THE USE OF GEOTHERMAL RESOURCES IN THE AZORES ISLANDS
• Nine small-scale **independent systems**
• Power transmission between the islands is **not technically feasible**
• Power production from renewable sources is **cost-competitive** when compared to fuel-based generation plants
• **Abundant** renewable energy resources in the Azores: geothermal, wind and hydro
Total Generation Capacity = 63.5 MW

3 Geothermal Power Plants
26.5 MW

7 Wind Farms
28.6 MW

12 Hydropower Plants
8.4 MW
In 2018, EDA RENOVÁVEIS produced 290 GWh of electric power from the following renewable sources:

- Geothermal - 204 GWh
- Wind - 59 GWh
- Hydro - 27 GWh

Representing a total of 36% of the energy produced in the archipelago.
GEOTHERMAL ENERGY

Geothermal ("Geo" = EARTH and "Thermal" = HEAT): Heat from the Earth

- Heat source inexhaustible
- Core: 3,450 km with temperature between 4,000-6,000°C
- Average geothermal gradient: 25–30°C/km

Tectonic plate boundaries / active volcanic zones:
- High geothermal gradient (>100°C/km)
- Ex: Açores

Global Geothermal Power Plant Map
GEOTHERMAL ENERGY USES

Lindal Diagram
Direct uses

Leisure/Balneotherapy

Greenhouses

District heating

Fish farming
Types of power plant

Centrais de flash
*Single flash power plants*

- Vapor Steam
- Separador Separator
- Água separada Separated water
- Água quente Hot water
- Turbina Turbine
- Grupo gerador Generator unit
- Vapor condensado Steam condensate
GENERATION TECHNOLOGIES
Types of power plant

Centrais de ciclo binário
Binary cycle power plants

Fluido de trabalho vaporizado
Working fluid after flashing

Turbina
Turbine

Grupo gerador
Generator unit

Fluido de Trabalho Líquido
Working fluid (liquid)

Permutador de Calor
Heat exchanger

Água quente
Hot water

Água arrefecida
Cooled water
AZORES GEOTHERMAL PROJECT

Benefits

ECONOMIC
• Saving in fuel imports
• Possibility to use the resource downstream (direct uses)
• Strengthens the Azorean economy

STRATEGIC
• Increases the diversification of energetic sources and self-sufficiency
• Protects the Azores from uncontrollable factors (oil barrel price and exchange rate fluctuations)
• Promotes the name of the Azores

ENVIRONMENTAL
• Reduces the emissions of air pollutants
• Reduces fossil fuel burning

SOCIAL
• Creates jobs in the area of new technologies
• Develops technical skills
RIBEIRA GRANDE GEOTHERMAL FIELD
São Miguel island
SÃO MIGUEL GEOTHERMAL PROJECT
Historical milestones

1971  Conducted geoelectric and magnetotelluric surveys, that revealed a resistivity anomaly in the northern side of the Fogo volcano.

1973  “Deep Drill” Project: investigation hole, for petrologic studies purpose, drilled by the Dalhousie University, Canada, intercepted productive formations and temperatures over 200°C.

1976  Drill of six thermal gradient holes, reaching maximum depths of 200 m, confirmed the presence of an anomalous geothermal gradient.

1978  Drill of five small diameter, exploratory wells, which confirmed high temperature below the 450-500 m deep.

Results of the developed exploration confirmed the presence of economically interesting geothermal resources at Ribeira Grande, leading to the exploitation phase of the resource.
1980-2005: Exploitation of the pilot plant

- Manufacturer: Mitsubishi
- Back pressure turbine Nominal capacity: 3 MW
- Steam consumption: 56 t/h @ 5.1 bar(a)
- Operating results: 84 GWh during 136 thousand hours

Pico Vermelho power plant operated during 25 years and served as a valuable training school for the technical staff regarding operation and maintenance of the wellfield and generation equipment.
SÃO MIGUEL GEOTHERMAL PROJECT
Ribeira Grande power plant

Phase A
2 x 2.5 MW

Phase B
2 x 4.0 MW

CL1 CL2 CL5 CL6 CL7

CL4 CL4A
SÃO MIGUEL GEOTHERMAL PROJECT
Pico Vermelho power plant

10 MW
SÃO MIGUEL GEOTHERMAL PROJECT
Contribution of the renewables 2018

São Miguel

Fuel 48.5%
Geothermal 42.1%
Hydro 5.0%
Wind 4.2%
Biogas 0.1%

São Miguel (April, 2018)

Fuel 42.7%
Geothermal 45.3%
Hydro 6.0%
Wind 6.0%
Biogas 0.1%
PICO ALTO GEOTHERMAL FIELD
Terceira island
2000-2004: Geophysical exploration and drilling of 4 thermogradients wells (400-600 m)

2006 and 2009: Drilling of 5 evaluation wells (1.100-1.900 m)

2009 and 2013: Productivity tests
Presence of a high temperature geothermal system (>300ºC) that extends over a considerable area and with heat reserves large enough to support a 10 MW project;

Although the temperatures of the wells are high, the productivity of the wells range from very low to intermediate due to the formations low permeability;

From the 5 existing wells, only three geothermal well has a commercial productivity, estimated in 3 MW;

The project was restructured in 2 phases:
Phase A - Pilot Plant 3MW, Phase B – Power Plant 7MW.
The power plant was designed and manufactured by the consortium **EXERGY-CME** and uses a **ORC Binary cycle technology**.

The 3.5 MW power plant started its operation in August.
In 2018, Pico Alto power plant produced 20,6 GWh, representing a contribution of 11% on the power production system of Terceira.