D2EPC

Building performance assessment towards Next generation EPCs

AALBORG UNIVERSITY

E-DYCE

A methodology to estimate space heating and domestic hot water energy demand in buildings from low-resolution heat meter data

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Session 3: Advancements in buildings sustainability assessment

Agenda

- Contact info
- Problem formulation and objectives
- Methodology
- Results
- Main conclusions
- Further work
- Current publication status

Contact info

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PhD fellow at Aalborg University – *"Development and application of data-driven methodologies for the district heating sector"*

Projects:

- E-DYCE (https://edyce.eu/)
- PRELUDE (https://prelude-project.eu/)

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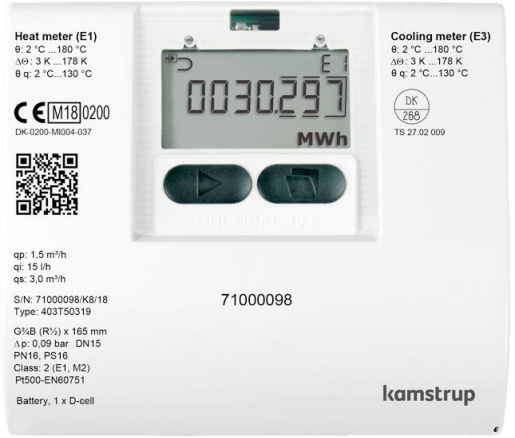
Problem formulation and objectives

Problem formulation:

- The smart energy meters **only measure the total energy usage** (space heating and DHW)
- By having only minimum information, is it possible to separate the energy demanded for the space heating and the DHW in buildings?

Objectives:

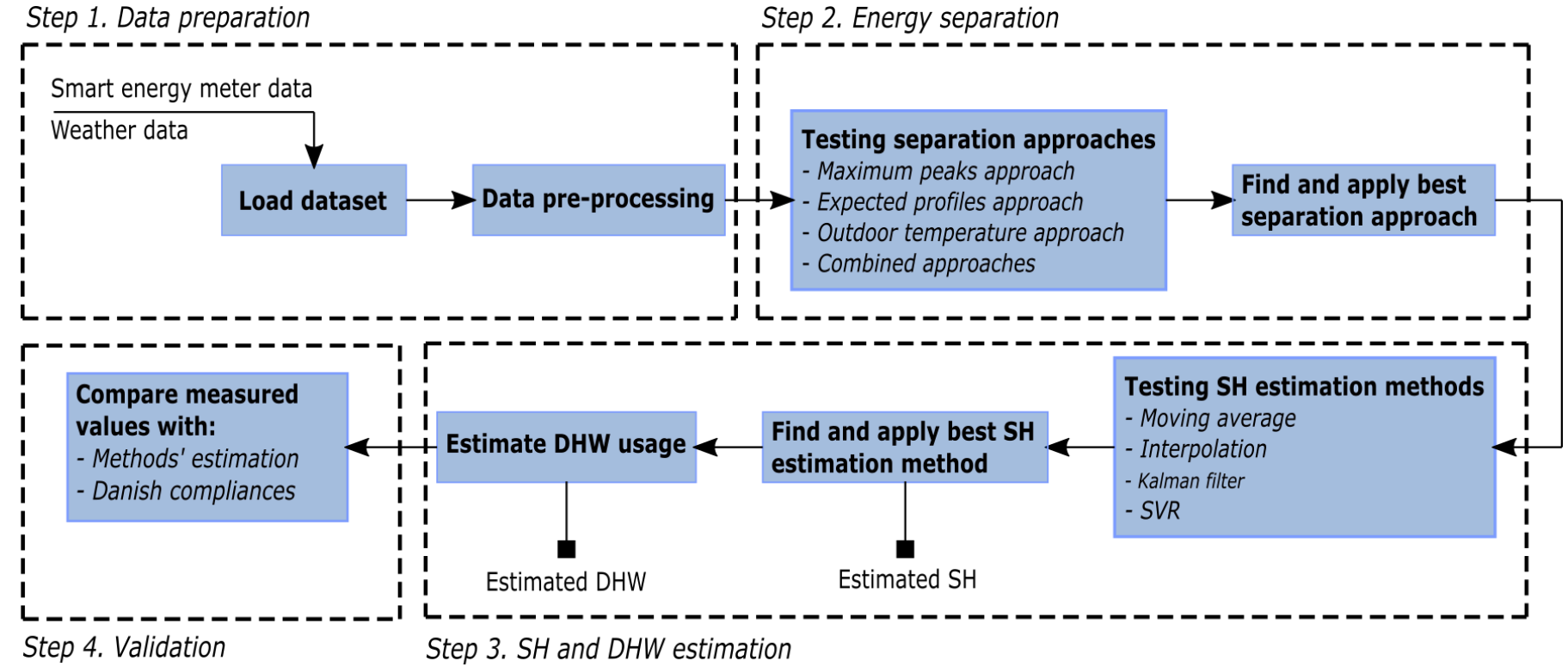
- Separate both energy components – Space heating and DHW
- Using hourly measurements
- Having minimum information (total energy and weather data)
- Residential buildings (scopus of this research)



Smart heating meter (https://www.kamstrup.com/en-en/submetering-solutions/property-management/heat-meters)

Methodology

Introduction

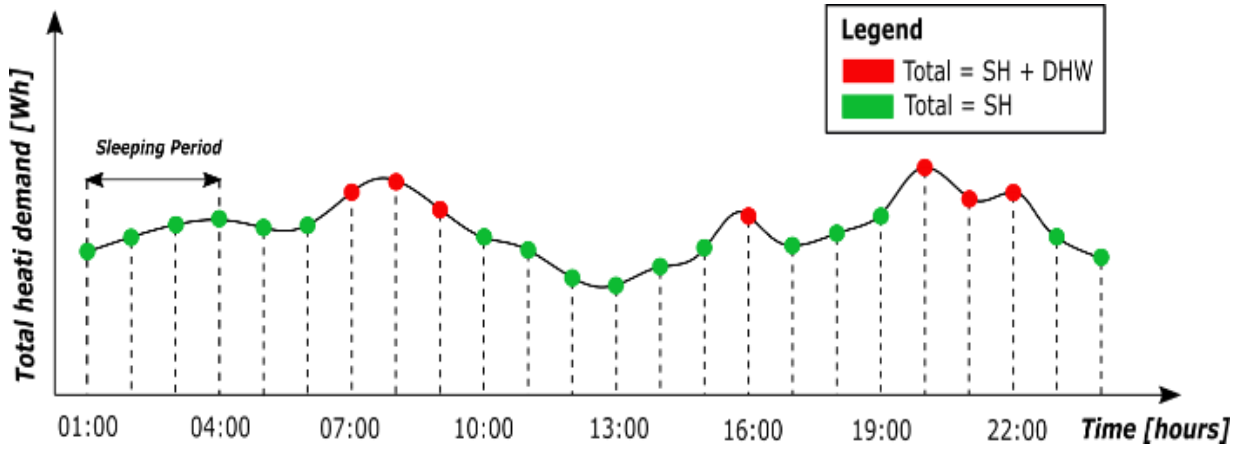


Leiria et al. (under review – 2022) 'A methodology to estimate space heating and domestic hot water energy demand profile in residential buildings from low-resolution heat meter data', *Energy*.

Methodology

Energy separation (Step 2)

- Hourly measurements – 24 hours (points) per day
- From 24 data points, only few are concerning DHW usage
- The other points are considered space heating data
- This step identifies these few DHW points



Leiria et al. (Accepted – 2022) 'Validation of a new method to estimate energy use for space heating and hot water production from low-resolution heat meter data', *BSN2022*.

Methodology

SH and DHW estimation (Step 3)

Several methods were tested

The best was:

- Gaps ≤ 2 hours → Kalman smoothing estimator

  Variables:

  ❑ E_{Total} (All time-series)

- Gaps > 2 hours → Support vector regressor (SVR)

  Variables:

  ❑ Outdoor temperature (i-1)

  ❑ Global radiation (i-1)

  ❑ E_{Total} (i-1, i+1)

Results

Validation (Step 4)

Used datasets:

- 28 Apartments in **Denmark** (Decimal and rounded measurements)
- 1 Apartment block in **Switzerland** (Aggregated users measurements)
- 1 Theater in **Italy**
- 1 Reabilitation institution in **Italy**

- **Comparison** with DHW compliances

$$E_{DHW}^{DK} = \frac{1}{3600} \cdot 0.25A \cdot \rho_w c_{p,w} \cdot (T_{DHW} - T_c)$$

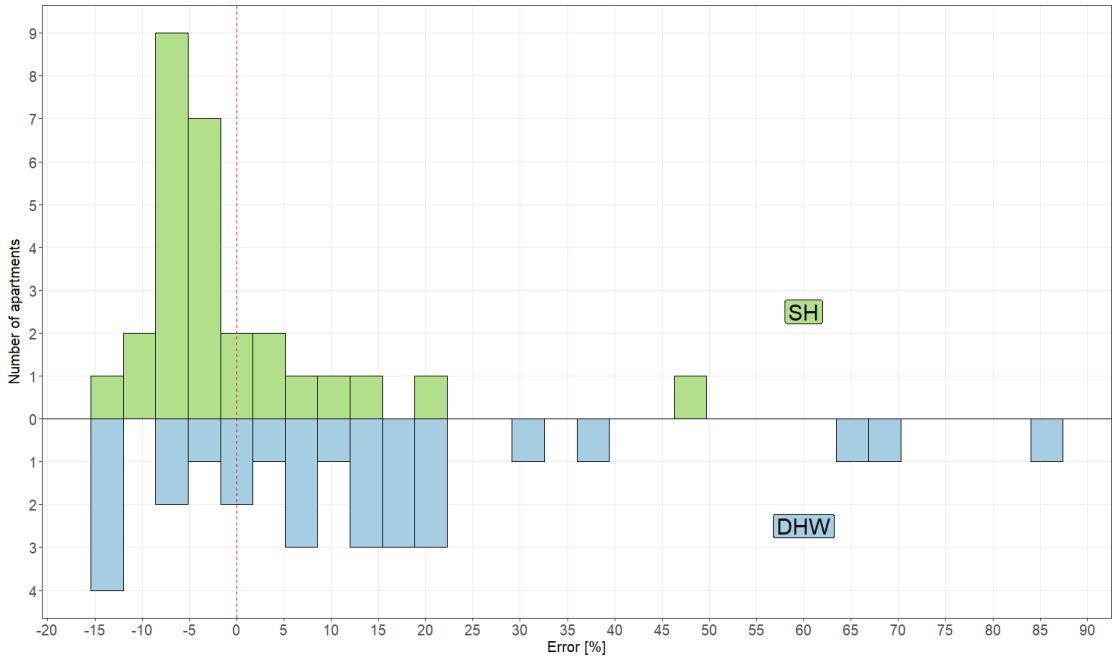
$$E_{DHW}^{CH} = \frac{365}{3600} \cdot \frac{0.035}{30} A \cdot n \cdot \rho_w c_{p,w} \cdot (T_{DHW} - T_c)$$

$$E_{DHW}^{ITLY} = \frac{G}{3600} \cdot 10^{-3} V_w \cdot n \cdot \rho_w c_{p,w} \cdot (T_{DHW} - T_c)$$

Results

Method's accuracy – Decimal data

Apartment ID	Country	DHW measured [kWh/h]	DHW compliances [kWh/h]	DHW estimated [kWh/h]	Error between Measured and Compliances	Error between Measured and Estimated
666	Denmark	0.314	0.167	0.315	-47%	0%
668	Denmark	0.286	0.165	0.346	-42%	21%
669	Denmark	0.184	0.164	0.224	-11%	22%
670	Denmark	0.588	0.165	0.555	-72%	-6%
671	Denmark	0.247	0.164	0.295	-34%	20%
697	Denmark	0.692	0.165	0.606	-76%	-12%
698	Denmark	0.674	0.165	0.627	-75%	-7%
699	Denmark	0.678	0.164	0.588	-76%	-13%
700	Denmark	0.074	0.165	0.137	123%	85%
701	Denmark	0.167	0.165	0.196	-1%	18%
702	Denmark	0.088	0.164	0.115	87%	32%
724	Denmark	0.229	0.164	0.255	-28%	11%
726	Denmark	0.116	0.165	0.132	43%	14%
727	Denmark	0.103	0.165	0.121	61%	18%
728	Denmark	0.148	0.164	0.203	11%	37%
729	Denmark	0.144	0.164	0.161	14%	12%
730	Denmark	0.388	0.165	0.406	-57%	5%
731	Denmark	0.087	0.165	0.142	90%	63%
732	Denmark	0.406	0.164	0.347	-60%	-15%
734	Denmark	0.091	0.145	0.106	59%	17%
735	Denmark	0.328	0.165	0.347	-50%	6%
736	Denmark	0.336	0.165	0.34	-51%	1%
739	Denmark	0.524	0.165	0.561	-68%	7%
740	Denmark	0.164	0.165	0.159	1%	-3%
741	Denmark	0.237	0.165	0.253	-30%	7%
742	Denmark	0.145	0.145	0.167	-1%	15%
743	Denmark	0.461	0.165	0.403	-64%	-13%
745	Denmark	0.093	0.165	0.157	78%	69%

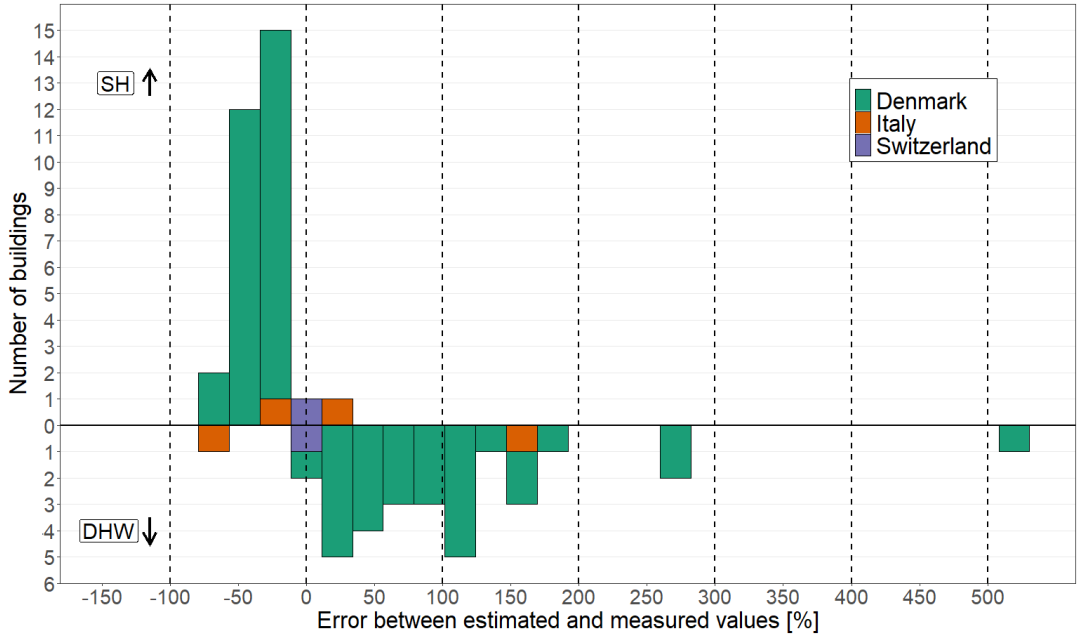


Leiria et al. (Submitted – 2022) 'A methodology to estimate space heating and domestic hot water energy demand profile in residential buildings from low-resolution heat meter data', *Energy*.

Results

Method's accuracy – Rounded data

Case building	Country	Error between Measurements and Compliances	Error between Measurements and Estimation
Apart. 666	Denmark	-47%	97%
Apart. 668	Denmark	-42%	103%
Apart. 669	Denmark	-11%	102%
Apart. 670	Denmark	-72%	21%
Apart. 671	Denmark	-34%	108%
Apart. 697	Denmark	-76%	12%
Apart. 698	Denmark	-75%	21%
Apart. 699	Denmark	-76%	10%
Apart. 700	Denmark	123%	510%
Apart. 701	Denmark	-1%	93%
Apart. 702	Denmark	87%	182%
Apart. 724	Denmark	-28%	89%
Apart. 726	Denmark	43%	70%
Apart. 727	Denmark	61%	149%
Apart. 728	Denmark	11%	152%
Apart. 729	Denmark	14%	119%
Apart. 730	Denmark	-57%	43%
Apart. 731	Denmark	90%	273%
Apart. 732	Denmark	-60%	24%
Apart. 734	Denmark	59%	144%
Apart. 735	Denmark	-50%	44%
Apart. 736	Denmark	-51%	40%
Apart. 739	Denmark	-68%	34%
Apart. 740	Denmark	1%	75%
Apart. 741	Denmark	-30%	59%
Apart. 742	Denmark	0%	121%
Apart. 743	Denmark	-64%	29%
Apart. 745	Denmark	78%	265%
Apart. block	Switzerland	4%	-9%
Rehab inst.	Italy	-59%	-79%
Theater	Italy	-35%	154%



Leiria et al. (Accepted – 2022) 'Validation of a new method to estimate energy use for space heating and hot water production from low-resolution heat meter data', *BSN2022*.

Further work

- **Improving this methodology for rounded measurements and commercial cases** is highly needed
- **Applying the methodology in other datasets from other countries or other heating appliances** to ensure the its robustness and applicability in different cases
- **Benchmark this novel methodology with other existing disaggregation methods on a common dataset**
- Additionally, a more extensive endeavor must be made **to collect good quality datasets and share them with our research peers**

Current publications status

Open access

- Treatment and analysis of smart energy meter data from a cluster of buildings connected to district heating: A Danish case
  - Johra et al. (https://doi.org/10.1051/e3sconf/202017212004)
- Using data from smart energy meters to gain knowledge about households connected to the district heating network: A Danish case
  - Leiria et al. (https://doi.org/10.1016/j.segy.2021.100035)
- **A methodology to estimate space heating and domestic hot water energy demand profile in residential buildings from low-resolution heat meter data**
  - Leiria et al. (*Energy* journal: Submitted – Under review)
- **Validation of a new method to estimate energy use for space heating and hot water production from low-resolution heat meter data**
  - Leiria et al. (*BuildSim Nordic 2022* conference: Accepted – August 2022)

Thank you for your attention