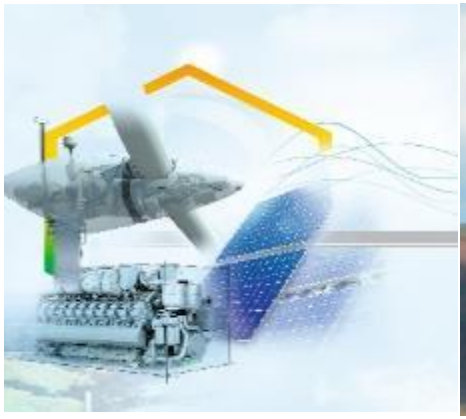
Renewable energy integration on islands and remote locations: A return on experience

27th Annual PPA conference – 30/07-03/08/2018 - PALAU





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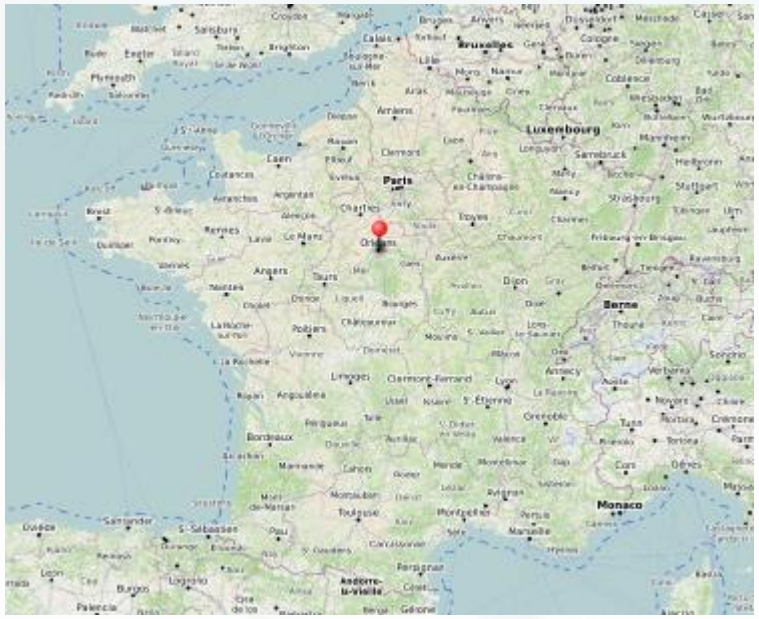
VERGNET

- **Location: Orleans, France**
- **Wind, Solar & Hybrid solutions provider**
- **29 years experience of project execution in complex and isolated areas**
- **Worldwide presence: 365 MW installed (Wind and PV) in 40 countries, permanent subsidiaries in**
  - **Pacific (Noumea)**
  - **Caribbean**
  - **Indian Ocean**
  - **Africa**
- **Pacific Presence:**

Australia, Fiji, French Polynesia, Guam, Japan, Kiribati, New Caledonia, Pohnpei, Samoa, Vanuatu, Yap



Connecting a 500kWp solar plant to a 5MW diesel grid is not considered hybridation…

…. Because saying a Hybrid grid is a grid with renewable energy is not enough

Hybridation at Vergnet

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

Examples

- Thermal gensets operational limits
- Spinning reserve
- RE Power excess (when battery grid forming)
- Voltage regulation
- Frequency regulation
- Grid safety
- Power quality (Harmonics, flicker)

Isolated Grid Key Issues

Small Islands grids are characterized by:

- Small installed power
- Limited short circuit power, high ratio of peak demand to short circuit power
- Limited spinning reserve
- N-1 contingency rarely used for diesels.

Theses 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

Project Insights – Hybrid systems by VERGNET

Vergnet has an extensive experience in connecting unpredictable renewable energy to weak grids:
First installation of wind turbines on a small island diesel grid in 1989.

Date	Name	Location	Total Renewables P	Diesel P	Grid P	Remark
2018	Amdjaras	Chad	1.1MW wind	500kW	700kW	3000 kW/2.5MWh storage Grid forming
2018	Yap	Micronesia	825kW wind & 502 kWp PV		4.1MW	2MW max
2017	Kiffa	Mauritania	1.3MW PV			
2015	Bonriki	Kiribati	1.3MW PV	5.5MW		
2013	Nouadhibou	Mauritania	4.4MW wind	44MW	16MW	
2013	Devil's point	Vanuatu	3.5MW wind			
2011	Marsabit	Kenya	0.5MW wind		2.4MW	
2009	El Toqui	Chile	1.5MW wind		6MW	
2007	Coral Bay	Australia	825kW			Low load diesel + Flywheel (Powercorp)
2005	Les Saintes	French Caribbean	1.9MW			

Les Saintes – Guadeloupe (2005)

Utility did not anticipate the connection issues

Impedance at point of common coupling was too high, this was the first time VERGNET encountered hybridization issues.

Solution

A basic form of automatic regulation had to be implemented:

- Voltage regulation at turbine level
- A power limitation
- Utility agreed on a downgraded Power Factor

Nouadhibou - Mauritania (2008)

SNIM iron ore terminal

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.

Site conditions

- Wind speed 8.78m/s at hub height, Weibull 3:63
- Near shore, hot climate, no rain, very high corrosion, sand
- Average load 5.5MW, max load 10MW
- 4.4 MW Wind
- 44MW diesel gensets

An EPC tender was issued in 2008

Nouadhibou - Mauritania (Studies)

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:

- Security of goods and persons
- Availability of the grid
- Power quality

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

Nouadhibou - Mauritania (Simulation)

We define the penetration ratio ‘r’ by :

r = [PW/PL] x 100 (1)

Where PW is wind power, PL is load power.

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

“Θ” represents impossible cases.

Load (kW)	Nb running groups		
	1	2	3
1000	*20.0%*	⊖	⊖
1500	*46.7%*	⊖	⊖
2000	38.3%	*20.0%*	⊖
2500	30.6%	*36.0%*	*4.0%*
3000	25.5%	*46.7%*	*20.0%*
3500	21.9%	43.7%	*31.4%*
4000	19.1%	38.3%	*40.0%*
4500	△	34.0%	*46.7%*
5000	△	30.6%	45.9%
5500	△	27.8%	41.7%
6000	△	25.5%	38.3%
6500	△	23.5%	35.3%
7000	△	21.9%	32.8%
7500	△	20.4%	30.6%
8000	△	19.1%	28.7%
8500	⊖	△	27.0%
9000	⊖	△	25.5%
9500	⊖	△	24.2%
10000	⊖	△	23.0%

Achievable long term penetration ratio

Nouadhibou – Mauritania (Field tests)

The behaviour of the diesel power plant and wind power plant was checked during both normal and unforeseen transient events like:

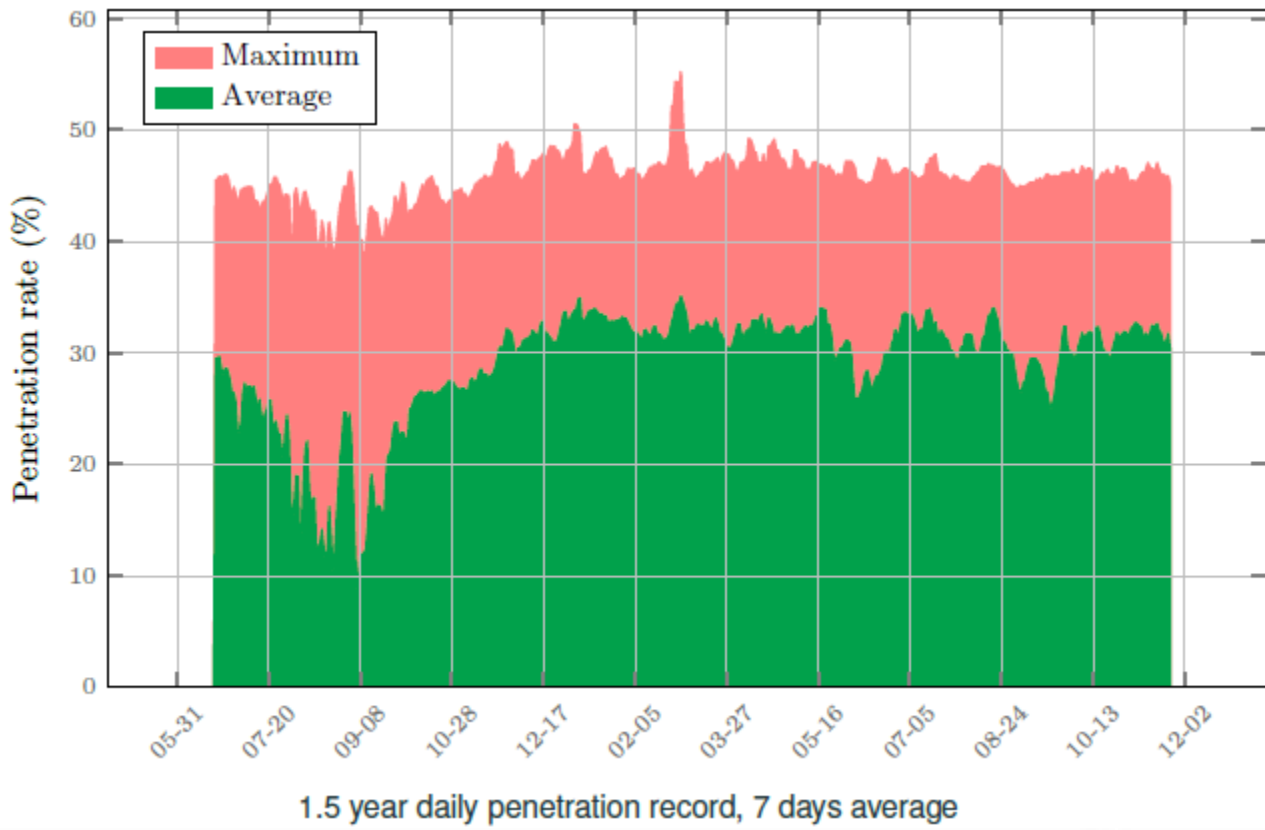
- Disconnection of one or several wind turbines
- Disconnection of the whole wind power plant
- Starting of power loads
- Disconnection of loads
- Disconnection of a diesel group

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.

Nouadhibou - Mauritania (RESULTS)

Very good results are achieved thanks to exceptional site conditions.

- Around 30% average wind penetration
- Wind power plant output: 19GWh/year
- Fuel savings : 4800 tons/year
- Pollution avoided (CO2;NOx ;SO2): 11 500 t/year



Yap – F.S.M (2018)

“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.M (System Architecture)

YSPSC- ADB - Entura

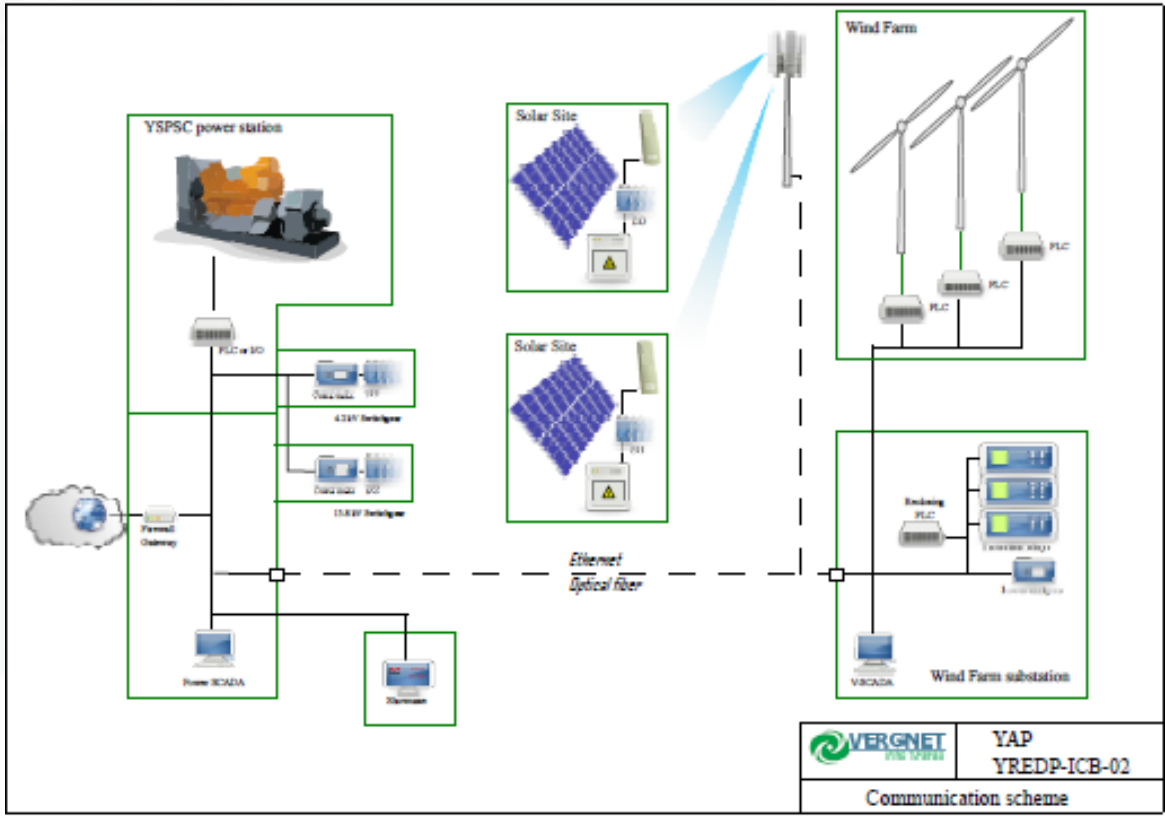
Real-time Hybrid Wizard™ showcase:

Architecture

- 3 x275kW wind turbines
- 5 solar plants : 508 kWp
- New Generators: 4 130kW
- Power analyzers at grid key points
- Island wide communication and power management

- Average load: 1 500kW

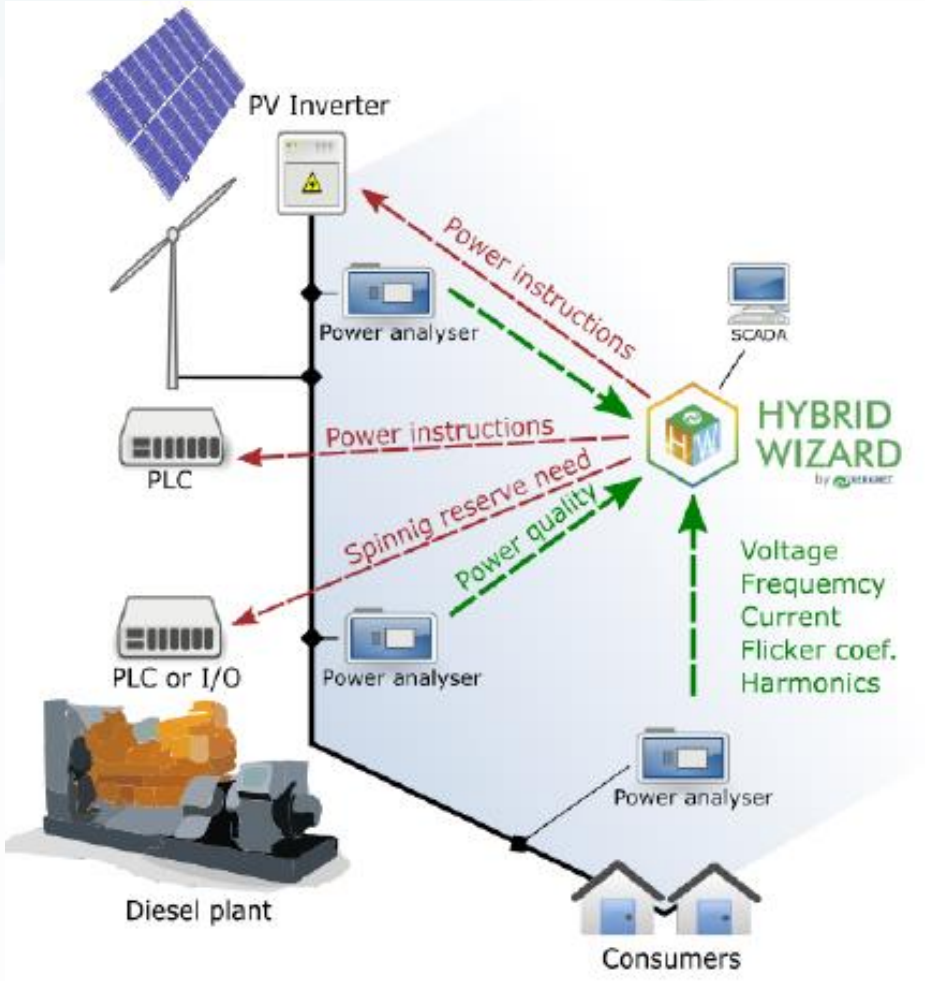
Grid study similar as Nouadhibou was performed.



Yap – F.S.M

Controller:

- Hybrid Wizard is the result of Vergnet's experience in non-interconnected grids
- Suitable for any combination of solar, wind, battery storage.
- Real-time control of Power Quality
- RE penetration is always maximized to what the grid can accept
- Grid stability is ensured
- Grid security is ensured



Yap – F.S.M

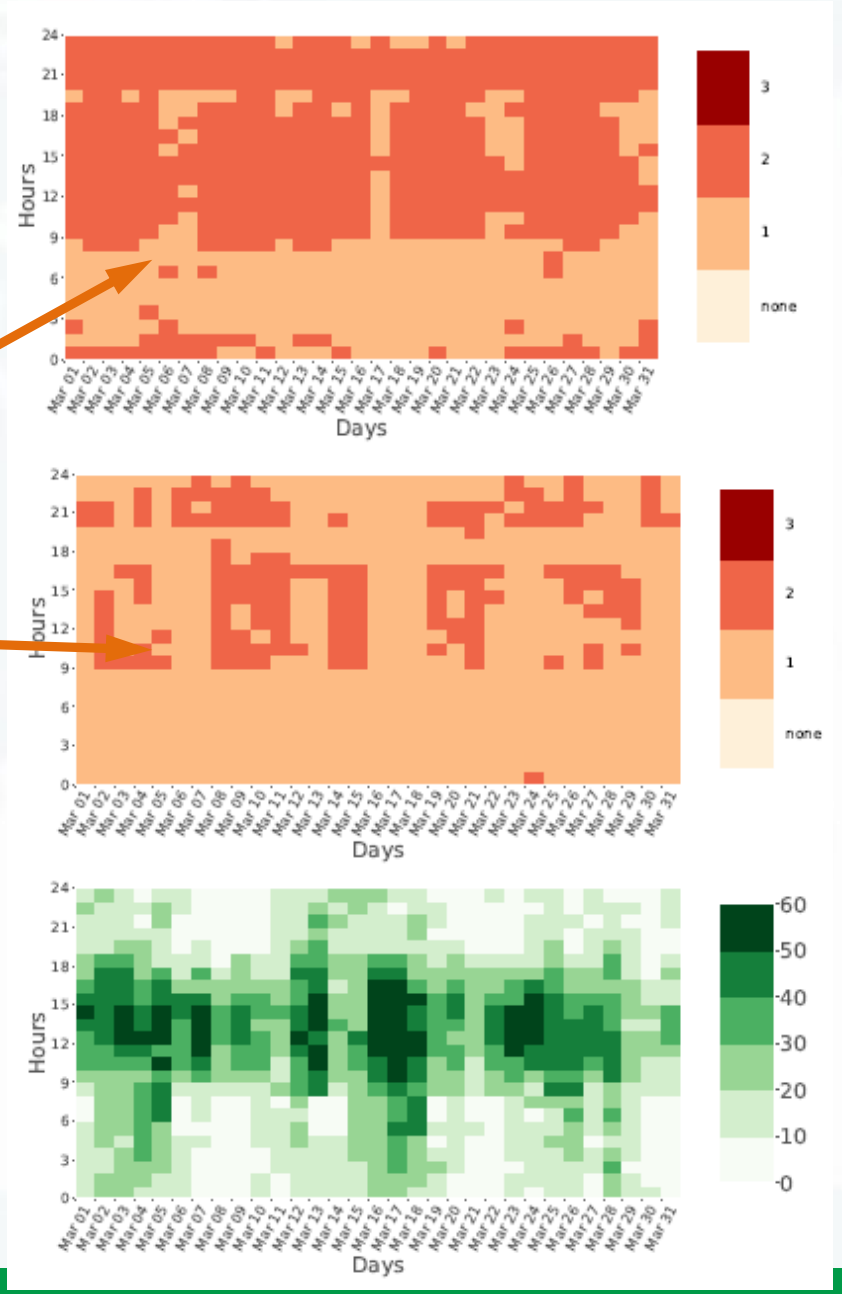
Studies:

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

Heat map of connected diesels without and with renewable energy.

Bottom graph shows the expected penetration rate.

Data is on one month to remain legible.

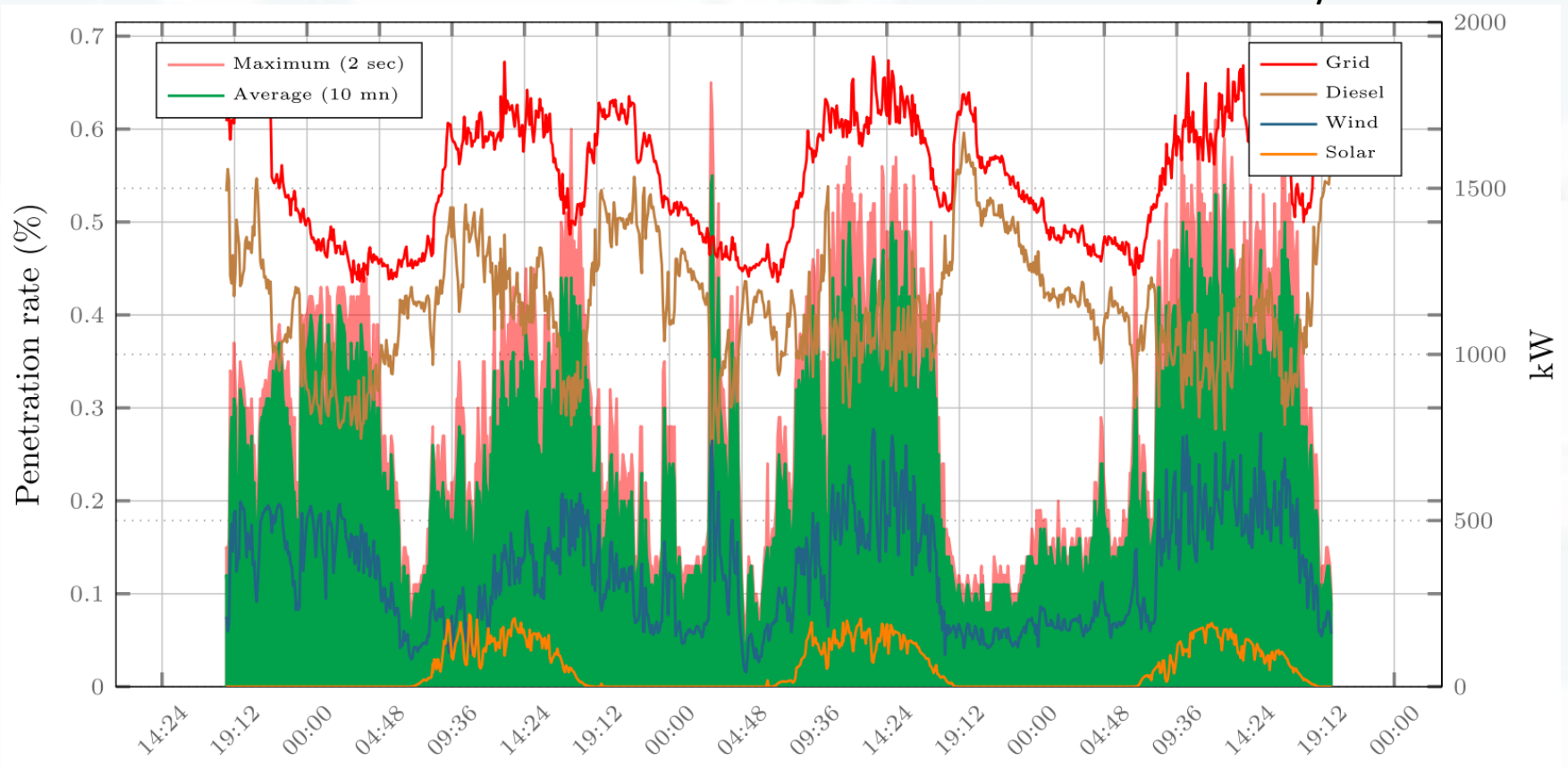


Yap – F.S.M:

HYBRID WIZARD by VERGNET

VERGNET GROUPE

Recent results -July 23-26 2018



- Up to +40% average RE share (Wind + PV)
- Instant RE penetration > 50%
- No battery storage

CONCLUSION

- *Preparation work is key: ensure that the concepts for a hybrid project are properly defined since the beginning (importance of hiring consultants to complement internal competencies)*
- *Technological choices and targets must fit to the local resources, capability and infrastructures*
- *Solar and wind and other RE sources are complementary, make the most of them*
- *Take hybrid configuration into account when creating or upgrading conventional power plants: most existing installations often have individual genset size generally too large for fine adjustment of spinning reserve*
- *Take Operation & Maintenance into account from the very beginning of the project*
- *If knowhow is not already available, include a capacity building programme*

Thank you!