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Vergnet company

- Location Ormes (France — Orléans)
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- Subsidiaries in the Caribbean, Indian Ocean, Pacific, Africa
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Saying an hybrid grid is a grid with renewable energy is not enough,
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There doesn’t seem to be a *precise* definition of what a power hybrid system is.

Saying an hybrid grid is a grid with renewable energy is not enough, connecting a 500kW solar plant to a 5MW diesel grid is not what we call hybridization at VERGNET.
Hybridization at VERGNET

We consider an installation to be hybrid if for a reason or another a curtailment of renewable energy is required:
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**Examples**
Hybridization at VERGNET

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- Voltage regulation
- Frequency regulation
- Grid safety
- Power quality (Harmonics, flicker)
Isolated grids key issues

Small Islands grids are characterized by:

- Small installed power
- Low short circuit power
- Small spinning reserve
- High ratio peak demand
- N-1 contingency rarely used for diesels

These specificities lead to potentially high variations of voltage and frequency in case of grid fault or power producer failure.

Grid security can be an issue when adding renewables

- Short circuit power can be too low to trip existing protections
- Specific grid protections have to be designed and properly set
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Grid security can be an issue when adding renewables

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Projects insights
Vergnet has a long experience in connecting unpredictable renewable energy producers to weak grids: first installation of wind turbines on an small island diesel grid in 1989.

<table>
<thead>
<tr>
<th>Date</th>
<th>Name</th>
<th>Location</th>
<th>Renewables P</th>
<th>Diesel P</th>
<th>Grid P</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018</td>
<td>Amdjaras</td>
<td>Chad</td>
<td>1.1 MW wind</td>
<td>500 kW</td>
<td>700 kW</td>
<td>300 kW/2.5 MWh storage Grid forming</td>
</tr>
<tr>
<td>2018</td>
<td>Yap</td>
<td>Micronesia</td>
<td>1.5 MW wind &amp; PV</td>
<td>3x1.6 MW</td>
<td></td>
<td>grid 2MW max</td>
</tr>
<tr>
<td>2017</td>
<td>Kiffa</td>
<td>Mauritania</td>
<td>1.3 MW PV</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>Bonriki</td>
<td>Kiribati</td>
<td>1.3 MW PV</td>
<td></td>
<td>5 MW</td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>Nouadhibou</td>
<td>Mauritania</td>
<td>4.4 MW wind</td>
<td></td>
<td>16 MW</td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>Devil's point</td>
<td>Vanuatu</td>
<td>3.5 MW wind</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>Marsabit</td>
<td>Kenya</td>
<td>0.5 MW wind</td>
<td>2.4 MW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>El Toqui</td>
<td>Chile</td>
<td>1.5 MW wind</td>
<td>6 MW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td>Coral Bay</td>
<td>Australia</td>
<td>825 kW</td>
<td></td>
<td></td>
<td>Low load diesel + Flywheel (Powercorp)</td>
</tr>
<tr>
<td>2005</td>
<td>Les Saintes</td>
<td>French Carribean</td>
<td>1.9 MW</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Les Saintes, Guadeloupe — Commissioned 2007

Connection issues

- Voltage regulation at turbine level
- A power limitation had to be implemented
- Utility agreeded on a downgraded cos φ
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Connection issues

Impedance at point of common coupling was too high, this was the first time VERGNET encountered hybridization issues and a very trivial form of automatic regulation had to be implemented:
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More than 12 Mt of ore per year is transported by train from the mines to Nouadhibou harbor to be loaded and exported by sea.
Nouadhibou, Mauritania — Commissionned 2018

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An EPC tender was issued in 2010.
VERGNET proposed a full grid study

To assess and guarantee the achievable wind power penetration according to wind profile, grid load cycles and diesel gensets characteristics while ensuring:
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- Power quality
Nouadhibou, Mauritania — Studies

The studies covered the following points:

• On-site measurement session to precisely characterize the gensets performances
• Numeric modeling of the whole grid with producers and consumers
• Simulation campaign addressing all possible cases
• Diesel-Wind power plant operating rules definition from analysis of simulation results
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The behavior of the diesel power plant and wind power plant was checked during both normal and unforeseen transient events like:

- Disconnection of one or several wind turbines
- Disconnection of the whole wind power plant
- Star-ting of power loads
- Disconnection of loads
- Disconnection of a diesel group

Customer did not allow a full automation of diesel Genset so operating values are set by operators. A set of operating rules were defined to set the wind power plant power level according to grid state.
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We define the penetration ratio $r$ by:

$$r = \frac{P_W}{P_L} \times 100$$  \hspace{1cm} (1)

Where $P_W$ is wind power, $P_L$ is load power.

“△” represents cases with a blackout risk due to lack of spinning reserve

“⊖” represents impossible cases.

<table>
<thead>
<tr>
<th>Load (kW)</th>
<th>Nb running groups</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>1000</td>
<td>20.0%</td>
</tr>
<tr>
<td>1500</td>
<td>46.7%</td>
</tr>
<tr>
<td>2000</td>
<td>38.3%</td>
</tr>
<tr>
<td>2500</td>
<td>30.6%</td>
</tr>
<tr>
<td>3000</td>
<td>25.5%</td>
</tr>
<tr>
<td>3500</td>
<td>21.9%</td>
</tr>
<tr>
<td>4000</td>
<td>19.1%</td>
</tr>
<tr>
<td>4500</td>
<td>△</td>
</tr>
<tr>
<td>5000</td>
<td>△</td>
</tr>
<tr>
<td>5500</td>
<td>△</td>
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<td>6000</td>
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<td>7000</td>
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<td>7500</td>
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<td>8000</td>
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<td>9000</td>
<td>⊖</td>
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<tr>
<td>9500</td>
<td>⊖</td>
</tr>
<tr>
<td>10000</td>
<td>⊖</td>
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</tbody>
</table>

Achievable long term penetration ratio
very good results are achieved thanks to exceptional site conditions.

- Wind power plant output: $19 \text{ GW h year}^{-1}$
- Fuel savings: $4800 \text{ t year}^{-1}$
- Pollution avoided ($CO_2, NO_x, SO_2$): $11500 \text{ t year}^{-1}$
The goal for integration and control system is to achieve highest possible renewable energy penetration, while maintaining power system stability and electric energy supply reliability at the same time. To ensure this, the integration and control system will take control over all other components in Yap power system, scheduling of diesel generators, and dispatching wind and solar generation...
Yap, F.S. Micronesia — System architecture

Architecture
Architecture

- 3 wind turbines
Yap, F.S. Micronesia — System architecture

Architecture

- 3 wind turbines
- Automation of Gensets
Yap, F.S. Micronesia — System architecture

Architecture

- 3 wind turbines
- Automation of Gensets
- Island power management
Architecture

- 3 wind turbines
- Automation of Gensets
- Island power management
- Wireless communication with solar plants
Yap, F.S. Micronesia — System architecture

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Grid study similar as *Nouadhibou* was performed.
Yap, F.S. Micronesia — Hybrid Wizard

Controller

- Real-time control of Power Quality
- Renewable penetration is always maximized to what the grid can accept
- Grid stability is guaranteed
- Grid security is guaranteed
Controller

*Hybrid Wizard* is the result of Vergnet’s experience
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- Real-time control of Power Quality
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*Hybrid Wizard* is the result of Vergnet’s experience

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- RE penetration is always maximized to what the grid can accept
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**Controller**

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Expected performances

At bid time a simple load flow study was performed to assess performances.

Above is heat map of connected diesels without and with renewable energy. Below is expected penetration rate. Data is on one month to remain legible.
Wind power plant output: 2.1 GW h year$^{-1}$
Solar power plants output: 1.2 GW h year$^{-1}$
Expected Fuel savings: 730 t year$^{-1}$
Conclusion
Conclusion

• Most existing installations have a huge installed diesel power with too powerfull gensets for fine adjustment of spinning reserve.
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- Preparation work from a consultant is paramount in tenders, for mutual agreements, companies must be competent or subcontract.
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- Take Operation & Maintenance into account since the very beginning of the project.
  - Technological choices and targets must fit to the local capability and infrastructures.
  - If knowhow is not already present, include a capability building programme
Thank you for your attention