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

Dwayne Mark Acosta (300665276)
Mohamed Amine Benaziza (300684553)
David Franz (add student id here)
Ray Marange (300671115)
James Thompson (300680096)

August 3, 2025

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.

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

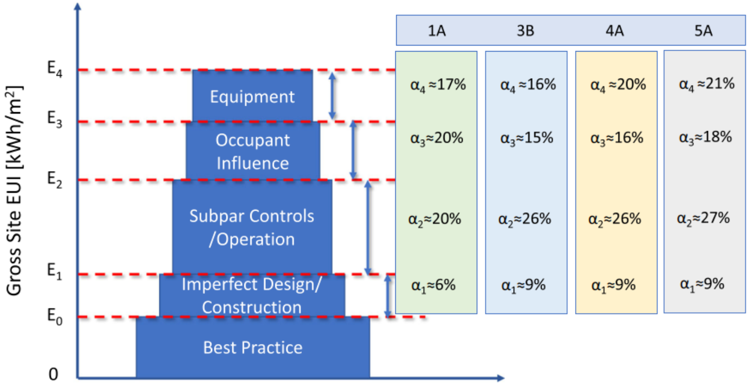

Figure: Energy-saving potential by category across U.S. climate zones.

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 & CO_2.
- AI + existing efficiency policies → 19 % extra cuts beyond policy alone.
- AI + strong policies + clean power (LEPG) → up to 40 % less energy and 90 % less CO_2 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

Two calculations used in this study. Lines up with

Methods

Presented by: James Thompson

Two calculations used in this study. Lines up with

- **Calculating potential savings**: simple model which is just summation of potential saving from each 4 categories

Methods

Presented by: James Thompson

Two calculations used in this study. Lines up with

- **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.

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.
- 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.

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.
- 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% depedning on scenarios. AI is just assumed to reduce cost premium by 10%, the effects of policy and autonomous decreasing is unreferenced.