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THE DEVELOPMENT OF AN RC-NETWORK SIMULATION MODEL CALIBRATED WITH MONITORING DATA FOR USE IN THE PERFORMANCE GUARANTEE OF NET-ZERO HOUSES

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BACKGROUND
PERFORMANCE CONTRACTS

- Energy transition → high cost of renovation to zero-on-the-meter: 50 k€ to 70 k€
- Need for business case → initiative in 2013: “Stroomversnelling” (“Speeding-up”)
- Construction companies give performance guarantee:
  - For 25 years, energy performance
  - In future: comfort & health
- In practice the effect of energy saving measures is often lower than expected
- → Need for method to test energy performance in practice
- Aim of the construction companies:
  - Help explain differences between theory and practice
  - Get insight in success factors of renovation concepts
  - Improve prediction of energy saving meaures

METHOD
GENERAL APPROACH

- Aim:
  - Develop data-driven model of individual zero-on-the-meter house that approaches the actual energy performance
- Focus:
  - User behaviour
- Steps:
  1. Gather data on energy use and user behaviour
  2. Develop model
  3. Estimate parameters in the model → focus on user behaviour

METHOD
USE CASE

- Emmen, the Netherlands
- Social houses, 2 floors: living room, kitchen, bathroom, 3 bedrooms
- Renovated to zero-on-the-meter level:
  - Heating & domestic hot water: heat pump
  - Ventilation: mechanical with heat recovery
  - Insulation: U = 0,2, H++ glazing

METHOD
OVERVIEW SENSORS

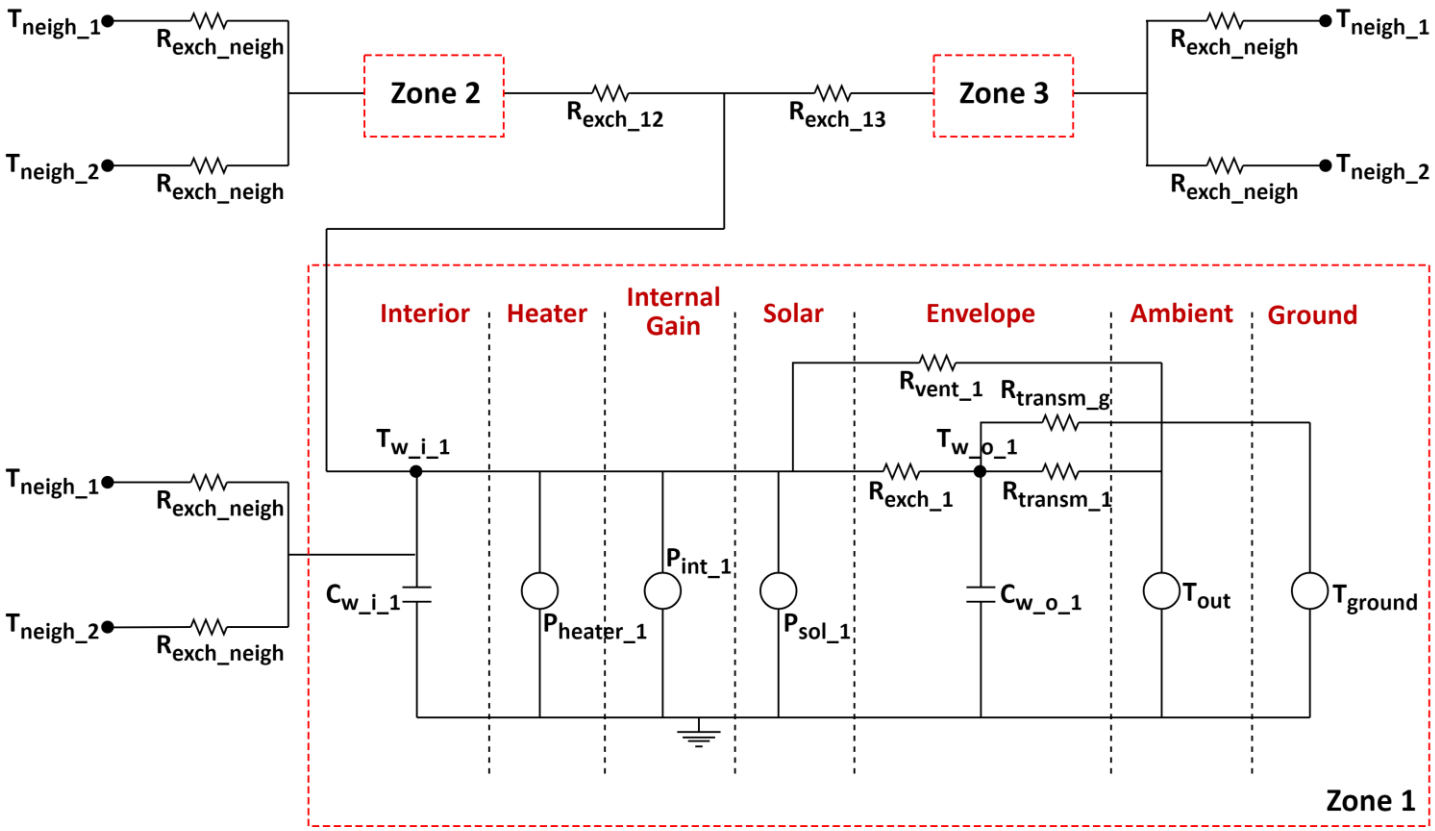
- Data gathered hourly
- One year of data

- Additional measurements:
  - Airtightness
  - Mechanical ventilation flows
  - Questionnaire on occupancy patterns

Sensor type	Location
Temperature [°C]	Living room
Temperature [°C]	Kitchen
Temperature [°C]	Main bedroom
Temperature [°C]	Bedroom 2
Temperature [°C]	Bedroom 3
Temperature [°C]	Living room neighbourgs 1
Temperature [°C]	Living room neighbourgs 2
Temperature [°C]	Radiators
Setpoint [°C]	Living room
Energy [W]	Heat pump
Energy [W]	Heat recovery system
Energy [W]	Solar panels
Energy [W]	Smart Meter
Status [-]	Heat pump (in use for space heating or domestic hot water)
Open/Close [-]	Front door
Open/Close [-]	Back door
Open/Close [-]	Kitchen window
Open/Close [-]	Living room window
Open/Close [-]	Main bedroom window
Open/Close [-]	Bedroom 2 window
Open/Close [-]	Bedroom 3 window

METHOD
MODEL

- Hourly 3 zone RC-network
  - Living room/kitchen
  - Heated bedrooms
  - Unheated bedrooms

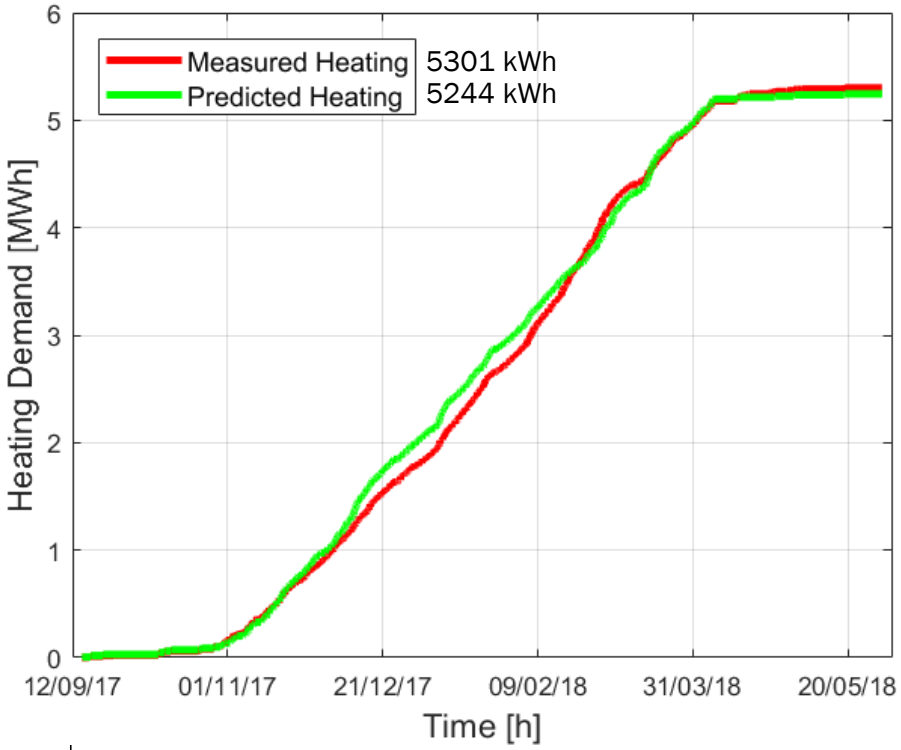


METHOD
MODEL PARAMETERS

- Building parameters & system parameters
  - Information from construction company (U-values, building materials, efficiency heat recovery)
  - Measured (infiltration, COP heat pump, ventilation flows
- Temperature and weather
  - Measured (setpoint, temperature in all rooms, temperature living room neighbours, weather data from weather station)
- User behaviour parameters
  - Measured (if/how long windows & doors were opened, internal gains from equipment/light, when rooms are heated/unheated)
  - Estimated based on questionnaire (how far windows were opened, internal gains from presence of people)

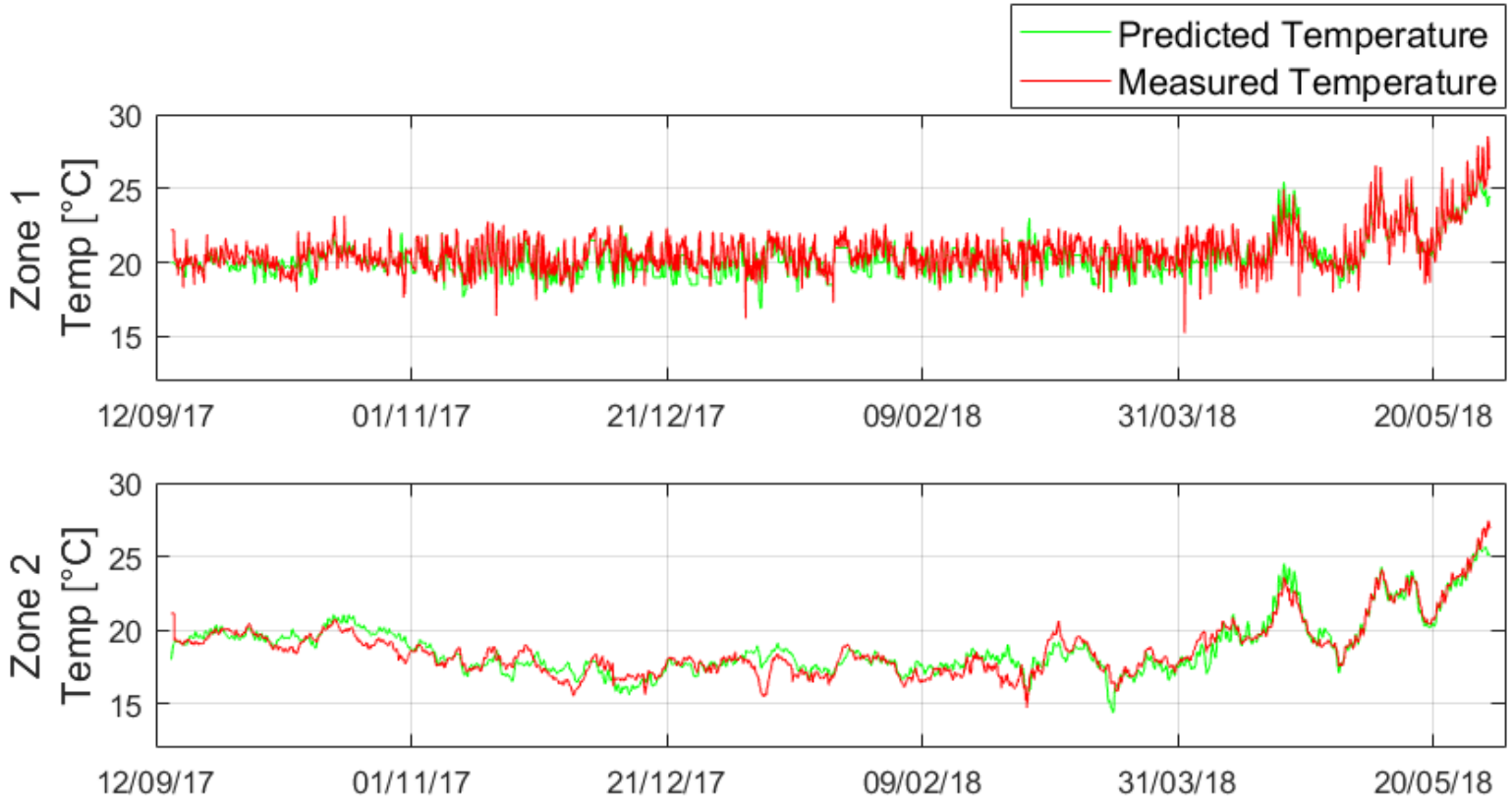
- Parameter tuning:
  - Most influencing factor: ventilation flow via open window
  - Based on: sensor (windows open/closed), questionnaire: how far open, weather data: wind direction/speed
  - Tuned by hand in few steps: window opening fraction

RESULTS
COMPARISON BETWEEN PREDICTED AND MEASURED DATA



Cumulative heating demand

Measured versus calculated



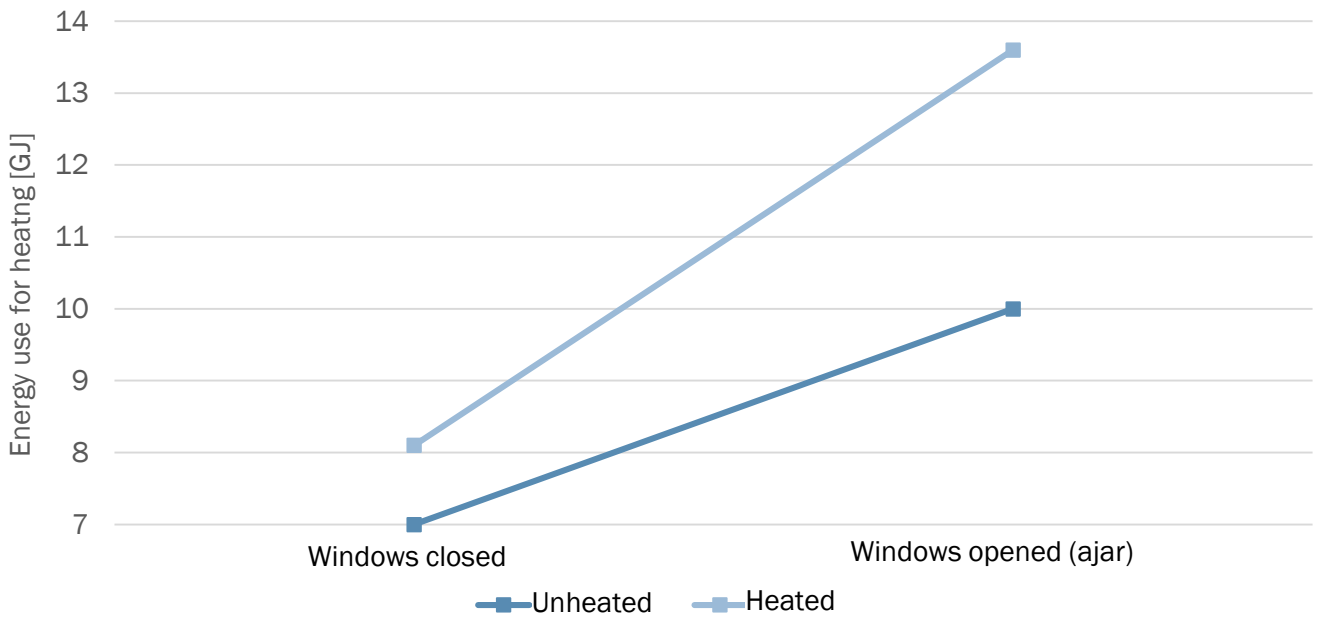
Temperature in zone 1 and 2

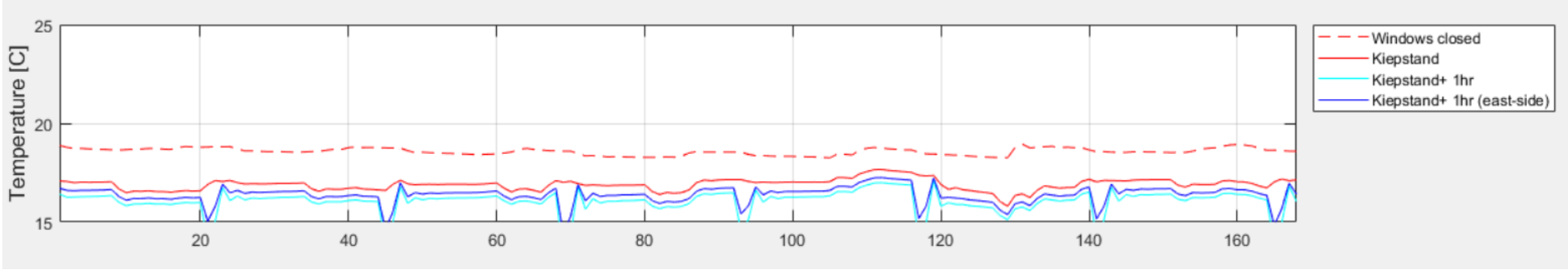
Measured versus calculated

RESULTS
LESSONS LEARNED WITH THIS MODEL

- Unexpected big loss of energy through window ajar in unheated bedroom
- Unheated bedroom relative warm in winter
  - Heated bedroom: limited extra energy use
  - Unheated bedroom: cooled by opening windows
- Much more opened bedroom windows than expected (other study: district in Almere City: av. 11u/day(winter)
- Warmer bedrooms in zero-on-the-meter houses due to less energy loss & equalization of temperature

  → Zoning in the house (insulation & heat recovery)





CONCLUSION

- Reasonable good reflection of both actual energy consumption & temperature progression with model fitted with data
  - Due to good mapping of user behaviour via data and survey
- Data driven model can give new perspective in renovation measures
- Big challenges:
  - Determine model parameters with more certainty
  - Using less sensors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YOUR TIME
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