Institut für Energetik und Umwelt

Institute for Energy and Environment

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Dienstleistung für
- Energie
- Umwelt

Economic Assessment of Geothermal Energy Generation

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

Agenda

- Introduction
- Geothermal energy production
- Economic analysis (Case Study)
  - Reservoir
  - Power plant concept
  - Investments and operation costs
  - Power generation costs
  - Sensitivity analysis
- Conclusions

Geothermal Energy

- Not only due to climate protection reasons renewable sources of energy gain more and more importance on a world wide scale as well as within Europe. This is also and especially true for the heat and/or electricity provision from geothermal resources due to numerous advantages.
- One of the main advantage of a use of geothermal energy is that heat, electricity and even cold can be provided easily with the already available conversion technology.

Advantages:

- No seasonal and daily course of the energy supply
- Demand-oriented energy provision is easily possible
- Quasi – renewable
- Energy provision potential is very huge
- Basically independent from a certain spot

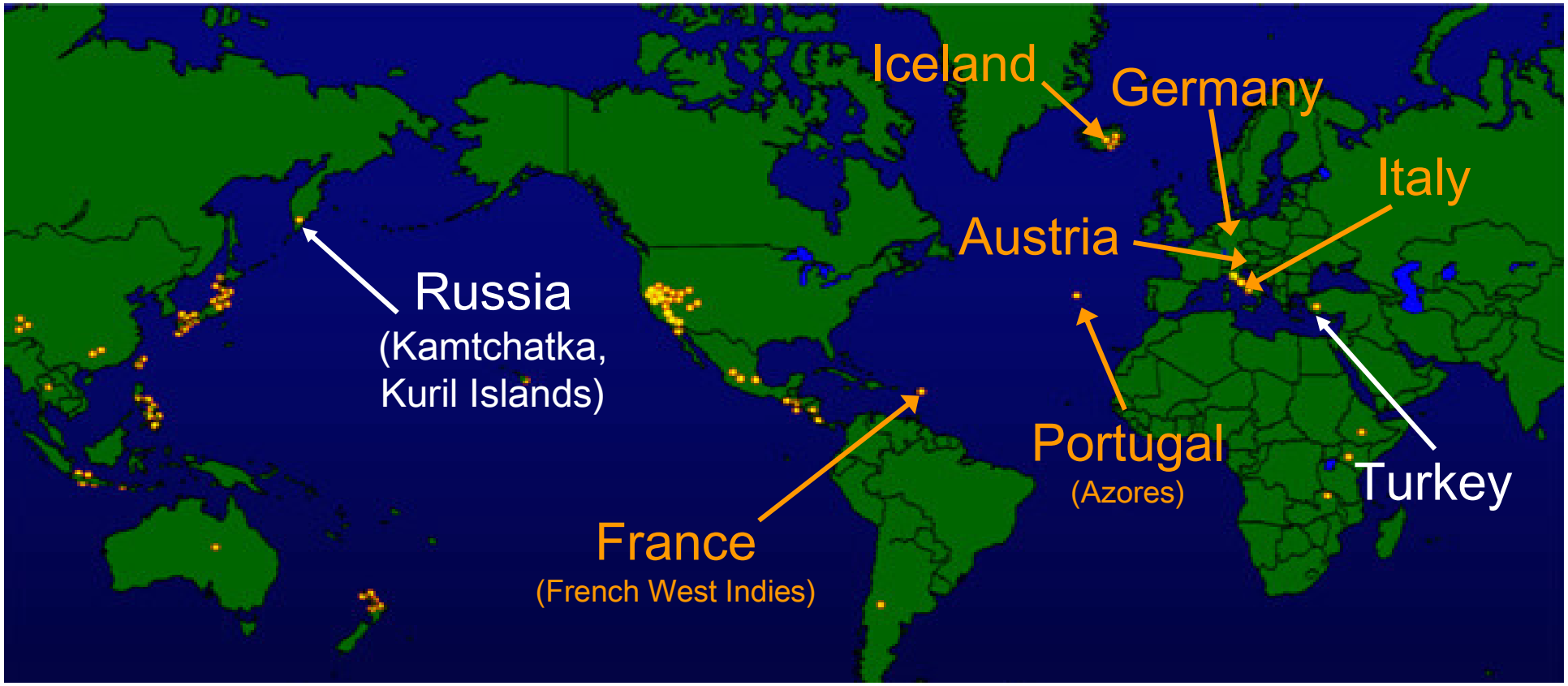
Disadvantages:

- Technology is still very much dependent from the local circumstances
- Low electrical efficiency due to thermodynamic restrictions
- High investments and substantial risks at the beginning which are hard to cover by an insurance so far
- Market penetration in Europe is still lacking

Geothermal Heat Production in Europe

Source: http://www.f-e-e.org/upload/DV20050528-Flovenz.htm

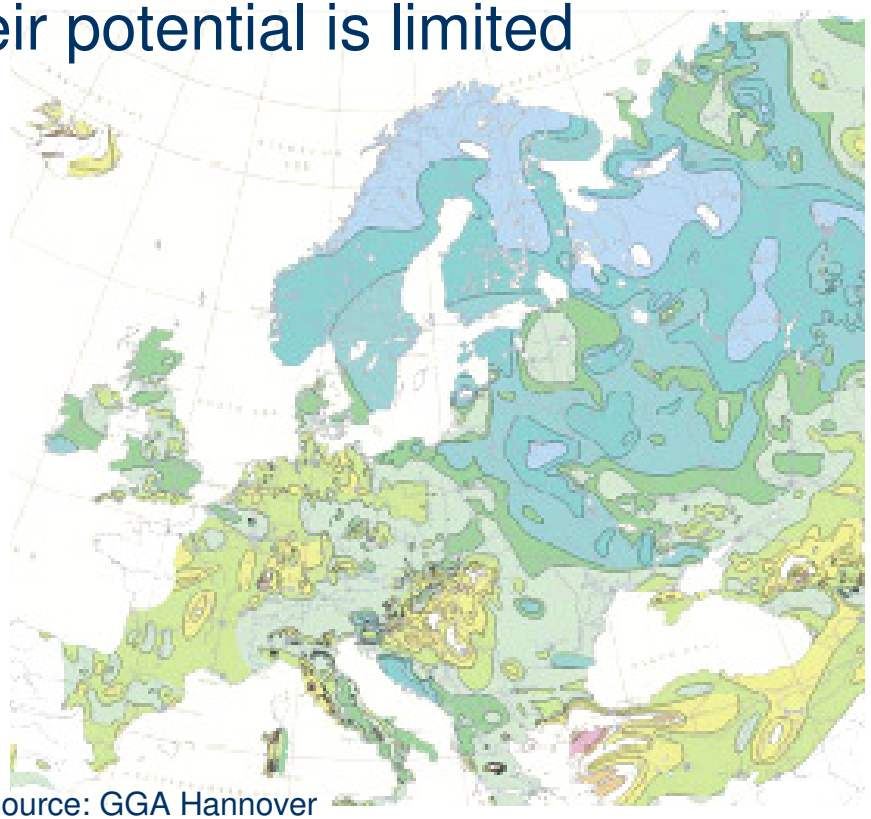
Geothermal Power Production in Europe



Source: IGG (A. Manzella)

Geothermal Energy Use in Europe

- Geothermal heat production is already widely used and can be seen as a competitive energy source for heat supply if the geological conditions are promising.
- For power production almost only geothermal high enthalpy fields are exploited so far; but their potential is limited throughout Europe.
- Power production from geo-thermal low enthalpy resources is only realized in some pro-jects so far. Beside consider-able technical challenges, predominantly economic barriers (i.e. too high costs compared to competing energy sources) hinder their wider use.

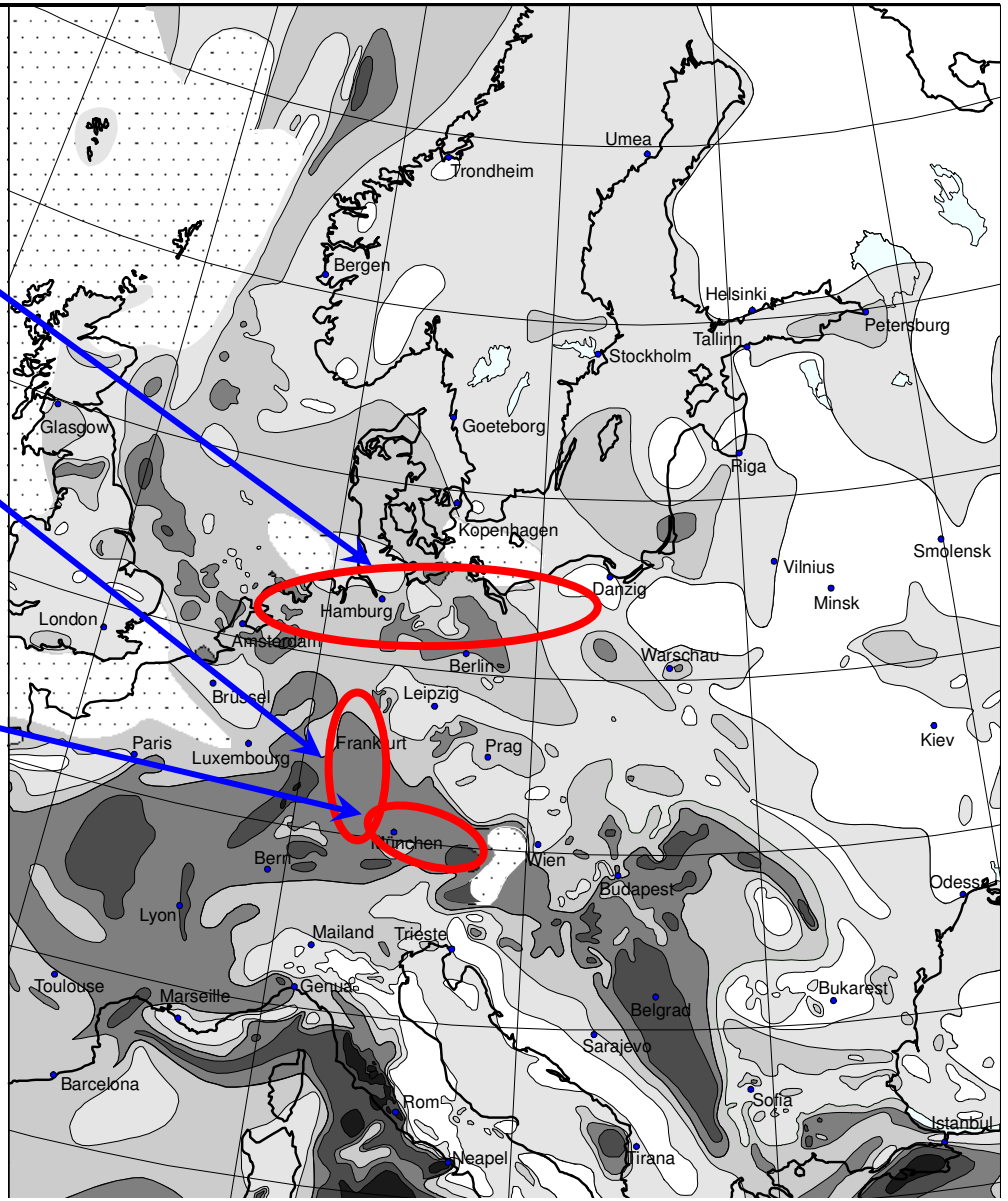


Source: GGA Hannover

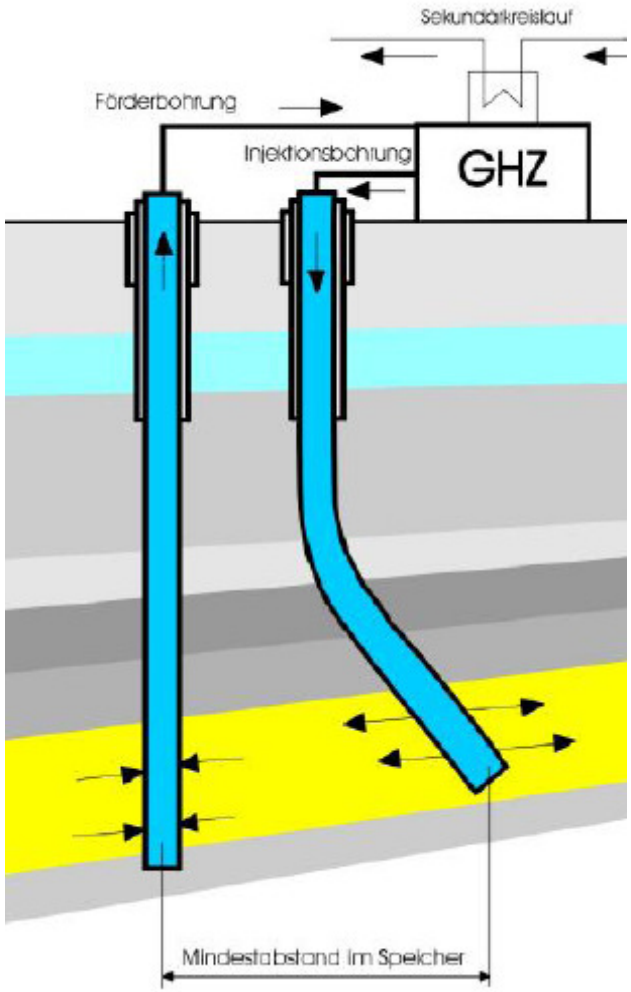
Power Generation Costs
- Reservoir Characteristics -

Typical low enthalpy reservoirs (predominantly hot water aquifers)

- Area 1: North German Basin (characteristic for parts of The Netherlands, Germany, Poland)
- Area 2: Upper Rhine Graben (characteristic for parts of Germany, France, Switzerland)
- Area 3: Molasse Basin (characteristic for parts of Germany and Austria)



Power Generation Costs
- Power Plant Concept -



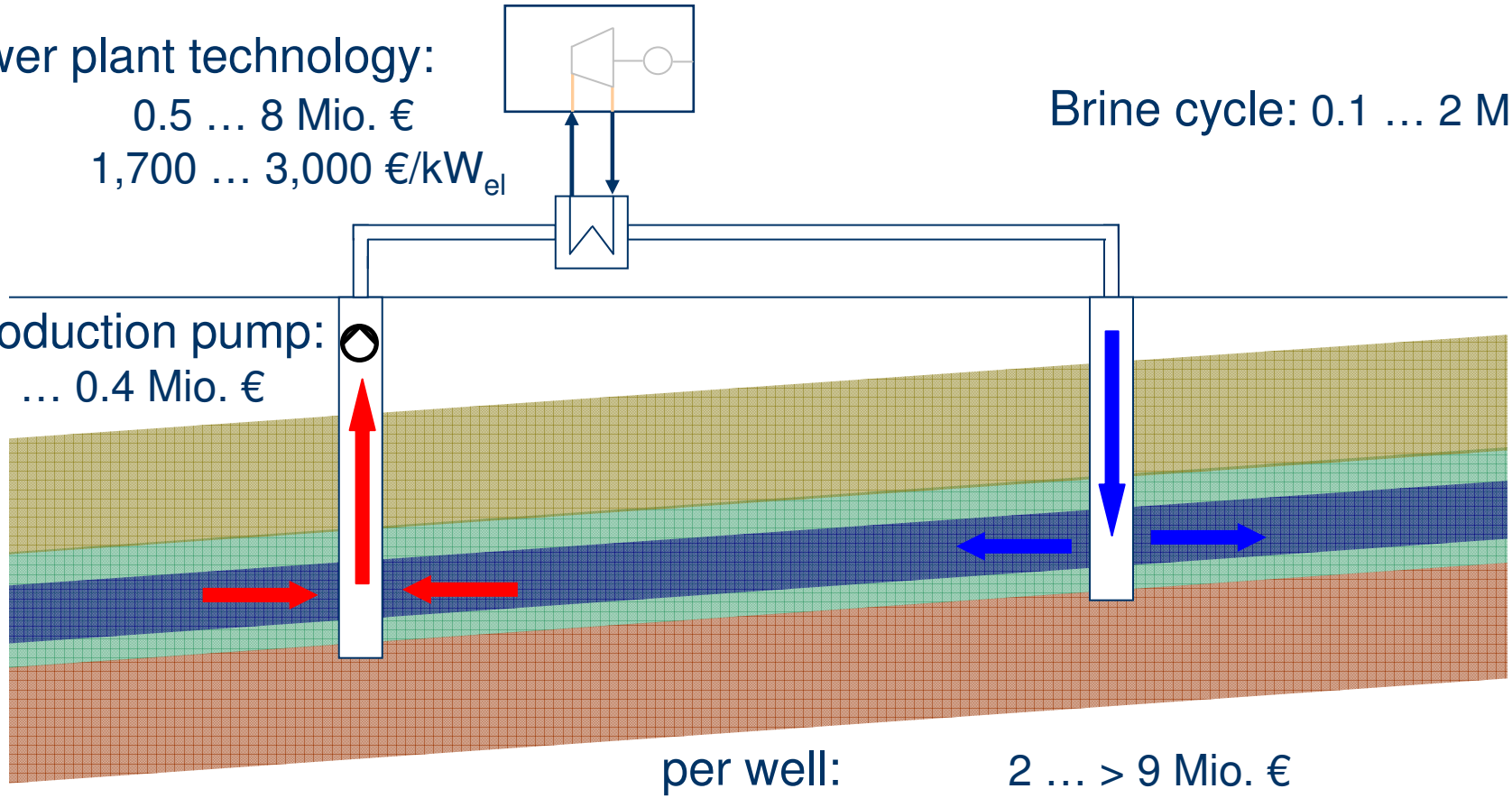
Source: GGA Hannover

	Upper Rhine Graben	Molasse Basin	North German Basin
Borehole depth	2,900 m	3,350 m	4,300 m
Brine temperature	150 °C	120 °C	150 °C
Flow rate	130 m^3/h	300 m^3/h	100 m^3/h
Operating water level under top ground surface	400 m	400 m	400 m
Power plant technology	ORC	ORC	ORC
Cooling medium	Water	Water	Water
Power plant capacity	1.4 MW	1.8 MW	1.1 MW
Power plant efficiency design point	11.5 %	10.2 %	11.5 %
Full load hours	7,500 h/a	7,500 h/a	7,500 h/a

Power Generation Costs
- Investments and Operation Costs -

Power plant technology:
0.5 … 8 Mio. €
1,700 … 3,000 €/kW_{el}

Brine cycle: 0.1 … 2 Mio. €



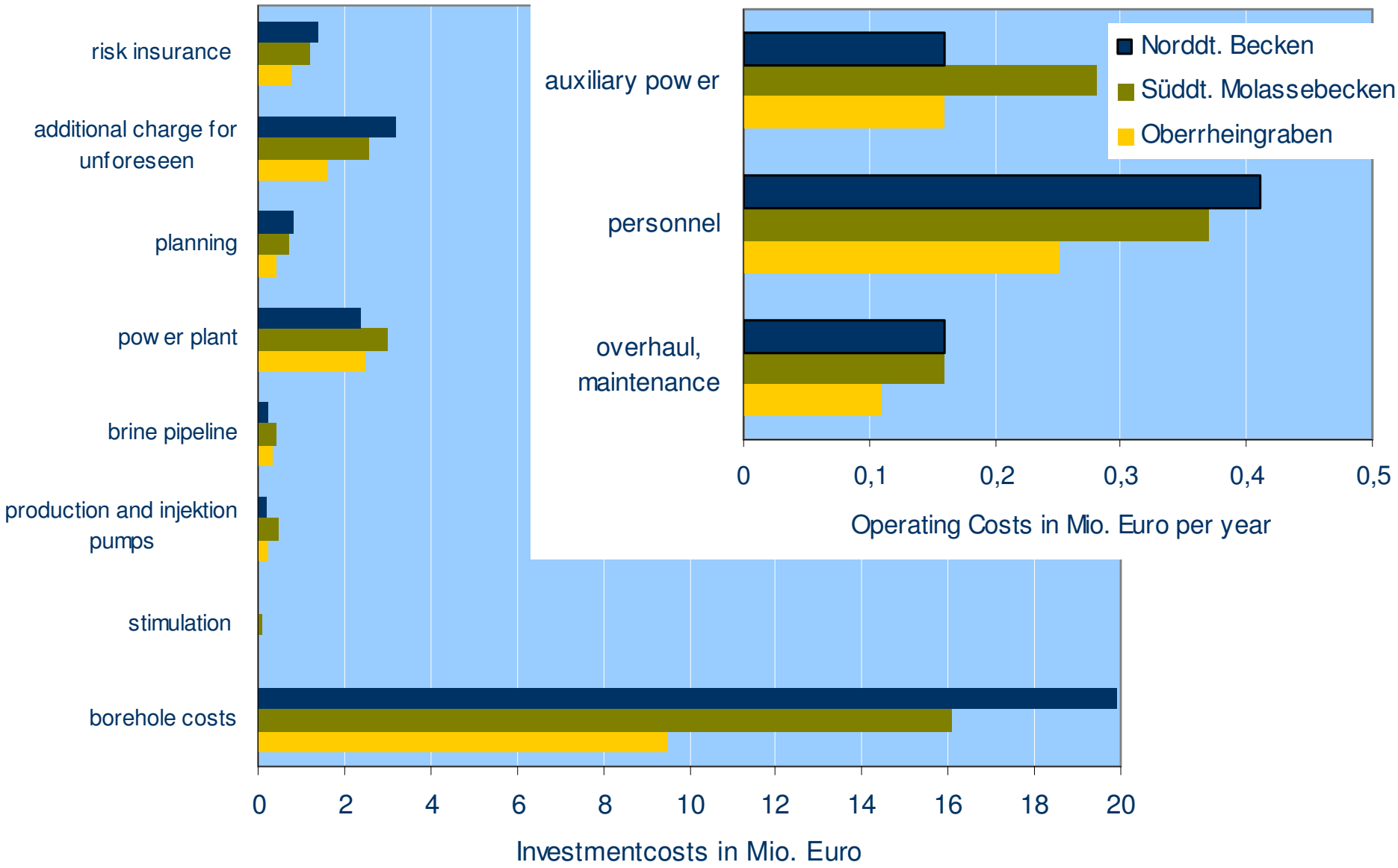
Production pump:
0.1 … 0.4 Mio. €

per well: 2 … > 9 Mio. €
depth ca. 2,500 … 5,000 m

Stimulation: 0.1 … 0.7 Mio. €

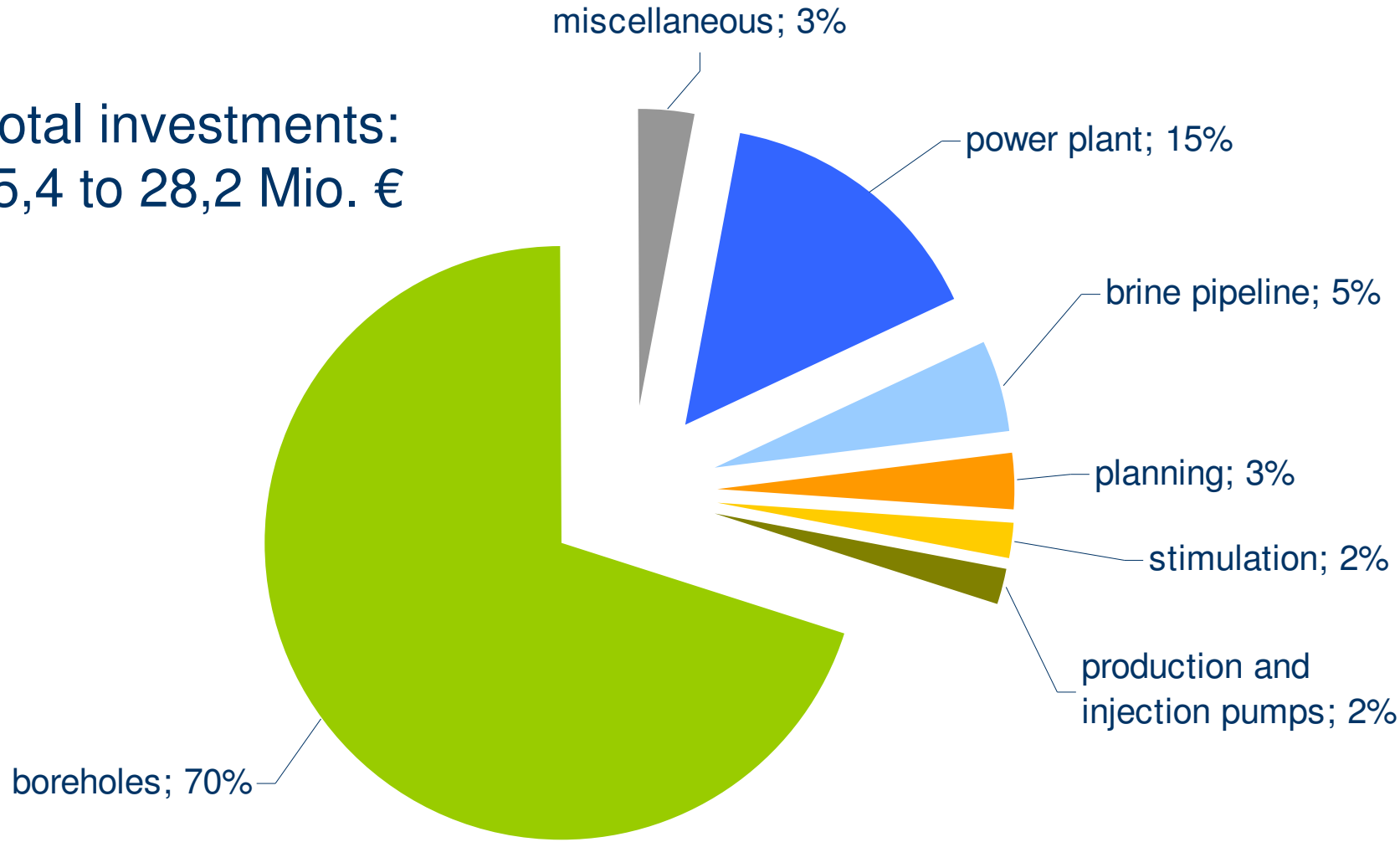
Drill site: 0.2 ... 1.2 Mio. € Bore hole measurement: 0.2 … 0.4 Mio. € Production tests: 0.1 … 0.7 Mio. €

Power Generation Costs
- Investments and Operation Costs -



Power Generation Costs
- Shares of the Investments -

Total investments:
15,4 to 28,2 Mio. €

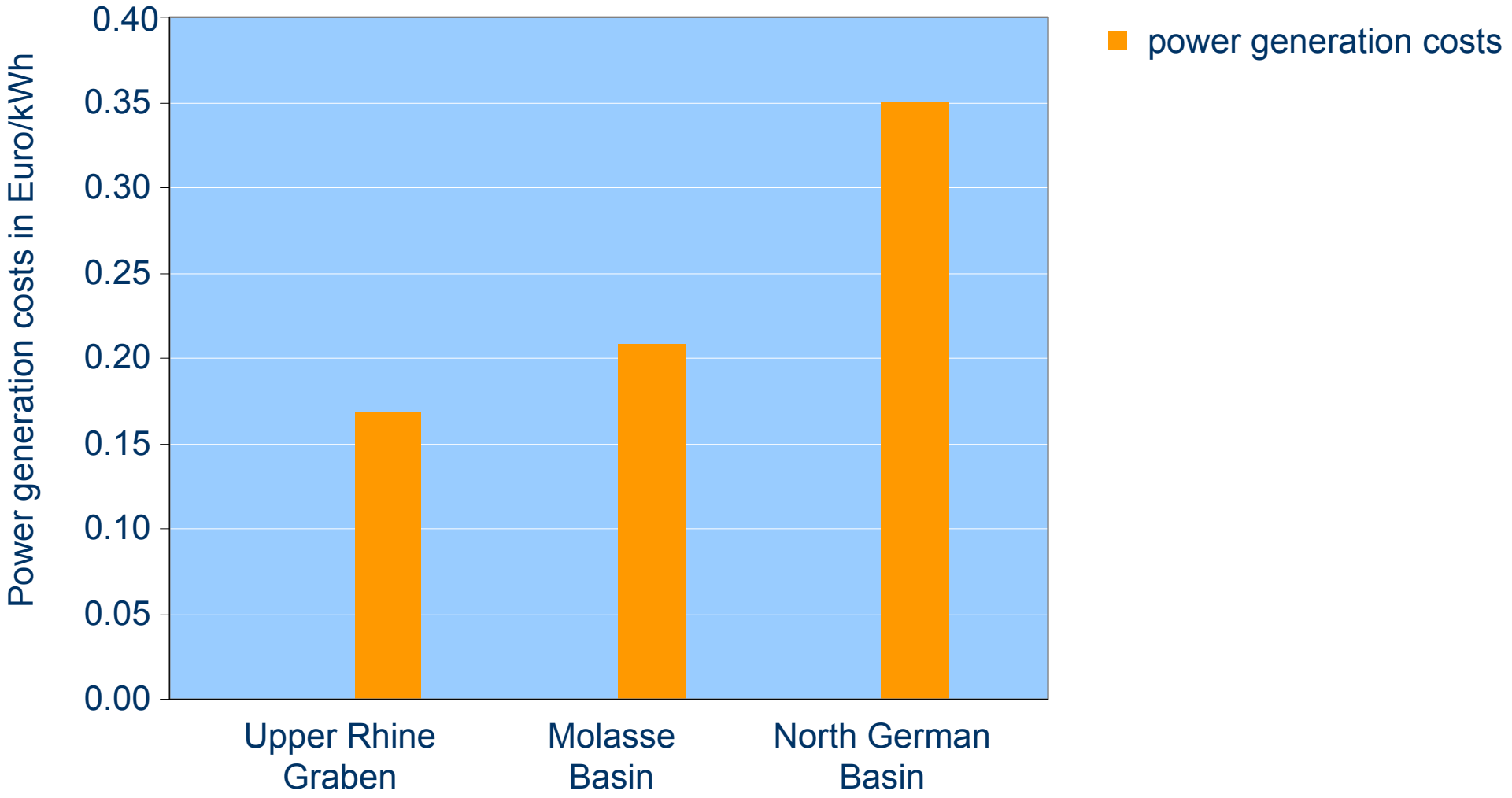


Power Generation Costs
- Frame Conditions -

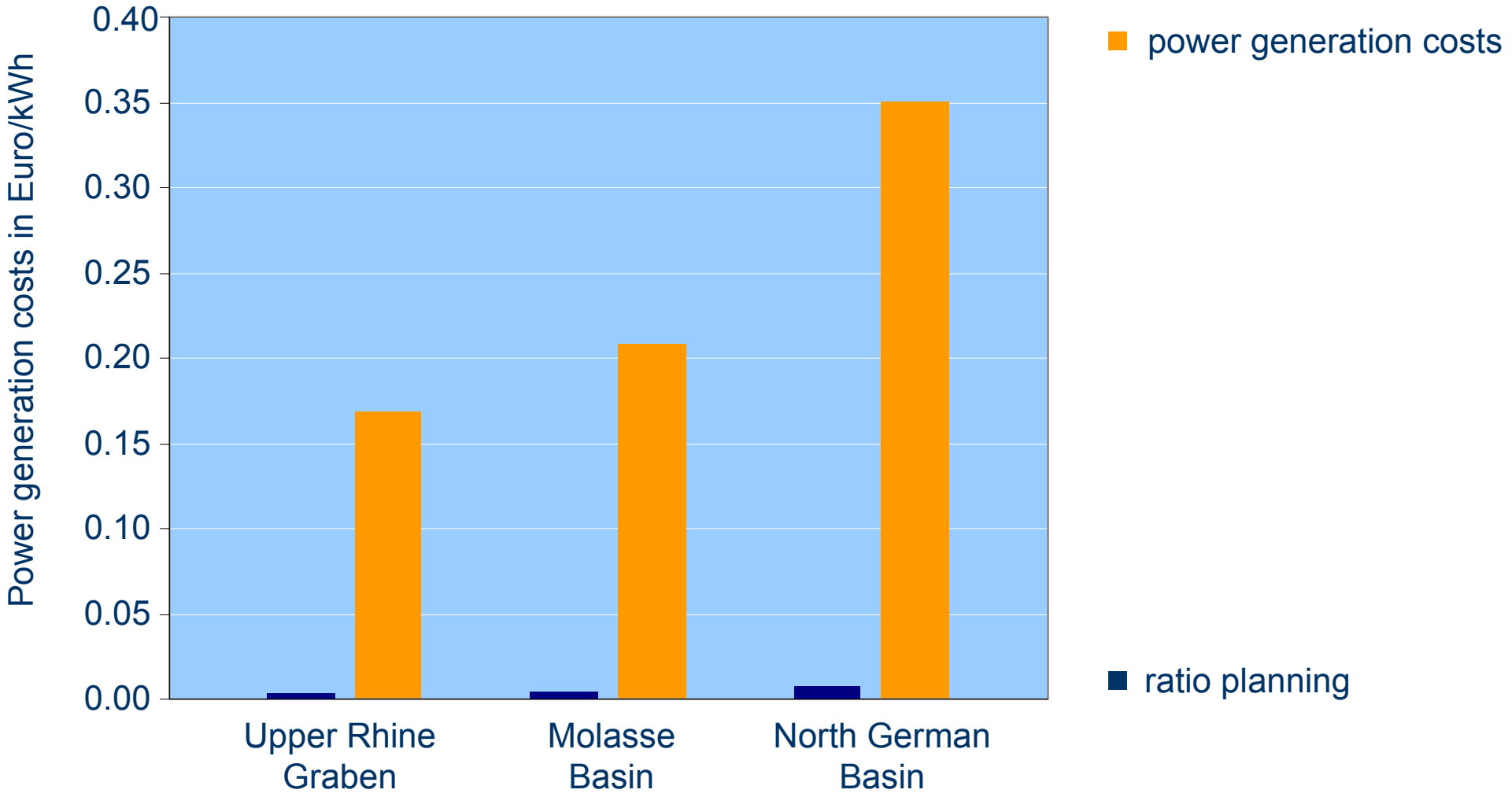
	Economic Basis Data
Depreciation period	30 a
Shareholders‘ equity ratio / interest rate	30 % / 12 %
Credit capital ratio / interest rate	70 % / 5 %
Electricity purchase price	0.07 €/kWh
Heat seeling price *	0.032 €/kWh

	* District Heat Provision Data
Flow / return temperature (low temperature district heating)	75 °C / 55 °C
Heat capacity	Upper Rhine Graben 3.0 MW Molasse Basin 7.0 MW North German Basin 2.3 MW
Heat full load hours	3,000 h/a

Power Generation Costs
- Generation Costs -



Power Generation Costs
- Generation Costs -



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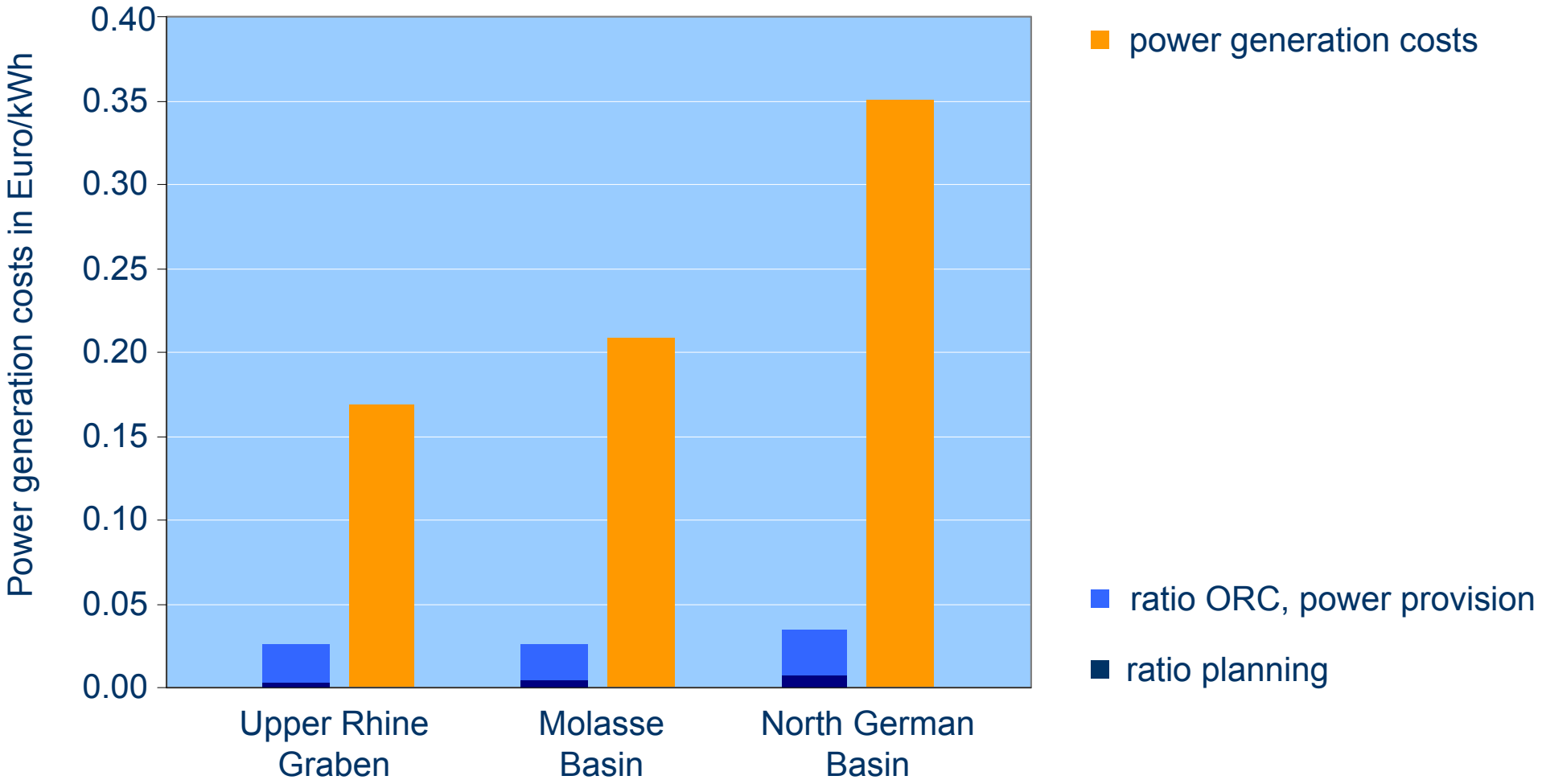

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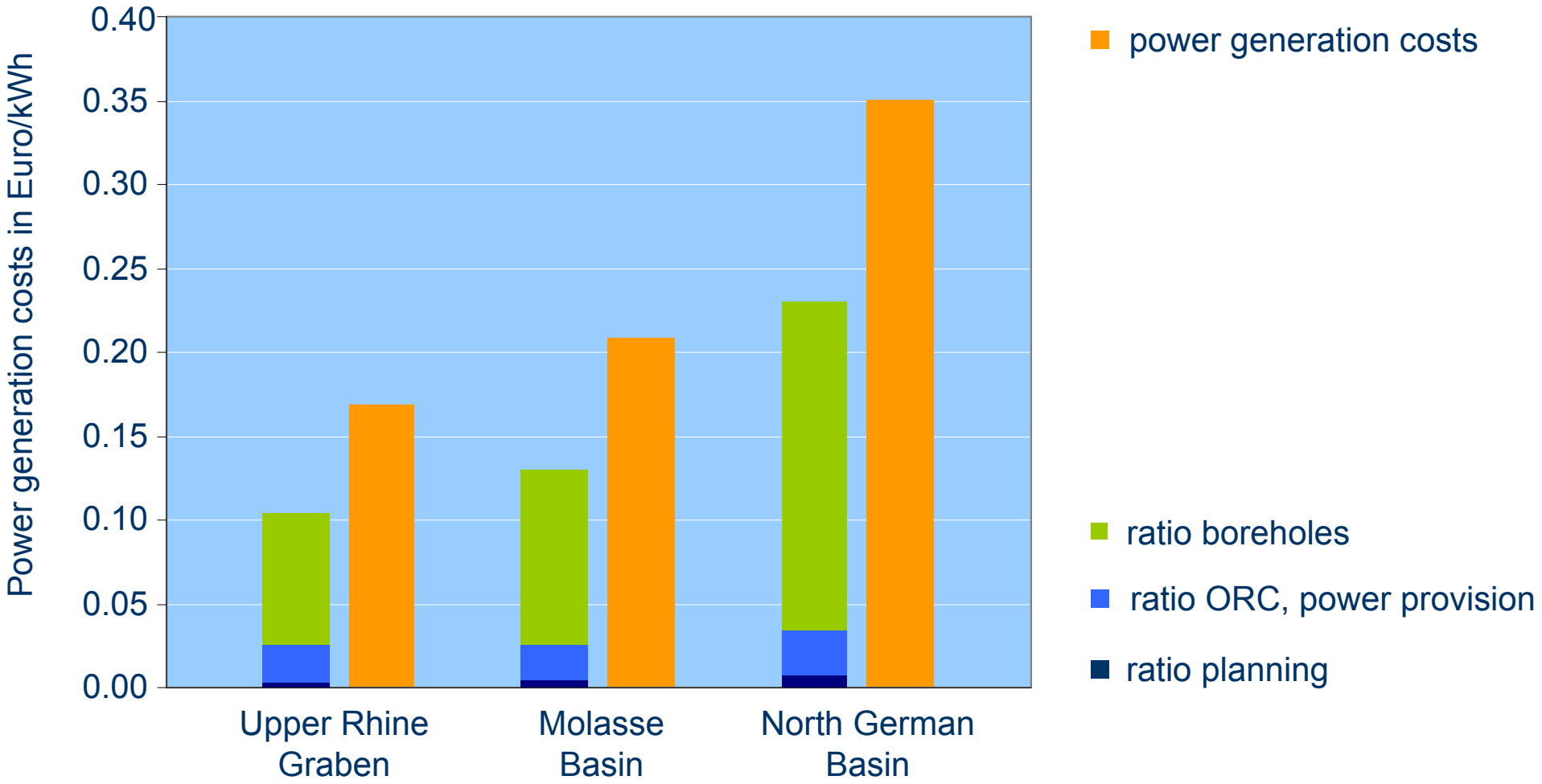

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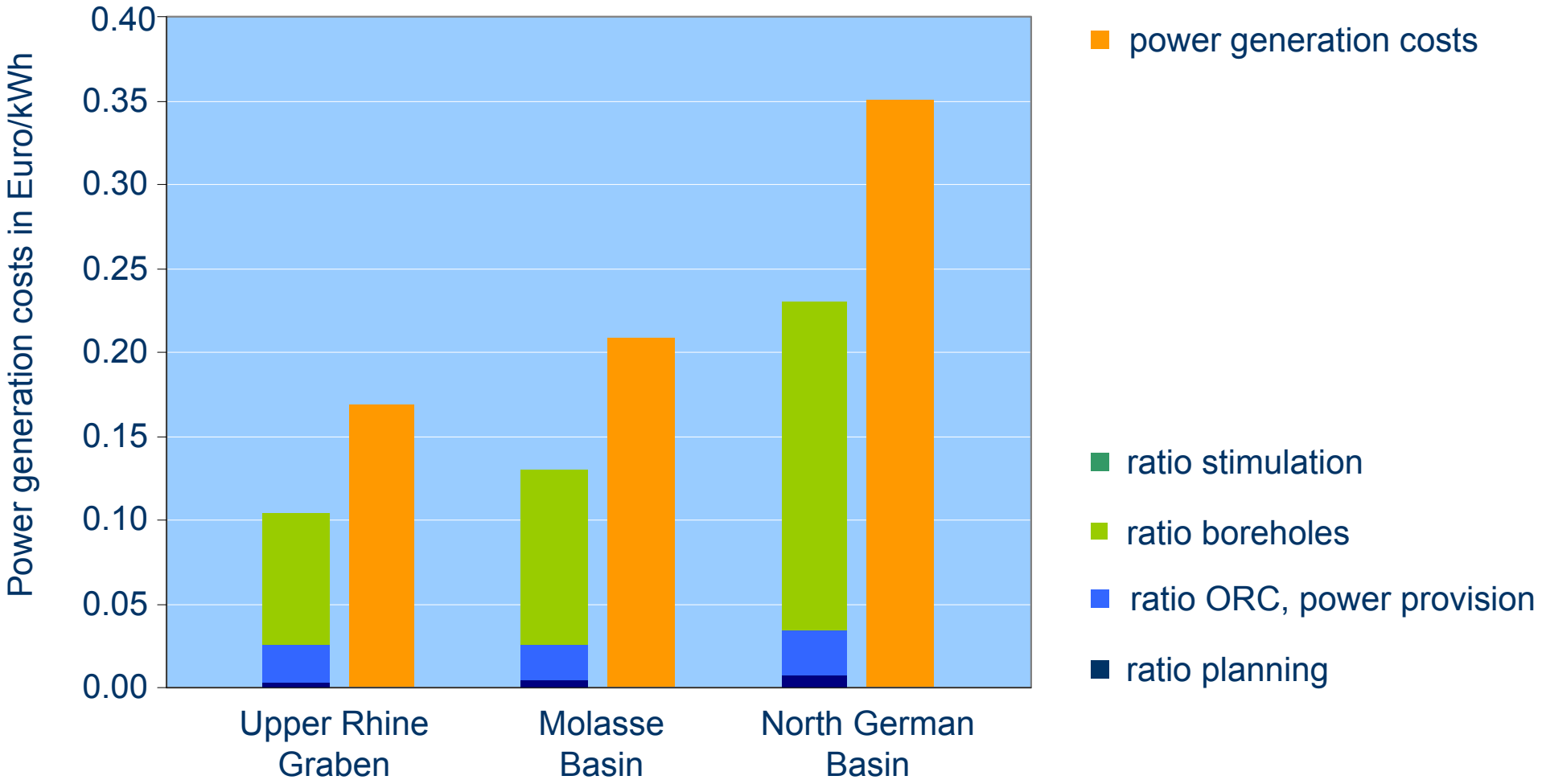

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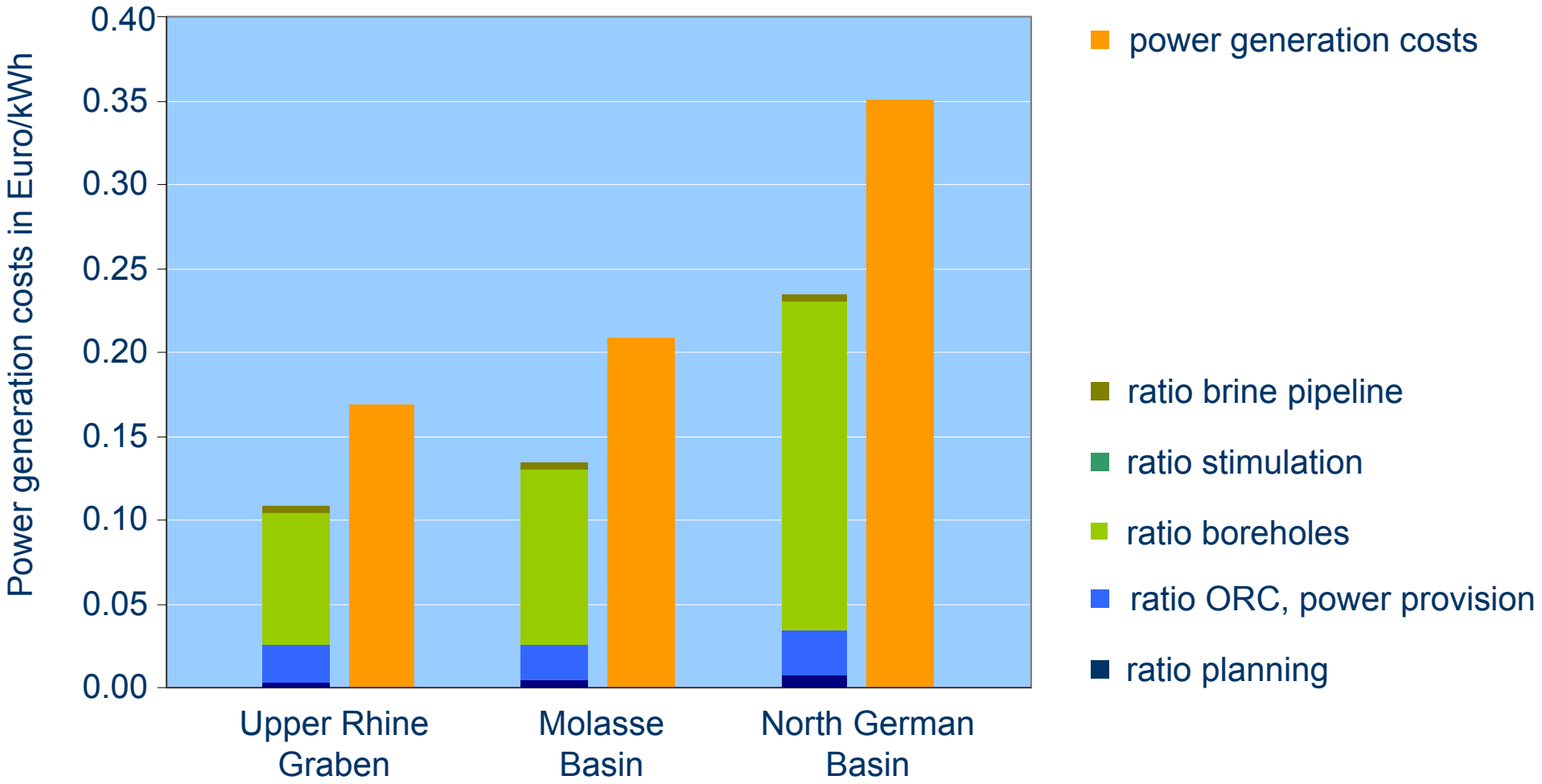

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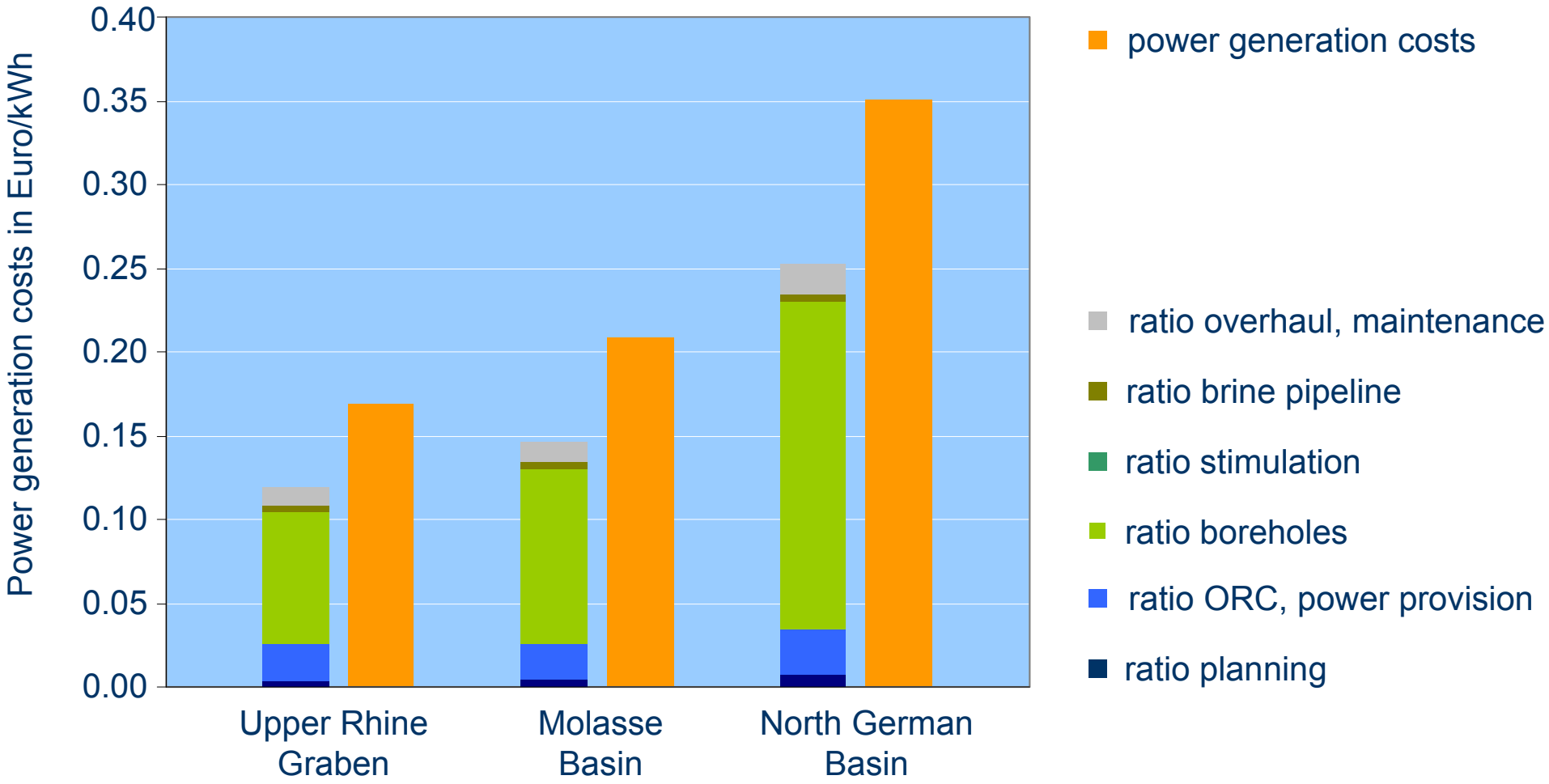

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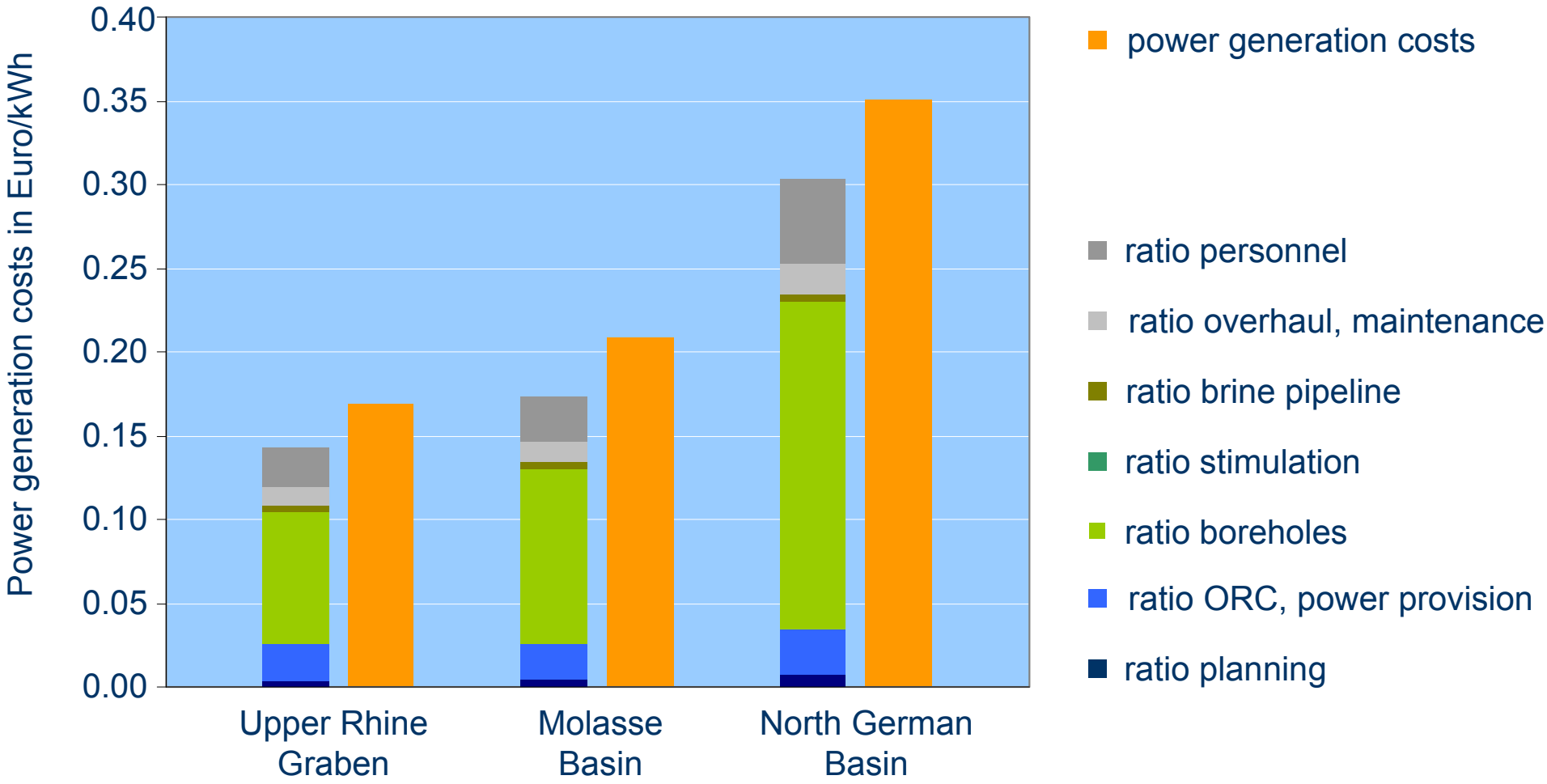

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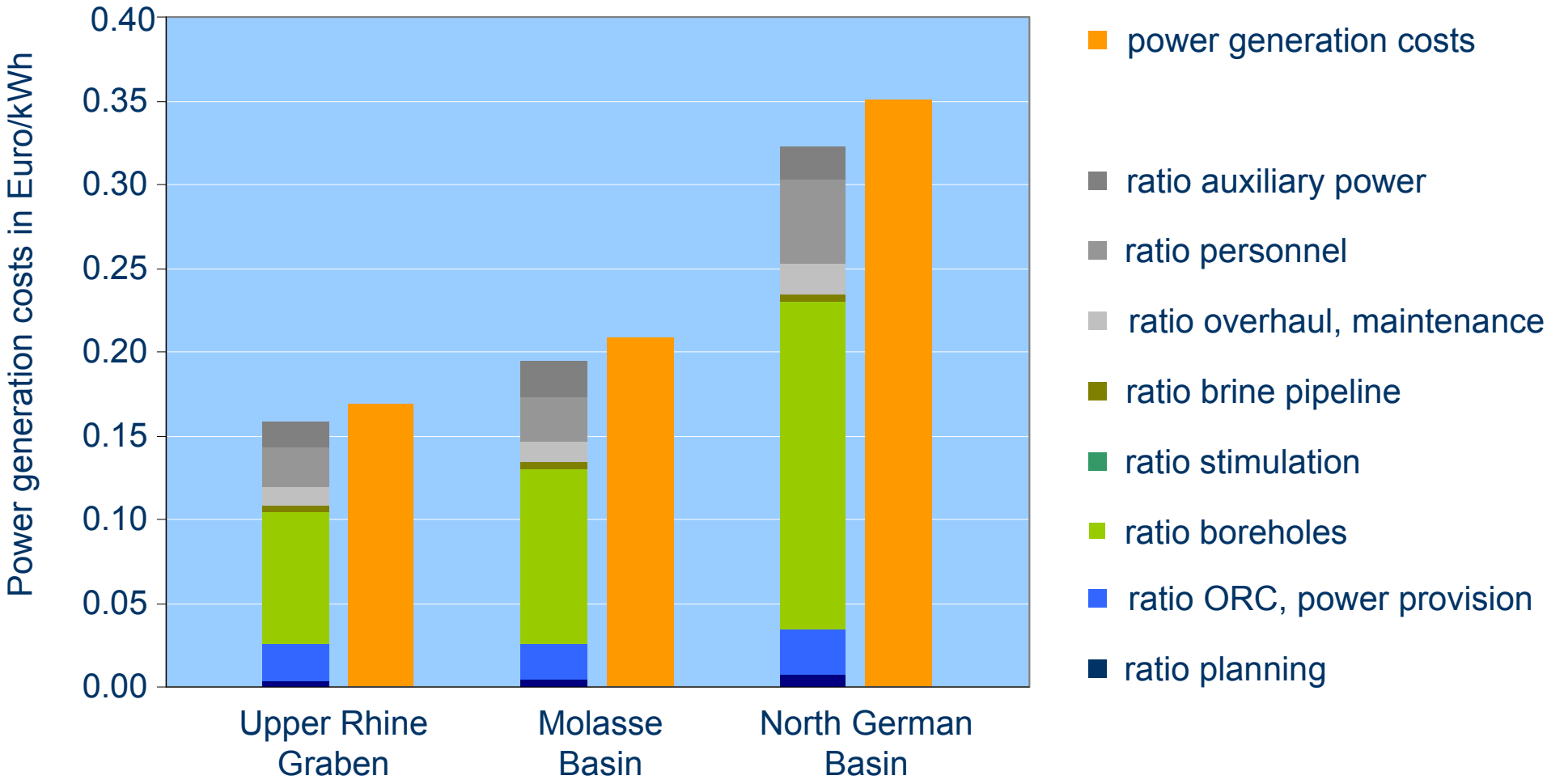

Power Generation Costs
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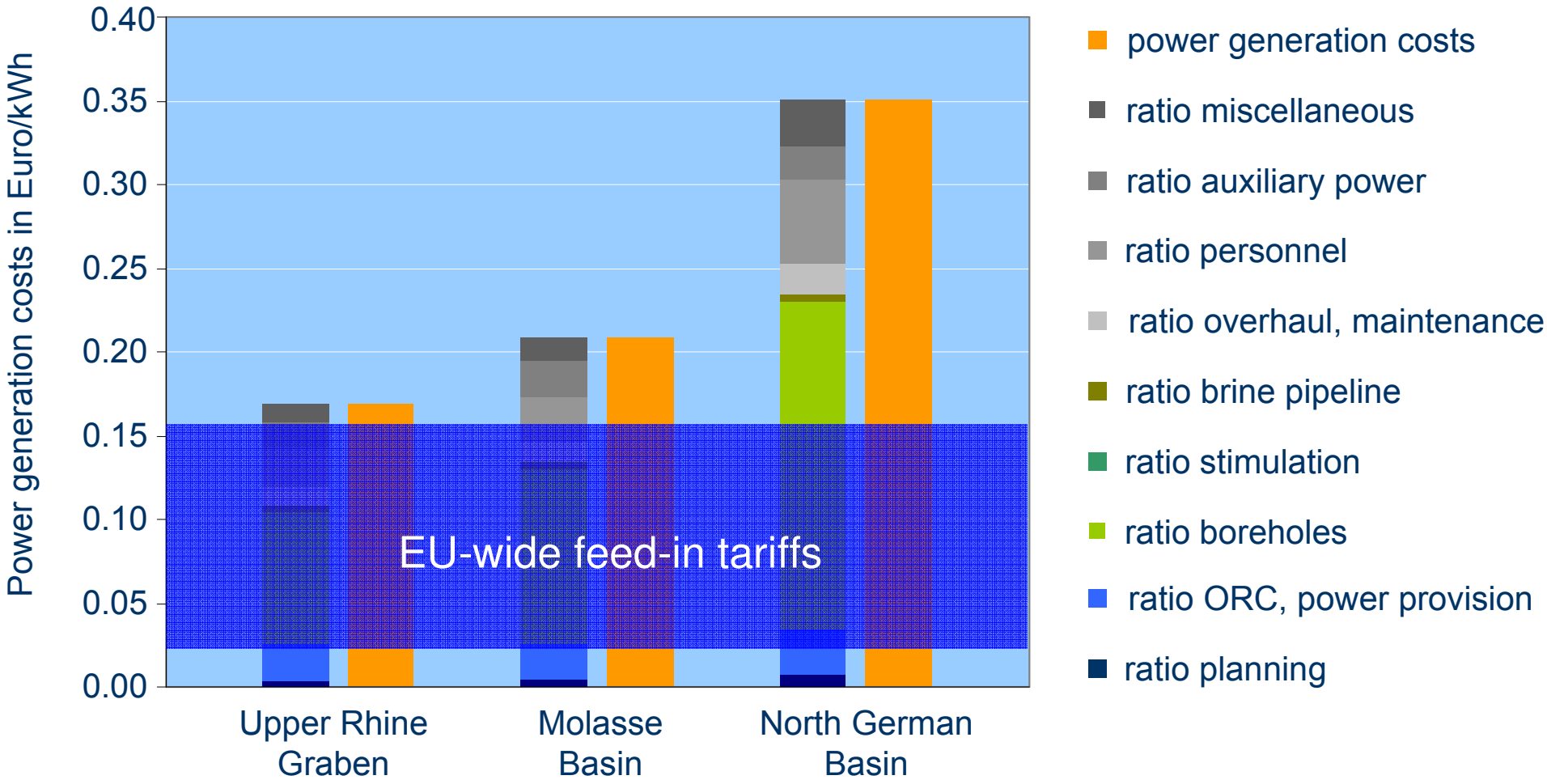
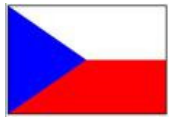


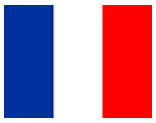
EU-wide Feed-in Tariffs for Geothermal Energy


Austria: 7,00 ct/kWh


Belgium: 2,50 ct/kWh


Czech Republic: 15,56 ct/kWh


Estonia: 5,10 ct/kWh


France: 7,62 ct/kWh (overseas: 7,93)


Germany: up to 15,00 ct/kWh

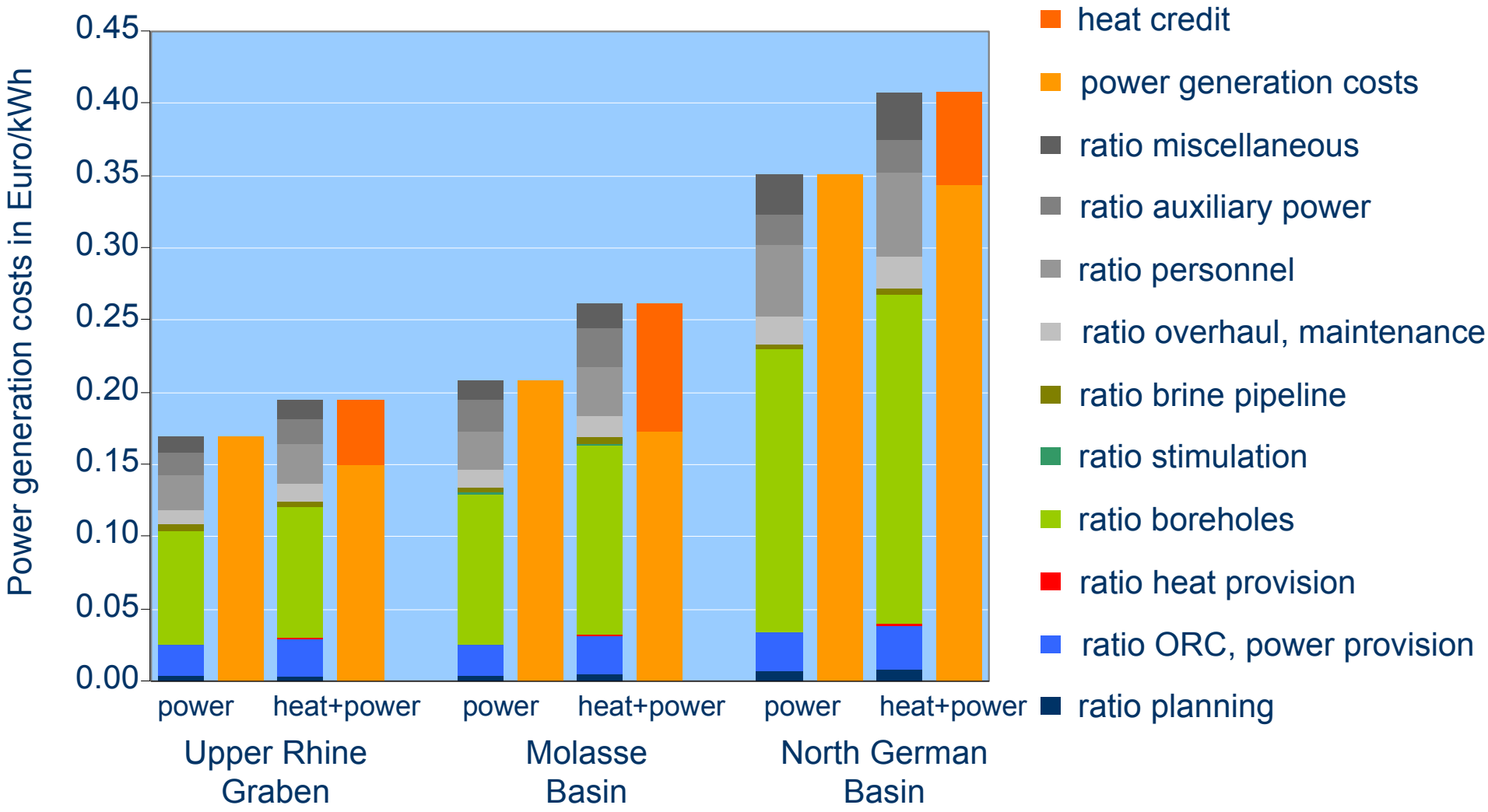

Greece: 7,31 ct/kWh


Slovakia: 9,04 ct/kWh

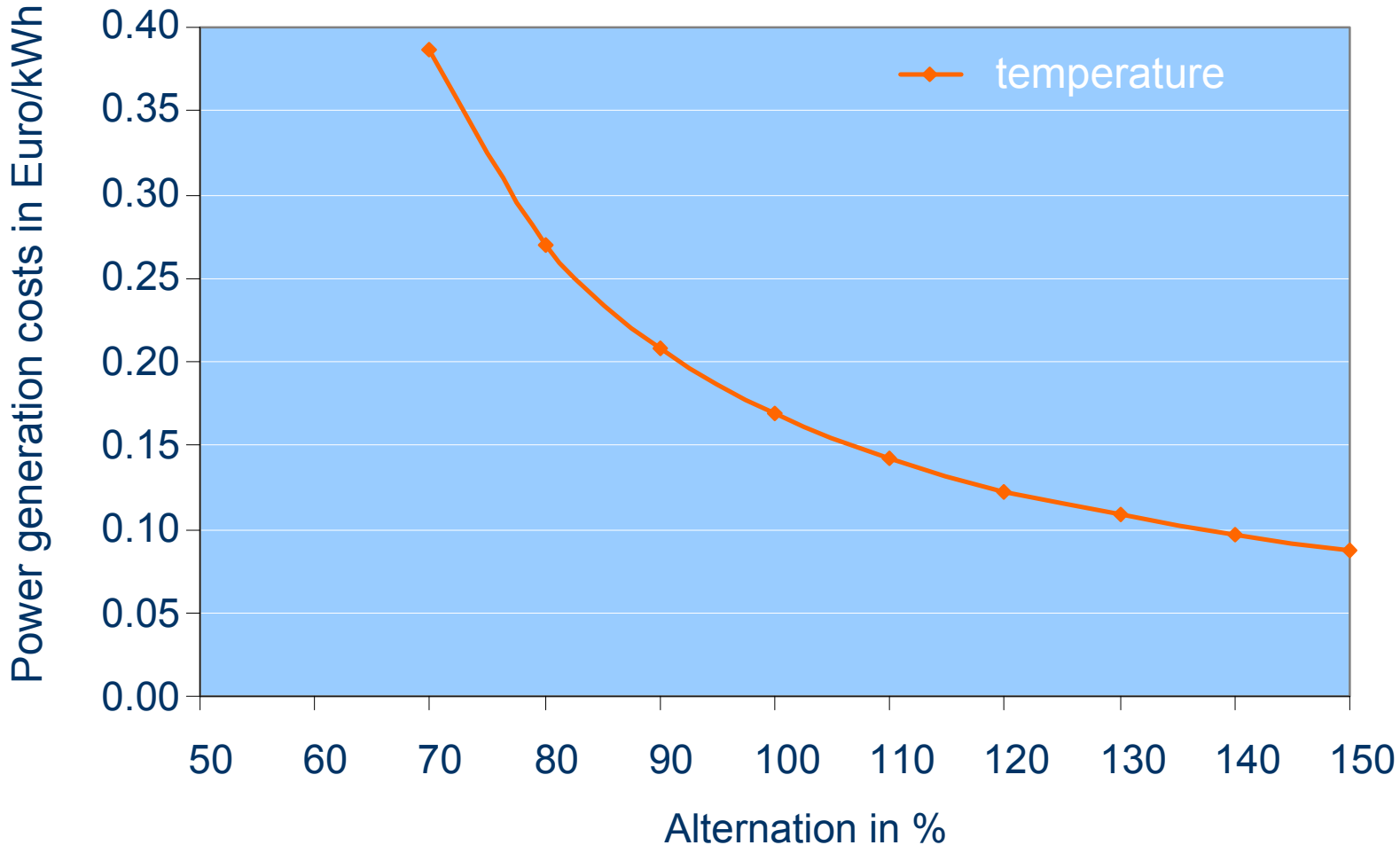

Slovenia: 5,85 + 2,52 ct/kWh


Spain: 6,49 + 2,94 ct/kWh

Power Generation Costs
- Heat and Electricty Costs -



Power Generation Costs
- Sensitivity Analysis -



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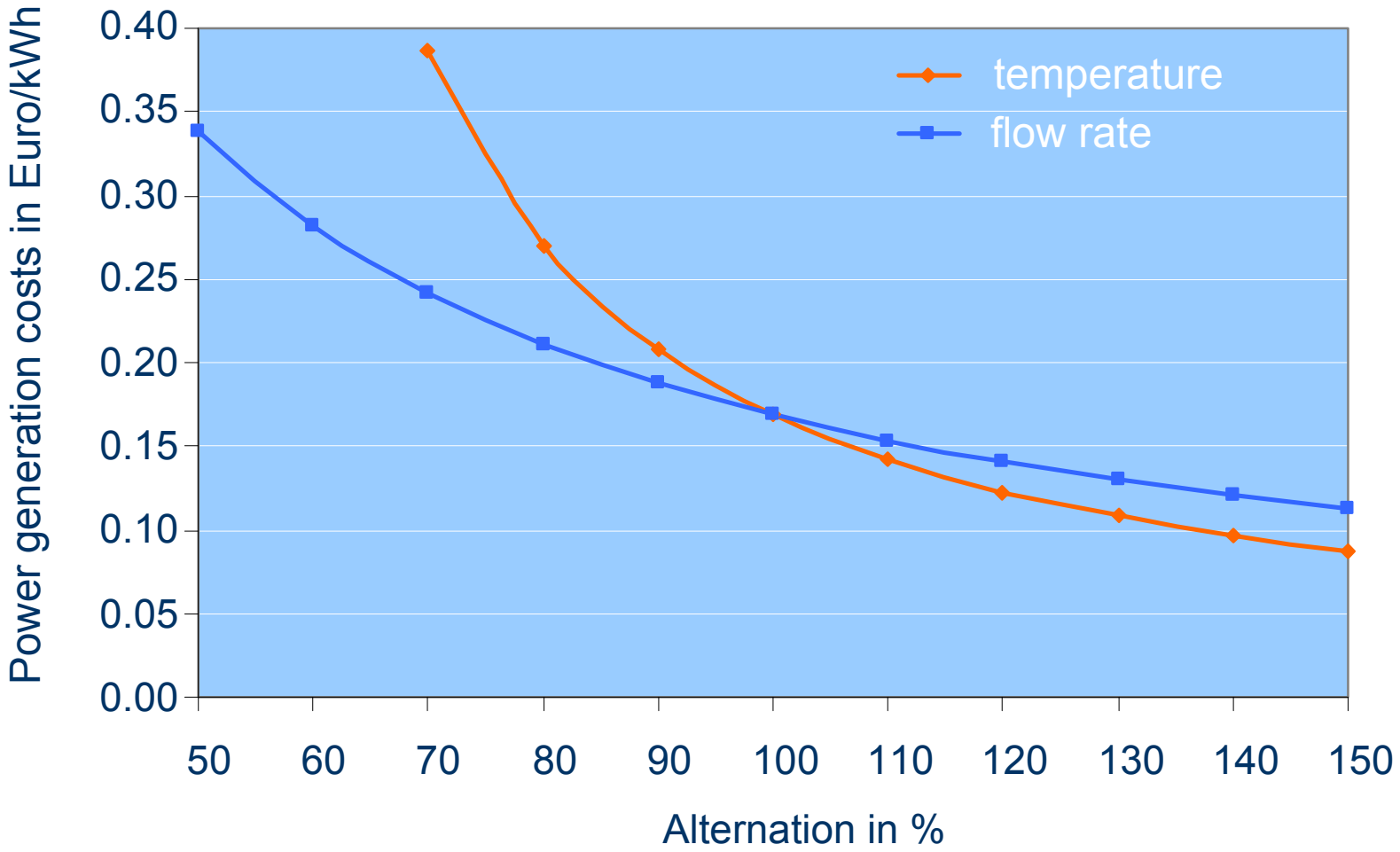

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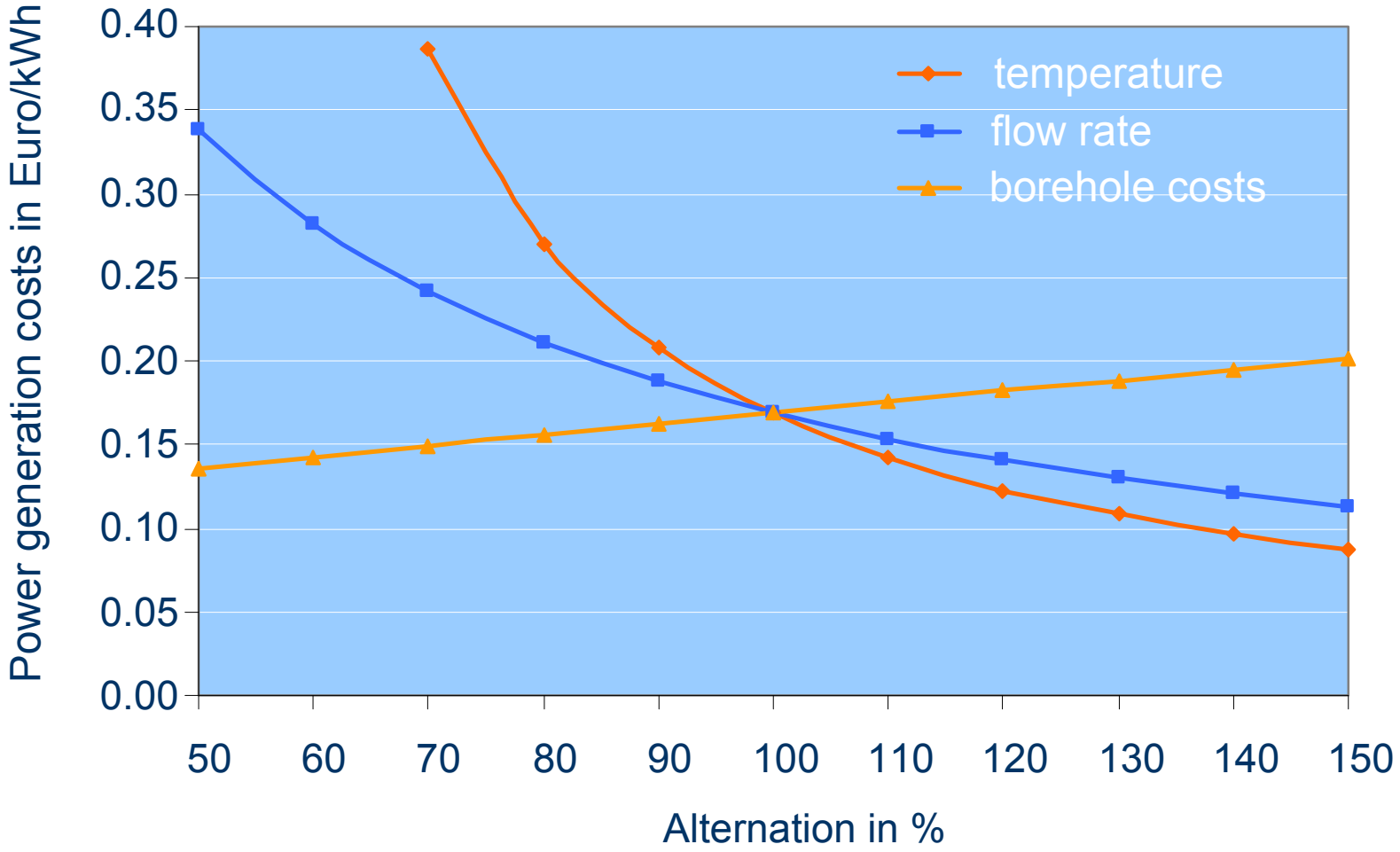

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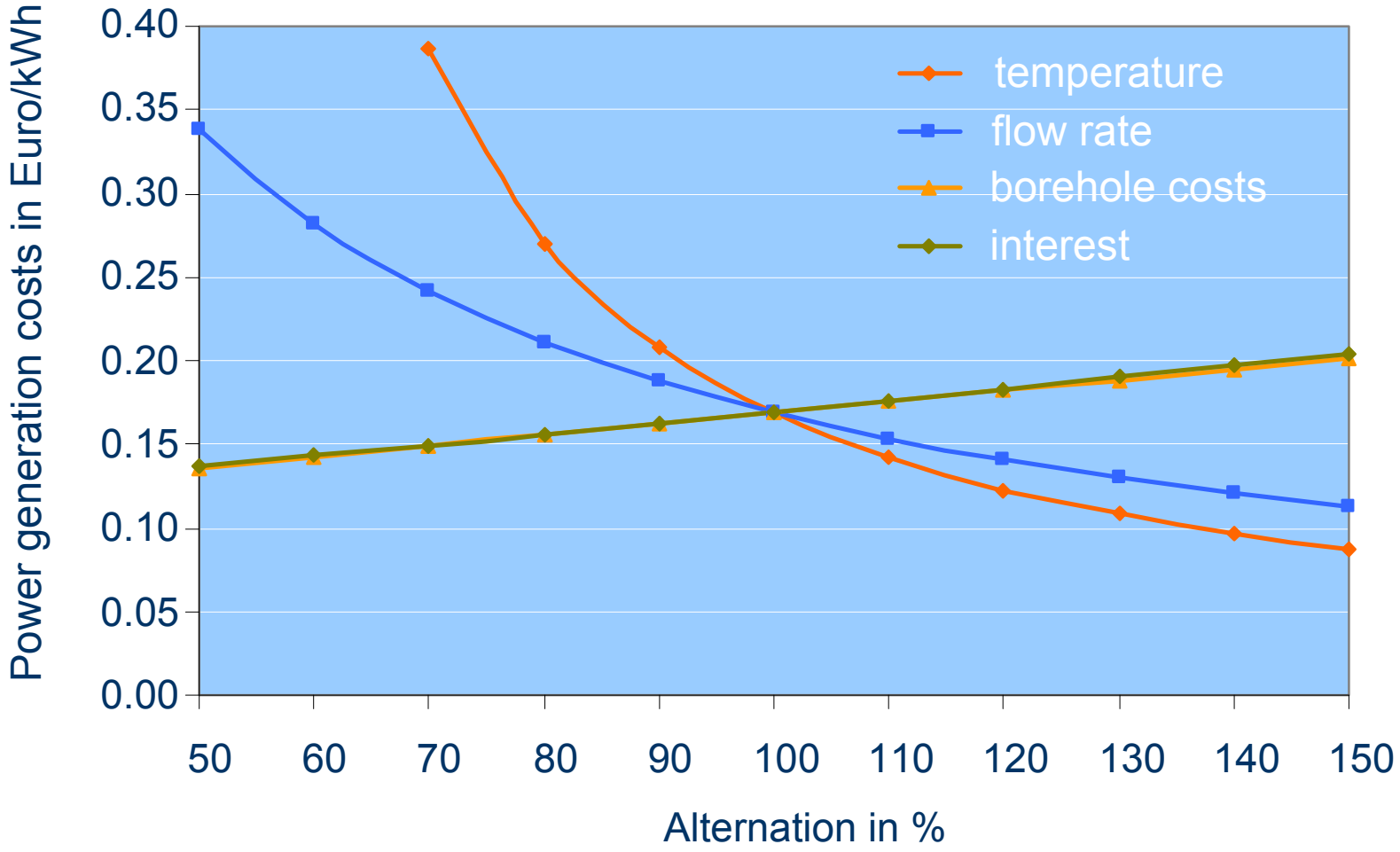

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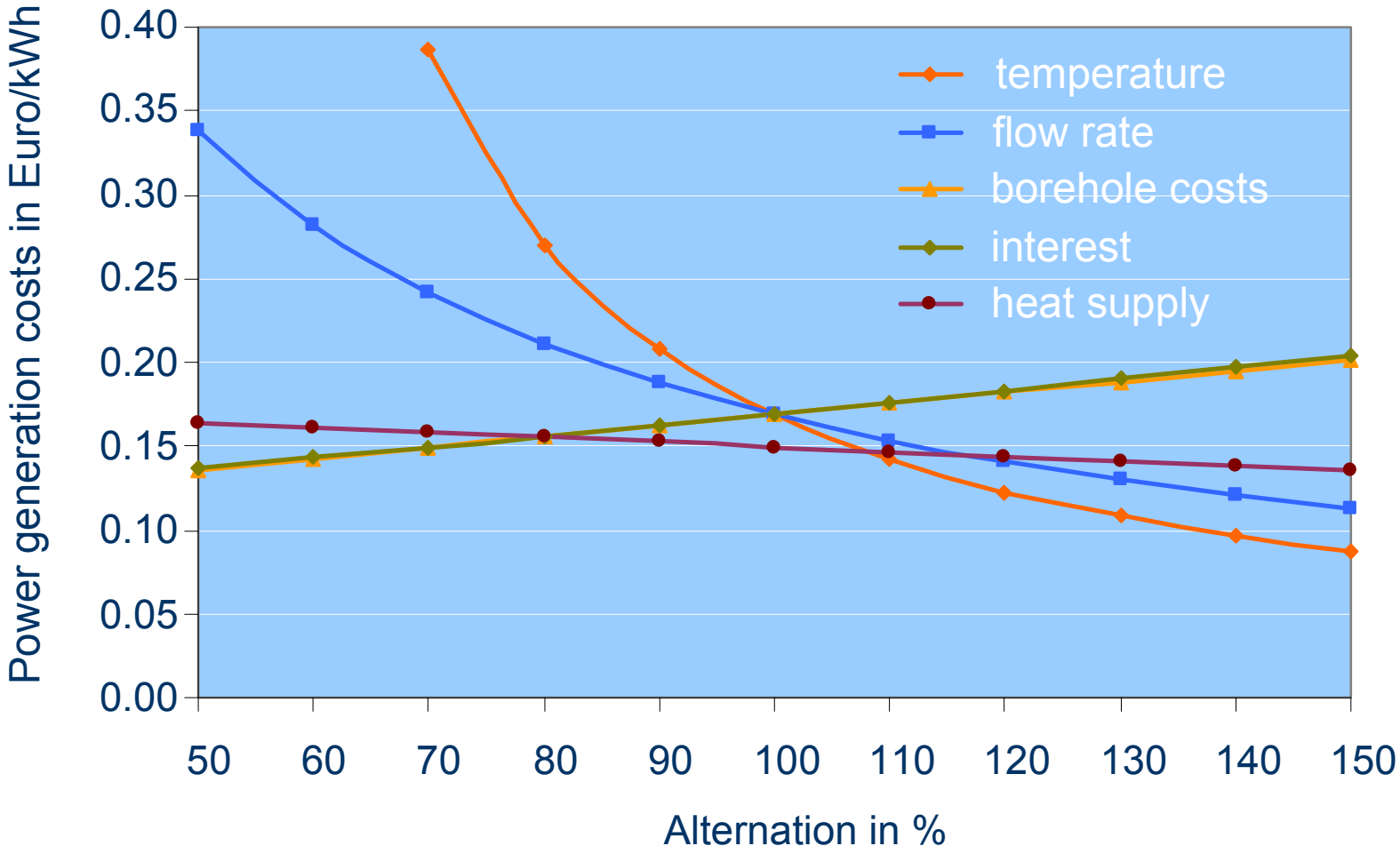

Conclusions

- In general geothermal electricity production from low enthalpy fields is only under very promising frame conditions economically feasible:
  - high reimbursement rates,
  - very good geological conditions,
  - sale of heat.
- To improve this situation among others the following measures have to be realized:
  - minimizing the geological risks by improving existing and developing improved and new exploration technologies,
  - cost reduction and risk minimization during drilling and stimulation,
  - optimization of the above ground power plant technology e.g. through a combination with other technologies,
  - improvement of the site specific heat demand.
- If these preconditions are fulfilled and these challenges are met there is indeed a good chance to develop technically promising, economic feasible, environmentally sound and socially acceptable geothermal energy systems.

Thank you very much for your attention!

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