Innovative technology versus tradition in energy efficient renovation

Speaker:
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Abstract. *Energy efficient residential renovation often does not match the calculated results. After considering the rebound effect the explanation tends to be: unpredicted user behaviour. The needs and user patterns in housing are diverse and may differ from input in calculation methods. Also, many technical services are not used according to plans and for obvious reasons. The conflict between theory and practice are compared for:*
-Manual or automatic inlet and exhaust and heat recovery ventilation;
-Local heating versus central heating;
-Manual or clock controlled thermostats and innovative home energy management.
Triple glazing is compared with double-glazing as an example of popular belief against facts. Robust systems that provide direct feedback and allow much flexibility during different seasons and during day and night are preferred. The first priority of renovation is to improve the envelope and the ventilation system.

Key words. Energy efficiency, residential renovation, user behaviour, climate control

Introduction

The energy policy is to save 20% energy in the building sector in 2020, compared to 1990, and receives wide support from social housing associations. During the past period homeowners in The Netherlands have picked "low hanging fruit". Practical new goals were chosen, for instance two energy-label jumps for the housing stock or from label E/F to B in retrofits. Selling part of the low-energy stock also increases the overall energy performance. A number of forerunners have adopted near-zero-energy renovation, using the capitalised energy cost reduction and the expected maintenance cost reduction for investments in zero-energy performance. By prolonging the life expectancy with 40 – 50 years the return on investment increases and plans become feasible. Forerunners are found in slow housing markets, where high quality is needed to be competitive. Energy Leap, Energy Momentum, Smart & Fast and Beem-Up (Building Energy Efficiency for Massive market Uptake) are among the creative slogans used to invite housing managers and construction companies to innovate. The majority of housing associations have problems with financing the renovation and the quantity of low-energy renovated dwellings is still low.

The notion of practical energy savings instead of label jumps seems to disappear. Using the actual energy data before and after the renovation is an "innovative" approach. The Dutch

tenant association Woonbond promotes the total cost of living guarantee that is based on real consumption patterns and that requires transparency about actual savings, but housing associations are reluctant to follow this recommendation. The push to reach energy goals seduces home-owners to follow trends that are politically correct but not practical. The PHPP (Passive House Planning Package) and TRNSYS are reliable calculation tools, but the simpler EPN (Dutch energy performance of buildings tool) is accepted for stock policy choices. Besides the discrepancy between input parameters and practical evidence, widespread failures in execution quality and unrealistic claims about the energy effect of products can cause discrepancy with field practice [3].

Majcen and Itard [1] [2] [3] found that a better energy performance coefficient is followed by lower energy consumption, but not to the same extent. Figure 1 shows the discrepancy. For low energy efficient dwellings (label E-G) the calculated consumption is too high. For dwellings with good energy performance (label A and B the actual energy consumption is higher than calculated, which also means that promised energy savings are not reached.

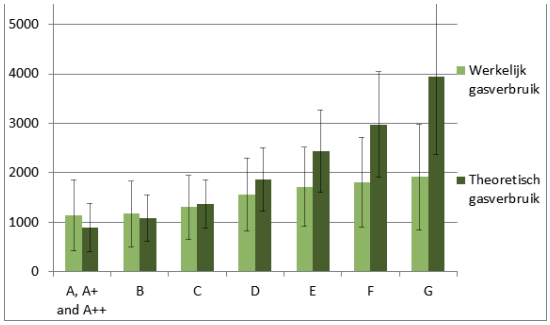

Figure 1. Actual (light bar) versus calculated (dark bar) energy consumption in natural gas per dwelling per year, from Majcen D. (2013), TU Delft

Housing associations normally ask rent increase for label jumps from D/E/F to B. Many tenants accept no more than 50% of what is calculated. Do they know better than experts what the practical effects will be?

Objective

The objective is to understand the reasons for the discrepancy between calculated and practical results of energy saving measures. The objective comes from the Beem-Up project, where partners develop and improve energy efficient renovation strategies in three pilot projects, namely Cotentin Falguière in Paris (78 apartments), Van der Lelijstraat in Delft (108 apartments/semi detached houses) and Brogården in Alingsås (300 apartments). The project goal is 75% reduction in heating energy demand through renovation. The project in Brogården is a passive house renovation with extreme heat demand reduction through insulation, sealing and heat recovery ventilation, but with little interest in user behaviour or individual heat metering, because the consumption is considered too low for that.
In Delft the focus is on a basic "free" package for insulation of the envelope (except floor insulation) and relies much on free selective measures that tenants can choose to further increase the energy performance: floor insulation, central heating with highly efficient heating/hot water source, solar domestic hot water system and an intelligent home energy management system.

The multi-storey apartment block in Paris shows a great improvement in installations for heating and domestic hot water and includes a home energy management system integrated in the videophone-door answering service. All have 75% reduction of heating demand [4]. Final data on practical energy consumption is not available, because construction work is still ongoing. However, the results so far deserve a discussion on further steps toward low-energy renovation.

Figure 2 (upper left): the street fcade of the project in Paris, before renovation

Figure 3 (ower left): project in Alingsås

Figure 4 and 5. project in Delft before (l) and after renovation ®

Figure 6: project in Alingsås after renovation

Method

The focus is user oriented. Insight in energy related behaviour and in the effect of the renovation comes from interviewing the tenants. Energy using installations and household appliances are the starting point for discussions with the users about their perceptions and behaviour. For that reason a survey and statistical analysis is abandoned and the open-interview method was chosen. In different projects (Green Solar Cities and a program of the Passive House Platform in Belgium) users of low-energy and passive houses were interviewed as well [5]. Listening to the tenant's stories with an open mind and confronting the energy consumption with different energy concepts results in a critical review.

Results

General reasons for he difference between calculated and practical energy consumption are:
-Household size and age causes occupancy periods and temperatures different from reference;
-Too high heat losses to neighbouring apartments;
-Tenants accept a lower comfort: non-heated bedrooms, warm clothing when cold outside;
-Technical installations are not used as predicted, because of noise or draught.

The energy claims of providers of new applications are a reduction of the energy performance coefficient (the Dutch EPC) between 0,1-0,23. It means that for instance heat recovery ventilation can reduce the EPC from 6,23 to 6.0 and then the design meets the building code. The EPC-tool includes tested applications. Non-registered innovative products can be accepted on the basis of a "certificate of equivalence". Many of these certificates cannot be evaluated, because the underlying test reports are not public [6]. Majcen [2], Santin [3], Fabriek [7] indicate that some building indicators are important for the energy consumption: ventilation rate, g-value glass (solar transmission factor), the wall heat transfer coefficient, and the heat gain. An important behavioural characteristic is the number of bedrooms heated (Santin) and the number of hours the heater is set at higher set-point. The better the dwelling is insulated, the less important is the temperature set-point, but the more important is the ventilation rate, the orientation towards the sun and indoor heat sources from persons and electrical appliances [7].

Some of these factors are highlighted in the following design choices in renovation projects: ventilation system, type of heat distribution, thermostat control, glazing type.

Ventilation system

About 50% of the housing stock and even more renovation projects in the Netherlands have natural inlet/exhaust ventilation. Exhaust ducts are poorly maintained and often wrongly used by blocking the exhaust duct with temporary-used bathroom fans or cooker hoods. The ventilation system is perceived responsible for mould problems in bathrooms and for draught complaints. In renovation projects the standard improvement is to install mechanical exhaust and to improve natural inlet services. Providers of ventilation products promote direct current fans, demand control and heat recovery.

When users have control over the set--point of mechanical systems, more than 80% chooses the lowest possible set-point, and air volumes are lower than before the renovation with natural ventilation [8], which potentially creates more mould problems. Demand control is normally based on CO2 concentration and will reduce the air change rate to maintain concentrations below for instance 700 ppm. This strategy can prevent peak concentrations if the ventilation capacity is high enough in the CO2-monitored room. Energy saving comes from lower fan electricity use and lower heat losses.

Overall, mechanical systems contribute less to practical energy savings than is suggested by providers, mainly because the systems are not used according to the input parameters. Important design criteria for renovation are often not met: flexible use, safety of natural openings, comfort both in winter and summer, contribution to summer "night-time" cooling, low noise level and high ventilation capacity especially in bedrooms. In well-insulated dwellings the heat demand is low and the period with preferred energy efficient ventilation is rather short. Both hybrid natural/mechanical exhaust ventilation and heat recovery ventilation are possible solutions for the short winter period in moderate climates. The decision to abandon natural exhaust is not based on good diagnosis and can be wrong.

Local versus central heating

The strategy in renovation projects is to install central heating at turnover or when tenants ask for it. Because of the high rent increase involved (> € 45- per month after correction for replaced appliances) the tenants have to agree with the change and this makes central heating a free-selective measure when occupied dwellings are renovated. Before the renovation of the Delft Beem-Up project, many apartments had either one chimney tied gas heater or the mother-fireplace in the living room with radiators in all other rooms. The tenants that still use a single chimney tied heater are satisfied with the improved comfort after insulation of the envelope, while showing lower energy consumption than in dwellings with central heating []. These findings raise the question of priorities in renovation. Better insulation of the envelope would increase the overall temperature without heating due to solar and indoor gains and lower heat losses to a degree that meets the needs of tenants who prefer unheated bedrooms. The combined heating/hot water appliance has developed into a high performance and cheap appliance, meaning that radiators are just needed in the living room and kitchen.

Temperature control of central heating

The EU directive [9] states that metering and individual billing must become standard, at least quarterly but preferably constant and at all time available for individual consumers. Modern energy feedback systems combine the thermostat function with feedback, with the intention of learning and to stimulate energy efficient behaviour. The question is what energy effect we can expect from the different metering and control systems in renovation projects.
The On-Off thermostat is user friendly and robust. The direct feedback leads to pro-active control behaviour: down when going out or one hour before going to bed, no heating while asleep, higher when the household tends to sit down in the evening etc. The clock thermostat allows pre-selection of certain temperature levels at different times per weekday with repetition of the week cycle. Santin [] found that the average temperature set-point with clock thermostats is lower than with manual thermostats, but the heating hours are longer and the clock thermostat ends up with causing higher energy consumption.

According to Dam [10] “home energy management systems (HEMS) are defined as intermediary products that can visualize, manage and/or monitor the energy use of products or entire households. They are intended to give households direct and accessible insight into their energy consumption and thus help them to reduce it.” A smart meter generally needs a HEMS to give users the intended insight [10].

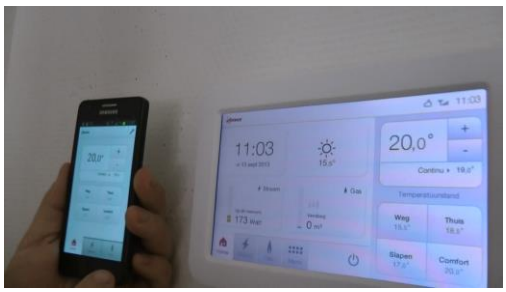

Figure 7. The display of TOON next to the application for a smartphone, products of ENECO energy company, NL

The HEMS in the Beem-Up project in Delft is called TOON and can give information on:

-Real time power use (electricity) and heat consumption;
-Comparison of electricity and natural gas or heat with the previous day, week, month or year;
-Expected energy consumption both in energy units (kWh and m3 natural gas) and in Euro's;
-Comparison of energy use with the average in the neighbourhood;
-Actual temperature and manual adjustment of the set-point for the actual period;
-Pre-set period with four set-points: away, home, sleeping and comfort;
-The weather (expected rain showers).
Interviews with users indicate that the real time information gives new insights and does have effect on behaviour. The learning curve is fast and will last a few weeks, but energy or cost minded people stay interested the energy consumption. When being faced with replacement decisions, they are more likely to take an A++ type refrigerator or a LED television, while taking long showers may be discouraged on the basis of the energy effect.

The TOON is a free service for two years, after that period the tenants have to pay a monthly fee of € 4,0 to € 5,0. Dam [10] found that the energy saving effect over period of months is around 7%, which is about 50-60% of the cost for using it. Almost all interviewed people choose to continue using the HEMS.

Double, triple or vacuum glazing

The last decennia have shown innovation in glazing. U values tumbled from 6 W/m2K to 1,1 -1,2 W/m2K. Now the focus is on triple glazing (U=0,5 -0,7) and vacuum glass appears at the horizon, again with the promise of reducing the U-value by 50%. In renovation projects the choice is between standard double glass (U=1,2) or triple glass (U=0,7). There is more to the comparison that the difference in U-value: the difference in embodied energy is large (mainly caused by Argon), the investment cost is higher, the panes are thick and heavy requiring strong frames and hinges, the handling of windows and doors is lees user friendly, the architect faces restrictions in shape and size, etc. Solar influx has more impact on the energy balance than the U-value. Over the whole year for The Netherlands there is no relevant difference in the energy balance of a dwelling with double glass and triple glass [11]. For the cooling demand triple glass wins, while the acoustic insulation and also the inner surface temperature of triple glass provides more comfort. Vacuum glass is becoming commercially available, but still at high cost. The extreme insulation value, high transmittance, low weight and small thickness due to a cavity of only 4-5 mm makes this innovation welcome and may push triple glazing aside as a detour in the transition towards better energy performance of building products.

Conclusion and Recommendations

High insulation level and good sealing are the first design steps in renovation plans. When the EPC tightens from 0,6 tot 0,4 in 2015 a practical check will be introduced in the Netherlands and this could promote the use of actual energy data in the renovation process. Renovation plans with high insulation level and simple ventilation, heating and hot water services with

low standby energy use are most likely to save both cost and energy over a long period of time. Advanced collective ventilation and heating services may cost more, also in energy consumption including embedded energy, than robust individual climate systems. A group of energy conscious occupants can be supported with smart energy feedback systems, but selective use and short heating periods are the key to low energy consumption.
HR++ double glass deserves priority over triple glass in a moderate climates (Netherlands, France) and extra insulation deserves priority over heaters in all rooms. Providing a choice of ventilation options for the varied needs of users is the key to healthy and comfortable housing. Low energy effect of renovation tells more about the people than the technology used.

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