Institut für Energetik und Umwelt

Institute for Energy and Environment

Forschung,
Entwicklung,
Dienstleistung für
- Energie
- Umwelt

Workshop "Electricity Generation from Enhanced Geothermal Systems"

Summary

Martin Kaltschmitt, Stephanie Frick

Mid-Term Conference, Potsdam, 11th January 2007

in cooperation with
Institute for Environmental Technology and Energy Economics
Technische Universität Hamburg-Harburg

ENGINE – **EN**hanced **G**eothermal **I**nnovative **N**etwork for Europe
Workshop 5, **Electricity generation from Enhanced Geothermal Systems**
Hôtel Régent, Strasbourg, 14-16 September 2006, France

Timetable (1/2)

Thursday, 14 September 2006

08:30-10:30	WP5 Meeting	
10:30-11:00	***Coffee Break***	
Session 1	**Introduction and Overview of Electricity Generation from Enhanced Geothermal Systems**	
11:00-11:15	Opening address	Laurent LE BEL
11:15-11:35	Status of Geothermal Electricity Generation in Europe	Martin KALTSCHMITT
11:35-12:05	The Organic Rankine Cycle – Power Production from low Temperature Heat	Hartmut SPLIETHOFF
12:05-12:35	Low Enthalpy cycles – Power Plant Concepts	Silke KÖHLER
12:35-13:00	*Discussion*	
13:00-14:00	***Lunch Break***	
Session 2	**Producer an Manufacturer of ORC-Technology**	
14:00-14:20	ORMAT: Projects and challenges	Hilel LEGMANN
14:20-14:40	Geothermal power generation by GEOCAL®	René NIESNER
14:40-15:00	Turboden ORC systems	Mario GAIA
15:00-15:20	Enex Binary Plant	Lilja TRYGGVADÓTTIR
15:20-15:35	*Discussion*	
15:35-15:50	***Coffee Break***	
Session 3	**Producer and Manufacturer of Kalina-Technology**	
15:50-16:10	Geothermal Turnkey Power Generation Solutions by Siemens	Sameer JOSHI
16:10-16:30	exorka	Magnùs GEHRINGER
16:30-16:50	Kalina and Organic Rankine cycles: how to choose the best expansion turbine?	Frédéric MARCUCCILLI
16:50-17:10	The new Generation Kalina Cycle	Manfred ENGELHARD
17:10-17:25	*Discussion*	
19:00-21:30	***Workshop Dinner***	

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Friday, 15 September 2006

Session 4	**Possibilities and Restrictions of Cooling Systems**	
09:05-09:35	Geothermal Binary Plants: Water or Air Cooled	Dimitrios MENDRINOS
09:35-09:55	Experience in running geothermal power plants in severe climate conditions in Russia	Oleg POVAROV
09:55-10:10	*Discussion*	
Session 5	**Running and Forthcoming ORC-Projects**	
10:10-10:30	ORC Power Plant Neustadt-Glewe Operational Experience since 2004	Thomas FUNKE
10:30-10:50	ORC plant Altheim – a progress report	Gerhard PERNECKER
10:50-11:05	*Discussion*	
11:05-11:20	***Coffee Break***	
11:20-11:40	ORMAT ORC-units for industry and Geothermics	Christian SCHOLZ
11:40-12:00	Power Production in HFR Soultz Project	Philippe LUTZ
12:00-12:20	Possible evolution of a small double-flash geothermal unit (5 MW)	Dominique TOURNAYE
12:20-12:45	*Discussion*	
12:45-13:45	***Lunch Break***	
Session 6	**Running and Forthcoming Kalina-Projects**	
13:45-14:05	The Kalina power plant in Husavik - why Kalina and what has been learned	Pall VALDIMARSSON
14:05-14:25	Presentation of Geothermal Project "Unterhaching", Germany	Ch. SCHOENWIESNER-BOZKURT
14:25-14:40	*Discussion*	
14:40-15:00	***Coffee Break***	

Saturday, 16 September 2006

08:00-17:00 ***Basel drilling site visit***

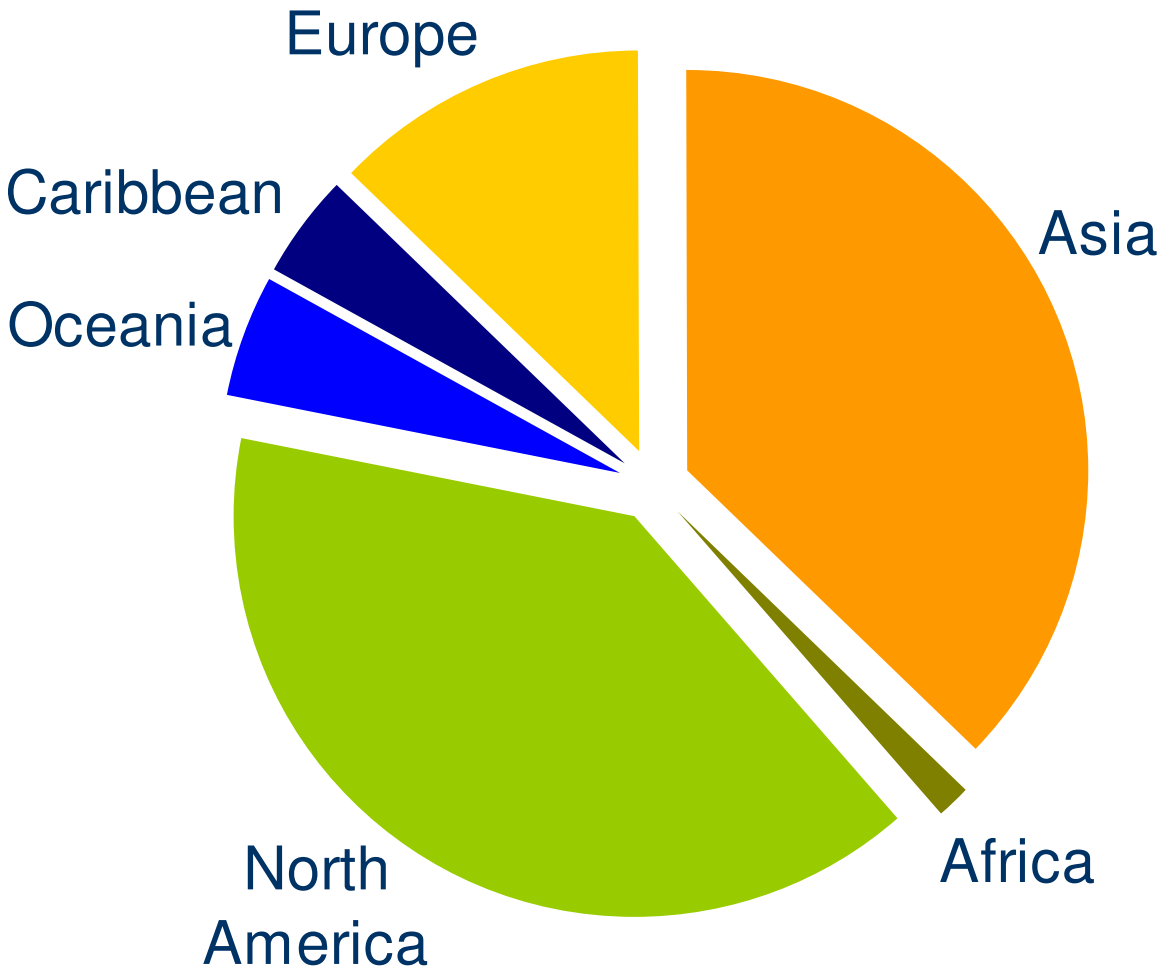
A bus will drive the participants during the day

Departure from Strasbourg station 8:00	Arrival in Basel 10:00
Drilling site visit 10:00 to 12:00	Lunch 13:00 to 14:30
Strasbourg airport 16:30	Back to Strasbourg station 17:00

Agenda

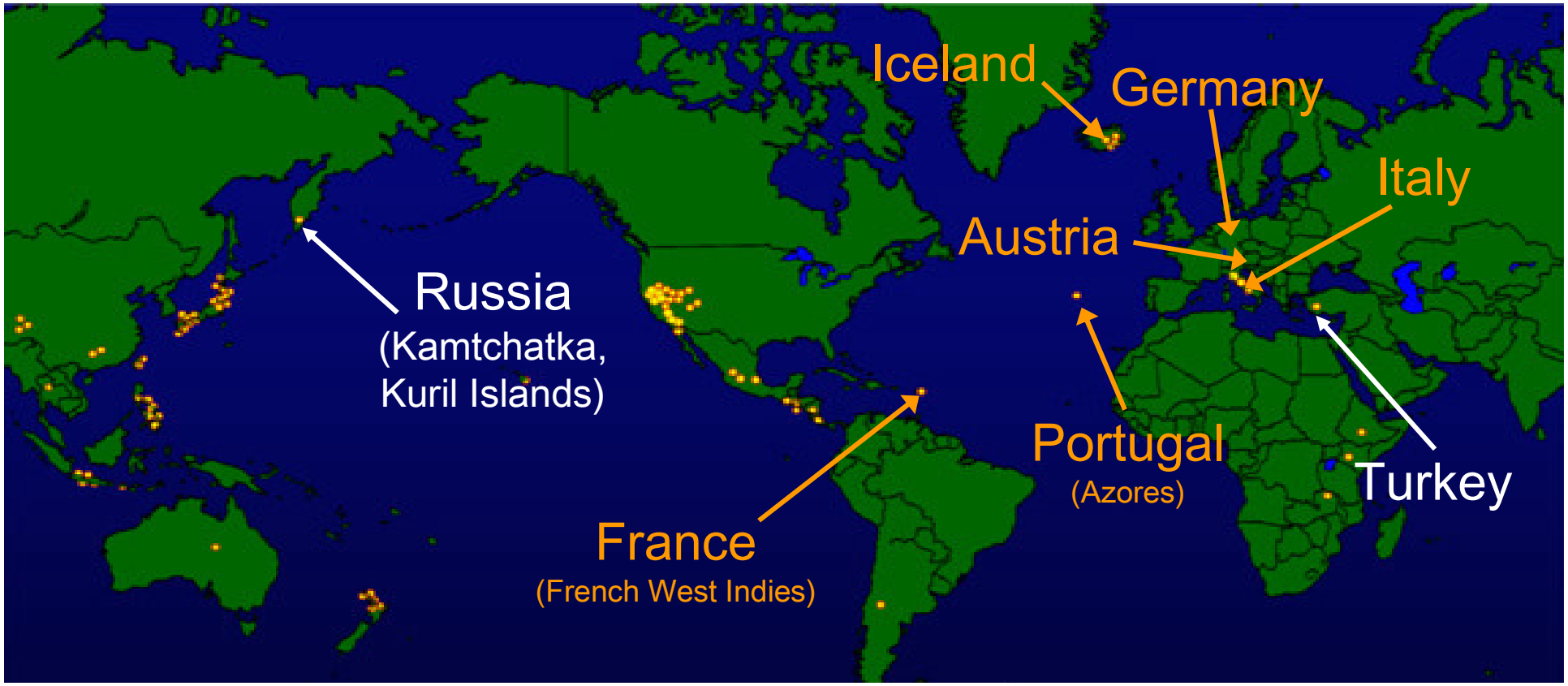
- Introduction
- Geothermal electricity production
- Open questions
  - ORC or Kalina cycle
  - Axial or radial turbines
  - Air or water cooling
  - Fancy or proven technology
  - Power or CHP
- Conclusions

Worldwide Geothermal Power Production



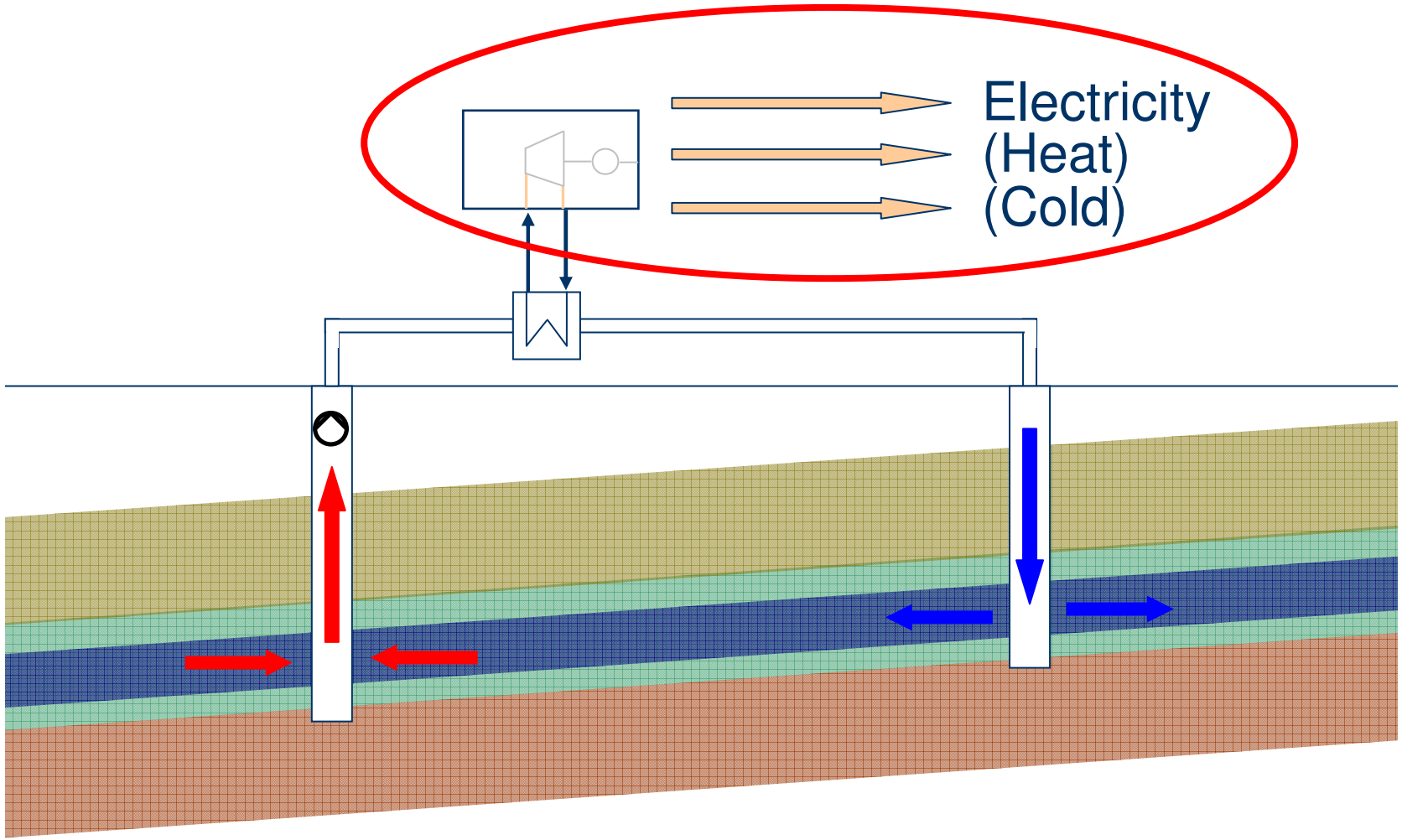
- 8,863 MW_{el} worldwide installed geothermal capacity
- 57 TWh/a produced electricity
- 6,400 full load hours in average

Geothermal Power Production in Europe

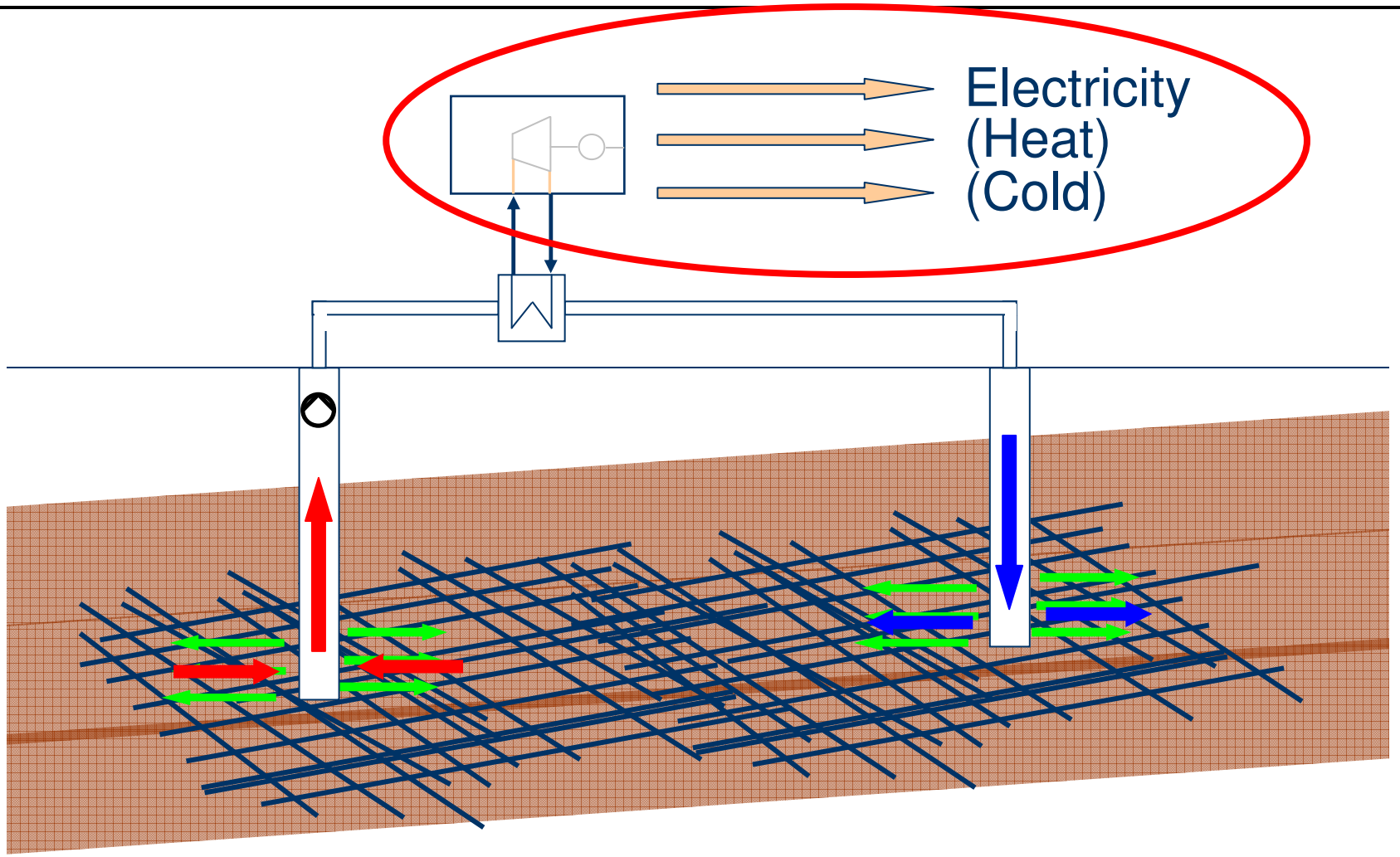


Source: IGG (A. Manzella)

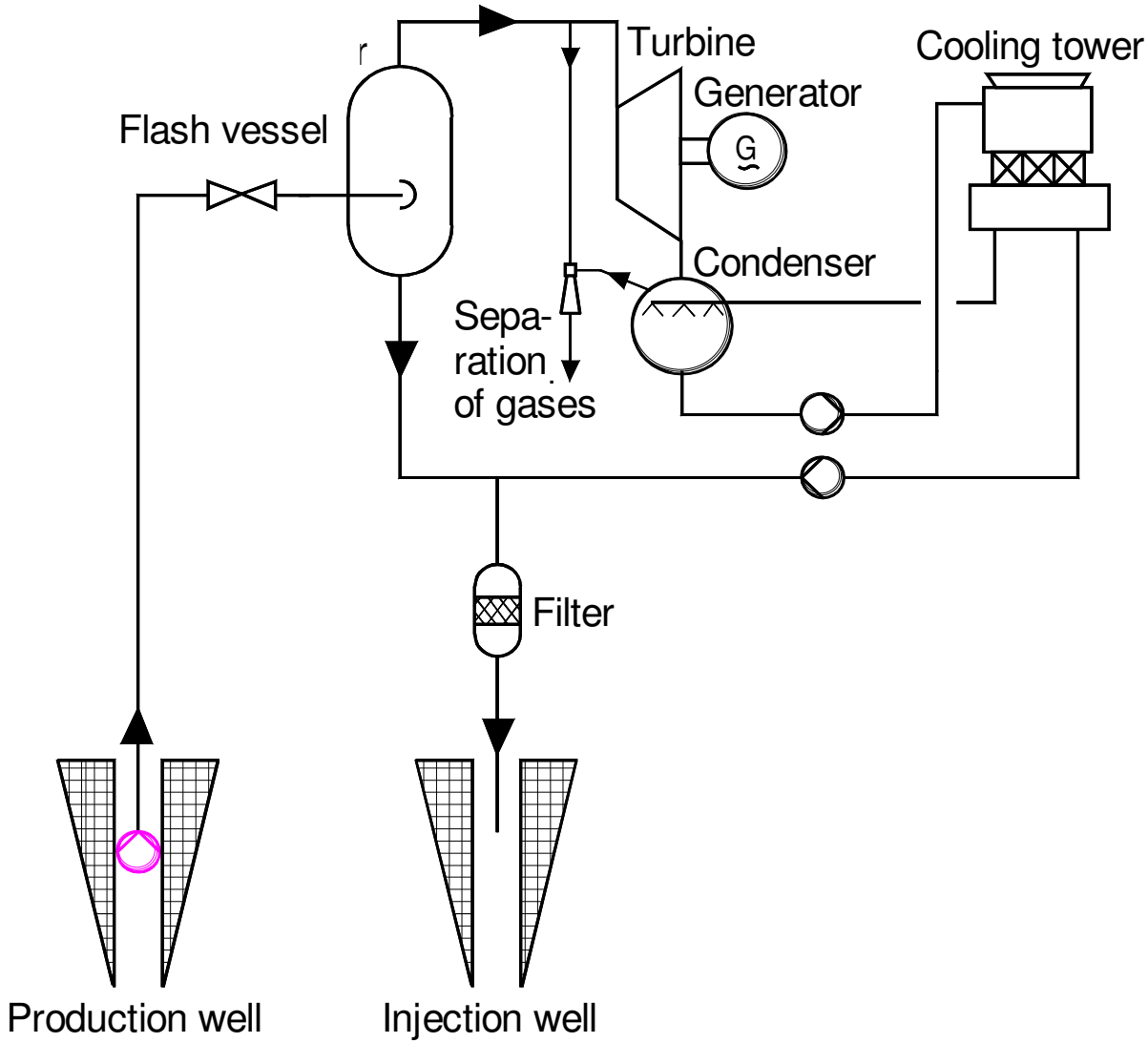
Geothermal Power Generation
- Aquifer -



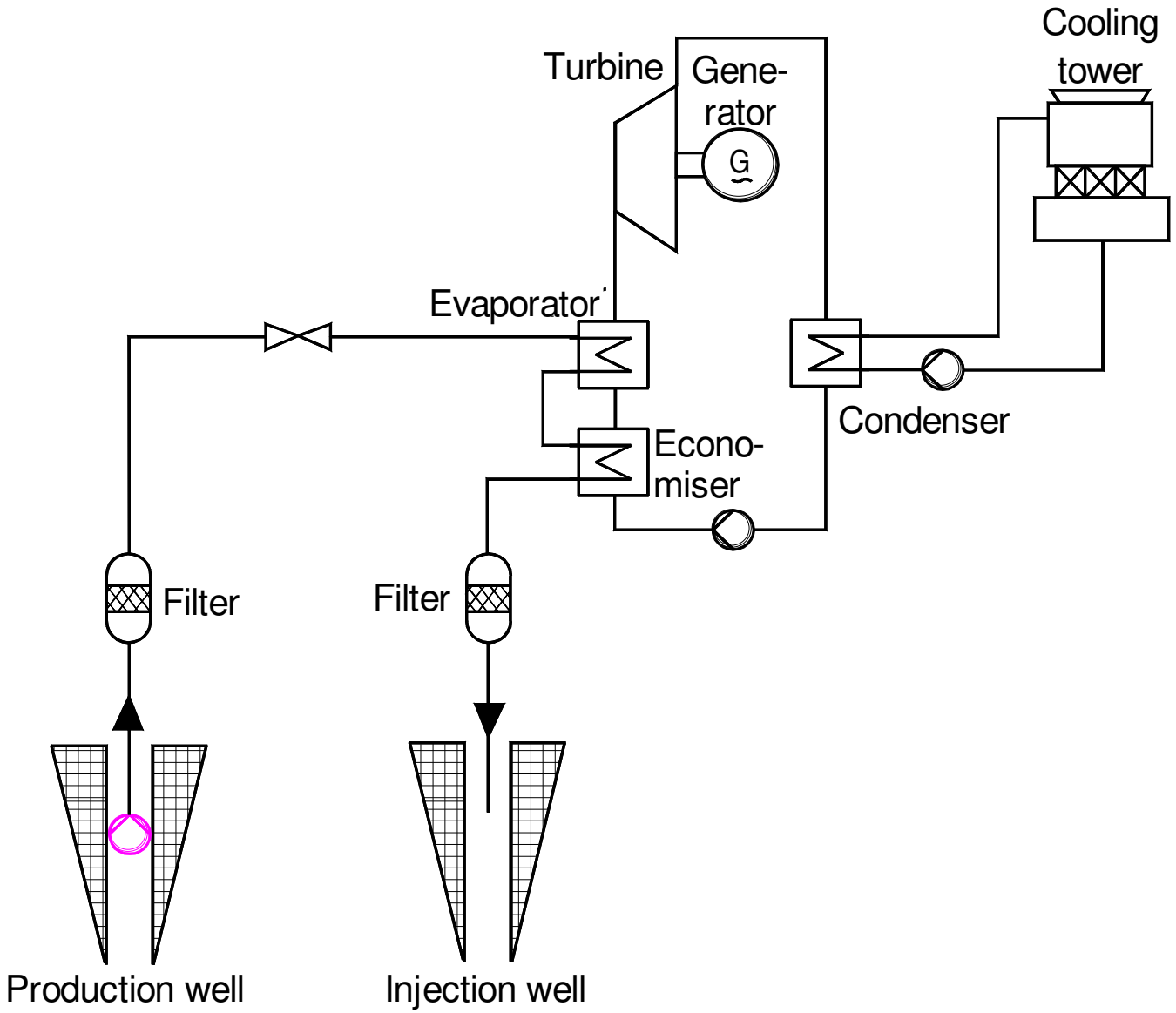
Geothermal Power Generation
- Bedrock -



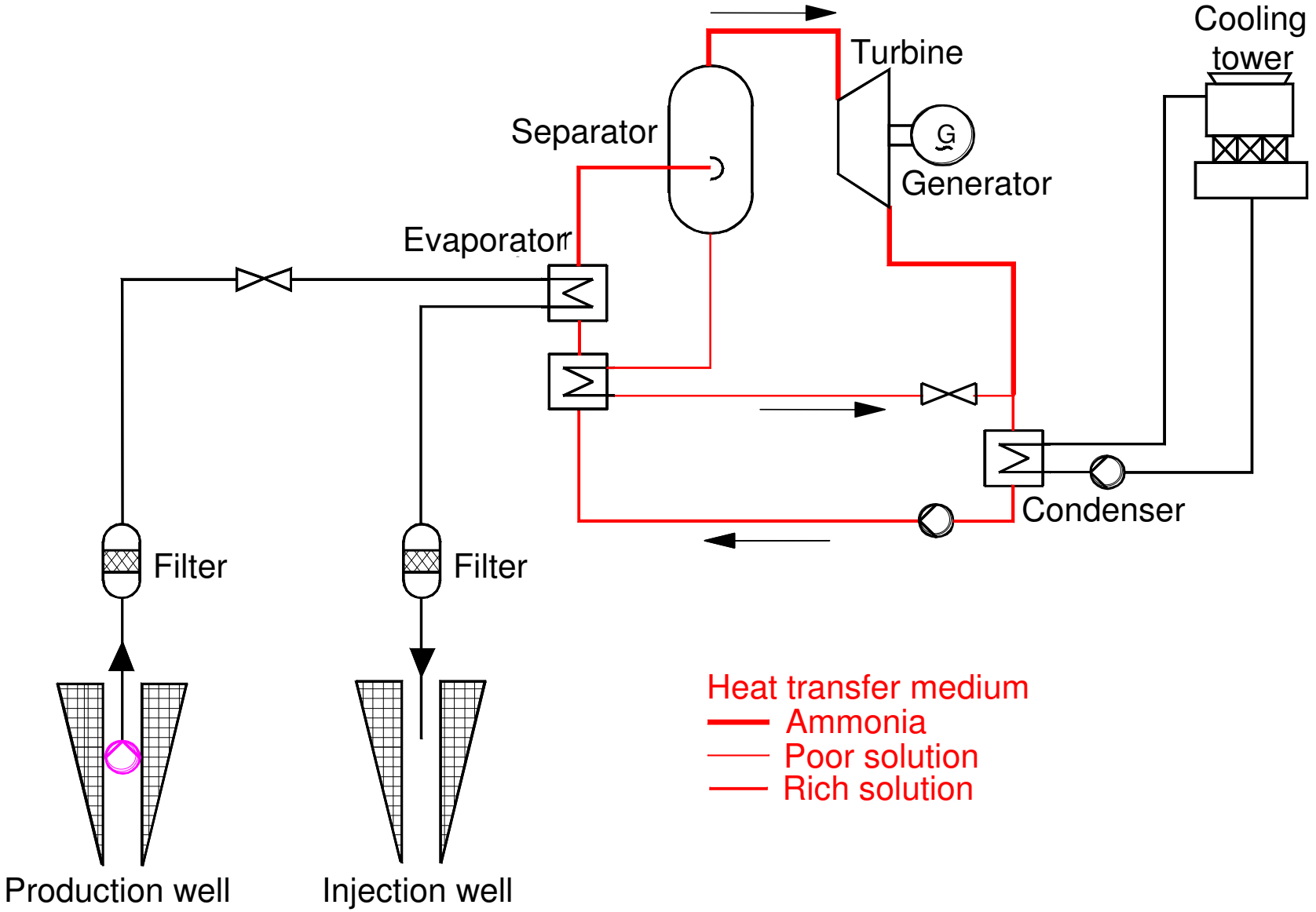
Geothermal Power Generation
- Open System -



Geothermal Power Generation
- Closed System: Organic Rankine Cycle -



Geothermal Power Generation
- Closed System: Kalina Cycle -



Open Questions
- ORC or Kalina Cycle -

- Geothermal electricity generation from low enthalpy resources is realized in binary plants.
- Two types of binary cycles are available:
  - Organic Rankine Cycle (ORC) (i.e. a Rankine cycle running with a working fluid evaporating at low temperatures)
  - Kalina cycle (i.e. a Rankine cycle being fed working with a mixture of two substances like e.g. NH_3 and water)
- Pros and cons
  - Kalina cycle promises higher efficiencies within a certain temperature window (below 130 to 140 °C)
  - A cycle with a mixture of two substances with a varying mixing ratio needs an ambitious and expensive technology
  - So far only one Kalina cycle is operated with geothermal energy. But there are numerous ORC plants under operation worldwide.
- These cycles have more in common than being contrary. And each cycle has for a certain application at a specific spot specific pros and cons.
- Both cycles show a significant optimisation potential concerning the design of e.g. the working fluid, the cycle, the turbine and the cooling system.
- The question is not ORC or Kalina cycle. The task is to find the right cycle for the circumstances given at a certain location.

Open Questions
- Axial or Radial Turbines -

- The turbine used within an ORC or a Kalina cycle is in most cases an axial inflow type.
- This is derived from the conventional water steam turbine industry where axial turbines are state of technology due to their promising performance within the respective application.
- The design parameters of the turbine used in cycles driven by geo-thermal energy from low enthalpy resources can vary decisively com-pared to a "classic" turbine used within a steam cycle (e.g. enthalpy drop, stream and rotor velocity).
- Therefore radial inflow turbines can lead under certain conditions to higher efficiencies.
- Thus considering the (economic) importance of optimising the efficiency of such cycles under the conditions defined by the geothermal reservoir without raising the overall complexity of a cycle radial turbines could be a promising opportunity.
- Therefore the question is not to use axial or radial turbines. The point is to choose the turbine type promising the highest efficiencies at lowest risks and minimised costs – without any ideology & predefined opinions.

Open Questions
- Air or Water Cooling -

- An power plant could be operated with air or water driven cooling systems.
- Air cooled power plants have among others the following pros and cons.
  - They are independent from the water availability.
  - They can be operated at temperatures significantly below zero.
  - They have to face seasonal changes in cooling temperatures (i.e. the cooling power changes throughout the year).
  - The running fans need a considerable amount of energy and space; noise emissions could be a problem.
- Water cooled power plants have among others the following pros and cons.
  - They could realise lower and over the year more constant condensation temperatures and pressures compared to air cooled systems.
  - They allow for a larger enthalpy drop in the turbine and thus slightly higher efficiencies compared to air cooled systems.
  - They need a certain mass flow of water in a defined quality.
  - At the cold end a certain water temperature level has to be guaranteed.
- Thus the question "air or water cooling" has to be solved site specific.
  - If e.g. enough water is cost efficient available probably a water cooling system will be implemented due to economic reasons.
  - If this is not the case there is only the chance to go for an air cooling system or even a combined system.

Open Questions
- Fancy or Proven Technology -

- Fancy ("high efficiency – high risk") or proven ("low efficiency – low risk") technology is a matter of the viewpoint resp. of the philosophy.
- Aiming for low risks one can get good and reliable power plant technology characterised often by relatively low overall efficiencies.
- Accepting a slightly higher risk one will find cycles which promise considerably higher overall efficiencies with the disadvantage that these cycles do exist so far maybe only as a demonstration plant or even only on paper.
- Thus the question is not to go for fancy or proven technology. The question is what technological risk a project can / will accept for the profit the project strives for.
- This optimisation problem is in most cases not solved by the project developer; often the bank or the investor decides what risk might be taken.
- Because the risk finding a reservoir suitable for an economic viable project is in most cases quite high most projects go for proven and well known power plant technology in order to minimise the overall risk.
- This attitude makes it very difficult for new and innovative technologies to break into the market. Therefore the provision of public money for demonstration projects is often important in order to prove technical feasibility of new technologies to allow them the market access.

Open Questions
- Power or CHP -

- Converting low enthalpy resources to electricity produces considerable amounts of waste heat.
- The consequence – regarding the relatively high investments of geothermal power production from low enthalpy resources – is therefore to try to sell this heat on the local heat market and realise combined heat and power (CHP) projects like i.e. in Húsavik, Iceland, or in Neustadt-Glewe, Germany.
- In order to further optimise this economic win-win-situation under the given frame conditions it might be even more promising to run a geothermal CHP plant heat leaded instead of aiming for the highest power output.
- Therefore the goal should always be to find a way to sell the heat locally respectively to identify a location where a heat demand is given to improve the economic performance of a geothermal power plant running on low enthalpy geothermal resources.

Conclusions

- By optimising geothermal power plants technical, economic and environmental aspects as well as the site specific frame conditions needs to be considered in order to allow for economic viable projects.
- Therefore the discussion about the pros and cons of ORC vs. Kalina cycle, air vs. water cooling, fancy vs. proven technology and power vs. CHP is not really helpful.
- Thus the main task is to take care of the site specific conditions and clarify the risks which can be taken. Based on this the project as a total needs to be optimised free of predefined opinions.
- With increasing technical effort (and higher costs) and innovative ideas the efficiency (and thus the income) of a geothermal power plant can mostly be improved. But new and innovative technologies are always connected with technical and financial risks. These risks need to be reduced which is mostly not possible on a purely commercial basis. Here the government is asked to support the market access of such new and innovative technologies.
- Geothermal electricity production can also be promoted in combination with other sources of energy (e.g. biogas plants). Such new concepts of combining different energy options can result in a higher overall efficiency and thus better profitability.

Thank you very much for your attention!

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