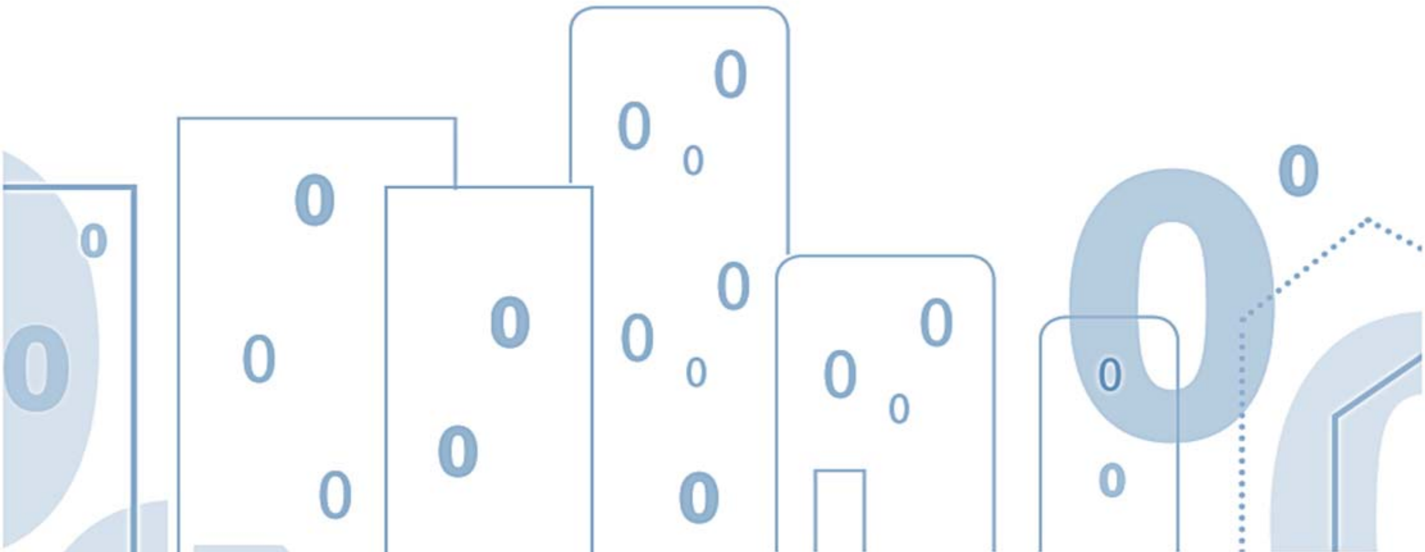
POWER HOUSE NEARLY ZERO ENERGY CHALLENGE

Co-funded by the Intelligent Energy Europe Programme of the European Union

NEARLY ZERO ENERGY HOUSING FOR COLD/CONTINENTAL CLIMATE ZONES

THE NEARLY-ZERO ENERGY CHALLENGE IN COLD AND CONTINENTAL CLIMATES

Operating Costs including Quality Assurance of nZEB in Cold / Continental Climates



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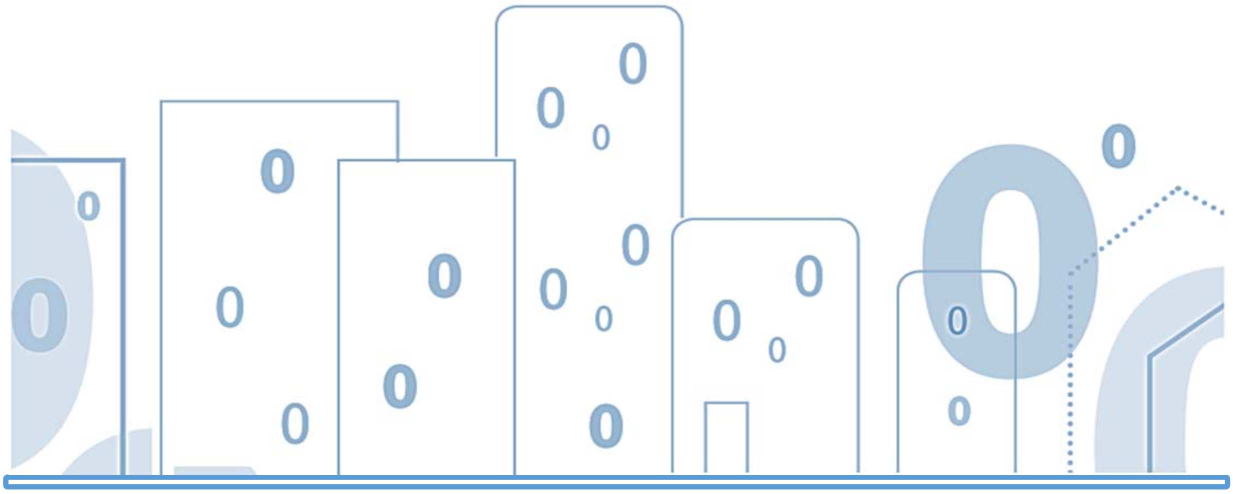

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Contents

1. Introduction

The following report is an analysis of running energy costs for 12 selected test cases which represent different types of low and lowest energy residential buildings in Austria constructed or renovated between the years 2002 and 2011.

The results of this investigation were integrated in the analysis of cost efficiency (see "Report on Cost Effectiveness of nZEB in Cold/Continental climates" available on the page dedicated to the Cold/Continental climates TaskForce on the POWER HOUSE Website).

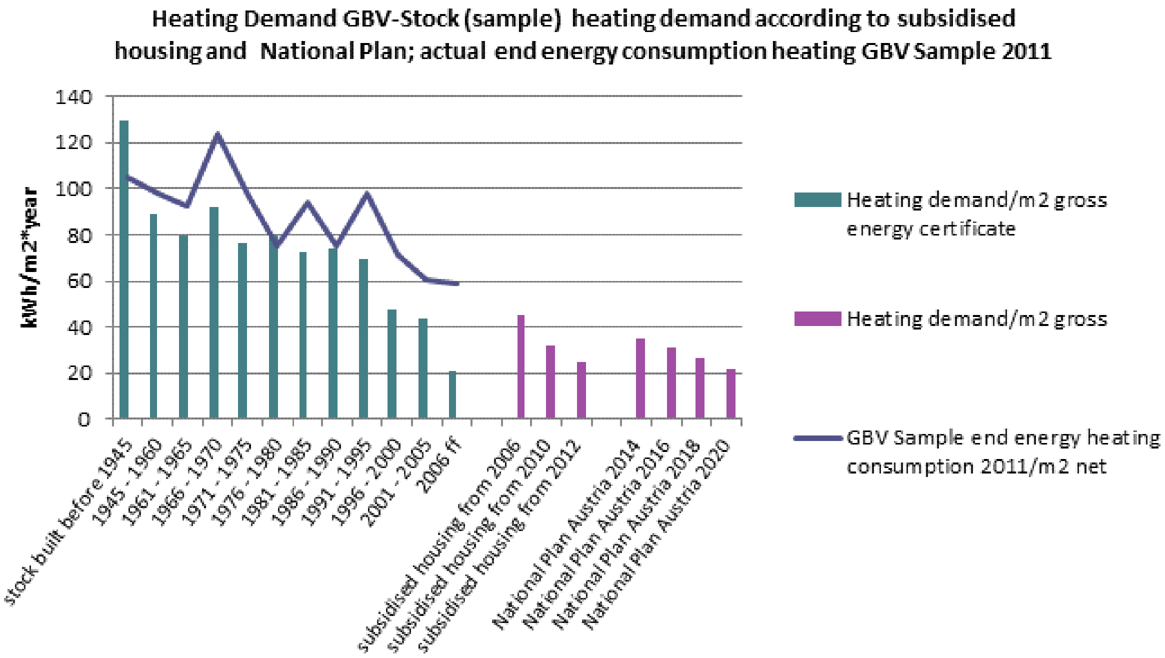
2. Reflections on the purpose and methodology

2.1 Purpose

The purpose of the following report is an analysis of costs, cost-efficiency and usability in different types of low energy buildings to come to a definition of the spectrum of optimal energy standards in housing – more specific: in affordable housing which is meant to cover needs of broad layers of population including low-income households.

Housing providers hold a position between consumers on one side and different actors, requirements and interests on the other: housing policies, energy policies, actors in the (building) industry and financing sector. Consumers (tenants) in multi-family housing are not the direct addressees of building requirement and choice is limited since housing tends to be a scarce commodity of a long-term character. Housing providers are the intermediaries between the cost of construction, financing and energy, the necessity to provide housing of reasonable quality and the limited purchase power of their customers.

Since the problems of energy security, pollution, greenhouse gas emissions and climate change have become more evident and the building sector has become one of the focuses of policy interventions, requirements for new housing and renovation have been tightened; that can be shown at the example of the existing housing stock (rental dwellings) of limited profit providers in Austria.



The energy performance of the stock is not only indicated by the calculated standardized heating demand according the energy certificates but also by actual consumption of heating energy (end energy) to show that both data show a substantial difference. Please note that the data shown may not be interpreted as deviation in absolute terms but should be regarded in a more labelling way since the calculated heating demand refers to the gross living surface (including aisles etc.), whereas the actual consumption is expressed in Kilowatt hours per square meter usable surface (surface of dwellings only) and does include transfer losses.

Nevertheless, the range of both indicators may be compared – with the result that the actual demand shows a smoother incline than the calculated demand. (That will be discussed in detail further below). The sample covers a stock of building which have not undergone energetic retrofitting to demonstrate the "historical" energy standard. However, one can assume that this standard is better than that of other buildings which have been renovated due to a less satisfying energy performance.

Nevertheless, the last years brought remarkable tightened requirements as well as a reduction in consumption. In Austria the (prospective) definition of nearly-Zero lies at about the same level as the requirements in subsidised housing from 2012 as regards the heating demand. Please note that for reasons of comparability the indicators defined in the National Plan here have been reduced; the more complex definition including primary energy demand, efficient factor and renewable energy are discussed later.

From the point of view of housing providers one crucial question remains to be answered: that for the optimal level of energy performance in relation to costs. From the data presented above it might be derived as a first finding that energy certificates cannot predict consumption – or consumption margins – perfectly. That might be caused by "pure" random behaviour differences of inhabitants. It might be also due to effects known as rebound effects which occur as consequence of technical improvements when instead of keeping the same level of comfort for less money one improves the level of comfort for the same amount of money. And there is also the possibility that new technologies used to reduce energy demand do not function properly or are not handled adequately. As regards costs, we not only have to compare operating costs (like energy and service) but also cost of construction. A better energy performance requires higher insulation, improved air tightness and above a certain tightness automatic ventilation not to disturb the effects. An addition moment is heat recovery to reduce energy consumption from external sources. These additional costs have to be taken into consideration comparing energy solutions. This moment is even reflected in the European building directive, requiring the nearly-Zero level to comply with cost efficiency.

According to the purpose of this TaskForce, we want to concentrate on "low energy buildings" and find a way to assess their energy performance and cost optimal level. According to this purpose we have to come to a definition. It was decided to set the range of low energy buildings in between passive houses on one side and that level that provides the lowest energy demand without using an automatic ventilation system.

In Austria the passive house level had been in discussion to be declared as nearly-0-level, but the cost efficiency calculations have shown that this energy technology is not cost optimal when adding investment costs and operating costs for a longer period. In the federal province of Vorarlberg the passive house standard had been compulsory for subsidised rental housing for a couple of years, but that obligation was suspended – due to the fact that there were doubts concerning costs.

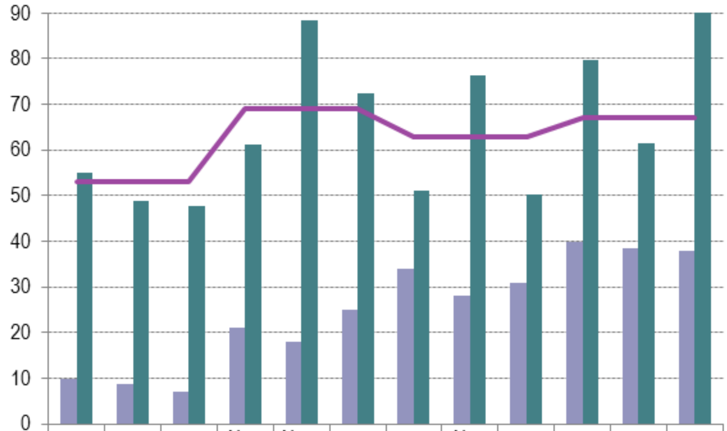
2.2 Methodology

The following report is based on an inventory of 12 cases of multi-family buildings of different types of low energy buildings in Austria as it was foreseen for this TaskForce. It is crucial to discuss the implications of this methodological concept: Investigating single "test cases" (buildings) should take place in a framework of an experiment, characterised by control of all (causal) variables. It is evident that this experimental design is hard to realise for our purpose. We have to deal with operating costs which involves energy consumption of a number of different households; different heating systems with trade-offs between investment and operating costs; costs of construction are of concern when analysing the cost efficiency; those costs are influenced by a wide set of variables (discussed below).

The other option for investigation – not foreseen here – would be a broader sample of buildings. This option has been realizes by the Austrian Federation of Limited Profit Housing Providers.

These 12 buildings have been selected out of a bigger sample of buildings in order to represent the "average case" identified in a broader sample – and they have not been chosen as "best practise" examples.

Test cases: energy performance



	New PASS 9 DW / 0,75 / West	New PASS 189 DW / 0,31 /West	Renovation Passive / 0,36	New Very Low 25 DW / 0,45 / East	New Very Low 104 DW / 0,42 / West	Renovation Very Low / 0,24	New Rather Low 6 DW / 0,46 / East	New Rather Low 37 DW / 0,30 /East	Renovation Rather Low / 0,25	New Low 21 DW / 0,53/ West	New Low 121 DW / 0,33 / East	Renovation Low 0,33
calculated Heating Demand (kWhm2GF)	10	9	7	21	18	25	34	28	31	40	38	38
Actual (measured) Heat+HotWat Consumption (kWhGF)	55	49	48	61	88	72	51	76	50	80	62	90
Average consumption per energy class of sample n = 52 projects/2.600 dwellings	53	53	53	69	69	69	63	63	63	67	67	67

Therefore, the selection has taken place with some knowledge in background – in first place knowledge as regards costs of construction. Since there are quite big differences in costs depending on the size of the building it is not advisable to compare buildings of different sizes (or ration between surface and volume) for our purpose – that could lead to wrong conclusions.

The chart above gives a description of the buildings selected; it indicates:

- the number of dwellings plus the surface/volume ratio (the lower the number the higher the building compactness);
- the location of the building (western or eastern part of Austria, that is of relevance for costs of construction;
- the energy performance of the building according to the energy certificate.

The **energy performance** as it is defined for our purposes needs some more explanation.

Before going into details it should be noted that the Austrian energy certificate until now assessed the energy performance of residential buildings according to the calculated energy demand for the components room heating, hot water production and transfer losses (end energy demand) per **square meter gross floor space** – which includes not heated areas like aisles outside the dwellings.

For our purpose, it was decided to **use only the heating energy demand** as labelling criterion. The energy demand for hot water is independent from the buildings quality, transfer losses depend on the heating system. Therefore, the heating demand refers only to the building quality, which depends on the insulation, air-tightness and way of ventilation.

- **Passive houses (PASS)**:

  According to the Austrian standard, they have a heating energy demand of max. 10 kWh/m2GFa (=gross floor space, including aisles etc), which is about 15 kWh/m2NFa (=net floor space of dwellings only). They use energy from passive sources (solar energy, waste heat) and avoid cooling by mechanical ventilation. In the original concept they were meant to get a sufficient room temperature without an extra heating source. A ventilation system in combination with a cross flow heat exchange system should replace mechanical ventilation (opening windows) and provide supply air – pre-warmed by the heat exchange in combination with e.g. brine circulation, heat pump, or other heater battery. In the original concept no other heating system should be installed. In that respect all existing passive buildings in the multi-family housing sector fail the passive house definition: It is common to install an additional heating source independent from the ventilation system, out of two reasons:

  - a comfortable temperature is not to be guaranteed without;
  - the air would be too dry.

- **Very low energy buildings:**

  These buildings have a heating energy demand between 10 and 20 kWh/m2GFa (= 15 – 27kWh/m2NFa). Automatic ventilation is required since these building are very airtight and mechanical ventilation would not be sufficient to reach a hygienic air quality.

- **Rather low energy buildings:**

  These buildings have a heating demand between 20 and 30 kWh/m2GFa (= 27 – 40kWh/m2NFa). If automatic ventilation is required is matter of discussion – dependent on the shape of the building. The test casts all have automatic ventilation. This class of buildings is close to the Austrian definition of nearly-Zero energy buildings applicable from 2020. There are not many buildings realized with this energy performance yet.

- **Low energy buildings:**

  These buildings have an heating demand between 30 and 40 kWh/m2GFa (= 40 – 53kWh/m2NFa). There is no need for automatic ventilation. That is the energy performance which was required by the housing promotion system up to 2012.

The chart also indicates the actual (measured) end energy consumption for room heating and hot water as well as the measured average level of a broader sample. That shows the range of deviance when comparing just a small number of buildings. Therefore, the passive buildings selected for our purpose are – as regards energy consumption - “better” than the sample average while the low energy buildings are “worse” than the sample average.

It also has to be mentioned that the use of renewable energy produced on site – like solar energy – has not been used as an energy label.

Finally yet importantly, it should be noted that the cases selected are no “brand new” properties since it was required to have at least two complete years of energy consumption to allow some cross checking of data.

3. Operating Costs

Operating costs in housing comprise different cost components:

- Energy for different purposes like heating, hot water production and auxiliary energy for ventilation systems and pumps;
- Service for all technical devices (heating, solar systems, ventilation);
- Inspection and control;
- Cleaning of ventilation;
- Maintenance and repair.

Not all of these components are always clear to separate and there is the “complication” of trade- offs between investment and operating costs: Some systems like pellet heating are more expensive but the energy source itself is less costly than others. District heating requires less investment costs at the building, but investments are offset by a lump-sum payment and/or are included in the regular energy bill. Energy costs comprise fixed and variable components with a wide variation between energy systems and energy providers. –

As stated in the remarks concerning the methodology it would require identical technical systems and identical energy providers to make costs comparable.

Some cost components may not be calculated since there is no extra metering – like very often for auxiliary electric energy for ventilation systems and pumps. Since these devices have a comparable low level of energy consumption there is no extra meter installed as that would increase costs.

Service, inspection, cleaning and maintenance are, due to their nature, not always easy to distinct, even when strict calculation rules like in Austria require separation.

A specific regard has to be given to solar energy gained on site. Solar panels produce energy which is stored and used for heating/hot water production. That reduces the energy consumption from other sources and thus reduces costs. On the other hand there are additional costs for the investment. To compare buildings with or without a solar system requires some extra calculations which are described below – to bring consumption data on a comparable level as well as cost data.

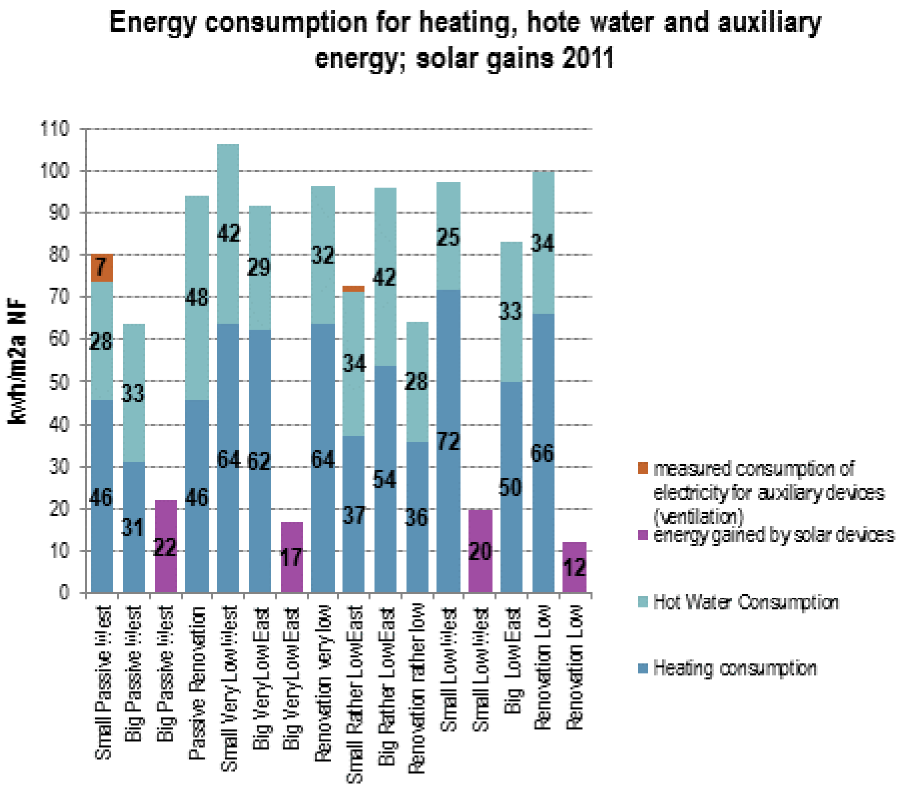
Last but not least to mention is the question of measurement of costs. That depends on the heating system as well as on the type of energy distribution.

3.1 Energy consumption for space heating, hot water production and auxiliary energy

The data used for the survey were derived from buildings with a central provider of heating energy – either a central heating system in the building or a district heating. It was either the housing management or the energy provider who delivered the data. The latter is the case for buildings where the tenants hold individual contracts with the district heating supplier.

After inspection of a big sample of date for energy consumption for heating and hot water production it turns out, that the sum of both components seems to be the most valid datum. A majority of data delivered covered a total of heating and hot water; in many cases, energy consumption for hot water is estimated.

Some extra explanation is needed for the use of solar energy. Solar energy covers a part of energy consumption and reduced the consumption of "bought" energy stated on the energy bill. To compare the quality of buildings the amount of energy generated by solar panels has been added to the amount stated on the bills.



The chart above presents the energy consumption for both heating and hot water production. As previously mentioned, these data contain partially estimations (as for the division between heating and hot water or the amount for hot water). Buildings represent energetic performance according to energy certificate beginning with passive houses from left to right. One of the core results is that in passive houses the consumption is above the expected value while in low energy houses it is rather in line with predictions if not better. If we inspect the range of consumption we find that the difference between the small passive house and the small low energy house is 25 kilowatt hours, the expected value according to the energy certificate would be 30 kilowatt hours (compare chart 1); the comparison between the big buildings of passive standard and low energy standard even show a smaller difference in actual consumption of 13 kilowatt hours.

Only for renovation projects, the difference in consumption is even higher than expected, since the low energy building is above the expected value – but mainly due to hot water consumption. In the buildings in between the passive and low energy standard we find consumption partially close to that in passive buildings, but also above.

3.2 Energy costs for space heating, hot water production and auxiliary energy

As mentioned above there is a variation between energy costs – depending on energy system, energy source and energy supplier. Trade-offs between investment costs and operating costs exist; heating systems for pellets heating have high investment costs but the price for the heating source is lower than others. In case of district heating there are lower investment costs but costs for connection to the net; service costs are incorporated in operational costs while the service costs of other heating systems are charged separately.

The following table give an overview of actual differences of energy prices:

Energy prices Austria

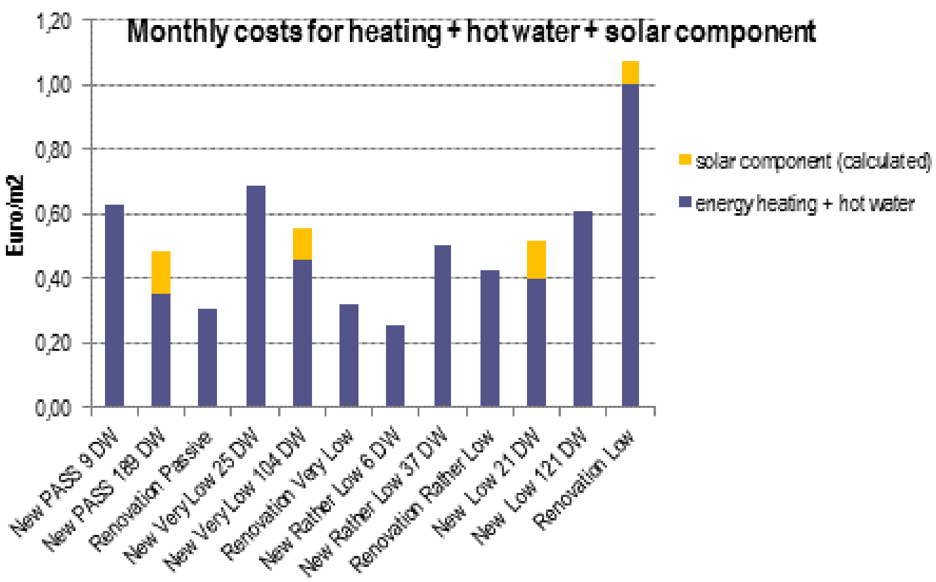
October 2014; average of energy suppliers

	euro/kwH
pellets	0,062
gas	0,074
oil	0,089
district heating	0,094
electricity	0,178

In addition, there is the “complication” with solar energy generated on site: there are no costs for this produced energy, but there are extra costs in investments, therefore, a “simple” comparison of costs stated on the energy bills would not explore the real costs.

To get a rather comparable level of operating costs for our purpose a few extra calculations were undertaken.

A “solar component” was added: for this purpose, the energy produced on site was multiplied with an average energy price; this amount may be interpreted as savings in operating costs. The costs indicated for heating and hot water were added to service costs for the heating system – if there were any. The result is presented in the following chart:



There is a rather big variation in costs; that has not only to do with the before presented variation in energy consumption – also other factors have an influence: partially missing data on service costs, different energy systems and the mentioned trade-offs. It has to be stated that for the purpose of energy costs comparison bigger sample show to be more robust.

Nevertheless to provide an interpretation: the variation in the small sample between about 30 Eurocent per month and square meter and 1 Euro – a value considerable higher than the average – is higher than expected even when we leave aside the highest value. Nevertheless, there is one fact which may not be overseen: the energy price does not only cover variable costs but also fixed components; these components are also responsible for the fact that lower energy consumption is not reflected in the costs 1:1.

3.3 Costs for other purposes – auxiliary energy, services & maintenance

Additional costs components are those for auxiliary energy (ventilation, exhaust air systems) plus charges for service and maintenance. As discussed above there is lack of data in case of auxiliary energy. The get these data extra meters are required – and since this states an extra element of costs such meters are not installed but metering is combined with other devices run by electricity. Data for service costs are available; comparing these costs one has to take in consideration that the services in respect may vary – e.g. due to the fact that residents might be in charge of taking over some of the required service activities (e.g. filter exchange). There are also all-inclusive costs for service of heating system and ventilations system.

Service costs reported in a bigger sample showed a variation between 1 and 14 Eurocent per month and square meter. Highest costs were reported for automatic ventilation systems. Since not for all test cases service costs could be split in an accurate for a part of the sample they were estimated. The respective data are presented within the calculation of cost efficiency.

Last but not least, costs of maintenance have to be mentioned. It is evident that for extra devices there are extra costs of maintenance. Bit since the buildings are quite new respective costs are either not existent yet or still subject of guarantee. Moreover, there is also the question of generalisation of these data.

To draw the conclusions of the inspection of extra costs for auxiliary energy, service and maintenance:

If we calculate with 5 kilowatt hours electricity per year and square meter for an automatic ventilation system that would account to about 6,5 Eurocent per month and square meter. It has to be noted that the price for electricity is considerable higher than that for other energy sources – see table above. Thus, even a low level of energy consumed leads to a noticeable financial component.

Together with the referred to service costs we have an amount of more than 20 Cent per month and square meter in buildings with an automatic ventilation system. If we re-calculate this amount based on an average price for energy that would account for about 30 kWh per year and square meter – and that comes close to the (calculated) difference in energy consumption between a low energy building without ventilation system a (passive) building with ventilation system.

4. Conclusions

Buildings of different energy performance have differences in energy consumption which seem to be a little below the expected difference. Differences in heating systems, energy prices and fixed components in energy prices lead to the fact, that difference in energy consumption are not reflected 1:1. Additional costs for auxiliary devices run by electricity and service compensate to some extent the advantages of lowest energy buildings in financial respect.

For further information, please visit www.powerhouseeurope.eu

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