Webinar "Hybrids: A Path from Intermittency to Stability"

Q&A

Answers by Reuniwatt and Wärtsilä

HYBRID POWER PLANTS

Q. Why are both thermal and energy storage needed in a hybrid?

A. Wärtsilä: Thermal and energy storage are highly complementary in a hybrid set-up. Thermal allows for intraday and seasonal balance to ensure reliable power regardless of solar or wind conditions. Energy storage allows for overall system optimization and maximizing use of renewable output.

Q. How is battery degradation being considered?

A. Wärtsilä: Battery degradation and augmentation are included in all calculations, assuming utilizing degradation curves. In general, when assessing the value of a hybrid system, we take in consideration all the costs and benefits of the assets during their lifecycle.

A. Reuniwatt: Battery degradation in relation to forecasts is not taken into account on our side so far.

Q. In the 2 hybrids classifications you mentioned (virtual and physical hybrids), how are the hybrid power systems managed by the operator?

A. Wärtsilä: The classification considers the point of view of how the grid is managed:

1) In the virtual hybrid, the power plant is managed by the TSO (Transmission System Operator), where multiple assets are connected and operated either each one by its own EMS/SCADA or a group of them through their common EMS, this is typical for any mainland electrical power system; and

2) In the physical hybrid, the system is managed by one EMS controlling the entire grid and all assets connected, this is typical for islands or mines.

Q. Would it not be easier to just have one EPC contractor for the whole hybrid?

A. Wärtsilä: Accumulation of asset specific guarantees don't allow for optimal integration of assets. Asset specific contracting ensures fair risk allocation to avoid excessive risk reservation for the different assets to cover for risk which are out of their control.

Q. Would a hybrid work in areas with no high-speed internet connecting the different power plants?

A. Wärtsilä: With no high-speed internet, we can adjust to information flow requirement and realities on the ground by rethinking the system architecture accordingly. Obviously, the key input

here is the PV forecast and set-point declaration, this information can be communicated in different means to allow for dispatch optimization.

A. Reuniwatt: Our sky imagers are designed and proven to work offline in remote areas without internet connection.

Q. How to define the optimal hybrid system? (PV+Wind+Energy storage w/hydro or battery)

A. Wärtsilä: The key element when looking for the right components of a hybrid system is, most importantly, the costs. Technically it is perfectly possible to have hybrid power plants composed only of PV + Energy storage. However, depending of the application, we might need reliable power 24/7. In this case, the renewables + storage becomes less competitive regarding the LCOE than a system including a thermal component (due to renewable required oversizing to meet energy demand at any point of time). The hybrid setup can be optimised by dimensioning the capacities based on a proper analysis. The system should be analysed in a very thorough manner in order to identify the optimal mix. Relying on a smart energy management system makes it possible to include as much renewable energy as can be integrated in the mix and optimise the usage of each of the components of the hybrid system, while ensuring reliability at all times.

A. Reuniwatt: We support our clients during the design process by helping them identify the optimal hybrid plant setup. To do so, we use actual forecasts and spinning reserve data to pinpoint the optimal design & engineering architecture. Once a power plant is operational, forecasts play an essential role in adapting your daily operational schemes to the actual weather conditions and PV performance.

Q. How do you guarantee the optimal operations of the hybrid system? Do you make any commitments on the PV integration rate or on the LCOE?

A. Wärtsilä: The level of integration of PV and the LCOE will ultimately depend on the dispatch profile from the customer, and are therefore difficult to guarantee. What can be insured is that the maximum possible amount of renewables will be used when possible (taking into account spinning reserves and technical limitations).

Q. In the 100% Renewable Generation Mix, what are the main cost-drivers as compared to the mix including a thermal plant (cost-optimal mix)? Could the thermal plant's OPEX elimination compensate the oversized CAPEX in renewables + storage?

A. Wärtsilä: The main cost-driver of the 100% Renewable Generation Mix is the extent of renewable oversizing to achieve the annual energy availability target. Whether the reduced thermal OPEX can compensate for renewable oversizing will depend on the extent of renewable oversizing.

Q. How can the GEMS software be obtained?

A. Wärtsilä: GEMS is offered as part of Wärtsilä's engine power plants and energy storage systems.

Q. In a green facility (absence of grid or genset back-up) where we cannot install 'unlimited' storage systems, the real challenge is: How to deal with the low generation periods of renewables (PV & Wind)?

A. Wärtsilä: Without thermal storage for intraday and seasonal balancing, this is a challenge. This is why thermal and energy storage are part of the optimal generation to achieve both low cost and reliable power, and renewable production forecasts play an essential role.

Q. What is the percentage of additional fuel saving achieved with your system?

A. Wärtsilä: The savings will be defined on case-by-case basis. It will be directly tied to the dimensioning of the different capacities in the hybrid system and to the penetration of the renewable component. If we take the example of Fekola Gold Mine with a hybrid power system composed of 64MW of thermal generation, 30MW of solar PV and 17MW/15,4MWh battery storage system, the expected fuel savings are 13.1 million litres per year.

A. Reuniwatt: Several systems are currently deployed at hybrid sites, awaiting for a return of experience to confirm numbers on additional fuel savings. Simulations performed based on a hybrid system with PV + diesel suggests LCOE reduction of ¢0,1-0,2 /kWh.

Q. Do you also use load forecasts?

A. Wärtsilä: During the design process we evaluate the load profile, that is a key element for dimensioning the capacities of each component of the hybrid system. Our energy management system GEMS is also considering the load forecast during operations and relies on machine learning to improve load forecasting capabilities over time.

A. Reuniwatt: No, we don't provide load forecasts, but it is significantly easier than providing solar irradiance forecasts and usually not a problem in hybrid plant operations. Our solar forecasts will be matched up with the load forecasts by the EMS, to ensure system reliability at all times.

FORECASTING CHALLENGES

Q. How far can the sky imager see? Can skycams work with strong windspeeds?

A. Reuniwatt: The answer to this question is related to the position of the clouds themselves. If the clouds move very fast at low altitude, the forecasting horizon of the sky imager can be reduced to up to 10 minutes. If clouds are higher and moving at a weaker speed, the forecasting ability of the sky imager will be enhanced up to 30 minutes.

Q. Why are forecasts limited to a 30-minute horizon?

A. Reuniwatt: The forecasts are limited to a 30-minute horizon based on the average cloud's time of presence in the field-of-view of the sky imager.

Q. For which plant sizes (MW) can the "sky cam" be used? In case of larger PV power plants, is it necessary to install more than one camera?

A. Reuniwatt: The sky imager is particularly useful for utility-scale power plants, as well as off-grid applications. A sky imager can cover a radius of around 2km around its position. If the surface area of the solar power plant exceeds that surface, it is recommendable to install more than 1 sky imager.

Q. What's the precision of your forecasts? How to best evaluate the forecast errors of the sky camera?

A. Reuniwatt: The question of precision is a real scientific issue, still much debated in the forecasting community. What is important to remember is that performance can be described along three axes:

- The **weather sensitivity** for the location: For the French overseas islands, it is mainly the tropical climate, to which must be added the extremely important concept of microclimates. For example, on the 2500 km² of Reunion Island, there are no less than 200 microclimates! We must also add the notion of seasonality. In tropical climates, the summer is generally very hot. With the sea nearby, this will create a favorable ground for evaporation and therefore for cloud formation. In winter, evaporation being weaker, we will mainly see clouds moving. Thus, the meteorological phenomena to be taken into account vary according to the location and will directly influence performance.

- The **quality of input data**: Reuniwatt aggregates a lot of data from different sources, as well as data from the power plant (in particular, measurements from pyranometers in real time and to which Reuniwatt applies a "quality check"). This input data is then used to calibrate our forecasts, which means that there is a real O&M (Operations & Maintenance) challenge to work on over time so that this quality monitoring system remains effective throughout the power plant's life.

- The **metrics**: How do we evaluate the precision of a forecast? The most commonly used scientific metric is the nMAE ("normalized Mean Absolute Error"). It is interesting and important, but knowing whether gaining 1 point of nMAE translates into an improvement in the plant's profitability is a subject that is still being studied at present. Indeed, profitability is expressed at several levels: Via the EMS and the forecasting system, but in terms of the plant's O&M.

Some opportunities allow us to assess the performance even before starting the operational phase of the plant: Climatological analyses to identify the meteorological phenomena at the plant location or "backtests" (forecasts made under real conditions but on past data sets) that can be transmitted to the EMS supplier in order to anticipate the management and operation of the plant with results close to reality. It should also be noted that forecast performance will improve during the lifetime of the plant.

Q. Will it be possible to model a Hybrid PV/battery storage/Diesel system to input forecast irradiance in DigSILENT Power factory and design an automatic control in case a drop in PV output has been forecasted for the near future?

A. Reuniwatt: As far as we know, current hybrid system modelling tools aimed at automated control modelling are still lacking short-term forecasts integration modules, for example for the forecasts provided with a sky imager.

FINANCIAL CHALLENGES

Q. Other than fuel savings, what are other cost-saving potentials of using a sky-imager in a hybrid system?

Q. Reuniwatt: Simulations performed for a hybrid PV + diesel system suggest that unnecessary start/stop actions can be prevented by using short-term forecasts, thereby providing better grid stability and reducing genset maintenance over time. Other hypotheses include lifetime extension of battery assets through optimal charging in relation to PV ramp-rate smoothing, performed with the data from a sky-imager.

R. Wärtsilä: Among the cost-saving potentials of using a sky-imager in a hybrid system, we can mention the reduction of variable operating costs of the thermal component and maintenance & overhaul costs due to optimised running hours.

Q. How do you approach hybridisation of an existing facility which has a fuel take or pay agreement?

Q. Wärtsilä: Hybridisation of existing thermal facilities is a common case. Some of our customers have fuel take or pay agreements or other particular requirements, which are taken into account during the process of hybrid design as existing constraints and will be addressed accordingly.

Q. Who guarantees the production/forecast accuracy and possible penalties? In some projects, liquidated damages have to be paid by the plant operator in case of wrong forecasts.

R. Wärtsilä: The contractual setup and performance guarantees can be tailored to specific project requirements. Operating philosophy is designed to allocate sufficient system reserves to allow for forecasting error tolerances based on specificities of each hybrid asset (i.e. Engines fast start to power, high ramp up/down rates and low minimum load / Solar PV generation variability at the project site). This would allow the system to rely on the assets' specific guarantees and the EMS to ensure optimal production.

R. Reuniwatt: Responsibilities on wrong forecast provisions are usually negotiated involving all parties in a given project and evaluated on a case-to-case basis.

OTHER QUESTIONS

Q. I am looking for the Wärtsilä/Reuniwatt responsible in my region. Who shall I contact?

A. Wärtsilä / Reuniwatt: If you have questions concerning the content of this webinar you can contact our speakers Tarik Sfendla (Wärtsilä), Michael Ball (Wärtsilä) and Louis-Étienne Boudreault (Reuniwatt) directly – we are happy to answer your questions !

For any other questions, be sure you will be forwarded to the right counterpart when contacting us here:
Wärtsilä https://addresses.wartsila.com/
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