The Challenges of Solar Power in European Power Markets

Riku Merikoski, Senior Power Analyst
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Author: Riku Merikoski, photos: Fotowerder, Axpo

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Agenda

- **Few words on Axpo and me**
- **Solar power data quality problems**
- **Subsidies as a challenge to commercial solar power**
- **Solar cannibalization**
- **Cross-border effects of solar power**
- **Solutions: Optimize for value, not for maximum production**
- **Solutions: Batteries**
- **Solutions: New demand**
- **Summary**

Data quality problems of solar power

- **Solar power has proven to be challenging for the transmission system operators to follow**
  - Based on Entso-E figures, it is easy to see that the TSOs are not reporting the same things at all
  - There are better sources for some data, but it is scattered and mostly not available on hourly level
  - If the data is lagging a lot, it is of much less value to a potential investor
- **Behind-the-meter production is a key source for the problems**
  - In several countries, we do not really know well how it behaves and how much of it there is
  - Increasing problem for many DSOs all over Europe as more solar can be installed quickly

Country	Installed capacity	Production (TSO)	Full-load hours
Germany	100	70.1	701
Spain	35.5	52.5	1479
Netherlands	29.3	0.5	17
Hungary	8.5	6.8	800
Denmark	3.1	4.5	1451
Finland	1.5	1.3	867

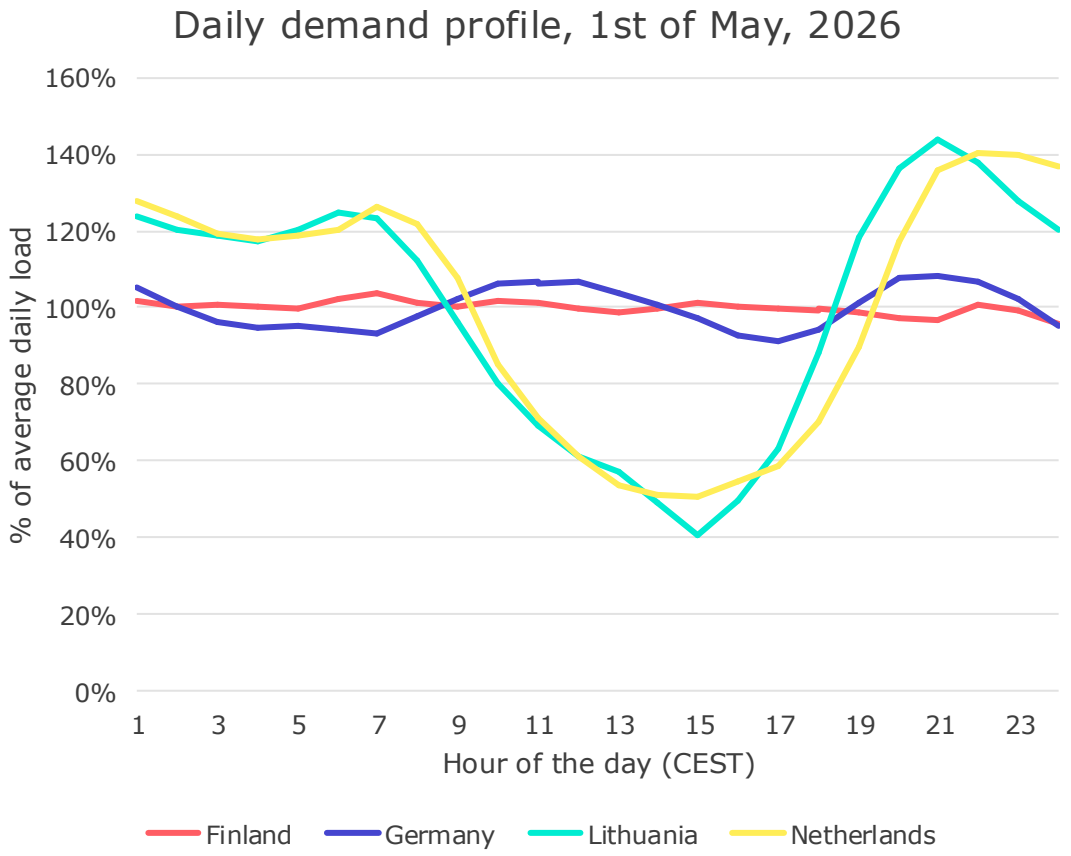
Note: capacities are annual averages in GW, production in TWh, both figures for year 2025

Source: Entso-E, Energy Charts

Data quality problems caused by solar power

- **Different approaches to demand estimation also make it harder to know what is the true power demand**
  - I do not think anyone believes that the consumers are just so different in these countries
  - It is not that Germany would not have much solar, but German TSOs are including most of that production when estimating demand, while some others are not
  - We actually even see the different timing of sunrise and sunset between Lithuania and Netherlands in here, but creating a data series comparable to others is hard

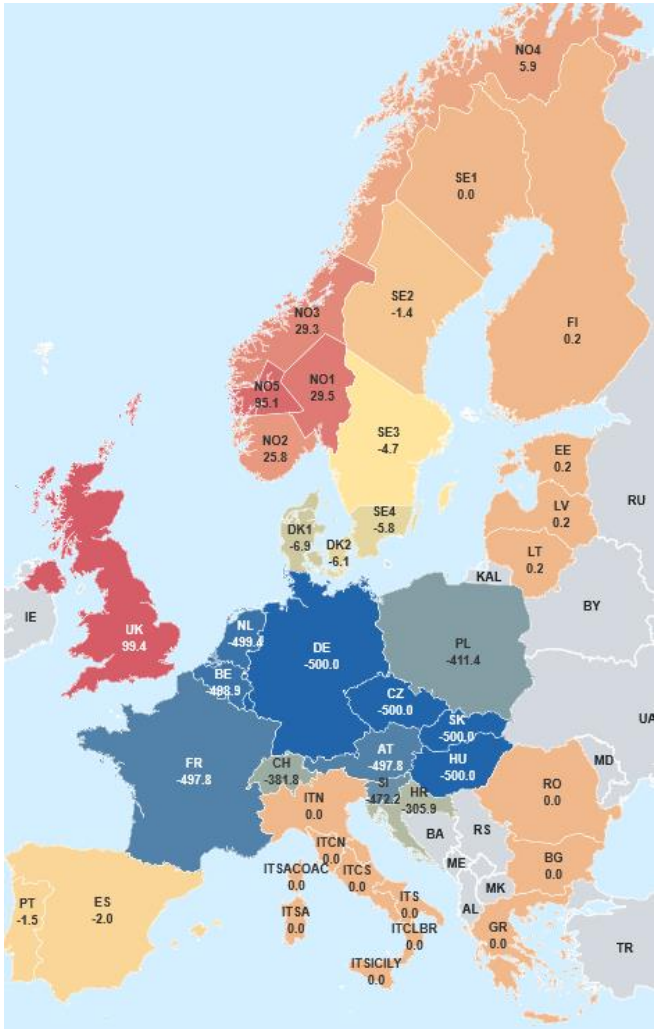
- **How do you forecast the future if you do not even know the past?**



Source: Entso-E, Montel Syspower

Subsidies as a challenge for commercial solar power

- **See the market situation in Europe on 1st of May 2026, early afternoon quarter**
  - Price is positive only in Norway and Great Britain, while Nordics was protected from the worst by Danish curtailment
  - The combined spot revenue of all European power production was **tens of millions euros negative**
  - This is only possible because so many producers are protected from market signals with poorly designed subsidies (or specifically instructed not to follow)
  - Such a policy is both wasteful financially and inefficient as climate measure; it is also endangering the grid
- **Such subsidies are actually one of the key problems for commercial solar power**
  - It is hard to compete against heavily subsidised producers, and the situation is hardly getting better



Source: Entso-E, Montel Syspower

Someone eventually pays for the subsidies

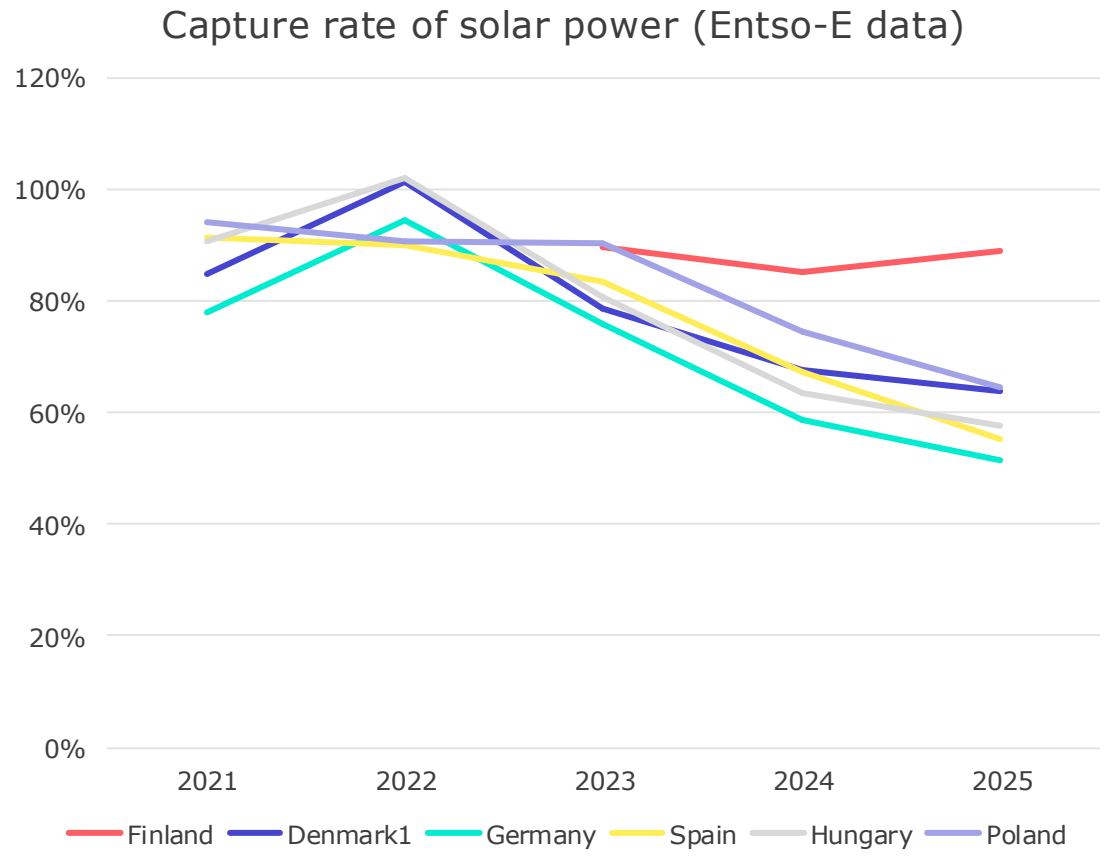
- **See the power bill of my family in Switzerland for Q1/26**
  - I live in an 100 m2 apartment in a densely populated area, comparable to a medium-sized city in Finland
  - But my power cost is 0.36 CHF/kWh or 0.39 EUR/kWh, and 2/3 of the cost is energy-based
  - In energy price, I lose a few cents/kWh due to non-liberalised markets in Switzerland and higher electricity price than in Finland
  - But the grid cost (10 CHF/month + 0.1 CHF/kWh before taxes) is much higher than in similar locations in Finland, especially the energy part
- **Why?**
  - Grid maintenance and investment is more expensive in Switzerland
  - The local monopoly company must pay at least 0.06 CHF/kWh for all small-scale solar power fed in the grid, regardless of its market value which is often negative

	Menge	Einheit	Preis	Betrag CHF
Strom Energie - einfachstrom				
Arbeitspreis	419	kWh	Rp. 10.20	42.74
Zwischentotal				**42.74**
Strom Netz - OL7				
Arbeitspreis	419	kWh	Rp. 9.20	38.55
Grundpreis	1	Mt.	CHF 10.00	30.00
Systemdienstleistungen Swissgrid	419	kWh	Rp. 0.27	1.13
Stromreserve	419	kWh	Rp. 0.41	1.72
solidarisierte Kosten	419	kWh	Rp. 0.05	0.21
Zwischentotal				**71.61**
Messkosten				
Direktmessung	1	Mt.	CHF 5.00	15.00
Zwischentotal				**15.00**
Abgaben				
Konzessionsabgabe	419	kWh	Rp. 0.03	0.13
Gesetzlicher Netzzuschlag	419	kWh	Rp. 2.30	9.64
Energieförderprogramm Baden	419	kWh	Rp. 0.55	2.30
Zwischentotal				**12.07**
Nettobetrag				**141.42**
0.0% Mehrwertsteuer (2.30)				0.00
8.1% Mehrwertsteuer (139.12)				11.27
Total Elektrizität				**152.69**

Source: Regionalwerke Baden

The value of solar power is falling over time

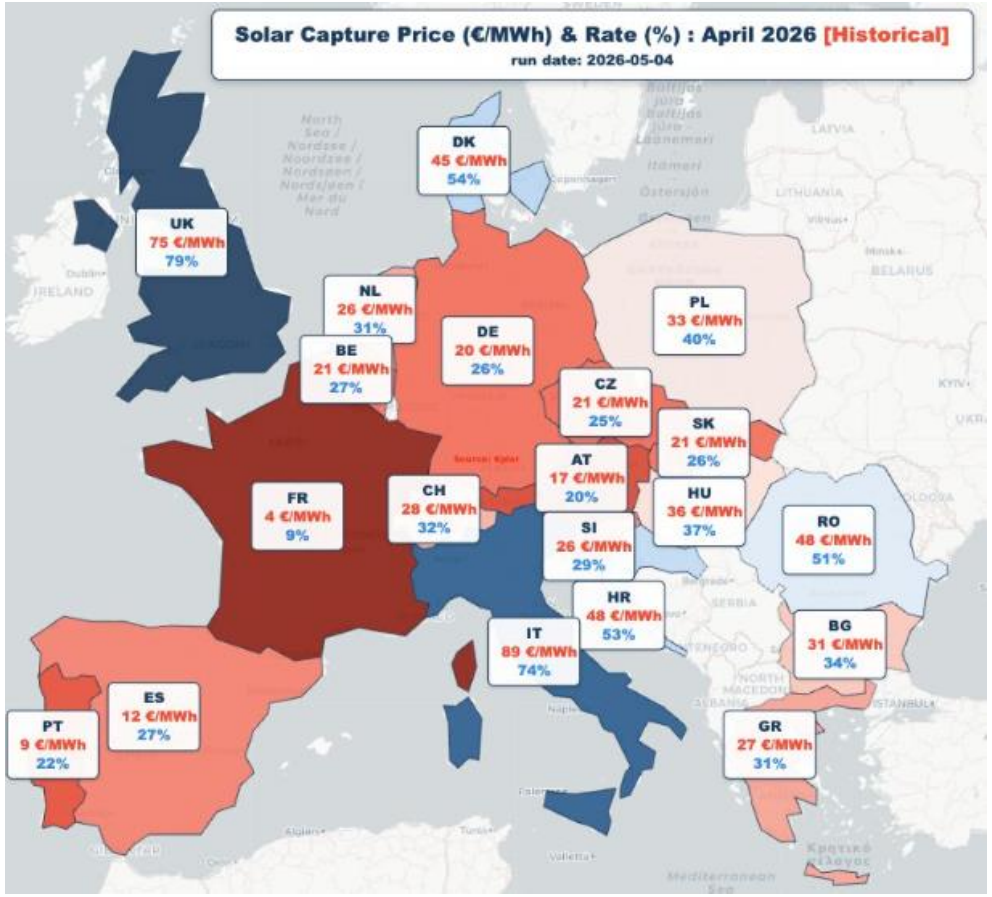
- **As can be seen, several EU markets are heading for 50% solar capture rate in 2026**
  - The energy crisis year of 2022 had an advantageous seasonal price profile for solar power as gas prices peaked in the summer
  - But thereafter the value of solar power has been falling fast in Central European markets where a lot of solar is installed every year
  - Of the compared countries, Denmark has the highest share of large-scale solar which is following market signals, explaining its deviating trend
- **The value of Finnish solar still holding up quite well**
  - But 90% of FI price is less than 60% of DE price
  - Baltic solar installation boom is taking the oversupply closer to Finland as well



Source: Entso-E, Montel Syspower

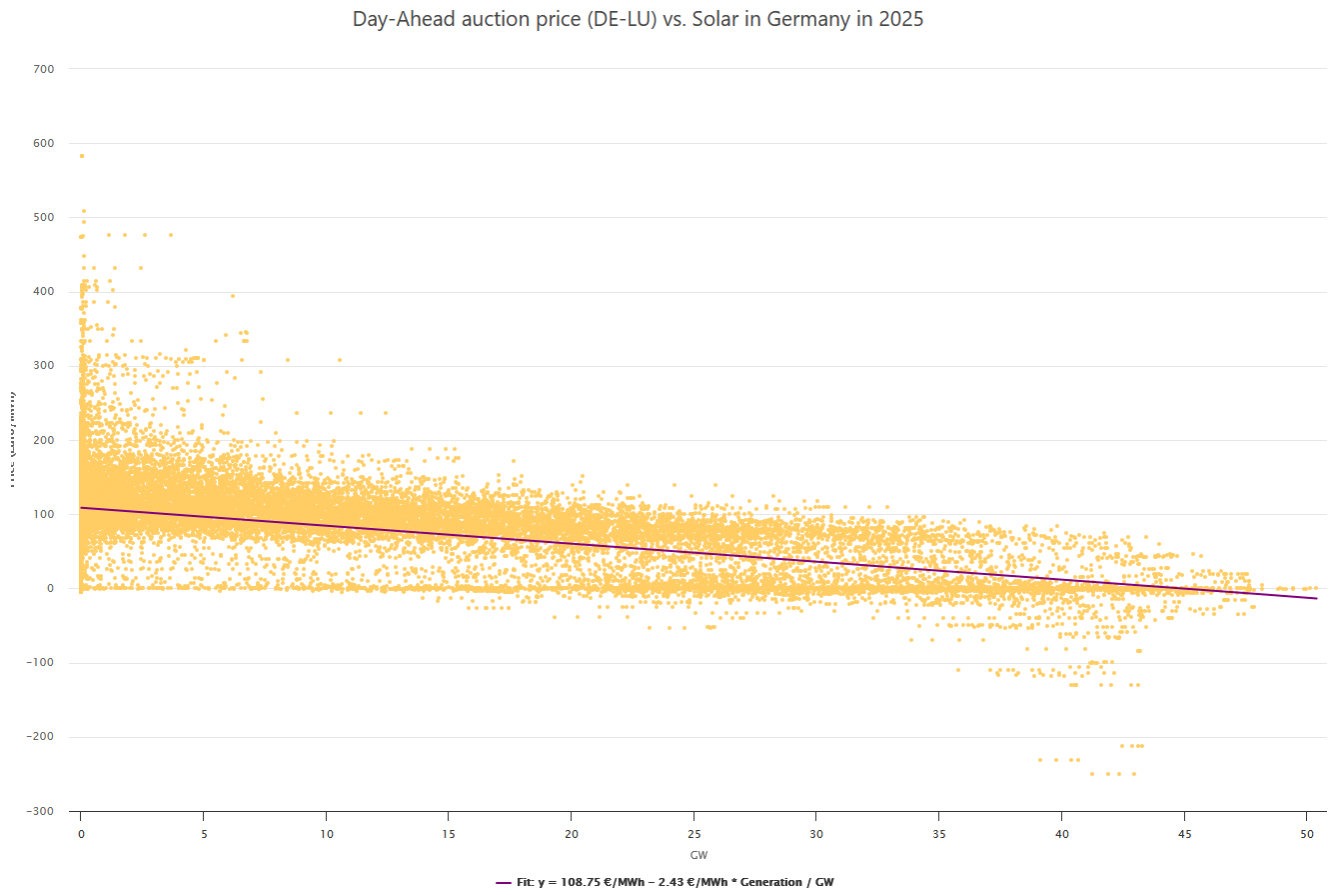
Solar cannibalization, short-term example

- **In spring and summer months, the cannibalization of solar is already much worse**
  - In most Central European countries, solar power was worth only 20-30 % of baseload power in April
  - Italy and Great Britain are still recording nice numbers, but that cannot continue for many years
  - Just for comparison, Finland still recorded a good figure of 91% in April 2026, as Finland is one of the few European countries which has never had an overly generous subsidy system for solar power
- **However, Finnish solar naturally suffers from seasonally non-advantageous profile**
  - In markets where peak demand is caused by cooling, solar has some natural support



Source: Kpler, Montel Syspower

German example: the more solar power is produced, the lower is the market price



Source: Energy Charts

Current solar power is too inflexible

- **If we look at who is producing power when prices are deeply negative, the answer is clear**
  - Even if we would invest massively in grids to remove all obligations to run any forced thermal power, we eventually have to do something with the solar inflexibility
  - Neighbouring countries are hardly willing or able to just take the German overload of solar, as they are also building a lot of solar
- **It is irresponsible to build more uncontrolled solar**
  - And also a poor investment unless subsidised

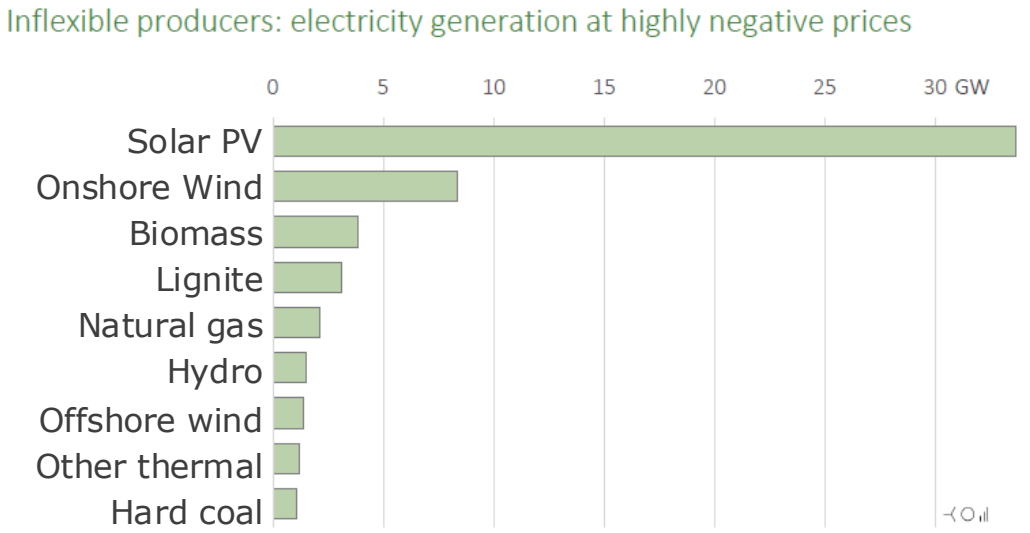


Illustration 3: In 2023 and 2024, day-ahead prices have fallen to -100 €/MWh or lower in 20 hours so far. During these hours, solar plants generated an average of 34 GW, other renewables 15 GW and conventional power plants just under 8 GW.

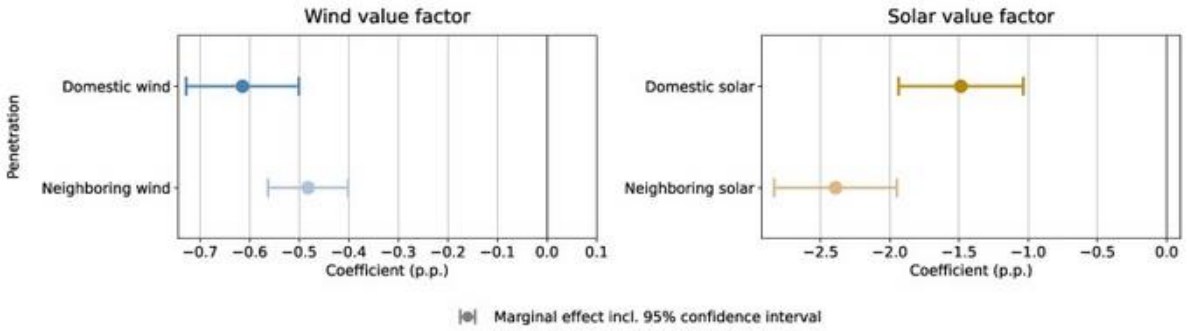
Source: Hirth, Excess electricity – Why unregulated solar is becoming a problem

Solar power production is heavily correlated over Europe

- **Europe is not a big continent**
  - So our solar panels are eventually producing simultaneously
  - Even Spanish solar production correlates strongly with Finnish solar production, although the distance is about as large as is possible in Europe
- **Consequently, your neighbour's solar is affecting the value of your solar quite a lot**
  - Stiewe et al. found that in Europe a 1 percentage point (p.p.) increase in domestic wind causes 0.6 p.p. loss in wind value factor, but if only the neighbours do it, the loss is smaller
  - While for solar, we see an opposite effect, so that if all the neighbours increase their solar, that causes a larger loss to the value of domestic solar than a domestic increase would have done
  - The loss in solar value is also clearly stronger

	FI	DK1	DE	ES	HU	PL
FI	100%					
DK1	81%	100%				
DE	84%	87%	100%			
ES	66%	74%	77%	100%		
HU	83%	78%	89%	72%	100%	
PL	87%	83%	91%	73%	91%	100%

The hourly correlation of solar power production across selected EU power markets

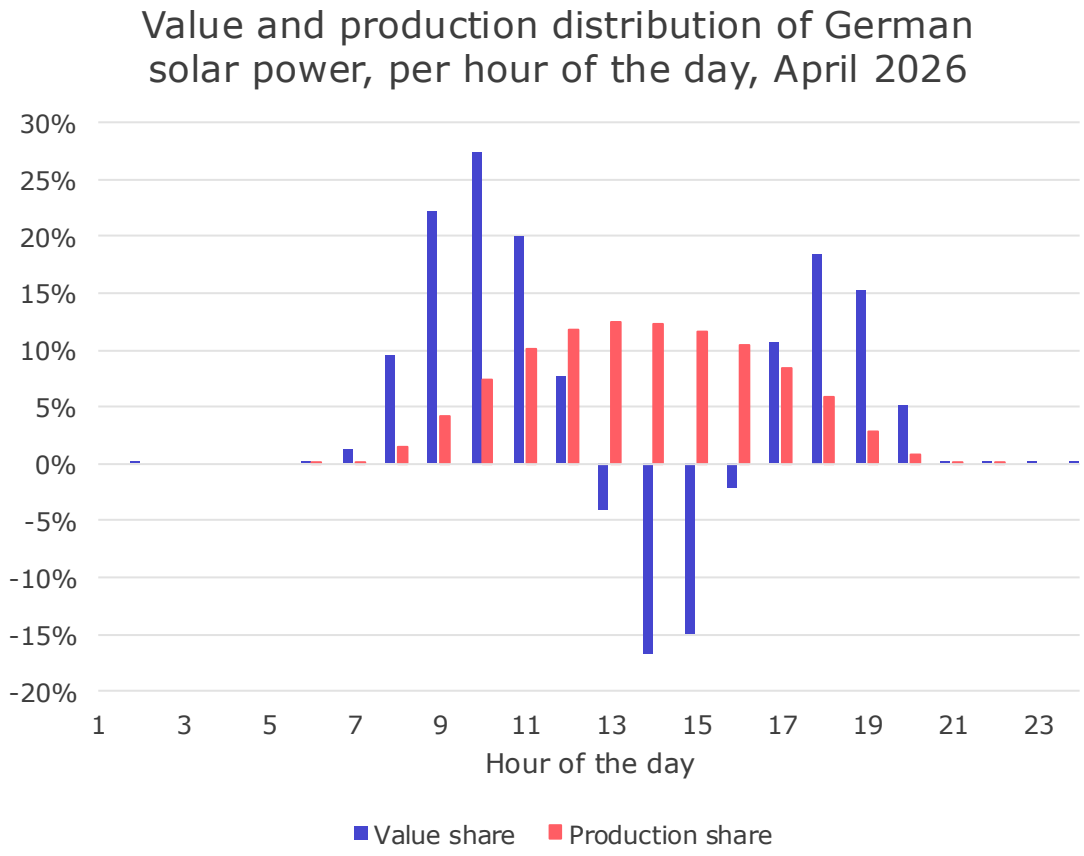


Source: Entso-E, Montel Syspower,
Stiewe et al.: Cross-border cannibalization: Spillover effects of wind and solar energy on interconnected European electricity markets

Solutions: Optimize for value, not for maximum production

- **In the ”old times”, a solar producer aimed to maximize the production**
  - But if we look at the graph, almost half of the German monthly solar production happened during hours which, on average, had a negative value if sold on spot
  - One should optimize value instead, unless there is someone to cover the losses with subsidies

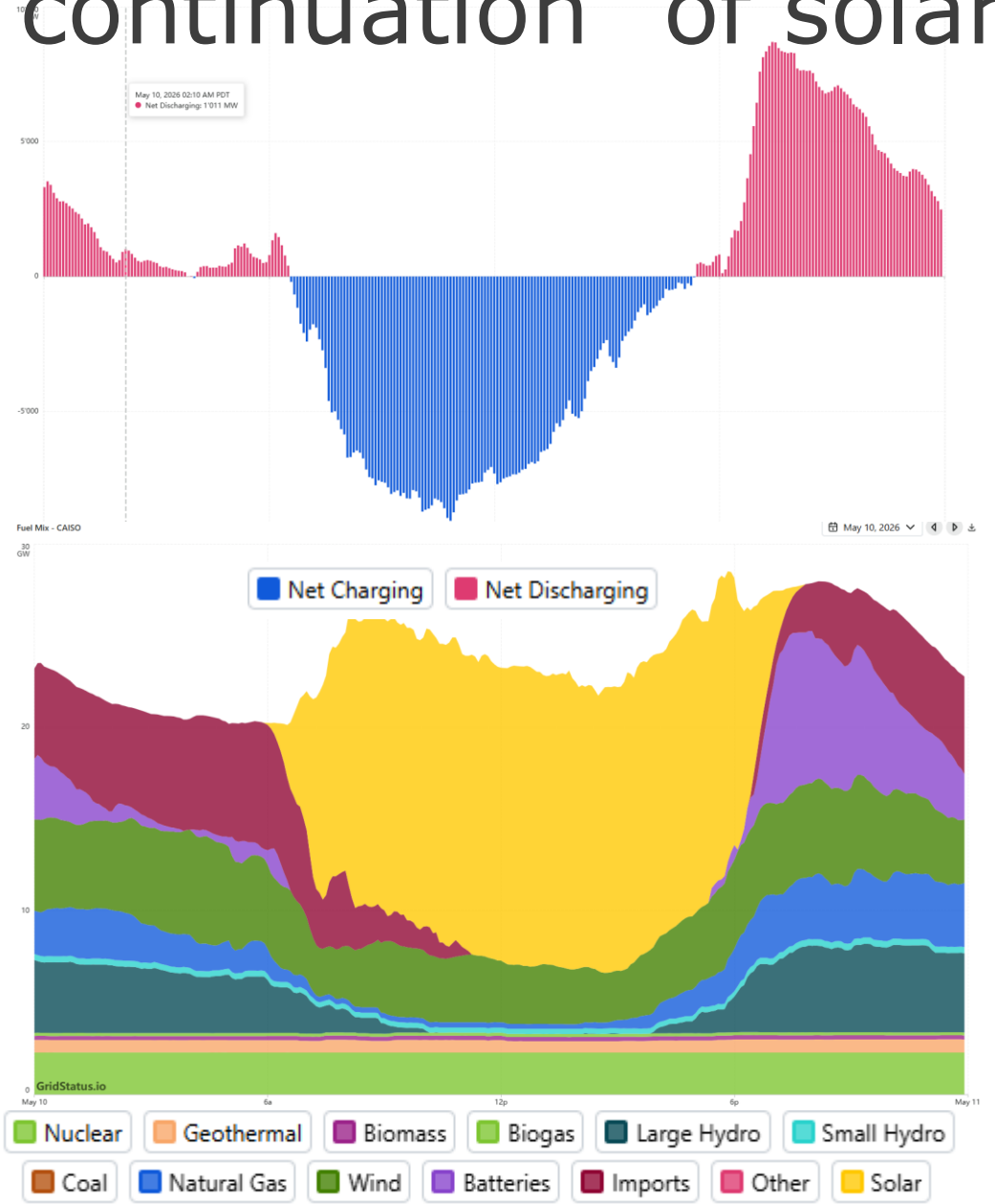
- **April 2026 is likely an extreme example**
  - But do you really think this is getting better with Germany planning to double the solar capacity by 2030, and also neighbouring countries adding more solar?
  - Maybe better to start thinking how one could produce more solar on the hours where there is value left



Source: Entso-E, Montel Syspower

Solutions: Batteries as a “continuation” of solar production

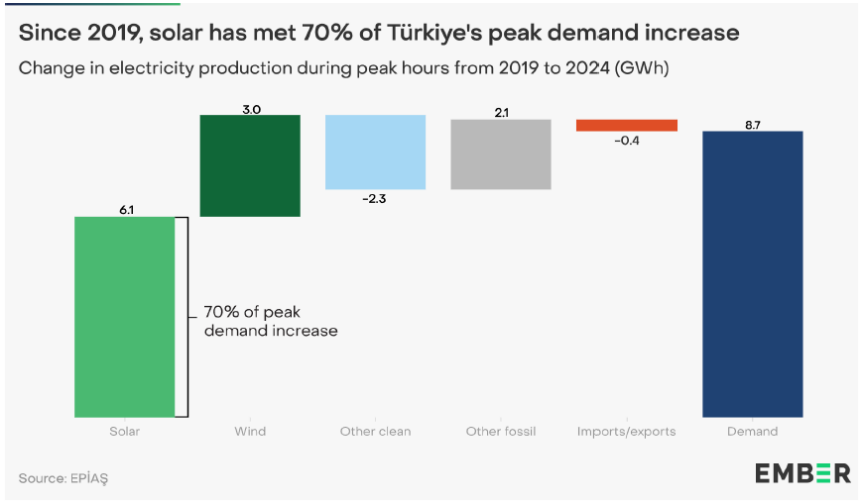
- **Continuing the solar production to the evening is already a standard mode of operation in some sunny markets like California in this graph**
  - Markets like California and Southern Australia already see this behaviour, and it is only a matter of time when this becomes profitable in Europe as well
  - But the more north one comes, the problem of dark, long winters increases
  - The periods of low wind are usually way too long to be covered with batteries
  - See also the heavy reliance on imports in meeting the Californian night demand, this option is not possible for everyone simultaneously
- **But what is the valuable asset here: the solar panel or the battery?**

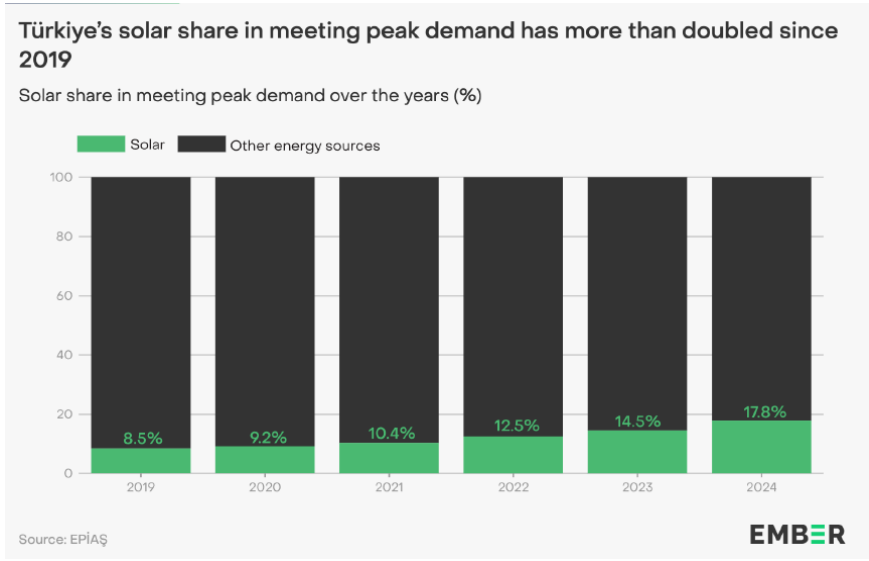


Source: CAISO, gridstatus.io

Solutions: new sources of demand

- **In many countries, extra solar power often does not anymore find a buyer at a reasonable price**
  - Creating new demand would be a straightforward solution
- **Most obvious candidate in warm countries is cooling demand**
  - See the examples from Turkey, where peak power demand is driven by cooling
  - Increasing solar power fits such a demand pattern well
- **Data centres**
  - Any data centre is obviously not going to run on solar only, but with the competitive price, one can expect data centres to use solar power as one part of their purchasing mix, even in Finland
- **Heating demand**
  - Naturally, it is not a seasonally perfect match, but the success of Finnish electric boilers mean that they will also absorb solar power, the main problem in many countries are taxes
  - Long-term heat storages such as sand batteries may also provide a way to use more solar power for heating





Source: Ember: Solar surge: Meeting two-thirds of the rise in Türkiye's peak electricity demand in 2024

Summary

- **Finland has thus far been spared of many of the challenges facing Central European solar**
  - But we are going to same direction as well, also because solar power is heavily correlated in whole Europe
  - Finland actually has a number of advantages for solar: a lot of available land, no excessive subsidies and still relatively low solar penetration

- **Some issues need to be urgently solved in Central Europe**
  - The current European development with recurring extreme low prices and grid stability challenges is an increasing risk for the industry reputation
  - As solar power has grown to be a major part of the power supply, solar producers should start behaving like a major force in the market

- **There is no easy way to solve the profitability challenges of solar power**
  - But good plant design, improved subsidy models, batteries and new power demand will all be partial solutions

Thank you!