The clean flexibility COP?

The COP29 presidency is proposing a hat-trick of measures on clean flexibility – a storage target, grid target and action on clean hydrogen. How will these unlock a tripling of global renewable capacity?

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Contents

About

This report analyses the grid, storage and hydrogen proposals of the COP29 delegation, to show their feasibility and to what extent there is an opportunity to extend the agenda of clean flexibility at COP29 to help deliver on the tripling of global renewable capacity.

Executive Summary

Grids, storage and the clean flexibility tool box

Clean flexibility is key to delivering tripling of renewable capacity

This year's United Nations climate summit in Azerbaijan (COP29) is set to be a pivotal moment in global climate action, with a pronounced focus on "clean electricity flexibility". The Azerbaijani COP Presidency has spearheaded this initiative by proposing two targets:

1. Achieving a Global Energy Storage Capacity of 1,500 GW by 2030
2. Expanding Grid Infrastructure by 25 million kilometres by 2030, and a further 65 million kilometres by 2040

A third proposal – to unlock the potential of a global market for clean hydrogen – would also go some way to help support the growth and integration of more solar and wind. If enacted, this hat-trick of proposals will help prepare for an electricity system dominated by solar and wind power.

This report analyses the deliverability of these findings. It finds that the storage goal is confidently achievable and likely too modest, but the grid goal will require the largest step up, and the expansion of hydrogen electrolysers is highly uncertain.

01 The surge in battery manufacturing capacity can supply the storage goal 8 times over

Meeting the 1500 GW storage target by 2030 would on average require 176 GW of storage installed per year. Since batteries are measured in terms of both power and energy, four hours of storage of 176 GW is equivalent to

704 GWh in energy terms. The world's battery manufacturing capacity in 2025 may exceed demand by 6000GWh. Therefore, there is potentially eight times more manufacturing supply capacity than would be needed to meet the 1500 GW storage goal. The goal is made more possible by a 39% fall in lithium LFP battery cell prices in the 12 months leading up to September 2024, and a rise in interest for combined battery-solar facilities – for example, 75% of new utility solar projects proposed in the US last year were planned with batteries.

02 The new 2030 grid goal requires build-rate to rise by 50%

The COP29 Presidency has proposed a new goal to add or refurbish 25 million kilometres of grids by 2030, relative to 2021. This would mean building or refurbishing 2.7 million km/year, 50% higher than the 1.8 million km built on average last decade (although this doesn't include refurbished).

03 Hydrogen electrolysers have the potential to rise 100-fold by 2030

Only around 5 GW of electrolysers are operating today. However, the global capacity of planned electrolyser deployment and manufacturing indicate a major expansion is potentially imminent. 516 GW of electrolyser projects are announced to be built by 2030 – although only 20 GW have had a financial investment decision. (This is similar to the 558 GW in the International Energy Agency (IEA)'s Net Zero pathway.) Also 166 GW/year of electrolyser factory manufacturing capacity has been announced to be built by 2030 (the IEA shows 179 GW/year is needed by 2030 to reach its 558 GW goal).

It is clear that the COP29 goal for storage is necessary and achievable, while grids and hydrogen will need extra attention.

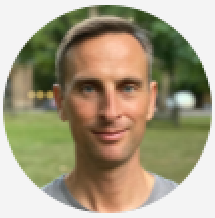
However, storage, grids and hydrogen are not the only available tools. Ember's new explainer on clean flexibility details the whole toolbox of flexibility options that will be required to ensure a reliable and cost-effective electricity system dominated by variably-generating renewables. Two more categories – shifting demand using price signals when it is sunny and windy, and supply flexibility – are also important.

The task for COP29 is not just to achieve consensus on the storage and grid goals, but to initiate a wider momentum for governments to focus on clean flexibility.

By creating a platform for clean flexibility, COP29 can create the right enabling environment for tripling global renewable capacity by 2030 en route to a truly decarbonised global energy system capable of delivering a sustainable and prosperous future for all.

“COP29 could provide a unique platform opportunity to discuss how clean flexibility can step up to make the transition towards solar and wind quick, cheap and secure.”

Dave Jones
Director of Global Insights, Ember



Chapter 1

This year will be the first clean flexibility COP

Getting goals agreed for storage and grids is key to enabling a tripling of renewable capacity by 2030

On the 16th of October, the COP29 Presidency published two ambitious goals that – if agreed and implemented – would add significant flexibility to the global power system:

1. **Achieving global electricity storage capacity of 1,500 GW by 2030**
2. **Expanding grid infrastructure by 25 million kilometres by 20230, and a further 65 million by 2040**

A third proposal – **to unlock the potential of a global clean hydrogen market** – should also help.

Together, the hat-trick of proposals will collectively go a long way to enable the huge planned build of solar and wind power.

The Azerbaijani COP Presidency also published a fuller text of recommendations for each of these declarations and pledges, including a policy checklist of 11 ways to support the storage target and 7 ways to support the grid target.

1,500 GW of storage

The Azerbaijani proposal “aims to increase global energy storage six times above 2022 levels, reaching 1,500 gigawatts by 2030”. This is consistent with the IEA Net Zero pathway modelling.

In the years ahead, that means building 1 MW of storage for just over every 5 MW of renewables. That is because 1,232 GW of new storage is needed from 2024 until 2030 to achieve the 1,500 GW total, at the same time as building 6,754 GW of renewables to achieve a tripling by 2030. The reason why this is not 1:1 is that storage is just one of the tools in the toolbox needed to ensure renewable supply matches electricity demand, so that renewables do not need to bear the full responsibility. There is nothing in the target to suggest the duration of storage, which can range from a few hours with batteries to longer durations with hydro and other technologies in development.

What technology?

The vast majority of this capacity will likely be lithium batteries. Lithium batteries for grid storage are already predominately free of both nickel and cobalt, which both carry supply chain issues; the IEA showed that 80% of grid storage batteries installed in 2023 were lithium iron phosphate (LFP) technology. Cheaper sodium ion “salt batteries” are already beginning to be manufactured at scale for grid storage, which means some will even be free of lithium.

Pumped storage will continue to be built - there is 155 GW currently under construction, according to Global Energy Monitor, almost all of which is in Asia.

Given the geographical, social and ecological constraints on the expansion of pumped hydro, other forms of longer duration energy storage (LDES) are also needed for the transition. There are numerous technologies in development in various stages of maturity, but none yet are deploying at scale. Therefore, government support is needed to help enable the research and development, pilot projects, and scale-up. There is every chance one or more of these technologies will become a must-have technology in the 2030’s.

Is 1500 GW achievable by 2030?

The IEA shows there was 268 GW installed in 2023 - 181 GW of pumped storage and 87GW of batteries. This leaves 1,232 GW of storage that still needs to be built from 2024 to 2030.

The 1,500 GW storage target would therefore need 176 GW of storage to be built on average per year from 2024 to 2030. That is just over a tripling of the 50 GW of grid batteries installed last year.

Batteries are measured in power and also in energy, so four hours of storage of 176 GW is equivalent to 704 GWh in energy terms. Four hours of storage was chosen because it was seen as optimal in a recent paper; it showed that one hour of batteries with wind and solar is a no-brainer, adding 49% to the revenues of the electricity generation, and that four hours of batteries is still value-enhancing, adding a further 23%-32%.

The supply side is far from constrained. According to Bloomberg, by 2025, annual battery manufacturing capacity could exceed battery demand by 6,000 GWh.

This means the 1,500 GW storage goal – if met solely with 4-hour batteries – could in principle be met eight times over with the spare battery manufacturing capacity available as of next year alone. Of course, factories will not run perfectly at 100% utilisation, and not all due to come online by next year may actually do so. Nonetheless, this should give some sense that the 1,500 GW goal is, indeed, possible.

Meanwhile, price falls make this more likely. LFP lithium battery cell prices fell by 39% in the 12 months leading up to September 2024, from $96/kWh to $59/kWh.

What's more, the storage target looks possible because larger-scale solar projects are increasingly planned to be built with batteries. For example, in the US, of the solar projects that were added to the grid queue in 2023, 75% (765 projects) were planned with batteries.

The latest IEA World Energy Outlook shows 853 GW of batteries are expected to be installed by 2030 in their current policies scenario. This is not insurmountably short of the 1,260 GW in their Net Zero scenario. And the 155 GW of pumped hydro currently under construction will complement battery expansion.

The policy landscape to enable batteries to be built is good in many countries, and market forces are playing an important role too. Low electricity prices in the sunny hours are providing the right financial incentive to build storage when new solar is installed. However, this is not the case everywhere, and lots of rules and regulations often get in the way of slowing down battery build-out.

If the right policies are enabled, the 1500 GW goal is not only achievable, it is possible to significantly exceed this.

Expanding grids

The Azerbaijani Grids Pledge proposes: “To enhance energy grids, endorsers will also commit to enhance grid capacity through a global grid deployment goal of adding or refurbishing 25 million kilometres of grids by 2030, recognising analysis from the IEA on the need to add or refurbish an additional 65 million kilometres by 2040 to align with net-zero emissions by 2050.”

To “add or refurbish” 25 million kilometres of grids by 2030 would mean building 2.7 million km/year (assuming the phrase “by 2030” is relative to 2021, which is consistent with the IEA analysis). This is 50% higher than the 1.8 million km built on average in the last 10 years prior to 2021.

Related, the draft pledge also proposes “Green Energy Zones and Corridors” to “act as centralised hubs where sustainable energy generation is maximised and allow for cost-effective transmission over large distances and across borders.”

The grid target follows analysis by the IEA, which recommended this level of investment. It includes both distribution (historically 90% of power grids) and transmission grids.

The IEA is so concerned about the slowness of grid expansion that it modelled a “Grid Delay” scenario, which showed that tripling of renewable capacity by 2030 would not be possible. This, it says, would keep 1.5C out of reach, slowing the uptake of renewables and increasing fossil fuel use. The problem is already manifesting itself. At least 3,000 GW of renewable power projects, of which 1,500 GW are in advanced stages, are waiting in grid connection queues.

How is the grid problem different from battery?

Building grids is a different challenge from deploying batteries. Because of these differences – especially the longer timescales to deployment – the case for strong policy is even more convincing than it is for batteries.

Batteries	**Grids**
Simple planning: local permit needed.	Slow planning: years of research and planning applications needed to get the right full route approved. For cross-border interconnection, negotiations may take longer.
Nice-to-have: can add value to new solar + wind installations plus providing benefits such as peak energy cost reductions and grid stability.	Must-have: new grid-connected solar + wind cannot be built without a grid connection.
Manufacturing capacity exceeds demand.	Supply chain constrained for cabling and transformers.
Policy tweaks needed to encourage investment.	Major policy changes are often needed: grid companies are often monopolies, slow and resistant to change.
Investment case attractive: especially with the falling cost of batteries.	Investment cases are often constrained by regulation.

The good news is that overachieving on batteries with solar may actually reduce the need for so much grid investment. Batteries added to utility-scale solar would enable more electricity to travel through the same lines by flattening peaks in the power supplied; and batteries added to rooftop solar would provide electricity throughout the evening to minimise the grid connection needed.

Hydrogen Action

The Azerbaijani proposal would “unlock the potential of a global market for clean hydrogen and its derivatives with guiding principles and priorities, to address regulatory, technological, financing, and standardisation barriers.” Unlike the storage and grids proposal, this does not have a quantifiable objective.

It is also unspecific about how the hydrogen would be produced, referring repeatedly to “renewable, clean/zero-emission and low-carbon hydrogen and its derivatives” – a phrase that can include both ‘green’ hydrogen made by using clean electricity to split water, and/ or ‘blue’ or ‘fossil hydrogen’ made by splitting fossil gas into its components of carbon and hydrogen and storing the carbon (as CO2) underground. For this section, we focus on ‘green’ hydrogen as it would play a more nuanced role in the power sector and is much more likely than fossil hydrogen to feature cost declines.

It would help triple renewables in two ways. First, it would help spur renewable development with the specific purpose of generating green hydrogen.

Second, low-utilisation electrolysers would buy cheap electricity at times of high supply to produce green hydrogen, avoiding costly curtailment of solar and wind. This provides a potentially large source of clean flexibility for power systems with very high wind and solar share. The green hydrogen can then be burned in a gas-fired power plant to return electricity back to the grid when there is little wind or sun, so that hydrogen is used as storage across weeks and months.

How might electrolysers help by 2030?

The IEA Net Zero pathway models 558 GW of electrolysers installed by 2030. However, the situation on electrolyser deployment is extraordinarily uncertain.

First, the build rate is slow. Only 5 GW (less than 1% of deployment in the Net Zero pathway) is forecasted to be built during 2024, and only another 20 GW is considered to have passed a financial investment decision, according to the IEA.

On the other hand, there are almost enough factories and projects planned on paper to reach the Net Zero pathway. There is 166 GW/year of electrolyser factory manufacturing capacity that has been announced to be built by 2030, according to the IEA, compared to 179 GW needed by 2030 – although only a third have reached a financial investment decision. There are also 516 GW of electrolyser projects that have been announced to be built by 2030, according to the IEA, compared to the 558 GW in the Net Zero pathway.

Much depends on cost. If electrolysers are only to run for a small proportion of hours where electricity is very cheap, then they need to be very cheap. At the moment they are not; maybe as the scale-up of manufacturing and the magic of innovation continue, costs will significantly drop.

The heady days of hydrogen hype are over, and the low rates of build rate seen currently could indicate that the IEA's modelled figure of 558 GW of electrolysers by 2030 is unrealistic. However there is undoubtedly a large niche for hydrogen – not least, to decarbonise the production of hydrogen today, which emits as much greenhouse gases as Indonesia and France combined.

Whatever size the green hydrogen market will be, building electrolysers that can run flexibly to take spare renewable generation in times of excess, would make them an important tool in the clean flexibility toolbox.

Chapter 2

The bigger clean flexibility discussion

COP29 has an opportunity to broaden the focus beyond just grids and storage – to bring attention to the whole clean flexibility toolbox.

The urgency for cleaner flexibility is growing as solar and wind deployment accelerates. Clean flexibility is not just grids and storage. COP29 provides an ideal opportunity to broaden the discussion on clean flexibility to the entire clean flexibility toolbox.

The clean flexibility toolbox

Ember's explainer on clean flexibility details the whole toolbox of flexibility options. There are two important categories of flexibility beyond storage and grids.

First is demand-side flexibility: using price signals to pass cheaper electricity to consumers when it is sunny and windy, so that electricity demand better matches electricity supply. Second is supply flexibility: all generation capacity supply needs to be as flexible as possible, whether it is older fossil plants, new carbon capture plants, or the flexibility of solar and wind itself.

The COP29 opportunity

The COP29 Presidency has already taken a major step towards getting grids and storage on the agenda. If it is able to get agreement on its pledges, and potentially see language on the importance of storage and grids included in the COP outcome document, this would mark real progress in highlighting the importance of two of the most important tools on clean flexibility.

However, there is an opportunity to broaden this around the full suite of clean flexibility solutions. Defining a goal around demand-side flexibility or supply flexibility perhaps presents more of a challenge. Global consensus on the crucial role of these tools would help to build a common understanding of the clean flexibility toolkit.

The urgency

The clean flexibility debate is increasingly urgent. In 2023, six countries generated 40% or more of their electricity from solar and wind. By 2030, the whole world on average will be at 40% if a tripling of renewable capacity is achieved.

The EU provides an example; already in the last 12 months, it has seen solar and wind hit 65% of total hourly electricity production across the entirety of the EU. The EU is planning to further double its solar and wind reliance by 2030 (from 27% of annual electricity production last year to 52%). It is easy to see how flexibility will quickly become even more urgent in the coming few years.

In October 2024, the IEA revised upwards its expectation for 2030 of renewable capacity under current policies, and now puts it at 9,800 GW, not far short of the 11,000 needed for a tripling of global renewable capacity. That was led by solar, which was raised by 24%, compared to the IEA's report last year.

Now that the world is getting real on renewables, the urgency to understand and act on improving clean flexibility has become more pertinent than ever.