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Year Report 2018

GAPxPLORE: ENERGY PERFORMANCE GAP IN EXISTING, NEW, AND RENOVATED BUILDINGS

LEARNING FROM LARGE-SCALE DATASETS

Scuola universitaria professionale
della Svizzera italiana

SUPSI

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Authors:
Stefano Cozza (UNIGE), Stefano.cozza@unige.ch
Dr. Jonathan Chambers (UNIGE), Jonathan.chambers@unige.ch
Carlo Gambato (SUPSI), carlo.gambato@supsi.ch
Laura Arnold (Solar Agentur), info@solaragentur.ch
Prof. Dr. Martin K. Patel (UNIGE), Martin.Patel@unige.ch

SFOE head of domain: Andreas Eckmanns

SFOE head of program: Rolf Moser moser@enerconom.ch

SFOE contract number: SI/501518-01

Office fédéral de l'énergie OFEN

Mühlestrasse 4, 3063 Ittigen, Adresse postale : 3003 Berne

Tél. +41 58 462 56 11 · fax +41 58 463 25 00 · contact@bfe.admin.ch · www.ofen.admin.ch

Objective

The GAPxPLORE project addresses the Energy Performance Gap (EPG), defined as the difference between measured and calculated energy consumption. Previous research has highlighted the importance of the EPG for the attainability of the Energy Strategy 2050 objectives, given that only part of the predicted energy savings in buildings is typically realized. This project aims to calculate the size of the EPG in new and renovated buildings in Switzerland using large datasets.

Summary

GAPxPLORE aims to explore large building datasets to offer statistically significant analysis of Swiss buildings, providing valuable guidance for policy makers.

A review of existing research in the EPG has shown that there is a number of different definitions for calculating the EPG, and a large range of values reported. This project used a definition of the EPG that is related to the building Energy Performance Certificate delivered by the Cantonal Energy Certificate for Buildings (CECB), which provides both a calculation of theoretical consumption according to the norms and real consumption from energy bills.

Focusing on thermal energy consumption (heating and hot water), we found that Swiss dwellings use on average less energy than expected. Buildings with low energy performance labels (E and lower) tend to consume less than expected, while buildings with higher labels tend to consume slightly more than expected. Nevertheless, we found that buildings with high performance labels were still much more efficient than those with low performance labels, even if though they did not perform as well as predicted.

Further work on retrofitted buildings found that buildings which reach a high-performance label through energy retrofit perform better in terms of actual energy consumption than buildings which have been built directly to reach the same energy label (CECB sample). From the perspective of a building owner considering an energy retrofit, a reasonably realistic assessment of their real energy savings can be achieved by comparing their actual current consumption with the predicted energy demand defined using theoretical calculations from the assessment norms. On the other hand, energy savings calculated as the difference between theoretical demand before retrofit and after retrofit were much larger than that actually achieved.

Work carried out and results achieved

1.1 Task 1 - Literature study (UNIGE)

University of Geneva (UNIGE) prepared an extensive literature review, which will be included in the final report as well as aiming to be adapted into a journal article for submission. The key findings of this literature review included:

- There are a range of methods of defining the Energy Performance Gap, which can be broadly classed as “Regulatory” (comparison of real consumption against national norms), “Static” (comparison against simplified building models created with real on-site building data) and “Dynamic” (comparison against detailed building physics simulations). This study is main concerned with the Regulatory performance gap.
- A very large range of values for the EPG has been observed, with two general trends:
    - The EPG tends to decrease as one moves from the Regulatory to Static and then to the Dynamic performance gap.

   - Buildings with poor energy performance labels tend to consume less than predicted by standardised assessment calculations, while buildings with high performance labels tend to consume more than predicted. Nevertheless, because of the very large improvement in energy efficiency between low labels and high labels, highly performant buildings still consume significantly less than low performance ones despite not reaching their theoretical performance levels.
- The causes of the performance gap are not well understood, with a very large number of factors being possible causes and no clear evidence showing conclusively the importance of one particular cause. Nevertheless, with regards to the Regulatory EPG it is clear that theoretical demands calculated using standardised methods and using standardised inputs (e.g. for weather and occupancy) *cannot* be expected to predict well the consumption under real conditions.
- In Switzerland, there is a very great diversity of cantonal energy policies. In addition, these are also changing over time as various reforms to the policies are undertaken. The MoPEC aims for a greater convergence of policies, this may or may not be achieved. The evolution of future policy can be expected to be reflected in the CECB database.

1.2 Task 2 - Energy Performance Gap (EPG) in the existing building stock (UNIGE - FHNW)

1.2.1 Evaluation of data quality

The CECB data was used for the analyses (SIA, 2016). FHNW supported the GAPxPLORE team at UNIGE by providing insight into the organisation and content of the data. This enabled the UNIGE team to understand the structure and possible scope of the collected and stored data. This also includes the outputs of the CECB tool and - to a certain extent - the handling and navigation within the CECB tool itself. The final extracts from the CECB database were received, processed and analysed in early 2018. The following key information was retrieved from the extract of data:

- Number of buildings: 45,000 buildings in the CECB dataset.
- Building types: 42,000 dwellings and 3000 administration and schools.
- Energy data: Both for Calculated and Actual energy consumption. Yearly time step. Actual Energy consumption given as average of 3 years.

Data based on current agreements the CECB data needs to remain in anonymized form. The GAPxPLORE team proposed an NDA to the CECB Association which was accepted in March 2018, hence allowing to match the CECB data by building with other datasets (Minergie and SolarAgentur).

The CECB data reports the energy efficiency of the building envelope and the energy requirements if the building is used in compliance with the standards. The calculated performance is divided into classes A to G (very efficient to very inefficient) by means of an energy label.

This database was found to be suitable to study the EPG as for each building both the theoretical and the actual energy consumption is provided.

The theoretical consumption represents the energy use of the building under the standard conditions of occupation and weather (SIA 2028). This standard defines the energy indices for primary energy, final energy and GHG emissions, according to the European ISO 50001 standard. The heat balance calculations follow SIA 380/1, based on the static monthly balance indicated in the European SN EN 13790.

The methodology to measure the actual energy consumption is also codified in the norms and described in the SIA 2031. Actual energy use is determined as average of the measurements taken over three consecutive years. These data are usually obtained from energy invoices for the different energy carriers used in the building: fuel for the heating system and electricity for lighting, ventilation system, and appliances.

An important advantage of using this dataset is the number of buildings and its geographical coverage of Switzerland as a whole. After filtering out certificates that did not contain the full required information (notably the real consumption from bills) and further cleaning the input data of errors and outliers, 34136 buildings were retained out of the initial 55 000 buildings provided. It was therefore important to establish that the resulting sample was representative of the Swiss buildings stock. The official buildings register database from the Swiss Federal Statics Office (FSO, 2017) was used as a point of comparison in order to check the representativeness of the CECB sample. Despite slight difference in representation between cantons, mostly due to differences in regulations, the CECB dataset used for this study is representative for the Swiss residential building stock.

1.2.2 EPG analysis task

This task addresses the EPG, defined as the difference between theoretical and actual energy consumption for thermal use (Space Heating + Domestic Hot Water), in the Swiss building stock. The analyses revealed the existence of an EPG in the Swiss buildings. When considering the complete CECB sample, the median EPG for a building was -5% (i.e. the median building performs slightly better than expected). The overall difference between the total theoretical final consumption (2.95 TWh/year) and the actual energy use (2.77 TWh/year) was -0.18 TWh/year, corresponding to a slightly larger -6% difference when accounting for the interaction between the change in EPG as a function of label and the different relative building ERAs for each label.

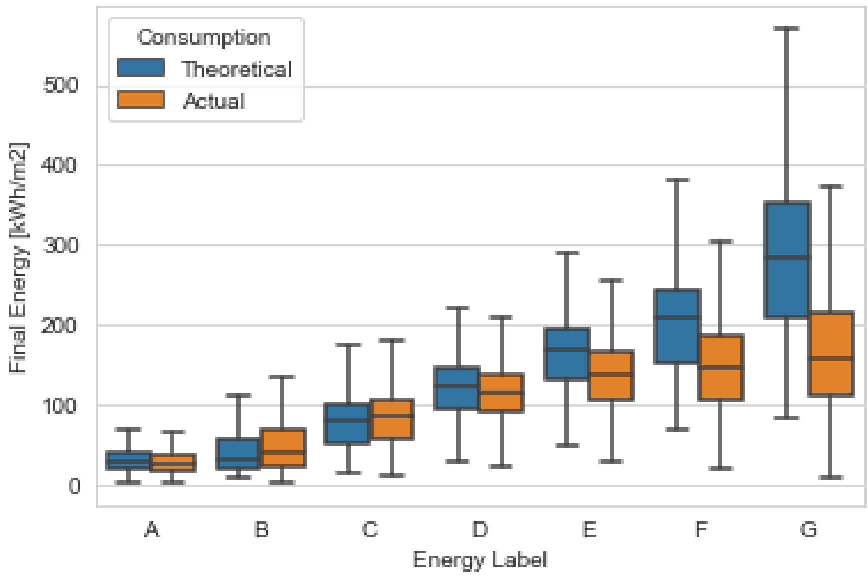

Figure 1: Theoretical and Actual yearly consumption as a function of energy label.

Figure 1 shows that buildings with low thermal performance (D, E, F, and G) tend to consume less than predicted. Vice versa, buildings with high thermal performance (B, and C) consume marginally more than predicted. This result supports previous finding in the literature (Delghust, Roelens, Tanghe, De Weerdt, & Janssens, 2015; Majcen, Itard, & Visscher, 2013; Merzkirch, Hoos, Maas, Scholzen, & Waldmann, 2014; Ramallo-González, 2013; Raynaud, 2014; Sharpe & Shearer, 2013). This is further illustrated in Figure 2 which expresses the difference between theoretical and actual consumption in terms of EPG [%]. The EPG shifts from a negative value to a positive one with as the energy label improves (with the exception of label A, see below). That is to say, the buildings go from consuming less than expected (negative EPG) to consuming more than expected (positive EPG). It is also important to note that there is a large spread between the minimum and maximum values for every label.

The trend for A-label is less clear. Although many buildings showed a positive EPG the median was negative, which could support the theory that the most efficient buildings are more robust to the EPG. However, the results concerning the A-label buildings should be treated with caution, as these buildings were poorly represented in the sample. Further analysis of this category of buildings will be the main focus of Task 4.

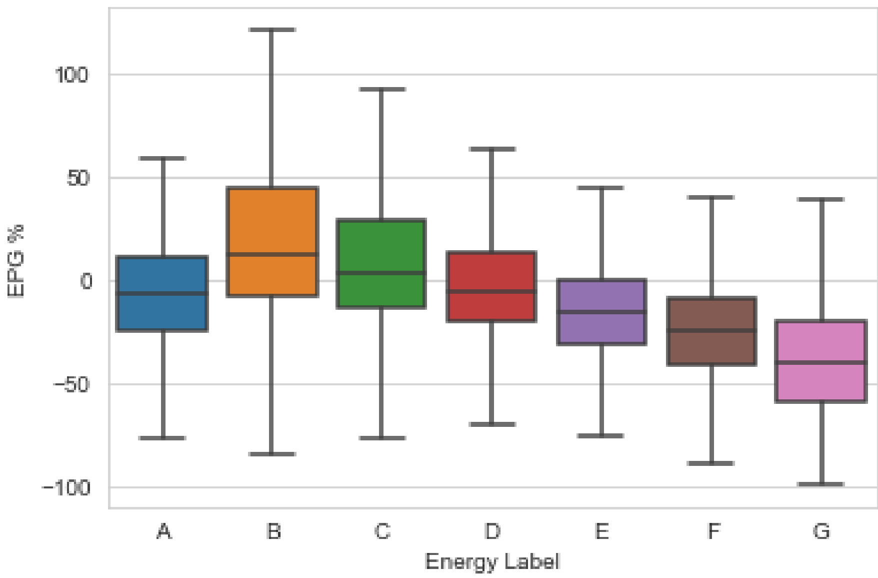

Figure 2: Distribution of Energy Performance Gap as a function of energy label.

1.2.3 Highlights of Task 2

- The actual energy consumption for thermal use in Swiss dwellings is lower than the predicted.
- Buildings with poor thermal performance consume less than expected, with a median EPG of -40% for G label buildings.
- A wide range of final energy demand [kWh/(m^{2}y)] was observed among buildings with identical energy label.
- If building stock energy savings are estimated using theoretical consumption instead of actual consumption, energy reduction targets for 2050 will not be met in reality.

1.3 Task 3 - Savings Performance Gap in buildings with energy retrofit, subset of CECB data (UNIGE)

Initial analysis has been completed for this task to produce the key figures, which are presented below.

We calculate several indexes to better investigate the Energy Savings Deficit (ESD) that is generally defined as the shortfall in savings, after an energy retrofit, as a proportion of the expected savings (Druckman, Chitnis, Sorrell, & Jackson, 2011; Galvin, 2014; Haas & Biermayr, 2000):

$$ESD\ [\%] = \frac{Calculated\ savings - Actual\ savings}{Calculated\ savings} \qquad \text{(eq. 1)}$$

The two terms, "Calculated savings" and "Actual savings" can be defined in different ways, resulting in different definitions for the savings and for the ESD ("before" and "after" always refer to the point in time before and after the energy retrofit):

$$\text{Theoretical savings} \left[\frac{\text{kWh}}{\text{m2}}\right] = \text{Theoretical consumption before} - \text{Theoretical consumption after} \qquad \text{(eq. 2)}$$

$$\text{Theoretical savings } [\%] = \frac{\text{Theoretical consumption before} - \text{Theoretical consumption after}}{\text{Theoretical consumption before}} \qquad \text{(eq. 3)}$$

$$\text{Anticipated savings} \left[\frac{\text{kWh}}{\text{m2}}\right] = \text{Actual consumption before} - \text{Theoretical consumption after} \qquad \text{(eq. 4)}$$

$$\text{Anticipated savings } [\%] = \frac{\text{Actual consumption before} - \text{Theoretical consumption after}}{\text{Actual consumption before}} \qquad \text{(eq. 5)}$$

$$\text{Actual savings } [\text{kWh/m2}] = \text{Actual consumption before} - \text{Actual consumption after} \qquad \text{(eq. 6)}$$

$$\text{Actual savings } [\%] = \frac{\text{Actual consumption before} - \text{Actual consumption after}}{\text{Actual consumption before}} \qquad \text{(eq. 7)}$$

In these equations the consumption is always intended as final energy consumption for thermal use (SH + DHW). Using the definition of ESD (eq.1) we calculated two variants of ESD using the different savings calculation equations. We defined:

- Energy Savings Deficit Regulatory (ESDr), using as calculated savings the difference in theoretical ones and as actual savings the difference in real demands.

$$ESDr = \frac{\text{Theoretical savings [kWh/m2]} - \text{Actual savings [kWh/m2]}}{\text{Theoretical savings [kWh/m2]}} \qquad \text{(eq. 8)}$$

- Energy Savings Deficit Anticipated (ESDa), the same as before, but using the Anticipated savings as the calculated one.

$$ESDa = \frac{\text{Anticipated savings [kWh/m2]} - \text{Actual savings [kWh/m2]}}{\text{Anticipated savings [kWh/m2]}} \qquad \text{(eq. 9)}$$

The ESD gives us a direct and simple measure of how well our energy saving aims have been achieved, without reference to the size of the energy efficiency increase (see Figure 3). It is useful for engineering assessments of retrofits, for energy planning, and as a first indication of possible problems related to functioning of the equipment and/or to user behaviour.

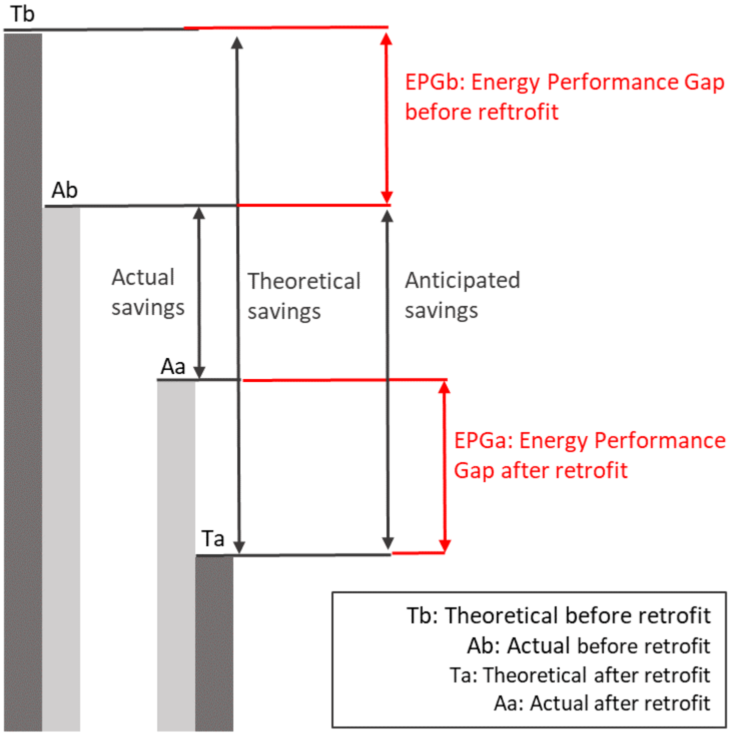

Figure 3: Illustration of the energy differences between theoretical and actual energy consumption, before and after energy retrofit.

A subsample of the CECB dataset was produced which consisted of residential buildings that had a CECB certification both before and after renovation and included real (billed) energy consumption for both. This sample included 1172 buildings. Figure 4 shows the distributions of energy labels of this sample before and after the energy retrofits were applied. It must be stressed that this sample, being a relatively small subsample of the CECB dataset, is not likely to be representative of the building stock as a whole. However, it constitutes a useful and important case study on the characteristics of retrofitted buildings.

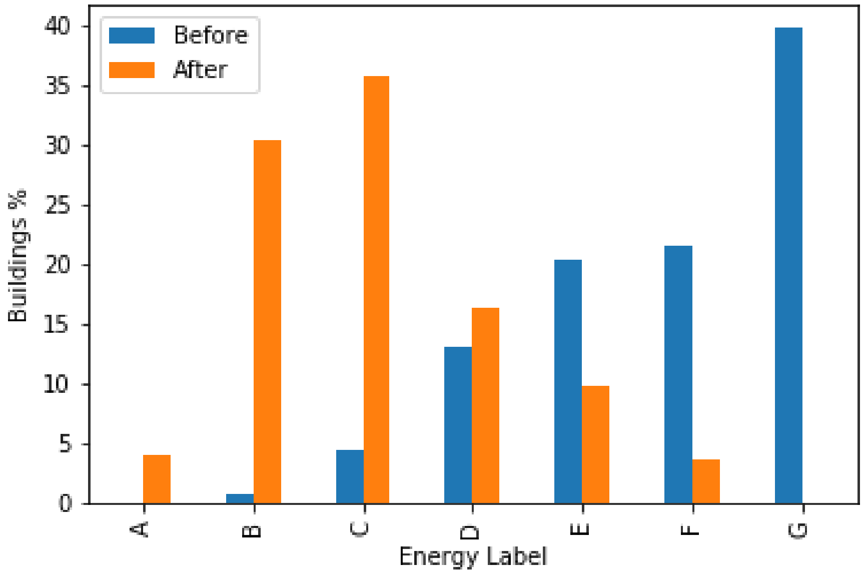

Figure 4: Distribution of energy labels before and after retrofit for the selected sample.

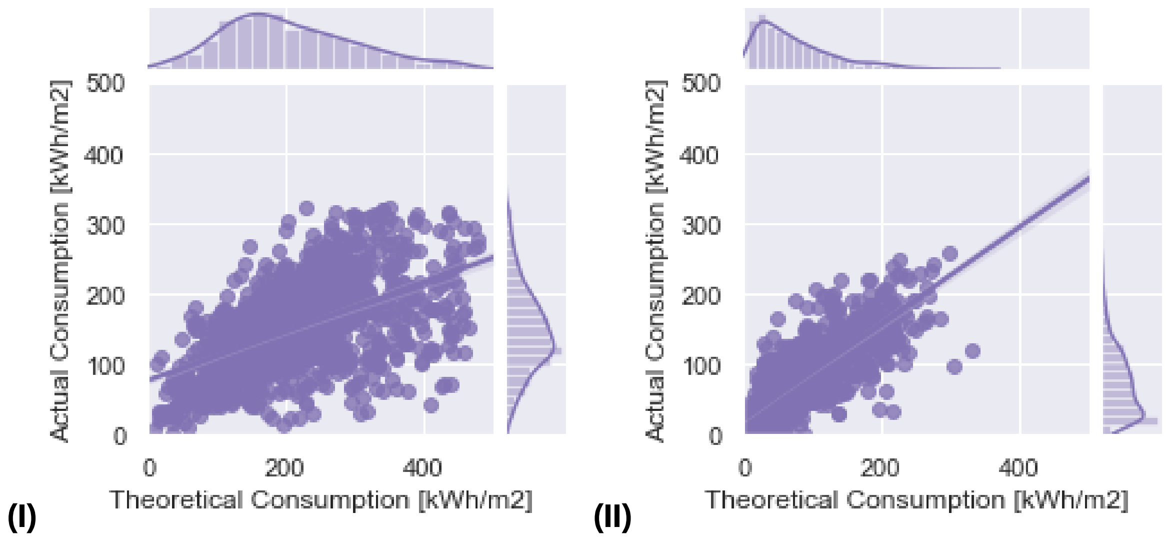

Figure 5 Relation between theoretical and actual consumption (I) Before retrofit (II) After retrofit

Independently from how the savings are calculated, it is important to note that the final energy consumption per meter square was halved by the energy retrofit. We also see a reduction in the spread of differences between theoretical and actual consumption after retrofit in absolute terms (Figure 5).

The main results for the sample used in the analyses (same set of buildings before and after retrofit) can be summarized as follows:

Before retrofit:

- Median Theoretical consumption per building [MWh/y]: 55.4
- Median Actual consumption per building [MWh/y]: 37.2
- Median Theoretical consumption per square meter [kWh/(m^2y)]: 199.5
- Median Actual consumption per square meter [kWh/(m^2y)]: 146.5
- Total ERA [m^2]: 544 272

- EPG [%]: -21

After retrofit:

- Median Theoretical consumption per building [MWh/y]: 15.9
- Median Actual consumption per building [MWh/y]: 18.0
- Median Theoretical consumption per square meter [kWh/(m^{2}y)]: 53.2
- Median Actual consumption per square meter [kWh/(m^{2}y)]: 59.3
- Total ERA [m^2]: 585 145
- EPG [%]: +5

Differences:

- Theoretical Savings [%]: -60
- Actual Savings [%]: -47
- Total ERA difference [%]: +7

Thanks to the energy efficiency improvements by energy retrofit, despite an increase of the 7% in the heated area, a global halving of the energy used for thermal purposes has been achieved.

Further calculations have been performed to explore the difference between theoretical and achieved savings and are presented in the plots below. These indicate overall trends in the savings deficit as a function of change in energy efficiency before/after retrofit, as measured by the number of energy label levels jumped in the retrofit. For example, an improvement from F to E or from C to B both gives a Label Delta of 1, from F to D or from D to B gives a delta of 2, etc. Therefore, *Label Delta* is here used as parameter to indicate the depth of the renovation. It was found that the strongest trends were observed when considering only the change in levels, rather than the actual label level either before or after retrofit.

The distribution of savings according to the theoretical, anticipated, and actual savings calculation methods is presented in Figure 6 as a function of the Label Delta. The corresponding energy savings deficits for theoretical savings (ESDr) and anticipated savings (ESDa) are presented in Figure 7 and Figure 8.

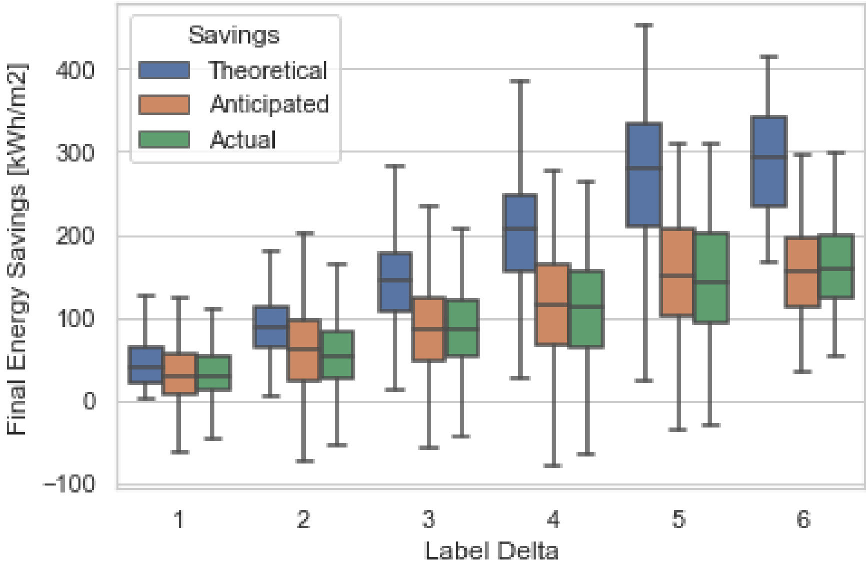

Figure 6: Distributions of savings according to the different calculations – "theoretical" (difference between the two theoretical energy consumptions), 'anticipated' (difference between current real energy consumption and expected energy consumption of the renovated building), and 'actual' (difference between the measured energy consumption before and after renovation).

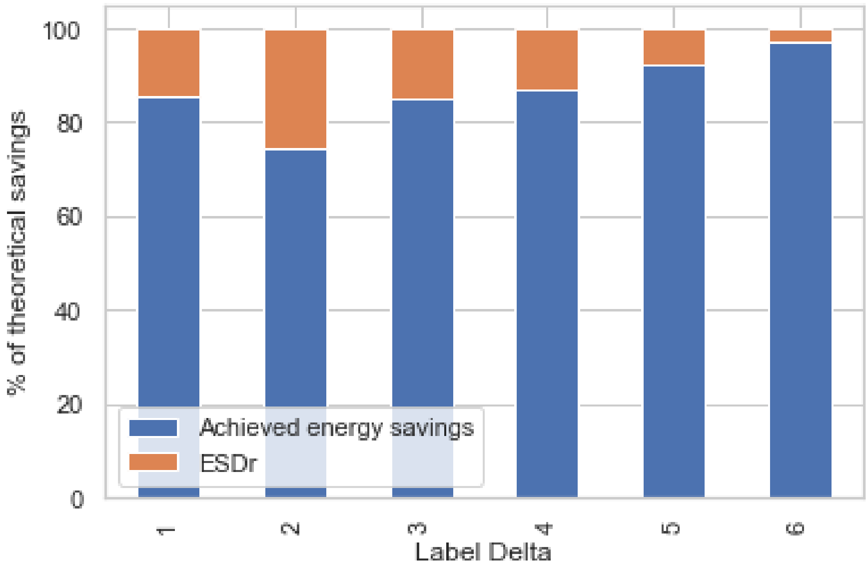

Figure 7: Fraction of achieved Theoretical savings as a function of the number of energy label improvement steps (Label Delta).

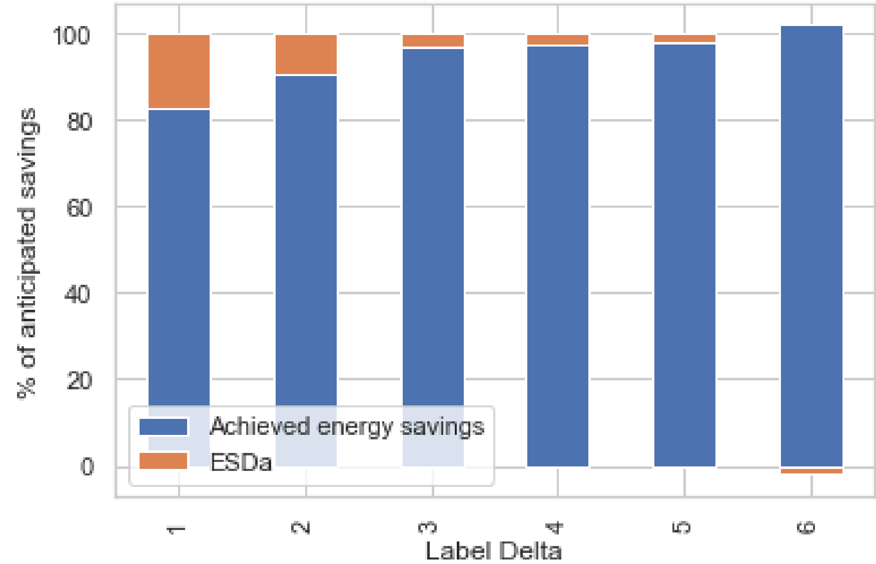

Figure 8: Fraction of achieved Anticipated savings (difference between real initial consumption and calculated renovated consumption) as a function of the number of energy label improvement steps (Label Delta).

1.3.1 Highlights of Task 3

- Despite an increase of the heated area by 7% in the course of energy retrofit, total final energy use for thermal purposes was halved in the considered building sample.
- The EPG within the same energy label is found to be the same for buildings before and after renovation.
- Buildings which reach a high-performance label through energy retrofit perform better in terms of actual energy consumption than buildings which have been built directly to reach the same energy label. The median energy consumption of retrofitted A label buildings is 42% lower than the median energy consumption of A label buildings which have not be retrofitted (i.e. that have been newly constructed to meet A label). Similarly, the median energy consumption for retrofitted B label buildings is 47% lower than for other B label buildings.
- The ESDr (calculated using the difference in theoretical consumption) is large (37%), indicating that predicting net energy savings using the theoretical demand model before and after renovation will not give reliable results. Instead, estimating real energy savings using the ESDa (comparing the known consumption before with the theoretical post-retrofit consumption) gives a much smaller difference compared to the actual achieved savings (ESDa 3.6%). In other words, from the perspective of a building owner considering an energy retrofit, a reasonably realistic assessment of their real energy savings can be achieved by comparing their actual current consumption with the predicted energy demand defined using theoretical calculations from the assessment norms.

1.4 Task 4 – Performance gap in new constructions and deep-renovations (UNIGE, SUPSI, Solar Agentur)

1.4.1 Overview

Task 4 is currently under way. For this task the Minergie and Solar Agentur database are used to investigate the EPG in newly constructed and deeply retrofitted buildings. Solar Agentur data (described in the following section) comprises the building variables as well as all conventional energy inputs and on-site energy generation. Design data on electricity, gas use and district heat demand as well as actual energy consumption are available for buildings which are more than one year old. Together with this SUPSI has provided access to the Switzerland-wide Minergie database of high-efficiency buildings which will be used for cross-checking and complementing Solar Agentur data and for separate analyses by type of Minergie labels.

Combining these two datasets will be used to establish whether the consumption predicted by the Minergie label is achieved and the size of the corresponding performance gap will be calculated. The size of the EPG will be distinguished according to the different types of Minergie labels (Minergie, Minergie-P, Minergie-A etc.) and building types, including an analysis of the trends over time. These results will furthermore be compared to the EPG and ESD calculated in previous sections, in order to evaluate the hypothesis that high efficiency buildings are more robust with respect to performance gap.

1.4.2 Solar Agentur Schweiz data

Since 1991 the Swiss Solar Agency is awarding buildings with exemplary solar installations and energy budgets. Until November 2018 a total of 3564 applications were reviewed by the Swiss Solar Prize Jury consisting of engineers, architects, professors and others. Since 2010 and in collaboration with Norman Foster and the about 20 participating universities, prizes have been awarded to buildings with a Minergie-P label energy efficient (passive house level), equivalent to U-values of at most 0.09 to 0.11 $W/(m^2{\cdot}K)$. As further requirements, the buildings must be aesthetically exemplary, and they must have built-in solar panels on the roofs and/or facades, qualifying them as net energy positive buildings. The net electricity surplus can be used to supply electric cars, thereby enabling emission-free transportation. If widely implemented, this would result in an 85%-reduction of CO_2 emissions at the local, national and global level.

In order to evaluate the buildings' energy performance, application forms containing various pieces of information about the applicants' buildings including their solar and thermal installations were developed by Solar Agentur Schweiz. For application to the Swiss Solar Price, these forms, pictures of the buildings and their solar installations, and electricity demand and feed-in data confirmed by the respective utility must be handed-in to Solar Agentur Schweiz. The application forms are usually filled in by the landlord and/or their architects. For the GAPxPLORE study, the following data have been copied manually from the application forms (which were received in printed form only) into an Excel file:

- information about the location of the building (street and place)
- type of building (single family house, apartment building, industrial building, etc.)
- information about energy labels, if any (Minergie-P, passive house or similar building standards)
- year of construction
- energy reference area
- measured and/or calculated energy needed for heating, warm water and electricity (with a clear separation between measured or calculated for each category)
- existence of a comfort ventilation (heat recovery from ventilation system)

- insulation level of the building (U-values, etc.)

Since 2012, the Swiss Solar Price Jury fills in an additional form with the verified and if necessary corrected total energy need data of the buildings. If available, these data from the Swiss Solar Price Jury are also copied to the Excel document. In addition, the buildings which the Swiss Solar Price Jury decides to award with the Swiss Solar Price have to submit revised, up-to-date values on their electricity balance (demand and feed-in into the grid). This allows to double-check and update the dataset. The confirmed values are finally published in the Swiss Solar Price Publication. Therefore, for buildings which obtained the Swiss Solar Price, the confirmed values reported in the Swiss Solar Price Publications are also transferred to the Excel document.

In sum, for the GAPxPLORE project the following work is carried out by the Solar Agentur Schweiz:

- Clarification of the type of data needed by UNIGE
- Assimilation and digitization of required data from printed application forms for the Swiss Solar Price 2008 – 2018
- Comparison with data from Swiss Solar Price Jury and Swiss Solar Price Publications
- Compilation of Excel documentation
- Delivery of the dataset

1.5 Task 5 – Feasibility study of in-depth analysis of individual building data including a validation of CECB data (SUPSI)

For Task 5 of this project SUPSI prepared an analysis aiming to provide: 1) a feasibility study on how to combine CECB data analysed in task 1-4 with real consumption data from case studies collected in the Energo platform; 2) possible explanations of causes of the performance gap. This in-depth analysis was performed on Minergie buildings. SUPSI used the Energo database to provide case studies in which collected data were robust enough to make the comparison between theoretical data and actual data (Figure 9).

CA/EL/ACQUA - Prospetto annuale

Start Date	Elettricità			Calore			Acqua			Temperature
10.09.2011	Ref.	Real	Eco	Ref.	Real	Eco	Ref.	Real	Eco	
	[kWh]	[kWh]	[%]	[kWh]	[kWh]	[%]	[m3]	[m3]	[%]	[°C]
10.09.2011	296'825	300'470	-1.23	367'474	366'327	0.31	1'652	1'668	-0.97	11.56
10.09.2012	296'483	312'017	-5.24	379'430	348'991	8.02	1'657	1'733	-4.58	11.08
10.09.2013	296'033	266'485	9.98	328'780	218'860	33.43	1'648	1'543	6.36	11.54
10.09.2014	295'019	316'633	-7.33	308'894	175'801	43.09	1'627	2'183	-34.16	12.58
10.09.2015	296'863	293'265	1.21	354'318	189'524	46.51	1'653	1'858	-12.42	11.52

Figure 9: Example of the yearly consumption of heat, electricity and water. Energy Savings in green (Energo platform).

The main work was to convert from the standard heating system efficiencies and conversion factors for primary energy used in the calculations for the building reports to actual values. This work was necessary because the actual consumption data is collected in the energy database, implying that these data are not directly comparable with the energy indices considered in the CECB and Minergie certifications.

In addition, it was necessary to pre-process the data present in the Energo platform to link and compare the different datasets. In the first step, it was determined which buildings on the Energo platform were also in the CECB database by comparing the EGID numbers of the buildings in the Energo platform and those of the buildings in the CECB list. 30 buildings were identified, for which an analysis of the actual consumption was began in order to compare with the theoretical consumption from the CECB calculation.

In the second step, a more in-depth analysis was began involving Minergie buildings. A selection of the buildings was carried out with an iterative analysis in the Energo platform (8000 buildings) considering that the selected buildings have to present: the data collected for at least 2 - 5 years, the optimization measures have to be listed correctly and the technical plans of the plants have to be present (not mandatory in energy contracts), as reported in Figure 10. The number of buildings selected to be analysed for the case study was 4.

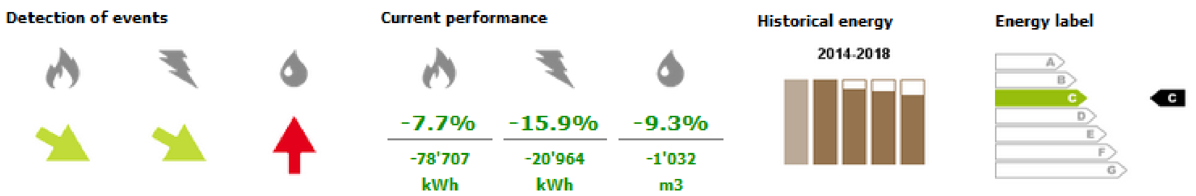

Figure 10: Example of the Energo energy panel and analysis of the consumption of building

The calculations carried out during the Minergie design phase and presented at the time for obtaining the certification were analysed. The theoretical consumption has been compared with the real consumption for each building.

It is assumed that the reasons for the difference in performance (theoretical / actual) of the building are in all or most cases caused by the problems encountered by the Energo engineer in his optimization work. So, it is assumed that the actions taken by the engineer are the reasons why the building consumes more than expected. In buildings where the Energo engineer performed the optimizations, we tried to quantify the impact of each action or group of actions (thanks to the monitoring of the building). In buildings monitored but not optimized, the difference in performance is determined and the motivations are deduced from the analysis of the Energo engineer.

National collaboration

- Olten 02.07.2018, general coordination meeting between project partners
- Numerous exchanges by e-mail and skype
- Minergie, collaboration to obtain an independent use of their data for research purposes
- Energo, collaboration to obtain an independent use of their data for research purposes

International collaboration

There is no international cooperation.

Assessment 2018 and outlook 2019

Following the 2017 assessment (Figure 11), we can confirm:

		April 2017	July 2017	Oct 2017	Jan 2018	March 2018	July 2018	Oct 2018	Jan 2019	March 2019	July 2019
START		X									
TASKS	1	Analysis		Results							
	2		Analysis			Results					
	3				Analysis		Results				
	4					Analysis		Results			
	5						Analysis		Results		
FINISH											X
MEETINGS			X		X	x	X		X		
REPORTS						Intermediate report		Annual report 12.2018		Final report on 31.3.2019	Acceptance of final report and payment by 31.7.2019

Figure 11: Timeline of the GAPxPLORE project and current status.

Task 1: The literature review has been finalized and will be submitted to the partners before the end of the year as stated in the work plan.

Task 2: The existing CECB database has been used to complete the analysis defined for Task 2 and to draft a paper with the aim of submitting it to a peer-reviewed journal (e.g. Energy Policy).

Task 3: The quantitative analysis of retrofitted buildings is complete and work is ongoing to document the findings.

Task 4: The request for additional data from the CECB database was successful, allowing UNIGE to get access to building identifiers which will allow to match the data with the Minergie and Solar Agentur datasets. Analysis on the resulting linked datasets is ongoing and expected to be completed by the end of 2018.

Task 5: This task is being undertaken by SUPSI in parallel to Task 4 and is expected to be completed by end 2018 or early January 2019.

Outlook for 2019: The majority of the remaining time in 2019 is planned to be dedicated to writing the final report, thereby making use of the inputs and reviews from all project partners.

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List of abbreviations

CECB = Cantonal Energy Certificate for Buildings
DHW = Domestic Hot Water
EPG = Energy Performance Gap
ERA = Energy Reference Area
ESD = Energy Savings Deficit
ESDa = Energy Savings Deficit Anticipated
ESDr = Energy Savings Deficit Regulatory
GHG = Greenhouse Gases
SH = Space Heating
SIA = (Swiss) Society of Engineers and Architects