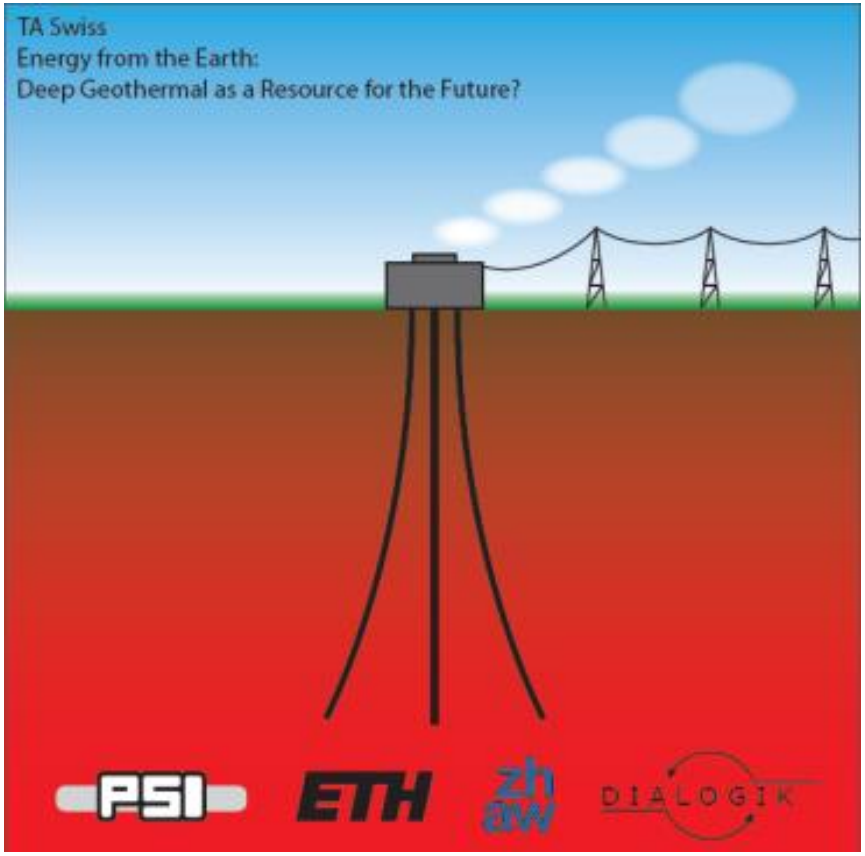
Drilling Deep for Heat:

Chances & Challenges of Deep Geothermal Energy



Session Overview

Energy from the Earth.

Deep Geothermal as a Resource for the Future?

Dr. Christina Tobler, TA-SWISS

Engaging the Public on Geothermal Energy

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Panel Discussion

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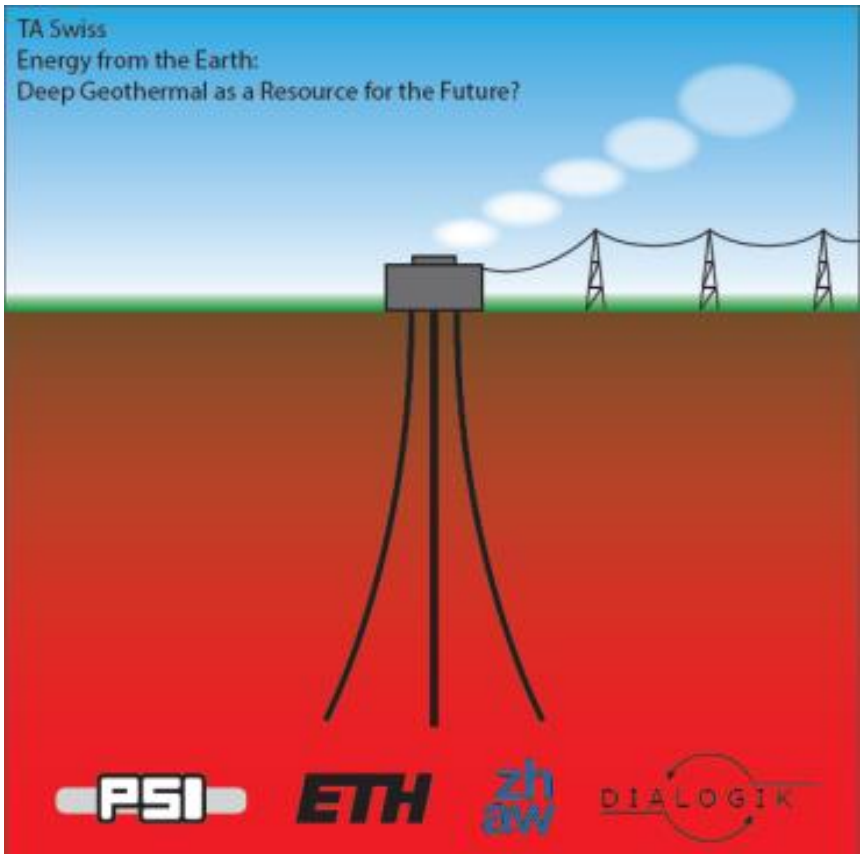


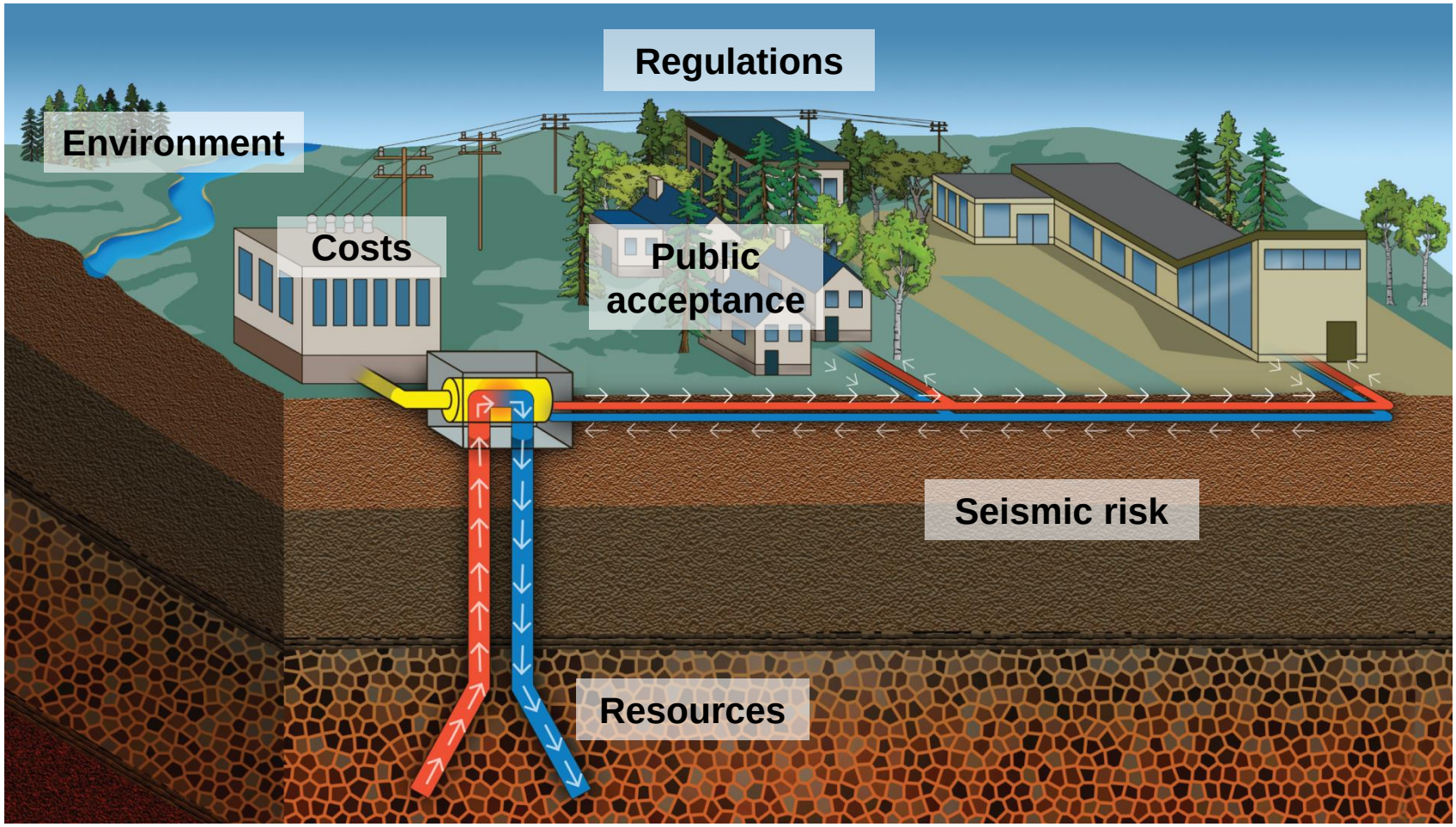
A TA-SWISS Study by Stefan Hirschberg, Stefan Wiemer, Peter Burgherr (eds.)

Research consortium:
4 organizations, 32 scientists

- Paul Scherrer Institute (PSI)
- Swiss Federal Institute of Technology (ETHZ)
- DIALOGIK/University of Stuttgart
- University of Applied Science Zurich

Advisory Board chaired by Dr. Gunter Siddiqi (Swiss Federal Office of Energy)

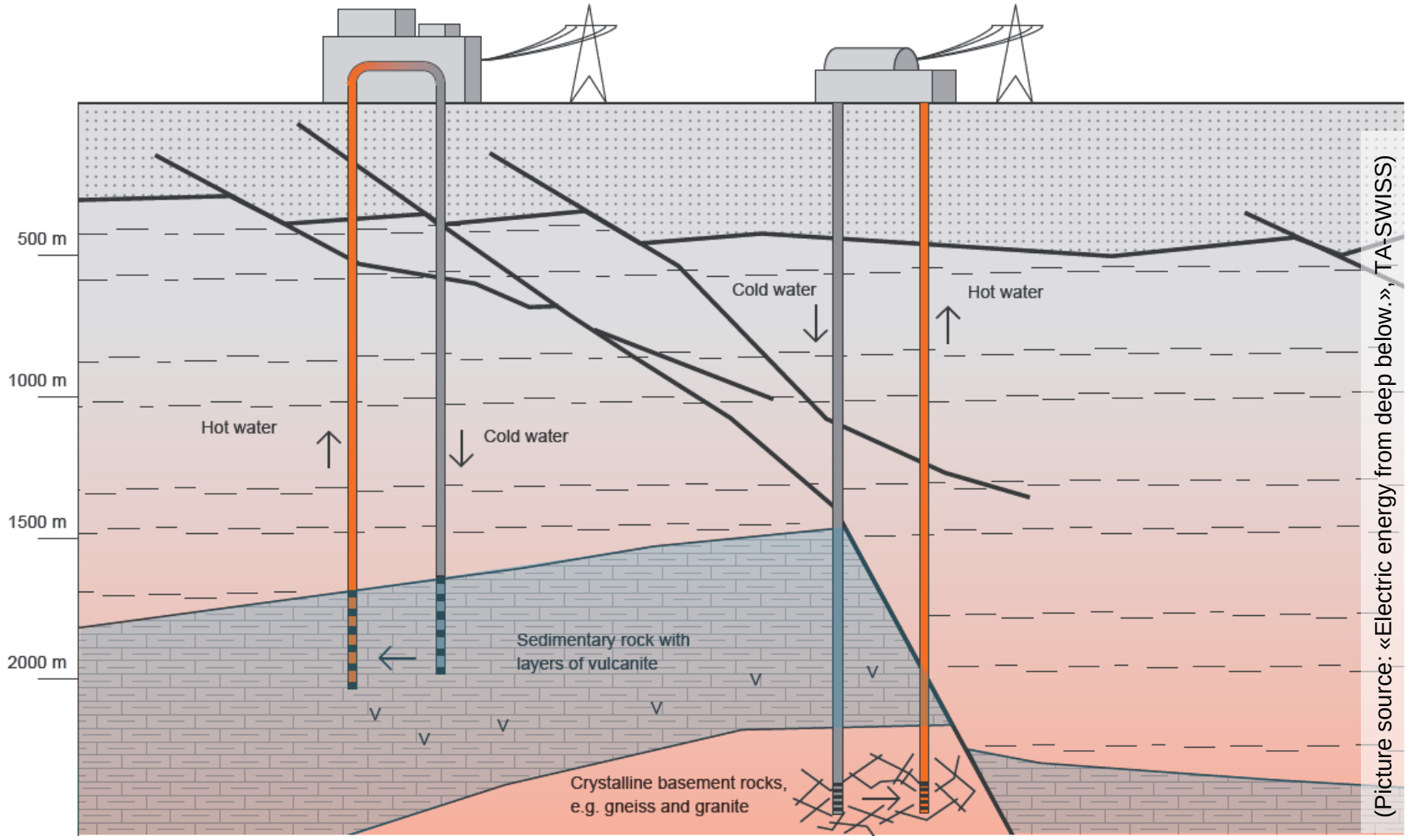
Deep Geothermal Energy: A TA-Topic



(Picture source: http://ntenergy.ca)

Hydrothermal Systems:
Direct use of geothermal energy
(hot water from natural aquifers)

Petrothermal Systems (HDR, EGS):
Stimulated reservoir system,
mainly in crystalline basement rock



(Picture source: «Electric energy from deep below.», TA-SWISS)

Status of technologies

Deep geothermal drilling: adapted from conventional oil & gas drilling → **mature and well-developed technology** with long standing experience.

Hydrothermal Systems:

- Mature technology
- 3 requirements:
  - High temperatures (>100 °C) in the subsurface (→ 3 km and below)
  - Water-bearing geological formations or structures
  - Adequate generation of hot water

Petrothermal Systems:

- EGS technology not mature
- Requisite temperature: 60 °C (→ 1.5 km and below)
- Potential: 10^{23} J (=100'000 x Swiss energy demand)
- Greatest challenge: controlling risk of induced seismicity

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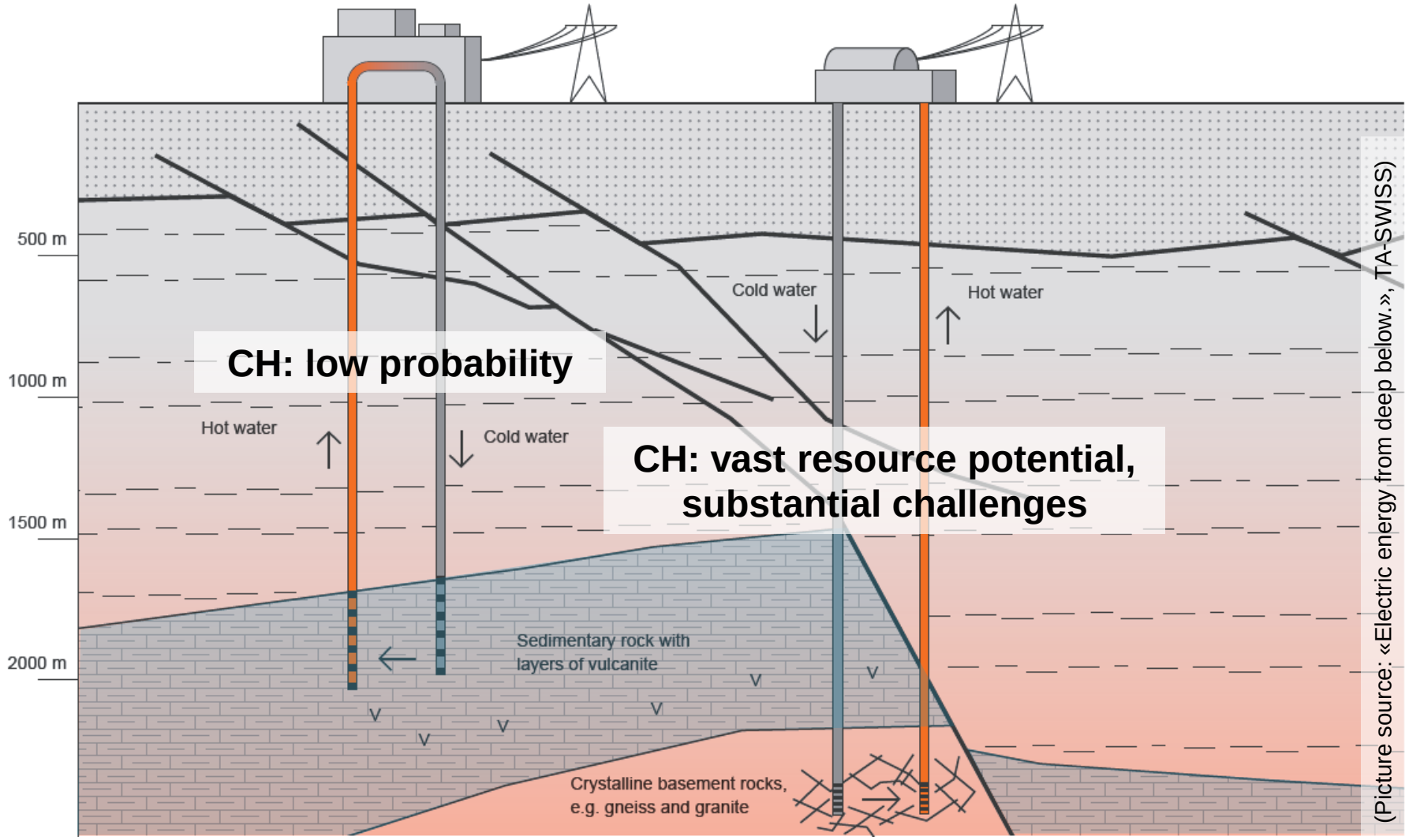
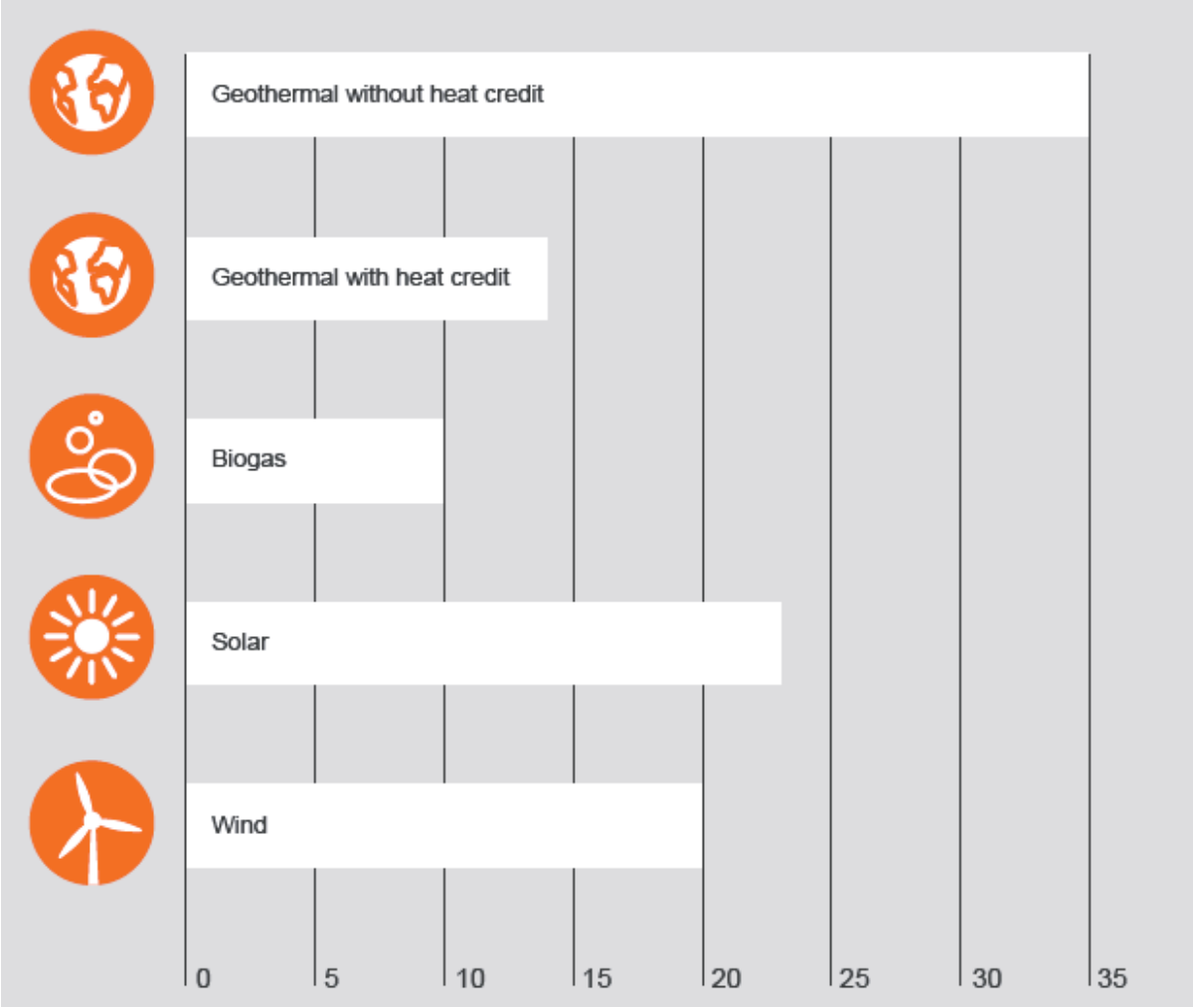


Average Generation Costs (Swiss Cents/kWh)

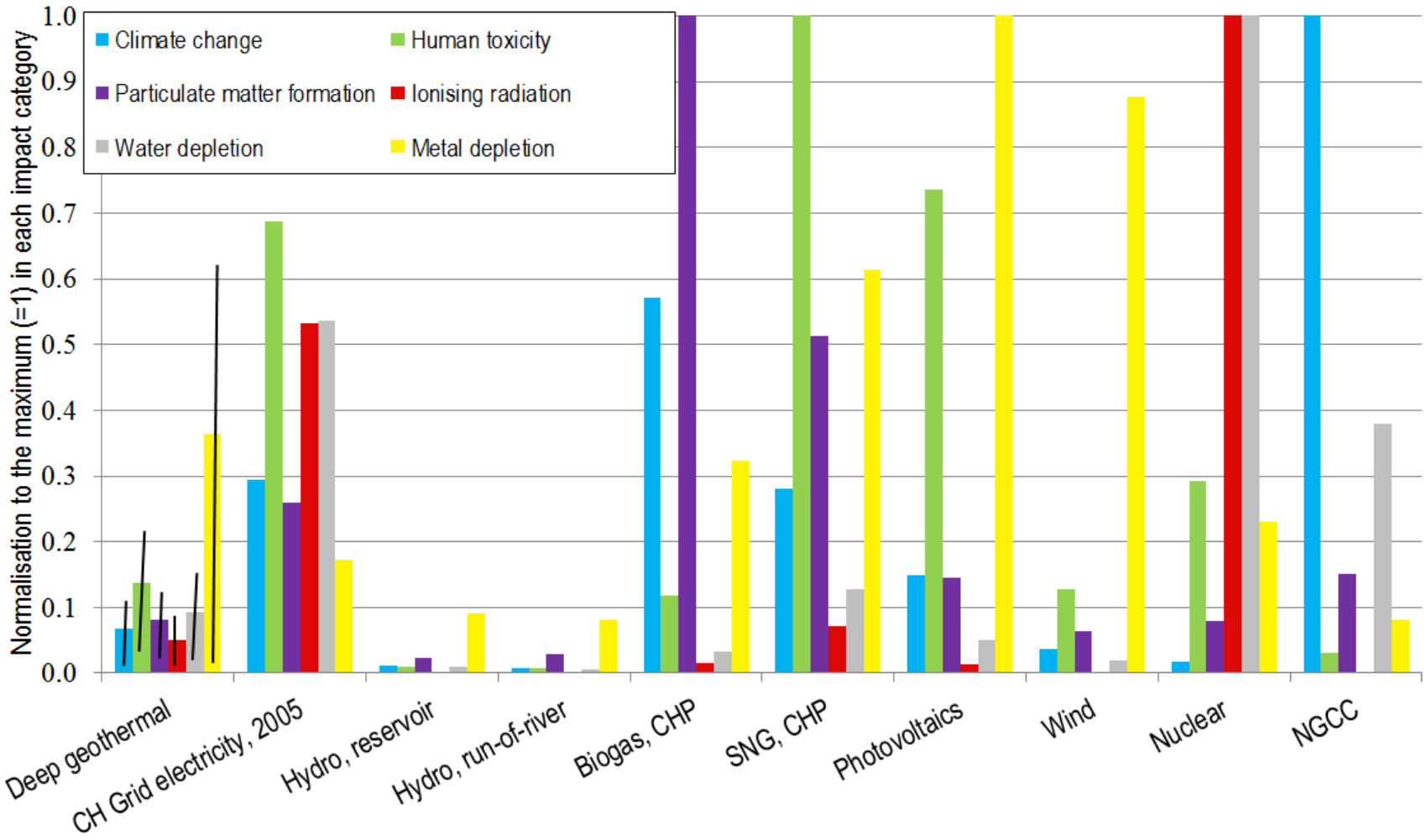


Economics: Results

- Swiss reference base case: estimated **average power generation cost of 35 Swiss cents/kWh** (fluctuation ranges from 18-61 Swiss cents/kWh)
- If **waste heat** could be sold, this reduces the **average cost to 14 Swiss cents/kWh**
- Well costs dominate (well number and life & drilling costs)

Heat credit can play a key role making geothermal power attractive
→ tension between heat market proximity and seismic sensitivity

Environment: LCA results



Environment: Results

- **Estimated greenhouse gas emissions: 8-46 g CO_2-eq/kWh**
- **Environmental impacts: lower** or in the same range as those from other electricity producing technologies

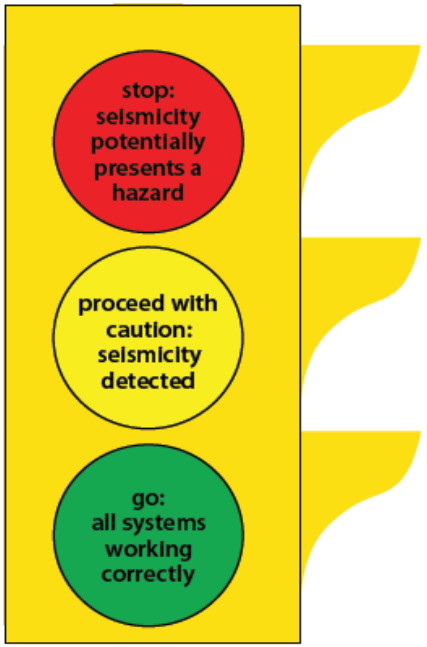
From the environmental perspective geothermal is attractive.

Risks

- The risks to human health and the environment, associated with **hazardous substances** (caustic soda, toluene and benzene) and on-shore well **blowout**, are relatively **low** but not insignificant.
- Both EGS and hydrothermal systems pose **risk of triggering earthquakes**
  - Experience in Switzerland: Basel (M 3.4) and St. Gallen (M 3.5)
- In view of the seismic risks, obtaining the appropriate insurance could be a factor having a substantial impact on the economics of geothermal energy.

Risks: Results

- **Seismic risk** dominates the risk profile
- **Induced Seismicity Risks can be assessed and mitigated, but not eliminated**
- → Goal: Keeping the seismic risk to people, the environment and infrastructures as low a level as reasonably practicable
- Models and strategies for minimizing earthquake risk must be validated, based on demonstration & pilot plants



It is ultimately a political and societal decision which level of (seismic) risk is acceptable.

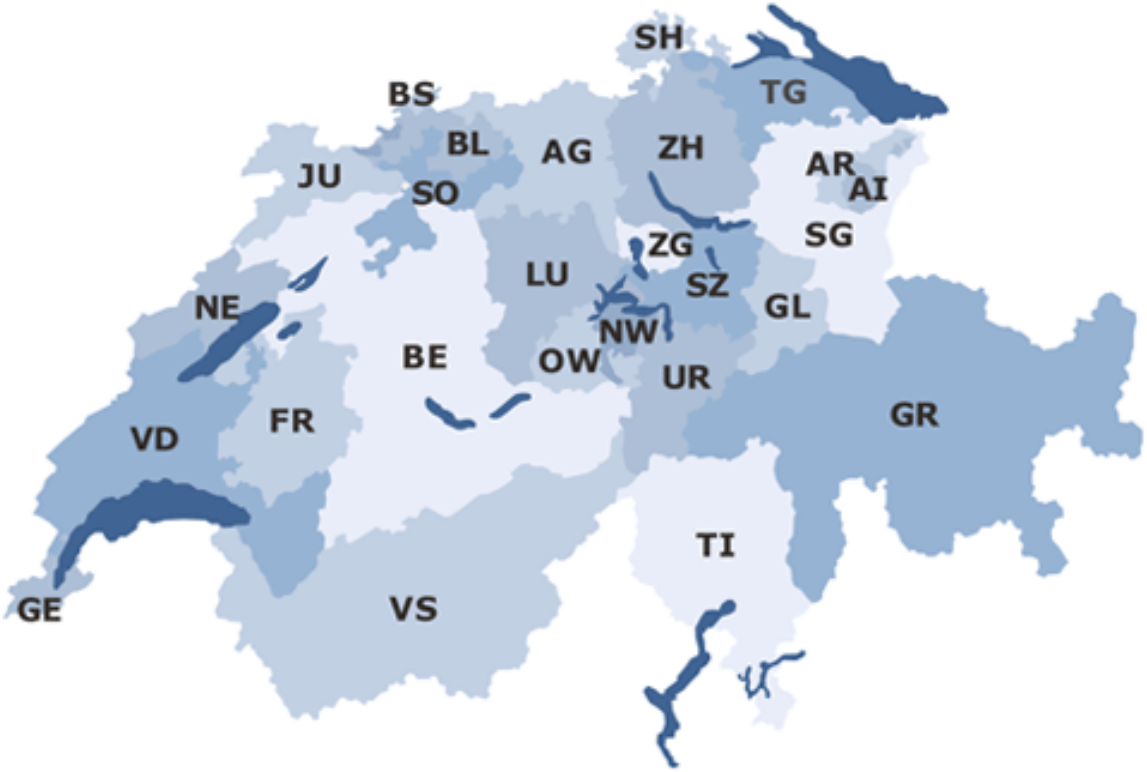
Public opinion: Results

- Public perception is highly volatile, with many people being ambivalent.
- Four different frames, i.e. **energy transition**, **risk**, **technology** and **costs**, were identified in the context of geothermal energy:
  - Politicians and public authorities do not emphasize a specific frame
  - Industry actors mainly favor the energy transition frame (i.e. potential)
  - Scientists clearly favor the risks frame (i.e., risks & uncertainties)
- Communication for geothermal projects should address **opportunities and challenges openly and transparently** (including risks and the strategies for minimizing them).

Information provided must be clear, balanced, and easy to understand.

All interest groups must be involved at the earliest possible time.

Switzerland - a complex, federal system



26 cantonal governments responsible for land and (ground)water use, forest clearance etc.

Legal aspects: Results

- The present process is extremely **complex, confusing and tedious**.
- It is recommended that the cantons enact regulation on the use of the deep subsurface.
- The focus should be on **accelerating the process**: for example by combining planning approval and the concessions process in one office (the concentration model).

A uniform regulatory framework is important for a simpler and accelerated process.

Deep Geothermal Energy: In a Nutshell

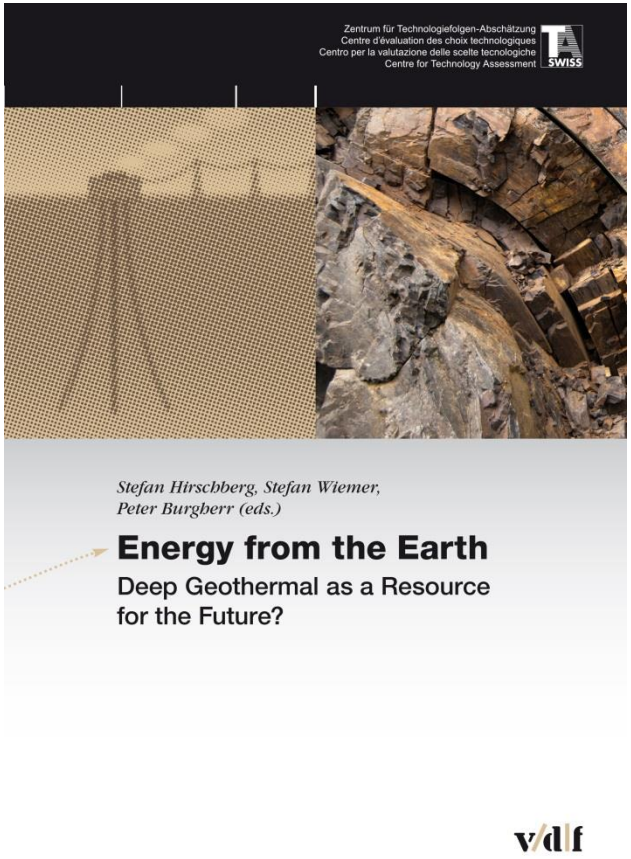
Chances:

- **Vast energy resource**
- **Environmental friendliness** with minimal CO_2 emissions
- **Security of supply** → not dependent on weather conditions, reliable supplies of **baseload power**
- If waste heat could be sold, geothermal power would be **cost-competitive**

Risks:

- **Risk of induced earthquakes**
- Geological characteristics of the subsurface remain largely unknown → Exploration involves **financial risks**
- **Public opinion** is neutral to moderately positive, but also ambivalent → attitudes to geothermal energy could rapidly shift

More information? Visit our website!



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  TA-SWISS Study, Stefan Hirschberg, Stefan Wiemer, Peter Burgherr (eds.), vdf Hochschulverlag AG (524 pages)

  Download open access:

  www.vdf.ethz.ch/vdf.asp?isbnNr=3654

- **Electric energy from deep below.**

  Abridged version of the TA-SWISS study. Centre for Technology Assessment (ed.), TA-61A/2014 (16 pages)

  www.ta-swiss.ch/en/publications/2015/

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