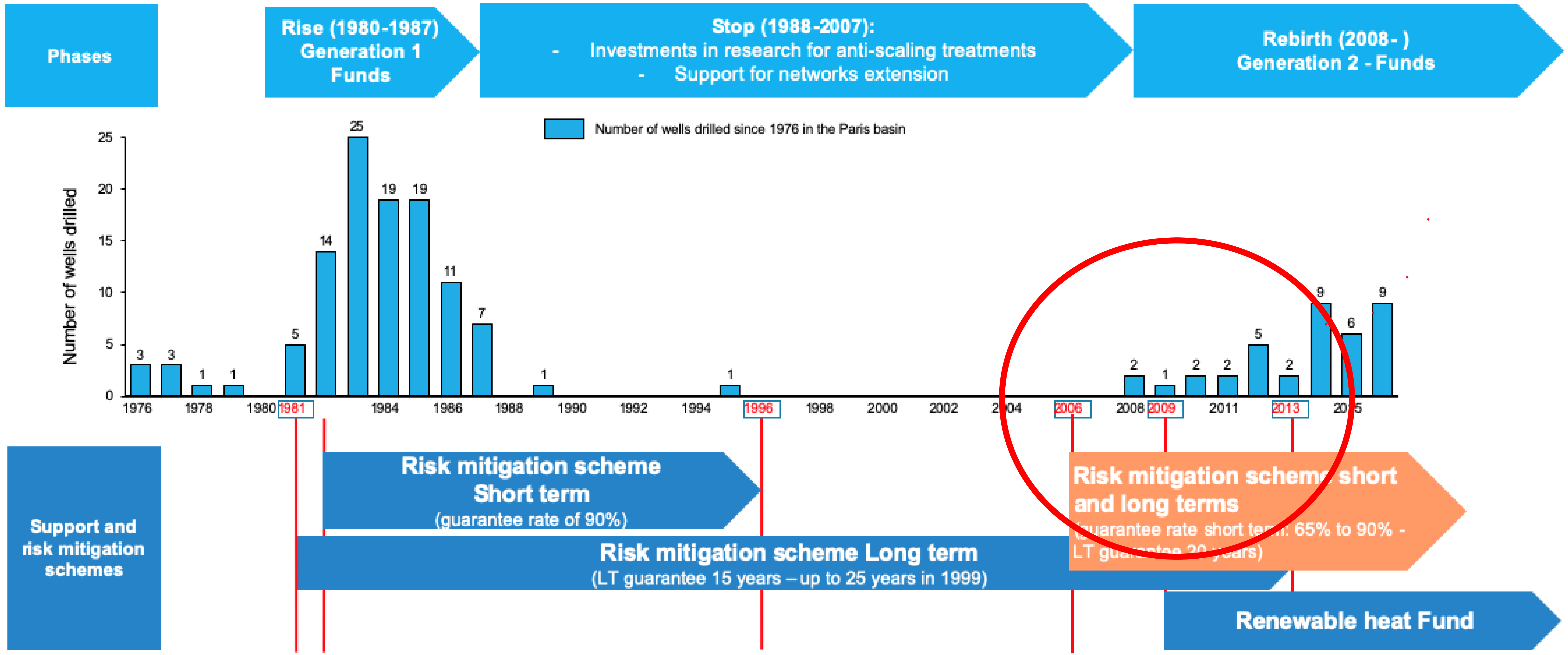
National Geothermal Energy Summit 2022
TU Dublin Grangegorman-November 9th

Geological guarantee schemes: strategic tools for the development of deep geothermal energy in France

1. French geological insurance scheme: a long experience
2. French energy programming: a massive role for geothermal energy
3. Typology of the new RMS model

afpg
ASSOCIATION FRANÇAISE DES PROFESSIONNELS DE LA GÉOTHERMIE

History of geothermal projects and support schemes



Geothermal Risk mitigation Fund (2008 – 2020)

Short term & long term

Risk mitigation scheme short and long terms
(guarantee rate short term: 65% to 90% - LT guarantee 20 years)

KEY FIGURES

Resources = 24M€

47% public allocation
53% private contributions

Uses = 24M€

- 53% ST & LT damages including provisions for 14M€
- 15% SAF Committee operating expenses and expertise for 4M€
- 32% Reserved funds for 8M€

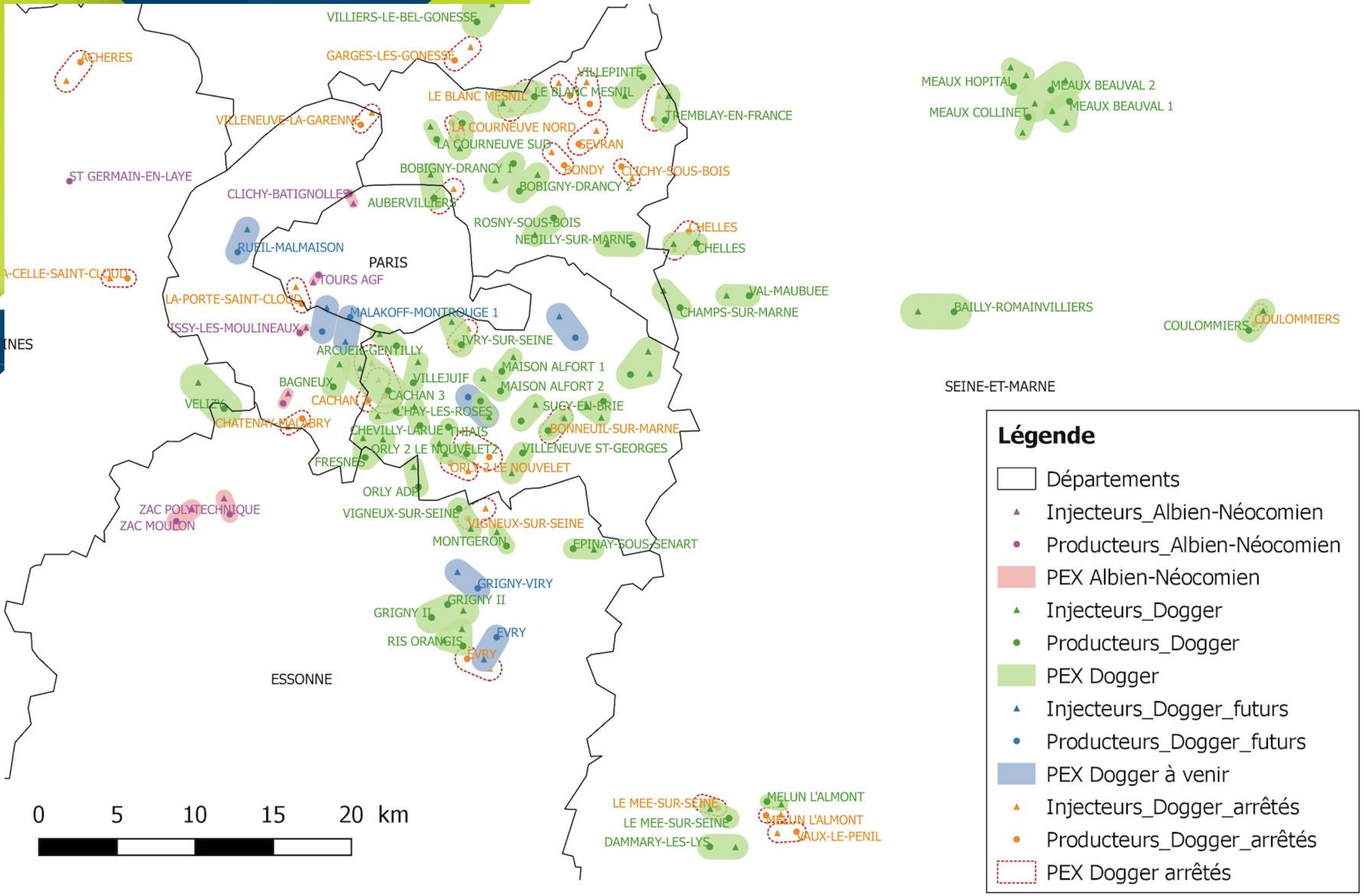
Short term activities

- 33 doublets/triplets + 13 lonely drillings => 80 drillings covered by the Fund
- 11 damages (7 failures partial or total, 4 geological over-costs)

Long term activities

34 signed contracts
180 cumulative operating years covered by the Fund
6 damages refunded and declared (3%/year)

Geothermal district heating doublets the Paris region



- **More than 120 geothermal wells drilled down to 2000m**
- **Based mainly on the exploitation of the DOGGER, but also ALBIEN reservoirs, since nearly 50 years.**
- **49 plants in operation for heating and sanitary hot water distributed to around 1 million inhabitants.**

Source : AFPG

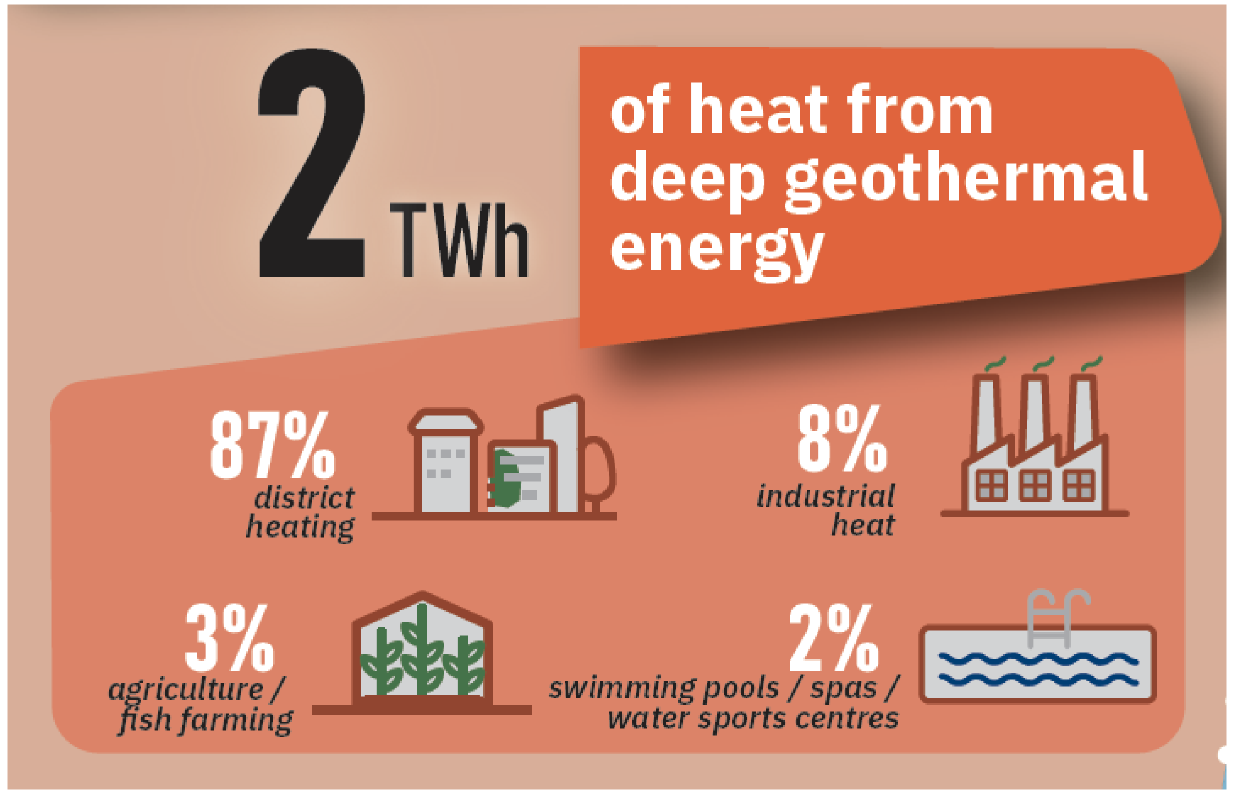
French energy programming:
a massive role for geothermal energy

afpg
ASSOCIATION FRANÇAISE
DES PROFESSIONNELS DE LA GÉOTHERMIE

Deep geothermal energy in France (end of 2020)

LOCATION	NUMBER OF OPERATIONS	EQUIVALENT RESIDENTIAL UNITS	TOTAL GEOTHERMAL PRODUCTION (MWh/year)
TOTAL PARIS BASSIN (incl. Moselle, Indre departments…)	**49**	**167 670**	**1 676 700**
TOTAL AQUITAINE BASSIN	**17**	**11 230**	**112 300**
TOTAL OTHER REGIONS	**6**	**21 090**	**210 900 (*)**
TOTAL	**72**	**Approx. : 200 000 E.R.U. => 1 inhabitants heated by deep geothermal energy in France**	**2 078 700 => 2TWh**

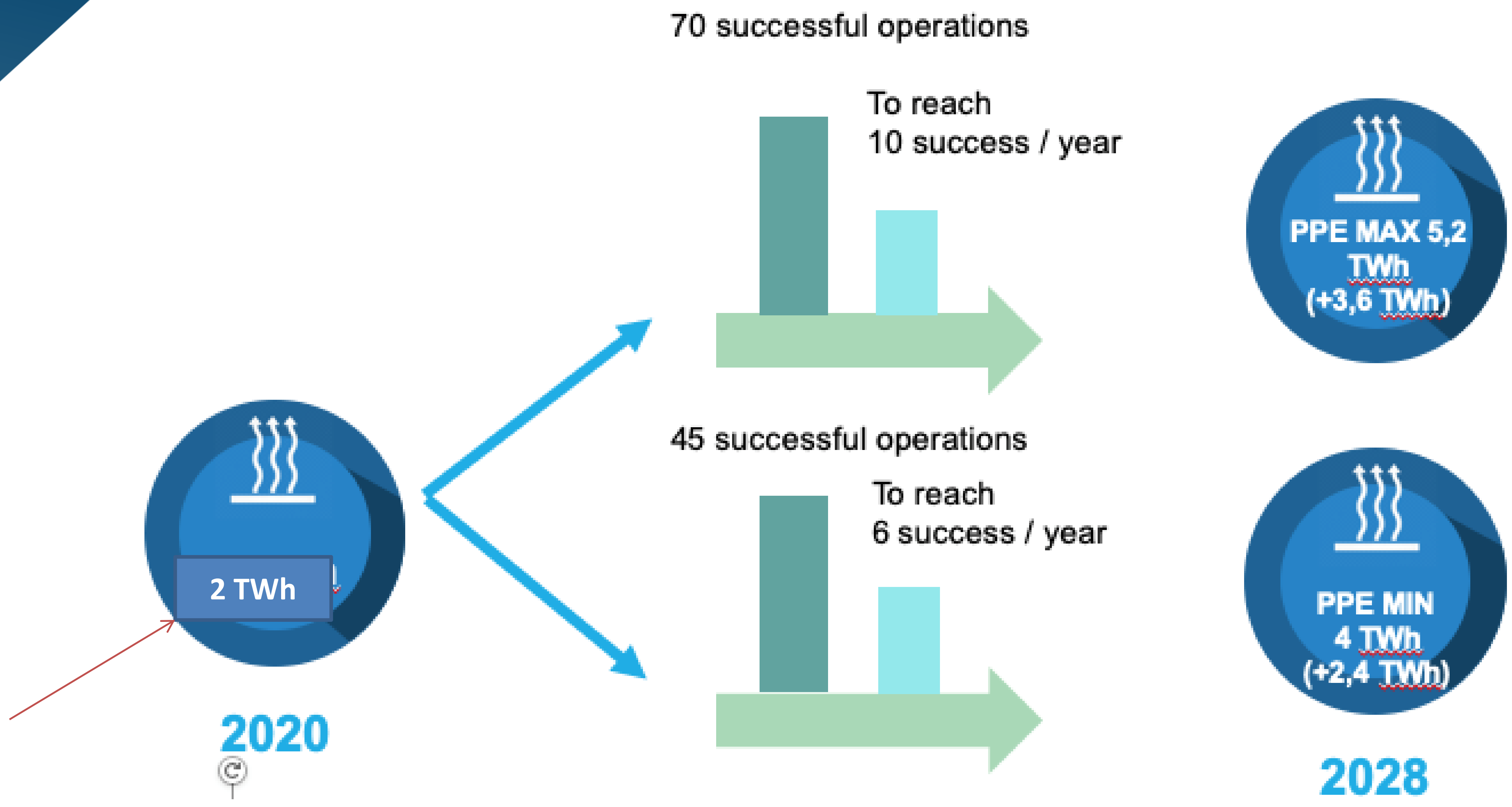
Source: AFPG



(*) among that 193 000 MWh/year for ECOGI in Rittershoffen (Alsace), geothermal heat for industrial process

afpg
ASSOCIATION FRANÇAISE DES PROFESSIONNELS DE LA GÉOTHERMIE

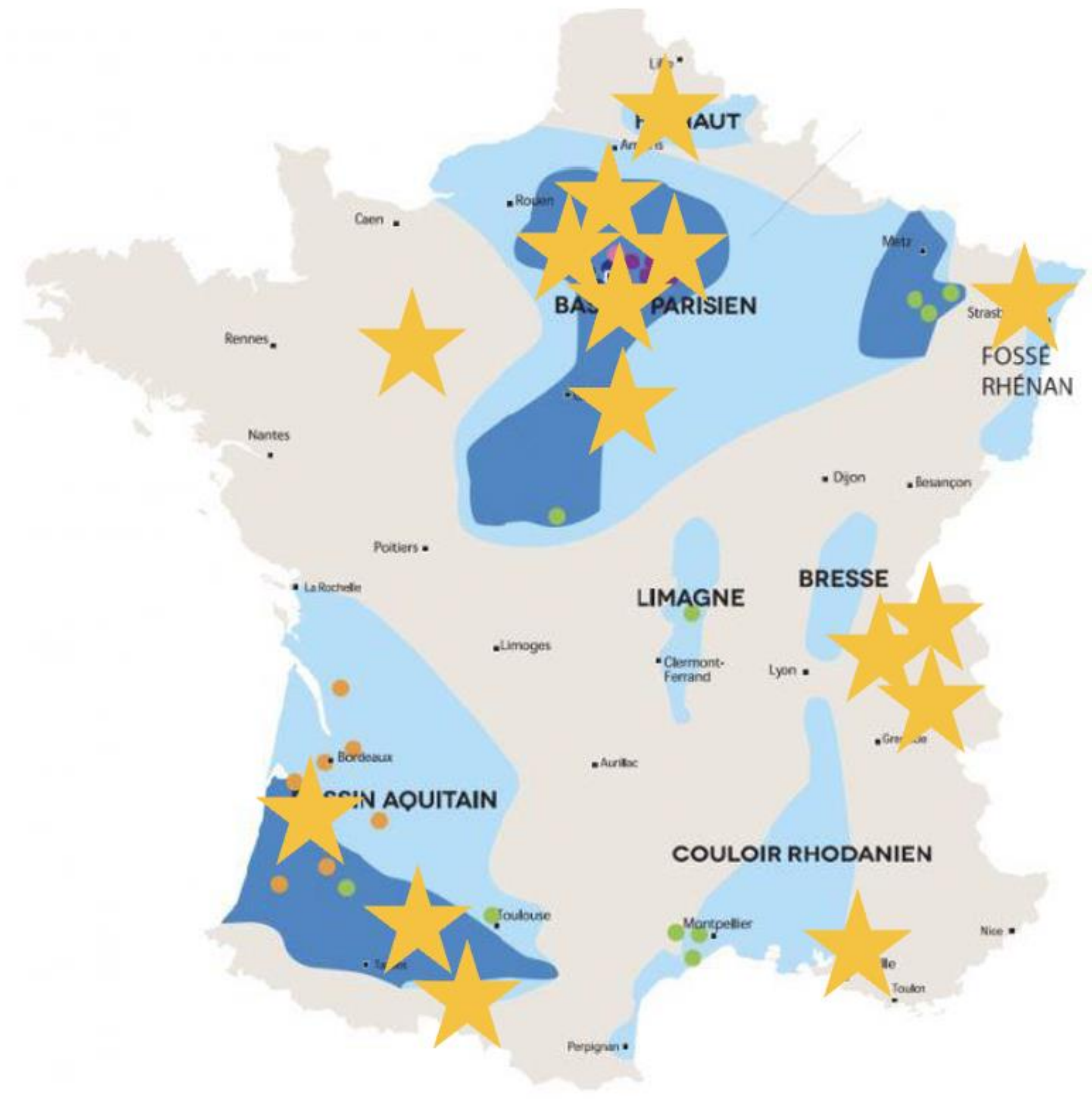
Target 2028 for deep geothermal energy in the French energy programme (PPE)



New areas to developed are more risky (less known as Dogger part in Ile-de-France region)
Number of "attempted" operations to be guarantee is higher

A greater need for a Risk mitigation scheme

The new geothermal fund will broaden its geographical scope to less known zones with more risky and innovative projects



-

French sedimentary cartography with positioning of main Basins dedicated to deep geothermal operations (BRGM, modified by AFPG)

At the moment already :

- 10 additional in Ile de France in Trias and Upper Jurassic aquifers
- 15 targeted project outside Paris area in aquifers of various ages in Aquitaine Basin, Alsace, Hauts de France and Provence-Alpes-Côte d'Azur

ADEME launched a study to work on a new model of RMS with consultation of French geothermal industry To identify risky zones and nature of projects to be guaranteed

Typology of the new RMS model

ASSOCIATION FRANÇAISE
DES PROFESSIONNELS DE LA GÉOTHERMIE

Main changes: 3 zones of risks instead of 1

SEGMENT	RISK RATE 1rst WELL	RISK RATE DOUBLET
1 Follow up with DOGGER operations in Paris Basin	5%	9%
2 New operation where geology is known but not the geothermal potential (others Paris Basin aquifers, others regions)	25%	45%
3 New operations in other regions where geological and geothermal potential are not known	40%	67%

afpg
ASSOCIATION FRANÇAISE
DES PROFESSIONNELS DE LA GÉOTHERMIE

Main principles

⇒ **SUSTAINABILITY** :

⇒for short term guarantee, segments 1&2 will be manage separately from segment 3

⇒When a compartment is empty, there is no more guarantee allocated

⇒ **MANAGEMENT:** Positioning of a project in a segment of risk will be manage by Technical Committee

⇒ **MONITORING:** Operation of the Fund is monitored and modified every year by a Strategic Committee

afpg
ASSOCIATION FRANÇAISE
DES PROFESSIONNELS DE LA GÉOTHERMIE

Main changes and perspectives: operational in 2023?

	ONLY HEATING PROJECT			
	Actual Short term RMS	New Model		
Guarantee base	4,8k€ maximum	3M€/km TVD With a limit of 3km deep		
Scope	1 well	2 wells		
		Segment 1	Segment 2	Segment 3
Contributions	3,5 – 5%	5%	10%	15%
Coverage rate	65% (+25% in Ile de France Region)	90%		

afpg
ASSOCIATION FRANÇAISE DES PROFESSIONNELS DE LA GÉOTHERMIE

For the Long term guarantee, the conditions will remain the same shifting the fee from 15 K€ to around 25K€

Thank you for your attention!

afpg
ASSOCIATION FRANÇAISE
DES PROFESSIONNELS DE LA GÉOTHERMIE