ASIA CLEAN ENERGY FORUM 2026

Beyond Transition: Building Secure, Resilient, Inclusive, and Intelligent Energy Systems

8–11 June | ADB Headquarters, Metro Manila, Philippines

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ADB

Next Generation Energy Systems in Central, West and East Asia: Technology, Markets and Regional Integration

Leveraging AI for Low Carbon Buildings : Key Technologies and Application Cases

11 June 2026 | 9 am- 12:30 p.m.

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01

The Imperative for Change

The Urgency: Global Building Energy & Carbon Footprint

02

AI Technologies and Applications

From Data-Driven Modeling to Dynamic Control

03

International Case Studies

Real-World Success Stories from Sweden to Dubai

04

Constraints, Challenges

Navigating the Roadblocks to AI Applications

05

Conclusion

AI Empowers a Low-Carbon Future

01

The Imperative for Change

The Urgency: Global Building Energy & Carbon Footprint

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The Urgency: Global Building Energy & Carbon Footprint

The global building sector is a major energy consumer and carbon emitter, facing a critical crisis that demands immediate, innovative solutions to combat climate change.

40%

Share of global energy consumption from buildings

40–70%

HVAC energy share (up to 70% in extreme climates like Kuwait)

35%

Global greenhouse gas (GHG) emissions from buildings

The International Energy Agency (IEA) highlights that achieving global net-zero by 2050 requires an **80% drop** in heating and cooling energy use, making AI-driven efficiency strategies an essential enabler.

The Core Problem: Inefficient HVAC Systems

In China and many regions, air conditioning systems account for **over 50%** of a building's operational energy consumption. The key problem lies in low system efficiency.

Poor Performance

< 3.5 EER

The measured Energy Efficiency Ratio (EER) for most domestic AC systems typically falls below this threshold.

Industry Benchmark

> 5.0 EER

ASHRAE guidelines define this as "excellent" performance, while any rating below 3.5 is considered in need of improvement.

Significant Gap

Untapped Potential

The substantial difference between current operations and optimal efficiency represents a massive opportunity for energy savings.

The Root Cause: The "Funnel Effect"

Poor operational performance is a systemic failure across the entire lifecycle, characterized by a "funnel effect" where quality degrades at each stage.

Strategy & Planning

High quality intentions and strategic goals are set at the outset.

Design Phase

Excessive oversizing and "gold-plating" occur under the guise of "safety."

Construction

Deviations from design, poor execution, and questionable engineering quality.

Commissioning

Rushed openings to meet deadlines, with systems never properly tuned.

Operation & Maintenance

Manual "firefighting" mode dominates, with no proactive optimization.

This lifecycle degradation results in poor performance over the system's typical **15–20 year** lifespan.

02

AI Technologies and Applications

From Data-Driven Modeling to Dynamic Control

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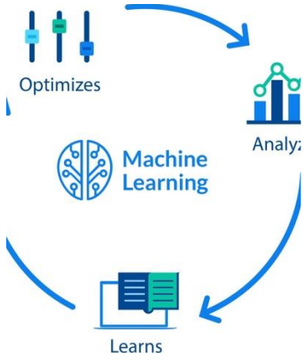
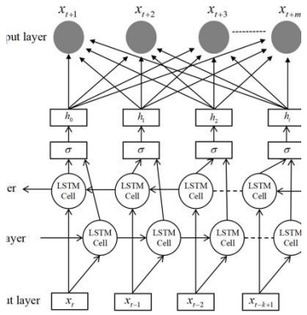
A suite of AI technologies is transforming the building sector, each playing a unique role.



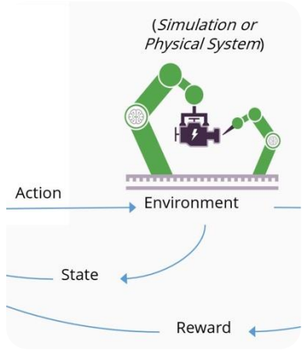
Machine Learning (ML)

For energy pattern recognition, dynamic prediction, and automated decision-making to optimize building performance.



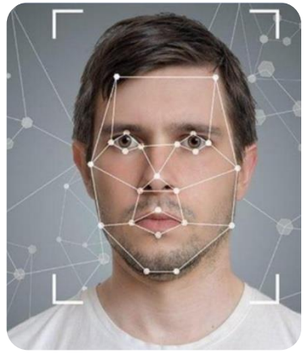
Deep Learning (DL)

For processing complex, unstructured data (images, time-series) to enable high-precision perception and prediction.



Reinforcement Learning (RL)

For generating dynamic optimization strategies through trial-and-error learning, perfect for real-time building control.



Computer Vision (CV)

For automated equipment condition monitoring, safety surveillance, and occupant pattern identification.

Data-Driven Modeling with Machine Learning (ML)

Core Function

Use historical data to train predictive models for load forecasting and fault detection & diagnosis (FDD) to enable proactive maintenance and energy optimization.

Input

Historical & real-time data (energy use, equipment status, weather), valve/fan speeds, and weather forecasts.

Output

Predictions for building cooling/heating load (e.g., next 24h) & identification of equipment fault types (e.g., clogged filters).

Key Algorithms

LSTM networks for load forecasting; Random Forest, SVM for FDD.

Data center servers processing building energy data streams for real-time analysis, model training, and fault detection.

Deep Learning (DL) for Visual Analysis & FDD

KEY BENEFIT

Core Advantage

Automatically extracts high-dimensional features from raw, unstructured data such as images, audio, and time-series signals, enabling unprecedented insights.

Visual Occupancy Analysis

Processes camera feeds to generate crowd density heatmaps, achieving **over 83% accuracy** in people counting, enabling dynamic HVAC adjustment.

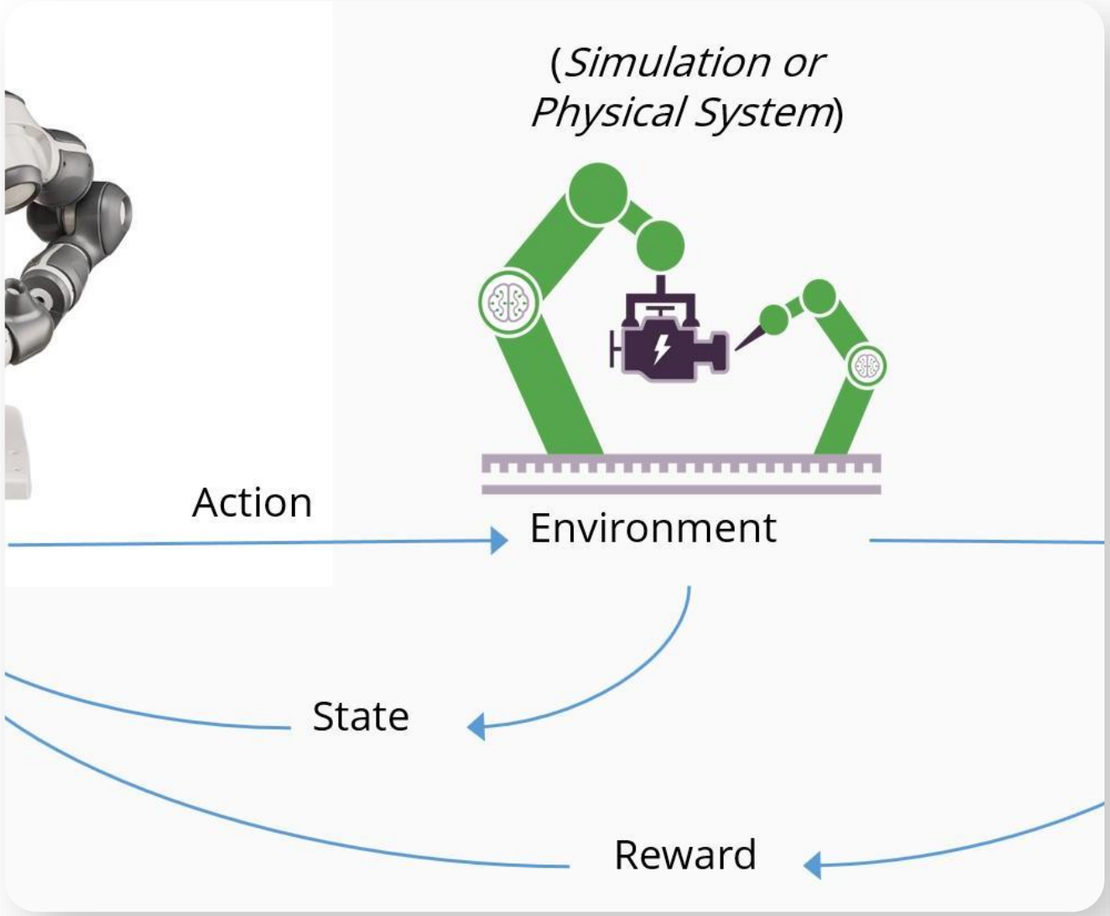
Load Forecasting

LSTM networks achieve high accuracy (e.g.,**R^2=0.98** for cooling load prediction) by learning complex temporal dependencies in energy consumption data.

Fault Detection & Diagnosis (FDD)

Analyzes sensor data (vibration, temperature) to pinpoint faults with**>98.5% accuracy** in chiller studies, and predict failures up to **48 hours** in advance.

Reinforcement Learning (RL) for Dynamic Control



Core Value

Enables adaptive, model-free predictive control by learning an optimal policy through continuous interaction with the physical environment.

How it Works

An "agent" takes actions (e.g., adjust HVAC setpoints) based on the current state (temp, occupancy, prices) and receives a reward (energy savings vs. comfort). It iteratively learns to maximize the long-term cumulative reward.

Key Application: Demand-Side Optimization

RL agents respond to real-time electricity prices to implement optimal pre-cooling/heating strategies, achieving a**peak demand reduction of 25–40%**and significantly lowering operational energy costs.

LLMs for Design & Knowledge

Core Capability

Possesses natural language understanding, knowledge retrieval, and logical reasoning capabilities.

Design Assistance

Translates ambiguous requirements (e.g., "low-carbon office") into structured design parameters.

Code Compliance

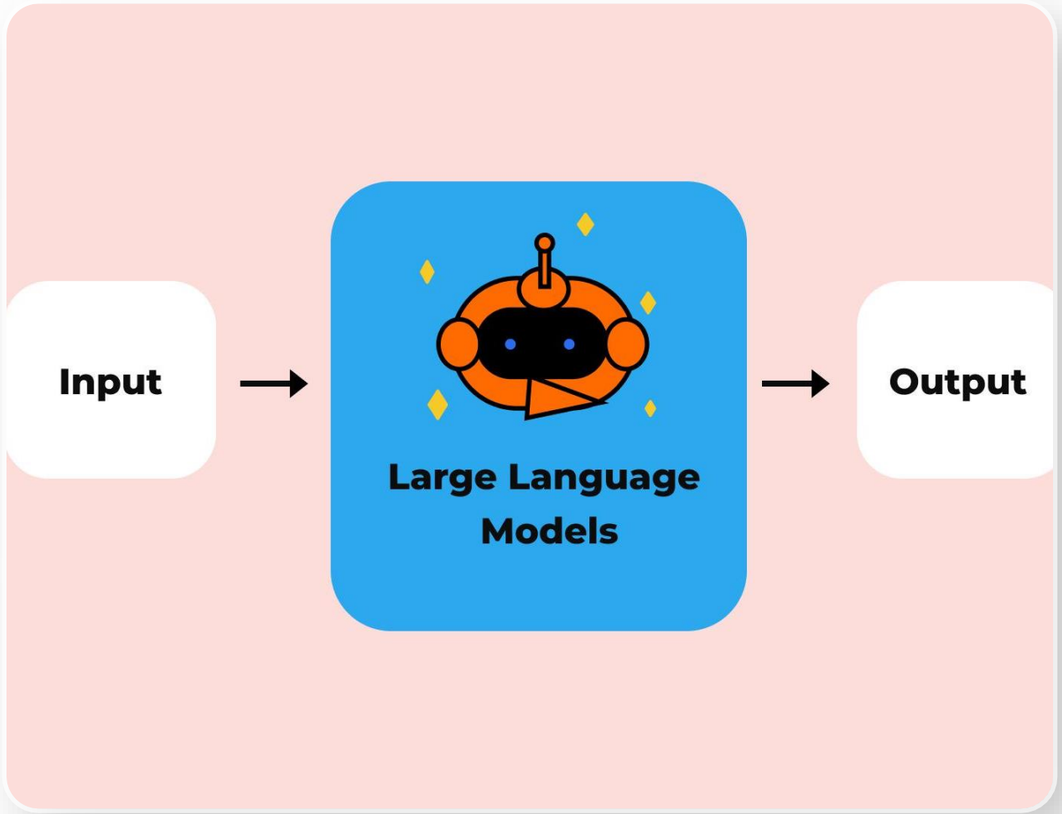
Verifies designs against standards like LEED with **over 90% precision** automatically.

Carbon Footprint Analysis

Integrates with BIM models to generate automated life-cycle carbon reports.

Technical Validation

LLMs like GPT-4 have successfully passed the ASHRAE Certified HVAC Designer (CHD) exam.



03

International Case Studies

Real-World Success Stories from Sweden to Dubai

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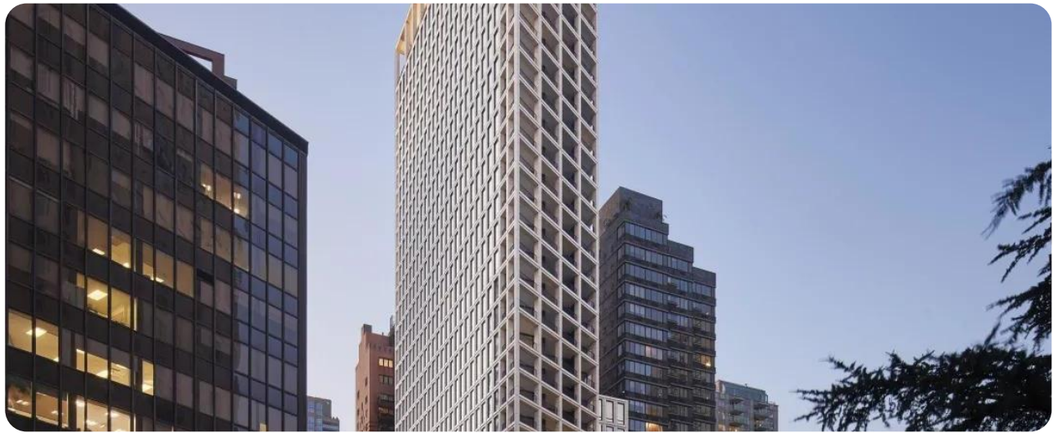
Stockholm Schools, Sweden

AI Tech: Reinforcement Learning (RL) + Deep Learning (LSTM)

Results: Heating energy**-4%**, electricity**-15%**, CO_2 reduced by**205 tons**annually.



45 Broadway Tower, New York, USA

AI Tech: Deep Learning (CNN) + Large Language Models (LLM)

Results:HVAC energy**-15.8%**, cost savings of**$42,000**, carbon reduction of**37 tons of CO_2e**per year.

Singapore Tech Manufacturer HQ

🤖 **AI Tech:** Deep Learning (optimizing cooling system)

📊 **Results:**Cooling energy**–23%**, investment payback period**< 2 years**

Dubai Mall, UAE

🤖 **AI Tech:**Multi-agent Reinforcement Learning + Computer Vision

📊 **Results:**Total energy**–22%**, peak load**–31%**, comfort complaints**–40%**

04

Constraints, Challenges

Navigating the Roadblocks to AI Applications

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Hard "Non-Negotiable" Bottom Lines

Physical Limits
AI cannot violate the Carnot efficiency limit or alter a building's fixed thermal envelope.

Regulatory Compliance
Must adhere to standards like ASHRAE 62.1 for indoor air quality.

Practical Challenges

Data Quality
"Garbage in, garbage out" – heavily dependent on accurate, calibrated sensors.

Model Generalizability
Models often struggle to perform well across diverse building types and climates.

Data Privacy & Cybersecurity
Increasing concerns under regulations like GDPR.

High Initial Investment
A significant financial barrier for many building owners.

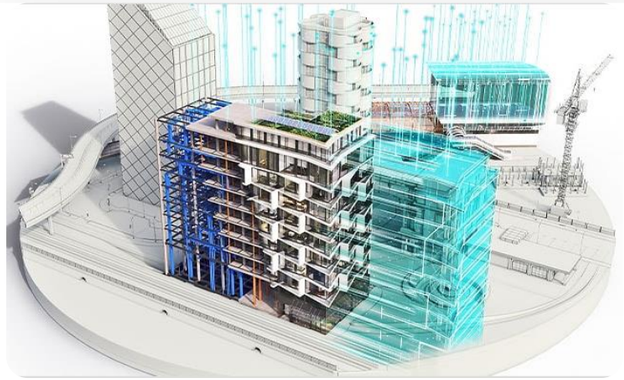
AI "Black Box" Problem
Lack of interpretability hinders trust and debugging, making it hard to validate decisions.

05

Conclusion

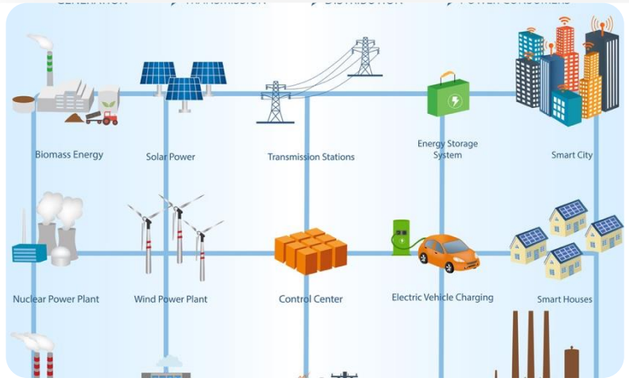
AI Empowers a Low-Carbon Future

Future Directions & New Research



Digital Twins & IoT Integration

Creating virtual replicas for simulation and optimization to enhance real-world efficiency and predictive maintenance.



Grid-Interactive Efficient Buildings (GEB)

AI enabling buildings to act as flexible grid assets through intelligent demand response and energy storage.

Generative Design

AI algorithms optimize architectural design for multiple conflicting objectives like energy efficiency, cost, and carbon footprint.

Conclusion: AI Empowers a Low-Carbon Future

AI is transforming energy management, design, and operations in the building sector, driving significant improvements in energy efficiency and carbon reduction.

The journey is evolving from optimizing individual devices to enabling collaborative intelligence across the **"human-building-community-city-grid"** ecosystem.

A Promising Outlook

IEA projects AI could save **300–500 TWh**/year by 2050 (≈ Aus + NZ's combined generation).

Thank You!