



# Geothermal Energy and Delft Geothermal Project

*Sustainable and innovative solutions, integrated in research and education, for CO<sub>2</sub> neutral heating using geothermal energy*



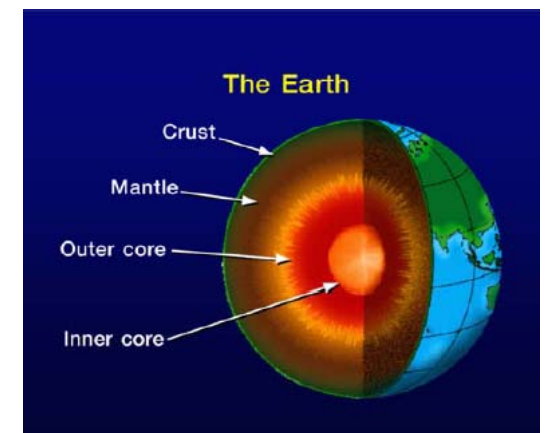
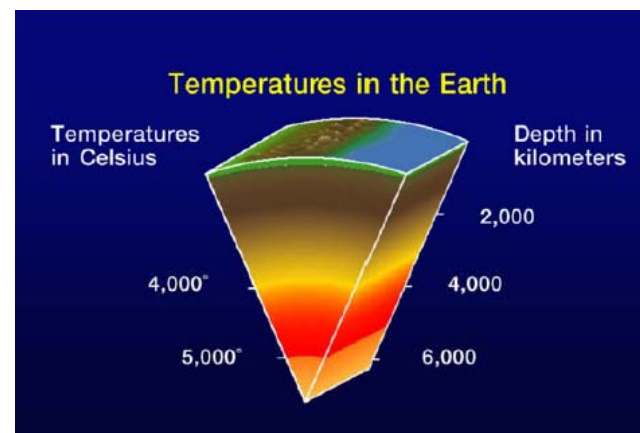
- Geotherman Energy
  - What is it, is it usefull, does it work?
  - What systems do exist?
  - What can we do with it in the Netherlands?
- What is the “Delft Aardwarmte Project”?
  - Generalities
  - G&G
  - CO<sub>2</sub> & system integration
- Innovative Drilling Technology for GE
- ... *time for questions you didn't ask yet*

# What is Geothermal Energy?

*... and why is it “green” and sustainable?*

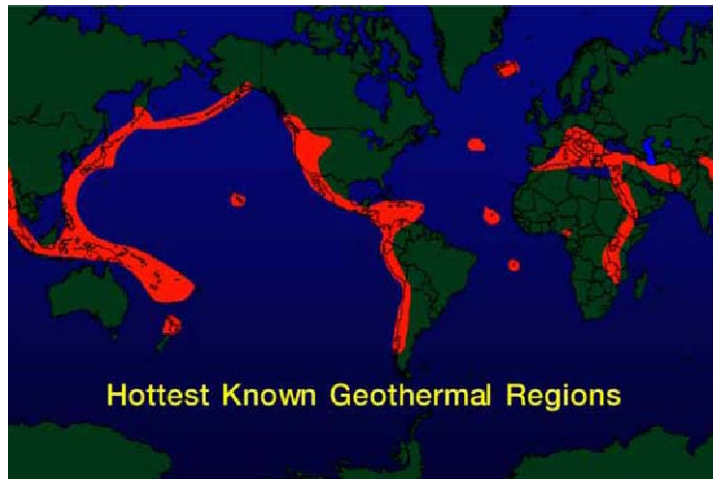


- Geothermal energy from large or shallow depths
  - Cold/heat storage
  - “deep” geothermal energy
- Use of heat from deep subsurface
- Sustainable energy
- The earth generates heat in the core ...



# International context ...

*Geothermal Energy is relatively new as sustainable source, but not as energy!*



- High geothermal gradient related to volcanic activity
- But this is not necessarily the case ...

# ... and within Europe



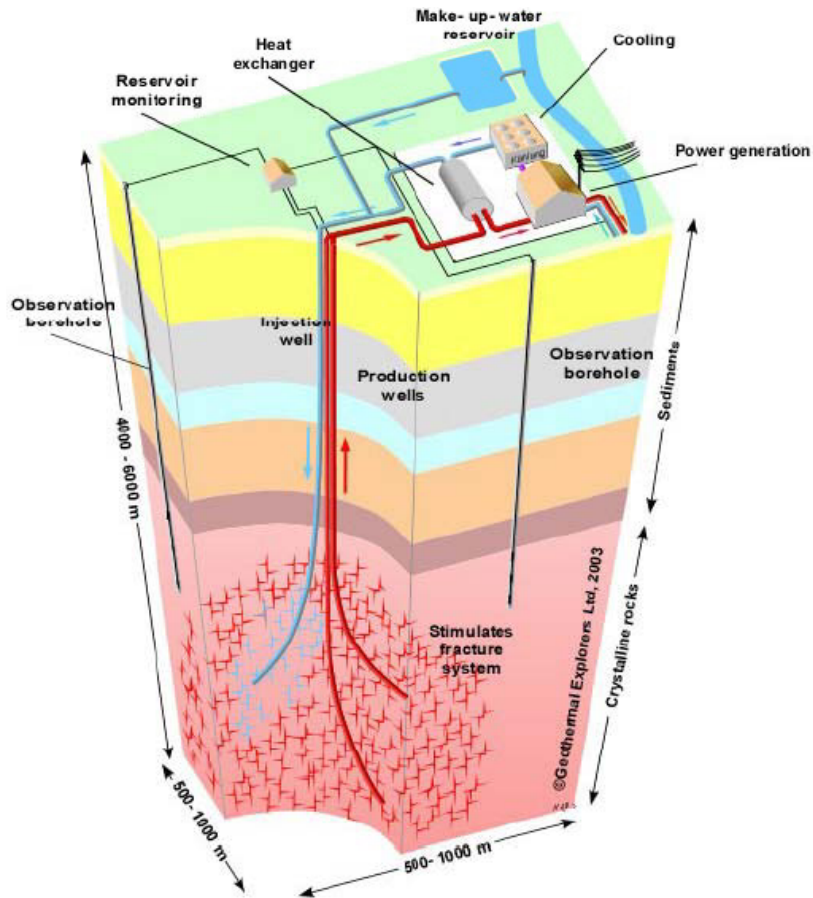
- High temperatures in Iceland and Turkey
- Medium temperatures in South Germany and Austria
- Low-temperature systems in France, and parts of Scandinavia

# What systems do exist?

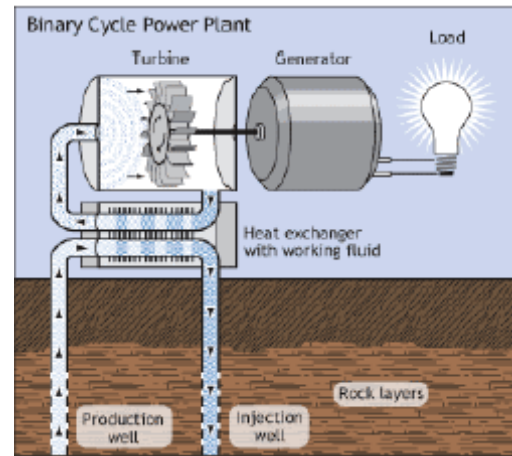


- Enhanced Geothermal Systems (hot-dry-rock)  
-vs- aquifer
- Single-well -vs- Doublet systems
- Electricity production with steam (high-temperature) or liquid with low boiling point (low-temperature using Organic Rankine Cycle and Kalina process)

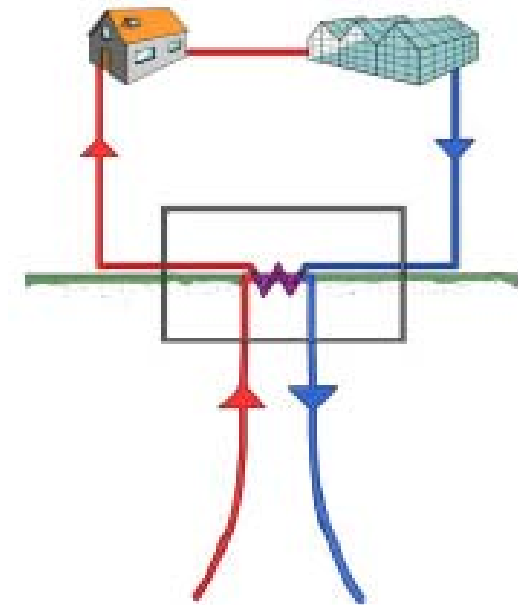
# Examples of systems



hot-dry-rock  
Soulz, France



Electricity production  
Schoenebeck (Germany)



Doublet-concept  
(v/d Bos, Blijswijk)

# Status in The Netherlands

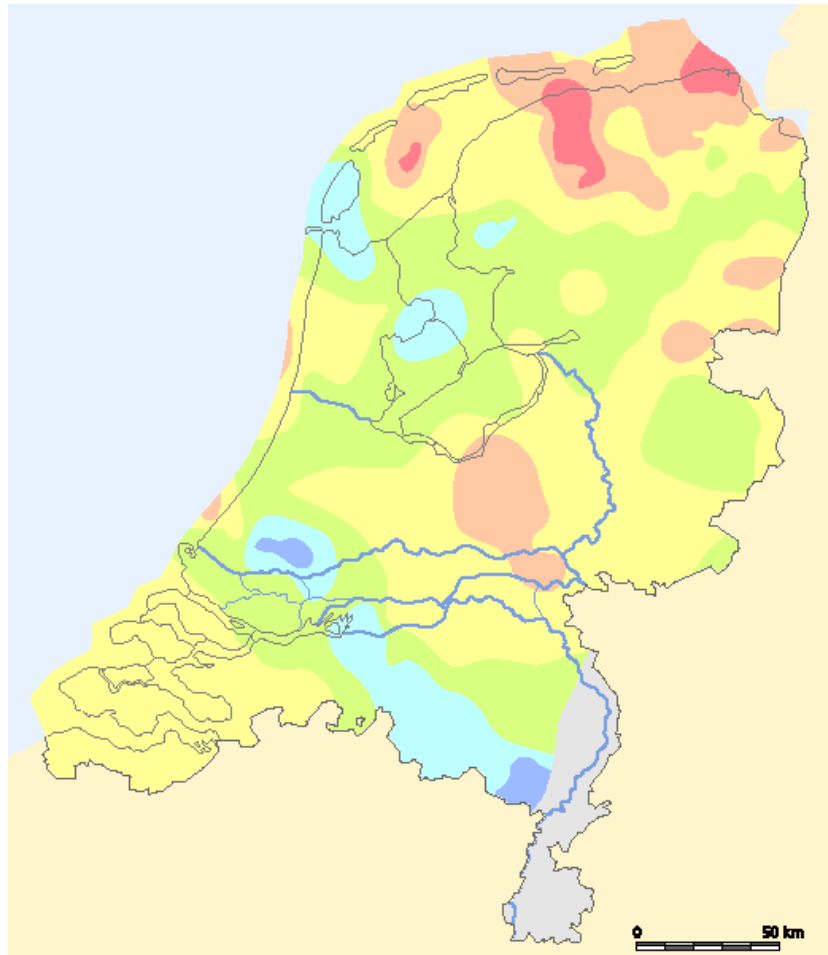
*Geothermal energy in The Netherlands is waiting for a technological breakthrough*



- Application of geothermal energy in The Netherlands is in its infantile stage
  - “Mijnwater Heerlen”
  - Blijswijk
  - Den Haag southwest
  - Delft Aardwarmte Project
  - Bergschenhoek, Drenthe, Gorinchem, ...
- Wide range of options
- Effective option to make energy supply more sustainable by prevention and capture and sequestration of CO<sub>2</sub> (CCS)



# Options are dependent on local situation ...



Temperature (°C)

> 90

85 - 90

80 - 85

75 - 80

70 - 75

< 70

no data available

Geothermal Energy by A. Lokhorst & Th.E. Wong  
in: Geology of the Netherlands, Edited by Th.E. Wong, D.A.J. Batjes & J. de Jager  
Royal Netherlands Academy of Arts and Sciences, 2007

- Map presents temperatures at 2000 m depth (TVD)
- Cretaceous, Triassic and Rotliegend sandstones most promising
- Natural heatflux 0,063 W/m<sup>2</sup>
- **About 100 PJ/jaar in The Netherlands only**
- 4 milion energy-efficient houses

... the total scope is very large ...



- Total “heat in place” in The Netherlands about 90 thousand PJ (*source: TNO*)
- More than the historic hydrocarbon reserves in The Netherlands
- Total demand for heat in Holland some hundreds PetaJoules

... but the true break-through is not yet there!



## ■ Technological challenges

- Subsurface: reservoir and quality
- Footprint while constructing
- Corrosive water

## ■ Infrastructural challenges

- Demand should be 'on top' of supply
- Feed-water temperatures

## ■ Legislative issues

- Dutch subsurface & mining laws optimized for hydrocarbons

➤ ***Innovative action needed***

Geothermal Energy can economically generate sustainable and CO<sub>2</sub> free heat



## IDEA

- Promote economic applications of sustainable energy
- Integrate innovation, research and application
- Promote technology and image of (geo-) technical and E&P sciences

## APPROACH

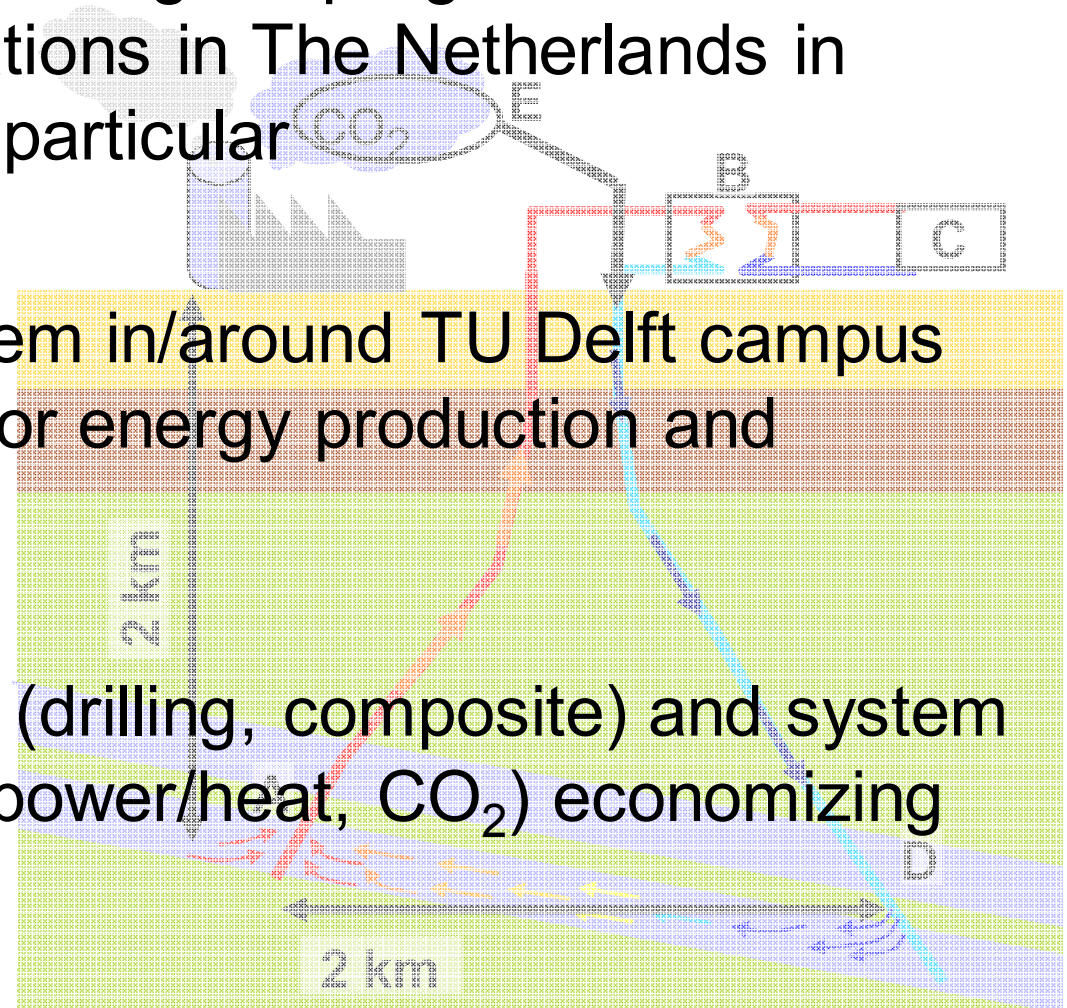
- Realise a geothermal system using break-through technology
- Investigates needs & options for geothermal energy on scientific level
- Integrate new and existing technologies & systems
- Expose and integrate students into 'real-life' project
- Demonstrate economic application of geothermal energy

# DAP Objectives

*Investigate, promote and demonstrate new technologies and systems integration, enabling economic geothermal energy implementation in urban areas*



- Promote scientific and technological progress & research on geothermal energy applications in The Netherlands in general, in/around Delft in particular
- Realize a geothermal system in/around TU Delft campus using composite material for energy production and research purposes
- Demonstrate technologies (drilling, composite) and system integration (geothermal & power/heat, CO<sub>2</sub>) economizing GE



# Some history... and a glance in the future

*Key milestones in the past 15-months of Delft Aardwarmte Project ... and key events in the near future*



- 28 Feb '07      Vodka tasting KIVI-Mijnbouw at 'Het Noorden', where the idea emerged
- 30 March '07    first project meeting DAP consortium
- 7 Nov '07        founding of 'Stichting DAP'
- 9 Nov '07        presentation at 23e lustrum MV
- 6 May '08        founding of "DAP B.V." operating company
  
- 10 Nov '08      *DAP symposium*
- Q3 '09            *start drilling*

# DAP approach

*Generate synergies in exploitation, research, innovation, education and demonstration to promote geothermal energy*



# Promote research on application and implementation of geothermal energy in the Netherlands



- Acquisition of relevant data, literature, case studies
- Academic interest for topic
- Scientific publications
- CATO-2 research consortium



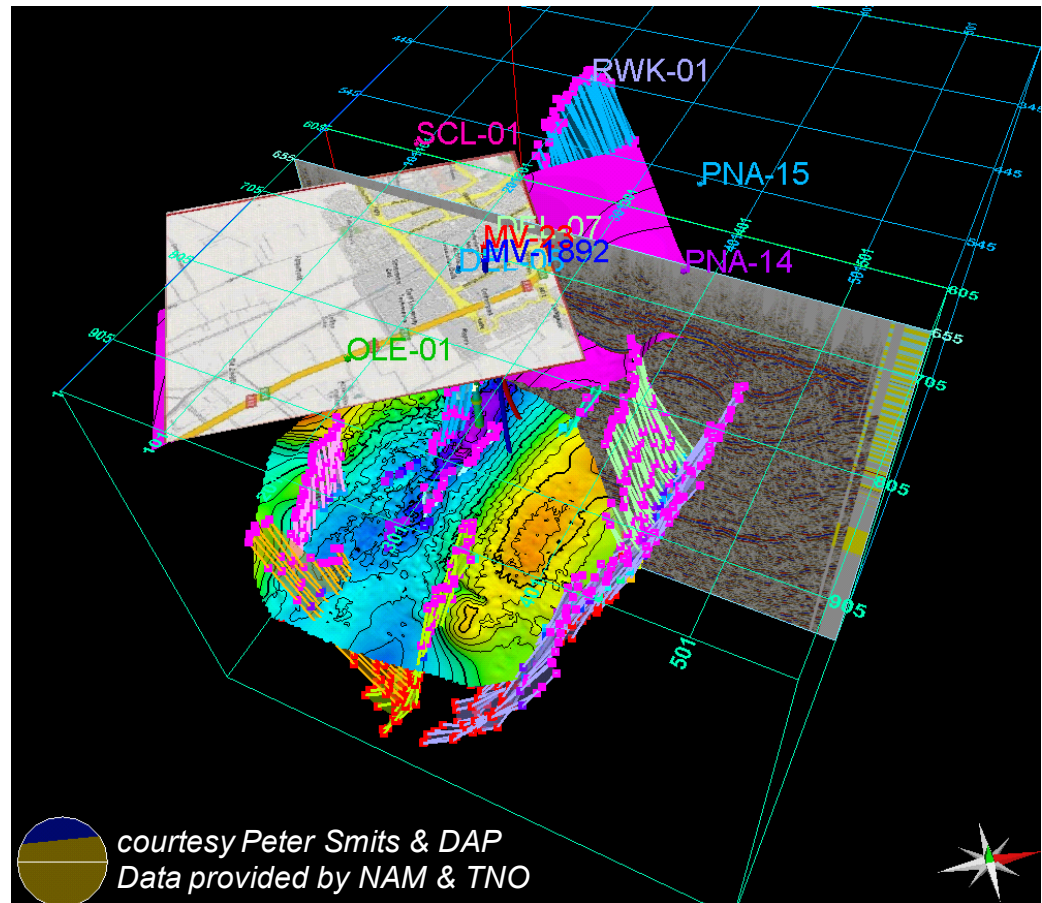
## The Development of a Multi-purpose Geothermal Site in an Urban Area

### Introduction

In the past decade, for the Netherlands, production of geothermal energy from greater depth was too expensive. However, with the present day's energy prices and improvement of development costs, geo-energy technologies are under consideration. In Bleiswijk (Netherlands) a first pair of geothermal wells (a doublet) produces water from 1700 m depth for heating glass houses. The Hague prepares a project in which about 6000 houses will be connected with a geothermally supported heating grid. In May 2007, students of Delft University, Department of Applied Earth Sciences, started their 23rd lustrum project dealing with CO<sub>2</sub>-reduced production of geo-energy. The two innovative aspects in this feasibility study, i.e. composite drilling and CO<sub>2</sub>-injection, got the attention of the industry, university and other (non-) governmental organizations. According to the pre-study in the Delft area, an

### "The Development of a Multi-purpose Geothermal Site in an Urban Area"

K-H.A.A. Wolf\* (Delft University of Technology), A. Willemsen (IF Technology - Arnhem), T.W. Bakker (BECi BV - Vries), A.K.T. Wever (Delft University of Technology) & D.T. Gilding (Delft University of Technology) 70th EAGE conf. Rome, 2008



courtesy Peter Smits & DAP  
Data provided by NAM & TNO



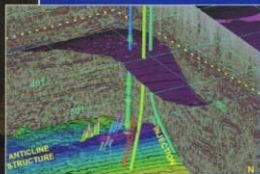
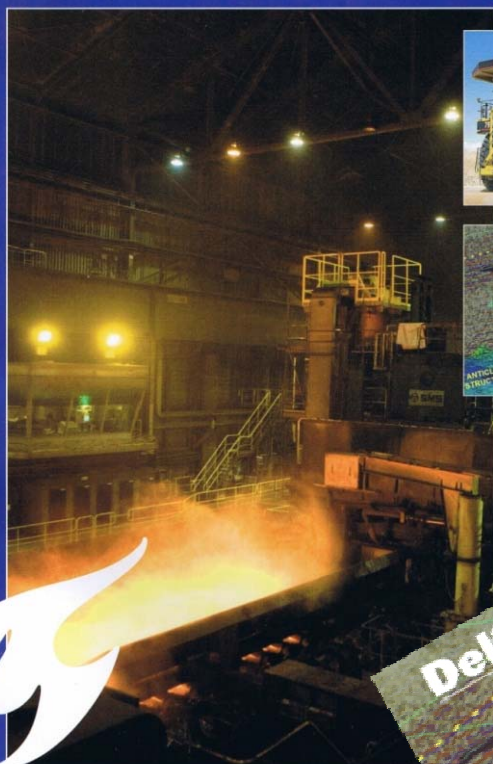
# Media attention for DAP

Natural Resource, KIVI -Mijnbouw, "Uit Delft" (TUDelft), SPE-YP NL, Studium Generale (TU Delft), NGMSO, etc



## Natural Resource

Jaargang 10 - Nummer 2



- Gashydraten
- Gas Markets
- Corus by Night
- Master Thesis
- Delft Aardwarmte Project
- Interview Bestuur
- Rambo

**Delft Aardwarmte Project**

SPE - NL Young Professionals

### "GREEN E&P: Geothermal Energy and applications around Delft"

This month the Young Professionals got introduced into a novel kind of prospect for exploration and production: Geothermal Energy. Under the title "GREEN E&P: Geothermal Energy and applications around Delft", Andries Wever, chairman of the Delft Aardwarmte Project (DAP - Delft Geothermal Project), gave a lecture on concepts and systems in geothermal energy, status of projects in the Netherlands, and the application of this concept in DAP.



Geothermal energy is based on the fundamental flow of heat, which is generated in the core of the Earth by nuclear decay. Therefore it is a recognized source of sustainable "green" energy. Applications are not only limited to areas with high volcanic activity resulting in high heat flow, projects are found throughout the world.

High-temperature systems are operated in Turkey and Iceland, medium-temperature systems in southern Germany and Austria, whereas low-temperature systems are being implemented in France, parts of Scandinavia, and now in the Netherlands. Depending on conditions and objectives, either a 'hot-dry-rock' system is used where steam is directly extracted, followed

Rancine Cycles" or "Kalina" processes.

After this introduction into geothermal energy systems, the potential for The Netherlands was evaluated in general, and particularly the local conditions for the greater The Hague area. In this context, DAP was used as case study on how innovative approaches, technologies and research can promote the application of geothermal energy. By introducing innovative casing drilling technology using composite pipe, less weight needs to be pulled by the derrick. Therefore a smaller drilling installation can be used, better suitable for urban operations. The composite material is not only very corrosion resistant; it also causes less friction for the rising fluids. In a second stage, DAP envisages the co-injection of CO<sub>2</sub> in the return water; for this option a research program is being set-up. Final conclusions of the talk were that geothermal energy is an under-explored and under-appreciated source of



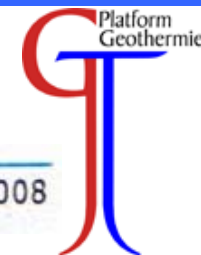
### Di 20 mei Het Delft Aardwarmte Project (DAP)

Mijnbouw  
Lezingen. (Diepe) aardwarmte wordt meer en meer als een van de meest veelbelovende, duurzame energiebronnen van de toekomst genoemd. Diverse lezingen van ir. Andries Wever en ir. Tom Bakker.

Tijd/locatie: 17.00 - 18.30 uur, TU Delft. Info/aanmelden: [www.kiviniria.nl/mb](http://www.kiviniria.nl/mb).



UitDelft 8 26 april 2008



### NGMSO Symposium De Toekomst van de Ondergrond 15 februari 2008 - Universiteit Utrecht

#### Programma

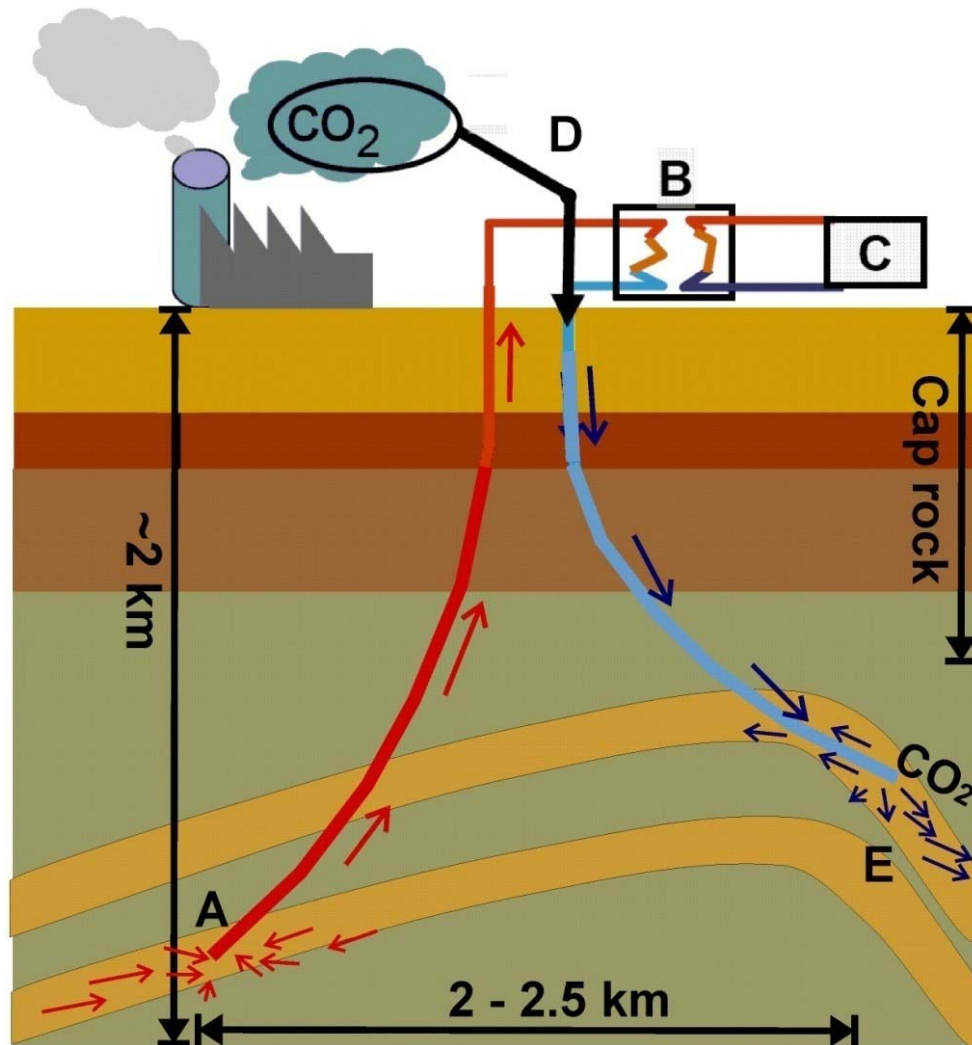
- 10:15 Ontvangst met koffie en thee
- 11:00 Opening door dr. Martin Hendriks (UU)
- 11:15 Dr. Mark van der Meijde (ITC, Enschede)  
Remote sensing en de toekomst van de ondergrond
- 12:00 Prof. Dr. Ruud Schotting (UU/Deltares/Roosevelt Ac.)  
en Drs. Guus Willemsen (IF-Technology)  
Duurzame energie uit de aarde: theorie, techniek en toekomst (met korte excursie)
- 12:45 Lunch
- 13:45 Douglas Gilding (TU Delft)  
Geothermische verwarming op de TU Delft
- 14:00 Wouter Smits (Shell)  
Onderweg naar 'warmere' velden
- 15:15 Koffie / theepauze
- 15:45 Dr. Thomas Keijzer (Tauf)  
Bodemsanering: beleid vertalen naar technieken en toekomstige effecten
- 16:30 Afsluiting en discussie o.l.v. Martin Hendriks
- 17:00 Borrel

Deelname gratis, inclusief koffie, thee, lunch en borrel  
Locatie: Aardwetenschapsgebouw, Budapestlaan 4, Utrecht



# Innovation by technology development and systems integration

*New drilling and well technology combined with CO<sub>2</sub>*

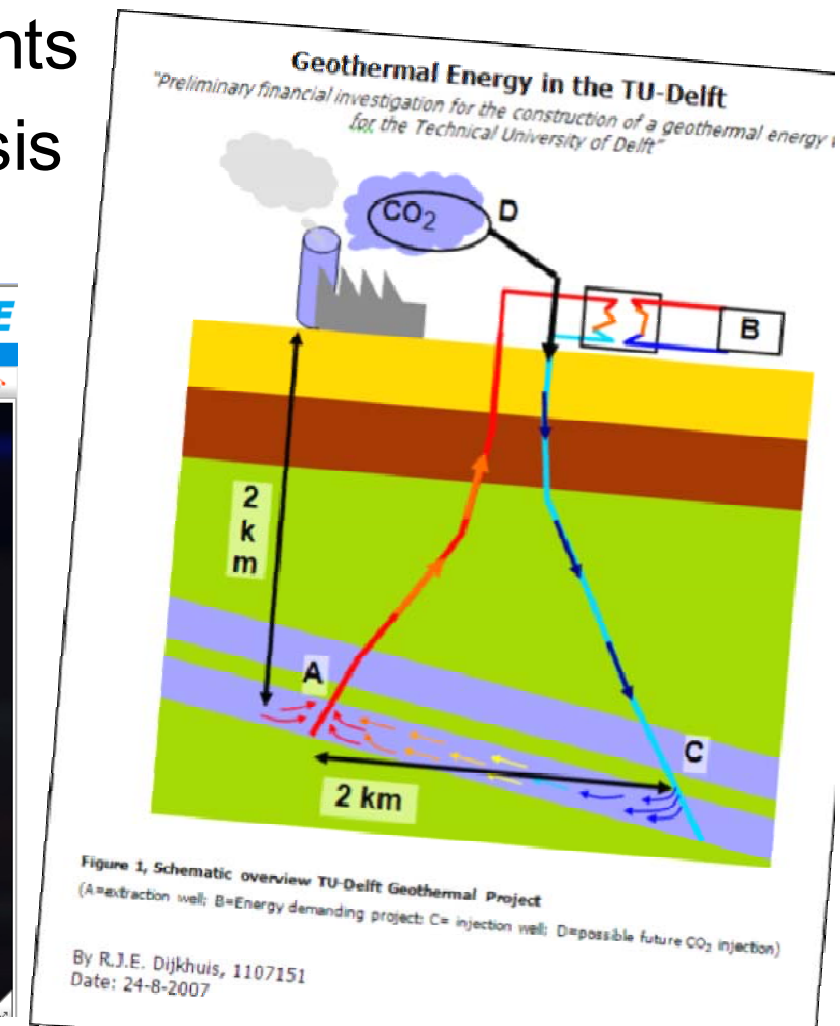


- GE 'doublet' concept not new in The Netherlands (Blijswijk – Van de Bos)
- Field-testing of composite drilling and equipment (DIRT project Acquit supported through DAP)
- Integration of GE and P/H coupled systems for dual-source heat, power and CCS

Expose students to sustainable, geothermal and E&P technology, let them work in & contribute to project



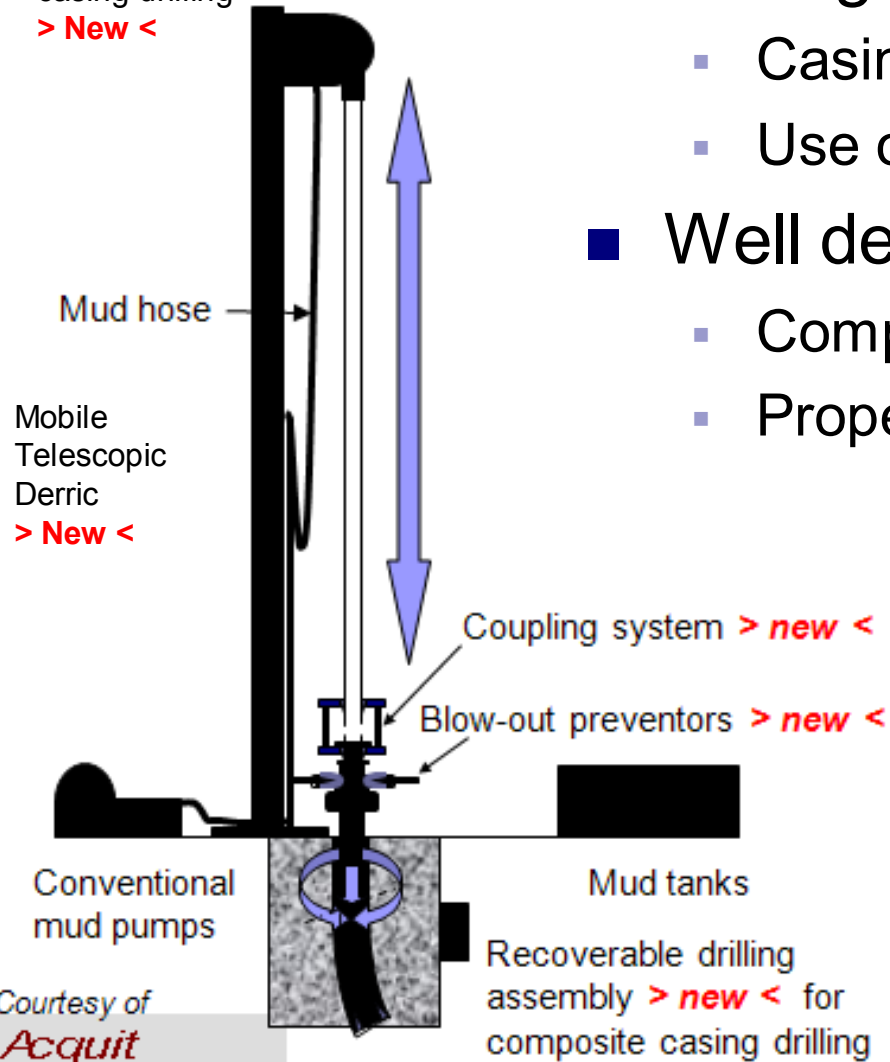
- Special lectures on “geothermal energy”
- Students writing special assignments
- BSc and MSc students writing thesis

A screenshot of a video lecture interface. The top left shows the TU Delft logo and the text 'Delft University of Technology'. The top right features the 'STUDIUM GENERALE' logo. Below the navigation bar, there is a video player showing a presenter, a slide titled 'De Delftse situatie' with the DAP logo, a 3D geological model of an 'ANTICLINE STRUCTURE' with wells labeled 'A' and 'C', and a satellite map of the Delft area with wells 'A', 'B', and 'C' marked. The video player controls show it is playing at 33:00/43:08. Below the video, there is a metadata section: 'SG Aardwarmte deel 1', 'Presenter(s): Studium Generale TU Delft', 'Date: 3/4/2008', 'Time: 8:15 PM WEST', and 'Length: 43 Minutes 8 Seconds'. At the bottom, there is a URL: [www.sg.tudelft.nl](http://www.sg.tudelft.nl) > recente lezingen > energie.

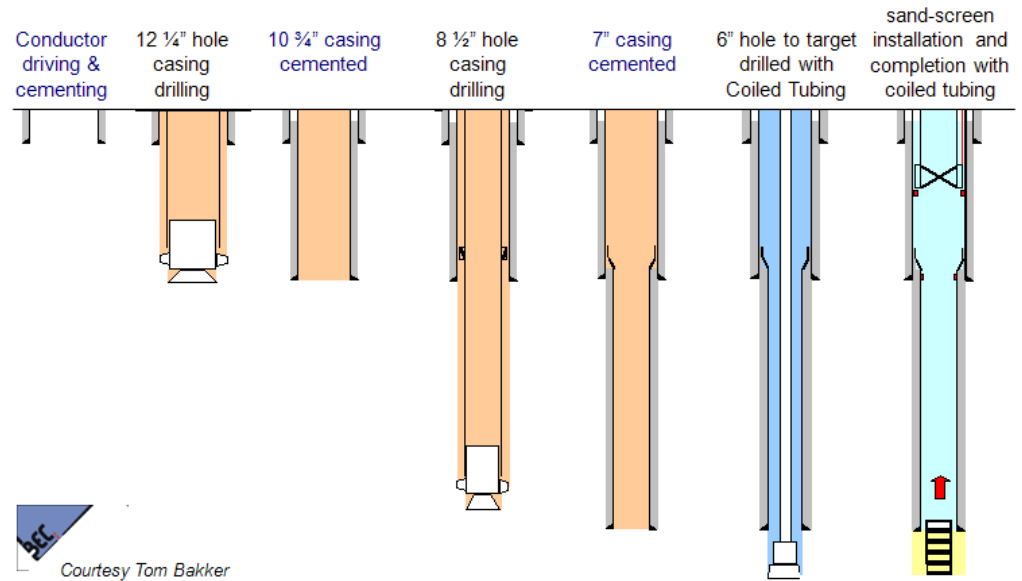
# Demonstration of break-through technology



Drill bit for composite casing drilling  
> New <



- Drilling technology
  - Casing drilling
  - Use of composite material for casing
- Well design & construction
  - Composite as base case, steel as back-up
  - Properties in the presence of CO<sub>2</sub>

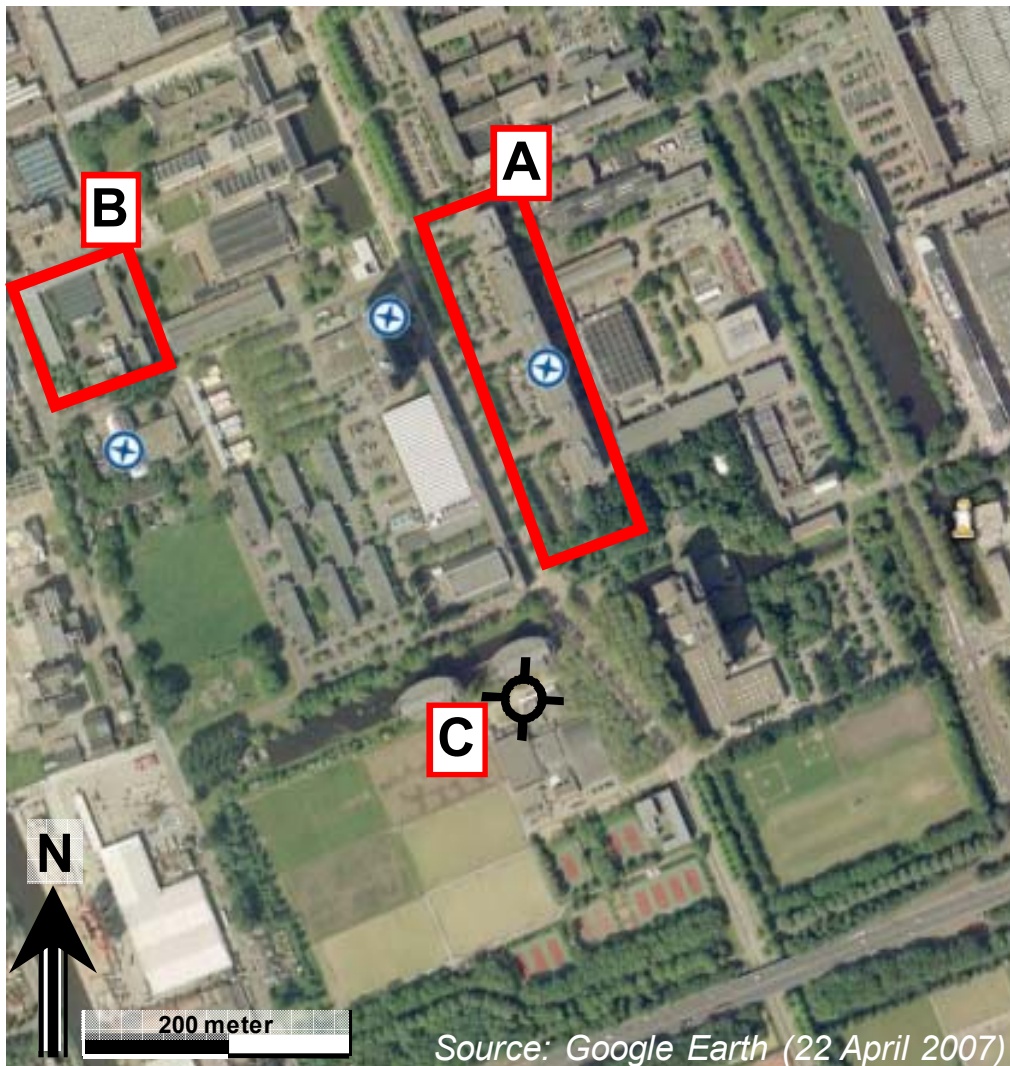


Courtesy of Acquit Business Development by

Courtesy Tom Bakker

# DAP at campus of TU Delft

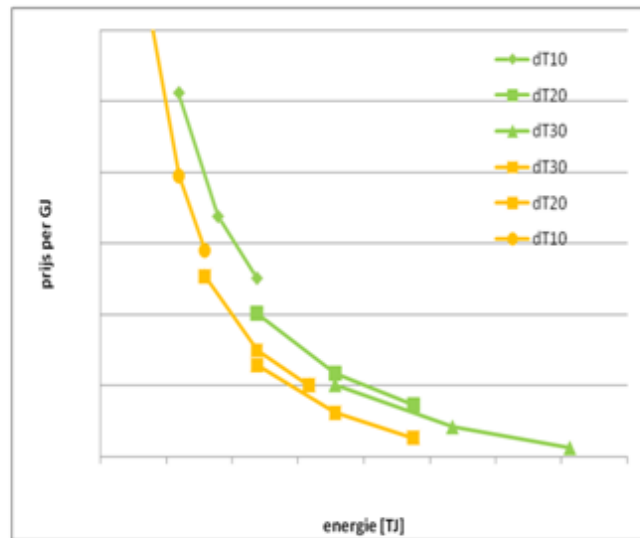
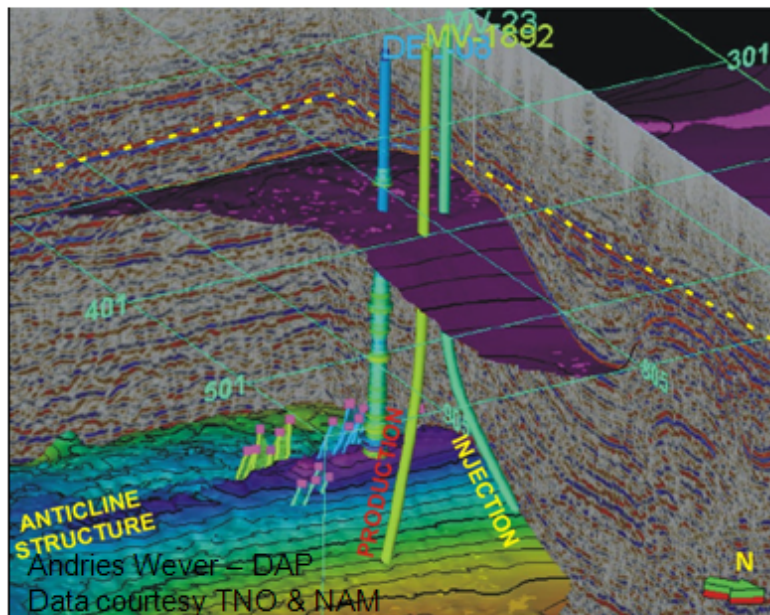
*All components and conditions for successful integration are available at close distance within the TU Delft campus*



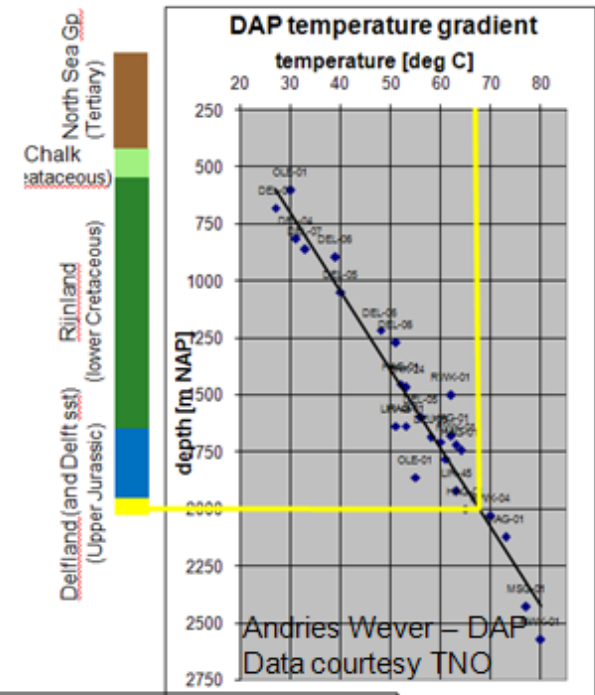
- TU Delft is equipped with a centralized heating network
- A: Faculty of CiTG, geotechnological research and education
- B: Integrated Heat & Power plant, combined heat and electricity production, and source of CO<sub>2</sub>
- C: location of NAM exploration well Delft-8 (1995), water bearing with traces of hydrocarbons (“Rijswijk” and “De Lier” sst)

# Exploitation requires preparation

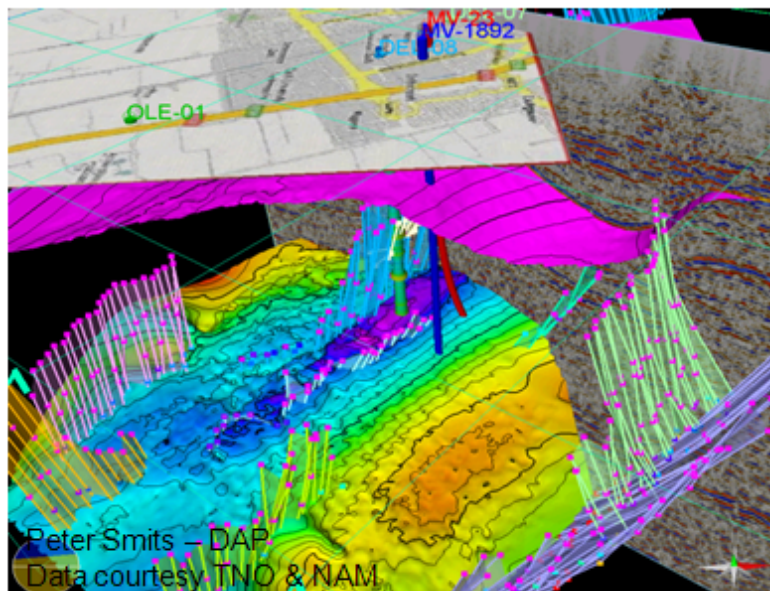
*Subsurface data analyzed and modeled, surface infrastructure designed and modified*



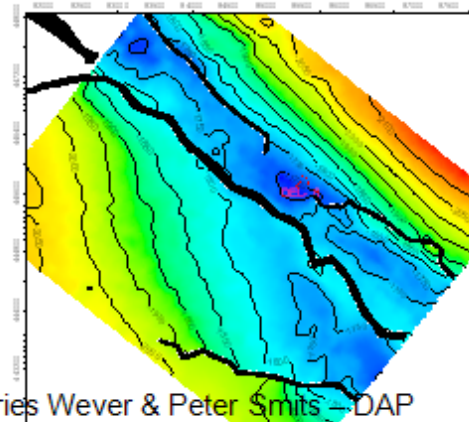
Guus Willemsen – DAP & IF Technology



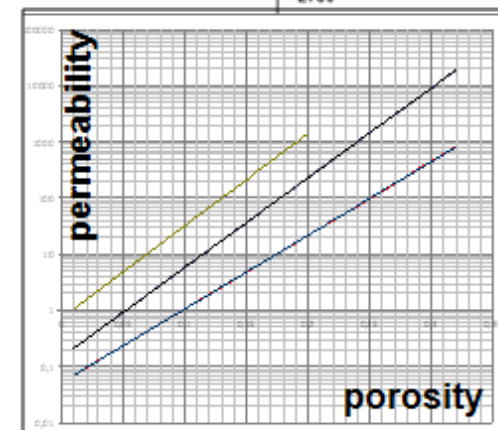
Andries Wever – DAP  
Data courtesy TNO



Peter Smits – DAP  
Data courtesy TNO & NAM



Andries Wever & Peter Smits – DAP  
Data courtesy TNO & NAM



Peter Smits & Douglas Gilding - DAP  
Data courtesy NAM, DHZW, TU Delft

# CO<sub>2</sub> and system integration ...

*Improve economics by smart systems integration*



- Heat production side economically marginal under current (model-) economic conditions
- Water-injection side creates options for CO<sub>2</sub> capture and sequestration
- Integration of innovative geothermal and conventional power-heat coupled systems ideal

... and more on CO<sub>2</sub> co-injection



- CO<sub>2</sub> injection not new
  - Sleipnir gas field (offshore Norway)
  - Enhanced oil recovery (CO<sub>2</sub> flood)
- Effects on reservoir, seal and storage capacity not sufficiently understood for urban applications
  - Research on technical issues
  - Lab experiments followed by field & in-situ verifications
- Some solution required for CO<sub>2</sub> from fossil sources to meet Kyoto objectives





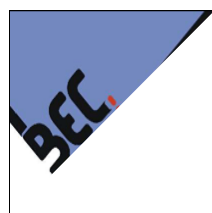
- Geothermal energy is an non-explored and under-appreciated source of sustainable energy with large potential
- Barriers prevent large-scale implementation
- Systems integration of geothermal systems and CO<sub>2</sub> injection promising

# DAP stake & share-holders

*A group of students, alumni, companies and institutions is supporting the initiative*



## Founding Fathers



**DSC**  
*Dick Swart Consultancy B.V.*

## DAP subsidizing group



# Contact details DAP Foundation



*Sustainable and innovative solutions integrated in  
research and education, for CO<sub>2</sub> neutral heating  
by means of geothermal energy*

## **Delft Aardwarmte Project**

P/a Mijnbouwkundige Vereniging  
Stevin weg 1, 2628 CN Delft  
telefoon 015-2782566

[dap@tudelft.nl](mailto:dap@tudelft.nl)

[www.tudelft.nl/dap](http://www.tudelft.nl/dap)

## **Stichting Delft Aardwarmte Project**

Bank: 24.91.74.103

KvK: 27.30.73.67

## **Delft Aardwarmte Project B.V.**

Bank: 24.91.74.???

KvK: 27.31.32.10



*Sustainable and innovative solutions integrated in  
research and education, for CO<sub>2</sub> neutral heating  
by means of geothermal energy*