Thermal Energy from Mine Workings

“No; this my hand will rather
The multitudinous seas incarnadine,
Making the green one red.”

Dave Banks
University of Glasgow
Holymoore Consultancy, Chesterfield

Macbeth, Crucible, Sheffield.
“....making the red one green”
Minewater

Pyrite + water + O₂ = acid + sulphate + iron
Pump and treat

Katowice mine, Poland
Closed loop – the low risk way

Heat pump

Heat to a building

Advantages:
- No abstraction of mine water
- No risk of geochemical fouling of heat exchanger

Disadvantages:
- May interfere with desludging of basins
- Modest heat yield

Heat absorbed from rock in shaft / borehole wall

If advection of water in shaft: greater heat yields achievable
The Big Risks
Geochemistry
Thermal feedback
If minewater throughflow is big enough.....

In winter

Warm water abstracted from deep in shaft (ultimately through deep roadways)

 Thermally “spent” cooler water flows away via higher roadways
Most GSHP schemes deliver savings on CO$_2$ emissions and on OPEX. BUT they require considerable CAPEX on borehole drilling and subsurface heat exchangers.

The use of mines and mine water can reduce capital expenditure because:

1. Flooded, interconnected mine workings allow access to a huge reservoir of warm mine-water via only one or two boreholes, or via existing shafts.

2. The interconnected network of tunnels within the mine itself represents an enormous heat exchange surface.

3. Some abandoned mines are already committed to expenditure on pumping and/or treatment merely for the purposes of environmental protection, while regarding the pumped water merely as a troublesome “waste” product.

4. The UK Coal Authority pumps and/or treats around 3000 L/s water from abandoned mines, with temperatures of 9-18°C, 3000 L/s x 4200 J/K/L x 5°C = 63 MW
Glenalmond Street, Shettleston, Glasgow
Workings in Ell Coal Seam
Completed 1999
Serves 16 newly-built dwellings (1600 m²)
Source = 100 m borehole in flooded coal mine workings of the Ell Seam
Water pumped at 12°C circulated via water-to-water heat pump (65 kW peak output), and returned via shallower reinjection borehole
Heat pump output = 55°C to thermal store. Designed with supplementary solar thermal heating.
Feeds DHW (with supplementary immersion heater) and central heating
Alkane, Markham Colliery, near Bolsover

20 kW heat pump

2-3 L/s at 15.4°C from 235 m

Return to 255 m at 12°C

Heat at 60°C to Alkane's offices

Heat at 60°C to Alkane's offices
Alkane, Markham Colliery, near Bolsover

Fe at 4 mg/L

No clogging or feedback problems observed
Ochil View, Lumphinnans, nr. Cowdenbeath, Fife

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>pH</td>
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<tr>
<td>Eh</td>
<td>+29 mV (reducing, H₂S smell)</td>
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<tr>
<td>Temperature</td>
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<tr>
<td>Alkalinity</td>
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<tr>
<td>Sulphate</td>
<td>1339 mg/L</td>
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<td>Chloride</td>
<td>20.3 mg/L</td>
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<td>15.6 mg/L</td>
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<tr>
<td>Potassium</td>
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<td>Iron</td>
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<tr>
<td>Manganese</td>
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Photos by D Banks
The Shettleston scheme has had no problems of clogging at all...

But the recharge well of the Lumphinnans scheme was vandalised (2005)...

- Degassing of CO₂
- Exposure to O₂
- Precipitation of ochre, other metal hydroxides, calcite
Coal Authority Trial at Dawdon, Co. Durham

75 to 150 L/s minewater treatment capacity
Danfoss 12 kW heat pump heats office and DHW
1.5 L/s of treated minewater at c. 20°C supports heat pump
Minewater saline, with c. 0.8 mg/L iron (peaks of 2-4 mg/L)
Coal Authority trial at Dawdon

When treated (aerated) water used, heat exchanger and filter rapidly became clogged.

but, after raw (unoxygenated) water used, few problems.
The secrets of success

A good understanding of subsurface geometry and hydraulics of mine workings

A good understanding of hydrochemistry

Gas management!