University of Applied Sciences Windesheim

Scan for short Twomes movie

Twomes

Digital Twins for the Home Heating Transition

Questions about all homes in a country

Questions about all homes in a city or neighbour-hood

Questions about specific homes and households

Questions that can be answered with help of monitoring data

Questions that require close personal contact to answer

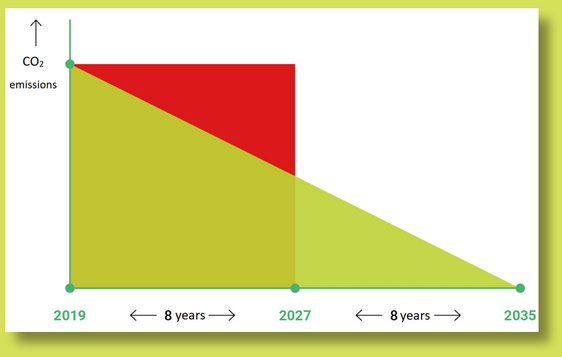
Who?

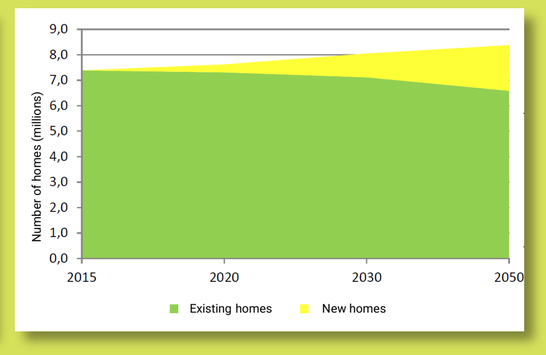
Henri ter Hofte, Marco Winkelman, Hossein Rahmani, in cooperation with 8 other researchers, 36 students & 10 teachers
Research Group Energy Transition, Windesheim University of Applied Sciences

What?

Which home heating model parameters of specific homes can we learn automatically from energy monitoring data in order provide better advice to a specific household about their home heating transition?

Why?

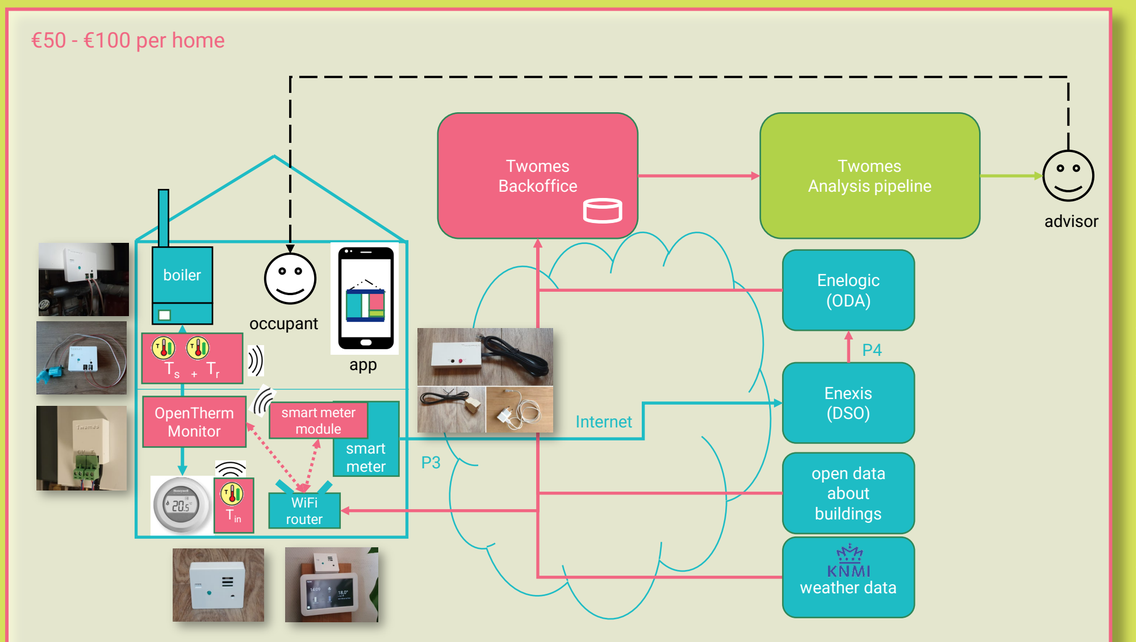




Data collection

edu.nl/demr9

Scan for open source software and open hardware repositories on GitHub



Data collected

category	measured data	symbol	unit	API	sensor
comfort	setpoint	T_{set}	°C		✓
weather	outdoor temperature	T_{out}	°C	✓ KNMI	
	wind	W	m/s		
	global horizontal irradiation	I	W/m²		
indoor	indoor temperature	T_{in}	°C		✓
installation	supply temperature	T_s	°C		✓
	return temperature	T_r	°C		✓
energy use for heating	electricity	E	kWh	✓ Enelogic	✓
	gas	G	m³		
occupancy/ventilation	CO_2 concentration	CO_2	ppm		✓
	Bluetooth presence	BT_{pres}	#pp		✓

Subjects & data

edu.nl/aqnhv

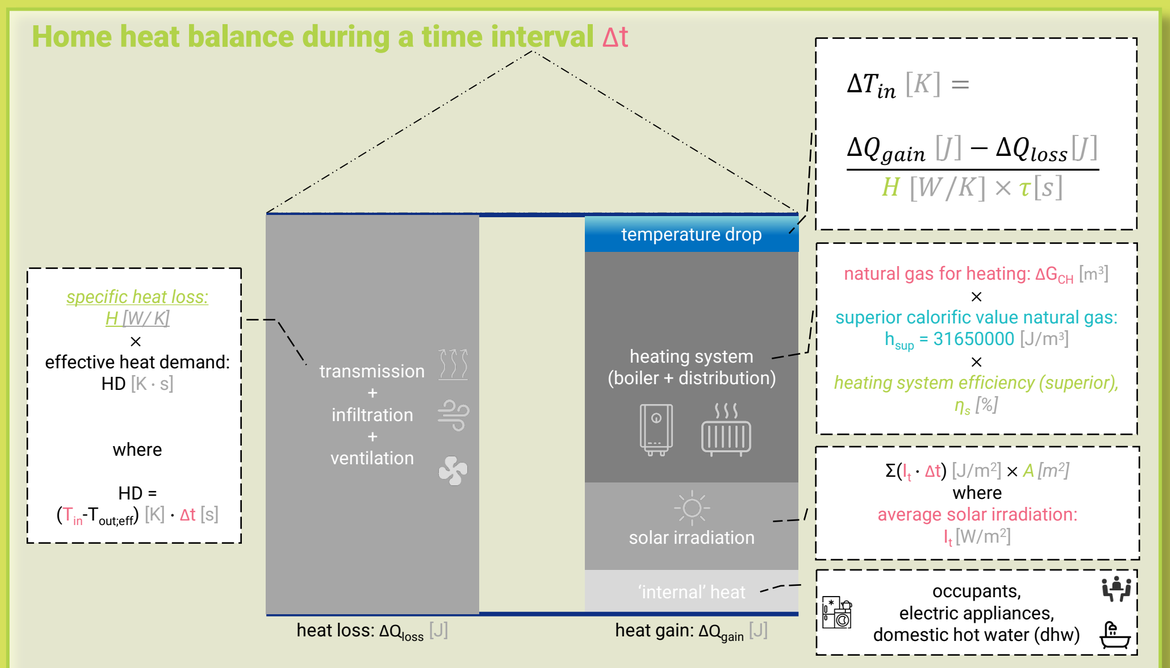
Scan for dataset

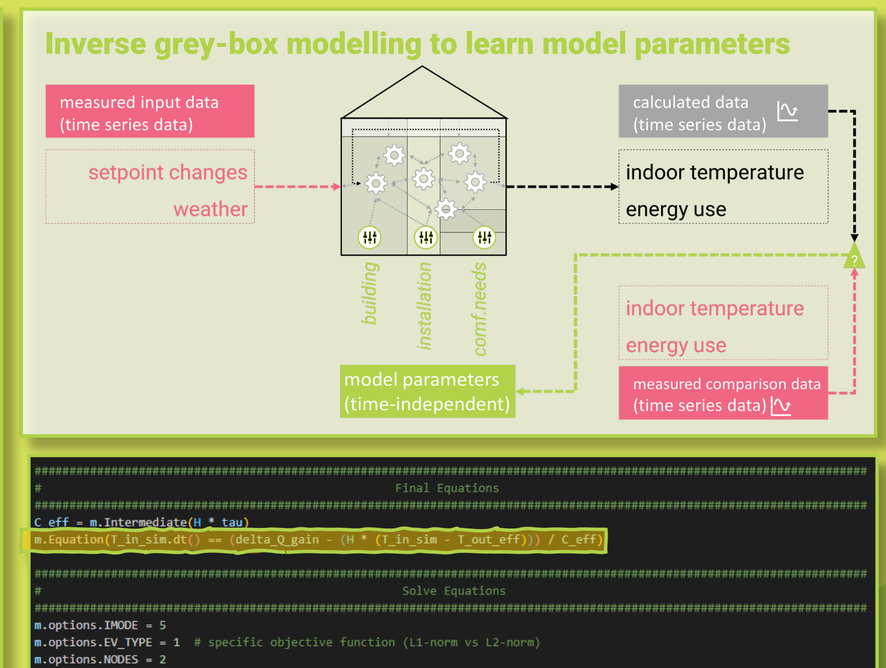
> 35 million data points; from 23 homes essential data properties longer than 3 weeks (> 70 days of data per home)

Data analysis

edu.nl/kttbe

Scan for GEKKO Python heat balance model






```
#                                                    Final Equations
C_eff = m.Intermediate(H * tau)
m.Equation(T_in_sim.dt() == (delta_Q_gain - (H * (T_in_sim - T_out_eff))) / C_eff)

#                                                    Solve Equations
m.options.IMODE = 5
m.options.EV_TYPE = 1  # specific objective function (L1-norm vs L2-norm)
m.options.NODES = 2
m.solve(disp=showdetails)
```

Results

edu.nl/jw9j3

Scan for more results

Model parameters to learn

symbol	scope	parameter	unit
H	building	specific heat loss	W/K
τ	building	thermal inertia	s (h)
C	building	thermal mass (C = H × τ)	J/K (Wh/K)
A	building	apparent window area (imaginary horizontal window in roof)	m²
P_{max}	installation	maximum heating system power (boiler + distribution)	W
η_s	installation	central heating system efficiency (superior value)	%
CD	behaviour	comfort demand (daily & hourly thermostat setpoints)	K·s

Conclusions

First indications that building parameters can be learned:

specific heat loss **H** [W/K], thermal inertia **τ** [s], thermal mass C [J/K]

Other parameters: work in progress

enpuls

BDR THERMEA GROUP

Breman

Witteveen + Bos

thuis Zwolle

50 TINTEN GROEN ASSENDORP

TECH FOR FUTURE
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mede mogelijk gemaakt door provincie verijssel