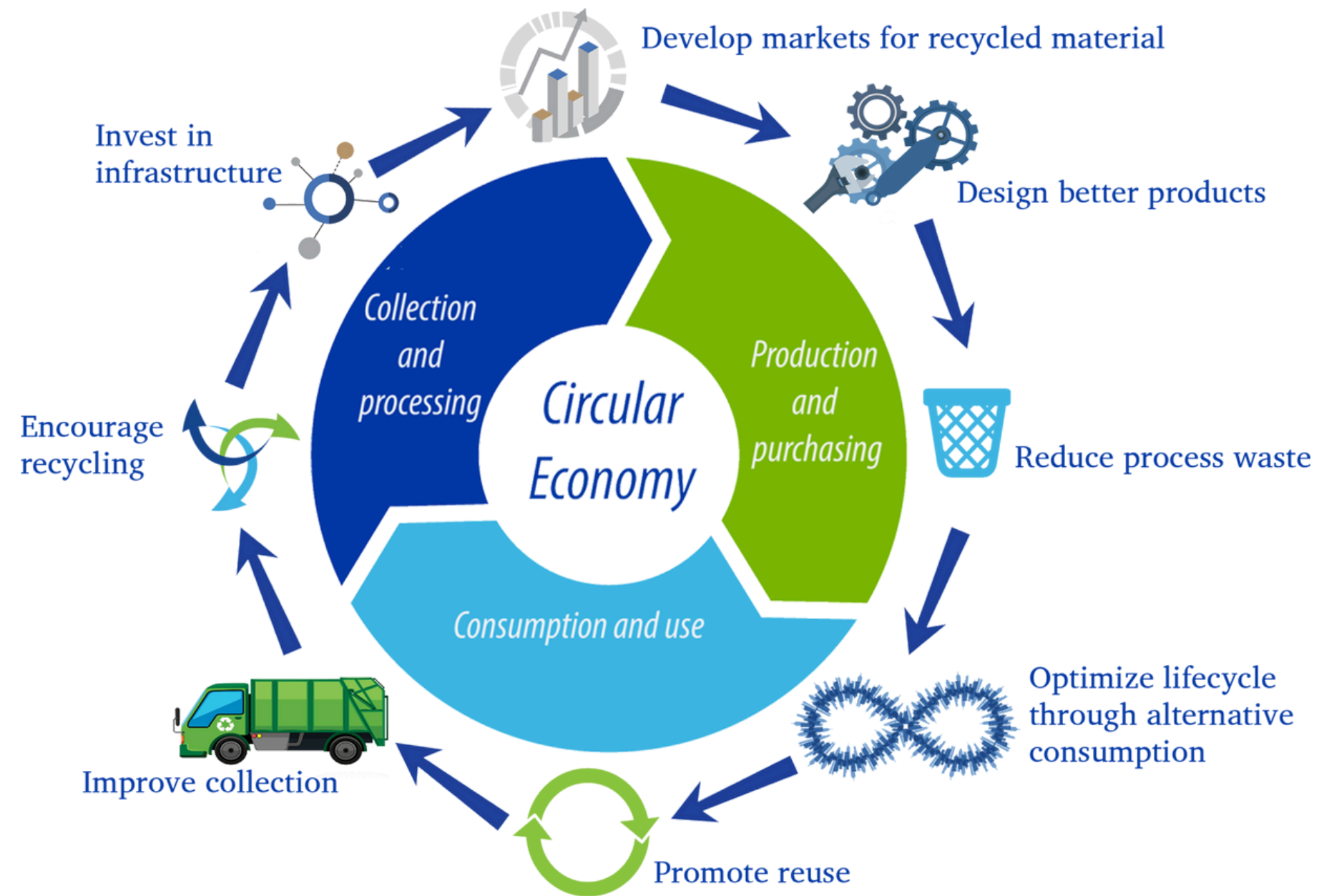


Closing the Loop

Reducing Energy Waste in Cooling Systems Through Predictive Maintenance



Team name:
The Loop Troop



Team 8
Yeonwoo Lee
Carlijn Taevernier
Denise Feldmann
Mohammed Almubarak

Challenge Statement

Wasteful Usage of Air Conditioning

- **Current HVAC** (Heating, Ventilation and Air Conditioning) **systems**
 - **Reactive maintenance**: expensive, energy inefficiencies, short lifespans
 - **Undetected faults**: refrigerant leakage, clogged filters contribute to greenhouse gas emissions
 - **Hinders** *preventive actions and sustainable resource use*
- **Optimize the energy consumption and the management of the air conditioners**
 - How? Digital technologies run virtual simulations
 - To aim what? **Predictive maintenance**, increases **product lifespans**



HOME > industry > Issues & Trends

Seoul National University ranks first in energy consumption for over 10 years... KT Mokdong IDC ranks first per unit area¹⁾

Reporter Kwon Seon-hyeong | Approved 2022.11.23 10:07 | Comments 0

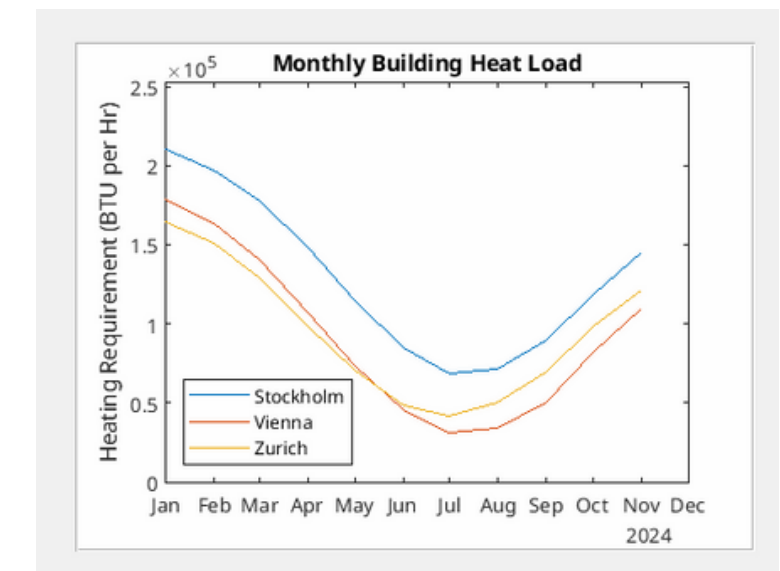
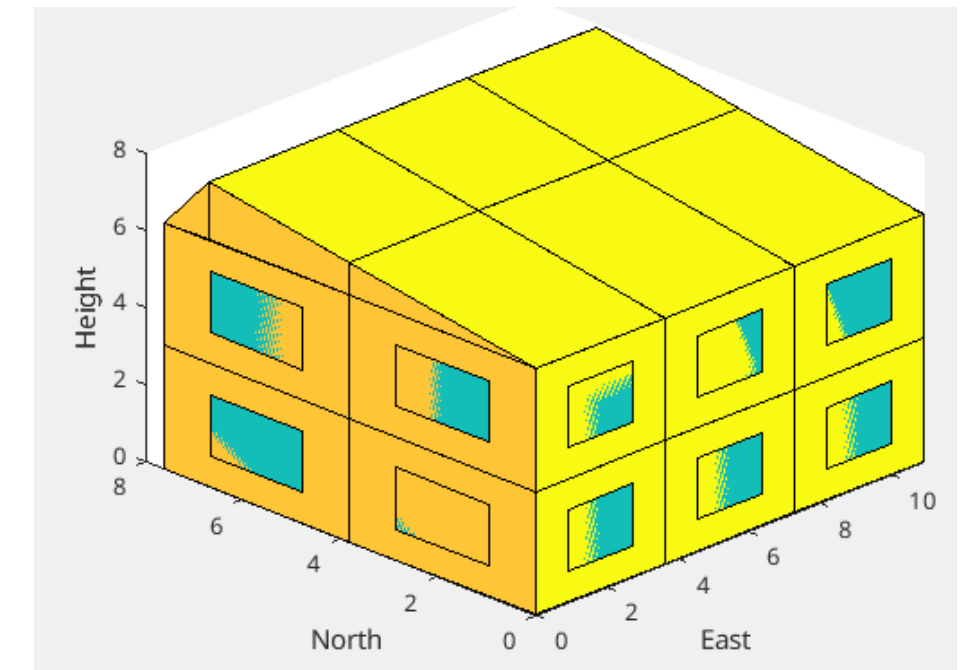
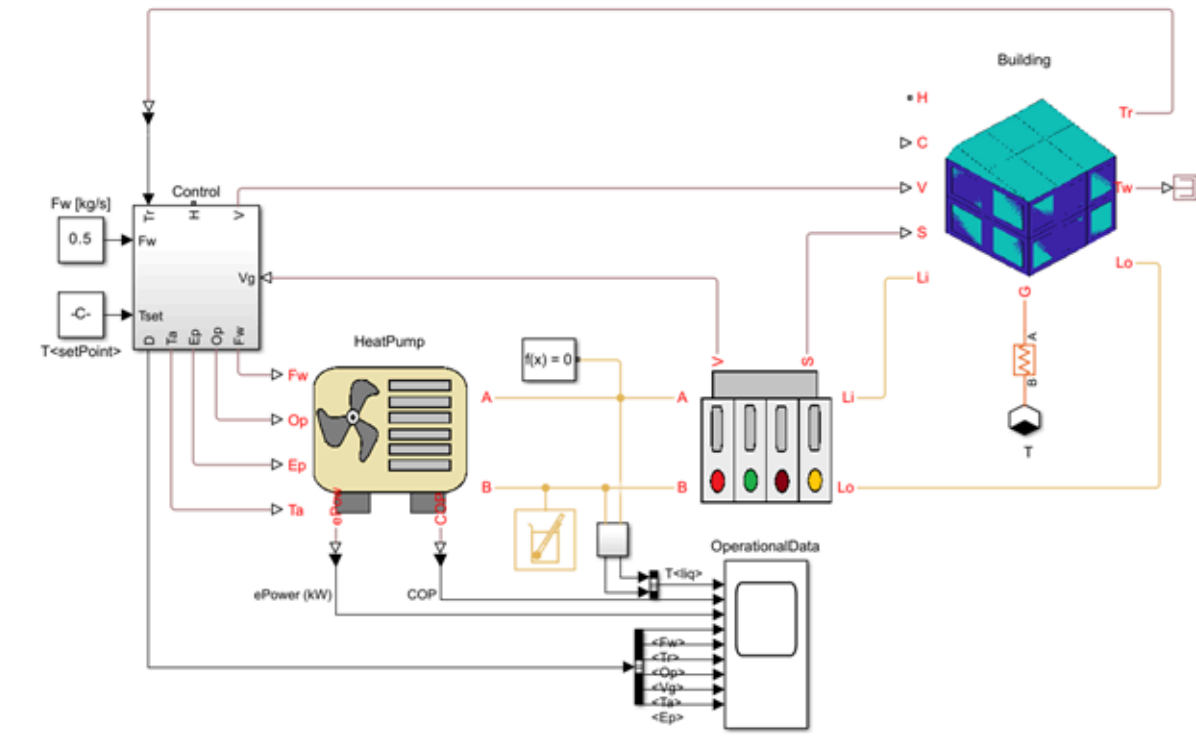


About 197 out of 316 energy-intensive buildings, or about 2/3, have increased their energy usage compared to the previous year.

Solution

Digital Simulation of HVAC for Circular Usage

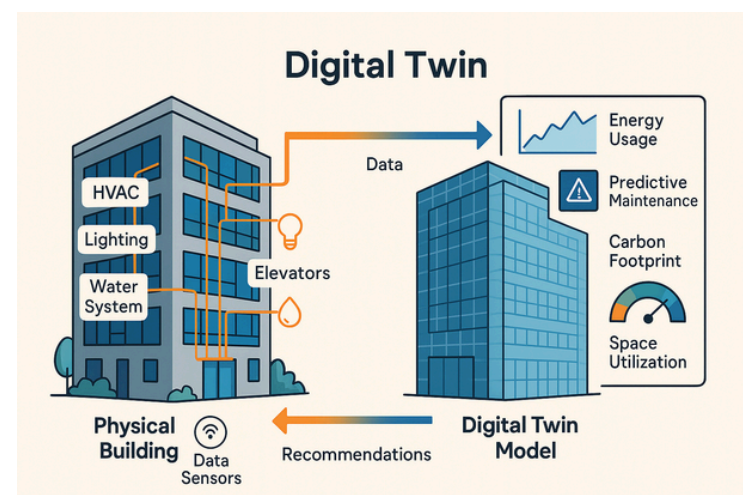
- A modular, parameterized digital-twin architecture built from 3D blocks for buildings, rooms, valves and heat-pump cycles combined with automated workflows.
- Rapid virtual prototyping, right-sizing, fault detection and control-optimization of air condition systems.
- Embedding circular-economy principles (reuse, repair, refurbish) into every stage of design and operation.



Business Model

For Circular Cooling Solution

Product



Software for Circular Cooling System

Customer



Universities, Public Buildings,
Ambition to expand globally

Revenue



Subscription model based on simulation complexity

Impact



Next slide! →

Required resources

- Technical: software (platform & AI tool), data sets, cloud services
- Financial: seed funding, government support
- Human: extra staffs, experts on software engineers and business development
- Partnerships: pilot companies, tech service

Impact

Enabling Circular Economy in the Built Environment

→ **Extend Asset Lifespan**

- Smarter maintenance can help cooling systems last 10% longer.⁴⁾

→ **Energy Savings**

- Saves 10–25% energy by running systems more efficiently.^{5),6)}

→ **Emissions & Waste Reduction**

- Cuts leaks, emissions, and repair waste by catching problems early.

→ **Enable Circular Business Models**

- Enables repair instead of replace, and supports service-based models.



Scaling Strategy

Expanding the Digital-twin Across High-Impact Sectors

| Sector | Target System | Main Benefit |
|-------------------|----------------------------|------------------------------------|
| Industry | Pumps, compressors | Fewer breakdowns, longer life |
| Cold Chain | Fridges, reefer trucks | Less energy & food waste |
| Data Centers | Cooling infrastructure | Energy savings, uptime |
| Smart Agriculture | Greenhouse climate control | Efficient use of water & energy |
| Transport | EV cooling, HVAC in fleets | Fewer failures, cleaner operations |

Thank You

References

- 1) Kwon, S. (2022, November 23). Seoul National University ranks first in energy consumption for over 10 years. . . KT Mokdong IDC ranks first per unit area. *Industry News*. <https://www.industrynews.co.kr/news/articleView.html?idxno=47932>
- 2) Mariano-Hernández, D. (2021). A review of strategies for building energy management system: Model predictive control, demand side management, optimization, and fault detection & diagnosis. *Journal of Building Engineering*, 33, 101692
- 3) Zhang, H., Seal, S., Wu, D., Boulet, B., Bouffard, F., & Joos, G. (2021). Data-driven model predictive and reinforcement learning based control for building energy management: A survey.
- 4) Aswani, A., Neal, Taneja, J., Krioukov, A., Culler, D., & Tomlin, C. (2012, April 20). Energy-Efficient Building HVAC Control using Hybrid System LBMPC. *arXiv.org*. <https://arxiv.org/abs/1204.4717>
- 5) Hosamo, Haidar & Hosamo, Mohsen & Nielsen, Henrik & Svennevig, Paul & Svidt, Kjeld. (2022). Digital Twin of HVAC system (HVACDT) for multiobjective optimization of energy consumption and thermal comfort based on BIM framework with ANN-MOGA. *Advances in Building Energy Research*. 10.1080/17512549.2022.2136240.
- 6) The power of digital twins in HVAC optimization. (n.d.). <https://www.exergenics.com/resources/the-power-of-digital-twins-in-hvac-optimization>

Net Positive? Yes. AI and Digital Twins Save More Energy Than They Use

The energy consumption of AI-driven digital twins is significantly outweighed by the energy they help save.

| Aspect | Energy Used | Energy Saved |
|---------------------------------|---------------------------------|---|
| Running AI models & simulations | Server usage (moderate) | Optimized HVAC cycles, fewer runtime hours |
| Edge device operation (sensors) | Minimal (low-power IoT) | Early fault detection → less downtime & overuse |
| Data storage & processing | Cloud or local processing costs | Improved efficiency → 10–30% energy savings |
| Maintenance-related computation | Predictive analytics | Avoids costly, energy-intensive emergency repairs |

Example: HVAC System in Commercial Building

Without DT: HVAC runs inefficiently → 20–30% energy loss annually

With DT: Optimized operation and early detection → net 15–25% reduction in energy use

DT energy footprint: Typically <1% of system energy use (edge + cloud combined)