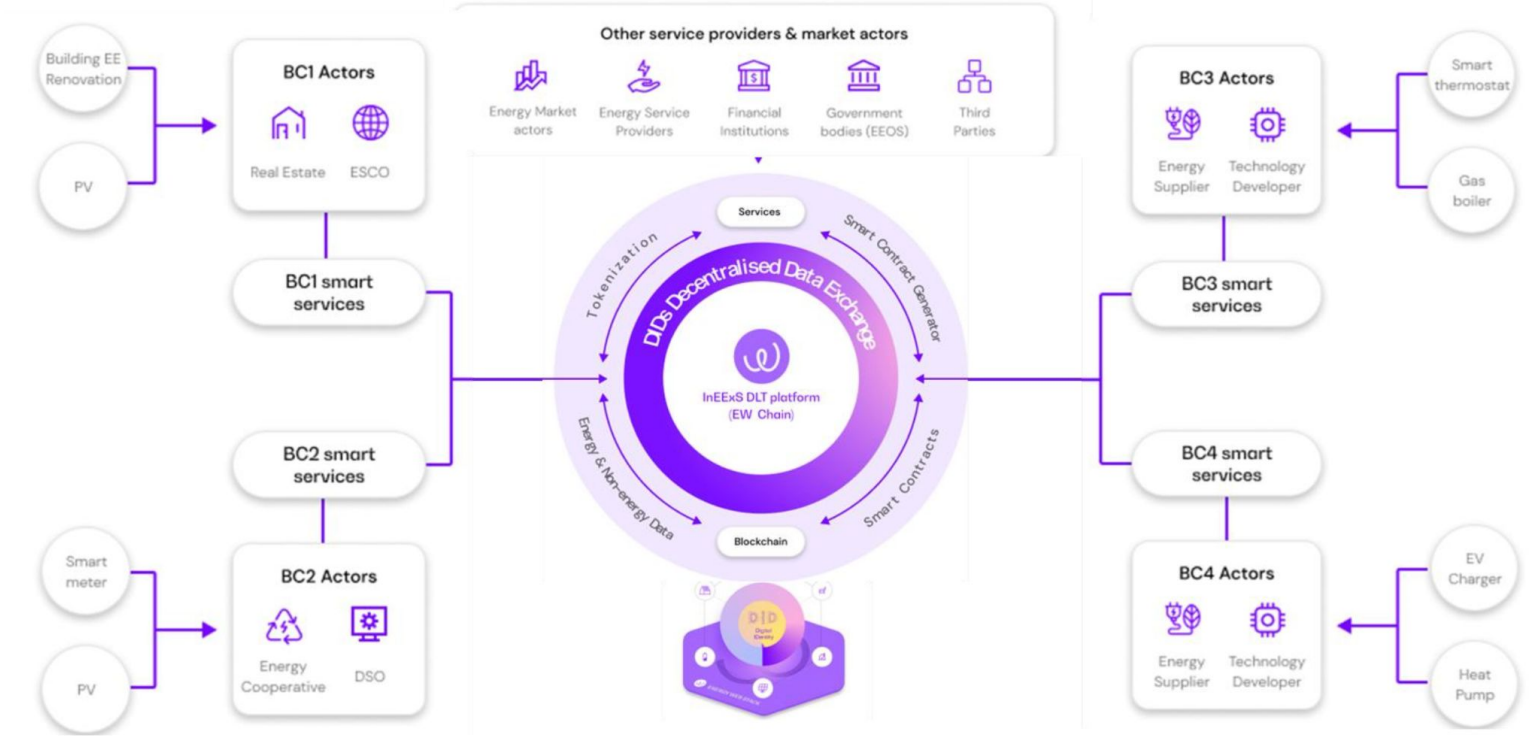
Stratos Keranidis, PhD

R&D Director, domx

04/02/25

The InEExS Blockchain platform and integration with the 4 pilots



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BC3 - Energy efficiency through Smart heating

Legacy Heating

domx
IOT TECHNOLOGIES

Gas Boiler

Heatpump

End user

Room thermostat

domx Smart Heating

Gas Boiler

Heatpump

Control

domx
Smart Heating Controller

Input

Wireless Room
thermostat

End
user

domx Smart Heating

Gas Boiler

Heatpump

domx smartphone app

End user

domx cloud services

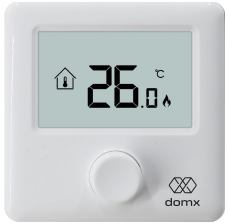
Wi Fi

Control

Input

domx

domx Smart Heating Controller



Wireless Room thermostat

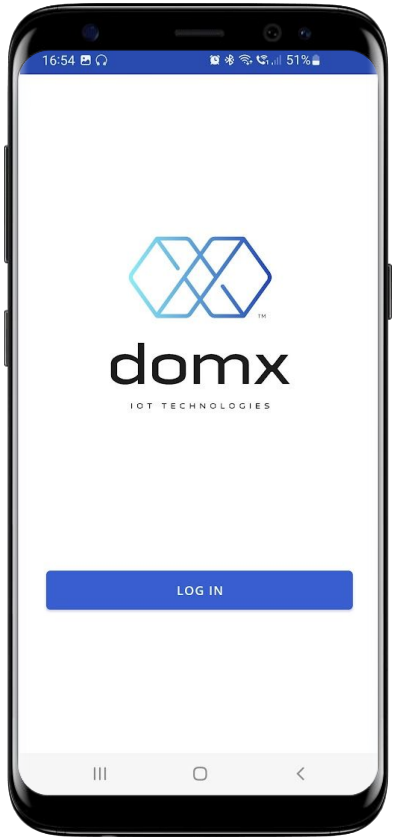
domx Smart Heating - Application

- **Device Benefits**
  - User friendly smartphone application
  - Wide system compatibility (>70% of gas boilers, >60% of heatpumps)
  - Thermal comfort management (avoiding room temperature overshooting)
  - Energy efficient heating (tuning of outlet temperature)
  - Energy saving tips (alerts, push notifications)
  - Error reporting (push notifications)

- **System Benefits**
  - Metering and control through a single device
  - Analysis of consumption (day/week/month)
  - Quantification of achieved savings (kWh, €, CO2)

Wireless Room Thermostat

- **Portfolio Management benefits**
  - Access to real-time and historical data through secure web API
  - Portfolio Management services and dashboard:
    - Operation monitoring
    - Error reporting



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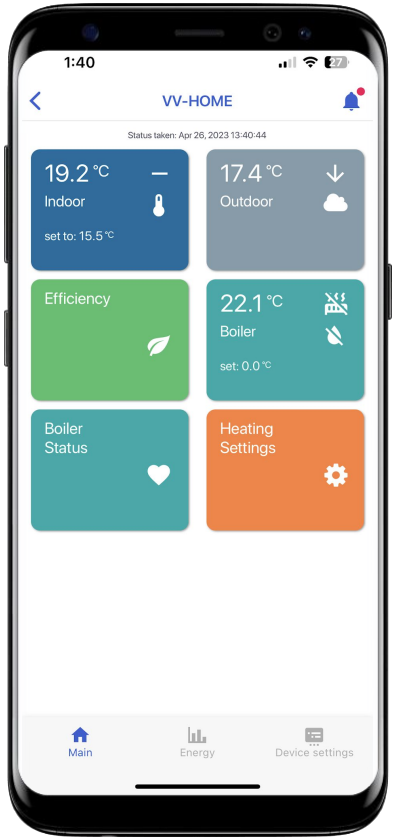

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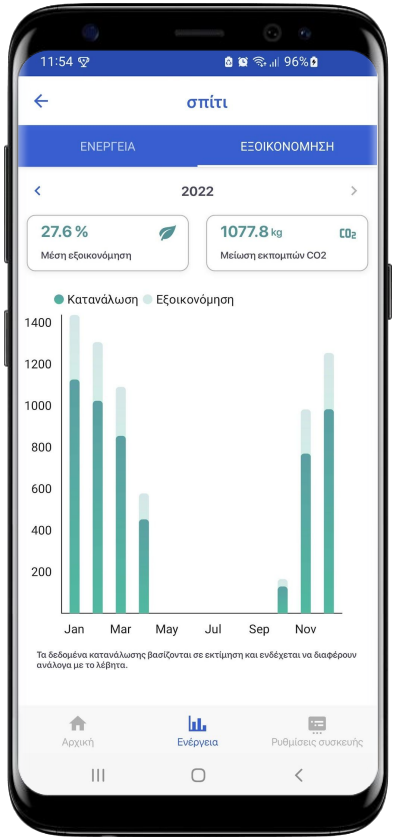

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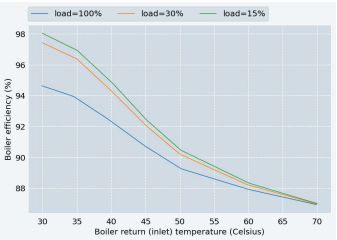
Energy Efficient Heating

Energy Saving Mechanisms

- Employ an **accurate** room temperature sensor (0.1C)
  - Control temperature overshoots - undershoots
- Indoor Temperature Compensation
  - PID controlled adaptation of **outlet** temperature, based on ΔT (target - room)
  - Avoid temperature overshoots - undershoots
- Use of **lower modulation** for increased duration per heating event
  - Avoid repetitive boiler activations (ON/OFF penalty)
  - Exploit building thermal inertia
- Outdoor Temperature Compensation
  - Restrict the **maximum boiler target** temperature based on outdoor temperature
- Physics-based ML algorithms to model the system's performance
  - Building
  - Heating System
  - User



Baseline vs Adaptive modes

Room temp/ Target

Outdoor temp

Boiler temp/ Target

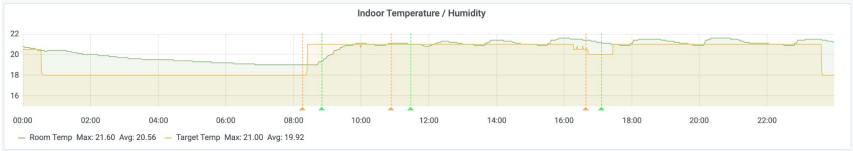
Boiler Modulation

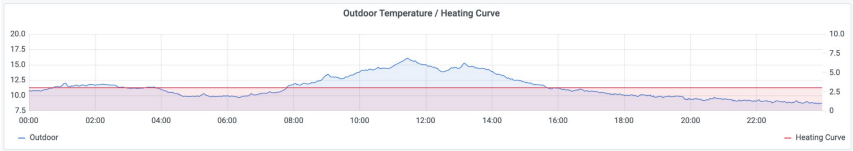
BASELINE

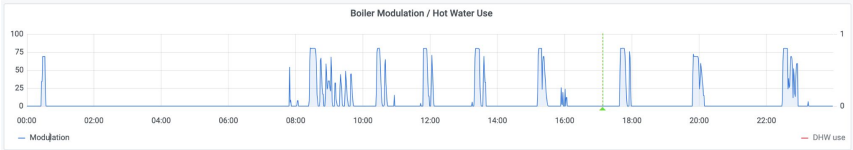
Fixed boiler target temperature of 65 °C

AVG boiler temperature 39.32 °C
Estimated consumption 40.31 kWh

Baseline vs Adaptive modes





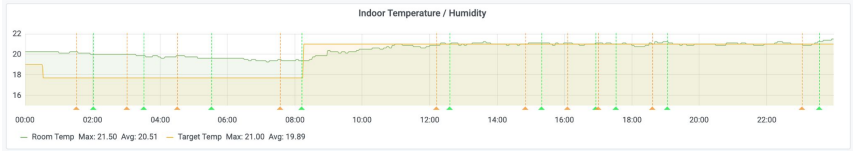


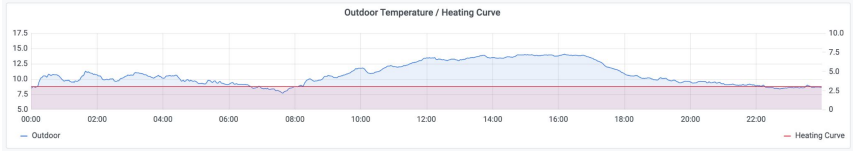
Room temp/ Target

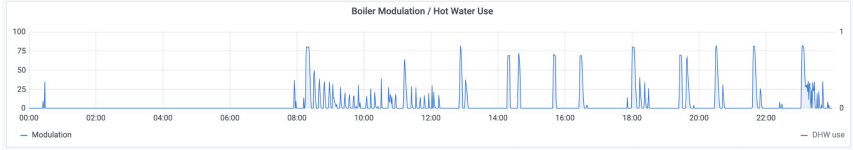
Outdoor temp

Boiler temp/ Target

Boiler Modulation







BASELINE

Fixed boiler target temperature of 65 °C

AVG boiler temperature 39.32 °C

Estimated consumption 40.31 kWh

29.7 %

Gas consumption reduction

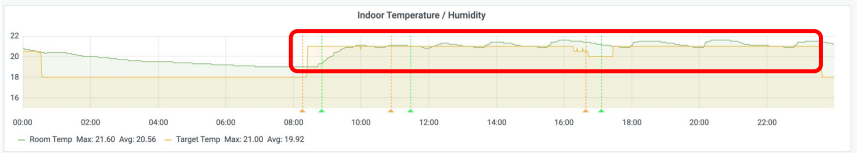
ADAPTIVE

Adaptive boiler target temperature

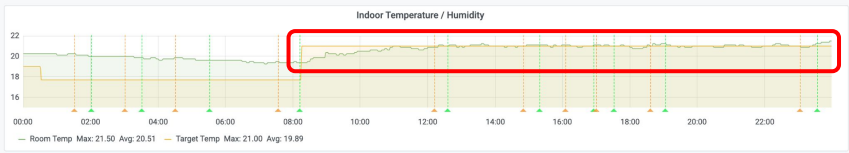
AVG boiler temperature 36.59 °C

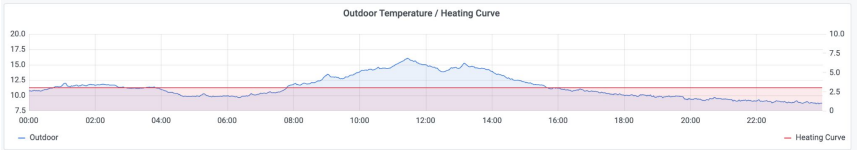
Estimated consumption 28.19 kWh

Baseline vs Adaptive modes

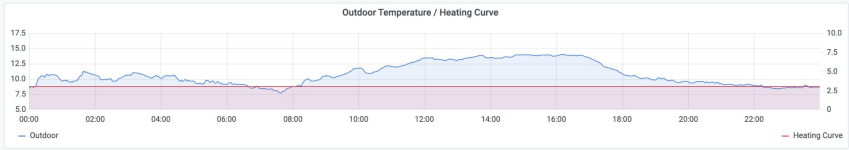


Room temp/ Target

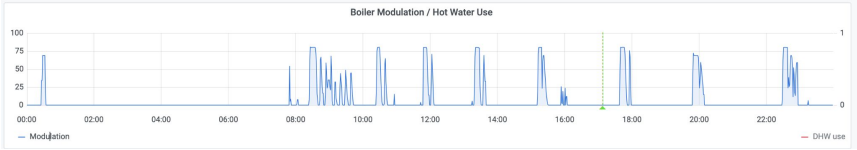




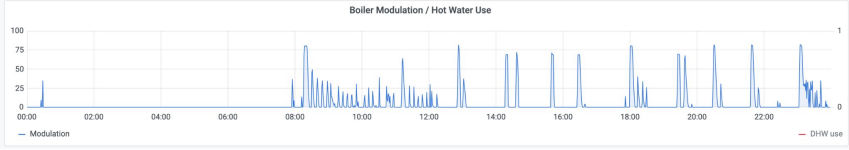
Outdoor temp



Boiler temp/ Target



Boiler Modulation



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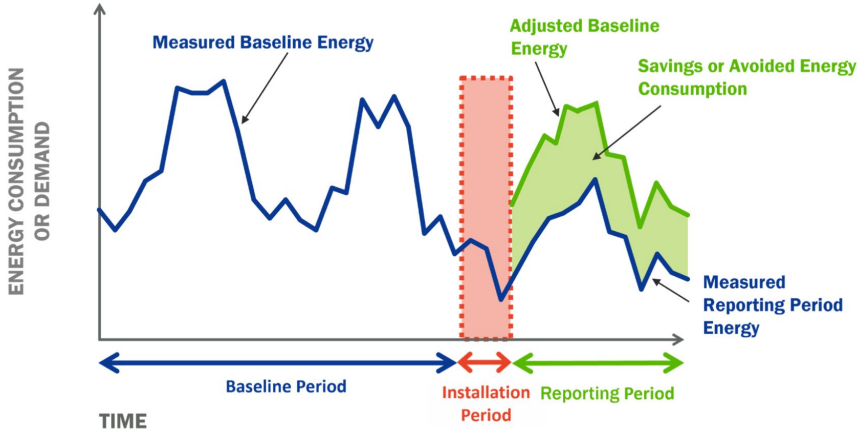
Measurement and Verification Approach

Energy Savings Calculation



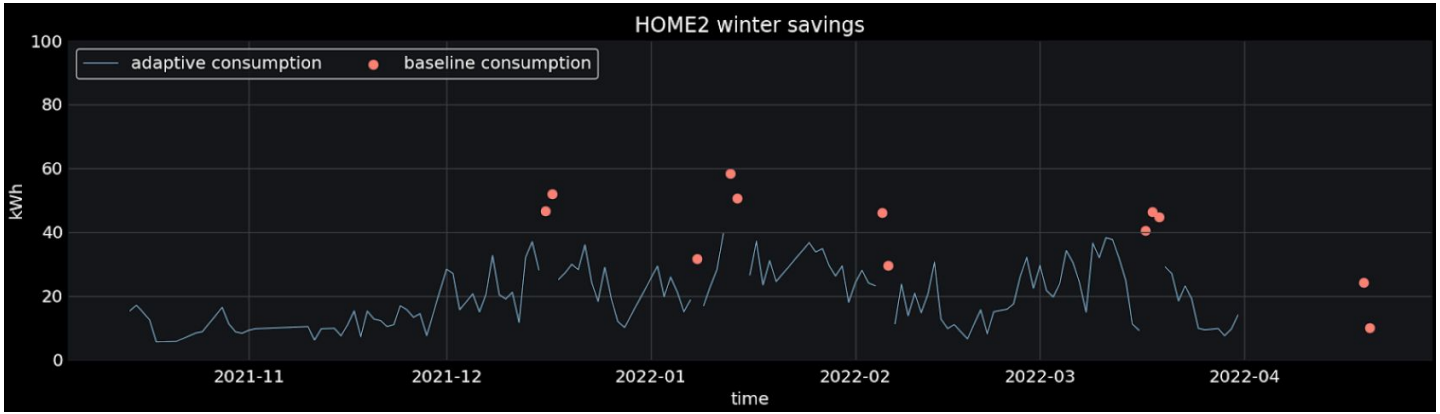
Energy Efficiency Measures and calculation of Savings

Energy savings cannot be directly measured, as they represent the absence of demand. Savings are determined by comparing measured energy consumption or demand **before** and **after** the implementation of an energy efficiency measure (EEM), making suitable adjustments for changes in conditions.

The **International Performance Measurement and Verification Protocol (IPMVP)** develops a consensus approach to measuring and verifying efficiency investments and requires the alignment with one or more of the four Options and impacts the granularity of the savings reported and the measurements required.

Option D: Calibrated Simulation
If the **Baseline** Period or **Reporting** Period data are unreliable or unavailable (e.g., new construction), energy data from a calibrated simulation model can be applied.

Energy Savings Calculation



Adaptive Consumption per day over the entire heating season + 12 Baseline days

BASELINE: use a fixed boiler target temperature of a high value (65 °C) to guarantee fast heating response under a wide range of outdoor conditions

ADAPTIVE: periodically adapted by a local algorithm that considers the indoor, outdoor conditions and user preferences

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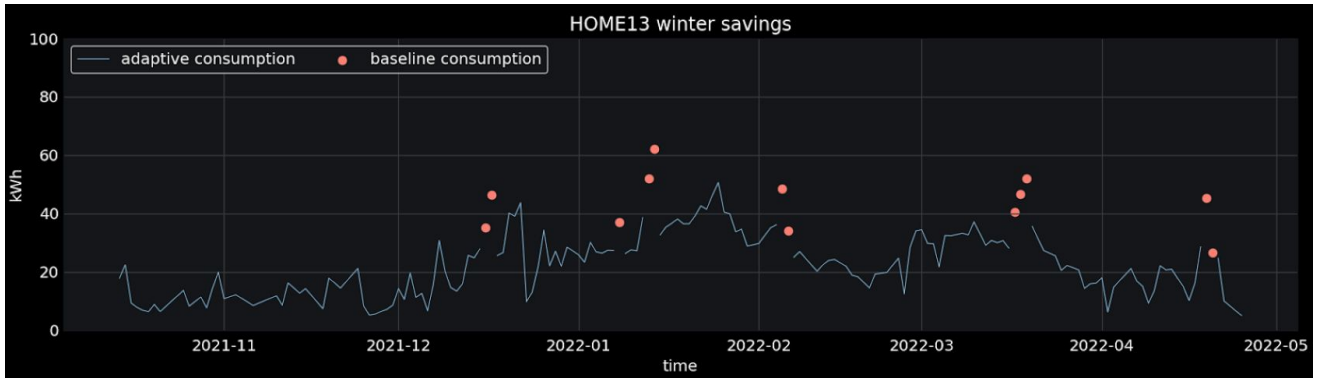
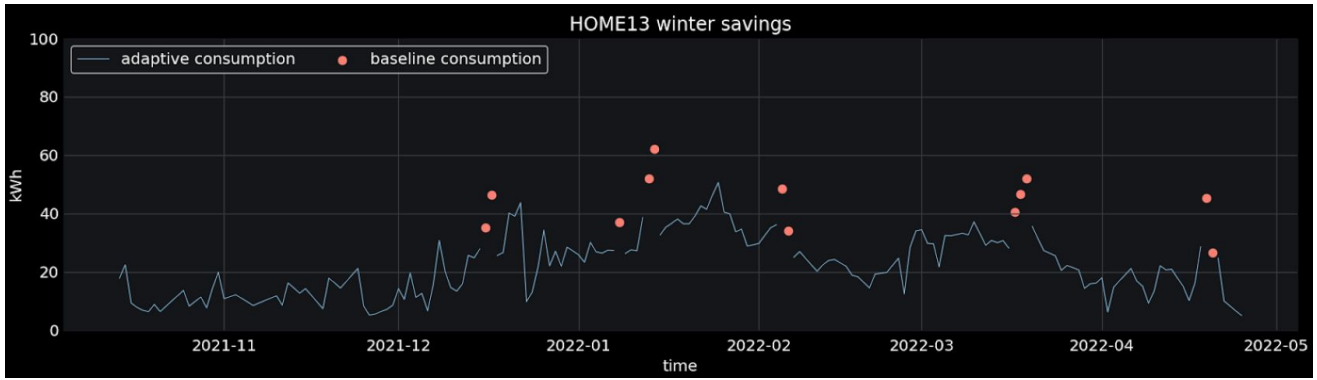
Baseline performance simulation

Baseline performance simulation



Real Adaptive Consumption per day + 12 Baseline days over the entire heating season

Baseline performance simulation

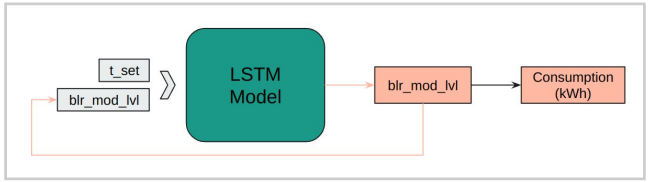


Real Adaptive Consumption per day + 12 Baseline days
over the entire heating season

Real Adaptive + Simulated Baseline Consumption per day
over the entire heating season

Baseline performance simulation

Training LSTMs for time-series forecasting and synthetic time-series generation



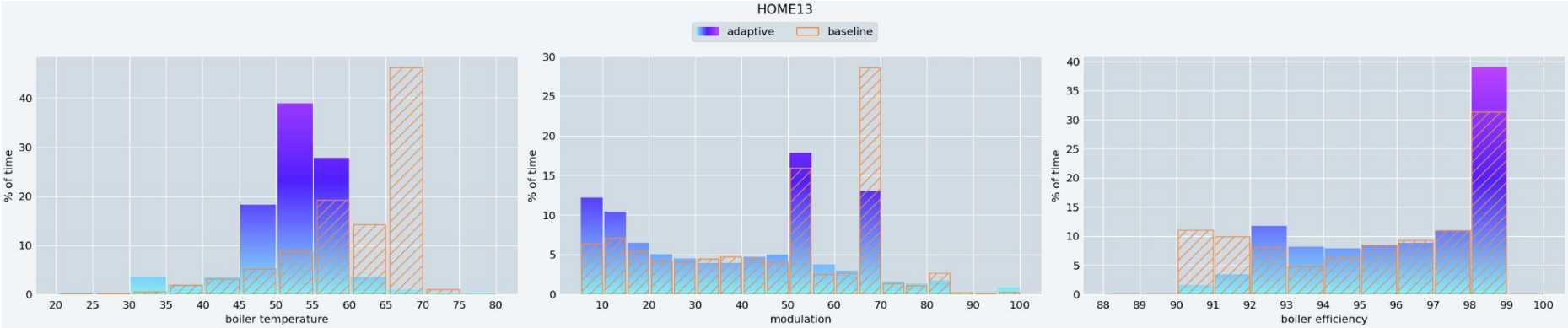
- Input features: modulation, boiler target | Output: modulation, consumption
  - Forecasting horizon: 24H
- Cross-validation with 30-day period
  - Parameter optimization:
    - Time-series smoothing parameters, sampling frequency, look-back window, prediction steps
  - Evaluation metrics:
    - Mean Absolute Error (MAE), Percentage Mean Absolute Error (PMAE)
- 1 model per home - trained on 30-day period
  - optimized based on min(consumption PMAE)
- **Time-series forecasting**:
  - Hold-out test sets: (a) forecasting on unseen adaptive data, (b) forecasting on unseen baseline data
- **Synthetic time-series generation:**
  - Adaptive-to-Baseline simulation for energy savings estimation (full winter)

Energy savings calculation

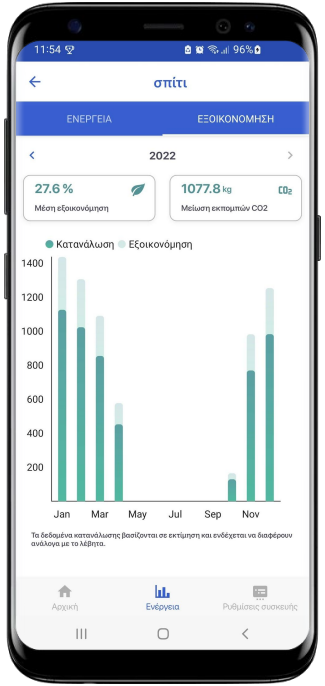
Home 13

Estimated Winter Savings

32.15%



Reporting of Savings



Consumer level savings reporting

Portfolio level savings reporting

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Thank you!

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Thessaloniki, Greece
2313-252420

info@domx.io

Baseline to Baseline simulation

Home 2

PMAE (%) = 5.83

MAE = 0.90

Home 9

PMAE (%) = 21.92

MAE = 1.84

Home 13

PMAE (%) = 25.34

MAE = 5.26

Adaptive to Baseline simulation

Home 2

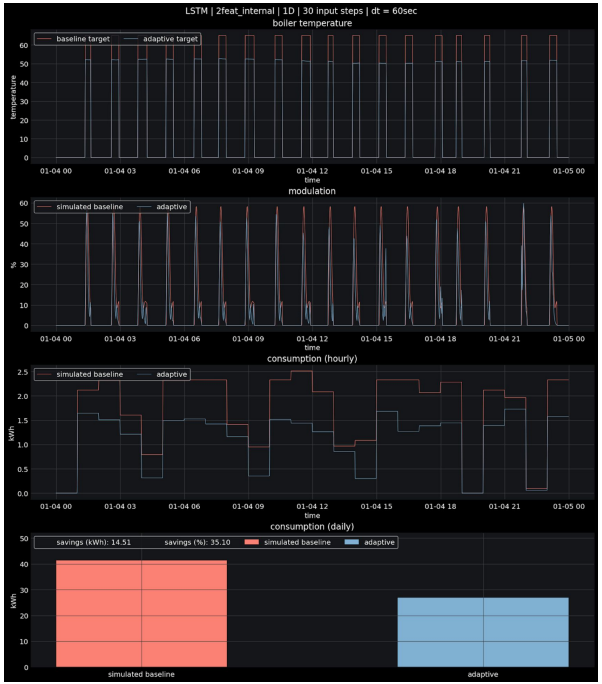
Estimated Daily Savings

27.45%

Home 9

Estimated Daily Savings

28.88%



Home 13

Estimated Daily Savings

35.10%