Mine water as an Energy Source for Heat Pumps: a case study from the South Wales Coalfield

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South West Regional Group of the Geological Society
Talk Outline:

• The Seren Project
• Geology and setting of the South Wales Coalfield
• Establishing a network to monitor mine water temps
• Initial estimate of heating potential
• What are Ground Source Heat Pumps (GSHP) ?
• Why bother with green technology ?
• Crynant project: case study of GSHP system
• Benefits of using mine water for GSHP
• Conclusions and future challenges
The Seren Project (2010-2015)

• European Regional Development Fund (ERDF)
• Aim to develop innovative engineering technologies
• Ground Source Heat is one of the five work packages......
• BGS role to characterise temperatures & improve 3D model
• WDS role to install and monitor working system
South Wales during the Carboniferous

The study area
Base of Coal Measures and the 5ft Seam
Base of Coal Measures and the 5ft seam

Improved 3D Geological Model

Andy Hulbert (BGS)
Available datasets

- Coal Authority Data 268 sites
- Natural Resources Wales 60 sites
- Priority Abandoned Coal Mine Discharges 29 sites
- BGS Borehole data 6563 sites
- Published and grey literature

Consultation with:

- Natural Resources Wales
- Local Authorities (x 6)
- Coal Authority and Tower Colliery

Consideration of:

- Proximity to existing urban areas
- Local Development Plans (LDPs)
- Geological and hydrogeological setting
COAL AUTHORITY MONITORING POINTS

The Coal Authority

BGS©NERC ©Ordnance Survey
Iron deposition on the temperature logger after just 3 months!
EXAMPLES OF MONITORING SITES

The Coal Authority’s ‘Cefn Hengoed’ discharge
The Coal Authority’s Celynen North discharge
Crumlin Navigation: a friends group hope to restore the buildings and to incorporate ground source heating into their final design.
RANGE OF MINE WATER TEMPERATURES

- Average mine water temp: 13.4°C
- Average groundwater temp in Wales: 9-11°C

n = 300,000 / 1 year monitoring period at each site with readings collected every 30 minutes
Initial estimate of resource*

- Outflow from abandoned mines = 3000 l/s
  (likely to be significant underestimate of true value and does not represent water that could be abstracted via pumping from the coalfield)
- average mine water temperature of 13.4°C
- removal of a maximum of 3°C by the GSHP
- disused mine waters could provide enough energy to heat ~20,000 homes (3 bed equivalents) in South Wales
RESULTS

- Currently no use for mine water
- Elevated temperatures
- 13.4°C average temperature (range from ~8 -19°C)
- >>3000 l/s pumped or discharged
- Potential to heat at least ~ 20,000 homes (based on standard 3 bed house)
- Further work needed to understand variation in geothermal gradient across the coal field
Talk Outline:

• The Seren Project
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• Establishing a monitoring network
• Mine water temperatures...are they hot?
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WDS GREEN ENERGY

- A specialist renewable energy company trading for over 12 years
- Based in Cardiff serving clients in Wales and England
- Over 450 ground and air source heat pump systems installed in UK
- MCS accredited installers

Projects include:
- Schools
- Social houses
- Arts centres
- New homes
- Offices
- Village halls
- Leisure centres
- Retrofits
- Swimming pools
- District heating system

- Award winning installer for Zoar Chapel Project in Merthyr
- Industrial Partner with the Seren Team at Cardiff University
HEAT PUMP OPERATION

1. **Source:** from Air or Ground 75%
2. **Source:** National Grid 25%
3. Heat source
4. Gas compressed to high temperature
5. Heat transferred to water in heat exchanger/condenser
6. Gas back returns to liquid through Expansion valve

- Heat onto refrigerant in evaporator - liquid/gas conversion
- Electricity supply

© DIMPLEX
GROUND SOURCE HEAT PUMP
GROUND COLLECTORS

©WDS Green Energy
APPLICATIONS

- New housing
- Visitor Centres
- Existing housing
- Apartments
- Offices
- Self Build
- Schools
- Commercial
- Swimming pools
- Leisure Centres
- Farm Buildings
GROUND ENERGY - WHY MINE WATER?

Planet earth is a large source of stored renewable solar energy:

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<tr>
<th>Source</th>
<th>Advantages</th>
<th>Disadvantages</th>
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| Ground (horizontal loops) | - Easy to construct                                  | - Large land area needed  
|                         |                                                      | - Land sterilised for building                                  |
| Ground (boreholes)      | - Need small land area                               | - Costly to drill                                               |
|                         | - Heat abstraction is reliable                       | - Numbers increase with capacity                                |
| River and streams       | - Easy source for abstraction                        | - Varying seasonal temperatures                                 |
|                         |                                                      | - Delta T can effects ecology                                   |
| Mine workings           | - Large volumes of warm water                        | - Depth of workings critical                                    |
|                         | - Pollution restricts other usage                    | - Location related to demand                                    |
|                         | - Only two boreholes required                        |                                                                 |
|                         | - Stable / elevated water temperatures               |                                                                 |
|                         | - No loss of water to surface                        |                                                                 |
MINE WATER POTENTIAL

South Wales coalfield

Seren ‘Crynant’ Project

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Water Temperatures Recorded by BGS

13.4°C av mine water temperature
8-11°C av GW temp

Mine Water Discharge Sites monitored by the Coal Authority and British Geological Survey
CRYNANT: SITE LOCATION

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Crynant site

Cefn Coed Colliery

Dulais Valley
The client already uses ground source heat pumps on his other properties and enjoys the benefits of low running costs < 50% of oil.

His farmhouse, workshops and family physiotherapy business on the site are all heated by either oil or directly by electricity with a total demand of 30KW’s.

Client owns land which overlies old mine workings from the Cefn Coed Colliery which closed in 1985.

Keen to unify his heating systems, save money and gain RHI payments.

Willing to participate in an ‘experimental project’ using mine water as the source of energy for a heat pump system.

Cardiff University, Seren Team, keen to gain data on heat transfer etc.
CRYNANT: INVESTIGATORY WORKS

• Project requirements and cost analyses/benefit
• Site evaluation for borehole locations and mine working options
• Discussions with Coal Authority leading to a ‘Minewater Heat Recovery Access Agreement’
• Approval to investigate ground water source (borehole drilling) from NRW
• Seren requirements for comprehensive monitoring and water quality testing
• Exploratory drilling, test pumping and water quality analysis
CRYNANT: SYSTEM DETAILS

Hydraulic diagram

From abstraction Borehole

To discharge Borehole

Heat pump with data collection and logger system

System data acquisition at site

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CRYNANT: INITIAL FINDINGS

- Mine water at Crynant is stable at 11.5°C
- Some water temperature gain from ground (1°C to 2°C)
- Borehole water levels constant at 25m below gl, (mine workings are at 65m)
- Heat transfer to heat pump > 10°C (<1.5°C loss)
- Heat output recorded at 19KW & 38kW’s for 1 & 2 compressors (manufacturers test data shows 14 & 30 kW’s at brine or ground zero)
CRYNANT: BENEFITS SO FAR

- Fully instrumented for performance monitoring across all seasons
- Data loggers and meters show running costs are < 50% of oil system
- Approved for 20 year RHI funding under commercial tariff scheme
- Proved retrofitting of house possible without changing radiators
- Created a benchmark project for demonstration of heat pump technology using mine water
- Purpose built housing for visits by interested parties
- Proved warm mine water has a new future as a low cost renewable energy source for heat pumps
- Our collaboration with Cardiff University Seren Team has proved benefit of industry/academy partnerships
The UK government tells us that:
• 80% of heating comes from natural gas: **this is not sustainable**

Welsh Government want to:
• Reduce greenhouse emissions by 3% every year and 40% by 2020

We need to:
• cut emissions of carbon dioxide
• replace fossil fuels with low carbon alternatives

In order to address:
• climate change
• energy security
• affordability of energy
CONCLUSIONS & FUTURE CHALLENGES

Mine water usage potential for GSH is considerable

• Currently there is > 10,000m$^3$/hr of mine waters in South Wales; the Crynant project uses only 7m$^3$/hr = 35kW from heat pump, average 3 bedroom house needs 16kW)

• Mine water elevated temperatures make heat pumps more efficient by >20%

• Excellent alternative to the use of LPG, oil and biomass and helps with CO$_2$ reductions

• Provides low cost heating for new houses, schools, hospitals and district heating systems

• With RHI tariff income project paybacks are circa 3 to 9 years

Regulation

We need to work together with NRW and the EA to address potential issues with the permitting and licensing requirements from abandoned mines.
THANK YOU

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