Geothermal Applications

Geothermal Cooling

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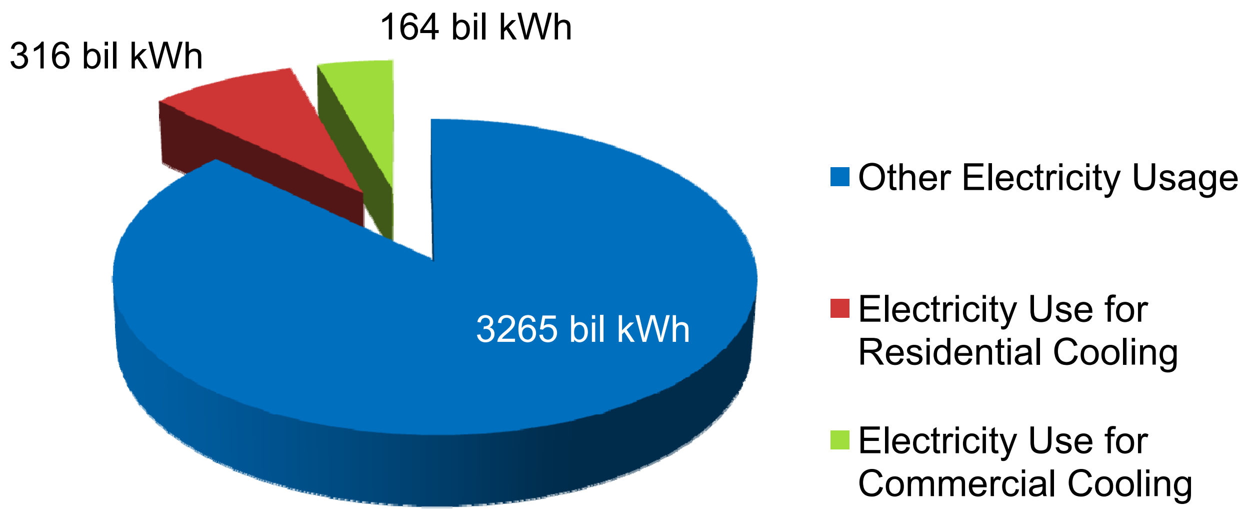
Outline

1	Cooling Demand: Worldwide, Energy, Costs
2	Principles of Cooling Technology
3	District Cooling
4	Geology and Geothermal for Cooling Purposes
5	Geothermal Cooling and District Cooling
6	Geothermal Cooling – Example from Qatar
7	Conclusion

Cooling Demand USA 2010

- Residential cooling energy consumption: 315 billion kWh
- Commercial cooling energy consumption: 164 billion kWh
- Together 12 % of total U.S. electricity consumption
- 9.2 Cent / kWh



U.S. Electricity Consumption 2010

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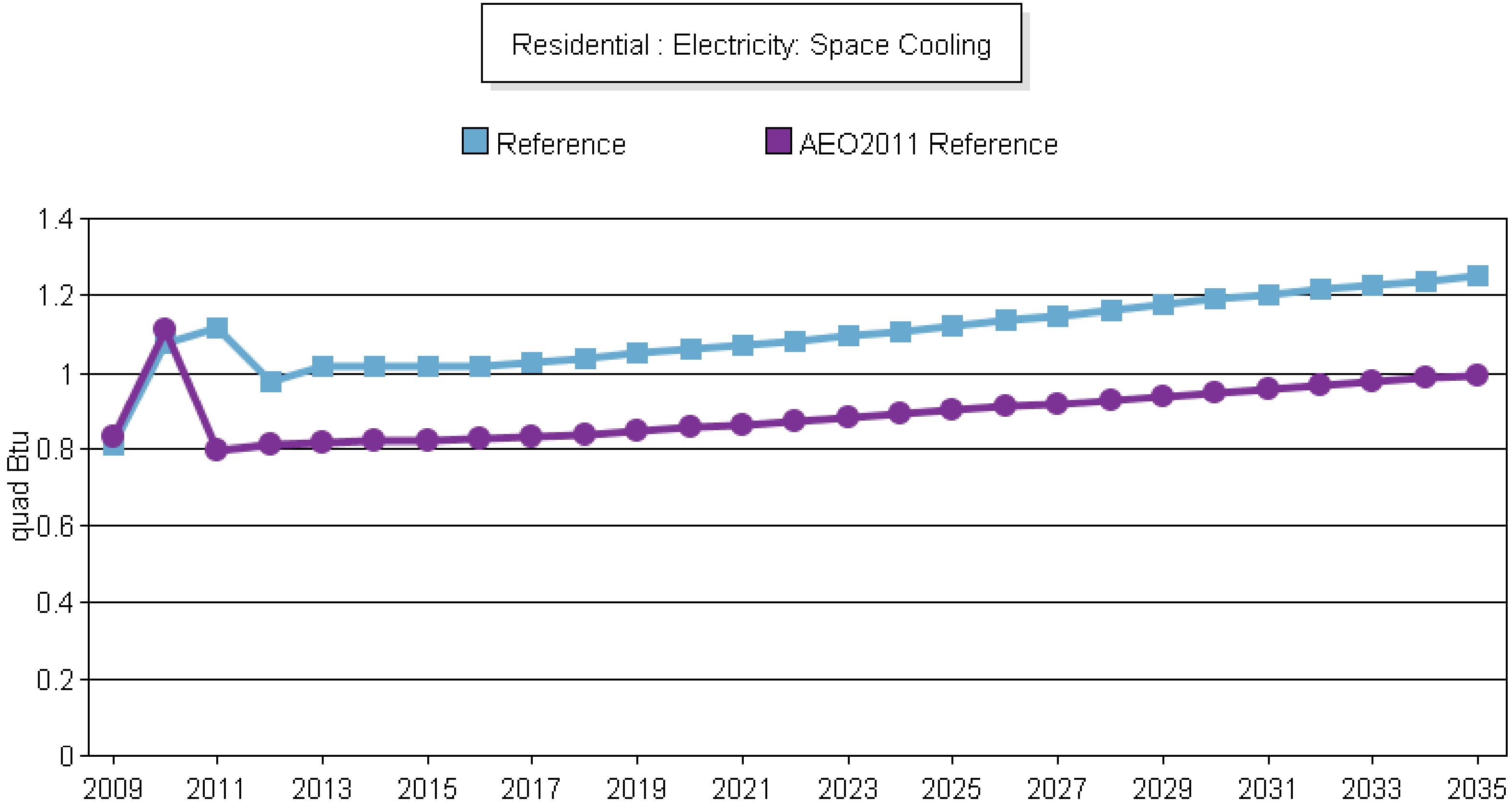
Cooling Demand USA Projection

- EIA projection to 2035 Residential Cooling Demand



Independent Statistics & Analysis
U.S. Energy Information Administration

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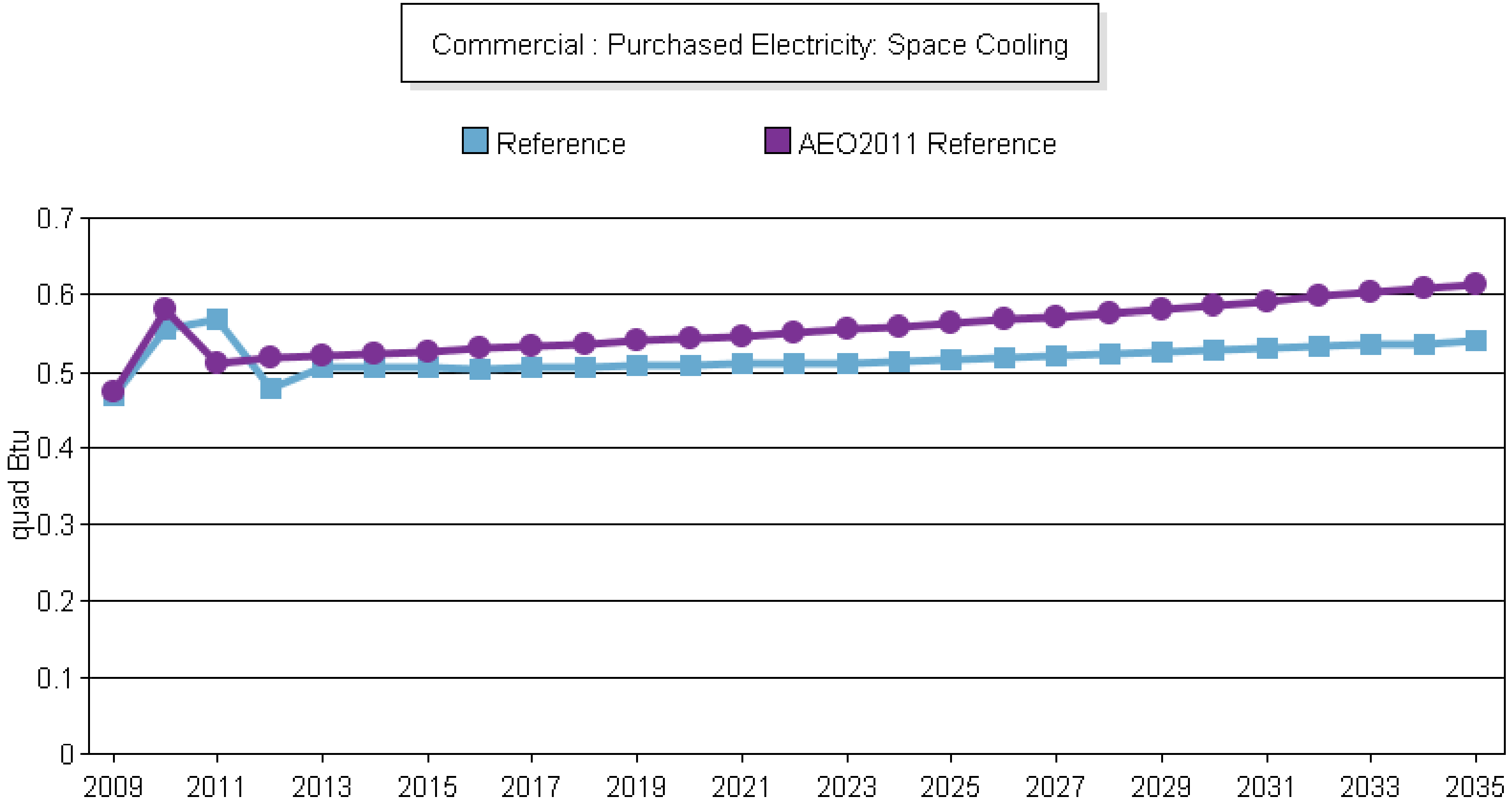
Cooling Demand USA Projection

- EIA projection to 2035 Commercial Cooling Demand



Independent Statistics & Analysis
U.S. Energy Information Administration

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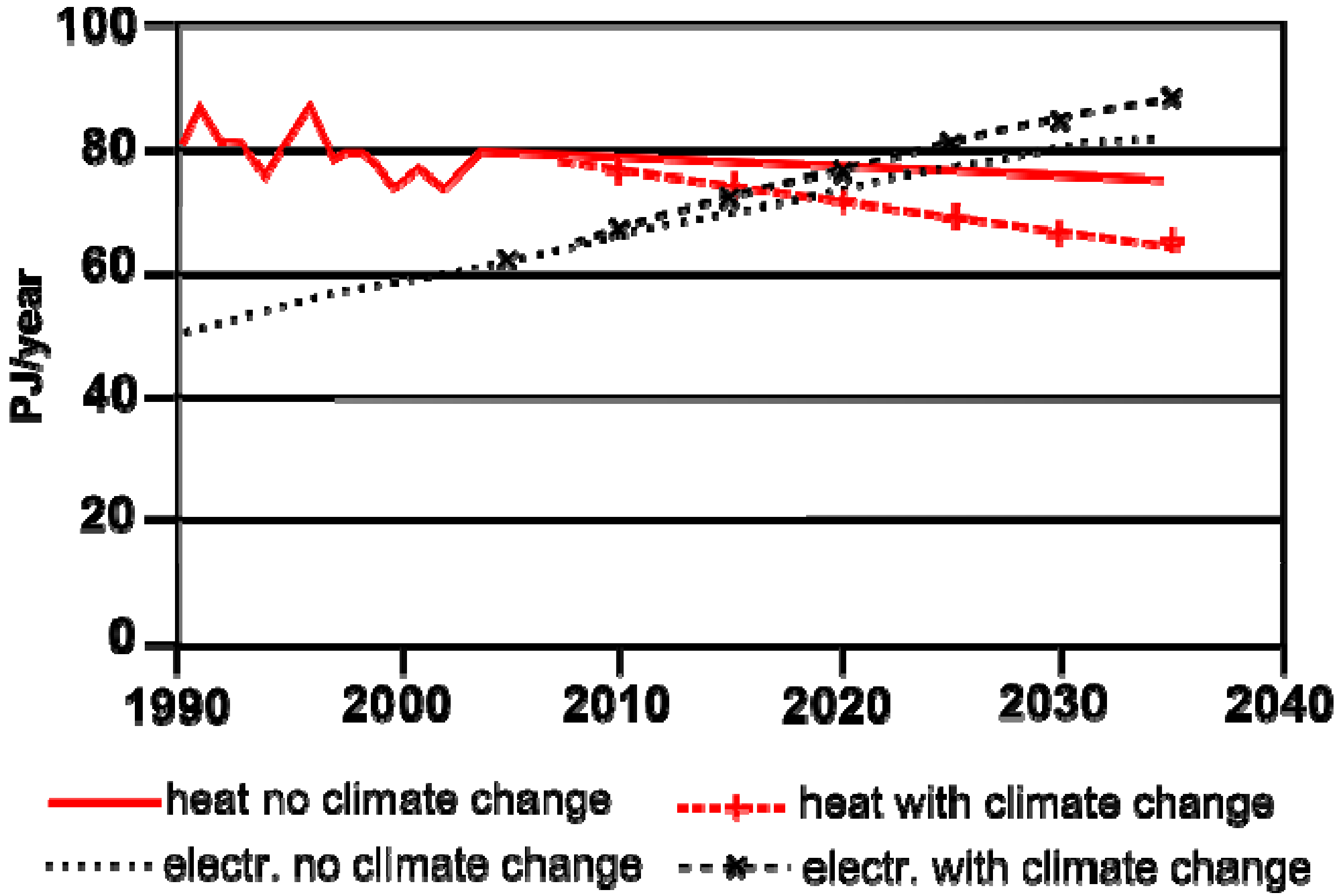
Cooling Demand Europe Projection

- Increasing electricity demand in Europe for cooling



modified after Aebischer et al. (2007)

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Existing Cooling Technologies

- Air-cooled chillers
- Water-cooled chillers
- Evaporative-cooled chillers
- Dry fluid coolers

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Cooling energy mostly produced by fossil fuels

→

- Cost extensive
- CO_2 emissions
- Negative environmental impact

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Principles of Cooling Technology

- Functional principle based on the evaporation cycle of a binary system:
  - Evaporation of cooling agent
  - Refrigerant bound in vaporous high pressure to a sorption agent or solvent
  - Sorption agent is replenished to evaporation process after thermal expulsion
  - Transfer of cooling energy to end consumer via pipeline network
- Absorption chiller: evaporation cycle NH_3/water or water/Li-Br
- Adsorption chiller: evaporaton cycle solid agent, e.g. Si-gel/water

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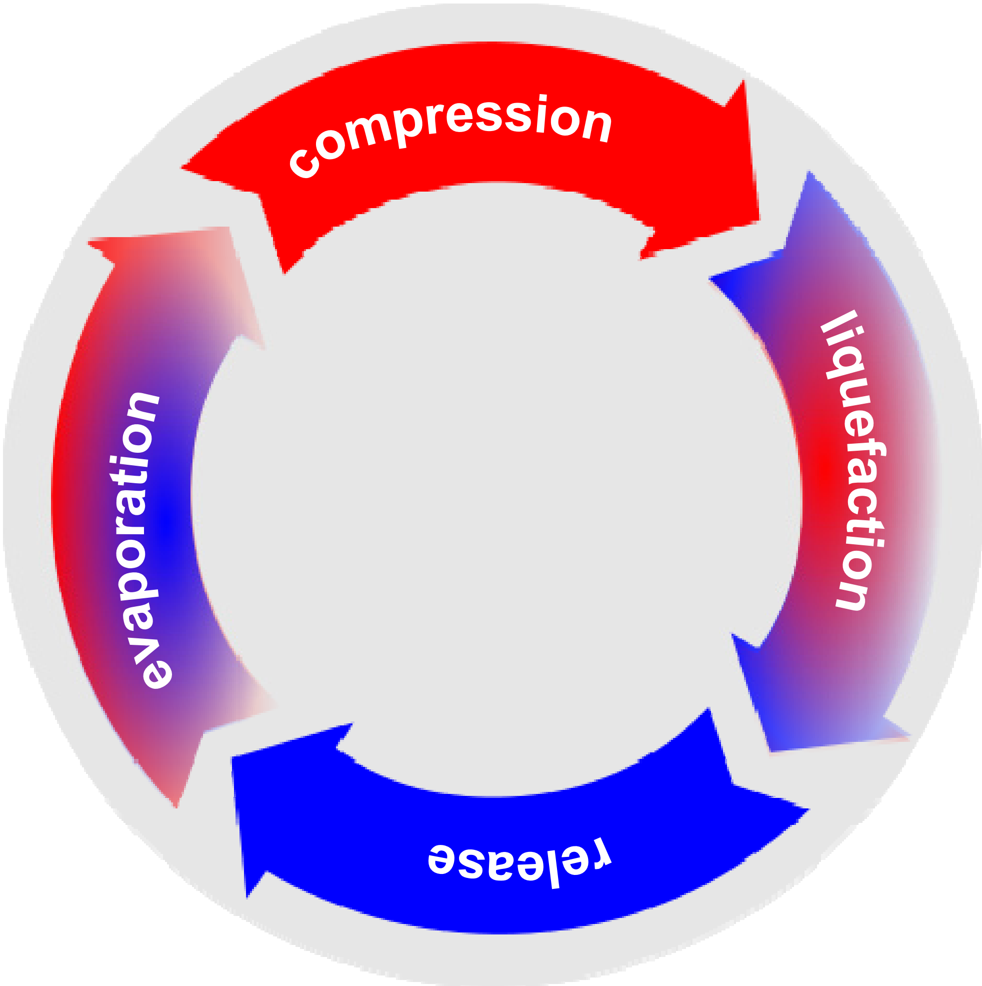
Scheme of cooling processes

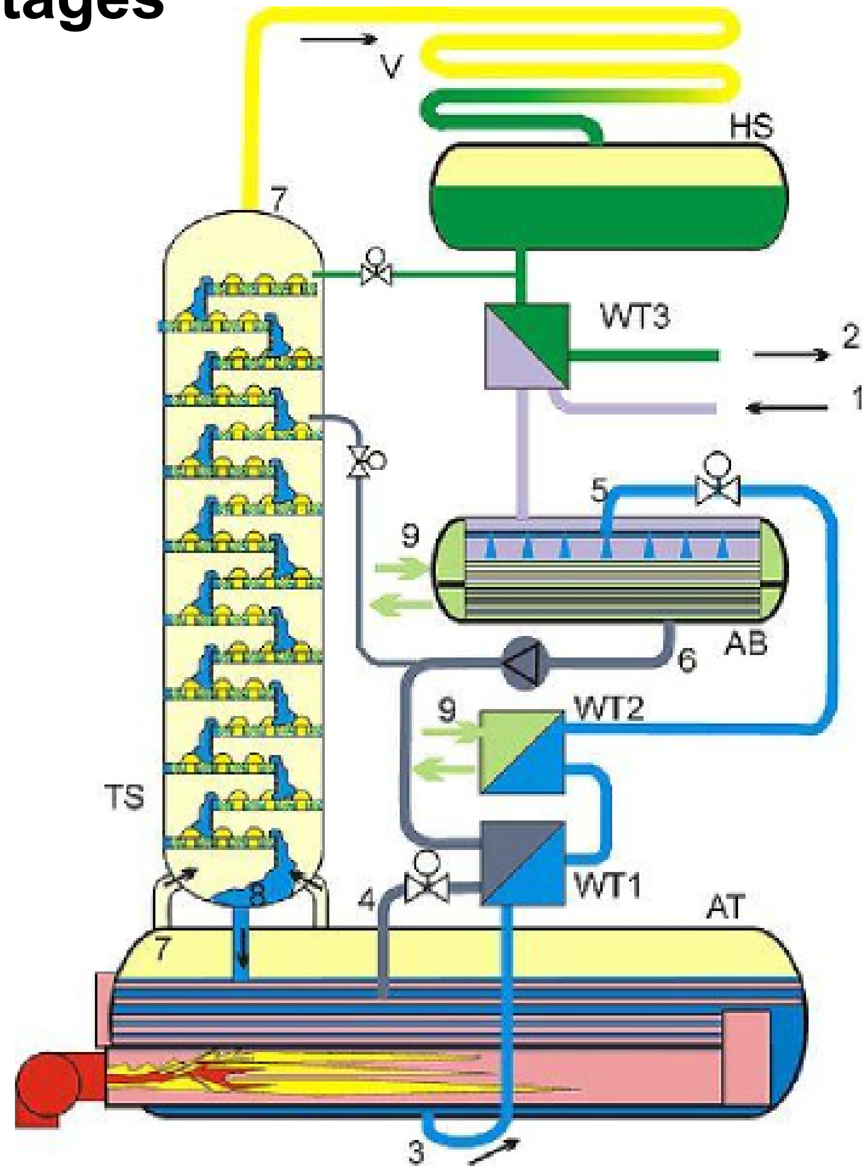


Physical cooling effect of refrigerant evaporation

Chiller Type	Compression Type	Energy Source	Cooling Agent
Compression	Mechanical Compression	Electric power	Halons, clorinated CHC, clor free hydrocarbons
Adsorption	Thermal absorption loop	Heat energy t=85°C – 150°C	Li-Br/water or ammonia/water as absorption agent
Absorption	Thermal adsorption of water steam	Heat energy t=55°C – 95°C	Water with solid as adsorption agent (e.g.silica-gel)

Absorption chiller – Advantages

- NH_3/water → T_{in} -60 °C
- Water/Li-Br → T_{in} +5 °C
- Noise reduced
- Cost-effective
- Reliable in power supply
- Energy efficient
- Can easily be operated by geothermal energy



Source: www.de.wikipedia.org

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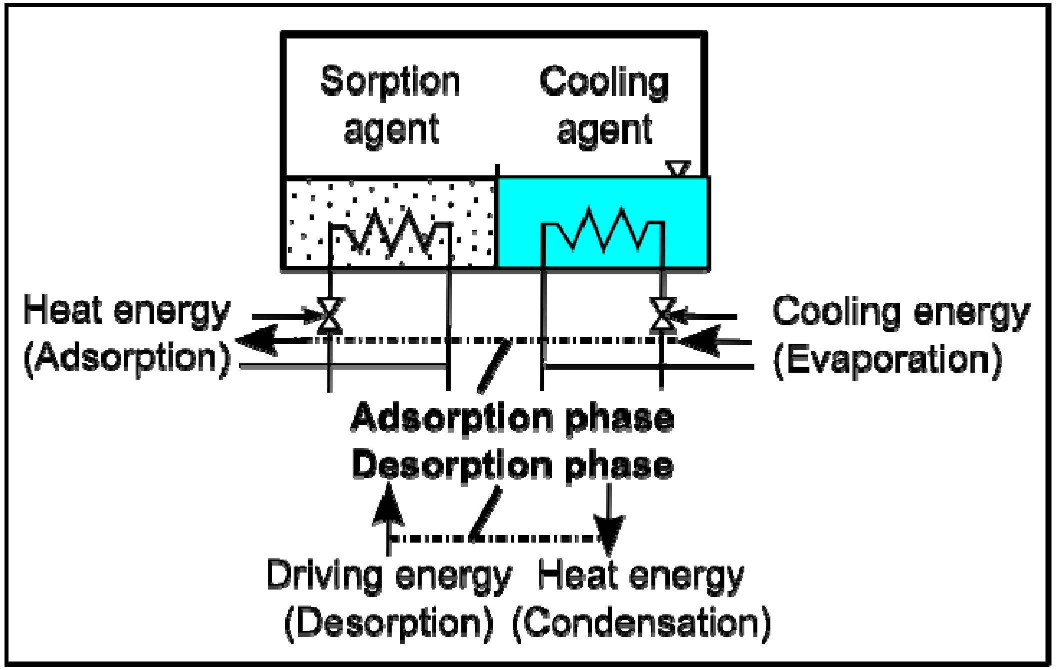
Absorption chiller – Operating mode

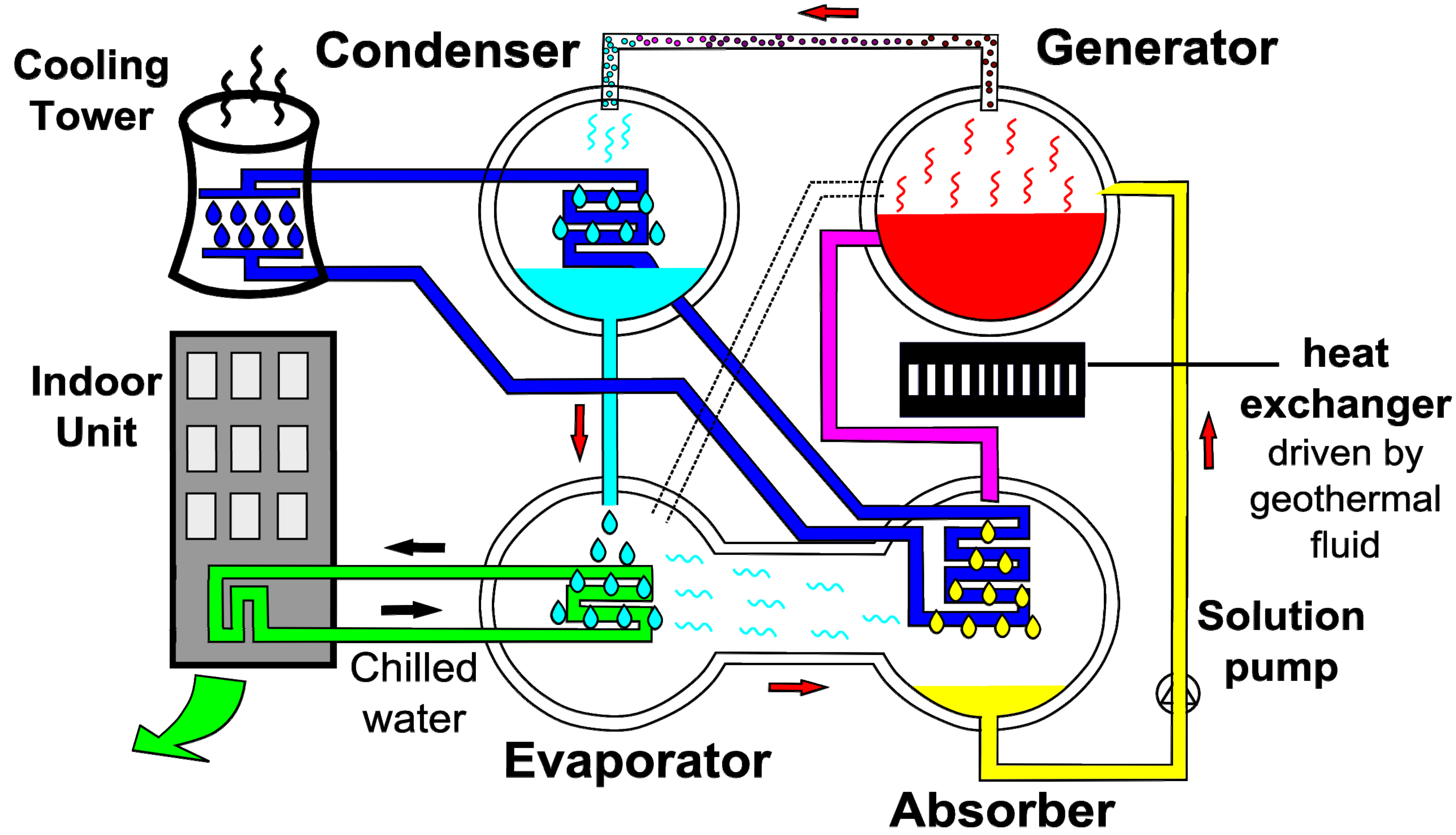
- Driven by hot water with broad temperature range
- Zero ozone depletion potential
- No halons, no oil changes
- Low power consumption
- Noice-reduced
- Stable cooling supply
- Easy in maintenance



Source: *modified after* www.de.wikipedia.org

- Fluctuations are avoided by use of geothermal energy
- Use with small localized chillers.

Absorption cooling – Cooling circuit



Cooling Mode

Modified after http://www.eurocooling.com/public_html/articleseagroup.htm

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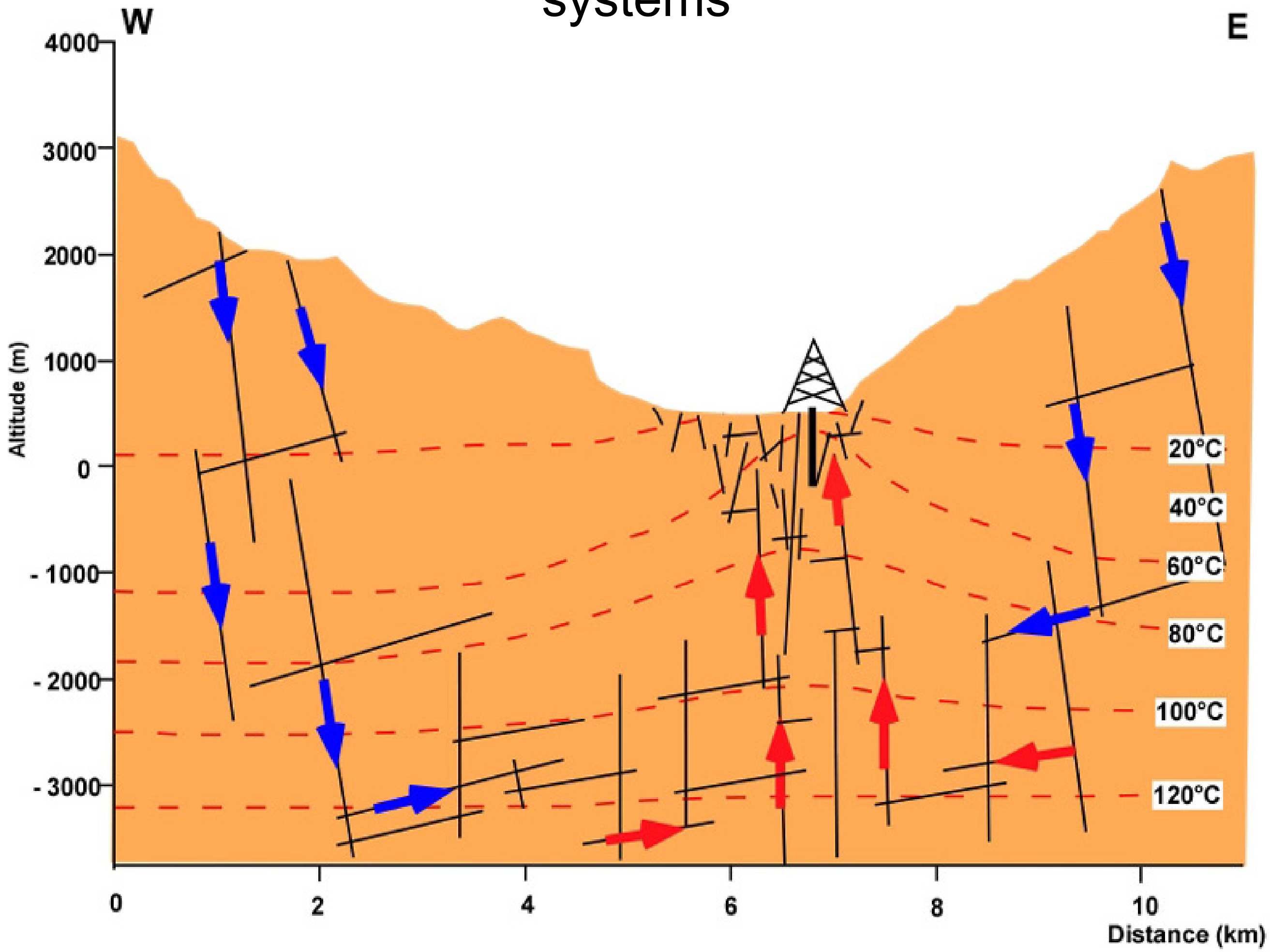
Geology and Geothermal for Cooling Purposes

Using ground water circulating along natural fault and fracture systems



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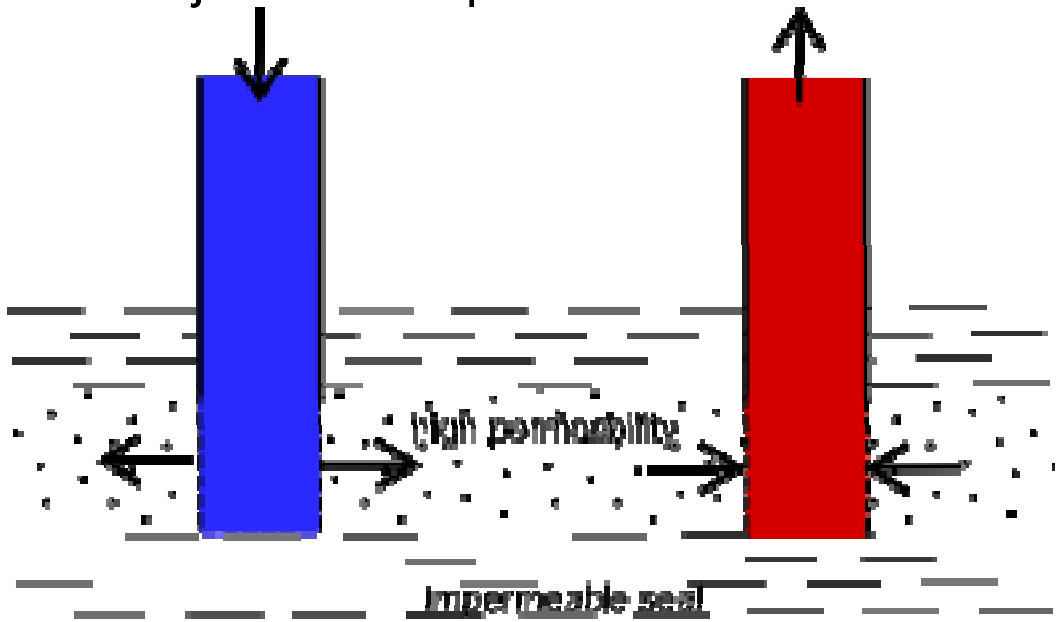
Principles of Geothermal Production

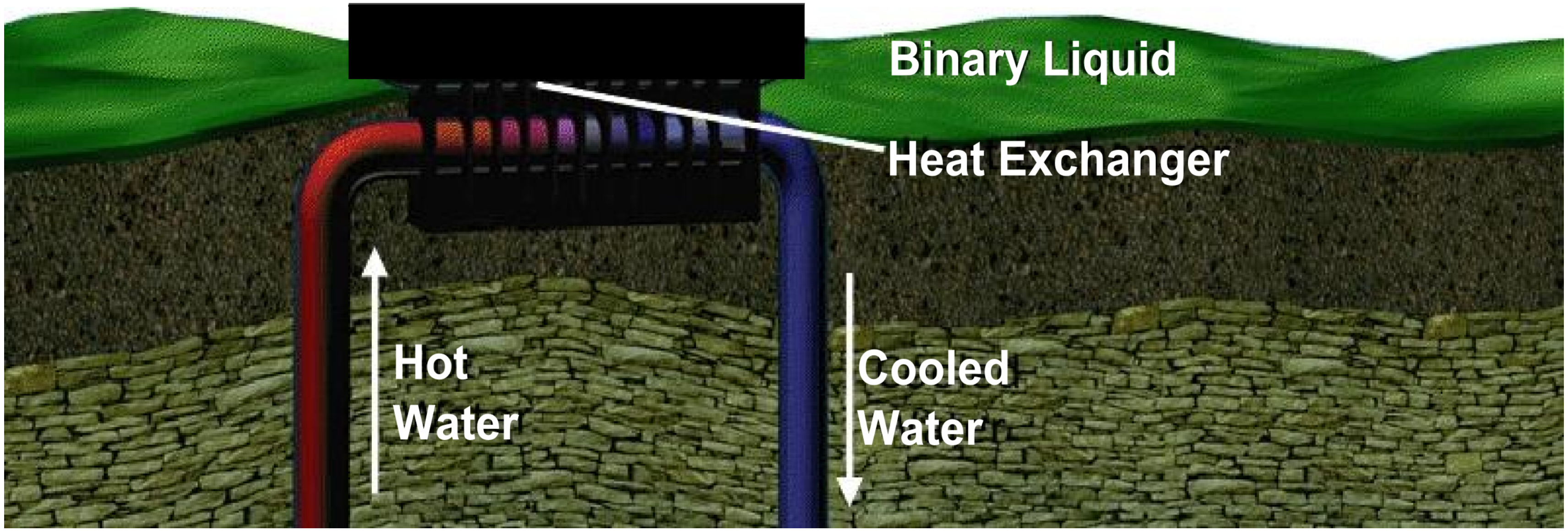
- Water-bearing sediments with high porosity and permeability, e. g. karstic voids, fractured and jointed carbonates
- Water temperatures between 70°C to 120°C required
- Desired production rates between 50 l/s and 75 l/s
- Two-well system: injection and production well



Geothermal Cooling Cycle

heat exchanger

driven by geothermal fluids



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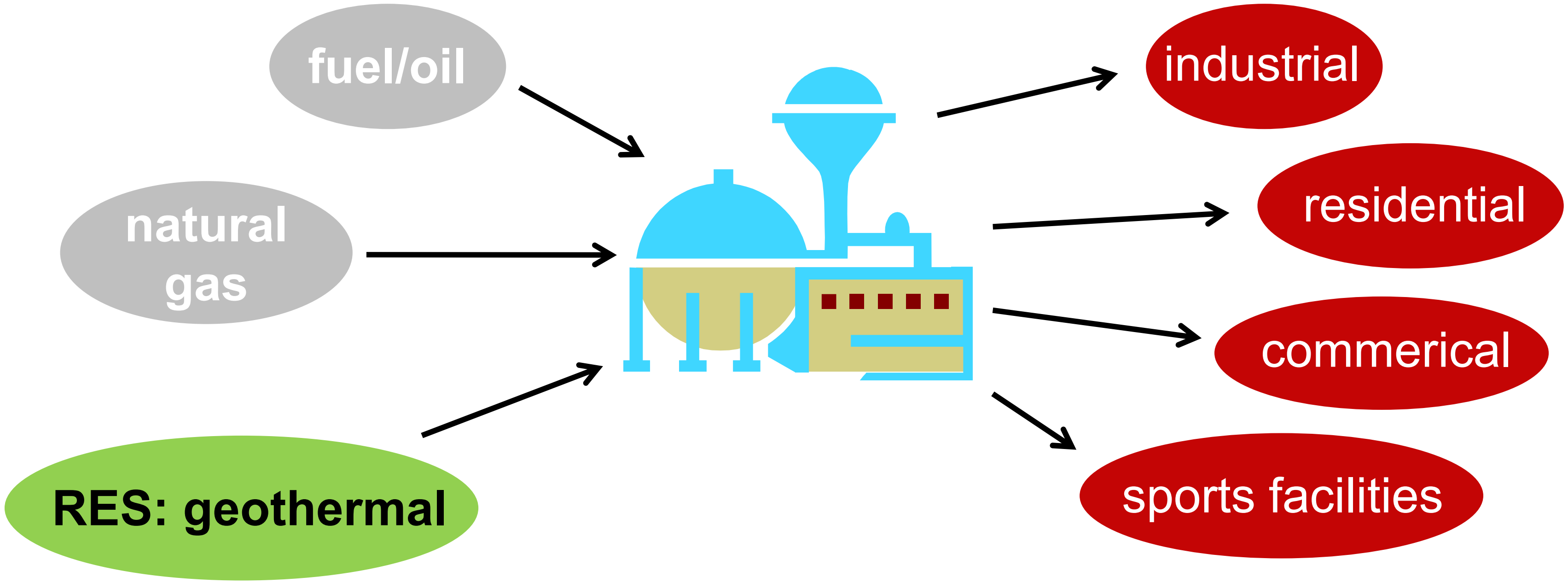
Principles of district cooling

- Cooling production in a central unit driven by primary energy
- Distribution to consumer via network of insulated pipelines
- Cooling storage system: cooling stored as chilled water or ice

Primary energy source **District cooling** **Consumer**



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Principles of District Cooling

- Local resources can be combined to different cooling sources. Cold water may be extracted from
  - Oceans
  - Lakes
  - Rivers
  - Ground water
- Use of surplus heat
  - Conversion of surplus heat into cooling
  - Recycling in district networks
- High-efficiency chillers necessary
- District Cooling fulfills the objectives of the EU energy policy: sustainability, competitiveness and supply security.
- Principles: http://www.youtube.com/watch?v=smirXWp6KTg

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Geothermal District Cooling

- Geothermal meets the temperature requirements of absorption and adsorption technology → cooling efficiency
- Evaporation cycle can be driven by thermal water extracted fom deep geothermal energy reservoirs
- Heat is transferred on heat exchanger that is coupled with an evaporating cooling unit.
- Centralized cooling station supplies district buildings
- No fossil fuels will be consumed
- No CO_2 emissions from combustion processes → geothermal source

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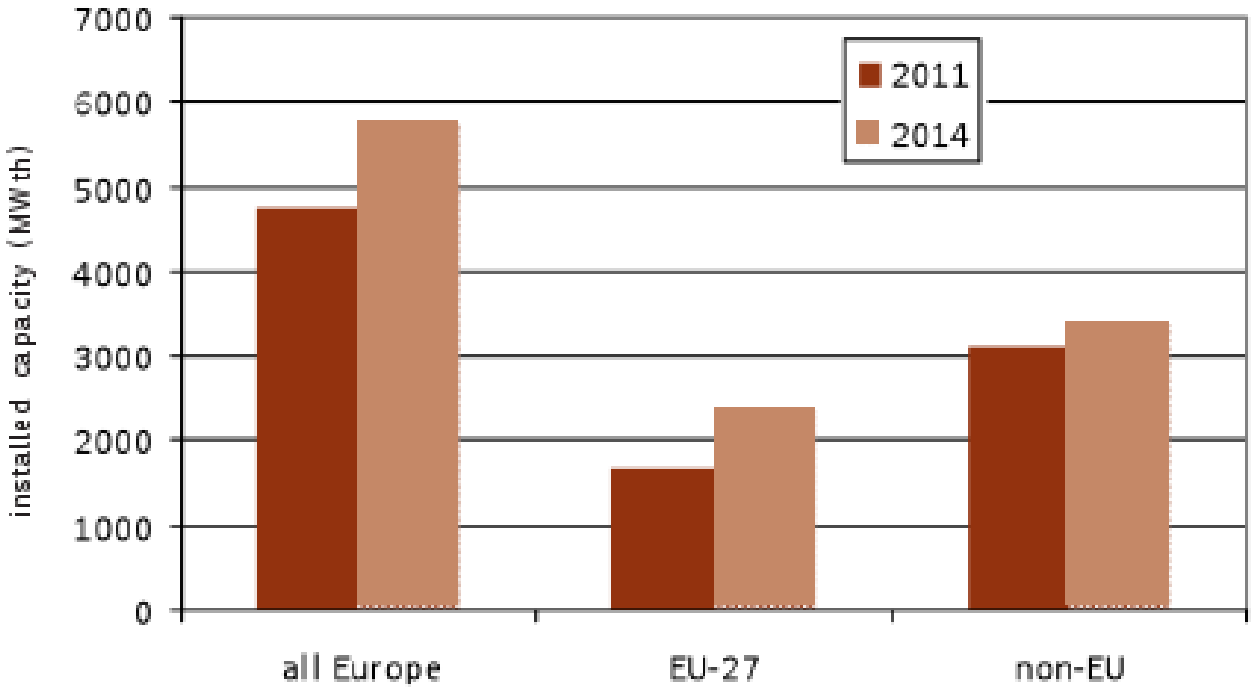
Geothermal District Heating Europe

- 212 geothermal district heating installations operating in Europe 2011
- Almost 1.7 GWth installed capacity



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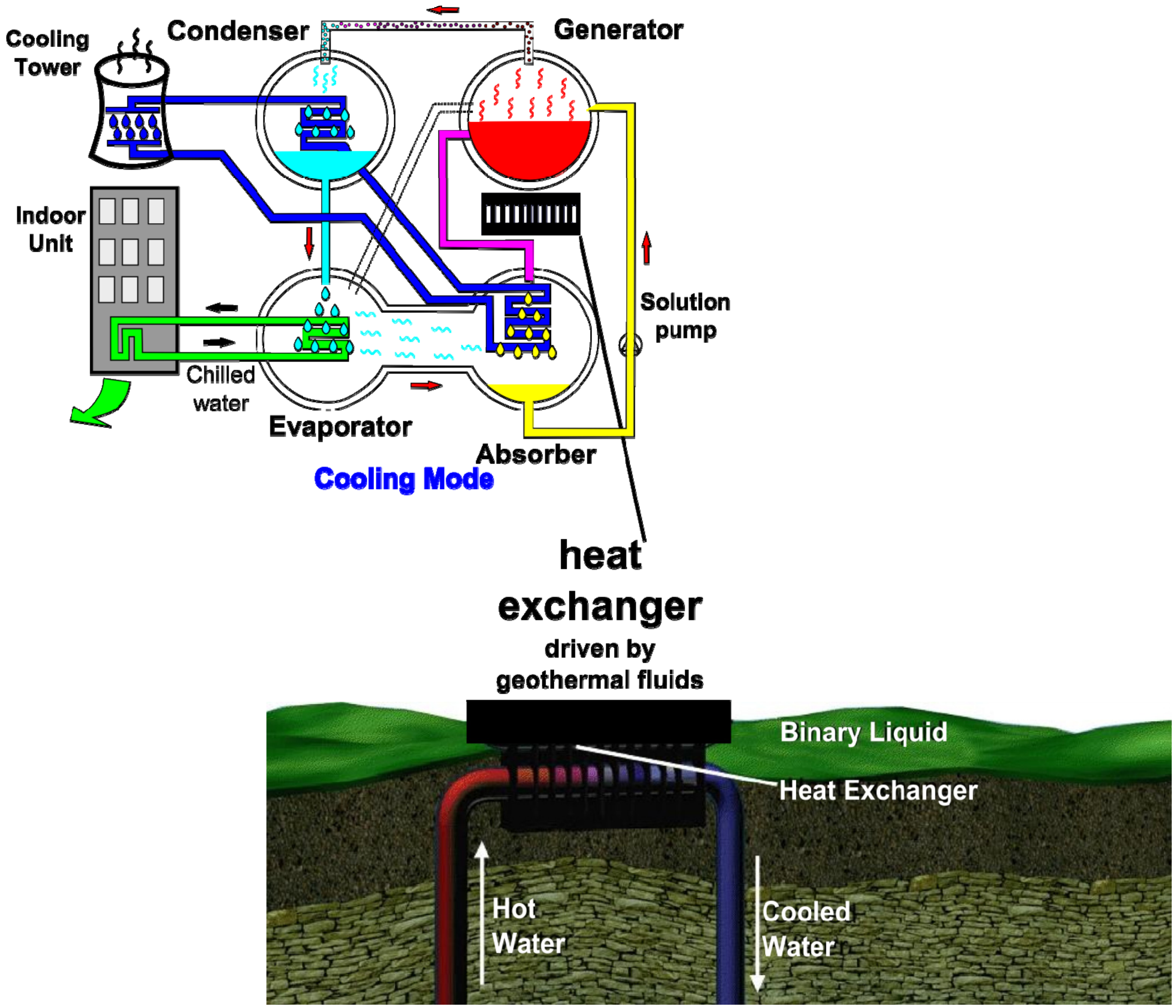
Geothermal District Cooling



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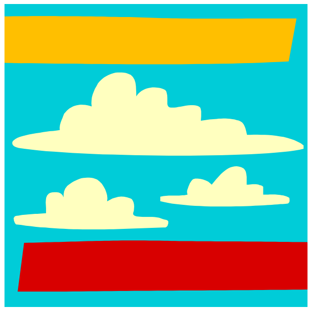
Geothermal District Cooling - Motivation

Primary energy source: Geothermal energy + efficient technology

Primary energy source: oil and natural gas

District Cooling

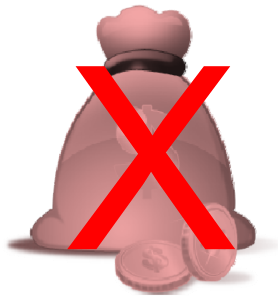
cut of CO_2 emissions



No dependency on oil/gas exports

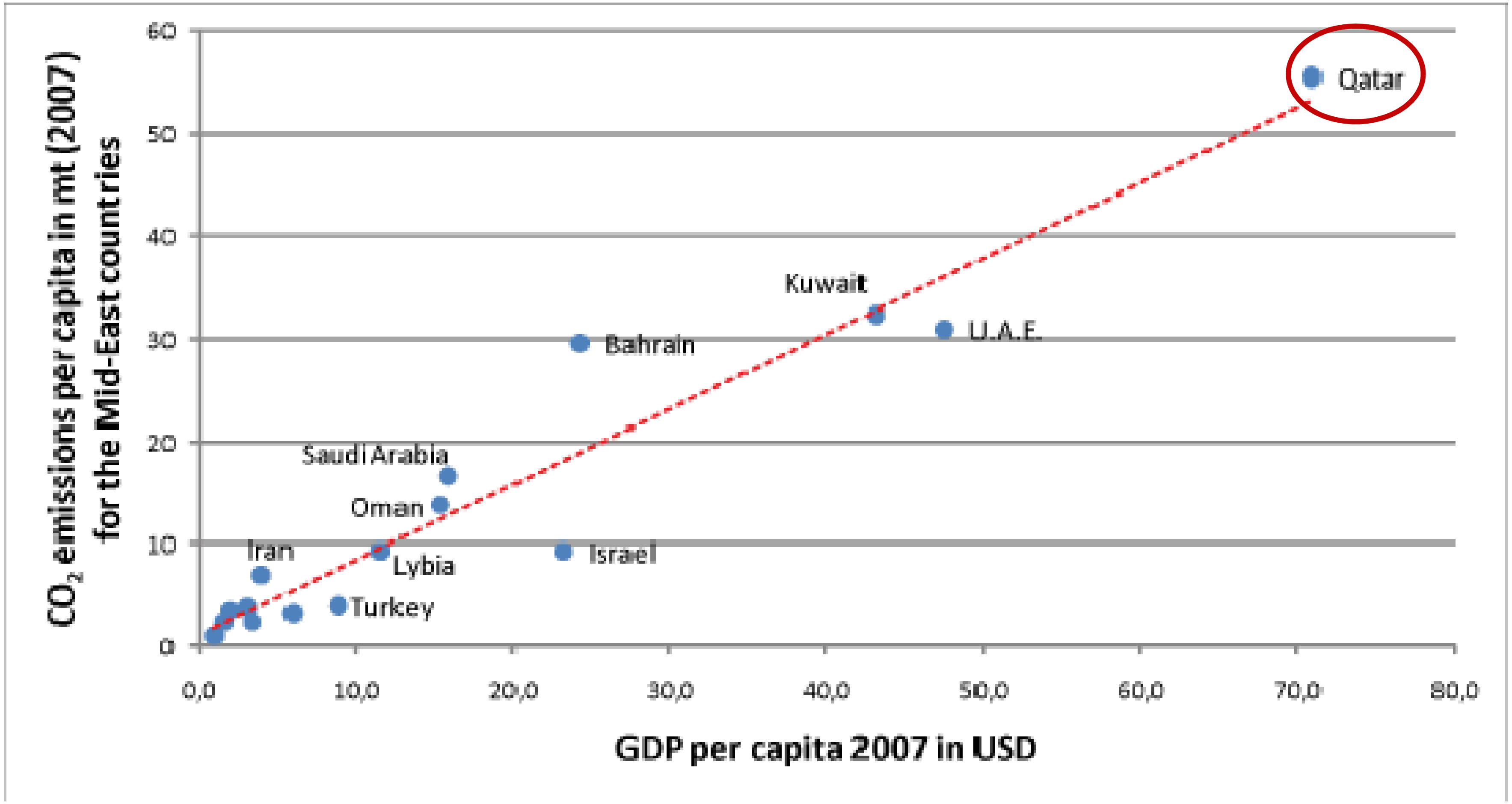
high CO_2 emissions

Dependency on oil and gas exports



Geothermal Cooling – Example from Qatar

CO_2 emissions per capita (2007) among the Middle East countries



Data source: Worldbank (2010)

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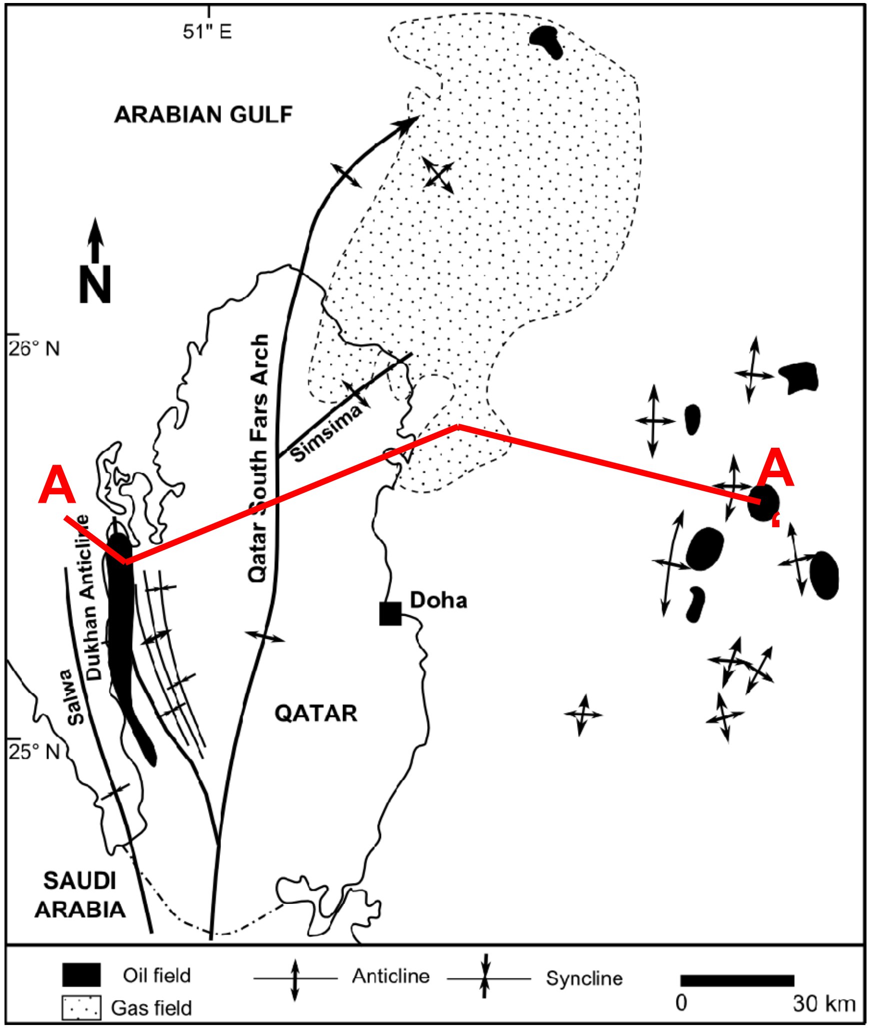
Geological Setting

- Qatar part of stable Arabian interior platform
- Dominated by ~ 10 km thick sedimentary sequences deposited since Paleocene (Alsharan and Nairn, 1994)
- Predominantly carbonates, evaporites, bitumen-rich black shales
- Structure dominated by NNE-SSW trending Qatar South Fars Arch
- Thorough oil and gas exploration on- and offshore
- Main production horizons within Jurassic and Cretaceous sediments



modified after Alsharan and Nairn (1997)

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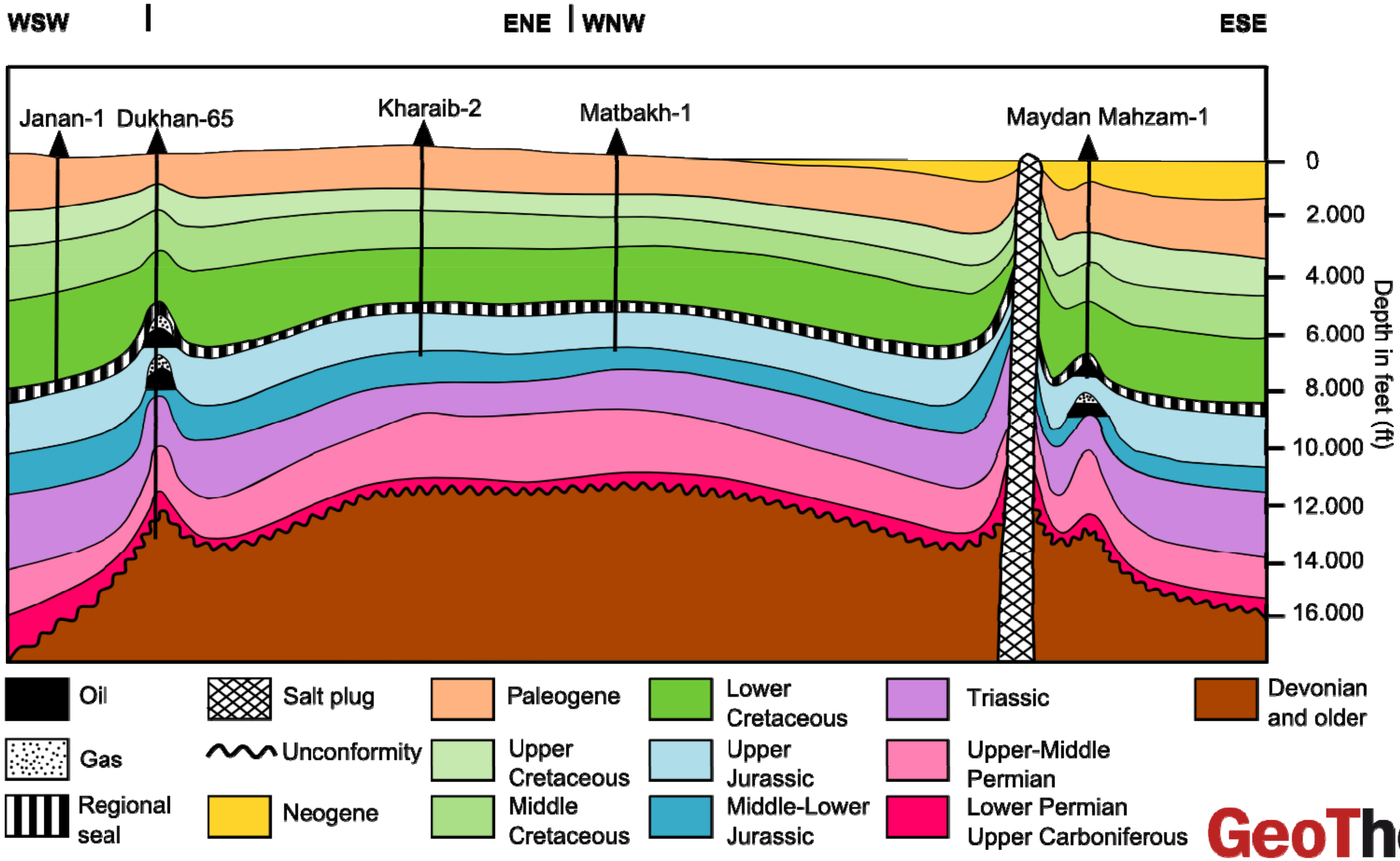
Geological cross-section

- Geothermal gradient between 30°C/km to 40°C/km
- Aquifers in Jurassic and/or Cretaceous sediments expected
- High salinity concentrations expected
- Good production rates expected



modified after Alsharan and Nairn (1997)

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Qatar host of 2022 FIFA World Cup

Chance to take responsibility for climate and environmental protection

Strengthen Qatar‘s position in the discussion on sustainable games

Chance to a fundamental change in Qatar‘s energy policy: Switching from fossil fuel to RES.

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Qatar and Geothermal District Cooling

- 63% of Qatar's domestic energy production is used for domestic district cooling, totally driven by fossil fuels → high CO_2 footprint to residentials
- Rising cooling demand requires sustainable source of energy production for Qatar
- Operating geothermal energy necessarily requires detailed hydrogeological and geological feasibility studies
- Qatar offers a prospective country for installing geothermal energy
- Suitable temperature regime is expected in the subsurface
- Geothermal saves fossil reserves, improves CO_2 footprint
- RES strengthens Qatar's position in the discussion on climate change among the GCC

Conclusion

- District cooling with natural sources offers environmental saving alternative and preserves fossil resources
- Geothermal district cooling uses the geothermal source and transfers heat to a high-efficient chiller
- Adequate chilling technology: ad-/absorption chillers
- Less CO_2 emissions
- Less investments
- Less operating costs

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Thank you for your attention!

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