Emerging trends in renewable power market earnings

Analysis of capture rates in Western Europe

November, 2023

EIFO

Long project lifetimes demands more forward-looking perspectives in financing

- The risk of (unforeseen) downward pressure on electricity prices and diminishing returns within renewable energy is a concern to investors and lenders since it may have a negative impact on the business case. It is important to have a forward-looking perspective on this since investments and loan financings have long durations.
- This analysis focus on estimating the revenue that wind- and solar power producers have earned as a share of the average market price based on historical data. We relate this to the share of renewable energy already in the power mix to identify any emerging trends. Furthermore, we use forecast data to get a sense of how capture rates are likely to develop in the future.
- The analysis also considers how price dispersion and predictability in wholesale markets change as renewable share increase. This is an important factor in the financing of new projects that must increasingly secure its income in the spot market.
- We focus on five markets in Western Europe: West Denmark (DK1), Germany, Netherlands, France, and Spain, a group of countries which includes both the biggest electricity markets in Europe, i.e. Germany, France, and the Netherlands – as well as countries that are ‘extreme’ in the installation of both wind- and solar power, i.e. West Denmark and Spain - to see how this affects our conclusions.
- This analysis is based on both historical data and forecasts data obtained from S&P Global. While there is no reason to believe that forecasts offer an exact reflection of the future power market, we do believe that the forecasts will at least provide an indication of the general direction of the electricity markets, and that these trends reveal important take-aways for investors and lenders.

Main conclusions

- Historically, renewable energy generators in Western Europe have experienced a slow, but steady decline in capture rates. Captures for both wind- and solar energy at their current levels of deployment are around 80-90% of the market’s average price.
- Forecasts show that capture rates are expected to decline over the next 15 years as renewable build-out continues. For wind energy the decline in capture rate is forecast to be less dramatic reaching capture rates between 50-70%. Forecasts show lower capture rates in DK1 (down to 40%) which is related to an expected strong buildout of offshore wind in this market.
- Solar power in particular shows a strong decline in capture rates and is expected to show capture rates in the range of 40-50% of the markets average price. Spain, the most sun-rich market in this study, shows even lower capture rates (down to 20%).
- Price dispersion is expected to increase quite significantly as low prices during renewable energy abundance is becoming more frequent and with longer durations. At the same time, pricing during periods of scarcity is becoming more extreme. This makes spot market income less predictable and increases risk on the income side.
- Declining capture rates can potentially make investors hesitant to commit sufficient capital to renewable energy projects, and ultimately, this may be a factor in how much renewable capacity that will be built in commercial terms. Maturation of the power-to-X industry and stronger electrical grids are important factors for mitigating capture rate decline and to keep the renewable power industry profitable at ever higher levels of deployment.

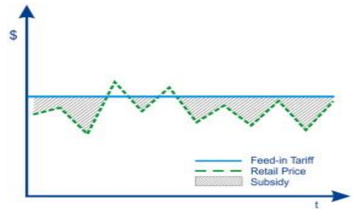
Financing of renewables relies increasingly on spot markets revenue

- Financing renewables has undergone significant change over the last decade. Early investments in renewable energy were driven by political targets and funded through public subsidies often in the form of feed-in tariffs. Maturing markets, more investor interest, and declining technology costs helped move towards competitive auctions and other competitive allocation methods such as auctions.
- The reduction in public subsidies makes spot market income an increasingly important part of the projects and the financing of projects. By engaging in a PPA the investor can get a level of security for the income stream, but the level of income under the PPA will likely mirror the projected price level in the spot market.
- Long-term price forecasts for electricity is therefore a main tool for making decisions on investments in generation assets that earn their revenue in the competitive wholesale market. By tracking the value and volatility that renewable generators face, we can make better financing decisions in the future.

Financing renewables has become more risky

From Feed-in tariffs…

- Politically set prices
- Often high level of subsidies
- Usually robust projects – but risk of retroactive changes to tariff

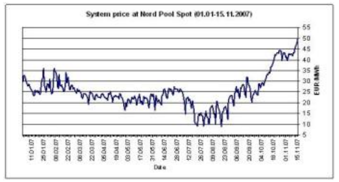


… over auctions …

- Fixed price through competitive auction
- Often low level of subsidies
- Usually robust projects – risk in less wind, unforeseen events or expenses

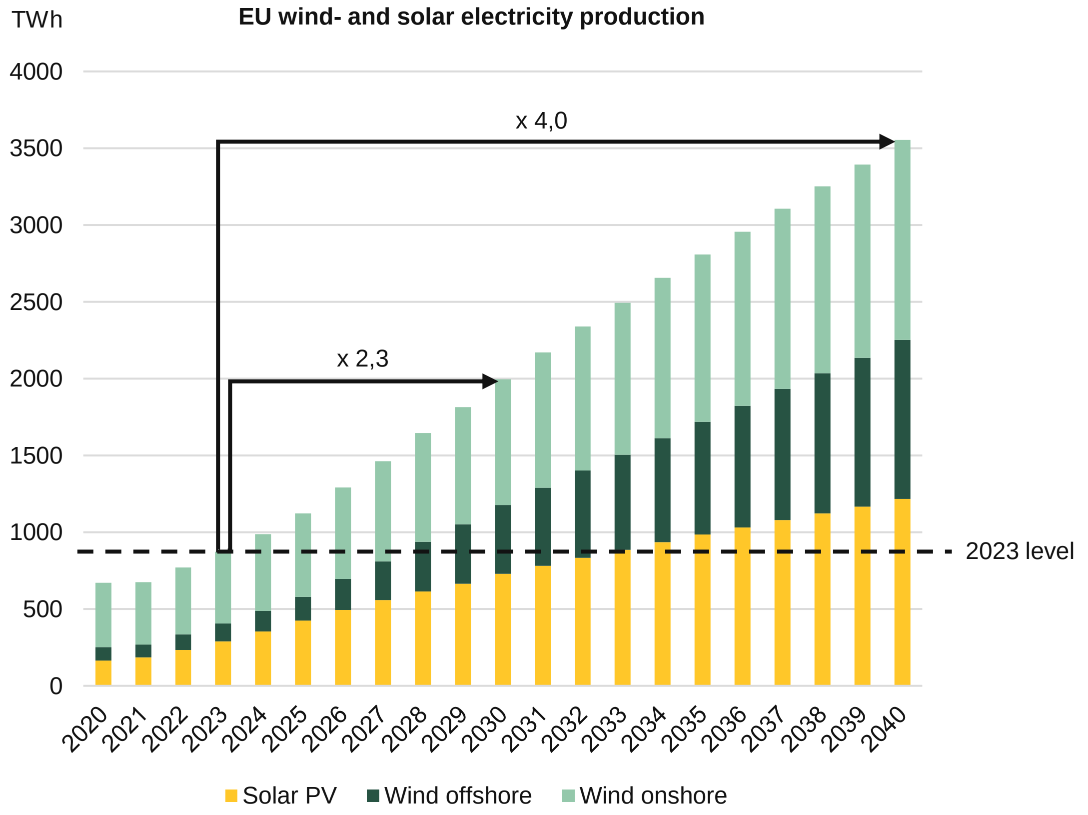
… to spot market competition

- No subsidies
- Projects earn their revenue in the competitive spot market
- Corporate PPAs helping to secure offtake, but price reflects spot market



More renewable production change spot market pricing dynamics

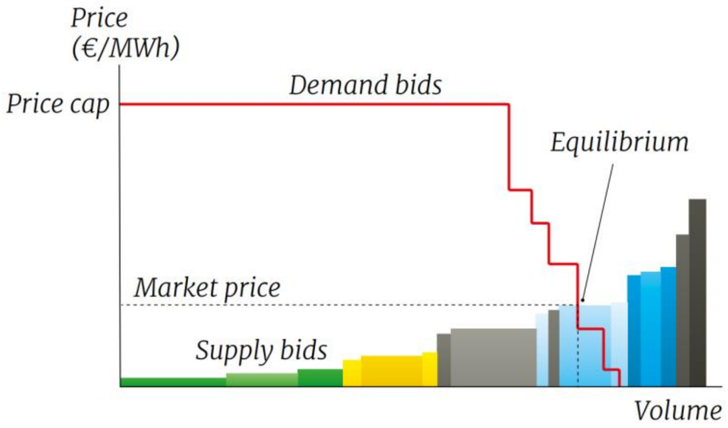
- The share of renewables in the power mix is on the rise and will increase more rapidly in the coming years. The simultaneity of wind power production and solar power production respectively, leads to abundant supply during favorable weather conditions.
- These are typically periods of low prices, meaning the price that renewable generators sell electricity at is on average below the markets average price (baseload power price). Even modest surpluses of energy offered at no cost, have the capacity to lower the marginal prices in the spot market.
- This relative declining value of renewable electricity is quantified as a reduction in the capture rate.
- The capture rate measures the volume-weighted average price that a power production asset can earn in comparison to the overall average electricity price for a given period.
- The capture rate effect becomes more pronounced in the countries where renewables make up a chunky share in the power mix and as wind- and solar capacity continues to expand.

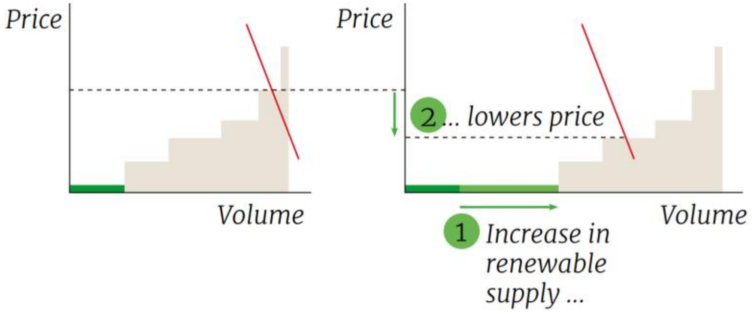


Source: *Connect by S&P Global.*

Box: Price formation in the electricity market

- Price formation in the wholesale market is the result of the balance between supply and demand for electricity on an hourly basis. The day before real time production, both producers and consumers submit bids to the power exchange (e.g., Nord Pool) for production, resp. offtake, electricity for each hour during the next day. The supply side of the electricity market is particularly interesting, since the supply curve reflects the available generation capacities and the price, they bid to supply electricity. The demand for electricity remains relatively inelastic to price changes in the absence of large-scale energy storage.
- The bids to supply electricity usually follow the marginal production costs. Variable power generation, like wind- and solar power, submit bids to supply power whenever they can and usually do so at a price of zero since their ‘fuel' is free. Firm electricity generation like a gas-fired power station submits a bid that equals its variable cost to supply this unit of electricity, and then hopes that the market clears at a higher price level, leaving revenue to finance the plant's fixed costs and profits.
- The power exchange ranks the incoming bids and calculate the intersections between supply and demand, taking any electrical exchange to/from neighboring prices areas into account. The market price – the price that all producers receive, and all consumers pay – is the price where the supply curve intersects with the demand curve.
- During hours where renewables can meet demand on its own, the market price becomes near zero. When renewables are not able to meet demand on its own, it is the bid size of the last activated producer that sets the market price. The more renewable capacity that is built, the more often will the market price become close to zero.





The capture rate is the average price earned by a project in percent of the market average price

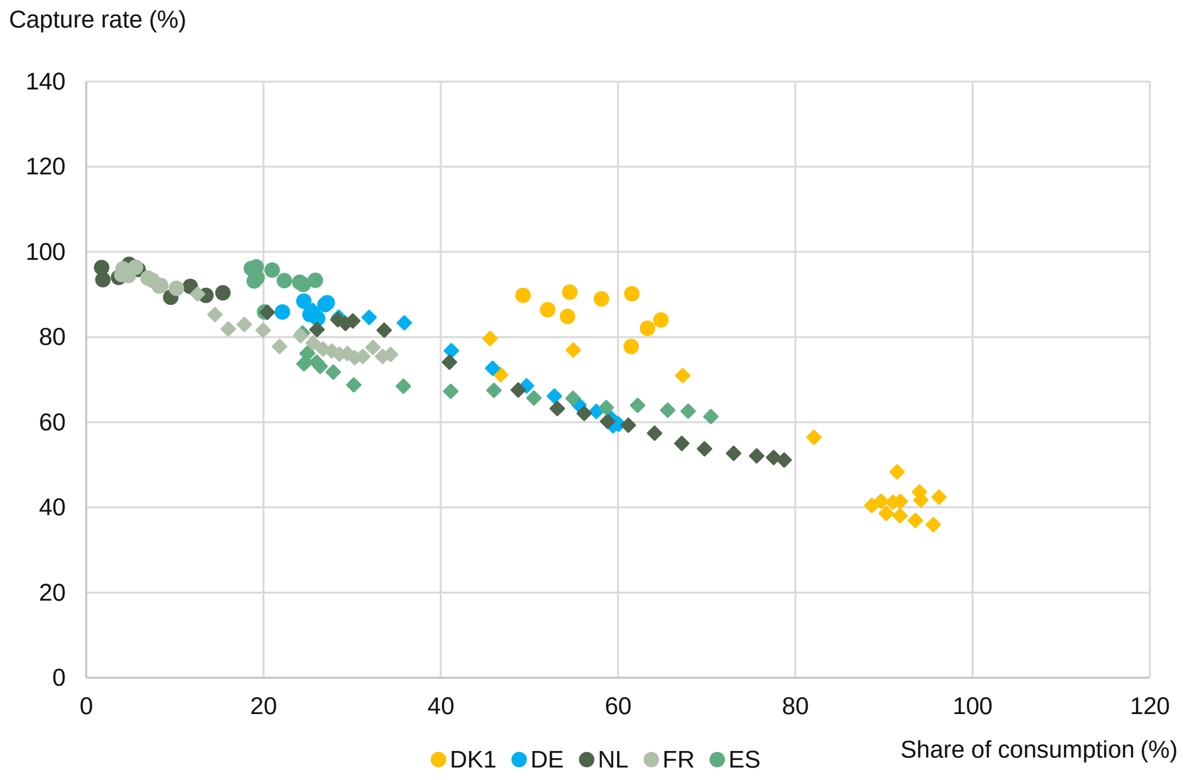
- The (forecasted) spot market price is the starting point in the evaluation of the long-term financial viability of renewable generation assets. The capture rate measures the volume-weighted average price that a power production asset (e.g. wind farm) can earn in comparison to the overall average electricity price for a given period. So, while average market prices provide a useful benchmark, it is the captured price that determines actual revenues which are available for repayment on debt and profits.
- Several factors affect the capture rate:
  - The analysis shows a strong relationship between capture rates for both wind- and solar power and their deployment in the market.
  - Expansion of the physical electricity grid. Increased opportunities to trade across markets helps to avoid situations of local over-supply in one market and the subsequent low prices.
  - New demand from hydrogen production facilities or heat pumps consuming electricity when the price is low all contribute to ensuring that prices and capture rates do not fall too low.
  - Storage facilities buying electricity when it is cheap and selling when it is expensive contribute to keeping capture rates from falling too low (and help to prevent prices from rising too high).
  - Regulation. Subsidizing renewable within a given market leads to greater investments than the market would otherwise have witnessed. This can make capture rates fall to lower levels.
  - Local resource availability /weather conditions, e.g. sunlight in Spain or wind in the North Sea, can lead to lower capture rates. Yet, lower income per unit of electricity produced can be offset by a greater overall production volume.
  - Technological progress and declining Levelized Cost of Electricity reduces project costs and mitigates the effect of falling income.

$$\text{Average price earned by wind turbines per unit of electricity} = \frac{\text{Monthly income of the wind turbine sector. This is calculated as the hourly price in the market multiplied by the wind energy production during this hour. This is then summed across the month}}{\text{Monthly energy production from wind turbines}}$$

$$\textbf{Capture rate (\%)} = \frac{\text{Average price earned by wind turbines per unit of electricity}}{\text{Average market price}} \text{ X } 100$$

Wind power capture rates declines moderately with production

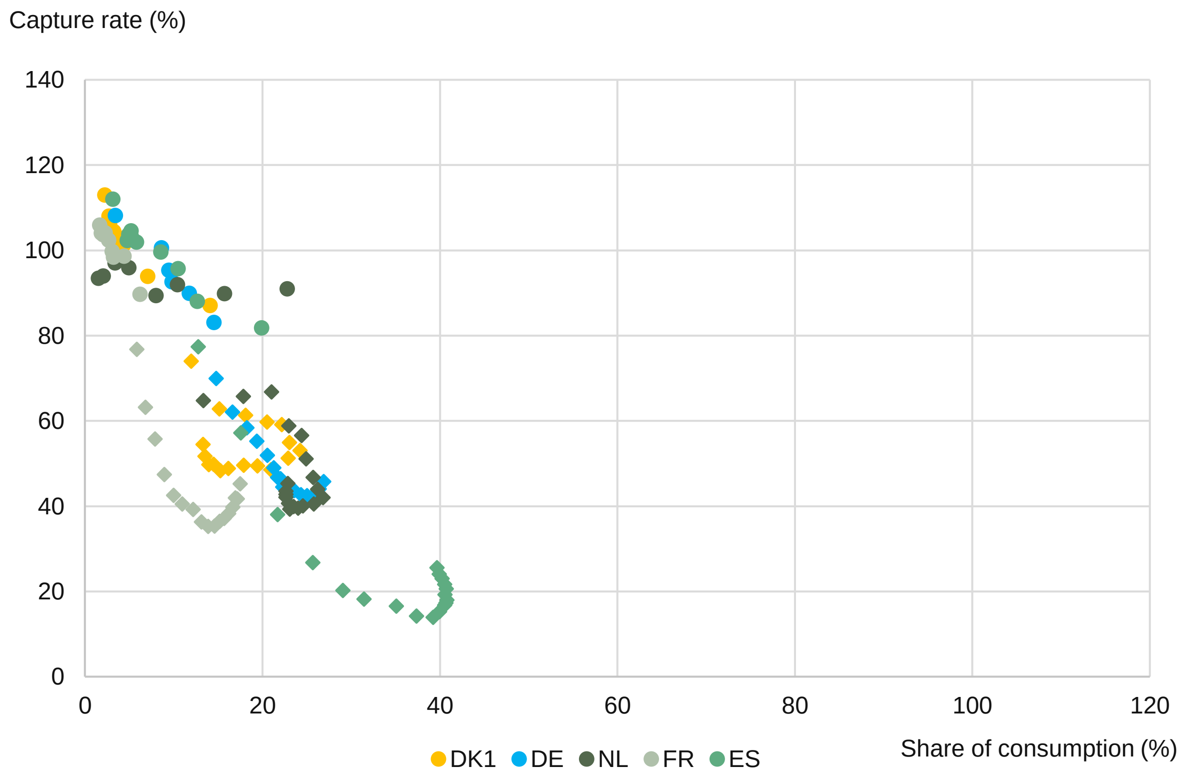
- Historical price data shows a shows a quite consistent (negative) correlation between capture rates for wind power and its share of electricity consumption. Capture rates for wind power remain mostly within the range of 80% to 90% and with wind power shares below 30% of consumption in the countries in the analysis.
- The exception is DK1 which currently has a wind share of consumption of above 60%, but with capture rates only slightly lower than the group. A likely reason for this is the exceptionally strong electrical interconnections coupling to five neighboring markets. Exports from DK1 keeps capture rates from falling too low.
- Forecast data shows that wind power capture rates are facing a moderate decline towards a level of 50% to 70% by 2040. DK1 remains the exception with capture rates as low as 40% which is mainly due to the strong expected build-out of wind in the North Sea, but at least partially offset by offshore wind having a high production volume (high number of full-load hours).
- The decline in capture rates as predicted by the forecast looks like a continuation of the effect that we already see today, thus, more wind power capacity leads to greater supply during windy conditions which results in lower prices.
- Further, as most (all) countries in Europe are expected to install more wind capacity, the opportunities to trade away production surpluses to neighboring countries becomes more limited, reinforcing low prices and low capture rates.



Note: *Round markers = historical data. Square markers = Forecast data (S&P Global).*
Source: *ENTSOE via Macrobond, S&P Global (forecasts).*

Solar power capture rates declines strongly with production

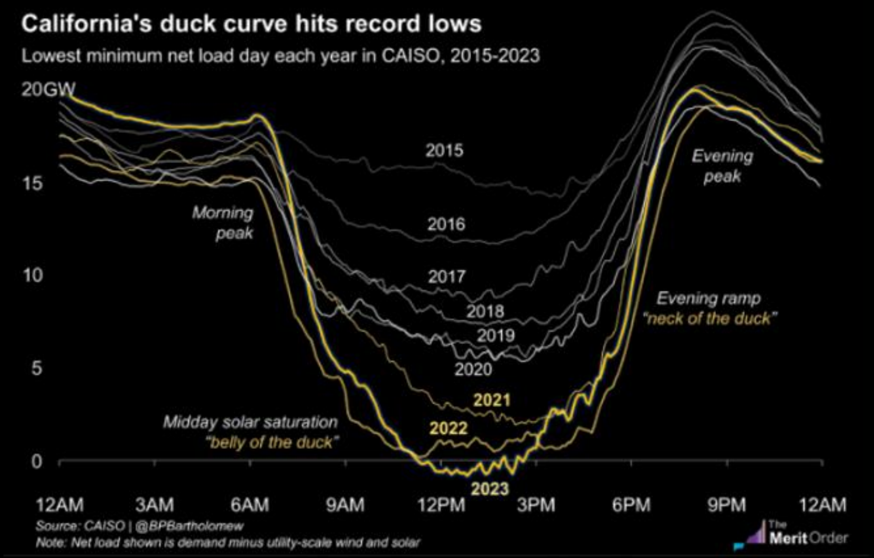
- Historical data shows a strong correlation between the penetration rate of solar power and capture rates. At very low penetration levels, capture rates of solar power are sometimes above 100%, indicating that it earns an average (volume-weighted) price that is above the markets. This is related to power prices used to being highest during the day, where demand was highest. At the current level of deployment, capture rates hover in the range 80-90% in all countries.
- Capture prices are expected to decrease quite strongly with solar deployment. The forecasts suggest that capture rates can reach 40-50% as solar power increases its share of consumption towards 30%. Sun-rich Spain is an outlier in the group of countries showing not only a stronger solar production but also lower capture rates. One reason why Spanish investors can accept a lower capture rate per unit of electricity produced is because of a higher production volume that helps to even out the business case.
- Capture rates for solar power shows a stronger correlation with deployment compared to wind power. One major reason for this is the localized nature of wind conditions versus sunlight. Abundant wind power production in one market can - to a certain degree - be exported to neighboring markets with less wind production during this time. Since the Sun shines everywhere at once in Europe, there is less opportunity to trade away surpluses to neighboring markets.
- There is also a much greater seasonality in solar production compared to wind production, leading to a very strong cannibalization during the summer and low overall capture rates. Lastly, market prices during winter also tend to be slightly higher than during the summer. This also contributes to the relatively low capture prices for solar power compared to the average annual market price.

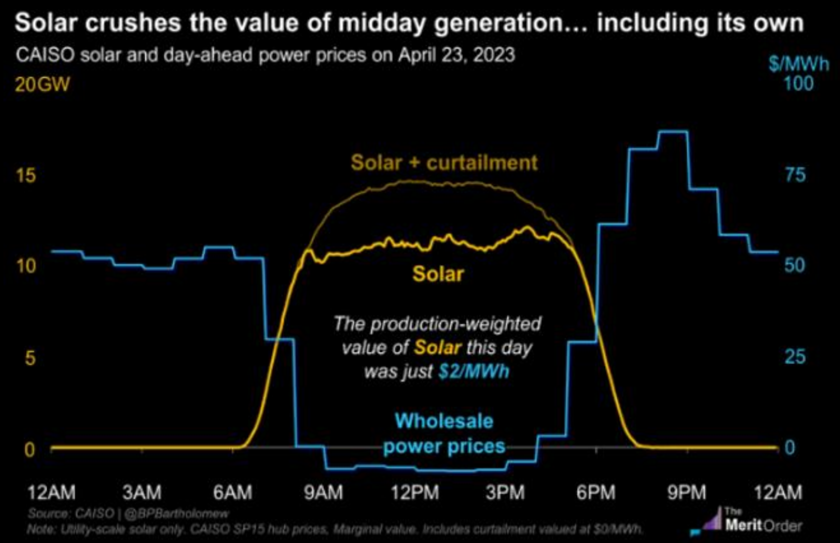


Note: *Round markers = historical data. Square markers = Forecast data (S&P Global).*
Source: *ENTSOE via Macrobond, S&P Global (forecasts).*

Box: The Californian duck curve

- California has one of the highest penetration rates of solar power in the world, with a share of total, annual demand of round 27% in 2022 according to EIA, even if solar production is most concentrated during summer and day-time. According to S&P solar power currently accounts for around 10% of total, annual demand across the five EU markets we consider in this analysis. This makes California an interesting test case for how renewables – and solar power in particular – influences market prices in Europe in the future.
- The upper figure illustrates a concept called ‘residual demand’ which is the size of demand after solar production has been subtracted. The figure shows that solar power dominates power supply during midday, leaving very little demand for other technologies to fill. As more and more solar power is built, the belly of the duck becomes fatter and fatter (lower and lower residual demand).
- The figure illustrates residual demand for the most extreme day of the year. Even if this is not representative, the illustration shows a clear direction for the power system given the continued extension of solar power. In 2023, for the day depicted, solar power covered the entire Californian demand at midday for the first time ever.
- The lower figure shows the relationship between solar production and market prices. Not surprisingly, the extreme supply of solar power results in very low (and even negative) electricity prices in the wholesale market. This figure also shows curtailment of solar production at midday, simply because there is no one to use this much electricity.
- In California, solar power has transformed the power system from having the highest prices during peak demand at midday to having very low prices at midday. Solar power also means that all other generators need to earn their revenues outside the hours 8-17.

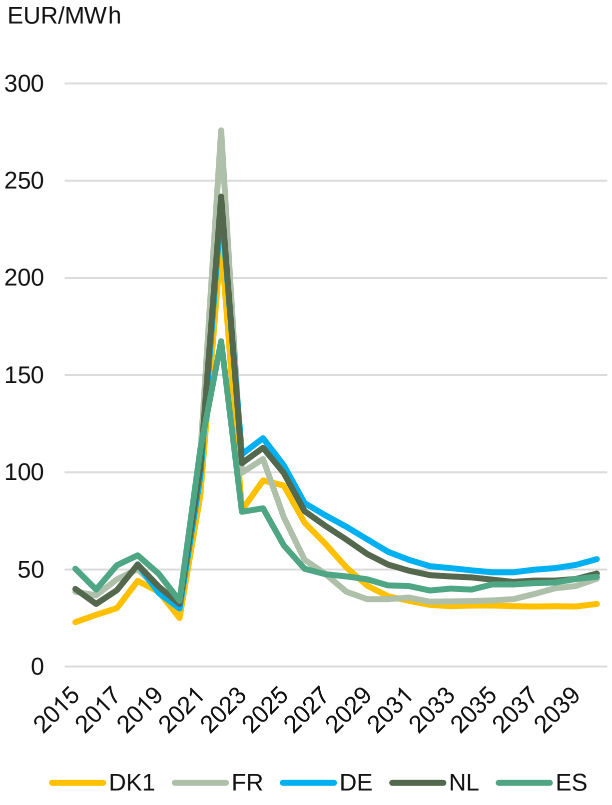




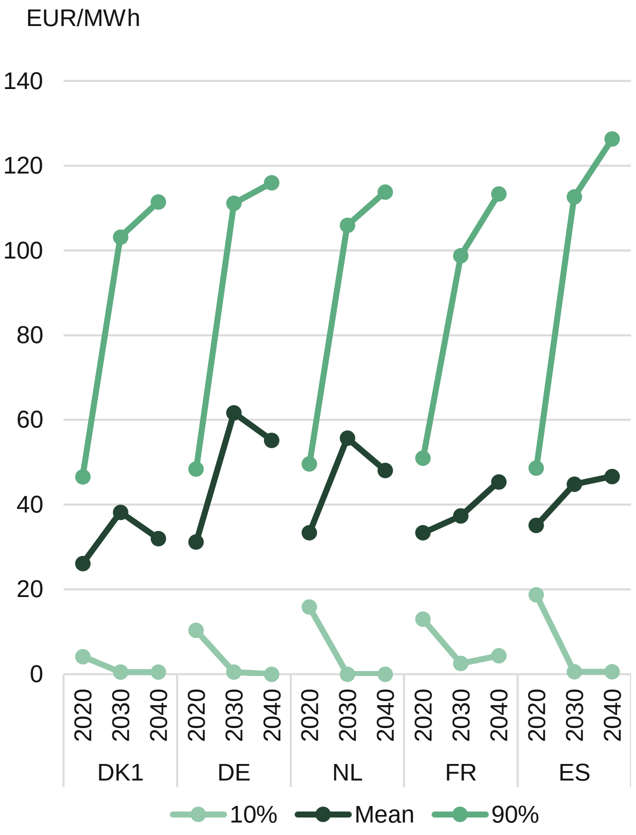
Source: *The Merit Order, The Merit Order | Brian Bartholomew | Substack.*

Renewables increase price dispersion and market risk

- The (forecasted) spot market price is the starting point in the evaluation of the long-term financial viability of renewable generation assets.
- The wholesale market price reflects the supply and demand balance in an hourly (or quarterly) basis. Increasing renewable deployment leads to more extreme prices in the wholesale market, both at the lower and higher ends.
- More renewable energy leads to more frequent and longer periods of oversupply when there is an abundance of wind and solar power. This leads to lower prices during those periods. One sign of this is that the 10^{th} percentile is close to 0 EUR/MWh in all countries, showing that (at least) 10% of the hours during the year will not contribute to the economics of the asset.
- More renewable energy erodes market opportunities for other types of generator, e.g., power stations. With fewer power available in the system, there are fewer suppliers available to meet demand in scarcity situations. This leads to higher prices during those periods. This effect can be seen on the 90^{th} percentile which is set to increase dramatically between 2020 and 2030 and beyond.
- Greater price volatility makes income to all power producers, including renewables, more unpredictable, being, as a rule, less attractive for investors and lenders.
- Dispatchable technologies in the market, such as power stations and storage assets, will be able to earn high prices although this will be balanced with a limited number of operational hours.



Note: *Real 2022 prices.*
Source: *S&P Global, Planning case September 2023.*



Note: *Figure shows power prices at the 10% and 90% percentiles and the mean price. Real 2022 prices.*
Source: *S&P Global.*

Falling capture rates will affect investment size and project design

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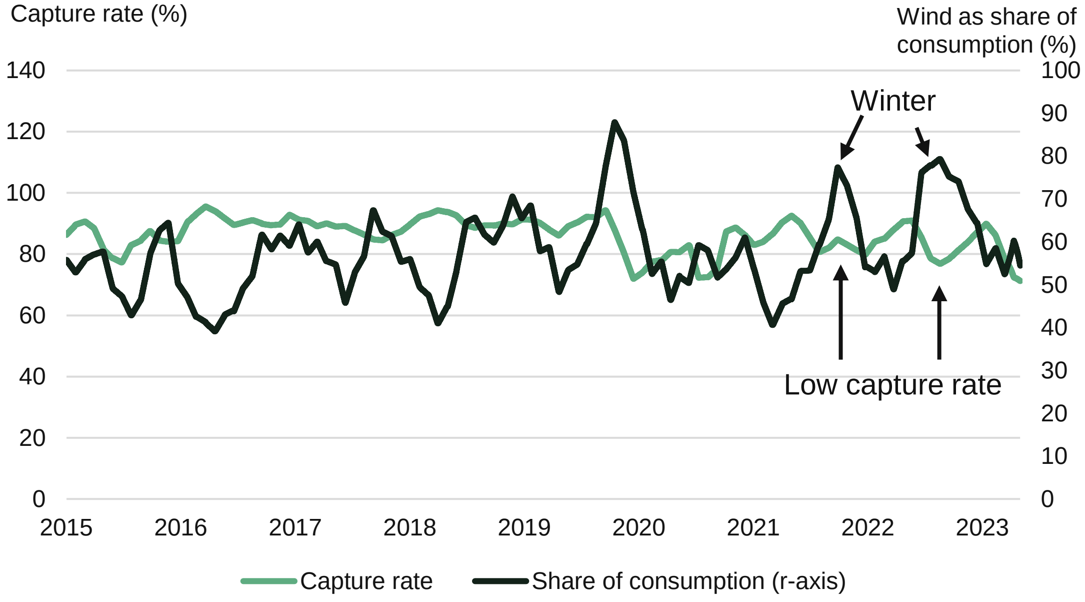
- Declining capture rates directly impact the revenue of wind- and solar projects. As these assets generate lower income from energy production, this type of investment may become less attractive compared to other investment opportunities.
- We believe that declining capture rates are bound to make investors hesitant to commit capital to renewable energy projects, and ultimately be a factor in how much renewable capacity that can be built in the commercial terms. The analysis shows that this effect is more pronounced for solar PV than for wind energy.
- Ultimately, the profitability of renewable investments relies on power prices in absolute numbers and not how big a share of this a wind turbine can capture. Forecasts shows that average prices in the market is set to return to pre-war levels over the next couple of years, without a major increase in price to compensate for lower capture rates.
- In the current market design, there is no mechanism to keep earnings of wind- and solar projects from falling too low except through fewer investments. This will have an impact on society's decarbonization efforts.
- Since decarbonization is a must-win battle for societies, we guess that over the next decade, we will see a discussion of how renewables are remunerated in the market to ensure that the current competition in the power market does not get in the way of decarbonization.

- The strength and timing of this investment-limiting effect is not trivial, and there are other factors that play into this equation which can have a mitigating effect:
- Falling technology costs (lower CAPEX) helps projects to maintain a somewhat higher contribution margin even if electricity prices fall.
- Continued European integration will also be a factor in finding bigger markets for wind power when it is abundant locally. Solar power may not benefit as much from this.
- High production volumes from locations at the best sites will only become more important in the future to compensate for falling prices
- Bundling renewable assets with storage, for example in the form of battery storage, can mitigate some of the negative consequences of low prices: Charging the battery during periods of low price and selling the electricity later does to some extent mitigate the negative effect.
- The competitiveness of power-to-X plants relies on access to cheap electricity. We believe that more projects in the future will be developed as a combination of both electricity generation and power-to-X, since these technologies essentially hedge each other. Whether power-to-X can ‘save’ renewable investment depends on how quickly the hydrogen economy can get traction.

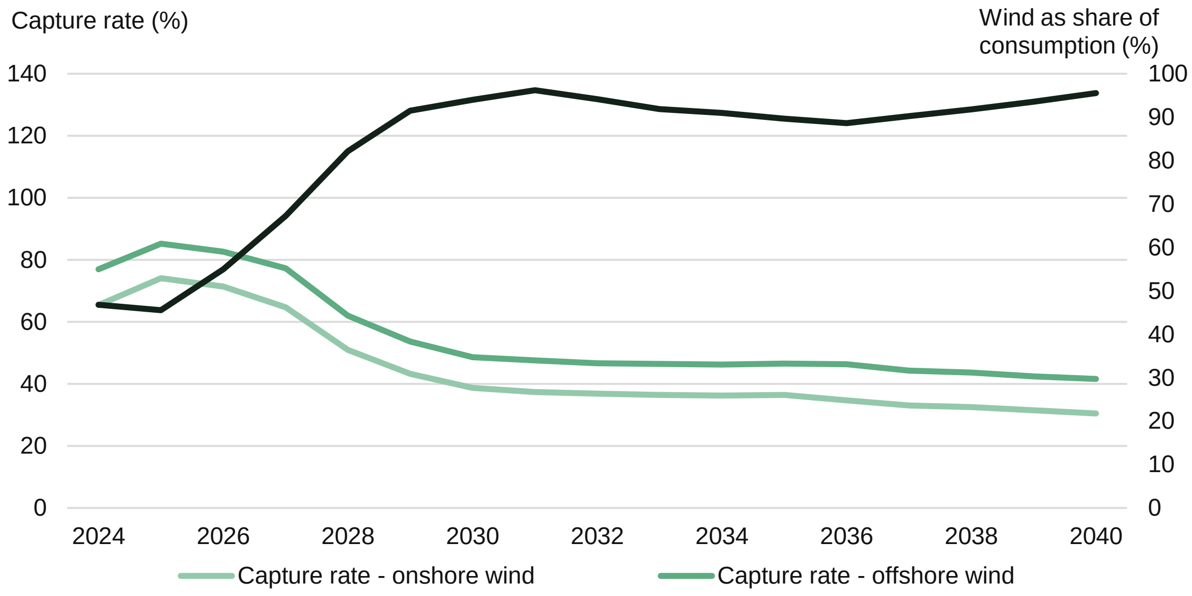
Country focus Denmark, DK1

- Note: All data sources are reported in the methodology section near the end of the analysis.

Denmark, DK1
Wind power capture rates

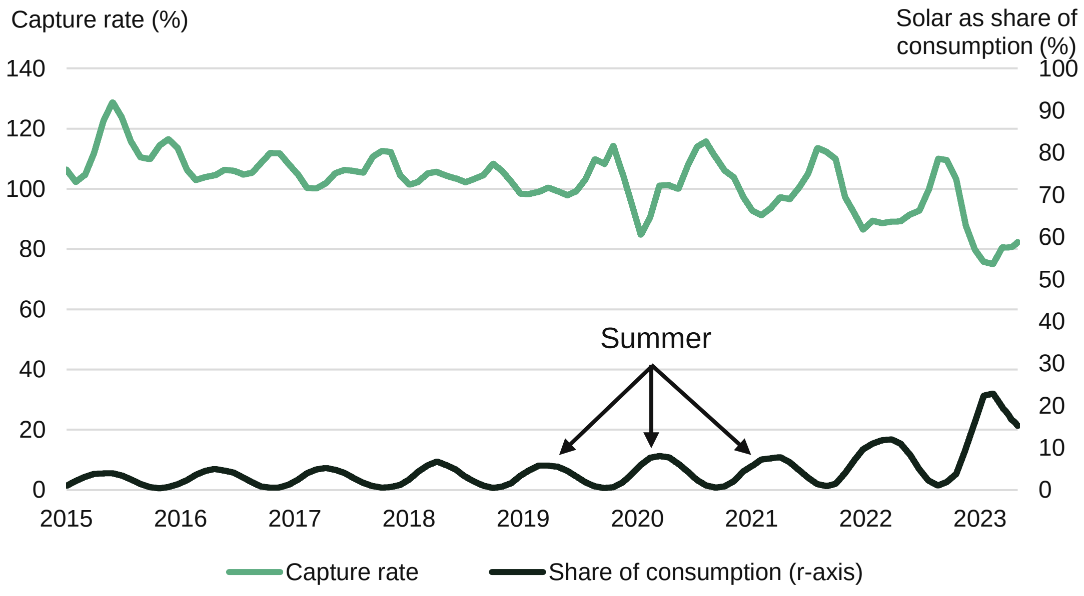


- Wind power features a capture rate that has remained reasonably stable at around 80-90% from 2015 to 2023 and is further expected to stay at this level until 2027. This is consistent with the share of wind energy in consumption has only increased marginally from 2015 to 2023, due to the slow buildout of wind energy in DK1 in recent years.
- Studying the graph closely, however, a negative correlation between capture rates and share of consumption seems to be present on a within-year scale. Wind power production is typically highest during the winter half of the year, as reflected in the graph by a higher share of consumption. During these peaks in 'wind as share of consumption (%)' the 'capture rate (%)' seems to be decrease.
- The forecast data in the next graph is based on annual data points. Therefore, we cannot conduct the same within-year analysis. However, the data clearly indicates a correlation between wind production as a share of consumption and the capture rate.

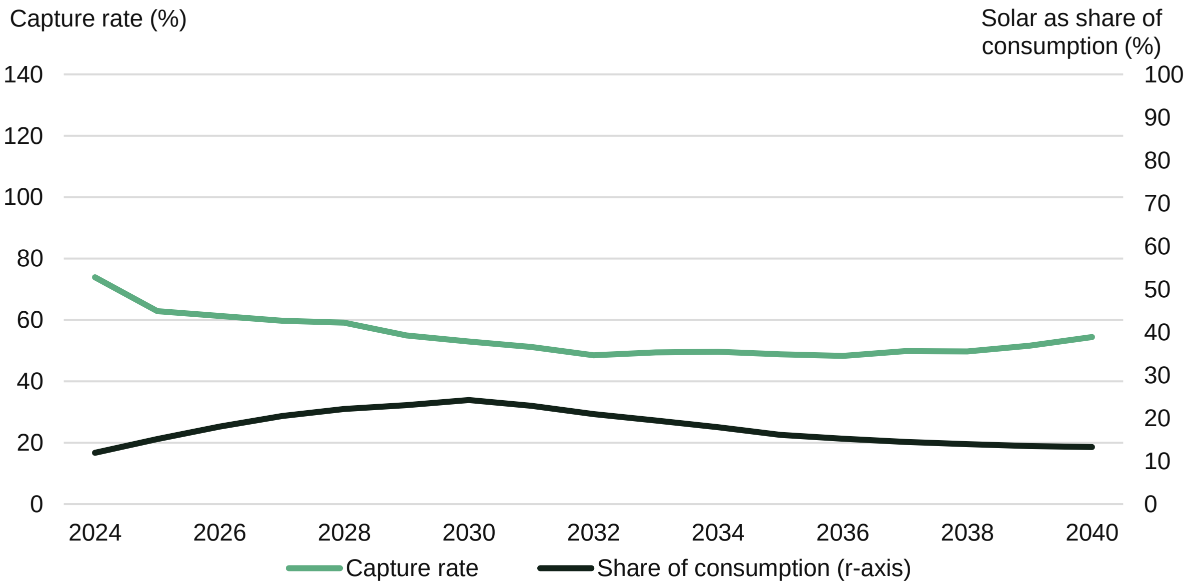


- Between 2027 and 2030, S&P forecasts a significant drop in the capture rate of onshore wind to around 40%, a level expected to persist until 2040 (the last year covered by S&P's forecast). This decline is likely linked to the commissioning of new parks in alignment with Denmark's 2030 renewable targets. This results in an increase in wind production and a higher wind share in Danish electricity consumption.
- The capture rate for onshore wind is anticipated to be approximately 10 percentage points lower than that of offshore wind. This is because offshore wind operates for more hours, allowing it to approach the market's average. Additionally, there may be an effect stemming from the broader geographical distribution of offshore wind farms (from the far west in the North Sea, Kattegat in the center, to the Baltic Sea in the far east), resulting in less correlation in offshore wind production.

Denmark, DK1
Solar power capture rates

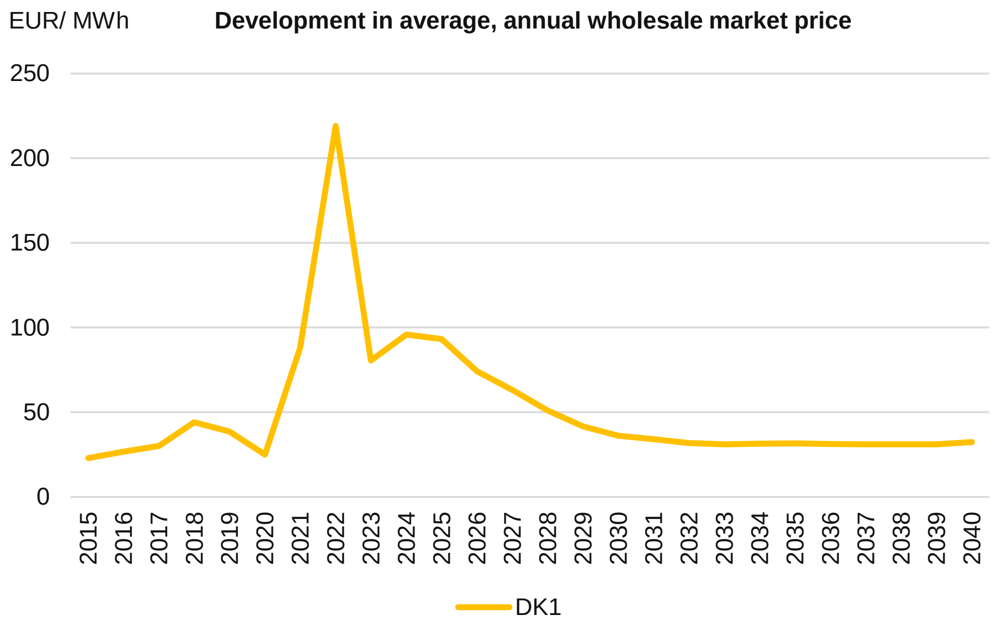


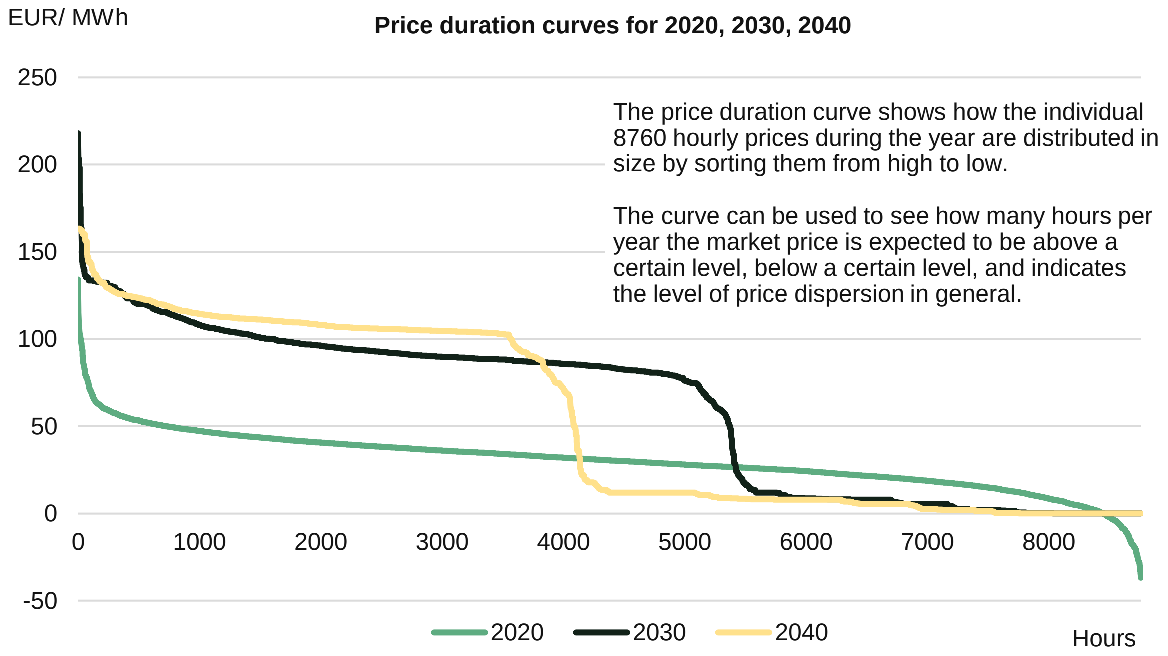
- Solar power's capture rate has been steadily declining from 110% in 2015 to around 65-75% currently across the year as a whole. The graph also shows a significant, recent increase in solar output in DK1.
- Electricity from solar cells does exhibit a very strong seasonal fluctuation, with high production during summer and low during winter. Consequently, the capture rate of solar power is low during summer but can be high during winter, where the impact of solar power supply is more limited.
- Capture rates above 100% indicates that the project earn an average price that is above the markets average price. In fact, capture rates of solar power still can exceed 100% during winter (as observed in the winter between 2022 and 2023).



- According to the S&P forecast, the capture rate is expected to transition from its current level of 65-75% to 50-55% starting in 2030.
- Interestingly, the S&P forecast predicts that solar power's share of consumption will peak at 24% by 2030 and subsequently decline to 13% by 2040. This outcome is influenced by solar power production reaching a plateau by 2030, while consumption continues to increase steadily. The plateau in the model signals that further commercial investments in solar power may be limited.
- It's important to note that the above figure represents percentages of the average price earned. To gauge the price earned by solar producers, one should consider both the above figures and the data on the next slide illustrating the development in the average annual wholesale market price for DK1. The figure does not seem to suggest a future increase in the market price that outweighs the declining capture rates.

Denmark, DK1
Price development and price dispersion





- Prior to the Ukraine war, electricity prices were (especially in hindsight) reasonably stable in the interval 22-44 EUR/MWh.
- In 2022, prices reached a high point of 219 EUR/MWh but are expected to return to a more stable range. From 2030 onwards, prices are anticipated to stabilize around 30-35 EUR/MWh, comparable to the pre-Ukraine war period.
- Beneath this average market price, there is an increasing degree of price dispersion. The rise in renewable energy results in more hours with very low prices, while periods of scarcity will exhibit more extreme prices. This is shown in the figure to the right.

- The figure illustrates that over time, the DK1 market will experience increasing 'fragmentation' in electricity prices. From 2020 to 2030 and on to 2040, there is a trend indicating a growing number of hours with low prices, attributed to the expansion of renewables.
  - 2020: price below EUR 10/MWh ca. 10% of the time
  - 2030: prices below EUR 10/MWh ca. 35% of the time
  - 2040: prices below EUR 10/MWh ca. 40% of the time
- The figure also shows that high prices in the future will become higher than in 2020, since more renewable energy erodes market opportunities for other types of generator, e.g., power stations. With fewer power available in the system, there are fewer suppliers available to meet demand in scarcity situations.

Denmark, DK1
Residual demand and the Duck curve

The figure illustrates the average daily residual demand after subtracting both solar and wind production for each year from 2015 to 2023. These curves, depicted in yellow, are commonly known as the ‘duck curve’.

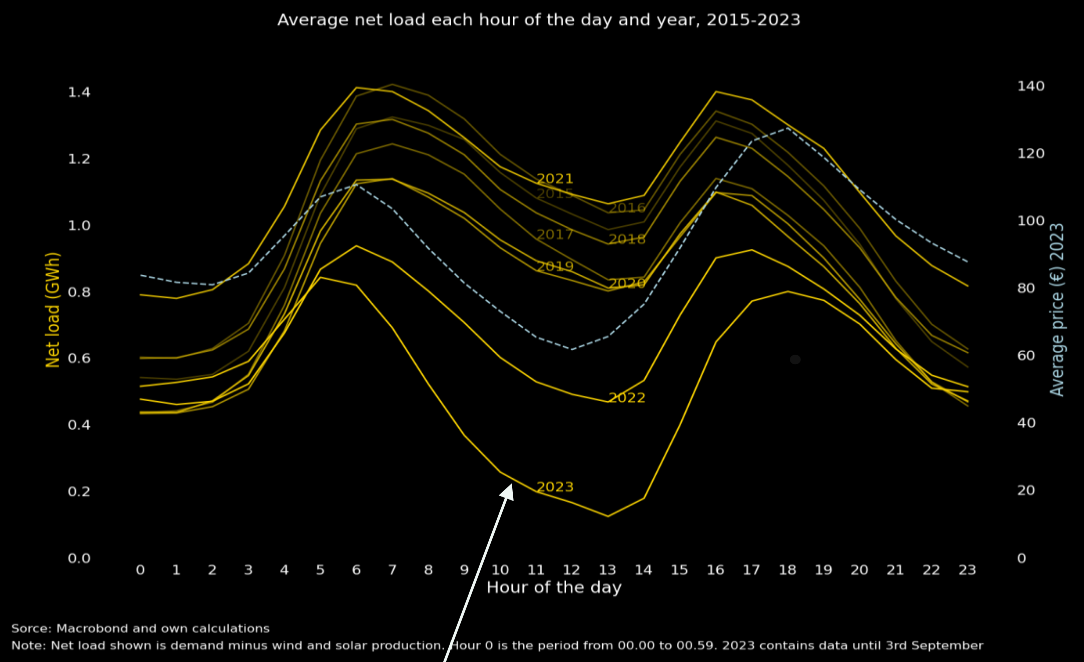
Despite high electricity demand at midday, the residual demand curve exhibits a midday-trough that is expanding over the years. This trend is primarily driven by the increasing solar power production.

A noticeable expansion of solar production during midday is evident in DK1. While DK1 has not experienced curtailment periods similar to California, the rapid buildout towards 2030 suggests it may become more likely in the future.

As the figure presents average annual values for residual demand, the extreme situations during high solar production in summer months are less visible. This also obscures the negative correlation between solar production and price. A similar figure focusing solely on the summer months would reveal a deeper belly of the duck, emphasizing a greater (negative) effect on price.

The average market price for each hour (00-01, 01-02, 02-03…) during 2023 is represented by the blue line. Showing the data as an annual average, therefore, also obscures the negative correlation between solar production and price. During the summer, high solar production has a more pronounced effect on price. The next slide considers this in more detail.

While solar production deepens the belly of the duck, wind power is more evenly distributed across the day, manifesting itself as a parallel, downward shift of the residual demand curve from one year to the next.



The duck’s belly is becoming deeper and deeper due to expanding solar production

Denmark, DK1
Solar deployment and its effect on price

The figure highlights the impact of solar power production on prices in a different manner than before to focus on price cannibalization during summer days.

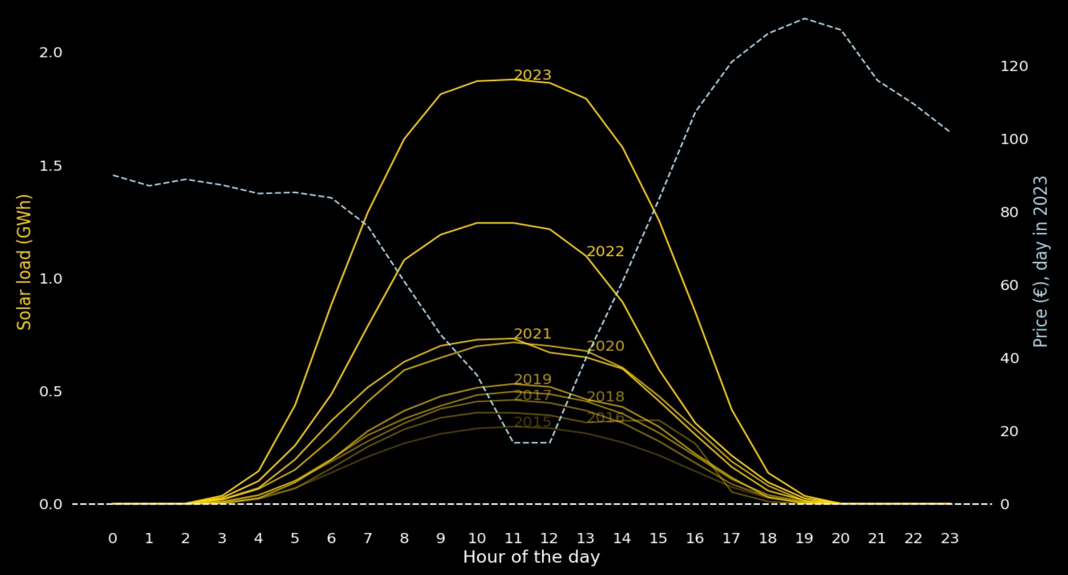
The yellow curve depicts solar production on the single day during each of the years 2015-2023 when residual demand was at its lowest after subtracting solar production. This curve is not an average but represents the actual aggregate solar production in DK1 on that particular, very sunny day. The yellow curves reveals a clear upward trend in solar production.

The blue line shows actual hourly market prices during this particular day in 2023.

Comparing the upper yellow line (representing the year 2023) with the blue line (also for the year 2023) provides another perspective to illustrate the significant price cannibalization effect of solar power.

The ongoing expansion of solar power results in lower prices, as demonstrated by the California example. This trend begins with negative prices during a few hours on very sunny days and extends to more hours and days.

The day with highest solar load each year, 2015-2023

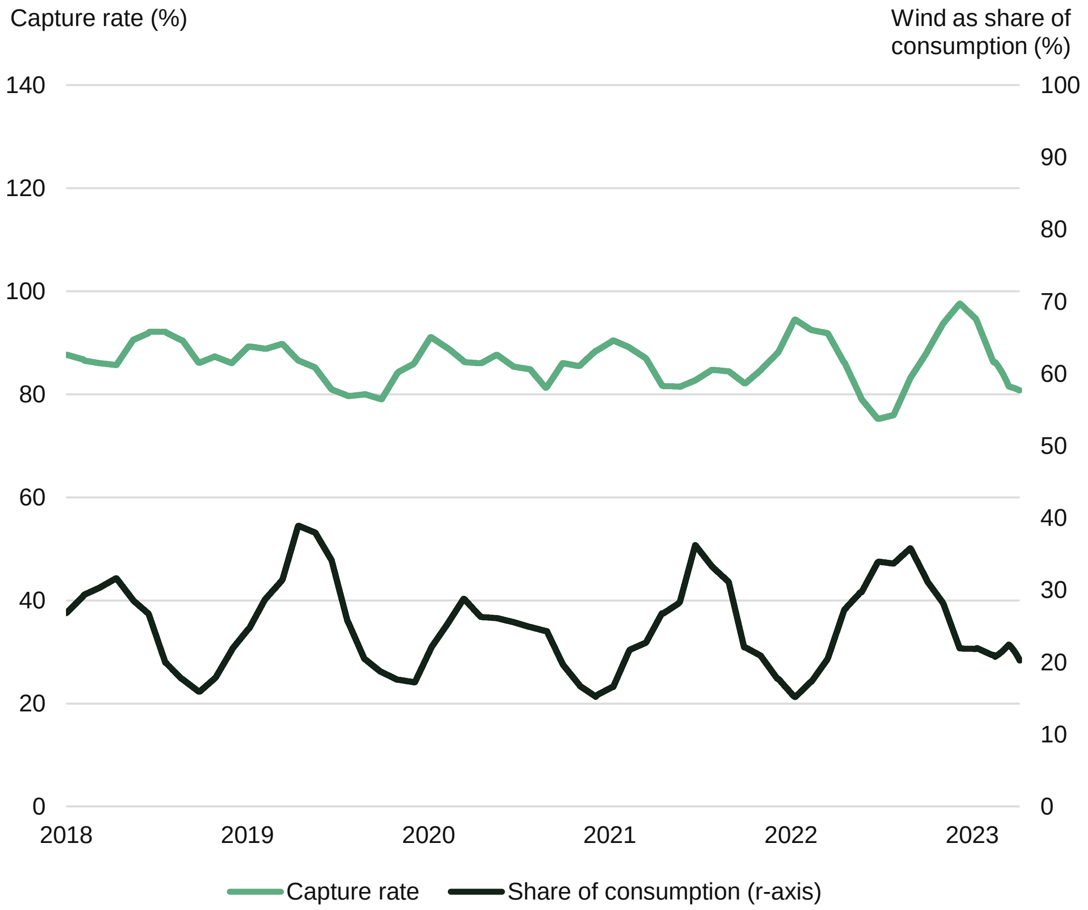


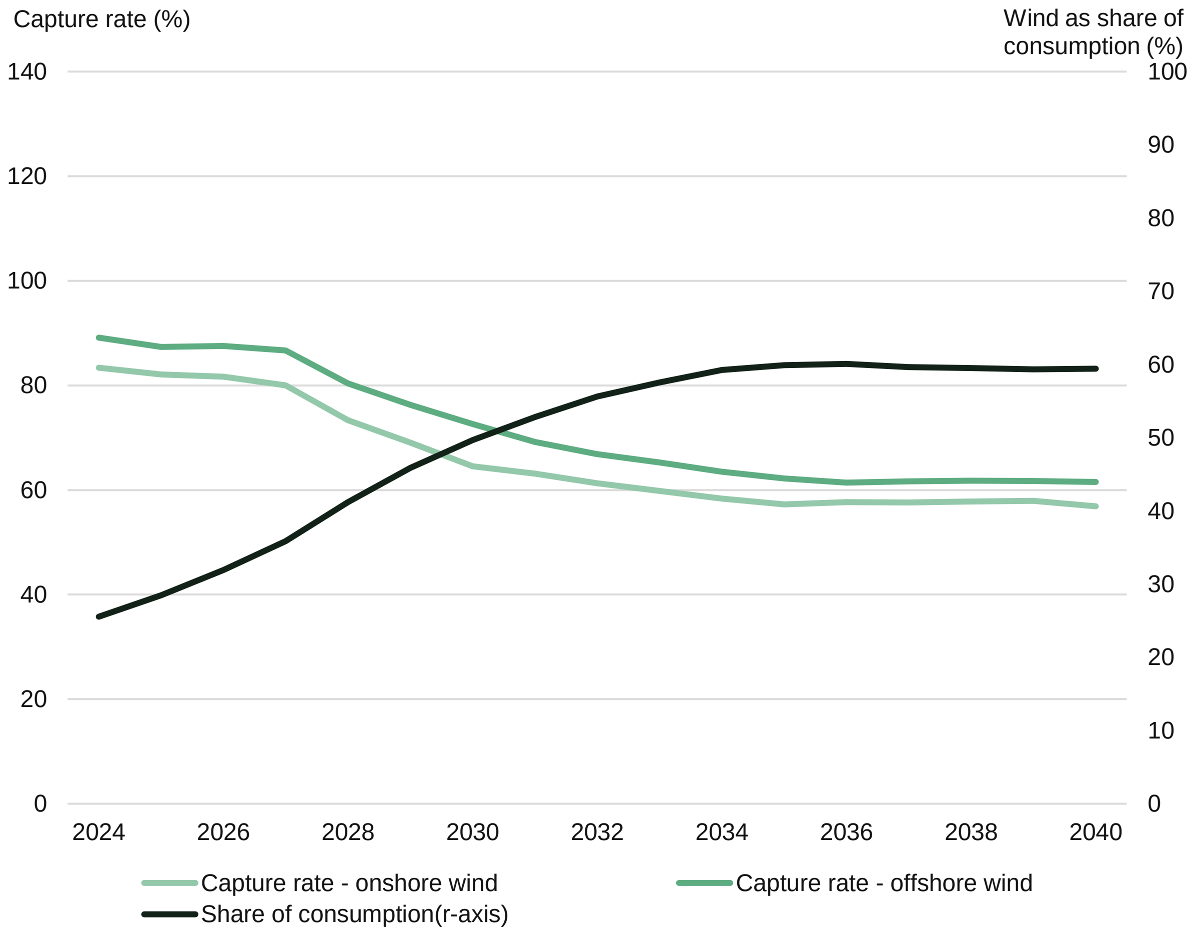
Sorce: Macrobond and own calculations
Note: Hour 0 is the period from 00.00 to 00.59. 2023 contains data until 3rd September

Country focus Germany

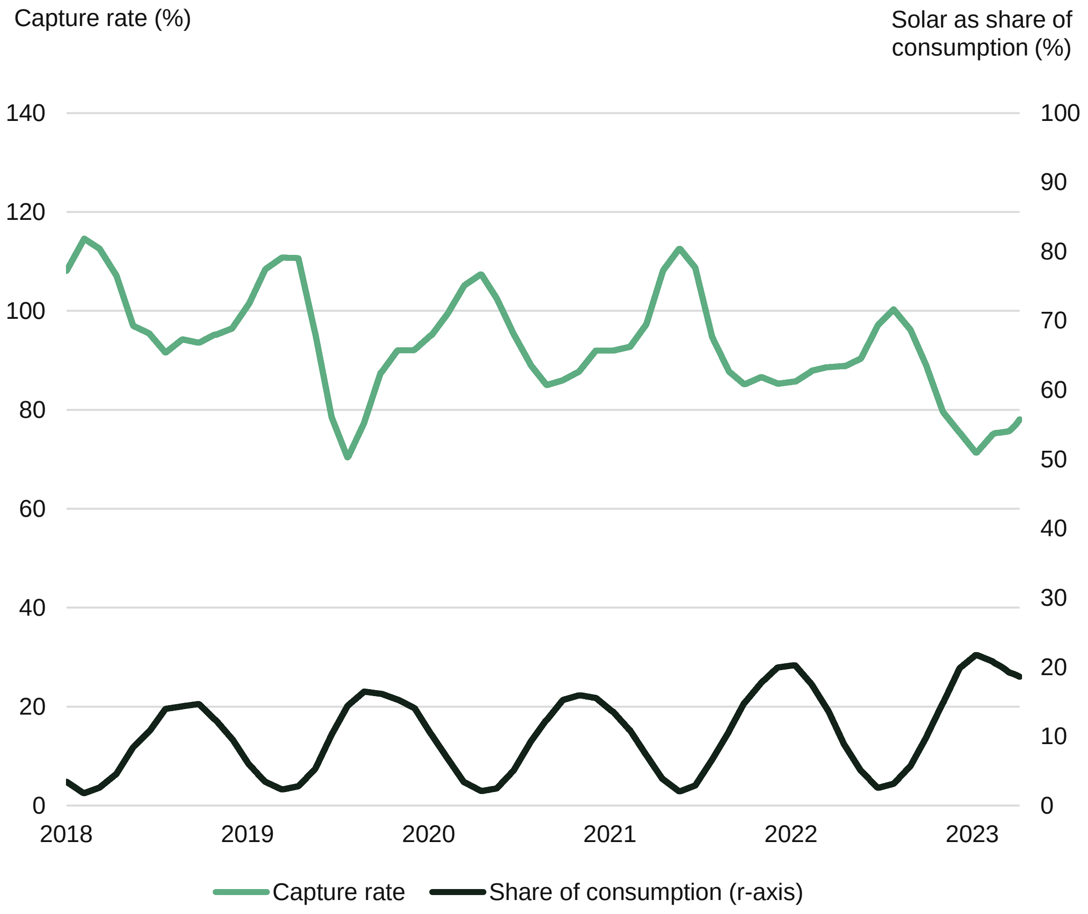
- Note: All data sources are reported in the methodology section near the end of the analysis.

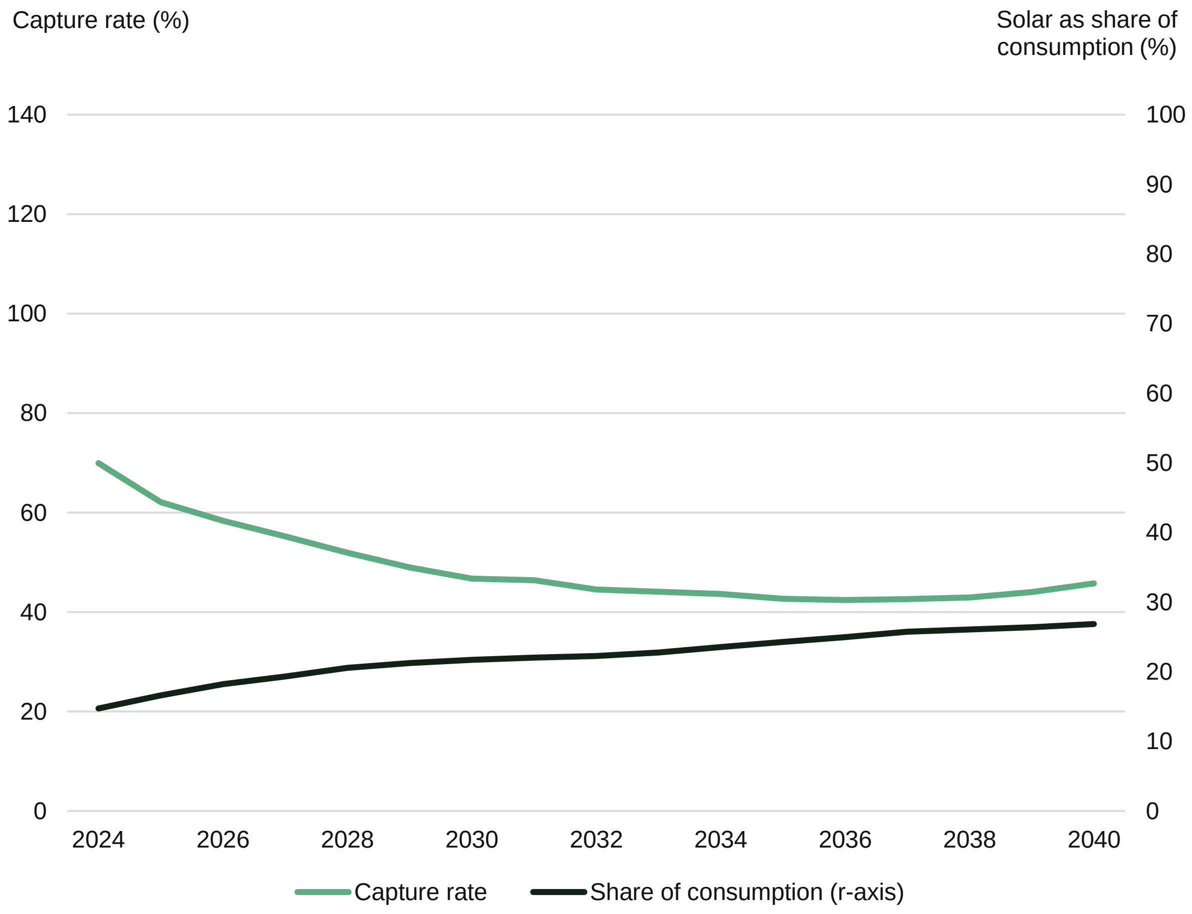
Germany
Wind power capture rates



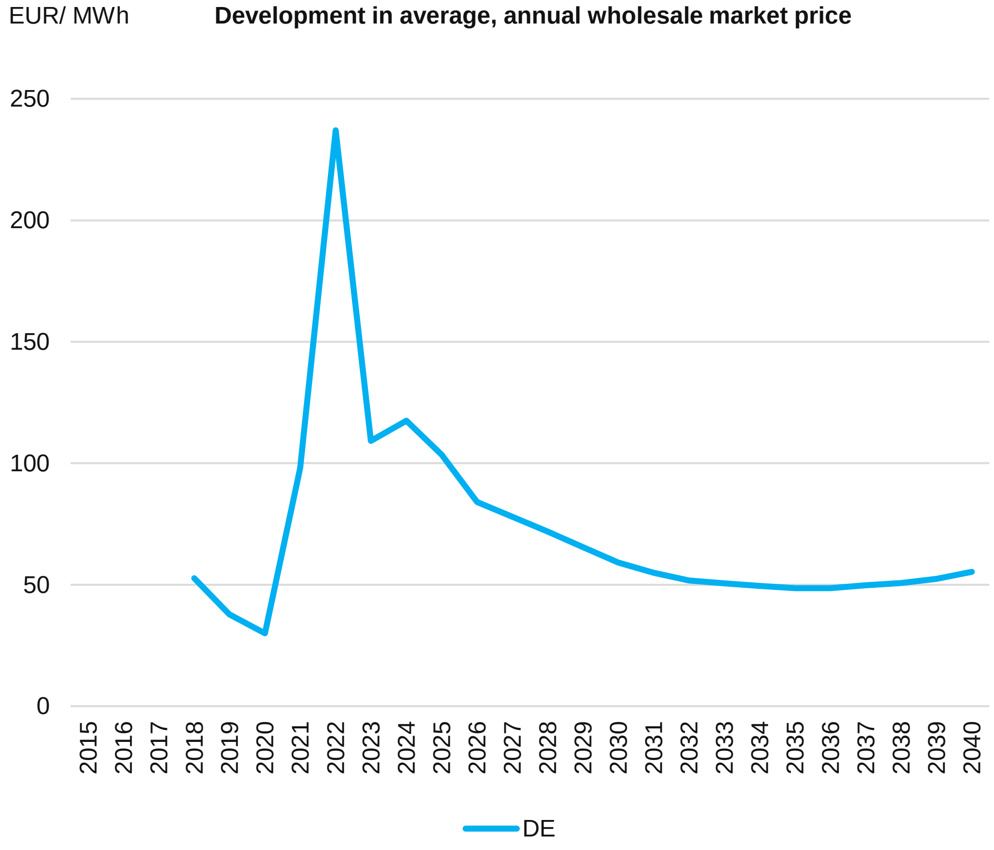


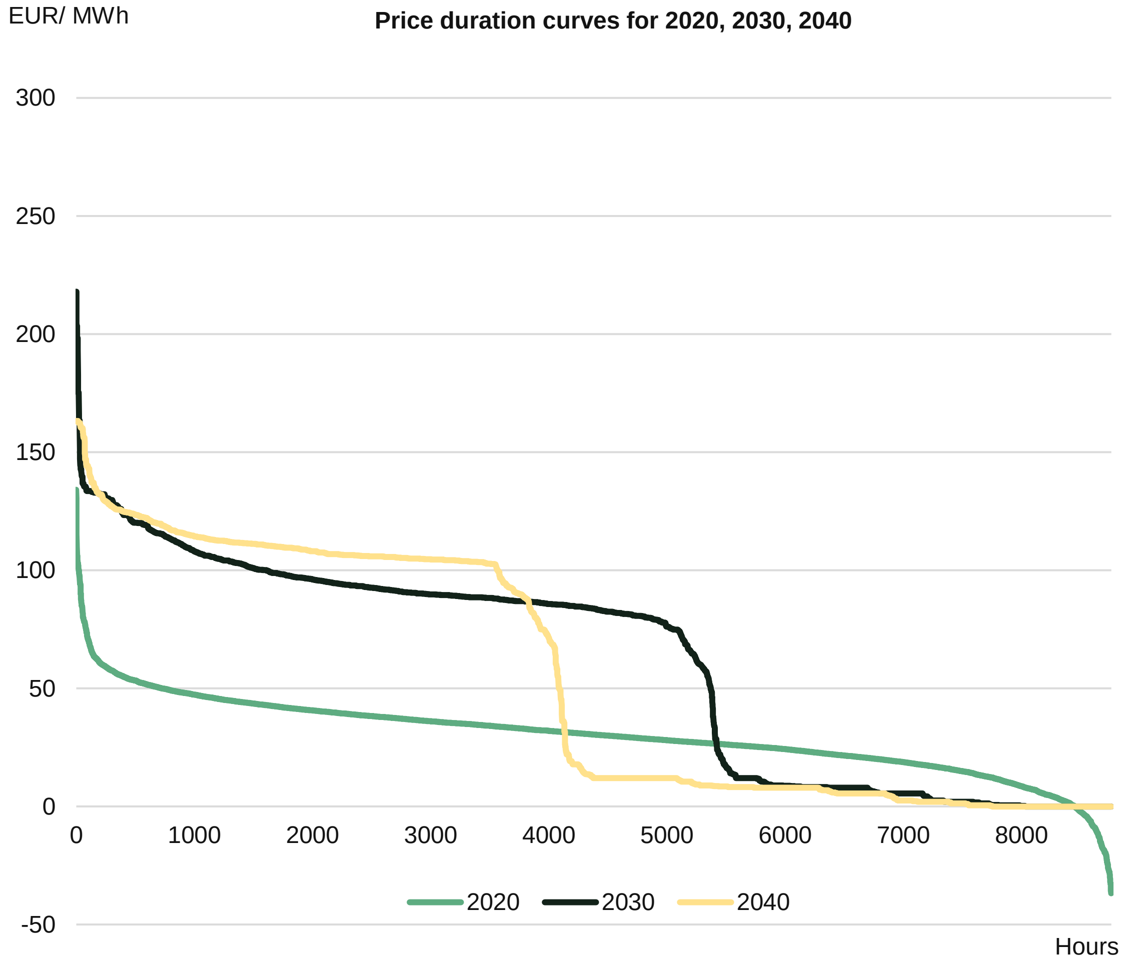
Germany
Solar power capture rates





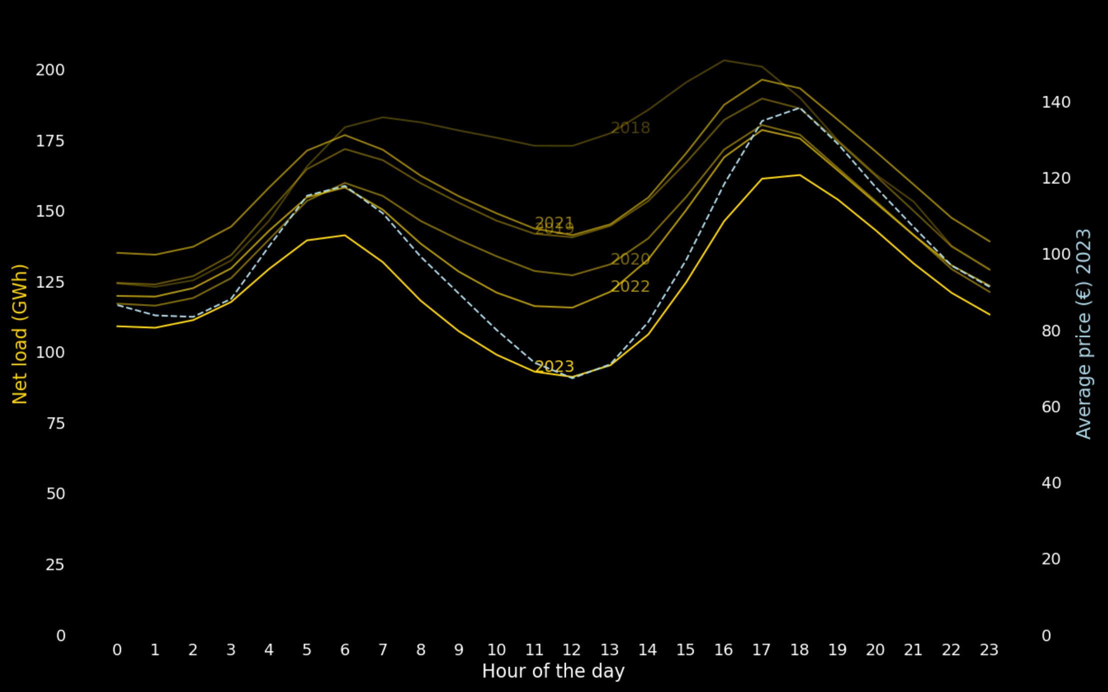
Germany
Price development and price dispersion





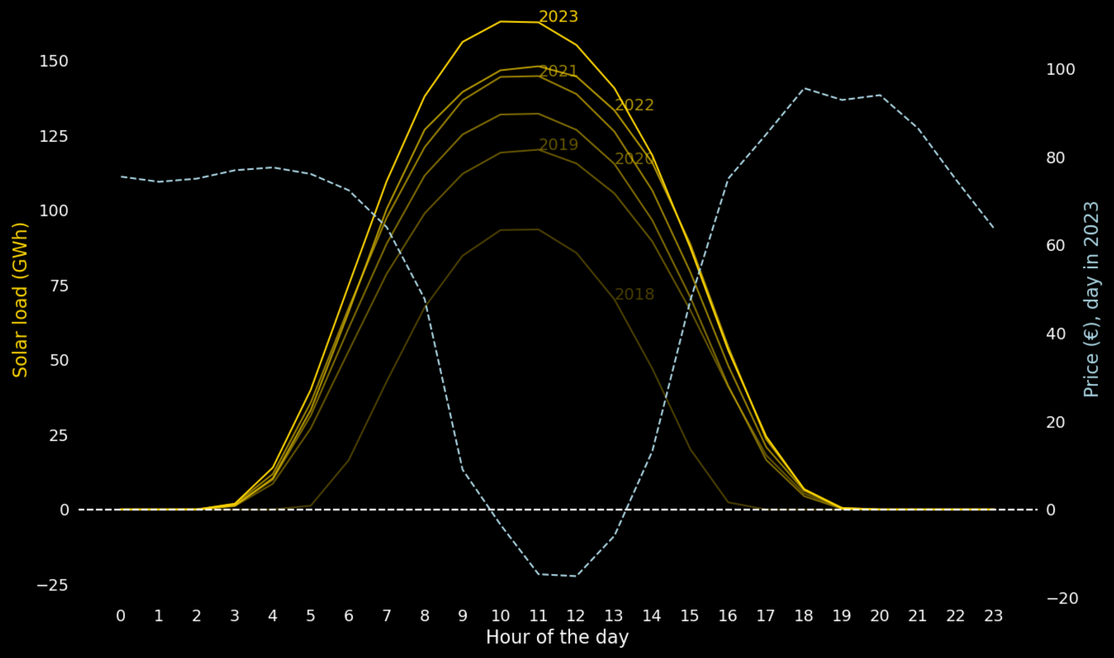
Germany
Duck curve

Average net load each hour of the day and year, 2018-2023



Sorce: Macrobond and own calculations
Note: Net load shown is demand minus wind and solar production. Hour 0 is the period from 00.00 to 00.59. 2023 contains data until 3rd September

The day with highest solar load each year, 2018-2023

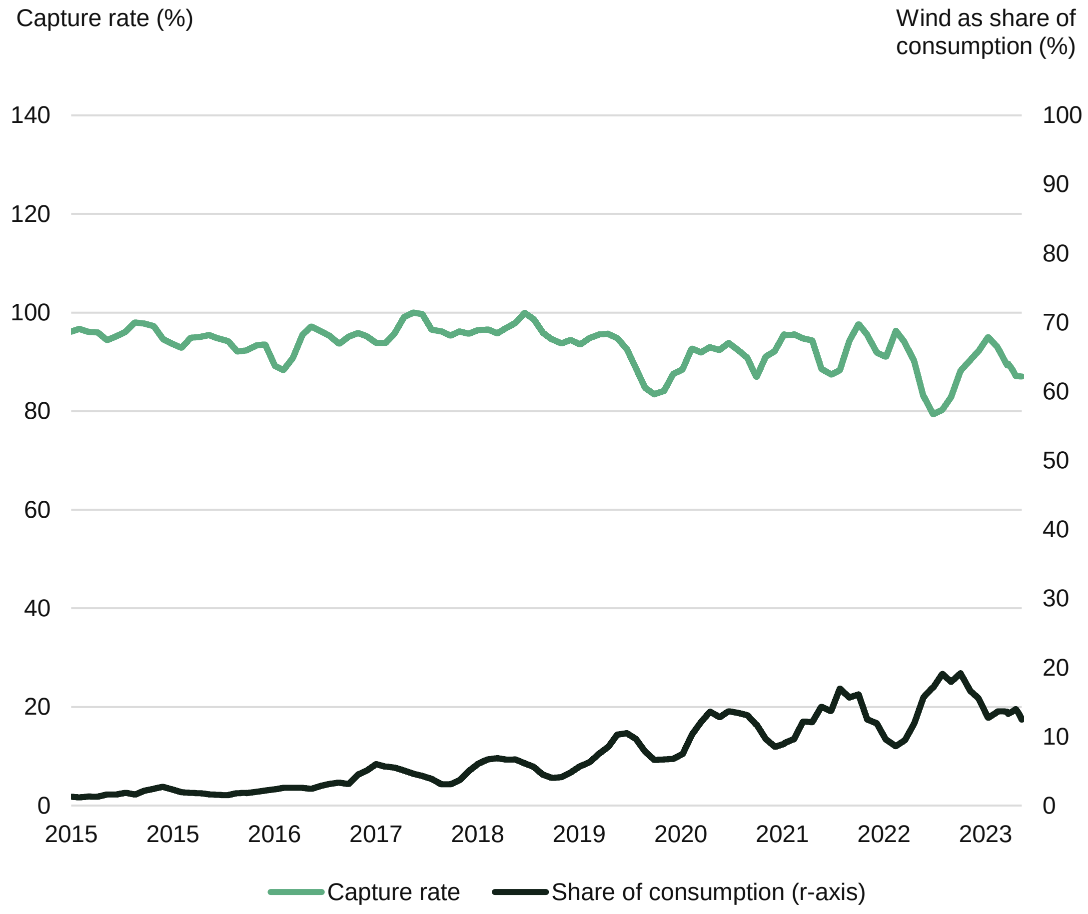


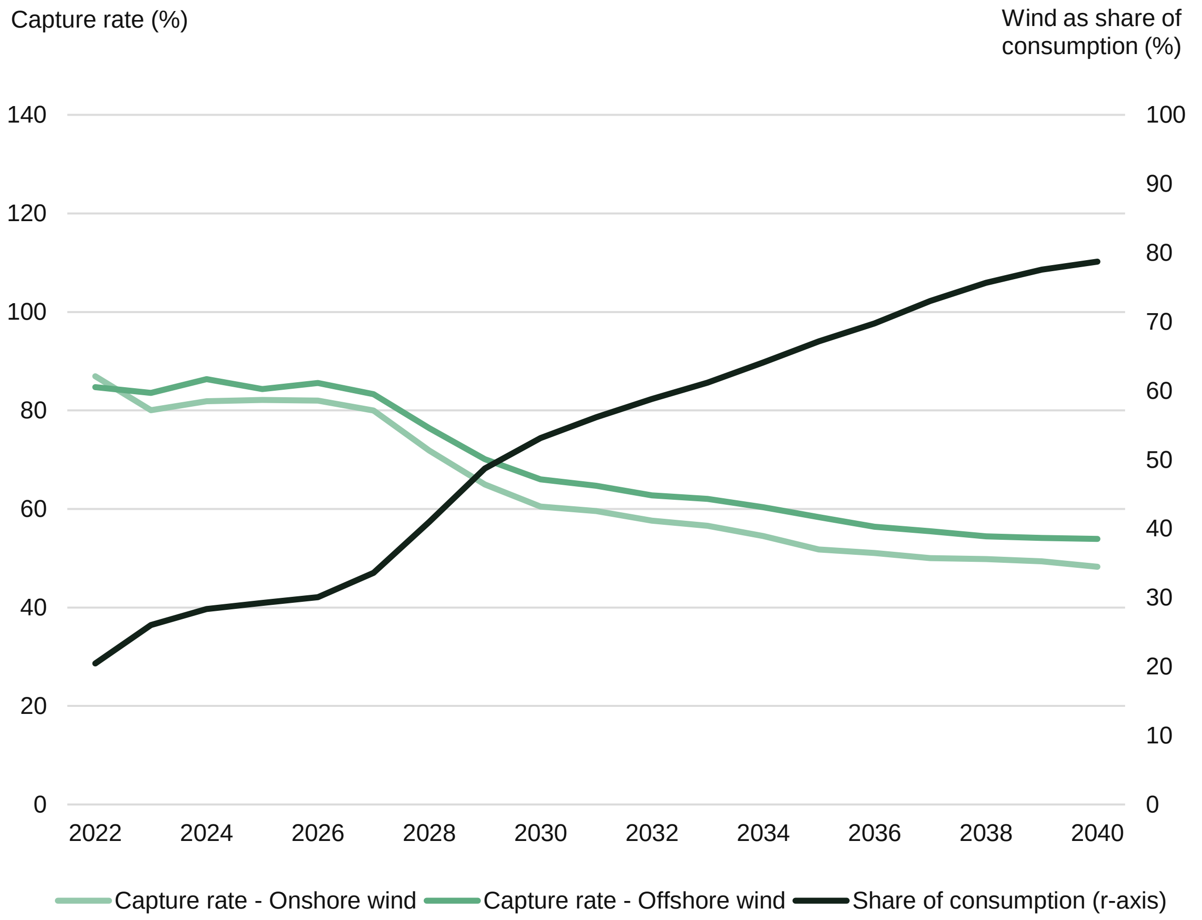
Sorce: Macrobond and own calculations
Note: Hour 0 is the period from 00.00 to 00.59. 2023 contains data until 3rd September

Country focus
The Netherlands

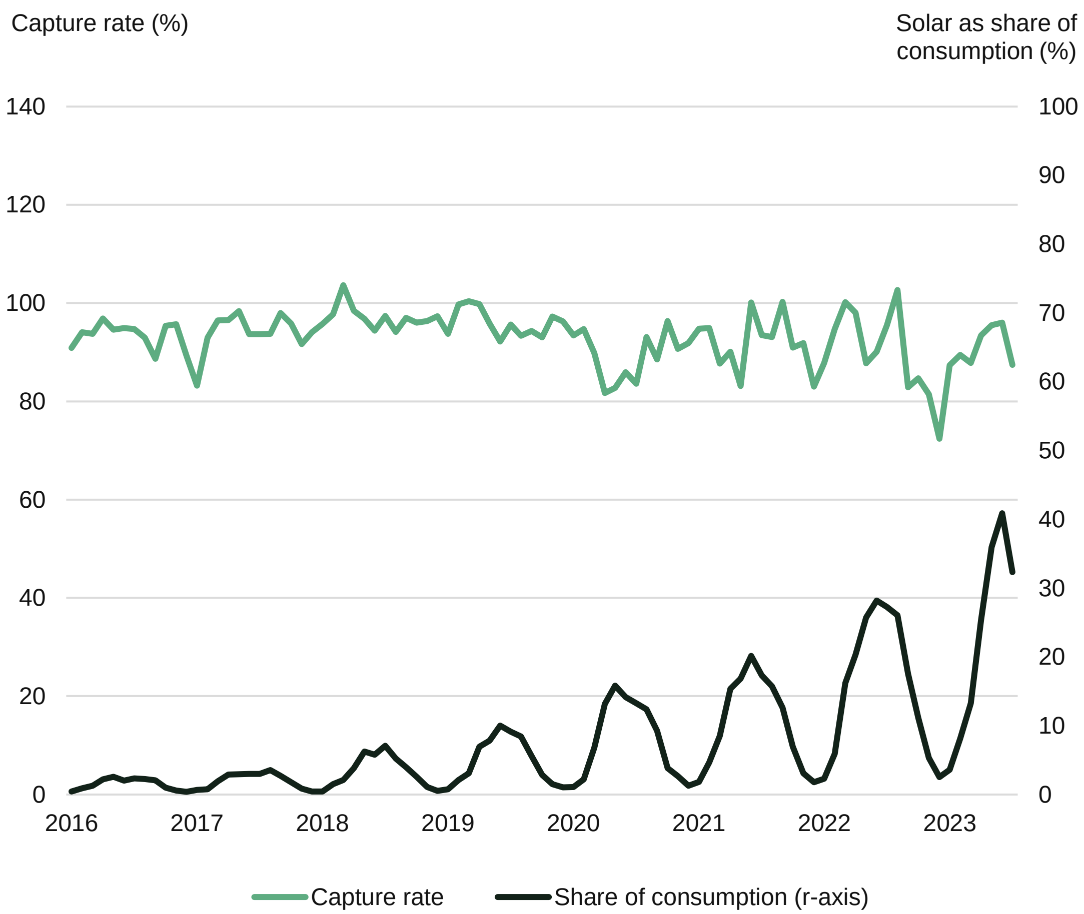
- Note: All data sources are reported in the methodology section near the end of the analysis.

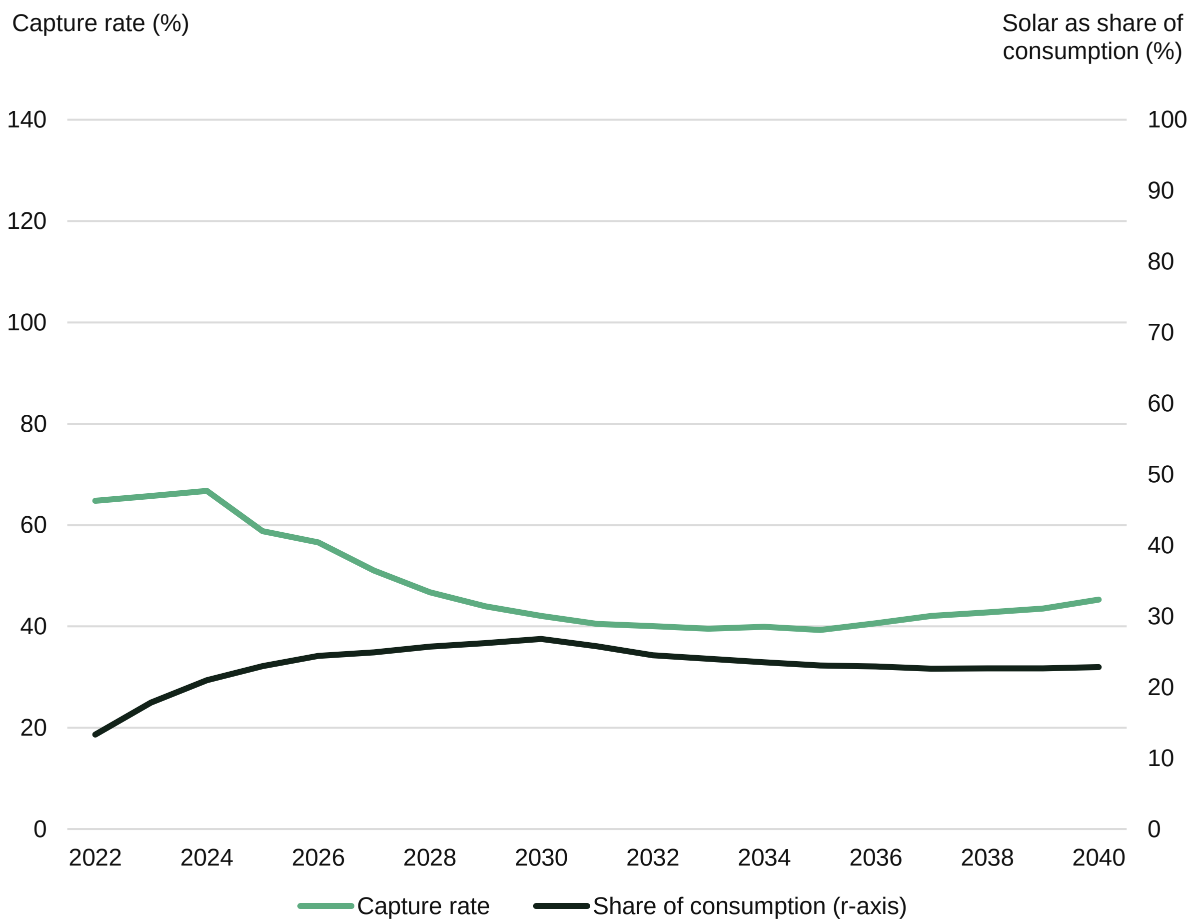
Netherlands
Wind power capture rates





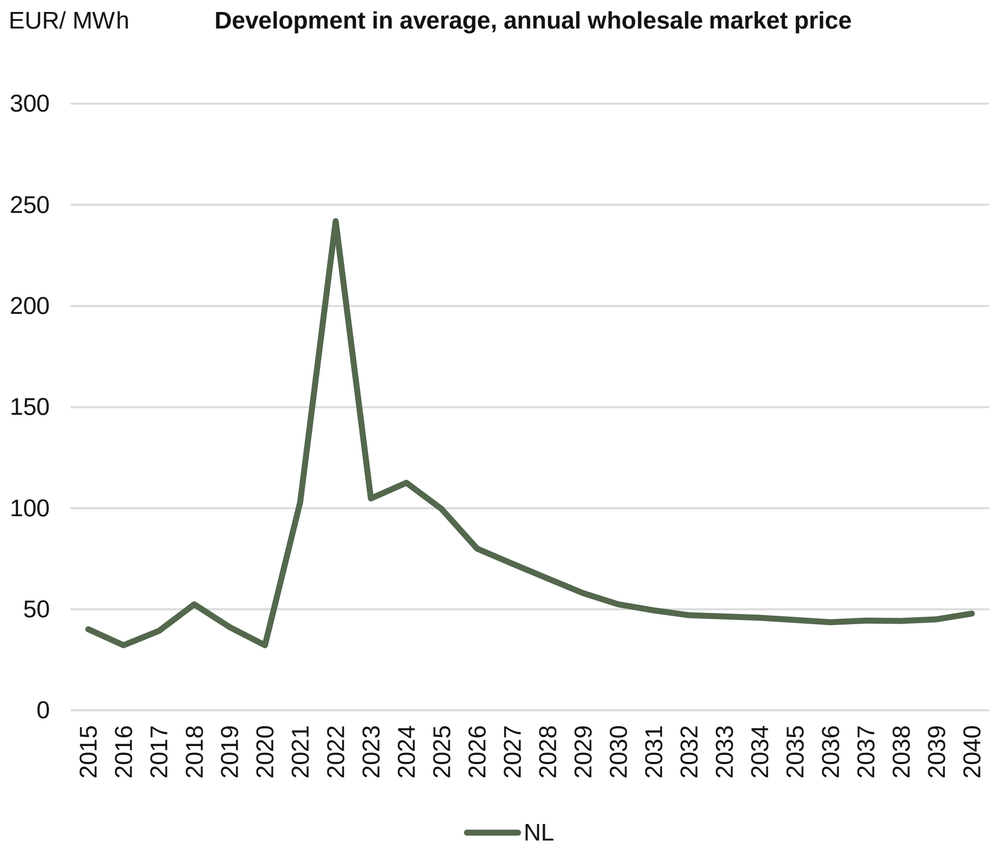
Netherlands
Solar power capture rates

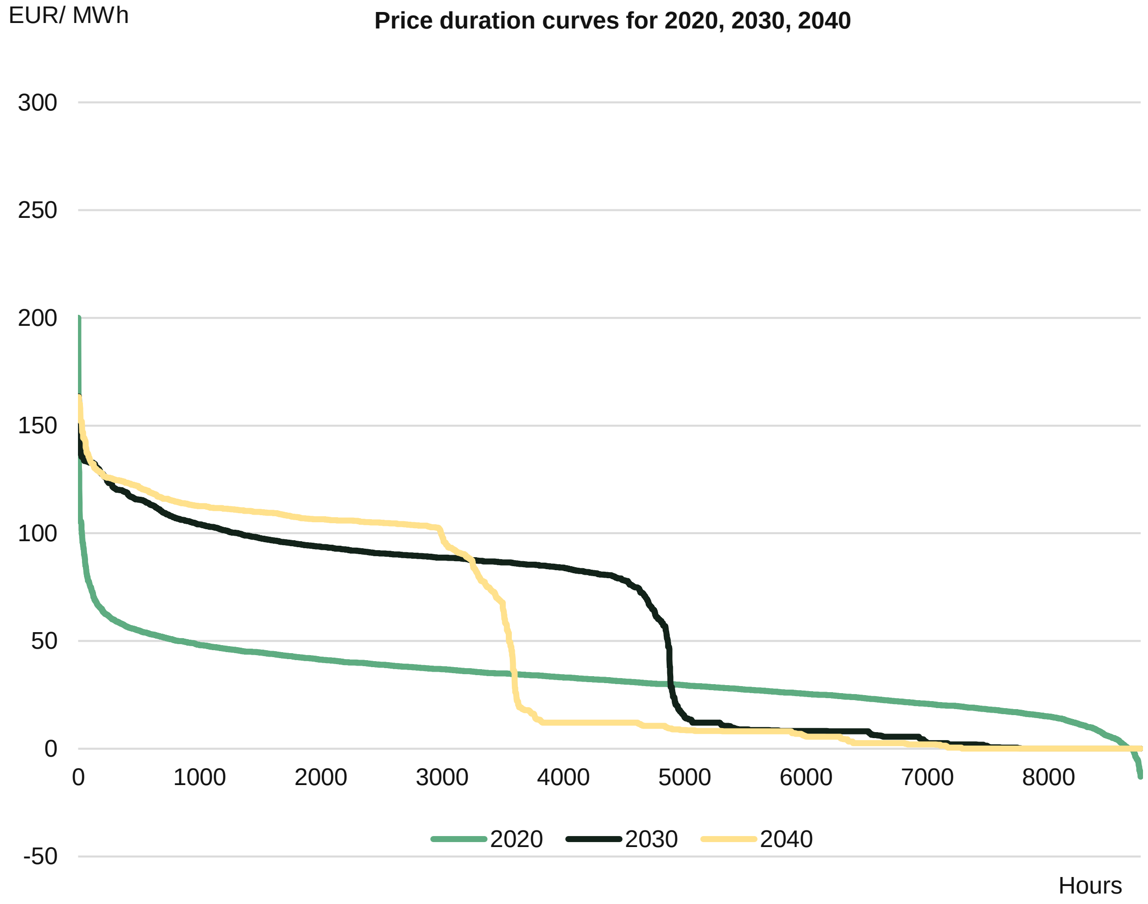




Note: Data from solar production is from opendata.dbs.nl and not ENSTO-E

Netherlands
Price development and price dispersion

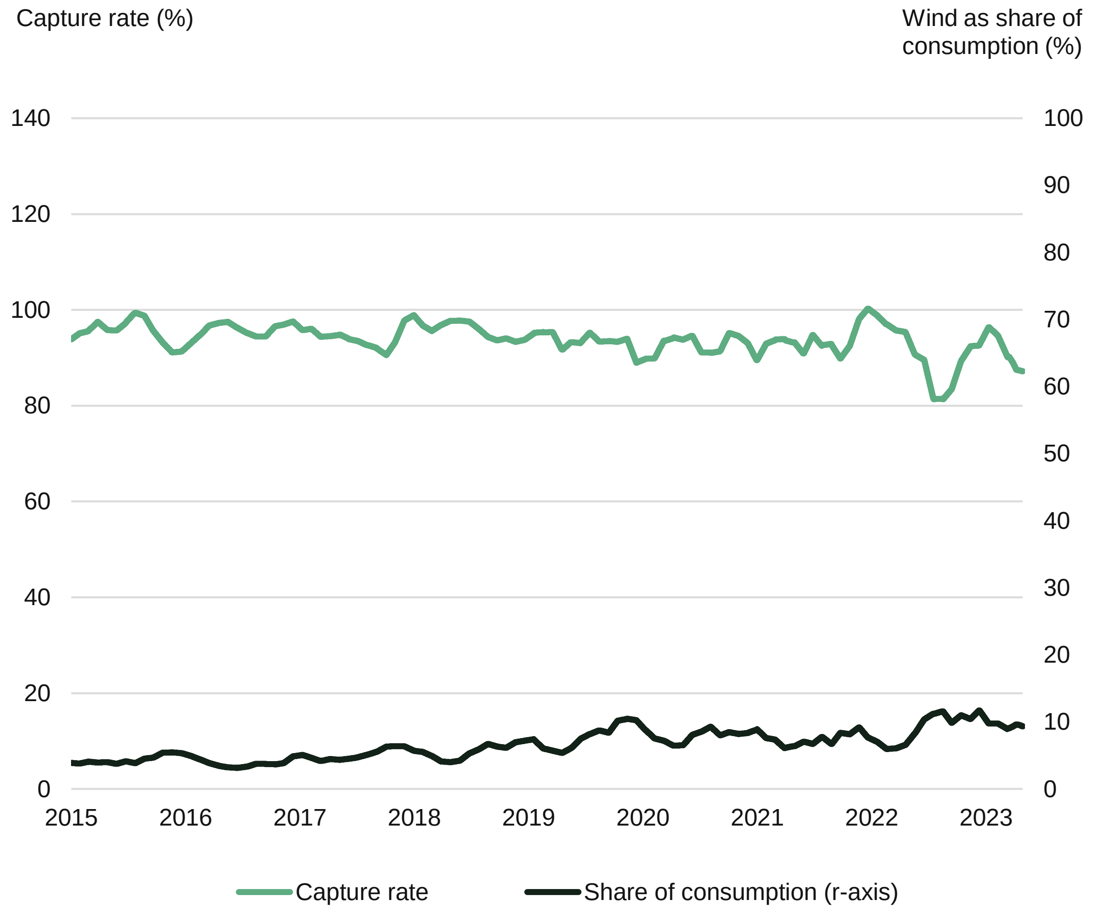


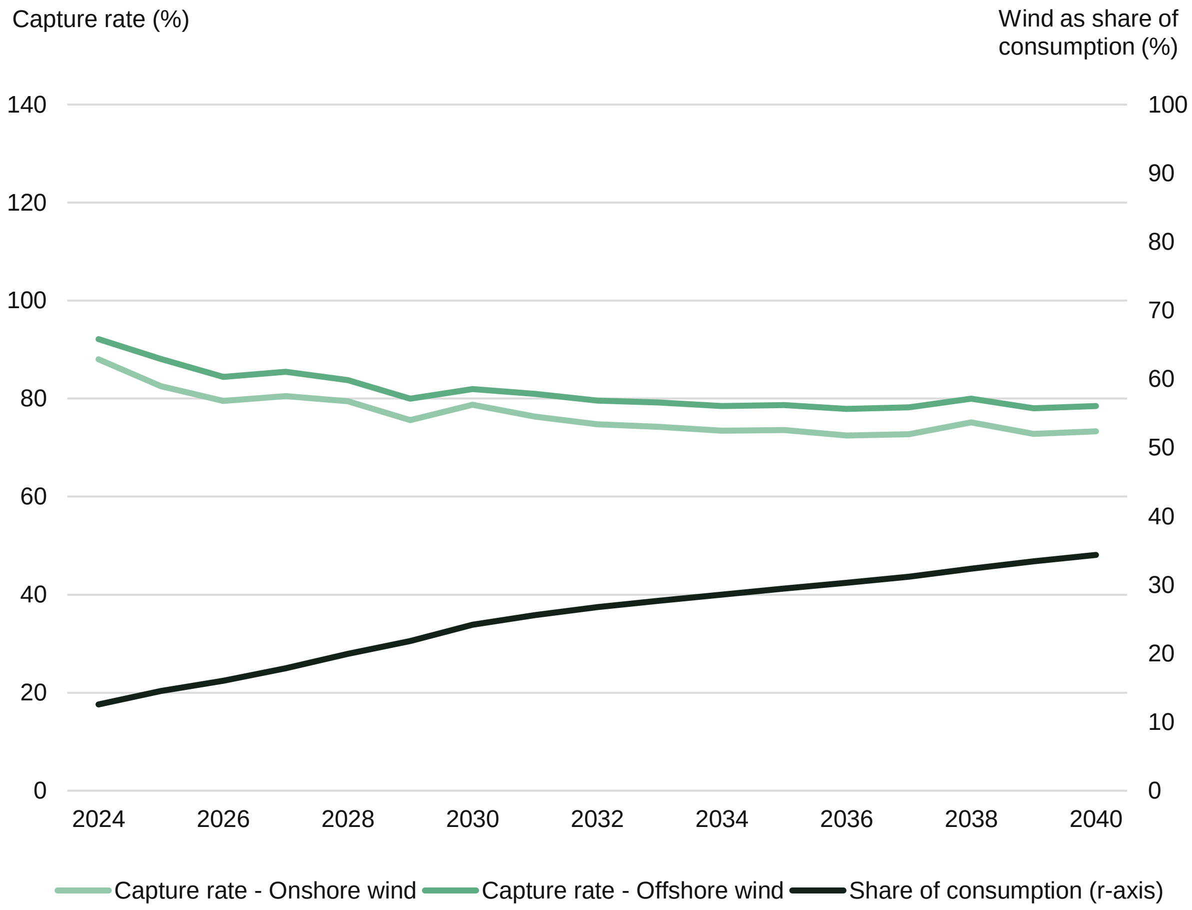


Country focus France

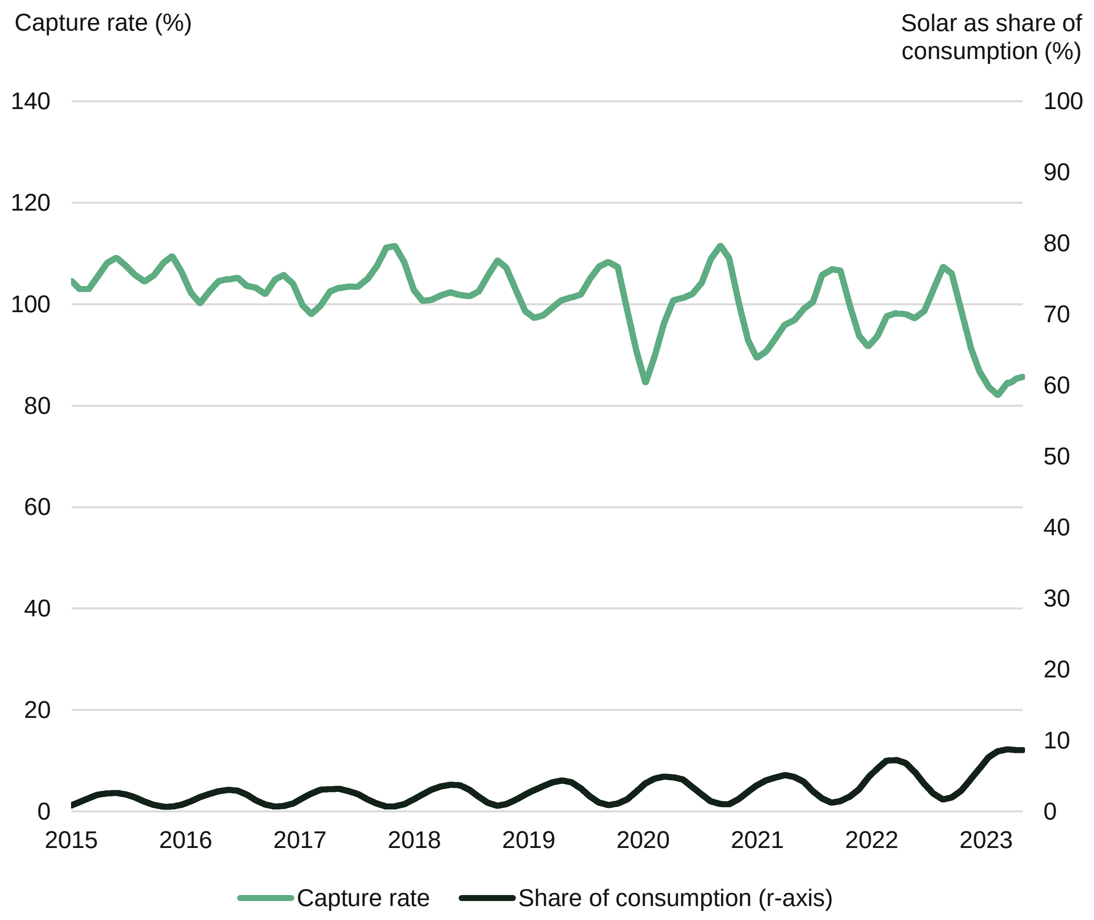
- Note: All data sources are reported in the methodology section near the end of the analysis.
- For the Netherlands, we only have monthly data on solar production and consumption (and not hourly data), and for this reason, we are unable to calculate the ‘duck curve’.

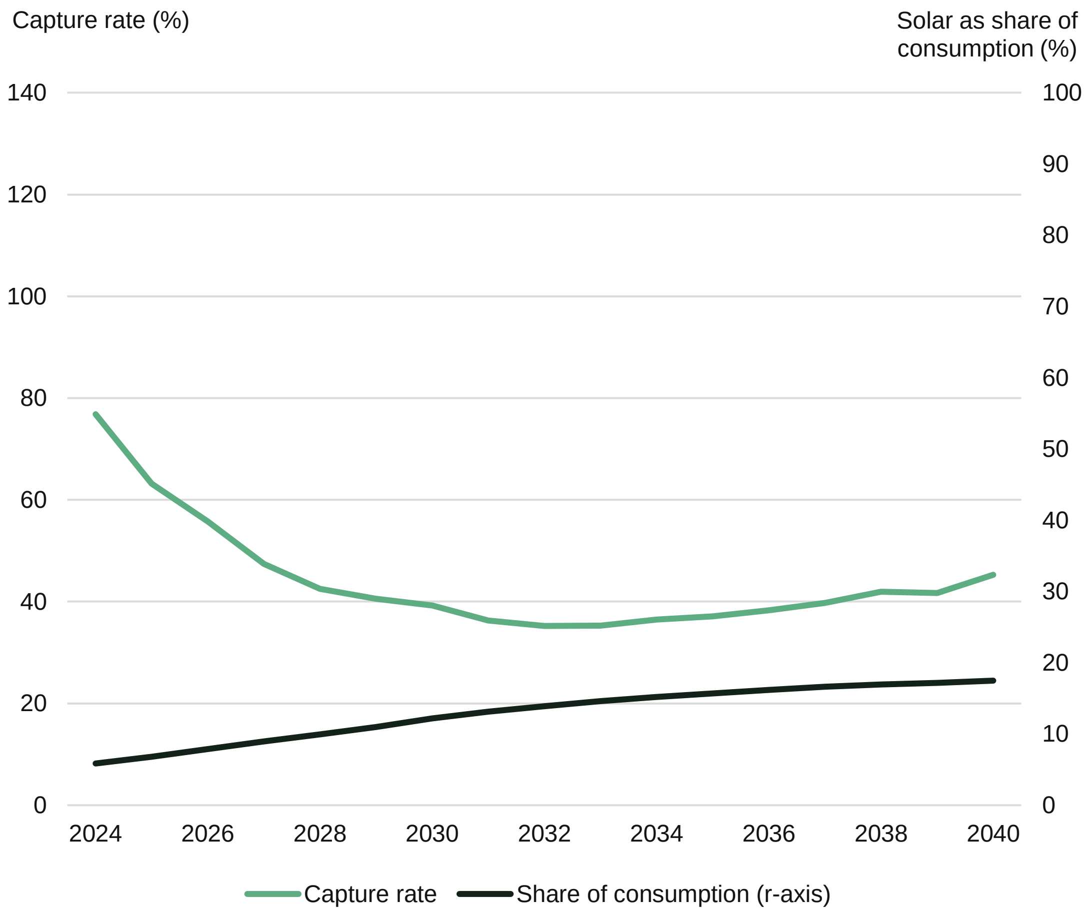
France
Wind power capture rates



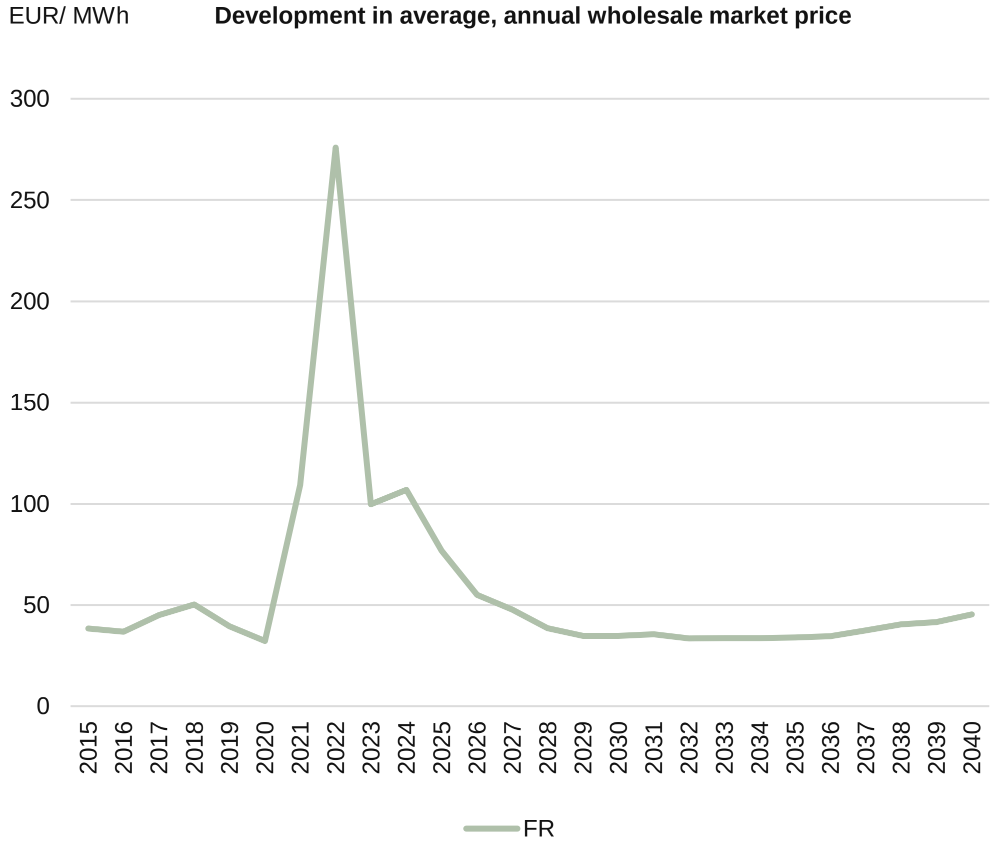


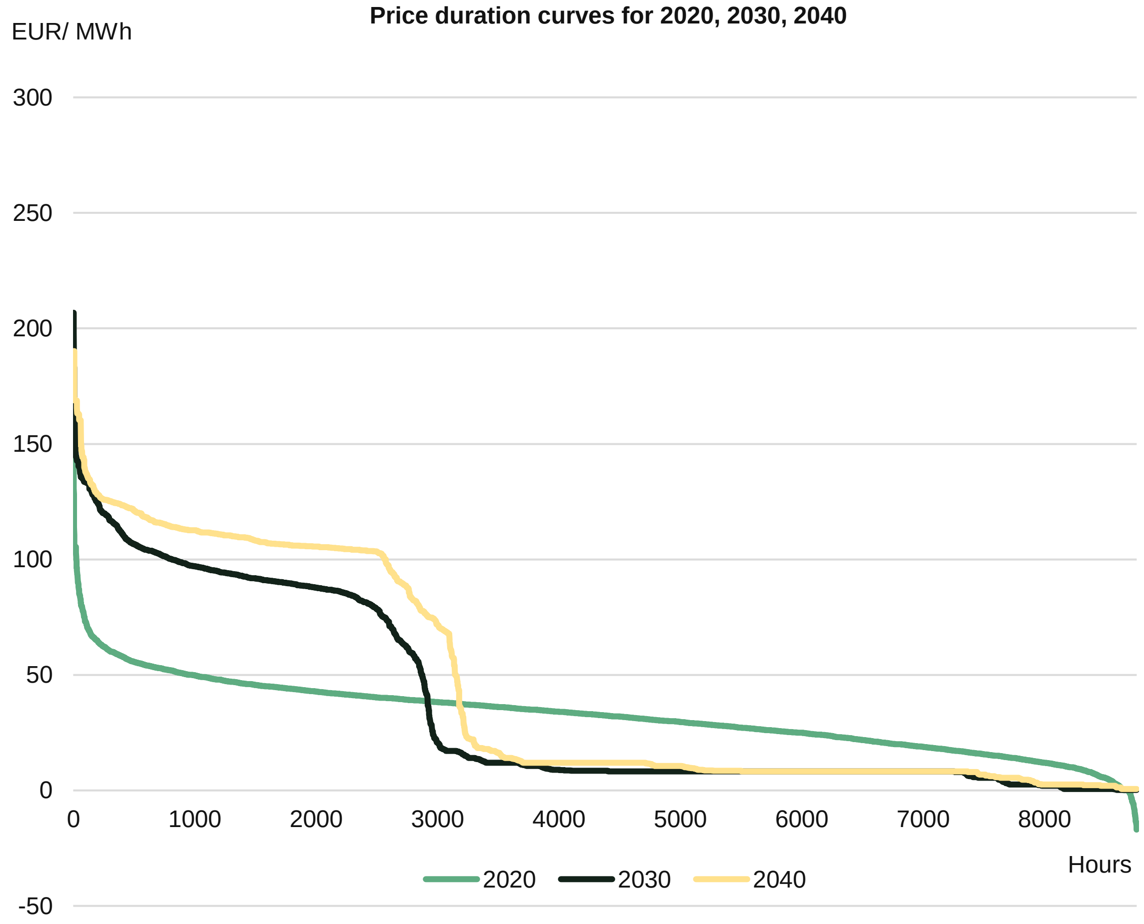
France
Solar power capture rates





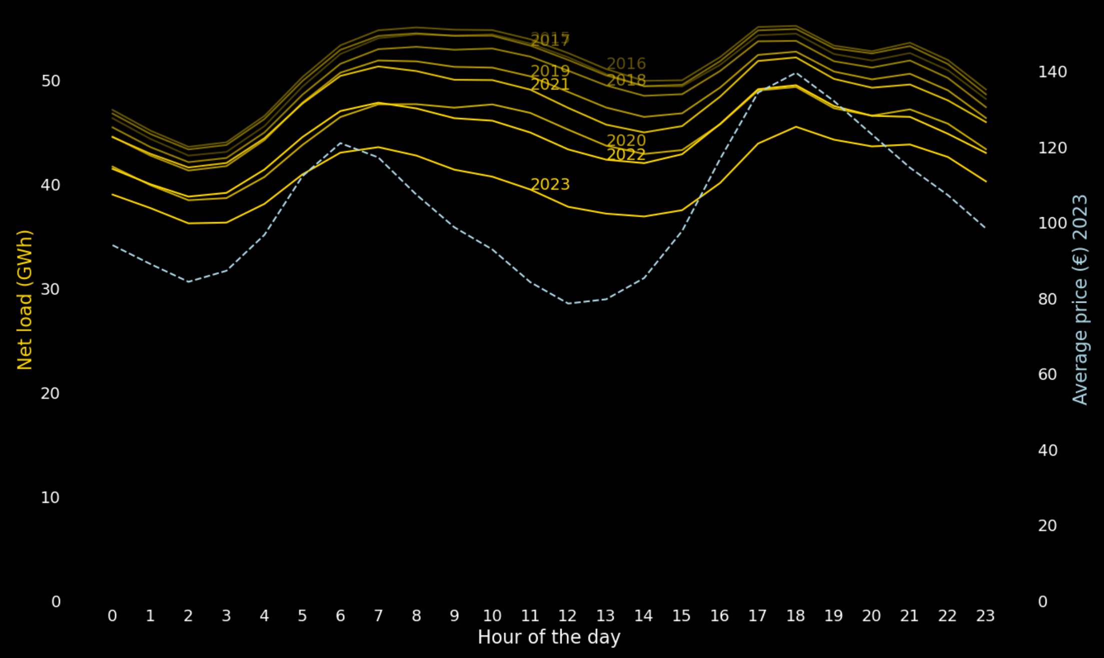
France
Price development and price dispersion





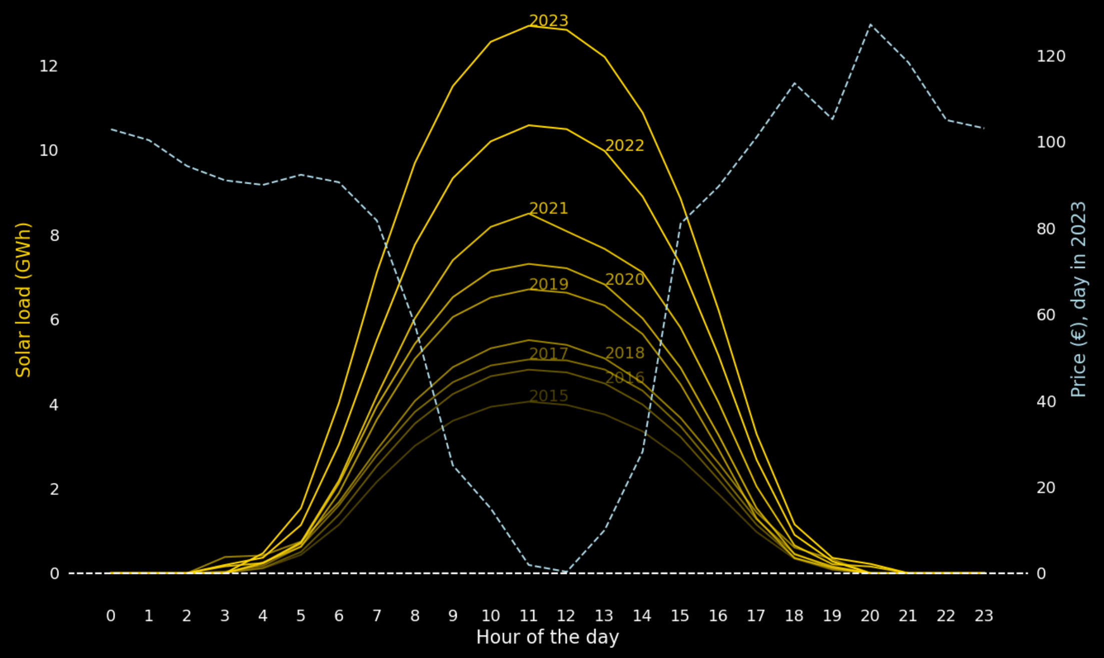
France
Duck curve

Average net load each hour of the day and year, 2015-2023



Sorce: Macrobond and own calculations
Note: Net load shown is demand minus wind and solar production. Hour 0 is the period from 00.00 to 00.59. 2023 contains data until 3rd September

The day with highest solar load each year, 2015-2023

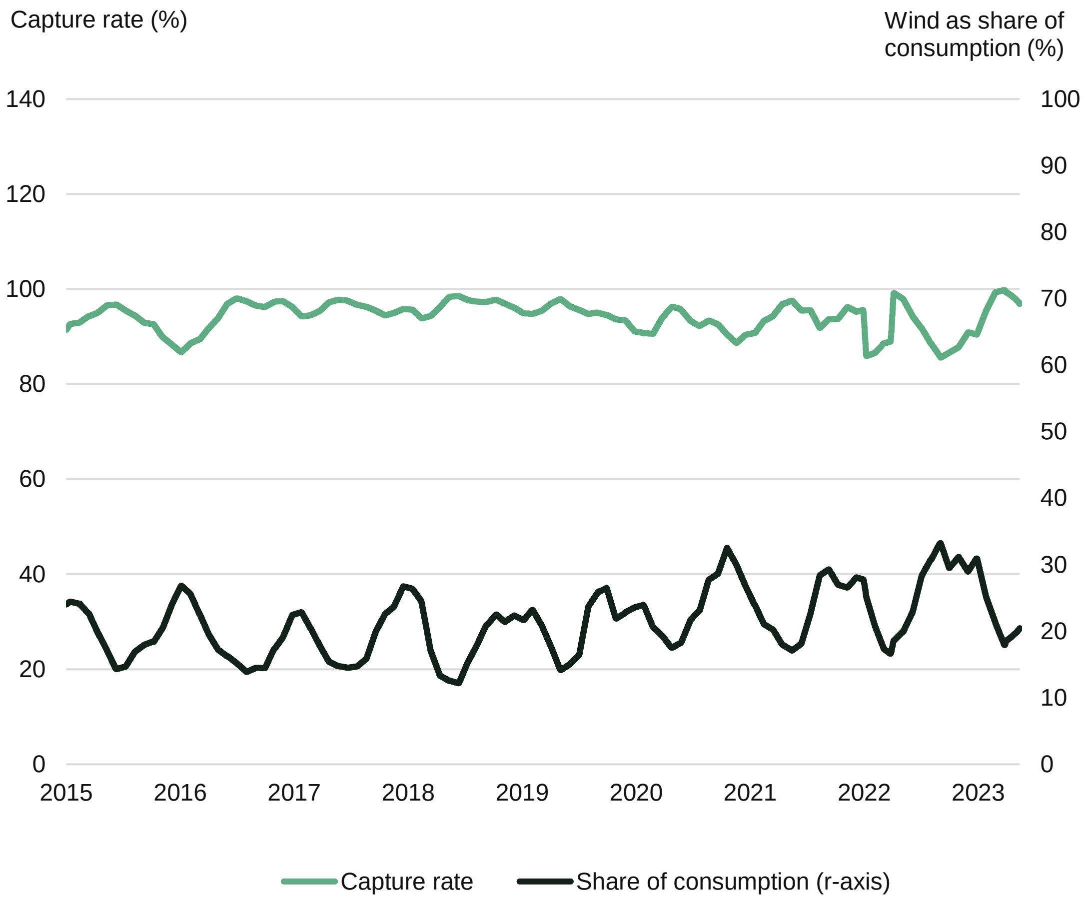


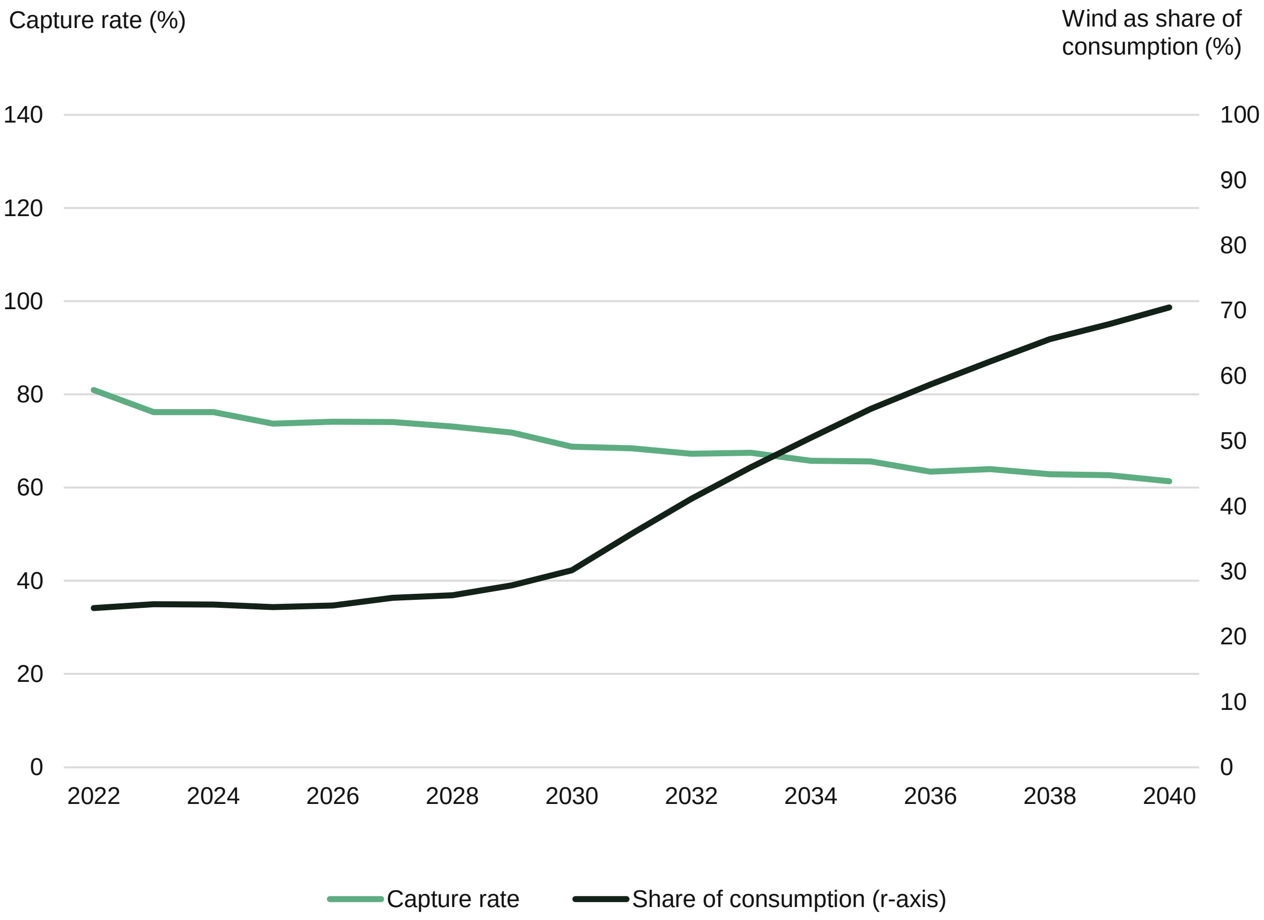
Sorce: Macrobond and own calculations
Note: Hour 0 is the period from 00.00 to 00.59. 2023 contains data until 3rd September

Country focus
Spain

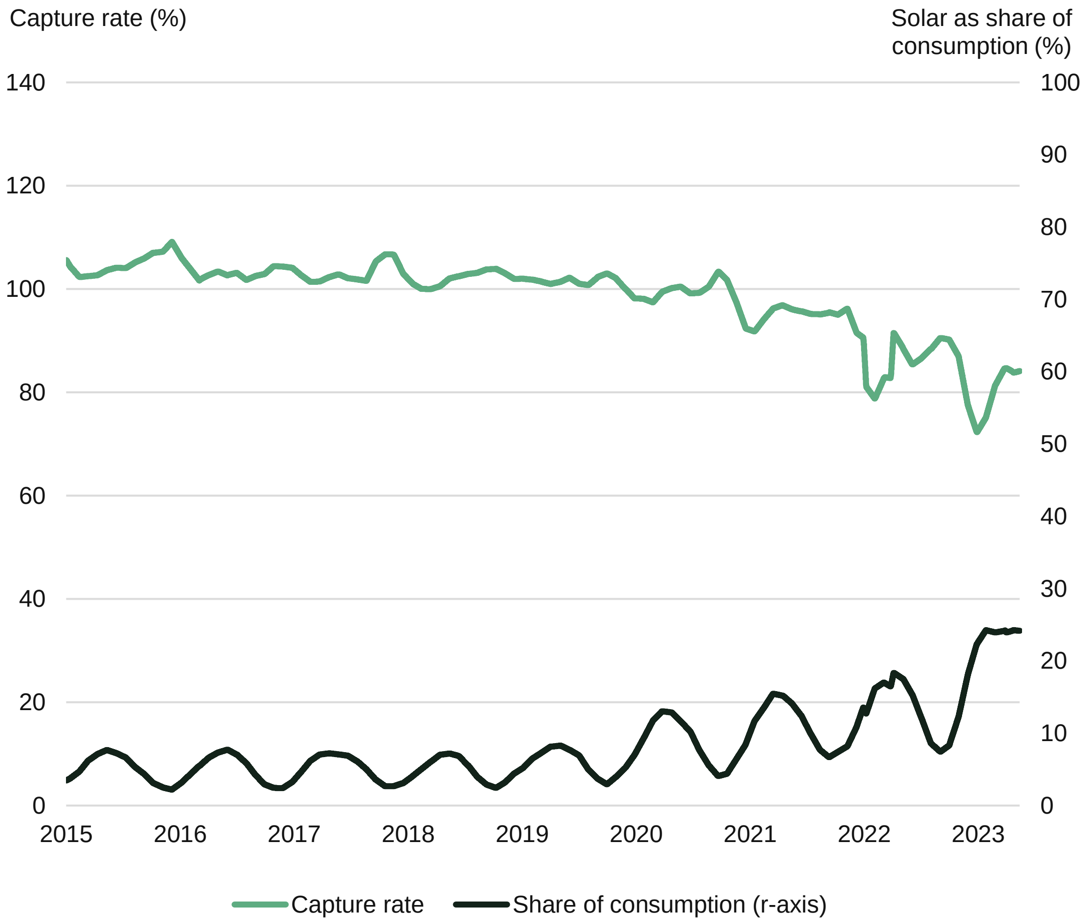
- Note: All data sources are reported in the methodology section near the end of the analysis.

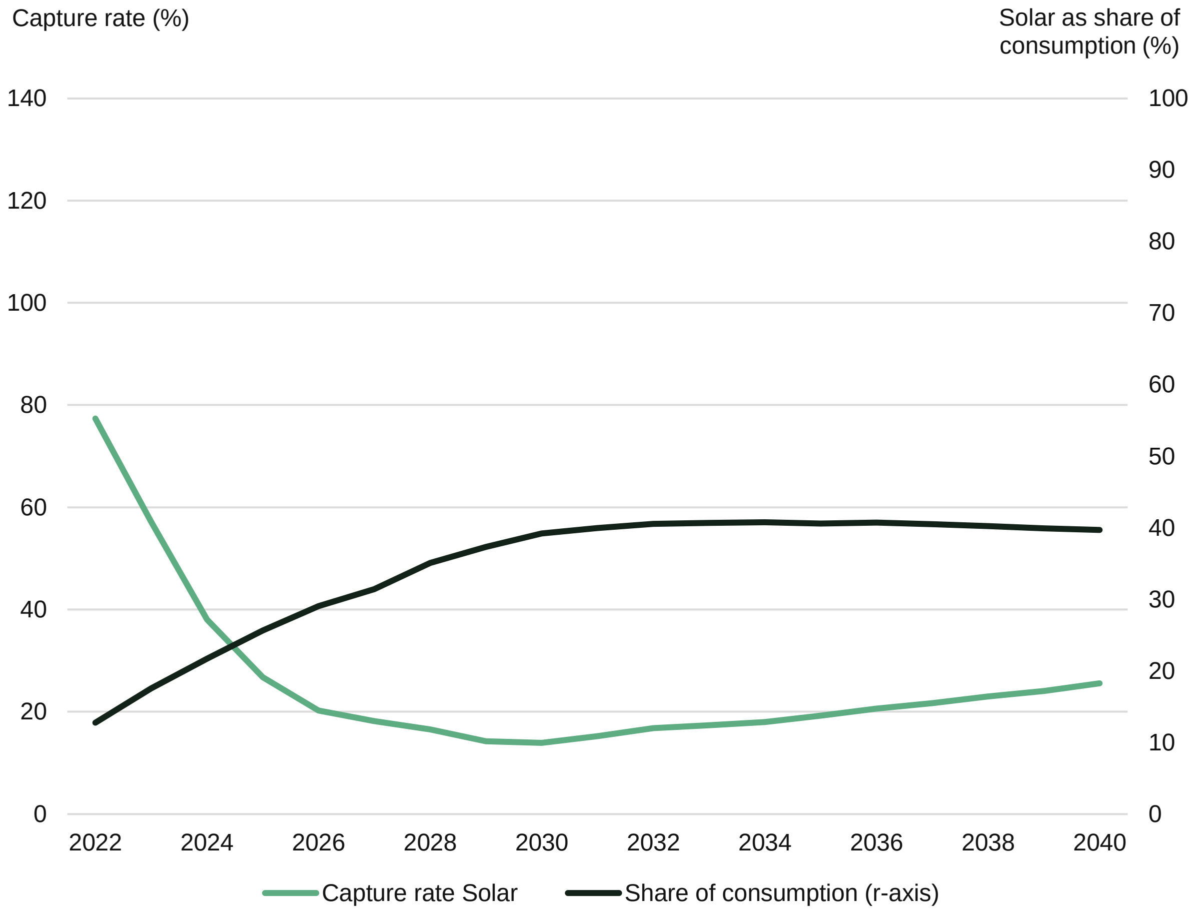
Spain
Wind power capture rates





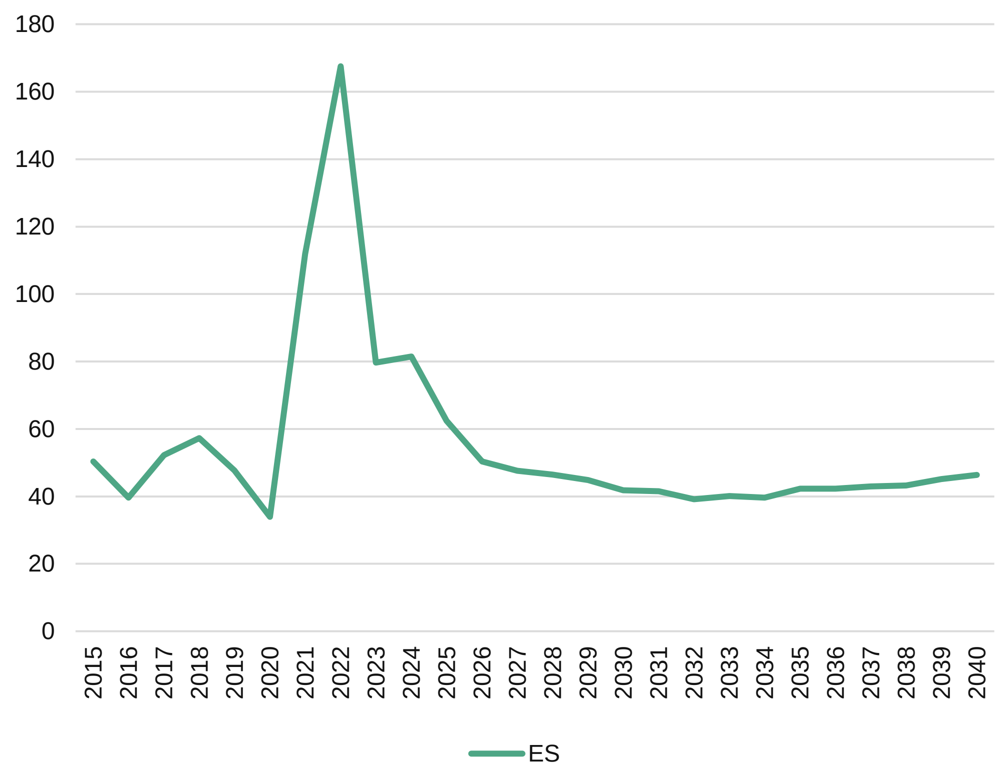
Spain
Solar power capture rates



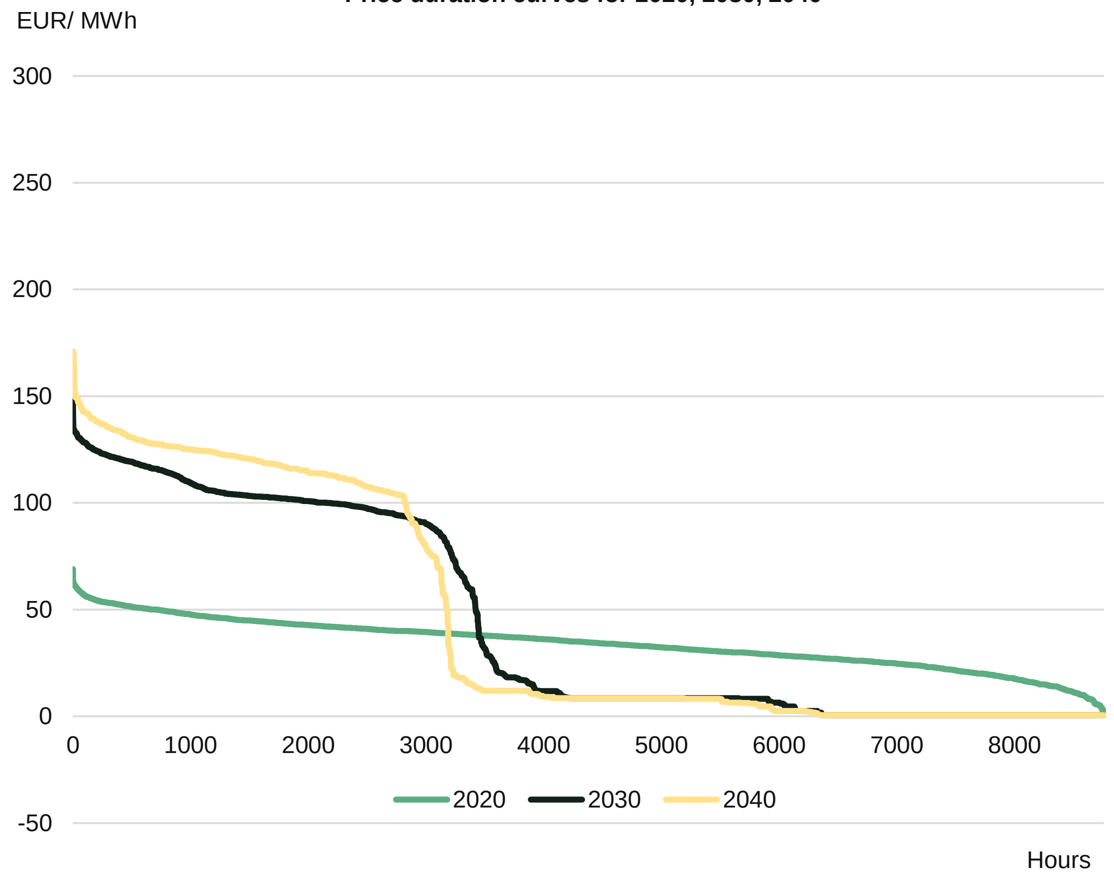


Spain
Price development and price dispersion

EUR/ MWh **Development in average, annual wholesale market price**

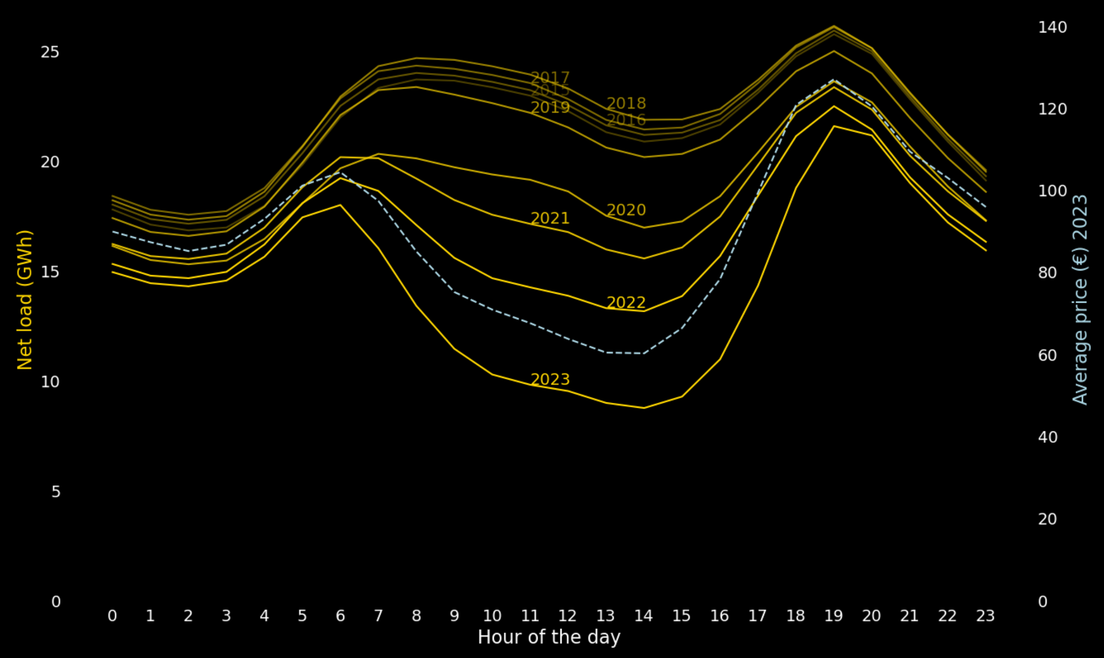


Price duration curves for 2020, 2030, 2040



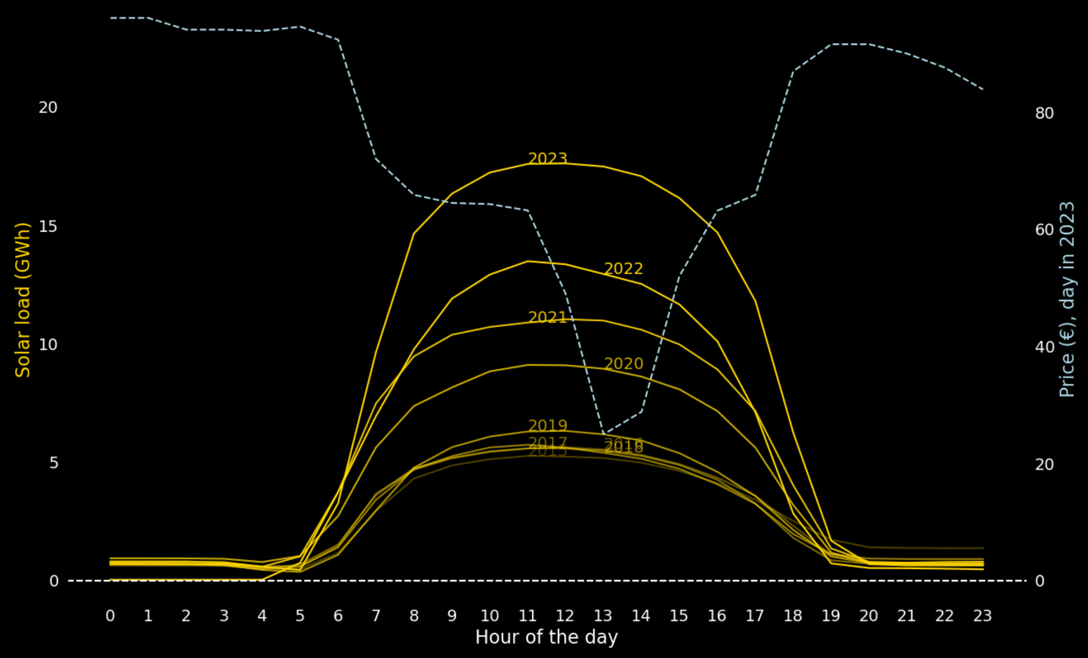
Spain
Duck curve

Average net load each hour of the day and year, 2015-2023



Sorce: Macrobond and own calculations
Note: Net load shown is demand minus wind and solar production. Hour 0 is the period from 00.00 to 00.59. 2023 contains data until 3rd September

The day with highest solar load each year, 2015-2023



Sorce: Macrobond and own calculations
Note: Hour 0 is the period from 00.00 to 00.59. 2023 contains data until 3rd September

Notes, methodology, and sources

Notes and methodology

- Gliding average for capture rate figures

For historical data, share of consumption and capture rates are shown as a three-month gliding average.

- Electricity production measure

Total production is calculated as the sum of production from individual sources available in ENTSO-E.

- Forecasted prices are real 2022 prices

Forecasted data are from S&P. S&P use real 2022 prices, meaning they are inflation corrected to reflect 2022 prices.

- Different time interval between transactions in the day ahead market

Some markets function with prices set on a quarterly or half-hourly basis. The pricing in these markets has been converted to an hourly average, and the corresponding production and demand has been calculated to an hourly level by summing either the quarterly or the half-hourly data points.

Sources

- Historical data based on ENTSOE’s Transparency Platform via Macrobond.
- Forecasts on prices, production, and consumption delivered by Connect by S&P.
- For the Netherlands, solar production and consumption is from opendata.dbs.nl.