Introduction & Energy resilience of buildings

Hassam ur Rehman

VTT – beyond the obvious

Interdisciplinary solutions developed by 100 teams

Industrial thought leadership since 1942

1000+ of research and innovation projects incl. Fortune 500 partners

World class research labs and facilities in 6 cities

VTT is a visionary research, development and innovation partner.

EUR Op Income 309 M

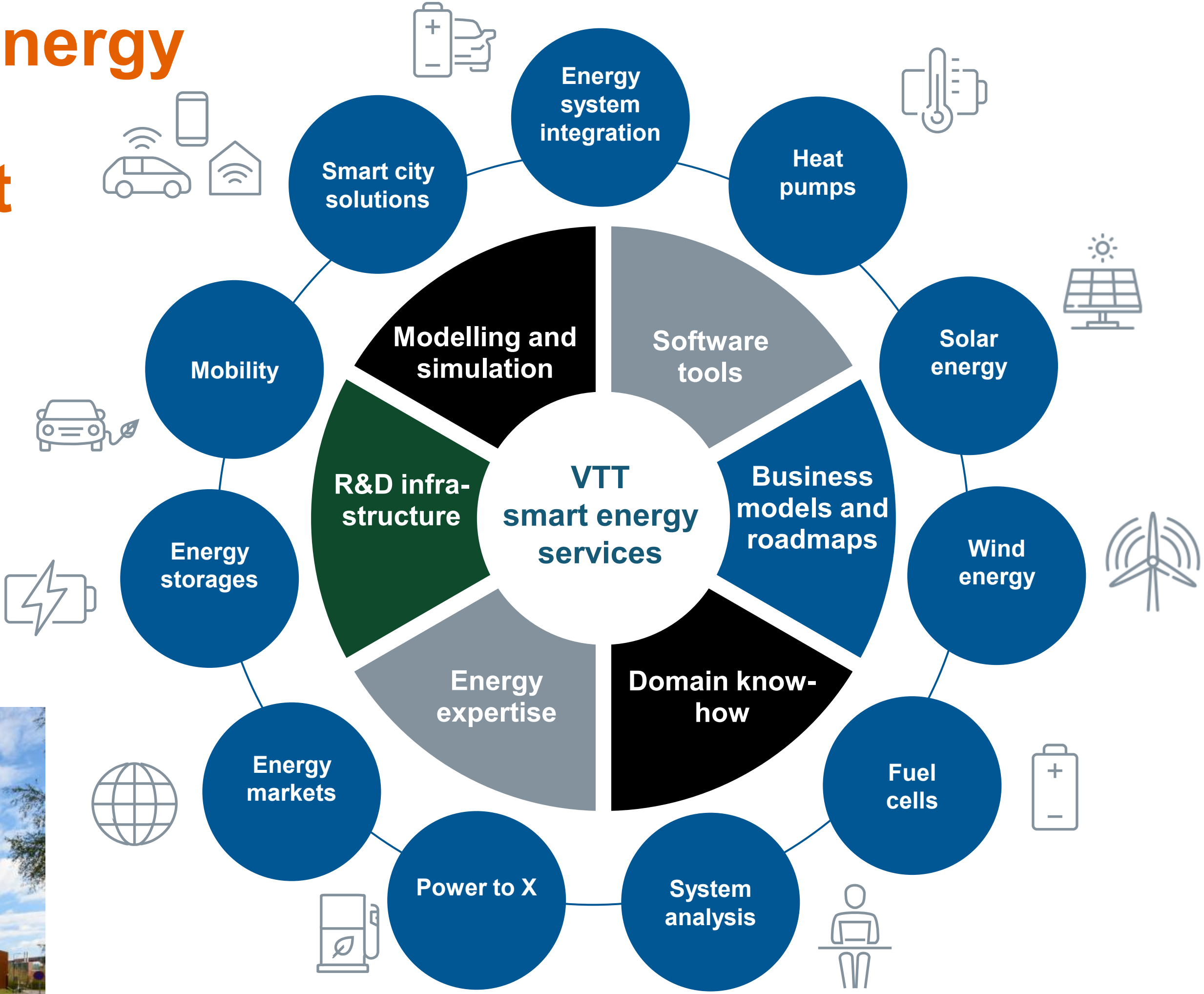
2349 employees

32% Doctoral level teams, 80% of employees with university degrees

Cutting-edge technologies from space to microbiology under one roof

Ministry of Economic Affairs and Employment of Finland

VTT Smart Energy and Built Environment



Briefly

- **Academics**
  - Bachelors, B.E. (Industrial and Manufacturing) – NED University of Engineering and Technology, Pakistan
  - Masters, M.Sc. (Project management in Energy and Environment) – Ecole des mines de Nantes, France & KTH Royal Institute of Technology in Stockholm, Sweden
  - Doctor of Science, PhD– Energy engineering, Mechanical department, Aalto University, Finland
- **Current work experience**
  - Senior scientist, IPMA-C certified PM & PI, VTT Technical research Centre of Finland Ltd, Espoo, Finland.
  - Academy Research Fellowship fellow (PI), Research Council of Finland
    - Visiting researcher, NTNU, Trondheim, Finland
  - IEA EBC ExCo representative – Finland
  - Operating agent and PM of IEA EBC Annex 93 on energy resilience

Topics of interest

- Positive and nearly zero energy building/districts
- Energy resiliency
- Renewables and energy systems
- Energy storage
- District heating/cooling
- E-mobility
- Optimization
- User-engagement

Why Energy Resilience Matters

- **Impact of climate and global disruptions**

Extreme weather, geopolitical tensions, and cyber threats increase risks to **energy systems and building** performance.

  - Energy security, crises, and shortage
  - Economic stability and safety

- **Risks to vulnerable populations**
- **Escalation** of negative and costly **cascading events** in society
- **Role of resilient buildings**

Resilient buildings protect occupants, reduce emergency burdens, and maintain habitability during crises.

- **Societal importance**

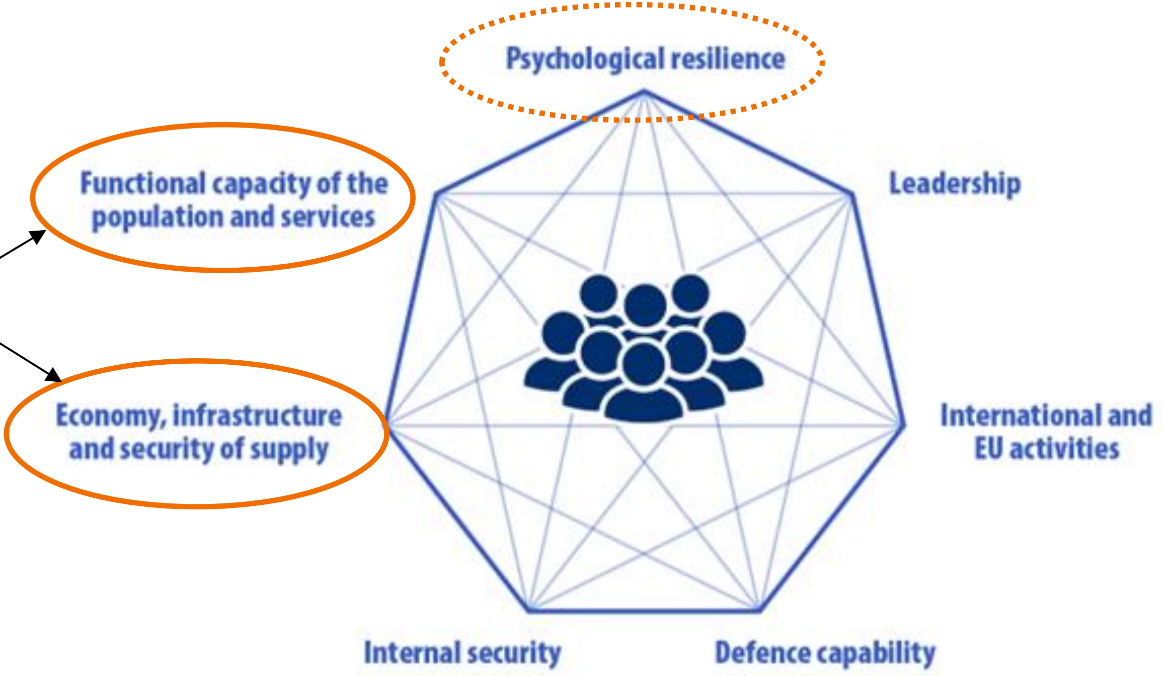
Energy resilience supports safety, economic stability, and sustainability through integrated design and policy.

Core emphasis

- Protect **continuity** of critical energy services under changing conditions.
- **Coordinate** generation, networks, storage and flexible demand as one system.
- **Use scenarios and evidence** to compare reliability, cost and decarbonisation trade-offs.
- **Translate resilience concepts into planning**, operation and implementation choices.
- Increase energy security and lower cascading costs
- **Finland published guidelines on 72 h preparedness for resilience in 2024.**

Comprehensive security in Finland (big pic)

BA4901 Energy resilient buildings and districts – team works mainly here



"The vital functions of society are essential for the functioning of society and must be maintained in all situations. The functions are highly interdependent. The vital functions of society form the basis of implementing comprehensive security. They serve as the foundation for planning practical tasks and responsibilities based on risk assessment. ." Source: https://turvallisuuskomitea.fi/en/security-strategy-for-society/vital-functions/

Addressing the Challenges of Achieving Energy Resilience in Buildings During Power Outages in Finland: A Human-Centric Approach Integrating Technical, Social and Economic Dimensions (REBUILD-Fin)

Research Council of Finland, Research fellowship, 2025-2029

Definition of energy resilient buildings

- Building that can maintain (during power outage):
  - the indoor temperature within the habitability thresholds
  - provide survivability conditions → low level of electrical power for essential services
- The aim:
  - reduce impact on the health of the building’s occupants
  - reduce damage to the building’s structure.
  - Energy-efficient to conserve heat and energy.
- Finally, improve its long-term resilience for future disruptive event

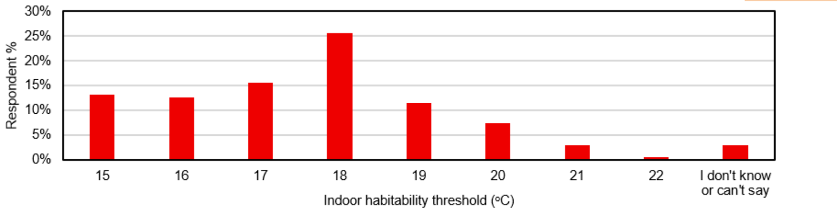
Research Scope and Approach

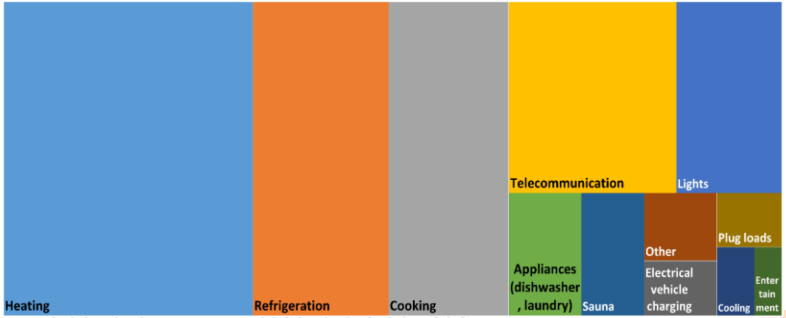
- Focus on Cold Climate Energy Resilience
- State of the art resilience and classification
- Technical and Social Integration
- Economic Evaluation and Practicality

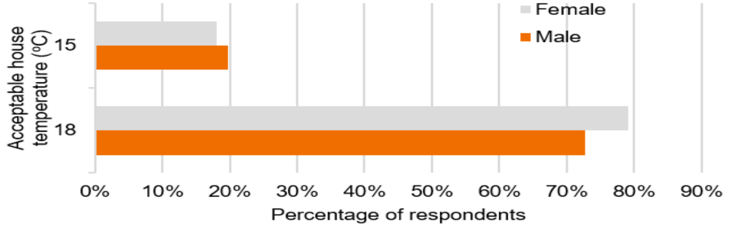
Human centric approach: survey

- ⚡ Focus: Energy resilience, habitability & survivability during disruptions,
- 📍 Participants: Finland (Climate Zones I–IV)
- 🏢 VTT-led pilot study (January–February 2024), Online survey (Microsoft Forms) distributed via Viva Engage, email, and QR codes.
- 👥 378 respondents from 2,386 (15.8% response rate).

Category	Questions
Background on demography	What are the gender and age limits?
Impact of location	Which city do you live in?
Impact of building type	What is the type of building you live in?
Awareness of energy crises	Are you concerned about the energy crisis and its impact on the supply?
Prioritization for survivability and habitability	What are the top priorities in terms of energy load during an energy shortage?
Habitability thresholds	What is the minimum indoor temperature that you are willing to compromise to stay indoors during the blackout?

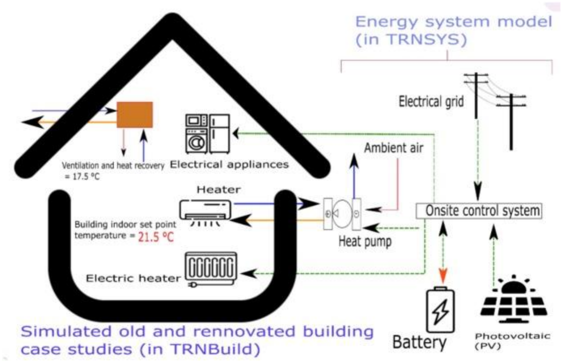






Data and inputs

- Weather data using 30 years of measured climate data
  - Typical representative year
  - Extreme cold and warm year



- Parametric study data

Design variables	Option 1
Photovoltaic area (m^2)	0, 50, 100
Battery size (kWh)	0, 50, 75
Blackout durations (hours)	24, 48, 72

- Cost data

Cost type	Building	PV	Battery
Initial cost	8189 €	124 €/m^2	600 €/kWh
Maintenance cost		1.5% (initial cost)	1.5% (initial cost)
Life cycle		25 years	12.5 years
Replacement cost		Included in the maintenance cost	200 €/kWh

Core areas of contribution

- Resilience modelling
- building resilience classification
- Renewable and storage integration
- Human centric approach for technical solutions
- Decision support for planners and operators

Impact and Applications

- **Policy and urban planning**
- **Building design and retrofitting (active and passive)**
- **Health and emergency preparedness**
- **Economic benefits**

Summary and Background

IEA EBC - Annex (93): Energy Resilience of the Buildings in Remote Cold Regions

This Annex is developing **technical, economic, environmental, policy, and societal frameworks** that will result in the development of Guidelines for improving the resilience of the buildings and building communities located in cold and very cold climates.

- Canada
- Denmark
- Finland
- Norway
- Sweden
- USA
- China
- UK
- Japan
- Iceland

https://annex93.iea-ebc.org/

https://www.linkedin.com/company/iea-ebc-annex-93/?viewAsMember=true

The keys aims of this project were / are to:

- Objective 1: Identify cold-region threats to buildings and energy systems; define resilience metrics and requirements for habitability, survivability, IAQ, and sustainability.
- Objective 2: Document case studies of resilient buildings and communities that reduce health and infrastructure risks.
- Objective 3: Assess (nearly) net-zero buildings for performance; develop scalable, local guidelines for resilient solutions.
- Objective 4: Share best practices through publications, presentations, and training.

The key stakeholders for this work were / are:

- Decision makers, energy planners, architects, engineers, building physicists, construction companies, facilities managers, and academia.

Subtasks

Subtask 1: Establishing energy resilience definition, threshold and challenges for the building clusters in cold climate

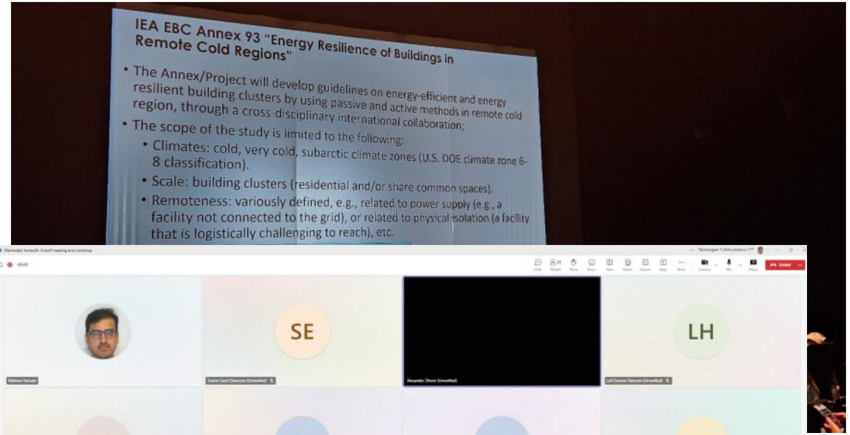
Subtask 2: Investigate specifics of buildings and their construction in remote cold regions

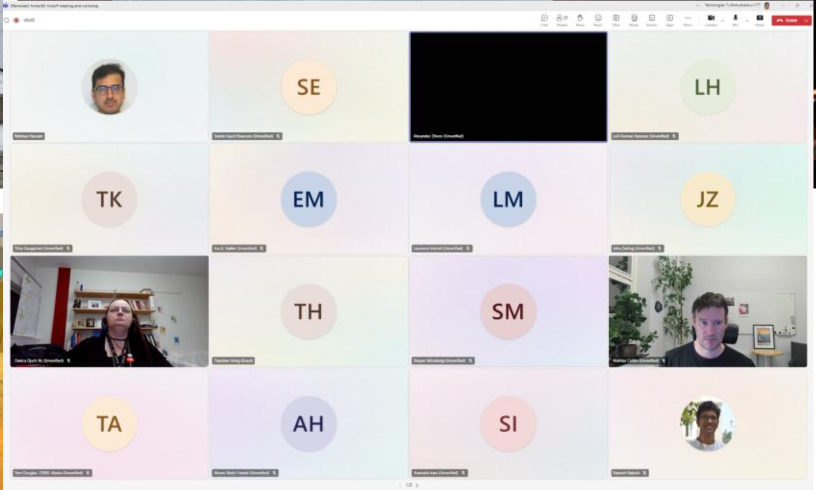
Subtask 3: Investigate resilient building and building clusters' energy systems, renewable energy sources, and systems integration

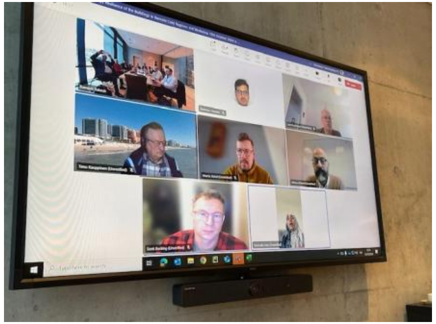
***Subtask 4:* Develop guidelines and disseminate knowledge**

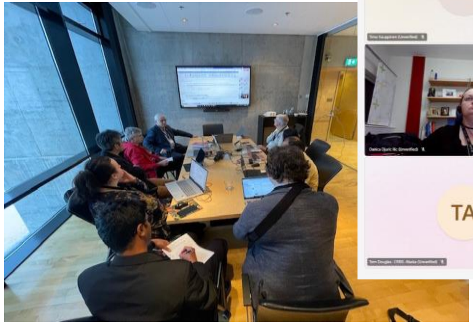
Workshops

- Akureyri, Iceland









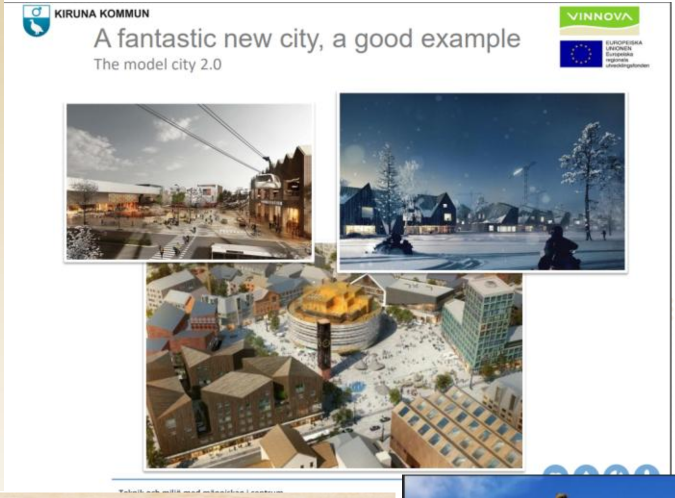
Workshops

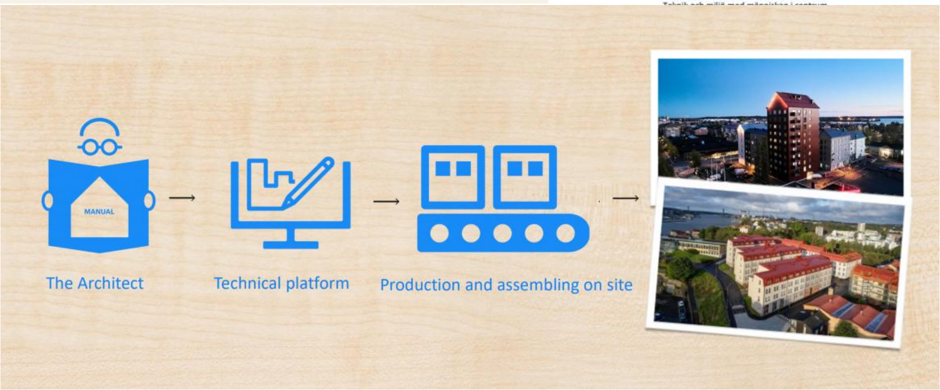
- Narvik, Norway

Case study, Kiruna

Our task

- ✓ Create space for 3000-4000 housing
- ✓ Plan for new commercial centre, offices and healthcare.
- ✓ Plan and build new infrastructure in the new city center.
- ✓ Plan and build new public buildings like cultural centre, swimming hall, upper secondary school, sportshall.





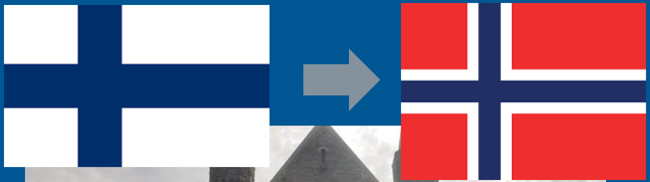
Collaboration with NTNU

Earlier collaboration with NTNU

- **2020-2024, Research Council of Finland,** Research project, Research topic: Integration of building flexibility into future energy systems-FlexiB
- **2022-2025, Research Council of Finland,** Postdoctoral Researcher Project. Research topic: Energy Resilience in Buildings in Extreme Cold Weather Conditions in Finland-FinERB

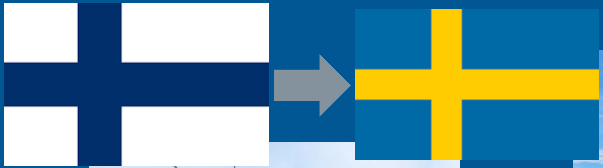
Ongoing and planned collaboration with NTNU

- **2025-2029, Research Council of Finland,** Research Fellow Project. Research topic: Addressing the Challenges of Achieving Energy Resilience in Buildings During Power Outages in Finland: A Human-Centric Approach Integrating Social, Economic, and Technical Dimensions (REBUILD-Fin).
- **2024-2028, IEA EBC Annex93** 'Energy Resilience of the Buildings in Remote Cold Regions' (https://annex93.iea-ebc.org/). It has (9 participating countries and 60 participants) Building-to-Grid Optimization for Nordic Resilient Citie
- **2026-2030,** Nordic Energy Research, Research topic: Building-to-Grid Optimization for Nordic Resilient Cities (NOIRC (B2G-NRC)

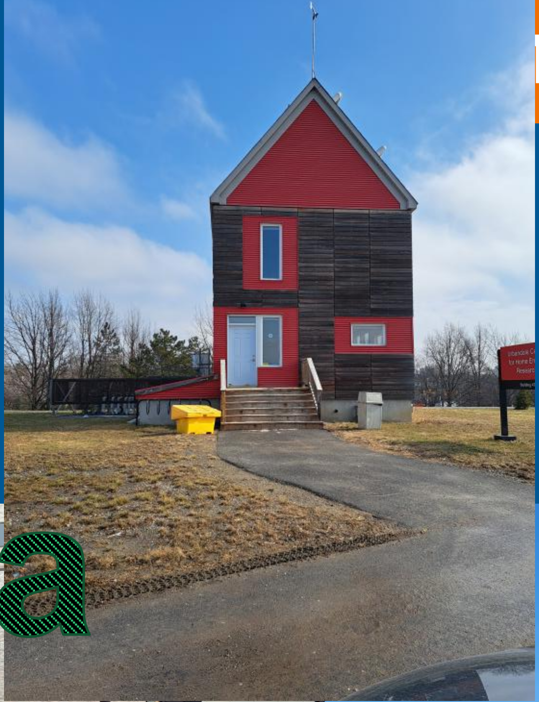


Norway

18/0



Sweden



Canada

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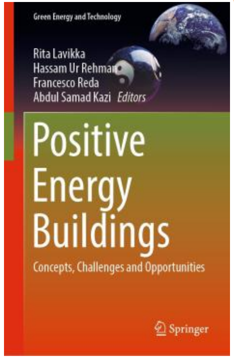
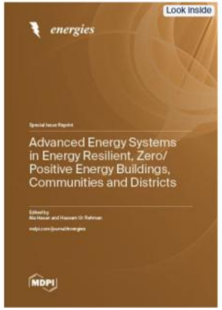
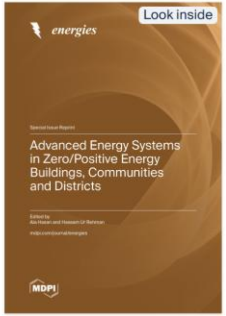


SUOMEN AKATEMIA
FINLANDS AKADEMI
ACADEMY OF FINLAND





RCF-Project (REBUILD-Fin) [Grant number: 367935]

ANNEX 93

EBC
Energy in Building and Communities Programme

VTT

beyond

the obvious