

Presentation of Potential of artificial intelligence in reducing energy and carbon emissions of commercial buildings at scale

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Introduction

Presented by: Ray Marange

This summary reviews the paper by Chao Ding, Jing Ke, Mark Levine, and Nan Zhou titled *Potential of Artificial Intelligence in Reducing Energy and Carbon Emissions of Commercial Buildings at Scale* [Chao Ding et al.](#) “Potential of Artificial Intelligence in Reducing Energy and Carbon Emissions of Commercial Buildings at Scale”. In: *Nature Communications* 15.1 (July 2024), p. 5916. ISSN: 2041-1723. DOI: [10.1038/s41467-024-50088-4](https://doi.org/10.1038/s41467-024-50088-4).

Introduction

Presented by: Ray Marange

- ▶ Climate change is intensifying, and buildings are major contributors—accounting for 39% of U.S. primary energy use.
- ▶ With urbanisation accelerating and building stock projected to double by 2060, improving building efficiency has become a critical global priority.
- ▶ While AI has transformed sectors like healthcare and finance, its application in building energy management remains limited.
- ▶ The paper outlines how AI can reduce costs, extend lifecycle benefits, and improve safety across the building lifecycle.
- ▶ This study focuses on medium-sized office buildings to examine AI's capacity to reduce energy usage and carbon emissions.
- ▶ It presents a scalable framework with global applicability, making its insights relevant across diverse building contexts.
- ▶ Though centred on medium-sized offices, the findings are generalisable to commercial buildings of various sizes.

Results part 1

Presented by: Dwayne Mark Acosta

- ▶ According to the 2012 U.S. Energy Information Association (EIA), office buildings account for 20% of commercial energy use.
- ▶ Median Energy Use Intensity (EUI) of typical office buildings: **167 kWh/m²** (EUI_{base}).
- ▶ Verified low-energy office buildings (EUI_{HEEB}) achieve: **57 kWh/m²**.
- ▶ This yields a Technical Energy Efficiency Saving (TEES) of: **110 kWh/m²**.
- ▶ TEES is broken into four key optimization categories:
 1. Equipment efficiency
 2. Occupancy influence
 3. Control and operation
 4. Design and construction

Results Part 1

Presented by: Dwayne Mark Acosta

- ▶ Medium office buildings make up **70%** of total U.S. office energy consumption.
- ▶ The study used DOE's EnergyPlus tool, based on ASHRAE 90.1, to simulate annual energy use.
- ▶ Simulations covered four U.S. climate zones (1A, 3B, 4A, 5A) using representative cities.
- ▶ Natural gas was assumed for heating and hot water, electricity for all other loads.
- ▶ A total of **24 improvement cases** were modeled:
 - ▶ 9 cases for equipment efficiency
 - ▶ 9 cases for design and construction
 - ▶ 6 cases for occupancy behavior and control

Results Part 1 – Equipment Efficiency

Presented by: Dwayne Mark Acosta

Table: Equipment Efficiency Improvement Cases

Case	Improvements	Adjustments
E1	HVAC – Cooling	+20%
E2	HVAC – Heating	+12%
E3	HVAC – Cases E1 and E2	+20%, +12%
E4	Lighting – Power density (LPD)	-15%
E5	Lighting – Power density (LPD)	-21%
E6	Equipment – Power density (EPD)	-10%
E7	Equipment – Power density (EPD)	-20%
E8	Combined – Cases E1–E7	
E9	Case E8 + Heat Pump for space heating	

Results Part 2 – Design and Construction

Presented by: Dwayne Mark Acosta

Table: Design and Construction Improvement Cases

Case	Improvements	Adjustments
D1	Orientation	East (90° rotation)
D2	Orientation	South (180° rotation)
D3	Orientation	West (270° rotation)
D4	Envelope (walls, slabs, roofs, windows)	High insulation
D5	Envelope (walls, slabs, roofs, windows)	Increased infiltration (60%)
D6	Window-to-wall ratio (WWR)	Variation 1
D7	Window-to-wall ratio (WWR)	Variation 2
D8	Window-to-wall ratio (WWR)	Variation 3
D9	Combined – Orientation, insulation, WWR	

Results Part 3 – Occupant Behavior and Control

Presented by: Dwayne Mark Acosta

Table: Occupant Behavior and Control Improvement Cases

Case	Improvements	Adjustments
B1	Ventilation control	Open/close windows
B2	Lighting use	Switch on/off lights
B3	Electricity consumption	Turn off plug loads
B4	Lighting use	Dim lights
B5	HVAC	Turn on/off HVAC systems
B6	Thermostat	Adjust thermostat settings

Estimated Energy Savings:

- ▶ Equipment: 11.5–17.3%
- ▶ Design and Construction: 5.9–9.1%
- ▶ Occupancy and Control: 15–20%

Integrated Technical Energy-Saving Potential

Presented by: Dwayne Mark Acosta

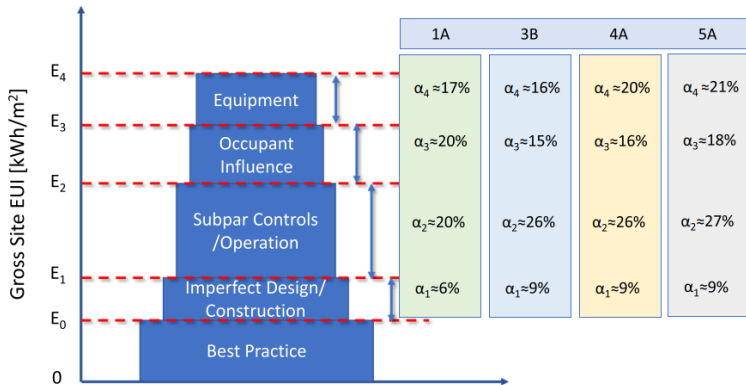


Figure: Energy-saving potential by category across U.S. climate zones.

Results part 2

Presented by: David Franz

Discussions

Presented by: Mohamed Amine Benaziza

Method & scope

- ▶ Mixed classic engineering with energy-simulation software (no single “magic” AI tool).
- ▶ Tested on a medium-size office, but the same method works for hotels, malls, etc.

Why AI helps

- ▶ Learns from building data to pick cheaper, better-fit efficiency fixes.
- ▶ Future add-ons (deep learning, reinforcement learning) promise even smarter control.

Discussions

Presented by: Mohamed Amine Benaziza

Key numbers for U.S. medium offices

- ▶ Four-part savings analysis (equipment, controls, occupants, design) shows the theoretical max each climate zone can hit.
- ▶ AI alone vs. Business-as-usual 2050 → about 8 % less energy & CO₂.
- ▶ AI + existing efficiency policies → 19 % extra cuts beyond policy alone.
- ▶ AI + strong policies + clean power (LEPG) → up to 40 % less energy and 90 % less CO₂ vs BAU.

Discussions

Presented by: Mohamed Amine Benaziza

Limits & take-aways

- ▶ Results hinge on how fast costs fall and buildings adopt AI; other building types still need testing.
- ▶ Big idea: AI's value is making proven high-efficiency designs affordable and widespread.
- ▶ Policy punchline: AI gets single-digit gains by itself; the huge drops only arrive when paired with clean-power policies and clear rules.
- ▶ Scaling to other sectors will need more research and skilled facility teams.

Methods

Presented by: James Thompson

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- ▶ **Calculating potential savings:** simple model which is just summation of potential saving from each 4 categories
- ▶ **Calculating market share of low and no energy buildings:** more complicated and done by calculating the market share of each building type over time.

Methods

Presented by: James Thompson

Calculation of the market share of different building types over time requires three things.

- ▶ The building type and its availability
There is a limit on the Net Zero market share which is from 59% - 79%, depending on policy and AI use. Estimates are based off of other studies.

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- ▶ The cost of the different building type
High energy efficient buildings and Net Zero energy building cost more than standard buildings, around 10%-20% more. Calculated from construction data.
- ▶ The reduction in cost of the building over time. The cost premium of HEEB and NZEB building is assumed decreased over time, with decreases of 60%-90% depending on scenarios. AI is just assumed to reduce cost premium by 10%, the effects of policy and autonomous decreasing is unreferenced.