LARGE SCALE SMART METER DATA ASSESSMENT FOR ENERGY BENCHMARKING AND OCCUPANT BEHAVIOUR PROFILE DEVELOPMENT

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Content

- Smart meter technology
- Smart meters in Hungary
- Methods
  - Smart meter datasets
  - Qualitative information
  - Time series analysis
  - Questionnaires and interviews
- Preliminary results

Introduction

- Building energy performance modelling:
  - Asset method: standard user behaviour
  - Operational method: only valid under specific circumstances
- Information on real occupants' behavior is scarce
- Smart metering (SM) technology offers new perspectives
- 700 million SM installed worldwide (2016)
- Smart meters promoted by new EPBD and other EU legislation: 80% customer penetration goal by 2020
- 72% of EU consumers expected to have smart electricity meters and 40% smart gas meters by 2020 (acc to cost-benefit analysis)

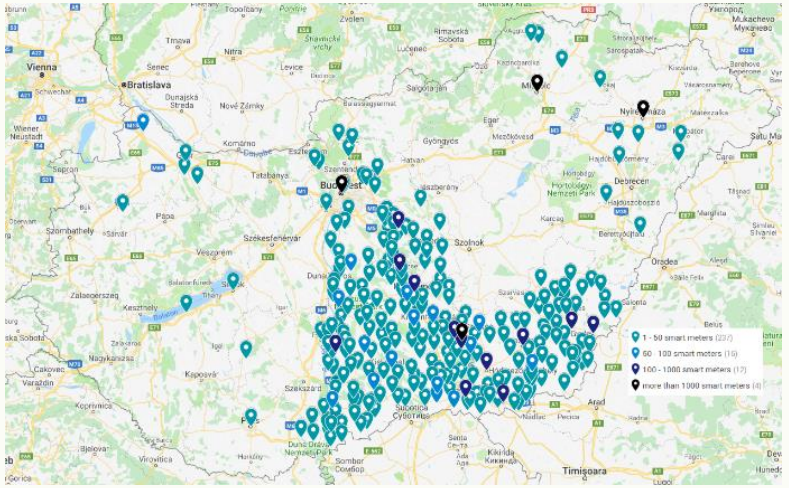
Smart meters in Hungary

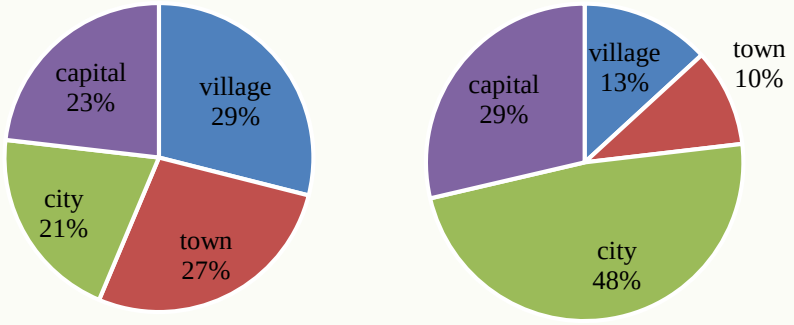
- Central Smart Grid Pilot Project (KOM):
  - To assess the possibilities of a national smart monitoring system
  - 139 901 smart meters installed in 2016-2017
  - Residential, public, commercial and industrial buildings

- Large Scale Smart Meter Data Assessment for Energy Benchmarking and Occupant Behavior Profile Development of Building Clusters (2018-2021)
  - New research project to analyse the data
  - More precise picture on the real energy consumption of the stock
  - Comparative analysis btw measured and modelled data
  - Establish user profiles and patterns

Methods – Smart meter datasets

- Residential buildings: 33761 smart meters for gas, electricity, heat and water consumption, 2016-2018
- Sampling time: 15 min/ hourly
- Smart meter dataset categorization:
  - geographical diversification,
  - type of settlement,
  - meter type / measured consumption





Distribution of residential buildings in Hungary and the installed smart meters by settlement type

Methods – Statistical Significance and Representative Sample

- Statistical significance is important to formulate statements on the Hungarian building stock
- Population groups determined:
  - size of settlement and geographic regions
  - necessary sample size was calculated, sampling error 3%, confidence level 95%
- Representativity ensured by preserving the ratios of population groups (e.g. in Hungary 26% of apartments located in cities)

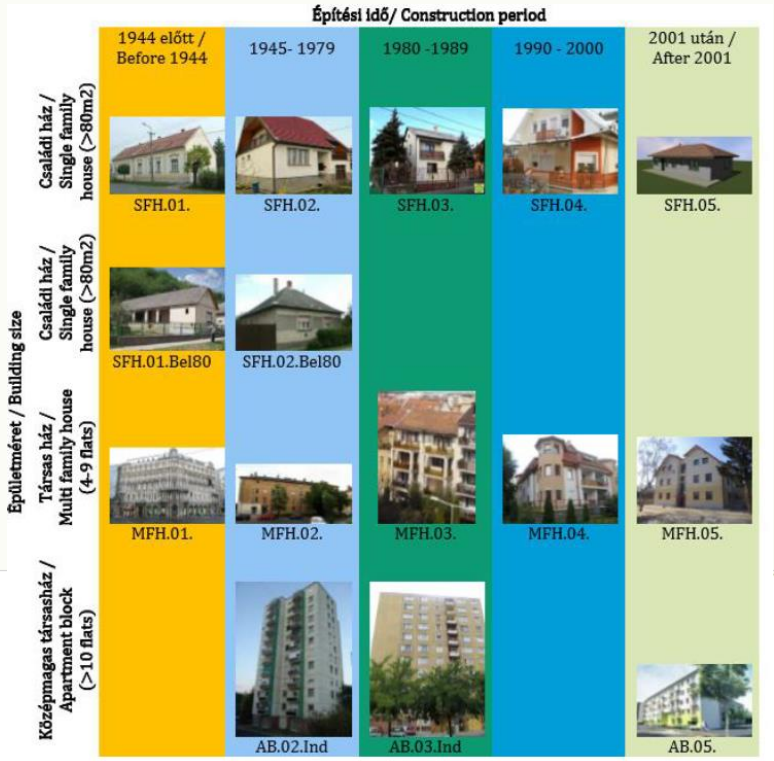
Size of town	Nr. of apartments	Geographical region	Nr. of apartments
Villages and towns	1 227 110 (23%)	Southern Great Plain	602 819 (11%)
Cities	1 370 964 (26%)	Southern Transdanubia	409 265 (8%)
County-seat cities	925 730 (17%)	Northern Great Plain	624 091 (12%)
Capital	1 832 310 (34%)	Northern Hungary	509 790 (10%)
		Central Hungary	2 318 556 (43%)
		Western Transdanubia	435 697 (8%)
		Central Transdanubia	455 896 (9%)

$$Ns = \frac{(Np)(p)(1-p)}{(Np-1)\left(\frac{B}{C}\right)2+(p)(1-p)}$$

Methods – Qualitative Information Assigned to Smart Meter Data Points

- Only address of the buildings is available
- Additional qualitative data is needed about the buildings
- Manual approach based on GIS mapping tool was chosen: compromise btw accuracy and time spent
- Parameters: building function, type, area, number of stories, condition of building, visible retrofit measures, type of roof, presence of solar panels/ collectors
- Subcategorization based on building archetypes
- Problems: streetview images not available in some villages (available for 42% of the sample), identification of building sometimes difficult, blocked by external obstacles

Building typology in Hungary



Methods – Time series analysis

- Analysis of natural gas consumption and electricity
- Data filtering to discard unusable and false datasets
  - Manual analysis of some series to identify typical errors
  - Development of algorithms to automatically categorise the time series
  - Manual investigation kept to a minimum

Methods – Questionnaires and Interviews

- Socio-demographic data will be collected
- Independent variables from four models commonly used to determine social-psychological determinants of energy efficient technology acceptance were selected for surveys
- Three rounds of data collection:
  - Public buildings without SM
  - Public smart buildings
  - Households with SM

Model	Variables
Theory of Planned Behavior	**Attitude** towards the technology
Technology Acceptance Model	**Perceived usefulness** **Perceived ease of use**
Norm Activation Model	**Personal norms (**moral obligations)
Sustainable Energy Technology Acceptance (SETA)	**Trust in technology providers** **Knowledge** **Perceived risk to privacy** **Problem perception** (awareness of consequences)

+ dependent demographic variables (age, gender, occupation, education level, perceived material status and building characteristics and retrofit)

+ support for SM technology, etc.

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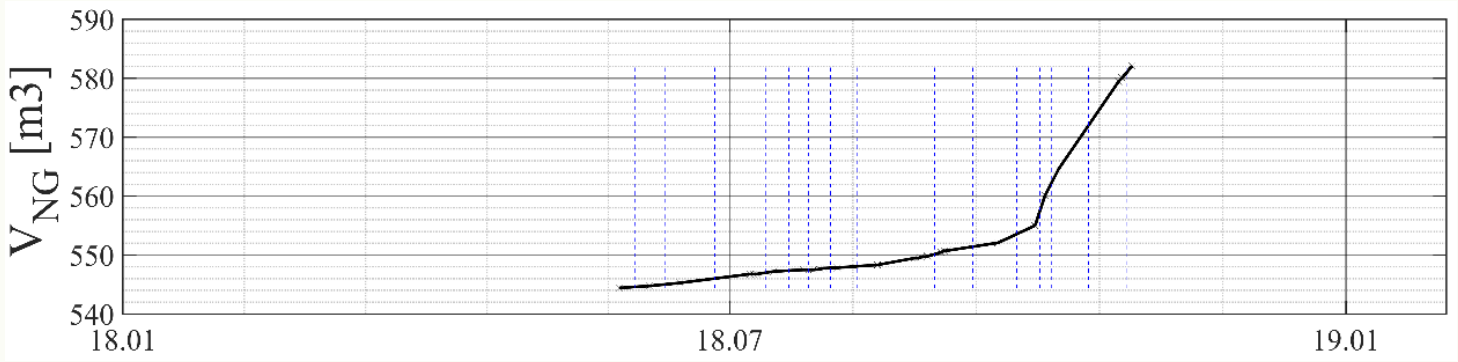
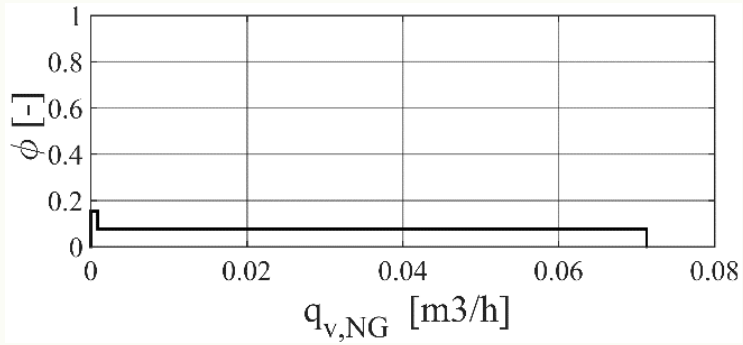
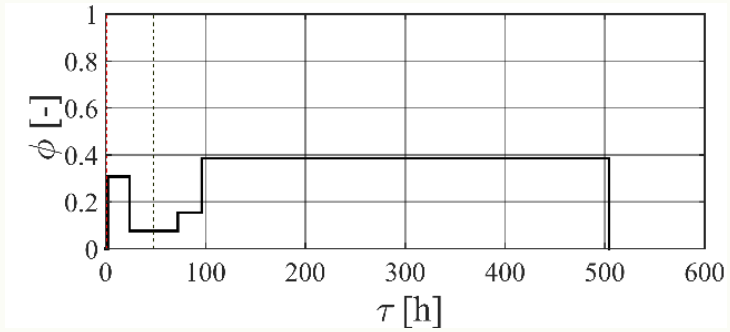
Preliminary results – data quality check



Time series – incremental gas volume flown through the meter



Histogram of the mean flow rate btw two adjacent samplings

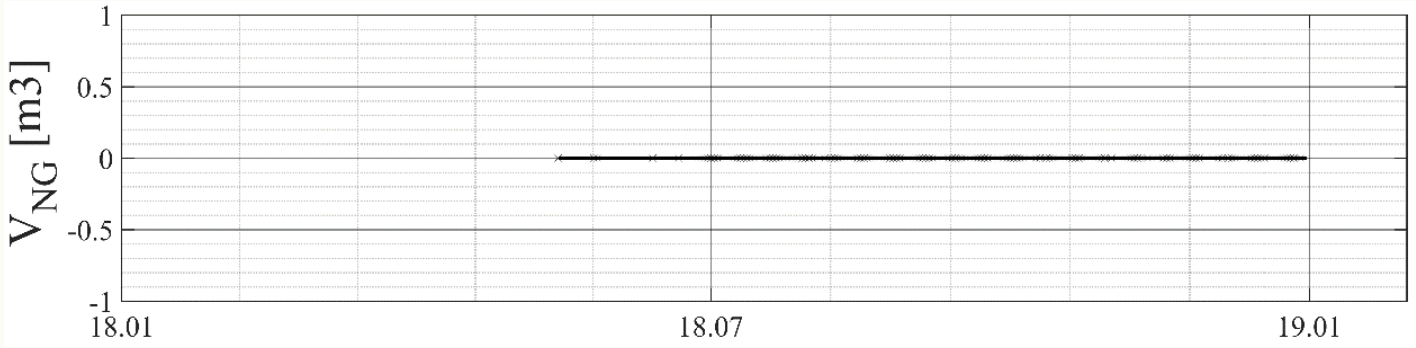


Histogram of the sampling time

Three common error types found – will be the basis of automatic data filtering

Type A error: the sampling time is longer than a user defined value in one or more points.

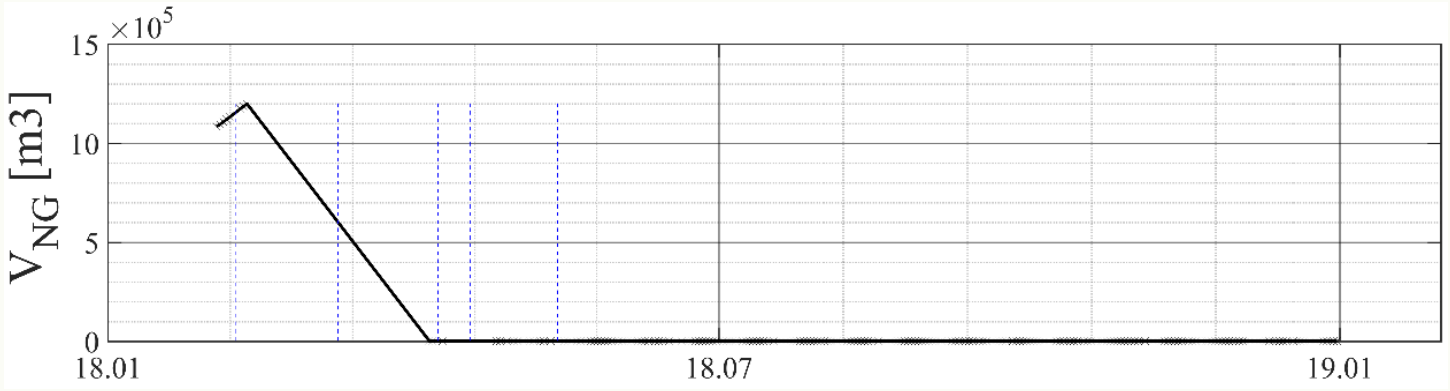
Preliminary results – data quality check



Time series – incremental gas volume flown through the meter

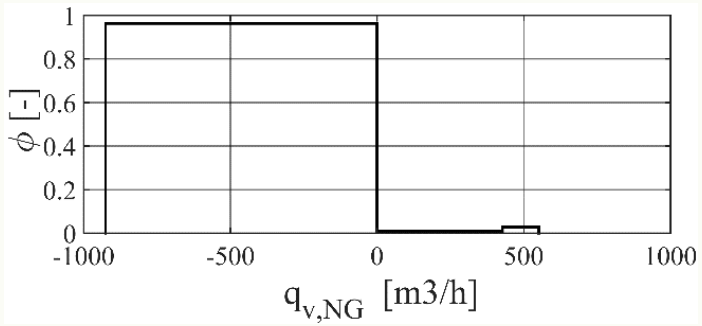
Type B error: no usable data is available (the meter did not record any data, or the change in the data is almost zero – probably the building was not used)

Preliminary results – data quality check



Time series – incremental gas volume flown through the meter

Type C error: small or large breaks in the time series



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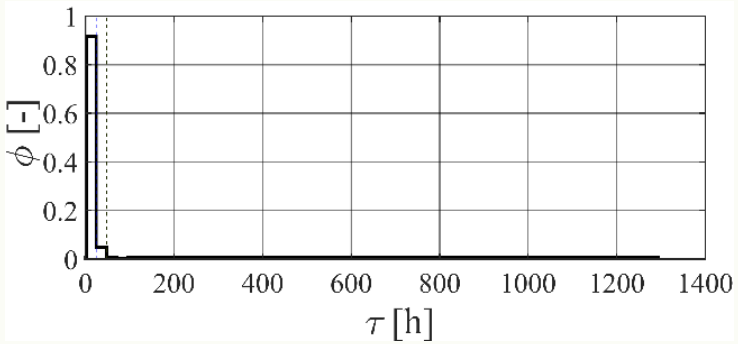
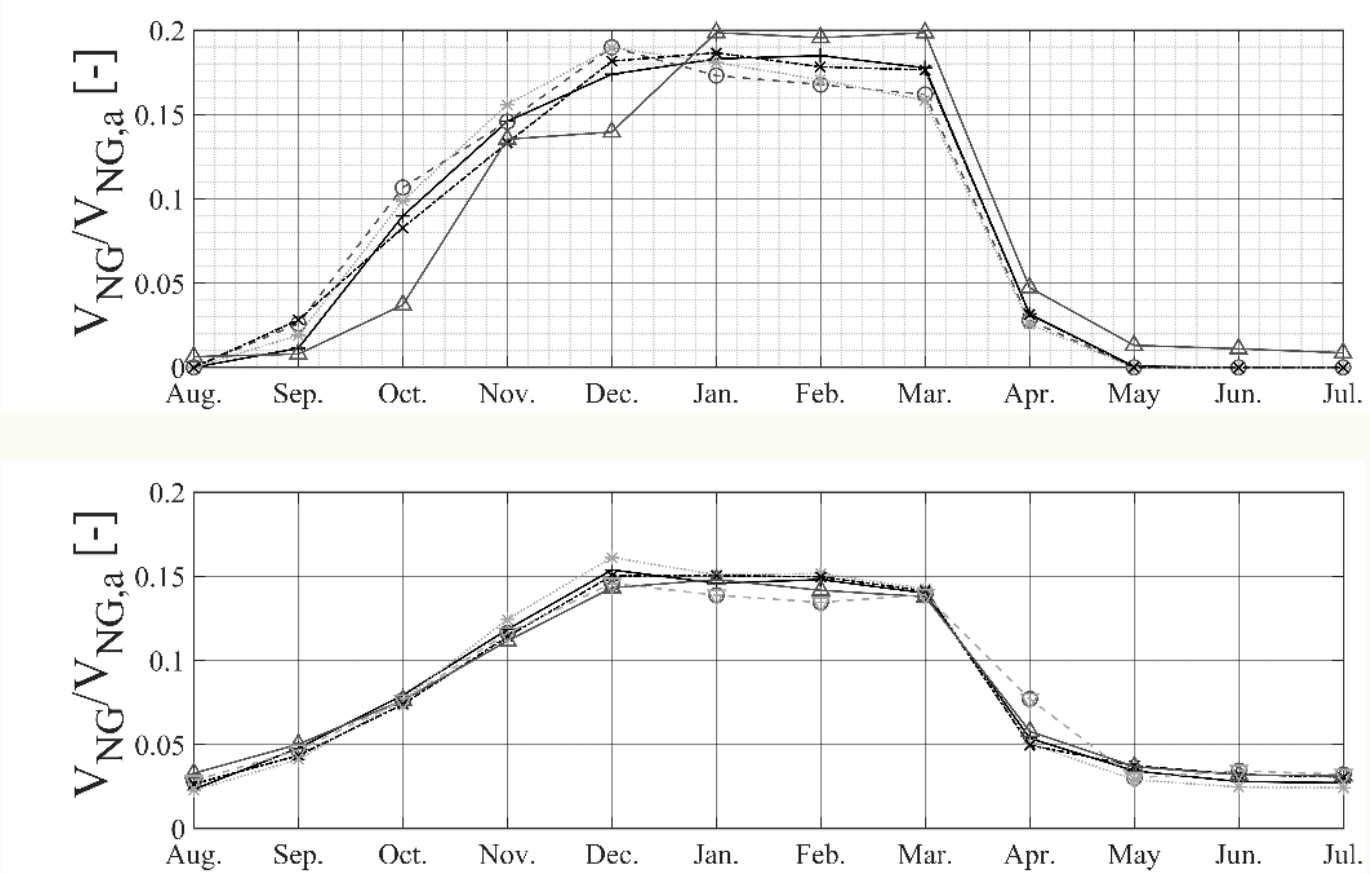


Histogram of the sampling time

Type A and C errors can be corrected in some cases

Preliminary results – natural gas



Monthly natural gas consumption in 11 locations:

- Locations where DHW and cooking probably by electricity
- Locations where DHW and cooking natural gas based

Conclusions and future plans

- Representative results can be achieved for settlement categories and building types but not for geographical distribution
- GDPR makes it challenging to collect qualitative supplementary data for residential buildings
- Data analysis will continue for gas and electricity use, user profiles will be developed
- Public buildings will be analysed in more detail
- Socio-psychological research with questionnaires and interviews will be conducted
- Dynamic building simulation of buildings will be performed

Thank you for your attention!

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Acknowledgments

Results and the determined trends are being fine-tuned and extended for other building types with a geographic scope of Hungary in another research project entitled “Large Scale Smart Meter Data Assessment for Energy Benchmarking and Occupant Behavior Profile Development of Building Clusters“. Furthermore, methods and approaches developed in the current work are being further developed for large scale data analysis. The project (no. K 128199) has been implemented with the support provided from the National Research, Development and Innovation Fund of Hungary, financed under the K_18 funding scheme.

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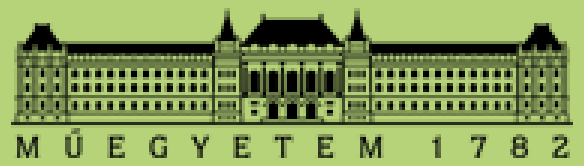

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