Theme: Energy storage

The power to lift solar and wind to the next level

An industrial revolution is under way, with a focus on energy. In the short term, this will be especially apparent in the Nordic countries, where various large manufacturing facilities are being built in such specialities as battery production and fossil-free steel. One factor that has held back the global climate transition so far is the shortage of energy storage capacity. Wind and solar power are competitive sources of power, but their Achilles' heel is uneven production that is determined by the weather. There are many energy storage solutions, with both advantages and disadvantages. We see enormous growth potential for several of them going forward.

The Nordics – an industrial revolution focusing on electrification and energy storage

At least seven new battery factories are currently being built in the Nordic region by companies such as Volvo, Northvolt, Freyr and Morrow. Many more are at in early planning stages. Investments are also being made by suppliers of materials and components for the rapidly growing battery industry. Meanwhile SSAB, H2 Green Steel and LKAB are investing huge sums in the production of fossil-free steel and sponge iron – projects that will require enormous quantities of electricity and green hydrogen. Alongside this, companies such as Sandvik, Epiroc, Volvo, Scania and Volvo Cars are working on electrification of the vehicles and machinery they deliver. The transformation of the passenger vehicle industry in recent years has scarcely gone unnoticed, and after a tentative start over a period of years, electrification is now making rapid advances, for example, in the mining industry. Mines that have switched to electric-powered equipment reportedly see only advantages compared to diesel-powered alternatives. Suppliers of electric-powered mining trucks have sold out all their production capacity for more than a year going forward.

Energy storage is critical to the industrial revolution now under way. Batteries replace the fuel tanks in vehicles, but they are also needed to create a balance in power systems that rely on a large proportion of sustainable but intermittent electricity production. To make fossil-free steel, "green" hydrogen (made using renewable energy sources) is needed. This will sharply increase demand for electricity, but green hydrogen can also play an important role in balancing the electricity market.

Wind and solar power have the same Achilles' heel

The biggest problem with wind and solar power is that the pace of production is determined by wind speed and sunlight, not by how much electricity customers want. This creates major imbalances between supply and demand. It means that these energy sources need to be supplemented with other more flexible sources that are often dirty and expensive and have low average capacity utilisation.

Power plants dedicated to handling peak electricity demand have an average capacity utilisation of 5 to 7 per cent and are powered by fossil fuels, according to the US Energy Storage Association. Even in countries like Sweden and Norway, with good access to cheap, flexible and clean hydropower, balancing wind power with hydropower is a problem. Short-term fluctuations have especially negative consequences.

While power grids that are supplied with a large proportion of renewable energy may have difficulty meeting demand during certain periods, at other times there is a surplus of electricity – with extremely low prices and power generation that is completely wasted. By supplementing renewable power sources with energy storage solutions – both of extremely short and much longer duration – supply can become more adaptable and flexible. Surplus production during favourable weather can also be utilised.

> *"Energy storage is crucial to the industrial revolution now under way."*

Numerous energy storage solutions

While this theme article deals mostly with the fast-growing market for gigantic batteries as energy storage solutions, the energy storage method that is by far the most widely used today is based on water.

Another alternative that almost certainly appears likely to enjoy some commercial success is production of hydrogen from water (through electrolysis) when there is surplus electricity and the price is low. This solution can help stabilise an energy system with a large proportion of intermittent sources. Green hydrogen can then be used, for example, to produce sponge iron that is processed into fossil-free steel, as a fuel for heavy vehicles, as an input for the chemical industry or as fuel for auxiliary power units.

There are also technological solutions based on flywheels (mainly to balance short-term fluctuations in production and demand), compressed air, thermal energy storage and molten salt. Among the more imaginative solutions are hoists that lift concrete blocks connected to a generator when electricity is cheap and then release them when electricity prices are high.

Hydropower in both directions

Good access to hydropower also gives countries like Sweden and Norway an advantage when it comes to their potential to expand wind and solar power. In practice, water reservoirs are giant energy storage units. They are very effective in balancing intermittent power, both for short periods and between seasons. On the other hand, they do not eliminate the need for other energy storage solutions, especially for short periods. But most countries are not blessed with these valuable natural resources to the same extent.

One way to increase a hydropower plant's ability to balance intermittent power sources is to supplement them with a pumped storage system. By pumping water back up to water reservoirs, the energy storage potential of a hydropower plant can be further increased. This is an old, widely-used technology found in many places around the world.

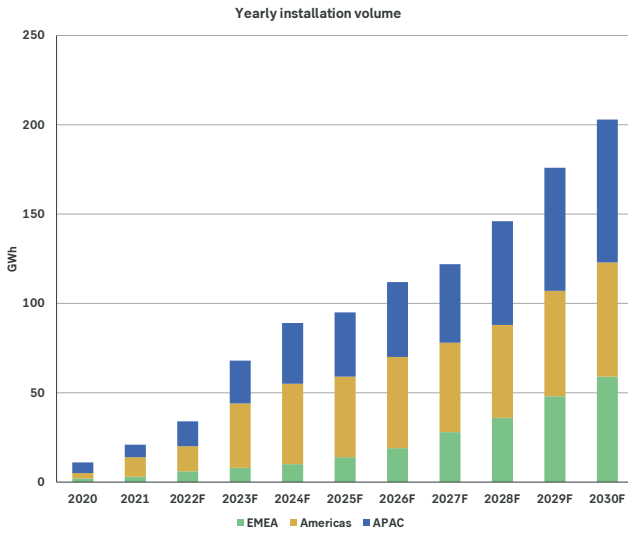
One variant of pumped-storage hydropower is a closed system using water reservoirs at two different elevations. Such systems can be located, for example, in shuttered mines – creating a pure energy storage unit that does not provide any new electricity production capacity but does not affect any waterways either.

Electric cars are only a sub-market

Many people probably associate energy storage mainly with batteries, and perhaps specifically with the rapidly growing market for electric car batteries. This is a large and expanding market. Global electric car sales this year are expected to be five times higher than the 2019 figure, but electric cars will be far from the only driving force for the battery market in the years ahead. According to Bloomberg New Energy Finance (BNEF), the sale of electric car batteries is expected to increase to four times the current figure by 2030.

Like the electric car market, the market for stationary energy storage in power grids, charging stations and other facilities has increased by about 400 per cent since 2019. This market is expected to grow even faster than the electric car market over the next few years. The forecast for 2030 is six times the record level of this year.

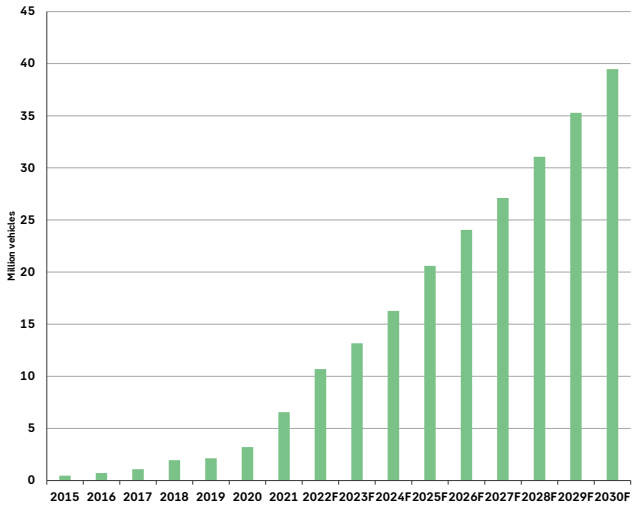
Strong growth expected for large batteries



Source: Bloomberg New Energy Finance

The chart shows the annual installation volume of large stationary energy storage batteries, for example those used by power producers, network operators and households. The statistics and forecasts are divided by geographic region, in this case Europe, the Middle East and Africa (EMEA); the Americas; and the Asia-Pacific region (APAC). A big increase is expected next year, mostly in the Americas thanks to US investment tax breaks for energy storage recently signed into law. A large proportion of capacity has historically been dedicated to frequency regulation (balancing supply and demand) and other services for network owners as well as auxiliary power in the event of outages. But in the future, batteries are expected to be used mainly for somewhat longer-term storage – between different times of the day.

Rapid growth in electric cars expected



Source: Bloomberg New Energy Finance

The chart shows annual global sales of electric cars and BNEF's forecast for the next eight years. From 2022 to 2030, the number is expected to nearly quadruple. The car battery market should grow faster, since the proportion of hybrid cars will decrease while the range of electric cars will increase.

Symbiosis between electric cars and renewable power

There is a natural symbiosis between the growth in electric cars and energy storage solutions used as a complement to renewable energy production. These two areas of energy storage applications intersect and reinforce each other in various ways:

- There is no climate-related reason to electrify the transport sector if this electricity does not come from sources with lower emissions than modern combustion engines (although electric vehicles may benefit the local environment in cities).
- There is a clear risk that peak loads in the power grid will be even more extreme if many vehicles must be charged quickly and simultaneously.
- Old car batteries can be connected to each other and can serve as stationary energy storage units.
- We foresee explosive growth, after a lag of several years, in the number of end-of-life (EOL) electric and hybrid car batteries.
- Electric cars that are connected to the power grid can also potentially lend or rent out storage capacity at certain times.

The energy source is also important in battery production

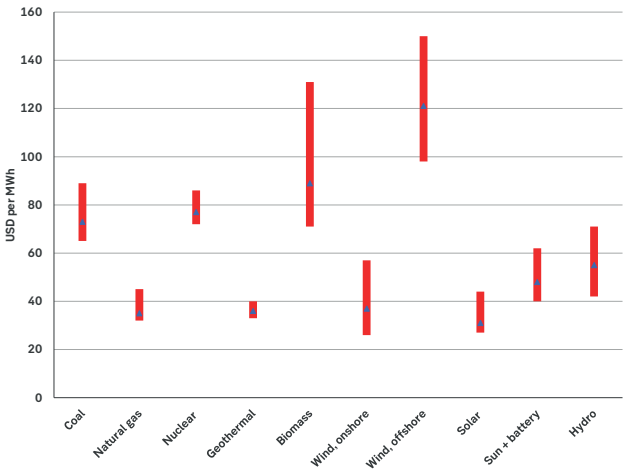
The biggest problem with electric cars from a carbon dioxide perspective is battery production. The emissions generated from making batteries are almost as great as those from manufacturing the entire car. There are also many reports in the media about poorly run facilities for production of critical minerals used in batteries. The new battery and battery component factories now being planned in the Nordic region will greatly improve sustainability in their industry.

For example, the Norwegian producer Freyr, which is building a factory in Mo i Rana, Norway, and planning another in Vaasa, Finland – each with its own battery cell production – will be completely fossil-free. This will reduce total emissions from battery production by 31 per cent compared to the global average today. By purchasing materials from local Nordic producers, emissions will be cut a further 19 per cent. Packaging and recycling solutions will add to this. In the long term, Freyr expects more Nordic suppliers to the battery production industry, which will have additional positive effects. All in all, Freyr calculates that its batteries will generate 81 per cent less emissions than the global average, which today is about 80 kg of CO_2 per kWh.

Car batteries can get a second life

Given the commercial success of electric and hybrid cars over the past decade, we are now seeing an enormous increase in the number of end-of-life (EOL) car batteries. What should we do with them? One interesting option is to give them a second life as part of a larger stationary storage solution. Even after a battery is too weak to power a car, it may be good enough to operate for ten years in various stationary applications; only after that is it optimal to recycle the battery materials. Old car batteries can also be connected to provide back-up solutions in the event of power outages and operate at electric car charging points and in server halls. Extending the service life of EOL car batteries can further improve the viability of electric cars in purely financial terms as well as from the standpoint of sustainability.

Wind and solar power are very competitive even without subsidies



Source: United States Energy Information Administration

The chart shows the cost (highest, lowest and average) per MWh of electricity over the 30-year expected life of different kinds of power plants, excluding subsidies, for a US power plant that can start production in 2027. Coal-fired power plants are assumed to include 30-90 per cent statutory carbon dioxide recycling. Including subsidies (tax breaks), the financial viability of a US power producer improves significantly, especially for renewable alternatives.

Energy storage has the power to lift solar and wind to the next level

The percentage of electricity production derived from renewable sources is growing sharply in the advanced economies of the 38 OECD countries. This is not only because they are environmentally friendly and thus receive government backing but also because they are highly competitive with all conventional sources of power (even without subsidies). Recently, supply security has become another strong argument, mainly in Europe, where the risks of dependence on fuel deliveries from dictatorships have become all too apparent.

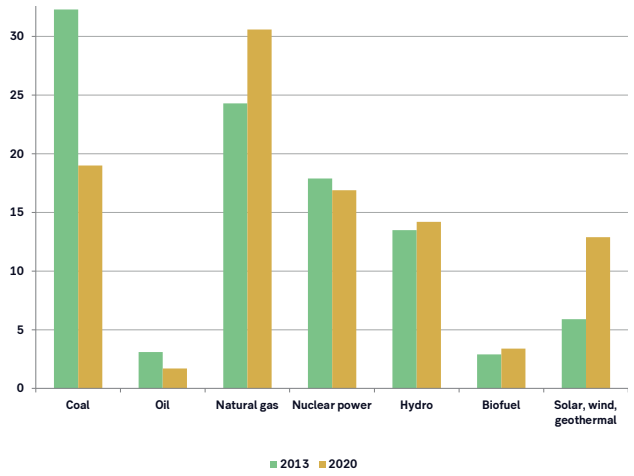
Since most exploitable hydropower resources have already been developed in the OECD countries, when new power capacity is to be built, in practice it is a matter of choosing between wind, solar or natural gas. In developing countries where emissions are not measured at all or very seldom, coal is the most important competitor. Even when a coal-fired power plant is legally required to recycle only 30 per cent of its carbon dioxide emissions, as in the US today, this increases the costs so much that according to the US Energy Information Administration, this dirty power source is far more expensive than natural gas, solar and wind power (excluding all subsidies). According to the EIA, nuclear power is relatively more expensive but may potentially see a renaissance (mainly in Europe) due to the current energy crisis.

Electricity production in the OECD countries from renewable sources increased by 8 percentage points over the seven-year period 2013-2020 to just under one third of the total, according to the International Energy Agency (IEA). This growth came primarily from solar and wind power, whose share more than doubled during the period. However, hydropower remains the biggest renewable source and still generates somewhat more energy than wind and solar power combined. Renewables are growing at the expense of fossil fuels, with a clear decrease in coal-fired power: more than 13 percentage points. But there is unfortunately a risk that the use of coal will increase again in Europe due to the Ukraine war.

Nonetheless, only about 40 per cent of the world's electricity production takes place in the OECD countries. The growth of renewables has unfortunately not been as strong in the rest of the world. The biggest difference between the OECD countries and the rest of the world is the use of coal. Coal-fired power production in the rest of the world is nearly four times higher than in the OECD, while production of solar and wind power – but also nuclear power – is only half as much as in the OECD. What slightly improves the renewable electricity statistics for non-OECD countries is that they have a larger share of hydropower.

One important reason why the global energy transition is not progressing faster is the lack of flexibility in using solar and wind power. This is a problem especially when they account for a high share of total electricity production in a system, which is where energy storage solutions come in.

Renewable energy is growing rapidly from a low level



Source: IEA

The chart shows the share of electricity production by energy source in the OECD countries in 2013 and 2020 (preliminary data). Electricity production from renewable sources increased by 8 percentage points to more than 30 per cent, while production using fossil fuels decreased by the same figure to about 51 per cent. There has also been a major shift from coal to gas, a trend that unfortunately has reversed due to Russia's restrictions on gas exports.

Summary and conclusion

We see very good potential for strong growth in energy storage and related solutions for many years to come. This trend is being driven by the need for cleaner power sources together with stable, reliable access to electricity and by the electrification of the transport sector, which is continuing at a rapid pace. Energy storage solutions will also enable the next big step in the growth of wind and solar power and thus be a key part of the impending global energy transition. The growth and changes in magnitude that we foresee obviously also offer significant investment opportunities.

Energy storage solutions recently implemented with good results

Kauai, the Hawaiian pioneer
The Hawaiian island of Kauai, which is green in many ways, has long had great ambitions for renewable energy. A breakthrough was achieved in the island's effort to increase the total share of electricity generated from renewable sources with the construction of a combined solar panel and electricity storage facility from Tesla in 2017. That year, Tesla delivered a 13 MW solar power plant supplemented with a battery system with the same flow capacity – 13 MW – and a 52 MWh storage capacity. The investment was quickly successful and was followed by similar but larger-scale projects. Kauai revised its target upward – to meet 70 per cent of its electricity needs using renewable sources by 2030, a goal it achieved as early as 2021. These successes have also inspired others. The Hawaiian Electric Company quickly followed suit and has already build several similar facilities and is also planning even more – contributing to the energy transition on the much more heavily populated islands of Oahu, Maui and Hawaii, which have a total of 1.3 million inhabitants compared to about 67,000 on Kauai.

The world's largest pumped storage power plant, 2021
China is the country that invests the most in pumped storage hydropower. Total capacity for the projects being planned is nearly twice as much as in the US. The Fengning Pumped Storage Power Station in Hebei province is the world's largest such plant, with a capacity of 3.6 GW. The project was completed in 2021 and the total construction cost was USD 1.9 billion. As a comparison, the three nuclear reactors at Forsmark, Sweden, have a total generating capacity of 3.27 GW.

Neoen's Tesla battery, Hornsdale, Australia, 2017
This battery is best known for being built by Tesla in 54 days. Elon Musk (Tesla's CEO and founder) made a bet with Mike Cannon-Brookes (an Australian IT entrepreneur) on Twitter that Musk could solve the problem of South Australia's chronic power outage problem with a gigantic battery. Musk promised that Tesla would deliver the battery within 100 days, and he did so with 46 days to spare.

The battery is now owned by the French company Neoen, which specialises in solar and wind power as well as commercial energy storage. Initially, the battery could store 129 MWh and handle a 100 MW flow. Success – both financial and operational – was immediate, so capacity was expanded by a further 50 per cent in 2020. The battery facility helps to stabilise the power grid in the region and generate profits for Neoen by purchasing electricity when it is cheap and selling it when it is expensive. This legendary big battery has also become something of a tourist attraction, and nowadays visitors must book ahead if they want to see the facility in real life.