Swedish wind power: On or off shore? That is the question.

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Sweden is planning a separate support scheme for large-scale offshore wind power development after 2020. Whereas offshore wind resources are largely located in the south of Sweden, there is also a large potential for cheaper onshore wind power in the north. Proponents of offshore wind argue that wind power in southern Sweden is advantageous as this area is likely to be a deficit area when Swedish nuclear is phased out, while increased wind power development in northern Sweden will trigger significant grid investments. The costs of offshore wind power are however substantially higher than for onshore wind power, even if additional grid investments are required. In addition, locating wind power generation in northern Sweden may require less reserves, due to its low correlation with wind power in Denmark and Continental Europe, and short distance to hydropower in the north.

New offshore wind power support proposed

On June 1st, the Swedish energy agency published its proposal for a separate support scheme for offshore wind power. The report was requested by the Ministry of Environment and Energy, and is now submitted for public consultation. Offshore wind power is more expensive than onshore wind, and Sweden has large onshore wind power potentials, primarily located in the north. Offshore wind power is considered because of the desire to phase out nuclear power in the south, where consumption is also high. Large volumes of power are currently transferred from north to south, and it is argued that increased generation in the north requires increased capacity in the transmission grid.

In a study commissioned by the Swedish utility Skellefteå Kraft, THEMA has compared the costs of two alternatives for large-scale wind power in Sweden, that is, onshore in the north versus offshore in the south. Large-scale development implies construction of an additional 37.5 TWh of wind power, bringing total wind generation in Sweden to 55 TWh from 2020 to 2030.

Offshore wind power 40 percent more expensive

The Baltic Sea provides beneficial conditions for offshore wind power due to shallow water, low salinity and low wave heights. Wind conditions are typically better offshore than onshore, but offshore wind power is substantially more complex in terms of construction and maintenance. The overall cost (LCoE) of onshore wind power is therefore significantly lower, as shown in Figure 1, even when we take into account that cost reductions due to learning effects are higher for offshore wind.

The difference in total investment and operating costs, including grid tariffs is estimated to about 44 percent, implying a total cost difference of almost 120 billion SEK, as shown in Table 1. The potential for large-scale offshore wind power in Sweden is however not well studied, and costs may increase as new wind farms enter deeper waters.

Table 1: Estimated costs (real 2015 SEK).

<table>
<thead>
<tr>
<th></th>
<th>Onshore</th>
<th>Offshore</th>
<th>Difference</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost [cr/kWh]</td>
<td>62.9</td>
<td>90.5</td>
<td>27.6</td>
<td>44 %</td>
</tr>
<tr>
<td>Annual cost [bil]</td>
<td>23.6</td>
<td>33.9</td>
<td>10.4</td>
<td>44 %</td>
</tr>
<tr>
<td>NPV [bil]</td>
<td>270.5</td>
<td>389.3</td>
<td>118.7</td>
<td>44 %</td>
</tr>
</tbody>
</table>

We apply a discount rate of 6 percent. Developers typically use a higher discount rate for offshore wind (around 10 percent), because such projects impose a greater risk. If we include the risk premium, the cost difference will be larger than in our estimates.

Current generator grid tariffs are significantly higher in Northern Sweden. Grid costs and tariffs are however likely to change with
large changes in the generation pattern. Estimates of such changes were beyond the scope of our study.

**The cost difference buys a lot of grid**

Large-scale wind power development represents a profound transition of the electricity system, whatever the geographical distribution of generation. Both alternatives are therefore likely to require internal grid investments in Sweden, particularly between SE2 and SE3 (“Snitt 2”). Increased wind power in the north requires increased export capacity, and increased wind power in the south requires increased access to balancing resources, which are available in the north of Sweden and Norway.

The cost of balancing (intermittent) wind power generation depends on the correlation with wind power generation in interconnected market areas. Denmark and Northern Germany have high wind generation capacity and ambitious expansion plans, both in the Baltic Sea and in the North Sea. The correlation between wind power generation in Northern Sweden and Denmark is significantly smaller than the correlation between Southern Sweden and Denmark, as shown in Error! Not a valid bookmark self-reference. Hence, through geographical diversification of wind generation, the overall variability decreases, and less reserves are needed.

**Environment, taxes and employment do not differ substantially**

Other welfare economic effects do not differ substantially between the alternatives. We have analyzed differences in state tax revenues, environmental effects and employment.

**Higher tax revenues from onshore wind**

In order to estimate tax revenues, we have assumed that onshore wind is financed via Elcertificates, while offshore wind is financed through auction-based feed-in tariffs, as proposed by the Swedish energy agency. We find that the tax revenues from onshore wind power are higher due to higher average profitability. Moreover, the linear depreciation over five years in the current tax regime, reduces tax payments more for offshore wind power, because it is more capital-intensive than onshore wind.

**Small differences in environmental effects**

Differences in environmental costs do not alter the overall conclusion. There are landscape and noise effects in both cases. Onshore wind power may influence birdlife negatively, whereas offshore wind power may have negative impact on fish and marine wildlife. The fundamentals of offshore wind turbines may however create habitats for fishes, a so-called “reef-effect”, which may in fact benefit marine wildlife. We have not assessed possible differences related to grid development in the two cases.

**Higher employment in offshore wind**

Offshore wind power is more labor-intensive than onshore wind power both in the construction and the operation phase. The estimated number of full-time equivalents (FTEs) in the offshore alternative is 146 000 FTEs, and about 3.5 times that of onshore wind. Experience indicates that about 75 percent of the construction work for offshore wind power is not carried out by Swedish residents. Thus, the number of Swedish jobs is at about the same level in the two alternatives. In the operating phase, we estimate that offshore wind power generates around 2 300 FTEs annually, while onshore wind power generates about 1 000 FTEs annually.

**Strong indication that onshore is cheaper**

The assumption of 37,5 TWh additional wind power until 2030 may seem extreme, but does reflect options and arguments used in the Swedish debate.

We have based our estimates on available public information. We have not estimated differences in market values (price differences between bidding zones), grid costs and balancing costs. Even if the grid costs are higher with onshore wind, there is a long way to go before offshore (in the south) is competitive with onshore wind (in the north). Our analysis strongly suggests that from a welfare economic point of view, much more thorough analyses should be made before Sweden embarks on a journey to substantially increase offshore wind deployment.

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