Framework Convention on
Climate Change

TEC/2025/30/5

Technology Executive Committee

18 March 2025

Thirtieth meeting

1–3 April 2025 (4 April 2025 TEC-CTCN Advisory Board joint session)

Concept note for a policy brief on Accelerating the Deployment of Energy Storage to Advance Clean Energy Transitions

Cover note

I. Background

1. As per activity A.2.1 of the Technology Executive Committee's (TEC) rolling workplan for 2023–2027 and building on the TEC's work on collaborative RD&D, TEC is to analyse the needs for RD&D for high-impact emission-reduction technologies to help countries implement their NDCs and other mitigation strategies, and ensure long-term environmentally sustainable energy supply.

2. Following the completion of the "Survey on Future Needs of CleanTech Research, Development, and Demonstration," together with Future Cleantech Architects, and a review of the results with subsequent guidance at TEC 27, the TEC is expected to prepare a policy brief on energy storage in 2026.

3. The TEC at its 29th meeting was unable to agree on the lead partner of this activity and requested the activity group to lead the development of the concept note, to be presented at TEC 30. TEC also requested the activity group to continue exploring potential partnerships with the organizations and provide an update at TEC 30. As there was no lead partner identified, the secretariat will need to consider the resources available when supporting this work.

4. TEC addressed next-generation batteries and thermal energy storage in a 2021 technical paper on Emerging Climate Technologies in the Energy Supply Sector.

5. At the 28th and 29th United Nations Climate Change Conferences (COP28 and COP29, respectively), the COP presidencies launched initiatives aimed at highlighting the urgency of accelerating the transition to clean energy. During COP28, over 130 countries committed to the Global Renewables and Energy Efficiency Pledge, which set a target to triple global renewable energy capacity to at least 11,000 GW by 2030. This target was subsequently incorporated into the outcome of the first Global Stocktake.

6. In recognition that additional supporting efforts would be needed to ensure that the tripling renewable goal resulted in energy systems that were resilient, reliable, and affordable, the Global Energy Storage and Grids Pledge, featured at COP29, included a collective target of deploying 1,500 GW of energy storage capacity in the power sector globally by 2030, which was supported by more than 50 countries.

II. Scope of the note

7. The annex to this note contains a concept note for a policy brief on Accelerating the Deployment of Energy Storage to Advance Clean Energy Transitions, developed based on exchanges with relevant partners and inputs received from members of the activity group.

III. Expected action by the Technology Executive Committee

8. The TEC will be invited to consider the scoping note and provide guidance on further work on this matter to the activity group.

Annex

Concept note for a policy brief on Accelerating the Deployment of Energy Storage to Advance Clean Energy Transitions

I. Overview

1. The global energy landscape is undergoing a significant transformation, driven by the increasing adoption of renewable energy sources such as solar and wind power. However, the variable nature of these energy sources poses challenges to grid stability and reliability. Energy storage technologies play a critical role in addressing these challenges by enabling energy flexibility, enhancing grid resilience, and supporting decarbonization efforts. Despite their importance, the deployment of energy storage systems is hindered by policy, regulatory, and economic barriers, as well as a lack of awareness and visibility.

2. Energy storage is a pivotal technology for achieving the Paris Agreement's temperature goals - limiting global warming to 1.5°C and well below 2°C—by enabling the large-scale integration of renewable energy. As a key enabler of clean energy transitions, energy storage directly contributes to mitigation (Article 4) by reducing reliance on fossil fuels, enhancing grid stability, and ensuring a reliable supply of low-carbon power. Simultaneously, it strengthens adaptation efforts (Article 7) by improving energy resilience, supporting decentralized power systems, and safeguarding communities against climate-induced disruptions.

3. Energy storage represents a critical set of technologies that will be required to support countries' clean energy transitions, implementation of the Partis agreement. This includes the combination of energy storage technologies and clean energy for continuous power supply, an upgrade of the grid, the replacement of high-cost backup generation, the transition towards zero-emission transportation, and other end-use applications. There may be opportunities to accelerate progress on energy storage technologies by fostering the development of collaborative partnerships among countries, including between developed and developing countries. Such partnerships can address technology development and deployment, sustainable material sourcing and supply chains, innovation for new energy storage technologies, and financing mechanisms that enable countries to meet their climate and energy access goals, among other objectives.

4. This policy brief will aim to analyse various types of energy storage as a pivotal technology for achieving the Paris Agreement's temperature goals and provide recommendations for policymakers to support their development and integration.

II. Energy Storage Technologies

5. There are many types of energy storage technologies that vary in terms of cost, duration, application, lifetime, opportunity to reduce costs, roundtrip efficiency and maturity. These technologies must be deployed in a coordinated manner across sectors, including power, transportation, industry, buildings, and behind-the-meter/off-grid applications, to minimize costs and maximize effectiveness. For instance:

(a) Short-duration storage technologies (0.5-4 hours) support daily renewable energy integration;

(b) Medium-duration storage technologies (4-10 hours) balance grid operations over longer timeframes;

(c) Long-duration storage technologies (10+ hours) enable seasonal energy storage and off-grid resilience.

6. Energy storage technologies also vary in their application, efficiency, and scalability, such as:

(a) Electro-Chemical Storage: Includes Battery Energy Storage Systems such as lithium-ion, solid-state, and flow batteries, widely used for grid support, electric vehicles, and distributed energy resources and capacitors, used for load-levelling and uninterruptible power supplies;

(b) Mechanical Storage: Includes pumped hydro storage (PHS), and Flywheels all well-established solutions but require significant infrastructure investments;

(c) Thermo-Mechanical Storage: Emerging technologies such as liquid air energy storage, compressed air energy storage (CAES) belongs in this category;

(d) Thermal Energy Storage: Includes technologies such as molten salt storage, Pumped Thermal Energy Storage, and phase-change materials are useful for balancing power loads and industrial applications;

(e) Chemical Storage: Includes green hydrogen, electro-fuels (e-fuels), sulphur, and ammonia, which presents a long-duration storage solution,[1] enabling energy decoupling and sector coupling for industrial and transportation use.

III. Challenges and opportunities

7. Energy storage deployment is heavily concentrated in a few countries and regions namely China, U.S. and Europe (BNEF and IEA). Coordinated actions and financing support are needed to scale deployment globally and, in particular, in developing countries, where the impact on the switch to renewable energy, energy access and resilience could be transformative.

8. Additional efforts are needed to accelerate renewable energy deployment as current projections have the world on pace to increase the deployment by 2.7 times by 2030, which is significant, but falls short of the goal to triple installed capacity (IEA, IRENA). The increased deployment of renewable energy technologies does have associated challenges, and, in this context, energy storage has the capability to address many of them while also contributing directly to emission reduction.

9. While the current deployment of energy storage worldwide is led by pumped hydro, batteries and thermal storage are projected to meet the majority of future demand. In fact, to meet the goal of deploying 1,500 GW of energy storage capacity, the IEA estimates that 90 percent of the increase will come from batteries, as for the thermal storage, the IEA has identified the need to include thermal energy storage (TES) as one of the key components to address variability of renewables. According to the IEA, it has the potential to retain heat for weeks or months, depending on the technology.[2]

10. More broadly, in the IEA's Net Zero Emissions by 2050 Scenario, roughly 60 percent of the expected emissions reductions by 2030 are associated with batteries, which encompasses direct (e.g. electric vehicles, power sector, rooftop PV) and indirect (e.g. end-use electrification) applications.

[1] Hydrogen is energy-intensive to produce and studies indicate it may have a limited role in a decarbonized energy system, See more information: https://fcarchitects.org/content/hydrogen-guardrails/ and https://www.catf.us/resource/hydrogen-power-sector/.

[2] https://iea.blob.core.windows.net/assets/bfe623d2-f44e-49cb-ae25-90add42d750c/ManagingSeasonalandInterannualVariabilityofRenewables.pdf.

11. Thermal energy storage is a strategic technology to enable power to heat solutions, which when adopted as a flexibility tool, has the potential to reduce the price of transitioning from unabated fossil fuels to clean electricity. Thermal energy storage can help overcome a key technological challenge to convert electricity into heat at high temperature, high energy density, high charge/discharge durability, decoupling of power and capacity storage and possibility to decarbonize hard to abate industrial sectors. Thermal energy storage is also a key solution to achieve higher energy efficiency of existing technologies, and in particular increase the seasonal Coefficient of Performance (COP) of heat pumps for industrial/residential heating and cooling due to the possibility to reduce the temperature lifts between sink and source with an optimal integration of thermal storage, eventually integrated into heat exchangers (active heat exchangers).

12. Rapidly falling costs - especially for batteries - position energy storage as an enabler for accelerating clean energy transitions. According to the IEA, battery costs have declined by more than 90 percent over the last decade and are projected to decline by up to an additional 40 percent by 2030. That cost decline, paired with similar cost declines in renewable energy-based electricity generation, is contributing to a new reality where the combination of renewables and energy storage are increasingly cost-competitive with traditional thermal plants.

13. Global supply chains for energy storage technologies, critical materials[3] and required inputs, particularly for batteries, are also heavily concentrated, which raises concerns about reliability and resiliency of supply, but these concerns can be addressed through efforts to diversify these supply chains, including through an emphasis on strengthening end-of-life product management and recycling. In this context, thermal energy storage carries a particular opportunity not only due to its vast potential: key thermal energy systems do not depend on rare materials and have less complex supply chains.

14. Batteries can address intermittency issues for households reliant on rooftop solar PV, making electricity more available and affordable, while also reducing dependence on fossil fuels. The pairing of rooftop solar and batteries can help advance energy access goals. In many regions, this battery-enabled solar power extends to electric mobility (e-bikes and e-scooters), offering a low-cost, zero-emission alternative that bridges transportation needs while minimizing fossil fuel consumption. Moreover, batteries in electric vehicle fleets can be used to support the grid stability through vehicle to grid solutions and smart energy management.

15. Cross-sectoral applications of energy storage offer the opportunity to better align with the sectoral transformation approaches identified in the Global Stocktake. This includes the linkages between energy storage and energy generation, as highlighted above, but also the linkage between energy storage and energy use in transport, buildings and industry.

16. According to the results of the survey[4] conducted by the TEC in collaboration with Future Cleantech Architects and presented at TEC 29, respondents identified a lack of enabling or supporting legislation, a lack of political support, or a challenging bureaucracy as the primary challenges currently inhibiting the deployment of storage technologies.

17. Energy storage can increase resilience to climate change by providing a backup power to prevent blackouts during extreme weather events, such as hurricanes, wildfires, and heatwaves.

18. Despite significant progress in the deployment of renewable energy generation, the energy sector remains the largest global greenhouse gas emitter (~34%, IPCC). Energy sector emissions must be addressed in order to achieve the goal of limiting average global temperature rise to 1.5 degrees Celsius.

[3] See document: Critical materials: Batteries for electric vehicles.
[4] Document is available at: https://unfccc.int/ttclear/tec/rdandr.

IV. Areas of Focus

19. Several areas of focus have been identified for inclusion in this concept note for the policy:

(a) The Critical Role of Energy Storage in Renewable Energy Integration

20. The policy paper will emphasize the essential role of energy storage in facilitating the integration of renewable energy, enhancing grid stability and providing other grid services,[5] their potential for enabling cross-sector coupling, and reducing dependence on fossil fuels.

(b) Technology Solutions and Case Studies

21. The document will categorize technology solutions and case studies from developed and developing countries, based on viability, applicability, scalability and key challenges, while considering:

(a) Geographic diversity

(b) Types of storage technologies

(c) Emission reduction potential

(d) Resilience enhancement potential

(e) End-use applications

(f) Innovative business and financing models, applicable to developing countries, with a particular focus on LDC and SIDs

(c) Enabling policies for their adoption

22. The document will include an analysis of gaps and enablers in Research and Development (R&D) and deployment of energy storage;

23. Analysis of policy regulations, including for the electric sector, that enhance the adoption of these technologies. (For example demand side management, V2G standards, hourly energy prices so arbitrage can be made, asset based financing for distributed deployment, etc).

(d) Analysis of Energy Storage in Nationally Determined Contributions (NDCs) and other Policy Frameworks

24. The analysis will build upon the findings of the NDC synthesis report, specifically examining the inclusion of energy storage targets or broader clean/renewable energy targets that necessitate energy storage;

25. The role of energy storage in supporting clean energy transitions and ensuring 24-hour power supply for households and commercial loads will be highlighted, the same applies for the role in industrial applications;

26. A broader examination of Technology Needs Assessments (TNAs) and Long-Term Strategies (LTSs) to explore and guide long-term planning and policy considerations for energy storage deployment, translating the global energy storage target (1,500 GW by 2030) into national and regional implementation roadmaps.

27. These roadmaps should carefully consider the varying starting points and technological readiness levels (TRLs) of the respective storage technology approaches. The

[5] Upgrade deferral, Energy arbitrage, Capacity firming, Seasonal storage, Frequency regulation, voltage support, black start, short-term reserve, fast reserve, Islanding.

maturity of required infrastructure as well as the financial capabilities and policy environments differ amongst countries and regions. These roadmaps cover practical pathways, key milestones, and tailored policy interventions that enable equitable and accelerated deployment of storage solutions.

28. Examination of just transition aspects of energy storage deployment including analysis of job creation, skills development, and social impacts across energy storage value chains;

29. Develop input on MRV approaches for tracking energy storage deployment and its contribution to NDC targets within the Enhanced Transparency Framework.

(e) Key messages and policy recommendations

30. Based on the main issues identified by the brief, key messages and policy recommendations will be developed for the COP and the CMA.

V. Timelines

No	Deliverable	Timeline
1	**Development and presentation of draft concept note (annotated outlines for the identified topics) of the publication at TEC30**	**April 2025**
2	Finalization of concept note based on the TEC feedback and get agreement from the TEC	June 2025
3	Development of the first draft of the publication	July 2025
4	Consultation with Activity Group and receive feedback	August 2025
5	**Presentation of the first draft of publication at the TEC31**	**September 2025**
6	Development second draft of the publication based on the feedback provided by TEC members	October-December 2025
7	Consultation with Activity Group on the second draft of the publication	January-February 2026
8	**Presentation of the second/final draft of the publication for TEC 32**	**April 2026**
9	Develop Executive summary and key messages and policy recommendations for COP and to inform the next round of GST	September 2026