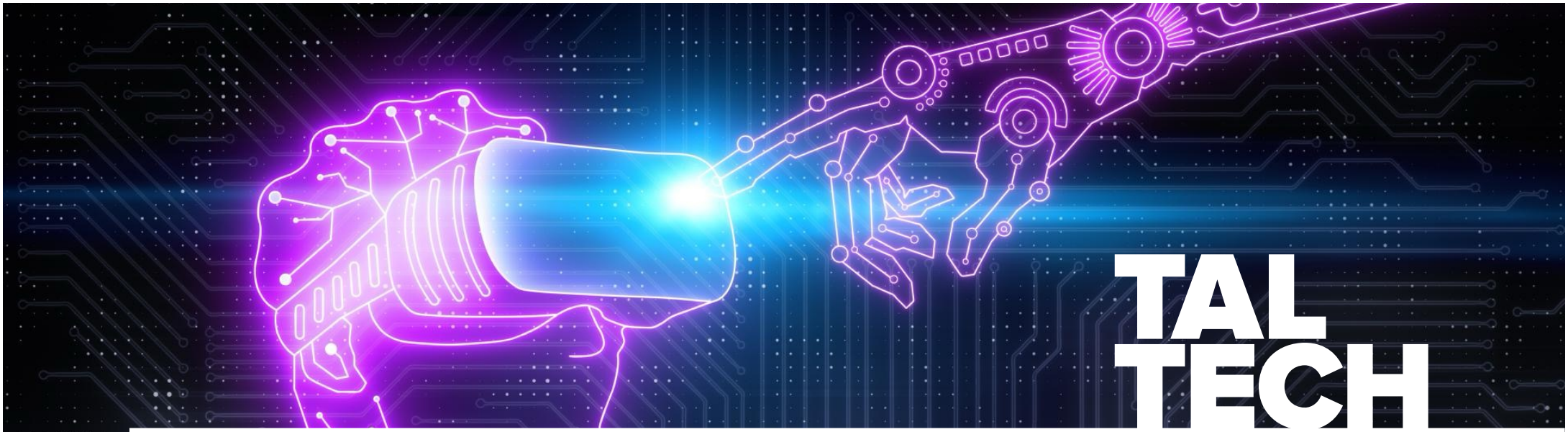

INTELLIGENT DATA-DRIVEN METHODS FOR ENERGY EFFICIENT CONTROL WITH APPLICATIONS IN COMMERCIAL BUILDINGS

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Head of the Centre for Intelligent Systems
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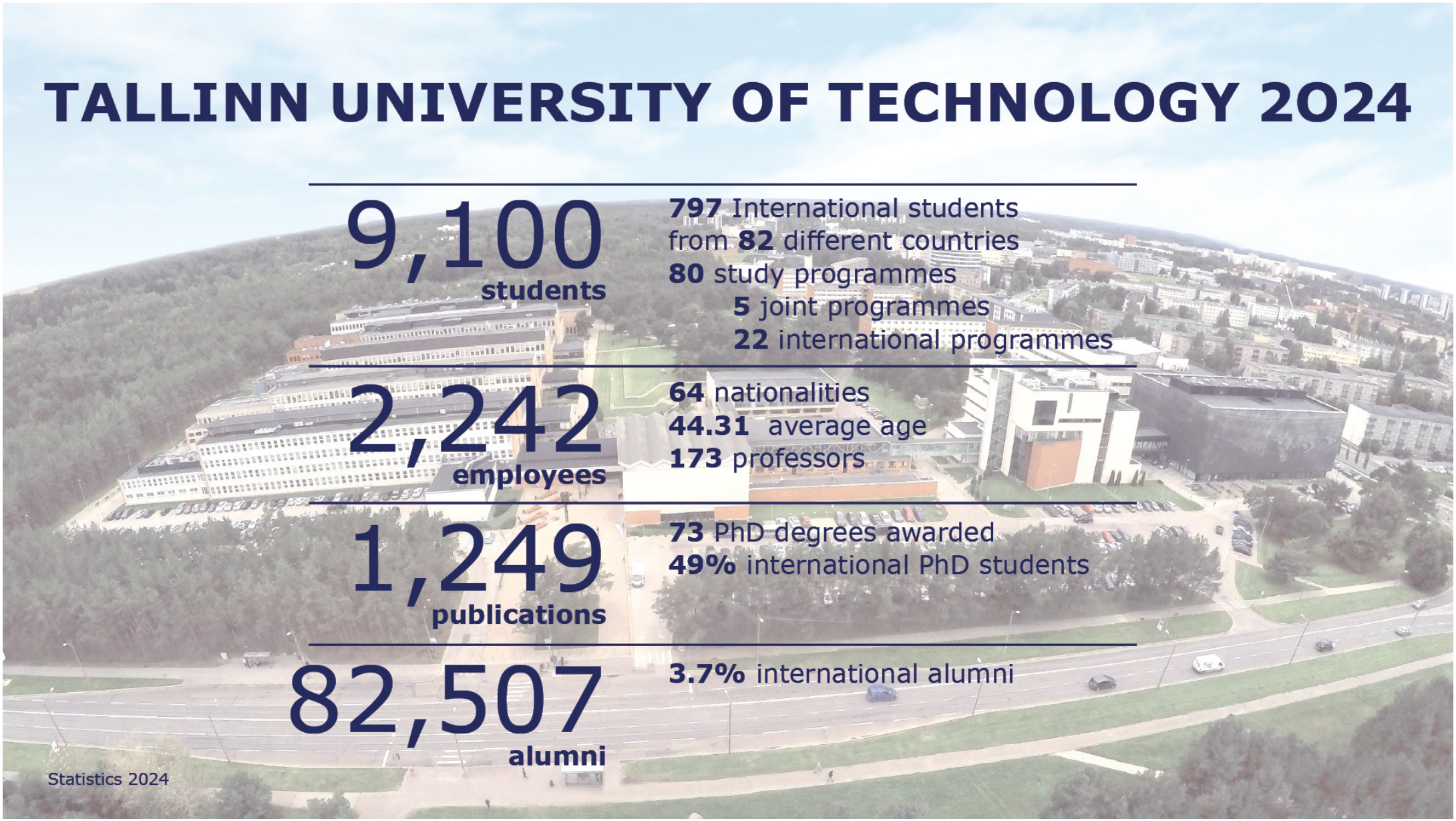
Energy Efficiency Centre of Excellence
ENERGIATÕHUSUSE TIPPKESKUS

16.09.2025


TAL
TECH
TALLINN UNIVERSITY
OF TECHNOLOGY


TALLINN UNIVERSITY OF TECHNOLOGY 2024
9,100
students
797 International students
from 82 different countries
80 study programmes
5 joint programmes
22 international programmes
2,242
employees
64 nationalities
44.31 average age
173 professors
1,249
publications
73 PhD degrees awarded
49% international PhD students
82,507
alumni
3.7% international alumni
Statistics 2024

CENTRE FOR INTELLIGENT SYSTEMS

Centre for Intelligent Systems (CIS, established in January 2017) is a part of the Department of Computer Systems covering the fields of

- Modelling, control, and analysis of complex nonlinear dynamic systems;
- Computational Intelligence based algorithms: Artificial Neural Networks, Genetic Algorithms, Fuzzy Logic, etc.;
- Self-learning and adaptation methods in control systems;
- Fractional-order modelling and control;
- Distributed control systems;
- Data analysis;
- Development of research software;
- Virtual and Augmented Reality applications;
- Digital twins;
- Energy efficient control;
- Buildings automation, modelling and performance analysis.

CENTRE FOR INTELLIGENT SYSTEMS

More information:

https://cis.ttu.ee

CENTRE FOR INTELLIGENT SYSTEMS

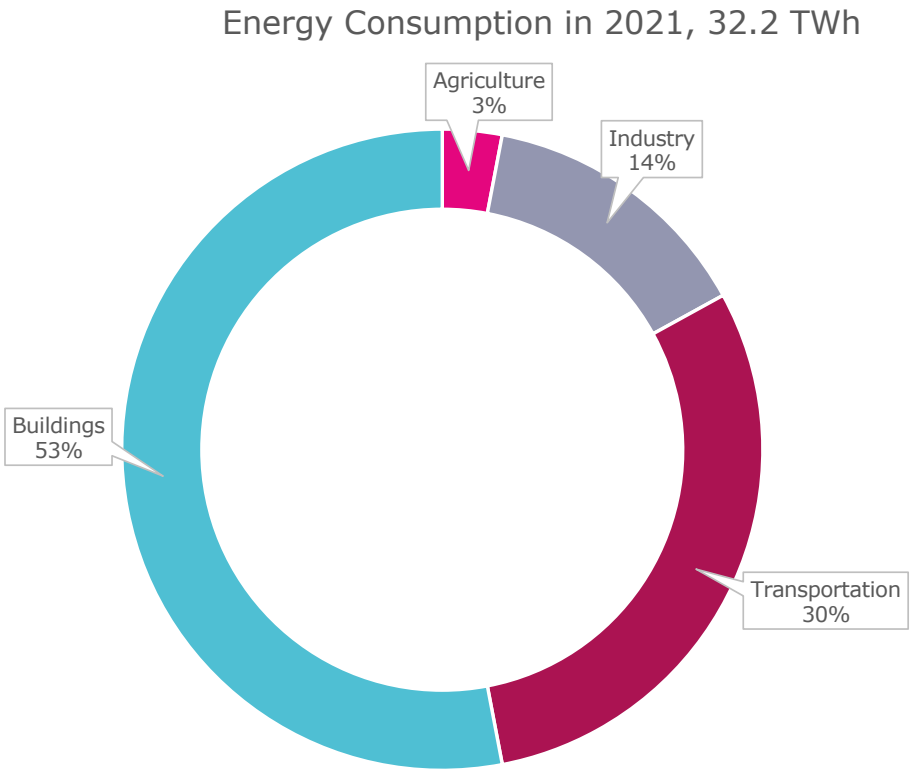
More information:

https://cis.ttu.ee

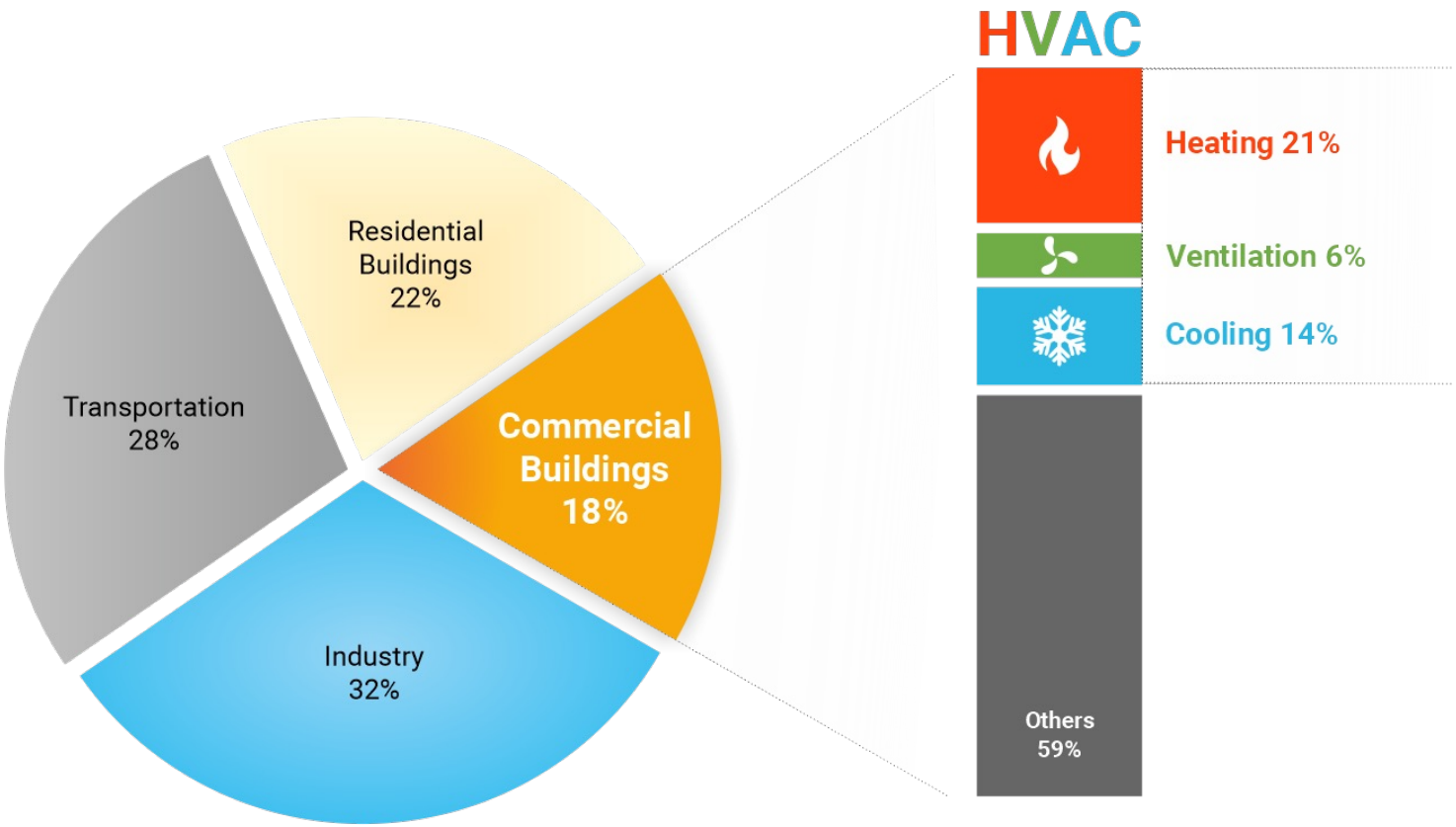
ENERGY CONSUMPTION IN ESTONIA AND EU

- **The energy consumption by Estonian buildings made 53% (17,1TWh)** of total energy consumption

- Whereas in the EU, the energy consumption by buildings (both commercial and residential) is estimated at 40%

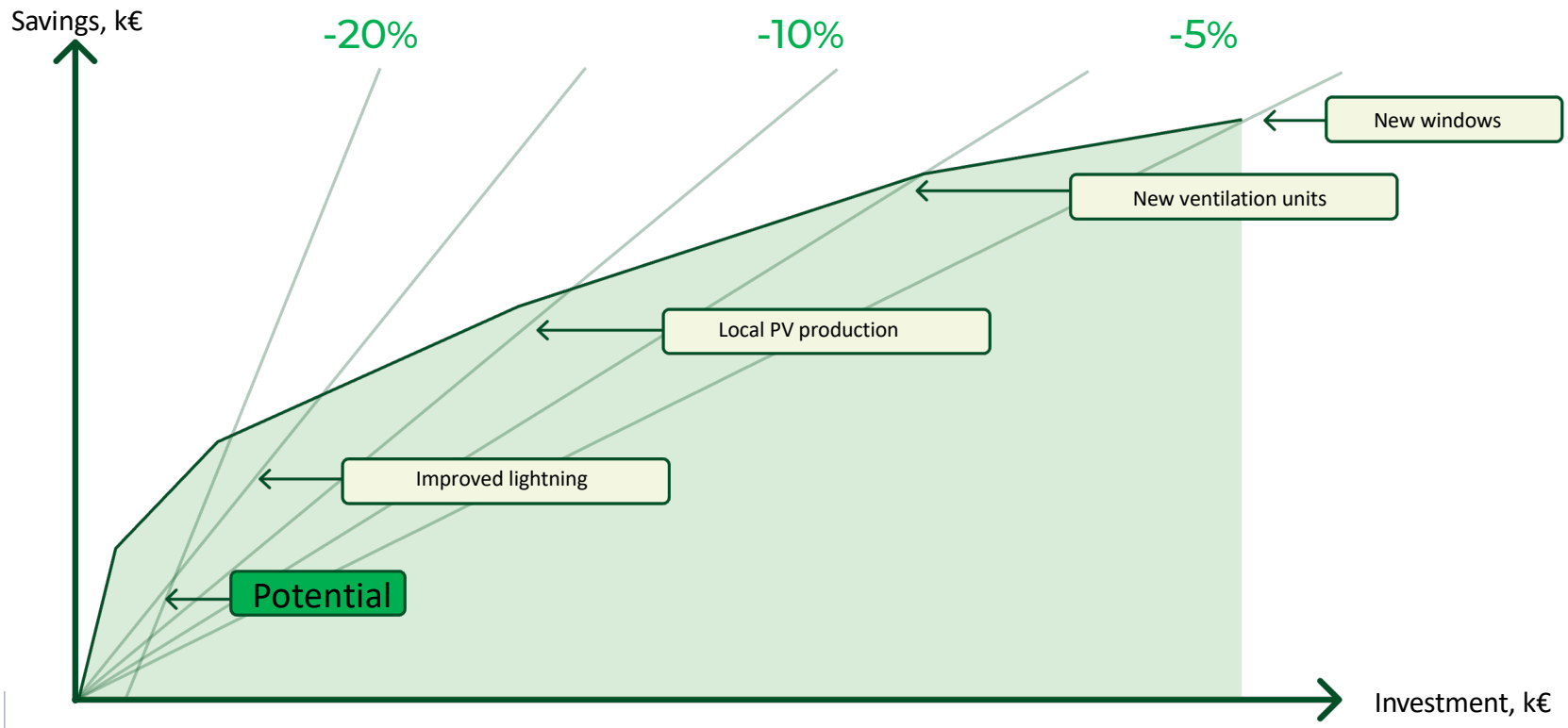


ENERGY CONSUMPTION BY SECTOR IN EU



How to Achieve the Zero-Emission Real Estate Goal

Internal Rate of Return (IRR)% on real estate assets investment

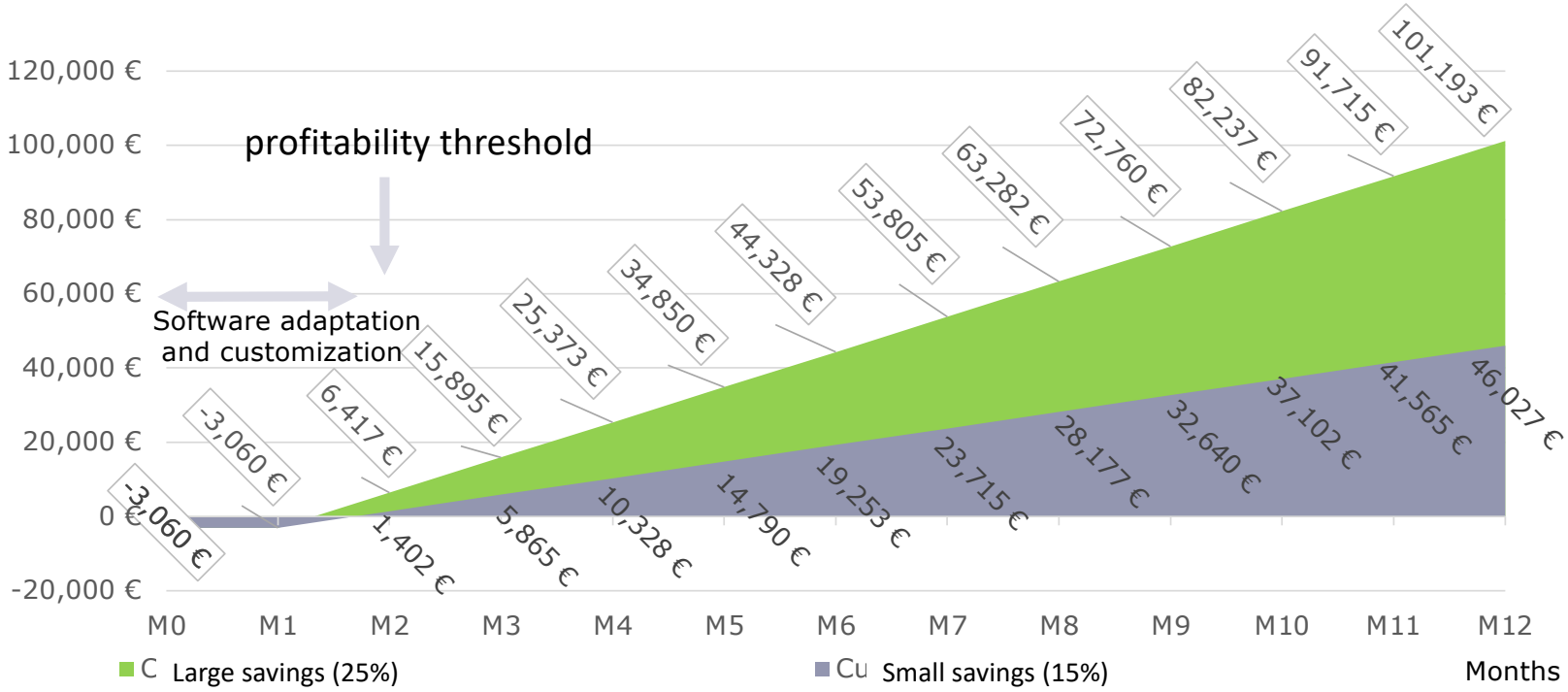


TALLINN UNIVERSITY OF TECHNOLOGY

Investing into real estate assets in the right order according Internal Rate of Return (IRR)%

ROI Calculations Based on an Average Building

Average building of 17 000 m2, at energy price of ~120 EUR/MWH and 300 kWh/m2/year



ENERGY INFORMATICS HOW ENERGY PERFORMANCE CAN BE IMPROVED?

ENERGY INFORMATICS: ENERGY + INFORMATION

Energy informatics is a research field covering the use of information and communication technology to address energy utilisation and management challenges.

Energy + Information < Energy

This equation is attributed to: Jørgensen, B. N. (2018). Energy Informatics. *Energy Informatics*, 1(7). https://doi.org/10.1186/s42162-018-0014-6

ENERGY INFORMATICS
HOW ENERGY PERFORMANCE CAN BE IMPROVED?

FUSION OF ENERGY AND IT

Energy (application areas):

- ✓ Buildings
- ✓ Cities
- ✓ Industries
- ✓ Grid
- ✓ Transportation
- ✓ Factories
- ✓ Agriculture
- ✓ …

Energy efficiency,
Cost savings,
Sustainability,
Energy management

IT (enabling technologies):

- ✓ Internet of Things
- ✓ Digitalisation
- ✓ Machine learning
- ✓ Artificial Intelligence
- ✓ Blockchain
- ✓ Cloud computing
- ✓ Big data
- ✓ Data analysis
- ✓ …

DATA!

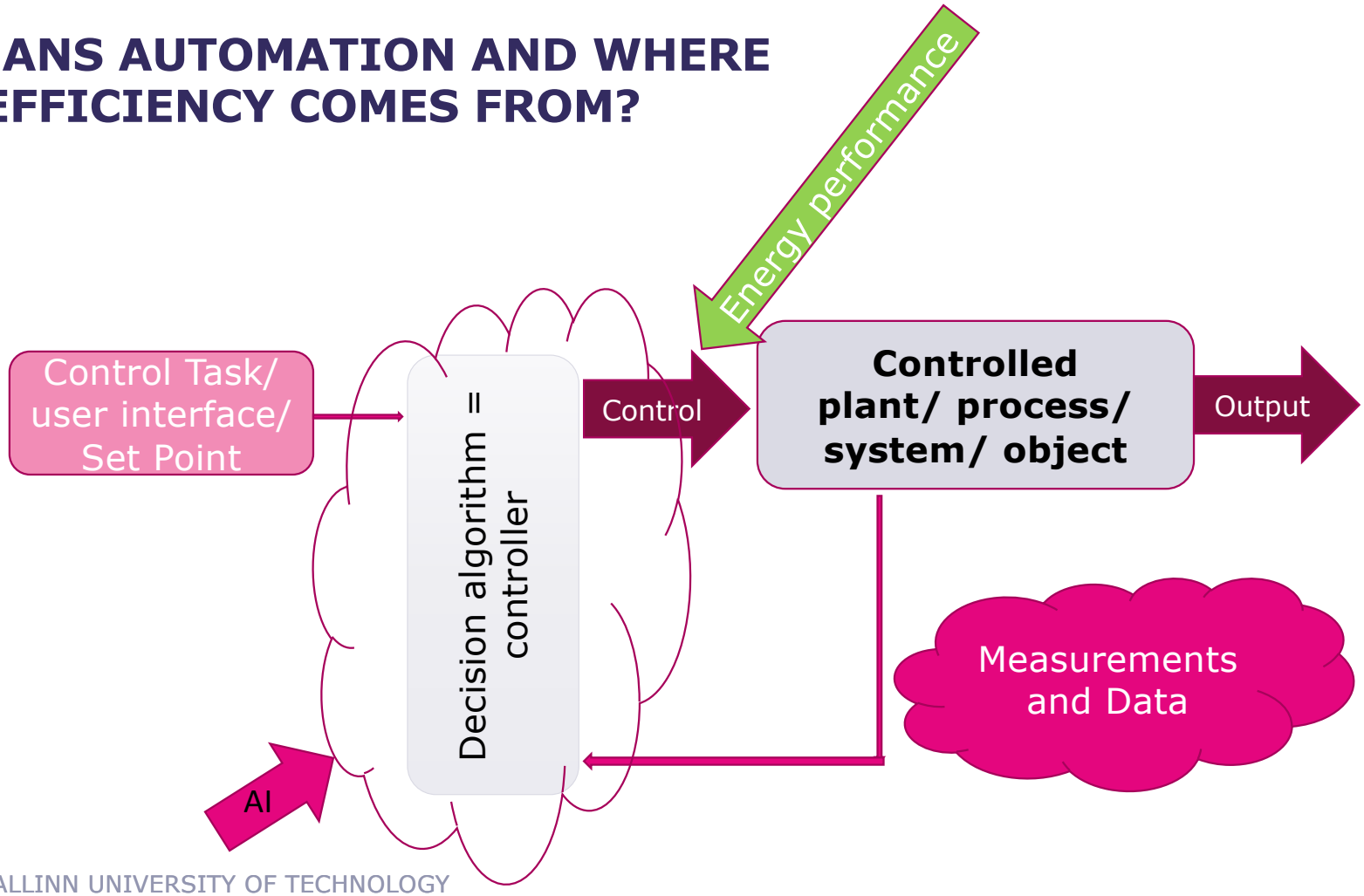
CONSUMPTION SIDE

Importance of efficient HVAC systems for sustainable buildings

Key Performance Indicators

- Comfortable Indoor Climate
- Energy Efficiency
- Technical Condition

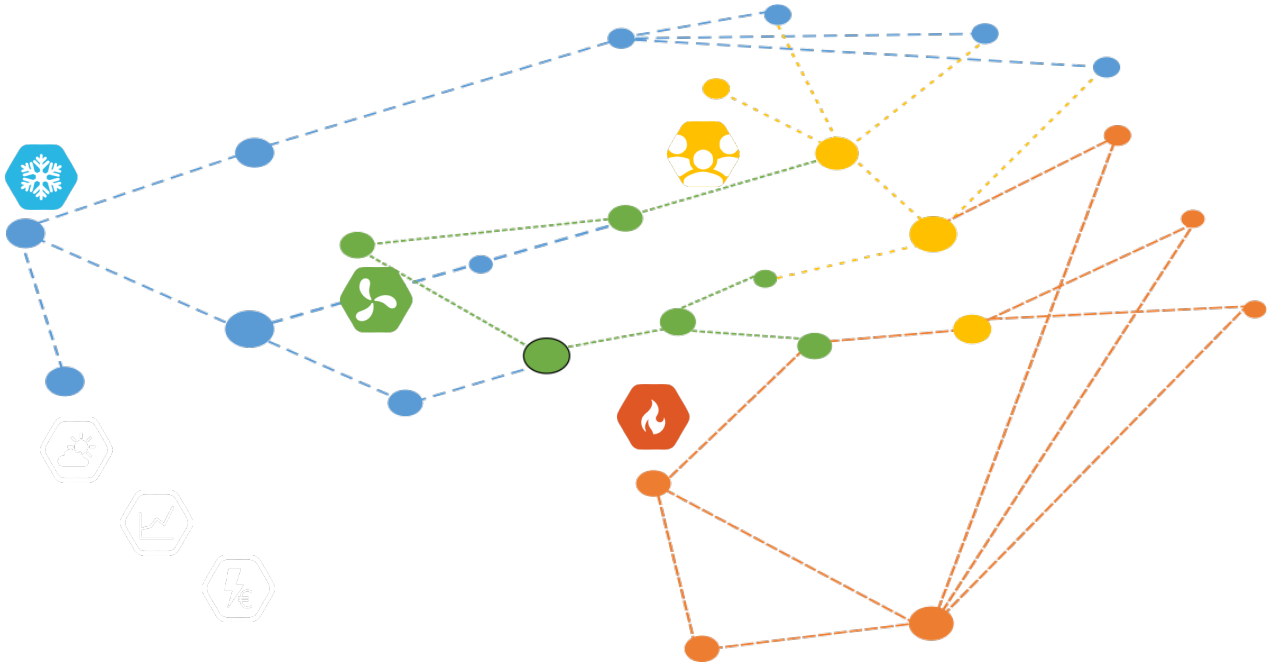
WHAT MEANS AUTOMATION AND WHERE ENERGY EFFICIENCY COMES FROM?



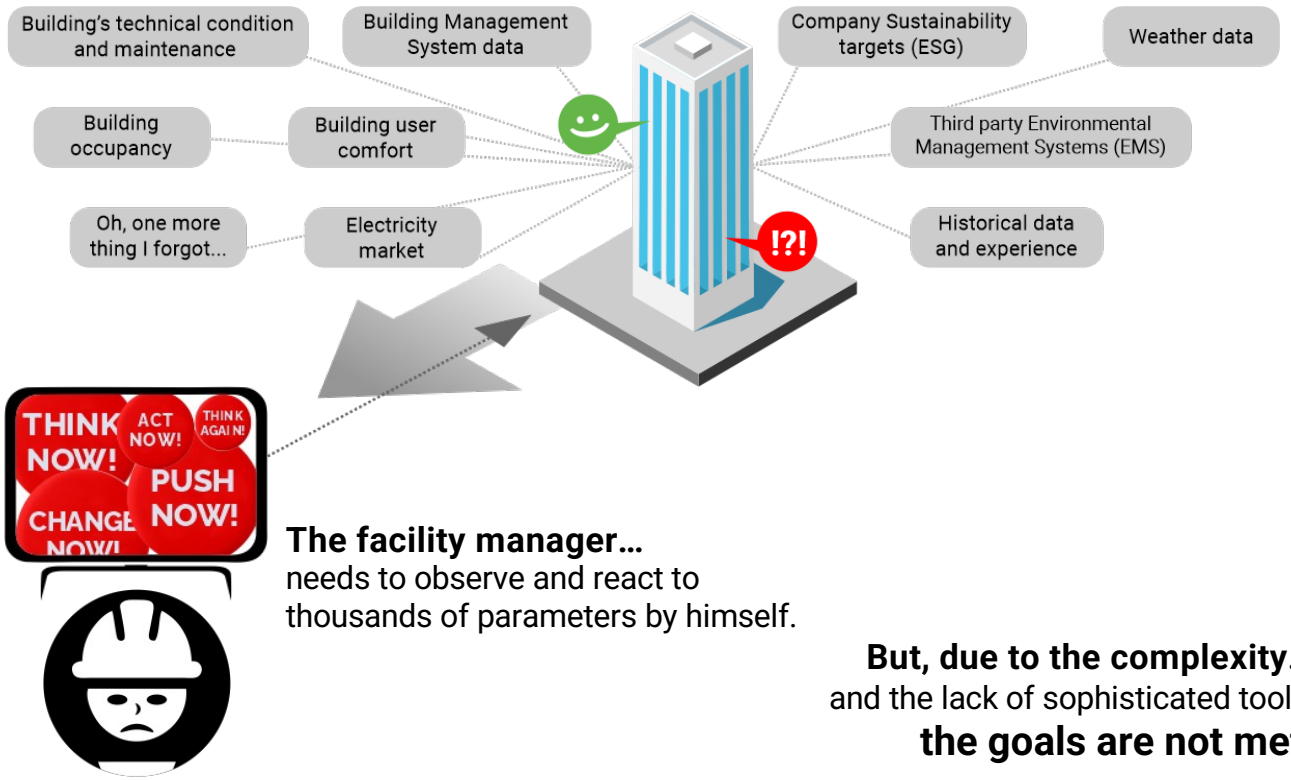
SMART CONTROL OPTIMIZES HVAC EQUIPMENT BY INTERCONNECTING THEM

Traditional: building technical systems are sub-isolated and “managed” independently:

Smart Controlsynchronizes all sub-components by micro adjustments:



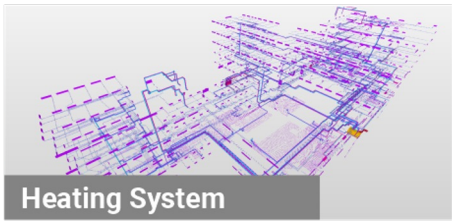
HOW CRE PROPERTIES ARE OPERATED TODAY?

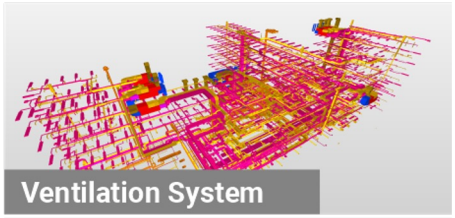


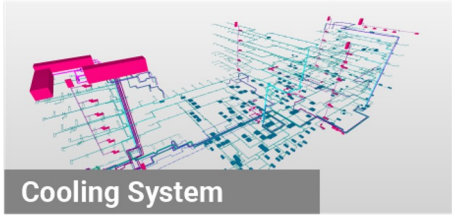
The facility manager…
needs to observe and react to thousands of parameters by himself.

But, due to the complexity…
and the lack of sophisticated tools,
the goals are not met.

SHOWCASE







constructed
2018

25 304 m²
office building

48 813
datapoints

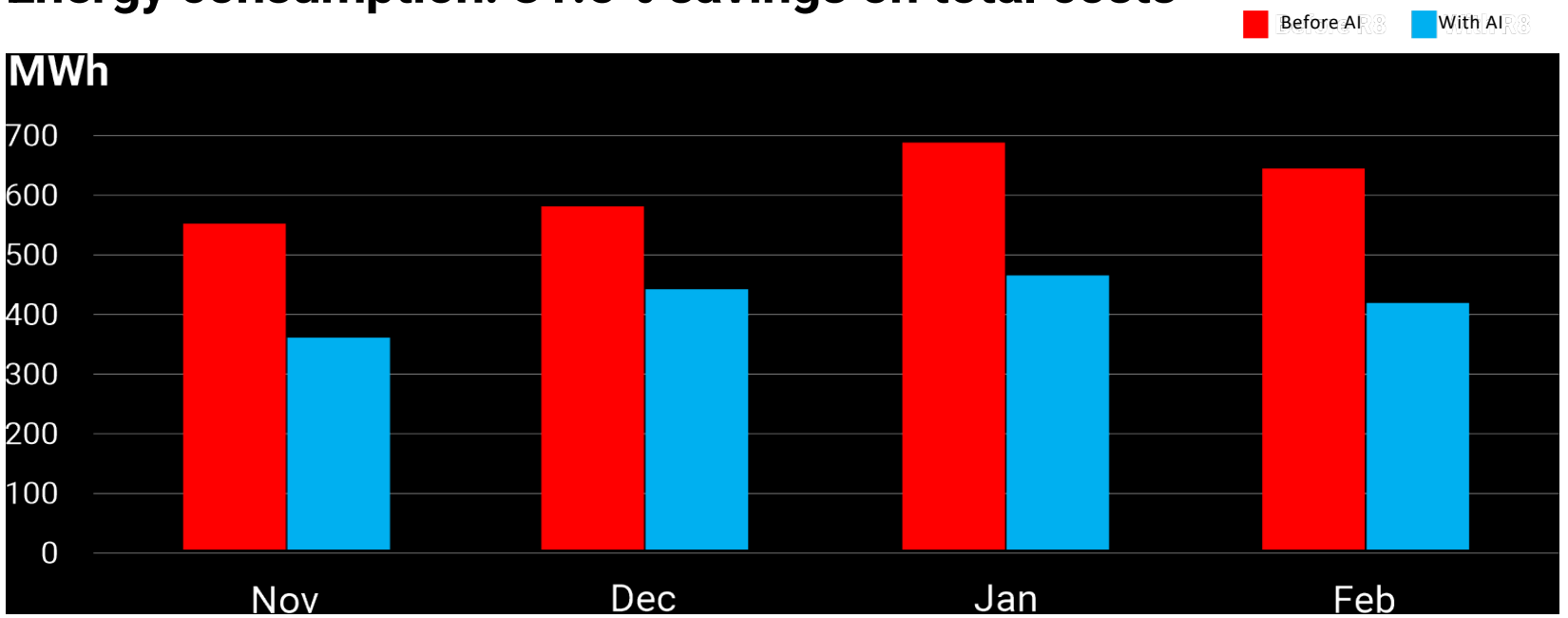
2 898 controllable
HVAC components

WHAT COULD IT LOOK LIKE IF A HUMAN COULD DO IT?

Takemoto, Y. (Director), & Gatoh, S. (Writer). (2006, June 11). *Iteza no Hi* [射手座の日] (Season 1, Episode 11) [TV series episode]. In T. Ishihara (Executive Producer), The Melancholy of Haruhi Suzumiya. Kyoto Animation.

SHOWCASE: COURT HOUSE, TALLINN

Energy consumption: 31.5% savings on total costs



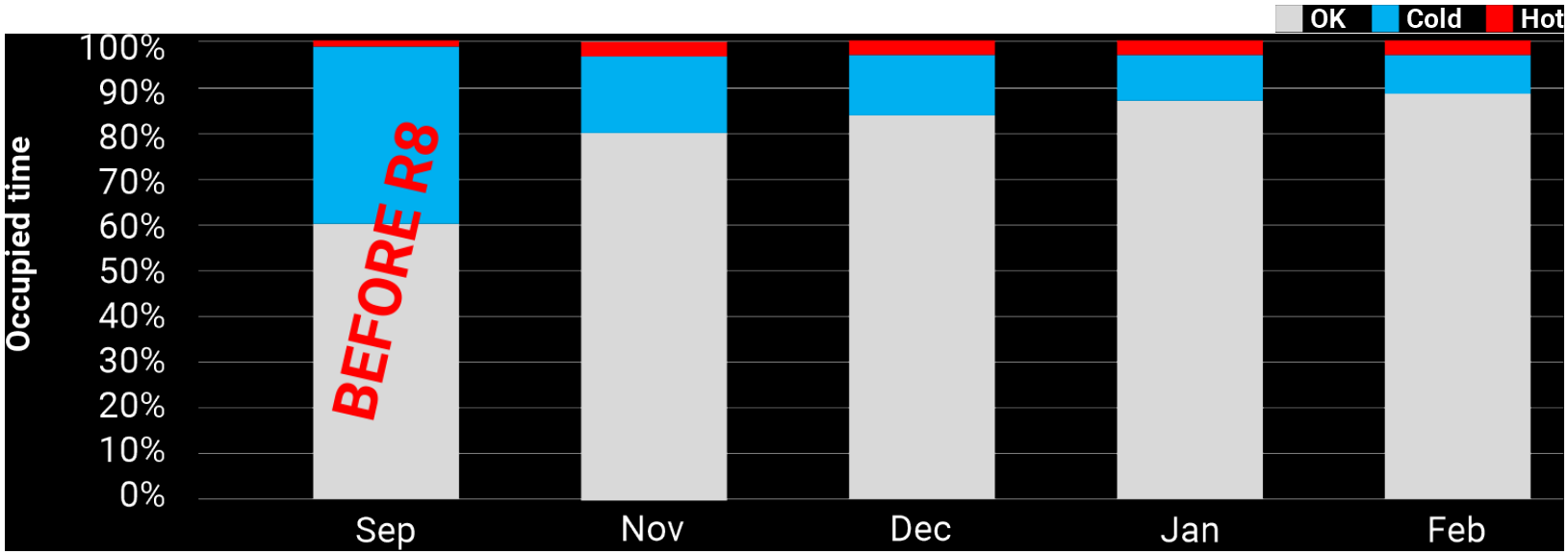
680 000 setpoint changes

900+ faults and anomalies detected

225 000+ kg CO_2 savings

SHOWCASE: COURT HOUSE, TALLINN

Thermal comfort increase from 60% to 90%

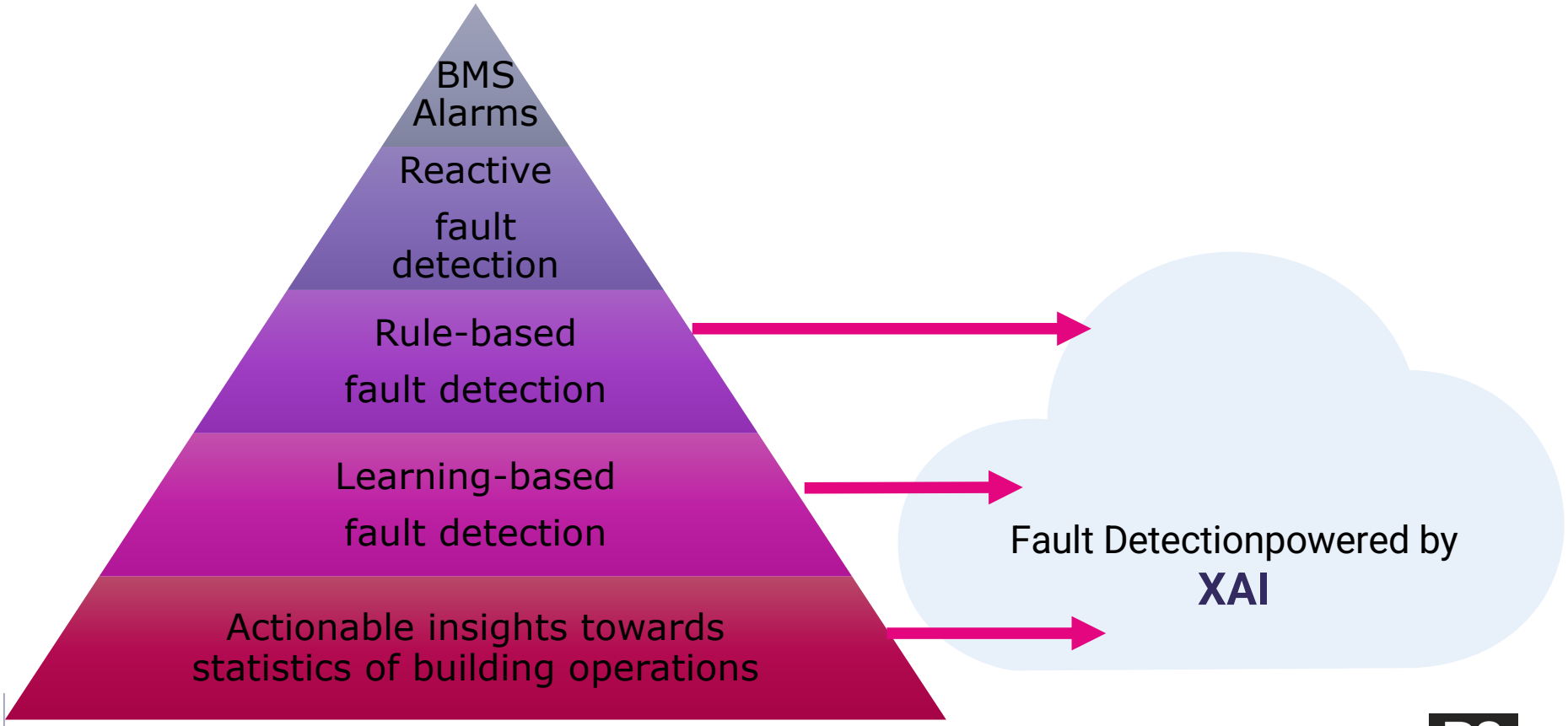


680 000 setpoint changes

900+ faults and anomalies detected

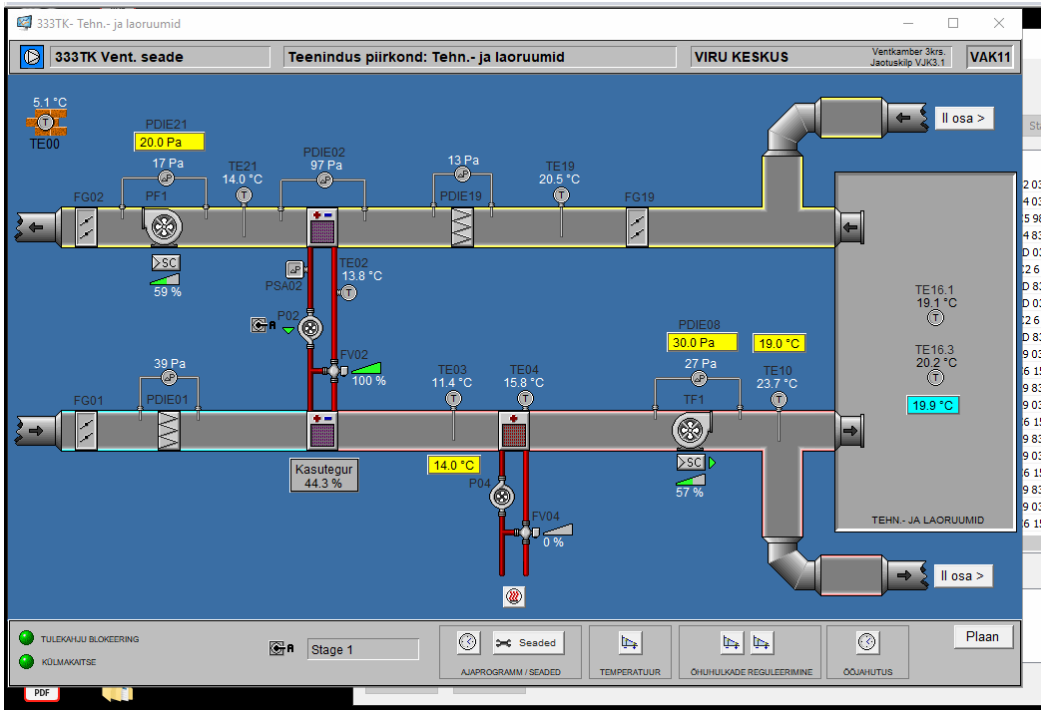
225 000+ kg CO_2 savings

COMMONLY USED FAULT DETECTION AND DIAGNOSIS (FDD) METHODS FOR HVAC EQUIPMENT

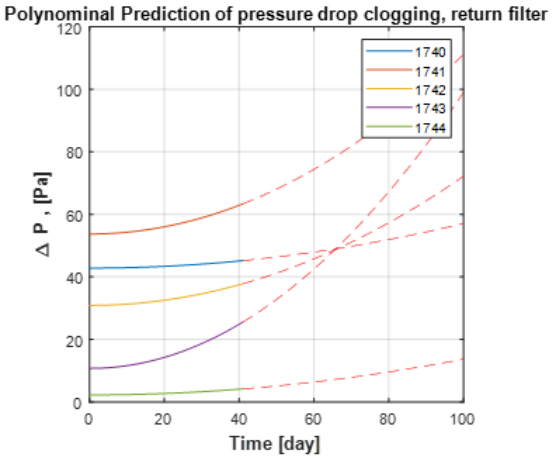


DATA-DRIVEN ANALYSIS AND FAULT DETECTION OF HEATING, VENTILATION, AND AIR CONDITIONING (HVAC) SYSTEMS.

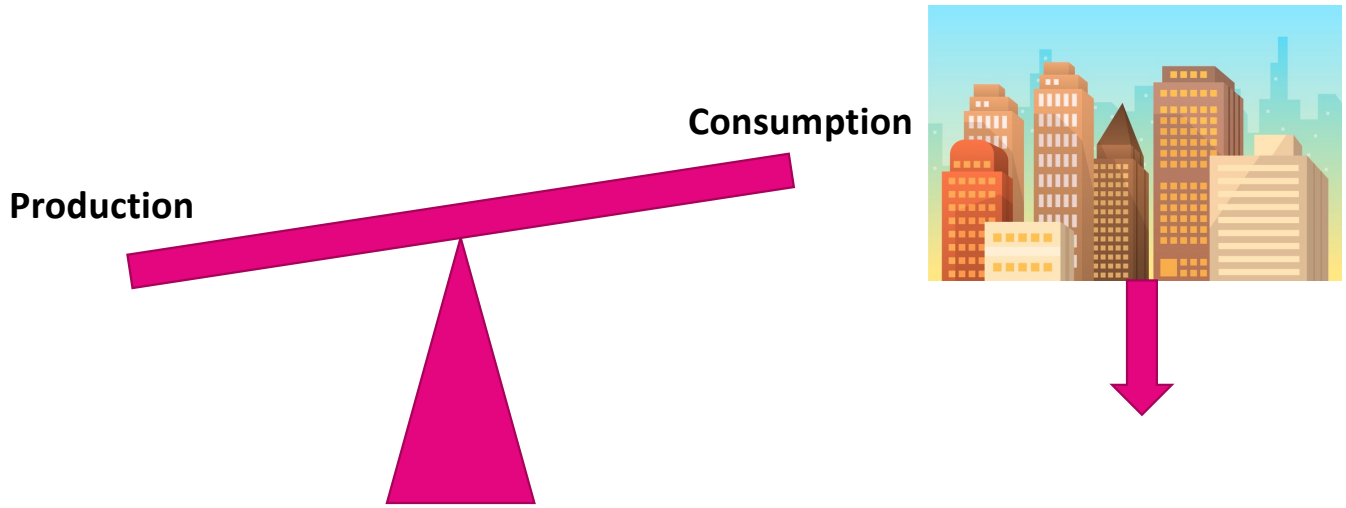
Data from Building Information System



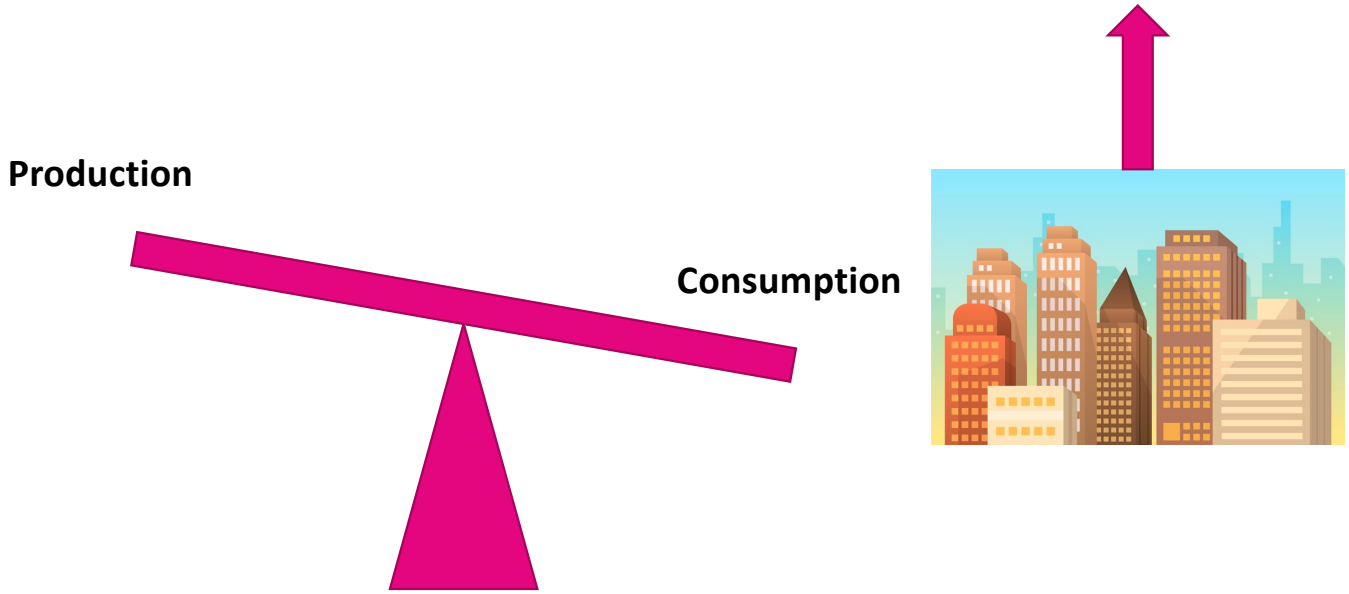
Prediction of filter clugging



DATA-DRIVEN DEMAND RESPONSE/ VIRTUAL POWER PLANT

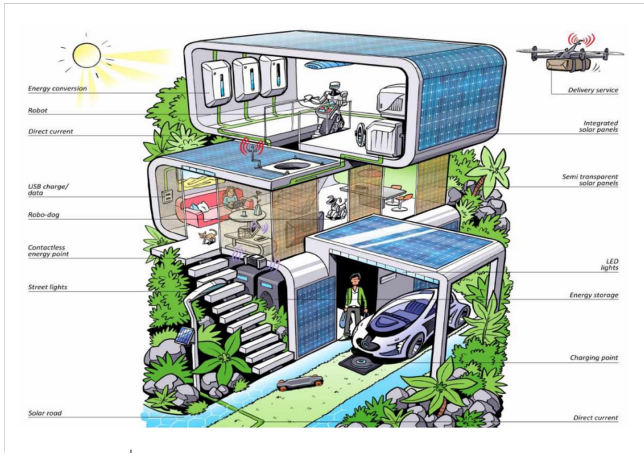


DATA-DRIVEN DEMAND RESPONSE/ VIRTUAL POWER PLANT

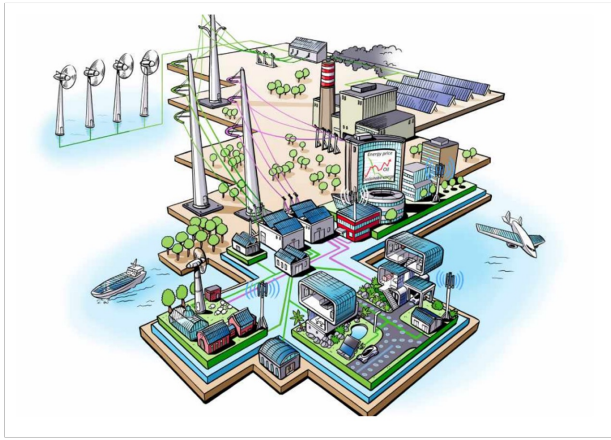


FUTURE SMART HOMES AND SMART CITIES

Future smart homes will be capable to satisfy their own energy needs.
They will be equipped with IoT devices to bring both user comfort and energy efficiency.



Future smart cities will be armed by smart technologies such as smart grids, autonomous transportation etc.
They will enable the city and their citizens to be connected in a smart and rational city environment.



BENEFITS OF AI-DRIVEN CONTROL

- Analyzes huge amounts of data (“Big Data”)
- Can model and predict complex dynamics
- Can make forecasts and be proactive
- Considers many different parameters
- Can learn
- Significant improvement in performance without additional hardware
- Can synchronizes many sub-components

As the result…

- Improved performance

CHALLENGES RELATED AI-DRIVEN CONTROL

- Explainability: Black box and grey box models
- Complexity
- Computational costs
- Data quality, availability and amount
- Trustworthiness
- Safety
- Reliability
- Stability

THANK YOU!

Contacts:
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