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Geothermal ORC Plant as a Replacement of Diesel Generators on Isolated Grid

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ABSTRACT

Geothermal power plants have frequently been phrased for their capability as base load power generation. There are on the other hand situations where geothermal units can also been applied for part load even in island mode. Geothermal plants can even be an alternative to Diesel (or gas turbine) for power generation in remote locations where fuel cost is high due to distance and size of that market.

The reliability of good binary plant can also be higher than of many grids [1]. Having the plant capable of running in island mode in case of grid failure has also shown reduction in maintenance cost in considerably increased availability.

This paper addresses ways of controlling and changes to equipment to enable ORC plant to serve as single source of power production on isolated grids and experience thereof.

1. INTRODUCTION

We are quite proud of the reliability of ORC geothermal plants and their capabilities to serve as base load units. There are examples of 99.5% availability when capable of island mode operation. Enel USA [2]

There has been less interest to use them for variable load like island mode or for peaks.

Lot of that has to do with the cost structure of such plants and the fact having variable load on geothermal wells is normally not considered advisable:

1. Cost of the power from geothermal plant is almost all fixed cost. Cost of operation in mostly the same if plant is run under full load or part load. [3]

2. Maintenance cost is if anything higher if the plant in stooped and started on regular basis and saving in personnel is none or little

3. Casings in wells are under significant load if production quantity is varied. Such load can lead to premature casing failure. [4])

2. REQUIREMENTS

The requirements towards a geothermal plant that is replacing the diesel option are:

1. Capability of regulating both frequency and voltage automatically
2. Swift enough reaction to supply the gird with stable power
3. No emission of brine or steam unless in emergency situation
4. No or controlled variation of the operation of wells,

2.1 Control of frequency and voltage

Having governor for frequency either separate or as part of PLC regulation is the norm not the exception and having AVR (automatic voltage regulator) on the generator in independent on what machinery is driving the generator.

We have to fulfil the norm EN 50160 and similar norm in other markets.

2.2 Swiftness

Swiftness can be one of ORC qualities. We have a Rankine cycle with radial inflow turbine. These turbines can be furnished with a quick actuator, even a hydraulic one to have reaction time from full load to only parasitic load consumption in a second.

2.3 No emission of brine

There is a need for different thinking of regulation compared to conventional diesel or gas plant. The “fuel” in this case the brine has only fixed cost associated with it. We can therefore throw off the brine that we do not need at each time. We could therefore throw it off or releases through chimneys when not needed. There are on the other hand very few or no sites where that does not have environmental implications. No release of brine or stem is therefore the target.

2.4 No or regulated changes to the operation of wells

Changing the temperature of wells rapidly causes thermal expansion or contraction in the wells casing. Such can cause mechanical strain on the casing that can lead to failure.

Table 1: EN 50160 Compliance Limits

Supply voltage characteristic	Statistical Evaluation	Compliance limit
Power frequency	95% of the time in 1 week 100% of the time in 1 week	50 Hz ± 1% 50 Hz + 4% to -6%
Supply voltage variations	95% of the time in 1 week	Uc ± 10%
Rapid voltage changes (and Flicker)	95% of the time in 1 week	Plt ≤1
Supply voltage dips	1 year	None given[1]
Short interruptions	1 year	None given[2]
Long interruptions	1 year	None given[3]
Temporary overvoltages	1 year	None given
Supply voltage unbalance	95% of the time in 1 week	<2%
Harmonic voltage	95% of the time in 1 week 95% of the time in 1 week	See Figure 1 THD <8%
Mains signaling voltage	99% of the time in 1 day	9% @ 100 Hz 1% @ 100 kHz

1. Indicative value of 1000 dips/year provided
2. Indicative value of "several hundreds" of short interruptions/year provided
3. Indicative value of 50 long interruptions/year provided

3. METHODS OF CONTROL

There are four ways of load controlling geothermal plants

3.1 Fuel dumping

Dumping of steam and/or brine. This method is frequently used for steam flash plants as some quantity of steam (~5-10%) is thrown off on a steady basis to regulate the production a set production level. This method is coming less appealing due to; steam plume, noise and NCG handing

3.2 Bypassing plant

Bypassing the plant. ORC's have been controlled frequently by bypassing the plant which is also a method of dumping fuel as above. This method has the main drawback that reinjection wells are experiencing different temperatures and thereby giving thermal expansion strain of the casings in the rejection wells with associated risk of casing failure.

3.3 Regulating fuel flow

Reducing the flow to the plant, either by pumping less (where production wells are pumped) or by regulating vales on wellheads. This method had the advantage of not straining the reinjection wells (if controlled not to do so) and saving the resource fluid. The disadvantage is that this method has long reaction time and is therefore normally used in cascade with other control methods.

3.4 Bypassing turbine

Bypassing turbine in the ORC cycle itself. The power generation efficiency of typical ORC in only in the range of 8-15%. Going from full load to parasitic load only, that will lead to a bit higher backpressure which as such does only help with the regulation of the generation.

4. OPERATION

4.1 Staffing

Both ORC and diesel have similar need for operational staff. There is a tradition to run both without constant oversight and ORC (not having water steam) can be run without 24/7 duty does therefore only increase the heat flow to the condenser of 10% or so.

4.2 Remote operation

The turbine is rotation machinery which has little or no wearing parts during operation. Such a plant can therefore run for years without having to be stopped put to replace worn parts.

4.3 Grid intervention

There are numerous examples of geothermal ORC plants that are maintained on 8/5 basis 5 days a week 8 hours day, but remotely operated from central control room on 24/7. (Enex, Berlin plant, …)

5. PROVE OF CONCEPT

Here are sample where this is being practiced

5.1 Berlin, El Salvador

The plant installed by Enex in 20015-2008 is capable of supplying a localized grid (island mode) with electricity. Actuator was enlarged and control valve added to achieve this. This plant was also installed controls enabling the grid operators to manage the plant.

5.2 Still Water, and Salt Wells, Utah

These plants have shown incredible availability under the professional management of Enel. The expanders from Atlas Copco, Mafi Trench are supplied with quick acting hydraulic actuators to make this possible. These plants go from full load down to parasitic load only (in case of grid failure) without going outside of the grid norms for power supply stability.

5.4 Canakkale, Turkey

Atlas Copco Gas and Porcess is delivering plant to Canakkale Turkey that is to be possible to operate in island mode. This is the first binary plant delivered by Atlas Copco where the feature is bought by our client. This feature enables the client to feed smaller network and will help the stable operation of the plant by keeping it running in the case of grid failure. This plant is scheduled to go on line mid-year 2015

REFERENCES

1. U.S. Energy Information Administration. “Levelized Cost of New Generation Resources in the Annual Energy Outlook 2013.” Wasington DC: U.S. EIA Accedssed September 20th, 2013

2. Woodward Application Sheet 51364, Enel Geothermal Plants, Sillwater and Salt Lake, Nevada, USA, (http://www.woodward.com/workarea/downloadasset.aspx?id=2147484588)

3. Subir K. Sanyal, *COST OF GEOTHERMAL POWER AND FACTORS THAT AFFECT IT,* PROCEEDINGS, Twenty-Ninth Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, California, January 26-28, 2004, SGP-TR-17

4. I. Fridleifsson, JHFÍ February 2006, , Rit14, http://www.jardhitafelag.is/media/PDF/Rit14.pdf