Mining for Heat
CIBSE Meeting 14th Jan 2020

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• Rationale
• Heat and heat networks
• Global projects
• What have we learned?
• Spennymoor case study
• Regional potential
• Challenges
• Making this happen

Source: www.readly.com
Great Britain’s Energy Vectors GWh per day

1st of March Cold Weather Event
3.5 times the daily energy demand of electricity

Natural gas demand, Non-Daily Metered (a proxy for heat demand)
When Coal Was King

Source: https://www.nmrs.org.uk
Celebrating the end of coal?

Source: Sky News

How secure are our future supplies?

Source: British Gas
Developing a Legacy

Former coal mining areas
Source: The Coal Authority

England and Wales heat demand
Local Impacts
Mine Hazards - Minewater

Over 70 sites across UK where minewater is treated

80MW heat released to atmosphere

This provides an opportunity…..
Mine Hazards - Gas

Source: iln.org.uk
What is the Potential?

- 15bn T extracted, now flooded
- UK has 23,000 former collieries
- 25% of UK homes overlie collieries
- 7 million homes that could use mine-water heat instead of gas
- Could save 10-15 MT carbon a year.
Heat Network Compatibility

• DHN decarbonisation for urban areas
• UK -14-43% building heat by DHN by 2050
• Current build rates = 27-83 years
• In Denmark over 61% DHN
• UK 2% of heat demand
• Depends upon design temp

Source: www.decentralized-energy.com
A New Approach

- Rethink heat
- Higher T = more gas and more CO₂
- Higher T = more losses
- Changes to policy and planning
- Consumer demand
- Design temps
## Brief History of heat networks

<table>
<thead>
<tr>
<th></th>
<th>1G</th>
<th>2G</th>
<th>3G</th>
<th>4G</th>
<th>5G</th>
</tr>
</thead>
<tbody>
<tr>
<td>Label</td>
<td>Steam</td>
<td>In situ</td>
<td>Prefab</td>
<td>4GDH</td>
<td>5GDH</td>
</tr>
<tr>
<td>Carrier</td>
<td>Steam</td>
<td>Pressurised hot water &gt;100°C</td>
<td>Pressurised hot water &lt;100°C</td>
<td>Often &lt;100°C</td>
<td>30-70°C</td>
</tr>
<tr>
<td>Pipes</td>
<td>In situ insulated steel</td>
<td>In situ insulated steel</td>
<td>Pre-insulated steel</td>
<td>Pre-insulated flexible (twin)</td>
<td>Pre-insulated flexible (twin or single)</td>
</tr>
<tr>
<td>Circulation</td>
<td>Steam pressure</td>
<td>Central pumps</td>
<td>Central pumps</td>
<td>Central and decentralised pumps</td>
<td>Central and decentralised pumps</td>
</tr>
<tr>
<td>Emitters</td>
<td>High Temp</td>
<td>High Temp</td>
<td>Medium Temp</td>
<td>Low Temp</td>
<td>Low Temp</td>
</tr>
</tbody>
</table>

**Sources:**

4GDH vs 5GDH

- 40 5GDH projects in Europe
- Higher efficiencies through lower temperature operation
- Numerous heat inputs
- Regenerative or non-regenerative
- Decentralised WSHP
- Works in heating/cooling mode independently of network
- Floating temp of network
- Seasonal CoP 4-6

How Mine Energy Works
What’s in a Heat Pump?

- An energy efficient heating/cooling device that absorbs heat from or rejects heat to the ground
- Uses the earth as a heat source in winter and sink in summer
- Like a fridge or air con it is based on a vapour compression cycle
- 1 unit of electricity = 3-4 units of heat

Source: https://www.heatpumps.org.uk

A simple stylized diagram of a heat pump's vapour-compression refrigeration vapour-compression refrigeration cycle: 1) condenser, 2) expansion valve, 3) evaporator, 4) compressor.
Global Mine Energy Projects

• Around 30 projects globally
• Working and abandoned mines
• Closed loop and open loop
• From few l/s to tens of l/s
• Range of thermal outputs
• Commercial and industrial
• Also non coal mines

Source: National Coal Mining Museum
What does this tell us?

• Mine energy systems are versatile
• Suit range of demands and settings

This is both good and bad....
• Difficult to generalise
• Each site is different

Source: Mijnwater.com
What makes a successful project?

• Grant funding offsets some of capital cost
• Lack of gas connection
• Social Drivers
• Use existing pumped mine waters
• Sustainability

Source: John Gilbert Architects
Source: Lanchester Wines
Source: The Coal Authority
Working Examples: Heerlen NL

- Water up to 28°C is extracted from 700m
- Supplies to homes and commercial buildings
- New and retrofit
- 7km heat distribution network comprising of 3 pipes (for the hot, cool and mixed water respectively) serves the connected buildings
- Supplies heating for around 200,000m² of floor area
- Smart grid – between buildings
- Keeps money spent on energy in the region
- **Operating since 2008**
Working Examples: Lanchester Wines

• Combined 4MW open loop water source heat pumps in Felling, Gateshead

• 2x Lanchester Wines warehouses
  • 2.4MW (220,000ft²)
  • 1.2MW (140,000ft²)

• Utilising water from flooded coal mines – a vast network going back to Victorian times

• Boreholes 80m – 120m deep

• UK’s largest geothermal heat system
Spennymoor Project

Source: Daniel Mallin-Martin MSc Thesis, University of Strathclyde 2017
Is there resource?

Source: http://mapapps2.bgs.ac.uk/coalauthority/home.html

Source: Durham Mining Museum
Modelling Approach

- Develop a model of the subsurface
- Calculate heat in place
- Type of working
- Consider flow through system
- Calculate extractable heat

Source: The Coal Authority
At 108m Below Surface

Source: Daniel Mallin-Martin MSc Thesis, University of Strathclyde 2017
Results and Next Steps

• Volume of Top Busty Seam approx. 50,000m³

• A flow rate of 65l/s could supply 200 homes if 3°C is removed

• Spennymoor has both good resources and planned new build

• Consultation with Coal Authority, Local Government and developers

Source: Daniel Mallin-Martin MSc Thesis, University of Strathclyde 2017
NE Potential

• 23,000 former collieries in UK
• 15 sites across NE where minewater emerges
• 21 MW Co Durham
• 7 MW Northumberland

Value of the heat e.g.
• 1 seam of area 65km stores 60GWh 4000 homes = £2M
Regional Opportunities

• Durham County Council
• Northumberland County Council
• South Tyneside Council
• Community Groups
Louisa Centre Study

- Located in Stanley, Co Durham
- Built in 1970s
- Includes gym, nursery, sports hall and two pools
- Well used community building
- Owned by Durham County Council
Is the area undermined?
Mining in Stanley

- Mine worked from 1779 to 1964
- 5 seams were worked at 75-255mbgl
- Shaft was filled to an unknown specification
- West pit disaster 1909, 160 killed

<table>
<thead>
<tr>
<th>NGR</th>
<th>NZ419264, 552692</th>
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<tbody>
<tr>
<td>Surface Level (mAOD)</td>
<td>220m</td>
</tr>
<tr>
<td>High Main Seam</td>
<td>75m below ground</td>
</tr>
<tr>
<td>Low Main Maudlin*</td>
<td>165m below ground</td>
</tr>
<tr>
<td>Low Main Brass Thill*</td>
<td>170m below ground</td>
</tr>
<tr>
<td>Hutton Seam*</td>
<td>182m below ground</td>
</tr>
<tr>
<td>Base of shaft</td>
<td>187m below ground</td>
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LOUISA COLLIERY SHAFT DETAIL
Estimating Resource

- Generate lateral extent from seam plans
- Stanley seams mined over approx. 17km²
- Multiply by seam thickness
- Correct for subsidence
- Choose best seams
- Equivalent to 1000-2000 homes
Carbon Savings

- Produce 550MWh with a heat pump rather than gas boiler
- Local savings of 84.8 tonnes CO$_2$/annum
- Key difference between two systems is water pumping

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<tr>
<th></th>
<th>Fuel Used to Meet Demand</th>
<th>Tonnes CO$_2$ per annum</th>
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<tbody>
<tr>
<td>Heat Pump</td>
<td>138MWh electricity</td>
<td>27.6</td>
</tr>
<tr>
<td>Gas Boiler</td>
<td>611MWh gas</td>
<td>112.4</td>
</tr>
</tbody>
</table>

- Pilot well drilled and tested
Making Progress

• Changes to UK Infrastructure Bill
• Westminster Debate
• Demonstrator Projects
• Public Lectures
• PR and Media
Challenges

• Depth to water
• Suitable mining connections
• Water quality
• Markets
• Policy and Licensing
• Demonstrators
Making this happen

Main science questions
• How is mine energy best integrated into energy networks
• Explore the vast opportunity for energy storage
• Longevity and connectivity of systems if uptake increases

Main barriers to development
• Upfront capital cost
• Risk averse attitudes
• Perceptions of heat
• Licensing and policy support

Implications for policy or regulation
• Planning policy should consider mine energy potential in coalfield areas
• Building regulations – more emphasis of low temperature systems

Source: www.geograph.org.uk
Summary

- The UK’s largest geothermal heat system is sourced from abandoned mines
- A vast infrastructure exists for heat supply and storage
- Mine energy provides indigenous and low carbon energy supply compatible with heat networks
- Mine energy could provide a low carbon source of heat in future
- NE has rich mine energy resources and could become a regional exemplar
Thank you for Listening

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