



Thermal inertia-based building electrical demand flexibility

Building as Batteries, development and calibration of a RC model

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Context and Background



Intermittent and uncontrollablegenerationinducessignificantpowerimbalancebetweenthegenerationand consumption.

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Context and Background



Centralized Grid Energy System



The increasing number of DERs connected to the demand side make the electric distribution systems more complex (i.e., the **bi-directional and decentralized systems**). It causes reverse power flows, voltages violations, congestion and line losses.



Context and Background

Annual heat pump installations in the European Union, 2021-2030



Controllable and flexible consumers

could be potential providers of flexibility.

In most buildings, large space availability combined with **the thermal capacity of internal mass** may provide viable cost-effective alternatives or complement conventional batteries.

Thermal inertia-based building electrical demand flexibility

Assessment Purpose: Estimation of Thermal inertia-based building electrical demand

flexibility of cooling dominated buildings



TEF of cooling dominated buildings is measured by the capability of a given building to eliminate HVAC related electrical energy demand through storage of sensible heat gains in exposed internal mass.



What is the challenge?

Implement and test a cost-effective solution to assess and optimize **the real-life energy performance** of a building and its energy systems.



Soft sensors integrate data from multiple sources to create new measurement possibilities, enabling real-time prediction of parameters that cannot be directly measured.



TEF Soft Sensor



One time fitting process

Continuos sensor operation

 $TEF (kW h/m^2) = APR (kW/m^2) x DHO (h)$



TEF Soft Sensor

Lumped Thermal Response of Air Volume and Light Elements





Lumped Thermal Response of Thermal Mass





Soft Sensor Calibration







Assess TEF potential

The threshold for thermal inertia flexibility is intimately associated with the occupants comfort.

	ASHRAE Standard 55–2017				
	Drifts/ramps duration (minutes)	Maximum operative temperature change (°C)			
Cat I	15	1.1			
Cat II	30	1.7			
Cat III	60	2.2			
Cat IV	120	2.8			
Cat V	240	3.3			



Soft Sensor Validation





Light Thermal Inertia Test Cell (LT):

- 37.5 m² floor area
- 3.05 m floor to ceiling height

Heavy Thermal Inertia Test Cell (HT):

- 21.0 m² floor area
- 3.20 m floor to ceiling height

Soft Sensor Validation





Soft Sensor Deployment in SATO pilots – Seixal Office Building





SATO

Seixal Office Building (SO):

• 15000 m² floor area

Open space office:

- 341.0 m² floor area
- 3.00 m floor to ceiling height

Soft Sensor Deployment in SATO pilots – Seixal Office Building



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Closing Remarks

- TEF in office buildings varies between 4.7 and 12.0 Wh/m² (ΔT = 1.1 °C).
- The minimum demand response **duration** in office buildings is **9 min** $(\Delta T = 1.1 \circ C)$.



Potential Applications

Existing markets:

- Implicit Demand Response (Day-ahead markets, Intra-day markets, Real-time markets)
- Explicit Demand Response (Balancing Reserve markets TSO market, Local Flexibility Markets DSO market)



Potential Applications – Examples of Balancing Reserve Market events in Statnett (Norwegian Grid Operator)

Sorvice type	Requirements			
Service type	Respond speed	Time of full activatio	n Duration	Typical Asset Size
Automatic Frequency Restoration Reserve (aFRR)	4 sec	< ±3 min	~15min	\pm 1 MW \leq Asset \leq \pm 5 MW
Manual Frequency Restoration Reserve (mFRR)	30s-15min	< ±3 min	15 min - 2 hours	\pm 1 MW \leq Asset \leq \pm 5 MW
Replacement Reserve (RR)	15 min - 1 hours	s 15 min - 1 hours	2 hours - 8 hours	\pm 1 MW \leq Asset \leq \pm 50 MW

Automatic activation of 1 MW equaling 160 cars



Statnett

Automatic activation of 1 MW electrical boilers in 4 buildings

JUSINELL



Next Steps











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Thank you



Assessment of KATION materials for energy transition

An industry point of view



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KNAUFINSULATION

Our Solutions



We offer a range of insulation solutions using various insulation materials





ACOUSTICS



HEALTH &



GLASS MINERAL WOOL



ROCK MINERAL WOOL

WOOD WOOL







The industry's widest range of products to suit every application and various industries



Construction

Green Solutions

Industrial Products Technical Solutions

SATO KNAUFINSULATION

Our For a Better World strategy, its four pillars and commitments



FOR A

The global temperature continues to increase

GLOBAL LAND-OCEAN TEMPERATURE INDEX





The pressure to reduce carbon emissions is all aroun



2. Demand for is increasing

Demand for low-carbon products is increasing

Certification schemes



Customers' Scope 3 reduction targets

Kingjisher

"Kingfisher is <u>committed reduce scope 3 GHG emissions</u> <u>from use of sold products and purchased goods and</u> <u>services by 40% per £million turnover by 2025/26"</u>

Travis Perkins

"For Scope 3 carbon, this target will involve a <u>63% carbon</u> reduction in the Group's supply chain emissions by 2035"



Our competitors are not waiting for us

"We aim to <u>reduce our Scope 1&2 emissions by 38% by 2034</u> compared to baseline 2019 through three main levers: energy efficiency of factories, technology innovation and circularity"

PAROC

"Our science-based target is to <u>cut the GHG emissions from our</u> <u>operations in half by 2030</u>, in line with the path to keep global warming below 1.5° C."



"Committed to achieve <u>net zero carbon emissions by 2050</u>, ... we have published a CO₂ roadmap our new <u>targets for 2030</u> validated by the SBTI initiative: <u>33% reduction in scope 1&2</u>, <u>16% reduction in scope 3 in absolute</u> <u>terms, compared to 2017 baseline</u>"



I SATO KNAUFINSL

We have set an ambitious target to <u>reduce our GHG Scopes 1 and 2 emissions by</u> <u>35% by 2030 compared to our 2018 baseline</u>.... we developed an extensive decarbonisation roadmap in 2022"

It is not just about energy efficiency and low carbon buildings anymore It is about <u>"Low carbon insulation" for "Low carbon buildings"</u>



- Insulation is central to the decarbonization of the building environment thanks to its capacity of decreasing energy demand for heating and cooling & guaranteeing optimal internal comfort
- <u>95 days</u> = average carbon payback for our products
- The manufacture of our products emits carbon
- Walk the talk and reduce our carbon footprint
- It is intrinsic to our value proposition

Knauf Mid-& Long-Term Goals – Zero Carbon





SCOPE 1 Direct emissions



SCOPE 2 Indirect emissions (owned)



SCOPE 3 Indirect emissions (not owned) **BY 2032**

-50%

CO₂ emissions (scope 1 & 2)

-30% CO₂ emissions (scope 3) BY 2045

NET ZERO

CO₂ emissions (scope 1, 2, 3)



Objectives in overall embodied carbon reduction





50% 100%

REDUCTION OF EMBODIED CARBON BY 2025

REDUCTION OF EMBODIED CARBON **BY 2032**

ZERO CARBON PRODUCTS BY 2045



Scope 1, 2 & 3: how we split our carbon footprint





Business as usual is not an option, only sustainable growth is! Sustainable growth means an even greater effort on CO₂ reduction...





KNAUFINSULATION

Where do we stand today?

Status and achievements



Compared to 2021, we have reduced our footprint by 17% in absolute... We still have a long way to go!





The main contributor to reducing our footprint so far: electricity from renewable sources

 Since 2022, Energy Attribute Certificates (EAC) procured to have green electricity



- A Power Purchase Agreement (PPA) pilot project in Novi Marof, the first phase in our sustainable expansion!
- In 2032, 100% of electricity from low carbon sources



Some example of projects under study that could contribute to achieving our goals



Biomethane

Hydrogen

Carbon Capture Use or Storage (CCU/S)



Main takeaways

- When it comes to buildings retrofitting, insulation is key: a wellinsulated building's envelope drastically reduces energy demand for heating and cooling, allowing at the same time occupants to experience indoor comfort for a long period of time (up to 4 days during winter, after having properly heated the apartment) and a more efficient and logic use and development of renewable sources such as photovoltaic
- It's no longer only about energy efficiency: for the insulation sector (and not only) the challenge is to sustain the growing demand of insulating materials for buildings' renovations (following the ambitious targets set by the EU with the recent EPBD recast) while **reducing its carbon footprint**



In the decarbonization path of our business, there's no magic solution: we'll be able to achieve our ambitious decarbonization targets only by finding the best combination of projects and innovative technologies for each and every part of our company



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Thank You