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Clean Energy Newsletter

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Editorial Note:

Welcome to our second issue!

As the world moves from making promises to actually building green energy projects, our newsletter is evolving too.

We are now moving to a biannual schedule to bring you deeper, real-world stories about this global transition as it happens.

In this edition, we feature six articles from experts in India, Sri Lanka, and Australia. Building a cleaner planet is a collaborative mission, and the stories in this issue prove that a sustainable future is no longer just a dream—it is being constructed right now through global hard work and innovation. We invite you to explore these articles and join us in documenting the journey toward a greener, more resilient world for everyone.

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Wind Energy's Social and Environmental Impact in Sri Lanka

Introduction

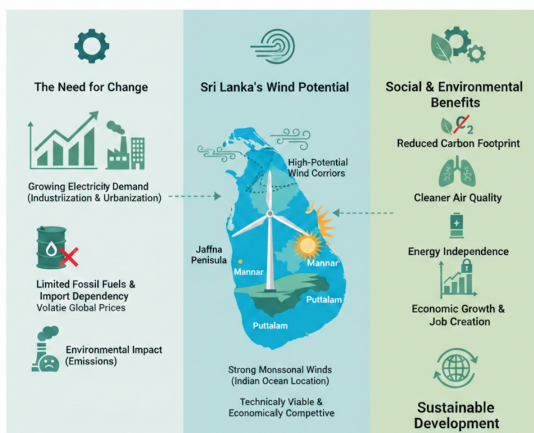
Sri Lanka is presently undergoing a significant transformation in its energy sector as it attempts to balance economic development with environmental sustainability. As a developing island nation with limited indigenous fossil fuel resources, the country faces increasing pressure to expand electricity generation capacity while reducing dependence on imported fuels and minimizing ecological damage. Electricity demand continues to grow due to industrial expansion, urbanization, technological development, and improvements in living standards. Energy access is widely recognized as a foundation for economic growth, and countries with high levels of development typically exhibit high per capita electricity consumption. For example, nations such as Japan, Singapore, and Republic of Korea have achieved advanced industrial status alongside substantial electricity usage per person. Sri Lanka's per capita electricity consumption remains comparatively lower, indicating both the need and the potential for expansion in power generation. Within this context, renewable energy—and particularly wind power—has emerged as a key component of the country's strategy for sustainable development.



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Wind Energy in Sri Lanka: a Sustainable Shift

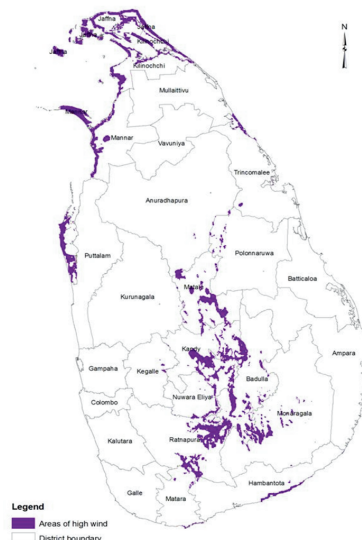


Source: Ceylon Electricity Board (CEB) & Government of Lanka Reports

Sri Lanka's traditional electricity generation system relied heavily on hydropower in the early decades after independence. Large reservoirs and dams once supplied a substantial share of national electricity demand. However, as demand increased, the limitations of hydropower became evident. Seasonal rainfall variability restricts hydroelectric generation capacity, and most viable large-scale hydro sites have already been developed. Consequently, thermal power generation using imported coal and oil became increasingly prominent. While thermal power provides stable baseload electricity, it carries serious environmental consequences, including greenhouse gas emissions and air pollution, and exposes the country to volatile international fuel markets. Fluctuating global oil and coal prices have repeatedly strained Sri Lanka's economy, particularly during periods of foreign exchange shortages. These vulnerabilities have strengthened the case for expanding renewable energy sources that are locally available and environmentally cleaner.

Among renewable energy options, wind energy is particularly attractive due to Sri Lanka's geographical position in the Indian Ocean. The island experiences strong monsoonal wind systems, especially along the northern, north western and southeastern coastal belts. Areas such as Jaffna peninsula, Mannar and Puttalam have been identified as high-potential wind corridors as shown in the figure 1. The Ceylon Electricity Board (CEB) has conducted wind resource assessments over several years to evaluate the feasibility of commercial wind projects. These studies indicate that certain coastal regions can generate substantial electricity through wind turbines, making wind energy a technically viable and economically competitive option. Unlike fossil fuel plants, wind turbines produce electricity without combustion, meaning that no carbon dioxide, sulfur dioxide, nitrogen oxides, or particulate matter are emitted during operation. This makes wind power an important tool in reducing Sri Lanka's carbon footprint and improving air quality.

Wind resources available in Sri Lanka



► Wind turbine's positive effect on environment

The environmental benefits of wind energy are significant. Lifecycle assessments show that wind power produces only a small fraction of the greenhouse gas emissions associated with coal-fired electricity. While some emissions occur during the manufacturing, transportation, installation, and decommissioning of turbines, operational emissions are virtually zero. For a country like Sri Lanka, which is highly vulnerable to climate change impacts such as sea-level rise, coastal erosion, extreme rainfall events, and prolonged droughts, reducing greenhouse gas emissions is both a global responsibility and a domestic necessity. Climate change poses particular risks to island nations, affecting agriculture, fisheries, water resources, and coastal settlements. Expanding wind energy contributes to mitigating these long-term threats while supporting national climate commitments under international agreements.

Energy security is another major advantage of wind development. Sri Lanka imports nearly all of its fossil fuels, requiring significant foreign exchange reserves. During economic crises, fuel shortages can lead to power cuts and industrial disruptions. By harnessing locally available wind resources, the country reduces its dependence on imported fuels and improves resilience against global energy price fluctuations. Wind farms, once constructed, have relatively low operating costs compared to thermal power plants, since they do not require continuous fuel purchases. Over time, this can stabilize electricity prices and strengthen national energy independence.

► Wind turbine's negative effect on environment

Despite these clear advantages, wind energy development is not without environmental concerns. Sri Lanka is internationally recognized for its rich biodiversity and diverse ecosystems. The island lies along the Central Asian Flyway, one of the world's major migratory bird routes. Each year, thousands of migratory birds travel long distances and use Sri Lanka's coastal wetlands as feeding and resting grounds. Mannar, in particular, hosts large flocks of flamingos, pelicans, and other waterfowl. The installation of large wind turbines in these areas raises concerns about potential bird collisions and disruption of established migration pathways. Rotating turbine blades can pose risks to birds flying at certain heights, especially during low visibility conditions. Habitat fragmentation caused by access roads and transmission infrastructure may also disturb feeding grounds and nesting sites.

In addition to birds, bats may be affected by wind turbines. International research has documented bat mortality near large wind farms due to blade strikes and sudden air pressure changes near rotating blades. Bats play an important ecological role in insect control and pollination, making their protection essential for maintaining ecological balance. While the scale of bat populations in Sri Lanka's wind corridors requires further study, precautionary measures such as careful site selection and operational adjustments during peak migration periods can reduce potential risks.

Coastal and marine ecosystems also deserve careful consideration. Construction activities associated with wind farms—such as foundation excavation, road building, and heavy machinery transport—can disturb soil structure and alter natural drainage patterns. Mangrove forests, sand dunes, and shallow marine habitats are particularly sensitive to physical disturbance. Improper waste disposal during construction could affect water quality. However, many of these impacts are temporary and can be minimized through strict environmental management plans, monitoring programs, and rehabilitation measures. Compared to the long-term pollution associated with fossil fuel extraction and combustion, wind energy's environmental footprint remains relatively modest.

Another environmental issue occasionally raised is the potential for wind farms to influence local microclimates. Some large-scale studies conducted abroad suggest slight temperature increases near extensive wind installations due to atmospheric mixing caused by turbine rotation. However, these temperature changes are small compared to broader climate change trends and are unlikely to significantly affect Sri Lanka's relatively moderate wind farm installations. Claims regarding rainfall reduction or sea-level changes due to wind turbines lack robust scientific evidence.

► Social impact

While environmental impacts are a key dimension of the debate, social concerns often play an equally important role. Renewable energy development must not only be environmentally sound but also socially equitable. In the coastal area such as Mannar, local communities depend heavily on fishing and small-scale agriculture for their livelihoods. Concerns have been raised that wind farm construction may restrict access to fishing grounds or reduce available grazing land. Even when scientific evidence of long-term harm is limited, perceptions of risk can influence community acceptance. For fishing communities, changes in coastal access or temporary construction disturbances may create economic uncertainty.

Balancing Progress: Challenges & Mitigation



Noise generated by wind turbines is another frequently discussed issue. Modern turbines produce aerodynamic noise from rotating blades and mechanical noise from internal components such as gearboxes. Sound levels generally decrease with distance and often fall within internationally accepted limits beyond a few hundred meters. However, residents living close to turbines sometimes report sleep disturbances, stress, or reduced comfort. Scientific studies in several countries have not conclusively linked turbine noise to serious health problems, but psychological and subjective impacts can still be significant if communities feel excluded from decision-making processes.

Shadow flicker is another phenomenon associated with wind turbines. When sunlight passes through rotating blades, moving shadows can be cast on nearby buildings. Although this effect occurs only under specific lighting conditions and typically for limited durations, it can cause annoyance if turbines are placed too close to homes. Visual impact is

also an important factor. Wind turbines are large structures that alter the appearance of landscapes. Some individuals view them as symbols of progress and environmental responsibility, while others see them as intrusive elements disrupting natural scenery. Public perception of visual impact varies widely and is influenced by cultural, economic, and aesthetic values. Land ownership and property value concerns also contribute to social tensions. Wind farms require substantial land areas, often leased for long periods. In cases where land documentation is unclear or disputed, conflicts may arise. Some residents fear that proximity to wind turbines could reduce property market value. Transparent compensation mechanisms and fair leasing agreements are essential to address these concerns and maintain trust.

Government policy and Public trust

Governance and public participation play crucial roles in shaping the success of wind energy projects. Environmental Impact Assessments must be scientifically rigorous and genuinely participatory. Community consultations should occur early in the planning process rather than after major decisions have been finalized. When residents feel informed and included, opposition tends to decrease. Conversely, lack of transparency can generate protests and erode public confidence in renewable energy initiatives. Ensuring that benefits—such as employment opportunities, infrastructure improvements, or revenue-sharing mechanisms—are equitably distributed can strengthen local support.

Public Misconceptions about Wind Turbines

There are several misconceptions among the public regarding the environmental impacts of wind turbines. Many of these concerns are not strongly supported by scientific evidence and require careful examination.

Changes in Rainfall: The claim that wind turbines significantly alter rainfall patterns has not been confirmed by reliable scientific studies. A few studies suggest a slight increase in rainfall in areas with large wind farms; however, the evidence remains limited and inconclusive. It is still too early to draw firm conclusions on this matter. In the context of Sri Lanka, variations in rainfall are more realistically attributed to global climate change rather than the localized effects of wind turbines.

Changes in Sea Water and Surface Freshwater Levels: Concerns about wind turbines affecting sea levels or freshwater sources lack strong scientific support. Any potential impact on water levels or quality is more likely to occur during the construction phase rather than during operation. For example, excessive use of freshwater for construction activities and improper waste disposal could temporarily affect local water resources. However, with proper planning, monitoring, and environmental management practices, such impacts can be minimized. During the operational phase, the primary risk may involve oil leakage from machinery, which requires regular maintenance and monitoring. There is also a theoretical possibility that turbulence generated by turbines could slightly increase surface evaporation, potentially contributing to dry conditions in nearby farmland. Nevertheless, this hypothesis requires further scientific investigation. Mitigation measures, such as planting suitable coastal vegetation like cashew trees, may help reduce potential localized environmental effects.

Impact on Marine Animals: The impact of wind turbines on marine life has been discussed in various studies, particularly in relation to offshore wind farms. Most concerns are associated with underwater noise and electromagnetic fields generated by submarine cables. However, considering the location and relatively limited spatial scale of current wind turbine installations in Sri Lanka, such impacts are expected to be minimal. Continuous environmental monitoring can further ensure that marine ecosystems are protected.

► Setback Distance Regulations for Wind Farms

Setback distance regulations for wind farms vary worldwide depending on safety requirements and land availability. Some countries apply fixed minimum distances, while others use formulas based on turbine height. For example, Poland and parts of Germany, especially Bavaria, follow the “10H rule,” requiring turbines to be placed at least ten times their total height away from residential buildings, often exceeding 2,000 meters for modern turbines. In contrast, France and Belgium generally require a minimum setback of 500 meters to reduce noise impacts. Denmark applies a 4× turbine height rule and also compensates property owners if nearby wind farms significantly affect property values. In countries such as the Netherlands, Sweden, and parts of the United States, setback regulations are performance-based rather than fixed. Developers must ensure that noise levels remain within limits, typically around 40 dB(A), and that shadow flicker stays within acceptable annual thresholds. Scotland commonly recommends a 2,000-meter distance near towns and villages, although this may vary depending on site conditions. These international practices highlight the importance of clear setback regulations to balance renewable energy development with public health and community acceptance. For Sri Lanka, establishing national setback guidelines would help reduce conflicts, minimize disturbance, and improve public support for wind energy projects.

► Conclusion

Ultimately, the expansion of wind energy in Sri Lanka requires balancing national climate goals with environmental and social concerns. The country must increase electricity generation to support economic growth and improve living standards, while ensuring that biodiversity, coastal ecosystems, and local livelihoods are protected. Achieving this balance requires careful site selection, environmental monitoring, transparent governance, and active public participation. Wind energy provides Sri Lanka with an important opportunity to move toward a cleaner and more secure energy future by reducing greenhouse gas emissions, improving energy independence, and supporting sustainable development. However, wind power also creates environmental and social challenges. Impacts on migratory birds and sensitive ecosystems must be addressed through proper scientific assessment, while concerns about land use, noise, property value, and livelihoods require fair compensation and open communication with communities. The long-term success of wind energy development depends not only on technical feasibility but also on public trust and responsible governance. If managed properly, wind power can become a key part of Sri Lanka’s sustainable development strategy, supporting both environmental protection and economic progress for future generations.



UAS-Based Remote Sensing for Clean Energy Asset Inspection

Remote sensing encompasses the acquisition and analysis of spatial and temporal information about physical objects and the environment via sensors mounted on aerial platforms, without direct physical contact with the targets of interest. Uncrewed Aerial System (UAS)-based remote sensing offers substantial advantages over conventional ground-based inspection methods, including very high spatial resolution (often below 5 cm), flexible and on-demand temporal coverage, cost-effective deployment, and rapid data collection capabilities. In combination with artificial intelligence (AI), UAS-based remote sensing is reshaping renewable energy management by enabling advanced monitoring, diagnostic assessment, and condition-based maintenance of clean energy infrastructure.

► How do UAS improve clean energy asset monitoring?

The integration of UAS platforms with advanced remote sensing payloads, such as thermal infrared (IR) cameras, light detection and ranging (LiDAR) systems, and high-resolution RGB cameras, facilitates comprehensive inspection and monitoring of clean energy assets at spatial and temporal scales that were previously impractical or economically prohibitive (Table 1). It also moves beyond traditional manual fault detection by incorporating sophisticated data-processing pipelines to derive actionable information. This evolution underscores the necessity of a thorough



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understanding of both the underlying sensor technologies and the computational methodologies, such as computer vision and machine learning, that convert raw sensor measurements into operational intelligence for clean energy asset management. Across current applications, AI-enabled remote sensing is used primarily for defect detection and for solar PV health monitoring, where thermal imaging supports the assessment of underlying panel health.

Modality	Common clean-energy use cases	Typical spatial resolution	Typical detection accuracy
Thermal infrared [1, 2]	PV hotspot/PV faults; wind-blade delamination indicators	15–20 cm	89–96%
Optical (RGB) [3, 4]	PV cracks/soiling; wind surface damage	1–5 cm	91–94%
LiDAR [5]	3D reconstruction; blade erosion; geometry/deformation	2–5 cm (XY); <1 cm (Z)	87–92%

► Where is UAS-AI defect detection used?

Recent studies show that UAS-based defect detection methodologies are predominantly applied in three major clean energy domains, namely solar photovoltaic systems, wind energy installations, and hydropower [1, 4, 6-8], to identify a wide spectrum of anomalies that may degrade energy conversion efficiency or induce collateral mechanical and structural damage to critical components. UAS-collected images are first pre-processed and then used to train and deploy AI models that can detect cracks and other forms of damage, classify the defect type, determine where the defect occurs, and quantify the number of defects identified. Figure 1 illustrates the sensor types and sector applications used for defect inspection. RGB imagery remains the most widely used data source in UAS based defect inspection studies due to its high spatial resolution and strong visual interpretability [4], while LiDAR-derived structural descriptors provide complementary geometric information that supports quantitative assessment of crack morphology and severity [5].

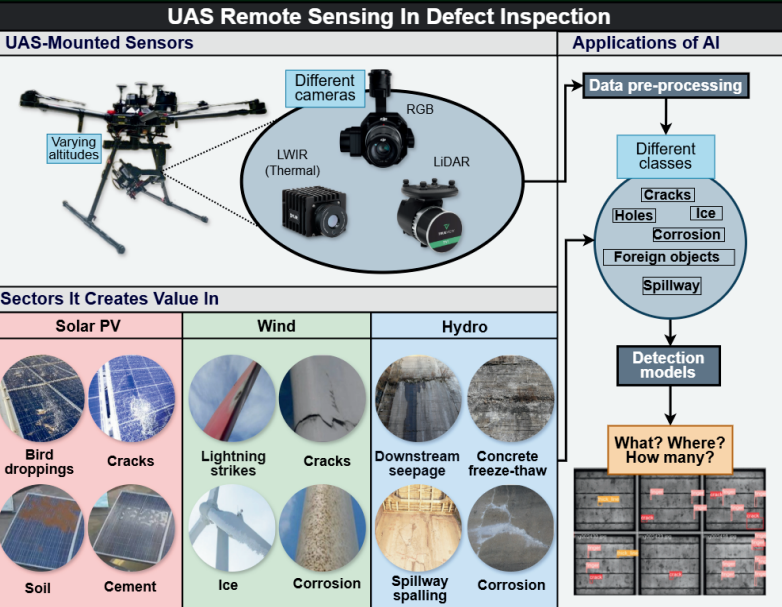


Figure 01: Illustration of defects and the object-detection workflow across sectors where UAS remote sensing creates value.

transition from reactive to predictive maintenance. Hybrid approaches combining thermal, optical, and LiDAR sensors integrated with AI enable comprehensive characterization of renewable energy assets in single survey flights [9]. Solar photovoltaic hotspot inspection using thermal imaging has identified defects across 232,934 panels, enabling localization of 2,481 defective modules for targeted maintenance [2]. Wind turbine blade inspection using multi-rotor UASs with LiDAR

► How Does Thermal IR Reveal Faults in Solar PV Health Monitoring?

In solar photovoltaic systems, thermal infrared sensing is particularly effective for hotspot detection because it resolves localised temperature anomalies on PV modules (Figure 2), which are commonly associated with electrical and material faults such as bypass diode failure, cell mismatch, snail trail related degradation, and internal short circuits, as well as externally driven conditions including partial shading and crack induced resistive heating [2].

► What benefits are driving UAS adoption in renewable energy inspections?

Key benefits driving UAS adoption include 70-96% cost reduction compared to ground-based inspections, 91-98% fault detection accuracy surpassing manual approaches, elimination of safety risks inherent to ground and climbing robot inspections, and rapid full-facility surveys enabling

has achieved Technology Readiness Level (TRL) 8, indicating production-scale deployment, with detection rates of 88-92% for blade erosion, cracks, and delamination [10]. In addition, a hybrid deep learning model based on ResNet-50 with attention-based extensions, trained on 20,000 labeled images of hydropower sedimentation patterns, photovoltaic microcracks, and wind turbine blade erosion, achieved 91% fault detection accuracy across solar, wind, and hydropower assets [11].

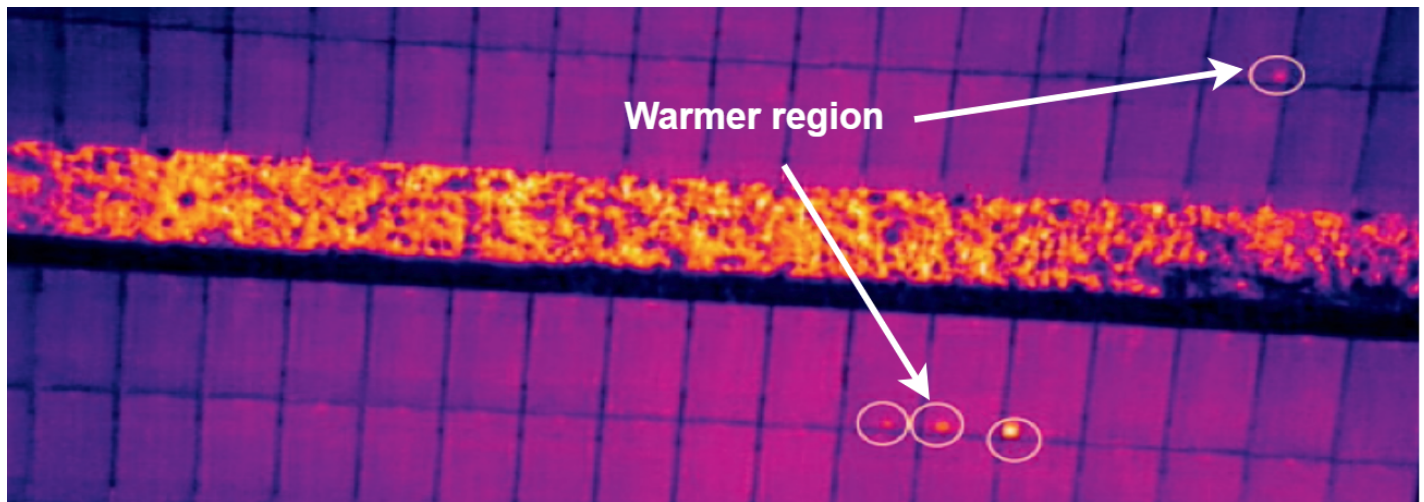


Figure 02: UAS thermal images showing hotspots (warmer regions) on solar panels.

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► Quick stats from the recent studies

- **Performance:** many field deployments report defect detection accuracy roughly in the 85–98% range, depending on sensor, defect type, and model design.
- **Scale:** surveys can generate 85–320 GB per mission; processing commonly ranges from ~6 to 24 hours, depending on modality and workflow.
- **Cost:** comparative analyses in the review indicate UAS monitoring can be substantially cheaper than ground-only inspection while enabling more frequent checks.

► Challenges and what's next?

- **Operational constraints:** UAS remote sensing is still limited by weather dependency, short battery life, regulatory constraints, inconsistent data collection and processing methods, and the lack of standardized quality and reporting protocols.
- **What's next:** Future work will focus on advanced AI integration, real-time adaptive processing, multimodal sensor fusion, temporal monitoring for predictive maintenance, emerging sensing technologies, and longer-endurance or cooperative UAS platforms.

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The Rainbow of Hydrogen: Understanding Energy's Colour Code

Amid humanities tireless drive toward a cleaner, greener next generation, a colourless, odourless, and explosive tiny molecule which is invisible to the eye, has stepped into the spotlight —Hydrogen. It has now become a Rainbow of colours in conversations about energy. Black, blue, green, grey, turquoise, pink, yellow, orange etc. and each shade tells you their birth story, from coal-fired plants to wind-powered electrolysis - every path to creating hydrogen reflects as a vibrant spectrum. The birth chart tells the hopes, challenges, and choices in our journey toward a greener cleaner and sustainable future.

Hydrogen might just be the universe's most popular kid, basically it is omnipresent, from the blazing sun to each corner of the solar system. But here on our own planet, it plays a little difficult to get. It's a bit of a spoiled and stubborn child, never seen alone, always tightly clinging to other elements. You will find it hidden inside water molecules or tucked away within hydrocarbons. To set it free, we have to coax it out using clever methods such as heating materials in special ways (that's the thermo-chemical route), going old-school with electrolysis, or even letting tiny microbes perform their bit of biochemical magic. Let me introduce you to the full, colourful rainbow of hydrogen "flavours." Do not be fooled, the gas itself does not change one bit! It's still the same plain, invisible boaring stuff, but there is a backstory and the colours simply give you the taste of how we made this hydrogen and each single flavour has its own price tag with carbon

baggage towards environmental impact. Fossil fuel born versions are inexpensive but drag along a hefty carbon baggage while Green hydrogen, made with clean energy, is the ecofriendly—but it is also the expensive one at the party, Thankfully, as technology gets advancing it is expected that the cost will drop faster than your phone's battery at 3%.

So yes, hydrogen may be colorless, but when it comes to saving the planet, it's got the most dramatic wardrobe in the clean energy closet. Hydrogen might be invisible and have no smell, but when it comes to clean energy, it loves to dress up in a whole rainbow of colors — and each one tells a different story about how it was made. Let us take a colourful tour through the hydrogen wardrobe!



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► Black & Brown Hydrogen

Black and brown hydrogen are the old-school, not-so-green members of the hydrogen family—produced by burning coal. When it comes from bituminous coal, it's dubbed **black hydrogen**; when it's made from lignite, the softer, earthier variety, it becomes **brown hydrogen**. Either way, the process releases a heavy load of carbon emissions — it's a bit like setting a bonfire in your living room and calling it "home heating."

► Gray Hydrogen

Gray hydrogen is like the middle child of the hydrogen family. It's made by steam reforming natural gas, which sounds fancy until you realize it is basically heating methane until it gives up its hydrogen. Over 95% of the hydrogen we use today comes from this carbon-belching method. Basically, we're addicted to the dirty stuff, similar like washing of our car with muddy water, Shine might have come but still mess is there.

► Green Hydrogen

The golden child (or rather, green) of clean energy. Made by splitting water with electricity from wind or solar power, and absolutely no CO₂ released! The downside? It is still super expensive. Imagine buying organic kale at triple the price of chips healthy, yes, but not budget-friendly yet. Also, green hydrogen currently makes up less than 0.1% of the world's hydrogen, means a tiny drop in the (eco-friendly) bucket.

► Blue Hydrogen

This one is made from natural gas, but with a twist, it captures the carbon dioxide instead of dumping it into the atmosphere. It is cleaner than gray hydrogen and kind of like wearing a gas mask while grilling burgers - not perfect, but a step up. It is also the cheapest "clean" option we have got right now

► Orange Hydrogen

This newcomer is made from plastic waste! It is like turning trash into treasure. Still in the lab stage, though, using wild-sounding methods like pyrolysis and microwave magic. If it works, it could solve two problems at once: dirty energy and dirty oceans.

► Pink Hydrogen

This hydrogen is made by splitting water using nuclear power. No CO₂, which is great, but since nuclear is not technically renewable, it is the cleanest non-renewable you can get. Think of it as wearing eco-friendly clothes made in a nuclear-powered sewing factory.

► Turquoise Hydrogen

Sounds fancy, right? It is made by breaking down natural gas at super high temperatures, leaving behind hydrogen and solid carbon instead of CO₂ gas. It is still in early testing — kind of like a fashion trend that has not hit the stores yet.

► Red Hydrogen

Made by using high heat from nuclear power plants to split water, these needs less electricity than normal methods. Imagine boiling your water with a volcano instead of a kettle

► Yellow Hydrogen

It is green hydrogen wearing sunglasses. This sunny version of hydrogen is made using solar power only, may become the cheapest renewable option in the near future.

► White Hydrogen

White hydrogen also known as natural hydrogen, this one just pops up from under the Earth's crust. It is naturally formed when water meets iron-rich rocks deep underground. The Earth's version of surprise party gas. Yah!! sounds cool, but we haven't figured out how to collect and use it yet.

► Other Labels You Might Hear

- **Low-Carbon Hydrogen** – Made from non-renewables but with low CO₂ emissions. Blue hydrogen fits in here.
- **Clean Hydrogen** – This is the umbrella term for both green and low-carbon types. Just remember: burning hydrogen is clean, but making it can be messy depending on how it is done.
- **Biohydrogen** – Made using bacteria or algae that naturally produce hydrogen. It is like letting nature do the work, kind of like hiring microbes as tiny eco-friendly factory workers.

So, while hydrogen may be invisible, its colourful family tree tells us a lot about our choices for the future. Some are clean, some are dirty, and some are still science experiments — but together, they could power a low-carbon tomorrow (with style).



Toward an Intelligent and Clean Energy Future for Sri Lanka

"The next generation of clean energy will not simply generate power; it will think, learn, and optimise."

Developing nations stand at a pivotal moment in the global energy transition. While industrialised countries focus on optimising mature power systems, developing economies face more complex challenges such as expanding energy access, integrating renewable energy, and building resilience against climate volatility.

Artificial Intelligence (AI) is emerging not merely as a technological enhancement, but as a strategic enabler of climate-resilient clean energy systems. For Sri Lanka, a nation with abundant renewable potential but significant structural and climate-related vulnerabilities, AI represents a transformational opportunity [1].



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The Sri Lankan Context

Sri Lanka has made notable progress in renewable deployment, particularly in wind energy at Mannar, hydropower, and rooftop solar initiatives. Yet the grid faces five persistent structural pressures that conventional rule-based management cannot adequately address:

- Monsoon variability is disrupting solar output
- Drought-induced reductions in hydropower generation
- Rising evening peak demand is increasing thermal dependence
- Limited energy storage deployment
- Ongoing financial stress on public utilities

These challenges expose a fundamental gap: Sri Lanka's grid was designed for predictable, centralised generation, not the variable, distributed renewables that its clean energy future demands. AI is the bridge between these two realities.

AI-Powered Microgrids for Sri Lanka

The Asian Development Bank (ADB) has formally recognised this gap. ADB launched the Technical Assistance project "Artificial Intelligence-Powered Microgrids to Enable a Futuristic and Reliable Distributed Renewable Energy System."

This aims to develop an AI framework for microgrids that enables the seamless integration of distributed renewable energy (DRE) systems and to implement a pilot project demonstrating a working AI-enabled microgrid. The project directly targets Sri Lanka's goal of 70% renewable power generation by 2030, while improving social inclusiveness through direct consumer participation in the energy sector. [2]

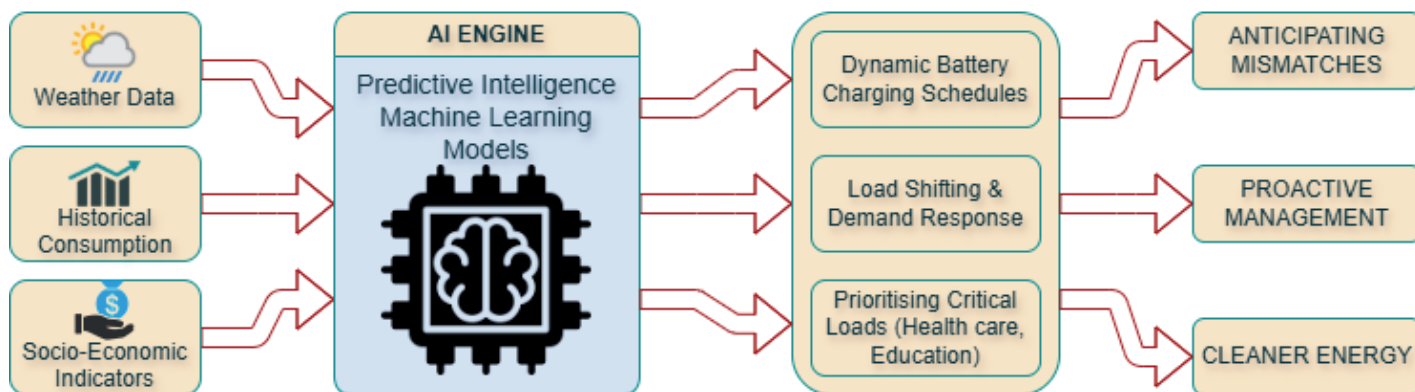
AI Engine for Intelligence Grid

Conventional grid management relies on fixed rules and historical averages. AI shifts the paradigm from reactive to predictive, anticipating supply-demand mismatches before they occur and optimising system responses in real time. The following four capabilities are central to this transformation.

► Predictive Intelligence

As shown in Figure 1, these structural and climate-related pressures collectively expose the limitations of conventional grid planning and rule-based operation. Variability in monsoon patterns disrupts solar predictability, drought conditions constrain hydropower reliability, and rising evening peak demand increases dependence on costly thermal generation. Machine learning models, including Long Short-Term Memory (LSTM) networks and transformer-based architectures, enable accurate short-term and seasonal forecasting of both renewable generation and electricity demand. By incorporating weather data, historical consumption patterns, and socio-economic indicators, AI can anticipate energy imbalances before they materialise.

AI Engine for Intelligent Grid

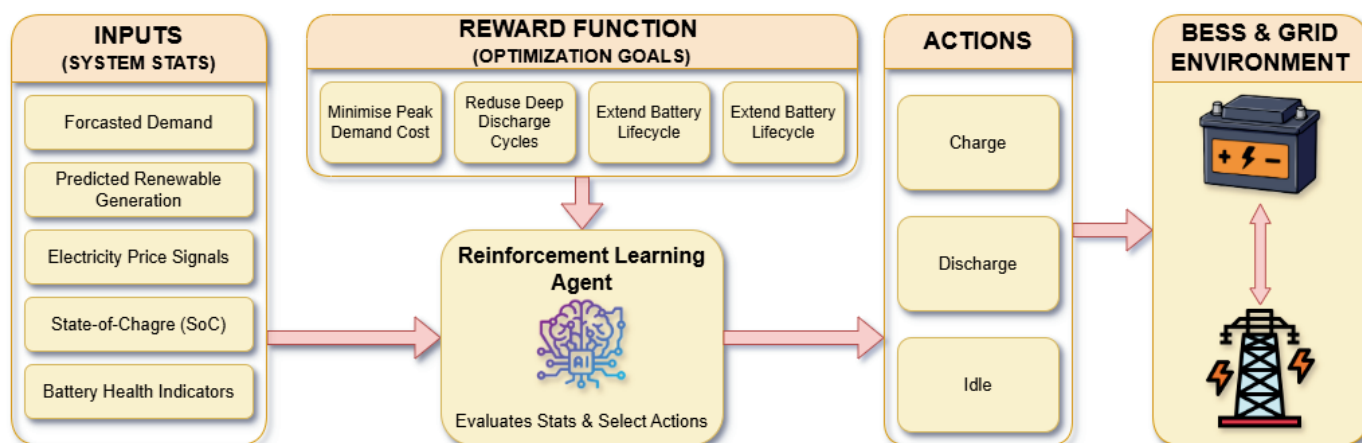


In practice, this means AI systems can forecast reduced solar output during heavy monsoon cloud cover and proactively adjust battery charging schedules, reducing deep discharges, extending battery life, and ensuring energy availability during evening peak periods. [3,4]

► Adaptive Energy Storage Optimisation

Battery Energy Storage Systems (BESS) are critical in renewable-rich grids, but improper charge-discharge cycling accelerates degradation and increases lifecycle costs. Reinforcement learning (RL) algorithms address this by dynamically determining optimal strategies based on real-time conditions, as shown in Figure

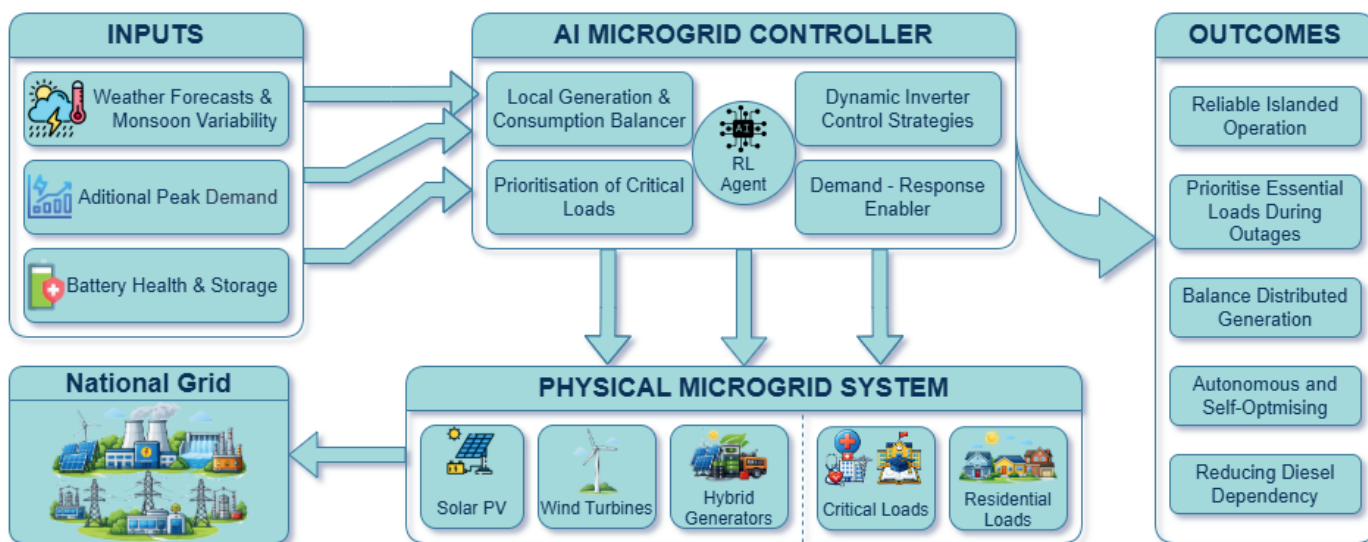
REINFORCEMENT LEARNING MODEL FOR BESS OPTIMISATION



By minimising unnecessary deep cycling and smoothing ramp rates, AI-driven control can extend battery lifespan by 20–25%, reducing replacement costs and improving long-term sustainability. This is especially significant in capital-constrained economies like Sri Lanka [3].

► Smart Microgrids for Energy Access

Many rural communities in developing countries depend on microgrids powered by solar, wind, or hybrid renewable systems. With the integration of AI, these microgrids can operate as intelligent and self-optimising energy systems by balancing electricity generation and consumption in real time, adjusting inverter operations dynamically, prioritising critical services such as hospitals during outages, and enabling demand-response strategies to reduce energy waste and improve overall efficiency.



AI Powered Smart Micrgrid for Rural Energy Access

AI-powered microgrids can operate reliably even when disconnected from the national grid, a critical capability for rural Sri Lanka, where grid instability remains a concern.

► Dynamic Pricing and Demand Response

AI-driven demand forecasting supports time-of-use tariffs and adaptive pricing models, encouraging consumers to shift loads during periods of high renewable generation. This strategy reduces evening peak stress and improves renewable penetration without costly infrastructure upgrades, delivering cost savings while accelerating decarbonisation.

Global Use Cases: AI Accelerating Clean Energy

The following examples from six countries demonstrate that AI is not merely optimising energy systems, but it is actively reducing emissions, enhancing affordability, and expanding access.

Country	AI Application	Key Outcome
Germany & Denmark	ML wind output forecasting	Wind penetration of 40–50%+ sustained with grid reliability [4]
USA	RL-based battery dispatch (California, Texas)	Battery installations outpaced gas-fired additions in 2024; 730 MW of ERCOT BESS optimised by AI [5]
United Kingdom	Real-time grid balancing + AI for households	National Grid–AI firm trials accelerate decarbonisation; government-backed AI cuts household energy costs [6][7]
India	Deep learning for solar forecasting in state utilities	Reduced imbalance penalties; higher renewable integration via AI-enabled REMCs [8]
Kenya	AI + GIS for microgrid site selection & load forecasting	Optimal rural microgrid siting; reduced diesel dependency [9]

“

Key Insight

The success of AI in clean energy is inseparable from data quality. Developing nations often face fragmented datasets, limited smart meter penetration, and inconsistent telemetry. Strategic investment in Advanced Metering Infrastructure (AMI), IoT-enabled substations, and digital data platforms is therefore a prerequisite, not an afterthought.

”

Policy Recommendations for Sri Lanka

Harnessing AI for clean energy transformation requires targeted policy action across the following areas:

Policy Area	Recommended Actions
National Energy Data Infrastructure	Mandate AMI rollout. Establish a centralised, anonymised national energy data repository.
AI-Integrated Renewable Policy	Require AI-based forecasting in large-scale solar and wind projects. Encourage predictive battery optimisation in utility-scale storage.
Smart Storage Incentives	Introduce performance-based incentives for AI-optimised BESS. Provide tax relief for grid-supportive storage installations.
Dynamic Pricing Framework	Enable time-of-use tariffs with AI-powered forecasting. Pilot AI-driven demand response markets.
Grid Modernisation	Upgrade substations with digital sensors and IoT infrastructure. Integrate AI-ready communication standards (IEC 61850, secure IoT protocols).

Clean Energy Impact: Why AI Matters

AI delivers three structural improvements that collectively accelerate the energy transition:

“

⚡ Efficiency Gains

Improved forecasting reduces curtailment and balancing costs, enabling higher renewable penetration without compromising grid stability.

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🌿 Carbon Reduction

Intelligent dispatch reduces reliance on thermal backup generation, cutting fossil fuel imports and lowering grid carbon intensity.

🔋 Asset Longevity

Optimised storage management reduces battery degradation, defers costly replacements, critical for capital-constrained economies.

”

► Conclusion

Sri Lanka's clean energy future depends not only on installing renewable capacity, but also on intelligently managing it. For a country where monsoon variability, drought-sensitive hydropower, and evening peak demand persistently challenge grid stability, AI offers a rare convergence of opportunity to accelerate clean energy adoption while simultaneously strengthening resilience.

AI enables grid operators to anticipate climate variability, optimise energy storage, balance supply and demand in real time, and enable transparent energy markets. The evidence from other countries confirms that this is not theoretical, but it is already happening. But we need some policy changes to accommodate them.

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Tandem solar cells breaking the efficiency limits of conventional photovoltaics

► Introduction

The global transition toward sustainable and low-carbon energy systems has accelerated dramatically in the past decade. Among the various renewable energy technologies, solar photovoltaics (PV) have emerged as one of the most promising solutions for meeting the world's rapidly growing energy demand while reducing greenhouse gas emissions. Solar power systems are now being installed at an unprecedented pace, from residential rooftops to massive utility scale solar farms covering thousands of hectares. At the heart of this remarkable growth lies crystalline silicon photovoltaic technology, which currently dominates the global solar market. More than 95% of all solar modules produced worldwide are based on silicon solar cells. Continuous advances in materials science, device engineering, and industrial manufacturing have transformed silicon photovoltaics into a mature and highly reliable technology. Over the past four decades, the cost of solar electricity has decreased dramatically while conversion efficiencies have steadily increased.

Despite these achievements, conventional silicon solar cells are approaching their fundamental performance limits. Laboratory silicon cells have already achieved efficiencies above 27%, leaving only limited room for further improvements within the single-junction architecture [1]. As a result, researchers and industry leaders are increasingly exploring new photovoltaic concepts capable of surpassing this efficiency ceiling. One of the most promising approaches is the development of tandem solar cells, also known as multijunction solar cells. In these devices, multiple

semiconductor layers with different bandgaps are stacked together so that each layer absorbs a different portion of the solar spectrum. By more efficiently utilizing sunlight, tandem solar cells can significantly exceed the efficiency limits of traditional single junction photovoltaic devices and potentially revolutionize the solar energy industry.

► Efficiency limits of single-junction silicon solar cells

For several decades, crystalline silicon (Si) has remained the backbone of the photovoltaic industry due to its abundance, chemical stability, and well-established manufacturing infrastructure. However, despite continuous improvements in device engineering, silicon solar cells are gradually approaching their fundamental efficiency limits. The theoretical efficiency of a single-junction crystalline silicon solar cell is estimated to lie between approximately 29% and 33% under standard solar illumination. The upper bound is defined by the Shockley-Queisser limit, a theoretical framework developed in 1961 by physicists William Shockley and Hans-Joachim Queisser [2]. Their analysis describes the maximum efficiency that a single junction solar cell can achieve based on the balance between photon absorption and radiative recombination. In practical Si devices, however, several intrinsic loss mechanisms further restrict performance. One of the most significant is Auger recombination, a process in which excited charge carriers recombine by transferring their energy to another carrier rather than emitting a photon. At the high carrier concentrations required for efficient solar operation, Auger recombination becomes increasingly dominant and limits the achievable efficiency of silicon solar cells to slightly below 30%. Nevertheless, remarkable progress has been achieved through advanced device

architectures such as heterojunction (HJT) and interdigitated back contact (IBC) solar cells. Continuous improvements in surface passivation, light management, and carrier collection have pushed laboratory silicon solar cells beyond 27% efficiency, with recent record values reaching approximately 27.9% [3]. These impressive achievements indicate that silicon photovoltaics are nearing their practical performance ceiling. While incremental improvements may still occur, achieving efficiencies significantly above 30% using single junction silicon alone is extremely challenging. This realization has motivated researchers to explore alternative device architectures capable of overcoming these fundamental limitations.

► Efficiency limits of single-junction silicon solar cells

The efficiency of single-junction solar cells is limited by the mismatch between the broad solar spectrum and the fixed bandgap of a semiconductor. A solar cell can only effectively absorb photons with energies equal to or greater than its bandgap, leading to significant energy losses. One major loss mechanism is transmission loss, where low-energy photons, especially in the infrared region, pass through the material without generating electricity because their energy is below the bandgap threshold. Another important mechanism is thermalization loss, which occurs when high-energy photons are absorbed. The excess energy above the bandgap is rapidly converted into heat rather than useful electrical energy. Additional losses also arise from radiative and non-radiative recombination, where electrons and holes recombine before contributing to current generation. These combined losses impose a theoretical efficiency limit of about 33% for ideal single-junction solar cells, according to the Shockley-Queisser limit. Reducing these spectral losses is a key reason for developing tandem solar cells, which use multiple semiconductor layers with different bandgaps to capture a broader range of the solar spectrum more efficiently.

► Tandem solar cells as a solution to spectral mismatch

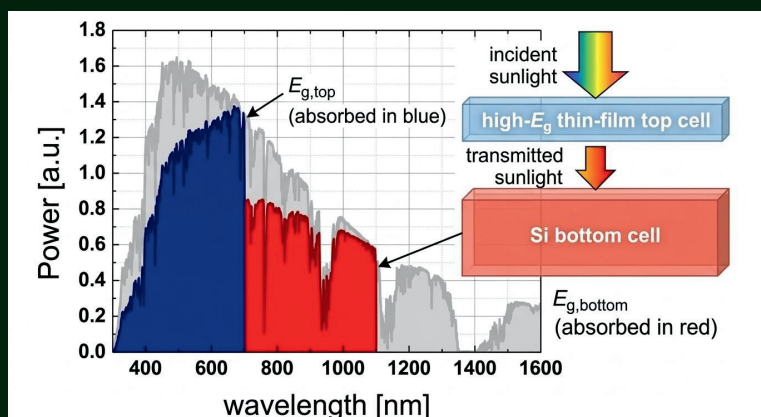
Tandem solar cells provide a powerful solution to the spectral mismatch problem by stacking multiple photovoltaic absorbers with different bandgaps in a single device structure. In this architecture, each semiconductor layer is designed to absorb a specific portion of the solar spectrum more efficiently. By dividing the solar spectrum among multiple materials, tandem solar cells can utilize a larger fraction of the incident solar energy compared with conventional single-junction devices.

In a typical two junction tandem solar cell, a wide bandgap material is placed at the top of the device. This top cell is optimized to absorb high-energy photons such as those in the ultraviolet, blue, and green regions of the solar spectrum. Because of its larger bandgap, it can convert these high energy photons with relatively small thermalization losses. Photons with lower energies, which cannot be absorbed by the top cell, pass through this layer and reach the bottom absorber. The bottom cell is usually made from a narrow-bandgap semiconductor that is capable of absorbing lower energy photons, such as those in the red and near infrared regions of the spectrum (see Figure 1). By capturing photons that would otherwise be transmitted through a wide-bandgap material, the bottom cell contributes additional electrical



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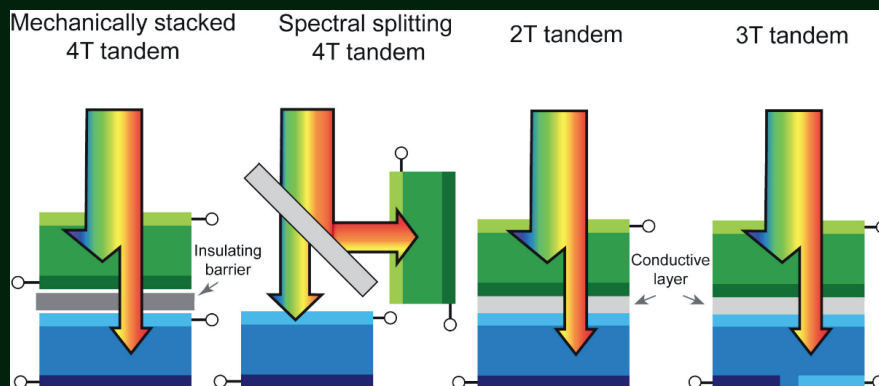


Spectral utilization in thin film on silicon tandem solar cells, showing the impact of thermalization and transmission losses. Inset: schematic representation of sunlight incident on the tandem device

power to the device. The two subcells are typically connected electrically through a thin interconnection layer, often referred to as a tunnel junction, which allows efficient charge transfer between the layers. This concept of spectral splitting allows each absorber layer to operate closer to its optimal bandgap energy. As a consequence, both transmission losses and thermalization losses are significantly reduced compared with single-junction solar cells. High-energy photons are absorbed in the wide-bandgap top cell, minimizing the amount of excess energy lost as heat, while lower-energy photons are effectively captured by the bottom cell instead of passing through the device. Because of this improved utilization of the solar spectrum, tandem solar cells can achieve substantially higher power conversion efficiencies.

Theoretical analyses indicate that the efficiency limits increase significantly when multiple junctions are used. For example, a two-junction tandem solar cell operating under standard sunlight conditions can theoretically reach an efficiency of about 42% according to detailed balance limits, which is significantly higher than the limit for single-junction devices. When a third absorber layer is added to form a three-junction device, the theoretical efficiency under ideal standard sunlight conditions can reach about 49% [4]. In practice, multijunction solar cells have already demonstrated remarkable performance, particularly in specialized applications such as space photovoltaics and concentrated solar power systems. Under concentrated sunlight, where optical systems focus a large amount of light onto the cell, advanced multijunction devices have achieved efficiencies exceeding 47% in laboratory demonstrations [5]. These results clearly illustrate the enormous potential of tandem and multijunction architectures for pushing photovoltaic technology beyond the limits imposed by conventional single-junction solar cells.

Architectures of tandem solar cells



Schematic of basic tandem solar cell configurations: 4-terminal stacked (4T-stacked), 4-terminal with spectral splitting (4T-spectral), 2-terminal (2T), and 3-terminal (3T) [7].

To fully exploit the potential of tandem solar cells, researchers have developed several device architectures that integrate multiple absorber layers into a single photovoltaic system. Each architecture presents distinct advantages and trade-offs in terms of efficiency, manufacturability, and flexibility. The most widely studied configurations include two-terminal (2T), four-terminal (4T), and three-terminal (3T) tandem structures as shown in Figure 2, each optimized for specific performance or manufacturing goals [6].

The two-terminal (2T) configuration is the most commonly pursued architecture for commercial tandem solar modules. In this design, the top and bottom cells are electrically connected in series through a thin interlayer known as the recombination layer or tunnel junction, which facilitates the transfer of charge carriers between the subcells. Because the device has only two external electrical contacts, it functions similarly to a conventional single junction solar cell, allowing it to be integrated into standard module manufacturing lines with minimal changes.

One of the primary advantages of the 2T design is its simplicity in module assembly and integration. The monolithic structure reduces the number of electrical connections required, lowers balance of system costs, and maintains the same form factor as traditional silicon panels. However, the series connection imposes a strict current matching requirement. The overall current output of the tandem device is limited by the subcell generating the lower current, meaning that careful optimization of the absorber thickness, bandgap selection, and light management layers is essential to maximize efficiency. Additionally, variations in the solar spectrum throughout the day or under different weather conditions can lead to temporary current mismatch, which may reduce the device performance under real-world operating conditions.

- **Four-terminal tandem cells**

The four-terminal (4T) architecture overcomes the current matching constraint of 2T devices by electrically isolating the top and bottom cells. In this setup, each subcell operates independently, connected to its own external circuit, allowing each absorber to generate its maximum possible current regardless of the other layer. Two main 4T configurations are commonly used: stacked 4T, where the top and bottom cells are physically layered with a transparent interlayer, and spectral-splitting 4T, where incoming sunlight is divided by wavelength using optical elements before reaching each subcell. Both configurations provide greater flexibility in material selection and enable the use of high efficiency single junction cells without extensive modification. The 4T approach is particularly advantageous under variable spectral conditions, as each cell can respond optimally to changes in light intensity and wavelength distribution. However, these designs introduce additional transparent electrodes, interlayer substrates, or optical components, which can cause optical and resistive losses, slightly reducing the active area and overall efficiency. The more complex wiring and module design can also increase manufacturing costs and complicate large scale deployment.

- **Three-terminal tandem cells**

The three-terminal (3T) configuration represents a hybrid solution that combines the benefits of both 2T and 4T architectures. In this design, an additional electrical contact is introduced, allowing power extraction from each subcell independently while still maintaining a more compact monolithic structure than 4T devices. 3T tandems are particularly effective at mitigating spectral mismatch and current limiting effects, as the intermediate contact allows each subcell to operate near its optimal power point even if the other subcell is underperforming. Some 3T designs utilize interdigitated back contact (IBC) silicon cells integrated with a perovskite top cell, which enables higher bifacial performance and improved light harvesting efficiency.

Recent experimental results have demonstrated that 3T tandem cells can achieve efficiencies exceeding 30%, rivalling the performance of 4T devices while retaining the potential for monolithic fabrication and simplified module assembly. Their robustness against varying illumination conditions and flexibility in material selection make 3T tandems a promising architecture for next-generation photovoltaic systems, particularly where a balance between efficiency, scalability, and cost is required.

► **Materials driving the tandem revolution**

The rapid advancement of tandem solar cells has been fueled primarily by innovations in semiconductor materials, with metal halide perovskites emerging as a particularly transformative class. These materials have captured the attention of researchers and industry due to their remarkable combination of tunable optoelectronic properties, strong light absorption, and facile processing methods. One of the most compelling features of perovskites is their adjustable bandgap, which can be precisely engineered by modifying the chemical composition, such as by varying the halide or cation content. This tunability allows scientists to design materials that are optimized for specific portions of the solar spectrum, making them ideal as top absorbers in tandem architectures. Beyond bandgap flexibility, perovskites exhibit high absorption coefficients, meaning that even very thin layers can capture a large fraction of incident light.

They also possess long carrier diffusion lengths, which reduce recombination losses and enhance charge collection efficiency. Additionally, perovskite films can be fabricated at low temperatures using solution processing or vacuum deposition techniques, offering a pathway to scalable, cost-effective manufacturing. Together, these attributes make perovskites an attractive material platform for next generation high-efficiency photovoltaics.

- **Perovskite-silicon tandem solar cells**

Among the various tandem configurations, perovskite-silicon tandem solar cells have emerged as the most advanced and commercially promising. In these devices, a wide bandgap perovskite layer is deposited directly onto a conventional silicon solar cell, forming a monolithic tandem structure. The perovskite top cell efficiently absorbs high energy photons from the ultraviolet and visible regions of the spectrum, while the silicon bottom cell captures the lower energy photons in the near infrared, which are transmitted through the top layer. This complementary absorption maximizes the use of the solar spectrum and significantly reduces the energy losses associated with single junction devices. The performance of perovskite-silicon tandems has improved rapidly over the past few years. Laboratory-scale demonstrations have reported efficiencies exceeding 35%, a milestone that surpasses the limits of single-junction silicon cells and validates the potential of tandem architectures. Industrial prototypes have also shown large-area efficiencies approaching 29%, demonstrating the feasibility of scaling these devices for commercial production[8]. Major photovoltaic manufacturers, including companies such as LONGi Solar, QCells, and Oxford PV, are actively developing production ready tandem modules, highlighting the transition from laboratory research to market-ready technology.

• Alternative tandem technologies

While perovskite-silicon tandems currently lead research and commercialization, other tandem solar cell architectures are also being explored. Perovskite-CIGS tandem cells combine perovskites with copper indium gallium selenide (CIGS) thin-film solar cells, making them suitable for lightweight, flexible, and semi-transparent applications such as building-integrated photovoltaics (BIPV) and portable power systems. Their thin-film structure also enables integration onto curved or unconventional surfaces. Another promising approach is the all-perovskite tandem solar cell, where both absorber layers are made from perovskites with different bandgaps. These devices offer the potential for low-cost manufacturing through printing or roll-to-roll fabrication methods while maintaining high efficiency. Laboratory-scale all-perovskite tandems have already achieved efficiencies close to 30%, demonstrating their potential for lightweight and flexible photovoltaic applications. The development of these alternative tandem technologies highlights the versatility of perovskites and their important role in the future of high-efficiency solar energy systems.

► Challenges facing tandem solar cells

Despite their remarkable efficiencies, tandem solar cells still face significant challenges that must be overcome for widespread commercial deployment. A primary concern is long-term stability, as perovskite materials are inherently sensitive to moisture, oxygen, heat, and ultraviolet light. Exposure to these environmental factors can trigger degradation mechanisms such as ion migration, phase segregation, and structural deformation, which gradually reduce device performance[9]. To address these issues, researchers are developing more robust material compositions, cation engineering, advanced encapsulation strategies, and protective interlayers. These innovations aim to enhance the durability of tandem modules and extend their operational lifetimes closer to the 25-30 years typical of conventional silicon solar panels. Another critical challenge is the environmental impact of lead, a component of many high efficiency perovskites. Even though the amount of lead in a solar module is relatively small, preventing potential contamination is essential for safe commercialization and regulatory compliance. Current strategies focus on both lead free perovskite alternatives, using elements such as tin or germanium, and protective lead-sequestering layers capable of capturing over 95% of lead in the event of module damage. By addressing both stability and environmental concerns, these approaches aim to make tandem solar cells highly efficient, durable, and environmentally safe, setting the stage for their widespread adoption in the near future.

► Conclusion

Tandem solar cells are among the most transformative advances in modern photovoltaic research. By combining multiple semiconductor absorbers with complementary bandgaps, these devices can surpass the efficiency limits of conventional single-junction solar cells, making far more effective use of the solar spectrum. In the past decade, rapid progress in materials science, especially the development of metal halide perovskites, has accelerated the evolution of tandem photovoltaics. Laboratory demonstrations now achieve record efficiencies exceeding 35%, and the first commercial tandem modules are beginning to enter the market, signaling the shift from research to real world application. While challenges remain, particularly in stability, scalability, and environmental safety, ongoing research is steadily addressing these issues. As manufacturing technologies mature and production costs decrease, tandem solar cells are poised to become a cornerstone of next generation photovoltaic systems. The transition from single-junction to tandem architectures represents not just an incremental improvement in efficiency, but a fundamental transformation in how humanity captures and utilizes energy from the Sun, unlocking new opportunities for sustainable electricity generation worldwide.

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TACKLING THE SILENT EPIDEMIC: GREEN TECHNOLOGIES FOR SAFE DRINKING WATER IN SRI LANKA'S DRYZONES

Chronic Kidney Disease of unknown etiology (CKDu) has become one of the most serious environmental health challenges facing Sri Lanka's North Central Province (NCP) and adjoining dry-zone districts. Thousands of farming families have been affected over the past three decades, often without clear warning signs until the disease has progressed. Similar patterns have been reported in rural communities of India, Central America, and parts of Africa—linking CKDu to groundwater quality, extreme heat, and prolonged dehydration during field work.

The Hidden Chemistry Behind CKDu: Most investigations now point to chemical and environmental stressors rather than infectious causes. In the affected regions, untreated well water remains the main drinking source for farmers working long hours under the tropical sun. These waters typically show:

- High salinity (electrolyte imbalance leading to kidney stress)
- High hardness (excess calcium and magnesium carbonates)
- Elevated fluoride levels (often exceeding WHO's 1.5 mg L⁻¹ limit)

When consumed repeatedly under heat-stress conditions, this chemical cocktail is believed to accelerate renal damage. Globally, about half the world's population still depends on groundwater for drinking and cooking, and more than 200 million people are estimated to be at risk from excess fluoride exposure.

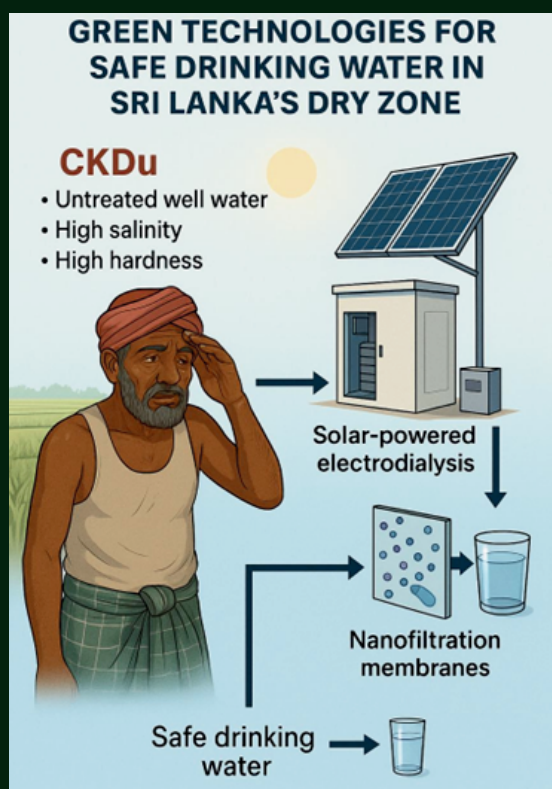
► Green Engineering Interventions

To address this pressing issue, our research team developed solar-powered electrodialysis (ED) systems capable of removing fluoride, salts, and hardness from groundwater at high flow rates and current densities. These compact units were deployed on a community and household basis across the Rajarata region and at the Rajarata University of Sri Lanka. Each installation operates primarily on solar energy, with a minimal battery backup to ensure uninterrupted operation during power fluctuations—a critical feature for remote rural communities.



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► Nanofiltration Membranes for Cleaner Water:

Complementing the ED technology, we also engineered advanced nanofiltration (NF) membranes that effectively remove the same causative ions—fluoride, calcium, and magnesium—while retaining beneficial nutrients. These membranes offer a passive, low-energy purification option for small-scale water-treatment units and can be integrated with renewable-energy-driven pumping systems.

► Toward Sustainable Water and Health Security:

Together, these green technologies—solar-powered electrodialysis and nanofiltration membranes—represent a practical pathway toward sustainable, community-level water purification. Beyond protecting public health, they demonstrate how renewable energy and advanced materials can work hand-in-hand to solve real-world environmental problems.

► The broader lesson extends far beyond Sri Lanka:

As climate change intensifies droughts and groundwater dependence, clean water is no longer just a resource—it is resilience itself. The fight against CKDu reminds us that science, compassion, and sustainability must flow together.

Call for Articles: Clean Energy Newsletter (June 30, 2026)

The **ANCEHA Research Consortium** is pleased to announce the call for submissions for our upcoming June issue. As we navigate the complexities of the global energy transition, we are placing a special emphasis on the **Multidisciplinary Approach to Clean Energy Technologies and Policy Development**.

We invite researchers, engineers, economists, and policymakers to contribute content that bridges the gap between technical innovation and real-world implementation.

► Special Focus: The Multidisciplinary Framework

Modern energy solutions require more than just engineering excellence; they require a wicked problem-solving mindset. We are seeking articles that explore the intersection of:

- **Engineering & Physical Sciences:** Breakthroughs in hardware (e.g., storage, grid stability, and efficiency).
- **Economics & Finance:** Market design, carbon pricing, and reducing the Levelized Cost of Energy (LCOE).
- **Social Sciences:** Public acceptance, energy justice, and addressing "NIMBY" (Not in my backyard) challenges.
- **Law & Public Policy:** Regulatory frameworks, permitting reform, and international climate mandates.

► Submission Themes

In addition to our multidisciplinary focus, we welcome submissions on:

- **Decarbonization Strategies** for heavy industry.
- **Grid Modernization** and smart infrastructure.
- **Green Hydrogen** and the future fuel mix.
- **Nature-Based Solutions** and biodiversity in energy projects.

► Submission Guidelines • Word Count: 800 – 1,500 words.

- **Format:** .docx files; please include high-resolution charts and/or images.
- **Perspective:** We highly encourage co-authored pieces that reflect a mix of technical and policy expertise.
- **How to Submit:** Please email your draft and a brief author bio to thanihai@univ.jfn.ac.lk

► Important Deadlines

- **Submission Deadline:** June 15, 2026
- **Review Period:** June 16 – June 25, 2026
- **Publication Date:** June 30, 2026

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