“POWER-TO-VALUE”: CONVERTING EXCESS WIND POWER INTO VALUABLE PRODUCTS OR PROCESSES

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Overview

Wind power is associated with fluctuations – that can be the difference between day and night, or seasonal, or in fact from minute to minute. These fluctuations are a big challenge for the electricity supply system. Technically they can lead to reliability and availability issues and economically they can cause volatile prices.

To elucidate the effect of the variable supply of wind energy, the demand and supply for West Denmark[1] for the last week of March 2012 are given in Figure 1. As Denmark is a frontrunner in wind energy, these data can be regarded as a picture of the future state of affairs in countries that plan to increase the amount of wind power capacity vastly, such as the Netherlands. The demand line shows a day/night rhythm, where the maximum demand doubles the minimum demand. On the supply side, the wind energy production fluctuates, randomly distributed in time, from zero to almost the maximum demand, which equals around 2000 MW for this West Denmark example. When wind power production exceeds power consumption, the price drops below zero. If that power cannot be used, part of the generated wind power should be curtailed, which is seen as a loss for sustainability.

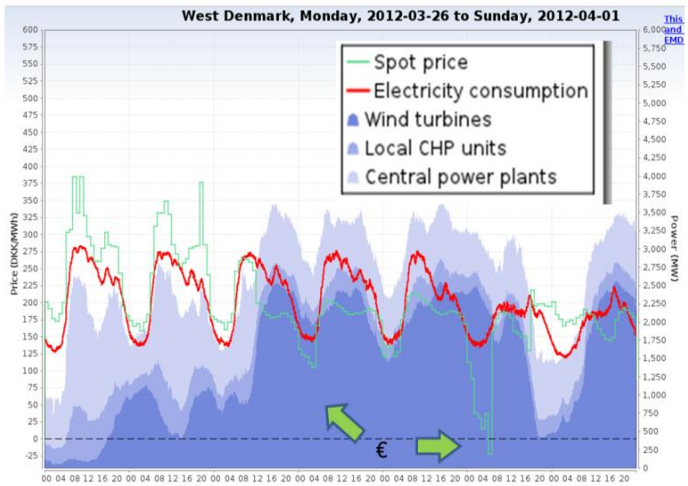

Figure 1 Electricity Demand and Supply in West Denmark[4]

The sustainability drivers at EU and Member State level will result in an increased share of renewable energy sources. Wind energy is the most important renewable energy source in the Netherlands. To meet the long term targets, large investment in wind-energy will be inevitable in the near future. Operators of the grid and the system have to find ways to deal with the technical challenges posed by the fluctuations accompanying wind (and solar PV, which is currently also developing rapidly). At the same time, a sizeable production of wind power may offer economic opportunities since its marginal cost is almost zero and, hence, it could be a source of very cheap power. Could it be possible to use this opportunity in order to develop efficient mechanisms through which the peaks and troughs of wind power can be managed? That is the central issue addressed in this paper.

We acknowledge that there are many initiatives and research projects about finding ways to deal with the intermittency of renewable energy sources such as wind or solar energy, but this project (Stikkelman *et al.* 2014) has its unique, distinct approach. Unlike demand response initiatives that use the possibility to shift demand for power over time (heat pumps, electric vehicles), our project involves the creation of *additional* demand when prices are very low. In addition, the options we look at, concern an order of magnitude of MWs (compared to kWs for the typical heat pump or electric vehicle). Moreover, we search for solutions within the context of a large industrial zone that includes chemical industry, such as the Rotterdam Harbour. The goal is to find ways of converting cheap (excess) power into products or processes with a high added value, so no subsidies are needed.

We develop a *novel* approach to explore the most promising options of using the excess power and to assess the economic viability of each option (as the traditional approaches do not work well in this case). In addition, we have developed a method for the institutional design, starting from a risk assessment for the entire chain. Our approach combines an economic analysis with an analysis of the technologies and the process.

[1] http://www.emd.dk/el/

Methods

For the design problem we are dealing with in this project, we need to make analyses for the technical context, the economic context as well as the actor and process context.

To deal with the technical possibilities we organised several expert meetings in order to generate a wide range of possible chemical and industrial processes which can "absorb" excess power, and identify their links.

For the analysis of the economic viability of certain options, we developed a new assessment tool. We first calculate the "break-even" electricity price: for this price the variable cost of the process (or product) concerned can be recovered. That means that during all hours that the electricity price is equal or below that "break-even" price any fixed costs can be recovered. Based on estimates about the future price curves, one can then get some idea about the maximum acceptable level of fixed cost. We also developed a simple way of displaying the economic viability of the different options in a graph, which allows to easily compare several options.

Concerning the actors, we perform a systematic actor analysis combined with a risk analysis of the process in order to identify if there are reasons for integration along the value chain of the process. Based on that analysis we can recommend a design for the institutional organization of a certain "power-to-value" option.

Results

Based on a first 'quick scan' analysis of the wide range of options to use the excess wind power in the context of the Rotterdam Harbour, we selected two "power-to-value" options for which a complete technical and institutional design has been elaborated.

The first one is converting excess power into steam ("power-to-steam"). There is a large demand for steam in the Harbour area, which is currently produced from natural gas. If electricity prices are very low, however, using electricity may be a cheaper option. As the fixed costs for a boiler are not that high, this option might already be profitable with a small numbers of running hours in the year.

The other one is the production of (in the end) methanol through the Olah process ("power-to-liquids"). In this chain, the excess power is first converted into hydrogen through electrolysis and this hydrogen subsequently reacts with CO_2 to make methanol. This process is appealing because it allows to get rid of CO_2 and with low electricity prices it may become economically viable as well.

Conclusions

The aim of this research project is to make an integrated technical and institutional design to outline how wind energy peaks can be converted into value-added products by making optimal use of the synergies that may exist in the Rotterdam Harbour area. As the number of hours that power prices are very low is limited, the existing industrial infrastructure and (local) market for steam and intermediate or final products is vital for reducing the (additional) investment cost for the power-to-value options, which improves their economic feasibility, in particular compared to other sites that lack such industrial clusters and local market(s). Consequently, the implementation of such "power-to-value" options in the Port of Rotterdam can contribute to the greening of the industrial processes in that area.

Of the two options we considered in more detail, the most promising appears to be the conversion of (cheap) excess power into steam. That would mean that industrial plants would switch between gas and electricity as its energy source for producing steam, depending on the (relative) prices of the two. The production of methanol through the Olah process would be very interesting (and novel) from a technological perspective, but we estimate that in the current market conditions it would not (yet) be economically attractive in the Port of Rotterdam area.

References

Stikkelman, R.M., W. van der Lans, H.P.A. Knops, A.C. Patil *et al.*, *Converting excess wind power into valuable products. Greening the Port of Rotterdam by "transshipment" of wind,* Delft/Rotterdam: Next Generation Infrastructures Foundation, 2014.