Generation While Drilling (GWD) Strategy in Geothermoelectric Project Development

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Outline

• «Generation While Drilling» – the idea
  • advantages
  • technical feasibility

• Theoretical Modeling on real DATA
  • Load
  • Generation unit

• Simulations and results

• Conclusions and Outlooks
Geothermal Energy: a renewable resource but still exploited less than its great potential

Initial expenses for assessment are very high

Project development is very long (high TTM)

No financial or technological tool is yet available on the market for investors to reduce time, risks and costs
### The Idea

Early installation of a small Geothermal Unit (Wellhead Power Plant) on the first production loop to:

- **Self-produce the electricity for drilling and construction**
- **Produce electricity for possible distribution on a local network**

#### BENEFITS

- **Reduction of the time-to-market**
- **Sharing benefits to increase social acceptance**
- **Longer production tests while operate**

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**GWD**

- **Early production**
- **Simple and modular systems**
- **Reduced installation time**
GWD: a WHPP that generates in isolate network, to supply drilling rigs, construction site and local population

<table>
<thead>
<tr>
<th><strong>Advantages:</strong></th>
<th><strong>Feasibility:</strong></th>
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<tbody>
<tr>
<td>Economic (early earning and saving)</td>
<td>Geothermal Units are not so flexible as diesel generators to supply «Free» load of Drilling Rigs, that produce very relevant electric transients</td>
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<td>Knowledge of the Geothermal Reservoir (increased <em>well-testing</em> time)</td>
<td></td>
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<td>Positive influence on social acceptability + workers’ comfort</td>
<td></td>
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</table>
GWD: improving feasibility

Generator side

Backpressure Steam Turbine (BST) 
Franco Tosi

Organic Rankine Cycle (ORC) 
Exergy

\[ \text{Geothermal reservoir} \]

\[ \text{Free discharge} \]

\[ \text{Geothermal fluid} \]

\[ \text{ORC cycle} \]

\[ \text{FESS} \]

\[ \text{Drilling Rig} \]

\[ \text{Local grid} \]
GWD: improving feasibility

“Load” side

- 2 Rig Drillmec HH 220 Extreme
- Power generation unit
- Eventual auxiliary systems (flywheels storage)

Analysis of 3 operating conditions, either individually or combined

- Normal drilling operation
- Rods lifting
- Emergency stop
GWD: theoretical model implementation

Power consumption trend modeled from real values, measured on an operating drilling rig

Interpolation of the sampled data for each of the 3 phases using the «cubic splines» method

Creation of compound curves after appropriate combination of the «normal» conditions
GWD : theoretical model implementation

**Drilling**
- Time to go to full capacity: \( \sim 300 \text{ s} \);
- Load that varies around a mean value:
  \[ P_{\text{TOT}} = 1080 \text{ kW} \pm 3.5\% \rightarrow P_{\text{MAX}} \approx 1200 \text{ kW}; \]
- Phase-controlled cessation in approx 20/25 s.

**Rods lifting**
- Time to go to full capacity: \( \sim 10 \text{ s} \);
- Quite variable load depending on the climb:
  \[ P_{\text{MAX}} = [460 \div 517.5] \text{ kW}; \]
- Duration of the single operation: 100 ÷ 120 s.

**Emergency stop**
Worst condition: total loss of one of the unit when operating under normal drilling.
GWD: theoretical model implementation

- Both plants drilling
- Both plants under rods lifting
- One plant drilling, the other in rods lifting regime
The generation unit to be simulated, in the Laguna Colorada case, consists of two elements:

**Turbine-alternator system**
- Synchronous three-phase generator
- Excitation system
- Turbine and speed regulator

**Auxiliary storage devices**
- Vacuum flywheels with magnetic bearings (FESS) simulated by R-L load insertion via switch
GWD : theoretical model implementation

- **ORC:** \( P_{\text{MAX}} \approx 100 \ [\text{KW/s}] \)
- **BST:** \( P_{\text{MAX}} \approx 13 \ [\text{KW/s}] \)
GWD : Numerical simulation and results

Simulation of the 6 exposed cases for both types of generation units

<table>
<thead>
<tr>
<th>Single RIG</th>
<th>Double RIG</th>
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</thead>
<tbody>
<tr>
<td>• Normal perforation</td>
<td>• Both in normal perforation</td>
</tr>
<tr>
<td>• Rods lifting</td>
<td>• Both in rods lifting</td>
</tr>
<tr>
<td>• Emergency stop</td>
<td>• Rigs in different phases</td>
</tr>
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</table>

Analysis of the mechanical shaft $\Delta \omega$

Flywheel intervention limit: $|\Delta f_n| = 3.5\%$

24 simulations performed
GWD: Numerical simulation and results (single RIG)

**Binary cycle ORC**

**Backpressure steam turbine**

[Graphs showing rotor speed comparison with and without flywheels for different scenarios.]
GWD: Numerical simulation and results (double RIG)

Binary cycle ORC

Backpressure steam turbine
GWD : summarizing the results

• Electric transients capable to cause frequent trips of the Plant, have been confirmed
• Anyway, a technical solution is commercially available at reasonable costs
• Other technical challenges are all solved:
  • Wellpad design
  • MV line implementation between wellpads
  • Admission pressure flexibility
GWD : rough financial analysis

**General parameters**
- Installed electric power: 5MW<sub>e</sub>
- Applied discount rate: 4%
- O&M charges: 10 %/y

**Drilling unit**
- No. of wells to be built: 25
- Drilling time per well: ~3 mesi/peno
- Energy consumption: 7500MW/anno

**Current solution**
- Fuel consumption (for each ICE): 110000 l/month
- Fuel cost: 1,4 $/l

**GWD**
- ORC cost: 3000 $/kW
- BST cost: 1500 $/kW
- FESS cost: 900 $/kW

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<tr>
<th>Year</th>
<th>ORC</th>
<th>BST</th>
<th>Diesel</th>
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<tbody>
<tr>
<td>0</td>
<td>12,900</td>
<td>6,900</td>
<td>0,000</td>
</tr>
<tr>
<td>1</td>
<td>13,024</td>
<td>7,024</td>
<td>7,185</td>
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<tr>
<td>2</td>
<td>13,143</td>
<td>7,143</td>
<td>14,093</td>
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<tr>
<td>3</td>
<td>13,258</td>
<td>7,258</td>
<td>20,735</td>
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Discounted cost [M$]
**GWD : conclusions - outlook**

- The model must be verified on the field, but it provides encouraging results for GWD.
- Is a winning solution for greenfield projects in remote areas with social challenges.
- Technical problems are solved or affordable using commercial equipment.
- Now is no more time for engineers, but for lawyers and economists...
THANKS FOR YOUR ATTENTION

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