ePANACEA
Smart European Energy Performance Assessment & Certification

Data-driven automated EPC generation from on-board-monitoring data

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This project has received funding from the European Union's HORIZON 2020 research and innovation programme under grant agreement No 892421

What is ePANACEA

ePANACEA
Smart European Energy Performance Assessment & Certification

- ePANACEA

Smart European Energy Performance Assessment and Certification

- HORIZON 2020 Innovation project
- Duration: 01.06.2020-31.05.2023

Project Partners:

Why ePANACEA?

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Challenge 1: **gap between standard outcomes of EPC schemes and real consumption patterns**

Challenge 2: **lack of accuracy of the building's energy assessment results**

Challenge 3: **poor user awareness related to energy efficiency**

Challenge 4: **lack of convergence across the European Union**

Challenge 5: **inclusion of smart and novel technologies**

Challenge 6: **lack of trust in the market**

Aim = overcome these challenges by developing a holistic methodology for energy performance assessment and certification

ePANACEA methodology

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Three methods:

1. Smart & performance data-driven building energy performance assessment
2. Simplified method based on monthly calculation interval
3. Advanced & automated simulation modelling based on dynamic simulation for EPCs

ePANACEA methodology

Smart & performance data-driven building energy performance assessment

- Derive input parameters by means of energy decomposition
- Two methods to define the energy performance from on-board-monitoring data
    1. Correction by means of elaborated version of MEPI tool (= Measured Energy Performance Indicator) developed within X-Tendo
    2. Heat loss coefficient characterization

1. Energy Decomposition

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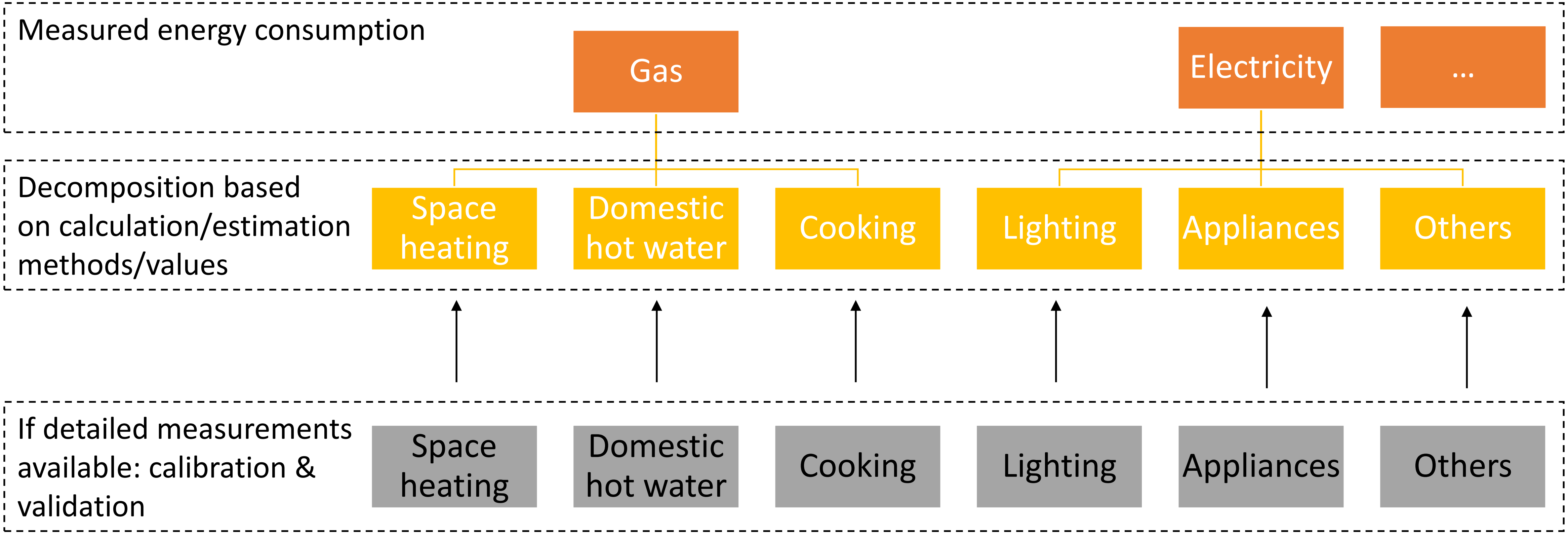


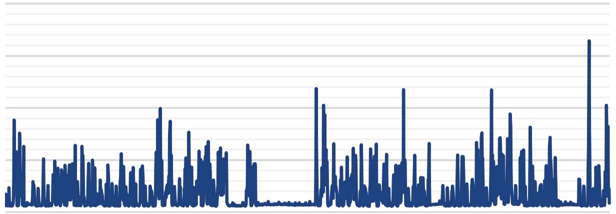
1. Energy Decomposition

Based on the **nature and frequency** of energy consumption data, several **scenarios** can be distinguished in the energy breakdown method:

1. **Annual** energy consumption
   - ➢based on simplified monthly calculation, estimation methods from international standards and statistical/empirical values

2. **Monthly** or **periodical** energy consumption
   - ➢based on simplified monthly calculation, estimation methods from international standards and statistical/empirical values
   - ➢Additional advantage: calibration based on monthly data

3. **High-frequency** data
   - ➢More advanced techniques e.g. Kernel smoothing



2. Two methods to define the energy performance from on-board-monitoring data

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CORRECTION

ePANACEA elaborates the **MEPI tool of X-tendo**

- following the general principles as described in EN 52000-1 series
- Input = measurement data of energy delivered to and exported from the building unit per energy carrier and per application
  - ➢ Default corrections applied to the space heating and cooling energy for external climatic conditions by means of heating degree-days and cooling degree-days method
  - ➢ Optional correction for solar irradiation, domestic hot water energy and indoor temperature
- Output = the annual specific primary standard measured energy performance
  - ➢ calculated using the non-renewable primary energy conversion factors and taking into account the electrical energy produced on site and exported.
  - ➢ Additional output = Renewable energy ratio and specific CO2 equivalent emissions

More information:

- Verheyen J., Lambie E., Boneta M.F., Maia I., Kranzl L. and Urbanz T. Next generation energy performance assessment methods for EPCs using measured energy data. Conference paper in preparation for CLIMA 2022 the 14th REHVA HVAC World Congress, 22nd – 25th May in Rotterdam, The Netherlands.
- A calculation spreadsheet with accompanying guidelines of the MEPI tool including a description of the calculation algorithms is available on the X-tendo website (www.X-tendo.eu).

2. Two methods to define the energy performance from on-board-monitoring data

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CORRECTION

ePANACEA elaborates the **MEPI tool of X-tendo**

➢ In ePANACEA more detailed high frequency (sub-)hourly data is available

Three alterations/additions:

1. Heating/cooling degree days calculated from measured high frequency outdoor and indoor temperatures
2. Correction of DHW based on number of default occupants
3. Self consumption derived based on the actual hourly measurement of the PV generation

More information:

- Verheyen J., Lambie E., Boneta M.F., Maia I., Kranzl L. and Urbanz T. Next generation energy performance assessment methods for EPCs using measured energy data. Conference paper in preparation for CLIMA 2022 the 14th REHVA HVAC World Congress, 22nd – 25th May in Rotterdam, The Netherlands.
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2. Two methods to define the energy performance from on-board-monitoring data

CORRECTION

Case example

- Newly built terraced house constructed in 2018
- Part of multi-family building block
- Biomass boiler
- Measurement data 17th of October 2019 - 31st of December 2019

2. Two methods to define the energy performance from on-board-monitoring data

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CORRECTION

Case example

- Average indoor temperature in the living room = 22.5°C
- Average outdoor temperature = 5.1°C
- Total electricity use of the building = 561.1 kWh
- Energy use for space heating = 1318.8 kWh
- Energy use for domestic hot water = 405.3 kWh

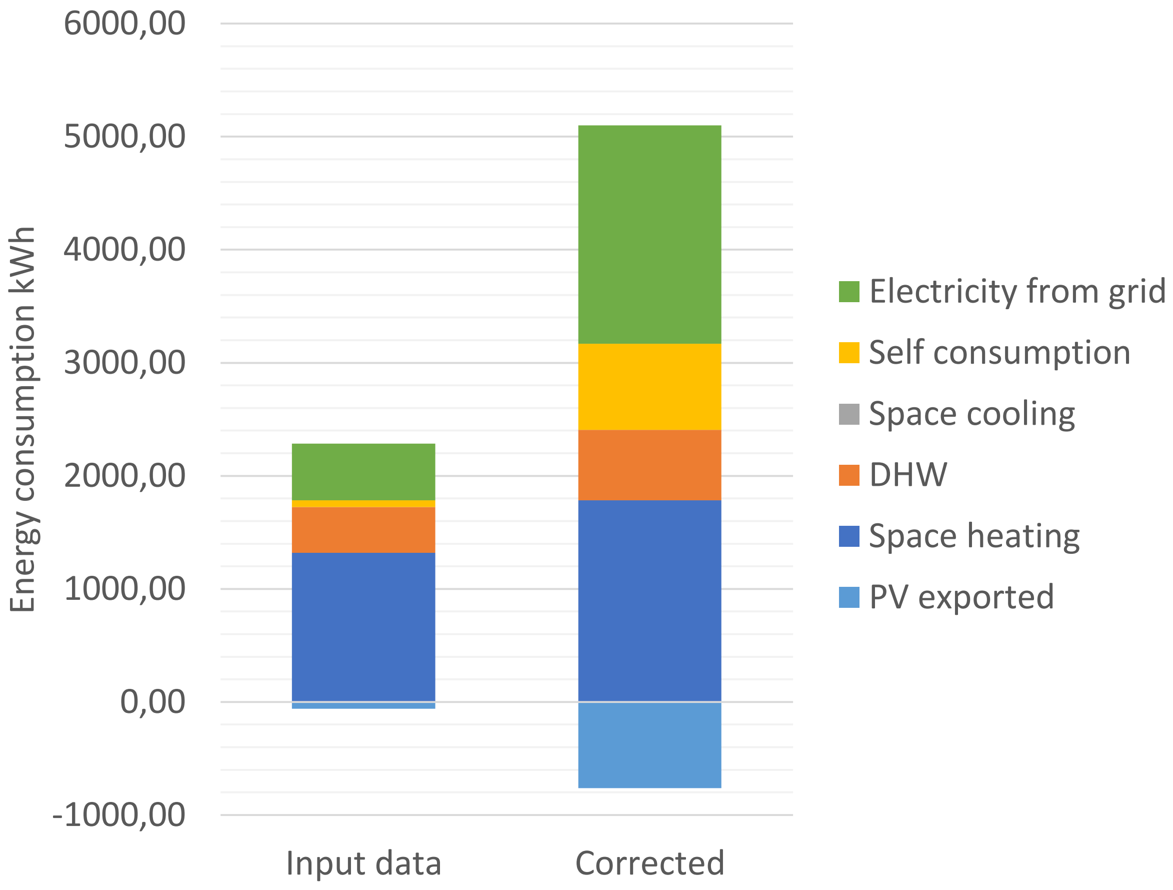
2. Two methods to define the energy performance from on-board-monitoring data

CORRECTION

Case example

Input data for 2.5 months in winter vs. corrected energy consumption for default outdoor climate

- Low degree of **solar radiation** in winter months
  → exported electricity & self consumption significantly increases
- Large share of energy demand for **space heating** during winter months
  → space heating only changes limitedly
- **Electricity** is corrected based on period
  → correcting 2.5 months to 12 months results in significant increase



2. Two methods to define the energy performance from on-board-monitoring data

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HEAT LOSS COEFFICIENT CHARACTERIZATION

$$Q_{heating/cooling} + Q_{internal} + f * g_{shade} * g_{glass} * A_{windows} * P_{sol} = \Sigma U * A_{envelope} * (T_i - T_e) + (1 - \eta) * m_v * C_p * (T_i - T_e) + m_i * C_p * (T_i - T_e)$$

HEAT GAINS:

- Heating/cooling demand
- Internal gains:
  - Q_{person}
  - $Q_{lighting}$
  - $Q_{appliances}$
- Solar gains:
  - Psol: global solar radiation on a vertical surface
  - $A_{windows}$: surface of the window
  - g_{shade}: solar factor of the blinds
  - g_{glass}: solar factor of the glazing
  - f: reduction factor for heavy buildings

HEAT LOSSES:

- Transmission loss:
  - U: Heat transfer coefficient
  - Ti: indoor temperature
  - Te: outdoor temperature
  - $A_{envelope}$: Surface area of the envelope (roof, wall, floor, window)
- Ventilation loss:
  - m_v: mass flow rate of ventilation
  - C_p: specific heat of air
  - η: heat recovery efficiency, 0 if without heat recovery
- Infiltration loss:
  - m_i: mass flow rate of infiltration air

2. Two methods to define the energy performance from on-board-monitoring data

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HEAT LOSS COEFFICIENT CHARACTERIZATION

Different methods:

1. Average method

$$HLC = \frac{\sum_{j=1}^{n}(\Phi_h + \Phi_{int} + \Phi_{sol} + \Phi_{inf} + \Phi_{vent})}{\sum_{j=1}^{n}(T_{i,j} - T_{e,j})}$$

2. Two methods to define the energy performance from on-board-monitoring data

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HEAT LOSS COEFFICIENT CHARACTERIZATION

Different methods:

2. Linear regression

Model with the least parameters:

$$\boldsymbol{Q_h} = -HLC * \boldsymbol{T_e} + Int \text{ with } Int = HLC * T_i - gA * I_{sol}$$

can be elaborated

$$\boldsymbol{Q_h} + \boldsymbol{Q_{int}} = HLC * (\boldsymbol{T_i} - \boldsymbol{T_e}) - gA * \boldsymbol{I_{sol}}$$

2. Two methods to define the energy performance from on-board-monitoring data

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HEAT LOSS COEFFICIENT CHARACTERIZATION

Different methods:

3. Auto-Regressive models with eXogenous inputs (ARX-models)

$$\omega_i(B)T_i = \omega_h(B)[Q_h + Q_{int}] + \omega_e(B)T_e + \omega_s(B)I_{sol} + \varepsilon_j$$

heat losses are defined using the Lagrange weighting, which is a linear minimum variance weighting between H_e and H_i:

$$H = \lambda H_i + (1-\lambda)H_e$$

$$H_i = \frac{\omega_i(1)}{\omega_h(1)} \;\&\; H_e = \frac{-\omega_e(1)}{\omega_h(1)}$$

More information on ARX-modelling and Lagrange weighting can be found in the research of Bauwens and Senave:

- G. Bauwens. In situ testing of a building's overall heat loss coefficient. Embedding quasi-stationary and dynamic tests in a building physical and statistical framework. PhD thesis, KU Leuven, 2015.
- M. Senave. Characterization of the Heat Loss Coefficient of Residential Buildings Based on In-Use Monitoring Data. PhD thesis, KU Leuven, 2019.

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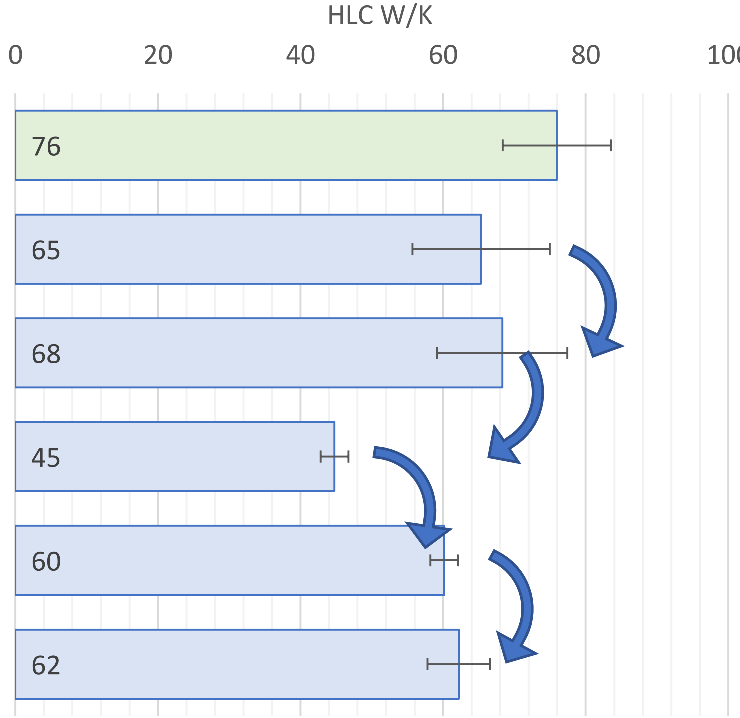
HEAT LOSS COEFFICIENT CHARACTERIZATION

Case example: results of the identified HLC

Theoretical value

1. $Q_{total} = -HLC * T_e + Int$
2. $Q_h = -HLC * T_e + Int$
3. $Q_h = HLC * (T_i - T_e)$
4. $Q_h + Q_{int} = HLC * (T_i - T_e)$
5. $Q_h + Q_{int} = HLC * (T_i - T_e) - gA * I_{sol}$



Conclusions

- Included parameters & model result in range of results
- Importance of energy breakdown for space heating
- Adding indoor temperature to the model improves reliability
- Internal gains have a significant impact & should be included as well
- Limited added value of adding solar gains to the model

Conclusion

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Smart & performance data-driven building energy performance assessment

- Methodology for energy decomposition
- Two methods to define the energy performance from on-board-monitoring data
    1. Correction by means of elaborated version of MEPI tool
    2. Heat loss coefficient characterization

Next steps within ePANACEA

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- **Demonstration & validation** of the developed methods with regard to their reliability, accuracy, user-friendliness and cost-effectiveness through **15 case studies** in 5 European countries (Austria, Belgium, Finland, Greece and Spain)
- **Implementation** of the methods in the Smart Energy Performance Assessment Platform (SEPAP)
- Development of a **decision matrix** in order to provide guidance or recommendation on the most suitable method to use with a reasonable accuracy and uncertainty levels

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Thank you for your attention

For further information, please contact evi.lambie@vito.be

or visit www.epanacea.eu

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