Turboden's ORC grid balancing capability

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ABSTRACT

The paper describes the advantages of ORC geothermal power plants to ensure a secure and stable energy supply. Thanks to these features, geothermal technologies could therefore positively contribute to the stabilisation of the electricity grid. A geothermal power plant can be efficiently used in partial load operation and, especially with new ORC technology, can quickly ramp its output down on demand. Turboden's ORC (Organic Rankine Cycle) binary geothermal power plants have already implemented this kind of features that suitably match the needs of modern electric grids. Moreover, stability during the Low Voltage Ride Through (LVRT) is guaranteed and, in case of electrical fault on the grid, the ORC is able to operate on island mode (keeping the geothermal pumps in function).

The development of a geothermal ORC plant will result in reduced system costs, a benefit which should be highlighted when comparing geothermal ORC plant to other power plant technologies. There is an urgent need to develop mechanisms that reward the flexibility a geothermal plant can provide.

1. INTRODUCTION

The spread of renewable energy power plants in the last decade is well known. Most of them exploit non-programmable resources, such as wind power and solar power (mostly photovoltaic systems, PV). Nevertheless, these producers benefit from the priority dispatch, i.e. the TSO (Transmission System Operator) and/or the DSO (Distribution System Operator) do not ask them to regulate their production based on the electric demand. This implicates instability problems to the electric grid, because of their unpredictable production. Furthermore, a large-scale deployment of distributed generation may affect grid-wide functions such as frequency controls [1].

Many countries have recently issued grid codes to contrast these problems: power plants, by means of various ways, are required to be able to control active power, voltage and to be stable during sudden low voltage situation, i.e. have a LVRT (Low Voltage Ride Through) capability.

2. GEOTHERMAL POWER PLANTS

Geothermal as well as hydro, instead, are both renewable resources and programmable resources: they do not give instability issues; on the contrary, they can help to support the grid.

The main advantage of geothermal power is its base load capability. In contrast to other volatile renewables, geothermal power plants are capable of responding to system operators' needs and can produce more than 8.000 hours per year, being flexible and predictable (e.g. not depending on weather conditions except for a minor influence related to ambient temperature which influences condensation temperature).

2.1 ORC geothermal power plants

ORC geothermal plants are suitable to exploit low-to-medium enthalpy resources, both liquid and mixed (liquid and steam). They convert thermal power into electric power practically without any resource consumption, as they re-inject the resource underground entirely [2].

Turboden ORC plants adopt various solutions in order to support the grid and comply with its requirements. Indeed, in Turboden's geothermal ORC plants located in Germany, it was proved that power output can be regulated very fast; also voltage stability and LVRT capability are supported thanks to the adoption of synchronous generators.

3. TURBODEN'S ORC

Turboden designs turbogenerator based on the ORC technology since 1980. Its experience allows to develop innovative solutions in order to make ORC plants very reliable and be able to contribute to grid balancing [3].

3.1 Active power control

Turboden's ORC geothermal plants can reduce power from 100 % to 30 % in 15 seconds and bring it back to 100 % in one minute. A software (Turboden's patent pending) controls the ORC turbine power output combining a predictive model to the standard PID set point controls in order to react very fast [4].

The output power control could be carried out in two ways:

- resource flow rate regulation (slow)
- turbine valves regulation (fast)

The resource flow rate regulation has reaction time of many minutes, as it requires to control the geothermal pumps, and is not suitable for the grid requirements. Furthermore, in presence of artesian wells, it is best practice to keep the well flow as much as possible constant during operation.

The turbine valves regulation is required in order to balance the grid quickly. Turboden has developed a software that allows to control the turbine admission by an effective model. This system is able to avoid any plant instability by means of simultaneous adjustment of both admission and by-pass valves (Fig. 1).

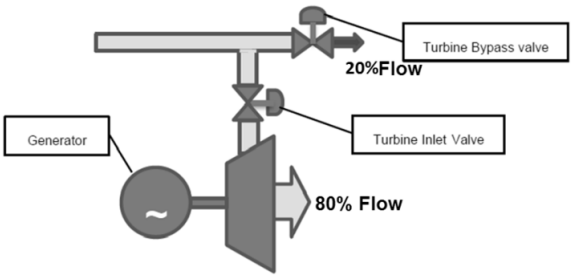


Figure 1: Admission valve control together with by-pass control

Although the control principle is basically simple its implementation could cause control issues and ORC cycle instabilities, in particular related to ORC feed pumps control. Furthermore, valves have different characteristic curve and their large dimensions are not suitable for fine regulations. An appropriate algorithm has been developed to avoid these issues.

3.2 Voltage control and LVRT

Voltage control means to balance grid voltage changes by reactive power regulation: when the produced power decreases, the power factor (cos ϕ) has to change according to a curve supplied by the local system operator (Fig. 2).

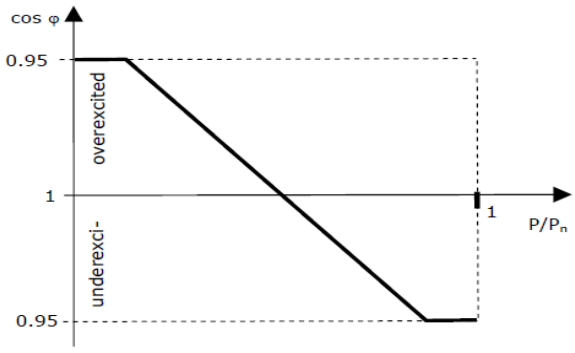


Figure 2: Power factor Vs reactive power

Low Voltage Ride Through is the capability of electric generators to stay connected in short periods of voltage dip (Fig. 3).

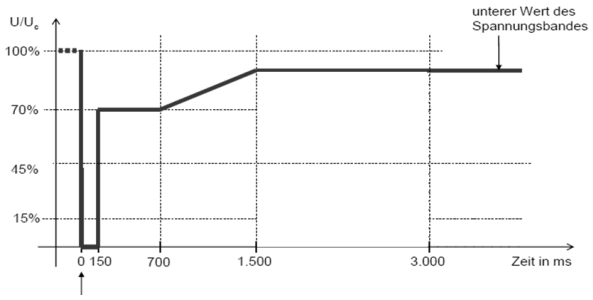


Figure 3: Low Voltage Ride Through

Turboden ORC plants are able to run also during deep voltage variations and to give dynamic support through reactive control. The network operator aims at avoiding generating power plants disconnection from grid during voltage dips (caused by electrical fault or network disturbances), hence a LVRT capability is more and more requested to the distributed power generators [4].

Synchronous generator as well as special AVR (Automatic Voltage Regulation) settings and protections allow to achieve those capabilities.

3. CONCLUSIONS

Where sources are available, geothermal power generation is the perfect candidate to increase the renewable power production share of many countries, thanks to its base load capability and programmability.

Turboden's ORC geothermal plants have both these features and strong grid balance capability: indeed, they can contribute to the ancillary services of the electric grid, such as frequency control, voltage control, operating reserve.

There are some markets in which these capabilities are rewarded, e.g. a plant that operates as a reserve can be rewarded even if is shut-down.

Several solutions were undertaken in order to reach this feature. A specific solution (patent pending) that controls properly the turbine valves and the adoption of synchronous generators as well as special AVR settings allow to accommodate the hardest grid requirements worldwide.

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