SUSTAINABILITY MONITORING OF VIENNESE HOUSING ESTATES. POST-OCCUPANCY-EVALUATION, ENERGY MONITORING AND COST ANALYSIS OF PASSIVE AND LOW ENERGY HOUSING ESTATES

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Summary

The research [1] covers an analysis of all Viennese Housing Estates in Passive House (PH) Standard that are inhabited since more than two years and a comparison with selected Housing Estates of the same building period. The reference buildings already fulfil the Low Energy House (LEH) standard that is required for basic subsidies.

Quantitative and qualitative indicators are used for the evaluation of social, ecological and economical aspects of a Sustainable Development and for the interpretation of pros and cons of the PH-Standard within the subsidized social housing scheme. The Post-Occupancy-Evaluation (POE) compares the actual energy performance and living comfort with the planning intentions and analyzes supporting and hindering psychological and economical factors for market introduction of PH estates.

The average value for living comfort in PH is better than in LEH. A demand exists for intelligent mediation in the adjustment period as network model between planers, house management and residents as equally important and learning partners. PH-standard has several advantages compared with conventional buildings: Living comfort, energy efficiency, climate protection and energy costs. PH-Standard is the basis for energy efficient construction. Further considerable contributions can be achieved by efficient building equipment, efficient household appliances and active solar energy utilization.

A POE including energy monitoring is not just quality assurance but also fine-tuning and increase of energy efficiency as well as gathering knowledge – closing the feedback loop - for planners and developers.

Social aspects have been evaluated by Alexander Keul (University Salzburg) and economical aspects by Andreas Oberhuber and his team of FGW Vienna (Forschungsgesellschaft für Wohnen, Bauen und Planen). Detailled energy measurements of AEE INTEC (W. Wagner) and TU Vienna (T. Bednar) were also taken into account.

Keywords: Energy efficiency, Post-Occupancy-Evaluation, Monitoring, Passive House, Vienna

1 Background in Austria and Vienna

Until 2015 the PH standard as target value for all subsidized residential buildings is sought for [2]. In 2008, 7% of all new buildings in Austria were constructed in PH standard. Special subsidies for research & development of passive houses came from the Austrian Federal Ministry of Transport, Innovation and Technology (bmvit). The impulse-program "Building of Tomorrow" (www.hausderzukunft.at) has supported the realisations of the first housing estates in Vienna - Anton-Heger-Platz, Esslinger Hauptstraße, Mühlweg-C and Utendorfgasse. As figure 1 shows this was an essential and sustainable impulse for Vienna.

The further development in Vienna was driven by special competitions for housing developers. These competitions have a long history in Vienna and each competition focuses on a different innovative topic. The passive house competition for the Kammelweg-site resulted in a major increase of the useful floor area in passive-house standard in Vienna. Further competitions have been executed for the area of Nordbahnhof (project Vorgarten and Busgarage in figure 1) and the area Eurogate.

Beside the competitions there exists a special advisory committee for housing estates „Wohnfonds Vienna". The submitted plans are evaluated in terms of ecology, economy, aesthetic and social aspects. Passive Housing estates are currently subsidised with approx. 35 % of the overall construction costs.

Vienna was the place where the largest passive-house worldwide was realized with its 13 234 m² gross floor area. The residential building Roschégasse 20 was planned by Treberspurg & Partner Architects and completed in 2006.

Vienna has meanwhile the highest density of passive housing estates in the world. About 70 000 m² gross floor area has been realized so far and further 50 000 m² are planned until 2012.

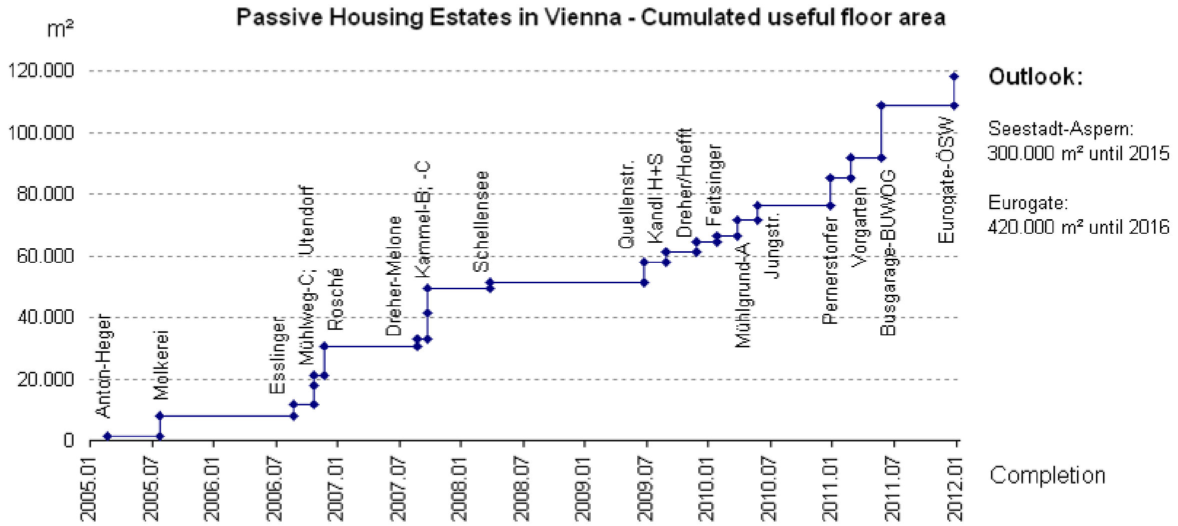

Fig. 1 Passive housing estates in Vienna – Recent development and prospects

Figure 2 shows the selected passive house buildings (and the building developers and architects) for the evaluation in the NaMaP project. All of these buildings use geothermal energy to preheat the fresh air used for ventilation, but they vary in energy supply, technical details, building construction and the thermal envelope.

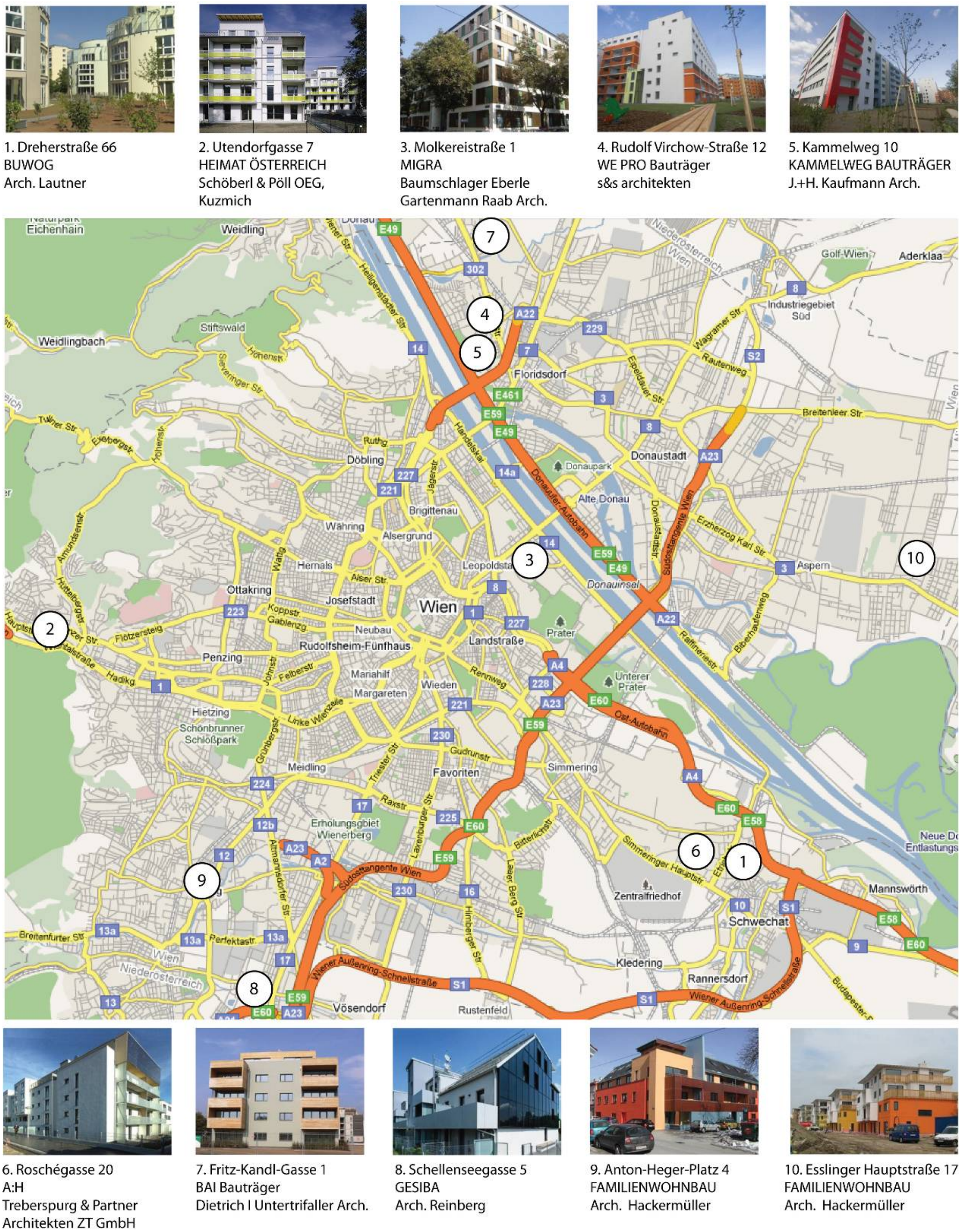

Fig. 2 Analysed Passive housing estates in Vienna. Sources: Vienna-GIS stadtplan.wien.at 15.08.2009, Fotos from building developers and architects

Tab. 1 Overview of analyzed multifamily passive houses – energy system and construction

Passive housing estates	Flats	Construction	Energy supply - space heating	Space heat emission	Ventilation system
Dreherstraße 66	27	Concrete	District heating	Heater battery (register)	Central with decentral regulation
Utendorfgasse 7	39	Concrete	Gas	Heater battery (register)	Semi-central
Molkereistraße 1	133	Concrete	District heating	Mini-Radiator	Decentral
Rudolf Virchow-Str. 12, (Kammelweg Site-B)	92	Concrete	District heating	Mini-Radiator	Central with decentral regulation
Kammelweg 10 (Site-C)	80	Light-weight timber	District heating	Mini-Radiator	Decentral with central support
Roschégasse 20	114	Concrete	Geothermal energy, photovoltaic	Heater battery + E-Radiator	Decentral
Fritz-Kandl-Gasse 1	70	Massive timber	Gas, thermal solar energy	Mini-Radiator	Central with decentral regulation
Schellenseegasse 5	22	Concrete	Gas, thermal solar energy	Mini-Radiator	Central with decentral regulation
Anton-Heger-Platz 4	15	Light-weight timber	Gas	underfloor + heater battery (register)	Decentral
Esslinger Hauptstraße 17	46	Light weight timber	7 Variations of geothermal energy + electricity	underfloor + heater battery (register)	Decentral

2 Methodology

Living comfort, construction costs and energy performance (according to EN 15603) of all PH estates in Vienna that are occupied more than one year have been analyzed and compared with the ambitious planning objectives. The measured energy savings are related to selected housing estates of the same construction period 2005-2007 that already fulfil LEH-standard. The study covers 1367 dwellings, thereof 492 dwellings in PH-standard.

3 Results

3.1 Space heating

The measured indoor air temperature in dwellings is 22-24 °C according to several monitoring results of AEE INTEC. The useful space heating demand was re-calculated for 23 °C.

The measured consumption values of useful energy correspond very well with the calculated values for 23 °C. Equipment losses have to be investigated more in detail and are so far underestimated for PH. The annual energy consumption of PH is 17 kWh district heating per gross floor area. About 30 kWh or two-thirds of energy are saved compared with conventional housing estates of the same construction period.

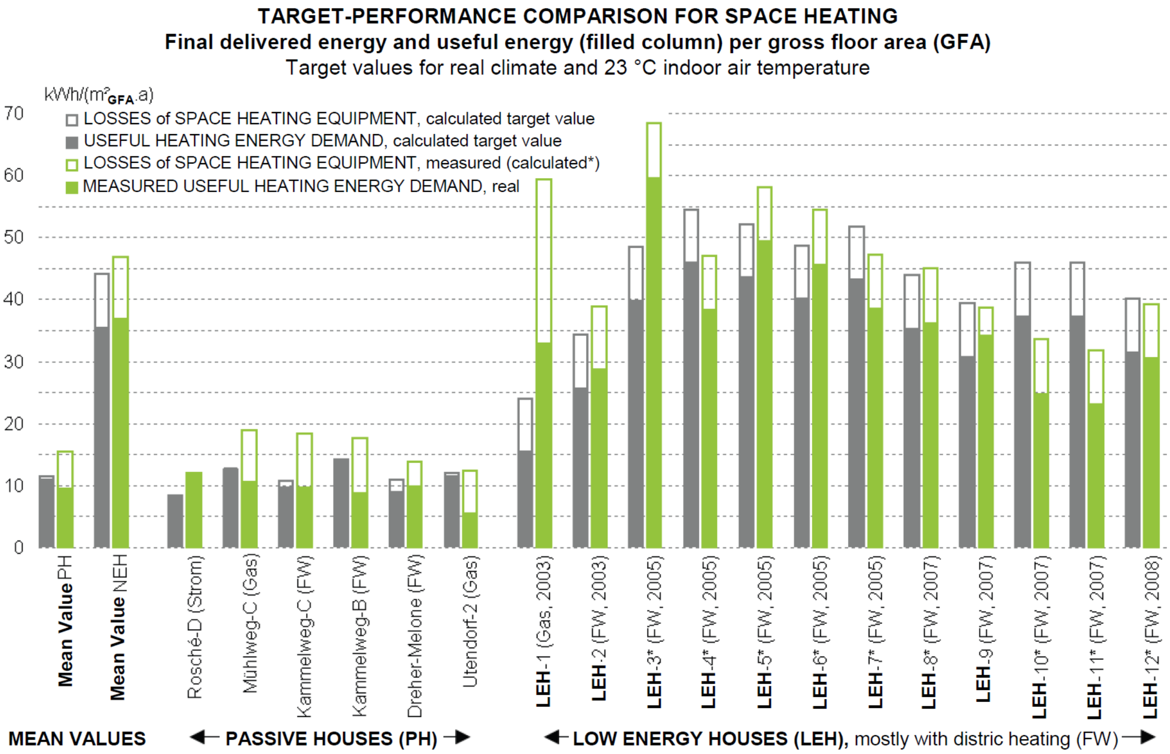

Fig. 3 Target-Actual-Comparison for space heating. Final delivered energy and useful energy

3.2 Final energy for space heating and hot water

The delivered final energy for space heating and hot water was analysed, excluding electric energy for ventilation an circulation pumps.

Referring to 2006, the PH-standard saves about 30 kWh/(m².a). For households, this means savings of about 2,5 MWh, 230 € (price of September 2009) and 500 kg of greenhouse gases per year.

PH cause a more balanced energy consumption throughout a year, which is favourable for the supply of district heating. This also causes lower greenhouse gas factors in case of a monthly calculation. The annual greenhouse gas emissions of PH are approx. 8 kg CO_2-equivalent per m² and not dependent on the energy carrier (district heating, gas, electricity). The major energy flow of new LEH is transmission losses. The PH-concept effectively reduces this energy flow by 23 kWh/(m².a). Further energy savings of 10-15 kWh/(m².a) can be achieved by optimised equipment for heating and hot water. About 10 kWh/(m².a) energy savings have been documented for solar thermal installations. Even higher yields are possible for solar space heating with large-scale collectors. Heat recovery from waste water enables minor extra savings.

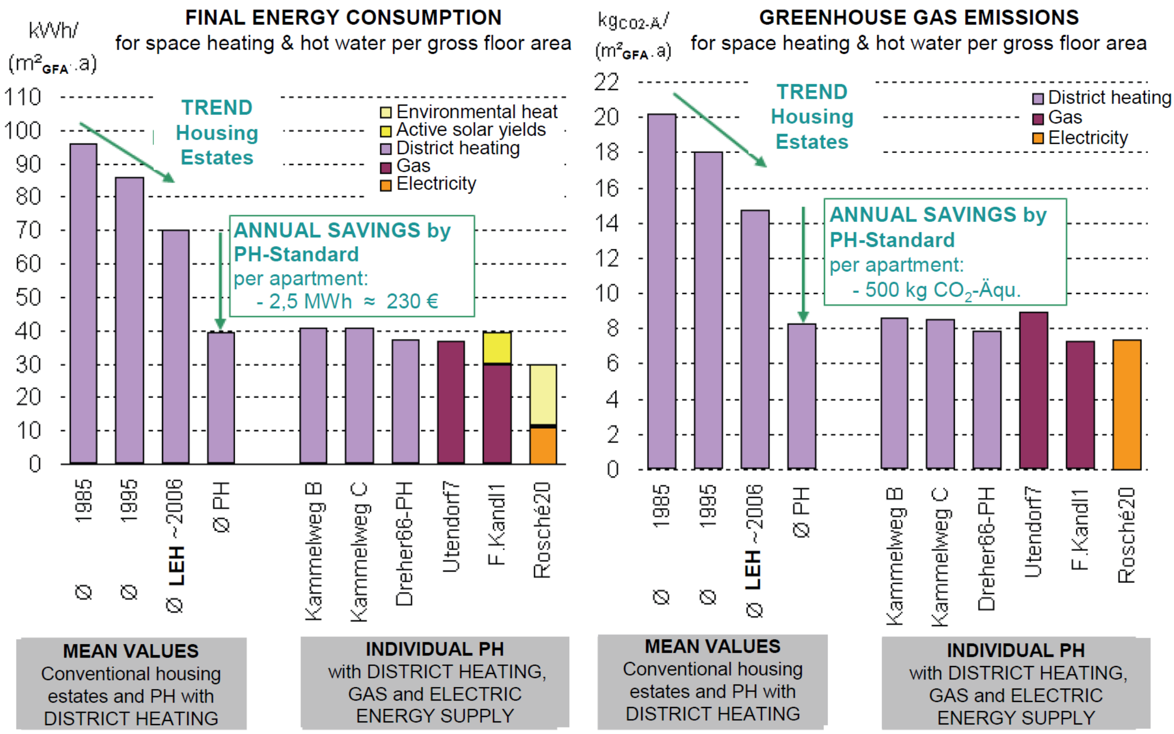

Fig. 4 Space heating and hot water - final delivered energy and greenhouse gas emissions

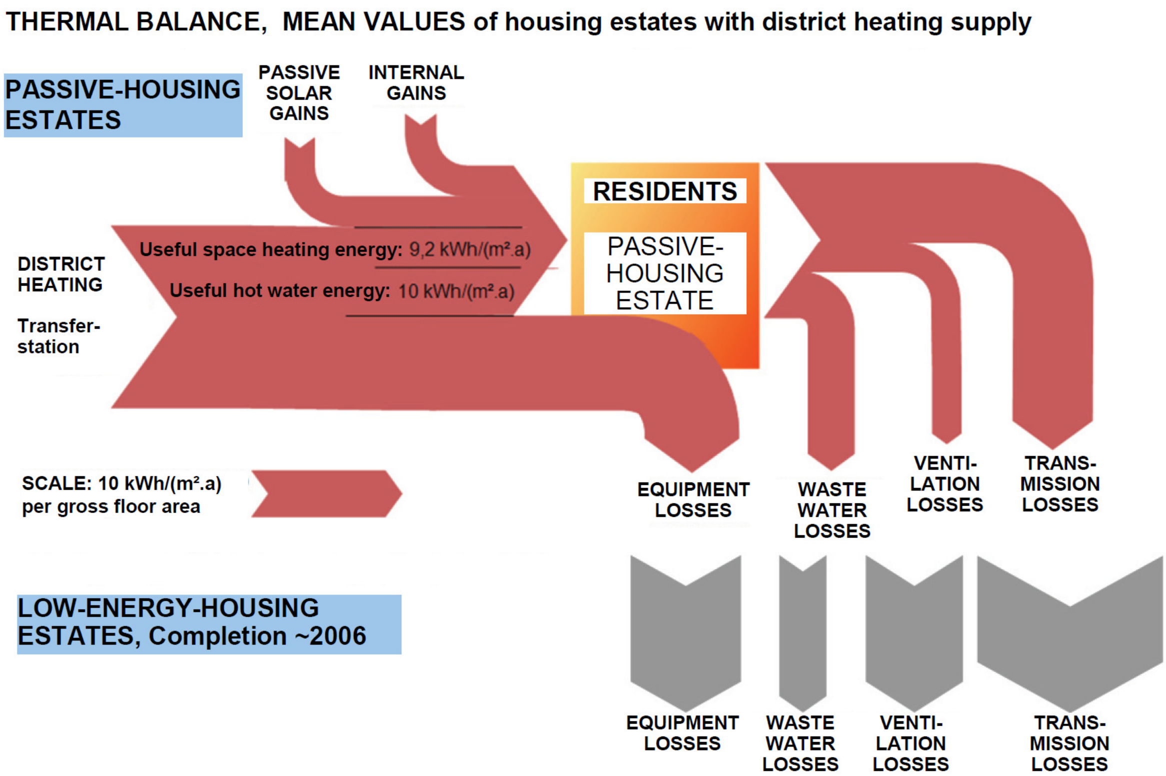

Fig. 5 Thermal balance for PH and LEH – mean values for district heating supply

3.3 **Post-Occupancy-Analysis of housing satisfaction** (Uni Salzburg, Alexander Keul)

A POE series reached 399 new flats and 225 of them returned data (56%). A comparison with conventional housing (156 flats/houses) was also done.

5 of 6 PH estates show a high tenant satisfaction (3 even at the level of detached single housing), 1 was on conventional level with a reported improvement in 2008/09.

Flats were mostly not selected because of energy standard; the tenants being no „green party“ population. Problems were noticeable in the technical regulation and adaptation phase after moving in. PH information was rated good, but has potential for improvement. A short operating instruction or checklist would be helpful.

PH has passed the Austrian „mainstream test“ with success. Everyday PH acceptance needs well-being, technical briefings and good service.

3.4 Cost analysis

The first generation of housing estates in PH quality generated 4% - 12% higher construction costs compared to LEH. The variation of additional costs was mainly due to different ventilation concepts: The first buildings with decentralized ventilation systems caused high additional costs. Central ventilation systems caused only small or no additional costs.

The costs for PH windows are about 25% higher than for conventional windows. Due to further diffusion of PH and the development of innovative components (e.g. vacuum windows, frameless windows) price reductions are possible.

The most important cost factor for all investigated PH and LEH was the compactness. Less important was the date of completion and the energy efficiency class – whether PH or LEH.

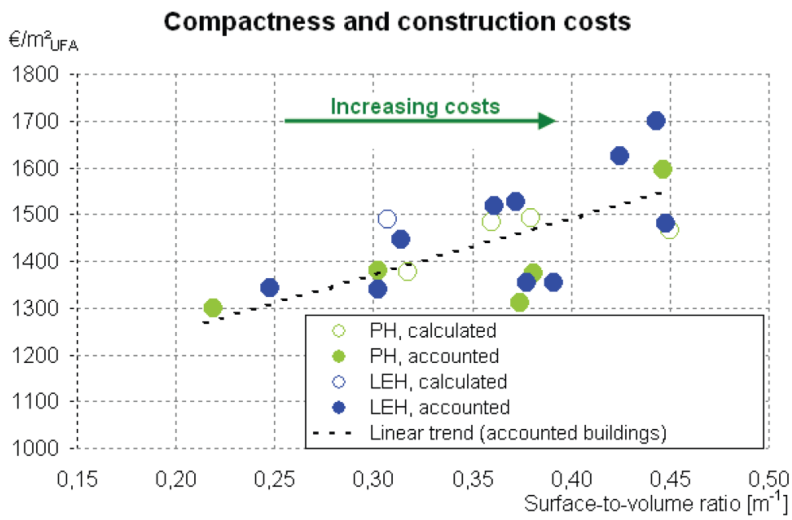

Fig. 6 Construction costs and compactness

4 Conclusions

PH-Standard for new buildings creates benefits in living comfort, energy efficiency, climate protection and energy costs with economically justifiable construction costs.

The higher indoor air quality in PH requires extra electricity for ventilation. But the consumption - 3-6 kWh/(m².a) - is not significantly higher than in conventional flats with demand-driven sanitary ventilation.

PH-Standard is the basis for energy efficient construction. Further considerable contributions can be achieved by efficient building equipment (ventilation and circulation pumps) and active solar energy utilization. For the heat distribution system, it is recommended to use insulation with a thickness of twice the diameter of the pipe. Newly built PH have important indirect contributions for climate protection due to learning effects for thermal refurbishment to PH-standard.

New buildings should be constructed in PH-Standard, otherwise they could become objects for refurbishment in the future which will result in higher life-cycle costs, e.g. due to insufficient insulation or due to mould problems.

Energy monitoring is not just quality assurance but also fine-tuning and increase of energy efficiency. The cooperation with socio-scientific analysis provides synergy effects and delivers new knowledge for developers, planners, energy suppliers and administration.

Obligatory monitoring for all subsidized buildings is suggested, as well as a publicly visible information board for the final energy demand.

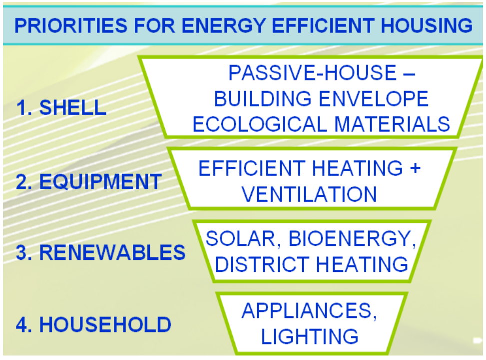

Fig. 7 Priorities for energy effiecient housing – path to plus-energy buildings

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[2] *Bund, Länder Vereinbarung gemäß Art. 15a B-VG zwischen dem Bund und den Ländern über Maßnahmen im Gebäudesektor zum Zweck der Reduktion des Ausstoßes an Treibhausgasen.* 2008