Geothermal Energy
and
Delft Geothermal Project

Sustainable and innovative solutions, integrated in research and education, for CO_2 neutral heating using geothermal energy

KIVI mijnbouw 21 Mei 2008 – "back to the roots"

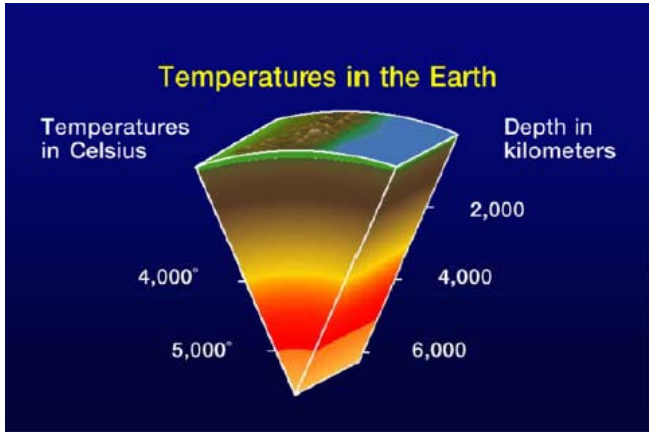
Overview of presentation

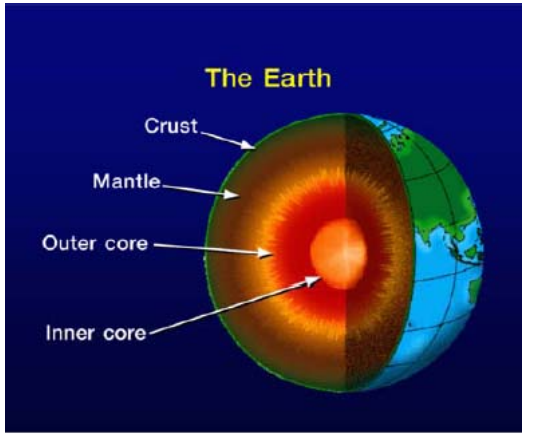
- Geotherman Energy
  - What is it, is it usefull, does it work?
  - What systems do exist?
  - What can we do with it in the Netherlands?
- What is the “Delft Aardwarmte Project”?
  - Generalities
  - G&G
  - CO_2 & system integration
- Innovative Drilling Technology for GE
- *... time for questions you didn’t ask yet*

What is Geothermal Energy?

… and why is it "green" and sustainable?

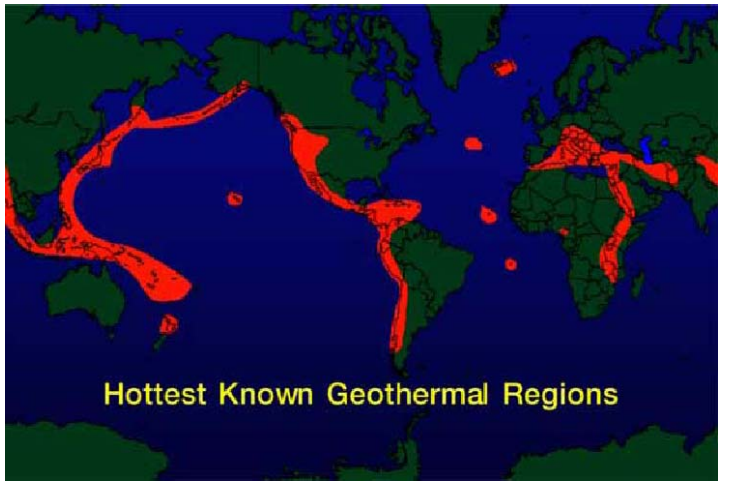
- Geothermal energy from large or shallow depths
  - Cold/heat storage
  - "deep" geothermal energy
- Use of heat from deep subsurface
- Sustainable energy
- The earth generates heat in the core ...





International context …

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



- High geothermal gradient related to vulcanic activity
- But this is not necessarily the case …

… and within Europe

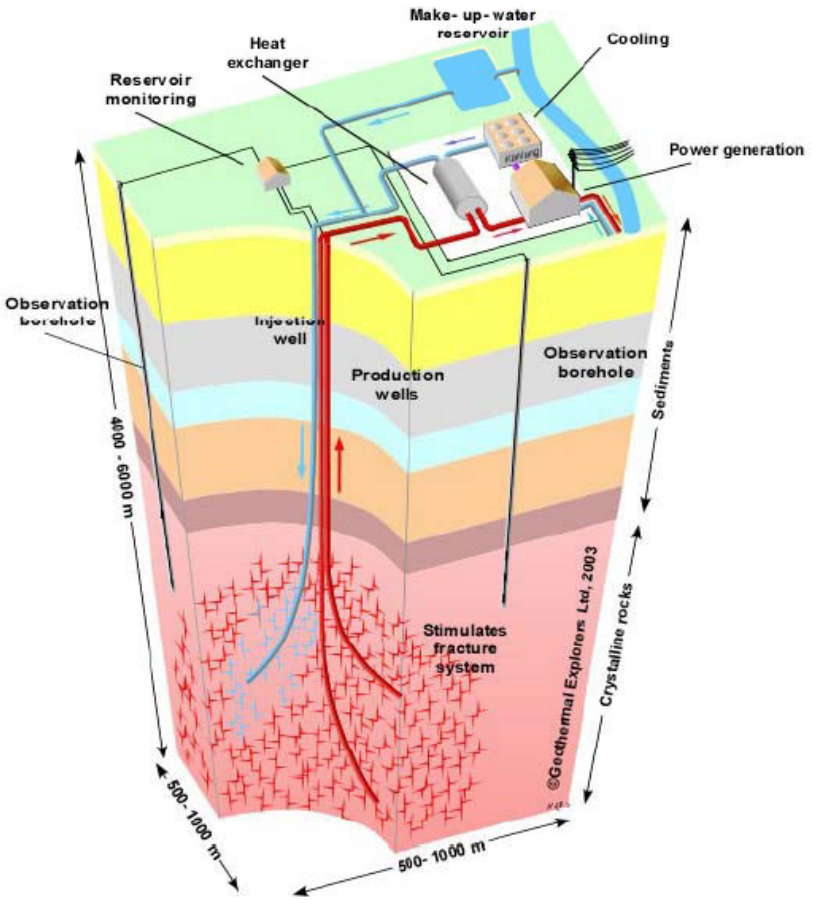
Source: EGEC - Dr. Burkhard Sanner

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

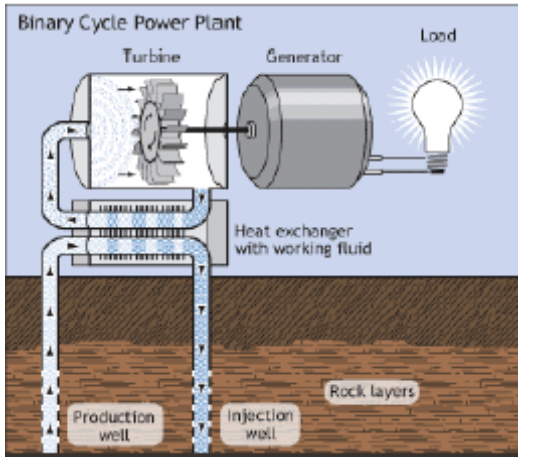
What systems do exist?

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

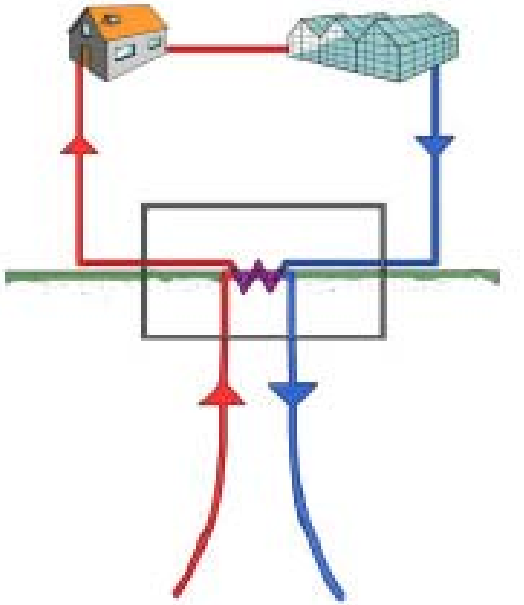
Examples of systems



hot-dry-rock
Soulz, France



Electricity production
Schoenebeck (Germany)



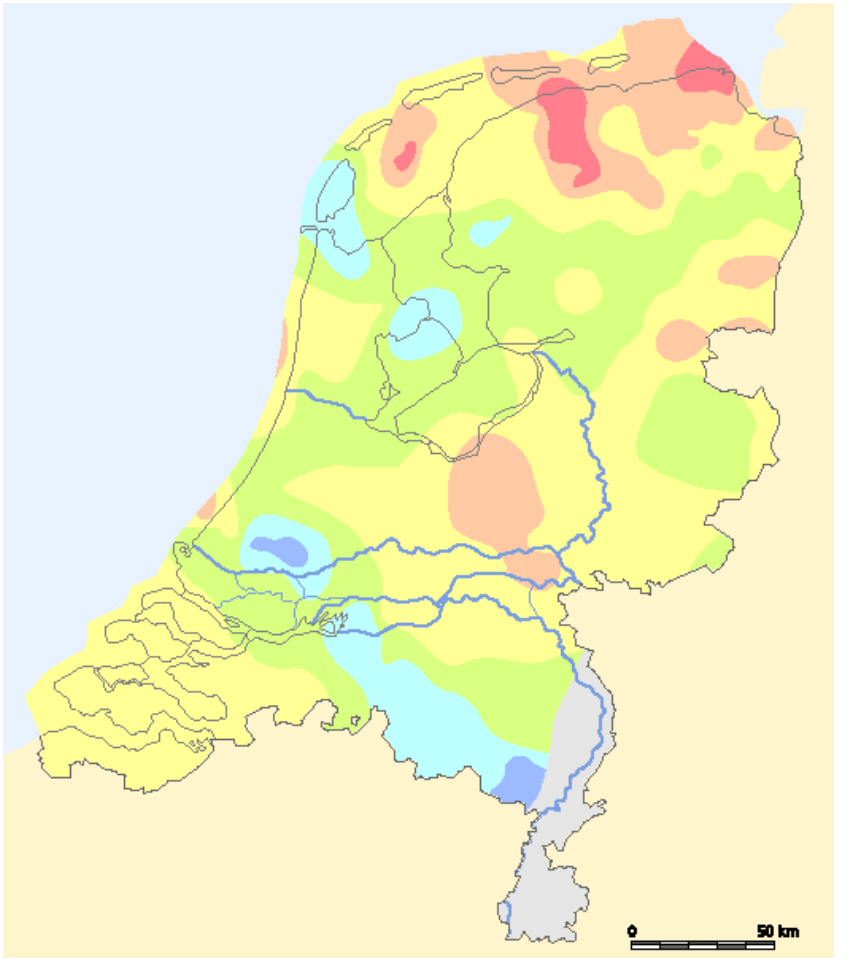
Doublet-concept
(v/d Bos, Blijswijk)

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_2 (CCS)

Options are dependent on local situation …



- Map presents temperatures at 2000 m depth (TVD)
- Cretaceous, Triassic and Rotliegend sandstones most promising
- Natural heatflux 0,063 W/m2
- **About 100 PJ/jaar in The Netherlands only**
- 4 milion energy-efficient houses

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

… the total scope is very large …

- Total “heat in place” in The Netherlands about 90 thousand PJ *(souce: TNO)*
- More then 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_2 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

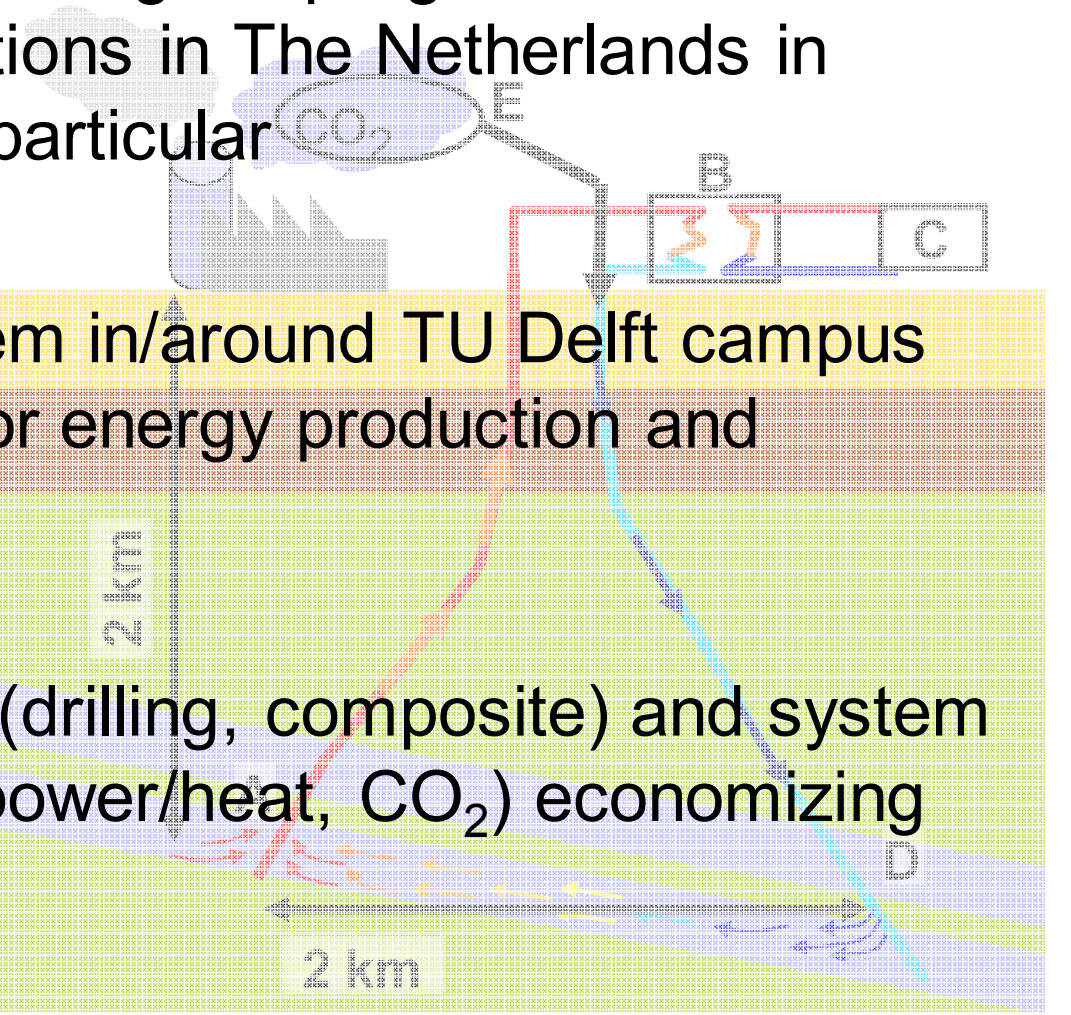
APPROACH

- 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_2) 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

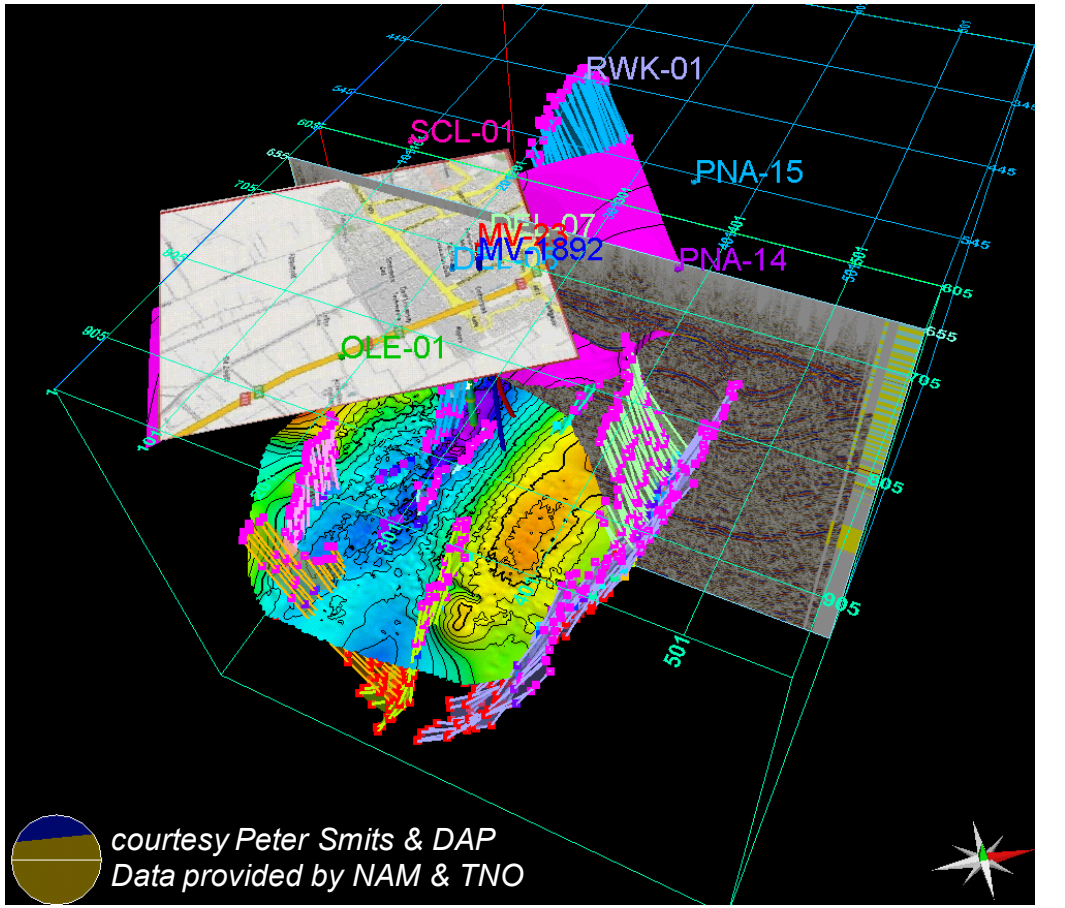
ROME 2008
LEVERAGING TECHNOLOGY

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

Introduction

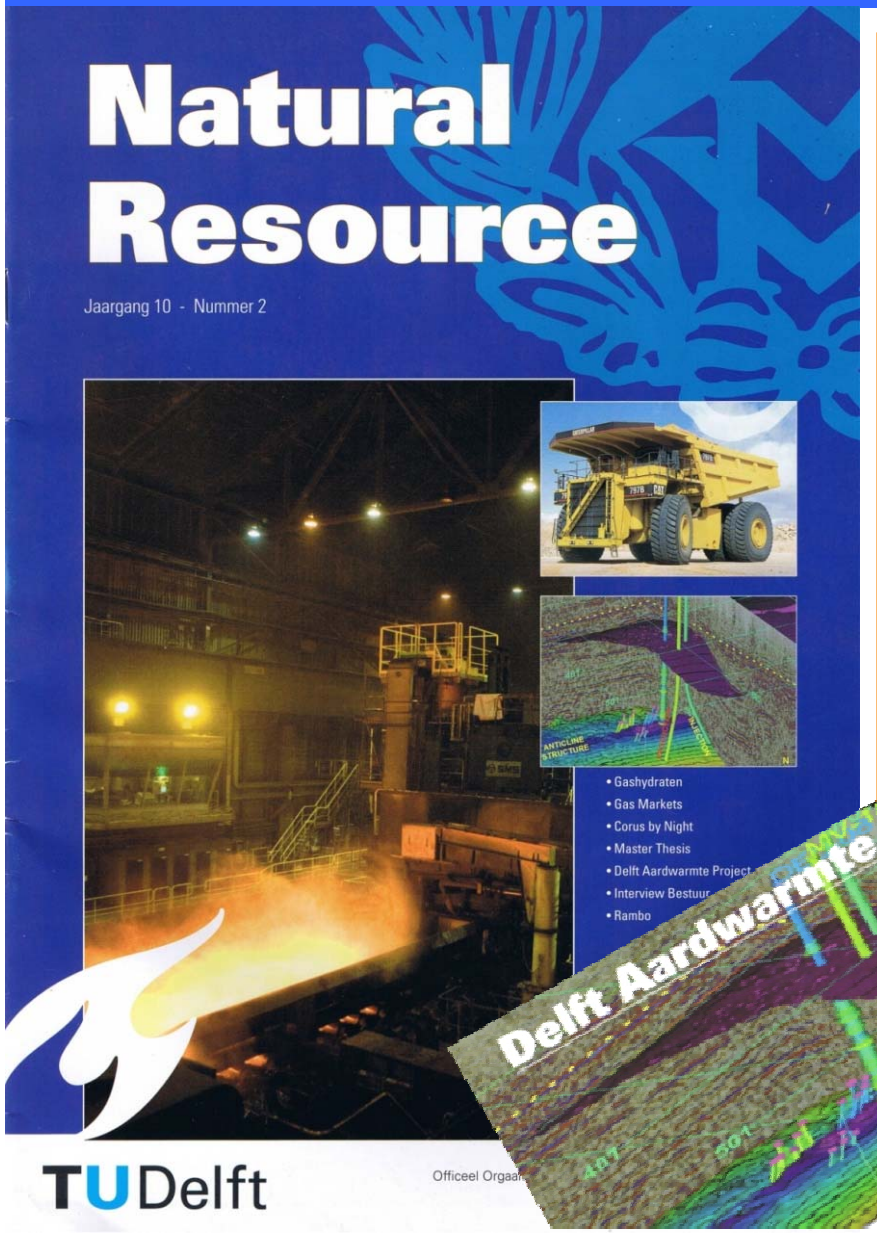
In the past decade, for the Netherlands, production of geothermal energy from greater depth was too expensive. However, with the present day's energy prices and improvement of development costs, geo-energy technologies are under consideration. In Bleiswijk (Netherlands) a first pair of geothermal wells (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_2-reduced production of geo-energy. The two innovative aspects in this feasibility study, i.e. composite drilling and CO_2-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



Media attention for DAP

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



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.

KIVI NIRIA

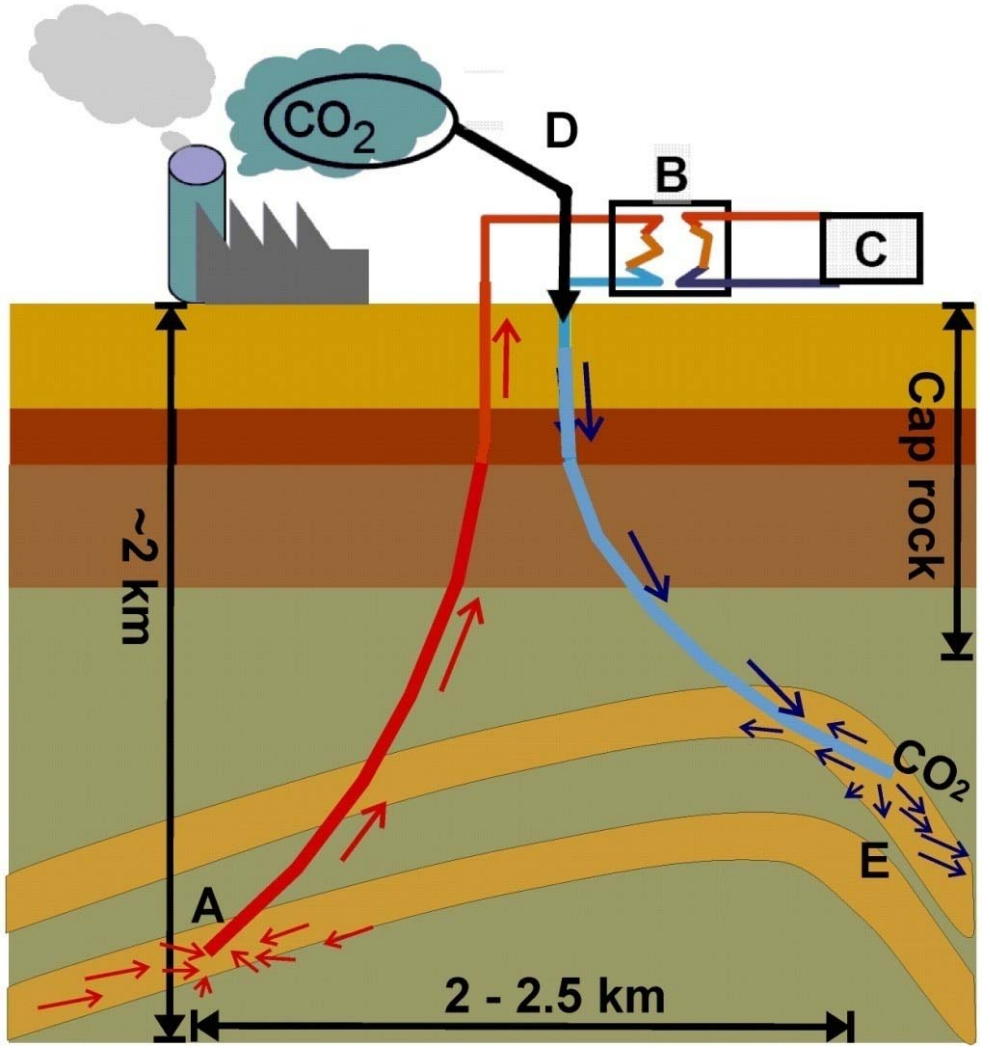
SPE International

Platform Geothermie

UitDelft 8 **26** april 2008

Innovation by technology development and systems integration

New drilling and well technology combined with CO_2

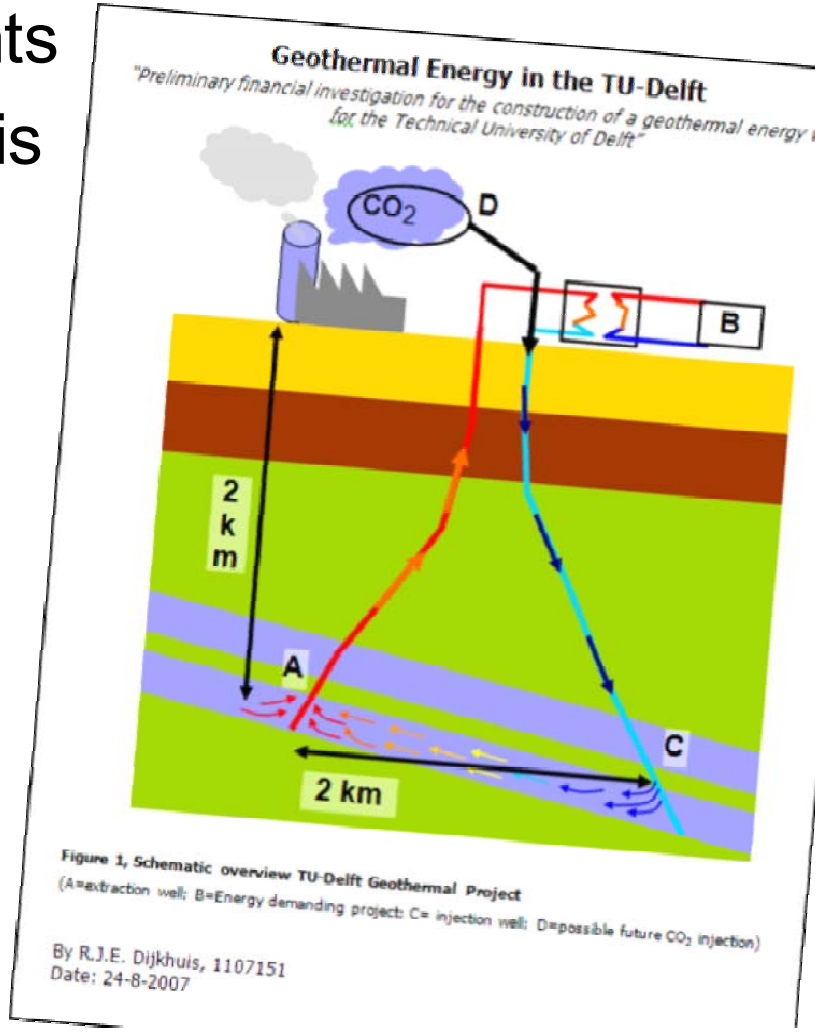


Courtesy K-H Wolff & CATO-2 documentation
TU Delft / DAP

- 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

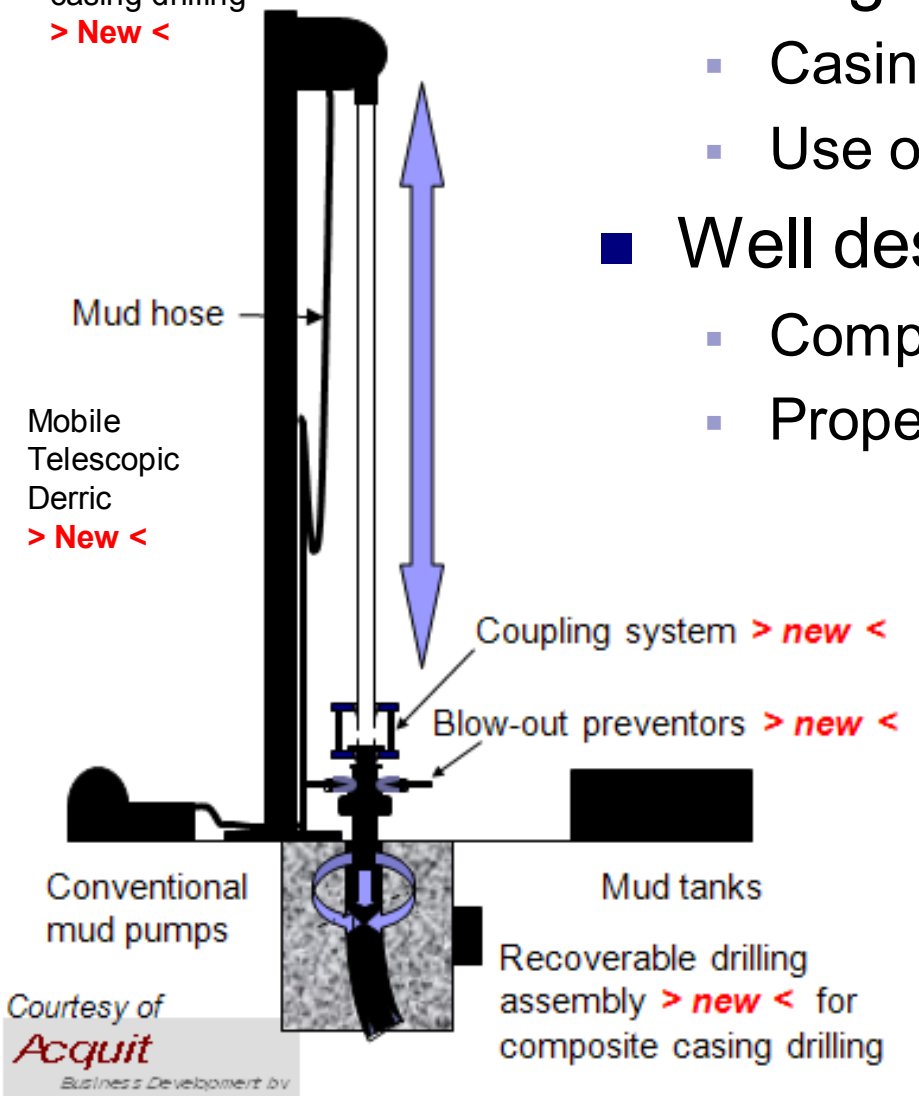
- Special lectures on “geothermal energy”
- Students writing special assignments
- BSc and MSc students writing thesis



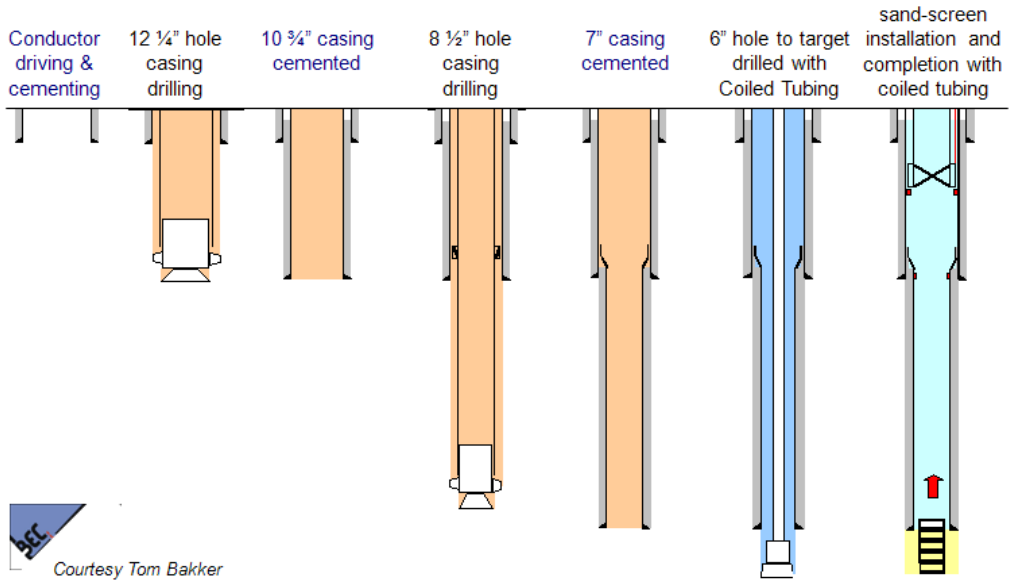
www.sg.tudelft.nl > recente lezingen > energie

Demonstration of break-through technology

Drill bit for composite casing drilling
> new <

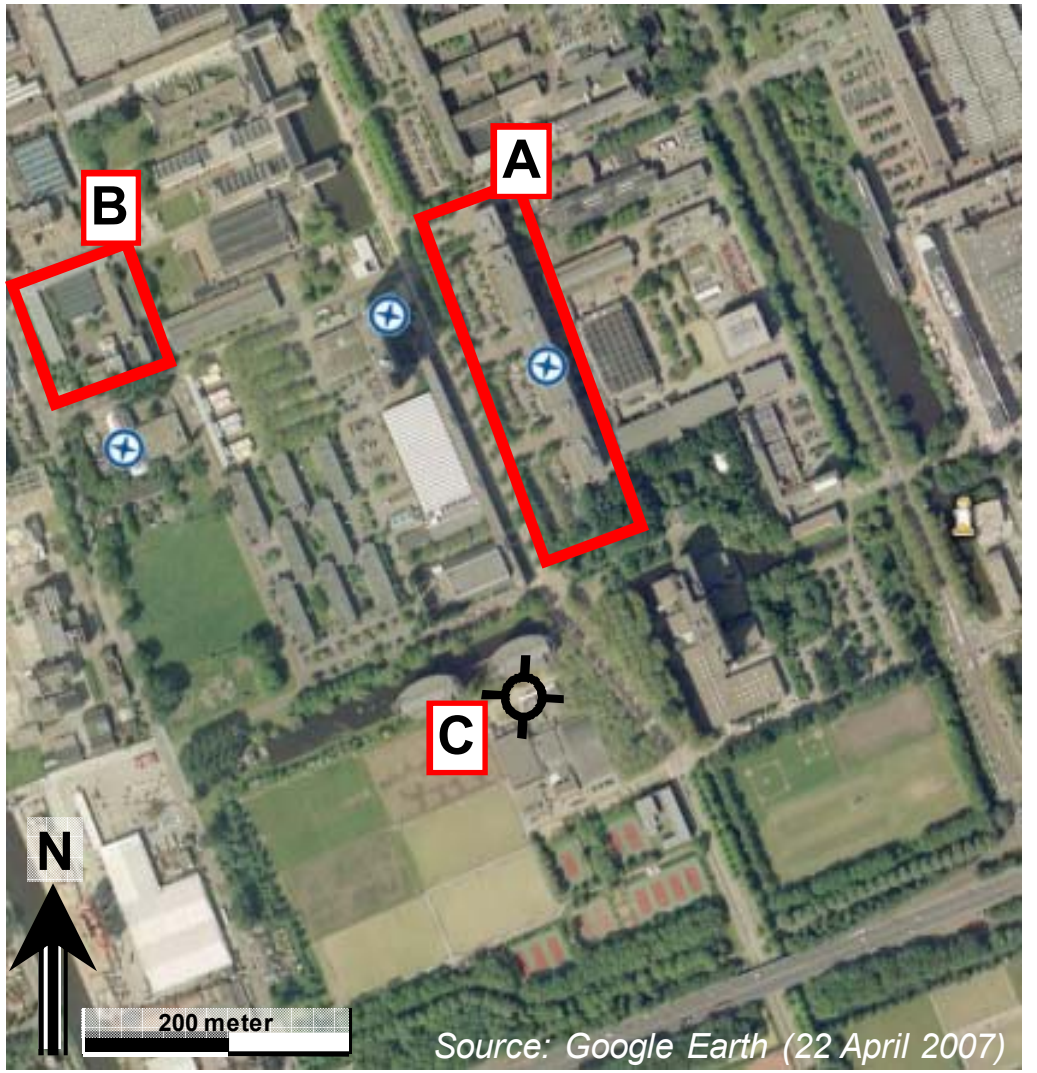


- Drilling technology
  - Casing drilling
  - Use of composite material for casing
- Well design & construction
  - Composite as base case, steel as back-up
  - Properties in the presence of CO_2



DAP at campus of TU Delft

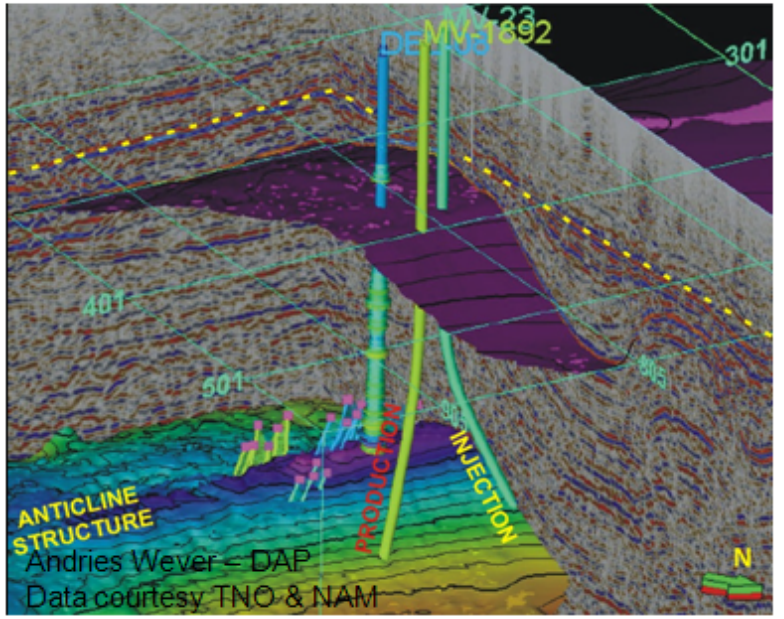
All components and conditions for successful integration are are available at close distance within the TU Delft campus



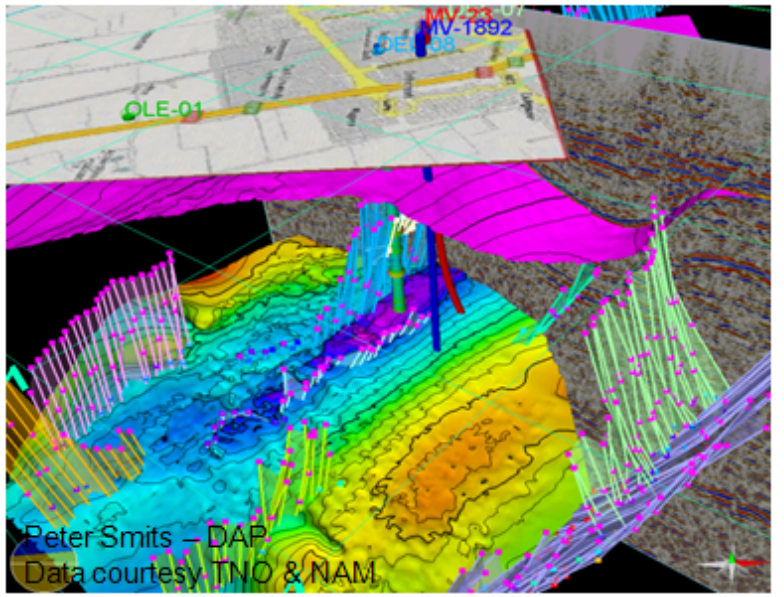
- TU Delft is equiped with a centralized heating network
- A: Faculty of CiTG, geo-technological research and education
- B: Integrated Heat & Power plant, combined heat and electricity production, and source of CO_2
- C: location of NAM exploration well Delft-8 (1995), water bearing with traces of hydrocarbons ("Rijswijk" and "De Lier" *sst*)

Exploitation requires preparation

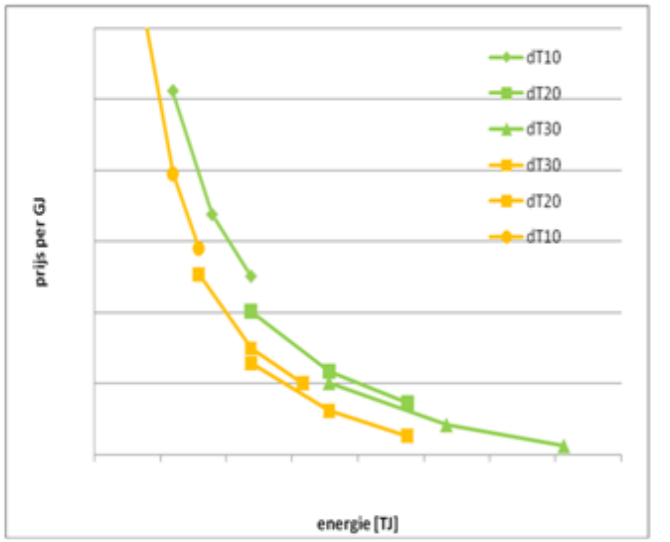
Subsurface data analyzed and modeled, surface infrastructure designed and modified



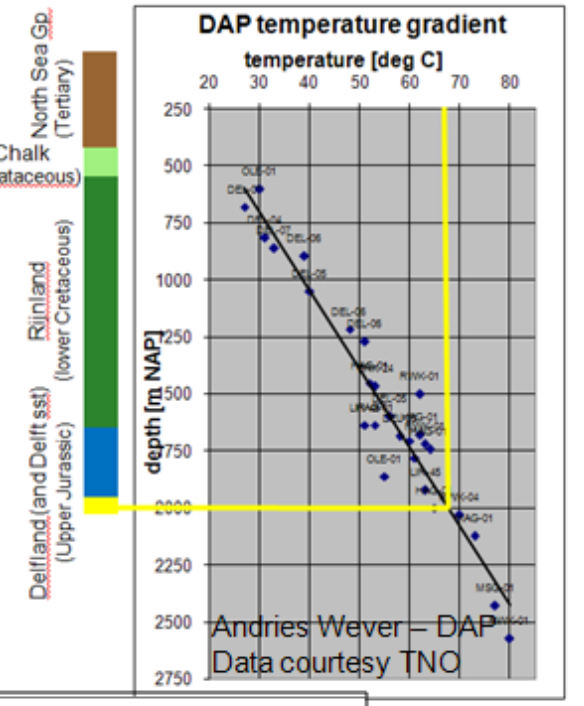
Andries Wever – DAP
Data courtesy TNO & NAM



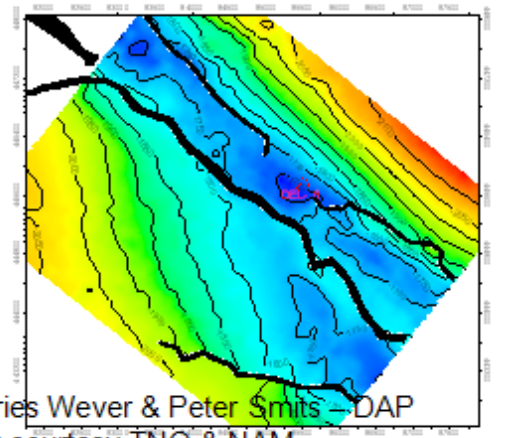
Peter Smits – DAP
Data courtesy TNO & NAM



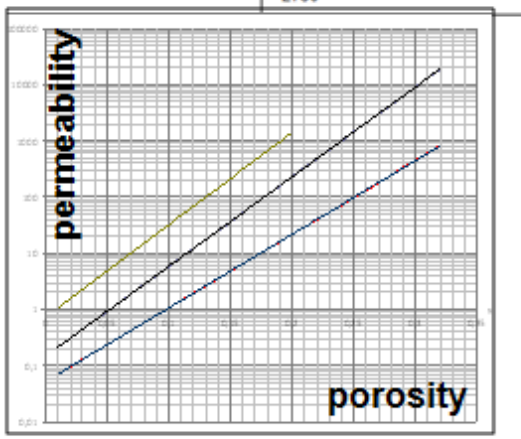
Guus Willemsen – DAP & IF Technology



Andries Wever – DAP
Data courtesy TNO



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



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

CO_2 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_2 capture and sequestration
- Integration of innovative geothermal and conventional power-heat coupled systems ideal

… and more on CO_2 co-injection

- CO_2 injection not new
  - Sleipnir gas field (offshore Norway)
  - Enhanced oil recovery (CO_2 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_2 from fossil sources to meet Kyoto objectives

Conclusions

- 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_2 injection promising

DAP stake & share-holders

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

Founding Fathers

Lustrum 23

if technology

Airborne Composites

VERKLEY

BEC

TU Delft
Technische Universiteit Delft

DSC
Dick Swart Consultancy B.V.

DAP subsidizing group

Ministerie van Economische Zaken

Acquit
Business Development bv

wintershall
BASF Group

provincie ZUID HOLLAND

Eneco

NAM
Nederlandse Aardolie Maatschappij

ebn
best access to dutch gas

DSM

CIRRUS
energy corporation

Contact details
DAP Foundation

Sustainable and innovative solutions integrated in research and education, for CO_2 neutral heating by means of geothermal energy

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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_2 neutral heating by means of geothermal energy