Design Approach for Geothermal Binary Power Plants

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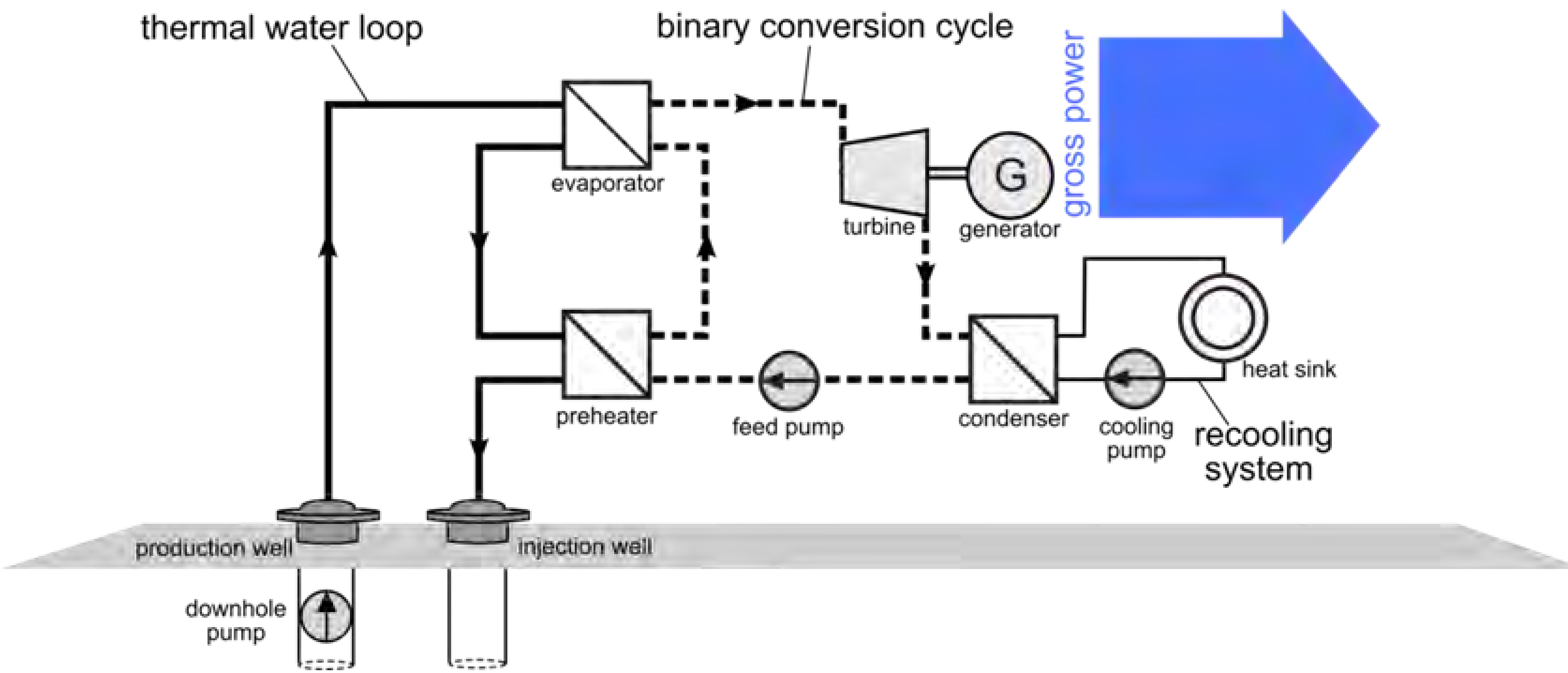
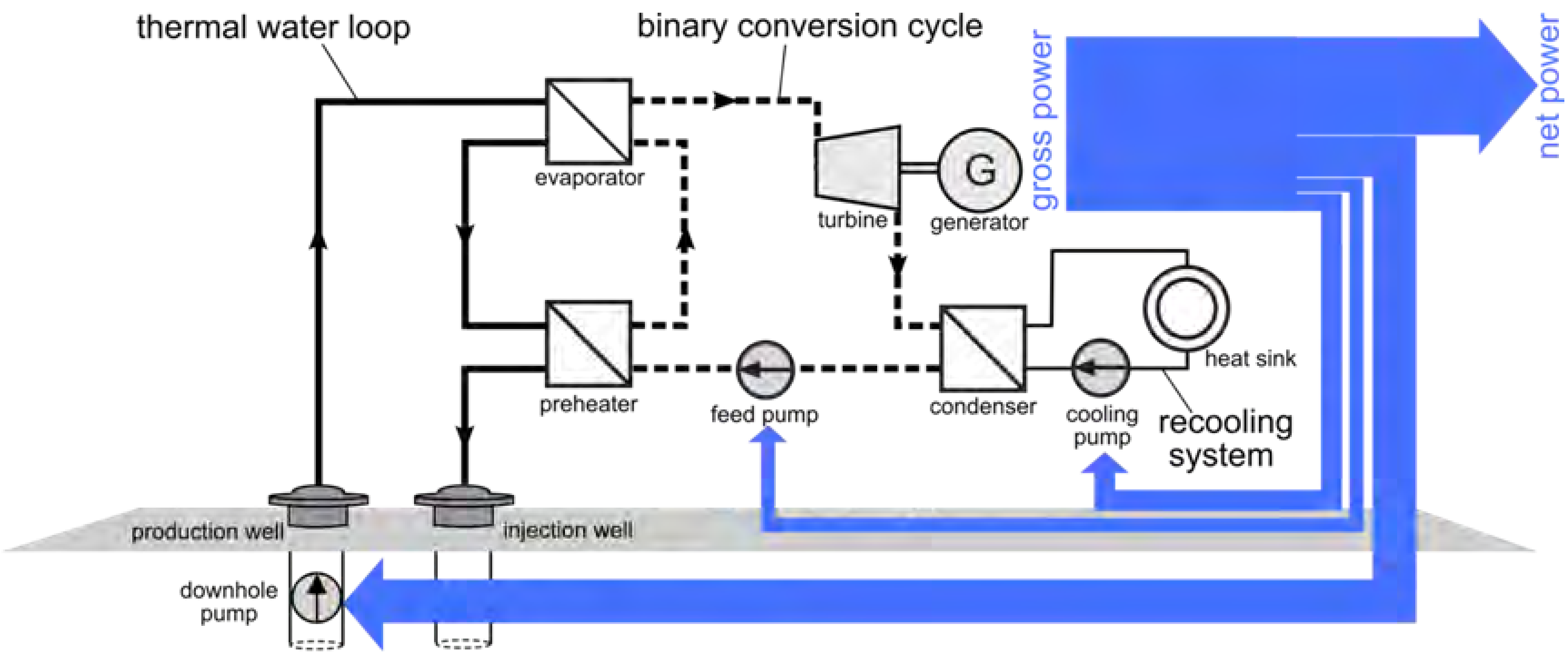
Introduction



→ **Power plants serve for net power provision**

Introduction

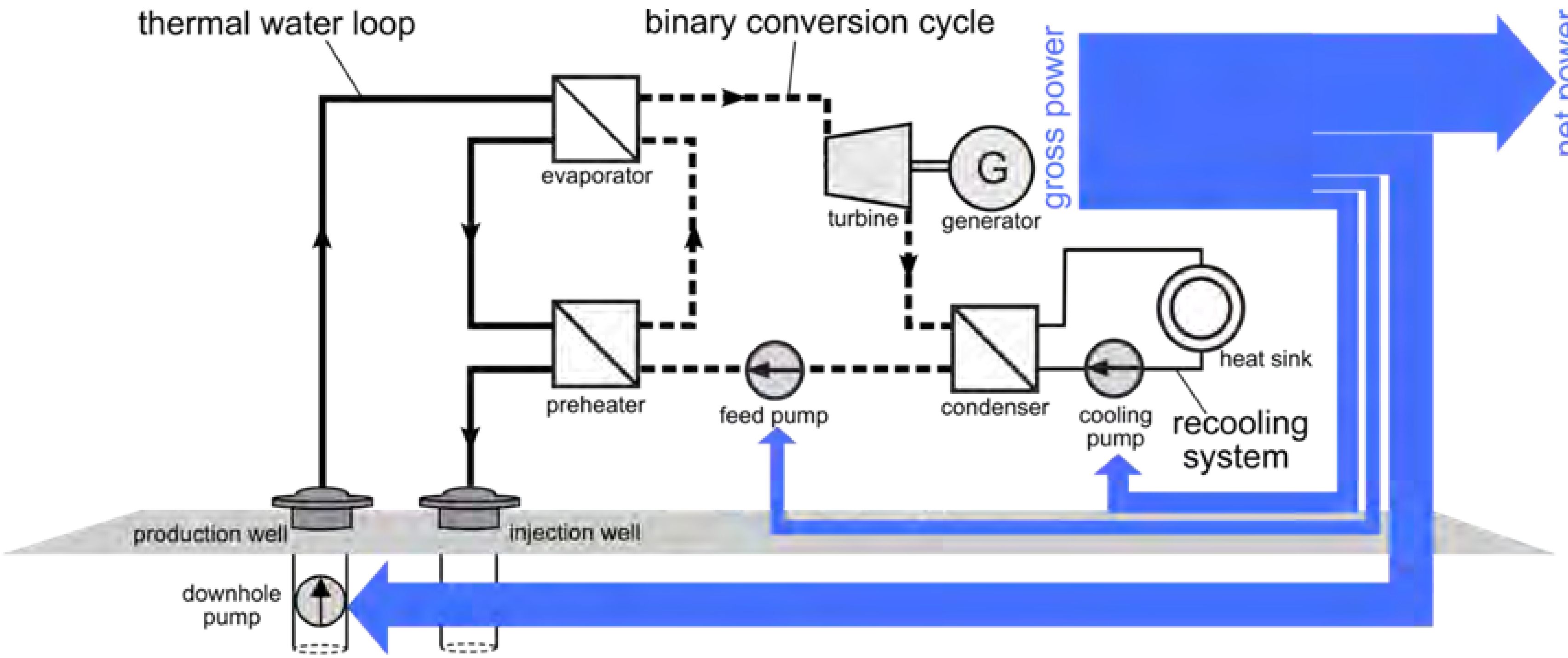


→ **Geothermal binary plants need holistic design approach**

Overview

- Design approaches: net vs. gross power maximisation
- Influence of surface installations and preconditions on maximum net power and optimum geothermal fluid flow
- Conclusions
- Outlook

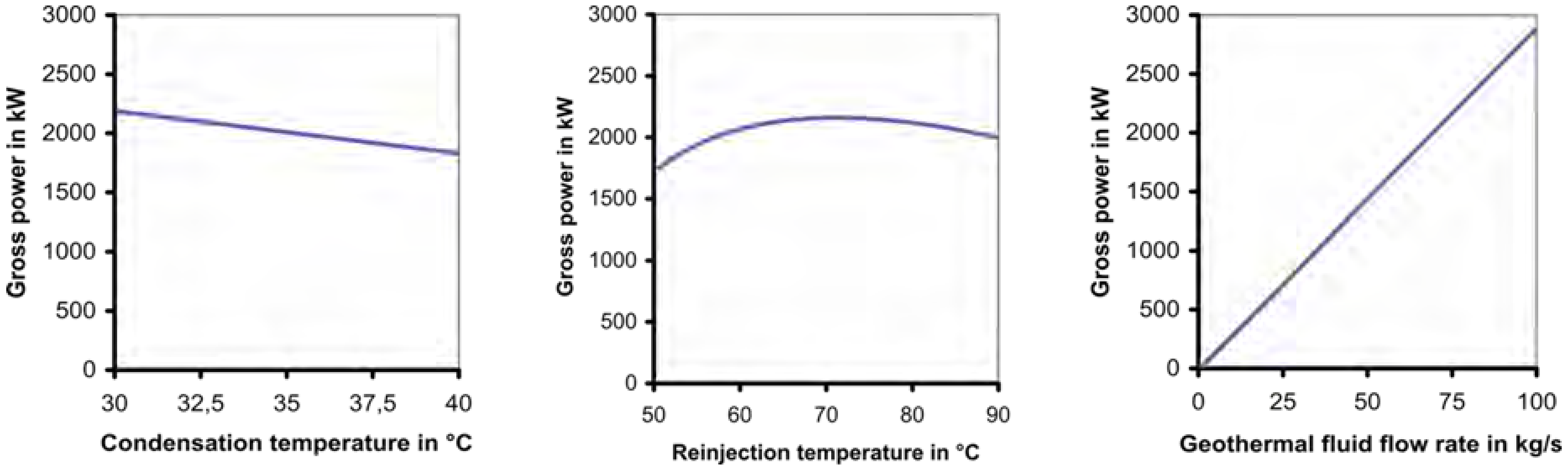
Introduction



Net vs. gross power maximisation

Design approach: **Gross** power maximisation

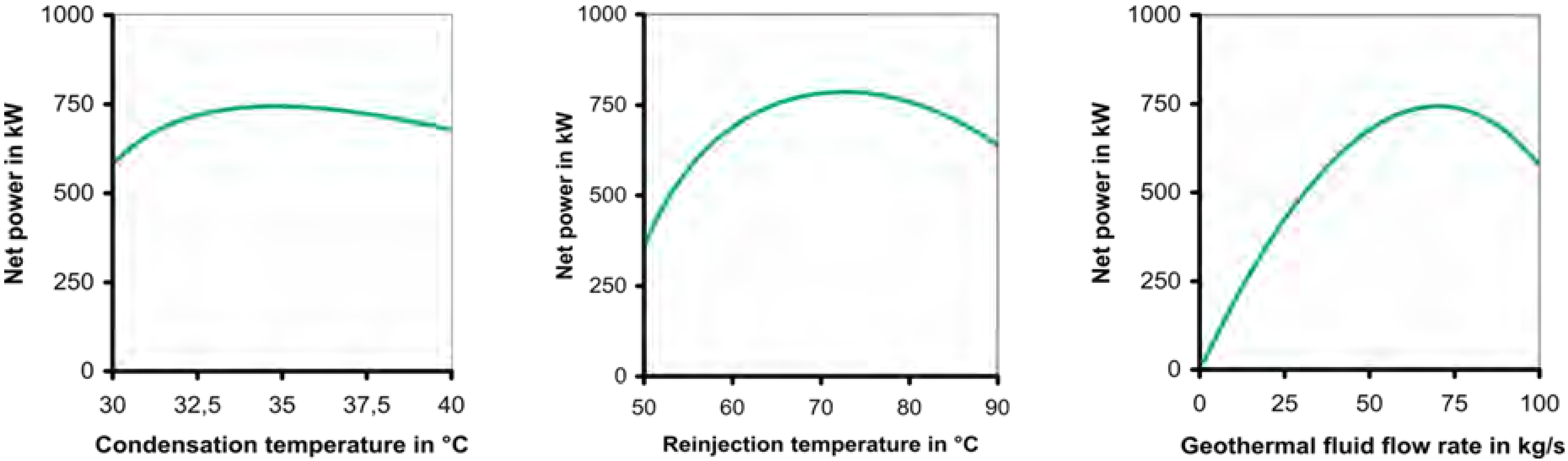
- Minimum condensation temperature
- Optimum reinjection temperature (or evaporation temperature)
- Predefined flow rate (maximum flow rate)



Net vs. gross power maximisation

Design approach: **Net** power maximisation

- **Optimum** condensation temperature
- Optimum reinjection temperature (or evaporation temperature)
- **Optimum** flow rate



Net vs. gross power maximisation

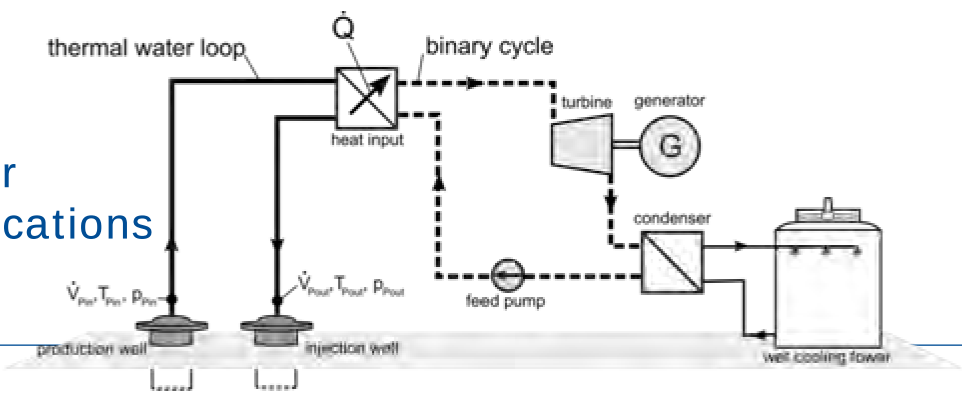
Case study

– Example site with well doublet:

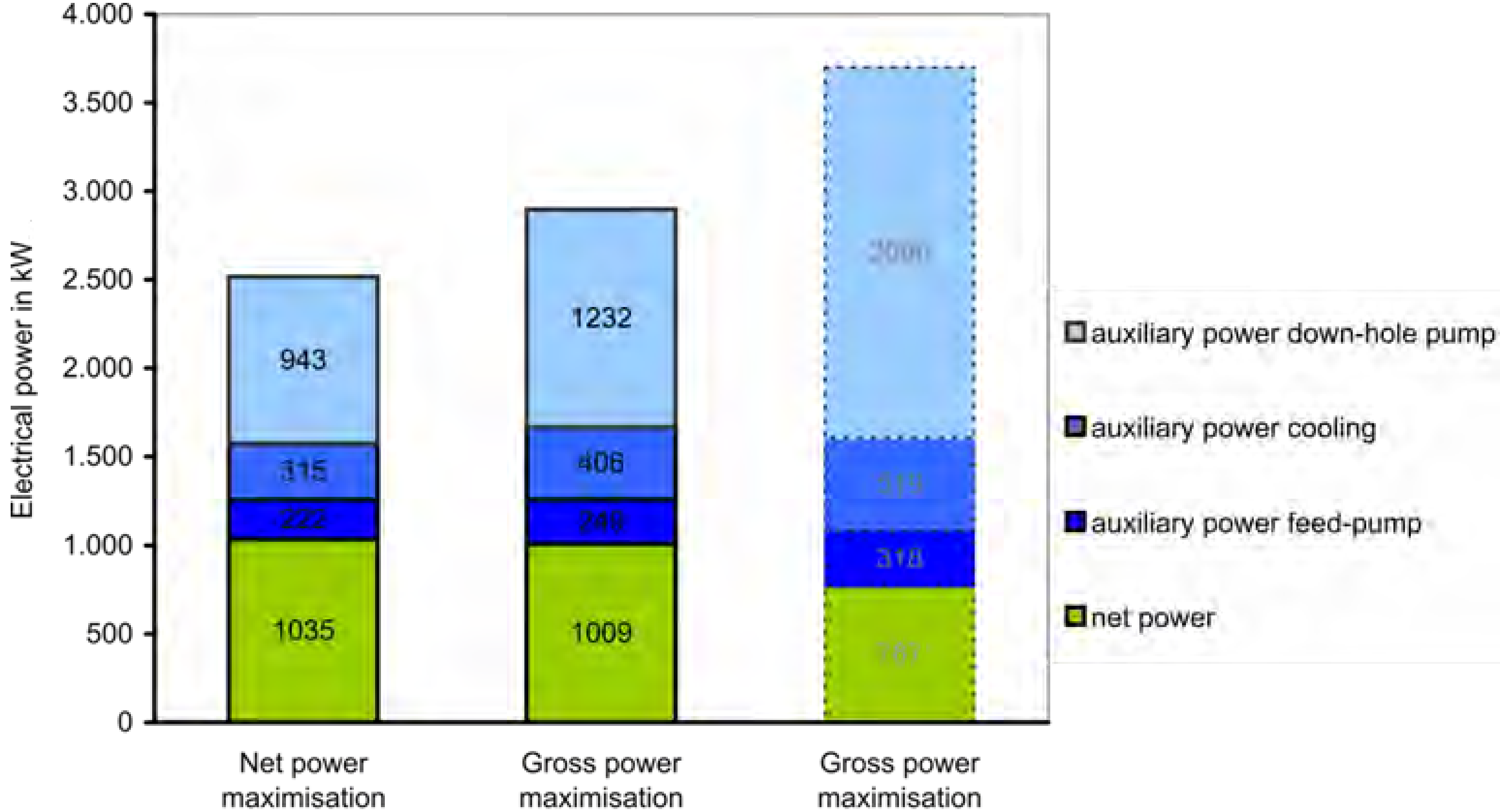
reservoir temperature	150 °C
reservoir depth	4,000 m
productivity / injectivity index	30 m^3/(h MPa)
pore pressure gradient	10.7 bar/100m
specific heat capacity geothermal fluid	3.8 kJ/kg K
geothermal fluid density	1.147 kg/m^3
average ambient temperature	10° C
average relative humidity	80%

– Surface installations:

ORC with pure working fluid
forced draught wet cooling tower
equal general component specifications



Net vs. gross power maximisation



isobutene	isobutene	isobutene
T_C=29.8°C	T_C=29.1°C	T_C=29.1°C
T_Twout=68.7°C	T_Twout=65.5°C	T_Twout=65.5°C
m_TW=79.2kg/s	m_TW=90.0kg/s	m_TW=115.0kg/s

Optimum geothermal fluid flow rate

Case study

- Example site with well doublet

- Surface installations:

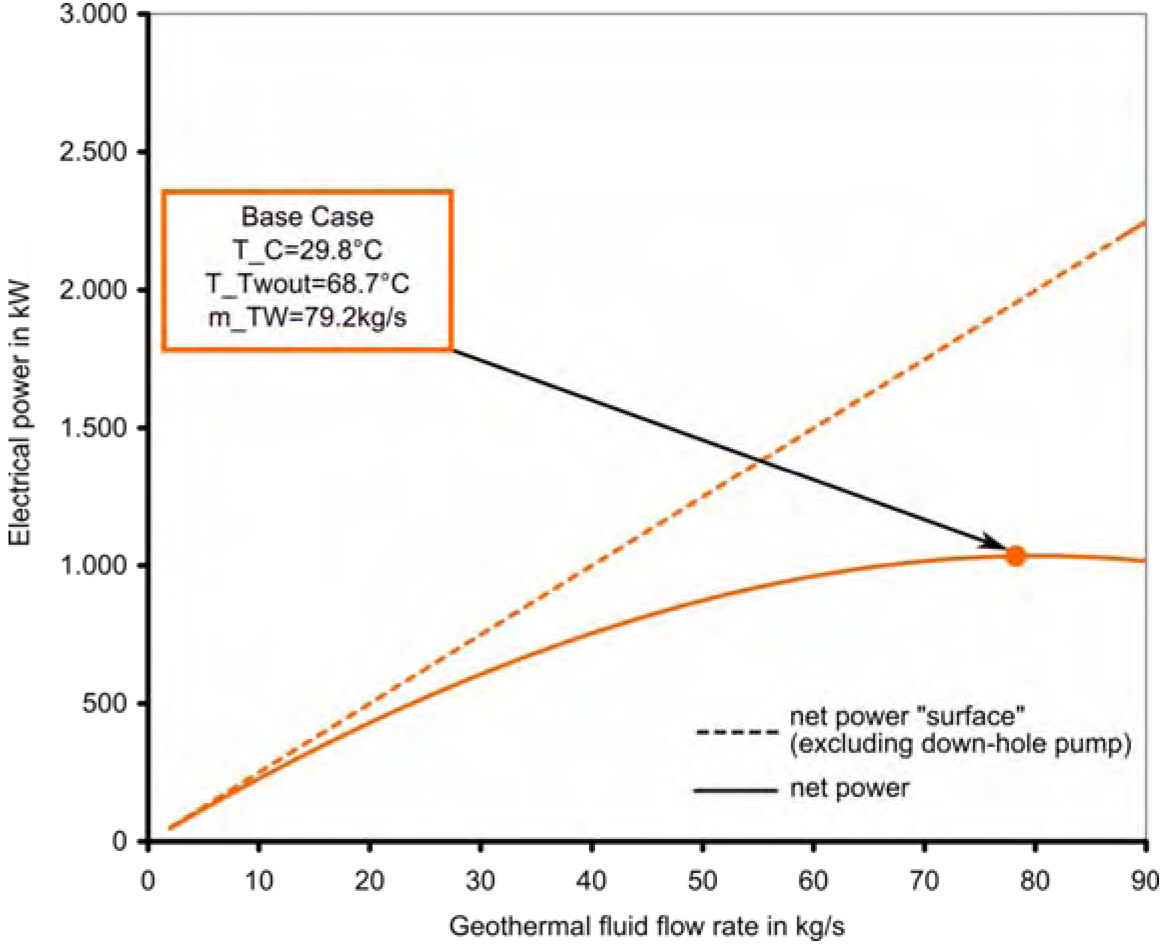
  Base Case

  Scenario 1: „Improved binary unit“
  improved heat transfer heat input, more efficient turbine

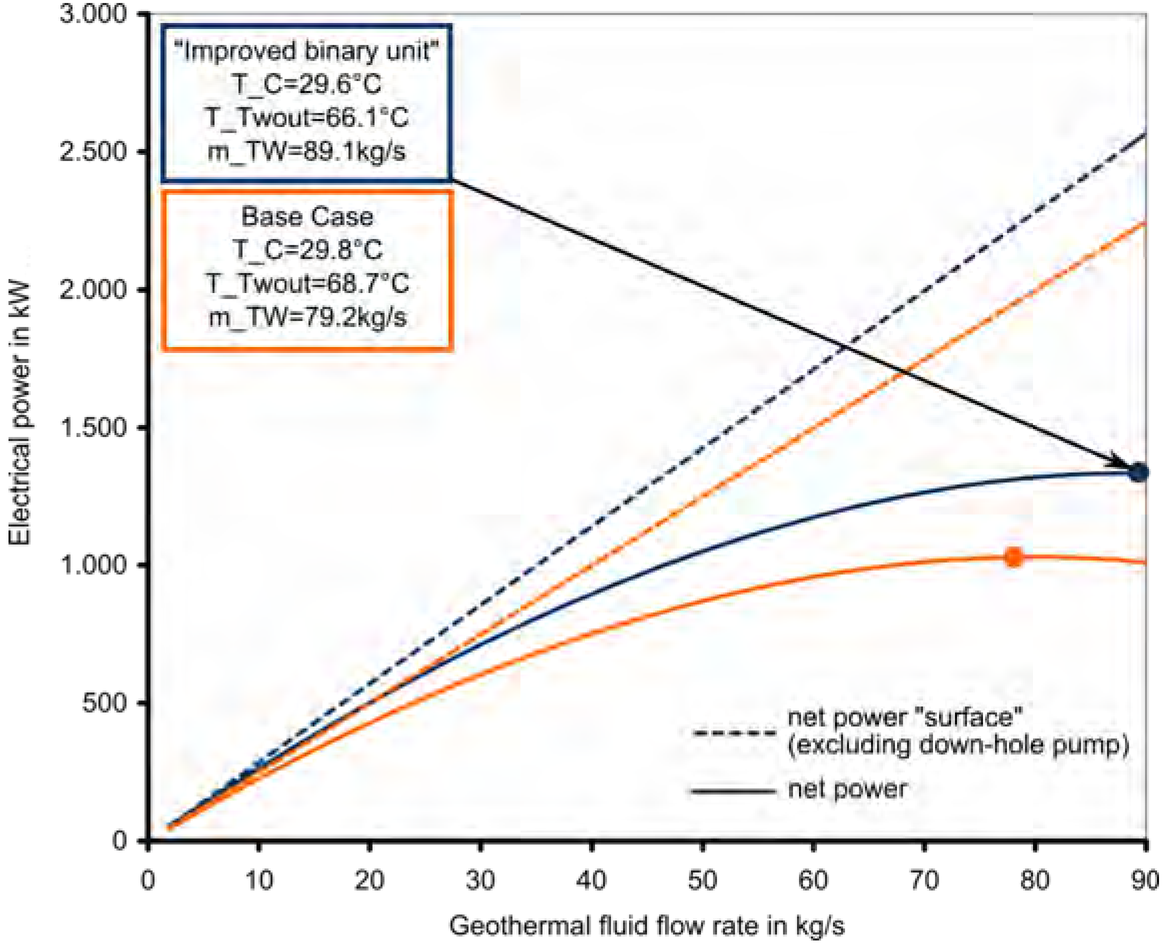
  Scenario 2: „Ambient conditions“
  ambient temperature 15° C, relative humidity 75%

  Scenario 3: „Air cooling“
  air cooled condenser

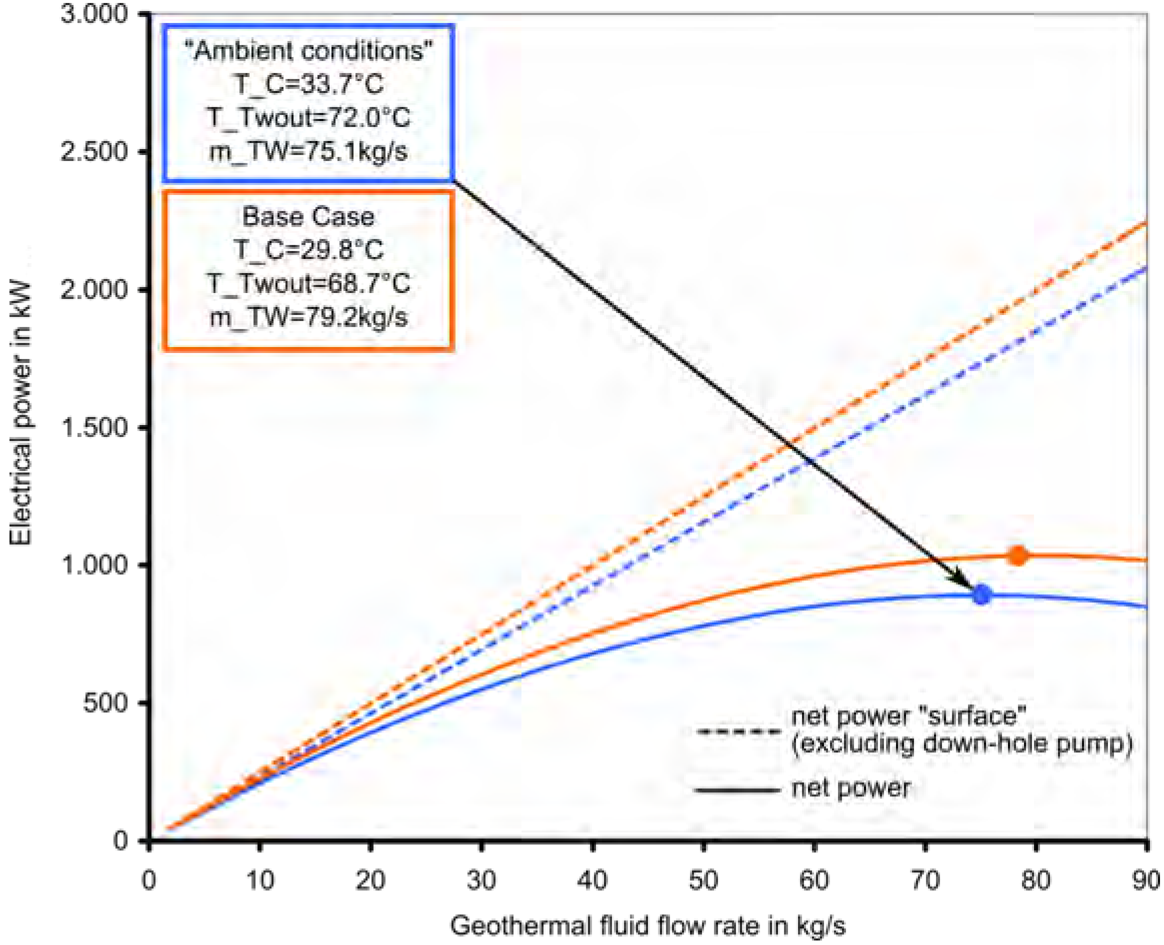
Optimum geothermal fluid flow rate



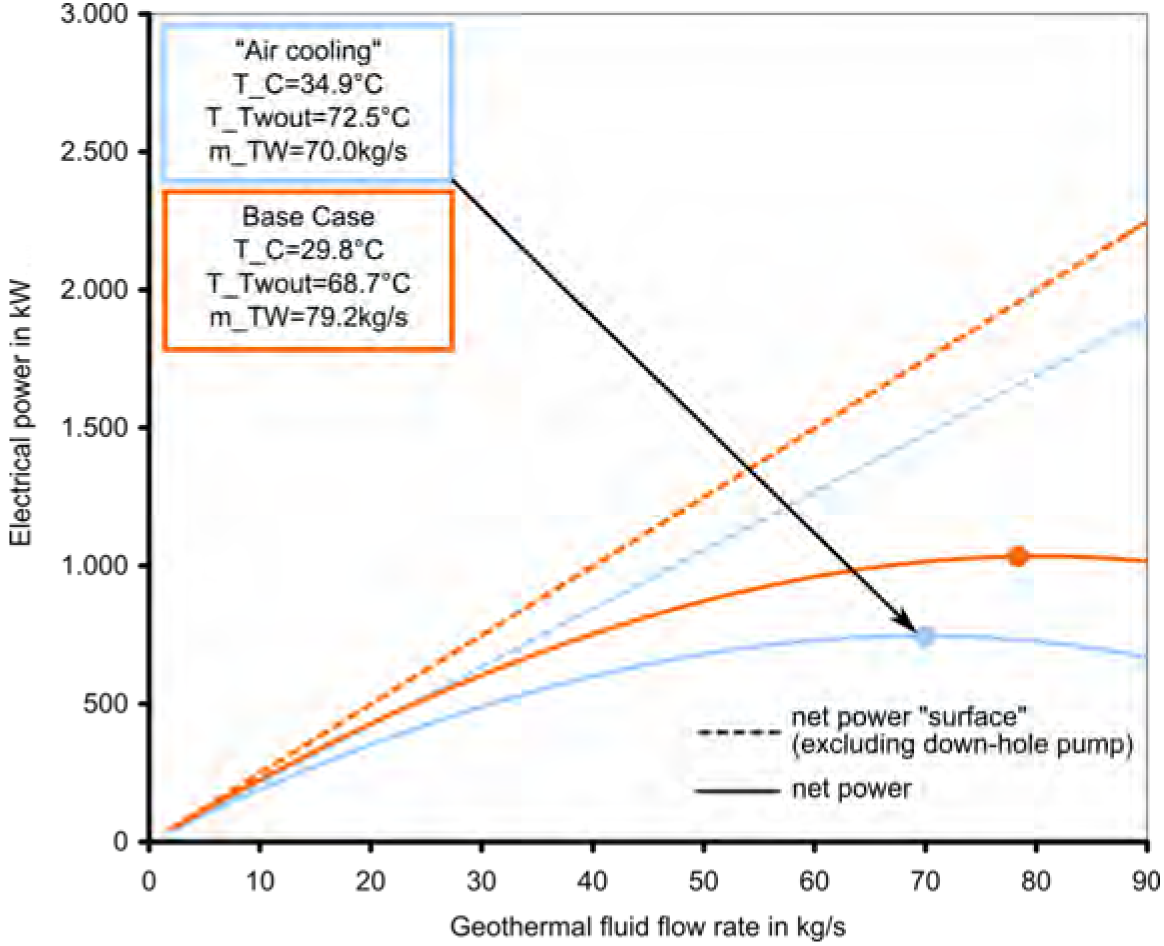
Optimum geothermal fluid flow rate



Optimum geothermal fluid flow rate



Optimum geothermal fluid flow rate

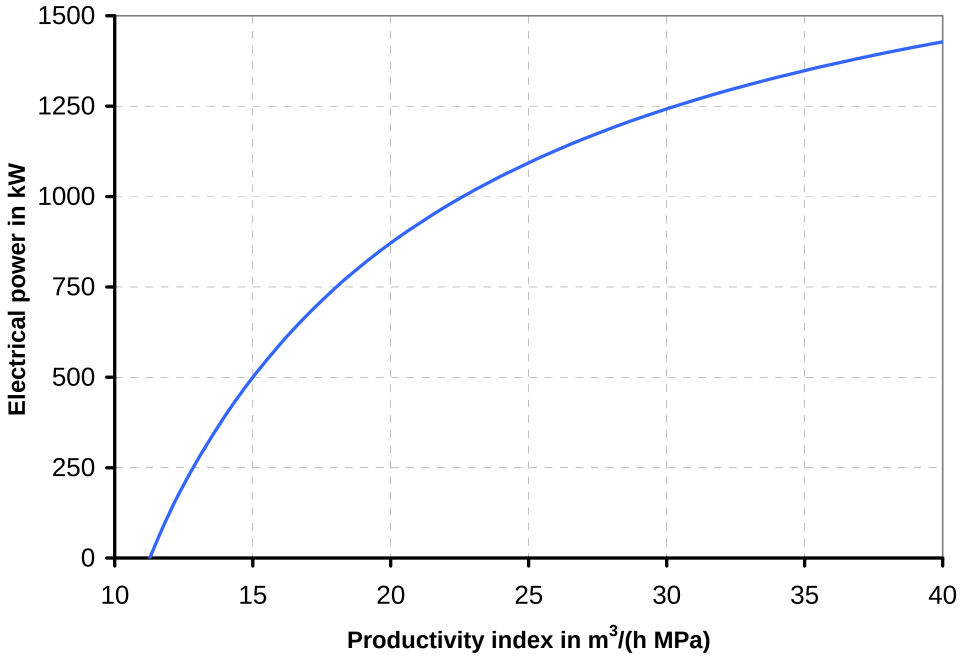


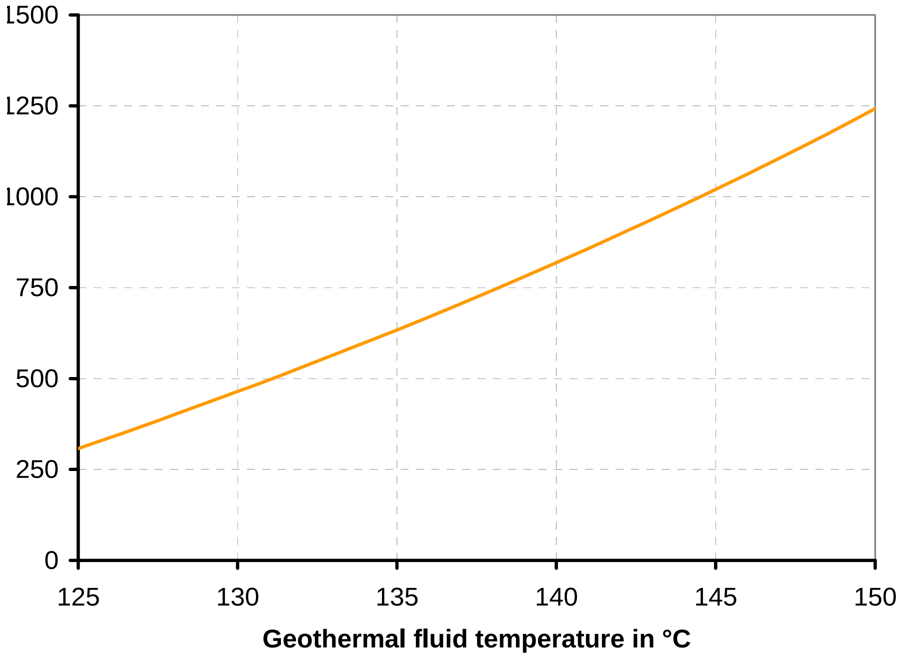
Conclusions

- Typical geothermal binary power plants
  → large auxiliary power demand (above 30%)
- Maximum net power output
  → net power optimisation with holistic design approach
- Planning and designing real plants
  → holistic design needs interaction of different disciplines
- Site-specific approach → no general plant design
- Reliable design recommendations
  → holistic design needs larger scope and more reliable data

Outlook on scope

- Holistic plant design can/must also consider:
  - seasonal part load behaviour
  - part load behaviour due to reservoir changes
  - combined energy provision
  - ...





Outlook on scope

- Holistic plant design can/must also consider:
  - seasonal part load behaviour
  - part load behaviour due to reservoir changes
  - combined energy provision
  - ...
- Holistic plant design can also integrate non-technical aspects:
  - cooling water availability
  - economic considerations
  - required space
  - noise emissions
  - ...

→ Holistic plant design needs powerful simulation tools

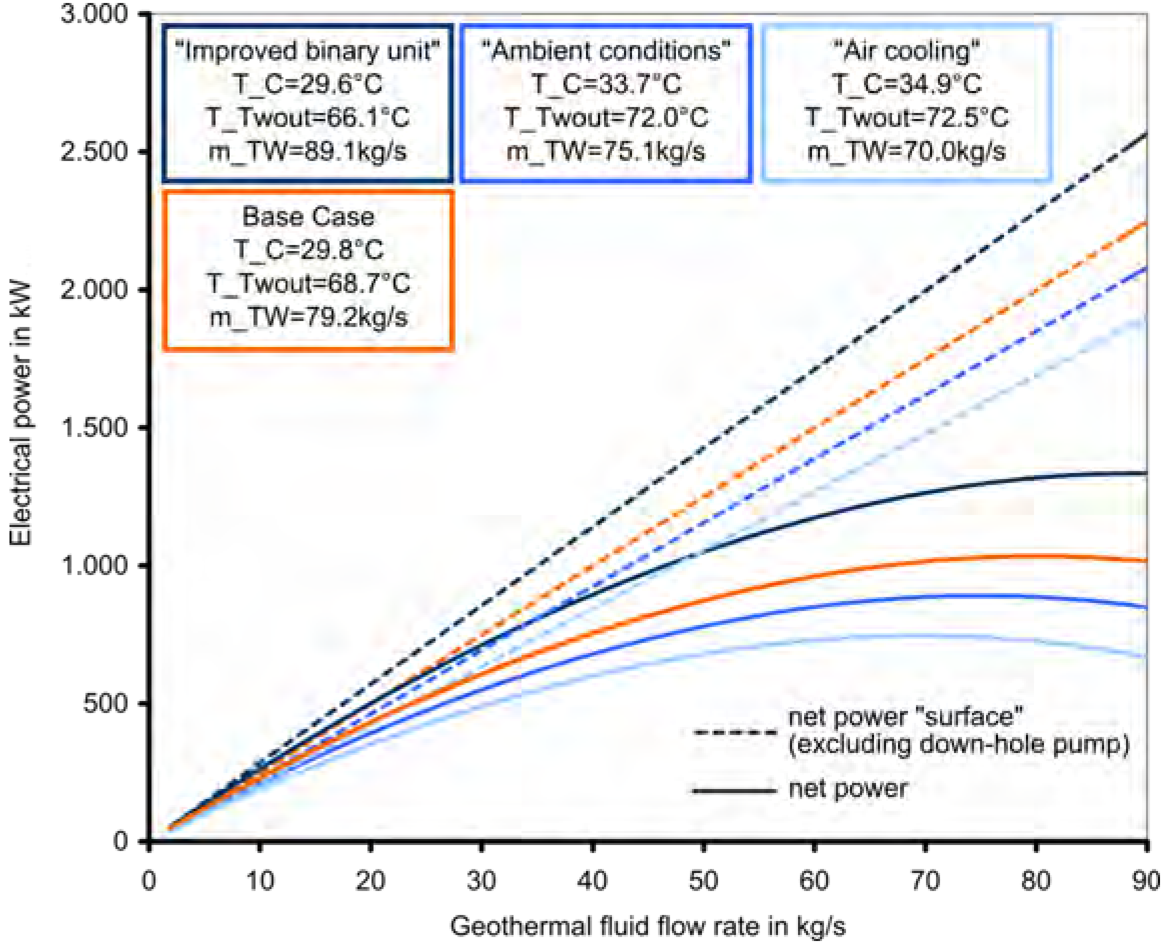
Outlook on data base

- Improvement of data reliability
  - site specific geothermal fluid characteristics
  - heat transfer between geothermal fluid and working fluid
  - local flow conditions in geothermal fluid loop
  - working fluid characteristics
- Validation of theoretical approach with data of real projects
  - monitoring concept
  - project planning

→ Development of generally applicable design approach for site-specific plant optimisation

Thank you very much for your attention!

Optimum geothermal fluid flow rate



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