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MINISTRY OF
ELECTRONICS AND
INFORMATION TECHNOLOGY

AI IMPACT SUMMIT
भारत 2026 INDIA

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INDIA AI IMPACT SUMMIT 2026

COMPENDIUM

Real-World Impact of AI in Energy

International Energy Agency

INDIA AI IMPACT SUMMIT 2026

COMPENDIUM

Real-World Impact of AI in Energy

INTERNATIONAL ENERGY AGENCY

The IEA examines the full spectrum of energy issues including oil, gas and coal supply and demand, renewable energy technologies, electricity markets, energy efficiency, access to energy, demand side management and much more. Through its work, the IEA advocates policies that will enhance the reliability, affordability and sustainability of energy in its 32 Member countries, 13 Association countries and beyond.

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Foreword

Dr Fatih Birol
Executive Director
International Energy Agency

Artificial intelligence has rapidly emerged as an important technology with transformative potential – especially for the global energy sector. As AI's capabilities advance, building our understanding of it is essential.

Attention has largely focused on how much electricity will be consumed by AI. This is a critical question, particularly for the regions that stand to be most affected. But we should also consider how AI can be deployed to optimise energy use. If effectively harnessed, AI could improve the efficiency and management of vast, increasingly complex energy systems. This would reinforce efforts to ensure energy security, affordability and sustainability around the world.

At the International Energy Agency (IEA), we have been at the forefront of collecting and analysing data to better understand AI's implications from an energy perspective. At the AI Action Summit in Paris in February 2025, which was chaired by President Macron of France and Prime Minister Modi of India, I emphasised the importance of grounding discussions about the energy-AI nexus in numbers and facts. Shortly thereafter, the IEA published a major, first-of-its-kind report on this topic, Energy and AI, and launched a new Energy and AI Observatory to collate and disseminate the latest information.

This publication you are reading now is a collaborative effort from the IEA and the IndiaAI Mission, as a contribution to the India-AI Impact Summit being held in New Delhi. By presenting 15 impactful case studies from across the energy sector, it shows the ways in which AI is being deployed to optimise how energy is produced, consumed and distributed. They illustrate what is possible – minimising grid losses, reducing the energy needs of heavy industry and unlocking greater financing for energy access projects. They also point to how much further we could go with the right enabling conditions in place.

The case studies presented are excellent demonstrations of the India-AI Impact Summit’s principles: shaping AI for humanity, inclusive growth and a sustainable future. We hope they will support conversations among government, industry and civil society on how AI can be leveraged to deliver widespread benefits. With energy and technology now on a journey together, the IEA will keep working on this issue, ensuring that all stakeholders can navigate the energy-AI nexus with reliable information in hand.

I would like to extend my heartfelt congratulations to Prime Minister Modi for the success of the India-AI Impact Summit. Exchanges among global decision-makers on challenges of this scale are vital, playing an instrumental role in shaping our shared future.

Foreword

S. Krishnan
Secretary
Ministry of Electronics and Information Technology
Government of India

The India AI Impact Summit 2026 marks first of such AI convenings in the Global South region and is rightfully defined by three core sutras of *People, Planet, and Progress.* These sutras guide all the effort leading up to the Summit, as we focus on the impact and replicability of AI solutions across sectors and geographies.

One of our seven working group's key focus is ensuring resilience, innovation, and efficiency in AI ecosystems. We are all aware of the energy needs for large-scale AI adoption, however, the large-scale potential of AI in ensuring energy efficiency and sustainability remains to be part of regular discourse.

AI is a critical accelerator for the global energy transition. For the Global South, the opportunity is to leap-frog traditional, carbon-intensive development pathways by integrating AI into the grid from the ground up. Whether it is optimising renewable integration or enhancing grid stability, AI is becoming essential for ensuring that energy access does not come at the cost of planetary health.

Through the IndiaAI Mission, we are building the digital foundations for this transition. By democratising access to high-performance compute and energy datasets, we are empowering researchers and innovators to build solutions that enhance energy security and affordability. Our goal is to foster an ecosystem where innovation drives sustainability.

The *Casebook on Real-World Impact of Artificial Intelligence in Energy*, developed in partnership with the International Energy Agency (IEA), represents a significant step in this journey. It serves as a comprehensive reference for policymakers and innovators, providing evidence-based models for how AI can drive the digital transformation of energy systems across the world.

We acknowledge with appreciation the leadership of the Ministry of New and Renewable Energy, and the Ministry of Power, the partnership of the International Energy Agency (IEA) and the contributions of the global research community. Together, these collective efforts demonstrate that artificial intelligence can serve as a powerful instrument for equitable development—accelerating the transition to a sustainable energy future while upholding the highest standards of safety and transparency.

Foreword

Pankaj Agarwal
Secretary
Ministry of Power
Government of India

Artificial Intelligence (AI) is emerging as a transformative force across economies, with profound implications for the energy sector that underpins growth and development. While AI is itself increasingly energy-intensive, it also offers powerful tools to improve the efficiency, reliability, and resilience of energy systems. Harnessing this potential responsibly is therefore a shared global priority.

This Casebook on the ‘Real-World Impact of AI in Energy’, prepared for the AI Impact Summit in collaboration with the International Energy Agency and the IndiaAI Mission, presents practical and measurable examples of how AI can deliver value across the energy value chain. Covering energy, transport, buildings, industry, and financial access, the case studies focus on real-world deployments that demonstrate outcomes.

Collectively, they underscore a clear message: high-impact AI applications in energy are use-case driven, explainable, and resource-efficient, and can strengthen energy systems rather than strain them.

It is hoped that this casebook will serve as a valuable reference for policymakers, regulators, utilities, and industry leaders worldwide as they design AI-enabled energy systems that are resilient, affordable, and efficient.

Foreword

Santosh Kumar Sarangi
Secretary
Ministry of New and Renewable Energy
Government of India

India's energy transition is unfolding at an unprecedented speed and scale, driven by the ambitious Renewable Energy targets and reinforced by sustained Government policy support. The increasing complexity of energy systems, characterized by rapid Renewable Energy deployment, decentralized generation, and evolving end use consumption patterns, necessitates critical analysis and inputs through Artificial Intelligence (AI) intervention.

AI can potentially emerge as a key enabler to support data-driven decision-making, enhancing operational efficiencies, and facilitating seamless integration of renewable energy into the national energy mix, thereby surpassing the conventional approaches. AI can play an important role in forecasting accurate demand and generation, optimizing power flow management and estimate need for energy storage.

The use of AI would facilitate better integration of decentralized energy resources, enhancing energy efficiency across industrial, commercial, agricultural, and residential sectors, thereby supporting electricity market operations, financial risk assessment, and policy planning. These innovations are particularly relevant for a country like India, where scaling up Renewable Energy deployment must go hand-in-hand with energy access, reliability, and affordability.

As India advances towards achieving its climate commitments, responsible adoption of AI will be crucial. Knowledge-sharing of AI use-cases can play an important role in encouraging collaboration, promoting adoption of proven solutions, disseminating best practices, and enabling scalable deployment, for effective harnessing of AI in energy sector.

The Casebook on the 'Real-World Impact of AI in Energy' presents valuable insights into practical and replicable applications that demonstrate immense technical and economic benefits. I complement the authors and participants of this publication for their valuable efforts.

Foreword

Abhishek Singh
CEO, IndiaAI Mission
Additional Secretary, Ministry of Electronics and Information Technology
Government of India

The India AI Impact Summit 2026 is driven by the conviction that the three pillars of People, Planet and Progress are mutually reinforcing. The energy sector seamlessly encapsulates these interdependencies. As the world's energy infrastructure becomes increasingly electrified, digitised and decentralised, AI provides the critical intelligence needed to manage this new complexity effectively.

The global AI agenda has moved decisively to deployment and adoption. We are seeing AI deployed across the entire energy value chain—from optimising energy supply and electricity generation to enhancing efficiency in industry, transport and buildings. AI-driven predictive maintenance extends the lifespan of critical assets, while Machine Learning models manage the variability of renewable sources like solar and wind to ensure grid stability.

The IndiaAI Mission is committed to democratising these capabilities. We believe that the tools for energy efficiency should be accessible to all nations, particularly emerging economies where the demand for power is growing fastest. Through our collaborative platforms, we are facilitating the exchange of best practices, for solutions developed in one context to be adapted to strengthen energy security across the globe.

The *Casebook on Real-World Impact of Artificial Intelligence in Energy*, developed in partnership with the International Energy Agency (IEA), is a realisation of this commitment. This joint initiative invited contributions from experts worldwide, receiving 72 abstracts across energy domains like supply management, electricity generation, transmission and distribution, and energy use in industry, building and transportation. The submissions underwent a multi-stage screening process, following an evaluation by an inter-ministerial expert committee to secure the inclusion of the most impactful, evidence-based and replicable solutions.

The resulting Casebook presents a curated set of 15 case studies that demonstrate the transformative potential of AI in the energy domain. The Casebook also presents an overview of use-cases identified by IEA over time under IEA's global observatory. We extend our sincere appreciation to leadership provided by the Ministry of New and Renewable Energy and Ministry of Power, and the partnership of the IEA for advancing responsible AI in the energy sector. Together, these efforts reaffirm that AI is a critical enabler of a secure and sustainable energy future.

Disclaimer

The case studies included in this compendium have been evaluated based on information submitted by the respective authors and participating organisations. Responsibility for the accuracy of data, metrics, and representations rests solely with the submitting authors. The evaluation committee and partner institutions shall not be held liable for any discrepancies, omissions, or subsequent changes in the information provided.

Partners

IndiaAI Mission, Ministry of Electronics and Information Technology (MeitY) and International Energy Agency

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Table of contents

Introduction **13**
The role and potential of AI in energy systems 14
What this compendium contains 16
Energy supply **18**
Case study 1: Accelerating biofuel and hydrogen production in AI-powered biorefineries 18
Power generation and electricity systems **21**
Case study 2: AI unifies renewables, storage and trading for smarter grid management 21
Case study 3: AI helps map the grid, cut losses and modernise power distribution 25
Case study 4: AI-driven solar power forecasting cuts penalties for large-scale solar plants 28
Case study 5: AI-driven energy cloud reduces operational costs and improves capital efficiency in off-grid electricity assets 31
Case study 6: Keeping electrical addresses current with AI in smart metering programmes 34
Case study 7: AI-powered rooftop solar design tool boosts productivity for solar installer 37
Energy consumption **40**
Case study 8: AI-enabled smarter, flexible charging at electric bus depots 40
Case study 9: AI-powered efficient routing of vehicles 44
Case study 10: AI helps transform buildings from passive consumers to active energy optimisers 47
Case study 11: A retrofit-first AI strategy delivers efficiency gains in buildings 50
Case study 12: AI-powered automation cuts energy use at super-specialty hospital 53
Case study 13: AI-enhanced rail inspection reduces rework and emissions in steel production 56
Case study 14: AI-powered analytics for blast furnace thermal control reduces fuel consumption and emissions in steel production 59
Energy access **62**
Case study 15: AI helps unlock clean energy asset financing, accelerating energy access 62
Case studies from the IEA Energy and AI Observatory **65**
Energy supply 65
Power generation and electricity systems 67
Energy consumption 70
Energy innovation 74
Glossary **76**

Introduction

Artificial intelligence is one of the most consequential technological developments in recent years, and energy is at the heart of it. The relationship between energy and AI is bidirectional: on the one hand, AI demands energy, and this energy demand has been steadily growing. On the other hand, AI can help optimise the energy sector, unlocking efficiencies and improving its management.

Analysis by the International Energy Agency (IEA) estimates that global electricity consumption by data centres could double by 2030, by which time data centres globally are projected to use as much electricity in a year as Japan. At the same time, AI is already being deployed by energy companies to transform and optimise energy supply, consumption and operations. There are numerous objectives in play, including lowering costs, reducing energy demand, boosting supply, extending asset lifetimes, limiting downtime and curbing emissions.

The IEA has been at the forefront of setting the agenda on the energy-AI nexus. In 2025, it launched *Energy and AI*[1], its flagship global study on the topic, and the *Energy and AI Observatory*[2], a platform that provides up-to-date data and analysis on the links between the fast-growing technology and the energy sector. This follows continued engagement with government, industry, innovators and civil society in recent years, including through IEA's *Global Conference on Energy and AI* in 2024.

To further advance this work and support the objectives of the India-AI Impact Summit 2026, the IEA and IndiaAI Mission, under the aegis of Ministry of Electronics and Information Technology, Government of India, solicited case studies that illustrate the impact of AI on the energy sector. The objective is to present examples of the potential and impact of AI in energy and fuel supply, electricity generation and grids, energy consumption and more, with 15 shortlisted case studies that span a range

[1] IEA, 2025, Energy and AI, https://www.iea.org/reports/energy-and-ai.
[2] IEA, 2025, Energy and AI Observatory, https://www.iea.org/data-and-statistics/data-tools/energy-and-ai-observatory.

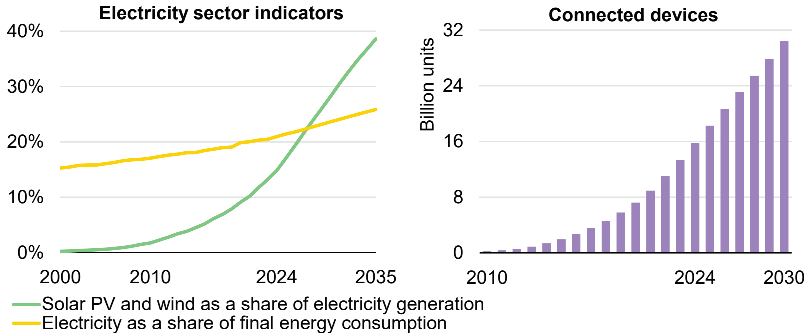
of energy sub-sectors. The compendium also provides an overview of an additional 20 case studies that are a part of the IEA's *Energy and AI Observatory*.

The role and potential of AI in energy systems

The energy sector, which serves as the backbone of the global economy, is currently undergoing a series of structural changes, which create new challenges as well as opportunities. These key trends include:

- **Rising electrification**: The overall share of total final energy consumption met by electricity has been steadily rising, and is projected to accelerate over the coming decade.
- **Growing digitalisation**: Energy systems are becoming more digitalised and integrated through the proliferation of connected devices and appliances, electric vehicles (EVs), and smart meters and sensors.
- **Increasing complexity**: Patterns in supply, demand and energy flows are becoming more intricate as power systems integrate growing shares of variable renewables such as wind and solar; greater installed capacity of batteries, which have complex charge and discharge cycles; and an increasing number of connected devices and appliances. This has raised the sheer volume of individual components and nodes that require monitoring and management.

Global electricity sector indicators, and stock of connected devices



IEA. CC BY 4.0.

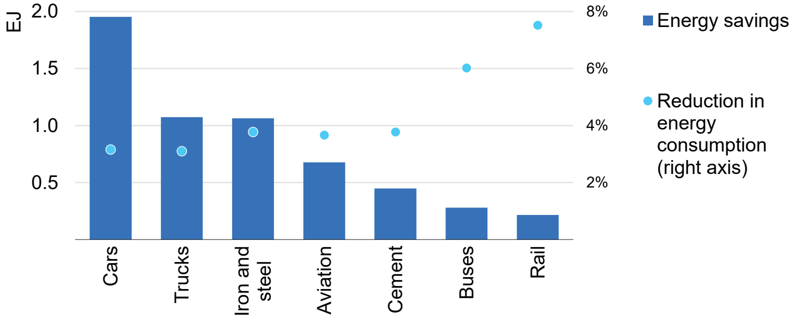
- **Pressure on costs**: Recent years have been challenging for energy consumers around the world, with high energy prices putting significant pressure on the cost of living. The energy sector has also become more competitive, with new entrants on both the supply and end-use sides of the market. These factors have introduced new pressures in established markets.

- **Competition and pressure on supply chains:** With high degrees of geographic concentration in the supply of key energy minerals, fuels and technologies, there is rising pressure to bolster energy and economic security.

In addition, the energy sector is also the focus of several important policy priorities and ambitions set by governments. These include objectives by countries to decrease their dependence on energy imports, reduce pollutants to address air quality concerns, and reduce greenhouse gas emissions to tackle climate change.

It is in this complexity and wide range of competing objectives that AI thrives. AI applications in the energy sector have been documented to reduce costs, energy use and emissions, while helping improve the accuracy of forecasts and automate the management of energy systems.

Global energy savings potential from the widespread adoption of AI-based optimisations, 2035



Source: IEA (2025), World Energy Outlook.

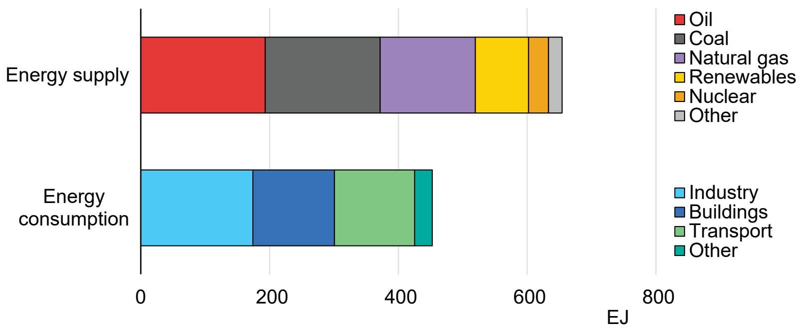
The IEA's *Energy and AI* special report published in April 2025 estimated the potential for AI to deliver optimisations across the energy industry. The analysis found that the widespread adoption of commercially deployed AI applications in the energy sector globally has a potential to save over 13 exajoules (EJ) of energy by 2035, which is larger than the annual energy consumption of Indonesia today. These savings come from improved efficiencies across the key energy consuming sectors. In the transport sector, for example, the widespread adoption of AI applications could lead to annual energy savings equivalent to the energy used by 120 million cars by 2035. The report explores similar global potential across other key energy sub-sectors.

What this compendium contains

This compendium contains case studies of AI optimisations across the key parts of the energy system. It spans energy supply, power generation and electricity systems, and end-use energy consumption, which includes transport, buildings and industry.

The case studies collectively demonstrate how AI is already delivering significant, measurable gains across the energy sector. These include, for example, an AI system for building management that reduced energy consumption by 20-25% and avoided significant emissions and AI-enabled electric bus charging that increased fleet uptime to over 90%, and cut peak electricity demand charges by over 20%. They also cover an AI-enabled tool that improves solar forecasting accuracy, helping to reduce regulatory penalties for generation companies, as well as an AI-driven industrial inspection tool that reduced defects, avoiding waste and reducing energy consumption. Together, these examples and others showcase the breadth of AI's real-world impact, demonstrating how rapidly and practically AI is transforming energy systems end-to-end.

Total energy supply by source, and total final consumption by end-use sector, 2024



These case studies were solicited in an open call that resulted in more than 70 submissions from around the world. The case studies featured in this report were selected for publication by a committee comprising of officials from the Government of India's Ministry of New and Renewable Energy, Ministry of Power, and Ministry of Electronics and Information Technology – and the IEA. The committee sought AI solutions that have had a measurable impact in the energy sector and could be scalable. For the purposes of this compendium, AI is broadly considered to comprise the modern AI approaches, such as machine learning and deep learning.

In addition to the case studies featured in this compendium, some submissions were from organisations that enable and support the broader AI innovation ecosystem. While they were not included in this compendium as they are not technology solutions, two notable examples bear mentioning. Climate Collective, an organisation that provides support to climate technology startups, runs the ElectronVibe programme, which helps utilities in India identify, test, and deploy AI-enabled startup solutions to improve grid management, forecasting, asset performance and overall system flexibility. Since 2020, the ElectronVibe platform has engaged 22 utilities and 63 startups, leading to over 15 pilot projects. These pilots include a project with a Delhi power utility that reduced outage response times, and another project that enabled the optimised scheduling of EV charging. These projects also helped reduce greenhouse gas emissions. A second example is ENGIEUrja.ai, a programme that connects global startups that seek to solve critical challenges in India's renewable energy sector to Engie India, an established industry player. These programmes illustrate the role of platforms and networks in fostering a community of innovators and solution providers from which future AI solutions for energy might emerge.

Energy supply

Biorefining

Case study 1: Accelerating biofuel and hydrogen production in AI-powered biorefineries

BIOLOOP

Summary

Unstable yields in biorefineries due to contamination and inconsistent conditions hinder reliable fuel production of next-generation fuels such as biofuels and low-emissions hydrogen. A low-cost AI system provides real-time monitoring and autonomous adjustment of reactor parameters for stabilisation. When deployed at a biorefinery in Karnataka, India, biofuel output increased by 18-27% and hydrogen production by 14-22%, and energy consumption was reduced by 10-15%.

Context

India is rapidly expanding its clean energy portfolio through advanced biofuels and green hydrogen under national missions to lower emissions and reduce fossil fuel dependence. Algal bioreactors are a promising pathway for next-generation fuels, but their performance is often unstable due to high biological variability. Maintaining steady output requires constant control over light, nutrients, mixing and temperature. Traditional monitoring is often slow and resource-heavy, making consistent high yields difficult. The BIOLOOP team operates pilot-scale bioreactors in Karnataka where it has implemented a low-cost, locally automated system to stabilise production in real time.

Challenge

Algal biofuel and hydrogen production depends on living microorganisms, which makes the process highly sensitive to small changes in temperature, light, nutrients, contamination and mixing. Even minor disturbances can cause sharp drops in fuel output. In most pilot and early-stage biorefineries, reactor monitoring is still manual and intermittent. Operators rely on visual checks or delayed lab measurements, which means problems are detected only after a loss has already occurred.

Contamination is a major challenge in this sector. Bacterial growth or imbalance in algal health can spread quickly through a reactor, leading to full batch loss and long downtime before recovery. Traditional sensors used in industrial bioprocessing are expensive, require skilled technicians, and are often unsuitable for smaller or rural clean-fuel units.

These limitations create inconsistent yields, higher operating costs and difficulty in scaling production to meet national clean-fuel targets under India's National Biofuel Mission and National Hydrogen Mission. Small clean-energy developers, universities and start-ups often lack access to advanced control systems, resulting in energy waste, lower productivity and dependence on intensive human supervision. There is a clear need for an affordable, automated, real-time monitoring and control system that can maintain stable production and reduce failures across biofuel and hydrogen reactors.

Solution and impact

The BIOLOOP team developed a low-cost AI system that continuously tracks biological and environmental signals inside algal reactors. Instead of relying on delayed lab tests, the AI observes real-time changes in emissions, growth patterns, temperature, light and nutrient behaviour, allowing it to detect early signs of contamination, stress or imbalance.

The core technology uses machine learning models that learn and define "normal" reactor behaviour. When the system notices unusual activity, it alerts the operator and automatically adjusts parameters such as mixing, light levels or nutrient supply to stabilise the culture. The solution was designed to run on a compact edge device that does not require cloud computing, making it suitable for rural or small-scale clean-fuel facilities.

During pilot deployment, the AI system delivered 18-27% higher biofuel lipid yield and 14-22% higher hydrogen production. It resulted in 10-15% energy consumption reduction. These improvements were possible because the AI intervened earlier and faster than what is achieved with manual checks, preventing losses that normally occur between human inspections. This system is more affordable and easier to deploy compared with traditional automation tools, as it does not depend on expensive industrial sensors or specialised technicians.

The solution was designed and developed by the project team and is operated in pilot-scale reactors in Karnataka. The solution can be scaled across the biofuel and hydrogen sector, especially in distributed or village-level biorefineries. Supportive policies under the National Biofuel Mission and the National Hydrogen Mission could accelerate adoption by encouraging low-cost automation in emerging clean-fuel plants. The system has low operating costs, minimal computing requirements and no major risks beyond standard biological safety practices, making it a practical tool for India's clean energy supply growth.

Based on information provided by BIOLOOP

Power generation and electricity systems

Power project operations

Case study 2: AI unifies renewables, storage and trading for smarter grid management

Smart Grid Analytics

Summary

The modern-day grid is complex and requires modern management tools and techniques, factoring in variable renewable electricity generation, energy storage and interactions with trading exchanges. This AI solution brings renewable electricity generation, storage and India Energy Exchange (IEX) trading into one decision loop. It predicts near-term generation and market price movements, plans battery charge and discharge within safe operating limits, and produces dispatch schedules that are ready for execution and trading. In operation, it has improved forecast reliability to around 95%.

Context

As the share of renewables in the electricity mix rises, the system becomes more variable: solar and wind output changes by the hour; grid operators expect tighter discipline; and commercial performance increasingly depends on how well generation and storage are planned, controlled and traded. In parallel, the electricity exchanges such as IEX are making energy value more time-sensitive: the same unit of electricity can be worth very different amounts depending on when it is delivered and how reliably it follows the schedule. This also has an impact on emissions from the electricity sector. Better forecasting and dispatch reduce avoidable curtailment of renewables, reduce inefficient balancing actions and allow clean energy to be absorbed more effectively. By reducing avoidable curtailment and last-minute balancing actions, AI-enabled dispatch improves renewable absorption and lowers the emissions intensity of grid operations.

Challenge

Most renewable energy operations today run in a siloed way. Forecasting is typically handled separately from plant control, often by different teams or tools. SCADA[3] operations focus on alarms, availability and compliance. On the other hand, commercial decisions, especially market participation, sit outside the operational loop. Battery energy storage, where it exists, is frequently used as a reactive buffer to manage deviations, rather than as a planned economic and grid-support asset.

This fragmentation creates operational stress. Trading teams have limited visibility into true plant capability, battery constraints, degradation risk and fast-changing grid conditions. Operators, on the other hand, are asked to execute schedules that may not fully reflect weather uncertainty, battery limits or market dynamics. The result is a suboptimal pattern: last-minute schedule changes, avoidable deviations, conservative bidding on some days and aggressive battery cycling on others. Over time, this leads to missed market opportunities; higher imbalance exposure; and increased battery stress from high C-rate events (periods when a battery is pushed into unusually high charge or discharge rates), deep state-of-charge (SOC) swings (large or frequent fluctuations in battery charge level) or thermal excursions.

The challenge is compounded by strict market timelines. Day-ahead and intraday IEX windows leave little room for manual reconciliation when forecasts shift or prices move quickly. Decisions must be made fast, must be explainable to operators and must balance grid discipline with asset protection. Without an integrated, AI-driven approach, teams are forced to choose between protecting the battery and maximising value, when both are required.

[3] SCADA stands for supervisory control and data acquisition and is a system used in industry to collect data from equipment, control processes and monitor operations in real time.

Solution and impact

Smart Grid Analytics' solution addresses the challenge by treating renewable generation, battery storage and market participation as one continuous, AI-driven system, from grid to market. The platform, Solvyn AURA, applies AI to connect real-time plant behaviour with forward-looking operational and commercial decisions. At the foundation, it integrates with equipment already deployed at utility-scale sites, such as inverters, power quality meters, weather stations, protection relays, power plant controllers and energy management systems (EMSs), and battery energy storage system components through standard SCADA and industry protocols. This ensures the solution works with existing infrastructure rather than replacing it.

AI is used in a practical, explainable way. Operators and traders review the AI outputs through dashboards showing forecast confidence, dispatch rationale, constraint drivers (SOC/thermal/grid) and deviation risk, ensuring human approval remains part of every final schedule and bid. Forecasting models combine live telemetry with weather inputs to predict short-term generation and variability. Digital twin models represent how the plant and battery are expected to behave under different operating conditions. These models are fed into an EMS that evaluates battery limits, grid constraints and IEX price signals together, producing dispatch and trading schedules that are both executable and economically aligned. Unlike traditional rule-based or spreadsheet-driven approaches, the system continuously adapts as conditions change, rather than relying on static assumptions.

The solution is developed, owned and operated by Smart Grid Analytics Pvt. Ltd, and is commercially deployed across renewable and hybrid energy projects. In operation, it has improved forecast reliability to around 95%, reduced last-minute schedule deviations, enabled more disciplined IEX participation and shifted battery operation from reactive usage to planned, lower-stress cycling, supporting both revenue generation and asset longevity.

Adopters of the solution include independent power producers, renewable energy developers, and asset owners operating utility-scale solar, wind, and hybrid projects in India. The platform is being adopted by operations, maintenance and trading teams responsible for forecasting, dispatch, and battery operations. Internationally, the solution is being evaluated for deployment in regions with similar market-based renewable integration frameworks across Asia, the Middle East and Africa.

Solvyn AURA is designed to scale across solar, wind and storage assets, as well as across regions with similar market and grid structures. Wider adoption can be accelerated through policies that support data standardisation, encourage storage participation in energy markets and recognise AI-driven EMS platforms as grid support tools. The solution runs on conventional industrial computing infrastructure, requires minimal additional hardware, and is operated by existing plant and trading teams, making it practical, scalable and ready for broader industry deployment.

Based on information provided by Smart Grid Analytics

Power distribution

Case study 3: AI helps map the grid, cut losses and modernise power distribution

Pravāh

Summary

Indian electricity distribution utilities lose significant capital annually due to aggregate technical and commercial (AT&C) losses and inefficient power procurement. An AI-native decision support engine developed by Pravāh digitises the grid, forecasts demand and simulates power flows to localise losses. The solution was awarded by the Indian Ministry of Power and has been deployed with utilities in India in Maharashtra, Tamil Nadu and Delhi. The solution enables faster loss reduction, lower procurement costs and improved reliability.

Context

India's electricity distribution sector continues to incur significant losses, even though national AT&C losses have declined from over 25% to the mid-teens in recent years. India performs poorly relative to other major economies, where distribution losses typically range from 5% to 8%. These losses raise power procurement costs, weaken utility finances, delay payments to generators, and constrain generation and grid investment. Losses are highly localised, yet utilities often lack accurate digital maps, feeder-level analytics and real-time decision tools to identify and address them systematically.

Challenge

Indian electricity distribution companies face three interlinked challenges that directly drive AT&C losses and financial stress:

First, poor network visibility. Many utilities do not have accurate maps of poles, lines, transformers and feeder topology. Manual network mapping typically takes five or more years and requires large field teams, delaying loss audits, load flow studies and investment planning. Without a digital network model, losses cannot be localised beyond broad feeder averages.

Second, limited ability to isolate and explain losses. Even where accurate geographic data exists, utilities struggle to distinguish among technical losses,

overload-driven losses, power factor issues and commercial losses. Load flow studies are often static, and fail to fully reflect real operating conditions or changing demand patterns.

Third, inaccurate demand forecasting, especially at short time horizons. System-level forecast errors force utilities to buy expensive short-term power or dump surplus energy at a loss. At the feeder-level, lack of forecasting leads to overloads, outages and hidden technical losses that increase AT&C figures.

These challenges reinforce one another. Without a mapped network, load flow cannot be trusted. Without load flow, losses cannot be isolated. Without accurate forecasts, procurement and operations remain reactive. Breaking this cycle requires a unified, AI-native decision layer rather than isolated tools.

Solution and impact

Pravāh is building an AI-native decision support engine that integrates network mapping, load flow analysis and demand forecasting into a single operational platform for Indian utilities.

1. Automated network mapping

Pravāh uses satellite and street-level imagery with computer vision models to automatically detect poles, trace lines and reconstruct distribution topology. This approach has already been deployed in Sangli district with Maharashtra State Electricity Distribution Co. Ltd, mapping the entire network in months rather than the five or more years required for manual geographical surveys. The output is a digital twin of the grid, which becomes the foundation for loss analysis, planning and forecasting. The solution is now being scaled further across other states.

2. AI-driven load flow and loss isolation

Using feeder and substation telemetry, Pravāh applies AI-assisted load flow models to simulate real operating conditions and identify where losses originate: overloaded conductors, low power factor feeders, phase imbalance or abnormal consumption patterns. In Tamil Nadu, this approach is being used with Tamil Nadu Power Distribution Corporation Limited to prioritise high-loss feeders and guide maintenance and reinforcement decisions. Unlike traditional studies, the models update continuously as conditions change.

3. System and feeder-level demand forecasting

For BSES Rajdhani Power Limited in Delhi, Pravāh delivers system-level and feeder-level demand forecasts across day-ahead, intraday and week-ahead horizons. Improved accuracy directly reduces exposure to high-cost short-term power markets and deviation penalties. At the feeder level, forecasts help prevent overloads and outages, reducing technical losses and improving billed energy.

By reducing losses and forecasting demand more accurately, utilities can avoid emergency fossil-based procurement, integrate higher shares of renewable generation without curtailment, and operate the grid with greater stability during heatwaves and monsoon events. For India’s billion-plus population, AI-native grid intelligence offers a practical pathway to reduce losses, stabilise procurement costs and ensure that electricity functions as a reliable public good rather than a recurring constraint.

Pravāh’s AI-native approach was validated nationally as it won the Powerthon, a competitive innovation challenge organised by the Ministry of Power, Government of India. Following this recognition, the platform is now being scaled across multiple Indian utilities, including deployments and pilots with the Andhra Pradesh Eastern Power Distribution Company Limited, Himachal Pradesh State Electricity Board Ltd, Kerala State Electricity Board Ltd and Uttar Pradesh Power Corporation Limited, demonstrating replicability across diverse grid conditions and loss profiles.

Based on information provided by Pravāh

Solar power generation

Case study 4: AI-driven solar power forecasting cuts penalties for large-scale solar plants

Infutrix Technologies

Summary

Solar generation in some regions can be highly variable due to rapidly changing cloud patterns, leading to grid imbalances and financial penalties under certain regulatory frameworks. Voltura AI, a solution by Infutrix Technologies Pvt. Ltd, applies an AI-powered, multi-sensor forecasting system that combines satellite data, on-ground sky cameras, weather stations and supervisory control and data acquisition (SCADA) inputs. Across 500 megawatts (MW) of deployments, the deployed solution reduced forecast error from 30-40% to 15-20% and lowered penalties by nearly 50%.

Context

India has over 135 gigawatts (GW) of installed grid-connected solar capacity, which is projected to more than double by 2030. However, tropical weather, monsoon variability and sparse local sensing make short-term forecasting highly uncertain. Solar plants must submit day-ahead and intraday schedules, and deviations trigger DSM penalties[4] and balancing overheads. Large solar parks, often spread across kilometres, experience heterogeneous cloud movement that conventional forecasting based on numerical weather prediction fails to capture. Voltura AI was developed as a ground-aware, AI-native forecasting platform to improve short-term accuracy, enhance scheduling confidence and support grid reliability, which is essential for solar growth in India.

[4] India's Deviation Settlement Mechanism (DSM) is the regulatory framework that penalises or rewards electricity generators and buyers when they deviate from their scheduled generation or consumption. It is designed to maintain grid frequency, discipline and system reliability.

Challenge

Solar power producers face a fundamental challenge: electricity generation fluctuates continuously based on cloud cover, atmospheric conditions and solar position, while grid operations require advance commitments on how much power will be supplied. Traditional forecasting methods rely on historical averages or coarse weather forecasts, which often fail to capture sudden, localised weather changes.

As a result, many solar plants experience large deviations between forecast and actual generation. In markets such as India, these deviations lead to DSM penalties, reduced revenues and operational uncertainty. The problem becomes more severe for large solar parks and geographically dispersed plants, where cloud movement across different sections of the plant can vary significantly.

In addition to financial losses, poor forecasting impacts grid stability. Over- or under- scheduling forces to grid operators to rely on expensive balancing resources, undermining the reliability and efficiency of renewable-heavy power systems. The sector therefore needs a forecasting solution that can respond dynamically to real-world conditions, operate at scale and provide actionable insights to plant operators, not just static predictions.

Solution and impact

Voltura AI is an AI-powered, hyperlocal solar forecasting platform that fuses SCADA and plant performance data, on-site and peripheral 180 ° sky cameras, weather station parameters, satellite imagery, and historical operating patterns.

Computer vision models classify cloud type, estimate cloud motion vectors, and compute cloud modification factors. These are combined with irradiance-to-power regression models to produce real-time and two-hour-ahead power forecasts, enabling operators to proactively align schedules and reduce DSM risk. Voltura has been validated through pilots and proofs of concept across 500 MW of solar capacity spanning Northwest, Central and South India. Across these deployments, root mean square errors, which quantify how far predictions are from actual values, reduced from 30-40% to 15-20%, leading to approximately 50% reduction in DSM penalties, smoother dispatch planning and greater confidence in intraday decision-making.

If scaled across India's current 130 GW solar capacity base, even a 1% DSM reduction equates to approximately INR 150 crore (Indian crore rupees) to INR 200 crore annual savings. Improved forecasting reduces balancing power reliance. Enhanced renewable integration and grid reliability prevents grid failures, and the solution would also strengthen bankability of renewable energy investments.

If India’s installed grid-connected solar capacity increases to 280 GW by 2030, this could represent multibillion-dollar avoided risk and significant carbon-positive system benefits. Voltura operates as a Forecast-as-a-Service platform, designed for rapid scaling across portfolios. The strongest benefit is seen in large solar parks, where per-megawatt costs fall while savings increase. The platform is in advanced pilot and pre-commercial deployment, built for expansion as an Indian solution across emerging markets with similar tropical weather regimes.

Based on information provided by Infutrix Technologies

Power distribution, off-grid and microgrid projects

Case study 5: AI-driven energy cloud reduces operational costs and improves capital efficiency in off-grid electricity assets

Tata Consultancy Services

Summary

Utilities are experiencing steadily growing demand growth, contributing to higher investment needs, rising costs and system complexity. A patented hybrid AI platform from Tata Consultancy Services (TCS) has enabled 15-20% lower operational costs and 30-40% better capital efficiency in an off-grid pilot project in Uttar Pradesh by managing energy assets as an integrated "energy cloud".

Context

India's electricity demand has been surging with consumption growing by nearly 50% between 2020 and 2025. This growth is fuelled by increasing demand from appliances, cooling requirements, electrified fleets, industrial electrification and data centres. To keep up with demand and modernise India's power infrastructure, new investments will be needed over the next decade across the system, in generation, grids and storage.

Concurrently, the energy ecosystem is shifting towards distributed, cleaner sources such as solar and wind. Non-fossil sources now account for 50% of the installed capacity. Alongside this capacity expansion, off-grid solutions too have room to grow, unlocking greater distributed generation and the ability of consumers to switch sources, as the availability and price points vary across time.

Meeting the exponential demand in the context of an emerging diversified portfolio of distributed prosumers requires a unique approach that can deal with the complexity of the system and help reduce operational costs.

Challenge

As the electricity system grows more complex, flexibility becomes a more significant challenge. This is because energy sources are becoming heterogenous, distributed and intermittent, while at the same time, consumers are becoming prosumers, with generating as well as storage assets. As a result, the value of energy and its availability are becoming complex, influenced by source, volume, time and location. Static plans fail under emergent conditions such as cloud cover or spike in demand, requiring dynamic, near-real-time adaptations.

Harnessing the flexibility offered by distributed, cleaner energy sources goes beyond better analytics, pre-planned trading charts and power purchase agreements. This is a real-time energy value chain problem impacting every player across the ecosystem. Globally, concepts such as virtual power plants (VPPs) and microgrids are also being explored towards this end.

However, an over-reliance on rigid, predefined internal company rules can handicap today's approach to handle the dynamic nature of flexibility and emergent conditions. Since utilities connect customers and grids, utilities are in the best position to harness energy flexibility. Doing so is critical to improve margins and remain relevant to consumer needs. To leverage energy flexibility at scale for consumers, utilities can move beyond today's static services towards dynamic, smart, and personalised energy products.

Solution and impact

The hybrid AI platform developed by TCS is engineered for utilities and enterprises operating in complex electricity grids. It conceptualises the energy assets and sources as an integrated "energy cloud", enabling holistic analysis and actionable, transparent decisions with automated interventions that optimise both electricity and carbon costs. By dynamically clustering different assets and buildings across locations, it maximises the available energy flexibility with the consumers and ecosystem. It does so while remaining aligned to the business goals of the consumers and utilities, and also to grid constraints.

Unlike platforms that leverage generative AI as the primary technology producing stochastic and non-repeatable outcomes, TCS's approach integrates physics-based models with advanced AI techniques to deliver decisions that are deterministic, explainable and repeatable.

The hybrid AI platform is characterised by several facets, including:

- Physics-informed intelligence grounded in asset constraints and physical laws.
- Predictive decision-making that anticipates future system states for optimal decision-making.
- Multi-horizon adaptability that enables decisions across short-, medium- and long-term horizons for adapting to emergent conditions and ecosystem dynamics.
- Proactive uncertainty modelling that facilitates stable and dependable results.
- Dynamic response modelling that minimises decision reversals by anticipating system reactions.
- Transparent reasoning that provides clear explanations to foster trust.

The platform allows utilities to design dynamic, personalised products that reduce customer energy bills, lower capex for network roll-out, and lower their own energy generation and/or procurement costs.

Developed entirely in India by local researchers, this patented platform has been deployed in rural microgrids in Uttar Pradesh in collaboration with the Indian Institute of Technology Kanpur and the Department of Science and Technology, Government of India. This pilot deployment has demonstrated 15-20% reduction in operational costs and 30-40% improvement in capital efficiency.

TCS is currently engaging with the Department of Science and Technology, and India’s electricity market operator to scale this platform across rural microgrids, unlocking latent flexibility, enhancing financial viability and strengthening grid resilience.

Based on information provided by Tata Consultancy Services

Power distribution

Case study 6: Keeping electrical addresses current with AI in smart metering programmes

Secure Meters Limited

Summary

Many Indian utilities lack a reliable "electrical address" linking each consumer meter to the right distribution transformer (DT) and feeder. Dynamic Indexing is an AI-enabled service that reconstructs this connectivity from smart meter and geographic data. In a roll-out of an advanced metering infrastructure service provider (AMISP), it lifted topology accuracy from about 60% to above 90% in well-metered areas and reduced unassigned consumers.

Context

India is deploying smart meters at national scale to improve billing, loss reduction and service quality. This is being implemented through programmes such as the Revamped Distribution Sector Scheme (RDSS), including total expenditure delivery models that use private partners to finance, deploy and operate advanced metering infrastructure (AMI) services. By December 2025, over 20 crore smart meters had been sanctioned under RDSS and nearly 5 crore had been installed across schemes. Smart metering creates a new digital layer of operational and energy accounting data, but its value depends on trustworthy network connectivity, from feeder to DT to consumer.

Challenge

Even with smart meters, connectivity records often stay fragmented and out-of-date. Utilities may have partial geographic information systems (GISs), outdated asset registers and field changes that are not reflected in systems. In fast-growing urban and semi-urban areas, new connections, network reconfiguration and informal updates mean that a map produced by a survey can become stale over time. Traditional fixes such as manual surveys and periodic GIS clean-ups are slow, expensive and hard to repeat at the pace of change.

Data issues compound the problem: incorrect or missing co-ordinates, incomplete DT or feeder metering, communication gaps, and inconsistent scope boundaries across areas. In the field, this shows up as practical anomalies such as DTs with incorrect co-ordinates and parent assets that do not align with downstream reality, plus metering time drift that undermines comparability of profiles across assets.

Finally, if a consumer is manually or programmatically assigned to the wrong parent asset, downstream actions such as loss audits, billing investigations and maintenance planning can be misdirected, which reduces trust.

Solution and impact

Dynamic Indexing treats connectivity as a living data product rather than a one-off exercise. It combines smart meter profile similarity signals with available geospatial priors to propose feeder, DT and consumer linkages. An explainable and confidence-based framework applies data sufficiency and quality thresholds, so assignments are made only when evidence is strong, while low-confidence cases are published as an exceptions catalogue for field and/or data remediation. This reduces the risk of incorrect “force fit” assignments and provides clear work lists for operational teams and data stewards.

Secure Meters Ltd developed Dynamic Indexing and operates it as a commercially deployed service within AMISP programmes. Dynamic Indexing does not require personally identifiable information and keeps humans in the loop for verification and closure of exceptions.

Deployed as a modular service within an AMISP environment, Dynamic Indexing runs on a regular cadence and integrates into existing workflows for energy accounting, operations and maintenance, and loss management. In a large Indian utility roll-out across multiple subdivisions (hundreds of geographic areas, tens of thousands of DTs and millions of consumers), validation showed that in well-metered areas, DT-to-consumer indexing accuracy was about 90.3% and DT-to-feeder accuracy was about

82.7% on test sets. It reduced unassigned consumers and surfaced systemic issues such as incorrect GIS co-ordinates and time drift in meter clocks.

Impact spans people (fairer billing and faster field response), planet (better targeting of loss reduction) and progress (a scalable digital foundation for additional AMI analytics use cases).

Scale-up enablers include minimum data-coverage gates for parent assets, master-data quality standards for GIS and asset registers, and clearer governance on scope boundaries and exception closure. Costs are mainly data engineering, integration into existing systems and ongoing operational processes, rather than large bespoke field surveys.

Based on information provided by Secure Meters Limited

Rooftop solar

Case study 7: AI-powered rooftop solar design tool boosts productivity for solar installer

OpenSolar

Summary

To facilitate rooftop solar and to secure financing, consumers need fast, accurate and reliable solar proposals from installers with compelling financial savings. Ada Auto Design uses proprietary AI to automatically design multiple, buildable preconfigured solar systems in approximately 20% less design time and around 40% fewer errors for Sunsave. Ada has resulted in a labour cost reduction for Sunsave of over USD 26 000.

Context

Rooftop solar and battery storage is a fast-growing alternative to conventional grid electricity, unlocking savings for homeowners as well as reductions in carbon emissions. OpenSolar provides a free web-based technology platform for installers that includes tools for system design, sales, project management, payments and accounting, and hardware ordering. OpenSolar's AI uses a proprietary machine learning model to design systems, based initially on millions of manual designs. For its chat capabilities it makes use of several large language models and is technology-agnostic.

Challenge

Even for a skilled solar system installer, designing three system options for the customer and turning them into one compelling solar proposal can take up to 30 minutes. The longer a potential customer waits for a proposal, the less likely they are to proceed with the purchase.

The more team members who work at the installer business, where training of new staff is a constant need, the greater the likelihood that systems will be designed that cannot be fulfilled or built because they're designed with unavailable or incompatible equipment, and/or because they're designed over rooftop obstructions, or too close to the edge of the roof for permits to be approved.

Inaccurately or slowly designed solar systems can therefore result in lower sales conversion, higher cancellation rates, and increased costs/lower margins for the installer due to change orders and rework at the job site. They also harm the reputation of the solar industry when installed systems, based off the designs, don’t generate the promised energy and savings.

It's therefore essential to maximise speed, accuracy and buildable system designs to support a thriving community of solar installers, a strong reputation for the industry and rapid decarbonisation of the world’s housing stock. AI is uniquely positioned to help bring about these benefits.

Solution and impact

Ada Auto Design uses a machine learning model to automatically design systems on any type of roof structure, using the Google Solar API as the core dataset. Ada can be programmed by the solar installer with certain design rules including hardware types, system sizes and roof setbacks. Multiple system options can be designed and modified in real time using nothing more than the installer’s voice, which is particularly useful when the installer is mobile, short on time or face-to-face with a customer.

As a result of this application, a 20% reduction in design time was observed, together with an approximately 40% reduction in design errors. This is over and above the geospatial reconstruction, physics-based solar modelling and rule-driven automation originally offered by OpenSolar before Ada.

OpenSolar owns and operates the Ada Auto Design solution. Ada Auto Design was commercially deployed and made available to all OpenSolar users in more than 160 countries in September 2025. Ada will be scaled up and expanded to support other solar industry needs such as customer lead generation, hardware procurement, payments and cash flow forecasting, and grid planning.

Consumer energy resources (CERs) such as rooftop solar and batteries deliver low cost energy, reduce the need for grid investment and already form the largest power system on the grid. They are a critical part of a path to net zero. To achieve a low-cost energy transition, governments must give CERs – including solar, batteries, smart loads and electric vehicles – equal access to compete with traditional power plants and grid upgrades. This will pave the way for AI-designed systems to proliferate.

Ada was built for a very low cost, by a team of fewer than ten skilled AI and machine learning engineers and architects. Computing power is ample because it runs on a global cloud platform. The risk of inaccuracies decreases with every system design that is manually or automatically generated on OpenSolar. Millions of designs are generated per year. Applying the productivity boost observed by Sunsave globally to all OpenSolar Installers is conservatively estimated to be worth over USD 30 million.

Based on information provided by OpenSolar

Energy consumption

Electric bus depots

Case study 8: AI-enabled smarter, flexible charging at electric bus depots

Kazam EV Tech

Summary

Electric bus depots in the transport sector are emerging as multi-megawatt loads that challenge grid reliability and operational efficiency. Kazam's AI-enabled energy management system (EMS) applies predictive analytics to optimise charging and enable demand flexibility. During a six-month pilot, the solution increased fleet uptime from 85% to 92% and reduced peak demand charges by 22%.

Context

As cities expand the use of electric buses, bus depots are emerging as major energy hubs within urban transport systems. A single depot may operate dozens to hundreds of buses and draw several megawatts of electricity during overnight charging, creating concentrated demand on local distribution networks. Depot operators must carefully balance charging requirements, grid capacity and operational readiness to ensure buses are available for service each day. Kazam's EMS is designed to manage this complexity. It functions as a digital control layer for bus depots, integrating data from high tension and low-tension infrastructure to chargers and bus battery state-of-charge. This provides real-time visibility and enables co-ordinated, reliable charging operations.

Challenge

Electric bus depots currently operate under a "visibility gap". While modern chargers and buses generate vast amounts of data, fleet managers often lack real-time insights into the interplay among grid constraints, charger utilisation and mission readiness. This data fragmentation leads to critical inefficiencies such as unscheduled grid demand peaks, range anxiety resulting in underutilised battery capacity and frequent operational delays.

When these variables are mismanaged, the system risks grid overload or, more critically, a failure to meet uptime requirements. When this happens, to maintain service uptime, operators fall back on diesel alternatives. The challenge here is not a lack of data, but the complexity of translating non-linear variables such as ambient temperature, battery degradation and fluctuating energy prices into a cohesive charging strategy that ensures 100% uptime.

Solution and impact

Kazam’s AI solution utilises a predictive digital twin framework. The solution is structured into three distinct layers:

- Simulation and synthetic data layer: Using a digital twin of the depot’s electrical infrastructure, the solution generated over 10 000 stress test scenarios. This allows the AI to learn from "edge cases" such as simultaneous charger failure or extreme weather events that rarely occur in daily life but are highly disruptive when they do.
- Neural time-series prediction: The company deployed long short-term memory networks, a type of recurrent neural network specifically designed to recognise patterns in time-series data. This layer predicts energy demand and bus arrival states with high precision.
- Adaptive decision support: Unlike static software, this model uses feedback-driven logic to continuously refine its recommendations based on live telemetry, ensuring the system "evolves" as the fleet ages or the grid changes. This will pave the way to introduce reinforcement learning down the line to improve the model.

This AI system then provides depot managers with clear, actionable recommendations to improve charging efficiency. At the current stage of deployment, recommendations are reviewed by depot managers before execution, ensuring operational safety. As the model matures and performance stabilises, decision-making can be increasingly automated.

During the initial six-month pilot deployment, the AI solution outperformed traditional rule-based scheduling software across key metrics:

Metric	Rule-based system	AI intervention (pilot)
Fleet uptime (buses charged and operational)	85%	92%
Peak demand charges	Baseline	22% reduction
Mean time to dispatch	12-minute average delay	<3-minute average delay

The AI achieved these results by optimising the "slow versus fast" charging mix, utilising trickle charging during off-peak hours to preserve battery chemistry while reserving high speed bursts only for mission-critical windows.

While the solution involves incremental cloud computing costs, these are offset by measurable operational savings, including a 22% reduction in peak energy charges observed during pilot deployments. The system is designed for ease of use and provides clear, actionable recommendations, allowing depot staff to operate it without requiring specialised technical or data science skills.

The solution is developed and operated by Kazam EV Tech Private Limited, a Bengaluru-based start-up delivering full-stack charging hardware, software and energy management solutions.

Onboarding additional depots is inherently complex and difficult to optimise at scale. AI plays a critical role in addressing this challenge. A simulation-first approach makes the model highly scalable. By pre-training the AI on synthetic data, the system becomes manufacturer-agnostic and layout-independent, allowing it to adapt to new depot configurations in weeks rather than months.

Once the initial pilot meets the defined milestones, the solution can be rolled out to additional depots with minimal customisation, lower operational disruption and significantly reduced onboarding time.

The rapid growth of electric mobility necessitates a new policy approach to demand response and demand flexibility. State electricity regulatory commissions should progressively recognise electric bus depots and connected electric vehicle charging infrastructure as system-level flexible demand resources, supported by time-of-use tariffs and formal demand-response mechanisms. Establishing interoperable AI and data-exchange standards through a common digital architecture such as the India Energy Stack will be a critical enabler, allowing multiple stakeholders to participate in co-ordinated, grid-responsive e-mobility operations.

Based on information provided by Kazam EV Tech

Road transport navigation

Case study 9: AI-powered efficient routing of vehicles

Google Maps

Summary

How can vehicle owners reduce their environmental footprint when in transit, optimising energy use and saving money? With fuel-efficient routing in Google maps, AI models analyse various factors to help drivers choose more fuel-conscious routes, balancing fuel efficiency with time and convenience. In 2024, fuel-efficient routing enabled an estimated reduction of over 2.7 million metric tonnes' in greenhouse gas (GHG) emissions.[5]

Context

The road transport sector encompasses the movement of passengers and goods via motorised vehicles, including private cars, buses and freight trucks, operating across expansive urban and rural highway infrastructures worldwide. According to the IEA, carbon dioxide (CO_2) emissions from the transport sector accounted for over 20% of global energy-related CO_2 emissions in 2024, with road vehicles representing nearly 75% of these emissions[6].

Challenge

For years, navigation technology has focused on time efficiency, often not taking into account the energy cost of stop-and-go traffic, steep inclines and variable engine performance. Sector-wide inefficiencies arise from an "information gap" regarding how different vehicles consume energy under varying conditions. Traditional routing lacks the ability to account for complex variables such as road grade or engine-specific efficiency (such as how a diesel engine performs compared with an electric vehicle on a highway). This lack of transparency means drivers can unknowingly choose

[5] More information at www.gstatic.com/gumdrop/sustainability/google-2025-environmental-report.pdf.
[6] IEA, 2025, World Energy Outlook, available at https://www.iea.org/reports/world-energy-outlook-2025

routes that maximise fuel consumption. Consequently, the sector faces the systemic hurdle of "accidental" emissions – extra carbon released simply because individuals lack personalised data to make more sustainable travel choices. This creates a powerful incentive for AI solutions that can transform vast, disparate data points into actionable insights for the average driver.

Solution and impact

Google developed and launched fuel-efficient routing within Google Maps. This AI-powered solution, developed by Google in collaboration with the US Department of Energy's National Lab of the Rockies (NLR), is available globally, helping people all over the world cut down on fuel or energy use, reduce their impact and help their wallet.

For any given journey, there are often numerous ways to get from Point A to Point B. To calculate the fastest trip today, Google Maps' algorithm generates a set of potential route candidates incorporating data on road conditions (e.g. road closures, live traffic and historical traffic patterns) into routing algorithms to propose the optimal route. With fuel-efficient routing, Google uses an AI prediction model to estimate the expected fuel or energy consumption for each route option.

The intervention relies on machine learning models that process massive datasets to predict the most energy-efficient path. Google partnered with NLR in order to accurately predict the fuel consumption of a vehicle for any given route across diverse road segments and driving conditions; this partnership enables an integration of these fuel consumption models together with Google's routing model and real-time traffic predictions. Unlike standard navigation tools that prioritise distance or speed, this AI analyses variables such as:

- road incline: identifying flatter routes to avoid fuel-intensive hill climbing
- traffic patterns: predicting stop-and-go congestion that increases consumption
- vehicle specifics: users can select their engine type (petrol, diesel, hybrid or electric), allowing the AI to tailor recommendations.

Google identifies the route that is predicted to consume the least amount of fuel or energy. If this route is not already the fastest one and it offers meaningful energy and fuel savings with only a small increase in driving time, it is also displayed to the user.

To calculate enabled emissions reductions, the fuel usage was tallied from the chosen fuel-efficient routes and subtracted from the predicted fuel consumption that would have occurred on the fastest route without fuel-efficient routing and apply adjustments for factors such as carbon dioxide equivalent factors, fleet mix factors, well-to-wheels factors and powertrain mismatch factors.[7] In 2024, Google estimated that fuel-efficient routing reduced GHG emissions by more than 2.7 million metric tonnes. And it's not just for cars. In places such as Southeast Asia, where motorcycles and scooters are dominant, the company has expanded the model to include two-wheelers as well.

Based on information provided by Google

[7] This figure covers estimated enabled emissions reductions for the calendar year, from January through December. Enabled emissions reductions estimates include inherent uncertainty due to factors that include the lack of primary data and precise information about real-world actions and their effects. These factors contribute to a range of possible outcomes, within which we report a central value. The data and claims have not been verified by an independent third party.

Buildings

Case study 10: AI helps transform buildings from passive consumers to active energy optimisers

Enlog

Summary

Some estimates calculate electricity losses of 20-30% due to inefficient energy operations and inefficient peak-hour use in buildings. Enlog applies AI to continuously learn how buildings and their equipment operate, automatically improving performance, preventing failures, and adjusting demand during grid stress. The result is 20-25% energy savings, up to 20% peak demand reduction and lower emissions delivered autonomously while maintaining occupant comfort.

Context

Buildings consume over 40% of the generated electricity globally, and account for a large share of greenhouse gas emissions. Cooling, lighting and equipment account for most of the electricity waste as a result of inefficient operations and inefficient peak-hour use, yet a vast majority of buildings operate with no system tracking energy use. Energy use in office buildings, shops, schools, hospitals and apartments runs on guesswork and fixed schedules, wasting an estimated 20-30% of what they consume. Owing to the vast number of variables, appliances and demand patterns, it is nearly impossible to manually optimise building operations. AI for energy intelligence addresses this challenge by learning each building's energy patterns and optimising usage automatically, using the meters and sensors data of buildings and orchestrating connected internet of things (IoT) devices.

Challenge

The key challenge in optimal building energy management is often not a lack of equipment or data, but the variable and complex nature of energy use itself. Energy consumption in buildings is continuous, highly granular and shaped by real-world behaviour: appliances switching on and off, weather-driven cooling demand, changing occupancy, comfort expectations, and grid conditions that fluctuate minute-by-minute.

Most buildings already generate large volumes of data through meters, sensors and load surveys. However, these data are too complex, fragmented and fast-changing for manual analysis or static, rule-based systems. As a result, inefficiencies persist, equipment faults go unnoticed until failure, and buildings draw peak power at the same time, driving grid stress and higher emissions. Traditional building management systems, where deployed, are expensive, limited to large facilities and dependent on human oversight. They do not learn from actual usage patterns, cannot anticipate demand or equipment health, and are unable to co-ordinate energy use across appliances in response to grid conditions.

The fundamental challenge is straightforward: instead of requiring countless building operators to manually oversee complex energy systems or engage specialists for the task, it is far more effective to implement intelligent solutions that autonomously manage electricity, continuously learn and operate independently.

Solution and impact

Enlog's solution treats energy not as a static metric to be monitored, but as a live system to be sensed, learned and autonomously controlled. The platform integrates advanced edge hardware with a learning intelligence layer that continuously interprets how electricity behaves across appliances, buildings and grid conditions and acts in real time. Enlog deploys purpose-built connected devices that capture electrical, environmental and operational signals at significantly higher fidelity than conventional meters or off-the-shelf controllers. These devices are designed to be retrofit-friendly, grid-safe and resilient in electrically noisy environments, enabling reliable data capture from existing buildings without major infrastructure changes.

On top of this foundation, Enlog applies machine learning models optimised for temporal and behavioural energy data to three core functions: appliance-level visibility, system health monitoring and adaptive energy control. The models learn normal and abnormal operating patterns of equipment, forecast near-term demand using historical and contextual signals, and recommend or autonomously execute load adjustments within strict comfort and safety limits. Unlike rule-based automation or static analytics, the intelligence adapts continuously as occupancy, weather, equipment condition and grid stress change.

This is a full-stack energy intelligence system, where hardware, data and AI are designed together, enabling decisions that software-only or hardware-only solutions cannot reliably deliver. The platform is commercially deployed, developed and operated by Enlog, and currently live across more than 50 000 connected devices. It actively manages over 30 gigawatt-hours (GWh) of electricity annually, with 5 GWh already saved, corresponding to an estimated 5 500 tonnes of carbon emissions avoided. Typical deployments deliver 20-25% energy savings, reduced equipment failures and measurable peak-demand reduction.

The solution is inherently scalable across building types and geographies, with modest cloud computing requirements and no need for on-site energy expertise. Wider impact can be accelerated through policies that enable smart-meter data access, dynamic tariffs and demand-response participation for smaller buildings, unlocking efficiency and grid resilience at scale. When AI connects energy efficiency inside buildings with demand response on the grid, every saved unit of electricity delivers system-wide impact.

Based on information provided by Enlog

Buildings

Case study 11: A retrofit-first AI strategy delivers efficiency gains in buildings

Zodhya

Summary

Energy inefficiency in commercial buildings, especially in heating, ventilation and air conditioning (HVAC) and electrical systems, leads to high costs and excess emissions. Zodhya deployed a solution driven by AI, combining SaverX for HVAC optimisation and Soul for electrical performance analysis, achieving 25-30% reductions in energy consumption and reducing carbon dioxide (CO_2) emissions by 1 000 tonnes monthly. This solution delivers immediate impact without requiring infrastructure overhaul.

Context

Space cooling and heating, and water heating systems in buildings account for nearly 40% of total buildings electricity consumption globally. As the world increasingly urbanises, the pressure to make buildings energy efficient grows, especially in warm climates where cooling demand is high and also in regions with growing industrial output. Traditional building management systems and HVAC controls are static, unable to respond dynamically to changing conditions such as occupancy, weather or equipment performance.

Zodhya offers a retrofit-first, AI-powered energy optimisation solution. By integrating AI into existing HVAC and electrical infrastructure, Zodhya provides scalable, cost-effective energy savings without the need for costly infrastructure replacements.

Challenge

The core challenge in commercial building energy management is that HVAC systems are designed to handle peak conditions but operate under partial load most of the time. Static control systems fail to adapt dynamically to factors such as varying occupancy or weather conditions. Consequently, inefficiencies in temperature settings, overcooling, excessive cycling and energy losses are widespread, typically driving 20-40% of excess energy consumption according to some estimates.

Building managers often lack the tools to optimise energy use continuously or to assess system performance in real time. Periodic audits and retro-commissioning exercises are expensive and slow, and do not provide long-term solutions. The problem is exacerbated by ageing infrastructure and the risk-averse nature of the industry, where upfront capital expenditures are avoided.

Solution and impact

Zodhya's AI-driven platform combines SaverX (HVAC optimisation) and Soul (electrical performance analytics) to address these inefficiencies. The SaverX system continuously monitors and adjusts HVAC parameters such as chilled water set points, air supply temperatures and operating schedules based on real-time data. Soul analyses the energy consumption and efficiency of electrical systems, identifying anomalies such as imbalances, losses and faults, offering actionable insights for correction.

By using AI and machine learning models, the system adapts to each building's unique operational profile, reducing energy use without compromising occupant comfort. Proactive optimisation ensures that HVAC systems and electrical systems operate optimally in response to demand forecasts and changing environmental conditions, avoiding unnecessary cooling and reheating, meeting required energy demand.

The solution is implemented without replacing existing equipment. It is deployed as a cloud-edge hybrid system, enabling real-time decision-making on-site while benefiting from cloud-based analysis for continuous improvement. The system's flexibility and scalability make it suitable for a wide range of commercial buildings, from office complexes to large industrial facilities.

Since its deployment, Zodhya has achieved 25-30% energy savings across more than 50 buildings in India and Southeast Asia, with over 1 000 tonnes of CO_2 emissions avoided monthly. This approach has proven more effective than traditional methods, offering a rapid payback period and minimal operational disruption.

The solution has the potential for global scalability, especially in emerging markets where infrastructure retrofits are costly and often not feasible. It provides immediate financial and environmental benefits, supporting companies' environmental, social and governance goals and compliance with local regulations such as Local Law 97 in New York.

Based on information provided by Zodhya

Buildings

Case study 12: AI-powered automation cuts energy use at super-specialty hospital

Smart Joules

Summary

A 600-bed super-specialty hospital in Kerala faced significant energy waste from its cooling system, which relied on manual operations and fixed schedules that couldn't adapt to changing needs. Buildings' cooling systems are part of the commercial buildings energy subsector. DeJoule, a building management system powered by AI using reinforcement learning and deep learning, was deployed to automatically optimise the hospital's chiller plant and cooling operations in real time. The AI solution achieved a 15% reduction in energy consumption, saving 525 kilowatt-hours (kWh) daily and reducing carbon emissions by approximately 192 tonnes of carbon dioxide (CO_2) annually. This solution has been commercially deployed in more than 39 buildings across India, delivering an average 7% energy improvement.

Context

Commercial buildings in India, particularly hospitals, are major energy consumers, with cooling systems accounting for nearly 30% of electricity use by buildings in the country. Hospitals operate 24 hours a day, seven days a week, with varying occupancy and activity levels, creating constantly changing cooling demands throughout the day and across seasons.

The featured hospital is Kerala's leading super specialty facility with 600 beds, operating sophisticated medical equipment and maintaining strict indoor comfort requirements for patient care. Its cooling infrastructure included a chiller plant of 430 tonnes of refrigeration (TR) with pumps and cooling towers – equipment designed to remove heat from the building. Traditional building management systems rely on fixed schedules and manual adjustments by operators, who must guess when to turn equipment on or off and at what speeds to run them. This approach fails to respond to real-time changes in weather, occupancy or equipment performance.

Challenge

Prior to the AI solution being implemented, the hospital's cooling system operated inefficiently due to over-reliance on manual control. Operators followed rigid schedules, running all pumps and cooling towers at fixed speeds regardless of actual cooling needs – such as running air conditioning at maximum power even when rooms are empty or weather is cool.

This "one size fits all" approach created several problems: significant energy waste during periods of low demand, inability to respond quickly to sudden changes in cooling needs, reactive rather than proactive management requiring constant operator intervention, and equipment running harder than necessary, increasing wear and costs.

The system's energy consumption measured 0.87 kilowatts (kW) per TR – a figure indicating substantial room for improvement compared with efficient facilities that achieve below 0.80 kW/TR. Without intelligent automation, the equipment couldn't match its cooling output to actual moment-to-moment demand, resulting in costly overcooling and unnecessary energy consumption.

The hospital needed a solution that could eliminate this hidden waste while maintaining the precise climate control essential for patient care and medical operations, all without requiring operators to manually adjust settings throughout the day.

Solution and impact

To address the issue, Smart Joules deployed DeJoule, an AI-powered automation system that uses reinforcement learning and deep learning algorithms to control the hospital's cooling equipment. The system learns from operational data and continuously adjusts equipment settings – such as which chillers to run, pump speeds and cooling tower fan speeds – to match actual cooling demand.

Unlike traditional systems that follow fixed rules, DeJoule predicts cooling needs before they occur by analysing patterns in occupancy, weather and equipment performance. For example, it anticipates morning cooling demand before staff arrive, adjusts settings during humidity spikes and compensates as equipment ages. The AI runs on local controllers, making split-second decisions without requiring constant internet connectivity.

The deployment achieved a 15% reduction in overall energy consumption, with the chiller plant's efficiency improving from 0.87 kW/TR to 0.74 kW/TR. This translates to daily savings of 525 kWh and approximately 192 tonnes of CO_2 emissions avoided annually. These savings proved persistent across six months, adapting to monsoon conditions, peak summer loads and equipment wear.

Beyond energy savings, the system's nonstop monitoring enabled faster responses to issues. For instance, an automated alert about a chiller trip at 3:45 a.m. allowed immediate resolution, preventing disruptions to patient care.

This is a commercially deployed solution currently active in more than 39 buildings across India, delivering an average 7% energy improvement. The hospital implementation took approximately one month, with the main challenge being a planned shutdown to install measurement equipment.

DeJoule's design allows it to work alongside existing building management systems rather than replacing them, reducing adoption costs and disruption. This layered approach makes it suitable for hospitals, commercial buildings and industrial facilities nationwide.

The technology aligns with India's Energy Efficiency Financing Platform goals and could accelerate adoption in energy-intensive sectors such as healthcare. The combination of predictive savings and transparent reporting makes such systems attractive for both regulators seeking to meet climate targets and financiers evaluating energy efficiency investments. By standardising AI-enabled optimisation across the healthcare sector, India could achieve significant reductions in buildings energy consumption while improving facility reliability.

Based on information provided by Smart Joules

Steel production

Case study 13: AI-enhanced rail inspection reduces rework and emissions in steel production

Gazelle Information Technologies

Summary

Defects in steel rail manufacturing are often detected late, causing rework, energy waste and increased emissions associated with manufacturing. An inspection system based on AI predicts defects early using production data and visual inspection. In one year of operation, defect-related rework fell from 12% to about 1.2% observed, avoiding roughly 1 800 tonnes of carbon dioxide (CO_2) annually through preventive and data-driven quality control methods.

Context

Steel rail manufacturing is among the most energy- and emissions-intensive industries. Production involves multiple stages such as casting, rolling, cooling, finishing and inspection, each consuming significant energy. In this process, every detected defect typically requires cutting out approximately one metre of rail, followed by welding and reprocessing. This leads to additional electricity use, fuel consumption, material loss and emissions. The company operates a high-volume rail manufacturing facility producing hundreds of rails daily using automated rolling mills, inspection lines and visual quality systems. Traditionally, defects are detected late in production, leaving little scope to prevent rework upstream.

Challenge

In high-volume rail production, being a continuous process, quality defects are often identified only after the rail has passed through several energy-intensive processing stages, including rolling, cooling, finishing and straightening. When a defect is detected at this late stage, standard practice requires cutting out approximately one metre of rail per defect, followed by welding, reprocessing and re-inspection. This approach increases electricity use, fuel consumption, material waste, production time and associated carbon emissions.

Although large volumes of data are generated throughout the manufacturing process – such as bloom-stage characteristics, intermediate process parameters and historical defect records – these datasets are typically reviewed in isolation or used only for retrospective analysis. They are not systematically combined to forecast defect risk early, limiting the ability of operators to intervene before defects are embedded in the product.

As a result, defect management remains largely reactive, with rework treated as an unavoidable part of operations rather than a preventable outcome. This creates ongoing inefficiencies and undermines efforts to reduce energy consumption and emissions in heavy industry. With increasing regulatory and sustainability pressures, there is a clear need for solutions that can link upstream and downstream data, provide early warnings, and enable corrective actions before defects lead to material loss and reprocessing.

Solution and impact

The challenge was addressed through the deployment of an AI-based predictive inspection and defect-prevention system that shifts quality control from late-stage detection to early-stage prevention. The system is owned and operated by RITES Ltd and was developed by Gazelle Information Technologies Private Limited. It integrates computer vision with advanced AI models that analyse data across multiple manufacturing stages, including bloom characteristics, downstream process parameters and historical defect records.

Unlike conventional inspection systems that rely solely on end-of-line visual checks, the AI solution performs two complementary functions. First, computer vision algorithms identify and localise actual defects on finished rails with high precision. Second, predictive AI models analyse historical and process data to forecast defect probabilities earlier in the production cycle, allowing operators to take corrective action before defects are embedded in the product. This capability cannot be achieved through rule-based automation or traditional inspection tools, which lack the ability to learn complex, multistage relationships.

The system has been commercially deployed and in continuous production use since December 2024 at a high-volume rail manufacturing facility producing approximately 400 rails per day, or 146 000 rails annually. Before deployment, defect-related rework affected around 12% of rails. After one year of operation, the observed defect rate reduced to approximately 1.2%. As each defect typically requires cutting out one metre of rail, this translated into avoiding rework on about 15 700 metres of steel annually, corresponding to roughly 1 800 tonnes of CO_2 emissions avoided per year, based on standard steel emissions factors.

The AI Inspection system has been certified by the Research Designs and Standards Organisation as an alternative for rail inspection applications using ultrasound. The AI-based solution delivers comparable and superior outcomes at approximately one-tenth the cost of imported alternatives.

The technology is protected through patents and is designed to be scalable across all types of steel plant products, not limited to rails, offering significant global growth potential. Wider adoption can be supported through policies that encourage AI-driven industrial quality control, recognition of avoided emissions and digital integration across heavy manufacturing sectors.

Based on information provided by Gazelle Information Technologies

Steel production

Case study 14: AI-powered analytics for blast furnace thermal control reduces fuel consumption and emissions in steel production

ArcelorMittal Brazil

Summary

Integrated steel production is highly energy- and emissions-intensive. The AI solution anticipates thermal deviations and recommends operational actions pertaining to blast furnaces in steel production. This results in an average reduction of 1.5 kilogrammes (kg) of fuel per tonne of pig iron and 4.4 kg per tonne of carbon dioxide (CO_2) emissions in Brazilian steel plants where it has been deployed.

Context

Integrated steel making accounts for approximately 6% of global energy demand and 7% of CO_2 emissions from the energy sector. Studies estimate that blast furnaces are responsible for around 45-60% of total energy consumption in the sector. As a part of the process, iron ore is reduced to pig iron through the use of coke, pulverised coal and high temperatures. The thermal stability of the furnace is crucial for energy efficiency, pig iron quality and operational safety. ArcelorMittal's blast furnaces are large-scale facilities, operating with highly complex processes and large volumes of operational data.

Challenge

Controlling the thermal level of the blast furnace is one of the biggest operational challenges in steel making. The temperature of pig iron, the main indicator of thermal status, is influenced by several interdependent variables, such as raw material quality, load distribution, blowing parameters and fuel rates. In traditional practice, control decisions are heavily based on operator experience and operating patterns, which can lead to deviations from the optimal operating range. Thermal deviations increase fuel consumption, CO_2 emissions, equipment wear and the risk of operational instability. In addition, the slow and complex dynamics of the process make it difficult to predict the effects of corrective actions, often leading to conservative decisions and excessive fuel use. The central challenge is to provide predictability and standardisation to decision-making, enabling preventive actions and reducing process variability.

Solution and impact

The AI solution is called SENSEI, and it consists of a decision support system based on advanced analytics. The tool integrates historical and real-time blast furnace data and uses machine learning models to predict, up to one hour in advance, the thermal state of the furnace and the composition of the top gases. These predictions are combined with a mathematical optimisation model that simulates different set-point adjustments and recommends the most appropriate actions to maintain thermal stability and minimise fuel consumption.

The system updates its predictions every 15 minutes and generates operational recommendations every 30 minutes, while the final decision remains with the operator. By anticipating trends and recommending actions, the system reduces reaction time compared with reactive approaches based solely on alarms and descriptive dashboards. In addition, approaches with simpler statistical models did not perform well due to the complexity of the relationship among the many variables.

The tool was validated in a real operating environment by comparing periods with and without the use of the tool within the same day, reducing the influence of external factors. The results showed an average reduction of 1.5 kg of fuel per tonne of pig iron, an associated decrease in emissions of 4.4 kg of CO_2 per tonne of pig iron, and significant economic gains. This AI tool is in operation in three blast furnaces at ArcelorMittal Brazil, with clearly defined responsibilities: the Data Science Center maintains the analytical models, while the Information Technology and Automation teams support the infrastructure and integration with industrial systems.

Effectiveness depends on consistent operational data and training users to interpret recommendations. Risks include performance degradation due to process changes, data unavailability and inadequate adoption, requiring continuous monitoring and governance of use. Integration with industrial systems requires attention to cybersecurity and change management. The approach is scalable to other blast furnaces with similar characteristics and can be strengthened by policies that encourage industrial digitisation, energy efficiency and emissions reduction in the steel sector.

Based on information provided by ArcelorMittal Brazil

Energy access

Electricity access finance

Case study 15: AI helps unlock clean energy asset financing, accelerating energy access

Nithio

Summary

Around 600 million people in Africa lack electricity, mainly in sub-Saharan Africa, and 40% cannot afford basic energy solutions. Nithio uses AI to analyse credit risk and clean energy portfolio performance, enabling affordable off-grid energy finance. Its analytics have analysed more than 100 million payment transactions and financed hundreds of thousands of customers without bank accounts.

Context

Off-grid and clean energy solutions such as solar home systems, productive-use appliances and electric vehicles are critical to expanding energy access and reducing emissions across Africa. These sectors mainly serve rural and low-income customers who often lack bank accounts and have poorly assessed by traditional credit scoring methods. As a result, financing for both end customers and the small and medium-sized enterprises (SMEs) serving them is limited and costly, slowing energy access. Nithio operates at the intersection of clean energy, finance and data, working with clean energy SMEs, investors and development partners. Through its AI-powered Risk Analytics Engine, Nithio uses data-driven insights to improve lending decisions, optimise capital allocation and make financing more accessible, enabling the scaled deployment of clean energy solutions.

Challenge

Traditional credit scoring relies on bank histories and formal income records, which most rural customers lack. As a result, they are often deemed high risk by lenders, even when they demonstrate strong repayment behaviour. Clean energy companies operating on a pay-as-you-go basis face similar constraints, and investors struggle to assess their portfolio risk across thousands of small loans and distributed energy assets. This lack of transparent data increases perceived risk, raises the cost of capital and limits the funding available to scale solutions such as solar home systems, productive-use equipment and emerging e-mobility services across sub-Saharan Africa.

At the same time, innovative financing mechanisms such as securitisation and results-based financing depend on accurate, real-time performance data. Without reliable monitoring and verification tools, capital market and institutional investors remain cautious about participating at scale. Together, these challenges slow the deployment of clean energy, keep energy costs high for end users, and delay progress towards inclusive economic growth, universal energy access and emissions reduction.

Solution and impact

Nithio addresses these challenges through its AI-powered Risk Analytics Engine, which uses machine learning to analyse its robust database, which comprises geographical spatial data (including satellite imaging), macro- and micro-economic data, localised socioeconomic and environmental data (down to 1 square kilometre), and (energy) customer data (payment behaviour, energy usage patterns, device performance and operational data from clean energy companies).

Nithio currently uses its AI tool to first create (anonymised) fair and accurate credit scores for customers without bank accounts, allowing clean energy (asset) companies to access financing that would otherwise be too costly to them; and second, assess the performance and risk of clean energy customer portfolios and projects, giving investors a clearer, more transparent view of loan quality and asset health.

Compared with traditional analysis, the AI can process data continuously and at scale, identifying early warning signs of default or underperformance. This has helped reduce portfolio losses and improve repayment rates significantly, while expanding access to clean energy for thousands of customers across multiple African markets.

The same AI engine can also support more advanced financing structures. It can monitor and manage securitised portfolios, increasing investor confidence and helping attract larger pools of capital. In results-based financing programmes, the AI can automate verification, ensuring subsidies reach the intended beneficiaries faster and tailored to specific outcome objectives.

Nithio owns and operates the AI tool, which it has developed in-house and already uses commercially with energy companies, investors and development partners.

Based on information provided by Nithio

Case studies from the IEA Energy and AI Observatory

In 2025, IEA launched the *Energy and AI Observatory* to closely monitor and analyse the interconnections between the energy sector and AI. The *Observatory* is a platform that provides data of the implications of AI on energy demand, and also hosts case studies of AI applications for efficiency, innovation, resilience and competitiveness in the energy sector.

This chapter provides an overview of the case studies on the *Energy and AI Observatory* to present additional illustration of the impact of AI in energy*.* These summaries are derived from the original case study text as published on the *Observatory,* and are based on information provided by the respective companies and organisations that submitted them. The contents of the case studies are current as of June 2025, when they were first published. The original text of these case studies is available here: www.iea.org/data-and-statistics/data-tools/energy-and-ai-observatory

Energy supply

AI satellite image processing enables measurement of methane emissions

Methane, a greenhouse gas responsible for approximately 30% of the rise in global temperatures since the Industrial Revolution, is particularly problematic due to its high energy absorption. The energy sector contributes about 35% of human-related methane emissions, with significant quantities coming from oil (45 Mt), natural gas (35 Mt), and coal (40 Mt) operations. The challenge lies in detecting both large and numerous smaller emission sources, which traditional satellites often miss. In response, Google has leveraged AI image processing to create a comprehensive global map of oil and gas infrastructure. This map, combined with high-resolution methane data from MethaneSAT, a project deployed by the Environmental Defense Fund (EDF), enables precise tracking and quantification of methane emissions from both major and minor sources. MethaneSAT, launched in 2024, operates with a pixel size of 100 m by 400 m, detecting excess methane as low as 10 kg per hour per km², and covers areas accounting for 80% of global oil and gas production. Early results show that actual emissions in key regions can be more than nine times higher than previously reported, highlighting the importance of this collaboration in enabling faster, more effective emission reductions.'

Advancing mineral exploration with AI

The rollout of new energy technologies is dependent on securing a sufficient supply of critical minerals and metals, with projections from the IEA indicating that demand for these materials will more than double by 2030 and could triple by 2040. Traditional mineral exploration methods have become less effective, particularly in frontier areas where records are scarce and deposits are more deeply buried, posing significant uncertainty and requiring substantial investment, estimated at $2.1 trillion by 2050. The problem is compounded by the limitations of conventional and machine learning-based prospecting approaches, which struggle with uncertainty and transparency in data-poor regions. DeepIQ has addressed this challenge by deploying an advanced AI platform that combines deep learning with geoscientific expertise, offering high-quality, explainable predictions and rigorous spatial cross-validation. As a result, DeepIQ's solution has achieved a 97.6% true positive rate and a 20% false positive rate in frontier mineral prospecting, outperforming industry standards. The platform's scalability is demonstrated by successful application to 3D analyses across multiple countries, leveraging AWS Elastic MapReduce and Amazon SageMaker for near-unlimited data processing and model scaling.

Lithium extraction optimised by AI

As global lithium demand surges for batteries and other technologies, sustainable supply solutions have become increasingly urgent. Traditional extraction methods – solar evaporation and hard rock mining – face limitations, while direct lithium extraction (DLE) using selective ion filtration offers a promising alternative. However, deploying DLE processes is challenged by high capital and operational costs and the complexity of optimising multiple processing parameters to achieve battery-grade lithium carbonate purity (>99.9%). To address these barriers, CanmetMATERIALS – Natural Resources Canada and Telescope Innovations deployed AI-driven optimisation, specifically Bayesian active learning with Gaussian Process Regression (GPR) and Decision Trees Regression (DTR), to refine lithium extraction from battery recycling brine streams. This approach enabled rapid, data-informed experimentation, with only two AI-guided cycles required to reach lithium carbonate yields of 83%, significantly outperforming traditional methods (65%) and achieving comparable yields at 20–30°C lower temperatures. The result was a more energy-efficient, high-yield process that also enhanced impurity removal and reduced the overall carbon footprint, demonstrating broad applicability for optimising complex industrial workflows.

Power generation and electricity systems

AI-driven electricity planning model at the building-level

The International Energy Agency (IEA), in partnership with the MIT Energy Initiative, launched the Data-Driven Electrification in Africa programme to tackle the challenge of expanding electricity access for around 600 million unconnected Africans, a figure that has increased since the Covid-19 pandemic slowed grid growth. Traditional planning methods, reliant on infrequent household surveys and low-resolution night-time imagery, struggle to provide the granular data needed for effective investment and decision-making. To address this, IEA and MIT developed two digital tools: the Africa GIS Catalogue for Energy Planning and Open Energy Maps, an AI-powered platform that combines satellite imagery, utility consumption data and various socioeconomic proxies to predict electricity access and demand at the building-level. The solution demonstrated over 80% accuracy in identifying electrified buildings and reduced demand-estimate errors by 40% compared to previous approaches, allowing for targeted interventions such as tariff reform and network reinforcement. Early deployments in Ghana, Senegal and Uganda revealed both areas of hidden energy poverty and opportunities for rapid, cost-effective new connections, streamlining the planning process and improving project financing prospects.

AI-powered wind speed forecasting

Chile has set a national target of achieving carbon neutrality by 2050 and is rapidly transforming its energy sector, with renewables already accounting for approximately 65% of electricity generation and expected to rise to 93% by 2035. A key challenge in this transition is the accurate forecasting of wind speeds, which is essential for grid operators to reliably manage the integration of variable renewable energy sources. Traditional methods have struggled with the inherent variability and uncertainty of wind, leading to inefficiencies and increased costs. To address this issue, the GraphCast x Tapestry project, deployed by Google DeepMind in collaboration with Tapestry, leverages AI and machine learning to analyse extensive data sets, improving wind speed forecast accuracy through a combination of physics-based modelling and neural networks. The outcome is a Chile-specific forecasting model that is up to 15% more accurate than previous industry standards, enabling more effective grid management, greater integration of wind energy, reduced curtailment, and maximised use of clean energy resources.

Accelerated gas turbine design enabled by AI

In the context of industrial device design, engineers face the challenge of optimising multiple, often conflicting objectives within data-rich environments, traditionally requiring tens of thousands of hours of simulation time. Specifically, the efficient design of gas turbines – which contribute to over 20% of global electricity output – demands resource-intensive, iterative calculations to ensure mechanical integrity, aerodynamics, heat transfer, and energy efficiency. To address this, a Siemens R&D team supported Siemens Energy by deploying uncertainty-aware AI models and digital twins, enabling the rapid evaluation of hundreds of designs in seconds and bypassing unnecessary simulations. As a result, Siemens Energy shortened the design process by an entire year, reduced simulation compute time by over 15,000 hours, cut associated costs, and achieved a 20% increase in turbine blade component lifetime. This successful AI-driven approach is now being integrated into Siemens' HEEDS software, making advanced optimisation accessible to users without prior AI expertise and offering potential for broader application across industrial design problems.

Offshore wind operation with AI-powered virtual buoys

Offshore wind energy is rapidly expanding, with global capacity set to reach 212 GW by 2030 and the annual market projected to grow from 9.5 GW in 2023 to over 45 GW by 2030. Ørsted, a leading developer in the sector, faced the challenge of physical wave buoys –essential for collecting wave data for wind farm operations – frequently going offline due to power, communication, or mechanical issues, resulting in costly data gaps. To address this, Ørsted implemented the Virtual Wave Buoy project, employing robust machine learning (random forest algorithms) to infer wave conditions based on data from neighbouring buoys, achieving a mean absolute error of just seven centimetres. This solution enables Ørsted to reliably replace physical buoys after collecting sufficient data, leading to significant cost savings – around 5 million Danish kroner annually across four sites – and is set for wider adoption, amplifying its financial and operational benefits.

AI-driven models for electricity access forecasting

The United Nations Development Programme (UNDP), in partnership with IBM Sustainability Accelerator, has pledged to expand access to clean and affordable energy for 500 million additional people, focusing on vulnerable communities. The key challenge addressed is the difficulty in mapping global electricity access with high spatial and temporal resolution, as traditional methods are slow and remote sensing often misses critical data. To overcome this, UNDP and IBM co-developed AI-driven forecasting models, including the Electricity Access Forecasting AI model and the Clean Energy Equity Index, leveraging IBM watsonx and IBM Cloud. These solutions analyse diverse datasets to project electricity access up to 2030 for 102 Global South countries and provide equity metrics for 53 African nations. As a result, governments and investors can identify underserved regions, optimise infrastructure planning, and tailor interventions, with UNDP estimating that over 600,000 people will benefit directly from the collaboration.

Energy price forecasting with AI tools

The energy transition necessitates substantial investment in renewables and storage, which in liberalised power markets depends on private participants responding to wholesale price signals. However, increasing price volatility, evolving market designs, and the entry of less experienced participants have made accurate price forecasting more challenging. Traditional forecasting methods – historical trends, regression, and linear programming – each present limitations in accuracy, expertise required, or computational demands. To address this, Hitachi Energy conducted a case study deploying AI-driven probabilistic approaches, involving six teams and over ten algorithms, trained on data from CAISO, MISO, and AEMO markets. Their solution achieved 87% accuracy for CAISO locational marginal prices, 93% for MISO, and 86% for MISO ancillary services, outperforming the industry standard of 75%. The developed algorithms have been incorporated into Nostradamus AI forecasting software, enabling users to produce accurate forecasts efficiently without data science expertise.

AI-powered predictive monitoring in offshore wind project

The offshore wind sector is expanding rapidly, with global capacity forecasted to reach 212 GW by 2030 – almost four times the growth of the previous six years – driven by larger, more advanced turbines. This growth has introduced complex operational and logistical challenges, especially in the maintenance and reliability of offshore wind farms, where unpredictable weather and limited vessel availability can cause significant downtime and increased costs compared to onshore sites. To address these issues, Iberdrola deployed its Advanced System for Predictive Analytics (ASPA), an AI-powered cloud-based condition monitoring solution that uses real-time sensor data and machine learning to detect early signs of turbine failure and alert operation and maintenance teams. The implementation of ASPA in two wind farms led to €6.3 million in savings over four years by reducing downtime and enabling more proactive maintenance; the system is scalable across assets, provided sufficient high-quality historical data is available for effective model training.

Energy consumption

AI-Powered HVAC systems reduce electricity consumption in buildings

Skolfastigheter i Stockholm AB (SISAB), overseeing more than 600 educational facilities in Stockholm with an annual energy consumption of 250 GWh and expenditure of around €29.4 million, faced operational difficulties managing diverse building management systems and optimising energy use across both modern and older structures. To address the inefficiencies of manual and fragmented HVAC control, SISAB deployed a Schneider Electric cloud-hosted AI service, which acts as a virtual operator by making fine-tuned setpoint adjustments every 15 minutes using data from nearly 10,000 sensors and leveraging Microsoft Azure for data processing. This AI-driven solution, without necessitating hardware replacement, led to quantifiable benefits between 2019 and 2023: district heating consumption dropped by 3% (2,388 MWh), electricity use decreased by 9% (3,527 MWh), and overall carbon emissions were cut by 259 tonnes CO_2-equivalent, with an average annual saving of 65 tonnes CO_2-eq. The project delivered a substantial cost-benefit in carbon savings compared to traditional system upgrades, with Schneider Electric as the deployer of the solution.

"Demand Response 4.0" in buildings

The increasing integration of variable renewable energy sources into power systems has created a need for greater flexibility to balance supply and demand, especially when solar and wind generation is low. Historically, scaling demand-side response (DSR) solutions beyond the industrial sector has been hampered by unreliable forecasting, limited automation, and insufficient consumer engagement. Voltalis, an international energy company founded in France in 2006, has addressed these challenges with its "Demand Response 4.0" solution, which employs machine learning and dynamic optimisation to automatically manage heating, ventilation, and air conditioning devices based on real-time market conditions. This approach aggregates over 1.5 million devices across 250,000 buildings in eight European countries, forming a virtual power plant with a current capacity of 2 GW and a planned expansion to 10 GW by 2030. As a result, Voltalis customers typically achieve energy savings of around 15% annually, benefiting both grid reliability and consumer comfort.

AI-enabled smart campus improves energy efficiency

Infosys, a leading multinational technology and consulting firm, manages a 6.4 million square foot smart campus in Pune, India, accommodating over 30 000 people daily. Despite already achieving an energy performance index of 70 – well below India's Energy Conservation Building Code threshold of 180 – Infosys faced ongoing inefficiencies in heating, ventilation, and air conditioning systems due to factors such as insufficient commissioning, lack of maintenance, and limited system integration. To address this, Infosys deployed its AI-powered energy-as-a-service solution, which utilises Internet of Things technology and machine learning to optimise energy generation and consumption. The system predicts energy demand, optimises chiller and lighting operations, and enhances maintenance by identifying underperforming solar panels and potential equipment failures. As a result, within six months, Infosys improved campus energy efficiency by 7%, increased on-site energy generation by 5%, and reduced emissions by 7 900 tonnes of CO_2-equivalent.

AI process control for cement production

The cement industry is a major contributor to global greenhouse gas emissions, accounting for 8% of the total, and faces the challenge of reducing its carbon footprint while maintaining efficient and reliable operations. Traditional software solutions, reliant on static control methods, have struggled to optimise processes amidst increasing use of alternative fuels and the demands of carbon capture technologies. In response, Carbon Re deployed AI models at Heidelberg Materials' Mokra cement plant in 2024, integrating real-time clinker quality predictions and oxygen targets into the existing ABB Ability Expert Optimizer system. This AI-driven solution led to a 4.1% reduction in fuel costs, a 2.2% decrease in specific heat consumption, a 4.5 kg CO_2/tonne (approx. 2%) drop in fuel-derived emissions, and a 1.8% rise in alternative fuel use over a rigorous test period. Furthermore, quality stability improved significantly, with the share of clinker meeting targets rising from 79% to 96%. These quantifiable outcomes highlight Carbon Re's success in deploying advanced AI to address both environmental and operational challenges in cement production.

AI-enabled energy savings in steelmaking

Steel production is critical to global economic growth, yet the sector faces the dual challenge of meeting rising demand while reducing its substantial energy use and carbon emissions – currently accounting for about 8% of global final energy demand and 7% of energy sector CO_2 emissions. The primary problem lies in the inconsistent composition and quality of scrap metal, which hinders the production of high-grade steel and necessitates costly, carbon-intensive primary feedstock. Fero Labs addressed this issue by deploying their "white-box" machine learning software, which optimises the use of recycled scrap in electric arc furnace mills through advanced causal inference and generative AI, thereby maintaining steel quality while reducing alloy consumption. As a result, in 2024, one North American mill using Fero Labs' solution achieved a 3.3% reduction in global warming potential for a specific steel grade and a 1.5% reduction for its most common product, all without additional capital investment. Fero Labs continues to expand the technology's optimisation capabilities across various mill operations, offering scalable improvements for the industry.

AI-optimised gas use and waste heat recovery in steel production

ArcelorMittal Aviles, a major steel-making facility in northern Spain with an annual capacity of nearly 3 million metric tonnes, faced challenges in recovering and utilising basic oxygen furnace (BOF) gas due to the batch nature of the process and safety constraints, resulting in inefficient gas and steam recovery. In response, ArcelorMittal Aviles deployed a multidisciplinary team and invested approximately USD 5.4 million in 2020 to implement efficient new burners, boilers, and advanced AI tools – including thermodynamic and machine learning models – to optimise gas and steam generation and utilisation. Completed in 2022, this initiative led to a 49% increase in BOF gas recovery rate, a 14% rise in caloric value, and a 76% boost in recovered steam, resulting in natural gas savings exceeding 1,000 terajoules per year and annual CO_2 abatement of more than 62 000 metric tonnes, while delivering significant energy and environmental benefits.

Self-driving taxis

AI and autonomous vehicles (AVs) present significant benefits for large fleet operators, particularly in ride-hailing and shared mobility, enabling optimised fuel consumption and reduced urban car ownership. However, challenges remain, especially in urban areas with robust public transport and in rural settings where "last mile" connectivity is essential for those unable or unwilling to drive. Addressing these issues, Waymo deployed its fully autonomous driving technology, the Waymo Driver, which uses advanced AI and custom mapping to safely navigate complex environments without human intervention. As of the end of 2024, Waymo was delivering over 150,000 autonomous rides per week in Phoenix, San Francisco and Los Angeles, helping riders avoid more than 6 million kg of CO_2 emissions that year through its all-electric, renewably powered fleet.

Energy innovation

AI-powered materials discovery for battery innovation

Lithium-ion batteries are widely used in various technologies but face environmental and supply chain challenges due to the extraction and concentration of lithium resources. The key problem is the slow, labour-intensive process of discovering suitable alternative materials for solid-state battery electrolytes, which traditionally takes years of computational and laboratory effort. To address this, Microsoft, in partnership with the Department of Energy's Pacific Northwest National Laboratory, deployed AI and cloud-powered high-performance computing to rapidly screen and evaluate 32.6 million candidate materials. Their AI-driven approach enabled property prediction 1 500 times faster than conventional methods, narrowing the selection to 18 promising candidates in just a few days. The outcome included the synthesis and successful testing of a novel material that could potentially reduce lithium usage by approximately 70%, demonstrating a significant advancement in resource-efficient battery technology.

Inverse design of CO_2 reduction electrocatalysts using generative AI

The reduction of CO_2 to carbon monoxide or other carbon molecules is crucial for producing synthetic fuels, which are essential for decarbonising sectors such as aviation and shipping that cannot be easily electrified. A significant challenge is that current electrocatalysts often have low activity or poor Faradaic efficiency, causing wasted electricity and increased synthetic fuel costs. Traditional machine learning methods are limited to known material structures, making it difficult to identify new, effective catalyst alloys, while generative AI models have struggled to propose truly novel materials. To address this, the Chinese Key Laboratory of Quantum Materials and Devices developed the Material Generation with Efficient Global Chemical Search Space framework, employing a Bird Swarm Algorithm to efficiently search and propose new material candidates. This approach generated 250 000 material structures, with a 35% higher average performance than random selection. Through further screening, five alloys were tested, and two achieved over 90% Faradaic efficiency and high catalytic activity. This advancement could lower synthetic fuel costs and has broader applications for material design in energy sectors, though large-scale deployment and further evaluation of properties such as degradation rates are needed for real-world impact.

High-capacity carbon capture materials generated by diffusion AI approaches

Carbon capture, utilisation and storage (CCUS) technologies are vital for decarbonising power, industry and hydrogen production, but their effectiveness depends on materials that can efficiently extract and release CO_2. Metal-organic frameworks (MOFs) offer promising potential due to their tunable pore volumes, yet practical deployment has been hindered by their sensitivity to moisture and structural degradation, as well as the immense complexity of possible MOF configurations and difficulties in large-scale synthesis. To address these challenges, Argonne National Laboratory, part of the US Department of Energy, developed an advanced workflow combining conventional and AI methods. This approach generated over 120 000 candidate MOFs in less than 30 minutes, then filtered out invalid structures and used neural networks to assess their carbon capture capabilities. As a result, 364 promising MOFs were identified for further simulation, with six exhibiting CO_2 capture capacities in the top 5% of known performers. While this demonstrates the power of generative AI in material discovery and offers compatibility with future high-throughput screening, widespread deployment of MOFs in carbon capture remains limited, constraining the overall impact of the solution thus far.

Glossary

Abbreviations and acronyms

AI	artificial intelligence
AMI	advanced metering infrastructure
AMISP	advanced metering infrastructure service provider
API	Application Programming Interface
AT&C	aggregate technical and commercial
CER	consumer energy resource
CO_2	carbon dioxide
DSM	Deviation Settlement Mechanism
DT	distribution transformer
EMS	energy management system
GIS	geographic information system
HVAC	heating, ventilation and air conditioning
IEA	International Energy Agency
IEX	India Energy Exchange
INR	Indian rupee
NLR	National Lab of the Rockies
RDSS	Revamped Distribution Sector Scheme
SCADA	supervisory control and data acquisition
SMEs	small and medium-sized enterprises
SOC	state of charge
TCS	Tata Consultancy Services

Units

GW	gigawatt
GWh	gigawatt-hour
kg	kilogramme
kW	kilowatt
kWh	kilowatt-hour
MW	megawatt
TR	tonnes of refrigeration

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