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European Market Outlook

for Battery Storage

2024-2028

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Foreword

Welcome to the European Market Outlook for Battery Storage 2024-2028.

Solar and its renewable peers have proven their pivotal role for the well-being of Europe in recent years, as they have backed the continent's energy security, helping to manoeuvre through an unprecedented energy crisis. With renewables now powering over 40% of the European Union's electricity consumption today, it's high time to put the spotlight on a key enabler to advance on the clean energy transition road with the goal of energy independence ahead – stationary battery energy storage systems.

While policymakers have been looking closely at batteries in light of their instrumental role for the electrification of the automotive industry, it has been widely missed that they are indispensable for the green transition of Europe's power system too. On a daily, weekly, and seasonal scale, flexible renewables need large amounts of storage to provide power when there's not enough sun and wind, and absorb overcapacities generated on windy and sunny days.

Though solar's share in the electricity generation concert is still rather small, its rapid growth is worth careful management. Increasing negative power prices on sunny days, rising solar curtailment rates, and the value of solar power dropping in pioneering Members States, is causing developers to begin to re-consider investments in new PV projects. Without flexibility sources, like battery storage, a true renewable energy transition won't be possible.

Battery storage is the dream partner for solar and fits any application – from residential homes and commercial installations to utility-scale applications in stand-alone, co-located or hybrid configuration with other renewables. Stationary batteries also contribute to electrification of the heat and transport sectors as they make EV charging and heat pumps with own generated solar power more affordable.

Solar & storage is a clear win-win for citizens, companies, and the grid. Prosumers can reduce their energy bills through higher self-utilisation ratios enabled by batteries, and, if price signals are available, adjust consumption patterns in response to grid needs.

Our new report shows that the market is increasingly embracing the battery storage option. In 2023, Europe's newly installed storage capacity grew by 94% to 17.2 GWh to reach a total installed capacity of 35.9 GWh in 2023, after doubling in 2021 and 2022. But what looks very impressive at first glance, equals less than 15% of the global stationary battery market last year, which grew much faster, at 133%.

There are other caveats: the growth of the European stationary battery market was strongly relying on the residential storage segment, 70% in 2023, triggered by the high energy prices during the energy crisis, and driven by a handful countries, with most of them offering attractive storage incentives. There, household solar & storage had become the new normal. Europe's utility-scale segment, representing 21% of the market last year, was concentrated even more and in fact dominated by one country – the UK positively stood out in Europe for its regulatory framework that enables integration of battery storage in electricity markets, offering attractive benefits to both the grid side and storage project investors.

This year, we are seeing further growth in Europe, but at a much slower pace of 31%, as the leading residential battery markets are declining post-energy crisis. Although we expect deployment pace to pick up as of next year, primarily in the utility-scale segment, followed by Commercial & Industrial segments (C&I), our most realistic scenario is still lagging behind the about 200 GW of BESS power capacity we estimate is needed by 2030 to unleash the EU's solar potential.

As we outline in our policy asks (see p. 9), battery storage is still facing many obstacles across most European countries, including missing targets, market price signals, frameworks enabling procurement of flexibility needs, double taxation, and grid-connection policies for hybrid renewable power plants, to name a few.

In other words, flexibility using battery storage is not just a technical debate that should be left to regulators and standardisation bodies, it urgently requires political oversight and prioritisation if Europe really strives to structurally solve its energy security issues through renewables.

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Methodology: SolarPower Europe's five-year forecast consists of Low, Medium and High Scenarios. The Medium Scenario anticipates the most likely development given the current state of play of the market. The Low Scenario forecast is based on the assumption that policymakers halt solar and storage support and other issues arise, including negative policy changes, crisis situations. Conversely, the High Scenario forecasts the best optimal case in which policy support, financial conditions and other factors are enhanced.

Segmentation for BESS: Residential (<20 kWh); Commercial and Industrial (20 kWh to 1,000 kWh); Utility-scale (>1,000 kWh). For residential and commercial BESS, segmentation is based on the type of PV system coupled with the storage device. Industrial and utility-scale BESS can be either stand-alone or co-located with industrial and large-scale power plants. SolarPower Europe's methodology includes only grid-connected battery storage systems.

Segmentation for solar PV: Residential (<10 kW); Commercial (<250 kW); Industrial (<1,000 kW); Utility-scale (>1,000 kW, ground-mounted). SolarPower Europe's methodology includes only grid-connected solar PV systems.

Currency conversion to EUR has been based on conversion rates in May 2024. Installed PV capacity is always expressed in DC. All figures are based on SolarPower Europe's best knowledge at the time of publication.

Executive summary

Battery storage markets in Europe have developed significantly, especially over the past three years, driven by the need for renewable energy integration, technological advancements, supportive policies, and substantial investments. Most importantly, the rollout of Battery Energy Storage Systems (BESS) has seen rapid growth as an effective and cost-efficient response to the threat posed by the war in Ukraine to the security of energy supply in Europe. Battery storage, coupled with renewable generation, stepped up to provide a solution to the energy trilemma of security, affordability, and sustainability.

In 2023, Europe installed 17.2 GWh of new BESS capacity, with a 94% year-on-year market surge and marking the third year in a row of doubling the annual market (see Fig. 1). In tandem with solar PV, the growth was primarily driven by the residential segment, as a response to high electricity prices and the desire to become self-sufficient, with 12 GWh being installed in 2023 and 70% of the total added capacity. The promising and largely untapped commercial and industrial (C&I) battery segment contributed with 1.6 GWh (9%) and grid-scale batteries connected 3.6 GWh (21%).

At the end of 2023, Europe's total operating BESS fleet stood at 35.8 GWh, with the residential segment constituting the bulk of the accumulated capacity (63%), followed by large-scale battery systems (27%) and C&I (10%).

FIGURE 1 EUROPE ANNUAL BATTERY STORAGE INSTALLED CAPACITY 2014-2023

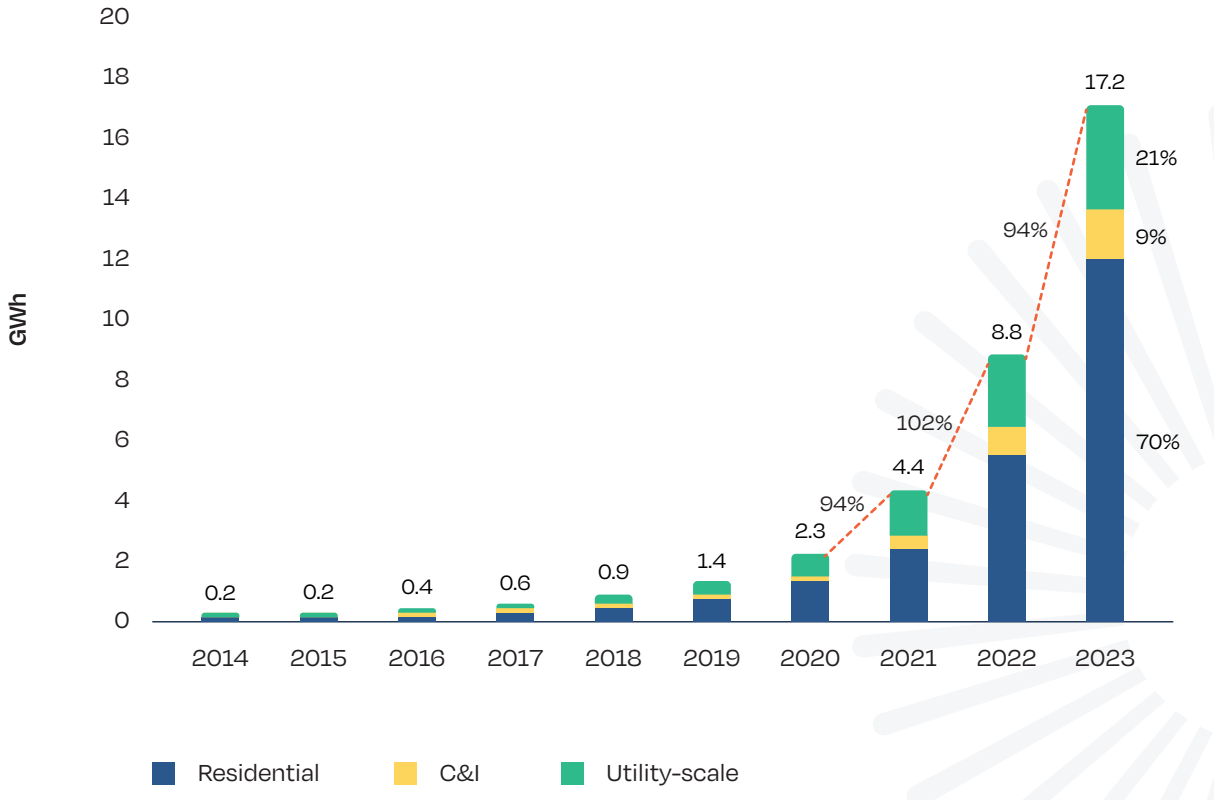
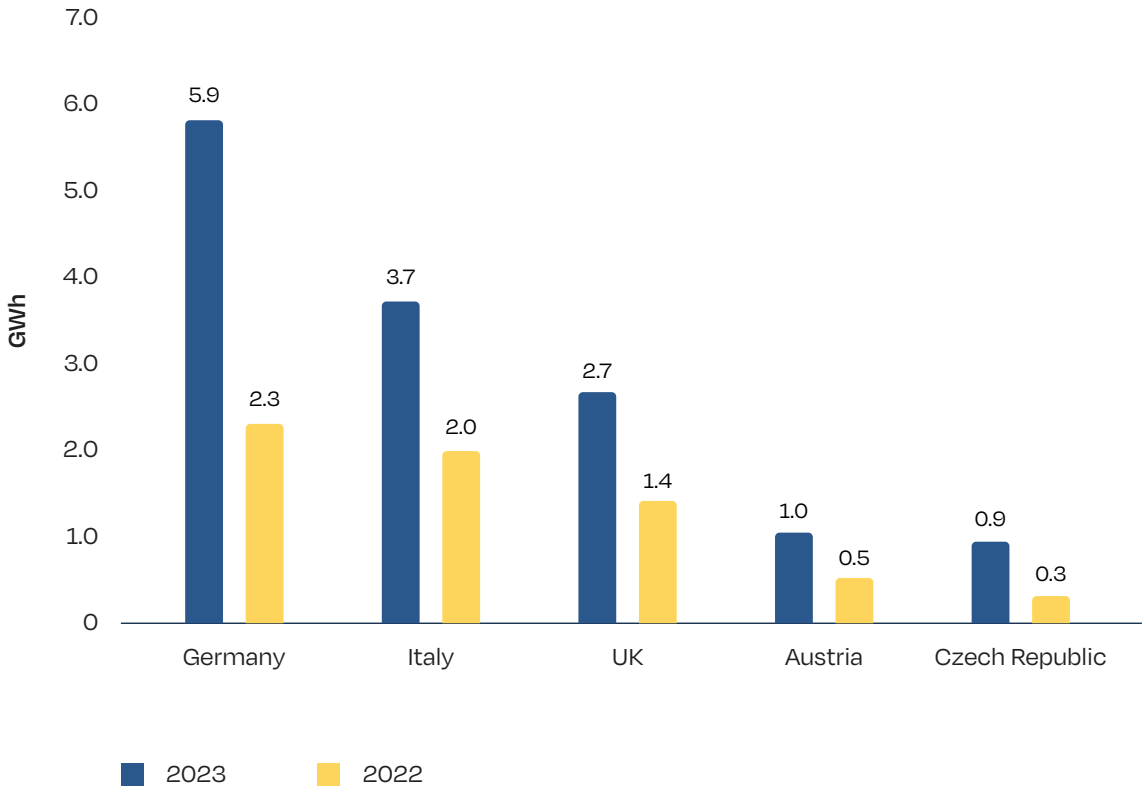


FIGURE 2 TOP 5 EUROPEAN ANNUAL BATTERY STORAGE MARKETS 2023



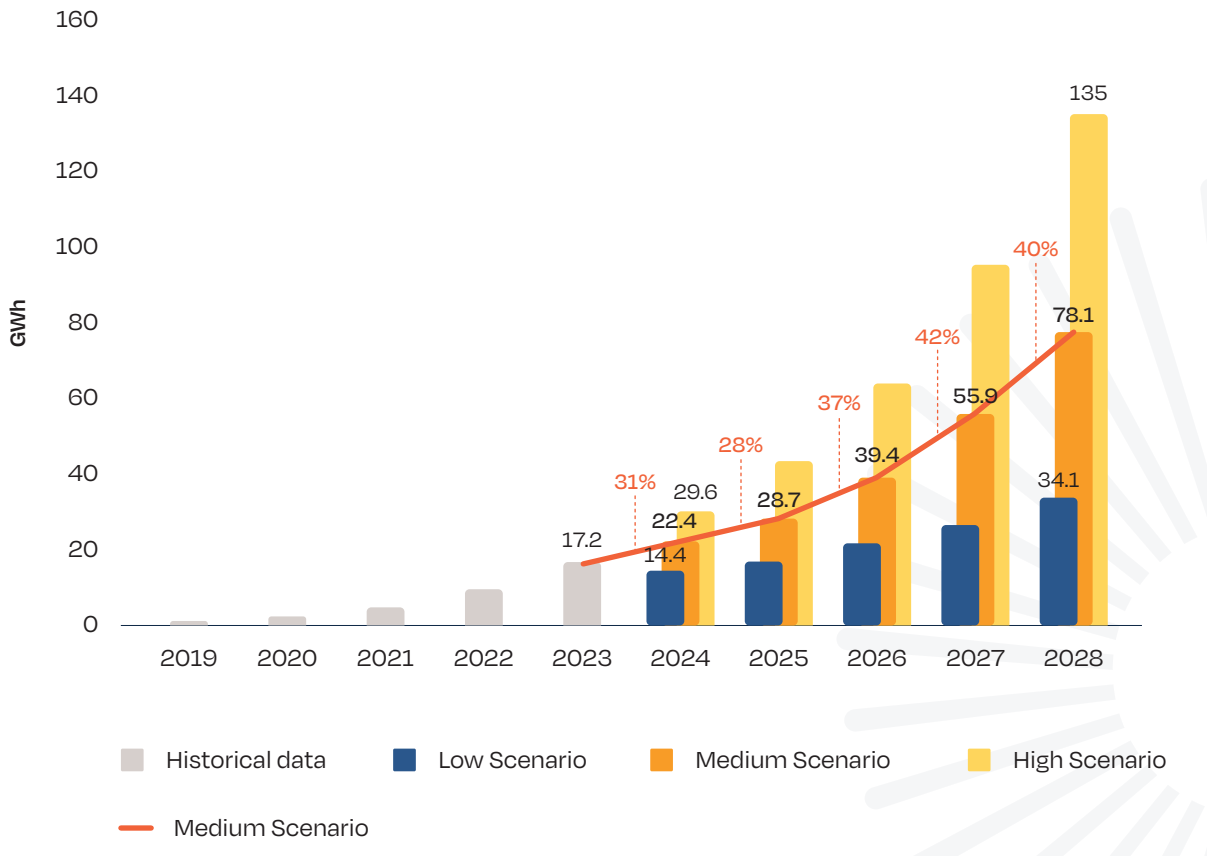
In 2023, three countries stood out as the most successful markets (see Fig. 2). Once again, Germany was the uncontested leader, with 5.9 GWh deployed last year (+152%), followed by Italy, which grid-connected a record amount of 3.7 GWh (+86%), and the United Kingdom with 2.7 GWh (+91%). Austria displayed yet again its robust growth trajectory adding more than 1 GWh of battery storage capacity (+95%), while the Czech Republic experienced spectacular ascension by tripling its annual market with more than 900 MWh installed in 2023, thanks to its strong residential segment.

Looking forward, the expansion of battery storage looks bright, as the exponential curve starts verticalising, driven by the ongoing energy transition. The continued growth in renewables is intrinsically linked to the deployment of clean flexibility sources like batteries, while the electrification of transportation and heating, as well as grid modernisation, also rely on battery storage. Technological progress is also expected with deep cost reductions that will boost the deployment of BESS. In this vein, policy and regulatory efforts should be directed towards providing a strong and stable battery framework.

If the residential segment has largely sustained the acceleration of BESS deployment until now, the dynamics are set to change as of 2024. With the leading home battery markets Germany, Italy, and Austria experiencing declines after the record levels registered in 2023, the residential segment is poised to shrink 26%. Despite this considerable reduction, we forecast that the total European BESS market will keep growing, as the space left by residential BESS is being filled by larger batteries in the C&I and utility-scale segment.

Our forecast anticipates that in 2024 the European BESS market will continue to grow and will reach 22.4 GWh. This constitutes a 31% annual increase after two exceptional years when growth has been in the 100% range. BESS markets will maintain their upward trajectory between 2025 and 2028, with sustained growth rates in the 30-40% range until 2028. By that year, our Medium Scenario expects 78.1 GWh BESS installed annually across Europe. The shift towards utility-scale batteries is projected to remain a prominent phenomenon, as they will continue to capture more than 45% of the newly installed capacity in 2028. C&I batteries will experience an outstanding jump of 13 percentage points by 2028, while the household BESS will record a decline to 29% of annual additions. Nonetheless, the residential segment will deploy 2 times more than in 2023, reaching almost 23 GWh in 2028. Additionally, utility-scale battery projects are expected to enlarge their average storage duration capacity as revenue stacking models and grid service requirements change. With increasing needs for power system flexibility and energy shifting, we will see a significant rise in BESS capacity duration, extending towards 4 to 8 hours, from around 1.5 today.

FIGURE 3 EUROPE ANNUAL BATTERY STORAGE INSTALLED CAPACITY SCENARIOS 2024-2028

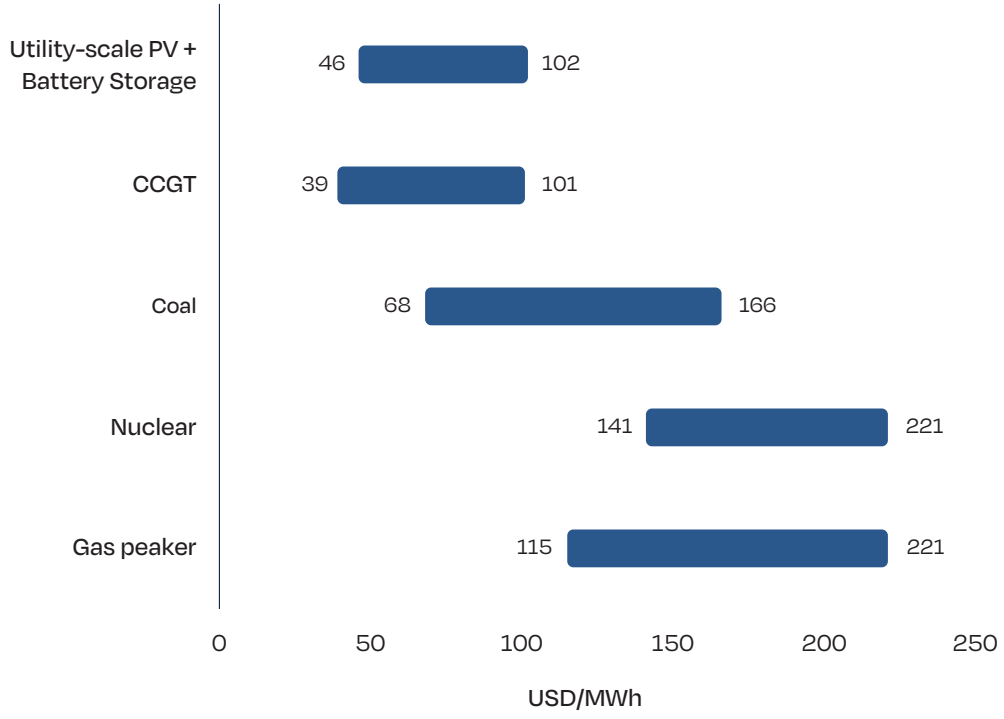


The cost competitiveness of solar & storage continues to increase. As reported by U.S. investment bank Lazard in its Levelised Cost of Energy (LCOE) 2023 analysis, utility-scale solar & storage display a much lower cost range than gas peakers (see Fig. 4). This is driven by the decrease in battery system costs, which are expected to drop 21% and 30% by 2030 for small-scale and large-scale BESS, respectively, according to the International Energy Agency (IEA).

This report also delves into the specific features of the top 5 European battery markets in 2024. These five markets will provide 83% of the European BESS added capacity in 2024, but their contribution is anticipated to shrink to 54% by 2028, implying a strong market diversification in the foreseeable future, as batteries emerge as a mainstream solution to meet energy and flexibility needs at all levels.

Our analysis has identified a number of challenges that hinder the rollout of BESS in Europe. These roadblocks, however, can be turned into opportunities for the sector, as illustrated in the recommendations for policymakers set out by the present report.

FIGURE 4 LCOE COMPARISON FOR BASELOAD TECHNOLOGIES 2023



Source: Lazard (2023).

Policy recommendations

Sellingen solar park, 41.1 MW floating PV coupled with 15 MW / 30 MWh BESS, Groningen, Netherlands.© BayWa r.e.

Clean technologies have proven their value in supporting Europe's energy security in recent years. Amid a dramatic energy crisis, renewables have emerged as the primary energy source in the EU, powering 44% of our electricity grid, while electrification has reached a 22-23% rate.

Electrification and integrating renewables into the grid is essential for the energy transition. It requires the adaptation of the system operation to accommodate new factors like weather-dependent energy production, new power consumption patterns, and a more distributed energy landscape. The energy transition therefore goes hand in hand with the development of more flexibility resources. Flexibility is not solely a technical debate that should be left to regulatory details and standardisation bodies. It requires political oversight and prioritisation if Europe is to structurally improve its energy security.

Battery storage is the ideal partner of solar PV and will be needed in all its various configurations: standalone at grid-scale, co-located with large-scale renewables, or in solar & storage systems at consumers' sites. At the same time, electrification presents significant potential for flexibility resources: electric vehicles (EVs) serve as mobile batteries that can adjust their charging to match the system's needs, while heat pumps offer thermal storage capabilities. Moreover, electrification enhances the economic appeal of storage solutions. Consumers and businesses can increasingly capitalise on low or even negative electricity market prices, from periods of high grid availability, or peak solar production on their roofs, by using storage technologies to adjust their consumption.

This report shows that the market is slowly rising to the challenge. In 2023 the European annual added storage capacity grew 94%, with about 17 GWh installed last year. That is well below the pace observed in other areas of the world, such as China, where installations tripled to 23 GW[1], or about 60 GWh, in 2023. The EU captured less than 15% of the global BESS market, which increased 133% year-on-year. We must improve the European growth trajectory to meet and exceed the identified flexibility needs within the system, which amount to 288 TWh or 24% of total annual electricity demand in the EU by 2030, according to conservative estimations of the European Commission.[2] SolarPower Europe has estimated that 200 GW of BESS power capacity needs to be installed by 2030, which is above projected growth levels by the end of the decade.

Growing battery storage and flexibility represents a fundamental shift from our current grid-centric view of the market. It impacts not only the way we plan infrastructure and the way we operate the system, but also the markets we engage with. Additionally, there is a critical need to deploy digital technologies and related analytics to observe and pilot the system. The recently adopted revised Electricity Market Design (EMD) legislation lays the groundwork for such a more robust energy policy. We need to urgently implement these measures and we call on the Commission to report on the EMD implementation ahead of the first Energy Council in 2025.

Against this backdrop, we ask policymakers to carry out the following actions:

1 IEA (2024): Batteries and Secure Energy Transitions.
2 EU Commission (2023): Energy Storage - Underpinning a decarbonised and secure EU energy system.

Policy recommendations / continued

1. Properly quantify the needs for battery storage

- **Assess the need for flexibility and develop a target for small-scale and large-scale storage.** Grid operators must swiftly implement their new obligation to assess flexibility needs, based on a soon-to-be-released methodology from the EU Agency for the Cooperation of Energy Regulators (ACER). The methodology should cover daily, weekly, and seasonal needs, but also future needs arising from systems with a high share of renewables. The methodology should be differentiated between TSO and DSOs, but in both cases, as part of this methodology or additionally, a costs and benefits assessment of expanding the grid versus using flexibility should be taken. It should assess the capabilities of existing technologies, including individual and collective self-consumers (see Box 5).
- **Ensure regulators allow grid operators to cover their flexibility-related expenses, as foreseen in the EMD review.** Grid operators were traditionally remunerated based on capital expenditure for grid infrastructure deployment (CAPEX). However, relying on flexibility resources requires operational expenditure, such as operating a digital grid and procuring from local flexibility markets (OPEX), which regulators need to allow.

2. Design price signals and financial incentives

- **Develop Time-of-Use grid tariffs and facilitate access to variable energy tariffs for distributed flexibility.** Time-of-use tariffs in commercial and residential settings encourage prosumers to charge from the grid during times of low market prices, in summer and winter, using automated systems. This additional value stream improves the business case for storage while mitigating low or even negative electricity prices.
- **Develop markets to procure flexibility needs.** As outlined in the EMD directive, grid services should primarily be procured by systems operators through the market, unless the regulatory authority has assessed that it is not economically efficient and has granted a derogation. This approach should be extended to new services, such as grid forming and inertia, following successful examples in Great Britain. Doing this could better reveal grid needs and facilitate the gradual integration of flexibility into the grid, ensuring the economic sustainability of energy systems. National energy authorities should ensure that battery storage assets can function on all electricity and ancillary services markets, thus allowing the stacking of multiple services and multiple revenue streams.
- **Enable users to seamlessly access flexible grid connection agreements, where grid capacity is scarce.** In these agreements, grid users opt for reduced capacity connection in exchange for economic incentives as a necessary condition, which encourage the hybridisation of rooftop solar with storage. These flexible connections should not delay the network reinforcements in the identified areas.

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- **Support battery storage deployment alongside large rooftop solar installations.** Storage is still a niche product for C&I rooftop solar. Incentivising storage will strengthen the business case for solar installations in regions with very low daytime electricity prices, such as Southern Europe, while alleviating these low electricity prices. Revenue stacking for these assets should be allowed and encouraged to ensure that they provide benefits to the overall energy system.
- **Set up competitive auction processes.** Auctions, whether for standalone or co-located batteries, are crucial to secure long-term contracts for battery storage projects. Member States should introduce appropriately designed storage, hybrid and flexibility auctions to support battery storage deployment, following the examples of countries like Italy, Poland, Spain, and Greece, which have shown that such mechanisms can be set up to encourage deployment and drive down costs (see Box 3).

3. Eliminate barriers

- **Address double grid charging on energy storage.** In some Member States, energy storage systems still face double charging: first as a consumer when storing energy from generators like solar PV and wind, and then as a generator when releasing energy to consumers such as businesses and households. This places a disproportionately high burden on energy storage and creates an uneven playing field compared to fossil fuel assets, which are only charged by the grid once. Despite the robust provisions in the 2019 Clean Energy Package, this issue has not been appropriately addressed in all Member States (see Box 2). It is crucial to provide guidance on implementation to unlock the flexibility potential, including at low voltage levels.
- **Unlock the business case of co-located storage by enabling the stacking of services for solar and storage plants.** In many cases, co-located battery storage with solar PV is prohibited from charging from the grid when benefitting from support schemes. This restriction hampers the potential of co-location: adding battery storage increases costs that cannot be offset by additional revenues. Addressing this challenge will facilitate co-location and unlock investments into battery storage. This could be achieved through new metering approaches that differentiate between grey and green electricity, or through different calculation methodologies for Contracts for Difference.
- **Deploy smart devices in the system and facilitate digital use of technologies.** Smart charging of vehicles or smart use of a heat pump must become the standard. Buildings should be further digitalised and equipped with energy management systems to unlock their flexibility potential. This requires the deployment of controllable and digitalised devices. The regulatory framework should ensure that devices are smart-ready when deployed. In addition, ensure that metering regulations enable the use of AC and DC coupled solutions.
- **Remove barriers to free movement of goods.** The lack of harmonised requirements for battery storage devices across European markets poses a challenge to the free movement of goods and the functioning of the EU single market. Some Member States are adopting prescriptive fire safety regulations for BESS that contradict each other, requiring BESS manufacturers to adapt their products to each national market, which is incompatible with mass production. The Requirements for Generators Network Code should provide for harmonised requirements, a crucial element for a cost-effective energy transition (see Box 4 pg. 36).

4. Adapt the grid connection framework

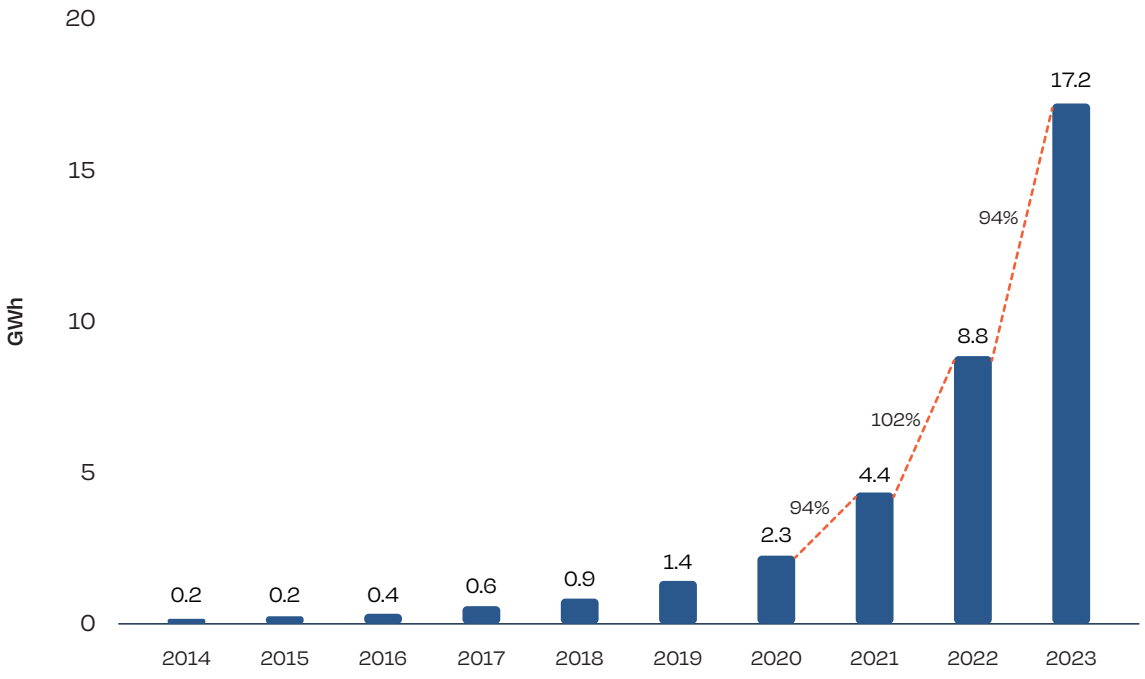
- **Define facilitated procedures for the hybridisation of renewable energy assets at the same connection point.** Hybridisation is understood as the addition of battery storage or another generation technology like wind to a solar power plant. Today, the permitting procedure to hybridise projects is unnecessarily restrictive and complex. In Ireland, for example, developers cannot change the maximum export capacity of an asset by more than 120%. On the contrary, Spain and Portugal recently adopted rules to facilitate the hybridisation of renewable capacity.
- **Specify grid requirements for aggregated solar and storage systems.** Grid requirements should be based on the maximum injected capacity of the aggregated asset, agreed upon by the developer and the grid operator. This approach, already adopted by TSOs in Spain and Finland, sets a precedent that should be replicated at EU level, through the Requirements for Generators Network Code (see Box 4).

1 Battery storage markets in Europe 2023

1.1. European battery storage markets 2014-2023

2023 was a breakthrough year for battery energy storage systems (BESS) in Europe, as the recognition of their critical role for a secure and cost-efficient clean energy transition keeps improving. Batteries have entered a new phase, as the exponential growth curve starts to verticalise. With 17.2 GWh installed last year, the market nearly doubled (+94%) relative to 2022 and crossed the 10 GWh threshold for the first time (Fig. 5). It was the third year in a row that the European BESS market basically doubled its size, after the record growth experienced in 2021 and 2022, when capacity additions increased 94% and 102% respectively. To put these figures in perspective, the size of the annual market in 2023 was 115 times larger than 10 years ago, when just 150 MWh were installed in 2014.

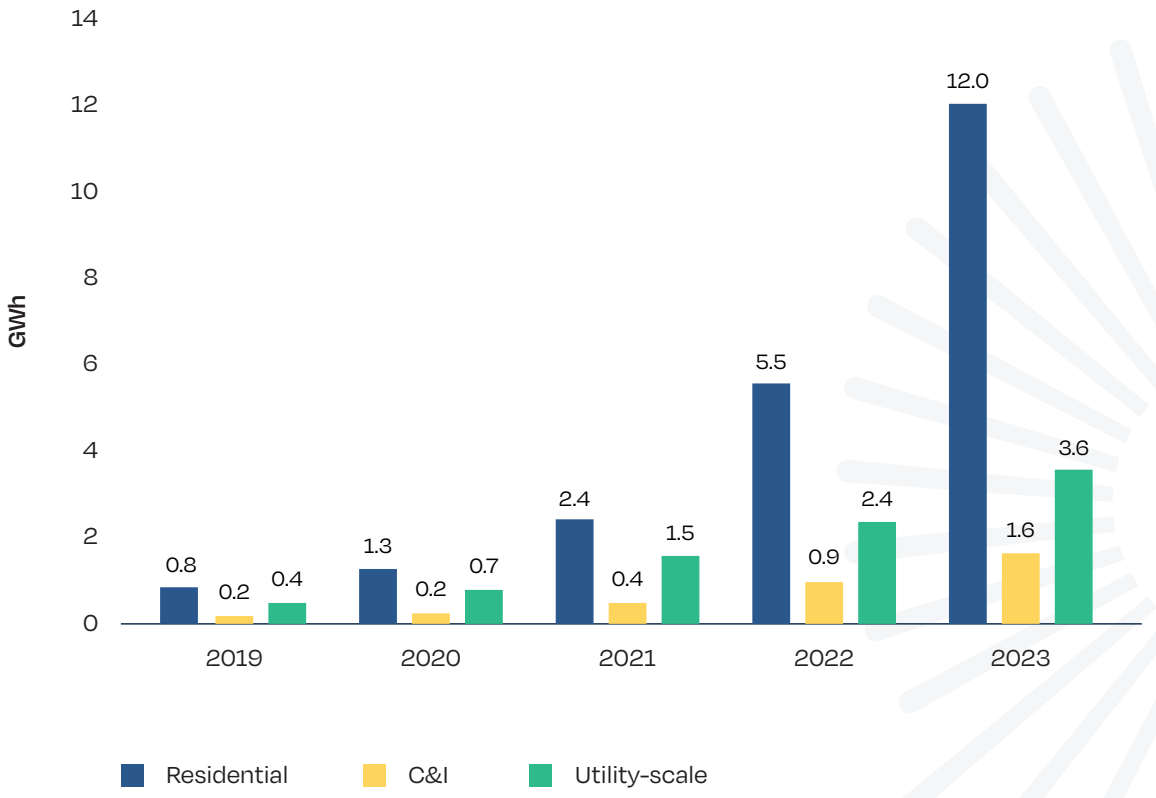
FIGURE 5 EUROPE ANNUAL BATTERY STORAGE INSTALLED CAPACITY 2014-2023



With very high annual growth rates throughout the last decade, 2023 was the first year since 2018 the market grew slightly less than the previous year, although the increase in absolute terms is unprecedented. Delays in the commissioning of front-of-the-meter (FTM) battery projects across several European markets caused a minor slowdown in the growth trajectory, still increasing the volumes deployed: in 2023, 3.6 GWh were installed in the FTM segment, compared to the 2.4 GWh added in 2022 (see Fig. 6). That signifies a 51% year-on-year increase, while in 2021, the large-scale battery annual market doubled (1.5 GWh) relative to 2020. The reasons behind these delays mainly have to do with regulatory frameworks, whereby developers face grid connection delays, inadequate legislation, slow permitting procedures, lack of standardised fire and safety protocols, and other hurdles that increase commissioning lead times, slowing down the rollout of grid-scale batteries across European markets.

If large-scale BESS growth was somewhat limited in 2023, the real driver of market expansion was behind-the-meter (BTM), especially in the home battery segment. New residential battery capacity increased more than twice (117%), adding 12 GWh, up from the 5.5 GWh installed in 2022. Though impressive, the residential BESS segment registered an even larger year-on-year expansion (+131%), in the midst of the EU energy crisis in 2022, compared to 2021 when 2.4 GWh had been installed. Major European markets like Germany and Italy, which registered record annual installation figures in the residential segment, have been showing signs of stabilisation in their growth trajectory. That is having a significant impact on the general growth trend of the market.

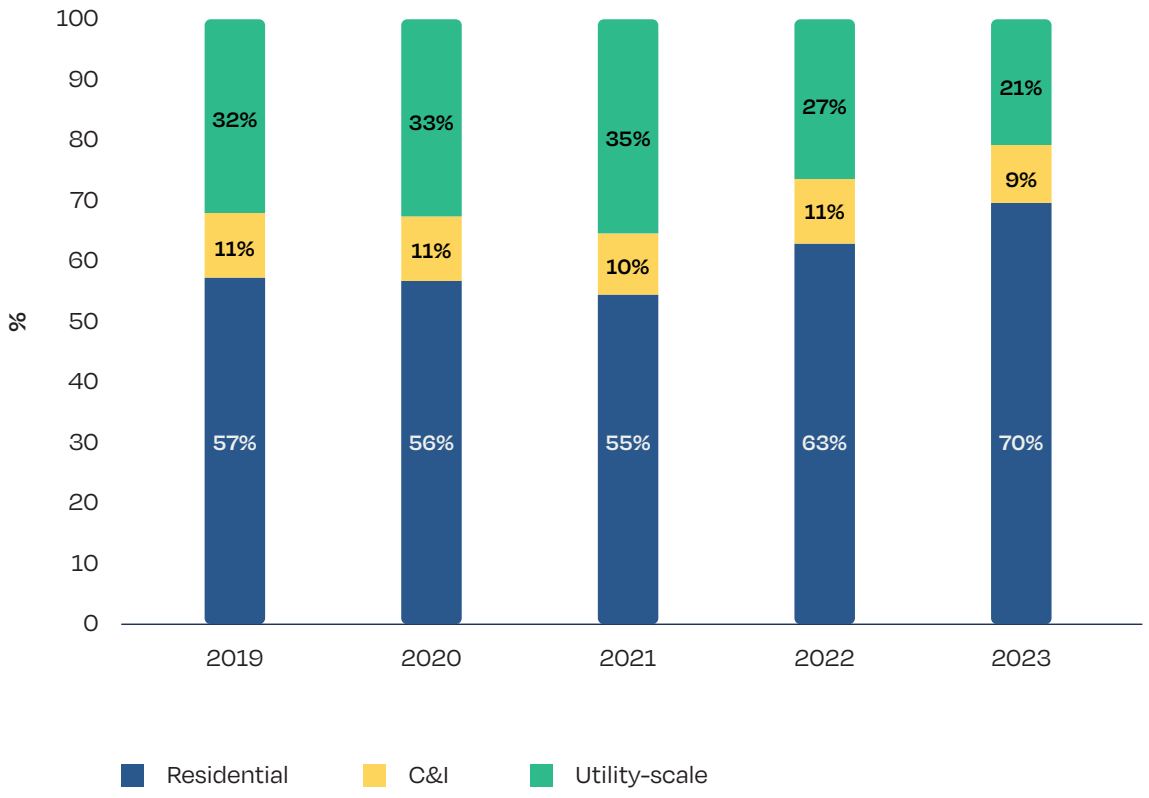
FIGURE 6 EUROPE ANNUAL BATTERY STORAGE SEGMENTATION 2019-2023



At a smaller level, the commercial and industrial (C&I) BESS segment presents an unequivocal enlargement trajectory, widely surpassing for the first time the GWh annual market size in 2023 (1.6 GWh). Still in its very early stages, the C&I BESS segment in Europe shows gigantic promise as companies have successfully started to utilise battery installations to electrify production processes, heating, and transport, particularly in Germany, the United Kingdom and the Netherlands. However, in percentage terms, yearly growth numbers at the European level decelerated from 112% in 2022 (945 MWh) to 72% in 2023. Far from a mature market where flexibility services are remunerated and active trading is enabled, installations are still contingent on electricity prices, which have receded with respect to the height of the energy crisis.

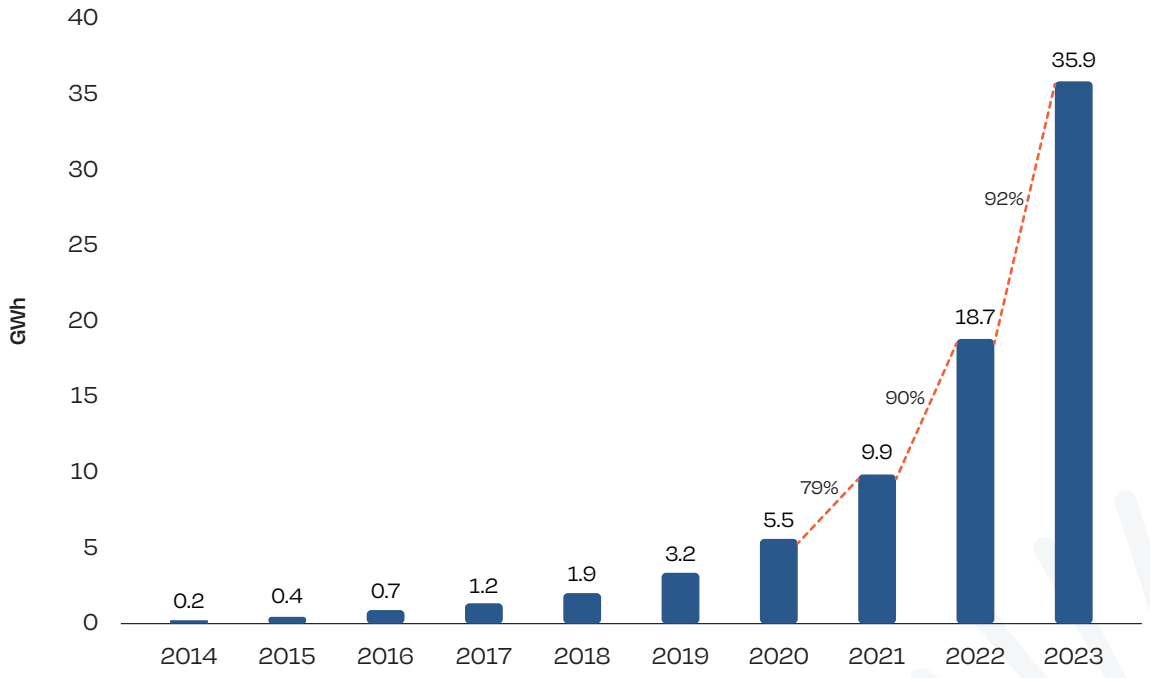
In 2023, residential batteries have increased their share in total European BESS capacity additions, increasing by 7 percentage points to 70% (see Fig. 7). By contrast, the contribution of utility-scale batteries has shrunk by 6 percentage points to 21%, while C&I batteries declined their contribution by 1.3 percentage points to 9.4%. Nevertheless, both segments registered a record expansion year in absolute terms.

FIGURE 7 EUROPE ANNUAL BATTERY STORAGE SEGMENTATION SHARES 2019-2023



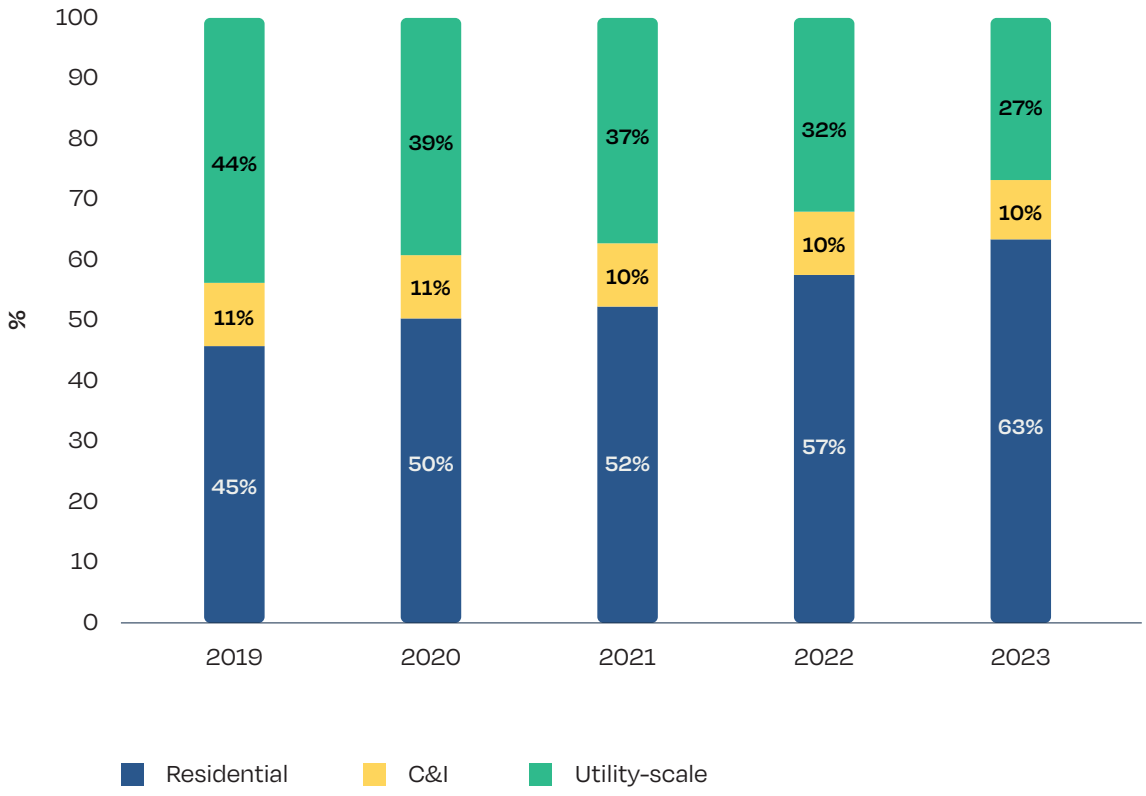
The exponential growth in the BESS annual market is reflected in the growth of the total operating battery storage capacity. The battery fleet augmented by 92% to 35.9 GWh by the end of 2023, from 18.7 GWh in 2022, an even higher growth rate than the year before, when BESS cumulative capacity in Europe amplified by 90% in 2022 (see Fig. 8).

FIGURE 8 EUROPE CUMULATIVE BATTERY STORAGE INSTALLED CAPACITY 2014-2023



The lion's share of the accumulated capacity is found in the home solar & storage market segment, which accounts for 63% of the total installed capacity (see Fig. 9). Thanks to the outstanding growth of residential solar PV, supportive funding schemes, and improved permitting procedures, at the end of 2023 this segment was significantly ahead of the utility-scale (27%) and C&I (10%) segments. This tilted-to-residential market trend has exacerbated since 2019, when home battery storage constituted 45% of the operating capacity. That year, the grid-scale BESS segment stood at 44% of the cumulative capacity. Since then, residential solar & storage has taken the leading role, as households' desire to become independent from the grid outpaced all the other market and regulatory drivers in the C&I and utility-scale segment. Nonetheless, and though not visible in installed capacities, the pipeline for utility-scale battery projects in Europe recently started to grow faster than any other segment, as the strong growth in solar has been resulting in increasing curtailment rates and decreasing power sales values (so-called capture prices), issues that could be solved through battery storage.

FIGURE 9 EUROPE CUMULATIVE BATTERY STORAGE SEGMENTATION SHARES 2019-2023



BOX 1: SCARCITY OF DATA ON BATTERY INSTALLATIONS IN EUROPE

In the preparation of this report, a significant challenge faced during the data collection process is the apparent lack of data on battery storage installations in Europe. At present, the majority of European countries lack national data collection and reporting on battery storage. This leads to inaccuracy as a large degree of data is based on estimates rather than official numbers. This widespread issue can lead to several problems. Lack of data makes it difficult to consider, design and review policy actions, as well as grid management, planning and reinforcement.

There are some best practice examples that can be used as a benchmark for setting up national data compilation centres. Germany is not only the leader in battery deployment, but also a notable example of data transparency on installed battery systems. Thanks to the efforts of the Federal Network Agency (BNetzA) and the Institute for Power Electronics and Electrical Drives of the RWTH Aachen University, there is a clear visibility on the expansion of battery deployment in Germany.

In 2019, the BNetzA launched its MASTR database, where all battery systems have an obligation to be registered if connected to the grid. After some initial difficulties, due to the fact that storage owners were unaware of the mandatory registration, the MASTR database now provides fair coverage of the market expansion.

The collected data is based on manual entries by private persons, which may lead to confusion about the technical aspects of the installation. To account for these, regular consistency checks are performed by the BNetzA and distribution system operators. Additionally, the RWTH Aachen University classifies and filters all the installation data, providing a clear market segmentation between home, industrial, and large-scale batteries. The collected information provides data on the location, type of operator, and the inverter power and energy storage capacity of the battery system. Although some delays in data registration can be observed, the majority of battery systems are registered within one year. Collected data is made available on a free-access online platform[3] and updated on a frequent basis.

Besides the positive features of this system, there is also room for improvement. The solar and storage industry stresses that the registration of PV systems ensures eligibility for the feed-in-tariff but registration of battery storage does not. This means that there could be cases of non-reporting of storage capacity. This adds to the inaccuracies driven by the delays in system registration mentioned above. One way to deal with this problem could be to work directly with manufacturers or aggregators as they have the metadata, similarly to the system present in Switzerland. Nevertheless, the RWTH Aachen University estimates that the share of non-registered storage systems is below 10%.

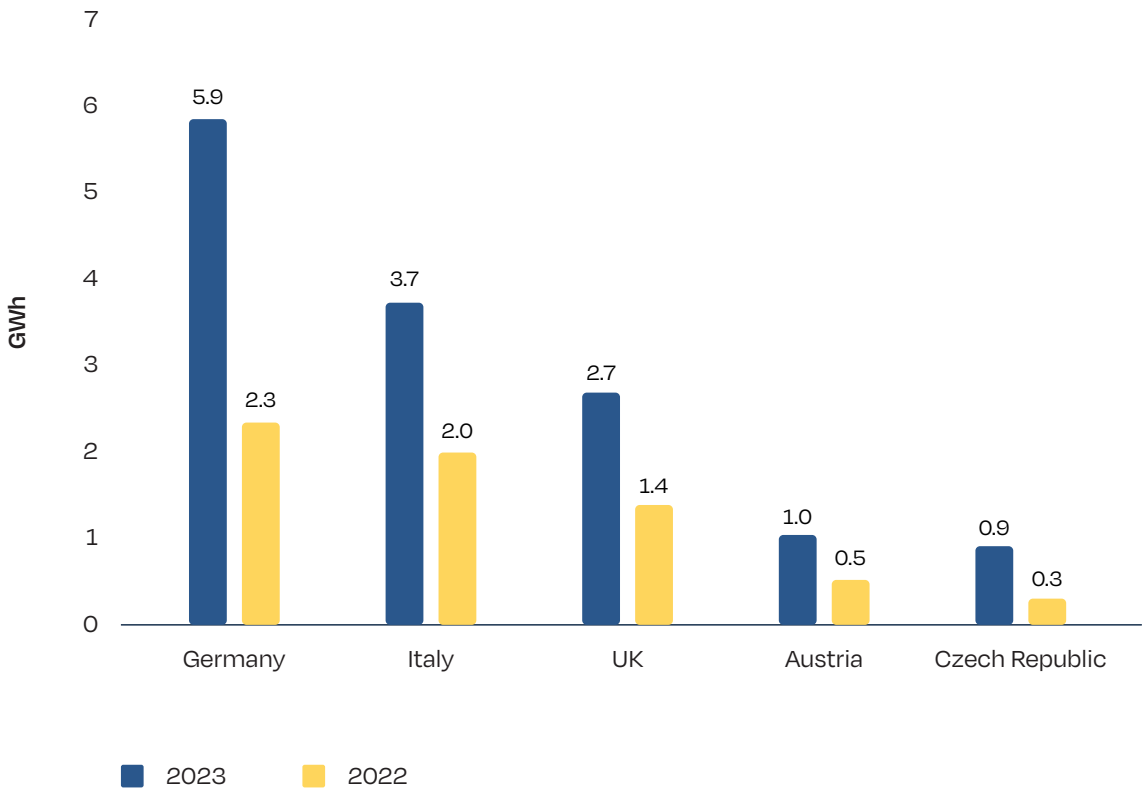
3 Battery Charts - (rwth-aachen.de)

1.2. Top 5 European annual BESS markets 2023

The top 5 total BESS market ranking in 2023 includes some traditionally strong residential markets, such as Germany, Italy, and Austria, as well as the long-standing utility-scale market leader the United Kingdom. The newcomer in this year's edition is the Czech Republic, which, after a strong performance in 2023, takes the 5th position in our ranking of the largest BESS market in Europe (see Fig. 10). As it can be observed in the graph, the ranking is dominated by the top 3 markets - Germany, Italy and the UK, which are playing in a different league, while Austria, coming fourth, just reached the GWh scale.

Germany remains the undisputed leader in Europe in terms of battery storage markets. In 2023, it installed 5.9 GWh to reach a total installed capacity of over 12 GWh. The country holds a strong lead compared to its peers, considering that in 2023 it grid-connected 1.6 times more battery capacity than Italy and over two times more capacity than the United Kingdom. In 2023, the German BESS market grew by 152% from 2022, when 2.3 GWh had been installed. Out of the annually built capacity, 87% was installed at the residential level (5.1 GWh), driven by the strong performance of the residential PV market last year. Home batteries make up over 80% of the total operating BESS capacity across the country. More

FIGURE 10 TOP 5 EUROPEAN ANNUAL BATTERY STORAGE MARKETS 2023



than 1.1 million solar & storage systems are now operating at the residential level, and nearly half of them were installed in 2023. This outstanding expansion of the market in 2023 has been largely driven by households to capitalise on the benefits of energy autonomy, the wide product availability, and the decline of battery prices.

At the C&I level, Germany remains the European #1 with 431 MWh installed in 2023, jumping 151% from 172 MWh added in 2022. Germany continues to operate the largest C&I BESS fleet with nearly 900 MWh. More and more companies are now storing solar power from their roofs to be able to use it during peak demand times when power prices are high, while the electrification of heat and transport adds to the appetite in solar & storage solutions.

Unlike the residential segment, which is very closely related to new solar installations, the large-scale battery market in Germany is in its very early stages. In 2023, 352 MWh utility-scale BESS were deployed, a 26% drop compared to the 477 MWh added in 2022. This decline was due to delays in the registration of battery projects, which should be accounted for during the present year. At the end of 2023, the grid-scale segment accounted for nearly 1.5 GWh, providing 12% of the total BESS capacity in the country.

Italy ranks second, with 3.7 GWh installed in 2023, an 86% annual growth from the 2 GWh in 2022. This extraordinary growth path has enabled Italy to become also the second largest European operator of stationary batteries, now at 6.5 GWh capacity. Similarly to Germany, the residential BESS segment has been the backbone of the market, providing 3.1 GWh and 84% of the added capacity in 2023. In terms of cumulative capacity, the residential segment accounts for 5.4 GWh, equal to 83% of the total running BESS fleet. The strong performance of the household market has been primarily driven by the introduction of the Superbonus scheme in 2020. The scheme offered homeowners to repay in tax credits 110% of the cost of energy-saving renovations, including the adoption of PV systems coupled with battery storage. Due to the huge success of the programme, the government has implemented a gradual phase-down of the incentive scheme and put restrictions on the transfer of the tax credit. This has left the market relatively unstable and has sparked a renewed interest to install before the scheme is finally phased out over the coming years.

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The Italian C&I BESS segment has also gained significant traction over the past two years, grid-connecting about 260 MWh in 2022, and over 410 MWh in 2023, with a 59% annual growth rate. It also ranks second in terms of total installed C&I capacity (765 MWh). Still subject to very high power prices at peak demand times, companies have a strong incentive to optimise their consumption profiles, which greatly improves BESS project bankability. Additionally, Italy's reliance on external energy sources and the push for decarbonisation incentivise the industrial sector to couple rooftop PV with battery storage systems as a cost-efficient, secure and green supply of energy source.

At the large-scale level, 2023 was a remarkable year. Around 220 MWh of utility-scale batteries were added, jumping from just 17 MWh in 2022. Despite this very significant leap, the large-scale segment still represents a minor share of the total storage capacity in the country, with less than 1%. Despite being one of the most attractive markets in Europe – thanks to the opening of key revenue streams, capacity auctions, ambitious storage targets, and the strong renewable penetration requiring flexibility – the segment had not yet taken off in 2023. Project delays affected the deployment of large-scale batteries, and the delayed Italy's record installation year to 2024.

The third place in annual battery installation volumes is now taken by the **United Kingdom**, which lost its second position to Italy. In 2023, the country installed over 2.7 GWh, nearly doubling the 1.4 GWh added in 2022, leading to an accumulated capacity of 6.1 GWh. Over the last decade, most of the UK's built capacity has been delivered by the utility-scale BESS segment, in which the country has been ahead of the curve. In 2023, the country deployed 2 GWh of large-scale batteries, 71% up from the 1.2 GWh installed in 2022. That makes the UK the European large-scale leader in 2023 as well, providing more than half of the continent's new capacity in this segment. At the end of 2023, large-scale batteries represented 80% of the cumulative UK fleet, with 4.9 GWh of installed capacity. The impressive growth in FTM batteries has been favoured by regulators through the removal of asset size limits and government funds supporting battery projects. As renewable energy shares increase in the country's electricity mix, there is a strong demand for battery projects for grid stabilisation to minimise network congestion, while the dynamic containment services for grid stability and the capacity remuneration market are further supporting deployment.

Claudia storage project, 105 MW BESS. Saucats, France. © Amarenco

The remaining 2023 capacity was connected by the residential segment, which experienced a three-fold annual growth with 620 MWh installed. The total residential BESS fleet now amounts to more than 1.1 GWh, which represents nearly 20% of the overall installed capacity. This notable expansion is largely due to the existing battery storage adoption framework, which is now more favourable after several administrative hurdles have been removed. New and retrofitted solar & storage home systems are now exempted from VAT, while various funding schemes support low-income households for the joint adoption of solar and battery storage. By contrast, larger BTM BESS solutions at the C&I level have not yet been adopted at scale and provide only marginal contributions to the BESS operating fleet with around 100 MWh.

Austria finished 2023 on the 4th rank after registering a record year with a GWh scale annual market size for the first time. That catapults the country to more than 2 GWh of installed BESS capacity. Similarly to Germany and Italy, the Austrian BESS market is strongly anchored on the residential segment. In 2023, almost 840 MWh, equal to 127% annual growth, were built in the household segment. The Austrian government has been supportive of renewables and energy storage solutions providing attractive financial incentives, investment grants, and subsidies to the segment. These incentives aim to accelerate the country's transition to a more sustainable and decentralised energy system. As a result, 75% of the total operating BESS fleet has been added in the household segment.

Also supported by governmental investment programmes, the commercial battery segment has expanded significantly to reach nearly 530 MWh, which adds up to 26% of the total BESS capacity of the country. Austria has been able to maintain a stable growth trajectory over the past three years, as the C&I segment added between 110 and 170 MWh from 2021 to 2023. Austria has the third largest C&I BESS cumulative market of the top 5, backed by its commercial and industrial sectors striving for decarbonised self-sufficiency by decoupling generation and consumption of power.

Concerning utility-scale battery expansion, the country is still in its pilot phase, as storage developers are starting to capitalise on the significant volatility and wide spreads in wholesale power markets. The country's large-scale BESS operating fleet remains below 40 MWh, but the country has taken significant strides to boost its deployment. While firm capacity of the grid decreases rapidly due to the penetration of intermittent renewable energy sources and the phase-out of traditional fossil baseload sources, in the end of 2023 the country approved a new Electricity Law that is expected to streamline permitting, improve market conditions, remove double charging, among others.

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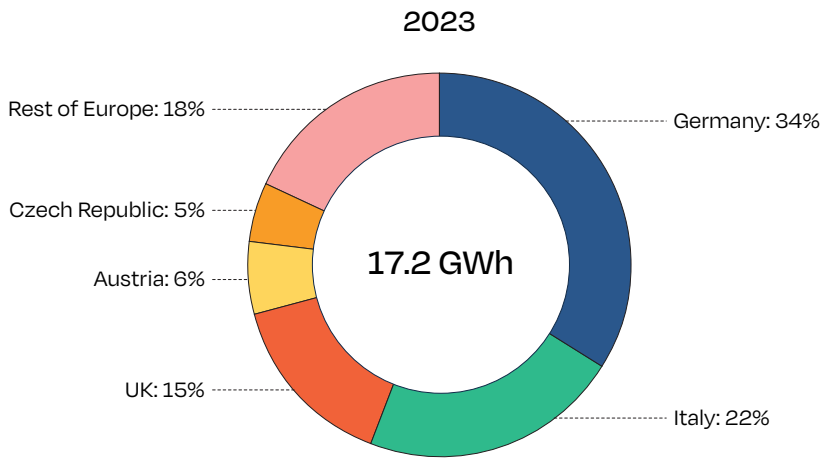
The **Czech Republic** closes the top 5 group, after it nearly reached the GWh landmark in 2023 with close to 920 MWh installed. It showed annual growth rates of 197%, mainly driven by the massive expansion of the residential battery segment. Last year, Czech households installed 910 MWh of solar & storage, the highest BESS-PV attachment rate in Europe (94%). This record level has been achieved thanks to the very well-established support of the New Green Savings Programme. This incentive scheme, which covers all clean electricity systems – solar PV, batteries, heat pumps, and EV charging stations – makes installations extremely attractive for homeowners, not only solar & storage but also through electrification of residential heating and transport. With home batteries contributing nearly 100% to new BESS installations, the Czech Republic is the top 5 market with the

FIGURE 11 TOP 5 EUROPEAN ANNUAL BATTERY STORAGE MARKET SHARES 2023



highest reliance on the residential segment. In contrast, C&I and large-scale batteries only provided a negligible share of the total added capacity in 2023, indicating that these segments have not taken off yet.

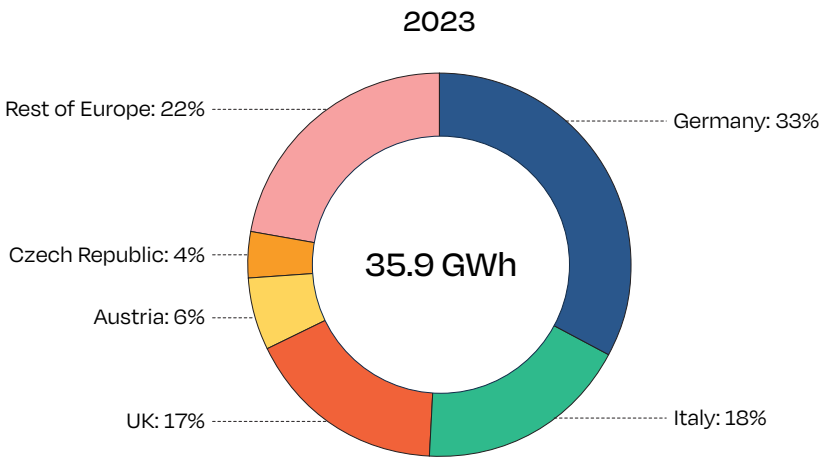
The European top 5 BESS markets accounted for 82% of new battery installations across the continent in 2023, an 8 percentage point increase compared to the year before (Fig. 11). This market concentration trend is also visible when looking at the top 3 markets, which added 71% of the European total in 2023, up 6 percentage points from the 65% share in 2022. This suggests that, for the time being, the European BESS market remains largely driven by a handful of battery pioneers, although things might change in the future, as several European countries want to profit from the battery revolution, which will likely result in diversification of the producers and supply landscape in Europe.

Looking beyond the leading battery markets in Europe, some emerging markets like Sweden and Belgium have started to play a more prominent role. Both markets, characterised by a flourishing residential PV market, have registered outstanding growth in 2023.

Sweden has been able to activate the residential segment by utilising a very successful tax deduction scheme for self-consumption models, which covers 48.5% of the upfront investment, up to a limit of 4,500 EUR. Additionally, thanks to the 100% penetration rate of smart meters, until recently households were allowed to participate in the balancing services market (FCR) to cut power peaks or deliver support services to the power grid. In 2023, Sweden installed about 660 MWh, 63% of which belonging to the residential segment, which got close to the GWh milestone of total installed capacity. Alongside home batteries, the C&I segment significantly expanded last year, adding about 180 MWh to reach 235 MWh of cumulative C&I battery storage capacity. The combination of the tax deduction programme and the possibility to bid in the balancing market has greatly improved the possibility to bid in the balancing market has greatly improved the business case and triggered a significant expansion, which is expected to continue.

Belgium's battery market has performed impressively in the last three years. Between 2021 and 2023, the country installed around 215 MWh, 450 MWh, and 340 MWh respectively at the residential level. In conjunction with the grid-scale segment, where Belgium operates more than 370 MWh of battery capacity, the Belgian BESS fleet almost surpassed 1.5 GWh at the end of 2023. Of this, the residential segment accounts for 1.1 GWh or 75%. When analysing the Belgian residential solar & storage market, it is key

FIGURE 12 TOP 5 EUROPEAN CUMULATIVE BATTERY STORAGE INSTALLED CAPACITY SHARES 2023



to segment the market among its three regions – Flanders, Wallonia, and Brussels – as local regulatory frameworks diverge significantly. In Flanders, a large market growth was supported by the introduction of a subsidy scheme in 2022 for the installation of household batteries, the phase-out of the net-metering scheme, and the impact of the energy crisis. In Wallonia and Brussels, despite the impact of the spike in power prices, the existing PV export tariffs and the lack of subsidies for residential batteries limited market expansion. As a result, nearly all the household battery installations materialised in Flanders.

At the grid-scale level, Belgium is making significant progress. A big driver of the multiple hours' duration and scale of projects installed during the last 2 years is the country's capacity market, part of the country's ancillary service opportunities, including restoration services, voltage service provisioning, or balancing services to manage imbalances between production and consumption. The combination of these revenue streams provides a strong business case for developing and operating large-scale battery projects.

Another case of a flourishing grid-scale battery market is **Ireland**. Similarly to its British neighbour, the country stands as one of the most attractive and developed markets, with a cumulative grid-scale BESS capacity close to the GWh mark. This notable expansion has been facilitated by the possibility to access four key markets – energy arbitrage in the wholesale market, the capacity market, frequency response, and balancing and restoration services. This allows battery operators to stack various revenue streams, making Ireland one of the best locations to invest in large-scale batteries.

Some other countries that have grown substantially over the past years are **Spain**, with about 800 MWh of grid-connected battery capacity at the end of 2023, **Switzerland** with more than 730 MWh and **Poland** with around 440 MWh. These countries, mainly due to the distributed segment, have been able to grow the battery storage base with the introduction of support schemes for the segment.

The top 5 largest European markets in 2023 are also the countries with the largest operating fleets (see Fig. 12). The ranking is also the same one, with Germany contributing the largest share (33%), followed by Italy (18%) and the UK (17%), which in 2023 lost one place due to the strong annual growth in the Mediterranean country. In total, the top 5 European BESS fleets were responsible for 78% of Europe's total battery storage capacity, while all other European countries together are sharing the remaining 22%.

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2 Drivers for battery storage deployment

2.1 Drivers to residential & C&I battery deployment

Electricity prices

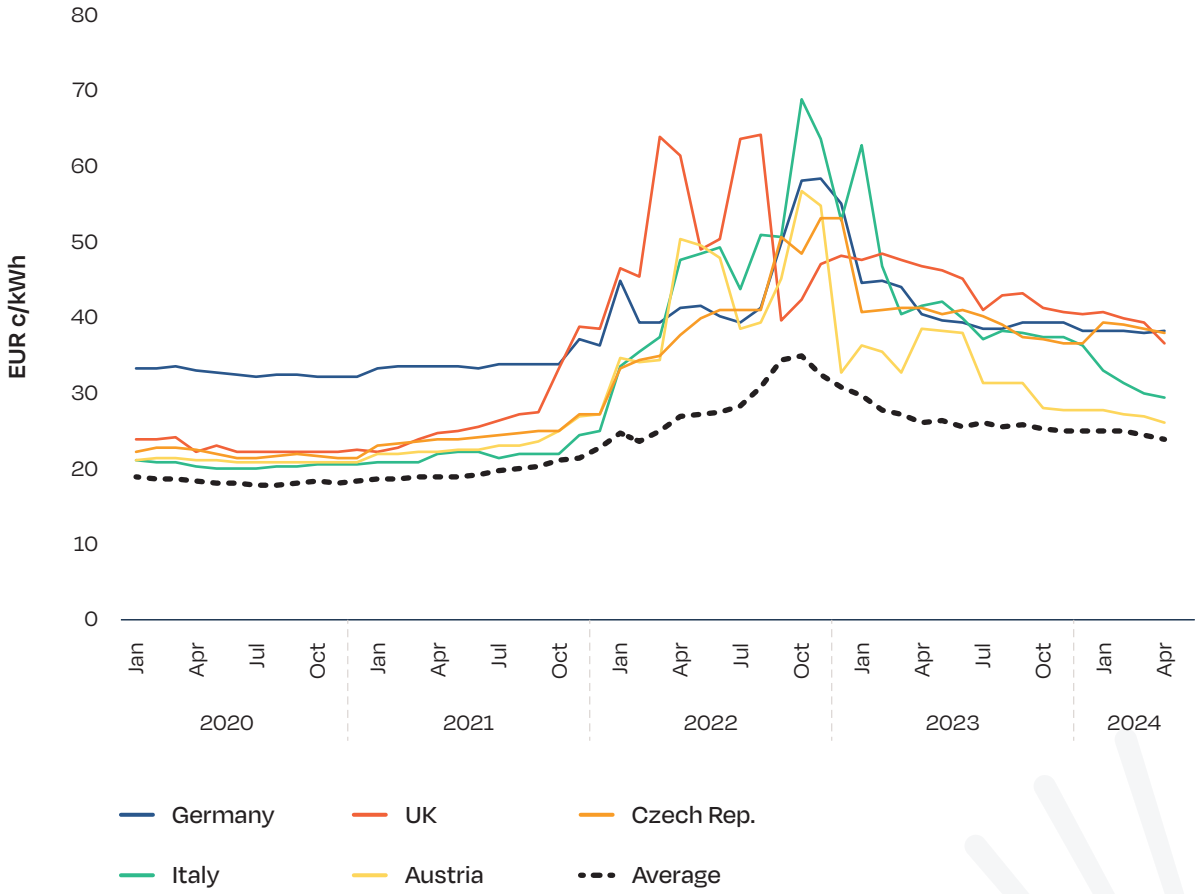
After the severe disruptions of the COVID-19 pandemic in 2020, which brought the world economy basically to a standstill, global energy consumption rapidly surged as economic operations restarted. This led to a temporary structural increase in electricity prices across European markets, due to the mismatch between ramped-up energy demand and restricted supply. The impact on electricity prices was already visible at the end of 2021.

This increase in energy prices was profoundly aggravated by Russia's invasion of Ukraine in early 2022, which plunged global and European energy markets into turmoil. Coupled with severe inflation, this led to the halting of production processes across European countries due to the extreme volatility and steep spikes in energy prices. Europe's reliance on natural gas supply from Russia had resulted in a major strategic economic and existential weakness that crippled its ability to react swiftly and absorb such an energy supply shock.

As natural gas generally sets the marginal cost of power in Europe, its price volatility was the main driver of the surge in electricity prices across the continent during the height of the energy crisis. This translated into an immediate increase in residential power prices that was felt harshly in many countries, in particular those heavily relying on Russian gas, like Germany, Italy and the United Kingdom (see Fig. 13). For instance, household electricity consumers in Italy, where prices spiked most, were facing a 214% increase between 0.22 EUR per kWh in October 2021 and the peak of 0.69 EUR/kWh exactly one year after.

Consequently, a quickly growing number of households across Europe resorted to solar PV and battery storage systems to trim their electricity expenses and bolster energy resilience, while reducing their carbon footprint. But the surge in demand for residential solar & storage outpaced supply readiness, exacerbated by a general shortage of installers across Europe, in particular electricians, which caused unseen delays in delivery and construction times. Nevertheless, major European BESS markets witnessed unprecedented installation volumes as households integrated PV systems with batteries. This trend is visible in the overall rise in average residential BESS-PV attachment rates (Fig. 14). In Europe's largest solar market Germany, 82% of all household PV installations in 2022 included a battery, marking a 10-percentage-point increase from 2021. In Italy, attachment rates surged from 49% in 2021 to 84% in 2022, driven by the energy crisis and the implementation of the Superbonus scheme. Austria experienced a 23-percentage-point increase in the attachment rate, while the Czech Republic saw a rise from 75% in 2021 to 91% in 2022.

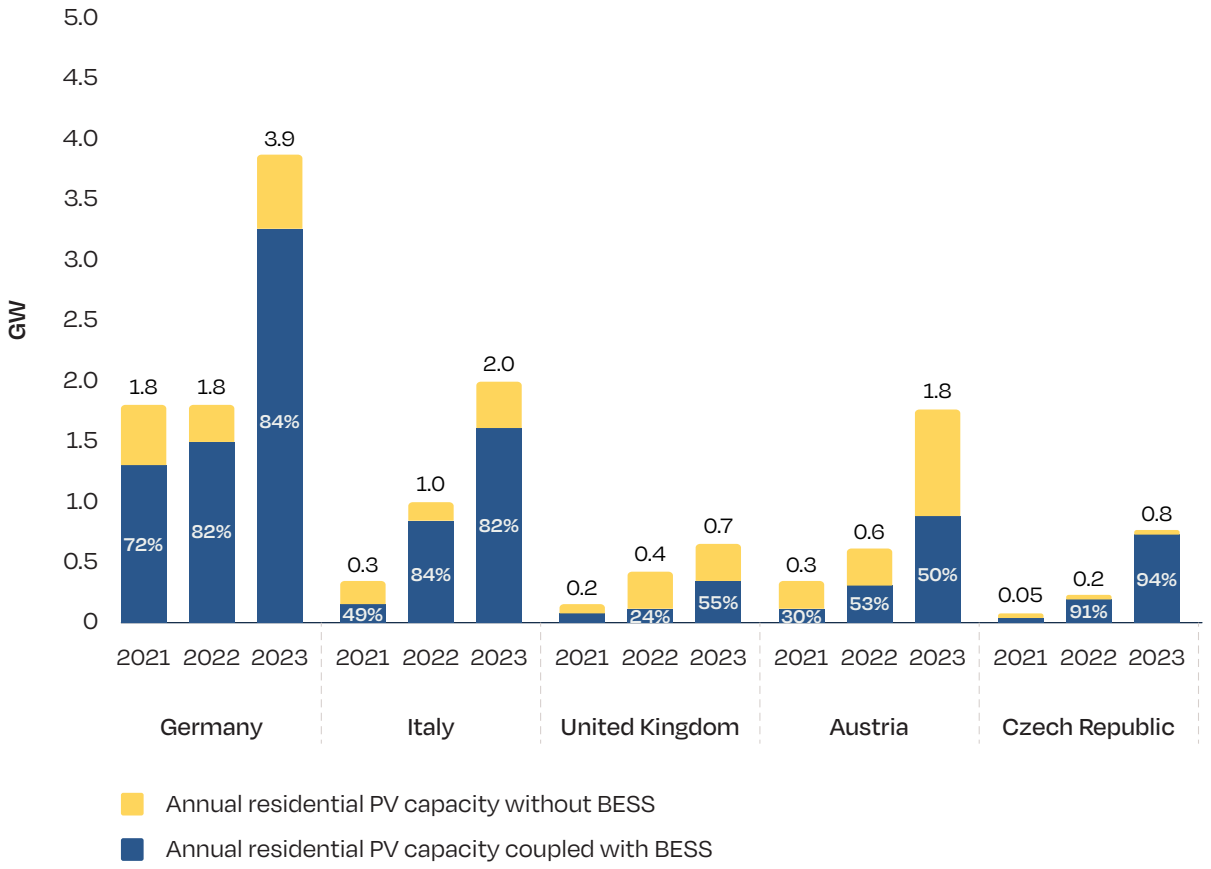
FIGURE 13 RESIDENTIAL ELECTRICITY PRICES IN THE TOP 5 BESS MARKETS AND EUROPEAN AVERAGE, JAN-20 – APR-24



Source: Household Energy Price Index (HEPI).

In 2023, despite the gradual decrease in power prices, elevated interest rates, and an inflationary environment, the business case for investing in residential solar & storage remained remarkably robust. While the first half of that business year was characterised by system installations from the huge pipeline of orders piled up during the energy crisis, the wish for more energy independency and the ability to hedge against future energy price spikes continued to nudge many European households towards solar & storage as the answer to their energy needs. Unlike in 2022, with battery manufacturing rapidly scaling up and a larger workforce available for installations, both the upstream and downstream industry sides were prepared to absorb much larger demand for battery products, resulting in new deployment milestones across residential BESS markets. Attachment rates persisted above 80% in Germany and Italy, surged to 55% in the UK, and achieved 94% in the Czech Republic, a level unseen before in Europe. Austria maintained coupling rates above 50%.

FIGURE 14 ANNUAL RESIDENTIAL SOLAR PV INSTALLATIONS COUPLED WITH BATTERY STORAGE 2021-2023



Not all new batteries are installed simultaneously with a new PV system, which was the norm in the past in all European solar markets. That leaves huge potential to retrofit the existing large volume of solar-only systems with battery storage. Until now, retrofitting residential PV with a battery has been negligible compared to new installations, also because installers focused on new customers where they could sell the whole solar & storage installation package rather than the BESS alone. The significant increase in electricity prices in the recent past and the growing number of solar-only systems reaching the end of their subsidy payment terms will likely make this segment more notable in the future. In Germany, Europe's earliest solar market, the first 20-year feed-in tariff contracts started in the 2000s have already ended. In the region of Flanders in Belgium, it is anticipated that more than 360,000 residential PV systems will lose their net-metering premium by 2025. By the end of 2026, all remaining household PV installations will be excluded from the support scheme. Once net-metering schemes are disposed of, the grid stops being the most profitable battery, and connecting one to the PV system becomes the first-best decision.

In 2024, retail electricity prices have notably declined, yet they remain generally elevated compared to pre-pandemic levels. Across all our top-5 BESS markets, residential electricity prices surpass the European average, indicating a persistent power price signal that continues to stimulate installations of residential solar and battery storage systems. Moreover, the economic and psychological repercussions of the energy crisis remain in the consciousness of European households, prompting them to view the integration of solar PV

with storage as a practical and financially smart approach to shield themselves against future energy disruptions. Although in some countries like Spain, where power prices have greatly receded, the perception of the energy crisis has quickly faded away, the business case for battery storage remains, as BESS can boost household self-consumption rates up to 80% and beyond. Appropriate support schemes for battery adoption have proven to be a sufficient incentive to sustain and boost demand in times when power prices come down, thereby ensuring families' resilience in times of crisis.

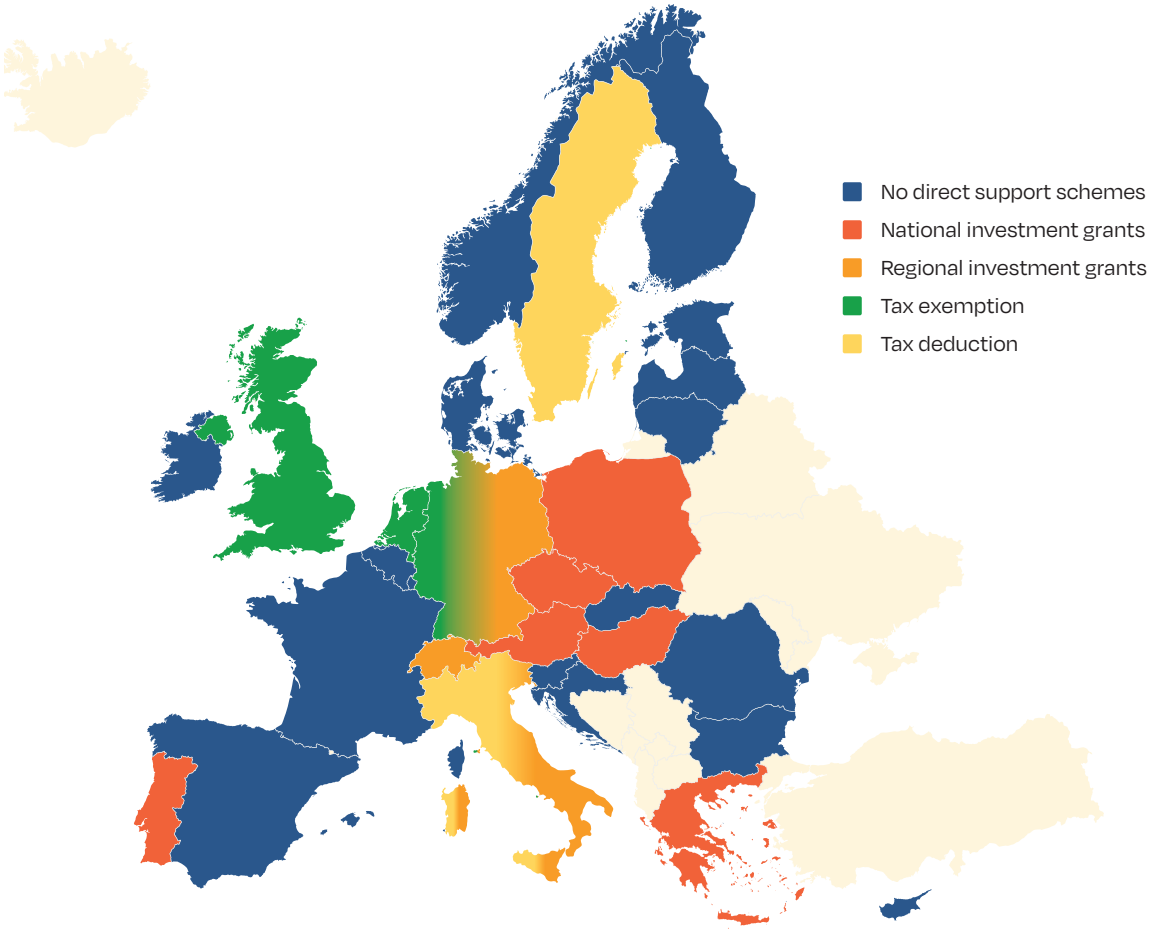
The high energy price landscape was similar in the C&I segment, as non-household electricity rates almost doubled from 2021 to 2022, which had a devastating effect on businesses and industries, whereby at times production processes stopped altogether. Against this background, the clean electrification business case improved in countries like Germany, the United Kingdom and Italy, which in 2023 saw a 150%, 60% and 73% yearly increase in C&I BESS installations, respectively. Companies decided to invest in clean electrification of their operations to de-risk their energy supply, at a time when batteries got more appealing as cheaper and better products were offered. Nonetheless, there is still a clear gap to bridge in policy frameworks across Europe to further strengthen the business case of C&I battery installations, as discussed in Chapter 3.

Support schemes

Government support schemes act as a significant catalyst for the adoption of residential batteries, assisting households in overcoming the upfront investment cost. In Europe, there are two main categories for direct support to home batteries – tax incentives and investment grants.

Tax incentives include tax exemptions and deductions, such as VAT exemptions in Germany, the UK, and the Netherlands, as well as tax rebate programmes like the Green Deduction programme in Sweden (see Figure 15). Such measures offer a direct, effective and transparent means of incentivising the installation of residential batteries.

FIGURE 15 TAX INCENTIVES AND DIRECT SUPPORT SCHEMES FOR RESIDENTIAL BATTERIES IN EUROPE 2024



Other countries such as Greece, Austria, Hungary, and Poland directly subsidise the uptake of batteries, whether retrofitted or in new installations, through a national CAPEX grant scheme. These subsidy initiatives tend to be temporary and subject to budget constraints, leading to a sudden and pronounced surge in applications until the budget is quickly exhausted. All these countries depleted their funds within the initial weeks of the scheme's introduction, which could leave the market relatively unstable. However, if designed and communicated properly, these short-lived subsidy programmes can also have long-lasting and sustainable effect. In May 2013, Germany launched the KFW investment programme, which helped lay the base for the country's industry leadership as the most important companies were established during that time thanks to the increased household battery adoption.

A clear example of a long-term funding strategy is the Czech Republic, which introduced the Green Savings Programme in 2022. Making use of the EU Modernisation Fund, this investment grant scheme encompasses energy-efficient home renovations, including solar PV and battery storage, without imposing a cap on the number of installations eligible for subsidy. This has resulted in an exceptional home storage deployment volume, exceeding 900 MWh in 2023.

The budget constraints challenge applies to tax exemption schemes as well. In Italy, following the resounding success of the Superbonus in driving battery adoption and amid concerns about public spending, the government opted to scale it back in 2023. For condominiums, the 110% Superbonus dropped to 90% in 2023, to 70% in 2024 and to 65% in 2025. The transfer of the tax credit has also been largely limited. The restructuring bonus, which also includes installation of photovoltaic systems and related batteries, remains structurally financed at 36% - an amount which, on several occasions, has been increased and currently amounts to 50% until 31 December 2024. The Superbonus law decree established a 30% reduction rate for expenses incurred from 1 January 2028 to 31 December 2033.

In parallel to national support schemes, certain regional governments may introduce short-term subsidy schemes to bolster installations at the local level. This has been the case in several German, Italian or Swiss regions.

Rooftop PV system with 234 kWh BESS in Girona, Spain. © sonnen

Lastly, besides the direct support schemes through CAPEX grants and tax benefits, governments can also provide indirect support through zero- or low-interest loans for green investments, which are particularly effective for households that cannot afford hefty upstream investment costs. For example, Germany provides low-interest loans for the installation of renewable residential energy systems.

In 2024, many financial support schemes favouring battery adoption across Europe were discontinued. Some notable examples are Belgium and Spain, where installation volumes in the last few years rose thanks to investment grants. In the Belgian region of Flanders, in 2022 and 2023 households installing a battery received an investment premium which varied depending on the size of the battery system. Those

BOX 2: REMOVAL OF DOUBLE CHARGING ON ENERGY STORAGE

What do we mean by double charging?

Double charging fees happen when energy storage is seen as both a consumer, absorbing electricity from the grid to help balance and reduce congestion, and as a producer, injecting the same electricity back into the grid when needed .

Since double charging doesn't affect fossil generators, energy storage is unfairly disadvantaged against fossil fuels in flexibility provisions, especially fr prosumers. This adds a big financial burden to energy storage projects and keeps us relying on non-renewable energy. Double charging is, therefore, one major hurdle to the deployment of energy storage, that must be tackled.

Removing double charging won't mean that taxes and fees won't be paid, for instance on grid usage. Taxes are paid when the electricity is purchased from or sold on the market in the first place – outside of flexibility services.

The Clean Energy Package of 2019 aimed to prevent double charging for prosumers providing flexibility services. But the wording of the legislation is unclear, and has resulted in insufficient action by several Member States so far. In addition, the Clean Energy Package addresses only prosumer storage, leaving out standalone storage. A recent analysis on National Energy and Climate Plans (NECPs) by our Energy Storage Coalition (ESC), co-founded by SolarPower Europe, reveals that:

- Only five Member States (Czech Republic, Germany, Portugal, Spain, Sweden) are effectively addressing the double-charging issue. In Czechia, a new energy law is expected to enter into force in 2025 containing a specific ban on double-charging.
- Seven Member States still lack actions to address the issue (Belgium, Finland, Greece, Hungary, Italy, Luxembourg, Slovenia). Belgium continues to lack a national action on double charging. Flanders partially addressed double charging in 2022, removing the grid charge only for new storage at the high voltage level.
- 12 Member States are not addressing double charging at all in their NECPs (Croatia, Cyprus, Denmark, Estonia, France, Ireland, Latvia, Lithuania, Malta, the Netherlands, Romania, Slovakia). Ireland's public authorities recognised double charging as a significant obstacle to reaching final investment decisions in energy storage and they ceased generation-related charging for commercial energy storage providers, which accounted for 25% of the total charges requested by the network operator. But as of January 2024, certain forms of double charging on energy storage persist and this issue is not addressed in the NECP. In the Netherlands, double energy taxation has been eliminated for large-scale consumers, but the issue remains unresolved for small-scale consumers, where removal is more complex. Since 2022, the Ministry of Finance has been looking for solutions to remove this double taxation but is yet to find one. Slovakia had a new law under preparation in 2022, but yet not reported in its NECP.

BESS installations with less than 4 kWh of storage capacity got the highest subsidy rate (225 EUR/kWh in 2022 and 150 EUR/kWh in 2023), while for batteries ranging from 4 kWh to 6 kWh, the CAPEX grant went from 187.5 EUR/kWh in 2022 to 125 EUR/kWh in 2023. Batteries in between 6 kWh and 9 kWh were subsidised with 150 EUR/kWh, but this subsidy tranche was eliminated in 2023. In 2022, there was a subsidy limit of 1,725 EUR per battery, which was halved to 850 EUR in 2023. This CAPEX programme was abruptly terminated in April 2023, and no new incentives have been introduced since then. In Spain, in 2022 a share of the Next Generation funds was utilised to provide financial support for the self-consumption segment. This created a queue in applications for the subsidy, which resulted in significant delays in the approval and payment process. Nonetheless, installation volumes increased to record levels in 2022 and 2023, the years when the scheme was in place.

Regulatory environment

Making the business case for battery storage appealing is not all about financial conditions, but rather a combination of policy instruments that incentivise investment into the technology plus an enabling regulatory framework that includes a reduction of technical and financial barriers, excessive bureaucracy and faster permitting procedures. In some aspects, what the storage business cases need is simply a level playing field to compete against fossil fuels (see Box 2 on double charging). The introduction of flexible electricity tariffs is also critical to improving the economics of residential battery systems. The United Kingdom stands out as a prime illustration of a regulatory framework that facilitates the integration of BTM storage in electricity markets, yielding advantages for the system and unlocking supplementary revenue channels. Here it is not only about self-consumption, the prime driver in most markets so far, but by means of aggregators, BTM batteries are able to engage in wholesale energy, capacity, and local flexibility markets, all while offering grid services.

© sonnen

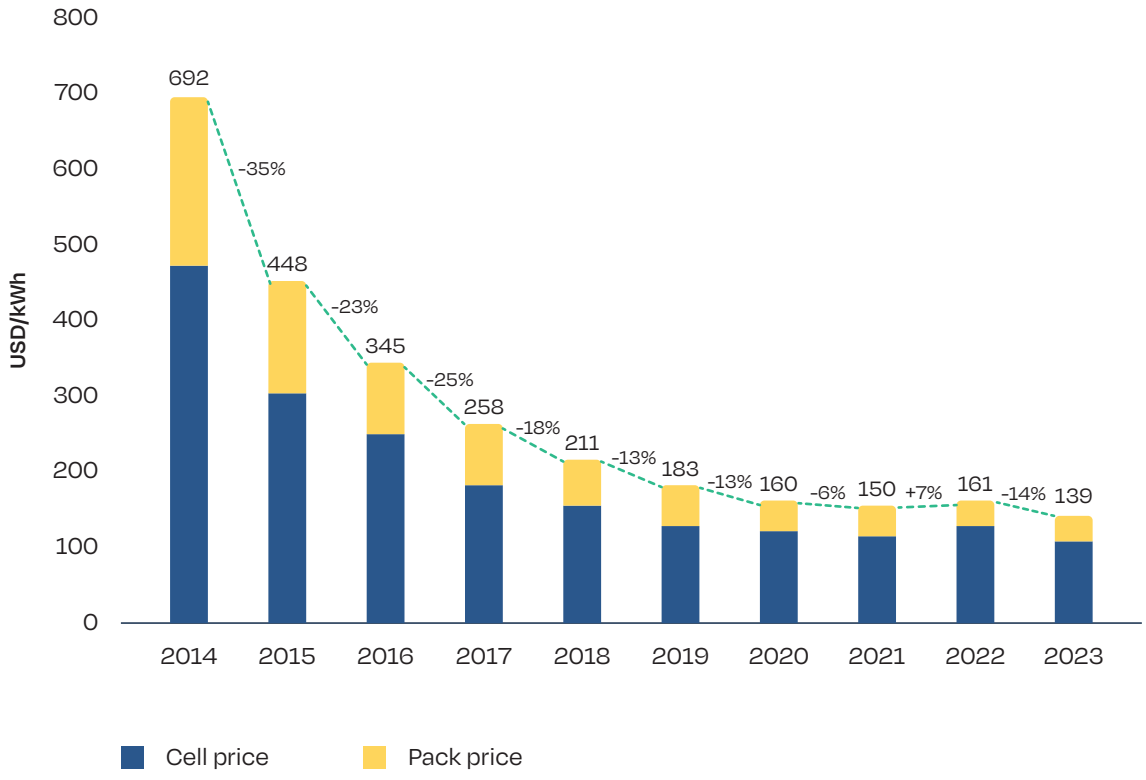
Battery prices

Another fundamental driver of battery deployment is the steep decline in the production cost of lithium-ion batteries, the technology that vastly dominates the market, compared to alternatives such as lead-acid or nickel-cadmium batteries. For stationary battery storage, and unlike batteries for EVs, size and weight are not that important – the key features are low costs and high durability. In this regard, lithium-ion batteries still have a significant edge over other technologies.

During the last decade, the prices of lithium-ion batteries, encompassing both cell and pack costs, have seen a notable decline from approximately 690 USD/kWh (635 EUR/kWh) in 2014 to less than 140 USD/kWh (129 EUR/kWh) in 2023, according to IEA/BNEF (Fig. 16). This equals a compound annual decrease of about 15%. This reduction can be attributed to ongoing advancements in research and development, economies of scale, and technological breakthroughs. Consequently, the proportion of raw material costs within the overall battery cost has increased, meaning that battery prices are now significantly influenced by the price of critical minerals, which may be subject to volatility. While technology improvements continue to drive costs further down, prices have been recently strongly under pressure due to fierce competition in an environment of massive production overcapacities.

In terms of lithium-ion battery manufacturing, the existing capacity has more than tripled in the past four years, reaching 2.5 TWh in 2023, according to the IEA (note that stationary storage absorbs a minor share of

FIGURE 16 PRICE EVOLUTION OF LITHIUM-ION BATTERY CELLS AND PACK, 2014-2023

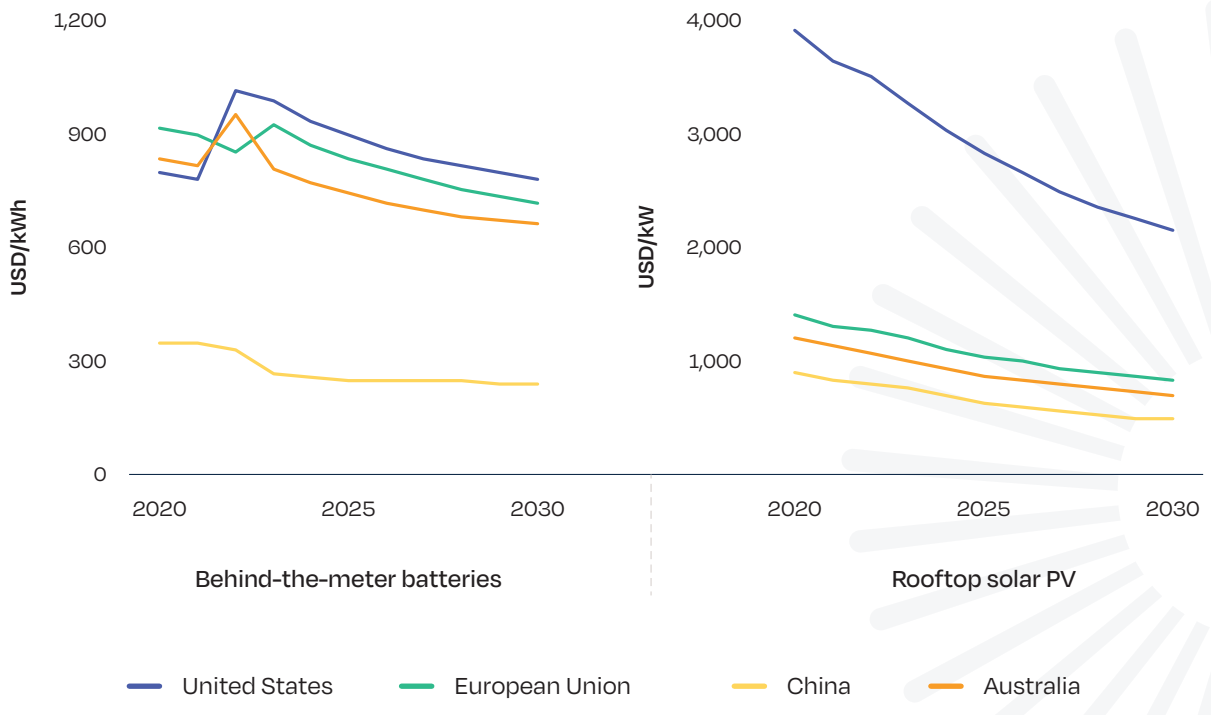


Notes: 90% of lithium-ion batteries in use are for electrification in the transport sector. Prices are weighted averages across regions and chemistries. Historical prices are updated in real terms to reflect USD in 2023.
Source: IEA (2024), based on BNEF data.

overall battery capacity volumes, which are predominantly feeding the EV sector).[4] A third of the global manufacturing base was added last year alone. The concentration of battery manufacturing capacity is primarily in China, which today holds 83% of the current production capacity, up from 75% in 2020. Europe and the United States collectively represent about 13% of the global capacity. Global manufacturing capacity of battery systems is projected to increase nearly fourfold by 2030 compared to current levels. Should all announced projects materialise, China's share is anticipated to decrease to 67% by 2030.

As the global manufacturing capacity of batteries will further expand over the coming years – expected to reach 9.4 TWh by 2030 (about 80% to serve the EV market), and technologies improve, the investment costs associated with the production of BTM batteries and rooftop solar PV are expected to further decrease (Fig. 17). This is a relevant trend: since BTM battery systems typically have minimal operating costs, the total costs are primarily determined by the upfront investment and the cost of capital. According to the IEA Stated Policies Scenario (STEPS), which reflects existing policy conditions, the costs of BTM batteries in the EU are expected to decline from 927 USD/kWh (852 EUR/kWh) at the end of 2023 to 722 USD/kWh (664 EUR/kWh) by 2030. This translates into a 21% drop in the investment costs of BTM battery storage. In conjunction, investment costs for rooftop solar PV in the EU will decline by 30% by 2030, according to the IEA Stated Policies Scenario. This will further improve the case for solar coupled with storage by lowering upfront costs and reducing the payback period.

FIGURE 17 COSTS OF BTM BATTERIES AND ROOFTOP SOLAR PV IN IEA STEPS, 2020-2030



Source: IEA (2024).

4 IEA (2024): Batteries and Secure Energy Transitions.

Environmental awareness and electrification

Finally, environmental awareness also holds significant sway in household decision-making processes. The desire for self-sufficiency often aligns with strong ecological values and a commitment to embrace greener energy consumption and contribute to the energy transition. According to BNEF, end-customers willing to increase self-sufficiency are usually early adopters that are green-minded or technology enthusiasts.[5] With the increasingly harmful impacts of climate change, this driving factor is likely to gain even greater prominence.

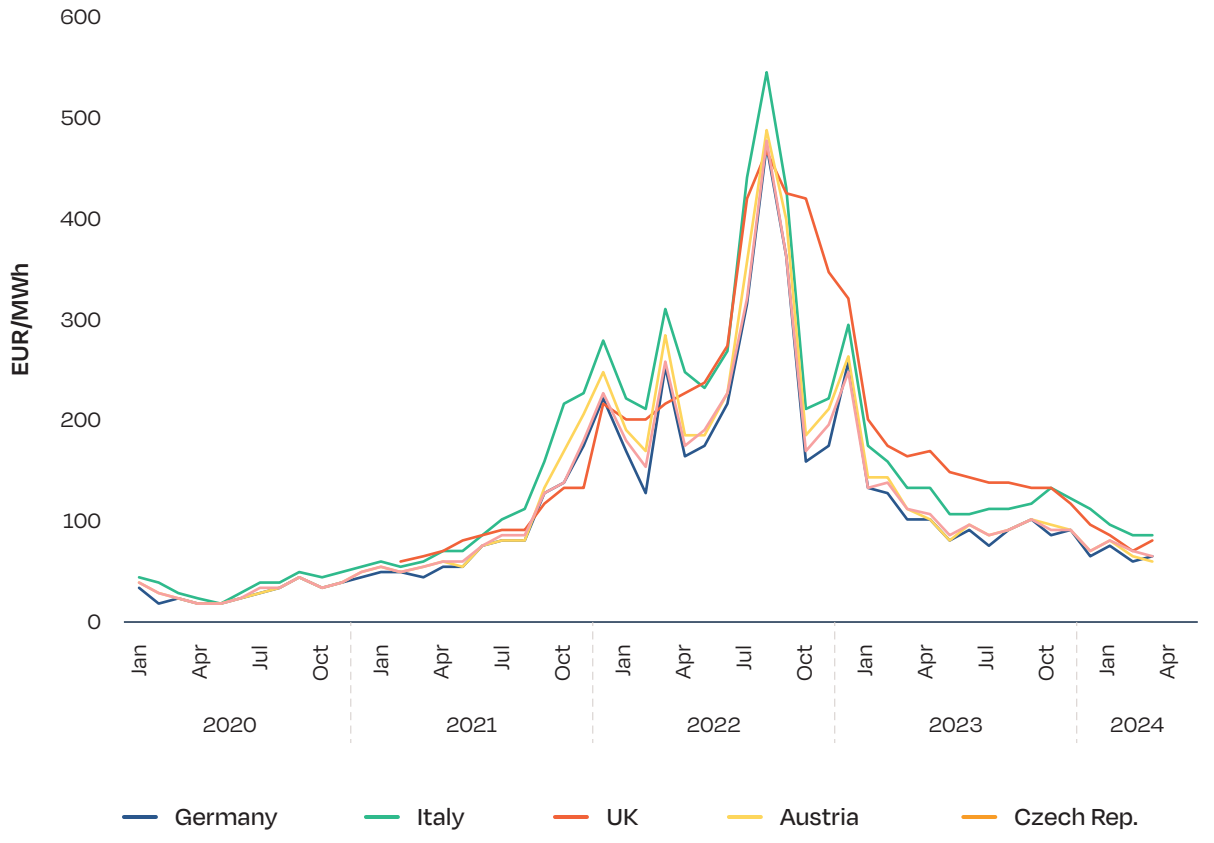
In addition, the adoption of electric vehicles and the electrification of heating with heat pumps increase the need for residential power storage to meet a larger demand for clean electricity. Countries like the Czech Republic are already supporting the electrification of residential energy generation and consumption. Against this background, batteries are playing an increasingly relevant role in meeting households' power needs as electrification rates continue to increase across Europe.

2.2 Drivers for utility-scale battery deployments

Electricity prices

Looking at electricity prices across European wholesale markets, it is easy to see a trend similar to household electricity prices in the last few years (see Fig. 18). Starting

FIGURE 18 WHOLESALE ELECTRICITY PRICES IN GERMANY, ITALY, THE UK, AUSTRIA AND THE CZECH REPUBLIC, JAN-20 – MAR-24



Source: Ember Climate (2024).

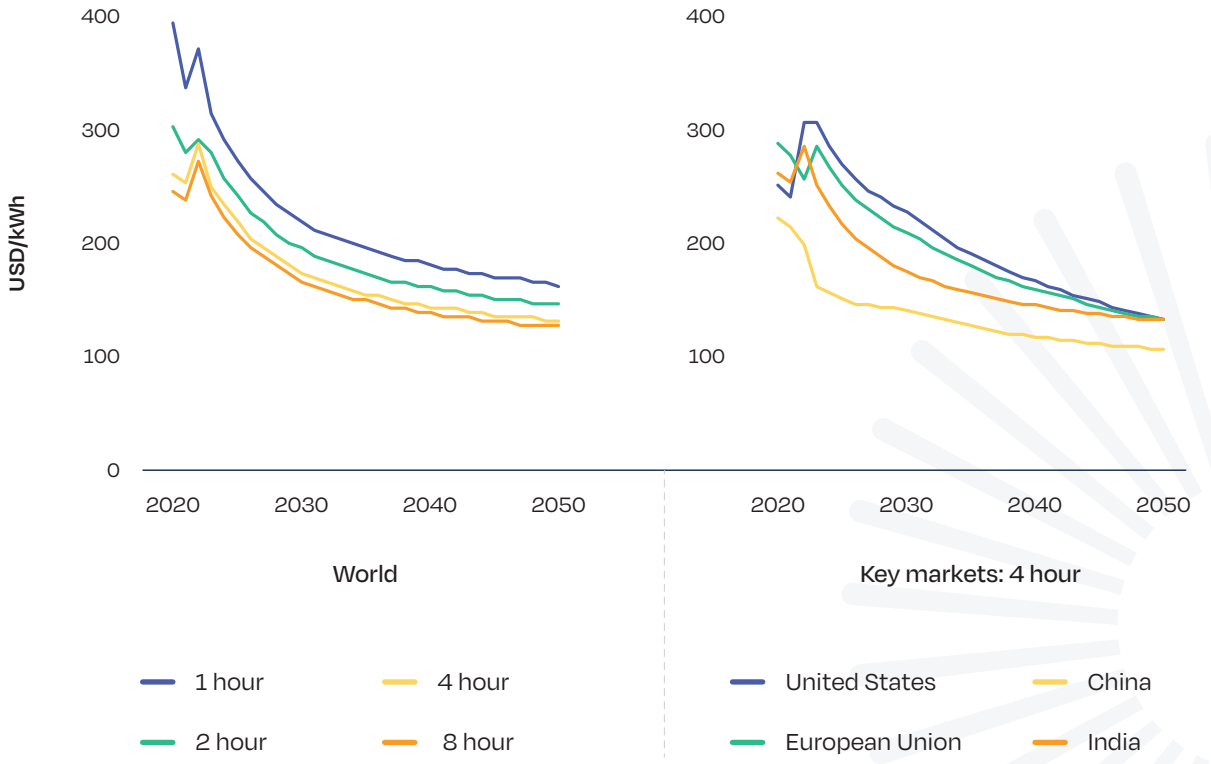
5 BNEF (2023): Scaling the Residential Energy Storage Market

from the second half of 2021, wholesale electricity prices increased substantially in 2022, reaching a peak in summer. Since natural gas often sets the electricity price in the marginal pricing system, the increase in gas prices caused a surge in electricity prices as well. In 2024, despite a decrease under the 100 EUR/MWh range and now much below the heights reached in the past two years, average electricity spot prices remain at higher levels than before the Ukraine war.

Cost competitiveness

Despite the temporary uptick in capital costs of utility-scale batteries, caused by a sudden shock in supply chains and critical mineral prices in 2022, the total upfront costs of FTM batteries will decline significantly. BESS with longer duration generally has lower average costs, as project expenditures are distributed across more units and there exist significant economies of scale for the balance of system costs. On average, total system costs of large-scale batteries, regardless of the duration, and relative to 2023 will fall by 30% by 2030, 42% by 2040, and 48% by 2050, according to the IEA Stated Policies Scenario (see Fig. 19).

FIGURE 19 AVERAGE TOTAL SYSTEM CAPITAL COSTS OF UTILITY-SCALE BATTERIES GLOBALLY AND IN KEY MARKETS IN IEA STEPS, 2020-2050



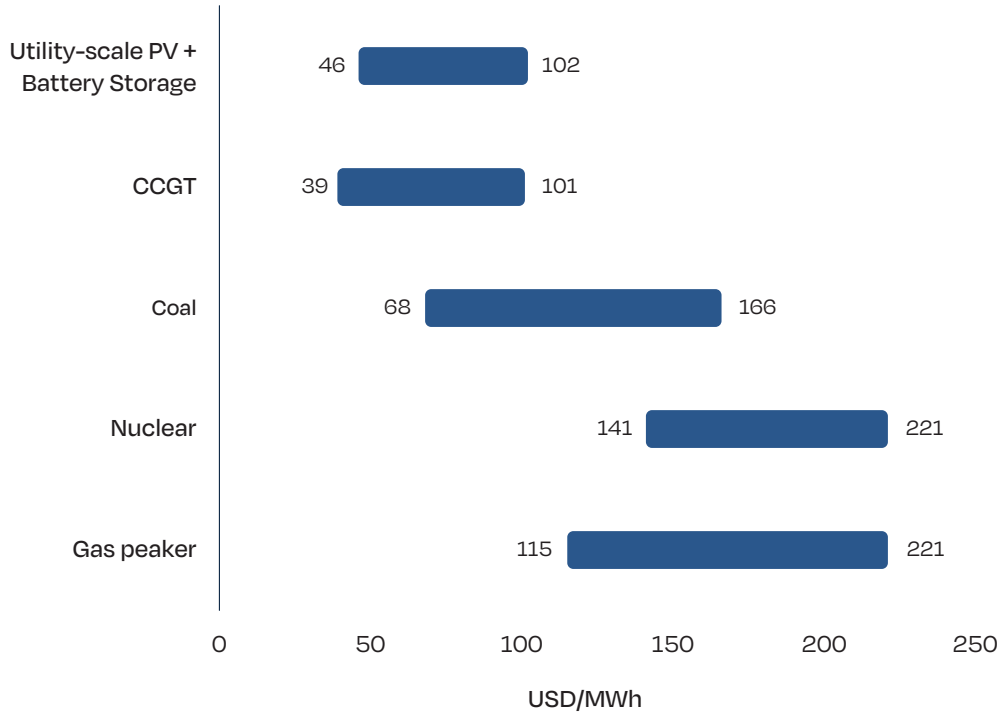
Source: IEA (2024).

In the EU, the upfront investment for a 4-hour battery project with 100 MWh of storage capacity, which stood at 28.6 million USD (26.3 million EUR) in 2023, will decrease by 25% to 19.3 million EUR in 2030 and by 57% to 12.1 million EUR in 2050, according to the IEA Stated Policies Scenario.

Against this background, the cost competitiveness of solar & storage continues to increase. As reported by U.S. investment bank Lazard in its Levelised Cost of Energy (LCOE) 2023 analysis, utility-scale solar & storage display a much lower cost range than gas peakers (see Fig. 20).

The rising interest towards large-scale BESS can be seen in an increasing number of countries worldwide setting hybrid renewable auctions. Such auctions involve the co-location of different renewable energy sources alongside battery storage, offering a flexible and versatile solution to meet energy requirements. An overview of the current status of hybrid auctions in Europe is provided in Box 3.

FIGURE 20 LCOE COMPARISON FOR BASELOAD TECHNOLOGIES 2023



Source: Lazard (2023).

BOX 3: CURRENT STATUS OF SOLAR & STORAGE AUCTION SCHEMES IN THE EU-27

Until now, only few EU Member States have set up competitive auction processes in which solar & storage assets can participate.

Member States that have opted for competitive processes dedicated to standalone batteries are Poland and Greece, where developers can decide afterwards and on a case-by-case basis if they want to co-locate or hybridise their project with renewable energy capacity. Greece recently received the green light from the European Commission to launch a new solar-plus-storage CfD scheme.

Other countries, like Germany, have created a specific segment called 'innovation auctions' where renewables coupled with storage assets can participate. But this segment has been significantly undersubscribed, mainly because of restrictive rules applied to winning projects. Under these rules, batteries are not allowed to participate and offer ancillary services and stack different revenues, two factors that put a barrier to their business case. At the end of 2023, Spain awarded its first storage grants through a specific auction segment, but unlike Germany, this one is specifically designed for co-location with solar and wind energy. Projects were assessed according to four criteria: economic viability, technical features, project viability and externalities.

More recent developments have occurred since the beginning of 2024, as more and more EU Member States are looking to support BESS projects. Italy just launched its new auction scheme for standalone storage called MACSE. The technologies will be limited to Li-ion batteries and pumped hydroelectric storage. Romania re-opened a call to support BESS projects specifically for renewable energy integration, while Croatia announced the future al location of 500 million EUR to large BESS, without giving more details on the nature of the scheme.

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Flexibility needs

As the green energy transition unfolds, rising flexibility needs and the corresponding battery storage deployment are primarily driven by the accelerated buildout of variable renewable generation in the energy mix, the decommissioning of traditional baseload and thermal assets, and the rising power demand driven by the electrification of transport and heat.

Germany stands as the perfect illustrative example as the country now lies at the forefront of the transition to a renewable-based energy system, but it's also navigating the challenges of intermittency and the lack of flexibility, demand-side response and storage. The country has enormously developed its solar infrastructure over the past decade, setting a new annual installation record last year with 15 GW of deployed PV capacity (see Fig. 21). This record figure, which was almost twice the governmental target of 9 GW, has propelled the country to a cumulative installed PV capacity of 83 GW by the end of 2023.

This remarkable growth trajectory set by Germany enabled record net solar electricity generation of 60 TWh in 2023. For the first time, renewables covered over half of its electricity consumption last year, growing by 9.4 percentage points to a 59.7% share, while generation shares from coal fell steeply. Lignite coal fell 27% from 106 TWh to 77 TWh, and hard coal 35% from 57 TWh to 37 TWh, while gas remained slightly below the previous year's level at 46 TWh for the public electricity supply and 30 TWh for industrial consumption, according to Fraunhofer ISE data.[6] As the expansion of batteries storage has been neglected in the past like the expansion and smartening of the

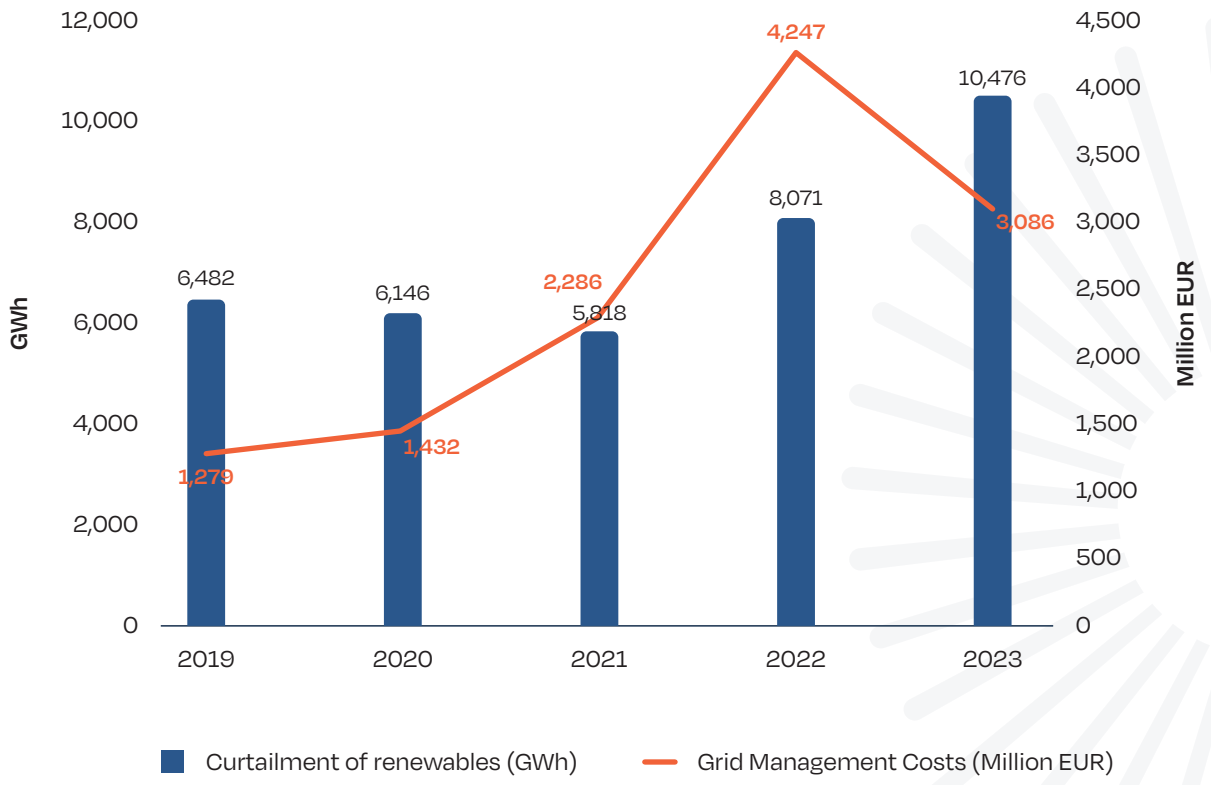
FIGURE 21 GERMANY SOLAR PV INSTALLED CAPACITY 2014-2023

6 Fraunhofer ISE (2024): Public Electricity Generation 2023

grid and respective policy frameworks, this decarbonisation milestone of the retirement of inefficient and expensive fossil-based sources brings challenges for the energy transition to renewables. The curtailment of renewable generation is on the rise in Germany as the grid is increasingly unable to manage the output of renewables (Fig. 22). In just two years, it increased by 80%, from 5.8 TWh in 2021 to a record high of 10.5 TWh in 2023. To put this number into perspective: last year, Germany consumed approximately 457 TWh of electricity, which means that the curtailed clean electricity could have provided 2.3% of the annual power consumption. With solar and wind power capacity in Germany planned to increase by a factor of 2.4 to a total of 360 GW until 2030, rather easy-to-deploy storage batteries will be the crucial technology to keep curtailment levels low.

Not only will rapid installation of battery storage capacity avoid growing curtailment and enable fast renewables growth, it will also help reducing expenses associated with grid congestion management, which have surged significantly to 3.1 billion EUR per year in 2023, 2.5 times higher than 4 years before. Today, in times of excess power output, renewable energy producers are compensated for halting electricity production, while fossil fuel power plants are remunerated to ramp up generation during periods of low renewable output. As more renewable capacity is added and thermal assets are progressively phased out, the number of hours with imbalances between supply and demand will increase, leading to higher curtailment and grid management costs unless sufficient clean flexibility, such as battery storage, is added.

FIGURE 22 COST AND LEVEL OF GRID CONGESTION IN GERMANY 2019-2023



Note: Grid management costs include costs associated with redispatch, compensations to plant operators, and turning on reserve power capacity plant.
Note: In 2022, grid congestion costs were at an all-time high of 4.2 billion EUR, but this year's costs were highly influenced by the energy crisis.
Source: Bundesnetzagentur.

BOX 4: HOW CAN NETWORK CODES VALUE SOLAR AND STORAGE

Demand Response network code

The integration of renewables into the grid and electrified loads require increased flexibility from the demand side. The IEA Net Zero Emissions by 2050 Scenario targets 500 GW of demand response by 2030, a tenfold increase from 2020. Interoperability and standardisation are crucial for integrating demand-side flexibility from devices like inverters, distributed storage, and EV chargers.

To unlock flexibility, EU institutions have engaged work on a new network code on Demand Response. This code will lay out the key principles for local flexibility markets that can be used by distribution system operators (DSOs) for congestion management, for instance, and to select which distributed asset can participate, including load, storage and distributed generation (aggregated or not). The drafting started in April 2023. It was supported by an informal closed-door Drafting Committee, which SolarPower Europe is a part of. In May 2024, transmission and distributed grid operator associations ENTSO-E and the EU DSO entity submitted the draft proposal to the Agency for the Cooperation of Energy Regulators (ACER), in charge of the ordinary revision process of a network code.

The network code will, in particular, provide for the following:

- **Define the principles for the design of market products for local flexibility services, as well as technical equipment required to provide the flexibility services** – Dedicated Measurement Devices (DMD). The Electricity Market Design legislation defines for the first time DMDs that can be recognised to offer crucial operational data for managing Distributed Energy Resource (DER) transactions in markets. According to SolarPower Europe, it will be critical that a sufficient level of harmonisation is ensured at the EU level, for instance with regard to Application Programming Interfaces (API) required. This would allow for an EU-level certification for product manufacturers.
- **Simplify market access by implementing clear EU rules.** Currently, access to the market for flexibility providers is complex and fragmented across markets. The network code will implement clear rules for enrolling distributed assets with service providers, such as procedures for ensuring consumer consent or standardising rules for data exchange for each flexibility product. SolarPower Europe calls for this aspect to be a high priority, as it can significantly reduce entry barriers to Pan-European markets.
- **Design the rules applying to flexible connection agreements (FCA).** Flexible Connection Agreements are agreements whereby grid users are not connected at full capacity on a permanent or non-permanent basis – and were introduced for the first time in the Electricity Market Design revision adopted in 2023. The network code defines under which conditions an FCA can be proposed and how a dynamic FCA should operate in parallel to congestion management markets. In addition, the network code will define what device will have distributed assets be equipped with Power Control Systems (PCS). SolarPower Europe calls in particular for an EU-level approach to the capabilities of Power Control Systems to ensure the possibility of an EU-level certification.

Following the Commission's revision and the Parliament's vote next year, the code is anticipated to be adopted in 2026.

Requirements for Generators' Network Code

The Requirements for Generator (RfG) network code is an EU regulation that establishes unified rules for generators connecting to the grid from low voltage to high voltage. This regulation entered into force in 2016 and is now in revision for adoption of the new version in 2025. SolarPower Europe has monitored

the implementation of that network code closely as one of the two renewable industry representatives in the related Stakeholders Committee held by ACER and ENTSO-E.

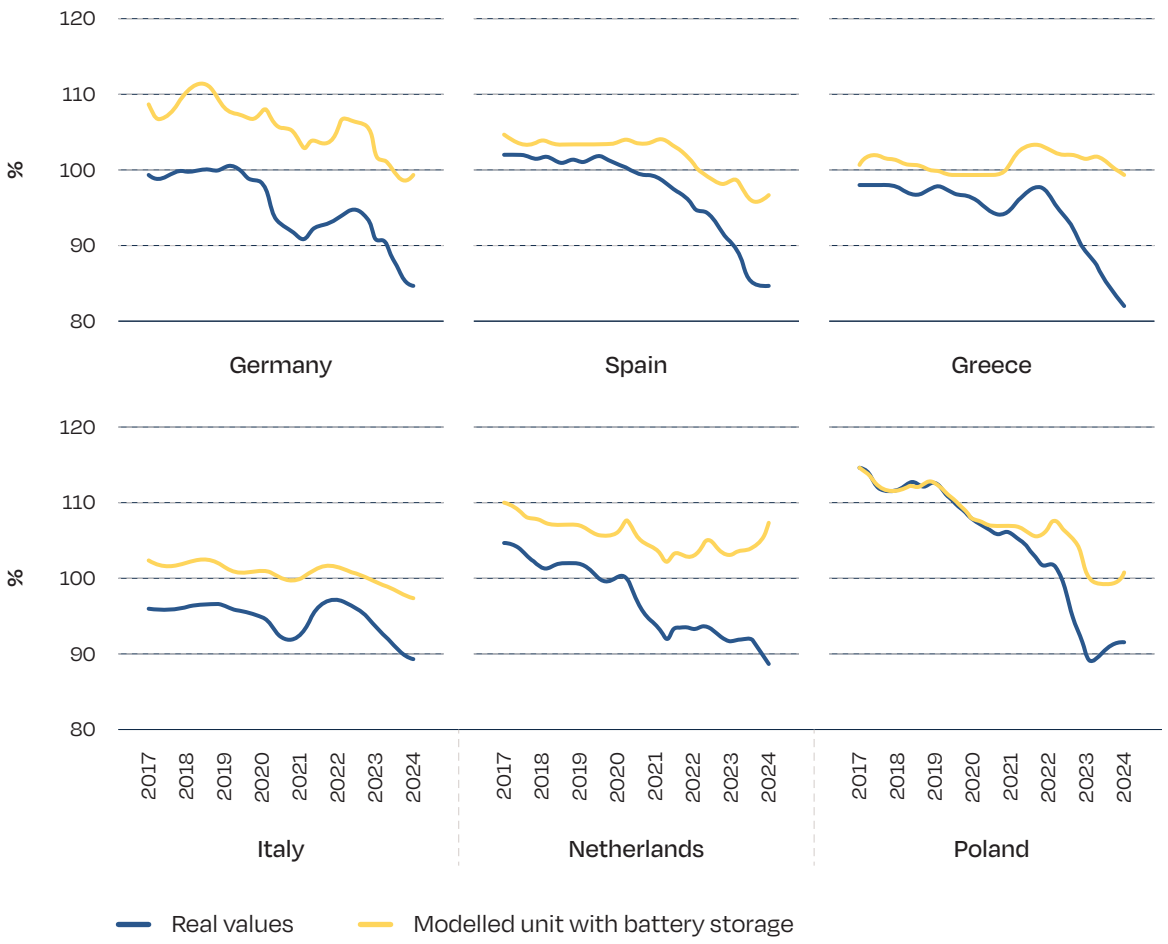
The solar industry highlights key priorities for fostering solar growth while maintaining robust system safety frameworks.

- **The updated network code need to have an accurate implementation timeline.** The timeline should be adjusted to a more realistic starting date for manufacturer compliance to allow time for adjustment after national rules are defined, ensuring a practical path for unified implementation across Europe. In addition, the Implementation Guidance Documents discussions need to be developed in close consultation with the industry to make the implementation smoother.
- The network code introduces grid-forming and storage as new requirements for new solar systems connecting to transmission grids. **Although grid forming will be critical in the future, it must not result into a disproportionate obligation to collocate systems with storage or be introduced where not needed.** Grid-forming services and systems hybridisation shouldn't be mandatory but be market-driven to benefit from a sustainable integration of solar and storage systems. In addition, grid-forming services must be introduced where needed: system operators must transparently assess grid stability needs before enforcing regulations, and be accompanied by a thorough cost-benefit analysis, approved by national regulators and involving solar industry players. Compensation mechanisms, like linking requirements to Contracts for Difference (CfD), should be in place for efficient storage rollout. All of this should be part of a mandated grid-forming roadmap with clear standards, which is essential for technology development.
- **The network code need to provide for harmonised requirements for solar products**, enabling an EU-level certification process for EU manufacturers. The network code currently provides too much flexibility at the national level, particularly for smaller power production assets (Type A). This results in different national certification rules and makes manufacturers repeat the process over and over for each country. CEN-CENELEC standards on Type A requirements should be promoted by ACER to NRAs and by the Commission through the High-Level Forum on Standardisation. European standardisation and harmonisation are crucial for a cost-effective energy transition, especially concerning mass-market products such as batteries.
- **The network code need to facilitate the combination of different technologies at the same connection point, which can enhance grid stability and flexibility.** SolarPower Europe suggests determining the significance requirements based on the maximum capacity agreed upon by developers and grid operators. However, this would require a new method for calculating capacity and establishing system requirements, which has already been successfully adopted by some EU TSOs. Such a successful approach should be adopted in the network code, and further implementation guidelines are needed to support connecting hybrid systems like solar and storage.
- **The network code need to weigh the costs against the benefits when considering new requirements, like safety regulations or grid codes.** Sometimes, these requirements come from the Member States' national grid codes rather than standard EU regulations. When adding new parts to a plant, such as a storage power system, it's important that the new requirements mainly apply to those new parts, rather than the entire system. For instance, depending on the rules set by the TSO and considering a solar PV system collocated with battery storage, both the old and new parts might have to meet the new requirements. This can be expensive and could potentially discourage building the new part altogether.

In summary, accelerated deployment of standalone or co-located utility-scale battery storage brings enormous benefits. This is a proven technology to reduce price volatility and lower system costs at peak demand and supply times. Batteries allow the grid to be operated more efficiently, acting as grid boosters, and enabling better utilisation of existing power networks. Co-locating batteries with solar PV can also increase solar capture rates – the market value of solar electricity compared to the base price of electricity – which are rapidly declining as more solar is added to the system, and to levels that at some point make it unattractive for developers to invest into solar power plant capacities. Across different European markets, battery storage solutions have proven to increase the value of solar electricity and, in turn, the revenues for solar PV generators (Fig. 23).

The topic of system flexibility has not captured the attention of European policymakers until recently, when a rising number of countries introduced strategies and targets for energy storage development, with notable examples like Spain or Italy (see Box 5). The outlook for battery storage deployment hinges on energy policy and regulation, as governments need to create better regulatory and market conditions for battery storage developers and operators. This should translate into ambitious targets and actions for renewables

FIGURE 23 HISTORICAL EVOLUTION OF SOLAR CAPTURE RATES WITH AND WITHOUT BATTERY STORAGE



Source: Ember Climate (2024).
Notes: Calculated scaling historic solar to create a generation profile for a 130 MW solar array, and then 2x60 MW batteries were added, which operate as price takers when they discharge. It is assumed that batteries charge without costs during the midday peak. The other times the battery charges is in the event it's not full and the solar output is higher than the inverter. Day ahead prices were used and a 12 month rolling solar capture rate calculated for the scenario with just solar vs solar & storage.

deployment and thermal generation phase-out, policy strategies and targets for system flexibility and battery storage, access to new market streams that battery operators can stack to increase revenues, coupled with more favourable regulatory frameworks for permitting and grid connection rules.

BOX 5: TARGETS FOR FLEXIBILITY: SOLARPOWER EUROPE'S ANALYSIS OF 2024 NECPs

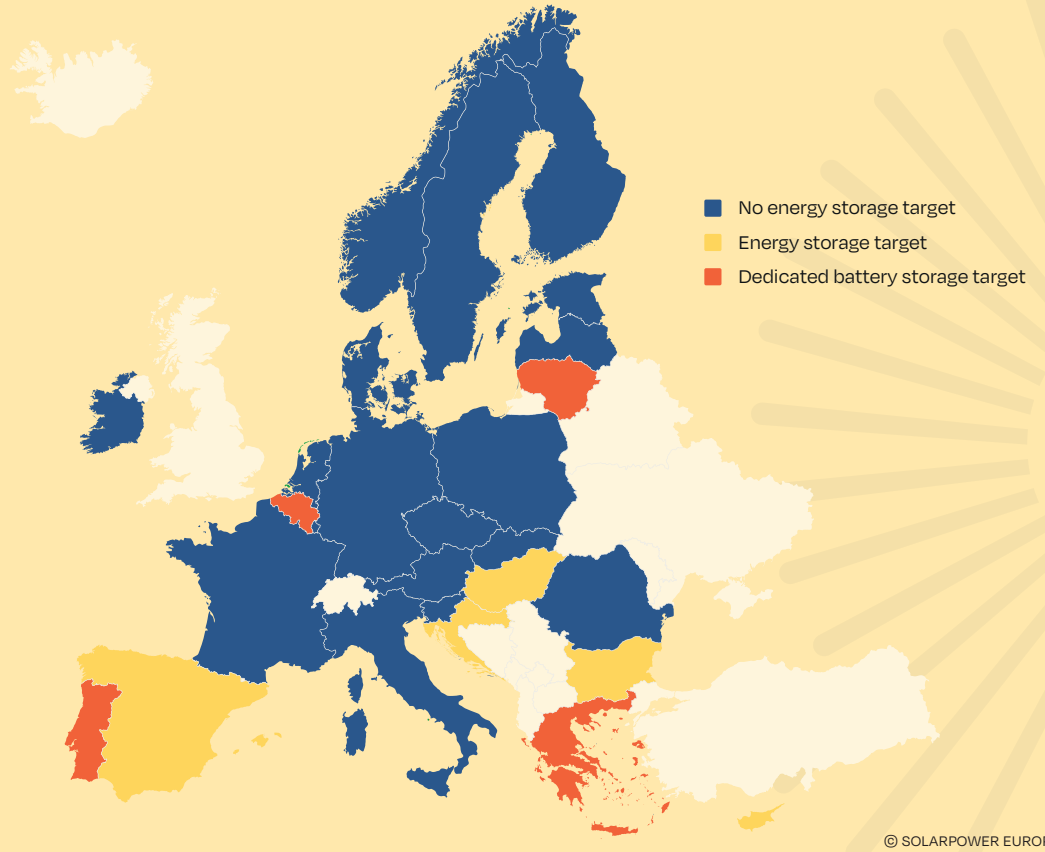
The National Energy and Climate Plans (NECPs) – national plans aimed at programming national energy and climate policy – have been presented by Member States throughout 2023/2024, as part of their regular planned revision. SolarPower Europe analysis shows an impressive 87% growth in the aggregated solar ambition.

Yet, NECPs do not reflect the investments needed for grid deployment, flexibility, and digitalisation. While most NECPs at least partially mention flexibility, only four provide a real target for demand-side flexibility via smart-meter roll-out or demand-side response (BE, BG, CY, HR).

This demand-side gap risks discouraging citizens' adaptation to the new energy reality. Europeans need support to flex their energy use sensibly and consume electricity when it is abundant – like charging e-vehicles in the middle of the day. Though overlooked in NECPs, demand-side tools are needed to ease pressure on the grid and support the system to add more renewables. Demand-side flexibility means less investment is needed for slow-to-build grid infrastructure.

When it comes to energy storage, nine countries have defined dedicated targets in terms of MW, MWh or euros (BE, BG, CY, EL, ES, HR, HU, LT, PT). Among these nine countries, four of them (BE, EL, LT, PT) have gone further with dedicated targets for batteries, small-scale storage or storage at the household level. Most EU countries fail to have plans for empowering the use of renewables 24/7, day or night.

FIGURE 24 ENERGY STORAGE IN THE NATIONAL ENERGY AND CLIMATE PLANS



3 Battery storage markets in Europe 2024-2028

Spitalhöfe solar park, 7 MW PV coupled with 3 MW / 4 MWh BESS. Pfaffenweiler, Germany. © BayWa r.e.

3.1. Europe BESS annual market scenarios 2024-2028

After three consecutive record years for battery deployments in Europe, 2024 is set to become the inflection point for the sector. Ahead of the true dawn of the battery revolution, dynamics have drastically changed this year, already having a strong impact on the market.

Up until last year, battery deployment was driven by the **residential segment**, which reached a 70% share of annual BESS deployment in 2023, and was strongly dominated by Germany and Italy. As the energy crisis unfolded, residential electricity prices skyrocketed and households turned to solar & storage as they were looking to take control of their power expenses. The economic and psychological drive of the energy crisis brought along a storage wave unseen before on the continent.

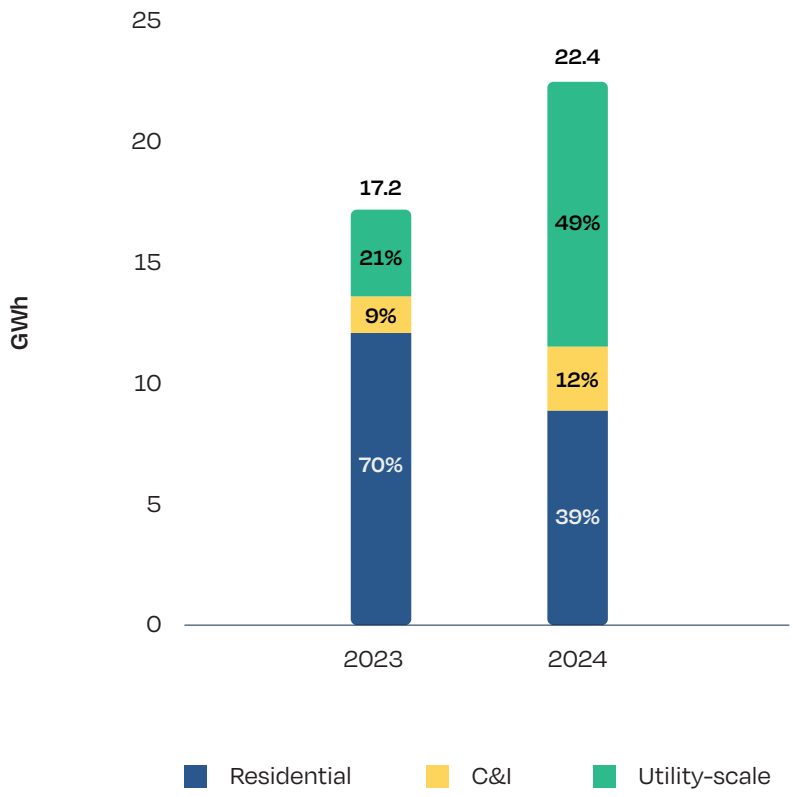
Favourable support schemes, not only in the top markets but also across other European countries such as Czech Republic and Austria, further boosted deployment in the residential segment. Under these improved circumstances, until about mid-2023, the main bottlenecks were the shortage of installers and the limited availability of products to meet the increased demand.

In 2024, after two exceptional years, the tables have turned. As the electricity price shocks have receded, inflation levels have come down and interest rates remain high, the motivation to become self-sufficient is less strong across European households, lowering the attractiveness of solar & storage. At the same time, the supply landscape has completely changed. On the back of EV battery production expansions that have led to global manufacturing overcapacities, there is now also vast availability of affordable stationary battery products. On top of continued cost improvements, severe price competition due to overcapacities and local inventories have been improving the economics of residential solar & storage. Additionally, relevant support schemes remain in place in countries like Germany, the United Kingdom or Austria, while others like Poland are channelling more and more funds to the self-consumption segment.

But despite much more attractive prices and abundance of products, the reservations on the residential solar's demand side seem to prevail, resulting in our Medium Scenario anticipating a decline in the residential battery market in 2024. We expect a contraction of 26% relative to 2023 and totalling 8.8 GWh of new installations. The residential segment's contribution to total battery storage capacity additions will shrink from 70% to 39%. This loss in market share has a further reason: deployment in the large-scale battery segment is poised to register an all-time high in 2024 (see Fig. 25).

Utility-scale batteries have experienced sluggish growth basically from the start of their commercialisation, primarily because policy

FIGURE 25 EUROPE ANNUAL BATTERY STORAGE INSTALLED CAPACITY 2023-2024



frameworks were missing, and the business case often not existing. There was also a lack of technical expertise on the ground, and long waiting times for grid connection points. Following on the heels of large-scale battery storage pioneer the UK, Italy is emerging as the new market leader in Europe this year. The country is expected to install more than 5 GWh in 2024. Resulting from the 2022 and 2020 auctions in the Capacity Market and Fast Reserve segment for grid stabilisation, the country managed to contract a gigantic battery storage project pipeline. Due to the slow progress in project completion, the kick-start of Italy's large-scale battery growth story has been delayed until 2024, when the auction results are becoming fully visible.

With Italy increasing its annual capacity deployment of the utility-scale battery by 23 times, and the UK by almost 2 times to 3.7 GWh, the FTM battery segment will add 11 GWh in 2024, growing three-fold from 3.6 GWh in 2023. Italy and the UK's combined utility-scale BESS share will grow to 81% in 2024, from 62% in 2023 – although in 2023, the UK alone added 56% of total deployment in this segment.

As a result, in 2024 utility-scale batteries will capture 49% of the annual BESS market, more than any other segment, and significantly up from its 21% share in 2023. Moreover, 2024 marks the first year that the large-scale battery market joins the European 10 GWh club, after the residential segment reached 12 GWh last year. Italy's growth example also illustrates that it is feasible for countries to deploy FTM batteries rather quickly and become champions in today's still nascent market if policymakers have a flexibility strategy for their energy transition.

The C&I segment is emerging as a highly attractive market in Europe, especially in countries like Italy, Germany, and Sweden. An improved business case is due to better economies of scale of larger solar & storage installations, still relatively high commercial electricity prices, fast permitting and easy construction, and large availability of products. Most importantly, C&I battery systems provide three mutually inclusive use cases that increase project bankability: increased self-consumption, frequency response, and provision of balancing services. Sweden is a notable example of incentivising adoption of batteries in the C&I segment, as companies are allowed to trade in the frequency containment reserve.

Thanks to the above mentioned factors, and the fact that it is still a niche and untapped segment, the C&I BESS market is expected to reach 2.6 GWh, up 62% compared to 2023. While raising its share by 3 percentage points to 12% in 2024, C&I will remain by far the smallest BESS segment in Europe.

Overall, our Medium Scenario forecasts the European BESS market to witness another record-breaking year with 22.4 GWh newly installed capacity until the end of 2024 (see Fig. 26). This signifies a 31% year-on-year increase relative to 2023. Our High Scenario contemplates a much more positive situation, which could see deployment nearly reaching the 30 GWh level. On the contrary, if project delays persist in the large-scale segment in Italy and the UK, and the residential markets in Germany and Italy show further declines, installations might drop by 16% to 14.4 GWh, which seems rather unlikely.

Looking beyond 2024, we anticipate that BESS deployment will continue to march forward in its growth trajectory. In line with current market and regulatory conditions, our Medium Scenario expects a 28% market

FIGURE 26 EUROPE ANNUAL BATTERY STORAGE INSTALLED CAPACITY SCENARIOS 2024-2028

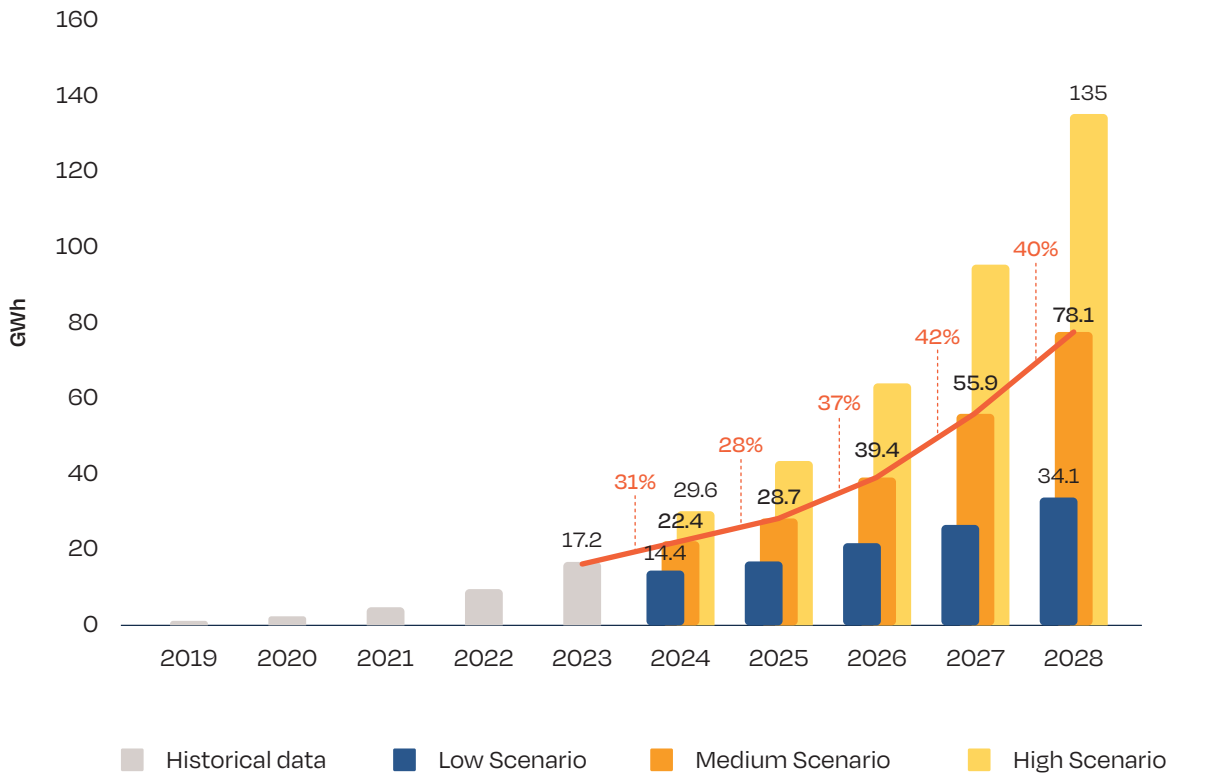
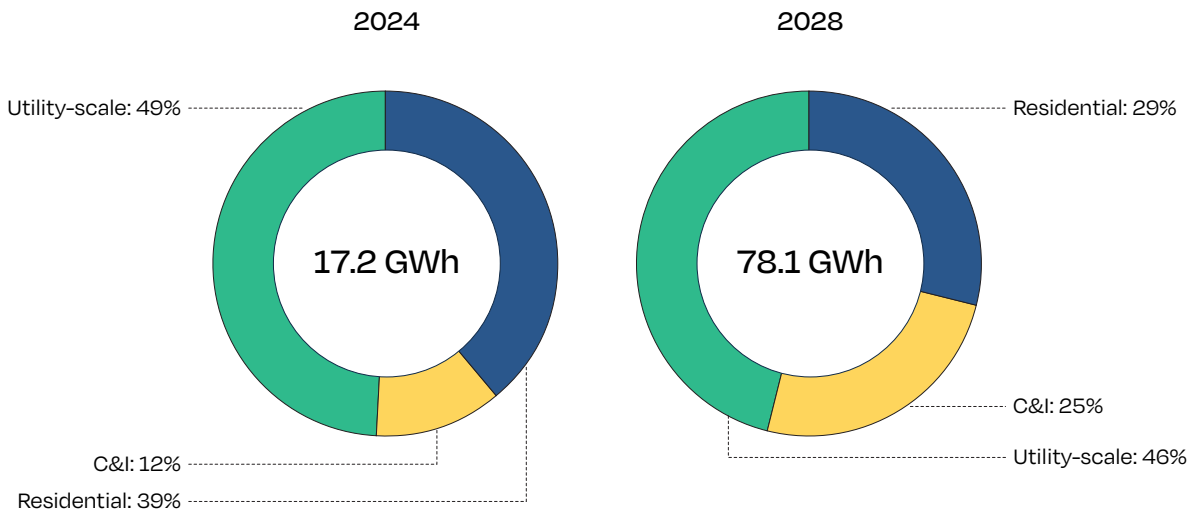


FIGURE 27 EUROPE ANNUAL BATTERY STORAGE SEGMENTATION 2024-2028



increase in 2025 to 28.7 GWh. This jump in installations is based on a strong recovery of the residential market, resulting in 18% growth, coupled with a year-on-year doubling in C&I and a 24% uptick in the large-scale segment. The overall BESS market is expected to maintain a growth rate above 35% during the following three years, with 39.4 GWh (+37%) in 2026, 55.9 GWh (+42%) in 2027, and 78.1 GWh (+40%) in 2028.

As the market evolution is highly dependent on enabling regulatory frameworks across European countries, the spread between the Low and the High Scenario gets wider. In the High Scenario, market and policy conditions are improved across all segments, as countries ramp up their decarbonisation efforts by deploying renewable energy and retiring fossil baseload sources. This leads to a battery growth path that is in line with the increased flexibility needs of a renewable-based energy system, bringing the total BESS market to 135 GWh by 2028, which is 72% higher than the Medium Scenario.

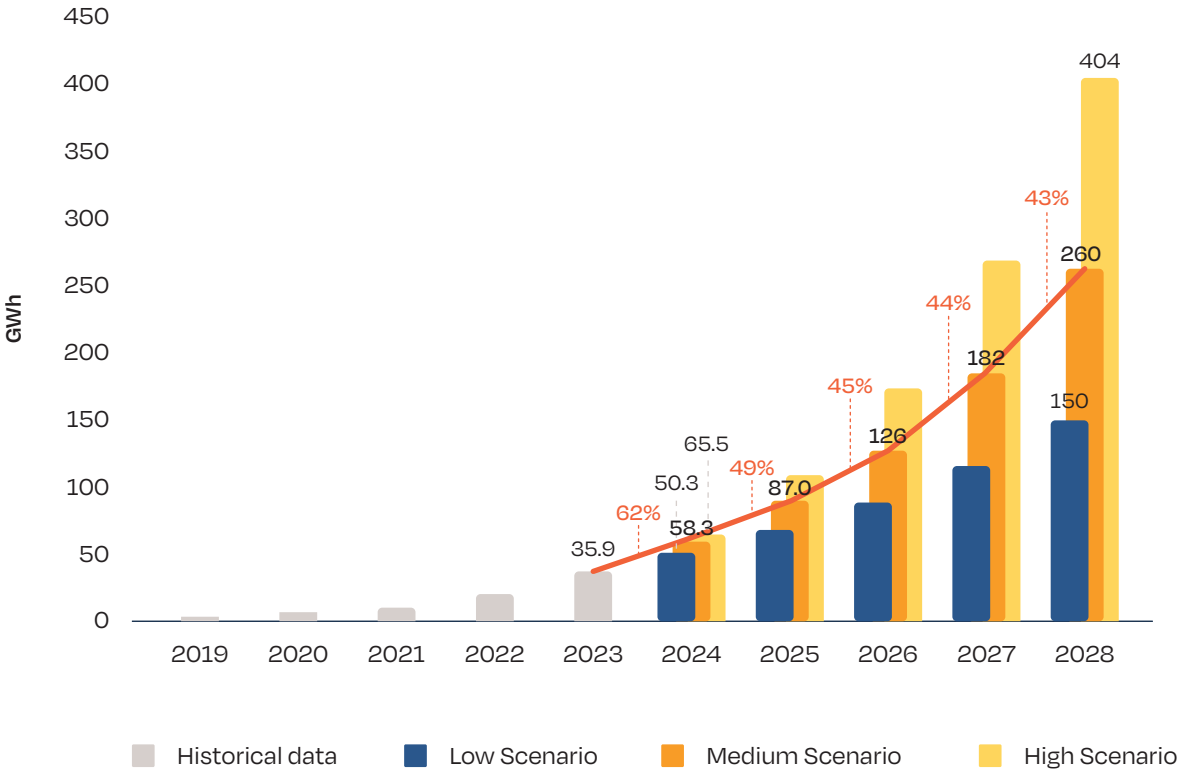
By contrast, lower renewable penetration, lack of BESS support schemes, delayed smart meter rollout at the residential level, reduced thermal generation phase-out, limited electrification of heating and transport, restricted market access for grid-scale batteries and other factors could trigger the Low Scenario, whereby the market remains as low as 34.1 GWh by 2028. This is 56% lower than in the Medium Scenario by the same year.

When looking at the segmentation of European batteries, we are facing a clear trend that is foreseen to materialise already in 2024. As previously discussed, grid-scale and C&I batteries are expected to compensate for the slowdown in the residential BESS segment this year. Together, they will provide more than half of the BESS capacity added in 2024 (Fig. 27).

This gradual takeover of larger batteries, especially at the grid-scale level, is expected to persist in absolute terms, but will partially slow down for FTM batteries in terms of annual market shares. C&I batteries in turn will absorb a larger market slice by 2028. That year, FTM batteries cover 46% of overall BESS capacity additions, deploying 36.3 GWh, under the Medium Scenario. That entails an annual level of deployment that is more than 3 times higher than in 2024 and a 59% compound annual growth rate (CAGR) in the five-year period.

This increasing predominance of large-scale battery additions as the energy transition unfolds is based on the fact that renewables-as-usual – meaning standalone renewable power plants – will morph into large-scale renewable plus battery projects. Co-located battery storage with PV/wind and hybridisation of existing renewable generation plants with storage is set to become an industry standard in

FIGURE 28 EUROPE CUMULATIVE BATTERY STORAGE INSTALLED CAPACITY SCENARIOS 2024-2028



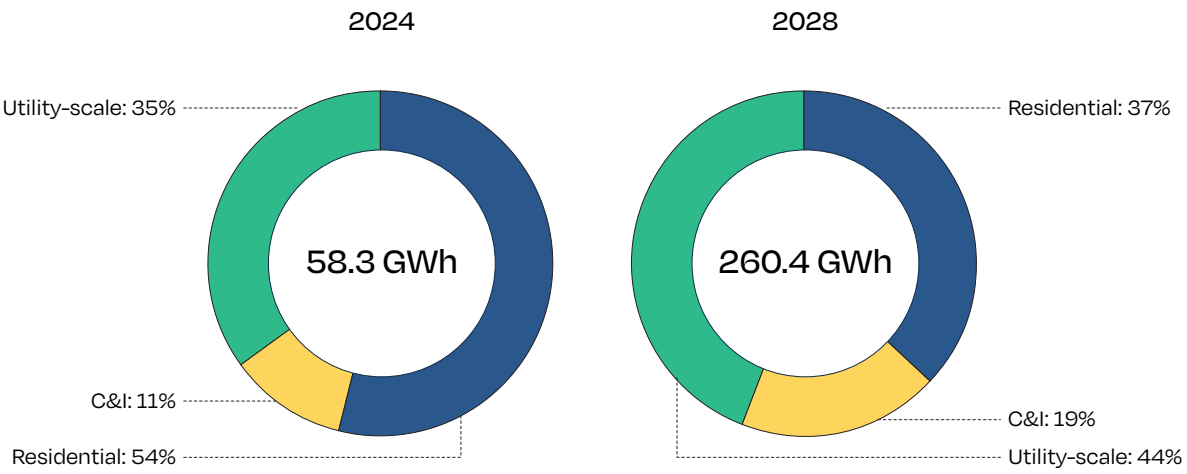
the years to come. Large-scale batteries are a perfect fit to variable production of electricity, as they increase the value of renewable electricity, while providing energy balancing and system services. This shift is poised to be particularly visible in European countries with high shares of solar PV in their electricity mix, where the integration of variable renewable energy sources necessitates storage solutions to manage supply and demand effectively.

Additionally, utility-scale battery projects are expected to enlarge their average storage duration capacity as revenue stacking models and grid service requirements change. With increasing needs for power system flexibility and energy shifting, we will see a significant rise in BESS capacity duration, extending towards 4 to 8 hours, from around 1.5 today. As the storage duration of large-scale batteries increases, so does its weight on the total storage capacity of Europe.

Despite the utility-scale segment's strong growth, BTM batteries are still expected to remain the main contributor to the new capacity in 2028, with 41.8 GWh, a nearly four-fold increase compared to 2024 and a 25% CAGR. That translates into a 54% market share in 2028, split into 29% from residential BESS and 25% from C&I systems. A more mature market, the residential BESS segment will continue to increase at a comparatively lower pace of 13% CAGR, reaching 22.6 GWh in 2028, while C&I batteries will surge from their niche status to 19.3 GWh in 2028 with a 64% CAGR.

According to the Medium Scenario, the cumulative BESS capacity projections for Europe spanning between 2024 and 2028 show strong growth rates between 62% in 2024 and 43% in 2028 (Fig. 28). The projected growth rates are significantly lower than the 90% and 92% achieved in 2022 and 2023, the years of the energy crisis and its direct aftermath, but indicate a remarkable increase in the expansion of the European battery fleet.

FIGURE 29 EUROPE CUMULATIVE BESS SEGMENTATION 2024-2028



In absolute terms, new installations between 2024 and 2028 will add up to 224 GWh, bringing up total installed BESS capacity to 260 GWh by the end of 2028, according to the Medium Scenario. This means that the total BESS running fleet will multiply its size by more than seven times in just 5 years, from 36 GWh in operation at the end of 2023. The High Scenario assumes much higher battery additions resulting in a total battery storage capacity above 400 GWh by 2028, compared to a 150 GWh battery fleet anticipated in the Low Scenario.

The breakdown of operating BESS capacity by 2028 in our Medium Scenario resembles the segmentation of the annual battery additions (see Fig. 29). BTM batteries will constitute 56% of the BESS cumulative capacity (145 GWh) while FTM battery storage will represent 44% of the market (115 GWh). While remaining the dominant provider of battery storage capacity, BTM technology's share will decline by 9 percentage points from 65% in 2024, which will lead to a more balanced distribution across segments.

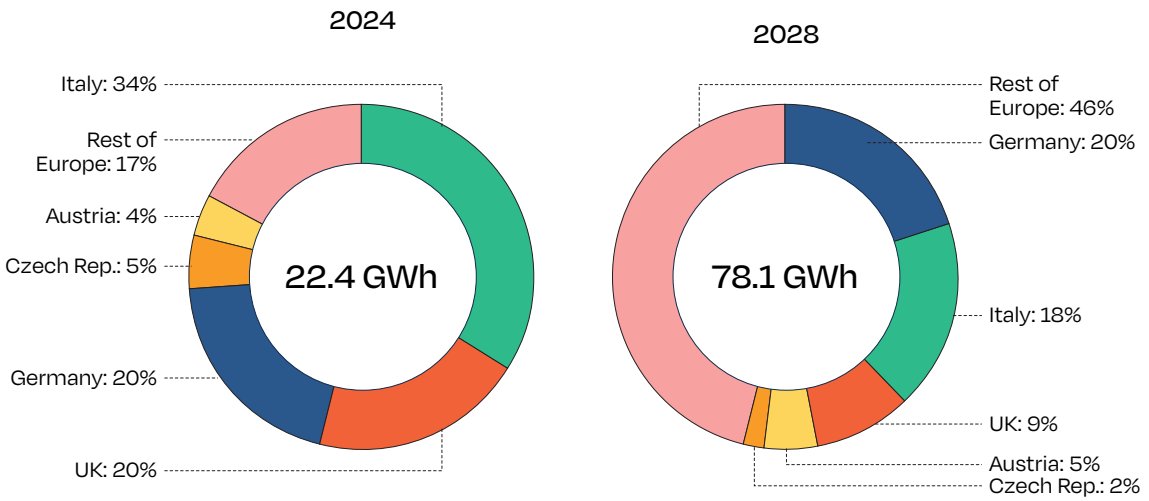
3.2. Top 5 European battery storage markets 2024-2028

When looking at the growth prospects of battery markets across Europe, it appears that in 2024 there will be a major change in our ranking of the top 5 markets (see Fig. 30).

Italy

Italy, the second largest annual market in 2023, is expected to surpass Germany in 2024, and rank #1, illustrating the relevance of the large-scale segment going forward. With 7.7 GWh of BESS capacity additions, the Italian market is foreseen to duplicate the installed

FIGURE 30 EUROPE TOP 5 MARKETS 2024-2028



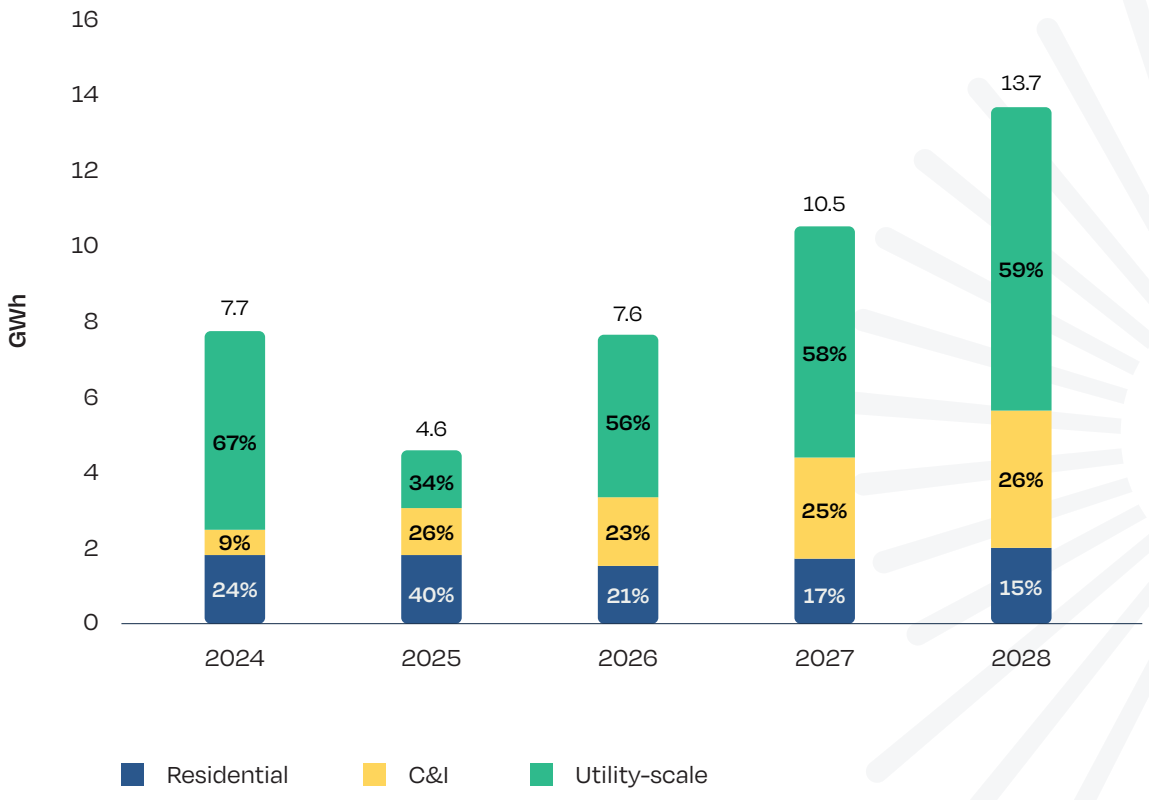
volumes compared to 2023 and capture 34% of the total European yearly built capacity. This means that the phasedown of the Superbonus, initiated in 2023, will have a negative effect on the residential segment, but not on total development volumes.

In the residential segment, installations are projected to decline 40% YoY, with 1.9 GWh, and are expected not to recover to the 2023 record levels in the next five years (see Fig. 31). The home battery segment is expected to retain a 24% share of the total market in 2024, further reduced to 15% by 2028.

The contraction in the residential segment opens opportunities for the C&I battery segment, where, similar to Germany, growth prospects are enormous. As investment payback times are on the decline thanks to a much-improved business case for C&I batteries, Italy is one of the most attractive countries for this segment. Peak shaving opportunities with predictable and pronounced price increases during high demand periods make it very profitable to engage in price arbitrage, once electricity needs are met. C&I BESS capacity additions will grow from 674 MWh in 2024 to 3.6 GWh in 2028, according to our Medium Scenario.

At the FTM level, Italy's anticipated success in 2024 owes to the commissioning of projects contracted in the Capacity Mechanism and the Fast Reserve auctions back in 2022 and 2020. By the end of this year, this will boost deployment levels to 5.2 GWh of large-scale BESS, 67% of the total Italian market, and is expected to represent nearly half of the total FTM battery deployment in Europe. This astounding result proves the effectiveness of Italian auctions to allocate massive storage capacity to developers. By 2028, the segment is poised to surpass the 8 GWh mark for annual deployment, providing 59% of the overall Italian BESS market.

FIGURE 31 ITALY ANNUAL BATTERY STORAGE INSTALLED CAPACITY MEDIUM SCENARIO 2024-2028



Tiln solar park, 61 MW PV coupled with 25 MW / 50 MWh BESS. Retford, England. © Lightsource bp

With ambitious renewable capacity targets by 2030, and a significant proportion of RE projects planned in the Southern and Island regions, Italy will soon face a critical need for flexibility. Against this background, Italian TSO Terna has been engaging with the industry to enhance energy storage deployment. Terna projects that 9 GW / 71 GWh of storage capacity will be needed by 2030.

The Italian large-scale market has three main pillars. Firstly, the capacity market, which offers 15-year contracts supporting investments in storage capacity – aimed at security of supply. The capacity payment, in EUR/MWh with derating factors, can be stacked on top of the merchant revenues. Secondly, the introduction of the much-awaited MACSE scheme provides 15 to 30-year contracts supporting electricity storage investments in batteries and pumped hydropower. Terna provides MACSE-backed projects with a capacity premium, which is exchanged for the merchant revenues. Thirdly, the spot market presents great revenue potential, with short-term price signals driving power system balance and asset optimisation. In addition, there is a new energy trading platform to be launched by Terna, whereby storage owners will be able to sell 'time-shifting' of energy to renewable energy owners, plus ancillary services. Projects will generally have a storage capacity of 4 hours or more.

2025 is expected to be a gap year for FTM storage in Italy, following the record performance in 2024, as fewer projects resulting from the auctioned capacities will be grid-connected. The segment is forecasted to regain traction already in 2026.

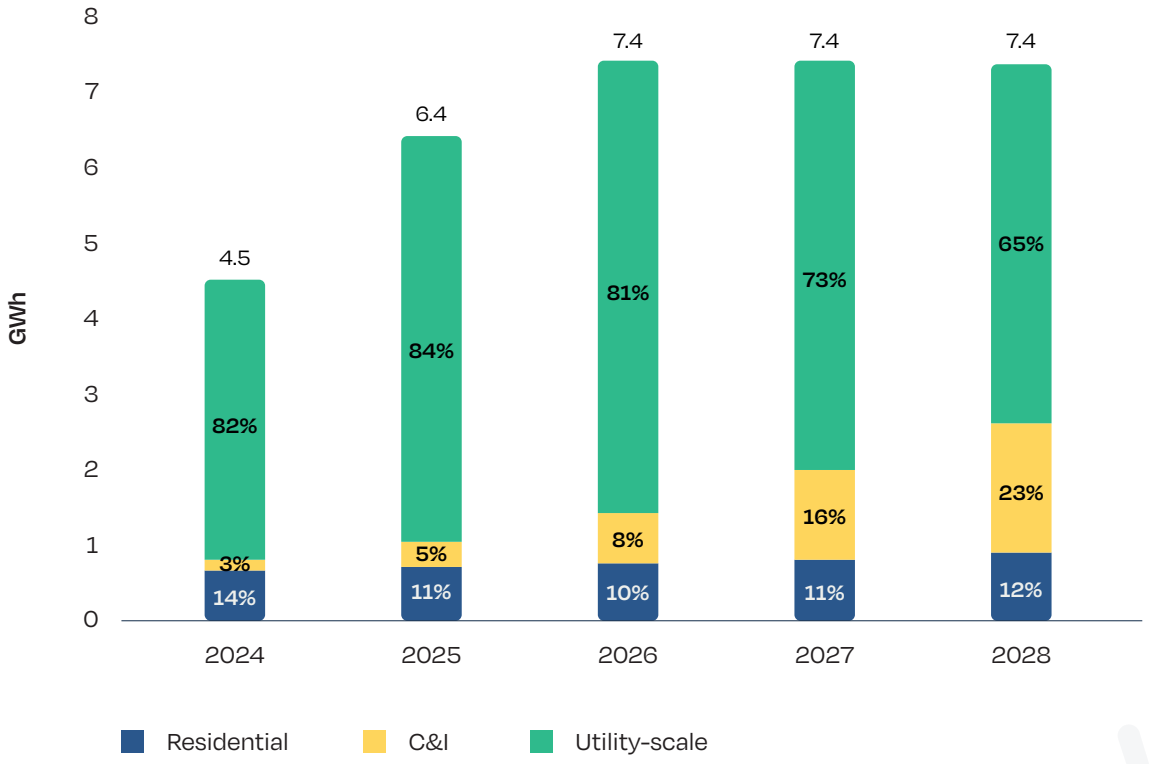
Overall, the Italian BESS market is expected to grow further in the next five years, reaching 13.7 GWh and a 18% share of the European BESS market in 2028. This, however, won't be enough to maintain the top spot across its European peers.

United Kingdom

Long-standing grid-scale battery leader, the United Kingdom is poised to slightly exceed Germany in 2024 and take back position #2 after a two-year hiatus, thanks to a 70% YoY growth and reaching 4.5 GWh in capacity additions. Though all segments registered strong growth rates in 2023, it is again the large-scale segment that will drive the growth in the UK in the coming years. The UK's large-scale market is regarded as the most attractive in Europe, with a massive project pipeline and very ambitious national targets for energy storage – 24 GW by 2030. Importantly, the government has removed asset size limits and is actively funding FTM battery deployment via its Capacity Remuneration Mechanism. In total, there are five different revenue streams that can be stacked by operators to optimise for revenue capturing.

All this points to a steady increase in the operating capacity, as the total pipeline for battery storage is

FIGURE 32 UNITED KINGDOM ANNUAL BATTERY STORAGE INSTALLED CAPACITY MEDIUM SCENARIO 2024-2028



expected to further increase, with more projects being submitted, approved and built. In 2024, the upcoming short-term prospect sites will be completed, leading to 3.7 GWh of large-scale BESS additions, equal to 34% of the European large-scale capacity additions in 2024 and 82% of the UK's overall market (see Fig. 32). In the medium term, due to its market maturity and revenue streams facing saturation, the FTM segment will face declining capacity additions, landing at 4.7 GWh in 2028. Its relative contribution to FTM development across Europe will also decrease to 13%, since the European large-scale market is foreseen to install more than 36 GWh. However, it will remain the main contributor to the UK BESS market, with a 65% share.

The UK's BTM markets are expected to contribute a minor but increasing share of total battery capacity additions, growing from 18% to 35% between 2024 and 2028. The UK has an emerging household BESS market due to improved regulatory conditions – VAT relief for both new solar & storage and retrofitted BESS, support schemes for low-income households, low PV exporting tariffs, and a substantial reduction of permitting requirements. In addition, residential electricity prices are still much above pre-crisis levels and above the European average, although high interest rates and inflation are having a detrimental impact on investment decisions. The UK residential BESS market is expected grow slowly but steadily in the next five years, rising from 649 MWh to 919 MWh in 2028. In parallel, the C&I segment presents much growth potential, as the policy framework has been greatly improved over the past years, and there are tremendous revenue opportunities in peak shaving and energy arbitrage. While C&I installations in 2024 remain marginal, at 150 MWh, they are expected to surge to 1.7 GWh by 2028.

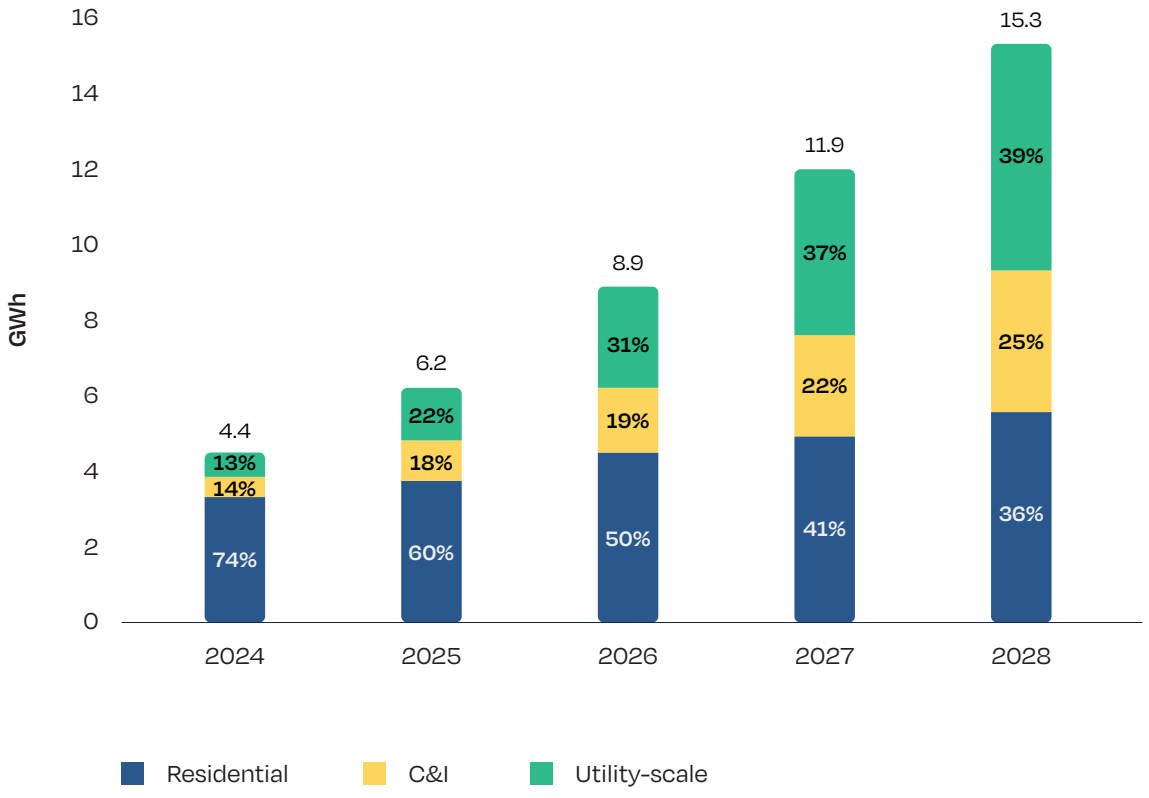
Across all battery segments, in 2028 the UK market reaches 7.4 GWh under our Medium Scenario, contributing 9% of Europe's total additions.

Germany

The #3 market in 2024 is Germany, which descends two positions this year, but still remains the country with the largest potential for expansion: residential installations are poised to drop significantly, but there are positive developments in the largely untapped C&I and utility-scale segments. In 2024, the German BESS is expected to deploy 4.4 GWh, capturing a 20% share of total European installations. This 14% decrease compared to 2023 is caused by a 36% decline in the residential segment, after an exceptionally good year. German home batteries are being impacted by the slowdown in the residential PV segment, but retain a strong attachment rate above 80%. In addition, retrofitting of existing PV systems is beginning to get some traction, as more and more residential installations run out of the 20-year feed-in premium started in the early 2000s and have a financial incentive to add a storage device.

After 2024, residential solar & storage is expected to make a comeback, as battery prices remain low due to large overcapacities and technology improvements, arbitrage opportunities improve, energy communities and aggregators emerge all around Germany, electrification advances, and retrofitting rates increase. The regulatory framework is expected to improve in Germany, with the recent and much awaited adoption of the Solar Package 1, and the introduction of the Electricity Storage Law, whose first draft was released at the end of last year and is still subject to improvements. The Medium Scenario anticipates that the home BESS market will surpass again the 5 GWh mark in 2028 (see Fig. 33).

FIGURE 33 GERMANY ANNUAL BATTERY STORAGE INSTALLED CAPACITY MEDIUM SCENARIO 2024-2028



In the medium-sized segment, installations are poised to grow remarkably over the coming five years, as the economics of C&I battery systems make headway, and regulatory conditions improve. Allowing companies and industries to easily become self-sufficient, but also opening market access for arbitrage and balancing services is key for unfastening the segment's positive prospects. Battery products are also expected to become better and cheaper, as companies are now targeting commercial and industrial customers due to the largely untapped opportunities. In 2024, the Medium Scenario anticipates 612 MWh to be added, volumes that are growing rapidly to 3.8 GWh in 2028.

At the larger scale, Germany presents a very bright outlook ahead, as its Energiewende advances, more renewables are added to an increasingly electrified energy system, thermal units are retired, and clean flexibility sources are needed. The FCR market remains one of the primary revenue sources for battery operators in Germany, but as the market is facing the first signs of saturation, asset operators are entering the secondary (aFRR) and tertiary (mFRR) control reserve markets. Additionally, operators can also engage in energy arbitrage operations in the wholesale market profiting from price volatility and the ability to forecast price spikes accurately. Capacity is also allocated through the innovation tenders, for renewable projects co-located with battery storage, but due to a very restrictive auction design, the scheme remains far from meeting investors' expectations. The main barrier is that BESS systems contracted under the innovation tenders can only store electricity generated by the co-located renewable generation asset and cannot charge from the grid when there are negative prices, undermining the attractiveness of this scheme for BESS developers.

Moreover, the country still has to open the capacity market for large-scale BESS, balancing and restoration services, and other ancillary markets like voltage control. Under these conditions, a steep growth in this segment is expected, with large-scale BESS capacity additions surging from 553 MWh in 2024 to 6 GWh in 2028, with their contribution to the overall German BESS market increasing from 13% to 39%. Thanks to this growth, Germany's BESS market is expected to become again the largest in Europe by 2028, reaching over 15 GWh and contributing 20% to total European capacity additions.

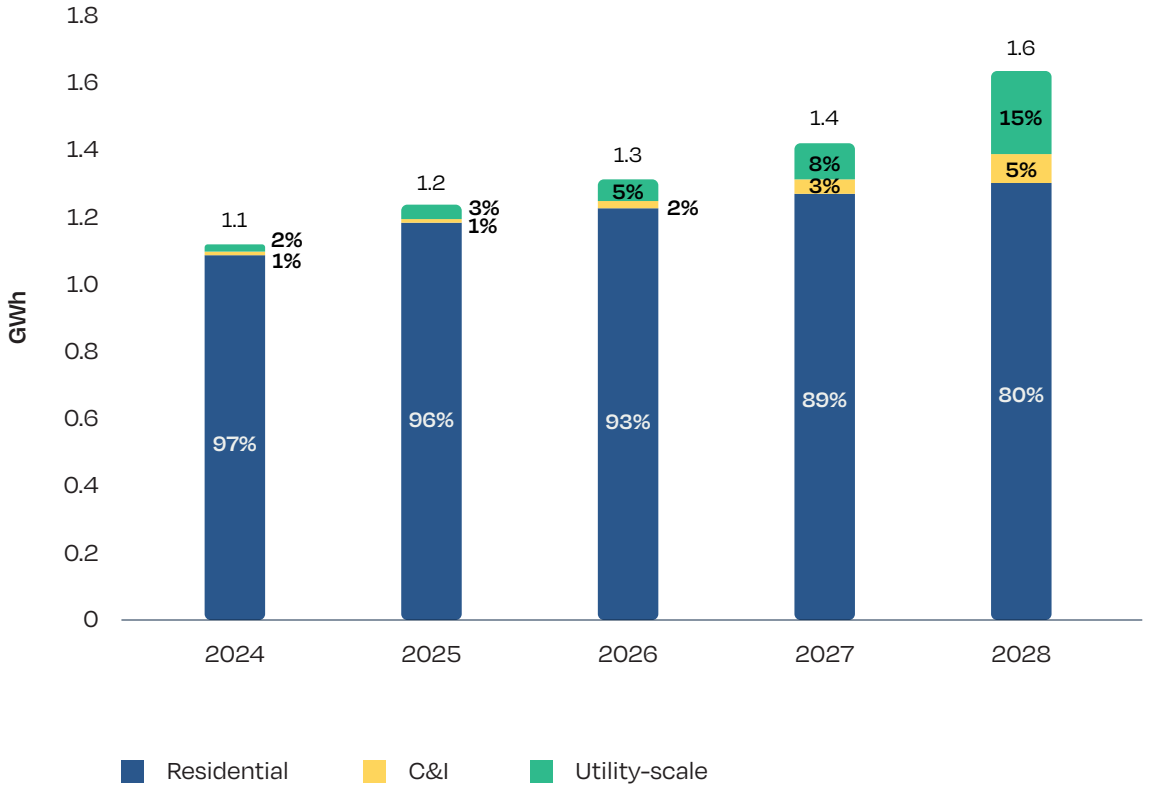
Deisenhausen solar park, 18.2 MW PV coupled with 6.2 MW / 20.7 MWh BESS. Krumbach, Germany.

Czech Republic

Ranking fourth in 2024, the Czech Republic is forecasted to continue growing with a stable upward trajectory between 2024 and 2028 and a market dominated by the home battery segment. Amid exceptionally high attachment rates above 90% and continued financial support for the household segment, in 2024 residential batteries will provide 97% of the country's BESS market, which is expected to reach 1.1 GWh (see Fig. 34). The New Green Investments Programme will continue to drive the growth in the segment, considering that the programme covers a wide range of electrification solutions – solar PV, heat pumps, and EV chargers – requiring significant home battery storage capacity. Moreover, residential power prices are among the highest in Europe (38 EUR/kWh in April 2024) way above the European average (24 EUR/kWh), which increase the attractiveness of decreasing dependence on grid power supply.

Other BESS segments have not yet taken off in the Czech Republic. The country is expected to expand both the C&I and the grid-scale storage segments in the coming years, but a clear legal anchoring of energy storage is still missing. Several amendments have been introduced to transpose missing European legislation on the internal market for electricity to apply as of next year, which encompass all essential points (energy storage definition, removal of double charging, and more). Still, further barriers need to be lifted to unleash the true potential of battery storage, as BESS can only provide ancillary or flexibility services if charged from 75% of the connected PV/wind on an annual basis. Neighbouring countries are also cheaper in providing cross-border regulatory power, which makes it less attractive to deploy large-scale BESS without competitive prices of ancillary service provision. The country should work to finalise the legal anchorage into the Energy Act and prepare

FIGURE 34 CZECH REPUBLIC ANNUAL BATTERY STORAGE INSTALLED CAPACITY MEDIUM SCENARIO 2024-2028



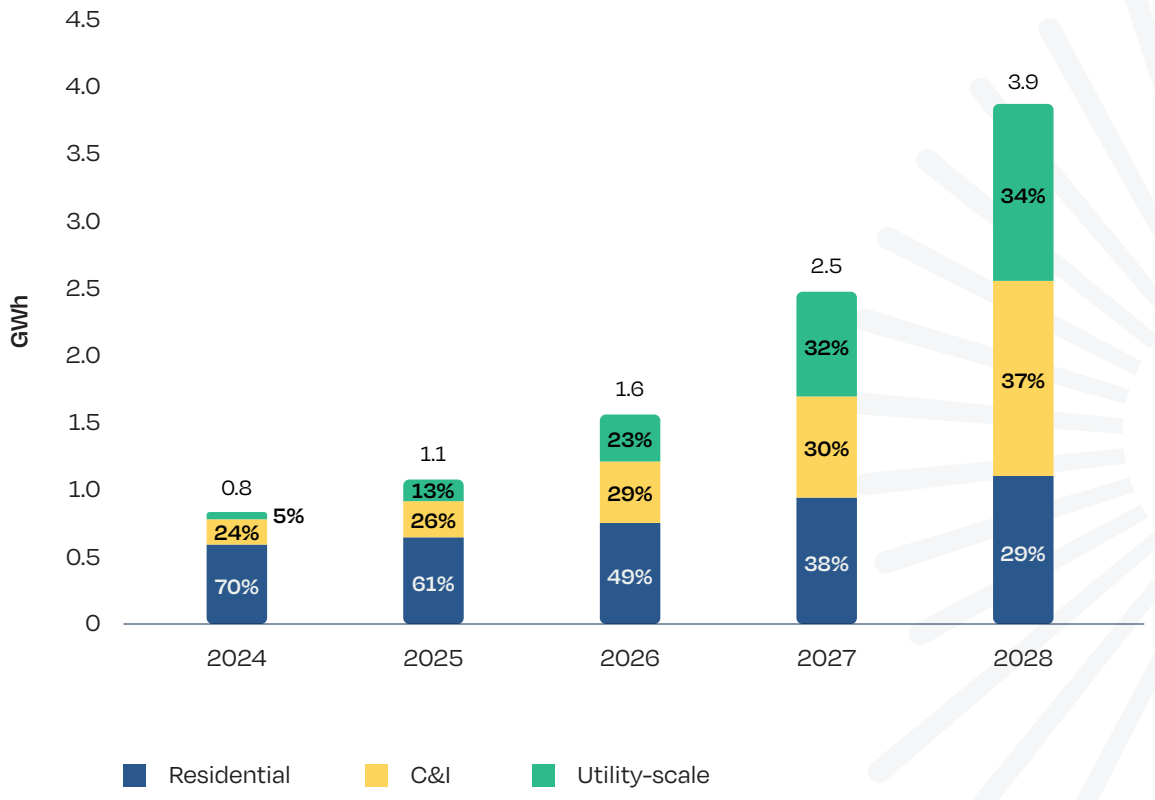
supportive secondary legislation, adjust the Modernisation Fund, National Recovery Plan and other subsidy schemes to further favour renewables and BESS. Additionally, the country needs to set binding targets for energy storage and flexibility to increase certainty for investors.

Austria

Closing the top 5 for 2024 is Austria, which is losing one position to the Czech Republic. In 2024, the market is expected to shrink 19% below the GWh level achieved in 2023, with 829 MWh of capacity additions. Significant changes have occurred in the financial support schemes available for batteries both at the residential and C&I segments, which make up the great majority of installations. Last year, there were two funding programmes, as a new scheme was added (KLIEN) to complement the existing one (ÖMAG). As ÖMAG was exhausted in all its funding rounds in 2023, funding 31,000 battery systems with 200 EUR/kWh, KLIEN served as a backup to cover additional requests for battery storage installations and provided the same flat-rate subsidy. More than 750 MWh battery systems were installed thanks to the investment grants. Both programmes covered solar & storage installations.

Since 2024, the new "Strompeicherlangen" (Electricity Storage) funding programme, which replaces ÖMAG and KLIEN, supports residential and small commercial BESS installations. However, battery projects are eligible only if the attached PV system has not received the sales tax exemption for small PV systems or does not receive support under the Renewable Energy Expansion Act (EEG). Batteries between 4 and 50 kWh receive a flat rate subsidy of 200 EUR/kWh of usable storage capacity. Batteries can only be used for temporary storage from an existing PV system. By May 2024, the 35 million EUR budget has been completely exhausted.

FIGURE 35 AUSTRIA ANNUAL BATTERY STORAGE INSTALLED CAPACITY MEDIUM SCENARIO 2024-2028



The government stopped the solar rebate scheme ÖMAG, which managed to allocate rebates for more than 2 GW of solar PV, and introduced a VAT exemption for small installations up to 35 kW. This should result in a positive market reaction as there is now no budget ceiling and the ultimate discount is similar to the solar rebate programme. However, changes in support frameworks tend to have a negative effect in the short-term, as households need to adjust to the new support scheme in place, which explains the market contraction in 2024.

At the FTM scale, the market is slowly advancing, as the technology is currently being tested by developers, and reached an important milestone last year by installing its largest BESS plant with 21 MWh. Currently, the market remains small, with less than 40 MWh installed in 2023. But, as renewable penetration deepens, electrification accelerates and conventional generation sources are phased out, Austria will require significant volumes of large-scale battery storage to maintain grid stability. The regulatory framework has also been defined with the Electricity Law, further streamlining permitting, improving market access conditions, removing double charging, and more. Across all segments, the Austrian BESS market is anticipated to grow to 3.9 GWh by 2028, with a balanced contribution across segments (Fig. 35).

Outside of the top 5 markets in 2024, our Medium Scenario anticipates a drastic change in the market dynamics across Europe, as batteries emerge as a mainstream solution to meet energy and flexibility needs at all levels. Many well-established solar markets, such as Spain, Poland and the Netherlands, are expected to jump on the battery bandwagon as soon as regulatory and market conditions are improved, a trend we are anticipating in our five-year forecast. The diversification in the European BESS landscape is reflected in the fact that the 2024 top 5 countries covered 83% of the market; these five countries will only provide 54% of capacity additions in 2028 (see Fig. 30).

Spitalhöfe solar park, 7 MW PV coupled with 3 MW / 4 MWh BESS. Pfaffenweiler, Germany. © BayWa r.e.

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