Santander Private Banking

Energy Storage: an imperative for the green transition

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Energy storage is key to supporting increased **renewable energy production, energy efficiency and energy security.** Thus, the energy-storage industry is moving rapidly from the periphery to the core of the energy sector.

As global climate change threatens environmental balance, the quest for clean energy and zero emissions technologies has become vital. This has translated into an increased share **of renewable technologies in the energy mix and the need for energy efficiency improvements for which energy storage will be crucial.**

The increase in renewable energy sources such as wind or solar in the mix requires more flexibility from national energy grids, to manage the variability and uncertainty caused by mismatches between supply and demand. Storage technologies offer a flexible buffer, soaking up excess generation and releasing it when consumers need it most.

According to the International Energy Agency, the expected increase in renewables under the Net Zero Scenario (NZS), requires a six-fold increase in **installed storage capacity, to roughly 1.5 TW by 2030.**

01. The Importance of energy storage

Energy storage is a fundamental **pillar of the energy transition,** and its deployment benefits can be summarized as follows:

Benefits

Renewable power integration in the energy system

Solar and wind power are inherently intermittent (producing energy only when the sun shines or the wind blows). Storage provides the flexibility of saving the excess energy produced during peak times to use it during periods of low production, balancing supply and demand. It also enables more people to rely on distributed energy resources, like rooftop solar and electric vehicles.

Grid stability & reliability

Large-scale fast responding storage such as batteries connected to the grid, can deliver frequency regulation in milliseconds: replacing costly gas peakers and reducing outage risks by improving energy safety. They also facilitate the deployment of local grids or microgrids. Integrating artificial intelligence and machine learning can optimize energy storage management, predicting demand and adjusting supply in a more efficient way.

Resilience & security

Distributed batteries can keep critical loads running during extreme weather and boost energy security by diversifying available power backup resources.

Price stabilization

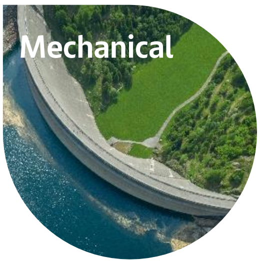
Energy storage can reduce price fluctuations, as storing energy when the price of electricity is low and discharging it during periods of peak demand, that can reduce energy costs. Additionally, by providing back-up power, it can prevent costly damages to families and businesses associated with power outages.

Local economies support

Storage can improve the energy independence of isolated areas or island nations commonly very reliant on fossil fuels, helping to create a more resilient and self-sufficient energy system, withstand supply disruptions due to geopolitical tensions, natural disasters, etc. Additionally, projects boost local economies and employment. The U.S. energy storage industry supports over 60,000 jobs at companies leading cutting-edge technological innovations, advanced manufacturing, engineering and construction, etc.

02. Types of Energy Storage Systems

Electricity cannot be stored as such and therefore it needs to be **transformed** into other types of energy, such as mechanical or chemical. In addition to batteries, there are many storage technologies for different needs. The main types are:



2.1. Mechanical

The main installed energy **storage method in the EU is by far 'pumped hydro'** storage. This method uses surplus electricity to pump water from a lower reservoir to a higher one. When demand increases, the water is released to drive turbines and generate electricity. It is the most efficient large-scale storage system in operation that provides stability to the electrical system and can generate significant levels of clean energy with rapid response times. Significant investments for building the infrastructure may be its main caveat.

Other mechanical technologies include flywheel storage (accelerating a rotor to high speeds and maintaining the energy as rotational energy, that can be converted back into electricity) and gravity-based storage (raising heavy objects to higher elevations and allowing the objects to fall generating kinetic energy that can be converted back into electricity).

2.2 Electro chemical (battery storage)

One of the most prevalent energy storage methods are batteries, where lithium-ion **batteries in particular have gained prominence lately**. Main advantages: efficiency, rapid response and scalability. Its is widely used in many applications from portable electronic equipment to residential or industrial applications.

2.3. Thermal

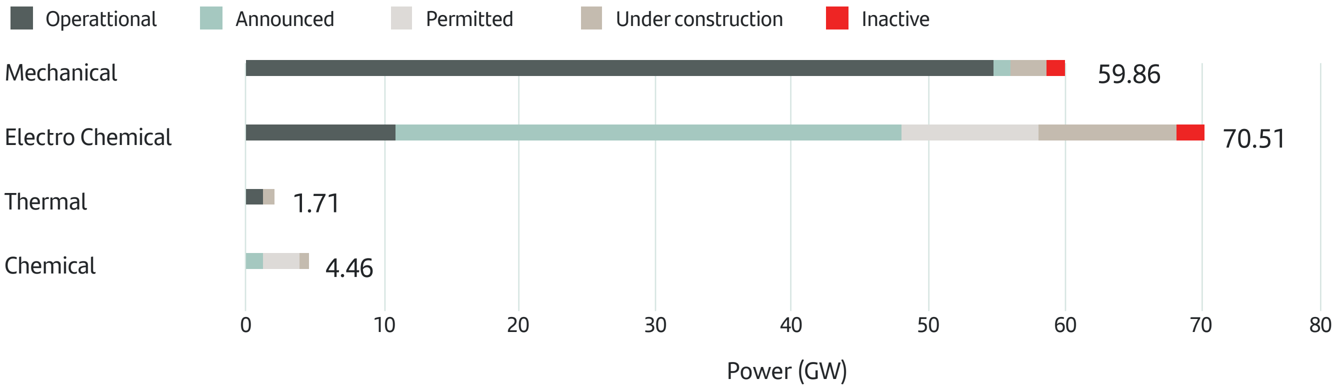
It consists in **accumulating energy in materials** (such as molten salts) by heating or cooling various storage mediums for later reuse. Also known as "heat batteries", they decouple the availability of heat generated from renewable electricity (as solar thermal energy or even recovered waste heat) from when it is actively needed, helping decarbonize especially industrial processes.

2.4. Chemical

In this case, **energy is absorbed and released when chemical compounds react**. Emerging technologies such as hydrogen storage, or advanced grid-scale batteries are set to revolutionize the industry. Still on demo state, these technologies advantage will be the longer duration of storage.

Figure 1. Status and technology in Europe

Source: European energy storage inventory

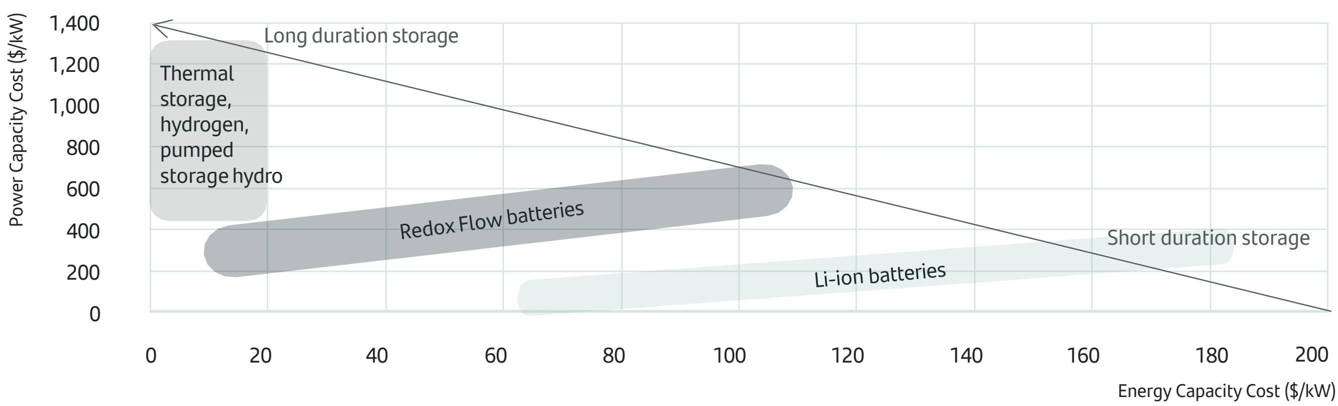


Expected innovations

Despite still in development, **for grid storage** technologies such as Vanadium & Zinc bromine flow or Sodium-ion are emerging as an alternative to lithium-ion. Going forward, **solid-state batteries are considered the next frontier** in battery technology - they replace the liquid electrolyte with a solid material, offering improved energy density, safety, and charging speed.

Figure 2. Storage technologies grouped based on power and energy-capacity cost

Source: MIT Power capacity cost = cost per MW of maximum instantaneous power Energy capacity cost = cost per MWh of energy storage capacity Duration = energy capacity / power capacity



03. Future Prospects

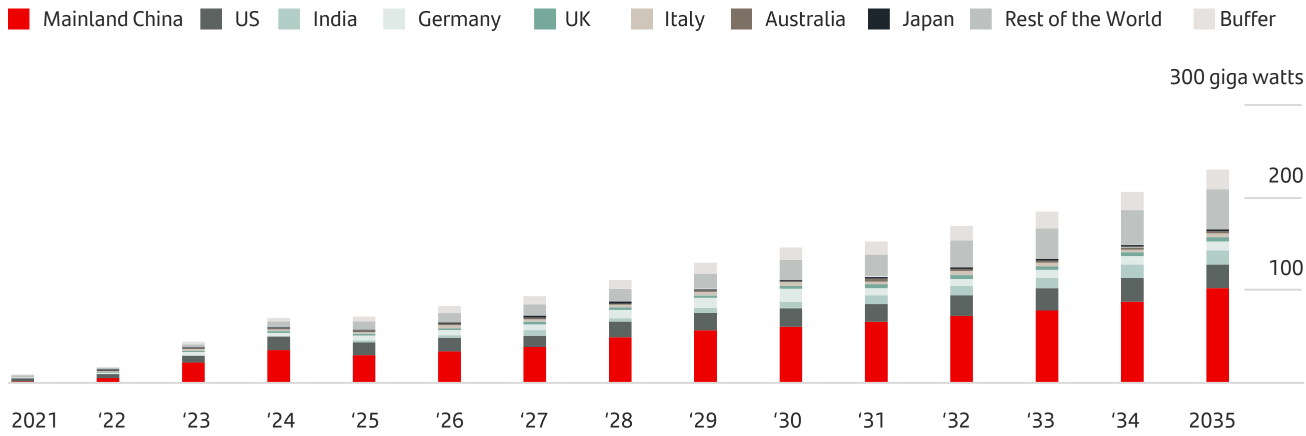
NZS requires to triple energy from renewable sources along with a sixfold **increase of global energy storage capacity to 1.5TW by 2030, of which batteries are expected to account for 90%. Investment in batteries** could reach **$800bn by 2030, up 400% vs 2023 levels, doubling the share of batteries in total clean energy investment in 7 years.**

Figure 3. Energy storage is set for a decade of growth

Global gross energy storage additions by market

Source: BloombergNEF

Note: Buffer = headroom not explicity allocated to a region

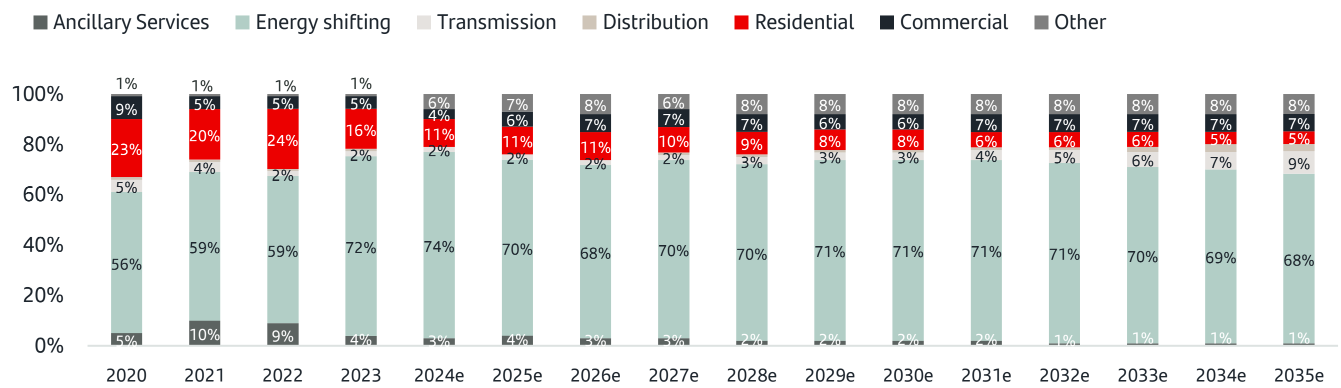


Main driver of energy storage increase in terms of capacity is expected to be the **support of renewable energy growth**. One of the promoters of storage to support solar energy production is Hornsdale Power reserve in Australia.

Figure 4. Application mix of storage projects deployed annually (energy capacity)

Source: BloombergNEF

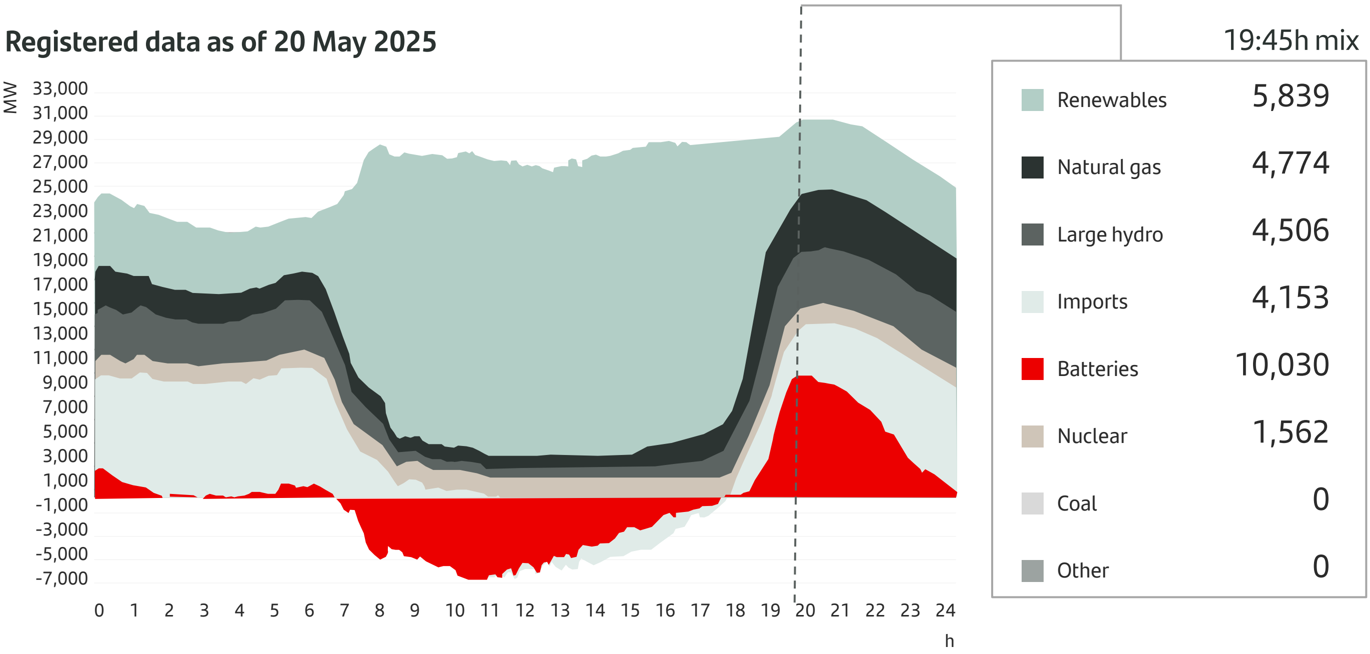
Note: Excludes pumped hydro projects. Includes "Other" application category and excludes global buffer. At a Project level, if multiple apllications are selected, the capacity is dividend equality among them. Energy shifting refers to capacity built for renewable integration, power Price arbitraje and/or providing reliable capacity to meet peak system demand.



Currently, large batteries already account for more than 30% of the supply during evening peaks on a regular basis in California and South Australia.

Figure 5. California current energy supply mix by source

Source: CAISO



Other **innovative application examples** of storing are:

- Vehicles with vehicle to grid (V2G) technologies
- Commercial buildings investing in storage to reduce their energy costs,
- Residential solutions for backup power
- Data centers replacing outdated backup generators with battery storage

04. Challenges in Energy Storage

Despite the promising technologies, several challenges remain:

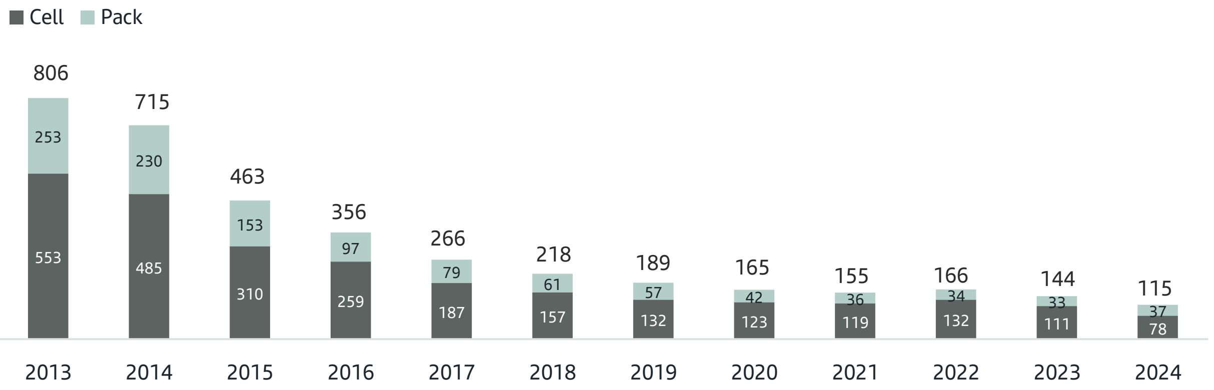
A Cost

The primary challenge in energy storage is its cost, specifically the high levelized cost of storage (LCOS), which hinders its widespread adoption and the better integration of intermittent energy sources. Upcoming innovation on this area is expected to reduce costs of battery storage by up to 40% by 2030. BNEF predicts a 50% reduction in the costs of lithium-ion batteries per kW/h by 2030, as demand takes off mainly in stationary storage and electric vehicles.

Figure 6. Volume-weighted average lithium-ion battery price evolution

Real 2024 $/Wh

Source: BloombergNEF



B Technical challenges

For batteries, drawbacks include sensitivity to extreme temperatures and design intricacies. Reducing weight, increasing storage capacity and safety improvement are also focus areas. Additionally, integrating storage systems with existing power grids and renewable energy sources require adequate infrastructure. Other technologies in early stages face a scalability challenge to reach commercial stage.

C Just transition

Ensuring ethical sourcing practices, fair labor standards, and investments in community development to mitigate mining adverse impacts on vulnerable populations should be at the center of these projects.

D Circularity

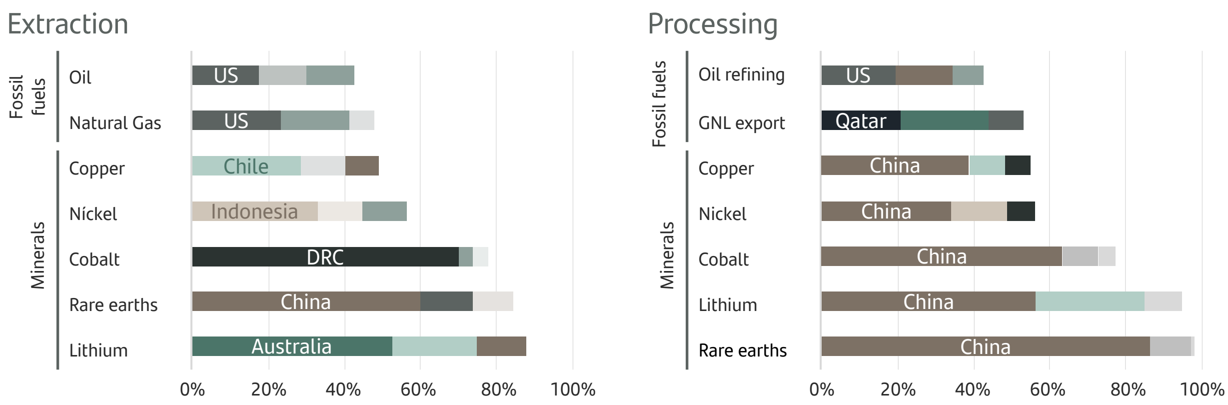
Recycling will have a critical role on these technologies at the end of the storage life cycle. Materials management from green energy systems as well as finding alternatives that may be less toxic after its disposal is a challenging issue that requires additional research to avoid harmful consequences for the environment. The EU Battery Regulation 2023/1542 imposes recycled content and due diligence rules on this sense, that companies like HiTHIUM are already compliant with.

E Availability of inputs

Many of the materials needed for these technologies, such as lithium, cobalt, and nickel, are extracted from mines located in developing countries. The demand for these critical minerals is set to rise significantly, requiring secure and resilient supply chains.

Figure 7. Extraction and processing of energy transition minerals is more geographically concentrated than resources for today's fossil fuel system

Source: MIT

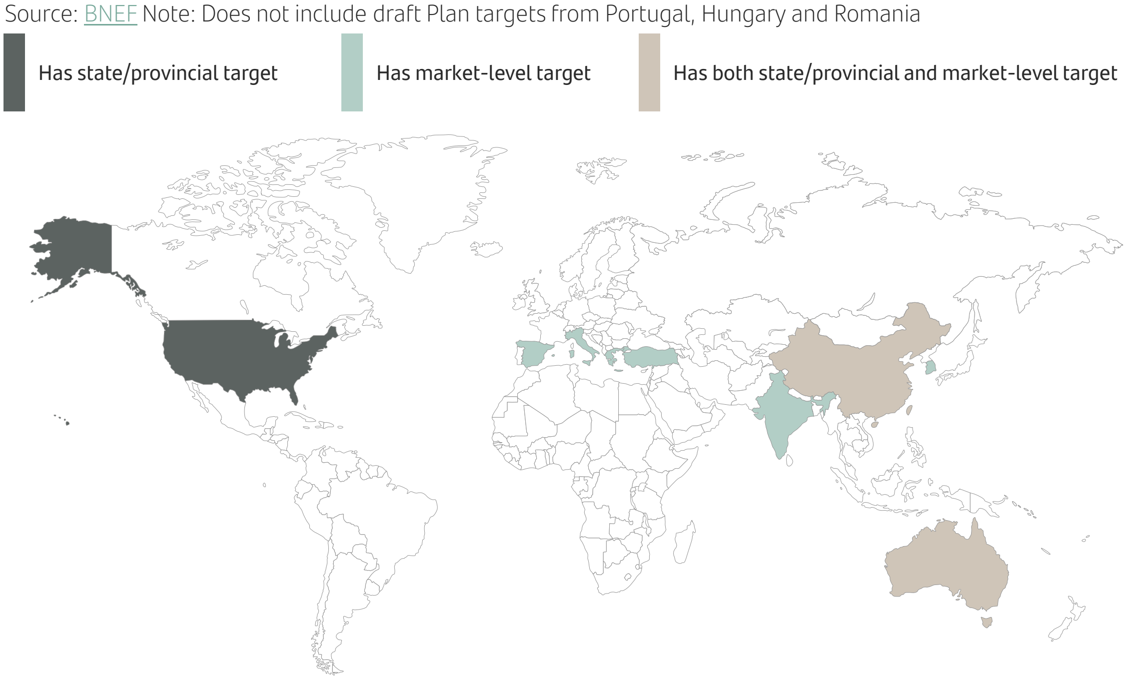


F Policy

Regulatory systems must recognize the full value of the services that storage offers. For example, in order to capture the full benefits of behind-the-meter batteries (private storage systems independent from the public grid), regulatory systems need to better align consumer and system benefits through cost-reflective variable electricity tariffs.

Figure 8. Energy storage targets

Source: BNEF Note: Does not include draft Plan targets from Portugal, Hungary and Romania



05. Conclusions

Energy storage linked to transition is an evolving field to watch out for the upcoming years specially for stakeholders across **the energy value chain.**

Energy storage is an imperative for a cleaner, more equitable, and energy-secure future. As we strive to mitigate risks from climate change and transition to renewable energy, advancements in storage technologies will play a crucial role. Whether through residential systems, commercial/industrial applications, grid-scale projects, or electric vehicles, the **diverse use cases highlight the versatility of energy storage technologies**.

Short to medium term growth in this sector will be driven by **lithium-ion batteries supporting the increase in renewable energies**. In the future, **flow and solid-state** batteries are expected to poise interesting applications. **Thermal and chemical** technologies may also play a key sustainable role specially in **hard to abate industrial businesses.**

Success will depend on **technical advancements that keep lowering the cost and increasing scale. In addition,** innovation to **improving circularity and recycling** of disposed storage systems will mitigate negative environmental impacts. Finally, **international co-operation and environmental, social and governance** standards for the mining / processing of inputs are key to ensure a **just transition**.

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