"CHINA: Carbon Neutral by 2060"

- Innovation -

Day 2: Grid Balancing & Storage

Participants

Octavian Stamate – Counsellor for Energy and Climate Action, EU Delegation to China
Guido Dalessi – CEO, Elestor B.V.
Walter Boltz – Senior Advisor on European Energy
Anders Hove – Project Director, Sino-German Energy Transition Project at GiZ
Matthew James (moderator) - MD, Energy Post

Highlights

Battery storage

- Under existing time-of-use power prices, the returns for urban customers in China of adopting PV and energy storage together is already economic.
- Flow batteries consist of large tanks and membrane stacks and can be used for long duration.
- Flow batteries have been developed to work with large-scale PV and wind parks and produce hydrogen while charging.
- Flow batteries use bromine, which comes from seawater, is very cheap and virtually unlimited.
- Flow batteries can replace fossil fuel power plants and be used as bi-directional power plants.
- The US Energy Information Administration estimates the market for long-duration power storage will increase by 10TWh by 2040, Mckinsey expects 140TWh by 2040, Elestore estimates 500TWh by 2050.

- Elestore has found that a fully decarbonised electricity supply is possible, with today's reliability, and would require overbuild of 50 percent on the generation side and would need a couple of days of storage capacity.
- Seaport terminals offer the ideal environment and infrastructure to build really large flow batteries.
- Pumped hydro has been the leading storage solution so far, but it needs certain geographies. It works well in China.

Vehicle-to-grid technology

- Vehicle-to-grid is a highly secondary solution to grid flexibility.
- Different smart charging scenarios appear to be very similar – whether you're maximising the absorption of renewable energy or flattening out the load or charging only when the net load is favourable.
- In Europe, vehicle-to-grid could be worthwhile even if a tiny proportion of consumers use an aggregator service to do it.
- In China, a grid company could offer incentives for smart charging, but the lack of a wholesale market, spot market and real-time power prices is an obstacle.
- This is neither the most economical nor the fastest way of boosting flexibility, both for China and the world.

Electric vehicle benefits

- China started adopting EVs because of air pollution, and is expected to see major improvements in Beijing by 2030 even if coal power remains dominant.
- The improvement in lifecycle emissions of EV adoption in China grows over time, but these vehicles are already far superior to combustion engines, even in the most coal-dominant regions.

The energy transition

- Based on forecasts of PV, wind and storage, the overall cost of a clean power system in Europe isn't expected to be much higher than we pay today – 10, 15, 20 percent additional costs, pre-pandemic.
- Based on today's energy prices in Europe, a fully decarbonised system would cost not even half the price.
- Flexibility remains an issue. Batteries are a good option for flexibility intraday or one day to the next, but there is no practical solution for seasonal storage.
- A renewable energy system requires an overbuild.
- The best way of using this excess generation capacity is to produce green hydrogen and store it in existing gas infrastructure.
- When there is little generation, some of the existing gas-fired power plants can burn green hydrogen and produce electricity.
- Grid balancing requires strong EU policy support.

The clean energy transition will require greater flexibility – and that calls for energy storage solutions.

A power system based on renewable energy is possible, but it comes with much greater intermittency than fossil fuel power, over days and seasons, depending on the location. Different types of technologies will be needed for different applications and different markets.

The exponential growth of electric vehicles, both in China and the European Union, offers a number of climate action benefits. In China, the shift to electric vehicles is already reducing air pollution, including in cities where coal-fired power remains dominant, and air quality will continue to improve over time.

In the longer term, electric vehicles could also offer a smaller option for improving flexibility, by feeding power into the grid when they're not being used. This could only involve a tiny portion of passenger cars – or only commercial vehicles such as school buses and food delivery trucks – but it would still benefit the market.

Flow batteries, consisting of large tanks and membrane stacks, are an emerging technology that could offer long-duration energy storage and replace fossil fuel power plants. Excess power generated from the batteries could be turned into hydrogen and transported.

Crucial to these technologies growing, however, is policy support, including a clear roadmap for developers and subsidies to encourage the uptick.

Panel Discussion

This is a summary, not a verbatim transcript, of the key points made during the online panel event.

Octavian Stamate
Counsellor for Energy and Climate Action, EU Delegation to China

This event is based on an idea developed some time ago by the project team of the EU-China Energy Cooperation platform. This resulted in a series of online workshops targeted mainly at audiences outside China to explain what is happening in China, the opportunities and challenges, and to incite interest and invite involvement for potential European business actors. This has proven to be the main tool for keeping up a meaningful level of engagement and dialogue between European and Chinese businesses, and to reach out to those in Europe who are able and willing to work with China on innovative and marketable solutions to support the transition to clean energy.

The platform has established a partnership with Energy Post, and eventually has grown into a more complex interaction involving the EU Chamber of Commerce in China as a fully-fledged partner.

I'm looking forward to an open and productive exchange on topics which are of great relevance and an integral part of the overall effort to ensure that the way energy is distributed and consumed effectively contributes to a pattern of development that is sustainable and climate-resilient.

Today we meet against the tragic backdrop of a war of aggression next to the EU's borders, with the immense destruction and suffering of people, but also with extremely negative consequences on the European energy landscape. The EU faces a very difficult situation for a variety of reasons, but mainly because it is still heavily dependent on imports of hydrocarbons from one source – which happens to be part of the conflict.

Therefore, the European Commission presented the REPowerEU Plan, a response to the global energy market disruption caused by Russia's invasion of Ukraine. This plan reflects the sense of a double urgency; on the one hand to transform Europe's energy system by ending dependency on imported fossil fuels, and on the other hand, tackling climate change.

The measures in the REPower EU plan can respond to this ambition through energy savings, diversification of energy supplies, and the acceleration of the rollout of renewable energy to replace fossil fuels in homes, industry, and power generation. The green transformation will strengthen economic growth, security and climate action for Europe and our partners.

The plan is an additional measure to the Green Deal, which aims at putting the EU economy and society on a more sustainable development path where actions designed to address environmental and climate challenges will also lead to fairer, more balanced economic growth. The EU climate law aims by 2030 to reduce emissions by 55% compared to 1990. The package of legislative proposals, Fit-for-55, is designed to deliver on this ambitious goal in a fair, cost-efficient and competitive way.

The EU and China are key parties to the Paris agreement. The EU aims to reach climate neutrality by 2050, China by 2060. There is great potential for mutually beneficial cooperation. The EU-China statement on energy cooperation, signed in 2019, identified cooperation between innovative businesses as a means to provide solutions for the acceleration of clean energy transition.

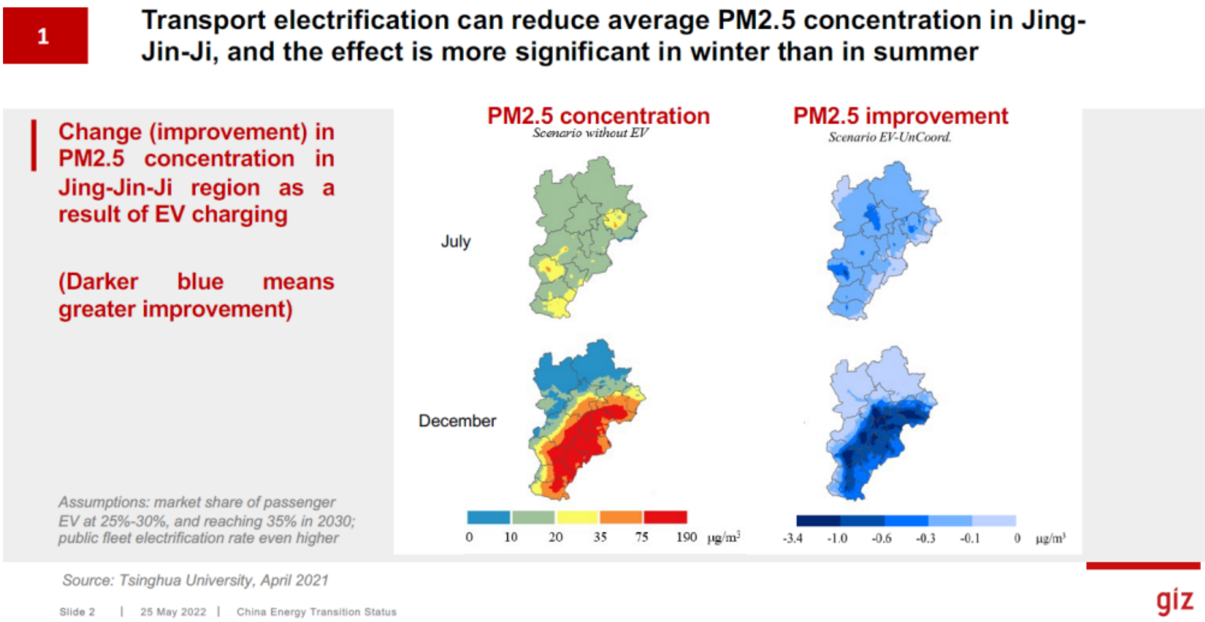
The EU-China Cooperation Platform has produced a number of comparative studies and reports on topics specifically identified in the joint statement, for example with its own methodology on grid modelling. Some of these reports were introduced at the EU-China High Level Energy Dialogue where they were well received at the highest official level.

I would also like to recall the importance of the exercise carried out every year by the EU-China Chamber of Commerce, entitled 'The Position Paper'. These are key documents supporting their advocacy efforts and are widely recognised by Chinese and European governments, institutions, business associations and media.

I hope that this workshop will not only help people establish new contacts and incite dialogue between stakeholders, but that it can contribute in a more general way to a stable and mutually beneficial relationship between the European Union and China.

Anders Hove
Project Director, Sino-German Energy Transition Project at GiZ

Although I'm going to focus on energy storage and electric vehicle charging, it doesn't mean I am positioning it as the main solution for grid balancing. I would rate it as a highly secondary solution, with the overall solution lying in flexible power systems, spot power markets that work efficiently over a broad geographical area, and the flexible operation of existing transmission systems.



We're approaching the topic of EV charging and energy storage from the perspective of the benefits, trying to evaluate the benefits that we don't often talk about, because those benefits do help justify investment costs that are required.

One of those is looking at how smart charging of electric vehicles could help reduce air pollution in urban areas in the developing world, like in China. China started down the path of adopting electric vehicles because of air quality issues more than any long-term desire to decarbonise transport. It is important to think about how smart charging fits into that.

We looked at what the impact of electric vehicle adoption in the Beijing region would be by 2030, given the power mix and the characteristics of non-electric vehicles at that time. We see a major improvement in air quality as a result of adopting electric vehicles, even though coal would still be the dominant form of electricity generation.

2

Tsinghua developed several charging profiles for Beijing based on trip data and generation profiles

Smart charging profiles look similar for several different scenarios

Uncoordinated

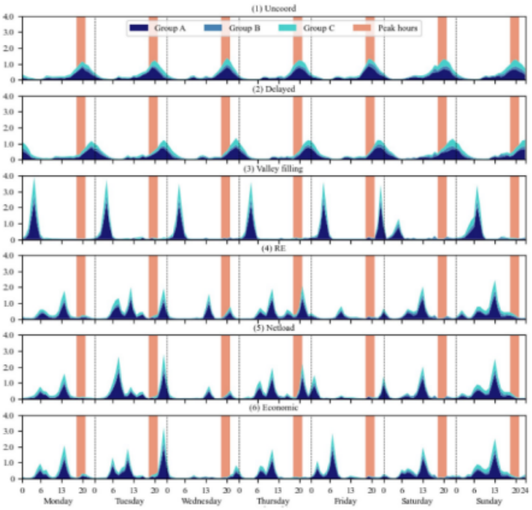
Delayed

Valley filling

Max RE

Net load

Economic



Source: Tsinghua University, April 2021

giz

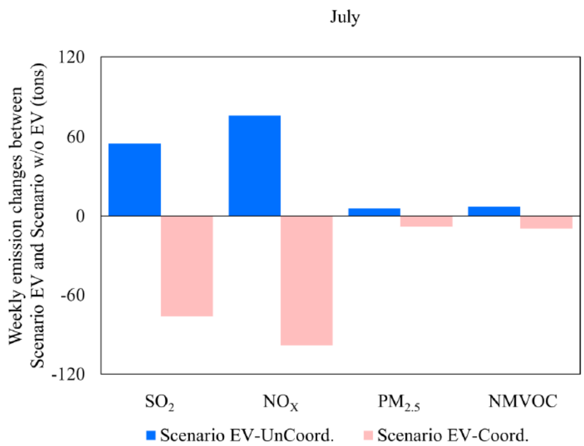
Next we looked at what the algorithm for smart charging would be in this region, given what we know about the trips people make and how big the batteries of the vehicles would be. We assumed that everybody would need to charge their battery every day, a fairly conservative scenario as most people would not necessarily need to.

We found that all the smart charging scenarios we modelled were highly similar. So if you try to maximise the absorption of renewable energy, if you try to flatten out the load or charge only when the net load was favourable towards charging your EV, or if you just tried to focus on when power was most abundant – all of these scenarios looked very similar.

3

Air quality improvement was significant for summertime smart charging, less so for winter

Difference in criteria air pollutants in July, Beijing



Source: Tsinghua University, April 2021

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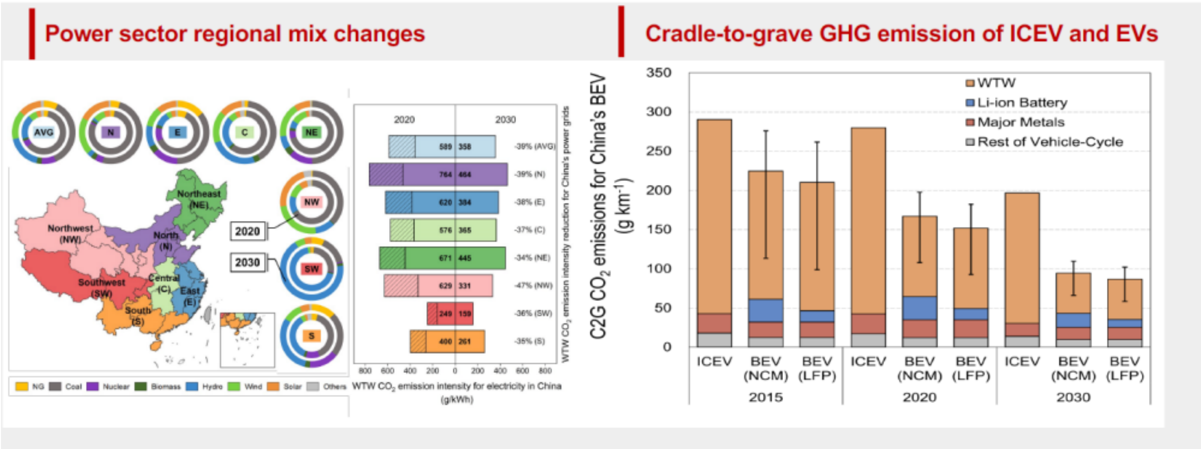
The results show that if you model an uncoordinated charging scenario against a smart charging scenario, you get a major improvement from smart charging, especially on the key pollutants of sulphur and NOx. This does not even bring vehicle-to-grid technology into the system, and that helps you understand that there is also going to be a very good grid balancing benefit to smart charging of EVs. That's whether you do it based on charging at the cheapest level, which benefits the consumer, or charging from renewables, which benefits the grid; they're both highly similar.

4 **Cleaner electricity mix in 2030 will lead to much lower GHG life-cycle emissions for battery EVs**



Source: Tsinghua University and GIZ, March 2022

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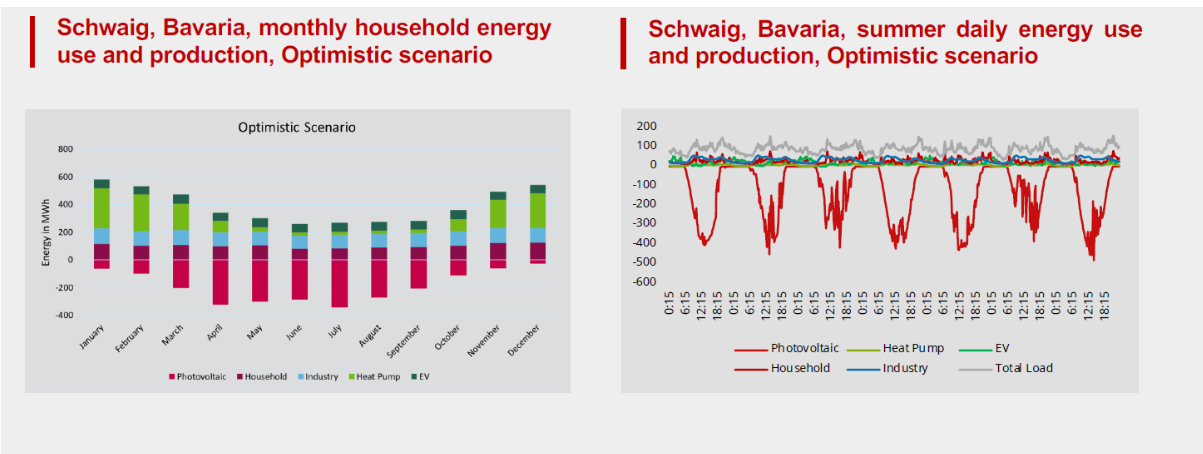
The improvement in lifecycle emissions of EV adoption in China grows over time, but these vehicles are already far superior to combustion engines, even in the most coal-dominant regions.

5 **For rural areas, modeling by our research partners showed EVs have strong potential to enable energy self-sufficiency**



Source: Wuppertal University, January 2022

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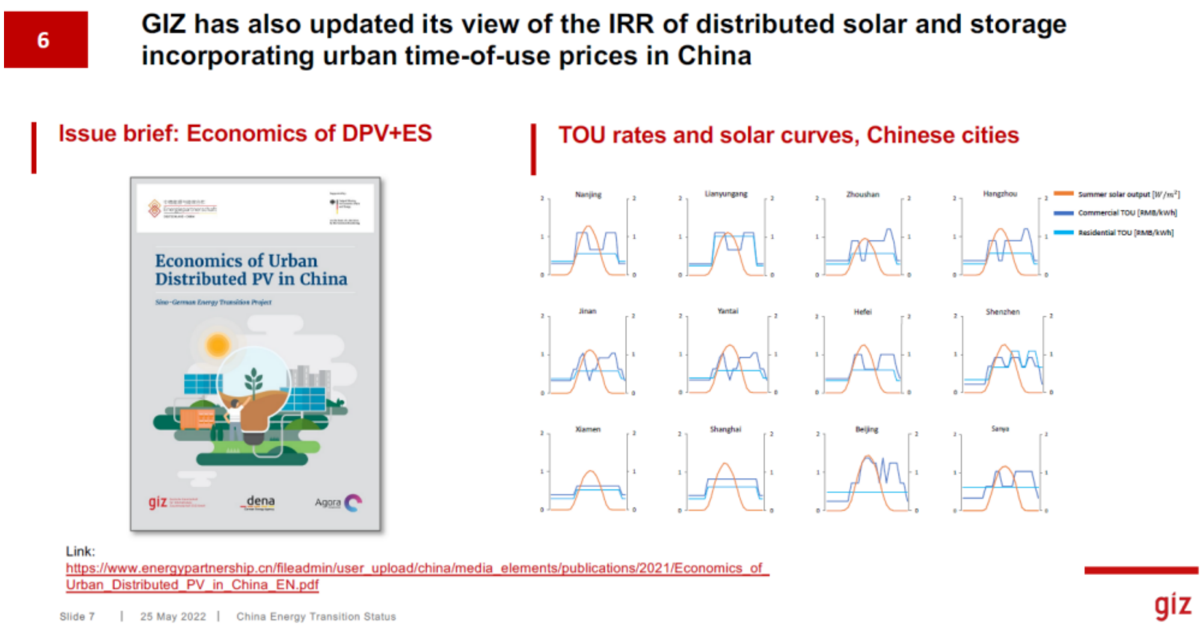
This is a view of the small Bavarian village of Schwaig. They have a large amount of solar installed but almost no electric vehicles today. In the future it is very likely they will have a large number of EVs and a large number of heat pumps.

We found that Schwaig is very evenly balanced in terms of household energy consumption and production, if we assume heat pump and EV adoption by 2030. We also found that there's a very strong seasonal imbalance. There is a strong overproduction in the daytime and then no production in the nighttime. But in the summertime, you would have a strong need for storage in this village if you are seeking to reduce distribution grid costs – but this would not solve that seasonal issue.

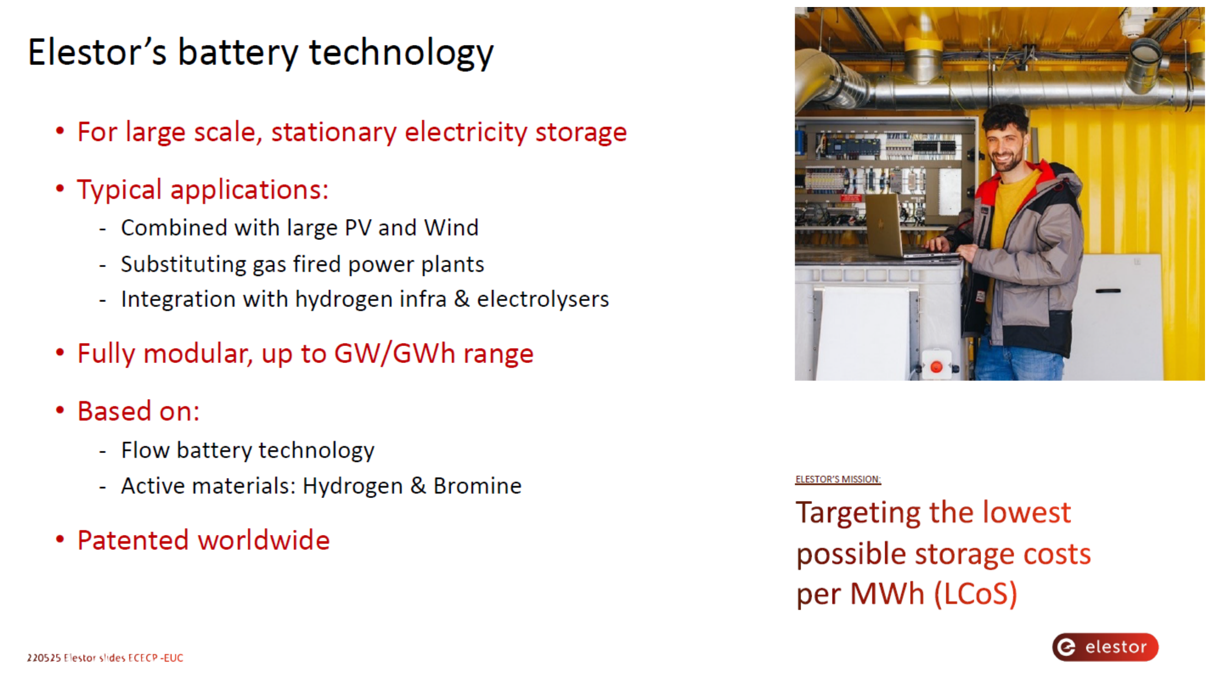
Initially we thought villages in China would be too poor to proceed with EVs or storage, but on reinterviewing people in one village we found that many already have EVs.



We have also looked at the issue of electricity prices in China and PV production times. What we see is that, under existing time-of-use power prices, the returns for urban customers of adopting PV and energy storage together is already economic under the slightly more aggressive price differentials that time-of-use pricing in most urban areas now have. This is most beneficial for commercial customers. Distributed solar and distributed storage have a huge market in China right now.

Guido Dalessi
CEO, Elestor B.V.

Elestor stands for electricity storage, we've developed a flow battery which we think can make a big contribution to energy transition.



A flow battery is a completely different technology compared to conventional batteries like lithium ion and lead acid. Flow batteries consist of very large tanks and membrane stacks. The essential difference between conventional batteries and flow batteries is that with flow batteries you can define the configuration in terms of megawatts and megawatt-hours. The megawatt-hours determine how long the battery can deliver its power, especially for a long duration – starting at eight hours or more, this technology becomes more economical.

The technology has been developed to work with large-scale PV and wind parks. The larger the better, as the technology becomes more economical with larger systems. The technology can also substitute gas-fired power plants, which sounds like a moonshot but is already happening. For instance, a project in California replaced a complete gas-fired power plant with a battery.

Our battery produces hydrogen while charging. Instead of putting that into a tank, you can connect it to hydrogen infrastructure. We use hydrogen and bromine, and I would like to underline that the success of grid scale storage is determined by the storage cost per megawatt-hour. This is referred to as levelised cost of storage (LCoS), and this is what we are targeting.

Global bromine reserves are virtually unlimited, thus extremely low cost

Material	Global reserves (Kilotons)	Usage (kg/MWh)	Sufficient for ...% of required capacity	Supply & cost contraints
3 Li Lithium — Li-ion batteries	16.000 [2]	0,9 [3]	4%	- >90% of global reserves in 4 countries: Chile, China, Argentina, Australia. - Oligopoly, no price pressure - Mining creates large scale depletion and pollution of groundwater
27 Co Cobalt — Li-ion batteries	7.100 [4]	0,2 [5]	7%	- Approx. 60% of global reserves in 1 country: Congo, extreme geographic dependency - Mined under torturous labour conditions
23 V Vanadium — Vanadium Redox Flow	20.000 [7]	4,4 [8]	1%	- 85% of the global supply comes from China, Russia, South Africa - Cost increased >400% from US$ 13.50/kg in 12-2015 to US$ 68/kg in 5-2018 - 90% of the Vanadium supply is used for hardening steel
35 Br Bromine — **Hydrogen Bromine Flow batteries**	**100.000.000.000**	**3,2**	**100%**	+ Only 0,0016% of the global bromine reserves are sufficient for a 100% decarbonized electricity supply

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This is one of the reasons why the battery can reach an extremely low levelised cost of storage. This table shows four elements that are used in the batteries. The bromine reserves are virtually unlimited. This means that bromine is very cheap today, it will always be cheap, and that is essential in reducing the storage cost per megawatt-hour to the absolute minimum.

The beautiful thing about bromine is that it is found in seawater. So, unlike lithium or vanadium or cobalt, it is not limited. There is no geographic limitation, no one region that supplies it. Nobody can dominate it. There is no opportunity to form an oligopoly. Few suppliers and huge demand does not lead to price competition.

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This yellow container contains power modules and membrane stacks. The balloon stores hydrogen, but it’s just one way, atmospheric.

The HBr flow battery as Bi-Directional Power Plants, replacing current gas fired power pants

An in-depth analysis shows that, with the optimal combination of Sun+Wind+Storage, Elestor’s technology offers the optimal economic solution for a reliable and fully decarbonized electricity supply, with 100+ hr storage duration

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This battery is an ideal candidate to build very large power plants to replace fossil fuel power plants, and then they become bi-directional power plants because you can also charge them. We foresee that this will be the long-term future of batteries. Wind parks and solar parks are not substituting the power plants, but the gas and the coal that goes into the power plants.

The analysis shows it is possible to build a fully decarbonised electricity supply based on sun, wind and storage. This leads to storage systems that can cover up to a couple of days and this kind of flow battery technology is really economical in these long duration, large-scale applications.

The market for Long Duration Energy Storage (LDES)

Battery storage grew by 50% in 2020 alone and this rapid trajectory is likely to continue [1]

However, the predictions for the future of storage vary dramatically:

- **IEA** (Energy Information Administration, USA) estimates that global installation of utility-scale batteries will increase 25 times between 2020 and 2040, reaching **10 TWh** by 2040, which equals 50 times the current market size[2]
- **McKinsey** predicts an even steeper growth, reaching **85 to 140 TWh by 2040** [3]
- **Elestor**'s estimate is **500 TWh** for a 100% carbon-free electricity supply

Clearly, the energy storage industry is set to thrive, with a particular focus on long-duration energy storage.

Whatever prediction turns out right, the need for 100's of TWh of electricity to be stored with flow batteries translates into **massive opportunities**.

[1] *IEA (2021): https://www.iea.org/reports/energy-storage*
[2] *IEA (2020): https://www.iea.org/reports/innovation-in-batteries-and-electricity-storage*
[3] *McKinsey (2021): https://www.mckinsey.com/business-functions/sustainability/our-insights/net-zero-power-long-duration-energy-storage-for-a-renewable-grid*

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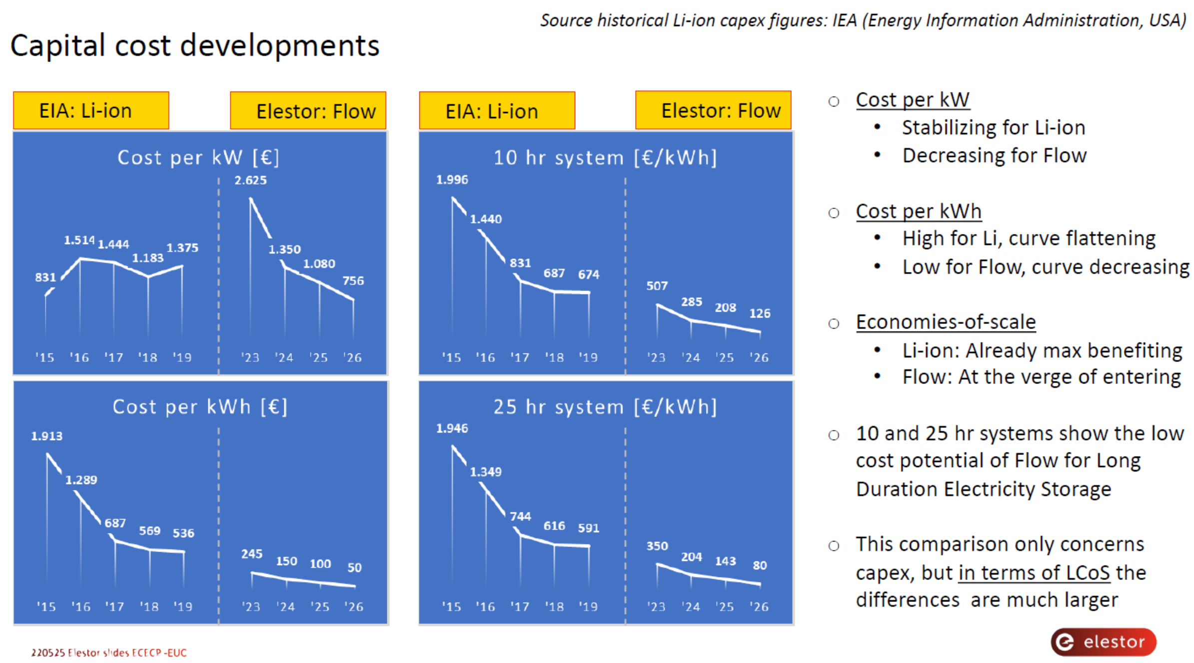
There are many predictions for the market for long-duration energy storage. The US Energy Information Administration thinks there will be about a 10TWh increase to 2040. Last year McKinsey concluded the world would need 140TWh by 2040. We estimate 500TWh by 2050.

Whichever prediction is true, it is clear that hundreds of terrawatts of electricity will need to be stored, providing massive opportunities to boost the energy transition. Long-duration energy storage is growing in popularity. With gas and coal-fired power plants, we would need batteries to bridge a few hours – but when we really abandon fossil fuel generation and rely on solar and wind, we will have to bridge up to a couple of days with stored electricity. This is where flow batteries come in.



This graph shows a comparison between what has happened to lithium batteries in terms of cost per kilowatt and per kilowatt hour in previous years and how we see the future for flow batteries. Especially on the long duration systems, you see that the euros per kWh is at a lower level than what can be achieved with lithium ion batteries.

Walter Boltz
Senior Advisor on European Energy

The EU has evolved its thinking on how to manage the energy transition. It was always clear we would go to zero carbon emissions, but only after the Paris accord have people started to consider that this means turning off every fossil fuel plant and ending the use of fossil fuel energy in heating, in transport, in the chemical industry, and so on.

When we were aiming for a large degree of decarbonisation, but not for zero carbon, we thought we could manage with the flexibility of the grid. But it became clear that these traditional concepts would not work.

Based on forecasts of PV, wind and storage technologies, the overall cost would not be much higher than we pay today – 10, 15, 20 percent additional costs, pre-pandemic. With today's energy prices in Europe, a fully decarbonised system would cost not even half the price.

The issue of flexibility still needs to be addressed. In a highly decarbonised system with no fossil fuel plants, batteries are a good option for flexibility intraday or one day to the next, but there is no practical solution from a technological level for seasonal storage. We have large seasonal energy demand fluctuation in Europe, particularly in the north where there is less PV. The biggest demand is in winter and, with no generation available from renewables, we need to survive these long periods.

When you calculate how energy could be supplied to a large part of the electricity need by using renewable generation, you find you need to overbuild – if you have a peak load of 10,000 MW, you need renewable generation capacity of 25,000 MW because only then, in times when there is no sun or wind, can you cover demand with renewable generation. That means we have many hours of excess capacity where there's a lot of electricity available at close to no cost.

All scenarios show that the best way of using this excess generation capacity is to produce green hydrogen and store it in existing gas infrastructure. In times when there is little generation, we can use some of the existing gas-fired power plants to burn green hydrogen and produce electricity.

Today, most electricity systems in Europe have between 50 and 75 percent fossil fuel generation. In the future, we will need between 15 and 20 percent capacity produced by renewable hydrogen or biogas, and we will need to store a sizable amount of energy in green hydrogen. It has been shown that it could work, but that it would be difficult with only electrons and no molecules, because of limitations in seasonal storage. We will need to use all the flexibility tools we have.

In Europe there have been thoughts about how to optimise the use of batteries in electric vehicles. I am not sure if the scenario assumptions we have been shown regarding the China analyses are possible in Europe. Knowing who intends to drive their cars and the statuses of individual batteries would be ideal information to manage flexibility needs, but in Europe there is much scepticism about this kind of data collection, so I doubt we could make optimal use of batteries in EVs. Price incentives or additional information provisions will always fall short of an engineering solution.

In Europe, there is a plan to decarbonise the energy sector with costs that are not excessive. We know there is a need for some molecules, which in Europe we intend to fulfil by providing green hydrogen. We will also need, in the transformation phase, some imported green hydrogen or synthetic methane. It seems this transition is manageable. We will be able to finance it but we still have a lot of challenges ahead of us.

Once we learn how to optimise the organisation of flexibility through technology, there are also behavioural considerations to make sure that people become aware that electricity demand can or should be changed or adapted to the availability. This is a big change for European customers who are used to turning things on and off and who always know there is enough electricity. Being cognisant of this need for balance and for flexibility will require some behavioural changes.

Panel Discussion

Matthew James
Managing Director, EnergyPost

Guido, is the vision Walter is painting for Europe compatible with your prognosis? Are your visions on the opportunities for storage different?

Guido Dalessi

In general I agree, a combination of solutions is required. Walter said that if we were to use long-duration energy storage in combination with solar and wind, we would need to overbuild. But it depends on the technology you use to store the electricity.

Last year we published an analysis, based on the Netherlands, showing we can create 100 percent carbon-free electricity supply with the same reliability we have today. We would need an overbuild of 50 percent on the generation side and would need a couple of days, not weeks, of storage to fill the gaps and maintain reliability. This goes for the lowest cost of electricity.

So there may be a mismatch in our ideas of necessary capacities and overbuild.

Matthew James

Anders, Walter alluded to cultural differences, and different market set-ups, between Europe and China that affect the opportunities for the development of two-way flows on demand, using people's batteries and managing grid resilience. What are those differences between Europe and China?

Anders Hove

I think I disagree with Guido’s point. The concerns and cultural differences are valid. I assume this could be overcome in Europe through aggregators that would take care of when your car charges or not in a way that doesn’t feel threatening in terms of data privacy, because you’re being paid for that service.

It could be a very small minority. Say everyone who owns a car now has an EV in the future, and only 5 percent subscribe to some sort of energy aggregation service for their home that allows their battery to both balance their solar production and help the grid for lower overall electricity costs. I think this is a viable solution for any place that has a retail energy market where aggregator companies are allowed to enter.

We’ve been talking about it in Europe and North America for a long time and it’s only happened on a tiny scale. I don’t think that’s due to privacy concerns, but to other obstacles that aggregation companies face in the markets.

In China it’s possible a stronger grid company could offer greater incentives for smart charging. Also, more batteries being located in commercial vehicles or in ride-sharing vehicles could lead to more incentives for smart charging. But the lack of a real wholesale power market, spot market and real-time power prices is the major barrier in China.

Matthew James

Walter, could you comment on what you’ve heard from Guido and Anders?

Walter Boltz
Flow batteries have a role. Given the current economics and predicting what happens in the next 10 to 15 years, I think the role will be limited to storing energy for a couple of days maximum and for special situations, in areas where there is no possibility to get rid of all the energy from wind parks or during peak wind time. I do see a role, and it’s probably still a huge business opportunity for companies involved.

Regarding vehicle-to-grid services, I think there’s a huge capacity to do it. It could solve a lot of flexibility issues. But I don’t think it will be a saviour of cheap flexibility in Europe. I do see a bigger potential for it in China. Europe needs generation capacity to provide flexibility in the next few years.

Q&A

Question: Peter Campbell

How far along is Elestor in commercialising this technology, where are the installations now, and where are they expected to be used?

I know there's a lot going on in hydrogen, with huge projects coming up in Groningen and the AquaVentus project on the German island of Heligoland, which are around 4-10 GW in scale. How do these hydrogen bromine projects fit into that picture, especially in the Netherlands and Germany?

Guido Dalessi

Elestor was founded in 2014 and reached the commercialisation stage last year and signed our first contract with Vopak, a seaport tank company storing liquids and gases.

Seaport terminals offer the ideal environment and infrastructure to build really large flow batteries. They have large storage tanks and necessary knowledge to store massive capacities of all kinds of chemicals.

Prior to that we developed a handful of demonstration installations with EU and national subsidies. This first commercialisation project is the breakthrough, it's initially relatively small, with up to 3 MWh of capacity to validate the business case, and will be expanded to 250 MWh.

Elestor is also on the verge of signing a very large funding round to bring these batteries into serial production, in the tens of millions of euros. We'll announce it in about two months. Then there's a pipeline of new development, including a membraneless flow battery we are developing with Shell and European universities. That will reduce costs and complexities.

Anders Hove

I do not regard energy storage and electric vehicle charging as the primary solution, especially in the next couple of years, for grid flexibility.

We have written extensively about how this is neither the most economical nor the fastest way of boosting flexibility, both for China and the world. Europe is making excellent progress in both developing energy markets, especially spot markets, and flexible use of transmission lines and conventional generation in order to provide flexibility to the market.

The secondary way of providing flexibility is through conventional demand-side flexibility, which also can be provided by the market. Certainly the market for EVs is growing exponentially, but it is many years before aggregation comes to fruition, even if we have companies. I want to show the benefits of that so we don't ignore it. I don't think it will be driven by consumer demand by itself.

In Germany, the power system is so reliable that the motivation to buy vehicles that can put power back into the grid is lower than in other markets. There are products coming online now that will probably speed up this discussion, especially in the commercial vehicle market, such as school buses and drainage trucks for port areas and vehicles that deliver food and aren't active at night or during peak travel hours. They would be excellent for using grid balancing services, so there's potential for balancing even if passenger cars never get involved – but still many years away and not as a primary source of flexibility.

Matthew James

Guido, you're based in the Netherlands, but your technology is just as useful in other markets, for example China. What are the opportunities for companies like yours in China?

Guido Dalessi

The Dutch market would be far too small for this company; we have an ambition to be a large player in the world. We have projects in the pipeline, for instance in Australia. We have not been talking to China, but the market is interesting there.

Matthew James

In yesterday's session we talked about green hydrogen and thermal being long-term storage solutions in China. How do you foresee your competitiveness? What is the levelised cost of storage against those two technologies going forward?

Guido Dalessi

I would never say that Elestor is the one and only solution, or that it's the best battery in the world, it depends on what you want to do with it and where you are in the electricity value chain. These technologies aren't necessarily competitors, heat storage is completely different and has a better fit for certain applications.

Ours fits for long-term, long-duration, large-scale stationary storage. There are different flow batteries, the most common is based on vanadium and a couple of these are built in China. The big difference is the cost of chemicals. There is a 20-factor difference between the cost of vanadium and hydrogen bromide, which determines the levelised cost of storage.

Question: Brian Edmonds

What is the footprint of battery storage compared to an equivalent gas turbine generator, and what active fire protection is required?

Guido Dalessi

This technology is a good candidate for substituting fossil fuel power plants, based on the technology and the space needed. It's whether we can deliver the same amount of power from a battery with the same footprint – yes.

The bromine we use is a flame retardant, it does not burn. Hydrogen needs to be stored, but it's not a challenge, it's done at a huge scale in many locations. The battery needs to contain safety precautions.

If you considered these kinds of scales for lithium, you would need a much bigger footprint because you need to keep lithium containers at a distance in case one is set on fire.

Question: Brian Edmonds

Can smart charging increase the cost of charging depending upon the energy mix?

Anders Hove

I don't think it would be very smart charging if it increased the cost of the power for consumers to charge their vehicles. I assume all smart charging will prioritise the price the consumer pays in the algorithm, followed by any sort of environmental or renewable energy absorption consideration.

There are exceptions, for example people living in the very small US state of Vermont received a rebate for their home battery systems in exchange for allowing the grid company to operate the battery system at the utility companies' discretion. So they don't face any cost pressure.

Obviously the consumer would probably not adopt any battery or vehicle-to-grid or smart charging policy if they had to pay more money. That said, it's difficult or almost impossible to write these algorithms to perfectly anticipate power prices in the next 15-minute or one-hour intervals. But over the course of the year I assume this would be easy to even out.

Question: Guoyi Han

China is investing and pushing hard on pumped hydro for long-duration storage and flexibility, with a range of plants. Guido, given that pumped storage normally takes decades to put into operation, to what scale could your long-duration battery option replace it?

Guido Dalessi

Pumped hydro has been the leading storage solution so far, but it depends on geographical possibilities, which is why we don't have it in the Netherlands, being flat and below sea level.

Compared to our batteries, the investment costs for pumped hydro are much higher and the building time is much longer. But the LCoS is very low because the plants can last 50 or 100 years, so if you realise it then it eventually becomes cheaper than our battery solution.

Technically there is no size limit to our technology. You can always build bigger. Realistically, it will be up to about 1 GWh. We believe there will be more local and smaller systems rather than fewer and bigger.

Anders Hove

I agree. It's great that China is building so much pumped hydro, and it's definitely the largest energy storage source worldwide now, but we're going to need everything and different types of energy storage play different roles in the market. Energy density isn't always the main consideration, although it's important in automotives.

The footprint of the batteries could be important in some cases. Technologies often work well together. We see a lot of advantages to having distributed energy storage, which pumped hydro is not.

Matthew James

Anders, does the amount of participation in the vehicle-to-grid systems affect its commercial viability or attractiveness? What support or subsidies are needed, or is it already efficient in Europe?

Anders Hove

The round trip efficiency of batteries can be in the 80-85 percent range, so lithium-ion batteries in vehicles would be a fairly efficient way in the case of vehicle-to-grid. Smart charging doesn't cause efficiency loss, just a change in the time the vehicle charges.

There is a cost, especially in markets where, if you inject power back into the grid from either your home or your plant, you might need to significantly upgrade your distribution line or install a shut-off switch for your house. I assume this would not be subsidised.

But there is a huge market worldwide for diesel generators in areas where power is not reliable. So there is a role for upgrades to home or business electrical systems and distribution lines, to enable distributed energy to enter and become part of the market. California has 12 GW of diesel gensets now – double what it was a few years ago and one-quarter of the state's peak generating capacity. They're sitting idle, very dirty, loud, noisy and have to be operated once a week, just to stay running. Those houses have already upgraded their power systems, so installing a battery or vehicle-to-grid would be no issue.

Matthew James

What are the key innovations we should be focusing on in grid balancing? Startups, existing companies, investments.

Guido Dalessi

To really deploy and implement these kinds of technologies, we need a lot of support from the European Union. There are still several hurdles in the energy legislation that make some installations impossible, and some applications can't be addressed as a result.

There should be a clearer roadmap to stimulate the adoption of storage technologies, especially in the EU. Without storage the energy transition will slow down rather than speed up.

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Produced by Energy Post for
EU China Energy Cooperation Platform (ECECP)

ECECP is funded by the European Union