Towards cost-efficient grid-connected PV power plants in Northern Scandinavia

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Background

It is a common misconception that Northern Scandinavia does not receive enough sunlight to make PV installations economically feasible. The available amount of solar radiation in Northern Scandinavia is in fact only slightly lower than in central Europe. The main limitation in northern latitudes is the large annual variations, where the major share of the solar radiation is received in the long summer days. However, a system with 360º solar tracking can harvest the valuable summer sun. Simulations show that the energy yield of such a system could be increased with as much as 50% in Northern Sweden.

The idea of a northern PV system was presented at a conference in 2010 and attracted the interest of the energy company PiteEnergi. It was decided to build a test system at the company premises in Piteå, and at present a 20kW$_p$ PV power plant is under construction and will be operational in late 2011. The planned PV power plant will be a commercial system, owned by PiteEnergi, but it will also be used for research purposes.

Solar resource in Northern Scandinavia

- Germany is among the top countries in the world when it comes to PV installations, with an installed PV capacity of over 17,000 MW by the end of 2010. The corresponding numbers for Sweden and Norway are only a small fraction of this, see table 1.

Table 1. *Comparison of installed PV capacity in Germany, Sweden and Norway by the end of 2010.*

	Installed PV capacity 2010 (MW$_p$)
Germany	17,320
Sweden	11
Norway	9

- However, the solar resource in Germany is only slightly better than in Northern Scandinavia for fixed installations, and if in addition two-axis tracking is used, parts of Northern Scandinavia receives more insolation than large parts of Germany (table 2).

Table 2. *Comparison of yearly insolation at four locations: Freiburg, 48°N, is one of the sunniest places in Germany while Halle, 51°N, like most of Germany has more moderate insolation. Piteå, 65°N, is located in the sunniest area in northern Sweden and Narvik, 68°N, is situated on the less sunny north Norwegian coast. Simulations are made in PVsyst with NASA-SSE 6 data and estimated horizon line.*

	Yearly insolation (kWh/m^2)			
Solar Tracking	Narvik	Piteå	Halle	Freiburg
Horizontal	740	900	990	1150
Fixed optimal	870	1160	1130	1290
Vertical 1-axis tracking	1200	1610	1370	1590
2-axis tracking	1210	1640	1400	1630

The conclusion is that the big difference in PV installations between northern Scandinavia and Germany cannot be blamed on limited solar resource!

Energy yield and energy price

As the proposed system in Piteå will be partly used for research it is not a realistic case for the economic analysis and we have chosen a simpler system setup for this. Three systems of around 20kW$_{peak}$ with different cell technologies have been analyzed for different locations in Scandinavia and Germany. Both fixed systems and two-axis tracking systems are considered. The annual yield and the levelized cost of energy (LCOE) is calculated. Results for Piteå and Freiburg are shown in table 3.

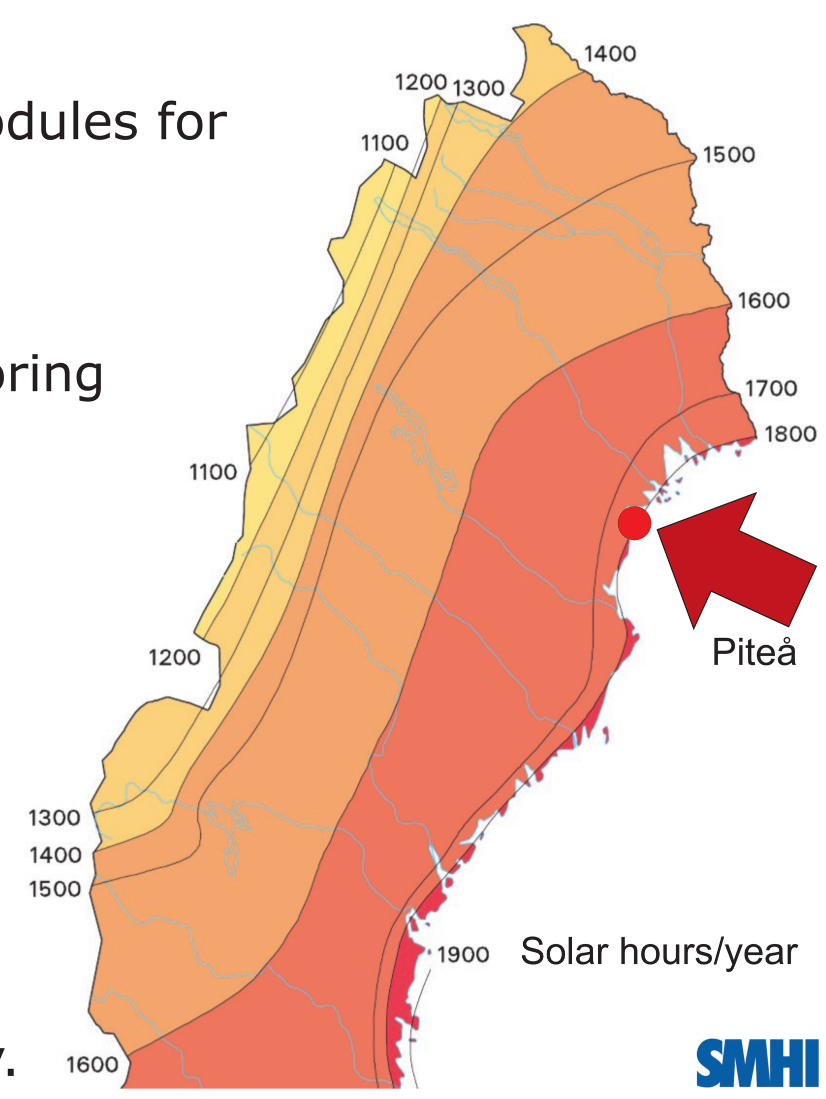
Table 3. *Economic analysis of three different systems for Piteå, Sweden, and Freiburg, Germany. *Price calculated for the planned system in Piteå. **Price based on average price for fixed system.*

	Piteå			Freiburg		
	Two-axis tracking*					
	Mono-Si	Multi-Si	CIGS	Mono-Si	Multi-Si	CIGS
Annual yield (kWh/kWp)	1440	1400	1480	1410	1360	1480
LCOE (€/kWh)	0.23	0.24	0.25	0.23	0.25	0.25
	Fixed, optimally inclined**					
Annual yield (kWh/kWp)	990	970	970	1090	1060	1100
LCOE (€/kWh)	0.27	0.28	0.30	0.24	0.26	0.26

The calculations show that it is economically beneficial to invest in a two-axis tracking system in Northern Scandinavia!

Piteå PV power plant features

- 20kW$_p$ of PV modules.
- CIGS, mono-Si and poly-Si modules for comparison between different technologies.
- Individual performance monitoring and logging of each module.
- Two different types of 2-axis solar tracking systems, approx. 80 m^2 each.
- Astronomical vs optical solar tracking.
- Monitoring of the quality and impact of the produced energy.



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