INTERNATIONAL SOLAR ALLIANCE

LDES LONG DURATION ENERGY STORAGE COUNCIL

SOLAR AND LDES: CRITICAL PARTNERS TO ENSURE 24/7 RELIABLE RENEWABLE ENERGY

Solar and LDES: critical partners to ensure 24/7 reliable renewable energy

Combining solar energy with long duration energy storage paves the road to industrialization without carbonization for the world's fastest growing economies.

The targets for solar energy are clear, with 75,000 gigawatts of generating capacity to be installed by 2050. Funding pathways to reach these estimates are also clear — if not mired in the politics of fossil dependence.

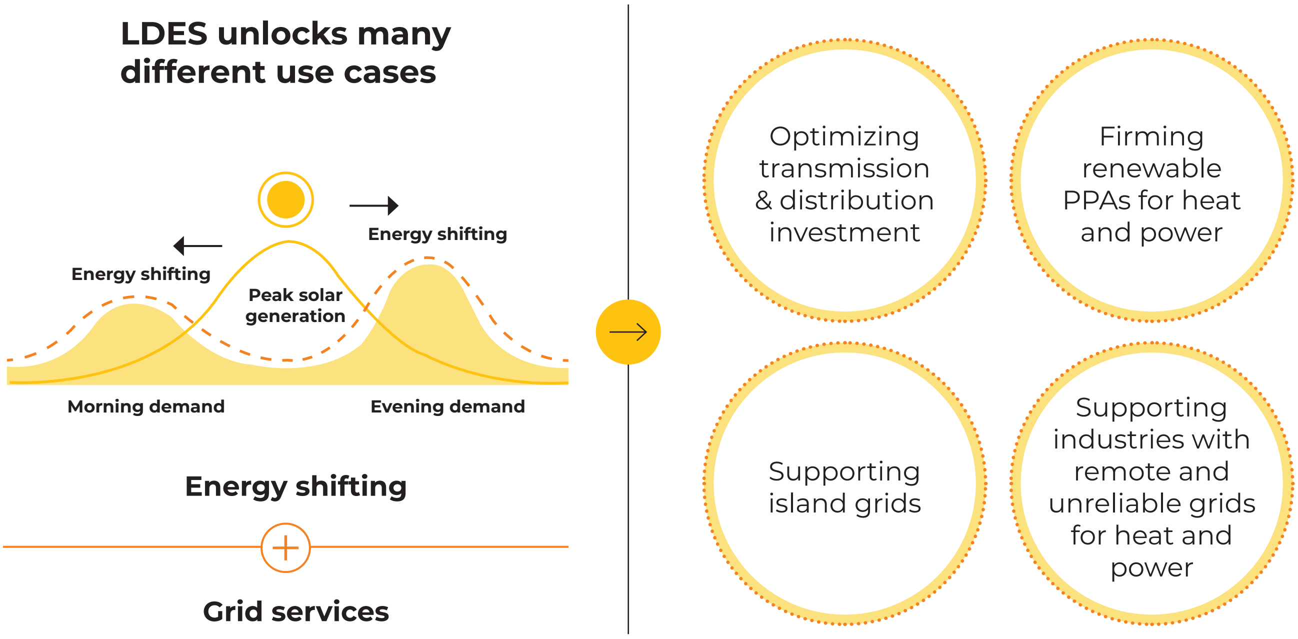
However, these solar installations will not yield full decarbonization without the means to store the electricity they generate for long durations.

Developed economies are beginning to take steps to encourage long duration energy storage development and deployment, but it is in the rapidly growing economies around the globe where long duration energy storage — combined with solar — may be most effective.

These economies can leapfrog fossil infrastructure through the deployment of solar and storage in the same way that the mobile revolution obviated the need for land-based telecommunications across continents.

Untethering from 20th Century energy infrastructure creates opportunities for a more economical, resilient, reliable, and secure engine to power the continued development and growth of the markets where this new energy is needed most. It allows these elevating economies to flourish without the same sunk costs as their counterparts.

Long Duration Energy Storage deployed in different contexts



The near-term financial viability of LDES for integrated utilities on isolated power systems with limited interconnectivity depends on local fuel costs and RE potential

Off the mainland, the US has multiple islands that have no connection to neighboring islands or the mainland grid. Hence, they are mainly dependent on coal and fuel-oil-generated power. The electricity cost for consumers on these islands is among the highest in the US[1]

At the same time, there is considerable potential for low-cost RE generation. These conditions have already led to a buildout of solar and wind capacity, increasing the share of RE in the generation mix. With the growing decarbonization of the island's power system, thermal generation will be decommissioned and stability services reduced.

To achieve full power decarbonization on such an island, the incumbent integrated utility could install a hybrid of additional solar and wind with Li-ion batteries and LDES. Detailed modeling of an isolated island system indicates that the lowest cost pathway to 100 percent fulfillment of energy demand by RE employs a combination of Li-ion and LDES. The LCOE of this configuration is 15 percent lower than a pure Li-ion battery system—caused by the significant RE overbuild—and 5 percent lower than a pure LDES system. This sort of RE + battery + LDES system is already economic for islands around the world.

1 Electric power annual", Energy Information Administration, 2019

LDES Council numbers on storage

Storage is maturing very quickly, and benefits are already being realized. In most jurisdictions today, the primary focus has been on Battery Energy Storage, particularly Lithium-Ion Batteries.

These two-to-four hour batteries are appropriate for providing grid balancing to smooth out the minute-to-minute and hour-to-hour variations of renewable energy. Globally, solar only provides 4.5% of the world's electricity mix[2], so short duration storage is sufficient to integrate solar and provide peaking support in most jurisdiction.

The ISA and its global partners are working to rapidly scale solar around the world, so that it can meet a significant share of global demand. As per ISA research, solar + storage is already the cheapest source of supply for over 350 million consumers worldwide who currently lack energy access[3].

However, for solar (and other renewables) to meet 100% of global electricity demand at an affordable rate, LDES is required to provide power 24/7/365. This is particularly true in high-latitude countries where the solar production can vary substantially not just from day-to-day but from season-to-season.

Research from the LDES Council estimates long duration energy storage (LDES) will be a USD $3.6 trillion industry with an installed capacity potential of 4-6TW by 2030. Its development will yield additional savings of up to $540 billion. We cannot reach these goals without significant LDES deployment starting today and throughout the next decade.

LDES must be scaled up dramatically and costs need to decrease by 60% over the next 20 years to build a cost-optimal net-zero energy system. Even greater cost reductions have occurred in other clean technologies like solar and wind. LDES is an essential technology to enable renewable energy to power our grids, provide clean heat, and accelerate carbon neutrality. It enables surplus energy to be stored from wind, solar and other clean sources to be available when needed and savings gained from minimizing curtailment.

With LDES, we can transition towards renewable energy in an affordable, reliable, and sustainable way. Wind, solar and other renewables have already

[2] https://ourworldindata.org/electricity-mix
[3] https://isolaralliance.org/uploads/docs/540dc1da191598c88320bf07b42e8d.pdf

become the lowest cost forms of generation but need long duration energy storage to match supply with demand. LDES can de-risk the transition to renewable energy.

The ISA and LDES Council are leading market changes in this pivotal moment as we move from energy systems supported by renewables to energy systems reliant on renewables.

Storage, particularly long duration energy storage, will be vital in enabling this future and creating flexible energy systems. Providing energy shifting services to ensure solar is available 24/7 is critical and LDES diverse technologies can fill in the gaps.

LDES must be scaled at pace to capitalise on the significant progress to date, and utilise the growing levels of solar that will be installed in the coming decades. The amount of solar needed globally is at least 630 GW/year[4] and as high as 1900 GW/year[5] by 2030. All communities will need some solar whether in homes, on roofs, in fields, or waterways, or on large scale if we are all truly going to leave our reliance on fossil fuels.

Long duration energy storage (LDES) offers a low-cost flexibility solution to enable energy system decarbonization. LDES can be deployed to store energy for prolonged periods and can be scaled up economically to sustain energy provision for multiple hours (ten or more), days (multiday storage), months, and seasons.

LDES can store energy in various forms, including mechanical, thermal, electrochemical, or chemical and can contribute significantly to the cost-efficient decarbonization of the energy system. Furthermore, it helps address major energy transition challenges such as solar and wind energy supply variability, grid infrastructure bottlenecks, or emissions from heat generation. (https://ldescouncil.com/assets/pdf/221108_NZH_LDES%20brochure.pdf)

[4] https://www.iea.org/reports/net-zero-by-2050
[5] https://isolaralliance.org/uploads/docs/903389b6da9999d4c7056ca13af1fa.pdf

Barriers to solar today

Many countries have made excellent progress in deploying solar, with annual installations from 77 GW in 2016 to 204 GW in 2022. However, in order to put us on the track to full decarbonization, many obstacles remain. Some are regulatory and some can only be removed through the deployment of new and existing land duration energy storage technologies.

For solar itself, the barriers vary by country, but a few common hurdles are:

1

Land acquisition and permitting, as well as genuine concerns over land use and displacement of existing users/owners

2

Financing, particularly for distributed renewable energy and in least developed countries

3

Delays in processing interconnection requests

4

Delays in building transmission infrastructure/green energy corridors

5

High taxes and non-tariff barriers, especially relative to fossil fuel investments

6

Lack of understanding by policymakers and grid operators of the options to integrate large volumes of solar (ie. Energy storage), leading to restrictions on the total volume of solar deployed

Barriers to LDES

Long duration energy storage faces some of the same obstacles as solar energy, with the added complication of its relative novelty in the pantheon of decarbonization solutions. While pumped-hydro storage was first used in the 1890s, new generations of alternative battery chemistries, mechanical energy storage, thermal storage, and chemical storage need support to overcome headwinds to their deployment.

Key barriers to scale of long duration energy storage:

- Limited policy certainty for LDES, compounded by concurrent jurisdiction
- Limited awareness and definitions of the asset class, leading to narrow technical taxonomy for energy storage and lack of a defined market and monetization opportunities
- High initial project costs due to limited commercial scale and deployment history
- Investor perception of increased project risks leading to elevated rate of return requirements
- Existing revenue streams in most markets do not sufficiently compensate LDES assets with necessary certainty for the range of grid services offered
- Lengthy development timeframes for grid connected assets due to permitting and interconnection queues

Overcoming these barriers can yield economic results. As a study from the Lumen Energy Group detailing the operations, costs and benefits of storage resources in California reveals. The study largely focused on lithium-ion batteries, but also including thermal energy storage and other battery chemistries.

Going forward, the study's authors expect that the net grid benefits of storage will grow to potentially $835 million to $1.34 billion annually by 2032, as battery installations ramp up to 13.6 GW to meet the state's 2021 preferred system plan. And with future policy measures to address existing and future barriers to the grid benefits offered by storage, "we believe California can secure these benefits and unlock the full potential of its energy storage portfolio: a more diversified and effective portfolio and a total net grid benefit of $1–$1.6 billion per year by 2032."

In developing countries, LDES has already shown it is cheaper that fossil fuel options. For example, India has seen series of “Round-the-Clock” and “Firm and Dispatchable RE Power” auctions where renewable energy capacity is integrated with energy storage to supply bespoke supply solutions. In the first tender of this kind in 2020, Greenko Group was the winning bidder at a fixed tariff of Rs 4.04/kWh (about $49/MWh) for supply of around the clock including a minimum of 6 hours peaking supply. The tender allows significant flexibility to the utilities in managing their demand and supply. The recipient states (Goa and Haryana) purchase new coal power for Rs. 6.2-6.3/kWh (about $75/MWh). Therefore, for the life of the 900 MW project, Haryana and Goa will save approximately 3000 Crore ($360 Million) per year in cost savings.

Since then, the Indian market has further matured with multiple auctions from utilities/ renewable energy developers for contracting standalone energy storage capacity. In the first such tender, NTPC, India’s largest power generation company, through its renewable arm contracted from Greenko 500 MW/3000 MWh of energy storage capacity for 25 years at fixed annual storage charges of $22 - 23/kWh. Greenko combines wind and solar with off-river reservoir pumped hydropower. This allows 6-12 hours of energy storage with a faster permitting timeline and minimal environmental impact relative to traditional pumped hydropower.

Thermal Energy Storage and Solar

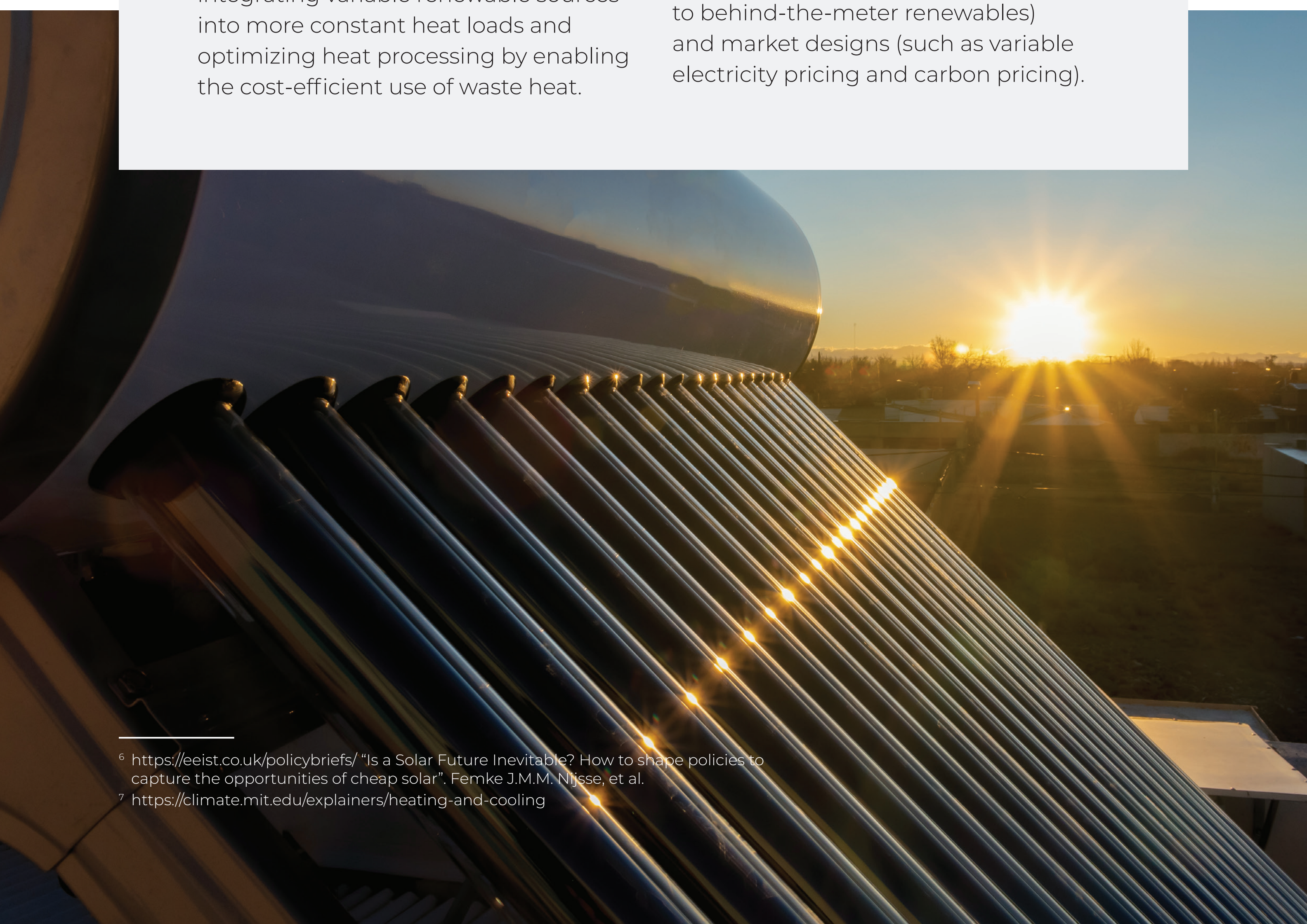
As of 2023, solar is already the cheapest form of new electricity in many countries and is expected to be the cheapest form in nearly all by 2030[6].

However, heating and cooling is responsible for 29% of global energy use[7], and decarbonization must also use renewable sources to displace heating and cooling from fossil fuels, in addition to electricity.

Thermal energy storage (TES) brings down heat emissions and decarbonization costs. The transition to a net-zero energy system with increasing variable renewable energy generation requires new forms of flexibility to ensure a reliable energy system. TES technologies can play a central role in realizing net-zero heat and power in a cost-optimized manner, integrating variable renewable sources into more constant heat loads and optimizing heat processing by enabling the cost-efficient use of waste heat.

This could enable the accelerated build-out of renewables providing stability and resiliency, the optimized use of generation capacity and energy shifting, and the improved utilization of grid infrastructure as the energy system decarbonizes. With initial TES technologies already available, there is an opportunity to consider action to achieve wider adoption.

Economic analyses suggest that TES could be among the most cost-effective options for decarbonizing steam, even in a non-net-zero scenario. A series of four TES business case assessments show it can generate profitable investments with IRRs of up to 28 percent. However, the commercial viability of TES depends heavily on local market conditions in terms of physical configurations (such as access to behind-the-meter renewables) and market designs (such as variable electricity pricing and carbon pricing).



[6] https://eeist.co.uk/policybriefs/ “Is a Solar Future Inevitable? How to shape policies to capture the opportunities of cheap solar”. Femke J.M.M. Nijsse, et al.

[7] https://climate.mit.edu/explainers/heating-and-cooling

Long duration energy storage enables a cost-optimized pathway toward net zero

A cost-optimized net-zero pathway could by 2040 result in...

2-8 TW

deployed LDES capacity

USD 1.7-3.6 tr

deployed LDES capacity

up to USD **540 bn**

system savings per year

In addition, specific enablers would help support profitable business cases, such as reducing grid connection fees for flexibility solutions. All stakeholders have the opportunity to help unlock TES's potential. TES helps realize a clean, low-cost, and reliable energy system. As such, raising awareness of TES's potential is in the best interest of many stakeholders as it could help them execute their decarbonization strategies. Various other relevant options could scale up TES, particularly rewarding flexibility and leveling the playing field. Stakeholders could take steps to reduce uncertainty in the long term.

TES can decarbonize heat applications by electrifying and firming heat with variable renewable energy sources. In addition, it can optimize heat consumption in industrial processes and facilitate the reuse of waste heat or the integration of clean heat sources (for example, from thermal solar).

TES can enable the cost-efficient electrification of most heat applications. TES covers a variety of technologies that can address a wide range of storage durations (from intraday to seasonal) and temperatures (from subzero to 2,400°C). According to the 2022 LDES benchmark results, TES enables cost-efficient electrification and decarbonization of the most widely used heat applications, namely steam and hot air. The benchmark results also indicate that firming heat is very cost-efficient when the final demand is heat.

Some TES technologies are already commercially available with various easy-to-customize uses. To date, the most commonly deployed TES technologies include medium-pressure steam, with various applications, including in the chemicals or food and beverage industries. Additionally, developing technologies will expand the TES solution space with innovative concepts and address temperature needs well above 1,000°C.

Nearly all categories of LDES are applicable to decarbonization in industry. A new report from the LDES Council estimates roughly 65% of all industrial emissions could be abated using existing energy storage technologies developed by its membership today.

If TES is deployed in new industrial facilities, 8 billion tons of carbon dioxide emissions could be avoided.

Action Items for Policymakers

How to work in Partnership to provide solutions

01

Increase global targets for solar to 1900 GW per year and LDES to 100 GW per year. Use of least-cost integrated energy planning to ensure sufficient volumes of renewable energy (including solar) and storage (including LDES) are built to meet both development needs and net zero goals.

02

Streamline permitting and siting to ensure solar and storage can be built at the pace required to meet our climate targets. Recognizing the climate benefits of solar + storage projects in the environmental permitting process

03

Properly price and value additional benefits of LDES such as blackstart, load following and inertia and benefits of distributed solar such as reduced transmission & distribution investment and losses

04

Continue to increase investment in R&D for next-generation solar and LDES technologies, with funding for both primary research and pilot deployment

05

End fossil fuel subsidies and reallocate to renewable sources and energy storage. Where required, increase the availability of incentives, grants and other supports.

06

Increase funding to climate facilities (such as ISA's Solar Facility) to fund solar + storage projects in least developed countries.

07

Capacity building and training among regulators, engineers, installers, etc. on the regulatory, economic and technical aspects of solar and LDES, such as through ISA's Star-C Centres

08

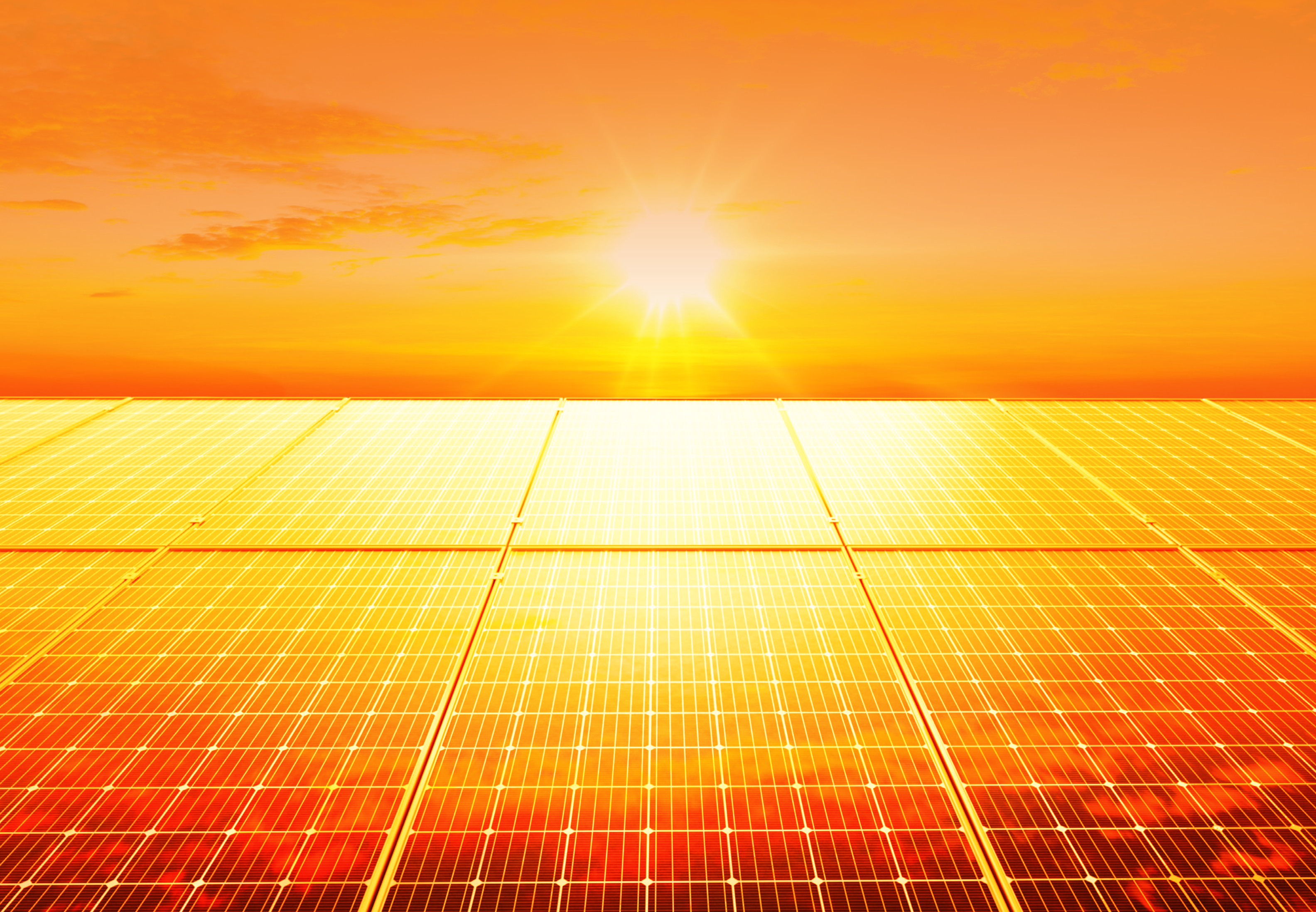
Recognize the socio-economic benefits of solar and LDES to alleviate poverty, create local jobs, improve health and increase energy security and resilience. Support a just and equitable transition by ensuring the benefits of solar and LDES are shared with traditionally disadvantaged and marginalized groups, as well as groups currently benefitting from fossil fuels. For example, wherever practicable, training fossil fuel workers on RE technologies or siting LDES at the site of existing fossil fuel stations.

Not only are Solar and LDES critical to support the journey to net zero, they will also provide significant economic benefits: it can create a new generation of green jobs, accelerate local economic recovery, fortify and help mitigate measures to address rising climate challenges.

In many jurisdictions around the world, particularly tropical countries which ISA targets, solar is already the cheapest form of new electricity capacity and is fast becoming the cheapest source in more and more countries around the world. Paired with LDES, solar can not only be the cheapest source of energy on the grids in emerging economies. It can be the primary source of energy.

The global stocktake of the Paris Agreement presents a pivotal point in the COP process, and vital moment for the renewables sector to speak with one voice. COP28 represents the last major chance to get the world back on track and hold nations accountable for delivering on their environmental targets.

ISA and LDES Council will continue to work together to support countries to ensure that Terawatts of solar and hundreds of GigaWatts of long duration energy storage are built annually, to meet the world's development and climate targets.



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