Ramping up energy storage: lessons for the EU

Eoin, Quill; Climate Analytics

Christina, Kurre; Climate Analytics

Olivia, Waterton; Climate Analytics

Andrzej, Ancygier; Climate Analytics

July 2023

Suggested citation

E Quill, C Kurre, O Waterton, A Ancygier (2023) Ramping up storage: lessons for the EU. Climate Analytics; Berlin

Acknowledgements

The authors would like to thank the participants in the workshops and interviews for their suggestions and comments. Different parts of the report have also been reviewed by experts in the respective areas. We would like to thank the reviewers for their constructive feedbacks.

Disclaimer

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 101003884.

This paper is based on the 4i-TRACTION Deliverable 3.4, 'What can the EU learn from non-EU countries on its path to climate neutrality?'

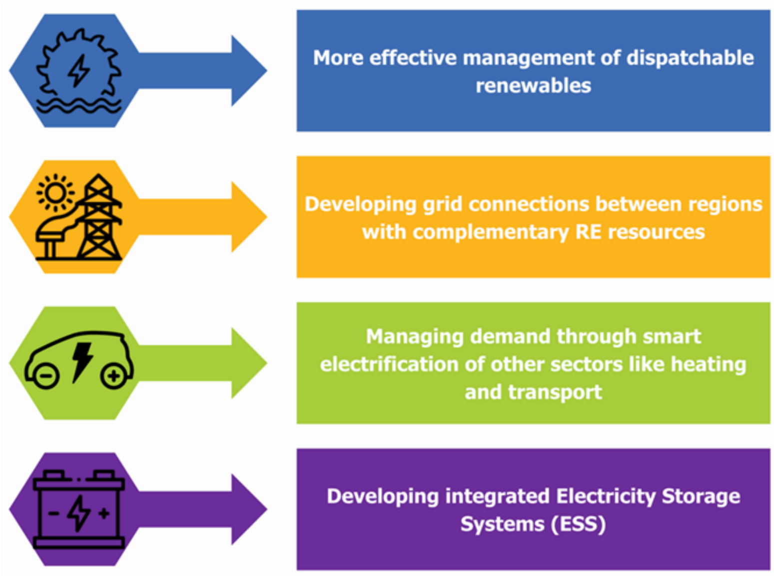
Content

1. Introduction

The share of renewables in electricity generation will rise exponentially in the coming decades, with wind and solar photovoltaics (PV) expected to become the dominant electricity sources (IEA, 2022). Despite the myriad benefits that come with decarbonising the energy sector, such a transition also brings challenges. More specifically, the variable character of renewables means there is an oversupply of energy when the sun shines and the wind blows, and a shortage when the sun sets or there is no wind. In the absence of a means to store energy during times of oversupply, some network operators need to curtail (temporarily switch off) or cap electricity generation from already installed units so that the grid is not put under too much pressure. This only decreases the profitability of renewable technologies and increases investment insecurity.

There are solutions to this conundrum. The variable character of renewables can be mitigated without increasing emissions by using dispatchable renewables such as bio- and hydro energy more effectively, developing grid connections (especially between regions with complementing wind and solar resources), managing demand through smart electrification of other sectors such as heating and transport, and electricity storage. Regarding the latter, Energy Storage Systems (ESS) have emerged as effective in bridging gaps between supply and demand. ESS can store energy for later use, meaning that sun or wind energy can be stored until it is needed for consumption. ESS can come in a variety of forms, including (but not limited to) pumped hydro, flywheel, liquid air, and compressed air. In order to fully decarbonise the energy sector and ensure consistent access to power for consumers, a combination of short and long-term storage is needed to resolve renewable variabilities.

Four solutions to RE variability



Various factors dictate which storage technology is favoured. For instance, round-trip efficiency (the percentage of electricity put into storage that can later be used), and the lifespan of a technology before it needs to be replaced offer more value and are thus important aspects when deciding which technology is used (Ruby, 2018). Technological developments and associated price decreases, combined with increased volatility of electricity prices due to the variability of production, will inevitably accelerate deployment of ESS into both national and regional grids. The role of policy, however, is also critical to developing these technologies. Just as tax credits for renewable energy sources helped to decrease costs (ibid), economic incentives and government mandates can provide market certainty and stimulate growth.

The most popular technology for short-term storage are lithium-ion batteries (LiBs). As is the case with wind and solar technologies, the growth of LiB ESS has been connected to a dramatic drop in costs, reporting an 85% decrease between 2010 and 2019 (IPCC, 2022). This is due in part to the electric vehicle industry, which has promoted manufacturing economies of scale, as well as government support for the clean energy transition, which has guaranteed demand for ESS and driven innovation (Deloitte Center for Energy Solutions, 2018).

As LiB ESS can discharge at full power for between four and six hours, they are well suited to managing the daily fluctuations associated with wind and solar energy. As a result, such storage systems are displacing fossil fuels, especially fossil gas peaker plants that have often been used to balance the grid (Argonne National Laboratory, 2021).

Alongside managing variabilities, storage can assist the grid in other ways. It can improve resiliency by acting as a source of emergency backup power, particularly in the aftermath of events such as storms (Al Shaqsi et al., 2020). The ability of ESS to load shift, i.e., move electricity consumption from one time to another, can reduce demand at peak times. This has multiple benefits, including less need for reserve capacity, improved efficiency, and cost savings for end users due to differing electricity prices between peak and off-peak periods (Märkle-Huß et al., 2018). ESS can improve the economic value of renewable energy by storing surplus power to participate in the energy trading market and through substituting the need to upgrade old distribution and substation facilities (Jo & Jang, 2019). ESS are also used to adjust the power frequency, which is essential to maintaining high-quality power. If the amount of electricity being used is not matched by generation, the frequency of electricity can be affected (World Bank, 2021; You et al., 2019).

Considering the European Union's (EU's) commitment to reduce its emissions by at least 55% below 1990 levels by 2030 and reach carbon neutrality by 2050, replacing fossil fuels with renewables will be essential to meeting these targets. The EU already intends to increase the share of renewables in the overall energy mix to at least 42.5%, complemented with an indicative additional target of 2.5% by 2030 (Council of the European Union, 2023). According to earlier modelling by the European Commission, this translates to a 69% share of renewables in the electricity sector. Around 55% of electricity is set to come from variable sources of energy, such as wind (onshore and offshore) and solar (European Commission DG Energy, 2022).

This increase in the deployment of renewables will also require an increase in storage. The Commission recognises the importance of storage to the clean energy transition, labelling batteries a strategic value chain which requires increased investment and innovation (European Commission, 2022). The Commission's much anticipated energy storage recommendations were released in March 2023, whereby ten recommendations were provided for member states to increase their storage capacity (European Commission, 2023a). These involve member states assessing their respective grids' flexibility needs going into the future, identifying how to properly value storage, removing regulatory barriers to storage, accelerating ESS deployment, and supporting research, innovation and investment. The storage recommendations were released alongside the EU's proposed electricity market reforms (European Commission, 2023c). Given the importance of improved flexibility to the proposed market reforms, member states are required – and not only recommended – to assess their flexibility needs and establish objectives to meet those needs. These objectives should then be reflected in their integrated national energy and climate plans.

There is no set way to increase storage capacity and member states can take various routes to meet their storage requirements. Learning from best practices outside the EU can help policymakers develop a robust regulatory environment which allows the storage market to flourish. This report looks at how California, South Korea and Australia increased their storage capacity, as well as how these policies can be applied to the EU context. A more detailed examination of the cases included in this report can be found in a longer-form report (see Ancygier et al., 2022).

2. Why are policies necessary to drive storage development?

Currently, gas peaker plants are the main tool to balance variable renewables. This is the remnant of the dependency path driven in the past by the flexibility and availability of cheap fossil gas, mainly from Russia. Due to this competition, cleaner ways of balancing the grid, such as ESS, did not have much chance to develop.

The Russian invasion of Ukraine and the subsequent energy crisis – which in the EU's case mostly took the form of a 'gas crisis' – has radically changed the situation. The price of fossil gas jumped from between 27 EUR/MWh at the start of 2021 to over 350 EUR/MWh in August 2022 (Trading Economics, 2023). While natural gas was generating a relatively small share of electricity, due to the merit order effect (according to which the most expensive source of energy determines the price of all electricity), this increase resulted in a surge in electricity prices. The risks of relying on external actors to supply Europe's energy needs were laid bare. Balancing renewable variabilities with technologies other than fossil gas can therefore cut emissions, improve Europe's energy resilience, and allow for a faster uptake of renewables. ESS can play an important role in this regard.

The EU's relatively slow uptake of ESS stands in contrast with its swifter deployment of renewables, which accounted for 39% of electricity consumption in 2022 (European Commission, 2023d). Solar PV, which can be deployed faster than wind technologies, has observed the fastest growth since the beginning of the energy crisis: in 2022 over 41 GW of solar was installed in the EU, an almost 50% increase compared to installed capacity in 2021 (SolarPower Europe, 2023).

Renewables make environmental and economic sense, but their unique challenges must also be accounted for. Oversupply on sunny and windy days can cause negative electricity prices, especially over the weekend when electricity demand is lower. Though somewhat counterintuitive, negative prices are not good for consumers. As they harm power producers' profits, they can discourage investment in renewables and, ultimately, these losses may be passed onto consumers. On 13 May 2023, the wholesale electricity price in the Netherlands fell to -100 EUR/MWh. Negative or close to negative electricity prices are also becoming common in Germany (RTE France, 2023). In these cases, diurnal electricity storage in the form of batteries brings the advantage of creating an additional load when electricity supply exceeds demand.

Storage installations are on the rise in Europe. In Germany alone, battery storage reached 5.3 GW in May 2023, or around 8% of peak demand (Fraunhofer ISE, 2023). However, far more needs to be done. Modelling carried out by the European Association for Storage of Energy (EASE) estimates a need for 200 GW of storage across the EU by 2030 to integrate the bloc's renewable targets (European Commission, 2023b). This would entail the installation of 14 GW of storage per year until 2030, a huge increase on the historical deployment of 1 GW per year. Wood Mackenzie forecasts the European market for energy storage to grow considerably by the end of the decade as investor confidence increases, especially due to decreases in cost. However, this growth is hampered by challenges around valuing storage and the absence of coherent storage strategies at the member state level (Clerens, as in Colthorpe, 2022; Darmani, 2022). Furthermore, member states have different legislative barriers which impede storage penetrating the market. For example, in the Netherlands issues exist around taxation and contracts with grid operators.

To rapidly scale up storage deployment, policy intervention is needed. This is especially clear against the background of decreasing fossil gas prices which, as of May 2023, fell below 25 EUR/MWh, levels close to those preceding the energy crisis (Trading Economics, 2023). While this may have a positive near-term impact on inflation, it may also decrease the competitiveness of ESS and discourage investments that could make the EU better prepared for future price shocks.

In early 2023, the Commission along with many member states discussed reforming the electricity market design so that developing clean sources of energy are incentivised (European Commission, 2023e). This discussion should also encourage flexibility provided by ESS. However, the high-level changes should be complemented with targeted policy measures which have been shown to be successful in other countries. The following three sections briefly describes three such interventions: a storage procurement mandate implemented in California, renewable energy certificates adopted in South Korea, and community battery trials undertaken in Australia.

3. Storage procurement mandate (California)

With a target of producing 90% of its electricity from zero-carbon sources by 2035, California is leading the clean energy transition in the United States (SB 1020, 2022). This target, in conjunction with the state's Renewables Portfolio Standard (RPS), provides certainty to investors and has led to an exponential growth in the share of renewables in the mix.

To integrate the high share of variable renewables into the grid, the state government targeted an increase in storage capacity. A procurement mandate known as Assembly Bill (AB) 2514 was thus proposed and became law in September 2010. It obliged the three major investor-owned utilities (IOUs) to procure 1325 MW of storage by 2020, with installations completed by 2024. Additionally, Community Choice Aggregators (CCAs)1 and Electric Service Providers (ESPs)2 were ordered to procure 1% of their 2020 peak load from energy storage projects (Decision Adopting Energy Storage Procurement Framework and Design Program, 2013).

Storage projects were to be financed by the utilities through competitive bids, where they could choose their preferred projects at a competitive price. This flexibility also extended to which technologies were used, with utilities open to choose whichever technology they wished. This flexibility represents a critical aspect of how AB 2514 was drafted. While the headline target was prescribed by the legislature, the means of how to get there was left to the affected parties (i.e., the utilities and the state regulator), who have a more intimate understanding of the technical realities of electricity supply. However, as a central goal was not only to increase capacity but also to transform the storage market by helping emerging technologies develop to maturity, large-scale pumped hydro storage projects were excluded as they would crowd out emerging technologies (Decision Adopting Energy Storage Procurement Framework and Design Program, 2013).

Discussion

By the end of 2022, almost 5 GW of battery storage were installed and operating on the Californian grid, considerably more than was initially required by AB 2514. Yet even this figure does not represent the amount of storage that has been procured. When projects in development are considered, a further 6 GW are in the pipeline (American Clean Power, 2023). CCAs have been particularly successful in deploying storage given their market size, reflecting the higher demand for clean energy when citizens exert greater control over energy decisions (California Energy Storage Alliance, 2022).

This progress has been accelerated by the rolling blackouts in the summer of 2020, which highlighted the need for California to be more aggressive in installing energy storage. At the time,

[1] Local, publicly owned electricity providers
[2] Non-utility entities that offer electric services to customers within the service territory of an electric utility

only 200 to 300 MW of storage capacity was installed. By the following summer, 1.5 GW were installed (Balaraman, 2022). It was largely because of this additional storage capacity that the Californian grid prevented rolling blackouts from wildfires in the summer of 2021 (California ISO, 2022).

The ability of storage to improve grid reliability has proven its importance in California. After a major gas leak in 2015 at the Aliso Canyon Natural Gas Storage Facility near Los Angeles, the California Public Utilities Commission (CPUC) ordered the installation of 120 MW of storage to manage anticipated peak demand in the coming summer. This was successfully achieved, with 70 MW brought online within six months (Energy Storage Association, 2017). In instances like Aliso Canyon, the prioritisation of market transformation proved valuable. Furthermore, the growth of California's storage market has had significant co-benefits for the economy, directly employing over 16,800 people of the state's 485,000 clean energy workers (E2, 2021).

As more renewables are added to the mix, the need for increased long-duration storage capacity has become apparent. Li-ion batteries, which tend to have durations of up to four hours, are not prepared to deal with occasions when there is insufficient wind and sunshine for over a day. In mid-2021, the CPUC ordered the procurement of 1 GW of long-duration storage and earmarked USD 380 million to advance the commercialisation of non-Li-ion long-duration ESS (Balaraman, 2021). Diversifying away from lithium, which is prone to market shocks and connected to destructive mining practices, can safeguard California's storage boom into the future.

The achievement in May 2022 of powering the grid entirely with renewables was a historic milestone and a glimpse into California's future. Yet despite the considerable progress so far, more needs to be done. The CPUC's decision to invest USD 49 billion in a range of clean energy technologies, including almost 15 GW of battery storage, is thus a strong message that the state is willing to continue scaling up its storage capacity into the future (Decision Adopting 2021 Preferred System Plan, 2021).

4. Renewable Energy Certificates (South Korea)

Unlike California's procurement mandate, South Korea has taken a more market-based approach to increasing storage capacity. Its Renewable Portfolio Standards (RPS) and the accompanying Renewable Energy Certificates (RECs) have been the principal market mechanisms through which the government incentivises investments in renewable energy technologies. The RPS works by requiring power companies to increase the share of renewables in their energy mix over time. If a power company cannot meet its renewable target, then it must buy RECs, i.e., proof that energy has been generated from renewable sources, to offset whatever renewable energy it was unable to produce (Korea Legislation Research Institute, 2004).

Once the generation of a certain amount of energy from renewable sources is certified, the companies are issued with the corresponding number of RECs. Companies who overachieve their targets in terms of the share of renewables in the electricity mix can sell the oversupply of RECs, providing them with additional income aside from the proceeds from selling electricity. This increases the competitiveness of renewable energy sources (S. Youn & K. Kwon, personal communication, July 21, 2022).

Depending on the type of renewable energy, the certificate has additional weight to it. Weights range from no additional weight to 5.0. If a renewable energy producer generates 1 MWh of renewable energy with a 5.0 weight, then the 1 MWh is treated as 5 MWh of renewable energy generation (Korea Energy Agency, 2015). The REC weighting is considered with regard to capital expenditure and carbon footprint (S. Youn & K. Kwon, personal communication, July 21, 2022).

In 2016, this weighting scheme was applied to wind and solar energy installations equipped with storage. The maximum multiplier of 5.0 was applied to storage, with the aim of boosting efficiency and economic feasibility while developing a strong domestic storage market and a competitive export industry (MOTIE, 2016).

Rather than being a permanent subsidy, the REC multipliers are designed to reduce over time as investment costs fall. The weights attached to ESS have therefore decreased over time, as illustrated in Table 1 (Korea Energy Agency, 2015). At first, they reduced gradually as costs improved, and then more suddenly. This sudden change was driven by safety issues; between 2019 and 2022, there were over 30 fires related to Li-ion batteries (Son, 2022). To mitigate the issue, in 2021, the multipliers given to ESS and renewable energy combinations were reduced from 4.0 to 0 (Renewable Energy Institute, 2023).

Table 1: Renewable Energy Certificate multipliers for 'wind and ESS' and 'solar and ESS' over time.

Technology	2016	2017	2018	2019	2020	2021
Wind + ESS	5.0	4.5	4.5	4.5	4.0	0
Solar + ESS	5.0	5.0	5.0	5.0	4.0	0

Source: Korea Energy Agency, 2015.

Discussion

The South Korean government's strategy to grow its domestic storage market has led the country to become one of the most successful countries in the world in deploying energy storage. By directing generous subsidies towards ESS, the early-stage risks linked to high upfront costs were avoided, making storage more attractive to investors. Rather than being a permanent subsidy, the REC multipliers were designed to reduce over time as investment costs fell. The government's storage strategy also focused on increasing domestic manufacturing and improving battery cell life. To this end, storage benefitted from strong government support and the South Korean economy received a range of co-benefits due to the growth in its domestic Li-ion battery market.

In 2013, installed ESS capacity was only at 28 MWh (Korea Energy Agency, 2016). By 2022, installed capacity had reached 10 GWh (MOTIE, 2023). The programme has exceeded the government's own expectations. When the RPS was expanded to include storage, the domestic market was projected to increase to USD 390 million between 2016 and 2020 (Deign, 2016). Yet by 2018 it had already grown to USD 1.5 billion (Hwang & Jung, 2020).

There have been drawbacks, however. The earlier generations of Li-ion batteries were prone to fires. Due to the numerous fire incidents, concerns over Li-ion battery facilities slowed installations. Government investigations aimed to address the causes with the intention of helping South Korea's storage market to rebound (Park et al., 2020). However, the sudden drop of installations as a result of issues with Li-ion batteries demonstrate the risk of focusing too heavily on Li-ion batteries to the detriment of other technologies. The government recognises that the policy focused too heavily on short-term battery storage to the detriment of longer-term technologies (MOTIE, 2023). Going forward, this will need to be rectified. Considering the recent market shocks and destructive mining practices associated with lithium extraction, strengthening support for other technologies would enhance the overall policy.

The aim of increasing the competitiveness of renewable energy systems equipped with storage is counteracted by stringent zoning regulations, which lengthen the investment process and increase the regulatory and construction costs of navigating the complicated process. These strict and complicated regulations could be streamlined, which would reduce the cost of renewable energy and the time required to build up the infrastructure (S. Youn & K. Kwon, personal communication, July 21, 2022).

South Korea's RPS scheme was not created solely for storage. It has also benefitted a range of other renewable technologies and helped them to gain a foothold in the market. However, the strong preference shown towards ESS and the rapid growth in capacity compared to other countries makes this aspect of the policy particularly noteworthy, providing a market mechanism which can drive private investment towards storage.

5. Community batteries

The final case study highlights the Australian experience of integrating community batteries into the grid. This was deemed necessary due to Australia's widespread adoption of household solar PV. The high household solar penetration has led to energy being curtailed. While this is not a major problem for most homes, some households lose up to 20% of their power of the power they generate – an issue which only increases as more household solar systems are brought online (Yildiz et al., 2021). Community batteries have emerged as an effective way of dealing with this challenge.

Community batteries are shared neighbourhood battery systems that improve grid reliability in a local area and promote a higher uptake of household solar PV systems (Western Power, 2022a).

Additionally, customers stand to gain directly from community batteries through reduced electricity costs.

Although it is possible to install storage at the household level, community batteries require no upfront costs for consumers and are around 30% cheaper over the course of the battery's lifespan (Western Power, 2022a). Ultimately, benefits at both the grid and customer level help to ease the clean energy transition and support a greater uptake of household PV systems, which is a critical aspect of integrating higher shares of variable renewables.

Leading the way: trialling community batteries

Australia has undertaken a range of trials to assess how community batteries work in practice. The first of these began in April 2016 at Alkimos Beach in the state of Western Australia (WA). Around 120 residential households took part and paid an AUD 11 monthly subscription fee. The trial succeeded in reducing electricity costs for participating households. Around 83% of participants benefitted financially, with the average household saving AUD 683.80 over the course of the trial. This translated to AUD 35.83 per electricity bill (Synergy, 2021). The battery also succeeded in taking pressure off the grid during peak periods. However, the AUD 11 subscription fee was highly subsidised and not commercially viable.

The Alkimos Beach community battery did not receive a discount on network tariffs. This partly explains the challenge in making the trial economically feasible. Adopting a discount for Use of System charges when the battery draws electricity from the grid could be an important step towards increasing community batteries' profitability. At the same time, the battery may even bring additional profits by using them for network stabilisation (Mountain & Burns, 2021).

Numerous other community battery trials are taking place across Australia. In WA, the learning lessons from Alkimos Beach were expanded to a set of trials known as the PowerBank trials. The PowerBank is a form of community battery which integrates bulk solar energy into the grid while providing virtual storage to customers for their excess solar energy (Western Power, 2022b). Some of these trials' central objectives were to gather performance insights, test the physical capabilities and needs of the infrastructure, and explore potential profitability (Energy Transformation Taskforce, 2019; Western Power, 2022b). The model allows customers to virtually store up to 6 kWh or 8 kWh of excess solar power. Participants in the PowerBank trials saved an average of AUD 70 per bill, doubling the savings seen in the Alkimos Beach trial (Synergy, 2023).

The Beehive Project is a first-of-its-kind shared community battery[3] trial in Australia. The trial includes 500 participants, of which half have rooftop solar systems and half do not. The 1.07 MW / 2.14 MWh battery is not designed to discharge power exclusively to the homes that feed it energy throughout the day. Instead, the energy circulates throughout a community of participants

[3] It is called a "shared community battery" because the stored energy is distributed to households that are not geographically close to the battery (Enova Energy, 2021).

by customers sharing and trading it on an app (Enova Energy, 2021; HIP V. HYPE Sustainability, 2021). Energy usage from households with solar is matched with non-solar households and participants can then conduct transactions with each other as well as with the battery itself. This peer-to-peer trading allows participants to access more renewable energy at a price they can decide on (Carroll, 2021). The flexibility afforded by this model lets renters participate in the project and allows people to move homes and continue their involvement in the trial (HIP V. HYPE Sustainability, 2021). The New South Wales (NSW) government is a major funder, providing AUD 1 million to support battery costs, upkeep of the app, and university-led research into how the project functions (Enova Energy, 2022).

In Victoria, the 'Electric Avenue' project consists of a fleet of 40 batteries (30 kW / 66 kWh each) installed on power poles to manage pressure on the local infrastructure (United Energy, 2021a). The project is designed to improve electricity reliability and enable greater solar PV exports in local areas where there is already considerable pressure on the low voltage distribution network (United Energy, 2021b). At a cost of AUD 11 million,[4] the trial is expensive compared to other community battery projects. However, it is still significantly cheaper than traditional network investments (United Energy, 2021a).

Although customers are unlikely to see reductions in their energy bills as a direct result of the Electric Avenue trial, they stand to gain in other ways. During peak demand, the network struggles to physically move enough electricity to meet customer needs and there is a threat of outages. The Electric Avenue project thus improves reliability while increasing access to renewable energy. At the same time, customers save on network charges that would otherwise be higher if traditional network upgrades were required (United Energy, 2021a).

These trials are far from the only ones taking place throughout Australia. The Alkimos Beach trial has led to a snowball effect for the community battery industry, with more companies and utilities supporting trials designed to integrate the technology into the grid. The Labor Party's election in 2022 signalled a big political push for community batteries. As part of its election campaign, Labor promised to invest AUD 200 million to install 400 community batteries across Australia, something which can impact up to 100,000 households (Labor, 2021). If the promised investments are realised, Labor's election will mark a significant shift for Australia's storage industry.

Valuing community batteries

A common thread across many of Australia's trials is how to design a model that is financially sustainable for all parties. As indicated by the Alkimos Beach and PowerBank projects, many are highly subsidised. While this effectively guarantees savings for customers, it is not economically

[4] AUD 4 million is provided by the Australian Renewable Energy Agency (ARENA) while United Energy, the network that owns the batteries, will fund the remainder (Colthorpe, 2021).

sustainable for networks and retailers. It is imperative then to develop a tariff system that benefits all stakeholders.

Updates to the regulatory environment have removed barriers to entry for storage in the Wholesale Energy Market (WEM). These include properly valuing batteries' dispatch speed in responding to grid and market signals (AEMO, 2021), allowing batteries to register and participate in the National Electricity Market in a more efficient way (AEMC, 2021b), and easing the ability of network companies to provide community batteries (Government of South Australia, 2022b; Government of South Australia, 2022a).

Australia is yet to make any major changes to network charges, which remain a significant barrier to the deployment of community batteries. In Australia, energy flows between customers and batteries are billed twice: once when the battery imports energy, and again when it exports energy to customers (Shaw, 2020). As community batteries reduce network costs, they are not adequately rewarded for this aspect of their use (Harris & Hoch, 2022). However, the Australian Energy Market Commission expects to consider such a rule change in more depth (AEMC, 2021a, 2021b).

Discussion

Given Australia's high rooftop solar PV uptake and the associated pressures it places on the grid, a solution that can retain excess solar energy and improve grid reliability brings benefits for all stakeholders, including those not involved in the project but benefitting from a more reliable electricity grid. Since the first trial at Alkimos Beach, community battery projects have sprung up across the country. Their potential to reduce the high investment costs of traditional network upgrades makes them financially attractive to network operators. Likewise, the ability to retain solar energy for use when electricity demand exceeds supply – especially mornings and evenings - can reduce energy generation from fossil fuels.

The trials show that community batteries work. The assistance they offer the grid in areas with high rooftop solar uptake has garnered national attention as a possible key technology for the grid's transition to a clean energy future. The ever-growing number of trials and the recently elected Labor Party's commitment to financing them nationally means that their growth will inevitably continue.

However, it must be stressed that community batteries should not be perceived as completely replacing in-home batteries. Instead, they offer households an alternative to benefit from storage – both in terms of reducing electricity oversupply during peak generation and providing electricity during peak consumption – without the high upfront investment. Instead, they are charged a monthly fee that in some cases could be further decreased by using the battery's proceeds to provide additional grid services.

Australia's high uptake of rooftop solar has meant that the need for technologies such as community batteries arrived earlier than for other countries. Yet, as solar uptake increases elsewhere, it is likely that other parts of the world, including Europe, will face similar pressures on the grid. The Australian trials, as well as the associated regulatory obstacles, thus provide early learning lessons for other countries who are following a similar path of household solar uptake.

6. Lessons for the EU

The recent energy crisis highlights the need to bolster European energy security. European countries have various methods at their disposal with which they can meet the storage targets necessary to integrate the bloc's renewables goals. Initially, member states can follow California's lead by requiring electricity utilities to install short-term storage. To avoid overburdening new entrants, the storage capacity installed could constitute a certain percentage of the average generation capacity that was managed by the utilities in the previous five years. Keeping in mind the ongoing energy crisis and the need to replace large portions of fossil gas while continuing with the coal phase-out, the deadline to meet these goals would have to be staged, with annual, steadily increasing targets.

South Korea represents a different method which member states can use to increase storage capacity. Rather than setting a mandated storage target, the South Korean case focused on a market-based mechanism to stimulate growth (in combination with mandated renewables targets). The central aim of the government's policy was to even out the costs of renewable and non-renewable energy production by effectively subsidising renewables. The high upfront investment costs of ESS were thus balanced out by the generous multipliers assigned to them. Both the government's clear strategy and its assistance in reducing the early-stage risks of storage investment provided certainty to investors and directly contributed to South Korea's storage boom. Given that European countries spent EUR 56 billion on fossil fuel subsidies in 2019, with 15 countries spending more on fossil fuels than green energy, a restructuring of market mechanisms to prioritise green energy systems is sorely needed (European Court of Auditors, 2022).

The Australian example highlights the benefits of community batteries to grids with a high share of household solar PV. Rather than focusing on utility-scale capacity, the Australian trials imbed storage directly in communities. This can bring savings to end users while reducing wear and tear on the grid, providing a win-win solution for all stakeholders. However, the Australian trials, as well as the Californian and South Korean cases, highlight the importance of properly valuing storage. One of the major barriers to storage uptake in Europe is that it is not properly valued. The variety of benefits that storage brings to the grid, including flexibility and grid resiliency, load shifting, and adjusting power frequency need to be adequately valued – not simply to attract investors, but to allow storage to fairly compete in the market. In Australia and the US, updating the regulations allowed storage to access multiple revenue streams and be rewarded for much faster dispatch times, thus aligning incentives with performance so that more efficient resources could receive better pay. European policymakers ought to pay attention to this element of the Californian and Australian case studies. Well-crafted policy will unlock the array of benefits that storage brings to the grid, while translating these benefits into financial rewards for investors.

All three case studies demonstrate the importance of supporting emerging technologies with high upfront costs. Storage will play a key part in the EU's clean energy transition, but unlocking its financial potential for investors is essential if the required capacity is to be met. Although South Korea directly subsidised storage, subsidies played a much smaller part in the Californian storage boom. However, Californian utilities continued to procure storage well in excess of what they were required to by law, showing that storage is already financially viable within a well-adjusted regulatory framework. However, in all three cases, LiB ESS was favoured to the detriment of other technologies. California's shift towards longer-term storage demonstrates the need to invest in technologies other than lithium. Considering the lack of sunshine in northern European countries during winter, early investments in longer-term storage will be critical to maintaining grid stability during decarbonisation.

The ongoing uptake of electromobility and battery storage worldwide has resulted in a lithium deficit. This will make achieving the binding storage targets more challenging. There is already competition over the resource between the US and China, and it is important that Europe is not left behind. However, destructive mining practices and local opposition in some countries to lithium extraction mean that diversifying storage technologies will safeguard European energy security into the future. Developing an export market for storage was a core element of South Korea's strategy, which was more successful than initially hoped. In the near term, ensuring consistent access to Li-ion batteries will be an important part of the clean energy transition. This should also include evolving the regulatory framework to improve the competitiveness of second-life batteries, rewarding circular use of the resource.

Energy utilities should be encouraged to diversify the technologies used to meet Europe's storage targets. European policymakers may recall the motivations behind California's AB 2514, which expressly intended to foster technologies and help them reach maturity, and South Korea's storage plan, which aimed to increase domestic manufacturing. A wide range of disruptive European start-ups already exist and, if investments and subsidies are well targeted, a European storage boom will also mean a European manufacturing boom.

Another aspect in which flexibility is important concerns the storage location: electricity utilities should be allowed to develop storage assets — or purchase certificates reflecting their installation — in any EU member state. Since it can be assumed that utilities will build storage in places where the diurnal electricity price is the most volatile, such an approach would increase the impact of the policy on grid stability and reduce reliance on fossil fuels.

Proactive policy will be necessary for storage capacity to increase in line with wind and solar PV. The three case studies provide important lessons regarding what works – and what can be improved on – as storage capacity is increased. Given the urgency to reduce emissions in this decade and the high shares of renewables to be deployed by 2030, it is imperative that Europe learns from other best practices in order to develop a comprehensive storage strategy which rapidly increases deployment.

7. Conclusions

The EU's goal of increasing the share of renewables to up to 45% of the overall energy mix by 2030 will necessitate a large increase in storage capacity. The Commission's recently released storage recommendations show that the bloc is getting serious about increasing its storage capacity. However, it is up to member states to ensure the job gets done.

Each of the three case studies offer different methods which European governments can look to in their efforts to increase storage capacity. At the utility-scale, California focused on procurement mandates that required utilities to obtain set amounts of storage within a given timeframe, while South Korea increased capacity through financial incentives. The dividing line between both examples is a greater commitment to either a carrot or stick approach, though a combination of mandates and financial incentives was present in both cases. Ultimately, both case studies represent the importance of government support and regulation for increasing storage capacity. Away from utility-scale storage, the Australian example shows how batteries can be embedded in local communities with only minimal regulatory changes. There is a common thread among all three examples; proactive policy is critical to unlocking the benefits of storage while decarbonising the grid.

Given the complexity of regulatory frameworks and the way in which different grids operate, what works in one state or country may not be directly transferable to another. Furthermore, different weather patterns require different solutions to manage renewable variabilities. For instance, countries in northern Europe which have numerous consecutive days with insufficient sunshine or wind will require technologies that can meet the grid's needs over days rather than hours. Battery storage will be an important solution to the challenges posed by relying on wind and solar energy, but it cannot be the only one. Each region needs to create a cost-optimal, technologically feasible, and socially acceptable mix consisting of grid development, smart electrification of other sectors, demand management, and different forms of storage, including green hydrogen. As it relates to storage, European countries can look towards international examples to guide their own policies. The ultimate lesson is that proactive policy can foster a regulatory environment which allows the storage industry to flourish.

References

National Electricity Amendment (Five Minute Settlement) Rule 2017 No. 15, National Electricity Law (2021). https://www.aemc.gov.au/sites/default/files/2020-09/ERC0201%20including%20Delayed%20implementation%20of%205MS%20%26%20GS%20for%20publication_minus%20old%20note_0.pdf

AEMC. (2021a). *National Electricity Amendment (Integrating Electricity Storage Systems into the NEM) Rule 2021* (No. ERC0280). AEMC. https://www.aemc.gov.au/sites/default/files/2021-12/1._final_determination_-_integrating_energy_storage_systems_into_the_nem.pdf

AEMC. (2021b, December). *Incentives for More Batteries to Enter the Market*. AEMC. https://www.aemc.gov.au/news-centre/media-releases/incentives-more-batteries-enter-market

Al Shaqsi, A. Z., Sopian, K., & Al-Hinai, A. (2020). Review of Energy Storage Services, Applications, Limitations, and Benefits. *Energy Reports*, *6*, 288–306. https://doi.org/10.1016/j.egyr.2020.07.028

American Clean Power. (2023). *Clean Power Quarterly Market Report | Q4 2022*. ACP. https://cleanpower.org/resources/clean-power-quarterly-market-report-q4-2022/

Ancygier, A., Wilson, R., Petroni, M., Waterton, O., Gonzales, C., Vasilj, L., Quill, E., Raibee, S., Singh, M., Schmidt, S., Kurre, C., Coleman, W., Ramalope, D., Waldmann, C., Martini, L., Jacob, M., Görlach, B., Gardiner, J., Park, A., & Hayakawa, H. (2022). *What can the EU learn from non-EU countries on its path to climate neutrality? 4i-TRACTION Deliverable D 3.4.* Climate Analytics, Ecologic Institute. https://www.4i-traction.eu/outputs/report-what-can-eu-learn-non-eu-countries-its-path-climate-neutrality

Argonne National Laboratory. (2021, March 17). *Reshaping the Future of the Electric Grid Through Low-Cost, Long-Duration Discharge Batteries*. Argonne National Laboratory. https://www.anl.gov/article/reshaping-the-future-of-the-electric-grid-through-lowcost-longduration-discharge-batteries

Balaraman, K. (2021, December). *Hydrostor Plans 4 GWh Long-Duration Storage Project in Southern California*. Utility Dive. https://www.utilitydive.com/news/hydrostor-plans-4-gwh-long-duration-storage-project-in-southern-california/610807/

Balaraman, K. (2022, April). *"Brand New Problem": California Grid Operator Considers Ways to Integrate Long-Duration Storage*. Utility Dive. https://www.utilitydive.com/news/brand-new-problem-california-grid-operator-long-duration-storage/621637/

California Energy Storage Alliance. (2022, April). *CESA Monthly Policy Update Call*. https://static1.squarespace.com/static/5b96538250a54f9cd7751faa/t/626b03b389b917154a00dbfd/1651180470907/2022-04-08+April+Policy+Call.pdf

California ISO (Director). (2022, March 2). *From Idea to Reality—Battery Storage Comes of Age on the California Grid*. https://www.youtube.com/watch?v=waY4yQkTeHA

Carroll, D. (2021, February). *Western Australia Continues Community Battery Rollout*. Pv Magazine Australia. https://www.pv-magazine-australia.com/2021/02/11/western-australia-continues-community-battery-rollout/

Colthorpe, A. (2021, September 20). Australia's Electricity Market Rule Change That Will Be 'Massive' for Batteries Is Imminent. *Energy Storage News*. https://www.energy-storage.news/australias-electricity-market-rule-change-that-will-be-massive-for-batteries-is-imminent/

Colthorpe, A. (2022, May 19). Europe Needs a 'Massive Rollout' of Energy Storage. *Energy Storage News*. https://www.energy-storage.news/europe-needs-a-massive-rollout-of-energy-storage/

Council of the European Union. (2023). *Council and Parliament reach provisional deal on renewable energy directive*. https://www.consilium.europa.eu/en/press/press-releases/2023/03/30/council-and-parliament-reach-provisional-deal-on-renewable-energy-directive/

Darmani, A. (2022, April 11). *Europe's Grid-Scale Energy Storage Capacity Will Expand 20-Fold by 2031*. Wood Mackenzie. https://www.woodmac.com/news/opinion/europes-grid-scale-energy-storage-capacity-will-expand-20-fold-by-2031/

Deign, J. (2016, October). *Who Will Benefit From South Korea's Solar-Plus-Storage Incentive?* GreentechMedia. https://www.greentechmedia.com/articles/read/who-will-benefit-from-south-koreas-storage-incentive

Deloitte Center for Energy Solutions. (2018). *Supercharged: Challenges and Opportunities in Global Battery Storage Markets*. Deloitte. https://www2.deloitte.com/content/dam/Deloitte/bg/Documents/energy-resources/gx-er-challenges-opportunities-global-battery-storage-markets.pdf

E2. (2021). *Resilient: America's Clean Economy Powerhouse in the Wake of Covid-19* (Clean Jobs California). E2. https://e2.org/wp-content/uploads/2021/08/E2-Clean-Jobs-California-2021.pdf

Energy Transformation Taskforce. (2019). *DER Roadmap – DER Project Stocktake*. Government of Western Australia. https://www.wa.gov.au/system/files/2020-04/DER%20Roadmap%20-%20Attachement%20B%20-%20DER%20Project%20Stocktake.pdf

Enova Energy. (2022). *Enova Community Energy Secures Funding for Its First Grid-Scale Battery as Part of a Multimillion-Dollar Collaboration*. Enova Energy. https://web.archive.org/web/20220322074916/https://www.enovaenergy.com.au/wp-content/uploads/2020/03/RCEF016-Shared-Soalr-Battery-Announcement-NSW-Government.pdf?hsLang=en-au

Enova Energy. (2021). *The Beehive Project*. Enova Energy. https://web.archive.org/web/20220417215302/https://www.enovaenergy.com.au/shared-community-battery

European Commission. (2023a). Commission Recommendation of 14 March 2023 on Energy Storage – Underpinning a decarbonised and secure EU energy system 2023/C 103/01. *OJ*, *66*(C 103). https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32023H0320(01)

European Commission. (2023b). *Energy Storage—Underpinning a decarbonised and secure EU energy system* [Commission Staff Working Document]. European Commission. https://energy.ec.europa.eu/system/files/2023-03/SWD_2023_57_1_EN_document_travail_service_part1_v6.pdf

European Commission. (2023c). *Proposal for a Regulation of the European Parliament and of the Council Amending Regulations (EU) 2019/943 and (EU) 2019/942 as Well as Directives (EU) 2018/2001 and (EU) 2019/944 to Improve the Union's Electricity Market Design* (COM(2023) 148 final). European Commission. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52023PC0148

European Commission. (2023d). *Quarterly report On European electricity markets With focus on price developments in 2022* (Volume 15 (issue 4, covering fourth quarter of 2022)). Market Observatory for Energy DG Energy. https://energy.ec.europa.eu/system/files/2023-05/Quarterly%20Report%20on%20European%20Electricity%20Markets%20Q4%202022%20v2C_0.pdf

European Commission. (2022). *Energy Storage*. European Commission. https://energy.ec.europa.eu/topics/research-and-technology/energy-storage_en

European Commission. (2023e). *Electricity market design*. https://energy.ec.europa.eu/topics/markets-and-consumers/market-legislation/electricity-market-design_en

European Commission DG Energy. (2022). *Non paper on complementary economic modelling undertaken by DG ENER analysing the impacts of overall renewable energy target of 45% to 56% in the context* *of discussions in the European Parliament on the revision of the Renewable Energy Directive*. https://energy.ec.europa.eu/system/files/2022-06/2022_06_20%20RED%20non-paper%20additional%20modelling.pdf

European Court of Auditors. (2022). *Energy Taxation, Carbon Pricing and Energy Subsidies* (Review 01/2022). European Court of Auditors. https://www.eca.europa.eu/Lists/ECADocuments/RW22_01/RW_Energy_taxation_EN.pdf

Fraunhofer ISE. (2023). *Installed Power*. Energy-Charts. https://energy-charts.info/charts/installed_power/chart.htm?l=en&c=DE&chartColumnSorting=default&legendItems=0011000000000&interval=year&expansion=installed_power

National Electricity Amendment (Regulated stand-alone power systems) Rule 2022, National Electricity (South Australia) Law § §90EB (2022). https://www.aemc.gov.au/sites/default/files/2022-02/SAPS%20NER%20amending%20rule%20final%202022.pdf

National Energy Retail Amendment (Regulated stand-alone power systems) Rule 2022, National Energy Retail Law (South Australia) § § 238AB(1) (2022). https://www.aemc.gov.au/sites/default/files/2022-02/SAPS%20NERR%20amending%20rule%20final%202022.pdf

Harris, R., & Hoch, L. (2022). *Local Use of System (LUoS) Tariffs Reconsidered: Network pricing to Grid-Side Batteries*. Oakley Greenwood. https://assets.nationbuilder.com/boomerangalliance/pages/295/attachments/original/1653005616/'LUoS'_tariffs_reconsidered_OGW_16May2022.pdf?1653005616

HIP V. HYPE Sustainability. (2021). *Neighbourhood Batteries: An Opportunities Assessment for Local Government*. City of Melbourne. https://www.melbourne.vic.gov.au/SiteCollectionDocuments/neighbourhood-battery-opportunities-assessment.pdf

Hwang, I., & Jung, Y. (2020). *Korea's Energy Storage System Development: The Synergy of Public Pull and Private Push* (No.1; Innovation and Technology Notes). World Bank Group Korea Office. https://documents1.worldbank.org/curated/en/152501583149273660/pdf/Koreas-Energy-Storage-System-Development-The-Synergy-of-Public-Pull-and-Private-Push.pdf

IEA. (2022). *Global EV Outlook 2022*. IEA. https://www.iea.org/reports/global-ev-outlook-2022

IPCC. (2022). *Climate Change 2022: Mitigation of Climate Change – Summary for Policymakers*. IPCC. https://www.ipcc.ch/sr15/chapter/spm/

Jo, B.-K., & Jang, G. (2019). An Evaluation of the Effect on the Expansion of Photovoltaic Power Generation According to Renewable Energy Certificates on Energy Storage Systems: A Case Study of the Korean Renewable Energy Market. *Sustainability*, *11*(16), Article 16. https://doi.org/10.3390/su11164337

Korea Energy Agency. (2016). *KEA Energy Issue Briefing*. Korea Energy Agency. http://www.energy.or.kr/web/kem_home_new/energy_issue/issue_y/pdf/energyissue_2016.pdf

Korea Energy Agency. (2015). *Renewable Portfolio Standards (RPS)*. Korea Energy Agency. https://dco.energy.or.kr/renew_eng/new/standards.aspx

Act on the Promotion of the Development, Use and Diffusion of New and Renewable Energy, 7284 (2004). https://www.iea.org/policies/4836-act-on-the-promotion-of-the-development-use-and-diffusion-of-new-and-renewable-energy

Labor. (2021). *Powering Australia*. Labor. https://keystone-alp.s3-ap-southeast-2.amazonaws.com/prod/61a9693a3f3c53001f975017-PoweringAustralia.pdf

SB-1020 Clean Energy, Jobs, and Affordability Act of 2022., Pub. L. No. SB 1020, 7921.505 Government Code (2022). https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=202120220SB1020

Märkle-Huß, J., Feuerriegel, S., & Neumann, D. (2018). Large-Scale Demand Response and Its Implications for Spot Prices, Load and Policies: Insights from the German-Austrian Electricity Market. *Applied Energy*, *210*, 1290–1298. https://doi.org/10.1016/j.apenergy.2017.08.039

MOTIE. (2023). *에너지 저장 장치 (ESS) 산업 육성방안 마련 추진*. MOTIE. https://www.motie.go.kr/common/download.do?fid=bbs&bbs_cd_n=81&bbs_seq_n=166719&file_seq_n=1

MOTIE. (2016, December). *Ministry Grants Incentive for Solar Power Plants with Energy Storage System (ESS)*. Ministry of Trade, Industry and Energy. http://english.motie.go.kr/en/pc/pressreleases/bbs/bbsView.do?bbs_cd_n=2&bbs_seq_n=474

Mountain, B., & Burns, K. (2021, September). *Who Should Pay the Network Costs of Neighbourhood Batteries?* RenewEconomy. https://reneweconomy.com.au/who-should-pay-the-network-costs-of-neighbourhood-batteries/

Park, C., Myong, S.-Y., & Seo, J. (2020). *National Survey Report of PV Power Applications in Korea 2018*. Korea Energy Agency. https://iea-pvps.org/wp-content/uploads/2020/03/NSR_Korea_2018.pdf

Renewable Energy Institute. (2023). *Battery Storage to Efficiently Achieve Renewable Energy Integration*. REI. https://www.renewable-ei.org/pdfdownload/activities/REI_BatteryStorage_EN.pdf

RTE France. (2023). *eCO2mix—Market data*. http://www.rte-france.com/en/eco2mix/market-data

Ruby, E.-C. (2018). *Analysis of California's Formative Energy Storage Policy* [University of Colorado]. https://www.proquest.com/openview/0c466e419cdb8512c8ea4c0842854d50/1?pq-origsite=gscholar&cbl=18750&diss=y

Shaw, M. (2020). *Community Batteries: A Cost/Benefit Analysis*. Australian National University. https://arena.gov.au/assets/2020/08/community-batteries-cost-benefit-analysis.pdf

SolarPower Europe. (2023). *EU Market Outlook for Solar Power 2022-2026*. SolarPower Europe. https://www.solarpowereurope.org/insights/market-outlooks/eu-market-outlook-for-solar-power-2022-2026-2#downloadForm

Son, J. (2022, May 3). Korea to Tighten Measures for ESS Safety as Batteries Catch Fire. *The Korea Herald*. https://m.koreaherald.com/view.php?ud=20220503000645

Decision Adopting Energy Storage Procurement Framework and Design Program, R.10-12-007 COM/CAP/jv1 (Public Utilities Commission October 2013). https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M079/K533/79533378.PDF

Decision Adopting 2021 Preferred System Plan, R.20-05-003 ALJ/JF2/jnf (Public Utilities Commission December 2021). https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M449/K173/449173804.PDF

Synergy. (2021). *Alkimos Beach Energy Storage Trial Final Report*. ARENA. https://arena.gov.au/knowledge-bank/alkimos-beach-energy-storage-trial-final-report/

Synergy. (2023, May 31). *Community battery storage trials*. Synergy. https://www.synergy.net.au/Our-energy/Pilots-and-trials/Community-Battery

Trading Economics. (2023). *EU Natural Gas—2023 Data—2010-2022 Historical—2024 Forecast*. https://tradingeconomics.com/commodity/eu-natural-gas

United Energy. (2021a). *Electric Avenue* [Fact Sheet]. United Energy. https://media.unitedenergy.com.au/factsheets/CHED0289_UE-Electric-Ave_FactSheet_v2_DIGI.pdf

United Energy. (2021b, August). *Melbourne to Host Australia's Largest Community Battery Rollout*. United Energy. https://www.unitedenergy.com.au/media-centre/melbourne-to-host-australias-largest-community-battery-rollout

Western Power. (2022a). *PowerBank Community Battery Storage—An Australian-First*. Western Power. https://www.westernpower.com.au/our-energy-evolution/projects-and-trials/powerbank-community-battery-storage/

Western Power. (2022b). *PowerBanks*. Western Power. https://www.westernpower.com.au/faqs/community-batteries/powerbanks/

World Bank. (2021). *Four Things You Should Know About Battery Storage* [Text/HTML]. World Bank. https://www.worldbank.org/en/news/feature/2019/05/16/four-things-you-should-know-about-battery-storage

Yildiz, B., Adams, S., Samarakoon, S., Stringer, N., Bruce, A., & MacGill, I. (2021). *Curtailment and Network Voltage Analysis Study (CANVAS)*. Department of Industry, Science, Energy, and Resources; AusIndustry.

You, S., Liu, Y., Liu, Y., Till, A., Li, H., Su, Y., Zhao, J., Tan, J., Zhang, Y., & Gong, M. (2019). Energy Storage for Frequency Control in High Photovoltaic Power Grids. *IEEE EUROCON 2019 -18th International Conference on Smart Technologies*, 1–6. https://doi.org/10.1109/EUROCON.2019.8861993

Youn, S., & Kwon, K. (2022, July 21). *South Korea's Renewable Energy Certificates* (A. Ancygier & C. Kurre, Interviewers) [Personal communication].

About the project

4i-TRACTION – innovation, investment, infrastructure and sector integration:
TRAnsformative policies for a ClimaTe-neutral European UnION

To achieve climate neutrality by 2050, EU policy will have to be reoriented – from incremental towards structural change. As expressed in the European Green Deal, the challenge is to initiate the necessary transformation to climate neutrality in the coming years, while enhancing competitiveness, productivity, employment.

To mobilise the creative, financial and political resources, the EU also needs a governance framework that facilitates cross-sectoral policy integration and that allows citizens, public and private stakeholders to participate in the process and to own the results. The 4i-TRACTION project analyses how this can be done.

Project partners

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement **No. 101003884**.