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

Climate change is accelerating, and buildings are a major contributor, responsible for 39% of U.S. primary energy use. With urbanization surging and building stock/demand expected to double by 2060, improving building efficiency is no longer optional but urgent. While AI has transformed industries such as healthcare and finance, its potential in building energy efficiency remains underexplored. AI demonstrates significant potential to reduce costs, enhance benefits, and improve safety across the building lifecycle. The study investigates how AI can reduce energy consumption and carbon emissions in medium-sized office buildings, offering a scalable framework that could be applied globally. We will explore four key areas: **Results**, **Discussion**, **Methods**, and **Takeaways & Reflections**. The study focuses on medium-sized offices, and the results can be extrapolated to offices of any size.

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/m^2** (EUI_{base}).
- Verified low-energy office buildings (EUI_{HEEB}) achieve: **57 kWh/m^2**.
- This yields a Technical Energy Efficiency Saving (TEES) of: **110 kWh/m^2**.
- 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

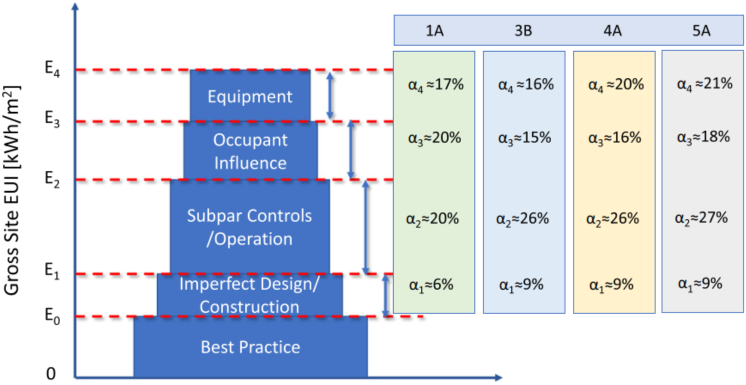

Figure: Energy-saving potential by category across U.S. climate zones.

Results part 2

Presented by: David Franz

Discussions

Presented by: Mohamed Amine Benaziza

Method and Scope

- Uses engineering + energy-simulation rather than one specific AI technology to estimate how AI can boost building-energy efficiency and cut carbon.
- The paper focuses on a medium-office as an example, yet methodology is transferable to other commercial buildings with adjustments.

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Why AI helps

- Data-driven modeling can tailor solutions and lower costs, accelerating adoption of high-efficiency / net-zero-energy buildings (HEEBs & NZEBs).

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- Data-driven modeling can tailor solutions and lower costs, accelerating adoption of high-efficiency / net-zero-energy buildings (HEEBs & NZEBs).
- Advanced control models (deep learning, reinforcement learning) could refine accuracy in future work.

Methods

Presented by: James Thompson

Two calculations used in this study. Lines up with

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