Key Performance Indicators: Reference plants & assets

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Agreed strategic targets in deep geothermal energy

- Increase reservoir performance resulting in power demand of reservoir pumps to below 10% of gross energy generation and in sustainable yield predicted for at least 30 years by 2030;
- Improve the overall conversion efficiency, including bottoming cycle, of geothermal installations at different thermodynamic conditions by 10% in 2030 and 20% in 2050;
- Reduce production costs of geothermal energy (including from unconventional resources, EGS, and/or from hybrid solutions which couple geothermal with other renewable energy sources) below 10 €ct/kWhe for electricity and 5 €ct/kWhth for heat by 2025;
- Reduce the exploration costs by 25% in 2025, and by 50% in 2050 compared to 2015;
- Reduce the unit cost of drilling (€/MWh) by 15% in 2020, 30% in 2030 and by 50% in 2050 compared to 2015;
- Demonstrate the technical and economic feasibility of responding to commands from a grid operator, at any time, to increase or decrease output ramp up and down from 60% - 110% of nominal power.

MONITORING BASELINE

- The DG-IWG decided to have as baseline the date of endorsement of the Implementation Plan by the SET Plan Steering Committee: 24/01/2018.
Reference Plants

Type of plants

Four plants are considered, three on power production and one on heat generation:

- 20 MWe high temperature plant (Flash turbine)
- 10 Mwe medium temperature plant (Binary turbine)
- 5 MWe EGS plant
- 10 MWth Deep geothermal plant for h&c (supply to DH, Greenhouses, Industrial process heat...): example with a geothermal DH (doublet) systems

- More Heat Plants as reference?
- What about CHP?
Costs structure

Cost range for the development of a 20 MWe conventional high temperature plant with a flash turbine. The graph shows the cost range for the different steps in field development and the construction of the power plant. 1,65 – 3,1 €mio / MWe

- upfront cost for exploration
- exposure to risk of failure
Costs structure

Cost range for the development of a 10 MWe medium temperature plant with a binary turbine. The graph shows the cost range for the different steps in field development and the construction of the power plant. **2.2 – 3.7 €mio/MWe**
Costs structure

Cost range for the development of a 5 MWe EGS plant. The graph shows the cost range for the different steps in field development and the construction of the power plant. **5.4 - 9.4 €mio/MWe**

- upfront cost for exploration
- exposure to risk of failure
Costs structure

Cost range for the development of a 10 MWth geothermal DH (doublet) systems, producing 40,000 MWh/year (investment cost = 1.3-1.8 €mio/MWth). Capital costs do not include costs for the installation of the district heating grid (about 1 €mio/km). **1,3 – 2 €mio/MWth**
Reference assets

The assets must answer the challenges brought by the SET Plan target on:

Reservoir pumps:
- Increase reservoir performance resulting in power demand to below 10% of gross energy generation and in sustainable yield predicted for at least 30 years by 2030;

Turbines:
- Improve the overall conversion efficiency, including bottoming cycle, of geothermal installations at different thermodynamic conditions by 10% in 2030 and 20% in 2050;

Exploration tools:
- Reduce the exploration costs (full phase) by 25% in 2025, and by 50% in 2050 compared to 2015;

Drilling
- Reduce the unit cost (€/MWh) by 15% in 2020, 30% in 2030 and by 50% in 2050 compared to 2015;

Power flexibility:
- Demonstrate the technical and economic feasibility of responding to commands from a grid operator, at any time, to increase or decrease output ramp up and down from 60% - 110% of nominal power.
Type of assets

Exploration assets:
- Reduce exploration costs by 25% by 2025 (including the costs of exploratory drilling)
- compared to the current situation:

The cost of identifying a resource is estimated to fall between €350,000 – €1,000,000.
Cost estimates for resource exploration range from one to ten million euros for the full exploration phase.
The contribution to LCoE is estimated at €3.5 per megawatt hour.

Costs of different assets:
- Modelling tools
- 2D & 3D Seismics
Drilling assets:

The graph below aims at presenting the drilling phase and the current costs per well.

In terms of assets, we will refer to costs of equipments manufacturing:
- Drilling rig with all equipment incl. BOP
- Drilling tools incl. bits, fishing tools etc.
- Raw material and consumables: drilling mud, cement, casing and casing accessories…
Development of the resource, Plant installation and Energy generation:

**Downhole pumps:** The investment cost for selecting and installing an ESP is in the range of between €180k and €300k. Yearly operational costs are estimated to be between €60k and €100k, without including the electricity costs for driving the pump.

**Steam gathering:** The cost of steam piping typically depends on the distance from the wells to the plant, the flowing pressure and the chemistry of the fluids.

**Heat Exchangers:** The cost of each heat exchanger was about €127k. The most expensive positions were manufacturing (welding, machining, assembling...) and the acquisition of tubes and sheet plates, representing about 37% and 30% of the total cost respectively. Other material acquisition (shells, flanges, bolts...) represented about 20% of the total cost, while engineering stood at 6%, painting and insulation at 5.5%, and control and EC certification at 1.5%.

**Non Condensable Gas (NCG) Removal System:** The industry standard for removing the NCG of conventional geothermal power plants (flash or dry steam) has been steam jet ejectors or a hybrid turbo-compressor system of steam jet ejectors and liquid ring vacuum pumps. ENEL Green power also has a patent for the AMIS system for improving the environmental performance of its plants by removing the H2S and mercury from the stream of NCGs. An abatement plant corresponds to a cost of 3.5 Mln € per plant.

**Cooling Systems:** Geothermal plants employ water-cooled systems – typically using cooling towers or air cooling. The investment cost of wet cooling towers is much lower than the cost of air-cooled condensers.

**Power Transmission Lines:** The costs of the individual components of a 1 MWe-transfer station are:

- Envelope of the station: €35,000
- Medium-voltage switchgear: €20,000
- Transformer (1000 kVA): €18,000
- Low-voltage distribution: €6,000
- Incidents: €3,000
Type of assets

Operation & Maintenance

The costs of O&M for deep geothermal represent about 2% of capital costs. They include:

- Personnel costs for the following actions: remote control, regular routine inspections, start-up / shutdown of the plant and during maintenance.
- Routine maintenance costs: replacing or cleaning equipment such as valves, pumps, the generator, switchgear etc.
- Consumables for the operation: filters, oil and chemicals.

About 1 to 2 weeks of scheduled shutdowns are foreseen each year for general maintenance and 5-8 weeks every 3-6 years for major maintenance.

This influences not just the maintenance cost but also the expected utilisation hours.
This potential cost reduction is linked to the third strategic target of the SET-Plan Declaration.

The target is set at a maximum production cost of 15 €ct/kWh for electricity and 6 €ct/kWh for heat by 2023, and 10 €ct/kWh for electricity and 5 €ct/kWh for heat by 2026.

These cost targets apply to all types of deep geothermal projects, including EGS and super-hot geothermal systems (> 350°C).
Learning curve
Thank you for your attention.