Carbon, Energy and Groundwater

A summary from a hydrogeology and physics perspective

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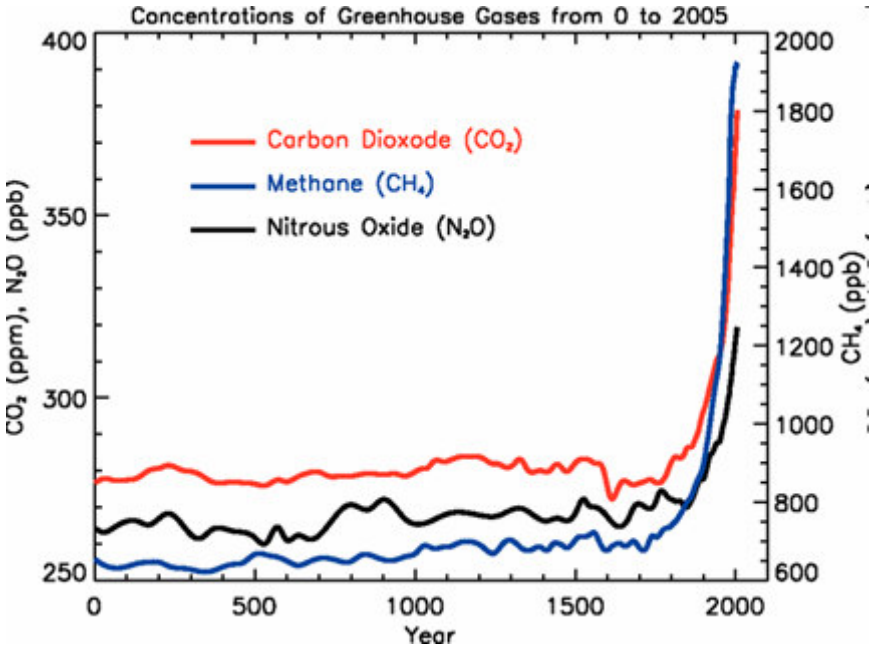
UK Groundwater Forum 26 May 2010

Themes / content

A. The CO_2 challenge and the geosphere (+other issues)
B. Looking for links and common themes:- energy
C. Groundwater's role + environmental assessment
D. The challenges for groundwater and hydrogeology
E. Questions



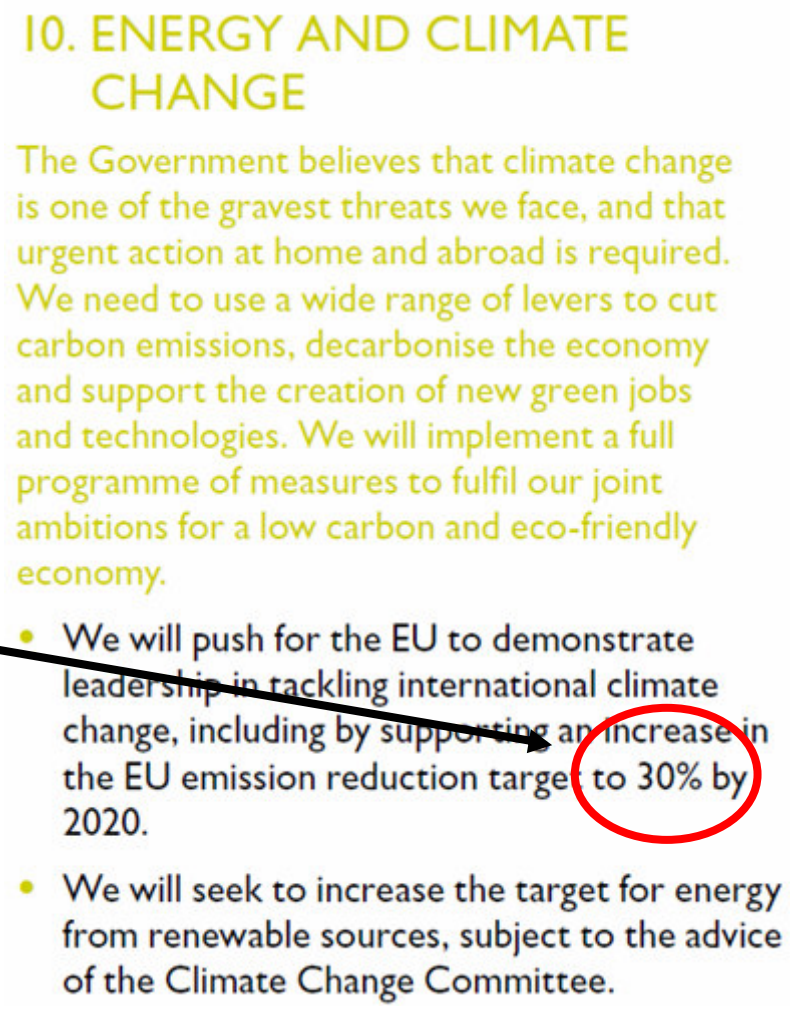
IPCC Fourth Assessment Report: Climate Change 2007

A. Scale of the challenge

Overall government targets:

- 20% (or 30%) reduction in CO_2 emissions by 2020
- 80% reduction by 2050

And the new government is committed to the targets – and may push for more stringent ones



10. ENERGY AND CLIMATE CHANGE

The Government believes that climate change is one of the gravest threats we face, and that urgent action at home and abroad is required. We need to use a wide range of levers to cut carbon emissions, decarbonise the economy and support the creation of new green jobs and technologies. We will implement a full programme of measures to fulfil our joint ambitions for a low carbon and eco-friendly economy.

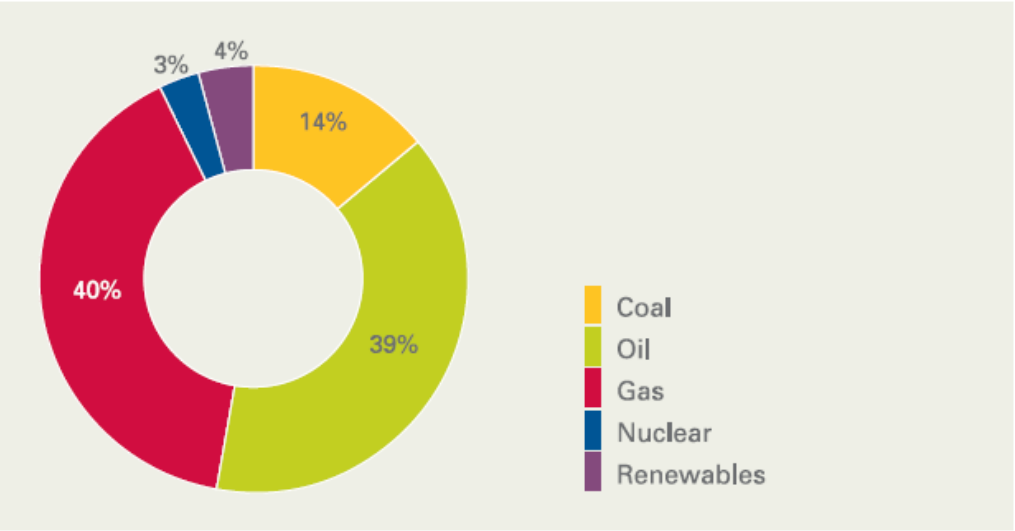
- We will push for the EU to demonstrate leadership in tackling international climate change, including by supporting an increase in the EU emission reduction target to 30% by 2020.
- We will seek to increase the target for energy from renewable sources, subject to the advice of the Climate Change Committee.

Source: "The Coalition: our programme for government"

A. Scale of the challenge: Geosphere perspective

- 2007, DTI expected Coal, Oil and Gas to make up 93% of UK energy by 2020
- That is 90% + dependency on Geosphere carbon
  - Coal
  - Gas
  - Oil
- This is:
  - dig it / drill it / extract it – from the geosphere
  - burn it – and dump the waste in th atmosphere

FIGURE 4.1 PRIMARY ENERGY DEMAND BY FUELS (2020)[103]



Source: DTI, 2007

Source: DECC

A. The challenge
Changes to our "geosphere use"

Less extraction of:

- coal
- oil
- gas

More:

- Extracting heat / geothermal energy
- Disposing of wastes

And a very different energy mix:

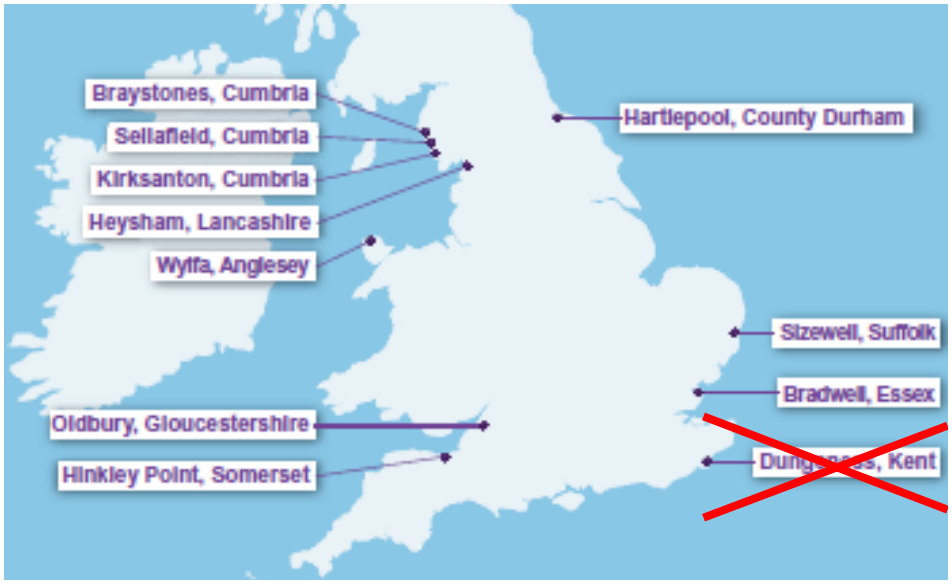
- brief look additional energy sources…

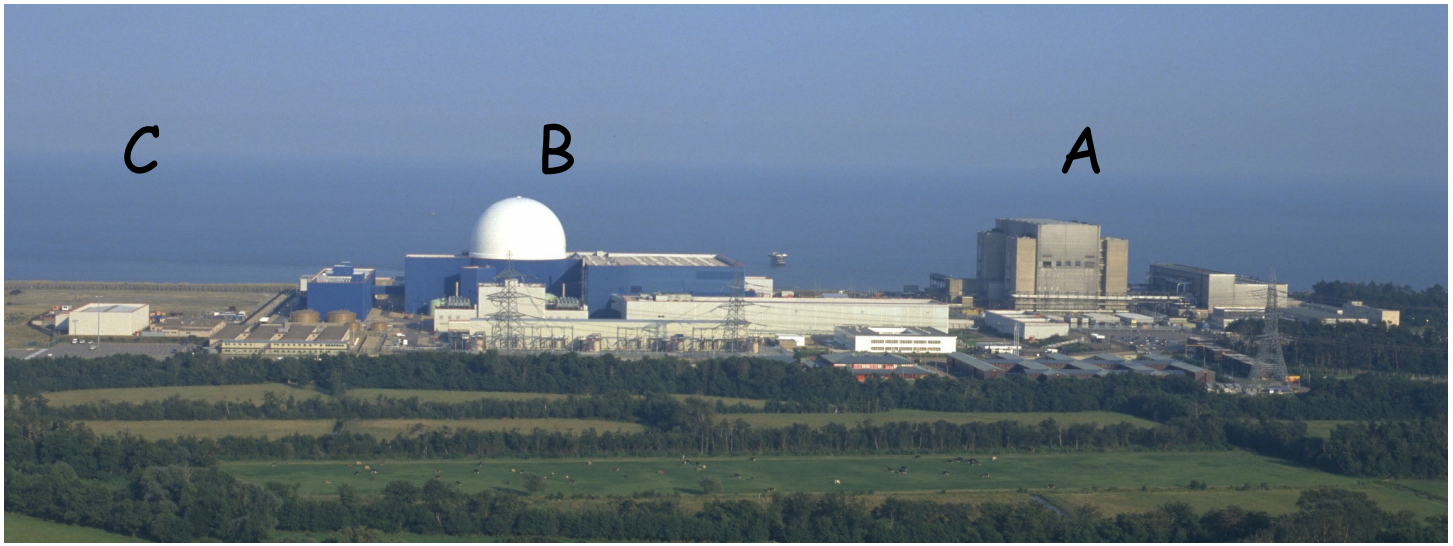
A. Nuclear Energy

Nuclear new build:

- Siting assessment completed
- Hydrogeological studies underway
- Now into permitting phase → EIAs

- AMEC a key supply to BE / EdF for new build, including environmental support and hydrogeology





A. Geosphere disposal of high/medium level radioactive waste

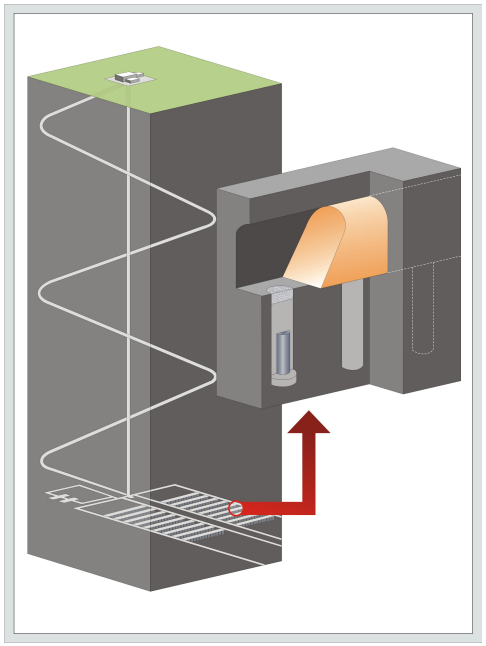
From:

CoRWM report (2006) and

Managing Radioactive Waste Safely: A Framework for Implementing Geological Disposal White Paper (2008)

- Geological disposal: only option under consideration
- Volunteer communities sought. 2 ½ replies:
  - Copeland
  - Allerdale
  - Cumbria County Council

i.e. West Cumbria - only



- After initial screening (2010?) on to geosphere investigations and substantial hydrogeological studies

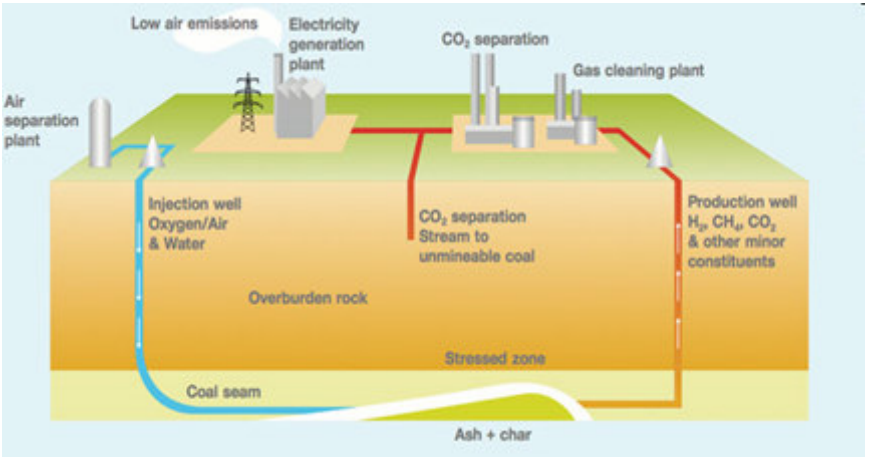
A. New energy sources
Underground Coal Gasification

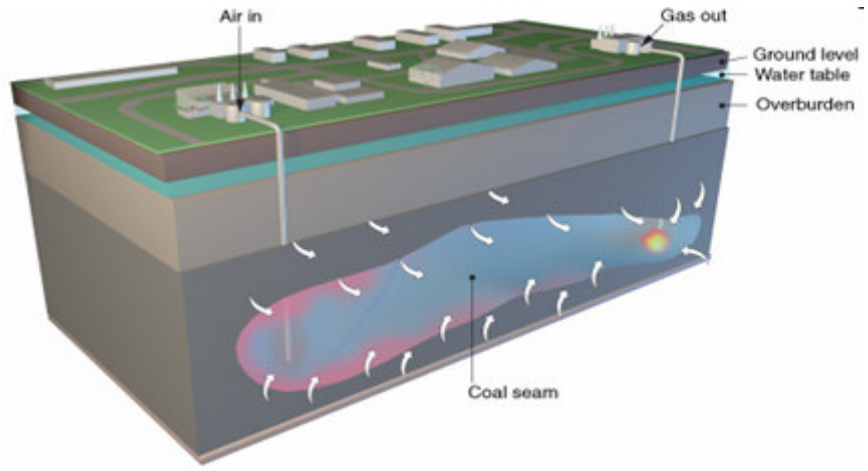
The concept:

- Drill boreholes
- Inject air / O_2 and water
- Burn the coal underground
- Extract syngas (mainly CH_4, CO, CO_2, H_2)
- Leaves most SO_2, $NO_{(x)}$, ash underground
- CO_2 *can* be recovered in gas purification stage

Issues:

- Impacts on groundwater?
- Permitting → EIA and regulation
- Not "completely clean coal", but cleaner coal





Source: Cleancoal Ltd and LLNL

B. Classifying energy sources: Technologies / low carbon initiatives of hydrogeological relevance

Closed loop Ground source heat

Very deep geothermal - for electricity generation

Carbon capture and storage

Open loop ground source heat

Nuclear waste disposal

Nuclear new build

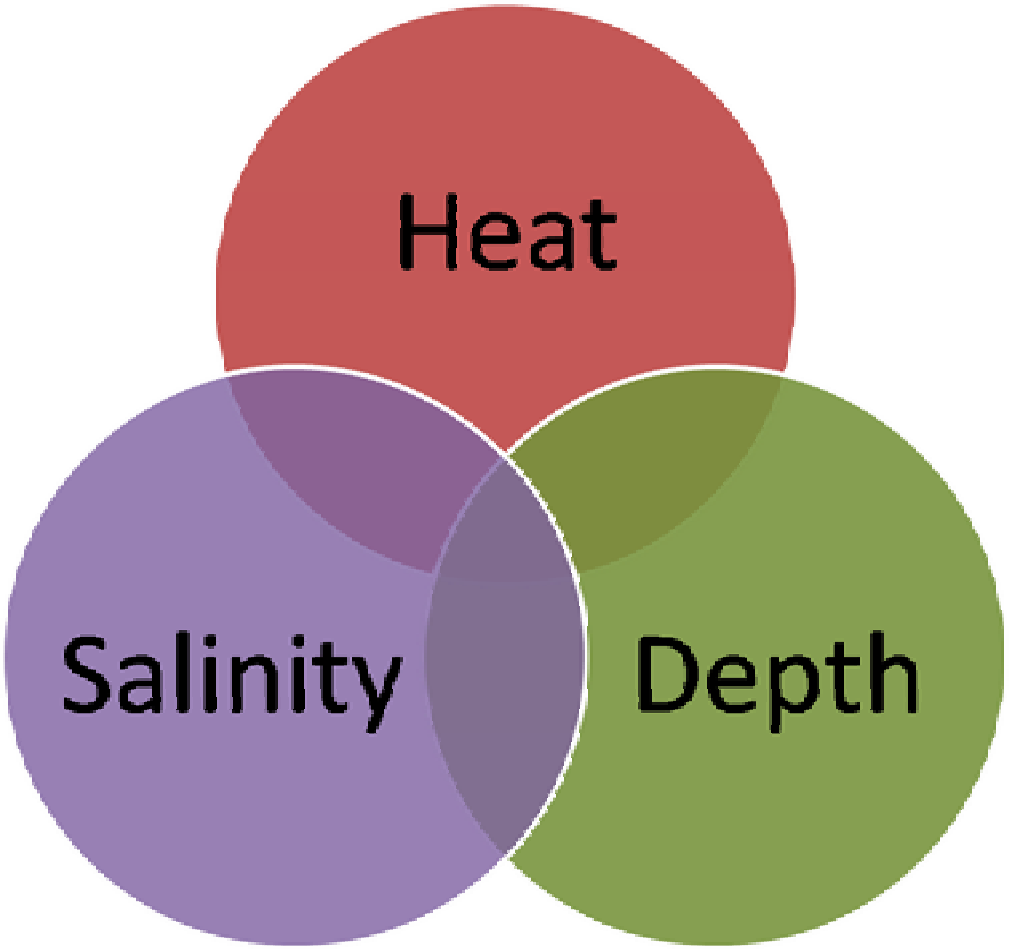
Underground coal gasification

Deep geothermal - for heat

Others….

??

B. Common elements



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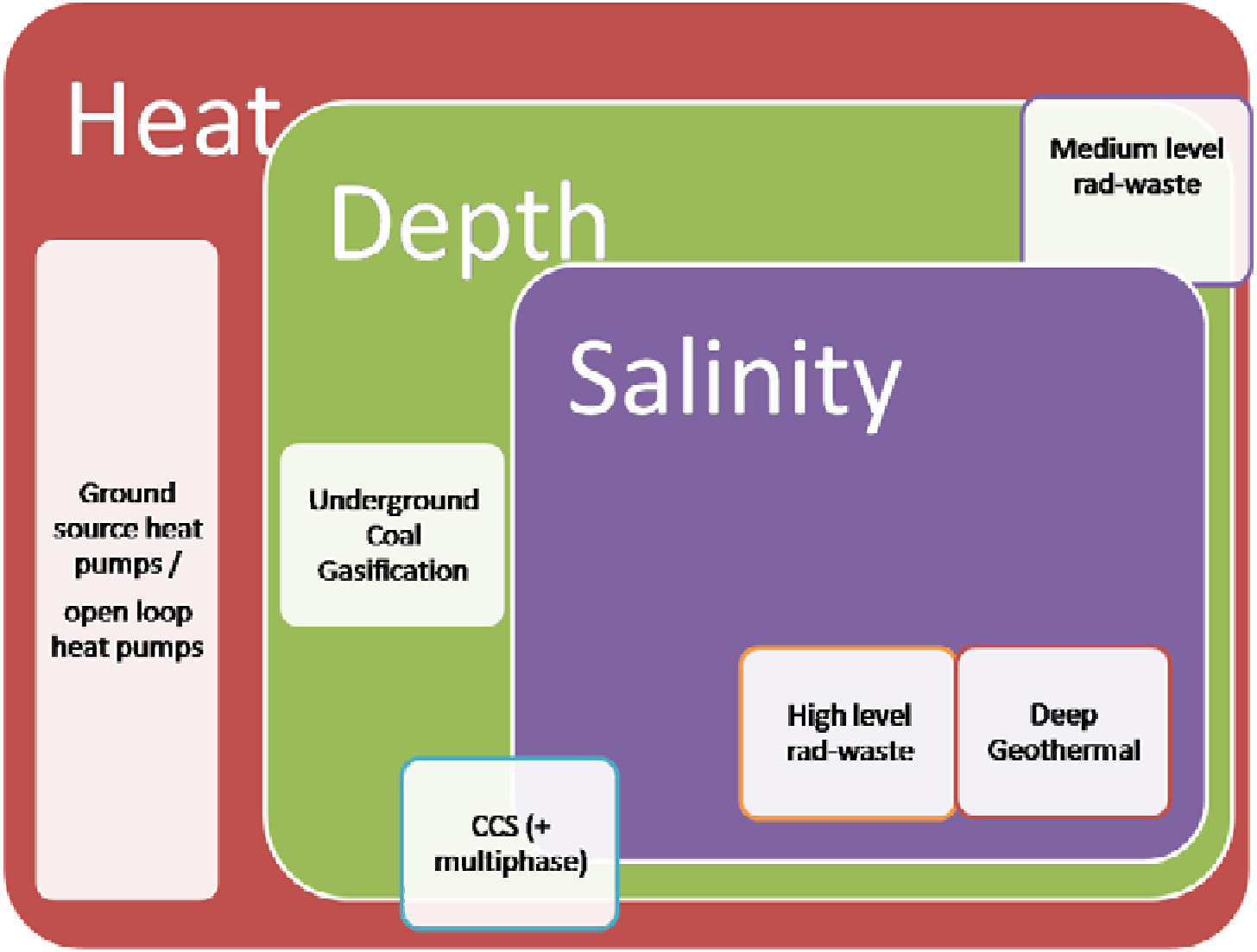


B. Themes linking areas

From consideration of low carbon technologies – some common issues emerge:

- Heat
- Depth
- Salinity
- Multiphase

Let's move on to consider Groundwater's role and environmental assessment

C. Groundwater's role in a changing climate

Can we minimise carbon emissions / increase efficiency by more use of groundwater?

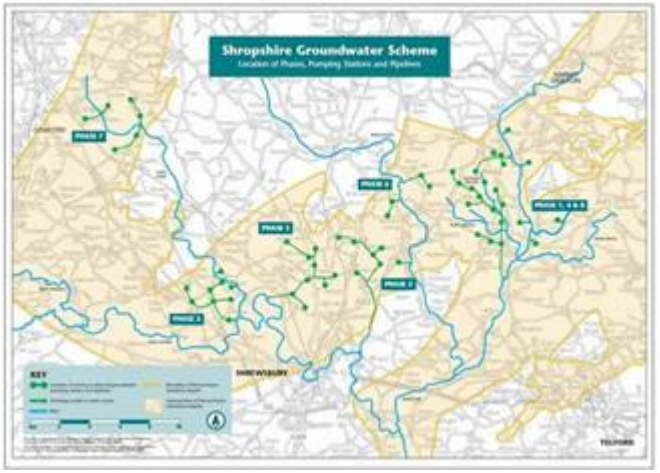
- A reliable source of water – at time of drought
- Groundwater is (probably) less carbon intensive than alternative sources – e.g. surface water reservoirs
- But main aquifers already under high abstraction pressure. Therefore:
  - Development of ASR
  - Conjunctive use

Hydrogeologist Martin Shepley* considers the past use of the Permo-Triassic sandstone aquifer for public water supply in the Midlands of England and predicts that its golden age is about to begin.

Geoscientist 20.01 January 2010

The Permo-Triassic Sandstone (PTS) is the second most important aquifer in the United Kingdom - second only to the Chalk. Interestingly, despite its much smaller outcrop, the PTS holds a lot more usable fresh water - which makes it the biggest strategic store of potable water in the UK. Almost two years ago in these pages, Mike Price discussed the importance of groundwater storage and how it could be critical in adapting to the impacts of climate change. Perhaps therefore it is about time that we had a closer look at this aquifer, and the opportunities it provides to secure water supply for the future.

Before thinking about the future, it is worth looking back and seeing what changes groundwater abstraction has made to the surface water



Sources: Geolsoc + Groundwater Forum

C. Groundwater's role in a changing climate

Is Groundwater less carbon intensive?

- Typically requires less treatment than surface water
- Typically is more local to demand – fewer
- Water companies often refer to it as their lowest cost source

- Energy efficiency is important – pump design, variable frequency controllers etc
- Groundwater could be greener still, with more flexible operation
  - Renewable electricity, particularly wind / wave is intermittent
  - Adapt infrastructure to accommodate renewables inconsistency →
  - More in-network storage??
  - Electricity price may become more volatile → worth adapting.

C. Environmental assessment

Current groundwater related impact assessments consider only local scale.

- e.g. Restoring Sustainable Abstraction – Review of Consents. abstraction impacts at individual wetland, river or coastal sites
- There is a final cost / benefit analysis – but is widest environmental impact – in terms of any additional carbon emissions considered?

The issue is the scale of impacts:

- Local impact – a stream flowing after augmentation, v
- Global impact of emissions from pumping

We don't really consider global impacts. Should we?

If we did – might we have to accept great local impacts?

C. Environmental assessment

Do you currently consider the carbon emission impacts of your research, your projects, your investments?

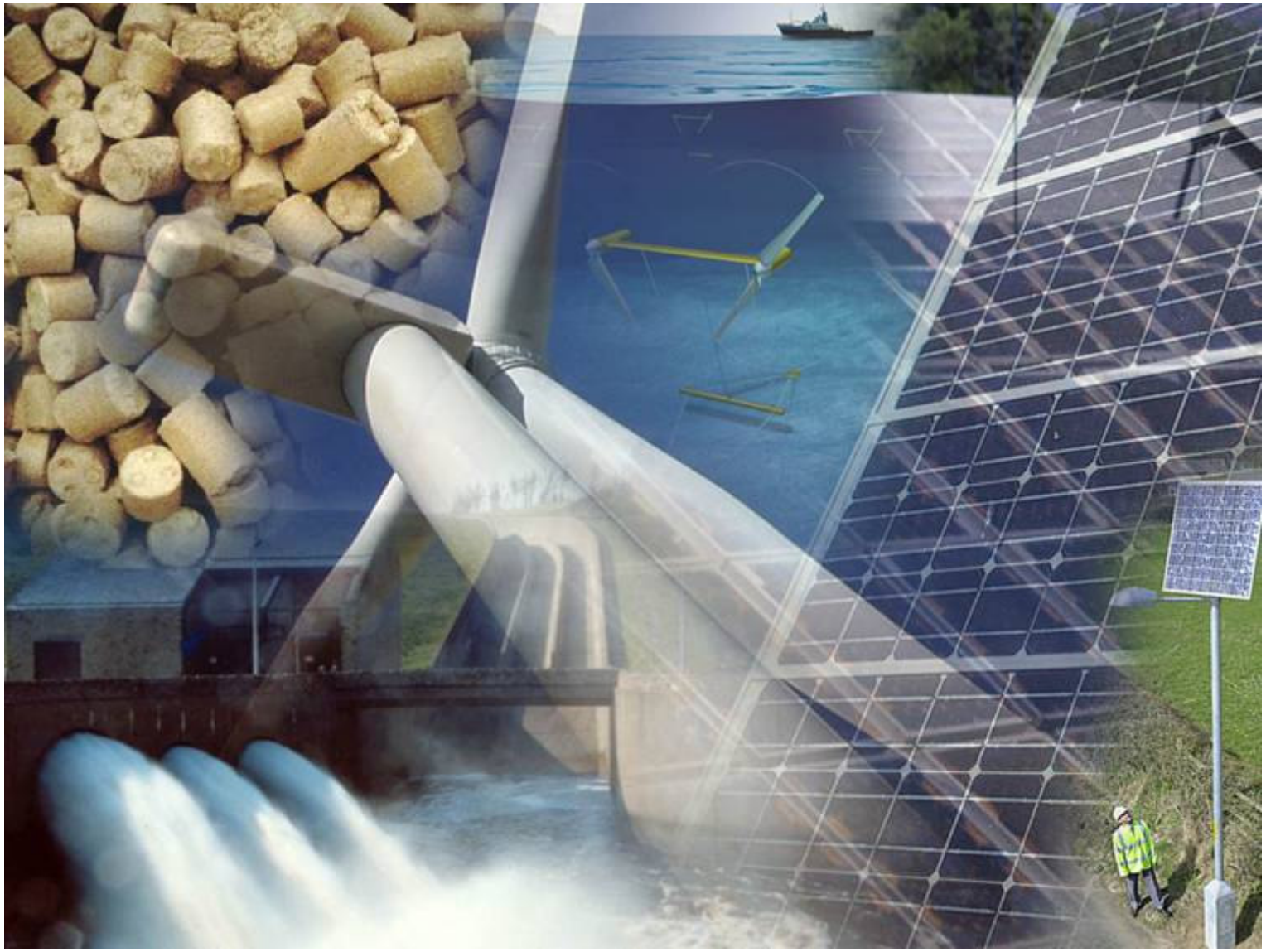
We are used to requesting environmental stats during procurement, or supplying them with quotes

Will this become a standard part of even a small project? Probably

So – what are the emissions from:

- Drilling 70 m at 200mm
- Sampling a borehole 4 times a year
- Abstracting 2.3 Ml/d
- Driving 150 miles

D. The challenges for groundwater and hydrogeology



D. Oil versus Water

Many of the technologies involve:

- Deep drilling and off-shore drilling
- Issues of salinity, precipitation and variable density
- Heat
- Multi-phase flow

The oil industry is much more familiar with these challenges than the "onshore" groundwater community.

There are different approaches and conventions: pressure v. head, intrinsic permeability v. hydraulic conductivity, single well / shut in tests v. pumping tests

To work in these environments – we'll have to learn to "talk" more petroleum engineering.

D. Education ~ MSc

Ground source heat already covered in Hydrogeology MSc courses

Birmingham (I believe) are considering a Hydrogeology and Nuclear…engineering / environmental science

From the themes:

- Depth – More emphasis on seismic techniques, deep drilling, and single hole testing and analysis
- Salinity – consideration of working with brines, scaling, environmental issues on disposal
- Geothermal development, v. deep drilling hydro-fracing
- For CCS, multi-phase flow, physics of super-critical CO2, injectivity

- Overall a shift from near surface, to deeper, and perhaps a little more physics?

D. Research

- Involvement in the Proofs of Concept stages – e.g. CCS demonstrations.
- Monitoring of deep technologies → Geophysics
- Drilling – deep drilling technology and lowering the price of deep holes
- Oil industry collaboration
- Risk. Other risks appear when injecting / extracting fluids from extreme depths → 3.4 magnitude earthquake induced from Basel geothermal borehole testing.

D. The challenges for hydrogeologists

Its not a completely clear picture - no one message, but relationships are there:

- Heat
- Depth
- Salinity
- ASR and conjunctive use
- Different environmental assessments
- What are the carbon emission from your projects

- Be prepared to be adaptable.

E. Questions

Amec Entec clarification:

- Entec UK Ltd was bought by AMEC Plc 30 March 2010, but continues to trade as Entec UK Ltd.

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