Process flow and gathering system

Session VI

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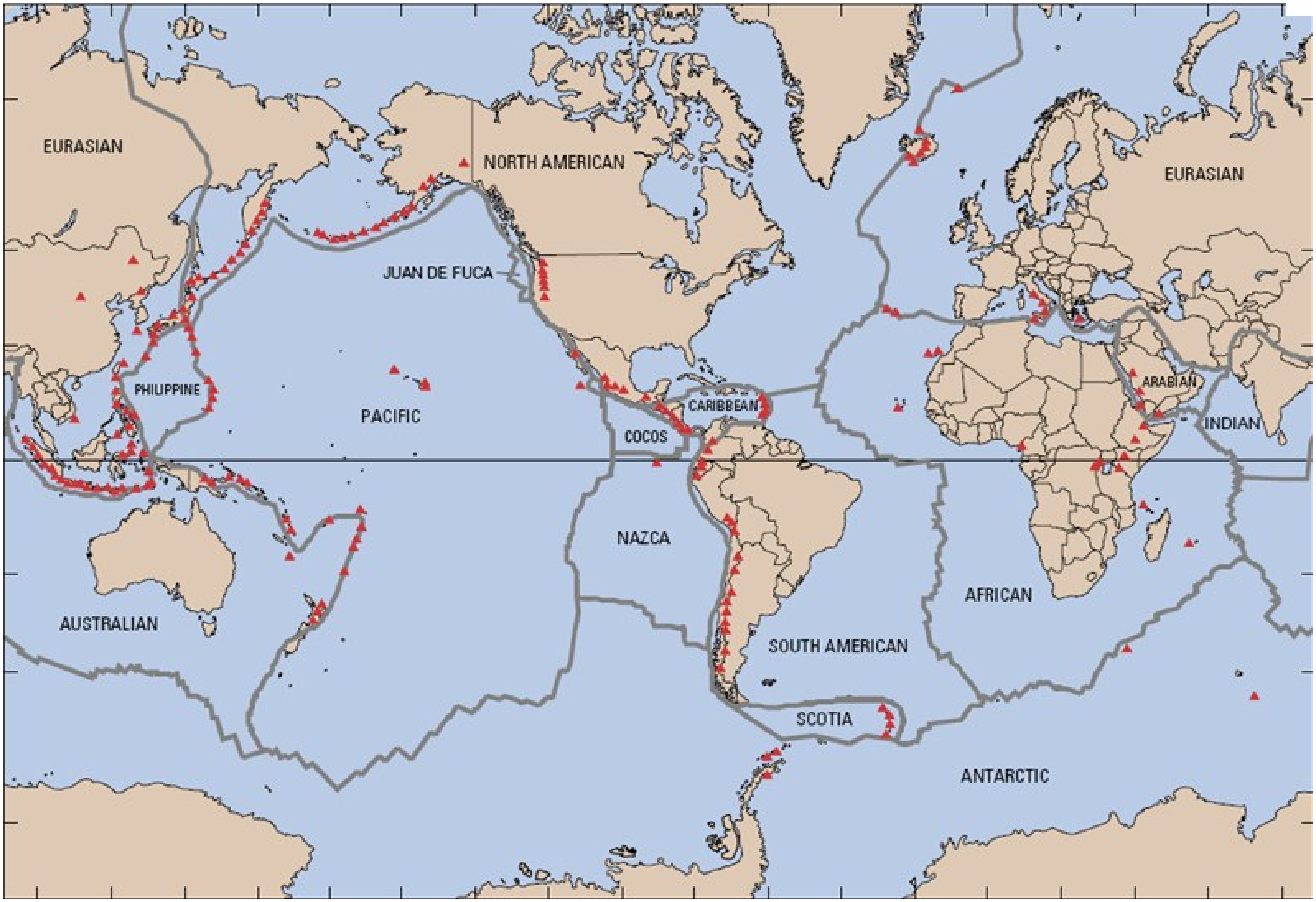
Mannvit

Strasbourg, Nov.8, 2012

Presentation overview

- Presentations reviewing different work cycles
- Main concept of the gathering system
- Calculated example showing methods used within geothermal steam gathering system design



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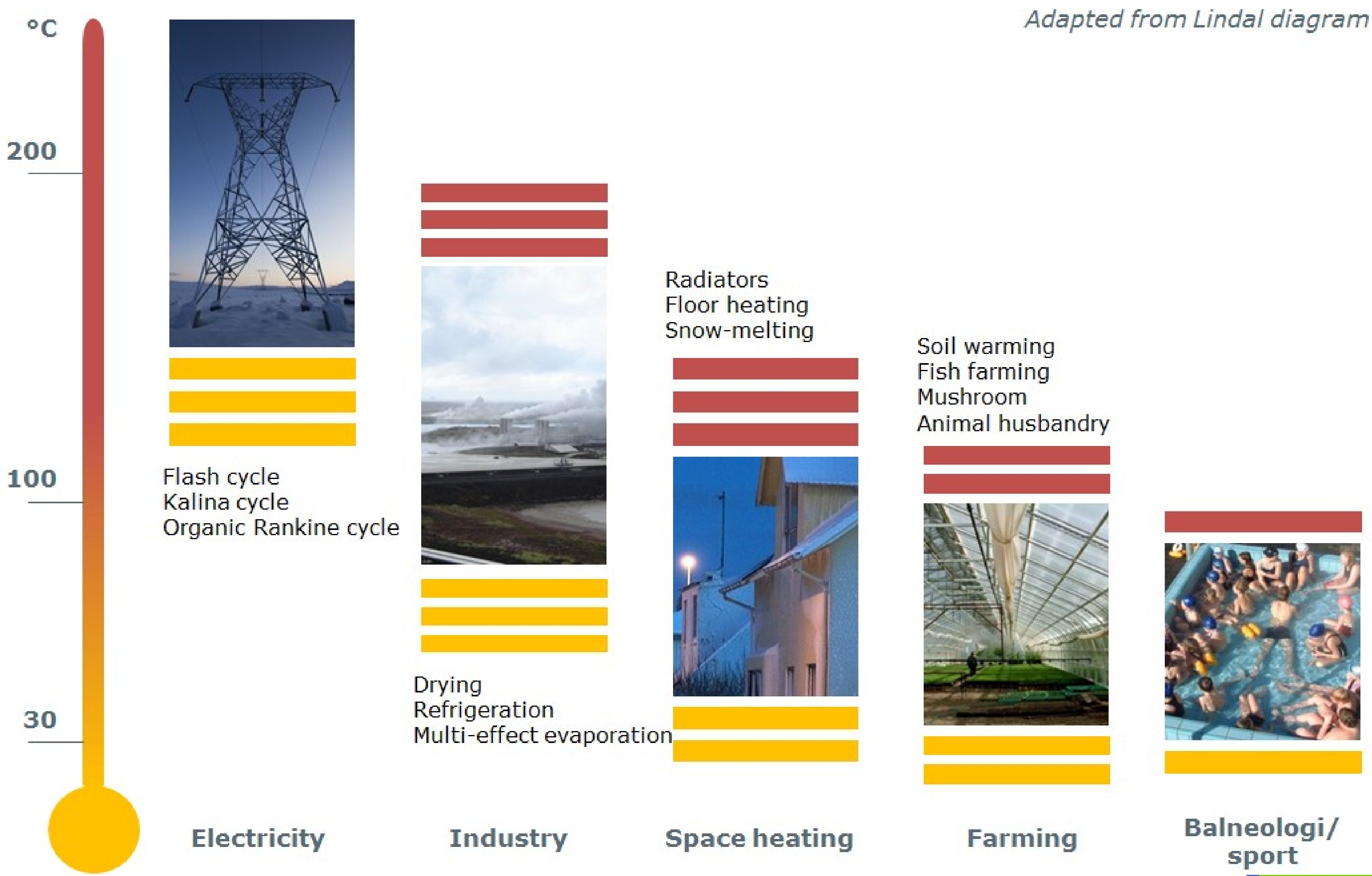
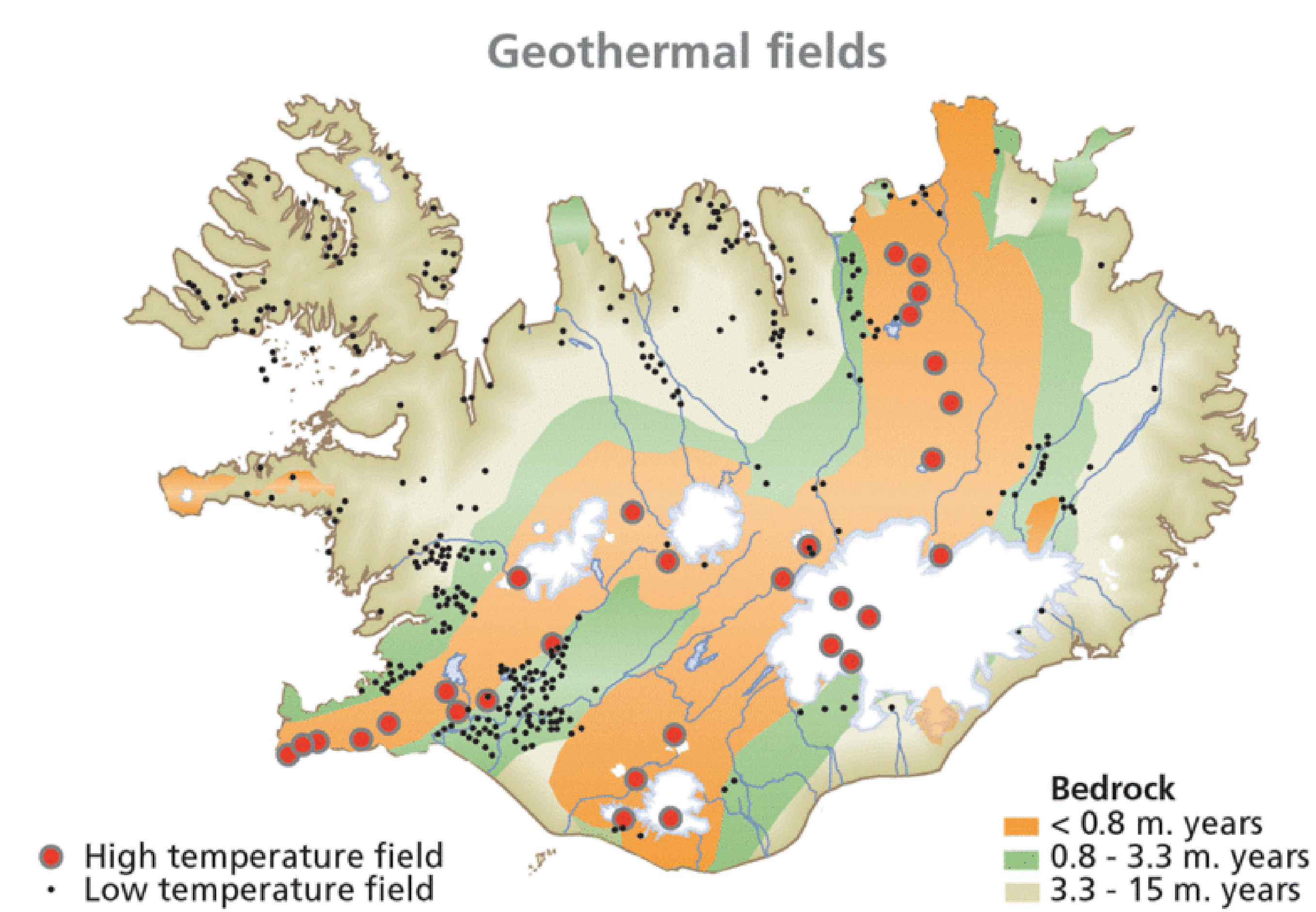


Adapted from Lindal diagram
°C
200
100
30
Flash cycle
Kalina cycle
Organic Rankine cycle
Drying
Refrigeration
Multi-effect evaporation
Radiators
Floor heating
Snow-melting
Soil warming
Fish farming
Mushroom
Animal husbandry
Electricity
Industry
Space heating
Farming
Balneologi/
sport

Geothermal in Iceland



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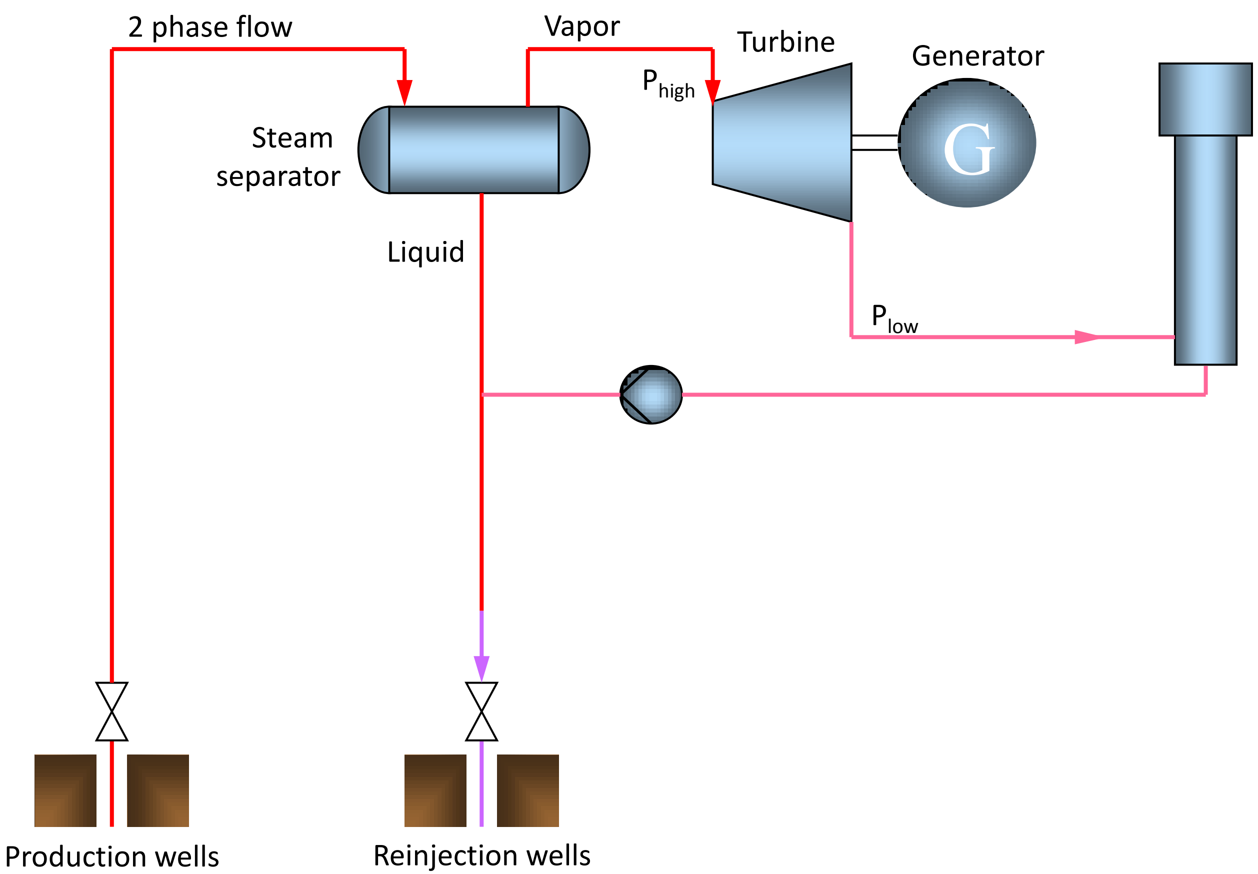
Process flow

- A review of thermodynamic cycles used in geothermal energy production with emphasis on electricity generation
- Flash steam cycles with single flash and double flash as well as different binary cycles as ORC and Kalina Cycle are introduced and compared

Back Pressure Steam Power Plant



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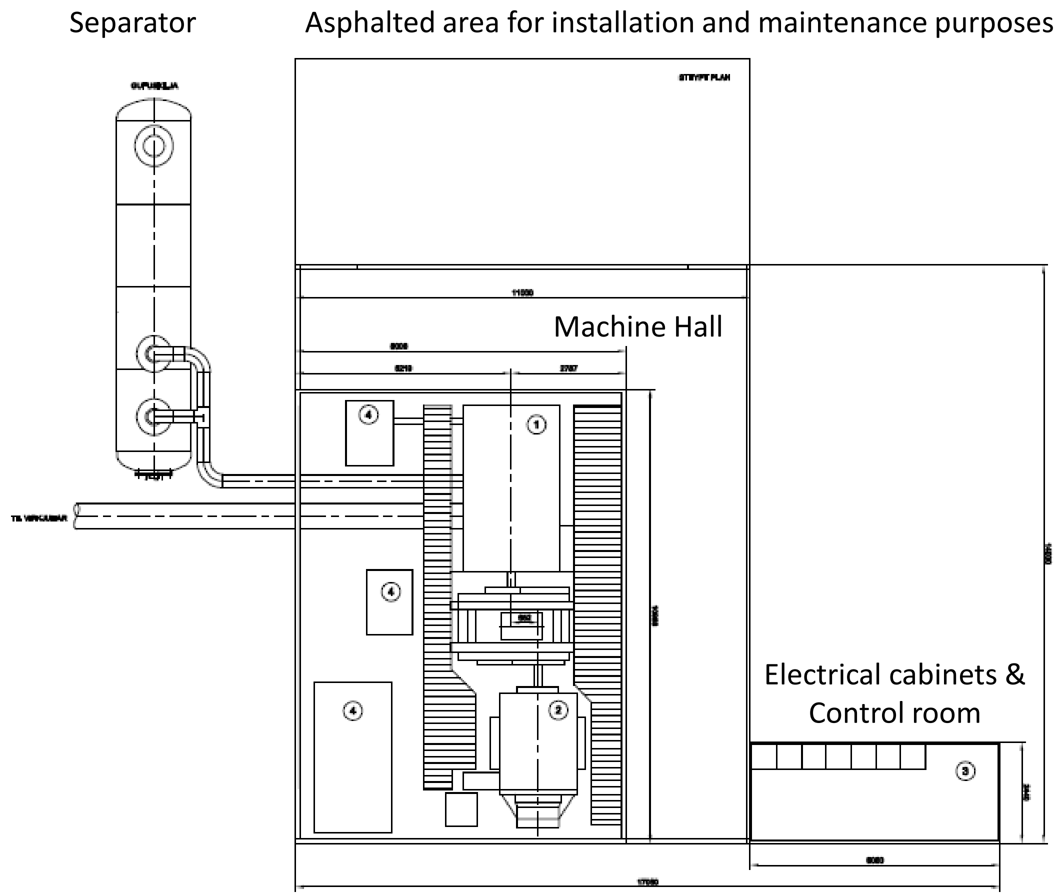
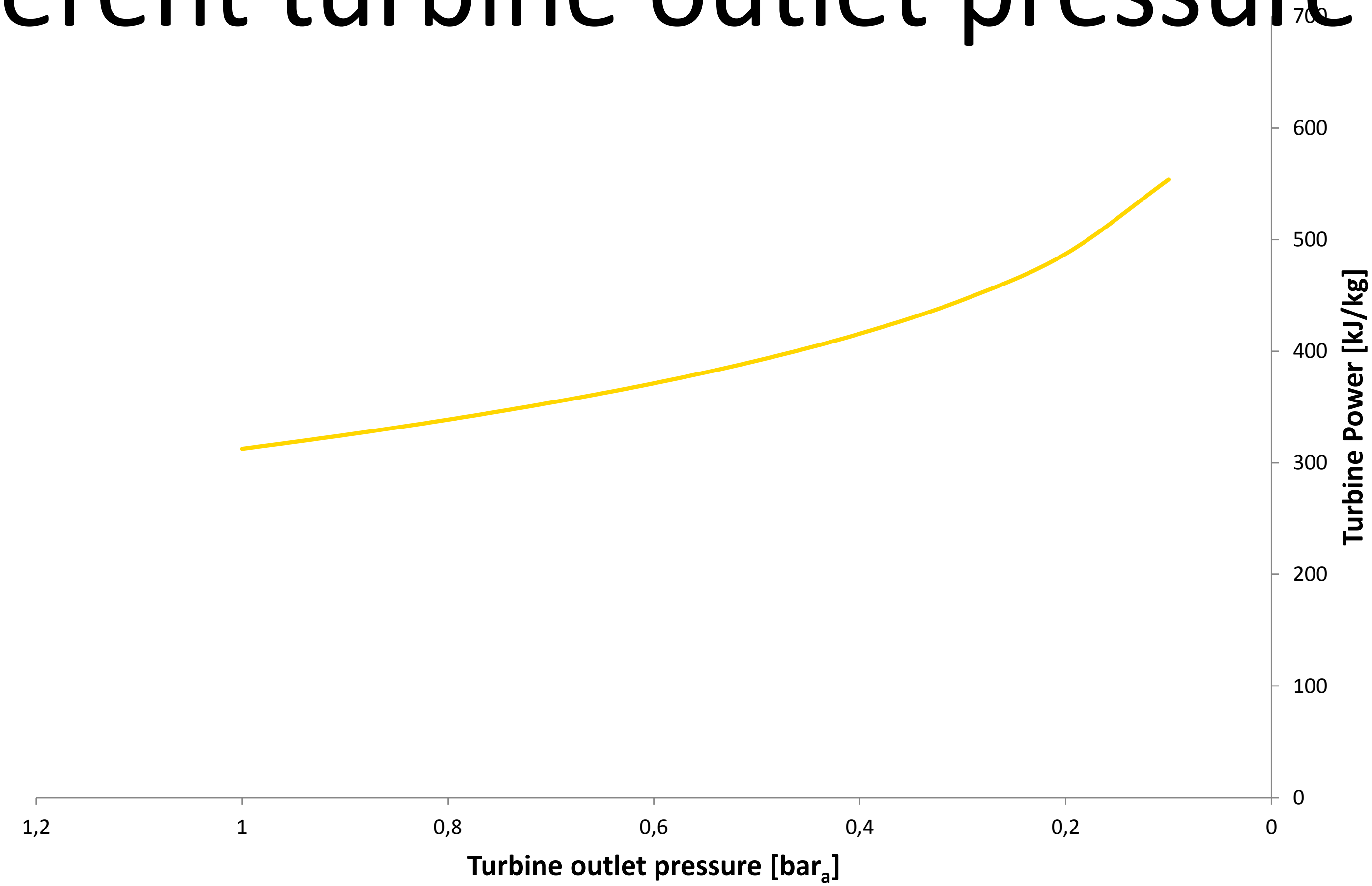
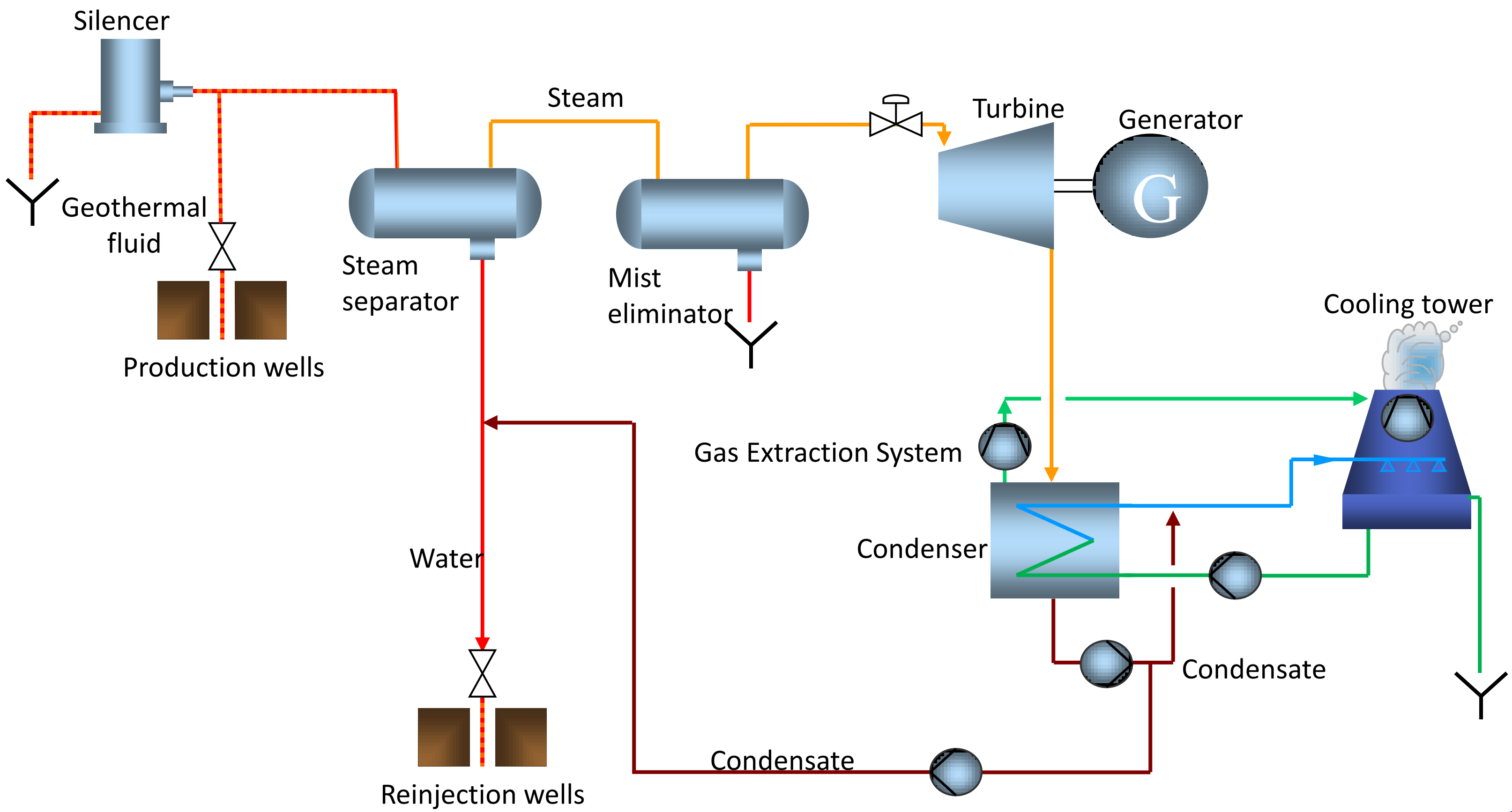
Back pressure unit - layout



Calculated examples
Different turbine outlet pressure



Steam Power Plant with Condenser



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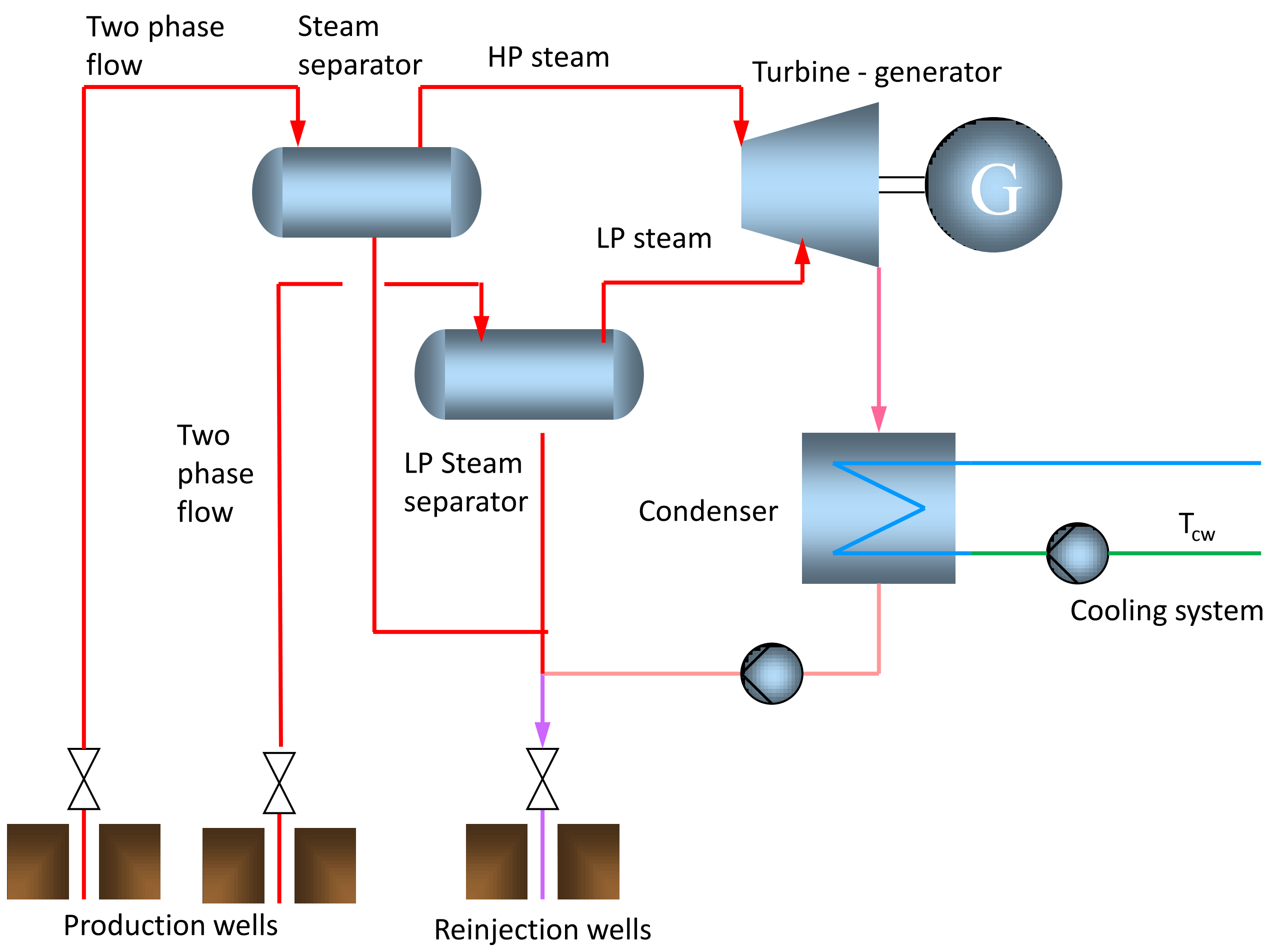
Steam Power Plant – Double Pressure



Svartsengi – the“Octopus”

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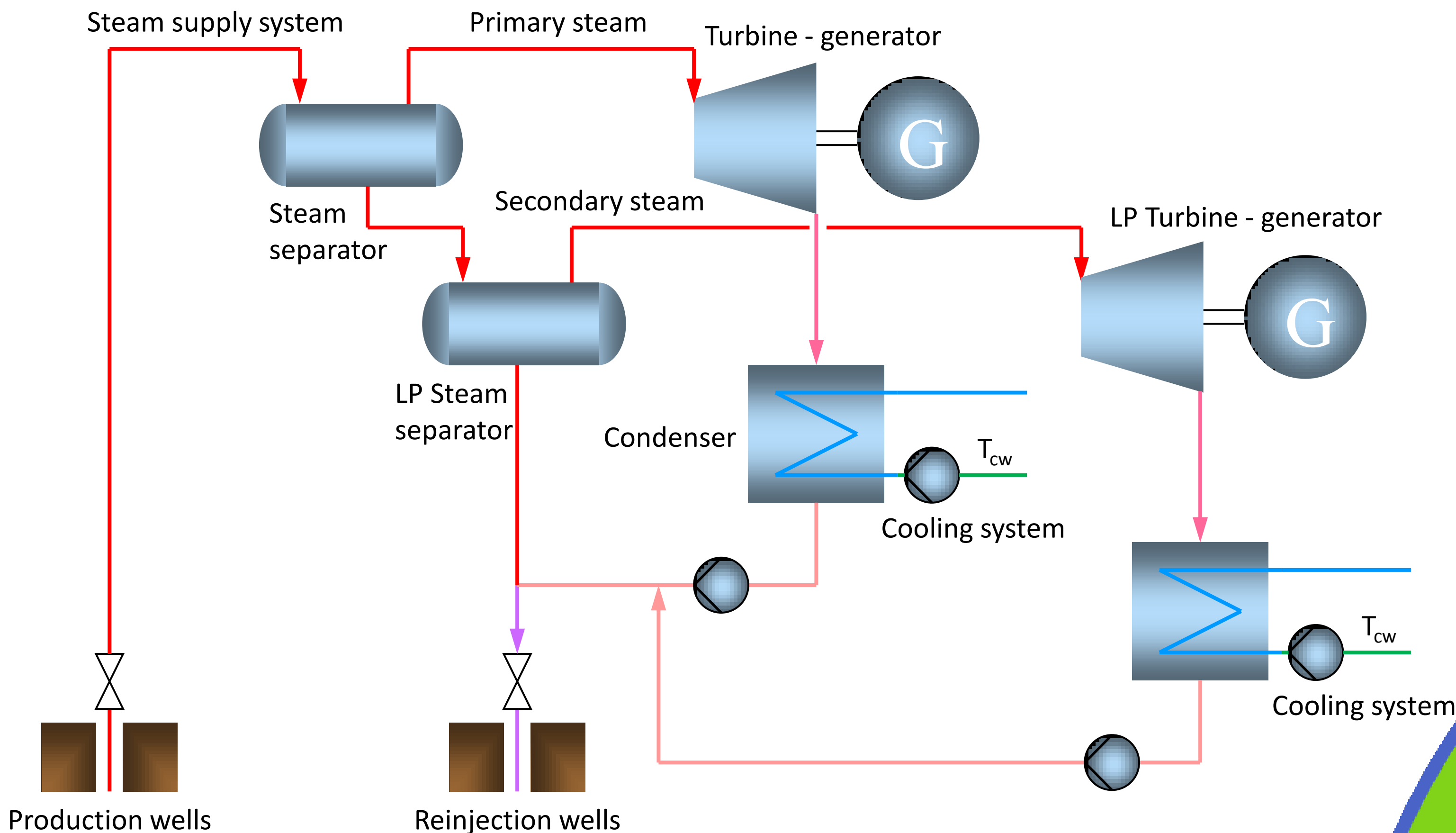
Steam Power Plant – Double Flash



Hellisheiði – low pressure unit

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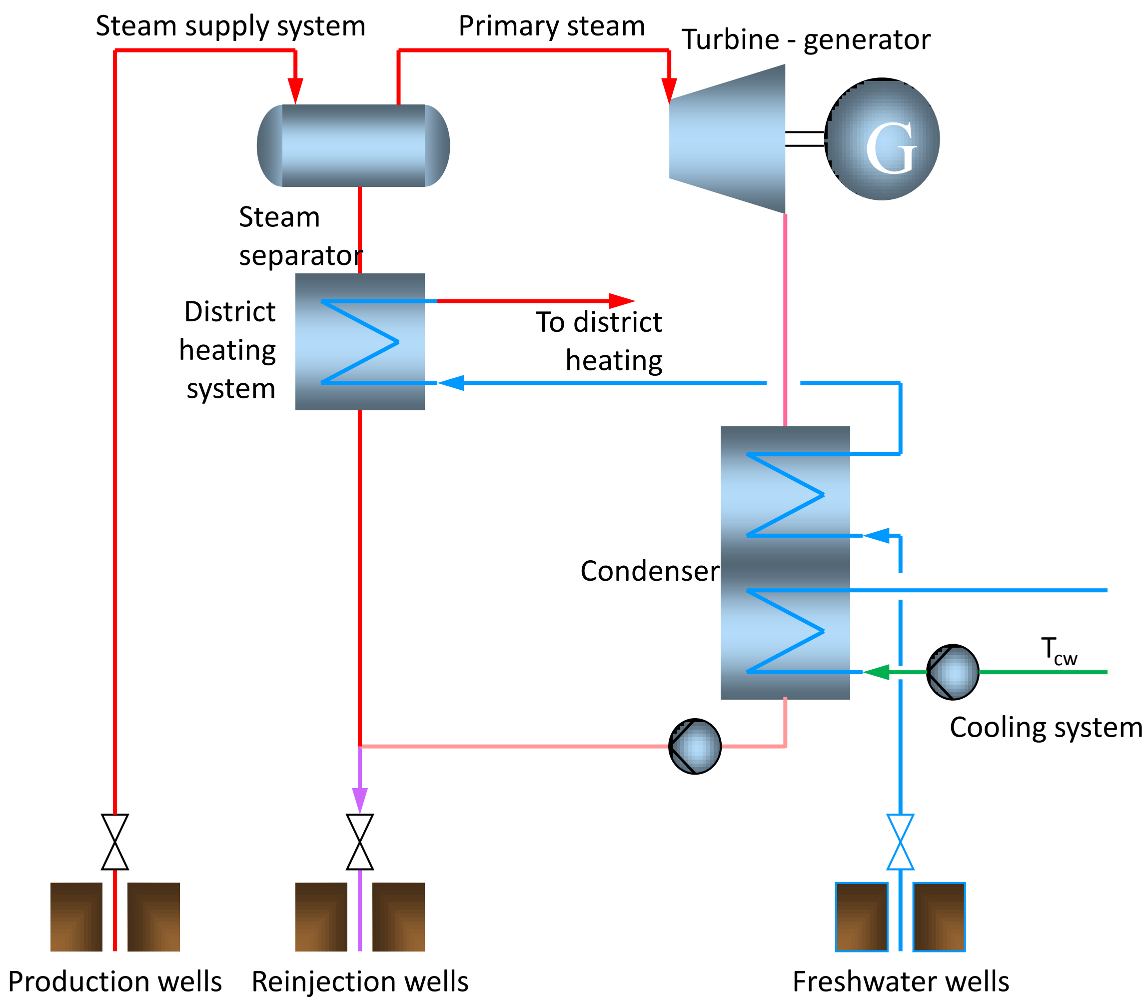
Steam Power Plant w. District Heating



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District heating plant

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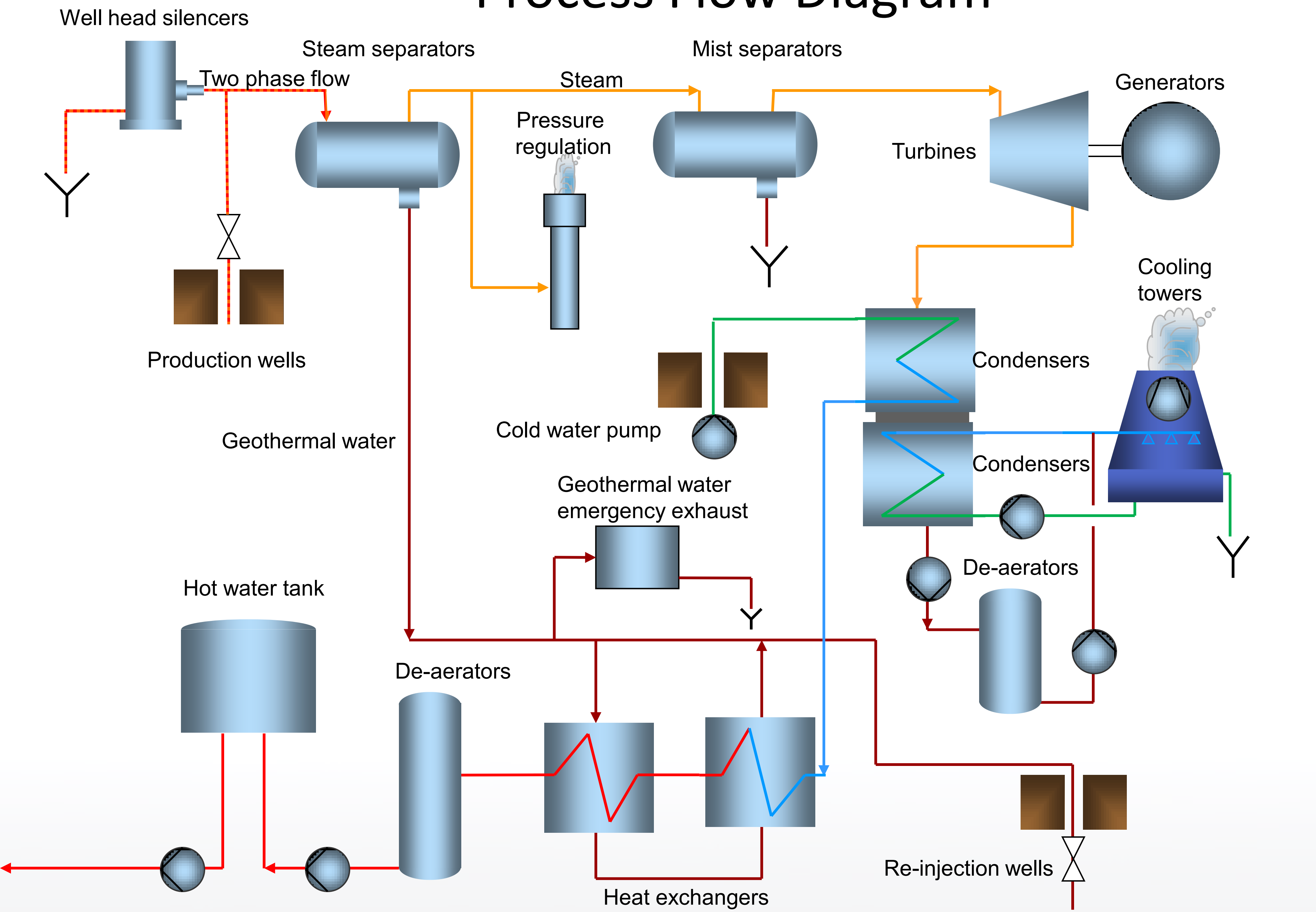
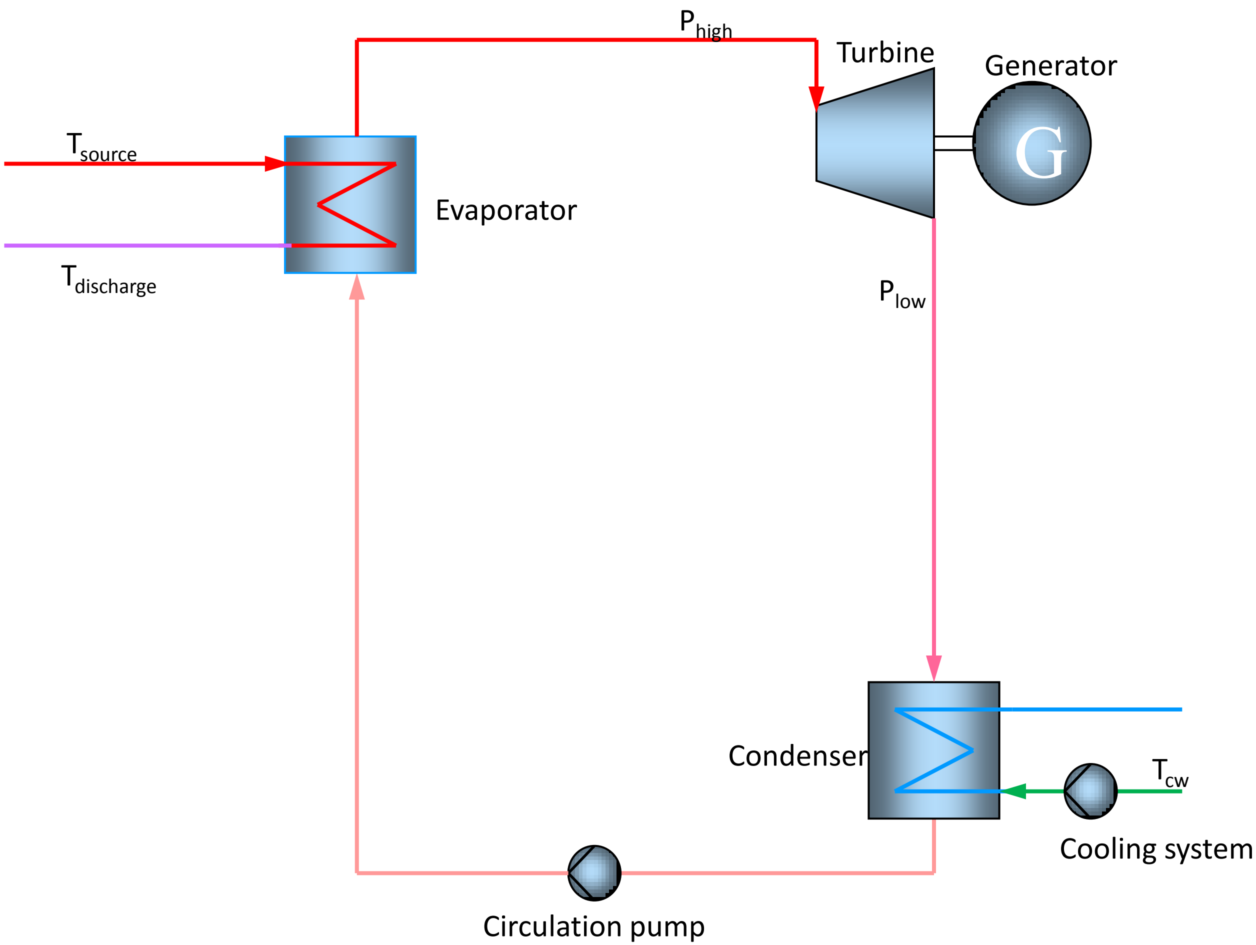
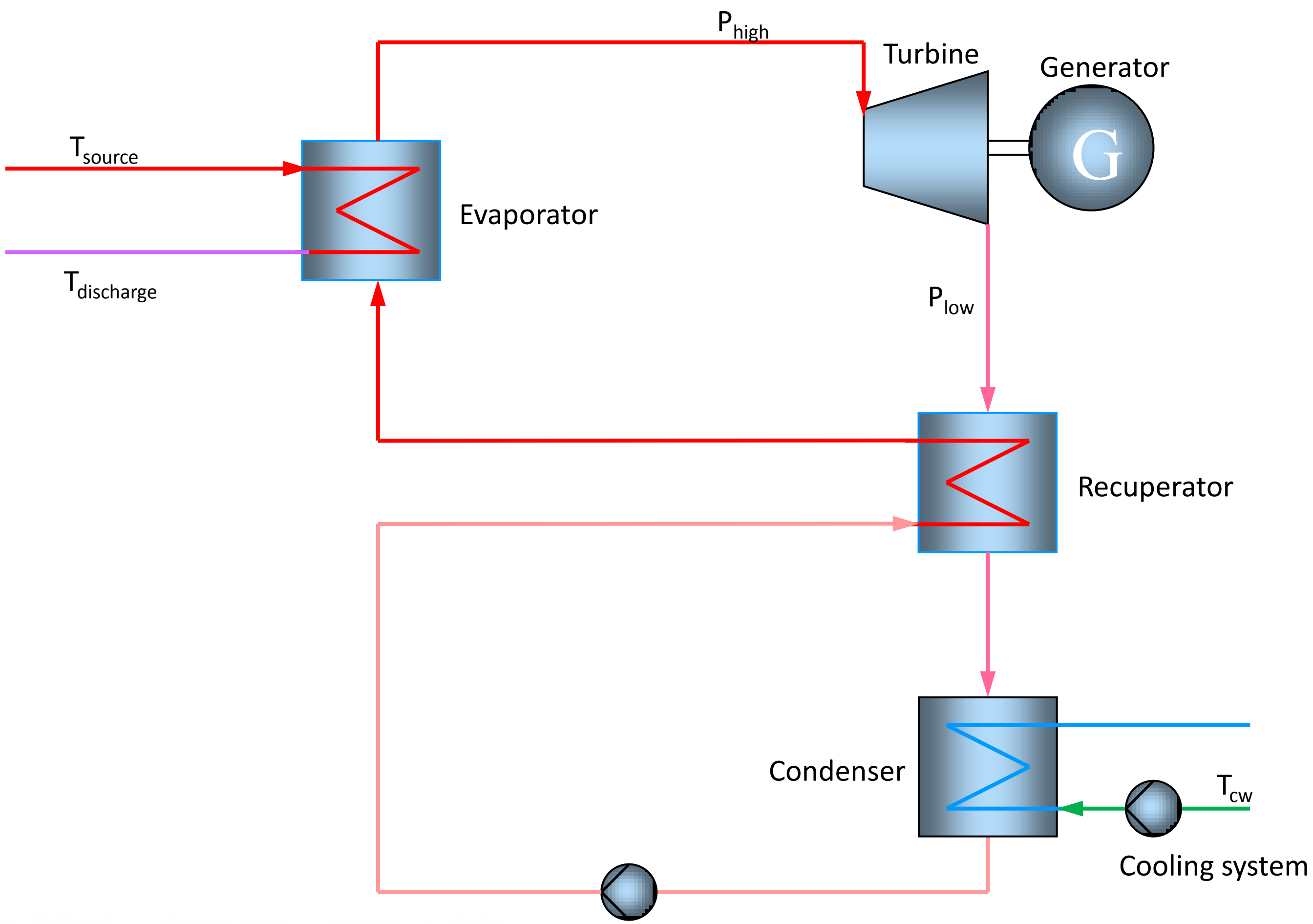
Process Flow Diagram



Binary Cycles



Binary Cycles – with Recuperation



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Binary Plant Berlin – El Salvador
LaGeo

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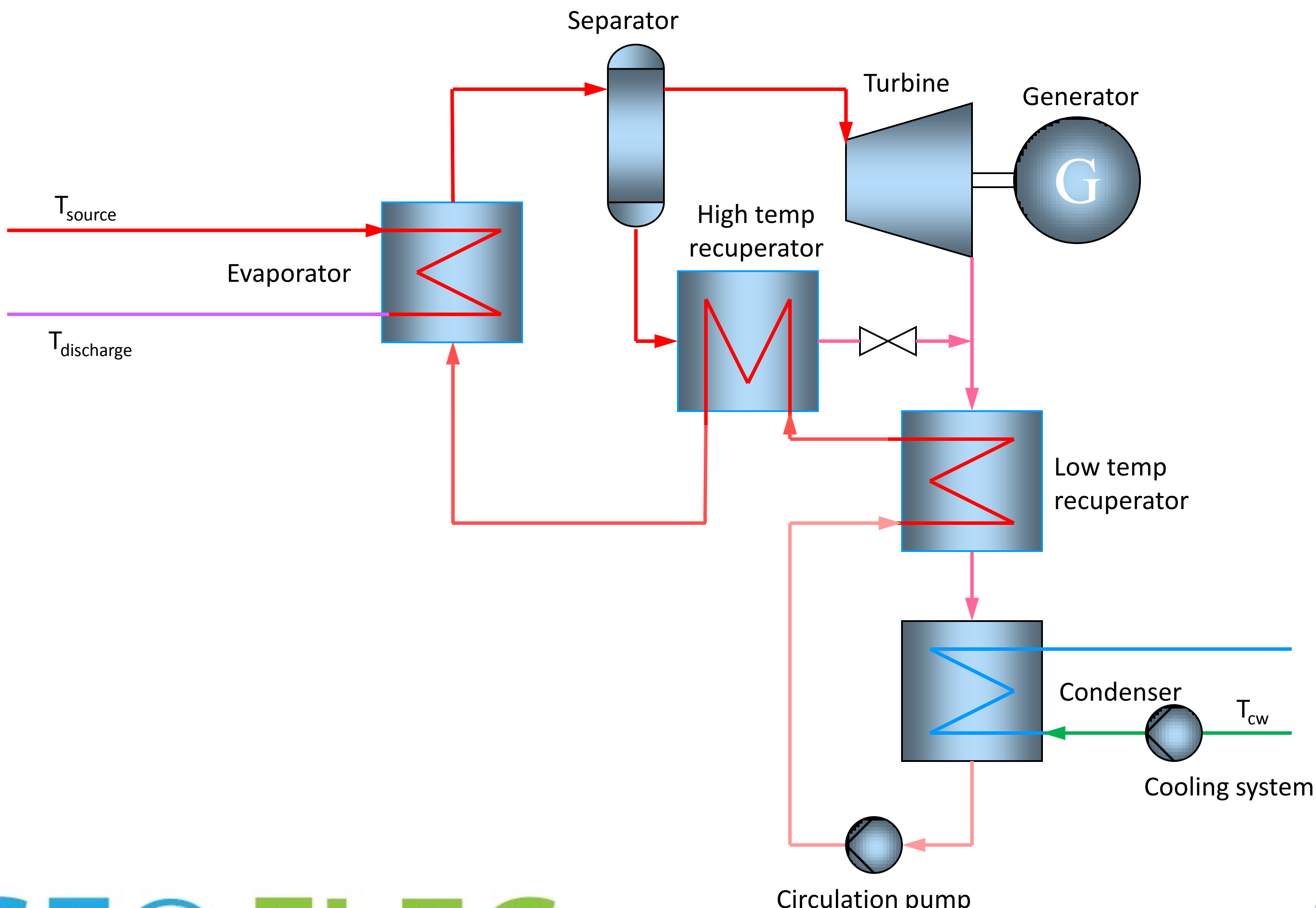
Binary Cycles – Kalina



Húsavik Kalina plant

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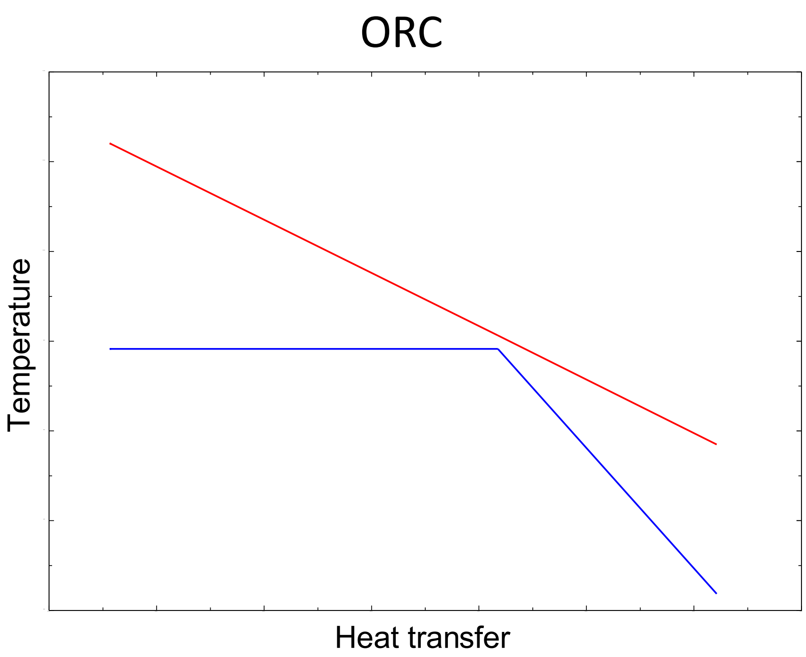
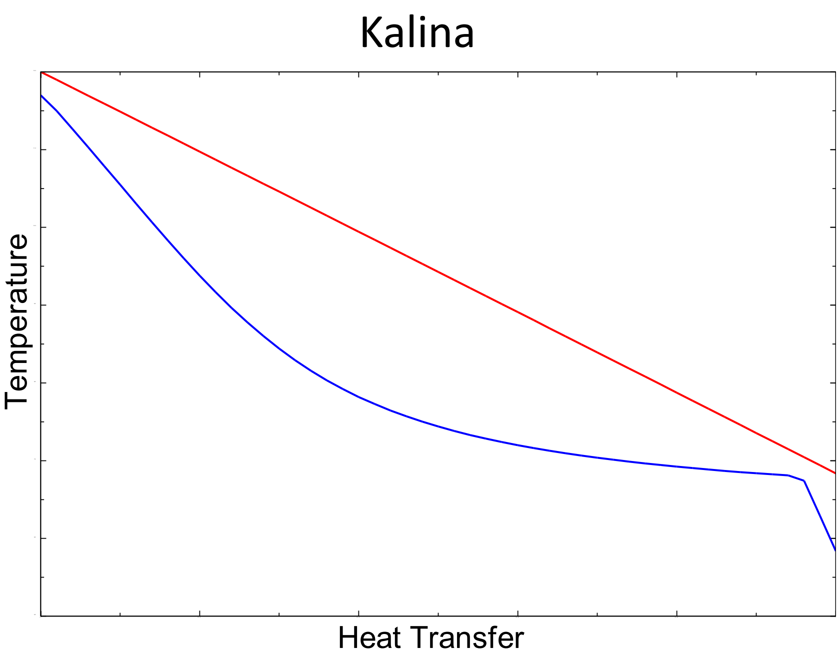
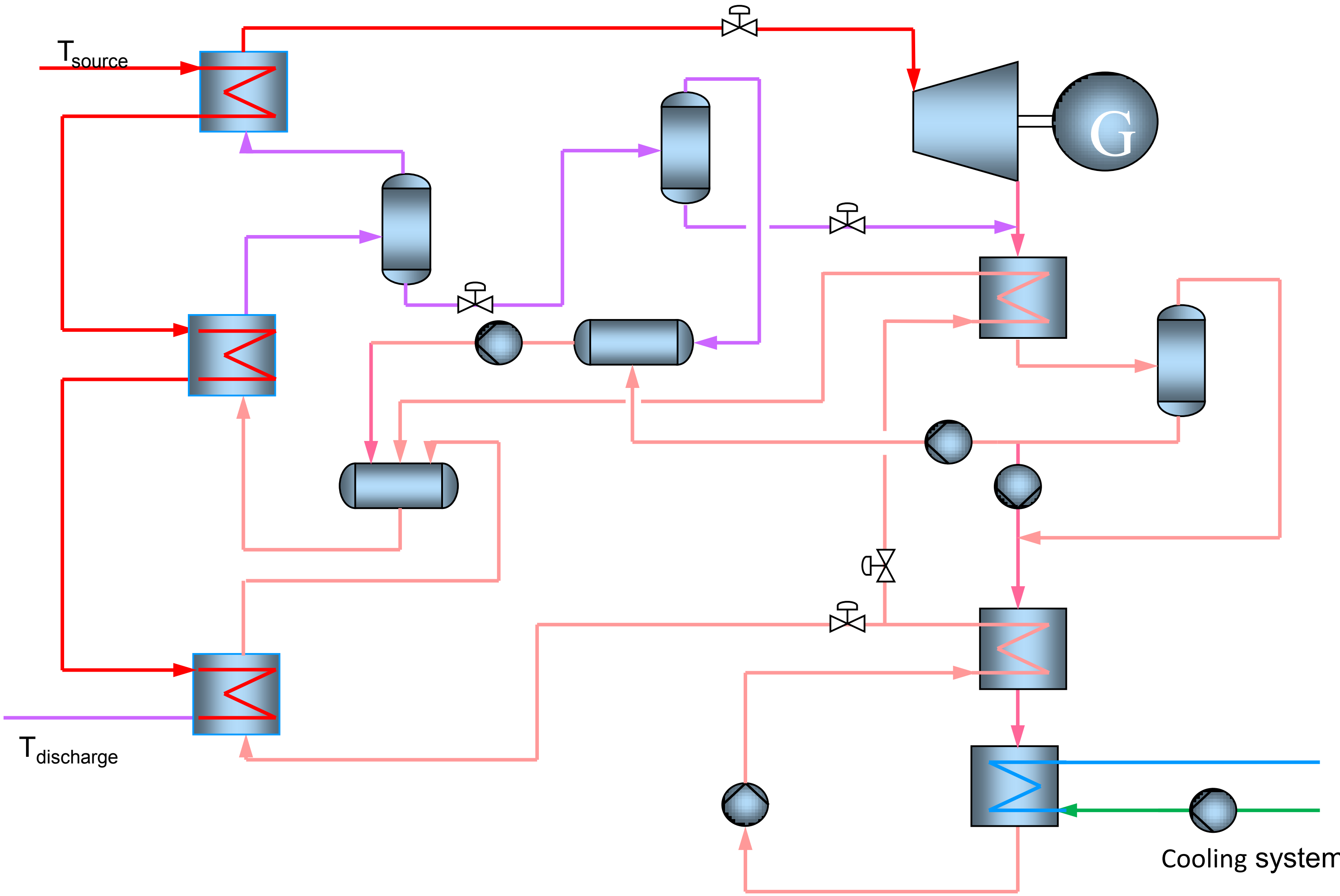

ORC
Temperature
Heat transfer


Kalina
Temperature
Heat Transfer

Binary Cycles – Kalex



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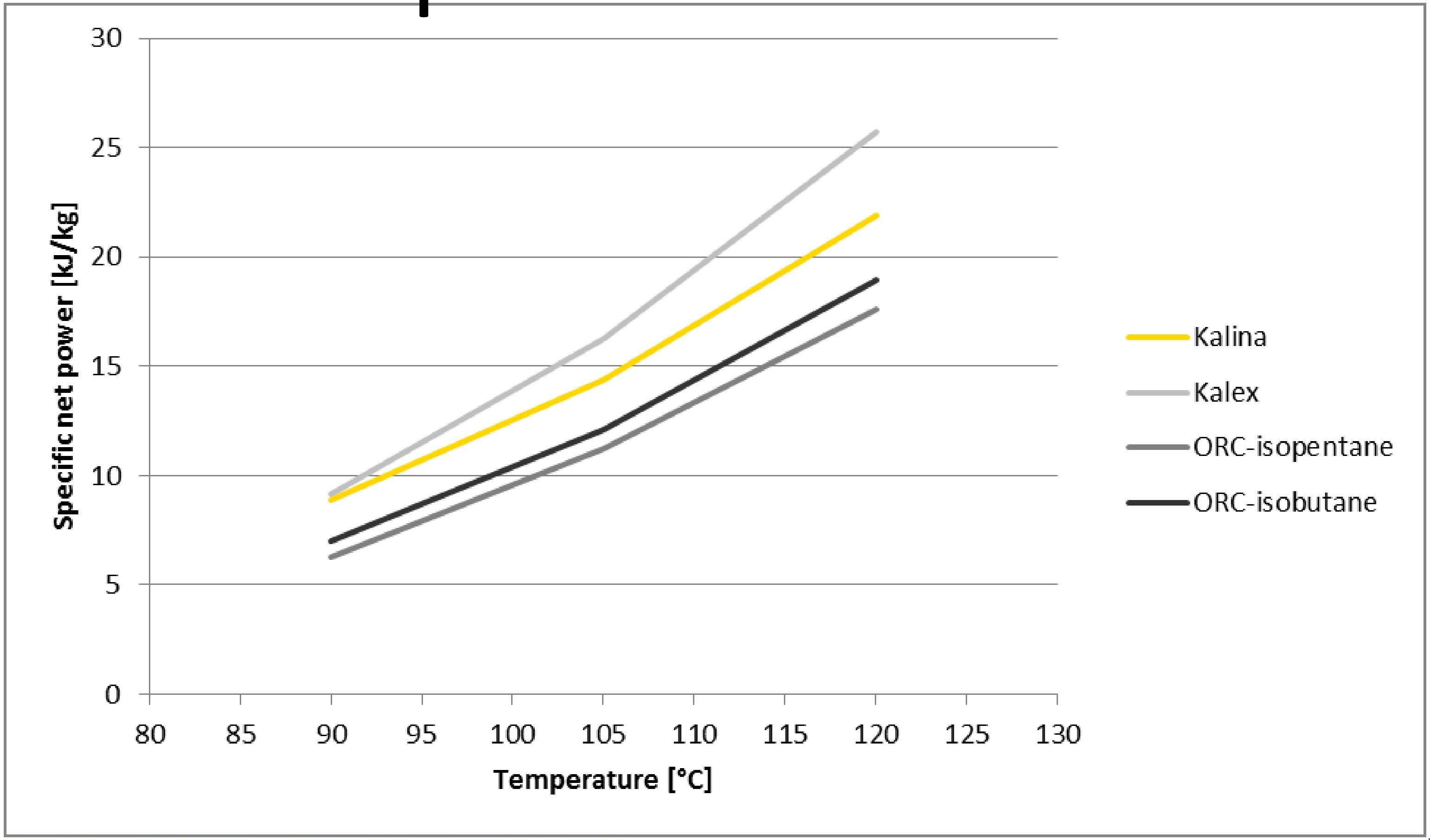
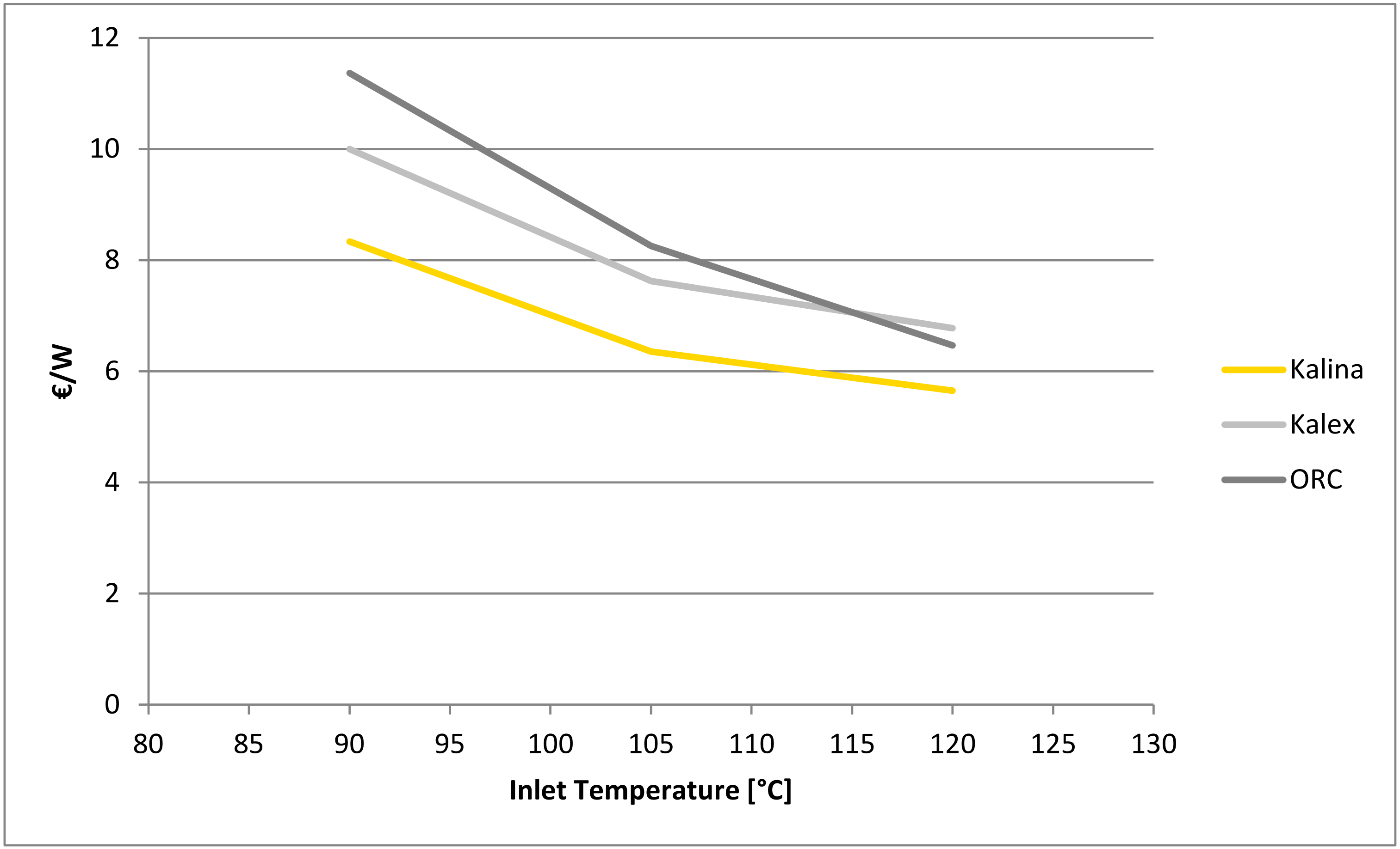
Work Cycle Comparison
Specific Power



Work Cycle Cost Comparison



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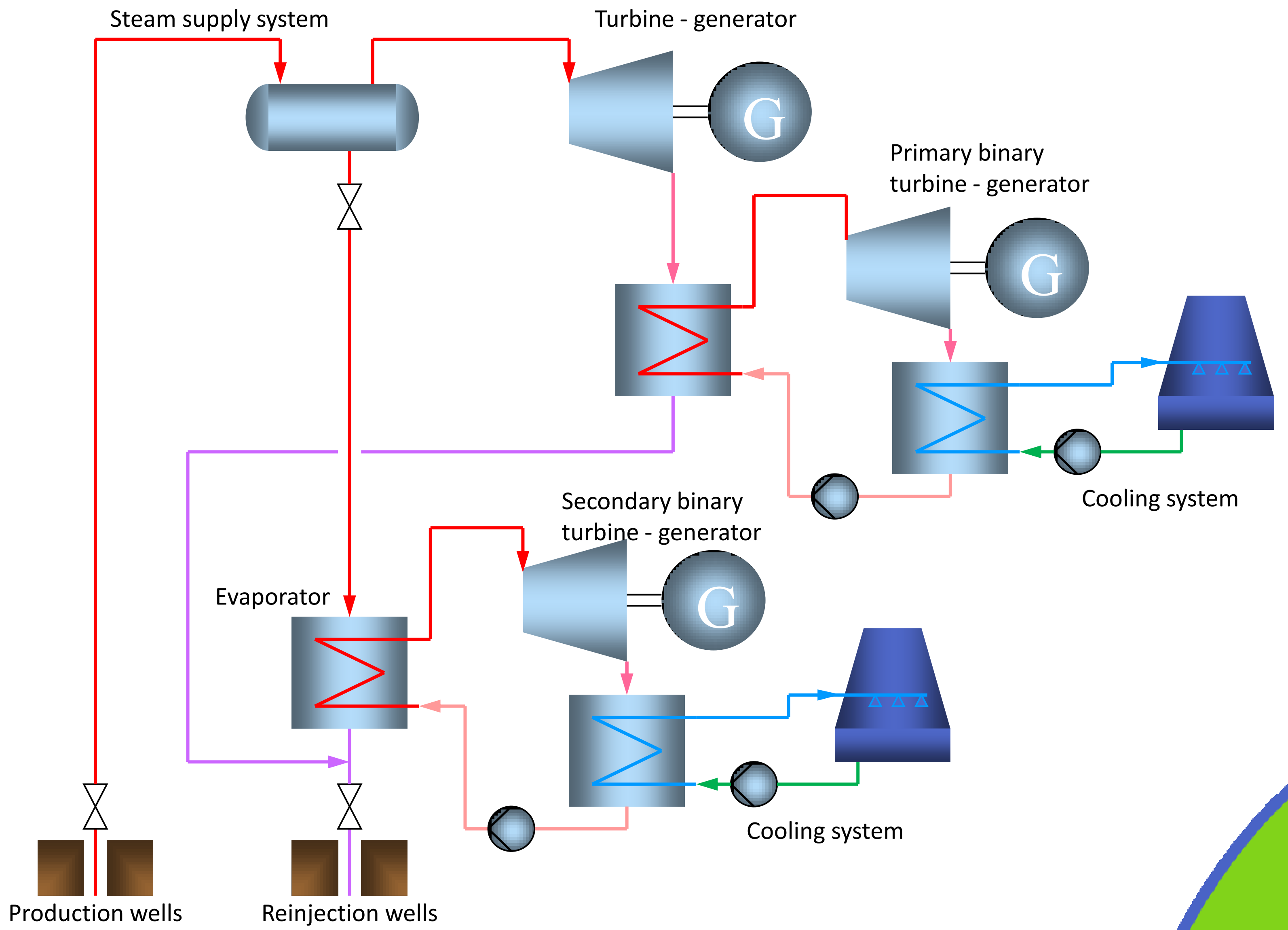

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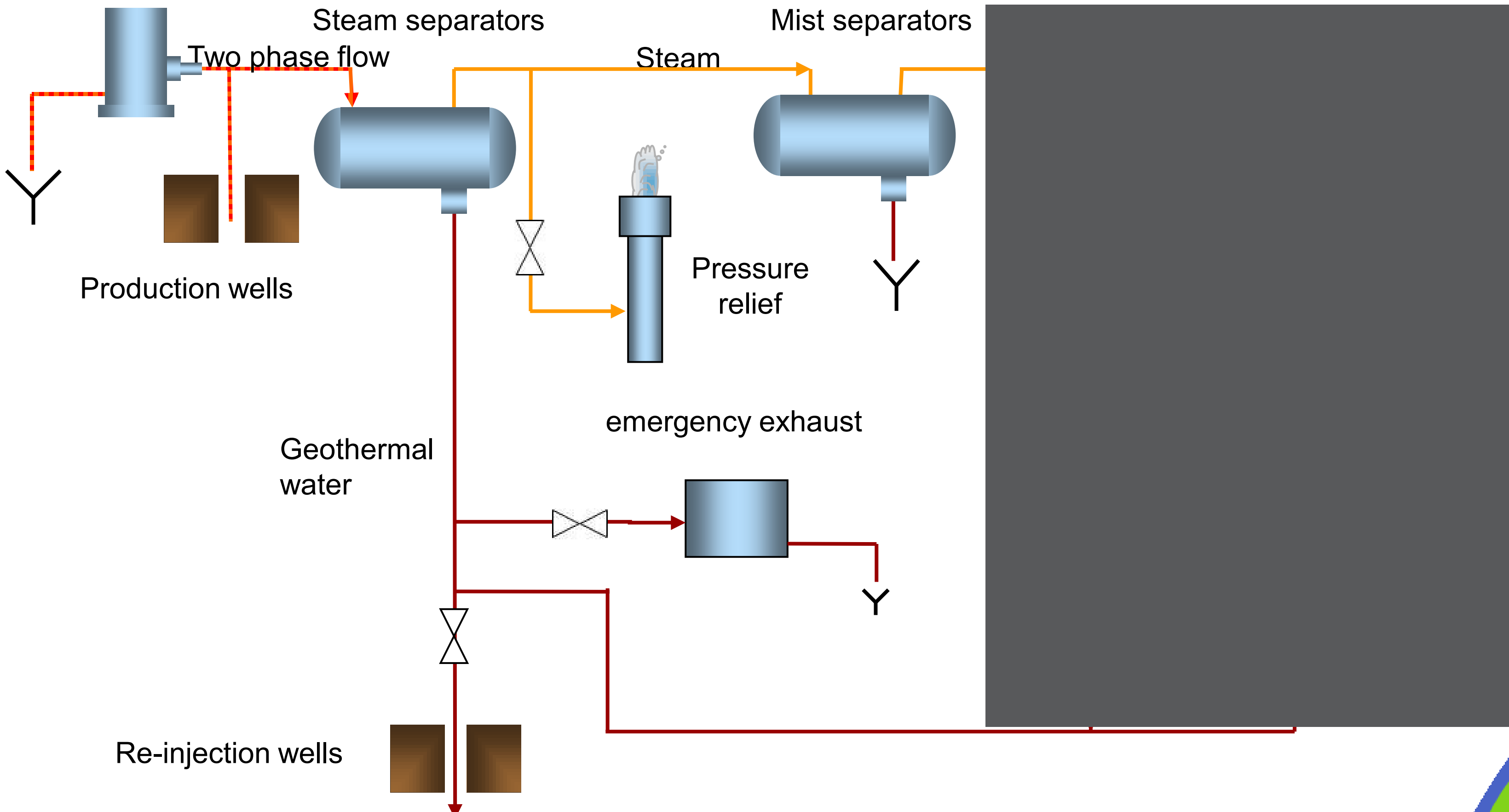
Demonstration of model

- Turboden ORC model: http://www.turboden.eu/en/rankine/rankine-calculator.php

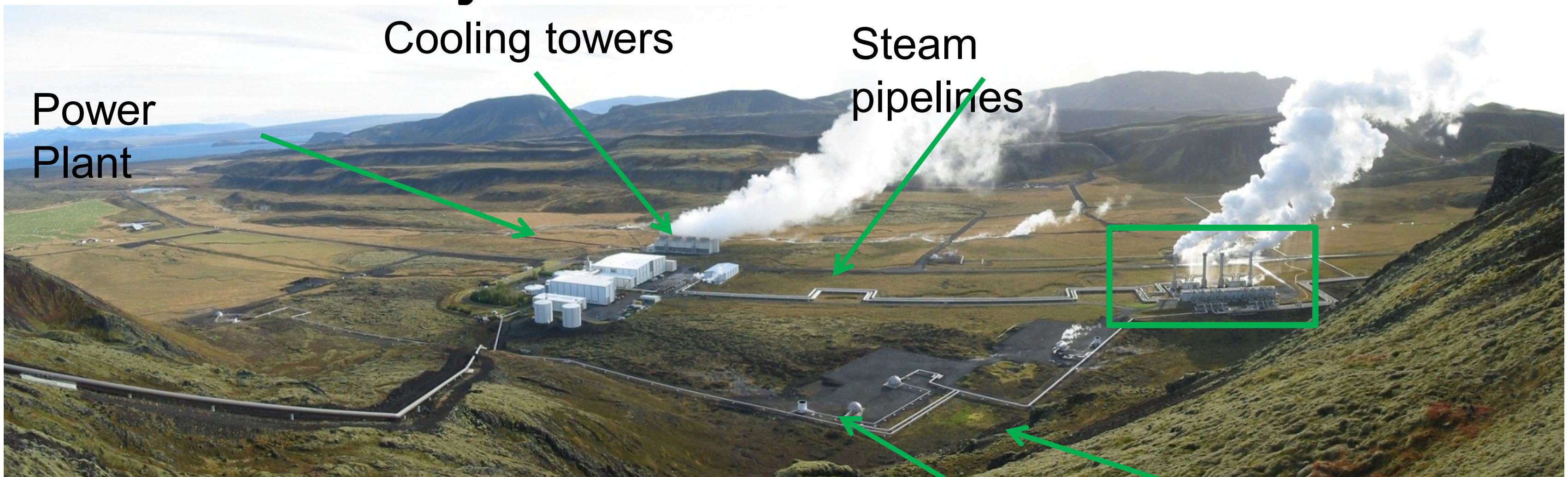
Gathering System

- This session will present an overview of the design process of a geothermal gathering system with emphasis on particularities of the geothermal fluid.

Steam Supply - Preliminary P&ID



Nesjavellir Power Plant



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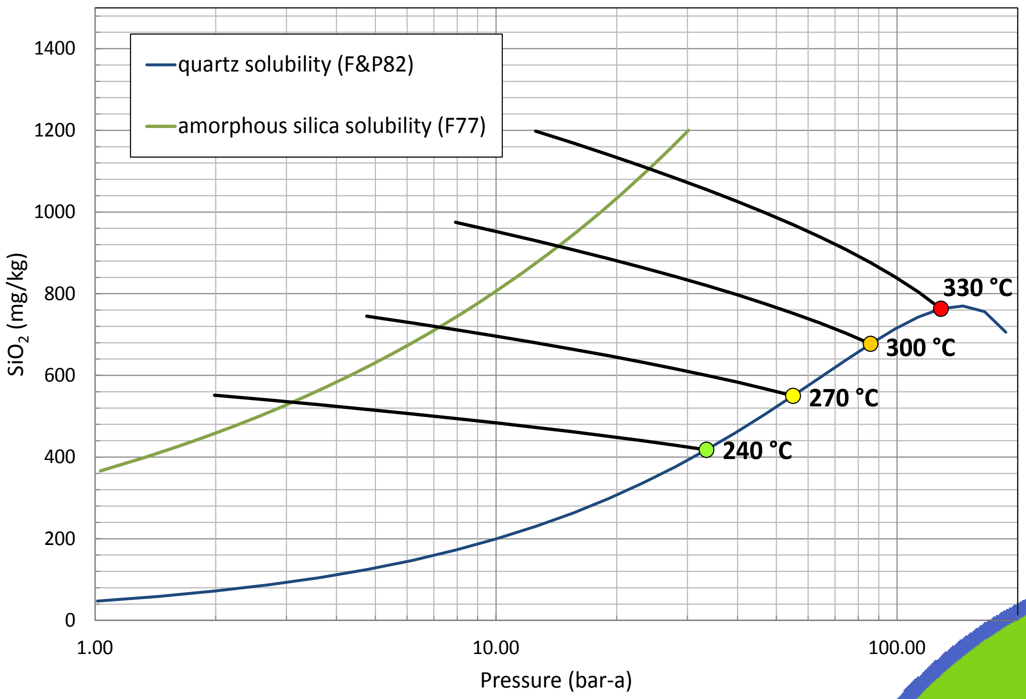
Gathering system- Design

- Design standards
  - Standards i.e. Pressure directive 97/23/EC
- Pressure selection
  - Chemical constraints
  - Power generation
  - Productivity curves



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Chemical constraints

- Scaling
- Corrosivity
- Radioactivity

Mitigation:

- Pressure control / closed loop system
- „cleaning“ of the steam
- Inhibitors

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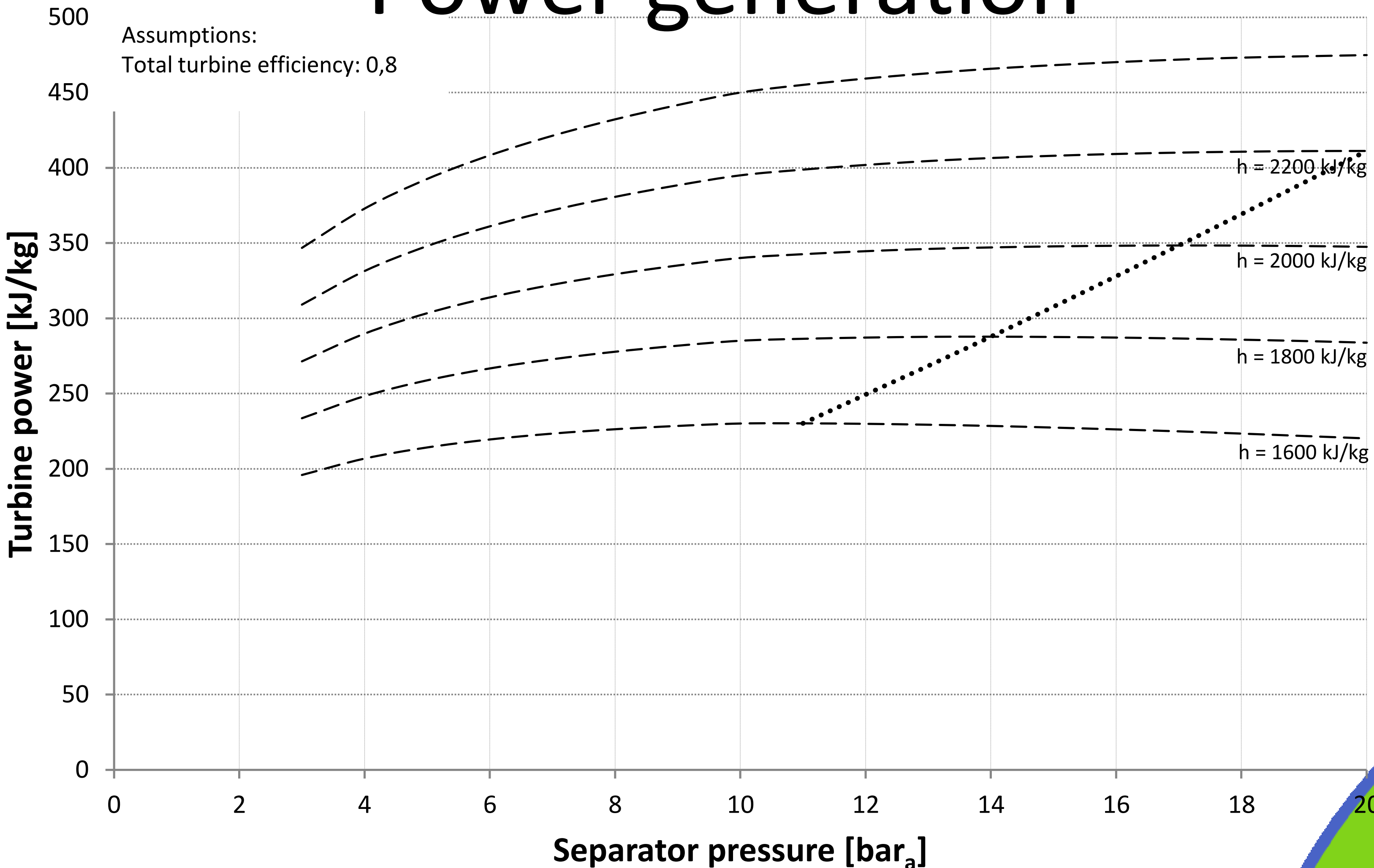
Power generation



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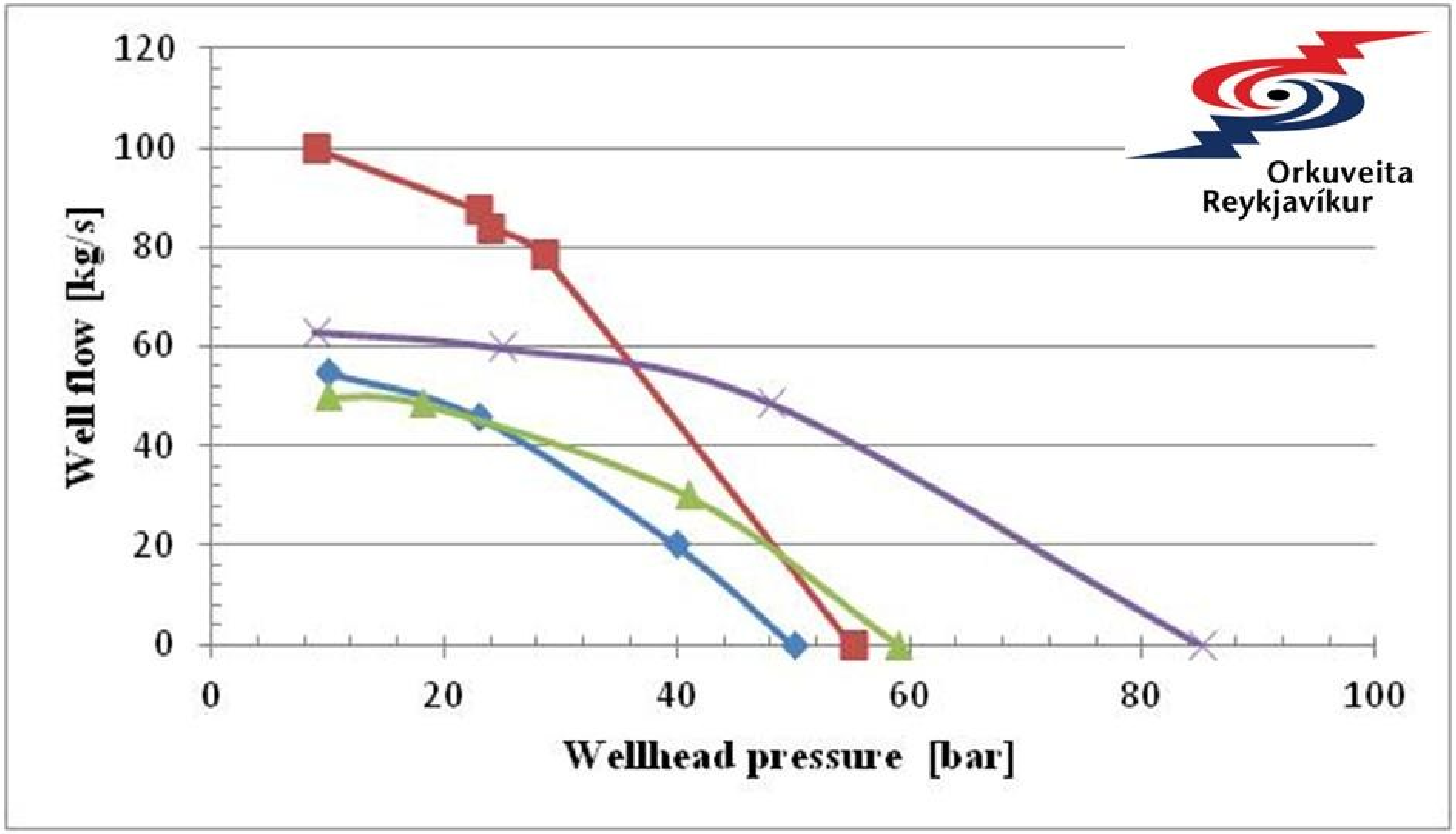
Typical productivity curves



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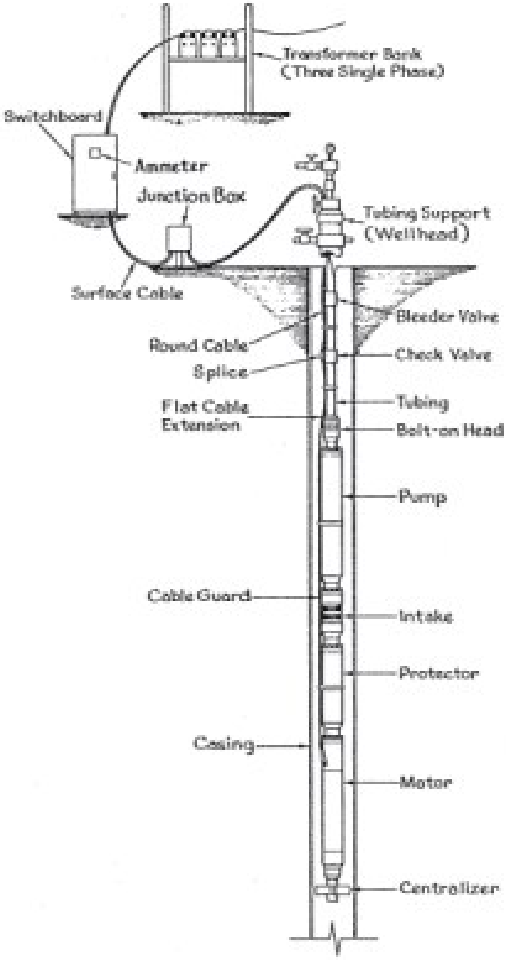
Well Pump – Low Enthalpy

- Type
  - Submersible pump
  - Line shaft pump
- Selection and operation
  - Depth
  - Temperature
  - Scaling
  - Bubble point



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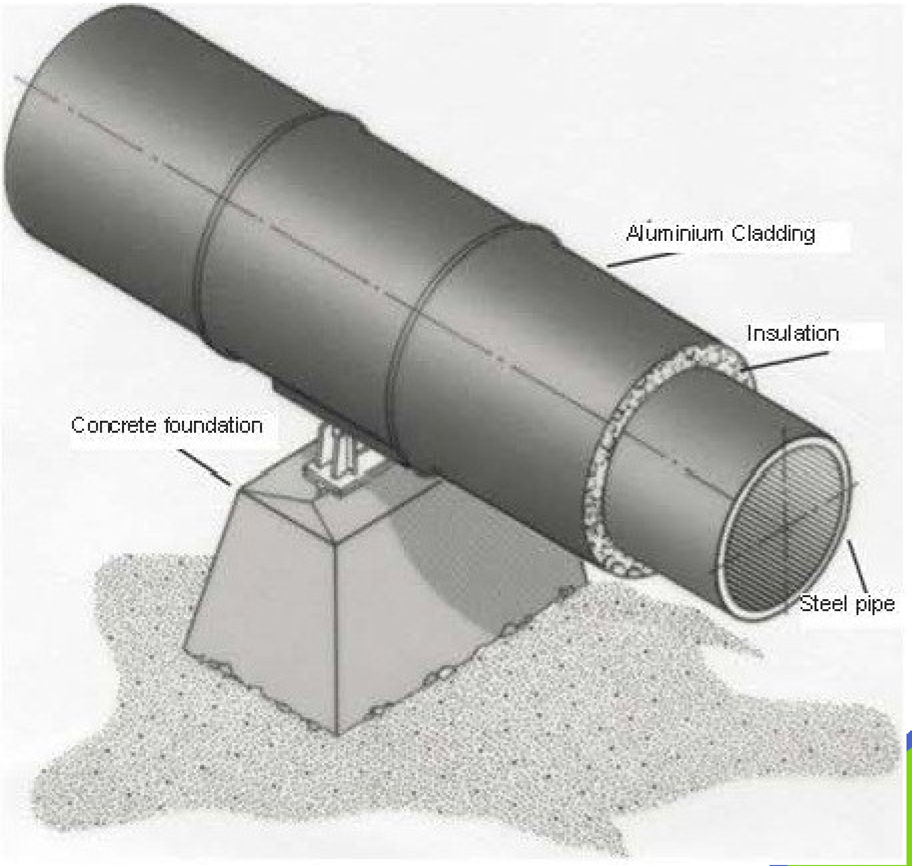
Gathering System– Design load

- Constant load
  - Weight
  - Pressure
- Variable load (depending on location)
  - Wind load
  - Snow load
  - Earthquake
- Frictional load
  - Thermal expansion
  - Friction

Gathering System - Pipelines

- Pipe laying
  - Under ground
  - Above ground
- Material selection
- Pipe size
  - Pressure/temperature



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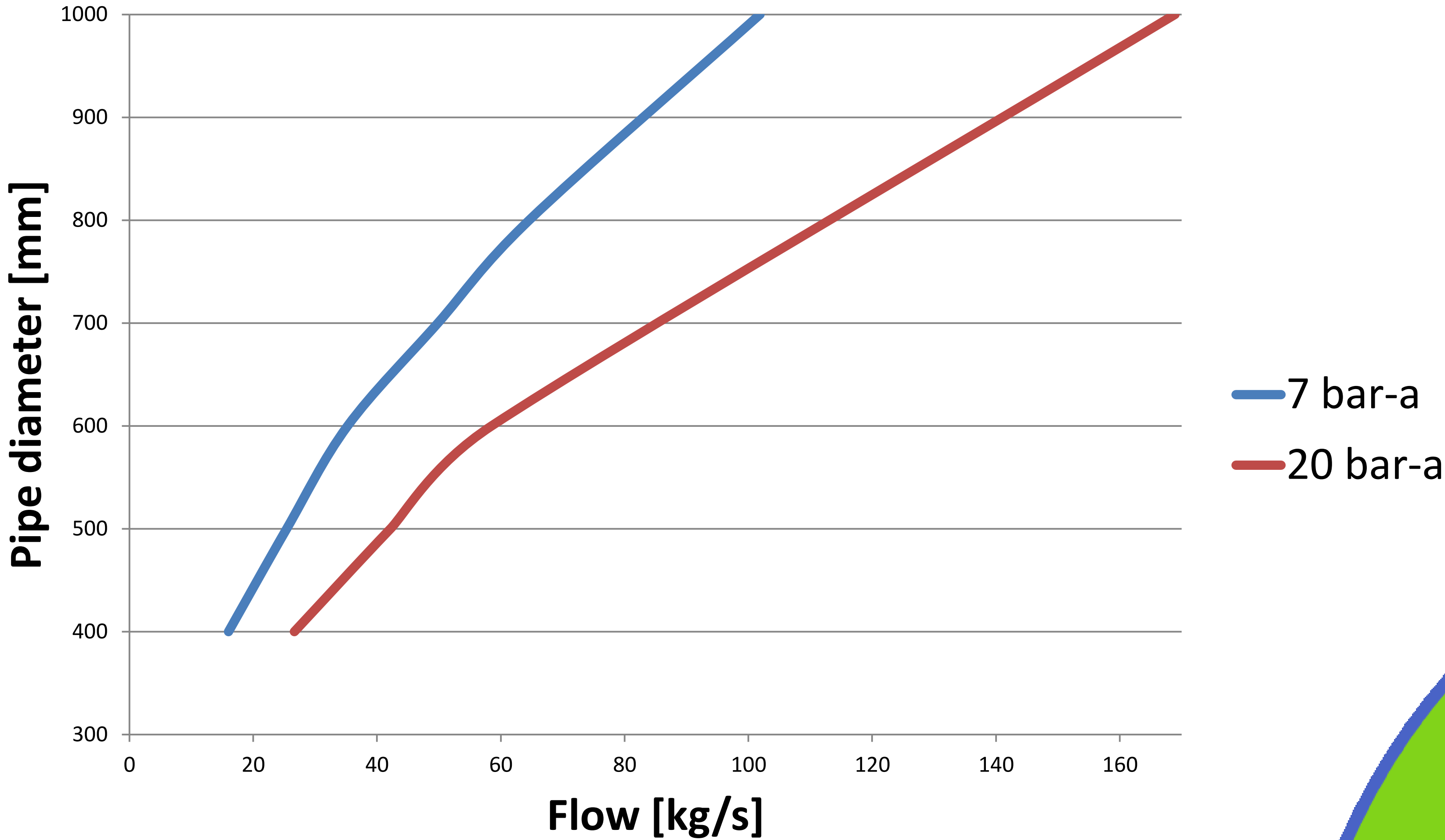
Steam Supply System – Pipelines



Gathering system – route selection

- Public safety
- Environmental impact
- Restriction on land
- Cost efficiency

Steam pipelines

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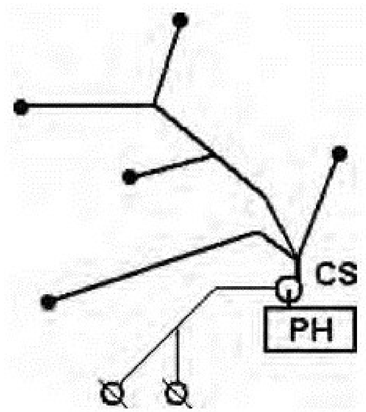
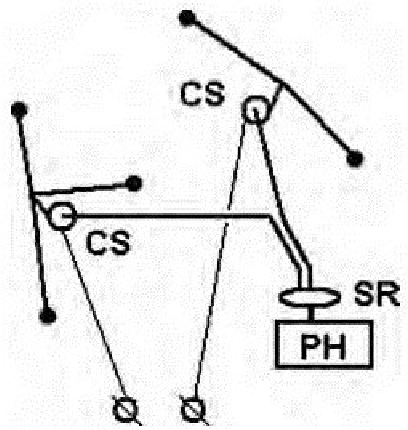
Steam Supply - Layout

- Central separation station
- Satellite separation stations
- Individual separators

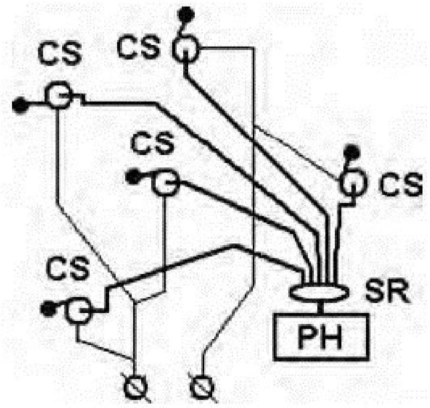
Central



Satellite



Individual



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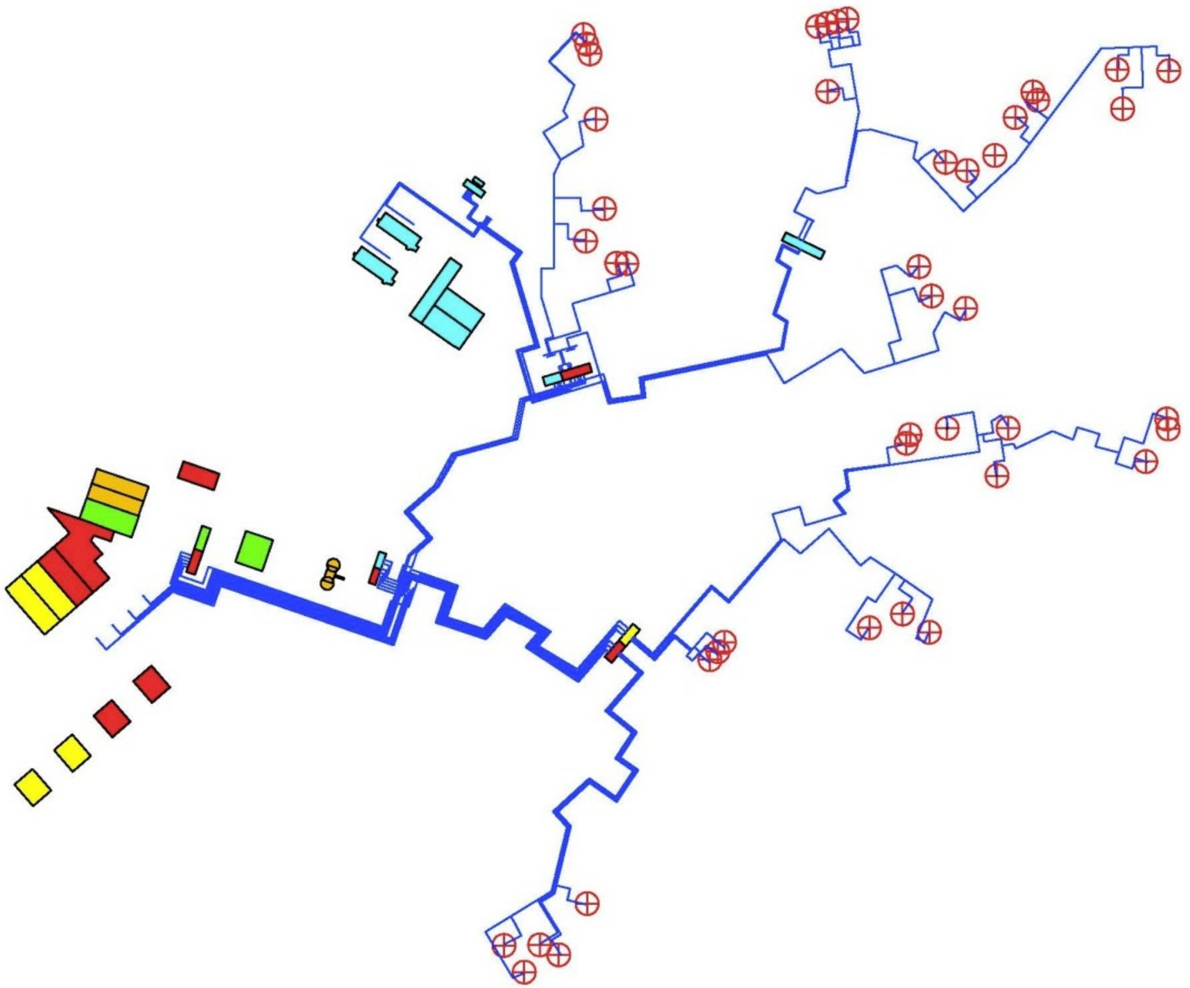
Power plant layout



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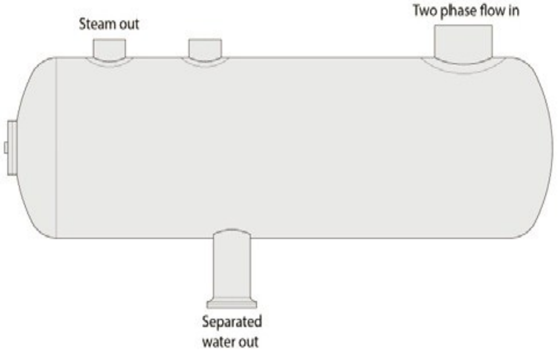
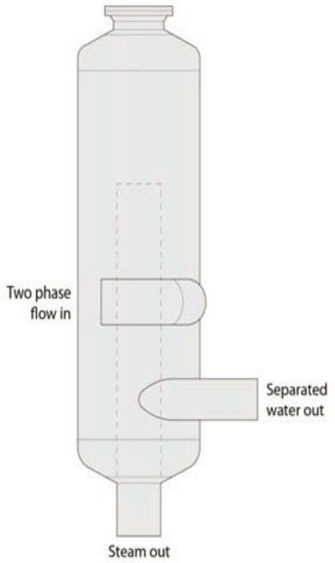
Steam Supply - Separators

- Cyclone separators
- Gravity separators





- Efficiency
  - Steam separator and moisture separator should together achieve 99,99 % bw. liquid removal or better

Calculated example

- The presenter will go through a calculated example to show methods used for basic engineering within steam gathering system design. The example taken will be connected to the special conditions encountered in geothermal energy.

Example

- Example for 1200 kJ/kg well enthalpy
  – 40-50°C condensing temperature
  – Back pressure

- Objective
  – Maximize the power production

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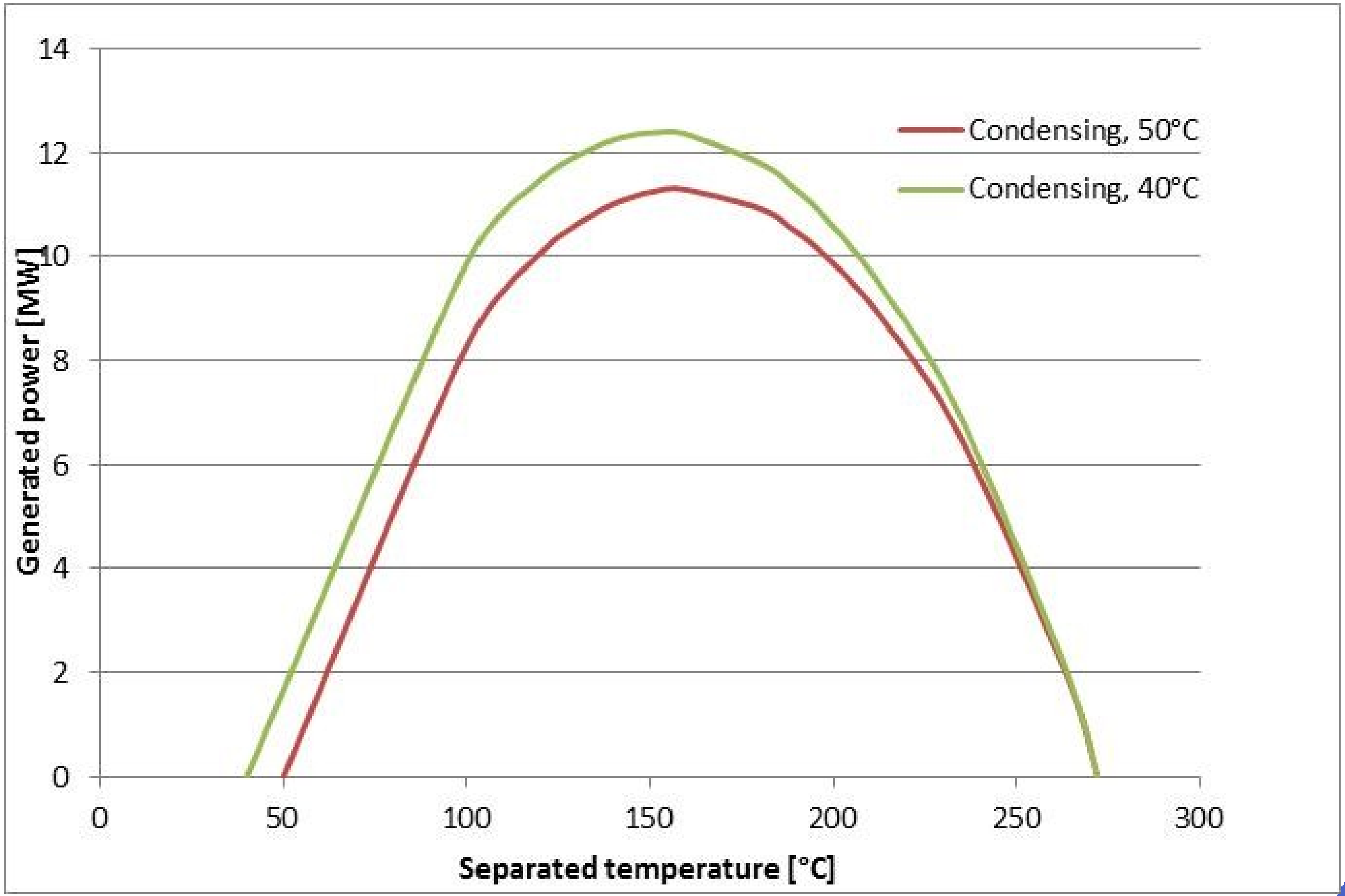
- Assumptions
  - We know the reservoir enthalpy
  - We know the condenser temperature
  - Separation pressure does not influence the well flow

Example, condensing unit



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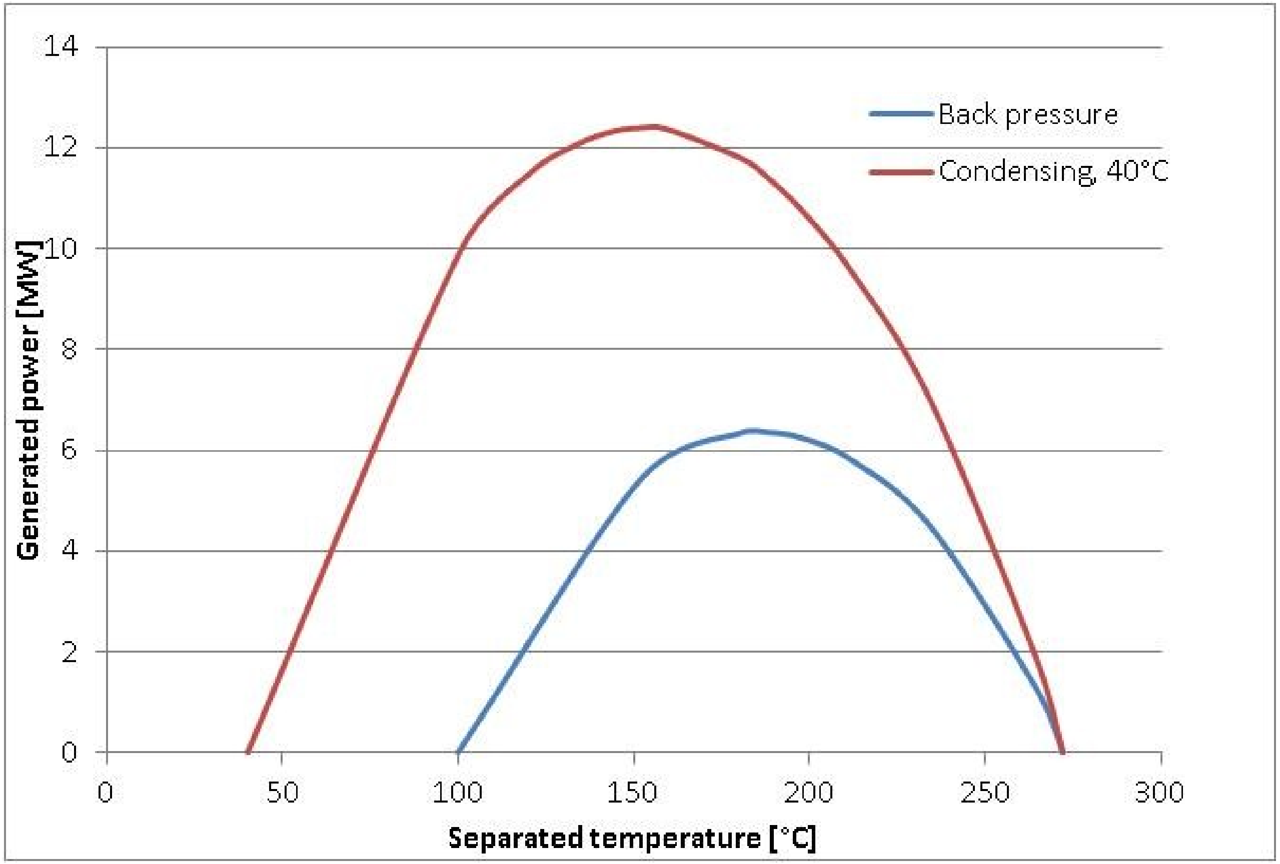
Example, condensing unit

- The maximum power will be 12,4 MW
  - Entalpy = 1200 kJ/kg
  - Condensing pressure 0,075 bara / temperature 40°C
  - Separation pressure 6 bar_a
  - Flow 100 kg/s

- What if we selected backpressure instead?

Example, back pressure



Example, back pressure

- The maximum power will be 6,4 MW
  - Entalpy = 1200 kJ/kg
  - Separation pressure 12 bar_a
  - Flow 100 kg/s

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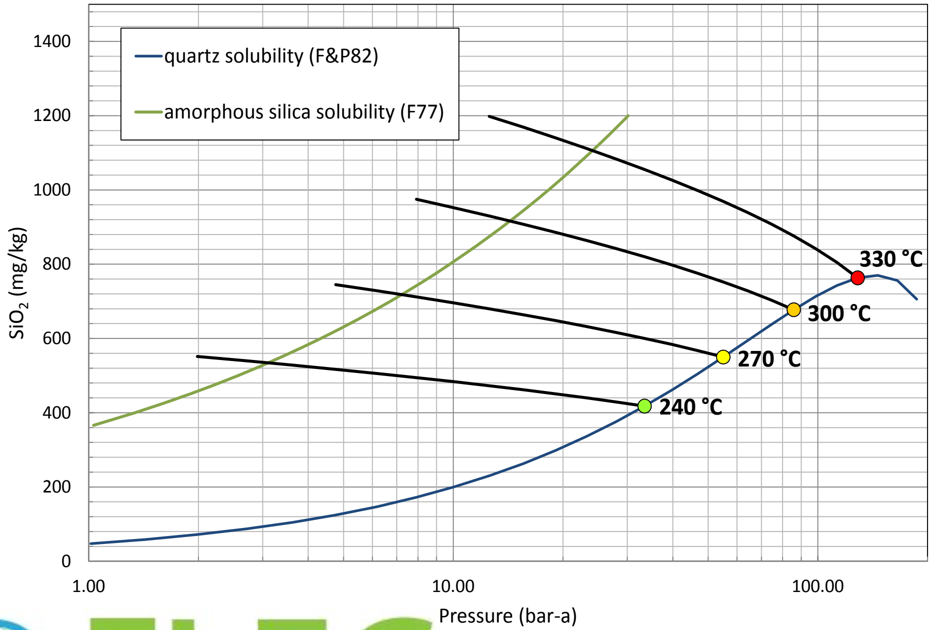
Example

- Optimum separation pressure is 6 bar_a, is that ok?
- Saturation temperature for 1200 kJ/kg is 273°C



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Thank You!

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