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Energy in the building sector: opportunities and challenges

ESC Symposium, April 2017 / Thomas Liesenfeld

The title is: „Energy in the building sector: opportunities and challenges“

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OK, then…

1. Energy in the building sector
2. Opportunities
3. Challenges

Energy in the building sector

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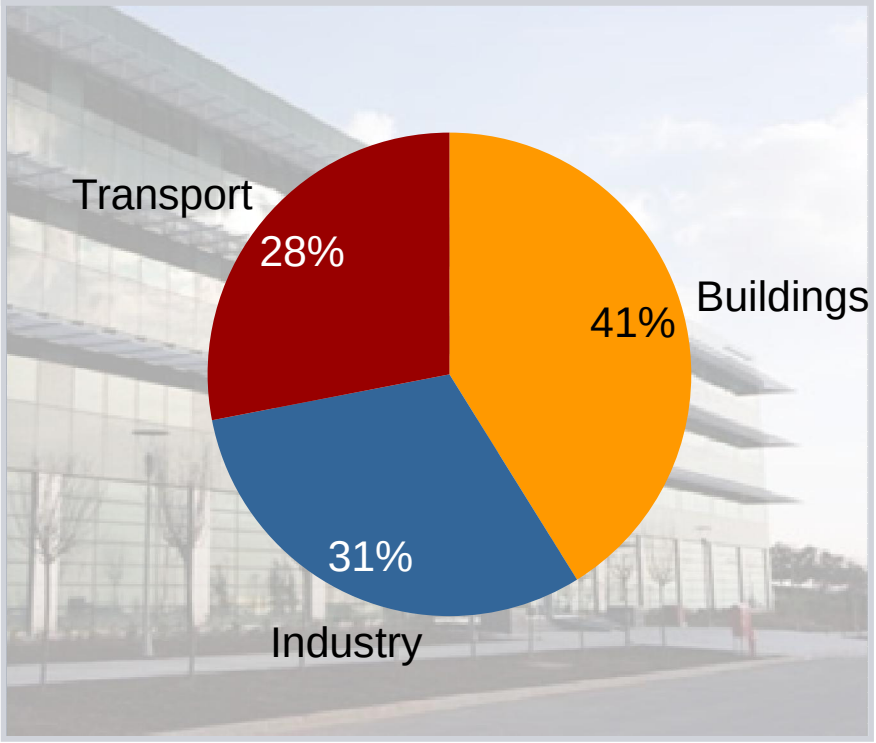
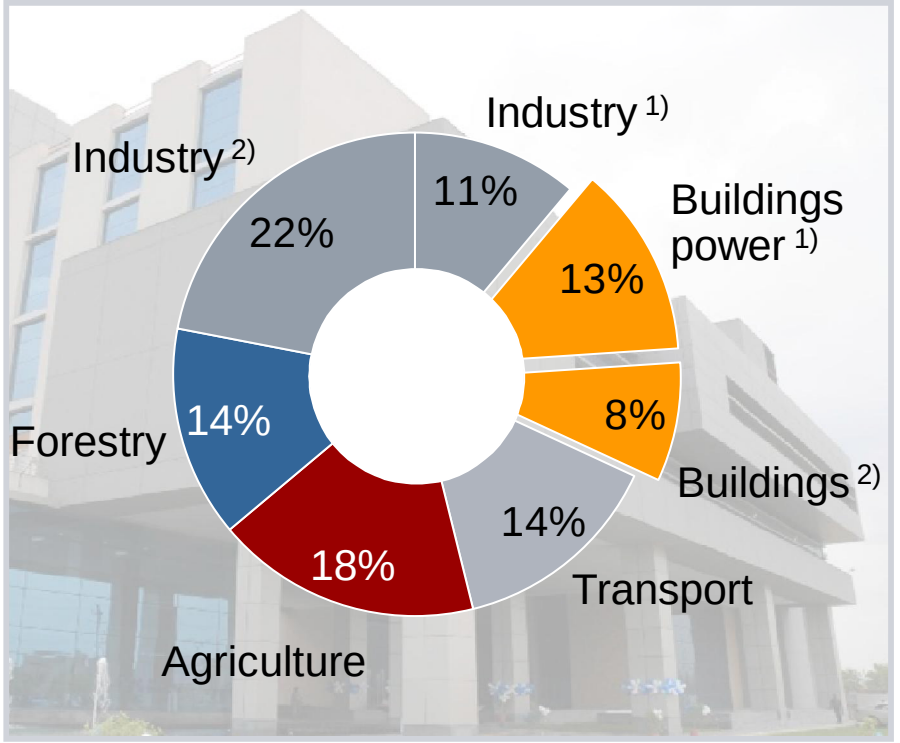
Energy… we'll look at some questions regarding power demand (kW) and energy consumption (kWh) in buildings during their active life. Construction and disposal are not in our focus today.

Buildings…

Consume ~40% of worldwide energy



Produce ~20% of CO_2



1) Indirect emissions through power usage
2) Direct emissions from primary energy usage

Reduction of energy consumption is possible using adaptive controls. The Siemens Smart Energy Box research project: automatic model-based simulation and optimization

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The Smart Energy Box (SEB) is a Siemens Corporate Research project that realizes significant (~40%) energy savings by continuously adjusting building settings to achieve specified outcomes at minimal energy consumption.

- uses Energy Plus to simulate alternative control strategies / schedules, then chooses the best.
- Communicates with field devices via BACnet and plug-load protocols (JADE)
- Integrates weather forecasts and occupancy inputs into its optimization
- Successful pilot projects at UC Berkeley, Carnegie Mellon and the US Air Force Academy (USAFA)
- communicates with the Smart Grid where available, reacting to Dynamic Pricing and Demand Response signals
- Keeps the building within operational parameters (defined by customer)
- Allows the building to re-schedule activities dynamically in response to changes in weather or energy cost.

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Other measures, like switching from air-based to water-based cooling, can also achieve a similar reduction in energy consumption. As shown at „3for2“, an ETH Zurich research project in Singapore.

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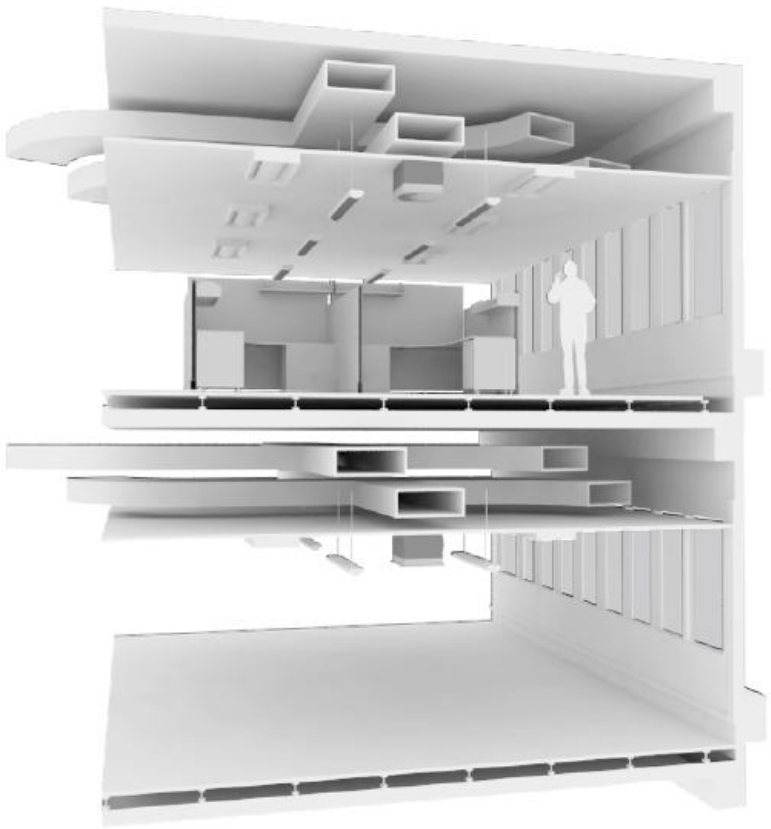

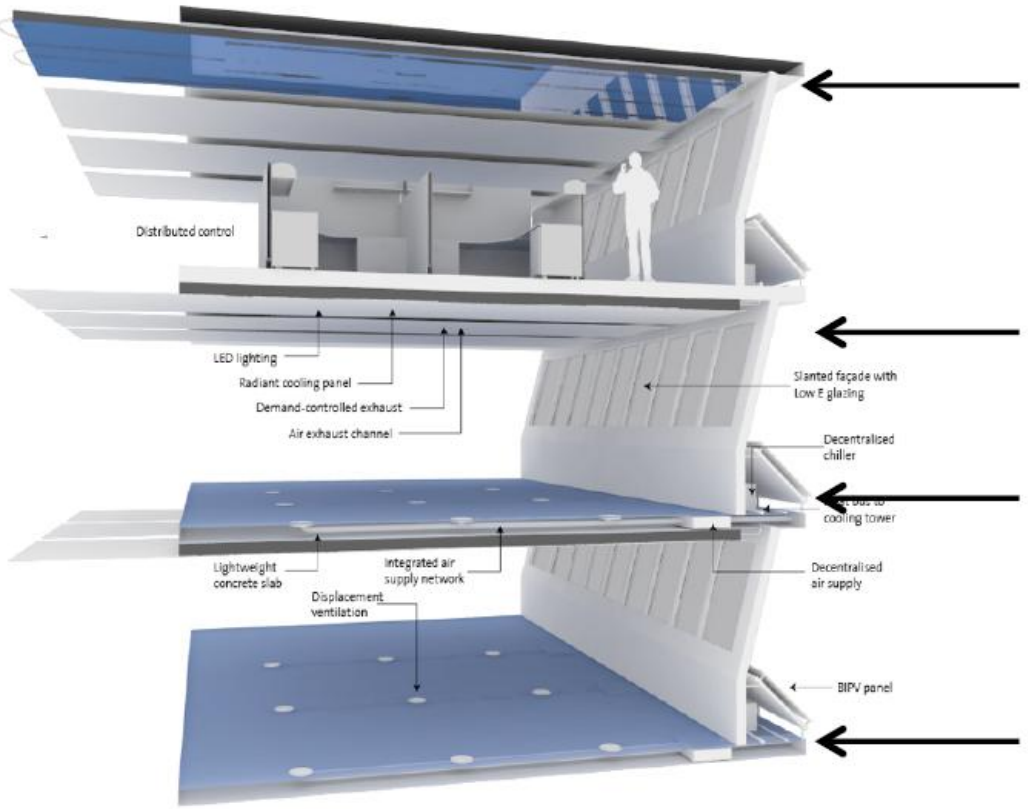

Key technologies:

Radiant chilled ceiling (supplied at high chilled water temperatures >16 °C)

Sloped glazing panels for reduced solar gains

Façade-integrated ventilation units and building-integrated PV

Dedicated outdoor air systems (DOAS) supplied through in-slab duct network and floor diffusers

(FCL) FUTURE CITIES LABORATORY 未来城市实验室

ETH Zürich

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in a conventional building.

Our „collaborative HMI“ research project has shown how building occupants can be engaged and motivated to provide the building automation system with cues about occupancy and their comfort level.

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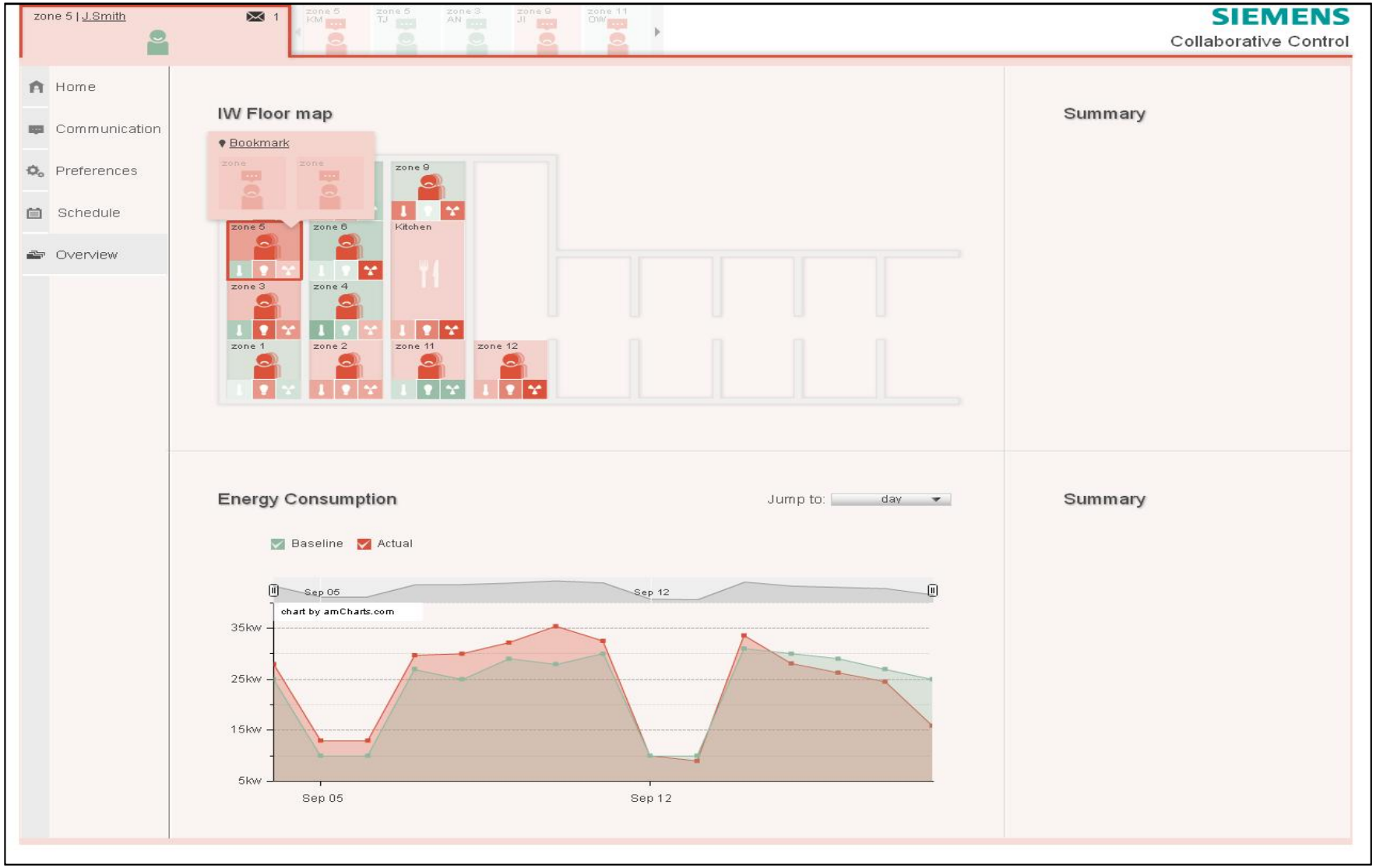

Occupants (office workers, students, military officers) provided with smartphone & web-based feedback mechanisms to convey their comfort level: smileys and frownies.

The system learns individual preferences over time and integrates them into its optimization considerations.

Continuous communication with occupants also enables contests: gamification of energy-saving behavior.

If you have remote access to a large pool of buildings, automation and clever engineering make it possible to take pressure off the power grid quite rapidly.

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Buildings can be grouped according to geographical location, or according to tags indicating their ISO.

à „Virtual Power Plant“

(Note: screenshot is from a pilot project)

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Looking at an individual site, we see that a custom load-shedding solution needs to be negotiated and programmed. The building‘s value-creating processes must not be interrupted!

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The Grand Del Mar Resort (San Diego)

Best Luxury Hotel in the U.S. (2011)[1],
250 rooms and golf course

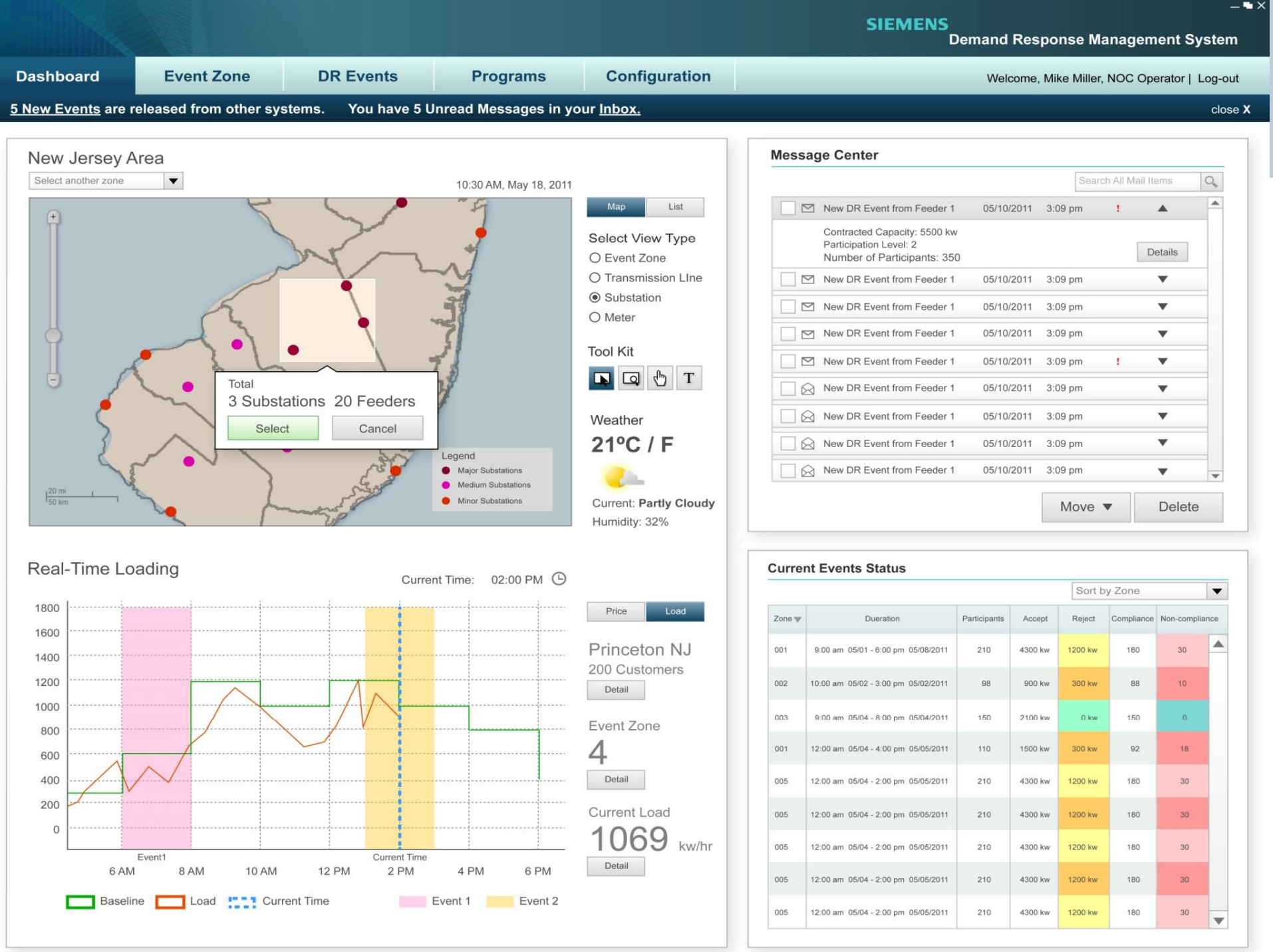
Fully automated load shedding **(300 kW curtailable load) without disruptions** to world class customer experience in hotel

Siemens system

- Building – **APOGEE** building automation system installed in property
- Grid – **ILM** Intelligent Load Management solution installed that interfaces with the building automation system

Value proposition

- Demand response system enabling **load shedding** in buildings by adjusting energy demand **based on price signals from grid**
- **Business rules** secure guest-friendly operation during demand response, e.g.,
  - No change in temperature in guest rooms
  - 4ºF temperature increase in common areas such as corridors
  - Shut-off of non-essential loads such as water features on golf course
- Example for **serving most demanding customers** with demand response



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Ideally, the utility is using a more sophisticated system to ensure that only relevant buildings are asked to contribute, avoiding unnecessary loss of comfort.

(Note: screenshot is from an early UI prototype of the Siemens DRMS. It does not represent the actual product)

So there are many opportunities to reduce power demand and energy consumption. What are the challenges?

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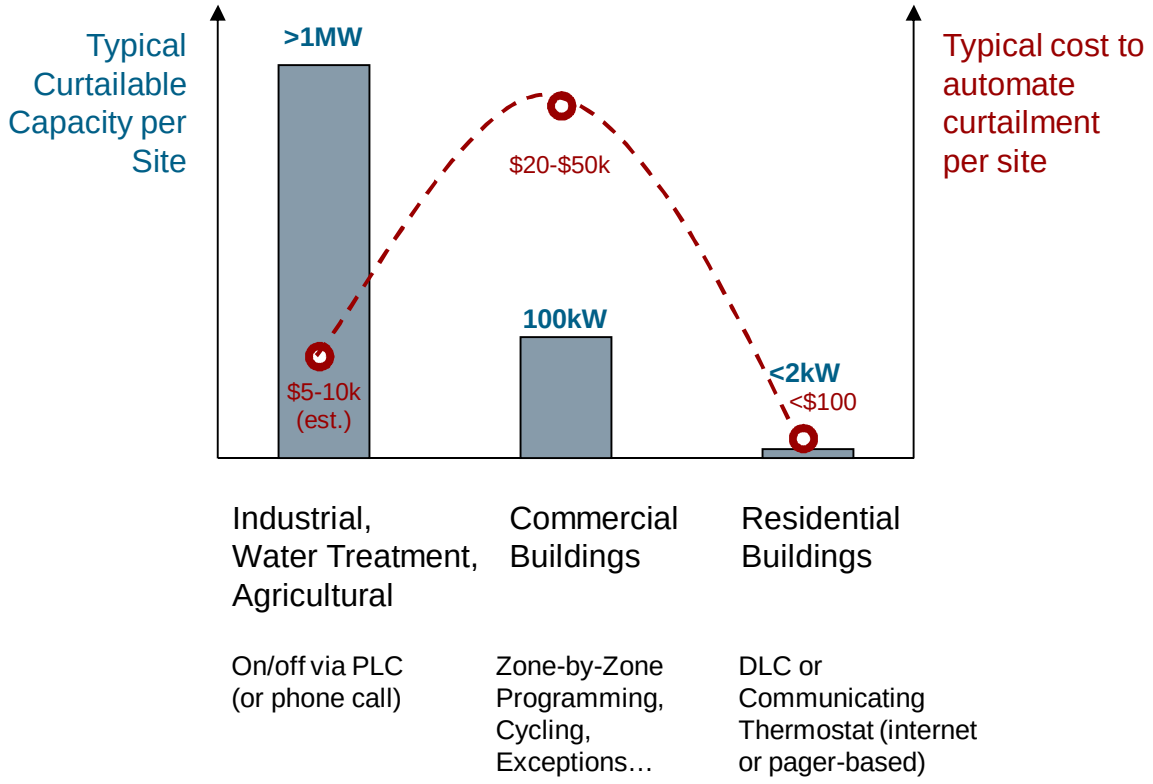
For commercial buildings, the current solution engineering costs usually far outweigh the financial benefit.
Returns on the investment are also uncertain (will the building still be used the same way in five years?)



Capacity and Energy are quite cheap, ie the benefits are modest. E.g. electricity prices in USA:

mean	10.52¢/kW·h
lowest	7.29¢/kW·h (Oklahoma)
highest	25.77¢/kW·h (Hawaii)

The engineering effort required makes it hard to convince investors:

- Highly skilled labor required e.g. to create models for model-based predictive controls
- Costs to keep the models / configurations up-to-date
- Re-commissioning costs when building use changes

Can we address these challenges through research?

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Yes! E.g. by bundling energy efficiency with additional economic incentives: by nearly eliminating air ducts, „3for2“ creates additional space (3 floors instead of 2). Will the combined value proposition convince investors?

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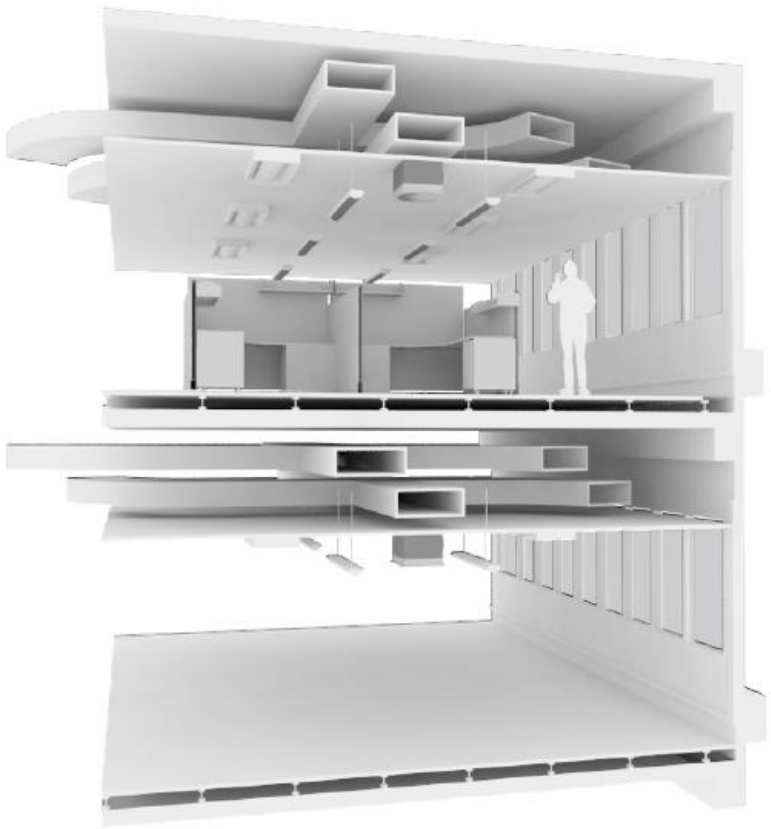

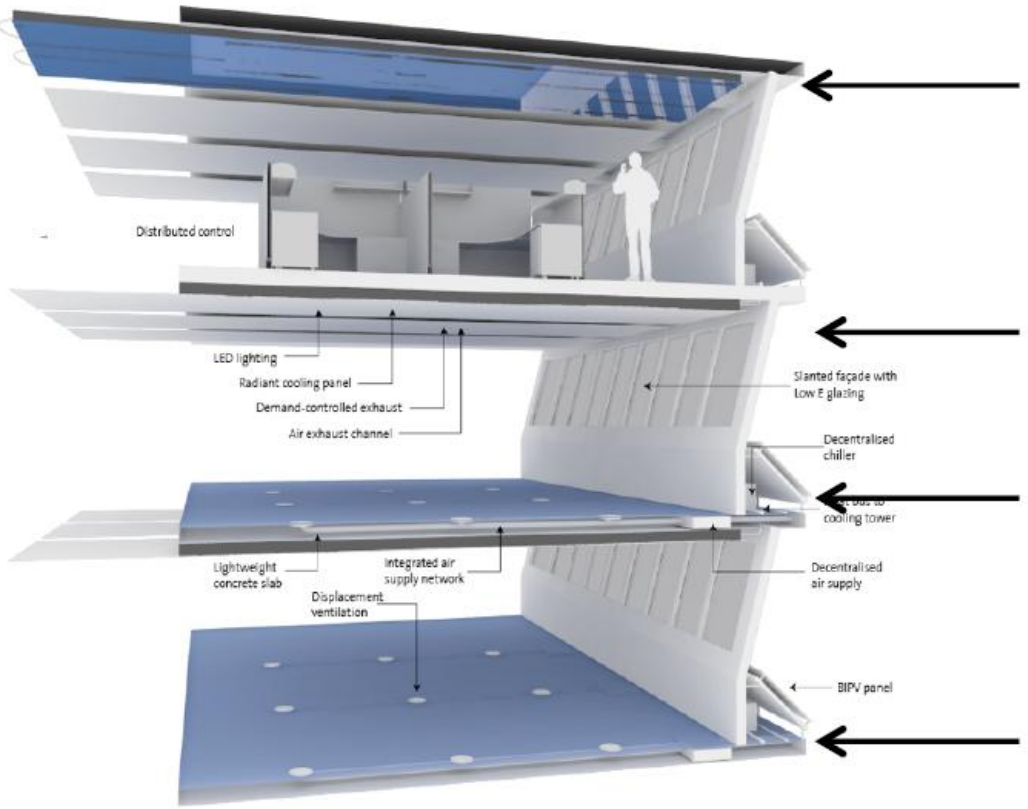

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in a conventional building.

By researching ways to lower engineering, commissioning, and maintenance costs of on-site energy-efficiency or demand-management solutions

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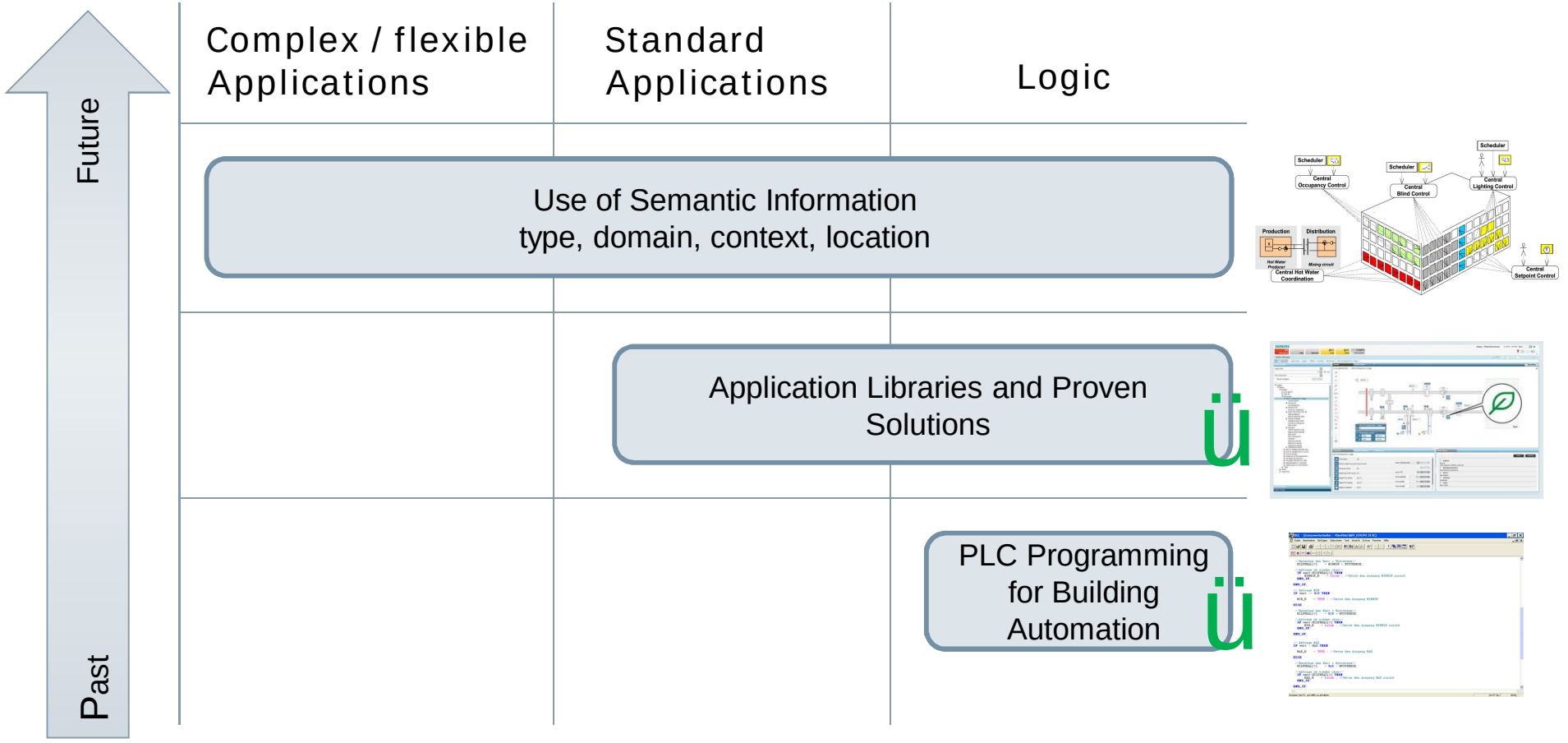
Currently, semantic information (e.g. control point names) differs from building to building. Standardization is implausible in the near term, so it‘s worth researching ways to interpret point names to infer their meaning. An effective machine-learning solution will allow better automated support of the engineering, commissioning and maintenance processes.



Energy in the building sector: opportunities and challenges

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1 Energy in the building sector

Buildings use a lot of energy! (40% of annual consumption)

2 Opportunities

There are many interesting approaches to save energy in buildings. And they work…

3 Challenges

…but they‘re expensive to engineer. Nevertheless…

4 Research can address the challenges

…clever bundling of benefits and automation-assisted engineering have great potential!

Thank you for your attention!

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