



Zero
Carbon
Analytics

Energy systems in transition: EU and US

REPORT OCTOBER 2023

Energy systems in transition: EU and US

REPORT OCTOBER 2023

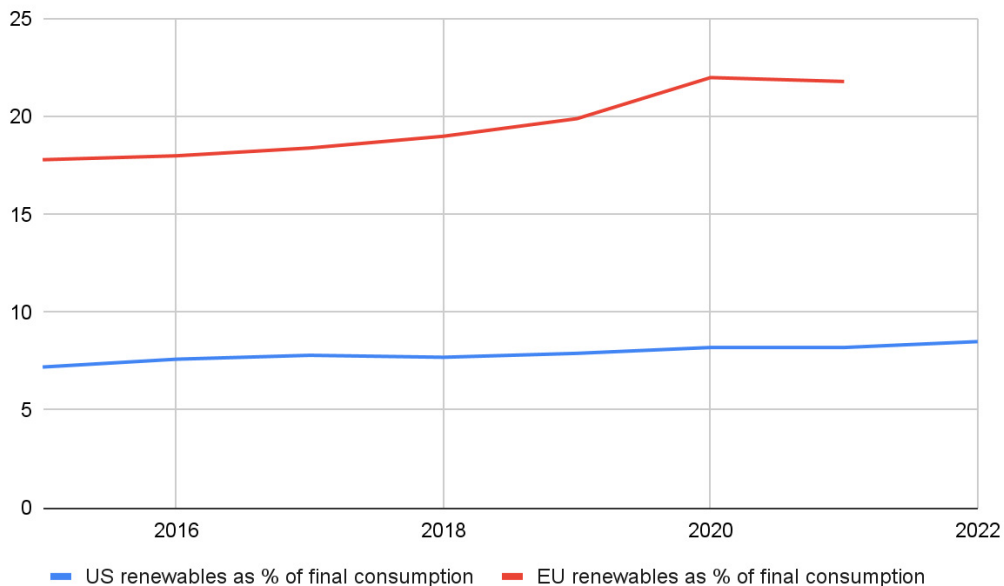
- Installations of wind and solar capacity are gathering speed in the EU and US. A record-breaking 33 GW of solar PV will be built in the US in 2024. New wind projects in the EU are also breaking records, growing by about 18% in 2022.
- Renewables generate more electricity than either coal or nuclear power in both the US and EU. Wind and solar generated enough electricity in 2022 to power about 85% of all households in the EU.
- Private equity firms have committed more than USD 100 billion in renewable energy investments eligible for tax credits since the US Inflation Reduction Act was passed.
- The US has already attracted USD 84 billion dollars in investments for energy transition manufacturing and has doubled its battery storage capacity, solidifying its position as a key player in the energy storage market.
- In Q2 2023, the US witnessed an exponential surge in EV sales of 48.9% YoY, with a record 361,000 passenger EVs sold.
- Europe ranks second in global EV sales, with 784,000 passenger EVs sold in Q2 2023. Norway stands out with EVs accounting for 90% of passenger car sales in the second quarter of 2023, driven by tax cuts and an extensive charging network.
- In 2022, Europe sold a record 3 million heat pumps, marking a 38% growth in sales. The EU leads in heat pump investments, contributing over a quarter of global funding.

We are at a pivotal moment in our response to climate change. We are off track, but meaningful action is happening, often faster than we think, and momentum is building towards an exponential shift in our energy systems. Some countries are getting ahead of the curve by taking significant steps towards decarbonisation, while at the same time building new industries, creating jobs, reducing dependence on energy imports and insulating consumers from volatile fossil fuel prices. This briefing presents evidence of where and how this is happening.

Building a net zero future

The United States and the European Union have implemented policies and provided financial support to encourage the adoption of renewable energy technologies since the 1990s. Deployment steadily increased over the following decades and the countries' renewable industries are now well established. Renewables supplied **22% of the EU's energy consumption in 2020**, exceeding its **20% target set in 2009**. In 2021, there was a slight decline, with renewables accounting for **21.8% of energy consumed in the bloc**. This may have been caused by lifting of COVID restrictions and the resulting increase in fossil fuel use. Sweden has the highest share of renewables in its energy mix with 62.6%.

Fig. 1: US and EU renewables share (% of total energy consumption)



Source: [Monthly Energy Review, 2023](#) & [Eurostat, 2023](#).

Game-changing legislation

Following an increase in political commitment, momentum is building for a shift to renewable energy. The US and EU, together with China, are expected to form the 'backbone' of **global renewables deployment** in the next few years.

Legislation to build momentum in the US and EU

In the US, the [Inflation Reduction Act \(IRA\)](#) was passed in 2022, authorising an [estimated USD 738 billion](#) for energy and climate measures. It targets USD 30 billion for renewables, [11 times more than total direct government financing between 2013 and 2020](#).¹ The IRA, along with the [Bipartisan Infrastructure Law](#), represents [the largest ever federal commitment](#) to modernise and decarbonise the US energy system. A recent [Department of Energy study](#) found that US greenhouse gas emissions are projected to be 35–41% lower in 2030 than in 2005, and without the two bills they would be only 27% lower.

The EU has adopted the [European Green Deal](#), aimed at transforming the bloc into a climate-neutral and sustainable region. It aims to enhance the competitiveness of the EU's net-zero industry and scale up manufacturing capacity for on- and off-shore wind, [batteries and energy storage](#), and heat pumps. The EU has also set an effective ban on sales of CO₂-emitting cars and vans by 2035.

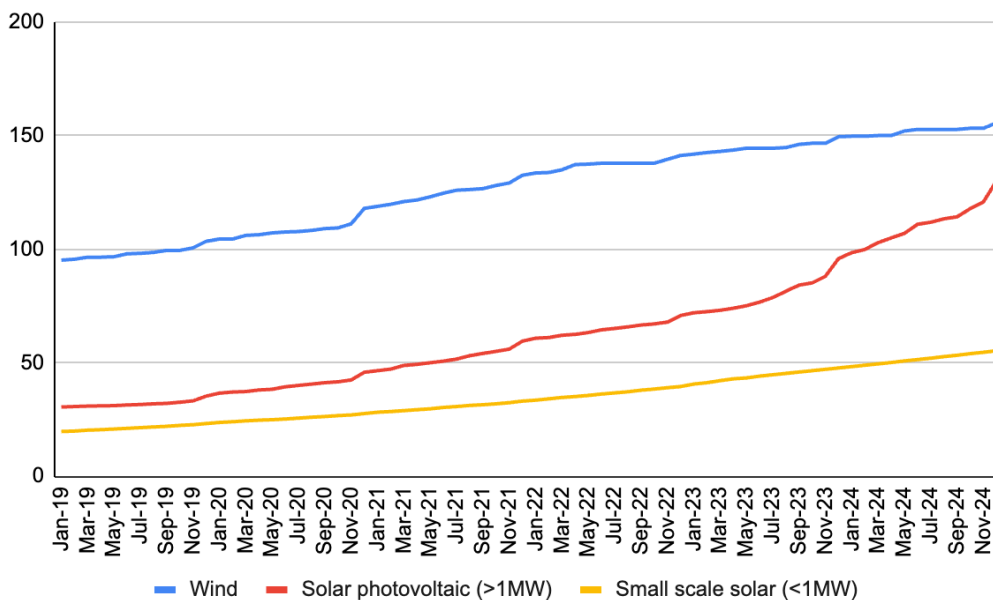
1: Many of the subsidies in the IRA are not capped, so the ultimate cost depends on the degree to which they are taken up by manufacturers or producers of electricity.

Expansion of renewables

Record solar capacity in US

In the US, 10 GW of new solar and 8 GW of new wind capacity were added in 2022 (figure 2). The US Energy Information Administration (EIA) projects that 25 GW of solar PV will be added in 2023, and a record 33 GW in 2024. A record 31,679 kW of solar panels were shipped in 2022, nearly 10% more than 2021 and almost double what was shipped in 2019. Solar panel shipments are tracked by the US government as a proxy for installations. The EIA also expects 8 GW of new wind power to be added between September 2023 and the end of 2024.

Fig. 2: US wind and solar electricity capacity 2019-2024 (GW)



Source: EIA, 2023.

Small-scale solar has steadily increased in capacity since 2019 and is set to continue rising up to the end of the projection period in 2024. The growth has so far been driven by residential installations which have risen by around 67% since 2019. More small-scale solar, as well as utility-scale solar and battery storage, will be added to the electricity system than gas-fired generation over this period. California has 36% of US small-scale solar capacity, far exceeding other states with 14.2 GW. Surprisingly, second and third positions are taken by New York with 2.6 GW and New Jersey with 2.4 GW, where less favorable solar conditions are countered by supportive policies to encourage deployment.

The International Energy Agency forecasts that renewable energy capacity in the US will [increase by 75% between 2022 and 2027](#). However, the impact of the IRA will only be seen after 2024, as projects which come online before then will have been developed under the previous tax regime. The IRA has pushed the US to the top of [Ernst and Young's ranking of countries on their renewable energy investments](#).

US IRA drives spending on wind and solar plants

Between the passing of the IRA and September 2023, [private equity firms committed more than USD 100 billion for renewable energy investments](#) eligible for tax credits in the next six years, potentially resulting in more than 350 GW of new capacity. There have been an estimated [36 announcements of new US solar manufacturing facilities](#) since the bill was passed, creating new jobs and reducing US reliance on solar panel imports.

Wind and solar electricity generation surpass coal and nuclear in US

Renewable electricity generation [surpassed both coal and nuclear generation](#) in the US in 2022, and the recent capacity growth means [renewables are forecast to provide 22% of US electricity in 2023 and 25% in 2024](#). Wind generation is expected to [increase from 434 TWh in 2022 to 458 TWh in 2024](#), enough to power more than 43 million households – around 35% of all homes in the US. The growth in solar PV generation is even more impressive, with 144 TWh supplied in 2022 and 233 TWh projected for 2024, an increase of around 61% in only two years. The increase in output from wind and solar will [displace some generation of coal and gas-fired plants](#) in 2023 and 2024.

Growth is expected to continue up to 2030. The US Department of Energy [estimates that solar electricity generation will increase seven- to eight-fold](#) by 2030 from 2022 levels, and wind will increase two- to three-fold. This growth is mainly driven by tax credit schemes in the IRA which give both project developers and generators certainty about returns on their investments. The US is also investing in battery technology to store excess generation from wind and solar plants.

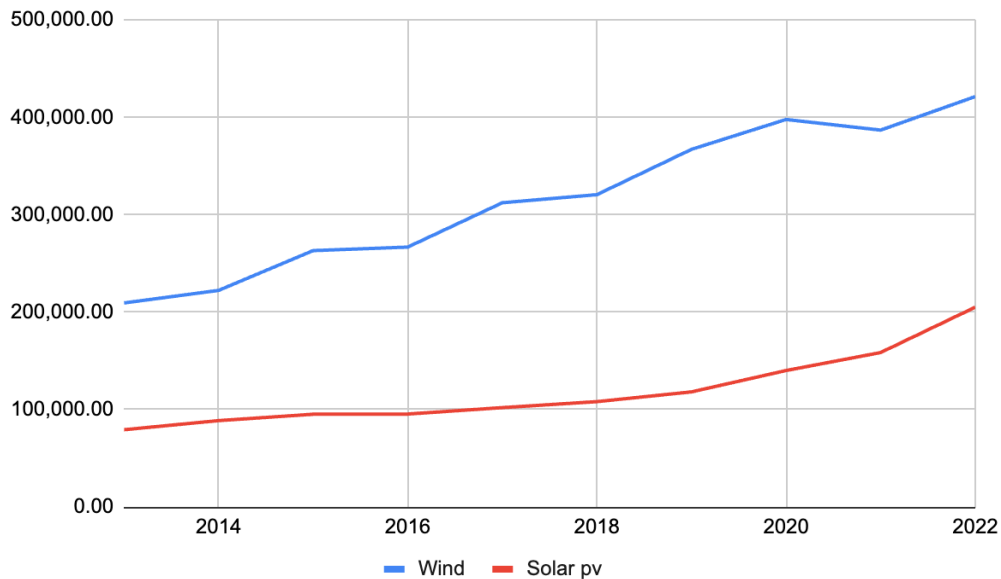
Record solar and wind capacity growth in the EU

Nearly [90 GW of new wind and solar capacity was installed in the EU](#) over 2020 and 2021, and another 60 GW is expected to come online in 2023, displacing around 20% of hard coal and gas-fired electricity generation. Wind capacity [grew a record 18.2% in 2022](#), largely because of new projects in Sweden, Finland and Poland. The International Energy Agency estimates that [average wholesale electricity prices would be about 15% higher in 2023](#) if this new renewable capacity had not been built, and that new wind and solar capacity has saved the EU around EUR 100 billion since the start of the energy crisis.

Solar PV provided 15.1% of electricity generated from renewables in 2021, and the amount of solar electricity increased by 29.3% in 2022, preliminary data shows. Wind accounted for 37.5% of electricity generated from renewable sources in 2021, and the amount of wind-powered electricity increased by nearly 9% in 2022 (figure 3). Together, wind and solar generated enough electricity in 2022 to power nearly 170 million homes, about 85% of all households in the EU.²

In 2022, investments in renewable energy fell across Europe to USD 55.9 billion, although this still placed the continent second to China. Some EU countries defied the trend, with Italy increasing renewable investments by 53.2% to USD 3.69 billion, and Spain increasing funding by 36.3% to USD 10.5 billion.

Fig. 3: Wind and solar generation in the EU (GWh)



Source: Eurostat, 2023.

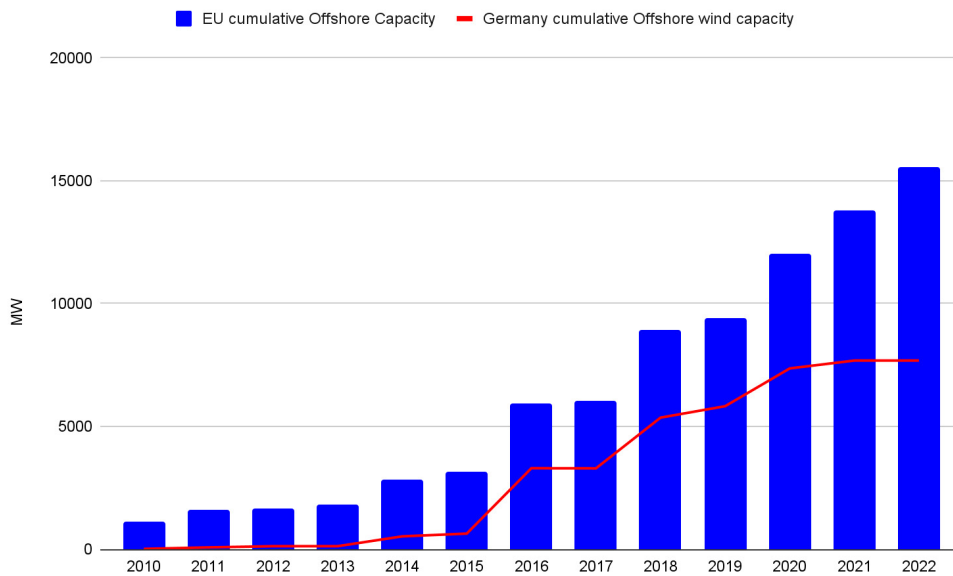
Despite impressive deployment levels, the EU wind industry is facing pressure from foreign competitors. To tackle these issues and speed up the roll-out of wind power, the European Commission released the 'EU Wind Power Package' in October this year, which includes extra financing from the bloc's banks.

2: EU households consumed 747,500 GWh of electricity in total in 2021. There are around 198 million households across the EU, meaning that the average household consumes around 3.7 MWh of electricity. Wind generated 421,264 GWh and solar 205,108 GWh in 2022, a combined total of 626,372 GWh. This means that wind and solar provided enough electricity to power more than 169 million average households.

Offshore wind industry in the EU

The EU is rapidly developing its offshore wind industry. In 2022, there was 15,555 MW of cumulative capacity in the EU. Almost 50% came from Germany, which ranked third globally in cumulative offshore wind installations. BNEF predicts that offshore wind in Germany will grow exponentially, reaching 41.2 GW by 2035. France added the most new wind capacity in 2022, after its 480 MW wind project offshore Saint-Nazaire, which can supply enough electricity to power 400,000 homes, was put into operation.

Fig. 4: Cumulative offshore wind capacity in EU and Germany



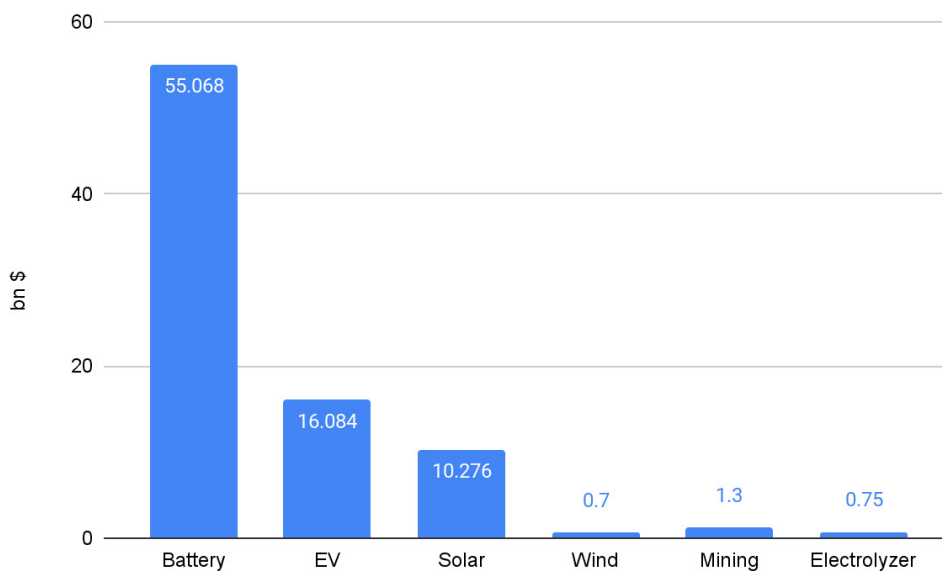
Source: BNEF, 1H 2023 Offshore Wind Market Outlook

Energy storage and EVs

US policy drives energy transition investments

The emphasis on domestically sourced components in the IRA has led to a surge in announced investments in energy transition technology since the bill was passed.³ About **USD 84 billion of investments** have been announced for factories for batteries and electric vehicles (EVs), solar and wind components, hydrogen electrolyzers and metal refining. About 65% will be spent on battery manufacturing, including cell and battery components, while about 19% will be invested in EV manufacturing technologies.

Fig. 5: Announced investments in US following IRA



Source: BNEF, *Sizing Up the Clean-Tech Manufacturing Boom One Year In 2023*.⁴

US energy storage market gains momentum

Although the US currently imports most of its energy transition manufacturing technology, its capacity for producing battery cells will exceed domestic demand if the announced factories are realised.⁵ In the first quarter of 2023 alone, **350 GWh of new manufacturing capacity was announced**, almost as much as in the whole of 2022. Batteries play a **vital role in the energy transition**, as they are used in both electric vehicles and stationary energy storage. Battery storage facilitates **the integration of various renewables** in electricity systems, providing flexibility and security of supply in the long term.

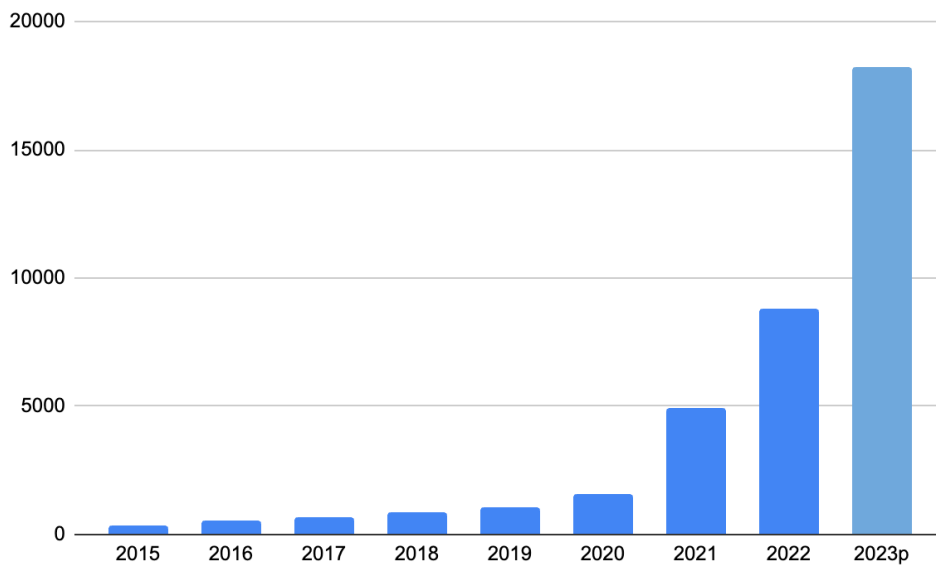
3: The briefing refers to batteries (cathodes, anodes, electrolytes, separators and cells), solar (wafers, cells and modules), battery metal refining and wind (nacelle, blades, towers and gearboxes) as manufacturing technologies for the energy transition.

4: Data gathered from August 2022 until the end of July 2023.

5: 2030 demand refers to BNEF's forecast for demand, including stationary energy storage and EV segments for batteries.

The IRA offers [crucial tax incentives](#) to boost battery production in the US, including USD 35 per kWh for battery cells and USD 10 per kWh for battery modules. However, the US was an active player in the energy storage market even prior to the IRA. New projects currently under construction mean that battery capacity [will more than double in 2023 to 18,200 MW](#) (figure 6). More than 70% of this storage will be based in [California and Texas](#), reflecting the high level of wind and solar plants in those states.

Fig. 6: Cumulative US battery capacity 2015-2023 (GW)



Source: EIA, 2023.

If the capacity of operational plants is combined with those under construction, the US will have the second largest energy storage market in the world, with 131,756 MWh of capacity.⁶

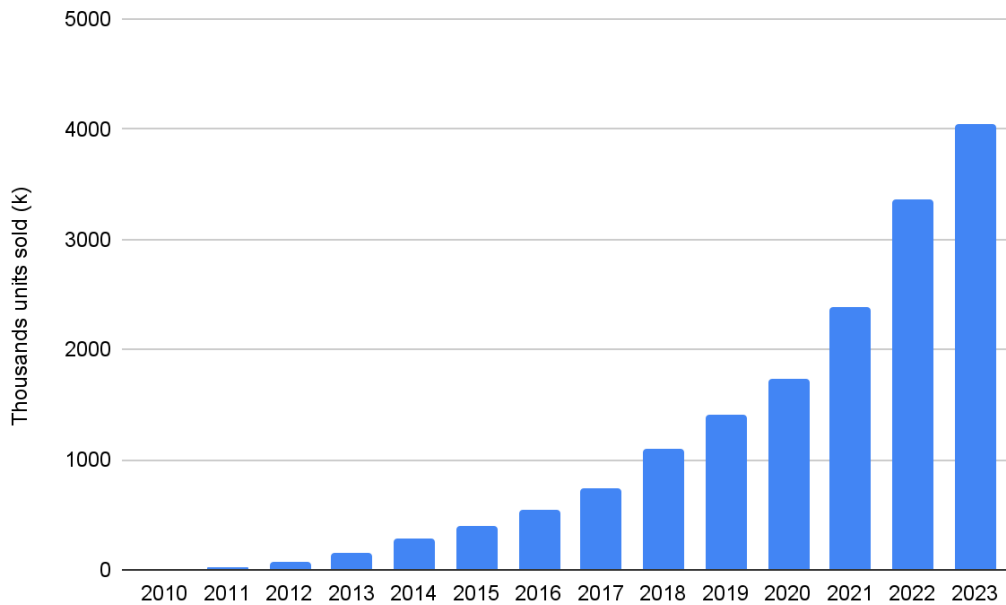
Surging EV sales in US

In recent years, the US EV market grew exponentially. Sales of EVs surged by 37.5% year-on-year in 2021 as the US began to recover from the Covid-19 pandemic, and growth has continued into 2023.⁷ In the second quarter of this year, the country achieved record-high sales of over 361,000 passenger EVs – a 48.9% increase compared to the previous year. Almost 80% were battery electric vehicles (BEVs), highlighting a shift to fully electric cars. Tesla dominated the market, accounting for 47.5% of BEVs sold.

6: BNEF, 2H Energy Storage Market.

7: EV Sales include BEVs and Plug-in hybrid vehicles (PHEVs) sales.

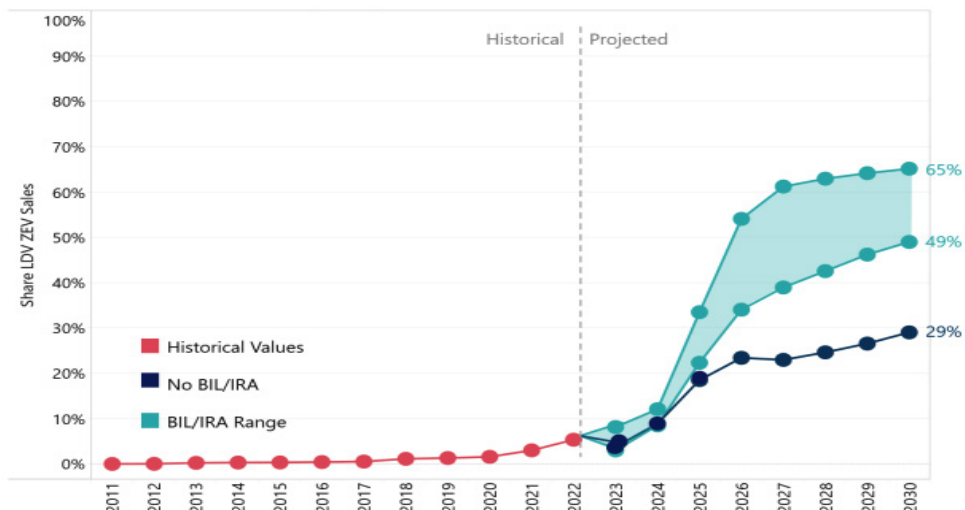
Fig. 7: Annual cumulative sales of EVs in the US (thousand units)



Source: BNEF, [Electric Vehicle Sales interactive dataset](#), accessed in October 2023.⁸

The adoption of the IRA and BIL means zero-emission light duty vehicles will account for **between 49% and 65% of the passenger vehicle market by 2030**. Without the bills, the projected market share is just 29%, demonstrating their potentially transformative effect.⁹

Fig. 8: Market share of zero-emission light-duty vehicles 2011-2030



Source: Investing in American Energy, [US Department of Energy](#), 2023.

8: For 2023 the data is collected until Q2.

9: According to the US Department of Energy, zero emission light-duty vehicles (ZEVs) include vehicles powered exclusively by electricity or hydrogen. If state agencies are unable to acquire ZEVs, a plug-in hybrid electric vehicle may be purchased instead.

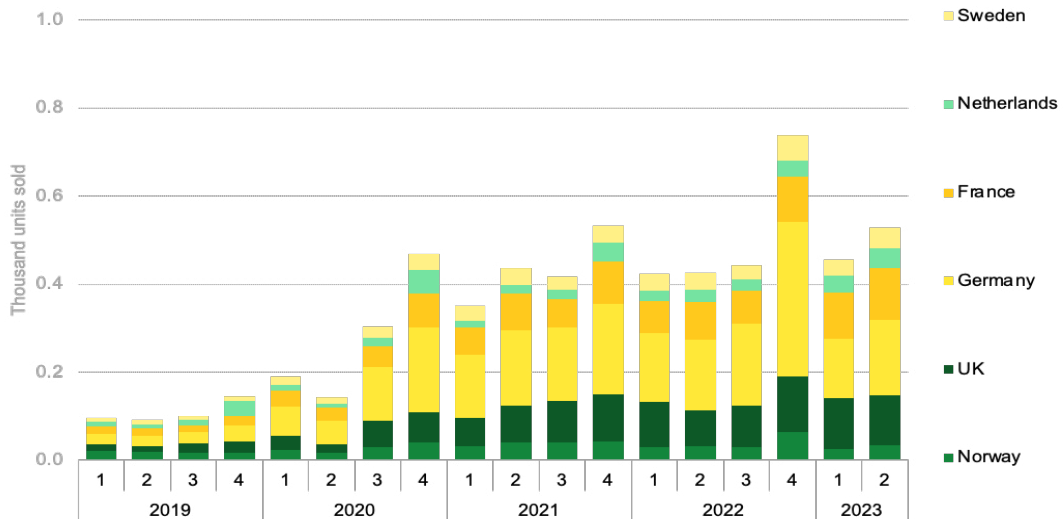
Georgia - a future EV hub

While Georgia hasn't historically been at the forefront of addressing climate change, the US state is aiming to position itself as "the electric mobility capital of the country". Following the passing of the IRA, the state took the lead nationally with USD 14.7 billion of announced investments in the energy transition. Georgia offered USD 358 million in grants, tax breaks and other incentives to convince Norwegian lithium-ion battery manufacturer Freyr to build a giant energy storage system in the state. The factory is expected to open in 2026, and will create 724 new jobs. Hyundai, Kia and startup Rivan are also establishing EV manufacturing plants in Georgia.

Europe accelerates EV adoption

Europe has the second highest EV sales globally after China, and in the second quarter of 2023 sold 784,000 passenger EVs, a 31% increase YoY.¹⁰ Germany, France and the UK accounted for 51% of total EV sales in Europe in the second quarter. However, the Nordic countries have the highest share of EVs to total passenger vehicle sales. EVs accounted for 90% of total sales in Norway, 60% in Sweden, and 52% in Finland and Iceland.

Fig. 9: European passenger EV sales (units sold)



Source: BNEF, Marklines, JATO, 2023.¹¹

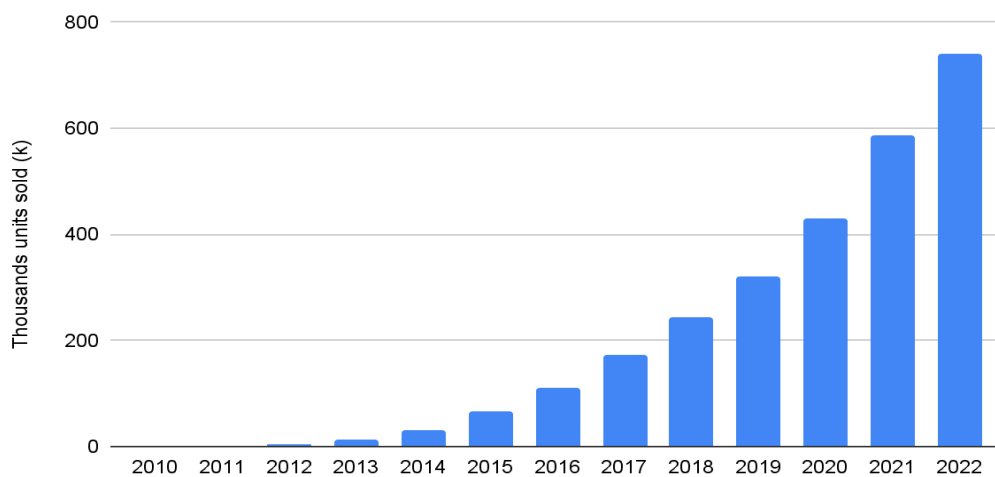
10: The following EV sales data for Europe includes EU27 countries plus Norway, Switzerland, Iceland and the UK.

11: EV sales include BEV and PHEV sales.

Rapid EV adoption in Norway

Between 2013 and 2022, EV sales in Norway grew exponentially to 741,853 vehicles from 12,529 (figure 10). Norway achieved [rapid adoption of EVs](#) through a blend of financial incentives and infrastructure. Exemptions from registration tax, VAT and motor fuel taxes, coupled with significant reductions in road, ferry, and parking fees, [made EVs more cost-effective than traditional vehicles](#). Norway also developed an [extensive network of over 13,000 EV charging points](#), including nearly 1,600 high-speed charging stations, often involving public subsidies. State enterprise Enova has [contributed to this success](#), by investing NOK 70 million (USD 6.3 million) in a charging infrastructure and providing grants for 150 electric buses in Oslo. Norway's approach shows how strategic policies and investments can drive a sustainable transition to electric mobility.

Fig. 10: Annual cumulative sales of EVs in Norway (thousand units)



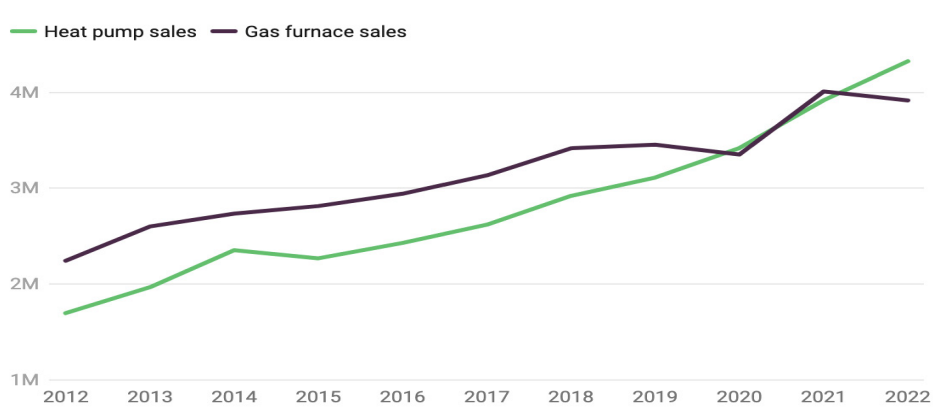
Source: BNEF, [Electric Vehicle Sales interactive dataset](#), accessed in October 2023.

Heat pumps on the rise

Rapidly growing market in the US

Over 17 million US households had heat pumps in 2020, 40% more than in 2015. Sales of air-to-air heat pumps grew by about 11% in 2022, exceeding gas boiler sales for the first time (figure 11). The US government plans tax credits for heat pump manufacturing and installation, and the US Climate Alliance, made up of 25 bipartisan governors, committed to install a further 20 million heat pumps in their states by 2030. This would quadruple the number of heat pumps, currently 4.8 million, operating in those states.

Fig. 11: Heat pump sales in US



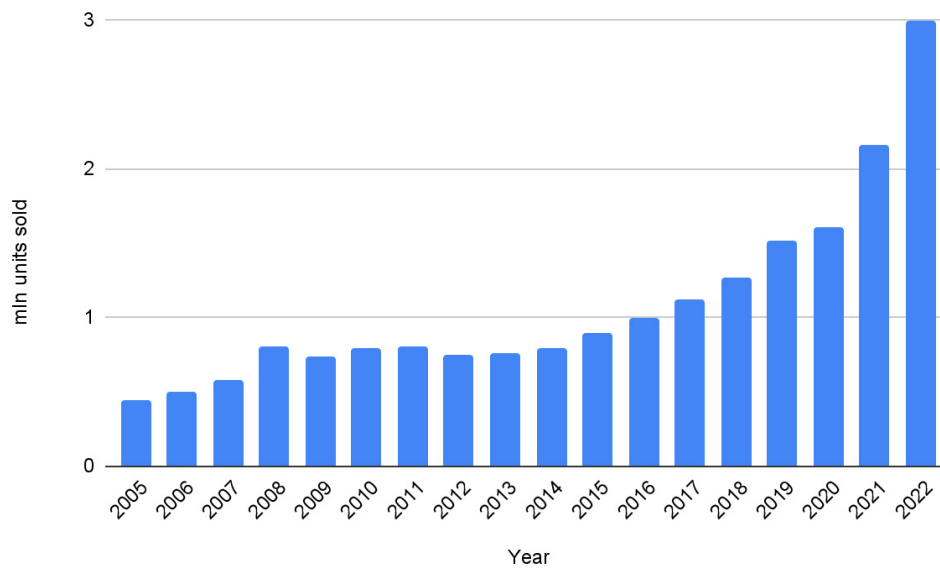
Source: Canary Media and Air-Conditioning, Heating and Refrigeration Institute, 2023.

Record sales of heat pumps in Europe

In Europe, a record 3 million heat pumps were sold in 2022, an increase of 38% from 2021.¹² The total number of heat pumps in operation reached 20 million, leading to the avoidance of 52.5 megatons of carbon dioxide emissions per year, around the annual total of Greece. France, Italy, Germany, Sweden and Poland sold the largest number of heat pumps in 2022.

12: The heat pump sales data for Europe was gathered from 21 markets: Austria, Belgium, Czechia, Denmark, Estonia, Finland, France, Germany, Hungary, Ireland, Italy, Lithuania, the Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Switzerland, UK.

Fig. 12: Historic heat pump sales in Europe

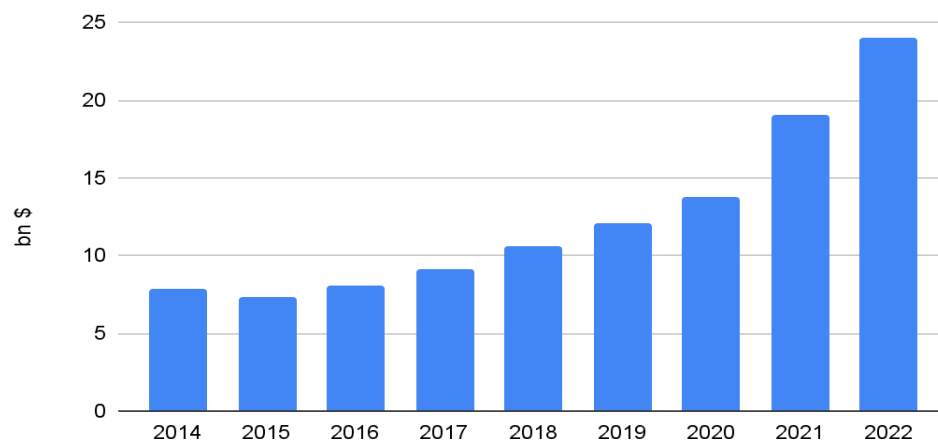


Source: EHPA, European Heat Pump Market and Statistics Report, 2023.

EU leads in heat pump investments

Over a quarter of investments in global electrified heat in 2022 took place in the EU. In addition, France, Italy, Germany, Finland and Switzerland saw the largest investments in heat pumps in the EMEA region, placing Europe as a global leader.

Fig. 13: Heat pump investment in the EU



Source: BNEF, Energy Transition Investment Data, accessed in September 2023.

Under the EU’s **RePowerEU** plan, which aims to end the bloc’s reliance on fossil fuels and speed up the transition to clean energy, 30 million additional heat pumps will be deployed by 2030, taking the EU total to 60 million. Heat pumps can use **50% less electricity** than traditional electric heaters, while providing the same level of heat.

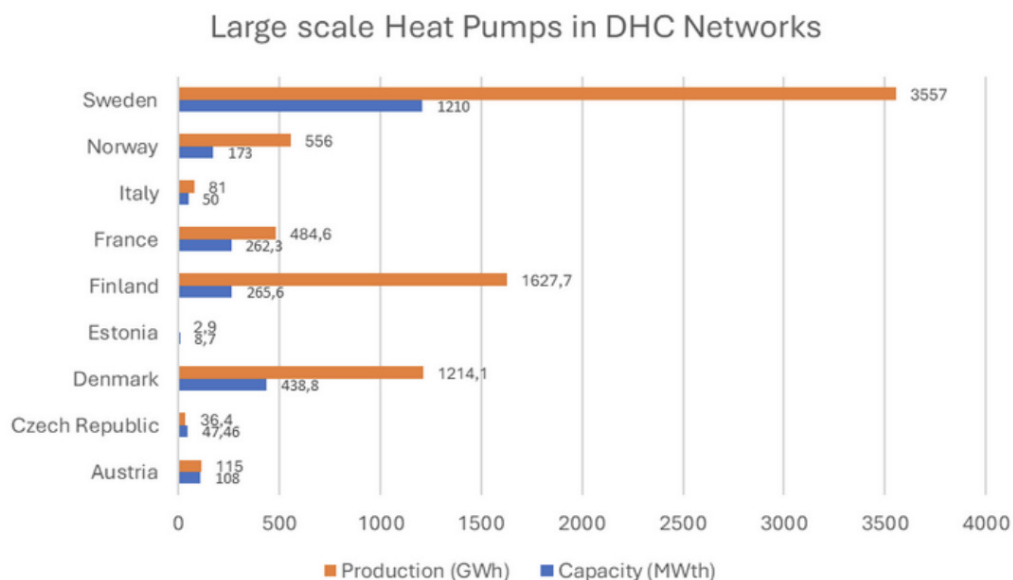
Poland: fastest-growing heat pump market

Poland hosts the **quickest-expanding market for heat pumps** in the EU. **One in three heating appliances sold** in Poland were heat pumps in 2022, a surge of just over 100% compared to 2021. The record high uptake is a direct result of government policy, including incentives for the **green retrofitting of buildings** and **increased financial support**.

Large-scale heat pumps in district heating systems

In the EU, most heat pumps are installed in residential buildings. In 2021, heat pumps accounted for only around **1% of installed capacity of district heating networks** in the EU. Based on the investment plans of large heating and cooling networks in Europe, the **installed capacity of large heat pumps** will increase by at least 80% by 2030. Sweden, where **more than half of residential houses** have installed heat pumps, is also a leader in the installation of large-scale heat pumps in district heating (figure 14), and is exploring the combined use of **domestic heat pumps with district heating**.

Fig. 14: Large heat pumps in district heating in the EU (production and capacity)



Source: Large heat pumps in District Heating – state of play, EHP.¹³

13: Figures for 2021.