Wellhead power plants

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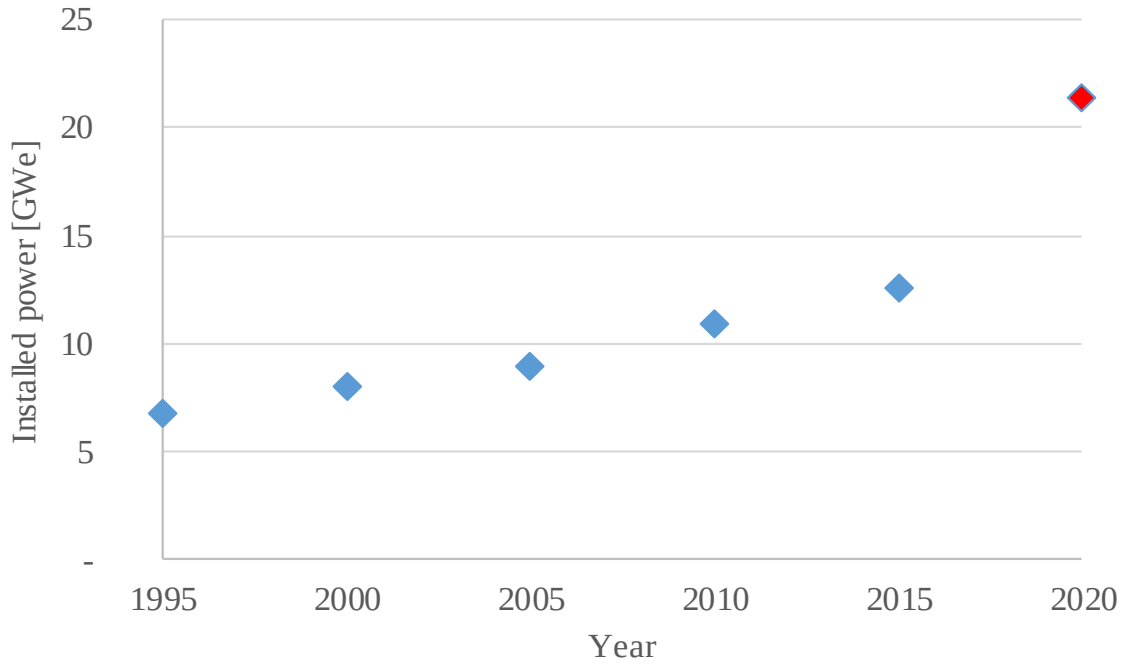
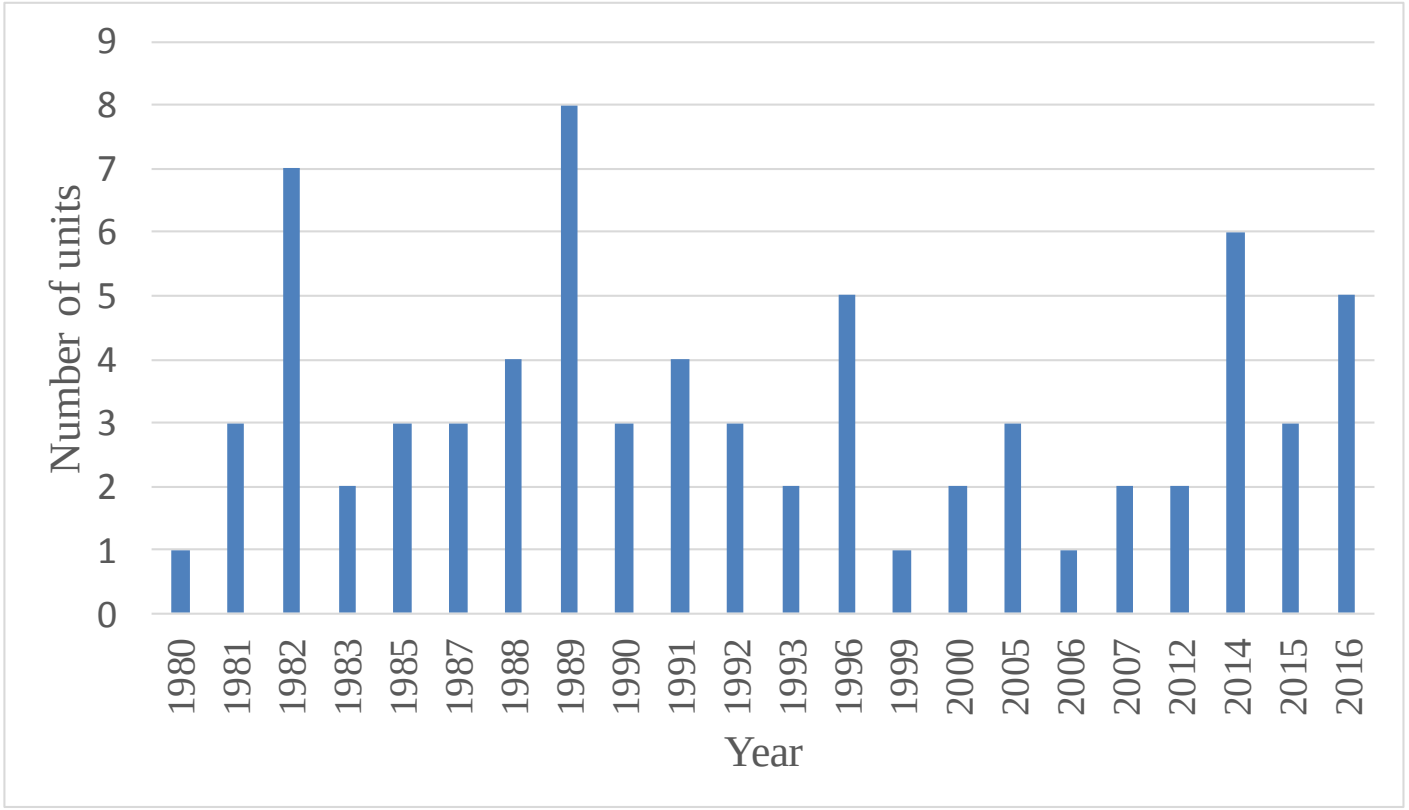
Installed and predicted future power generation



Geothermal power generation, updated report 2015, Bertani

Small 0-15 MW plants from 1980-2016



Reference list from manufacturer, single flash.

Wellhead power plants

Purpose

Permanent plants

- Long term utilization
- Optimally utilize the resource

Temporary plants

- Early generation
- Standard plants
- Information gathering

Wellhead power plants

Temporary

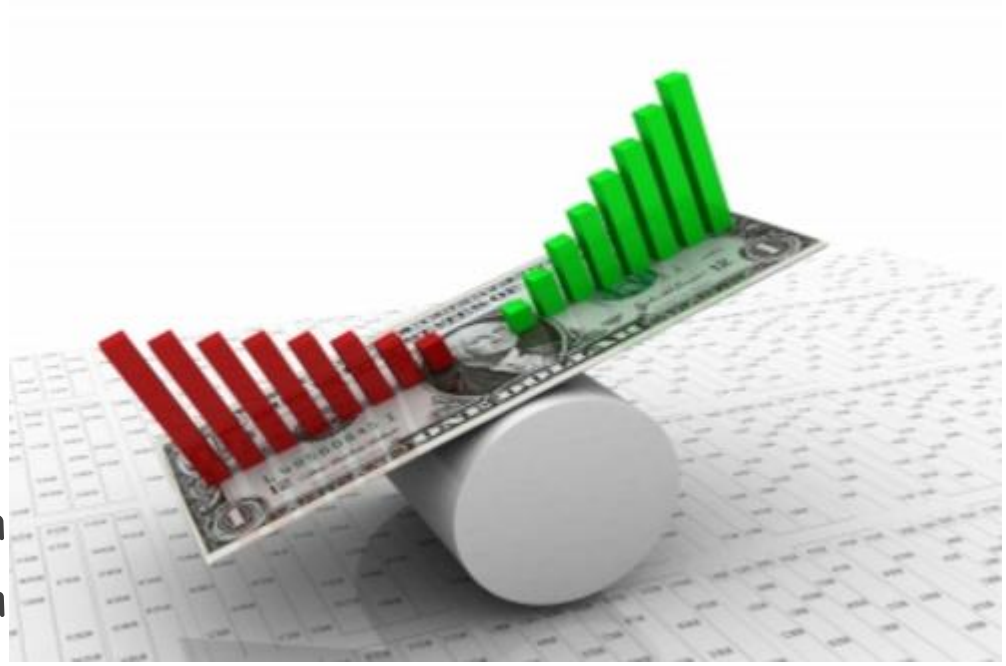
- Pros
  - Early generation
  - Continuous well testing
  - Small units, standard
- Cons
  - Grid connection
  - Decline
  - Relocation
  - Distributed operation

Permanent

- Pros
  - “Early” generation
  - Continuous well testing
  - Small units, customized
- Cons
  - Grid connection
  - Make-up drilling/decline
  - Distributed operation
  - Spare parts

Feasibility

- Cost
  - Well cost
  - Re-injection
  - Equipment
  - Grid connection
  - Capacity factor
  - Relocation (for tempora
  - Make up wells (for perm
- Feed-in tariff
- Depreciation period
- Well characteristics



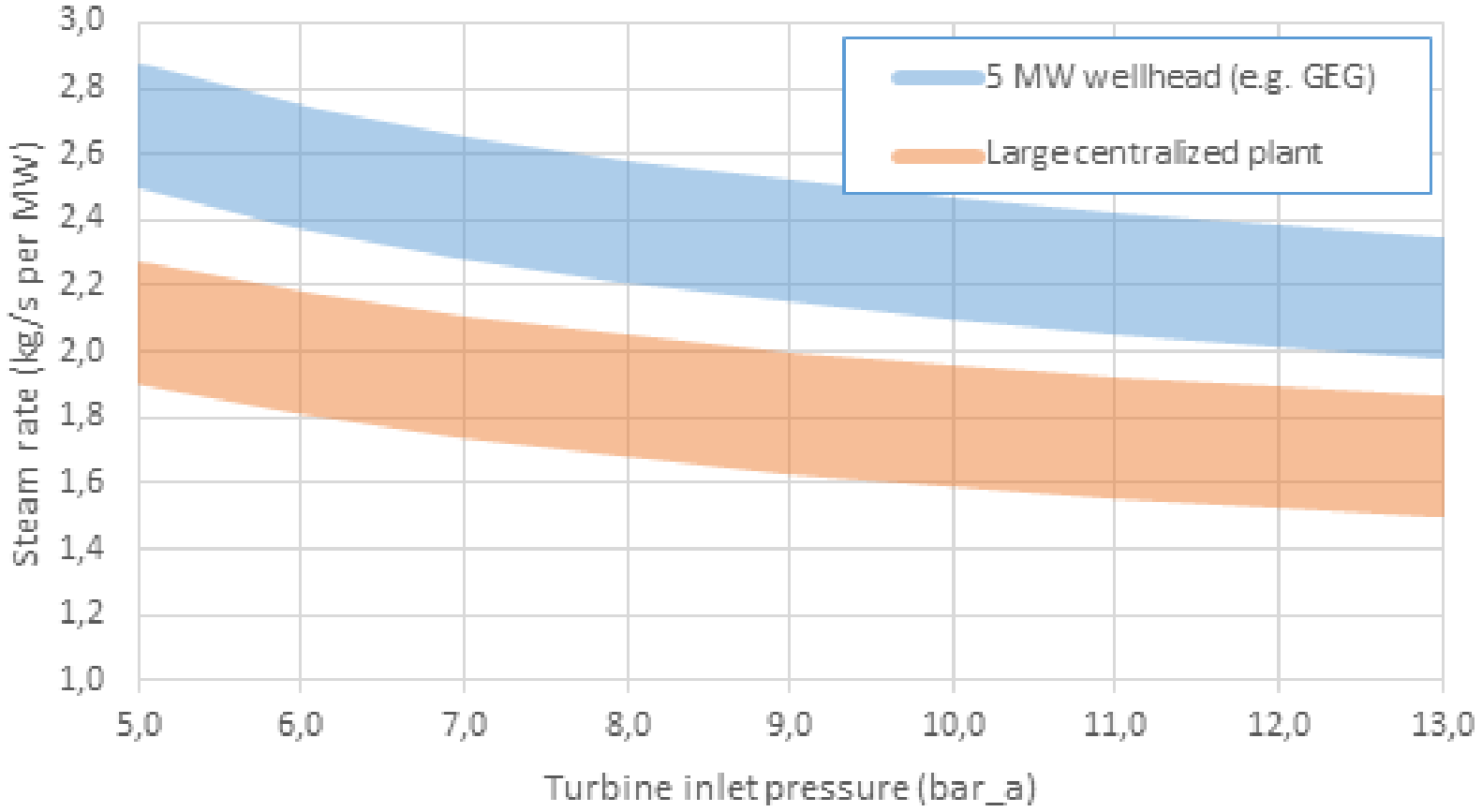
Technology

- Backpressure
  - Topping plants, temporary plants
  - Lowest capital cost
  - Lowest efficiency
- Condensing
  - Permanent plants
  - Higher capital cost
  - Higher efficiency
- Binary
  - Bottoming plants, permanent plants
  - Highest capital cost
  - Higher efficiency

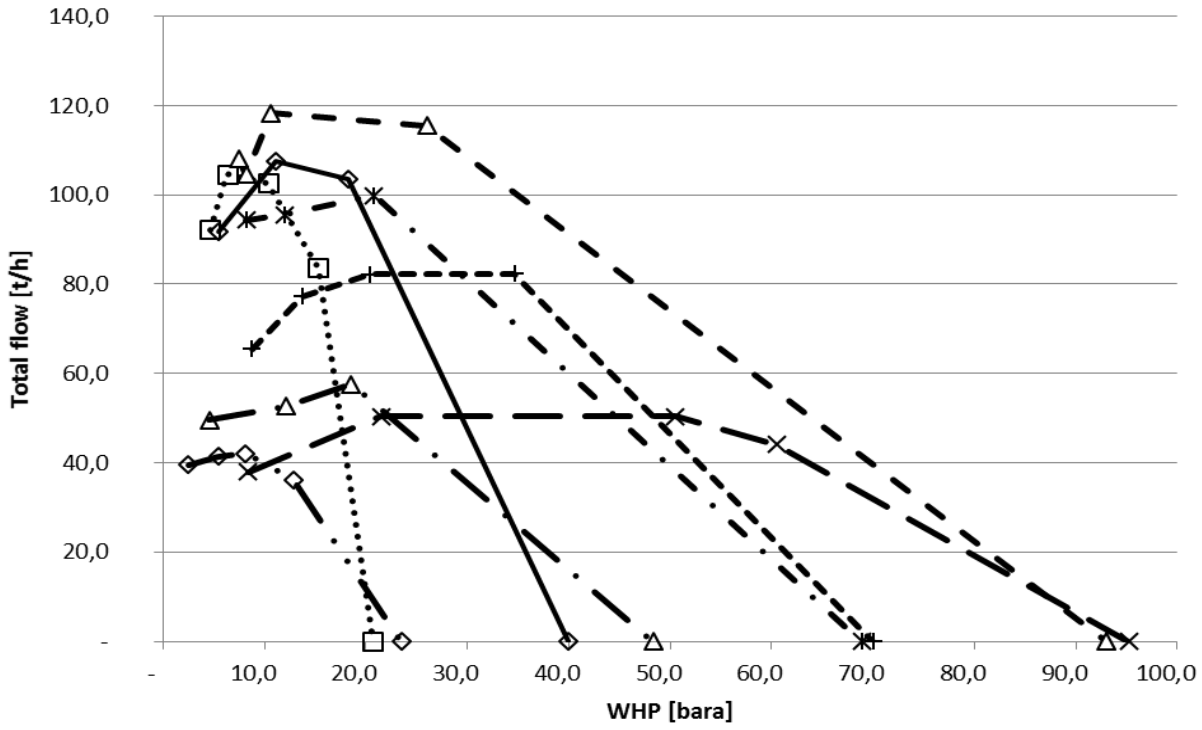
Environmental impact

- Gas emissions
- Noise
- Grid connections

Efficiency comparison, single flash



Pressure selection



Comparison

Conventional

Pros

- High efficiency
- Geothermal fluid mixing
- Simpler operations

Cons

- Single operating condition in the steam supply system
- Long lead times for large scale equipment
- Cross-country piping

Wellhead power plants

Pros

- Early generation
- Reservoir production response information
- Simple construction
- Relocation option

Cons

- Distributed operation
- Make-up wells
- Grid Connection
- Reinjection

Cost comparison

- Single flash condesing plant cost – excl. Wells
  - (50 MW, 6-16 bara, 1-2% NCG)
  - Large scale: **1,8 – 2,5 MUSD/MW**
  - Well head: **1,75 – 2,4 MUSD/MW**
  - **…… Mostly the same or even cheaper!**

- When wells are included, Large scale become cheaper because of higher efficiency

Conclusion

- Selection between one or the other does not seem obvious
- Well head power plants along side large scale plant most likely scenario for field development
- Combining the best of both by using a combination of both
- Temporary well head for early generation
- Permanent well head for “off design” wells and surplus steam
- Well head plant can be the key to project feasibility with early generation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