Hybrid solutions

New market opportunities for hybrid windfarm and battery plants

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Abstract

The price drop in electrical batteries offer new opportunities for economic optimizing the operation in the electricity markets of wind farms equipped with a large batteries, but requires a more complex daily operation of such hybrid plants.

This presentation examines through market simulations which added value a hybrid plant may have in 4 opportunities, compared to only operating the windfarm alone:

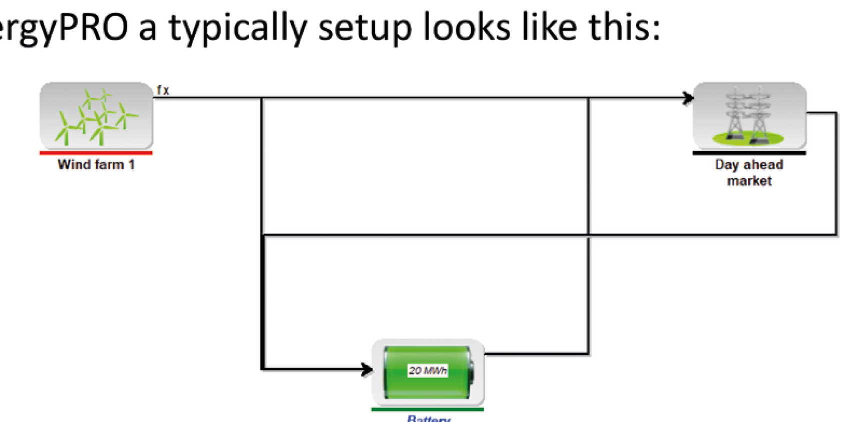
- The hybrid plant improves sale in Intra-day and Day-ahead markets
- The hybrid plant may reduce punishment for imbalances created in whole sale markets
- The hybrid plant may improve active participation in balancing markets
- The hybrid plant may improve sale when there is restricted grid capacity

In this poster it is illustrated, that the potential earnings depend on the specific location of the hybrid plant, considering the price volatility in the electricity markets and how the whole sale and balancing markets are organized.

Intra-day and Day-ahead markets

The wind farm production can be calculated in windPRO, a module-based software package suited for project design and planning of both single WTGs and large wind farms, or be actual measured production figures. The production is with hourly resolution transferred to energyPRO, which is an advanced and flexible modelling software for combined techno-economic optimization and analysis of a variety of energy projects.

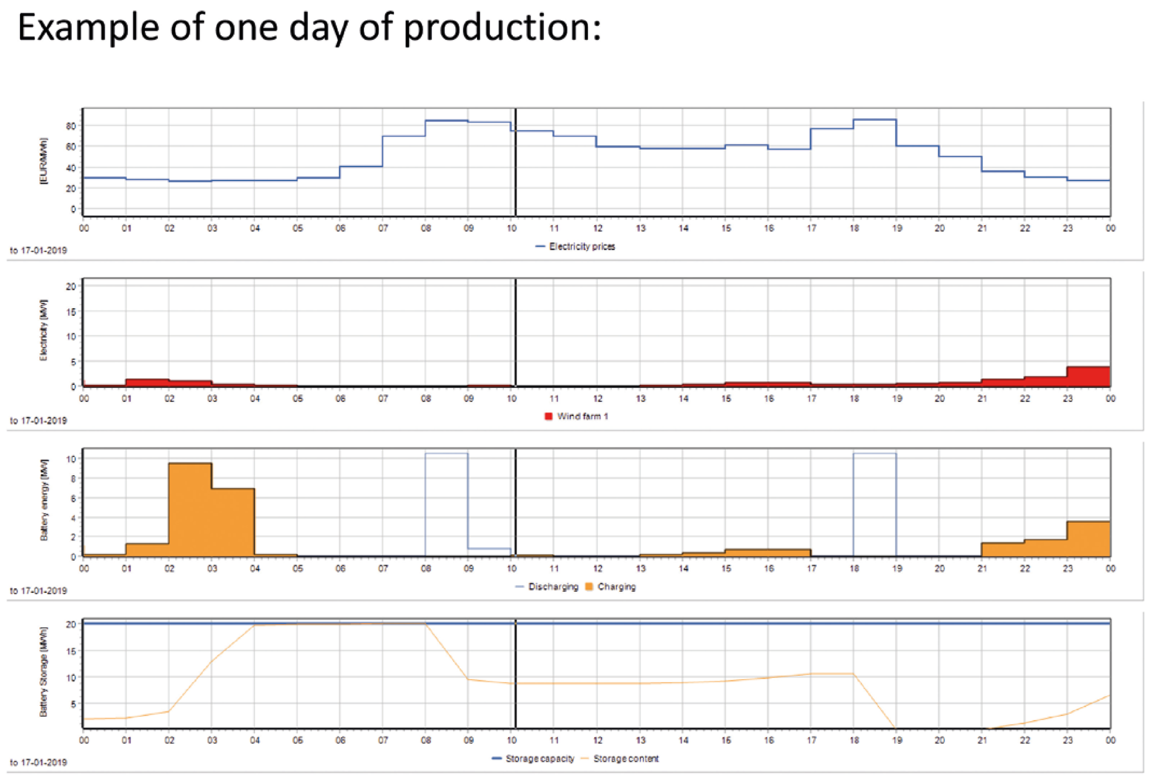
In energyPRO a typically setup looks like this:



The production from the wind farm can be sold directly to the day-ahead or intra-day market or it can be stored in the battery. The battery then sells its content to the market. The battery is also able to purchase directly from the market.

When selling to the market, the producer gets the market price. When purchasing from the market, the buyer has to pay the market price plus grid tariffs, taxes, etc. Charging the battery, the electricity coming from the wind farm only has the cost of the lost sale in market, while when purchasing electricity from the market the electricity also has the cost of grid tariffs, etc. Also, the charging and discharging efficiencies must be taken into account, when estimating when it is feasible to charge the battery.

Example of one day of production:



The wind production is low and the electricity prices are high. That is common, when the overall wind production on the market has a high share of the total electricity production. In situations with high wind share, the electricity prices are low and visa versus when the wind share is low.

The electricity price is high at 18:00, making the battery discharge. To deliver the necessary energy from the battery, it is charging in the hours before. Since the prices on the market are only a bit lower, it is only feasible to charge from the production from the wind farm.

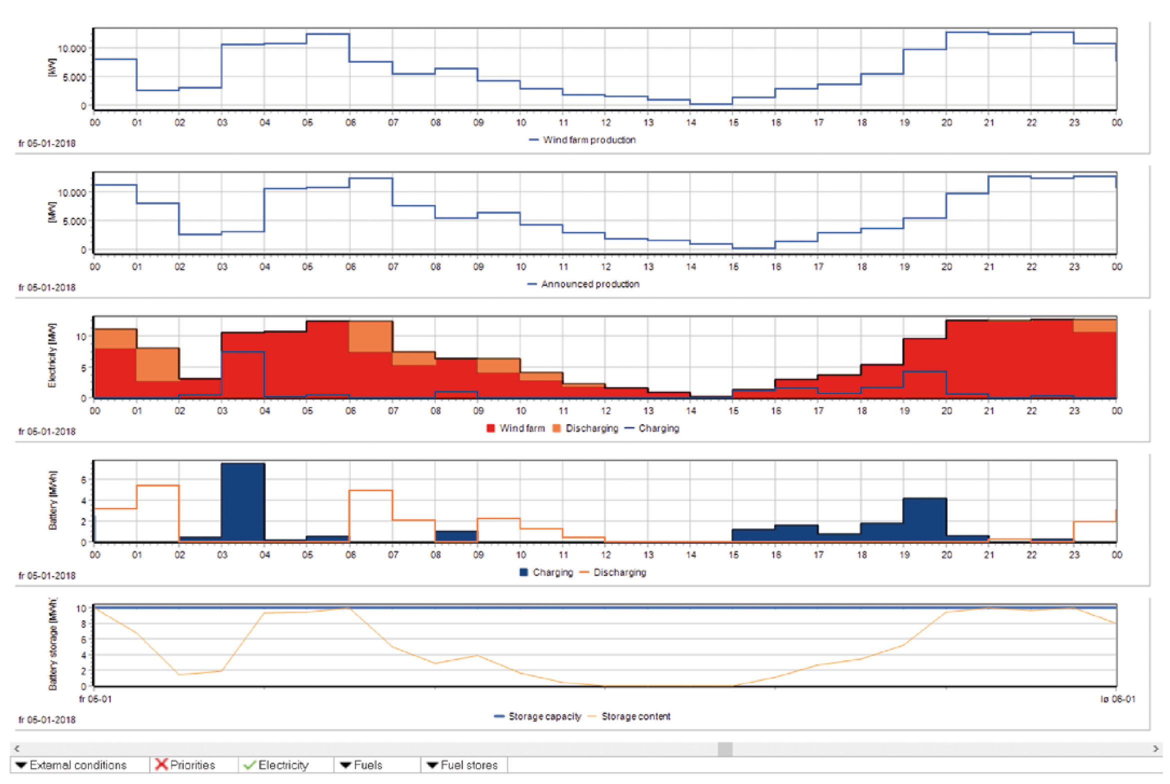
The battery is also discharging at 08:00. The charging in the hours before happens when the prices in the market is significant lower. Hence, it is feasible to charge from the grid.

Reduced cost for imbalances

Typically, the producer notifies the TSO about the expected production hour by hour in the coming period. If this expected production is not met, the producer is said to have an imbalance and can be subject to an economic punishment.

With a hybrid plant including a battery, this problem can be minimized.

The chart below shows a situation, where the actual wind farm production comes an hour ahead of the announced production.

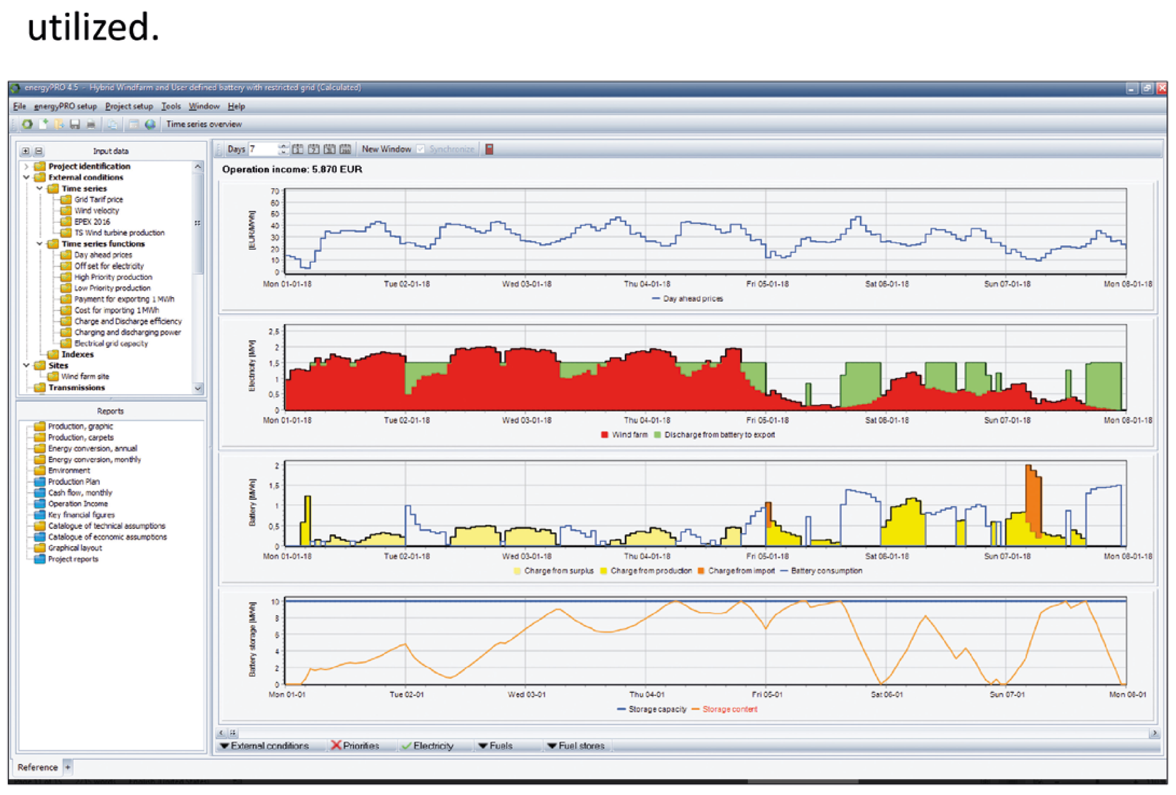


In hours, where the actual wind farm production is below the announced production, the deficit is discharged from the battery. As example, this happens in the first two hours of the day.

In hours, where the actual wind farm production exceeds the announced production, the surplus is charged into the battery. This happens in the next two hours.

Improved sale when restricted grid capacity

One reason for implementing hybrid solutions may be that the external electricity grid has restricted capacity. Consequently, it may be necessary to curtail some of the intermittent renewable energy production and thereby a potential production is lost. By including a battery in the system less curtailment is needed and thus a larger share of the renewable energy production can be utilized.

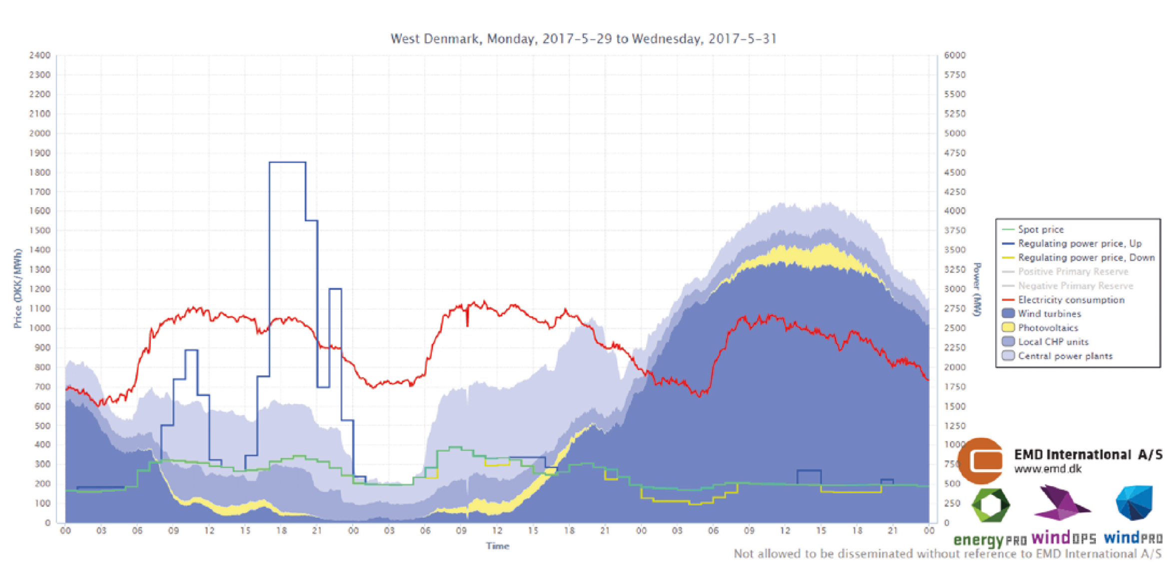


This figure shows a market optimization in energyPRO of a 2 MW wind turbine delivering electricity to a restricted grid of 1,5 MW. Notice that surplus wind turbine production and wind turbine production in hours with low prices is stored in the battery, and later on (5-1-2018) sold in hours with high prices. Furthermore, notice that electricity is purchased early Sunday to be sold at a higher price later on, still respecting the restricted grid.

Improving earnings in balancing markets

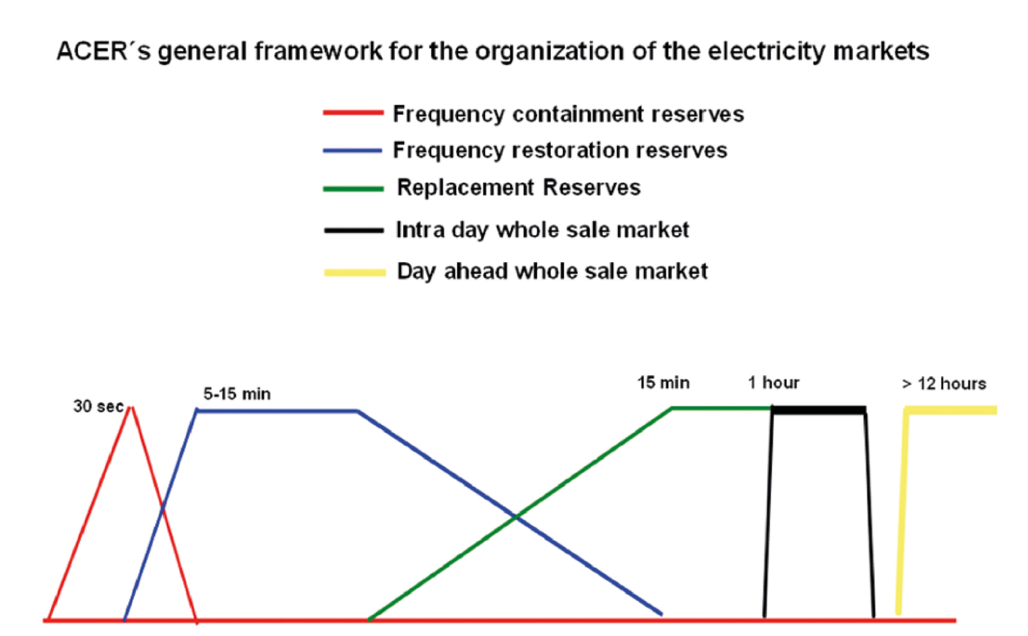
Often electricity prices in the balancing markets is particularly interesting compared to the prices in the whole sale markets, as shown in the figure below.

This market data is available at our online webpage: http://www.emd.dk/el



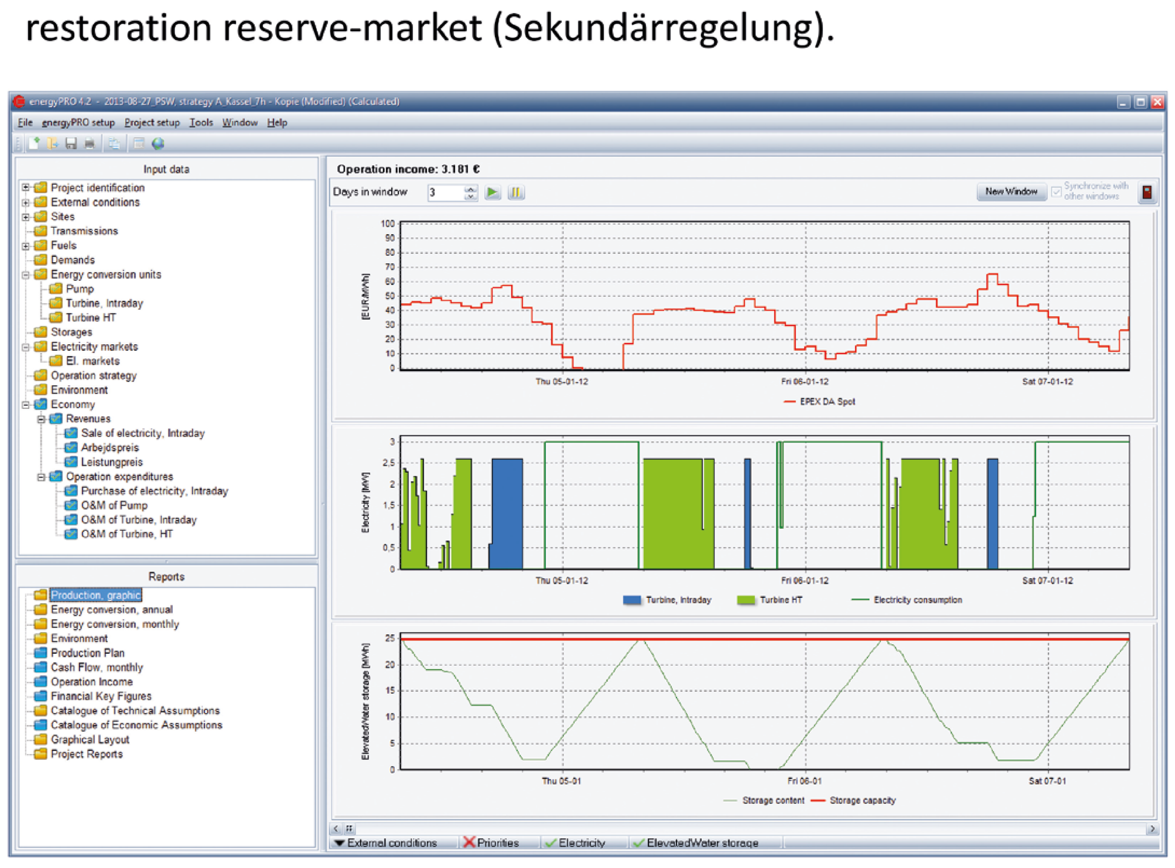
The three European balancing markets are shown in the figure below. Often these three reserves markets are referred to as:

- Frequency containment reserves = Primary reserves
- Frequency restoration reserves = Secondary reserves
- Replacement Reserves = Tertiary reserves



Several energyPRO models have been made for calculating the improved earnings when participating in both whole sale and balancing markets.

As an example of such energyPRO model, can be mentioned the model of a pumped hydro plant developed as a part of the EU-project stoRE: http://www.store-project.eu/. The project showed how the earnings of such plant can be improved by participating across the German Intra-day market and the German Frequency restoration reserve-market (Sekundärregelung).



The optimized operation in a 3-day period is shown in the above figure. In the 3 graphs can be seen the Day-ahead market price, the consumption and production of electricity and the storage capacity and content. In the calculation positive HochTariff Sekundärregelung is won, requiring upper reservoir to be filled at the start of each HochTariff period.

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