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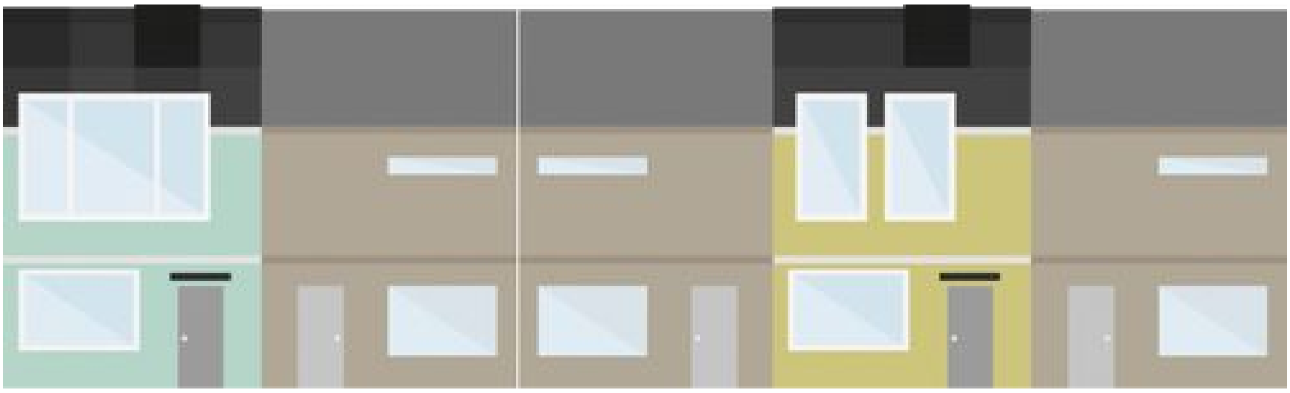

WP3: Deliverable 3.8:

Guide with concepts of renovation packages for different types of building

Huygen/RiBuilT-SBS/Zuyd

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More Connect plans to publish a book on mass retrofit with prefab elements for (n)ZEB performance. The deliverable 3.8 will be some of the core set of chapters of that book. To create some guidance for the material to be developed within More-connect, and for the ultimate book, a concept for the contents of that book has been developed. This is reflected by the contents below, in that del 3.8 is in bold characters, and the potential book chapters later are in grey.

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The More book to retrofit Europe

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1. Retrofit Europe's housing stock

introduction

It's a simple calculation, really: if we have to reduce energy consumption by 20% overall in Europe, so has the housing sector. There are two ways to reach this target; either applying measures to all houses to reduce their energy consumption by 20%, or: 20% of all houses have to become '0-energy'. This applies to Europe as a whole, or each country and region.

In Europe there are about 255 million houses, and for the 0-option this implies over 50 million houses to be retrofitted. The beautiful thing is that EU targets, adopted by the national governments, require this to be done before 2020. In other words, we now have 3 years left to deal with 50 million houses, or around 8.5 million a year.

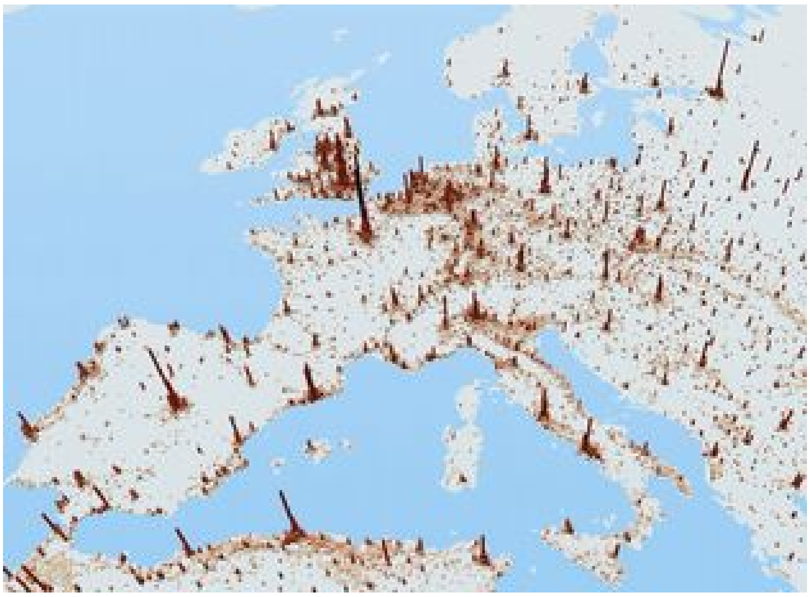


Illustration 1: cities and density in europe, PBL-NL, http://themasites.pbl.nl/cities-in-europe/

Realizing this, the only strategic option is to introduce immense, retrofit and upgrade programmes , for many years , to keep these targets in sight. This could and will provide a huge amount of work and thus counter unemployment. What remains is a focus on improving the built environment, which, combined with rising energy prices, requires a large-scale retrofit programme, creating jobs, and reducing energy impacts and costs of living.

Th EU has already recognized this, when posing its strategy to reduce consumption and increase RE production. As well as already in 2011 to introduce the EPBD recast, requiring buildings to become (near) 0-energy . [1]

Since then things have changed, in a way that it has become even more urgent to address the energy consumption from (among other sectors) housing , due to the Paris climate agreement, and the published data about remaining CO_2 emissions to stay below 2 degrees of global climate warming. The data show that we only have 800Gt CO_2-eq of emissions left, to have a 66% chance to stay below 2 degrees of global warming. At current emissions levels (which are even rising), this budget will be exhausted by 2035! [2 guardian] Globally that is, for the EU the targets are even higher.

As a spin off from More connect and in a cooperation with iiSBE [3] the consequences have been investigated, especially by the author with regards to retrofit housing towards 0-energy. And the figures show that we have to retrofit 6-10% of housing stock yearly to have a chance to meet the overall emission targets [3] This counts for retrofits with 0-energy ambition, highly reduced demand and including the emissions from energy embodied in the materials for retrofits. In MORE-DEL 3.2 the consequences of embodied energy are explored. [4]

With this in mind, the MORE Connect project is one of the solutions explored to create a mass approach and speed up the reduction of CO_2 emissions for building related energy demand.

[1] *http://ec.europa.eu/energy/efficiency/buildings/buildings_en.htm*
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32010L0031:EN:NOT

[2] https://www.theguardian.com/environment/datablog/2017/jan/19/carbon-countdown-clock-how-much-of-the-worlds-carbon-budget-have-we-spent?CMP=twt_a-environment_b-gdneco

[3] Staying below 2 (1,5) degrees of Global warming : a (near) 0 – CO_2 built environment expert explorations of CO_2 consequences for the built environment , iiSBE report. Ronald Rovers, Thomas Lützkendorf, Guillaume Habert, Launched at : COP22 Marrakesh, November 2016 Version 1.0 April 2017 available at: www.buildingscarbonbudget.org

[4] More-Connect, deliverable 3.2: Tool to optimize the combined energy and materials performance of the alternative configurations in relation to local typologies, January 2017

limiting (fossil) energy demand

0- or near 0-energy houses are in fact houses that meet their energy demand by on site production of (renewable) energy : Eliminating fossil fuels, and replacing these with local, building connected generation .
There is some discussion whether energy neutral buildings could sometimes be a better option: houses that only use renewable energy, but that can be produced elsewhere, either in the direct vicinity, or by the classic grid: National power supply is also in transition in most countries, and will shift towards renewable energy production as well. For housing however, it has been chosen to start as local as possible, and not to wait until the whole system has been transformed. In some countries local district heating will however be major option to explore.

This is the starting point in analyzing retrofit concepts for housing. With this in mind, to create 0-energy houses, or near 0-energy houses, 4 main areas can be targetted:

1 (local) production of renewable energy
2 reduce energy loss building
3 adapt use of building
4 changed behavior of inhabitants

The More connect approach focuses mainly on step 1 and 2, assuming for step 3 and 4 business as usual. Though it might turn out that to reach real 0-energy, and possible beyond: energy plus houses, that for instance include energy generation for electric driving) that step 3 ad 4 might have to be addressed as well. Under step 3 for instance its an option that the heated (or cooled) area should be reduced (in m2). Under step 4 its an option that average temperature levels are reduced, and or differentiated among different rooms. In some retrofit concepts step 3 and 4 is already addressed, as we will describe under 'concepts' .

The MORE Connect approach also focuses mainly on heating and ventilation (cooling), since this energy demand is related to the building itself. Household related use will not be influenced by a retrofit directly. Optimization in energy and materials input will mainly be decided by the heating/ventilation optimization. Household energy, when leaving out step 3 and 4, is a set demand that can be supplied by a related given amount of extra energy generation. This will be shortly addressed in chapter 2 and 3C.

Illustration 2: on the island of Eigg, Scotland, people have adapt their energy use to the amount of renewable energy generated. http://www.ronaldrovers.com/the-eigg-of-scotland-sharing-society-2-0/

2. The EU housing stock

The EU housing stock consists of around 250 million dwellings. Which all in some way “consume” energy for operational use, which is mostly fossil energy. The EU has set a target to reduce this fossil energy , and related CO2 emissions, by its communication known as the “EPBD recast” , stating that all buildings/houses in some way should be transformed to operate with “nearly zero or very low amount of energy required”

This is no sinecure, since this housing stock is very divers, is in different climate zones with different heating and cooling demands. Besides, there is different ownership situations, , different market organization and regulations.

Here is a short introduction into this housing stock, to have some insight in the task ahead of us.

Energy consumption in buildings accounts for roughly 40 % of Europe’s total final energy consumption, the share of households being 27 % of the total [1-Eurostat 2015a]. Final energy from renewable sources in households in the EU 28 accounted for only 15 % [1-Eurostat 2015b] . In 2012, greenhouse gas emissions generated by households caused 19 % of Europe’s total emissions [1-Eurostat 2015c]

.

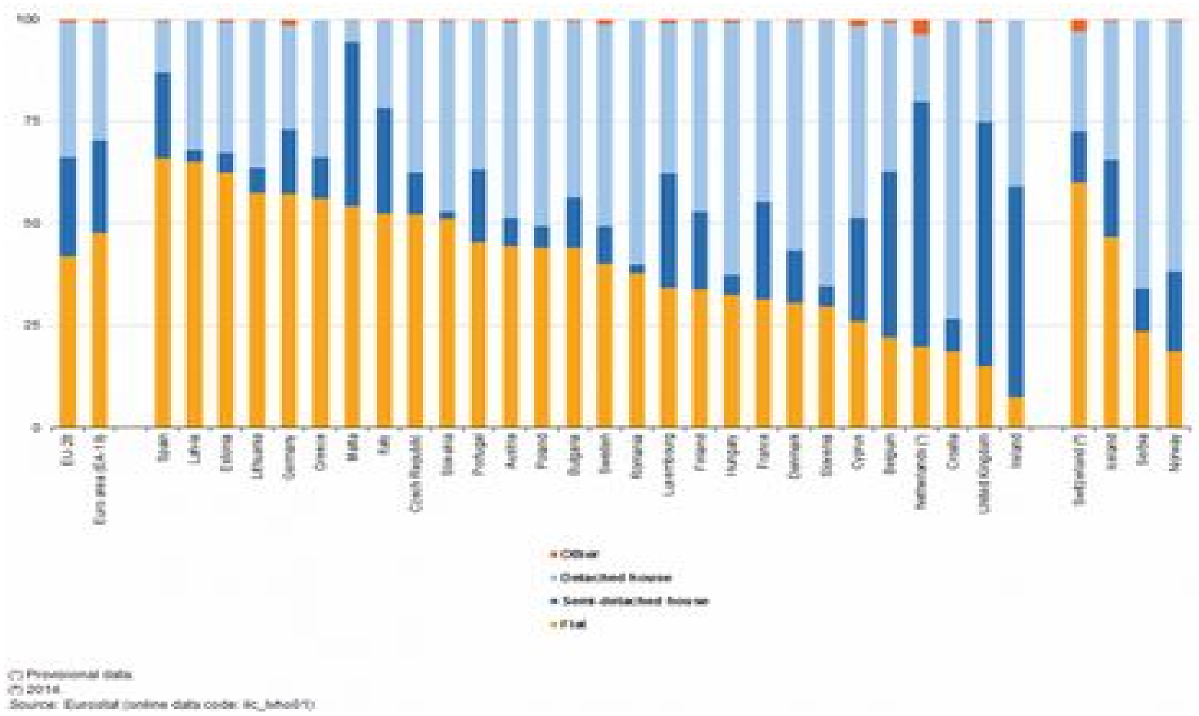
From the total EU housing stock, around 66 % is built between 1945 and 2000, 22 % from before that and 10% from after 2000.

Whereby Greece, Spain, Ireland, Portugal, Croatia and Bulgaria have the youngest housing stock, the largest proportion added after 2000.

Regarding the oldest fraction, before world War II , Finland, Slovakia, Greece and Cyprus have the least, less than 1 in 10 dwellings built before 1946, By contrast, more than one third of the housing stock in Denmark, Belgium and the United Kingdom was constructed prior to 1946 [2]

Another significant difference is the housing costs: it varies from 20% to 40% of income in the EU-28. Which on one side shows that the interest in reducing those costs might be high, but at the same time the remaining budget to invest might be low for that same group. And vice versa.

Interesting in the light of energy reduction, is also the type of dwellings and the distribution of population per dwelling (ill.3) . [3]



The main difference is between people in flats/apartment blocks, and the ones in individual houses. (terraced, semi detached and detached) This is a significant difference in the light of potential solar energy generation on or nearby the house: The average roof surface per house and per inhabitant differs greatly.

Directly related to that is the average m2 occupied per person, [4] which has a direct relation to the energy demand: The housing statistics report shows that the most m2's are for people in Luxembourg , 66 m2/cap, and the least in Romania: 15 m2/cap
These are two exceptions, the majority is between 25-50 m2. However, this already can imply a heated surface difference of a factor 2! Interesting is how these occupied m2's are devised over the different climate zones in the Eu: which relates directly to the amount of m2 Solar panels required, in the geoclusters solar potential If the less m2-occupied would be in areas with low insolation, that could theoretically compensate each other, and vice versa. Illustration 4 shows this distribution:

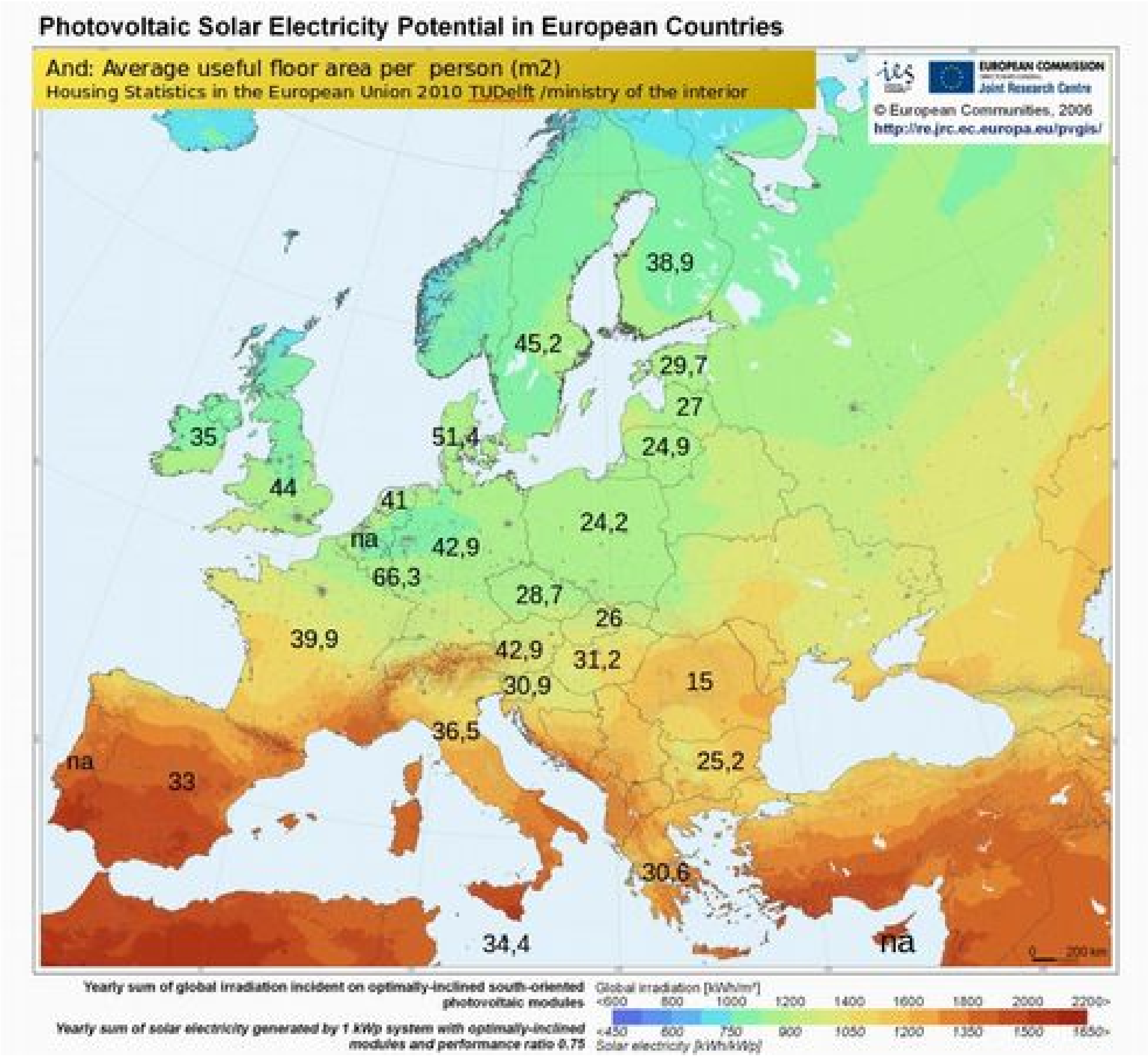


Illustration 3: Solar potentials over Europe, and average m2 of housing per capita

The warmer areas have significant lower average m2 per capita as colder North Western areas, while having a much higher potential in solar electricity per m2. On the other hand, the north and

west countries have lower potential in solar electricity, while having much more area to be heated on average (and potentially larger roof surfaces to install -more- solar devices) Middle and east European countries have lower solar potential but also lower demand in m2/cap.
Of course tis is only indicative, but to illustrate how divers the challenge can be spread over Europe. Other issues that will influence the potentials are the household size, and more specific housing typologies. Of which one aspect is especially important: the roof.

Illustration 4: some roofs in europe: Italy (left) The Netherlands (middle) and France (right)

Roofs -shapes

Roofs are of course crucial in a transition towards (near) 0-energy buildings, if the energy is to be generated on the building envelope. Roofs in Europe always have been a mirror of climatic circumstances. First there is the shape of the roofs. Where it is cold , in the North and the Alps, you see often a slightly steep roof, to guide the rain downwards , but not too steep because the snow helps to insulate the building in cold periods, and should not slide of. Which on the other side obstructs the harvest of active solar energy in colder periods.

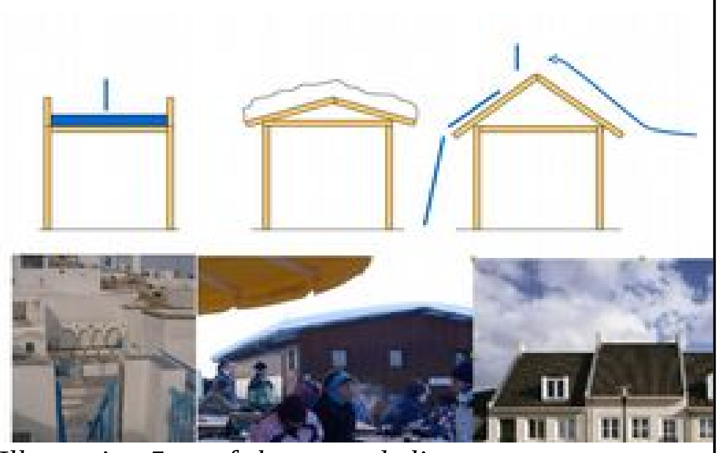


Illustration 5: roof shapes and climate

In the middle part of Europe you see a lot more very steep roofs: Mostly in densely populated areas: With not much space to build, or for financial reasons, people build on a limited amount of square meters, and could use the the space beneath the steep roof as an extra living area.
In the South we see more flat roofs. There are no direct weather problems, and the roof is left unfinished, or used as a roof terrace. (and sometimes for rainwater collection)
In the south there are also other things to observe: The construction of 'velo's and tolda's' , big sheets covering the roof or parts of the (narrow) street, to keep them cool. Which is a easy, cheap, and effective way to cope with heat. Which would make it in general more easy to install solar panels as roof terrace covers, but at the same limits the possibilities to use facades as Solar panel surface.

These are of course some very generic observations. Nevertheless, roofs have never been designed with the intention to harvest as much as possible active solar energy.   And are still today not designed as such. This poses a interesting challenge to retrofit concepts.
One other thing should be mentioned here, which is height differences between buildings and houses: This is seriously affecting the potential solar gains, when buildings shade each other [5]

conclusions

Its this divers housing stock that has to be addressed to create a near 0-energy performance, , and in the near future has to shift further to a 0-energy performance, as we now already know and demonstrate in several countries. But its not easy, and there are big differences. Not only in housing types but also in energy challenges.
The per capita final energy consumption in the EU is around 2 tonnes oil equivalent, or 23269 kWh. With 27 % is for households, this is 6280 kWh per cap . (this is without reduction measures, and including household energy) As an illustration: to provide this with final energy from Solar panels requires ~ 45 m2 in the southern regions up to 90 m2 per capita in the Northern regions (on average). Which is again a factor 2 difference. This influences again the amount of measures that have to be applied to reduce the demand before adding solar panels for production. The amount of m2 occupied, the local climatic potential in solar energy, local housing styles and available and shpe of roof surfaces combined making each house-transition each time a very delicate balancing act, not only in energy but also in respect of materials input with its rebound effects in embodied energy. [6]

Besides these building typology observations, there is a whole other range of issue sto address, to make a large retrofit program work.
The social and environmental urgency of large-scale integrated retrofitting of the European building stock is widely acknowledged and supported by Member states. However, the European building sector has not been able yet to devise a structural, large-scale retrofitting process and systematic approach.
The main reasons for this deadlock are:
- the European building sector is fragmented and not able to offer holistic, integral solutions for nZEB deep renovation toward nearly Zero Energy Building (nZEB) for reasonable costs and good quality;
- the European building process is typically based on a ‘layered’ structure, with many labour actions on the buildings site, with many sub disciplines involved, leading to extra costs and failure risks;
- the European building market is typically top down and supply driven, with a mismatch between the offered products and the end-users needs and the end-user's affordability;
- due to long-lasting renovation process and failures risks during that process, customers hesitate to renovate their property; sometimes high operating cost are more acceptable for owners-residences than deep renovation with low exploitation/ energy costs; a faster and quality guaranteed renovation solution is needed.

Yet there is a challenge to overcome these barriers by applying prefabricated multi-functional renovation elements which have the potential to reduce costs, reduce the renovation time and disturbance for occupants and, at the same time, enhance quality and performances (both in terms of energy efficiency as indoor climate). As the larger building companies are usually very traditional and have no specific economic interest in this transition, it is most likely that this transformation in building practice will be initiated by motivated innovative SME’s, combined with production-line-design specific experience.
The challenge is to make this major step forwards by a combination of product innovation, process

innovation and innovative market approach, in a process of cost and quality optimization, driven by motivated and innovation-driven SME's.

And there are 250 million houses to address, which makes projects as MORE Connect very valuable to explore how mass retrofit methods can be developed and applied .

[1] http://episcope.eu/fileadmin/episcope/public/docs/reports/EPISCOPE_FinalReport.pdf

[2] http://ec.europa.eu/eurostat/statistics-explained/index.php/People_in_the_EU_%E2%80%93_statistics_on_housing_conditions

[3] http://ec.europa.eu/eurostat/statistics-explained/index.php/Housing_statistics

[4] https://www.rijksoverheid.nl/documenten/rapporten/2010/12/17/housing-statistics

[5] Urban and building dynamics: a 3D (exergy) approach required , R.Rovers , 3 rd International Exergy, Life Cycle Assessment, and Sustainability conference (ELCAS3), 07 -09 July, 2013, NISYROS - GREECE

[6] More-Connect, deliverable 3.2: Tool to optimize the combined energy and materials performance of the alternative configurations in relation to local typologies, January 2017

3. Generic concepts of retrofit / The options to retrofit houses

There are in effect several options to renovate/retrofit houses with regard to limiting CO2 emissions. Here the focus is mainly on heating (cooling) and ventilation. Since this is the part that requires building and construction measures. All other demand will not have direct consequences for the building/house performance .

For all options: the targets are much easier to be reached when energy demand is reduced beforehand, demand in the sense of changing the inhabitants use and behavior of the house . (step 3&4 from the introduction) For instance: limiting heated floor area, accepting a reduced temperature level, etc. This will reduce the actual need for energy generation, (and reduce materials for this) , as well as reduce possible materials needs for instance for insulation, avoiding rebound effects in materials related CO2 emissions. In general the focus is here on step 1 and 2, unless otherwise indicated.

Near-0 or 0-energy?
In More-connect the starting point for analyses is Zero energy : it is chosen to analyze all options assuming retrofits to the ambition of 0-energy or energy productive. For several reasons: In due time all houses will become 0-energy Even if today its chosen for a near-0-energy retrofit, to meet climate targets it will be required to make the additional step to 0-energy somewhere in the years after. And to create a *near* 0-energy retrofit, might give a suboptimal result. (see Del 3.2) Even if the actual retrofit will be near 0-energy, for reasons of investment for instance, its better to make a plan for a 0-energy retrofit, and have only proportional measures executed, and others delayed to the future. This guarantees that a optimal solution is chosen for the future, a no-regret concept, avoiding disinvestments, and non optimal CO2 reductions. Besides, as Del 3.2 showed, a 0-energy retrofit in practice will in fact only be a 80% energy reduction result, when (fossil) energy embodied in materials is included. (life cycle energy) .

The options to establish 0-energy retrofits can be roughly characterized by the following list:

energy neutral (-operational)
All operational energy is directly obtained from renewable energy sources outside the buildings boundaries : as co-owner in wind turbine cooperation, as partner in a joint Solar PV cooperation, etc. Most likely the house will need to be all electric . There are some options for non electric heating, but these are not wide spread (ground source aquifer system, district heating). In Del 3.2 these are analyzed. The house will need minor adaptations , mainly to change for all-electric equipment.

0- energy (-operational)
All energy is obtained on site , within the building's legal boundaries. It is commonly accepted that the existing electricity grid is used to average seasonal demands imbalances. Most likely the house will be all electric, there are hardly any options for heating sources within a buildings plot. There might be some heat suppletion form Solar collectors , into a overall electric driven system.

In Both cases above mentioned the energy embodied in the materials is normally not included (for generation and/or reduction) , with a resulting rebound effect in CO2 emissions. This can be significant, and decisive for the ultimate retrofit plan. To optimize *CO2 emissions reduction*, the materials impacts have to be included, and below are some options described with increasing ambitions.

0-energy and low embodied energy (biobased)
The operational target is similar as above, but as far as possible, materials used are from biobased origin. In general biobased materials have a much lower Embodied energy/CO2 effect, per unit of service as non biobased materials. The reduced embodied energy is mainly to be obtained with reduction measures, like insulation. For energy generation and heating equipment its more difficult to change for biobased materials, though there are promising developments, like organic solar cells, and biobased plastics in parts of the equipment. (as well as a low-tech approach to installations)

'climate neutral' (in year x)
A building retrofit that eliminates CO2 emissions from both operational as well as materials embodied energy, can be typified as a 'climate neutral building'. Since all CO2 or Greenhouse gas emissions are addressed in combination and brought to 0 . In the case of a house it could also be named: 0-CO2 house/building, since other Greenhouse gases hardly play a role in a average housing situation.
This requires however a target-year to be introduced, since there will have to be anyhow materials invested with Embodied CO2 emissions, The 0-target can only be achieved after a certain amount of time, when reduced CO2 emissions from operational energy have compensated the invested CO2 emissions from materials. For example: For a retrofit to be 0-CO2 in 2030: the maximum CO2 investments via materials (for 0-energy retrofit) can not exceed the the avoided CO2 emissions from operational energy between now and 2030. This puts a limit on the materials embodied energy to be invested. If more materials (and embodied energy) are invested, the year in which can be claimed 0-CO2 will shift further away.

climate neutral (immediately, now)
A next level would be a house retrofit which is directly 'climate neutral', or has a 0-CO2 performance immediately . Its obvious that in this case all materials invested (to become a 0-operational energy house) should be 0-embodied energy materials and products from the start, which is only possible when all materials are obtained from industries that work with a 0-energy production facility (in similar terms as for a 0-energy house described above) . In other words, companies that already have established a production running 100% on on-site produced renewable energy. In theory its possible, there are a few companies that have already made this transition, but thats very limited. Its mentioned here, since if all materials would be 0-embodied energy produced, there would be no rebound effect in the 0-energy housing retrofit sector. This could be important to address in new policy programs. In fact, since industry will have to make the same transition, it would be more effective to start with industry.

system-neutral (year x)
For completion of this overview this category has been added. CO2 emissions have become our main concern nowadays, and provide a direct threat to society. However its actually a side effect of a even bigger problem, which is depletion of resources. To remain a sustainable level of resource stocks these will have to be restored, regenerated or exploited on a natural replenishment level. This could imply that energy has to be invested to restore or re-concentrate stocks, or land to regrow. It is beyond this project, but mentioned for completion, since ultimately this may also become a serious threat.

The More Connect aim is to have <u>0-energy retrofits with low embodied energy rebound effect </u>. The “ 0-energy target is a hard target, the 'low embodied energy' is a soft target, which provides first experiences in this field. For future projects a hard target for embodied energy should be included, to avoid a too large rebound effect. (See also IEA EBC annex 56 and 72)
Before we will describe the More Connect project more in detail, a analyses is made on the current state of affairs concerning housing retrofits, and the road so far.

Intermezzo: The Dutch practice-experiences :

Case The Netherlands: Mass retrofit, for 0-energy

Introduction

A few years ago, The Netherlands started with 0-energy housing renovation schemes. The main program was initiated by a government supported program-office to support social housing corporations with their community tasks. The program , called " Stroomversnelling" (literally river rapids, but meaning "flow acceleration" ,). started with 6 housing corporations and 4 building consortia to agree in a green deal to start piloting retrofitting houses, then upscale the project to batches of hundred houses, and then to a next level of neighborhoods with 1000 houses. All retrofitted for Nillonthemeter. (http://energiesprong.nl/transitionzero/)[1]

The program has set high ambitions, aiming at what is now called NulOpdeMeter: NOM (or Nill(zero) On the Meter). The difference with a general 0-energy approach is that 0-energy is addressing only building related (operational) energy, NillOntheMeter is addressing all (operational) energy demand (including building services, household appliances and total plug load), below to be specified. The project includes joint concept development, research, as well as building process and market process evaluation and improvements. The pilot projects are financed by the project partners (social housing corporations and construction consortium, the research and management by the program office, while the government committed to adapt regulations and tear down regulative barriers if required (for instance how social housing corporation are financed by the government) . Besides this major program, several other concepts have been developed by other parties, also offering 0-energy retrofits.

The roots for this NOM program were paved a few years before. Several projects experimented with a ambitious retrofit approach. (see for some detailed description of pilot projects in Del 3.1) One of the milestone projects is known under the name of "Kerkrade West" (KW) . (see for a technical description of these projects Del 3.1) . KW was about 150 (row-)houses with each house retrofitted in only10 days to create a (near) zero-energy building, whilst the residents remained in their home. The process entailed prefab panels for facade and roof, which were applied in a process that I called a "mass renovation trains" (Rovers 2014): the construction work was organized in continuous flow approach, moving every day 1 house repeating the same actions. The project was a huge success, technically and organizationally as well as from inhabitants' point of view. It showed that high ambitions were possible, with a new on site approach, without having to move inhabitants. Given the scale of the number of homes that need to be retrofitted in the Netherlands and other countries, it raises the questions of whether this retrofit process could even be more ambitious: can it be scaled up, faster, made more efficient and with less costs ? (see Table 1)

Time	*Can retrofit time be reduced from 10 days to 3? Or less?*
Cost	*Can the cost be reduced from €100,000 to €60,000 or even €45,000?*
Performance	*Can performance be guaranteed for 40 years?*
Design	*Can the installation of services be made more compact?*
Disruption	*Can the presence of workers inside the house be minimized?* *Can the turmoil to inhabitants be reduced?*
Energy	*Can energy generation match total energy demand?* *Can energy demand be managed?*
Construction	*Can the construction be done without the need for scaffolding?*

Table 1: Some Key project related challenges for the Stroomversnelling and the next generation of retrofits

1 English edited information videos and pictures : https://www.youtube.com/watch?v=6b22xNw_fFU&list=PLxqrMoxgE53ndDAFqpEb9h9tbLuB3MD7c&index=

Ambitious, nevertheless, these questions were the basis to start the Nill On the Meter houses program: Now aiming for 0-energy houses , and also known by the name of "Energiesprong" or by the name of the new foundation established: "Stroomversnelling" . As mr den Harder, director at Volker Wessels and one of the new program's construction partners stated at the start of the program: "if we take our climate targets serious, this is the only possible answer" .

The idea is simple: If the house does not consume net-energy anymore, the amount of money that had previously been paid on energy bills can be invested for the renovation , and the cost for the inhabitant (as a yearly redemption and interest) ,in the end could be the same. Besides: the lifetime of the (old) housing stock would be prolonged with 40 years and investments accordingly spread, leveling the energy bill for the same 40 years. Energy saved, inhabitants happy, housing corporation happy.

To retrofit 100.000 houses a year with Nill-on-the-meter ambitions, can't be done the way the market is organized now, is the assumption of the program. Not by a project by project approach,, going through all the hassle of a one of a kind project. It requires a process oriented focus in which a continuous flow of retrofits is established, a highly standardized and mass produced, as well as a to develop a interesting offer for tenants and house owners. (there are different ways for this, but the continuous process is basic) This prerequisite was recognized at the start of the program. It was even the main reason for it. The main focus for the construction and principal partners is developing retrofit concepts, doing pilots , organizing the suppliers and reducing cost, the main focus of the program management is on eliminating institutional barriers, like financing, licensing, performance guarantee mechanisms and so forth. This is the main focus of the program to investigate and develop. The project is running for 3 years and after some delays is now speeding up, with many barriers already removed and solutions developed.

Besides this formal and national ' Stroomversnelling program', other initiatives have grown in the periphery , Many in the construction sector partnered and have grouped together to come up with their own concepts. As well as the social housing sector is no longer the only sector targeted: the first NOM-retrofit projects with private home owners have been completed, and even many consortia now offer new housing as NOM-nillonthemeter concepts. This chapter will start from a focus on the social housing renovations sector aiming for NOM concepts but at the end will shortly describe the other initiatives.
In summary the main issues to deal with are technical concepts , organizing a different supply chain process,, bringing down retrofit cost, removing institutional barriers, and having inhabitants convinced and on board Of course many of these issues interact, and influence each other.

Technical concept
The first project in KW required still some significant work on location. A first main target in the new program is to avoid work on location as much as possible, to reduce costs and nuisance for inhabitants. The most successful pilot required 5 people on location for 1 day, to install the 4 facade panels and two roof elements. Though this is still not established in all pilots, experience suggests there is no main barrier for this to become the standard in future. For social housing this is less important, since rows of houses can be jointly retrofitted. When addressing home owners in the private market, from the contractor's point of view it's important to make offers for individual houses and still have a business case[2]

2 Of course, in general it could be more efficient to undertake complete neighborhood retrofits, which may also include urban solutions. This would require owners to organize themselves in a neighborhood trust, and possibly involve more stakeholders like the municipal level. Again, this would introduce an extra organizational challenge.

The panels itself are completely prefabricated in the factory, and transported to the site in one piece (see videos)[3]. There are in general 2 main ways in which the house can be prepared for the prefab-panels: directly against the old facade (sometimes stripped from balconies and small cantilevers, and old window and door frames removed), or with the old facade removed completely. (ill. 1)

This depends on the design and the technical state of the old facade (in some cases houses have some kind of wooden curtain wall infill facade, which is of no use afterwards) . Besides, architects prefer the full removal of facades, creating opportunities for a new design, not limited by fixed facade openings.

The prefab elements are either directly " mounted" on the old vertical structure (horizontal elements) , or can be supported on the original, sometimes extended, foundation (with vertical elements, in case of a weak main structure). (ill. 2)

The roof elements are usually placed on top of the old roof , with the roof tiles removed first. This way the inhabitants do not need to redecorate their attic . So far the only part that is not directly included in the one day make over: the PV panels. They are too vulnerable for damage during transport. Though this also may have been solved, since the first manufacturers are on the market who produce and transport prefab elements including the PV panels. (Unidek Kingspan- ill. 3). The wall panels are nearly all made of a wooden structure, filled with insulation material, with a vapor barrier integrated foils for airtight connections and optional finishes both inside and outside. They are completely prepared in the factory.

After a few first pilots with different energy concepts, now it seems that the 'all electric' concept will become the standard approach. Mainly since energy generating on location is by PV mainly. Sometimes solar collectors are introduced , (or combined PV and collector units) with ground source heat not really an option in individual existing houses retrofits, mainly due to cost. (though there are other ways, to be discussed below)

Since these are 'NOM' houses, the energy generation includes the production of electricity for household use, not only building related energy demand. This makes the roof surface a decisive parameter, since its should produce all the households energy on a yearly basis. As a consequence the heat demand has to be brought to very low levels, to preserve roof space for PV panels for the households energy part. The main equipment for

3 An example of a 1 day NillOntheMeter – NOM- retrofit in Nieuw Buinen, NL (equipment in white extension on facade): https://www.youtube.com/watch?v=I3WBT2eAArI

heating is a heat pump, air to air or air to water.

After the first few pilot projects, it has become more or less standard to have heating and ventilation installations brought together in a building extension placed outside the dwelling (the "engine room" or sometimes called the "outboard motor" ill. 4,5). This had a large effect on reducing the need to enter the (inhabited) house. Now there is hardly any need for real construction work inside, only some finishing work around windows and doors and making some fittings/ connections to the inside equipment.

Technically, construction wise on site , pilot experience learns there are no real difficulties in doing a NOM renovation on site: the main problems are to make the whole process before actual implementation more efficient, to reduce costs and to develop new installation devices, that is, to compact the whole installation into one small unit. Which seems like a matter of time and upscaling. The main barriers however are in in the process itself: both in the organization of a different construction supply chain, and in re-organizing the market. As one of the stakeholders puts it:" It requires a process oriented approach, no longer a project approach. " Since the projects are similar,, a facade is a facade, its the process that is turned upside down. This was recognized from the start , and small working groups addressed these issues from the start.

Inhabitants.

Some 1000 NOM renovations are now completed and the response from inhabitants has been favorable. As Jan Postema, one of the Social housing corporations directors and partner in Stroomversnelling states: .
"We ask the tenants what they want, and they are immediately enthusiastic. Every time we complete a project, the neighbors come and ask when we will start with their houses. "
Except for an occasional problem, the program performs beyond expectation regarding inhabitants. However it must be said that the main success is that people feel living in a new house, have much more comfort and the neighborhood is upgraded as well. One of the inhabitants: " The whole operation was less stressful as thought. In a few days everything was fixed, and we felt we had moved into a new house.

Advantages: table 2

– inhabitant satisfied
– comfort raised, housing cost fixed
– lifetime houses prolonged significantly
– new business model for construction sector
– CO_2 emissions avoided
– by upscaling cost reduced
– stimulates innovation
– cost neutral
– no direct subsidy

Financially it hardly makes a difference for the tenants. For the tenants the costs before or after the renovations are equal, or even somewhat less. After renovation the energy counter reads 0 each year. The money that normally went to the energy supply company, is now transferred to pay for a long term loan of equal monthly costs, for private home owners. In the case of social housing tenants, a new law has passed recently that allows the social housing corporation to charge tenants a 'Energy performance fee' (EPV), that will pay for the investment cost made by the corporation. The fee that can be charged by the social housing corporation is based on *the level of heating demand per m2 floor, in kWh. In practice this means that the tenant pays the same amount as the former energy bill, only now directly to the social housing corporation, who made the investments. This is one of the main issues already solved to make the whole program work, since before that it was not allowed, or only after all tenants had signed to agree. Which was a very time-consuming and unsure process. .*

On costs

The financial concept is simple. The sum that went to a former monthly energy cost can be considered as the capital and interest for a 25 or 40 year loan, of the same level. This provides the investment budget for the retrofit. In the Netherlands, this is based on an average of €175 per month , giving a loan/investment budget of around €47500 for the retrofit (on a 30 years loan pay off basis) . The cost for the initial project in Kerkrade West was €100.000 per house, but the cost has been reduced with subsequent pilots to €80.000 and now is around €60-65000. This amount could be acceptable in social housing sector because the calculations can be based on a longer period of return of investments, upto 50 years extended life time of the house. However, 50 years and €60,000 is too high for the private sector (housing loans are maximised for 30 years). Prices need to reduce further to be viable in the private sector.

A further radical reduction in the price of a retrofit is feasible. When considered pragmatically, the exercise consists of the production of 6 elementary prefab boxes (wood frames fitted with insulation, windows, doors and finishes) , the provision of an external, compact services unit and their fixing by a few people and a crane in one day. Why should this cost the equivalent of 6 small cars? As one of partners in the program sighed (a social housing corporation representative) : "The biggest problem (and cost) is that there is still a traditional construction firm in between factory and mounting...."

supply side process

Most important conclusion so far is that the step from a project to a process approach has not yet been made. As was concluded by the project team after analysing the latest group of pilots. , As JanWillem van de Groep, one of the driving forces behind the program puts it: " The project oriented builders make hardly contact with with the "component manufacturers and suppliers" , who are by definition process oriented, and these do not easy make contact with the (building) project industry."

Its two different worlds so far. While for upscaling and industrialization (and cost reduction) the two should co-operate. Builders are not yet fully convinced of the importance of industrialization. In his recent evaluation (vdGroep 2016) he concludes that there are only two consortia really developing a process approach, say " NOM 2.0" . Which will be completely industrialized production lines delivering on command, with flexibility in design built-in. The question is whether traditional builders will be able to develop and adopt this new process, or if it will be the existing component industry that develops the new market, and building and construction has to follow, or not. .

However, as vd Groep mentions, Going through this generation 1 process is unavoidable on the way to a generation 2 development. But the generation 2 is essential to really push of the transition, upscale and bring cost down.

A important role could exist for the supply industry, producing components like window frames and classic facade panel industries . They are equipped for prefab panel production, only the size increases. They could be the natural new market leaders, and learning fast how to extend their business to include installing and mounting the panels. At the same time the large construction companies from the first hour are also looking into building new production lines. The market is in motion , and future will learn how this ends.

Market organization

As mentioned, the main issues are in the institutional , and regulative sphere. This has been acknowledged and as a result a new association is established involving stakeholders in order to develop a clear supportive framework dealing with the issues in table 3. The organization is set up as a Foundation named "Stroomversnelling" , and companies and principals can join subscribing to the goals of the program. Even a police related organization dealing with burglar safety has joined, to help integrate this in the prefab concepts. As well as a fire safety organization, and many commercial industries joining, afraid to miss the train. From the start this program was nationally oriented, but more and more provincial governments are coming into play: its seen as a strong instrument to meet regional policies and targets , and support local organization and roll out of retrofits. It even drips down to municipal level initiatives. A recent independent survey showed that 42 % of people sees NOM retrofits as attractive to very attractive, and after showing pictures of pilot results this increases to 53% . People interviewed point to their municipalities as stakeholder to actively promote the scheme. The survey was initiated by the large energy company Eneco, as a gesture in becoming partner in the new Foundation.

Non-technical issues to solve, table 3
Energy Performance overall , and PV output
" Energy-bundle" to balance
Clear agreements with tenant
Monitoring performance
Maintenance and exploitation contract over 40 year
Financial agreements
Reducing electricity for household demand.
Licenses in 1 day
Thermostat level for the base case
Acceptable Temperature level in summer
Quality surveying
Guarantee scheme
Disputes settlement
Label /certification / NOM standard
Cost reduction
For private home owners: how to deal with contracts and guarantees when selling house
front facade extension over public land/sidewalk

Transition movement

The whole initiative has become a huge crowbar in creating transition, not only in reorganizing the process and market, but also as " a national movement" The initiative created substantial pressure on the "old fashioned industry" , as well as on politics to develop new innovative market approaches, . Here the new social media come in and could be a game changer in this new era: Most people involved in the program, are very active on twitter, linked in and the like, and push the new approach. Every quote from a politician which seems in favor of " the old school' , is heavily reacted upon. Its all included: closing coal mines, changing subsidy schemes, criticizing lobbying statements . Every report, publication or new item is directly responded to in the social media, either positive or criticized. The total creating hard pressure on the 'old economy sector' to make a real shift .

The private sector

The first projects now have been piloted selling 0-energy 'make overs' in the private sector. This entails a different set of financial parameters, as there is a different financial regime and ownership pattern to the social housing approach. The financing scheme for private sector homes entails the valuation before and after a retrofit, since this is a deal directly between market party and owner/inhabitant. One of the things already in place is that government has allowed for an extra loan-space when people retrofit to NOM standards. Normally when buying a house, the buyer is only allowed to have a banking loan no larger than the value of the transaction. This is a government regulation to create a healthy housing market without to much risks involved by over-financing. Now the government has adapted the rules to allow the amount of the loan to be extended if there is an energy efficient retrofit: , a maximum of €27,000 extra is allowed for a mortgage to cover this cost. Banks are interested as the living costs afterwards are fixed and there are no energy bills for the inhabitants.

Other issues for private home owners have not been resolved. For example: What happens when the house is decreasing in value? Or: What happens when the house is sold again? If the loan is person related and the *house has increased in value then no problems are expected. However, taxation experts will have to learn how to value property for NOM. How should the NOM value be included when the house is sold? The now prevailing idea is that loans, at least for the retrofit part, could be building related instead of person related. So when buying a NOM house, it comes inclusive the loan for the previous NOM retrofit by the previous owner. This makes sense as since the loan comes in place for the energy bill that new owners normally also have to adopt. Some financial oriented pilots are running, and one is where the NOM investments are part of service costs of the house (as for instance is common in privately owned apartments as part of a multifamily building) . The recently installed new government (oktober 2017) has announced to make preparations for a legal framework of building related loans.*

related initiatives

Seeing the issues to overcome described above, its obvious there are other concepts developed by "none" NOM partners, looking for other solutions, and the more since of course not all houses are fit for the standard NOM approach.

modular

The NOM approach is a all in once concept: the whole house is refurbished, financed and 0-energy performing. Since the cost are still high, its an option to do this process step by step: the retrofit is done in phases, and some organizations and industries have joined to offer a modular concept (Alliantie+): the Engine, the facades or the roof can be retrofitted separately. Of course the elements combined deliver a similar performance as the NOM concept. Its a way to spread investments.

Examples of retrofits with modular components: : facades and roof (NOM-ready), only facades (NOM-ready), only roof (NOM ready), facades and roof (' no regret'), and full NOM retrofit. (NOM ready is incl. hh energy, No regret is optimized for building energy coverage . Source: Bouwhulp, the consultancy partner, and most examples in cooperation with Eindhoven Social housing corporation 'Woonbedrijf'.

Pure 'PV'

This is the most basic approach: all operational energy (building related and/or household energy) is supplied by renewable energy sources: building connected (0-energy) , or distantly, trusting on a full transition for a national renewable energy supply (energy neutral). In fact a lot of people already buy so called " green electricity" , from a grid based supplier, and formally are 0-energy for their electricity . However, nearly all houses in the Netherlands use gas for heating, which therefor requires a additional and separate strategy to make heating 0-energy or energy neutral (see below) . Its possible to change the heating system to all electric as well, and produce or buy more renewable energy. Usually this is combined with basic reduction measures, like cavity wall insulation, roof /floor insulation and double or triple glazing.

Urgenda / thuisbaas

One of the alternative approaches is developed by the NGO Urgenda.[4] Two years ago they launched a plan to have the housing sector energy neutral in 25 years, and have started piloting 0-energy housing retrofits. Their approach is more case by case, and including behavior of inhabitants.
Their first pilots aimed at the private sector, in helping people to create a NOM-similar situation. Energy

4 Urgenda is the organization that successfully sued the Dutch government last year, which was convicted to increase the CO2 emissions reduction to 25% by 2020. They not only claim more should be done, but are active in showing how as well.

reduction by behavior is the start, people decide what can be reduced in demand, before to plan the retrofit. It must be said that the first pilots took place with families that already had a more sustainable attitude, and were prepared to accept adapted behaviour and in some cases a somewhat lower comfort (like putting on a sweater when needed) . This makes it possible doing a retrofit without a full façade make over, and for instance to have the former architecture preserved. Which has implications for the inside climate and comfort. The remaining demand is addressed more technical. Introducing efficient equipment , like heating with infrared panels, and a larger amount of PV panels installed, sometimes not only on the houses roof, but with some extra panels in the direct neighborhood, for instance on garage boxes. The result is Nill on the Meter as well, at a lesser extreme 0-balance level, that is, less extreme insulated house, but a lower overall energy demand, when including household energy. Also the rebound effect by embodied energy seems lower, though still has to be calculated in detail. They have succeeded in doing this for far less money, pilots range between 20000 and 35000 Euro per house. It however requires inhabitants that have positive attitudes in the process, since it requires adaptation to a new way of living in the house, whereas NOM renovation in the social housing sector are very vulnerable to inhabitants that don't want to have their way of living put upside down.

Retrofit or demolish and new construction?

Without going to describe all other options under development, there is one other approach that should be mentioned and that is the lobby by some stakeholders to claim that demolition and new construction is by far better then renovating old houses to NOM level. There are many reasons why a new house could be preferred before a nom retrofit, but cutting on CO2 emissions is not one of them. In the end, both retrofitted and new houses will be NOM houses, 0-energy houses, so both will have no emissions from operational energy anymore. However, as argued before the remaining CO2 emissions are from materials invested, their production has caused fossil energy invested and related CO2 emissions. It is not difficult to see that the new house will require around twice as much resources . Both have no emissions from operational energy, but the new house has roughly double CO2 emissions from materials,.

In other papers, results from work in IEA annex 57 (embodied energy, www.annex57.org) and DEL 3.2 from the MORE connect project (http://www.more-connect.eu/) more detailed calculations are presented .

(Not part of this chapter, but the NOM approach has now also been adopted by the construction of new houses as well.[5])

materials burden

As the example above showed, materials are becoming a more and more important factor. Also in comparing different renovation concepts from the perspective of resource use and CO2 emissions. In fact its a paradigm shift that takes place when creating 0-energy houses: At that moment, reaching 0 , operational energy demand becomes obsolete from a environmental impact perspective: the use of solar radiation (or sometimes heat from sub soil) is completely impact free, it has no side effects . What creates impact is embodied energy, by the use of conversion devices for capturing and converting that renewable energy and application of facade and roof panels to reduce demand. The level of balance at which 0-energy is established (more/less insulation, less/more generation equipment) can vary, but 0 remains 0, and the optimal level is decided by the least impact from all materials invested (As I sometimes put it: a solar panels is a building material, (and has impact) , the energy is a free bonus with the panels) (Rovers 2015).

There might be other reasons to change a particular retrofit concept (like facade renewal due to bad technical conditions) but from a resource and CO2 impact , there is no need to extremely insulate for instance. See the Del 3.2 from this project.

5The NOM retrofit approach has ignited new initiatives in the new housing market as well, and different comparable concepts are now on offer and realized in practice. One of the best scoring example is by Volker Wessels construction company, that has build around 500 new Nom houses last year, completely prefabricated in a new factory. The concept is concrete based, and the house is build in 1 day ! As Onno Dwars , innovation officer at VW, puts it: *" On construction day, at half past one the ground floor connections are installed and you can already go to the toilet..."*

VW plans another 1000 for this year, and is already expanding the market to Germany, for which they hope to contract a few hundred this year. (an example of a 1 day construction of a nillonthemeter -NOM – new constructed house : https://www.youtube.com/watch?v=G0nyZFYCF-I

The current concept is just a clumsy concrete poured elements based system, but they are aware of the materials impacts and will pilot a first biobased new NOM housing concept somewhere this year.

Seen from this perspective the Urgenda case is highly interesting, since it operates at a higher 0-balance level, with reduced consumption and relying more on new low impact technology like for instance infrared heating panels. A first rough calculation shows that in terms of embodied energy in all the measures to create a NOM house, the Urgenda approach might be even much lower . That is: the burden from operational energy impacts shifted to materials related impacts is lower , making it overall a better solution from environmental point of view. Its however a complete different business case, and requires inhabitants to cooperate. And as such is a different operation of the building chain, individualized and case by case solutions. not like the industrialized targeted approach in the Stroomversnelling. Both research and adoption in practice should show which will be more feasible, and for which kind of projects.

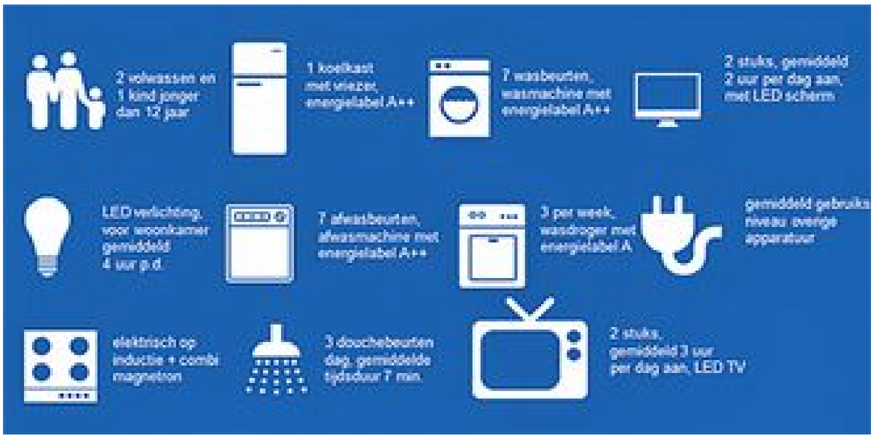
Behavior and guarantees.

Despite four decades of efforts to calculate and predict energy demand, practice is hard, to meet that goal, its a very complex thing: maintaining comfort levels, including inhabitant behavior and the constructions interaction with heat and ventilation. Nevertheless, 0- is possible , it has been proven by many (and clearly measurable, since the meter should be 0 at the end of the year) , but usually requires some calibrating by the inhabitant or owner: how to manage the installations, bringing night temperature down or not, what about ventilation, drying the laundry in or outside, opening windows at night in the bedroom, many things interact, and after a few years the front-runners have things under control. So , in fact 0 is possible, and not a big deal, with concerned people.

However with mass renovations of houses, inhabited by people that have no clue about all this, and still want to guarantee 0 over 25 years or more , its a different thing. In that case everything on the back end must be solidly boarded up, to avoid disappointments and even claims. And this still is a lot of work...

Besides: research shows that people in their old houses most of the time live more energy efficiently as the calculations predict. (Itard 2012, Sunnika 2012) One of the reasons is they behave more economically, and have years of experience of how their house interacts with their heating device. With a complete new installation, they have lost all contact with fine tuning the heating-building interaction. On the other hand, with the very low heating demand, things get less critical. But here, in the background, there is still a lot of work to do.

If the renovation includes energy supply for household use, its important to agree on the distinction of what part of energy is supplied for what use, and what the maximum use is for either building related or household related energy demand.



The NOM retrofit program contracts come with household energy use included. For this a basic standard is usually set at 2700 kWh, (see ill 6) , arranged in contracts and part of the “ blue table” performances agreements (see below) ,The list includes showering , cooking, lighting etc at a basic comfort level. Including the 2700 kWh to be generated by PV on the roof, requires a retrofit that is fully based on extreme levels of insulation and airtightness: to have enough roof surface available for this household demand besides the building related demand. (While a pure building related energy and materials optimization *might have led to a different concept.)*

Energy saving by inhabitants in the Stroomversnelling /NOM approach is not actively stimulated beforehand (although information is given) . Though its must be said that the NOM principle is such that in case people reduce demand afterwards, below the set standards, and as a result have a positive energy balance at the end of the year, they will be refunded for the delivered energy in the current business case. (this is according to current feed in tariff structure in the Netherlands. There is much discussion about this scheme: whether consecutive governments will maintain this scheme). Not directly intended, but in fact the 2700kWh scheme puts a cap on household energy demand. (and in fact a 'accepted level of consumption'... whether this can be sustained in future, with more harsh CO2 targets, is the question.)

Delivery agreement - Blue table

Now what if inhabitants leave the windows open in winter (i.e. willfully disregard the intended operation)? These kind of questions are the main regulatory problems to tackle, not the technical ones.

With regard to opening windows, the chosen approach is to guarantee a fixed-energy bundle for operational energy, to with a set standard of comfort and performance.. This poses another question: how to monitor the fact that energy increase is not related to malfunctioning of the equipment? This requires a monitor protocol, which is now being developed. Mainly based on long distant data gathering, but with the outdoor engine its easy to check equipment without disturbing inhabitants. And its intended to help guide the inhabitants, as when a strange data series pops up: the inhabitant can receive a mail showing that his energy demand is unusual high.

But to monitor and evaluate , you need to know not only how much energy is involved, but what in fact is delivered and guaranteed as "performance". Part of all this is of course a clear understanding and agreement with the inhabitants of what should be guaranteed: A so called Blue Table[6] is in place, listing

Blauwe tabel Prestatiespecificatie

	De minimale haalbare temperatuur in woonkamer en keuken	[Y] °C			De minimale haalbare temperatuur in woonkamer en keuken bedraagt 21 °C
	De minimale haalbare temperatuur in slaapkamers	[Z] °C			De minimale haalbare temperatuur in slaapkamers bedraagt 18 °C
	In de woonkamer en slaapkamers bedraagt de maximale luchtsnelheid (tocht)	[V] m/s			De maximale luchtsnelheid bedraagt 0.15 m/s conform NEN 1087.
	Het maximaal onderling temperatuurverschil tussen ruimteluchttemperatuur, stralingstemperatuur en temperatuur van de ventilatiestroom bedraagt	[T] °C			Het maximaal onderling temperatuurverschil tussen ruimteluchttemperatuur, stralingstemperatuur en temperatuur van de ventilatiestroom bedraagt volgens NEN 1087 5°C
	Maximaal aantal uren boven de 26 °C in de zomer in verblijfsruimten en slaapkamers	[H] uur/jr			150 uur wordt beschreven als maximum in ISSO 74. thermische behaaglijkheid.
	Beoogde beoordeling (rapportcijfer tussen 1 en 10) van de bewoner				Dit wordt middels enquête vastgesteld
Binnenmilieu	Ventilatie conform bouwbesluit nieuwbouw of bestaande bouw?	nieuw / bestaand			Het verdient de voorkeur de Nieuwbouweisen voor ventilatie te volgen.
	Indien de woning wordt voorzien van mechanische luchttoevoer en -afvoer	Ja/nee			Het verdient de voorkeur dergelijke ventilatiesystemen uit te voeren met 100% bypass en conform ISSO 62

all

features that are legally binding for the performance contract. It contains indicators among others like :

- minimal available renewable energy for household use
- maximum required energy for building related demand
- amount of hot water at x degrees at tap points
- the minimal indoor temperature for which the system is guaranteed,
- maximum difference between air temperature and radiant temperature
- maximum amount of hours of temperature above x degrees in summer

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6 Link to Dutch version of Blue table: http://www.svbrabant.itscreative.nl/downloads/index.php?file=20150217%20Blauwe%20tabel%20prestaties%20uit%20Afnameovereenkomst-16-2-2015.docx

- max CO_2 levels for certain % amount of time,

In fact this also includes minimal PV panel output throughout the years . Reason why most systems are somewhat overpowered. It has already experienced in the first pilots that a certain bandwidth in performance should be allowed, so that inhabitants occasionally can heat above agreed levels.

Disputes

Nevertheless : how well you arrange things, there will be disputes. One of the measures to tackle this is to have installed a a certification and labeling scheme , a independent evaluation of what is delivered by market parties. In March 2017 the first 'NOM labels' were issued for different concepts of parties involved in the program. (in fact three labels, one for NOM products design, one for NOM product application, and one for NOM product maintenance) This is also to safeguard the approach, since others outside the formal program are also developing market offers for NOM houses, and sometimes with different approaches. This is to protect the whole program scheme. . And of course a dispute settling protocol is needed, which is still in development.

First results are encouraging , a inquiry among inhabitants of pilots showed: the general score people awarded the retrofit was a 9 out of then, the least scored "honoring agreed commitments", a 3 out of 10. . Which already led to adapted approach on site: the workers won't leave until complaints are addressed!

'energy neutral' approaches : heating

So far this article addressed mainly 0-energy approaches. But there are other ways, like the energy neutral approach: the total is 0, but can also be derived from (controlled) local solutions, outside the buildings boundaries. Which is a less rigid focus to the individual house, and introduces more neighborhood or district oriented solutions . These could be interesting from a material perspective , to avoid the rebound effect from energy impacts to materials impacts. The main issue here is the heat supply. One of the options could be district heating, however this builds a case on often unreliable heat sources. For instance if its waste heat from industries, which are only available as long as the industry has a very inefficient organization of its production process, If the industry invests in energy efficiency measures, the waste heat source will run dry of course. Or , in case of longterm heat supply contracts, the industry is impeded in becoming more efficient (lock in).

Biomass to fire a heat-plant is in some countries popular. It depends of course on the availability of biomass not compromising agriculture, or clearcut of forests. Currently there is also much debate about the CO_2 effect: indeed using wood could be carbon neutral, the tree is replaced, but only after 40 or 50 year. This implies that at least the first 40 years the trees cut and burned will add to the CO_2 emissions.

Another more promising way is to use shallow or deep soil heat. Deep soil heat with aquifer technology is a interesting option, which becomes feasible when applied on street or neighborhood level. A even more simple approach is shallow soil heat : a basic piping grid (potentially made of small tubes from biobased plastics) applied at minus two meters (depending local situation)which can provide basic heat at 7-12 degrees year round. Its of course difficult to have such a grid placed under a existing building, but in the period ahead of say 35 years , all roads at some point will be replaced or re-paved. That could be a natural moment to bring in such heating grid, and connect houses to their grid section in front of their house. It requires a multi stakeholder approach, but could be very effective. The retrofit project would become a 2-phase process: in a first step only roofs would be retrofitted , insulated and with PV on top, which directly reduces CO_2 emissions by the household, without changing or interfering with their housing habits. In a second stage the heating is addressed , at any moment, since the grid is there , and could be connected for instance when new inhabitants move in. . This is not yet piloted, but it shows that a business case is one thing but optimizing should be considered not only from operational point of view (and from 1 buildings perspective) but also from a effective materials investment point of view. New business cases and cooperations would be needed.

Another interesting development is that the poly-crystalline PV panels may become obsolete to be replaced by thin film technologies, which by now already are stable in producing 12-14% efficiency.[Jager 2016]. And will be much more materials efficient, and more flexible in applying to roofs (as well as on facades !) Again , a detailed study should compare all these concepts in development.

Recent developments:

Infrared panels

There is one technical option that is hardly used , addressed or researched: heating with infrared radiation panels (used in the Urgenda retrofit approach) . These fit in a all electric concept, and can have interesting features: like only heating when people are around, and requiring reduced air temperature levels since heat radiation levels are higher as normal. There are some promising pilots carried out, but it requires a solid and robust research program to have all the ins and outs documented.

House Extensions

The retrofit options that include household energy, and little behavior reduction, face sometimes the problem of a lack of surface to install PV panels. Similar like multifamily houses have less surface per household available and have limited options for installing enough PV elements. (while less outside facade surface per living unit is of course a positive aspect, related to less heat loss through walls)
In case of single family houses we see some first initiatives to offer house extensions as carrier for additional PV, like green houses, pergola's and such. This is of course a doubtful trend, since its required to supply the original house, while at the same enlarging the m2's and (potentially) energy demand. (Lighting and in some case heating) Also it increases the rebound effect in Embodied energy, since more construction work is added. It might seem better to find nearby locations for PV panels, or have joint solutions on neighborhood level for these cases) (and or have demand reduced before hand) .

Research

Research for large scale prefab solutions is increasing fast. In preparation for a MORE-Connect contribution to the International conference Transition 0 in Utrecht in 2016, (a NORE Connect session on retrofitting the EU), a inventory was made on how many EU funded projects were related to large scale and prefab oriented retrofit for 0 and near-0 houses. Already 17 major H2020 projects were identified (early 2016) , all long term, 4 years, multi million projects. (table 4) The knowledge is growing as well as the urgency to act in this field, recognized by the EU. Which will however require serious research into the environmental impact consequences of all options, since we want to avoid ending up solving the energy issue, but finding that the materials impacts is even greater. That's in my view the most important task ahead.

2016 EU H2020 projects related to large scale prefabbed retrofits (2016) Table 4

More-Connect: prefab retrofit infor 5 climate zones: techn. Dev. & EU Guidelines http://www.more-connect.eu/
Refurb: Refurb gives an overview in a one-stop-shop model; http://go-refurb.eu/
BERTIM: Building energy renovation through timber prefab models; http://www.bertim.eu/
Breasar: a cost-effective, adaptable and industrialized "envelope system" http://www.bresaer.eu/
NewTREND: design methodology, to improve the existing European building stock; http://newtrend-project.eu/
OptEEmAL: Optimised Energy Efficient Design Platform for refurbishment ; http://www.opteemal-project.eu/
INSITER: self-inspection techniques and quality check for eff. constr.processes; http://www.insiter-project.eu/
E2VENT: integration of an innovative adaptive ventilated façade system; http://www.e2vent.eu/
HOMESKIN: Advanced Aerogel-Based Composite material insula for insulattion materials; http://homeskin.net/
MODER: business models for efficient refurbishment. http://www.vtt.fi/sites/moder/
CREATE: developing a compact heat storage no website
BUILD UPON: design and implement strong, long-term national strategies; http://buildupon.eu/
Europhit: EnerPHit Standard as the goal and Passive House principles as the basis; http://www.europhit.eu/
REVALUE: develop a set of norms, standards and policies for the valuation of ee property; http://revalue-project.eu/
Rennovates ; systemic deep renovation concept using smart services   http://rennovates.eu/
Energiesprong UK mass housing retrofit , removing institutional barriers http://www.energiesprong.eu/
EU-Gugle (FP7) nearly-zero energy building renovation models in 6 pilot; http://eu-gugle.eu/
Cohereno: (FP7) develop high efficiency refurbishment of single-family houses; http://www.cohereno.eu/about.html

Conclusions

Building for ages has been a ‘one time investment’ market, with longevities beyond someones lifetime. Thats changing. Just like other sectors are forced to develop new business models so has the building sector. And now we are at the moment that walls , roofs and complete building become a commodity , just as other building and housing elements before . [Rovers 2015] As described in this paper, the market organization and business models all will be turned upside down.
In terms of delivering panels and doing the retrofit on site this does not provide much difficulties, its fast developing and improved. The real innovations come from two other sides: re inventing the regulatory and institutional framework around housing, and secondly, innovating the supply chain. In order to speed up production and reduce cost of prefab retrofits , it needs to change from a (single) project orientation to a (continuous) production process organization. (at least part of the market)
The structure of the construction industry is changing. There are efficiencies to be gained by moving more of the production away from the site and into larger organizations -with a minimum amount of time spent on site to fix the new panels and new "service boxes'. In other words, the construction industry might move away from a craft-based industry to a service based industry - with the products made off-site and just bolted into place.

For the regulative framework and financial arrangements developments are going fast, procedures are adopted, financing schemes designed, and formats developed. The supply side development is going slower as expected, mainly due to the fact that construction firms still have difficulties in connecting to the component industry, and vice versa. “suppliers of components have to learn as well how to produce for a process market: As prefab element builders we want different specs as they are used to deliver for the construction site. “ as is the experience from Jan Kamphuis, BJW, one of the consortia doing NOM retrofits (and More-Connect partner).
After having optimized the work on site, the next step is to optimize the production of the prefab elements. And supplier cooperation is required to minimize cost in the factory. First talks between suppliers and panel builders are now ongoing.

The concept of NOM retrofits as in “ stroomversnelling” is gaining interest, and in 2016 a UK-France proposal led by energiesprong has received funding from the EU for building a similar organization as in The Netherlands to introduce energiesprong / stroomversnelling approach in England and France. A consortium has already been formed in England to have a quick start.
With RiBuilT/SBS center I am involved in developing a similar initiative for Ireland, as well as for Scotland. However it must be said, that besides retrofit, Ireland is in urgent need of new houses there is a big shortage at the moment And this could maybe even more interesting to introduce NOM concepts right from the beginning.

We are only at the beginning of this major change. Its still to see how for instance 3D printing will fit in this new market, as a alternative approach for instance , there are interesting pilots running at the moment. All those changes will be accelerated by the increasing pressure from climate change and scarcity of resources. A drastic reduction of CO_2 emissions of 255 million houses in the EU is at stake, and time is running out: Climate change wont wait for us to act, and is even going faster as expected. Which was stressed in March last year with the paper by 19 scientists headed by James Hanssen, and concluding: " we have a global emergency. Fossil fuel CO_2 emissions should be reduced as rapidly as practical." [Hansen 2016] The old model wont work anymore.

References

Friedlingstein P., Andrew R., Rogelj J., Peters G., Canadell J., Knutti R., Luderer G., Raupach M., Schaeffer M.,Vuuren D. Le Quéré C., (2014) Persistent growth of CO2 emissions and implications for reaching climate target , in Nature Geoscience 7,709–715

Groep, JWvd, (2016) column/report JWvdGroep, programm leader Stroomversnelling (in Dutch) retrieved from https://janwillemvandegroep.com/2016/02/28/industrieel-produceren/

Hansen, J., Sato, M., Hearty, P., Ruedy, R., Kelley, M., Masson-Delmotte, V., Russell, G., Tselioudis, G., Cao, J., Rignot, E., Velicogna, I., Tormey, B., Donovan, B., Kandiano, E., von Schuckmann, K., Kharecha, P., Legrande, A. N., Bauer, M., and Lo, K.-W.: Ice melt, sea level rise and superstorms: evidence from paleoclimate data, climate modeling, and modern observations that 2 °C global warming could be dangerous, Atmos. Chem. Phys., 16, 3761-3812, doi:10.5194/acp-16-3761-2016, 2016.

Itard, L., Macjen, D., & Visscher, H. (2012). Energy Labels in Dutch Dwellings: A comparison with the actual heating energy consumption. Research report. Delft University of Technology, Research Institute OTB, Delft, the Netherlands, and PLEA 2012 Lima Peru conference paper

Jäger K., Lenssen J., Veltman P., Hamers R., (2013) Large area production of highly efficient flexible leight weight thin film silicon PV modules HyET Solar BV, Arnhem, the Netherlands, white paper presented at 28th EU PVSEC 2013

Meinshausen M., Meinshausen N., Hare W., Raper S., Frieler K., Knutti R., Frame D., Allen M., (2009) Greenhouse-gas emission targets for limiting global warming to 2C . (2009) , Nature, Vol 458 April 2009.

More-Connect 2016: EU H2020 project: http://www.more-connect.eu/

Rovers R., (2014) .New energy retrofit concept: 'renovation trains' for mass housing , in Buiding Research & Information ,Volume 42 issue 6 2014, HYPERLINK "http://www.tandfonline.com/doi/full/10.1080/09613218.2014.926764" \l ".VKquEI-RA5Y " \n _blankpage 757-767.

Rovers, R., (2015), Climate Agreement (2) : your CO2 budget… , retrieved from http://ronaldrovers.com/?p=60

Rovers R., 2015 Houses as commodities, sold in parts, : retrieved from ***http://ronaldrovers.nl/?p=75***

Rovers R., (2015) Beyond 0-energy : paradigm shift in assessment, in Buildings, special issue low Carbon Building design, 2015 Volume 5, page 1-13

Sunikka-Blank, M. & Galvin, r. (2012). Introducing the prebound effect: the gap between performance and actual energy consumption. Building Research & Information, 40(3), 260-273. DOI: 10.1080/09613218.2012.690952

Additional material: (video's and websites)

2012-2013

first project retrofit in 10 days, in inhabited situation, near-0: https://www.youtube.com/watch?v=mvEOQTxFRYE

this was the inspiration to move to faster retrofit and real net zero retrofit. The program started under the name ("green deal") : Stroomversnelling,

2014

first Pilot net-0 : jan 2014: https://www.youtube.com/watch?v=BvXVVQZ_hso

the first Pilot, In English version: https://www.youtube.com/watch?v=6b22xNw_fFU

short lecture in English from 2014:https://www.youtube.com/watch?v=IYIa_JlcR3o

this was basic for a international EU proposal : Transitiom-0, now granted: see below "english

One of the first pilot houses, showing the labor intensive prefabrication: (Arnhem) :https://www.youtube.com/watch?v=qRCGZ6Y0ooc

another 1st serie pilot, (Nieuw Buinen):https://www.youtube.com/watch?v=UyEKBVEdgpM

1st multi-family house : https://www.youtube.com/watch?v=nHu52TMuGXo

The step to new housing construction: Building netZEB houses in 1 day:https://www.youtube.com/watch?v=G0nyZFYCF-I

2015:

Renovation in 1 day, by Volker Wessels Building company:https://www.youtube.com/watch?v=I3WBT2eAArI

pilot in Tilburg:https://www.youtube.com/watch?v=B_vLFZImCDw

2016

second generation pilots: (Roden) https://www.youtube.com/watch?v=cBDuBjZt9gU

general:

website for the partners in the Stroomversnelling program:http://stroomversnelling.nl/

website with photodocumentation of all projects:https://www.flickr.com/photos/140019931@N07/albums

website as knowledge base for the projects (standard contracts, performance statements, financing, etc)

http://www.energieling.nl/

In English: http://stroomversnelling.nl/initiatief/internationaal/ , http://transition-zero.eu/ , http://www.energiesprong.eu/

4. specific concepts compared

This chapter gives a general illustration of how the ambitions for *'0-energy housing retrofits with low embodied energy"* , and how these could be translated into different actual and practical building retrofit approaches. Below is such a summary, based on experiences in NL, however limited since many more are possible.

1 'pure supply' ,
2 Whole make over ('energiesprong/'NOM'),
3 'modular',
4 Individual case optimisation ('Urgenda'),
5 'summer/winter house' ,
6 hybrid/'gas phase out'
7 passive-unheated

1 **Pure Supply**: Nothing essentially is changed at the house/construction level, energy requirements are fully met by extensive renewable energy production and if required additional installation equipment, The supply can be on location (0-energy) or off location (energy neutral) . Basic reduction measures could be included, like double glazing and cavity wall insulation.

PROS: does not change inhabitants use of the house: no disruptions; no change of architecture, if combined with basic reduction measures; 0-operational fossil energy (building related); adaptation behavior not required (but possible).
CONS: requires change for all electric equipment; possibly not enough roof surface for all PV (especially when household demand addressed); no incentive for adaptation behavior (reduced demand)

2 Whole 'make over'/Energiesprong/NOM
The house is completely renovated, new facades and roof, at Passive house level standard, all electric outfit. All roof surface is used for solar panels . Buildings as well as household energy consumption is covered. No change in lifestyle required. Prefabricated elements, and the retrofit is carried out in a few days.

PROS: Creates more or less a 'new house' ; up to 50 year life extension; 0-operational fossil energy (building & household related); all measures in 1 phase; inhabitants don't need to move; covers near-future maintenance.
CONS: change for all electric; whole house comforted: lock in inhabitants behavior; large EE-rebound effect; (still) too expensive; no option for heritage buildings or special "architecture".

3 modular : Comparable with Energiesprong/NOM, only in phases and with modular components: investments can be spread over many years.
PROS: as 2,
CONS: as 2,

4 Individual case optimization / 'Urgenda': a personalized approach : with any mix of measures, aiming for 0-energy: inhabitants can choose to adapt behavior, or limit energy demand beforehand, accept a somewhat different comfort experience, apply a basic set of reduction measures (cavity wall insulation, double glazing) plus mix of installation measures: all electric usually, heat pump, combined with infrared heating .
PROS: "personalized"; less expensive as "whole make over" (2,3); including potential demand

reduction beforehand (behavior, use of house); flexible: (demand reduction afterwards possible by adapted behavior),
CONS: mainly all electric; normal maintenance remains.

5 Summer Winter house
Summer-Winter house concept: compartmentalization of the house, only core of the house is kept at comfort levels during the coldest periods, (or cooled during hottest periods) , only core is retrofitted for 0-energy performance. Outside the core basic on demand heating can be available (infrared panels for instance) (in fact a extreme version of 4)
PROS : less expensive; large demand reduction; low materials rebound effect; low impact on grid use; flexible, see also 4.
CONS : requires adaptation inhabitants to use and comfort levels; still some issues to be solved (cold bridges); normal maintenance remains.

6 hybrid / (Gas phase out concept[7]) :
Only basic measures (cavity wall insulation, double glazing) and a small heatpump added in hybrid operation with the existing heating system. Add PV on roof, or buy-in remaining need as renewable energy as in "energy neutral concept".
PROS : this solution can create a large effect in short time : millions of houses can be adapted this way in just a few years, having a significant contribution to CO_2 targets in short time. Only limited rebound effect (EE) , no comfort or behavior adaptation required. Can be applied any moment.
CONS: not directly 0-energy, requires additional work for that in future[8], no reduction from inhabitants behavior.

7 passive-'unheated'
A passive level house retrofit, combined with large investment in installations equipment, is not an optimal approach from Embodied energy point of view. The optimum is with lower insulation levels and some more PV panels. However, with passive house concepts in moderate climates , there is hardly heating required. There is a situation possible (and observed in practice) that inhabitants refrain from heating, when accepting a indoor temperature of 18 degrees (in the coldest yearly period) , and ventilating with opening windows. This would make any investment in installations/equipment obsolete, and justify the high (embodied energy) investments in insulation measures. It also prevents PV panels to be installed (for building related energy,). 18 degrees so far has the notion of uncomfortable, but the comfort boundaries might need adaptation, seeing latest research results[9]
This option is mentioned for completeness , has not been calculated nor researched, but should be investigated for some climate regions, and for inhabitants/clients that have a open mind for progressive climate adaptation behavior.
PROS: no operational energy demand, no impact on grid, no requirement for Solar panels, less expensive, whole house comforted (within the wider comfort boundaries), naturally ventilated .
CONS : no backup heating, strong adaptation inhabitants required, ventilation by inhabitants.

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7 The Gas Phase out concept could be used for regions that have a dense gas supply grid. A description is given in annex I .

8 This is a example of a practical approach on "stock level" The part of heating not covered with this approach initially, could also be practically addressed: All roads in front of houses need maintenance at some point in future. That could be the ' practical' moment to introduce heat collectors in road surface, to supply the houses. This way limiting material demand overall. In the end in 30 years all energy of houses would be addressed, not on a individual house level but at stock level.

9 Healthy excursions outside the thermal comfort zone,Wouter van Marken Lichtenbelt, Pages 819-827 | Published online: 25 Apr 2017 BRI **journal** ,http://www.tandfonline.com/doi/full/10.1080/09613218.2017.1307647

More Connect relation.
More Connect's main focus is on providing prefab panels in mass construction for several housing types in 6 geoclusters. As such its is related and supportive to several of before mentioned concepts, mainly the ones that apply facade and roof " make overs" : 2, 3, 5 and 7. All these concepts make use of prefab components for the whole house or part of it.
However More Connect relates mostly to the " whole house make over" -NOM energiesprong- and aims to generalize the approach, and standardize elements for use in more then one climate zone. As such its tries to reduce the disadvantages , as costs, and embodied energy rebound effects.

Critical (non-technical) issues

With all retrofit approaches there are critical issues, at housing level , at stock level or at grid level. A few of the most important are listed here.

The Cost: Costs or investments are of course a critical issue, especially since the focus is ultimately to retrofit the whole European housing stock. Without providing or searching for the solution within this projects ambitions, there are several ways to bring down cost (in random order):
1) change tax system, 2) reduce work 3) reduce material investments 4) reduce comfort levels, 5 reduce living space to be retrofitted (is also related to comfort) 6 upscale production.
There is also many differences between countries in tax measures, energy feed-in tariffs, and pay back periods for loans, that together create differences in ways of financing retrofits.

Speed: To have the whole housing stock retrofitted and perform at 0 or near 0 -energy levels (operational fossil fuel related energy) requires a sufficient speed: with around 250 million houses In Europe, thats 10 million a year to have CO2 tackled by around 2045. It is questioned if we have enough workforce available in the construction sector to manage that task, especially if we have labor or production time intensive concepts, and want to avoid to create too big rebound effects in materials and production energy. This is critical, since fast and large (total stock) CO2 reduction is the intention of all this work. Ways to address this: 1) reduce work 2) reduce retrofitted space 3) introduce no regret phasing, with easy and large effect measures first 4)

Household demand
Most concepts address the building related energy. Which is logic, since there is direct relation between building related measures and building related operational energy demand. However, when it comes to a household, there is also non building related energy demand, which somehow should also be covered to limit households CO2 impacts. This is outside the scope of the More connect project, but should however be addressed to create a future proof housing situation.

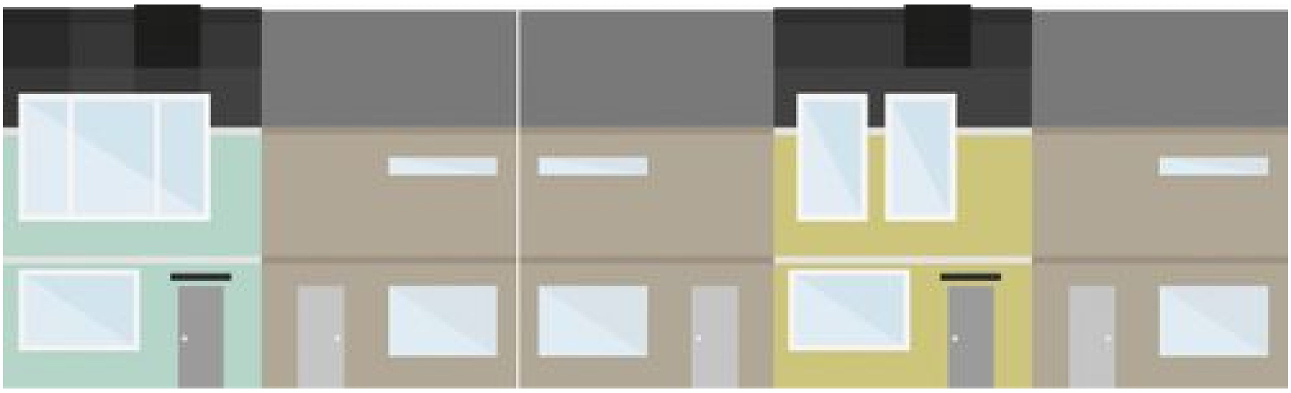
Roof surface
to create 0 or near-0 energy houses, which all have renewable energy generation on site included, makes roofs a critical issue: the roof surface is limited, especially in multifamily buildings, and in most cases not enough to cover building related energy demands , and even more critical when household energy demand is included. This can have unexpected side effects, like creating more roof surface with new building extensions. These in fact enlarge the living area, and as such enlarge the rebound effect in materials demand (and have the risk of in future being added to *heated* living area. Some ways to address this besides reducng demand options , are to add facade energy generation or create and facilitate neighborhood solutions .

5 The MORE Connect approach

The MORE-Connect approach has the focus on refurbishment with prefab facade and roof panels, and standard applicable, for full house or partial house retrofit . The focus is mainly on technical aspects, and how several solutions can be made insightful for clients . The approach is to develop a set of solutions, for several housing types in several climate zones.
Work is carried out on three angles of focus: technical, energetical and economical.
- Technically it should be feasible, and work for different housing types, and different combinations of heating&ventilation technologies.
- Energetically, it should aim for 0-energy (in the design phase, though in execution it might be near 0-energy) and with low embodied energy : solutions should be optimized to prevent a large rebound effect in materials related (fossil) energy consumption .
- economically it should be viable.

The concept
The More connect project follows the number 2 concept of the previous chapter, the NOM/Energiesprong approach, though without the standard inclusion of household energy . However its an option for the choices per geocluster. To either yes or no include this. In practice the hh issue comes down to a basic set of m2 PV to be added, on a set level of household energy demand. (in a all electric approach) .
As a result, the focus in More-connect is also on step 1 and 2 of creating (near) 0-energy concepts: energy production and building related reduction. Step 3 and 4, change of of use and behavior, are not included.

In this chapter the first (technical) results and choices are described, as well as to be followed in a next chapter with a summary of experiences and recommendations, as guidelines for others to follow up on. This deliverable will be the core document to produce a more elaborated book, with all the technical details and results at the end of the More Connect project.



5.1 The More-connect: Concepts of renovation packages.

This chapter contains a description of 5 concepts for the 5 different geo clusters, based on the developments so far in The More connect project. The 5 geoclusters are represented by :
Denmark / Estonia / Latvia / Portugal / The Netherlands / Czech republic.

5.1.1 DENMARK

1 housing type chosen , and why.

In Denmark, housing generally consists of single-family houses and apartment blocks. Both prefabricated elements and use of a robot for façade and gable wall insulation and finishing would generally not be cost effective for individual single-family houses. Therefore, apartment blocks are most suited for energy renovation using the technologies developed in the MORE-CONNECT project. The majority of apartment blocks are own and administered by social housing companies. Many of these apartment blocks have been constructed in the 1950-ies to 1970-ies in 3-5 stories. This is the background for choosing one of the choice of the Danish pilot project, which is one of 7 blocks of a department called “Korsløkkeparken afd. 34” administered by Fyens Almennyttige Boligselskab – FAB. The block selected for the pilot building is referred to a building 34.6. It has 170 apartments, which after the renovation will be changed to 166 apartments. The building is 205 m long and 13,6 m broad and has 5 stories. The total living area is 13685 m² and the basement area is 2737 m². The photoes below show the Danish pilot building before and during renovation.

2 general strategy chosen , to renovate housing type

Generally this type of buildings are energy renovated as part of a total renovation plan for the area in consideration, which means all the blocks of the department and the outdoor areas around the blocks. The energy renovation part of this total renovation typically consist of:
-replacement of windows,
-installation of mechanical ventilation system with heat recovery
-additional roof insulation
-insulation of facades and gable walls. Depending on the current conditions of the existing external wall this additional insulation will be partly or complete.
The exchange of windows and insulation of façade typically requires the use of scaffolding.

Considerations

External insulation of façades and gable walls is costly and normally only carried through when the conditions of the existing wall is rather poor and the wall is in need for repair for example with a new external climate protection layer. In this situation adding a layer of insulation becomes marginal costs and the costs will be manageable by the housing association.

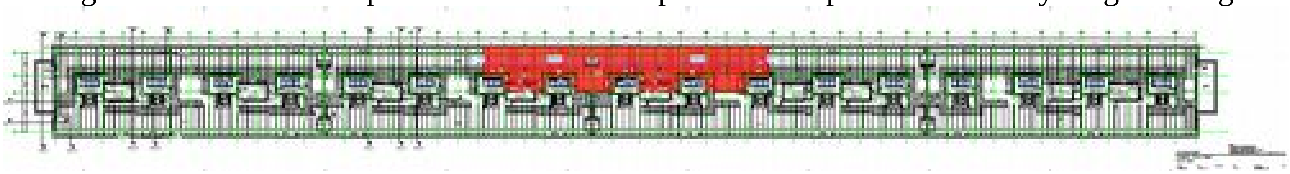
3 technical concept chosen for renovation:
The energy renovation technologies developed as part of the Danish participation in the MORE-CONNECT project is:

- Photovoltaic (PV) –roofing elements and
- Robot finishing of an insulated gable walls.

These two technologies are therefore chosen to be part of the total energy renovation concept for the building in Korsløkkeparken, which also comprises:
-replacement of windows,
-installation of mechanical ventilation system with heat recovery
-additional roof insulation

Considerations
The overall energy renovation concept is well known in Denmark, so no special considerations.

4 prefab panels:
The figure below shows the placement of the solar photovoltaic panels of the very long building.



The photo below show a prototype production of the robot gable wall decoration. The artistics will be different on the pilot project.

Considerations:
For the installation of the PV-roof panels the size and architectural integration are important issues that has been considered. The size is important because of the Danish legislation with respect to the use of the electrical output of the PV-system. In the situations where the produced electricity cannot be used for the operation of the building (pumps, fans, elevators and lighting in the stairwells) it has to be delivered to the grid without any payment. Therefore the size of the PV-system has to match the running operational load of the building. For the insulation of the gable walls and robot finishing the main considerations has been the timing with the general renovation process and the integration with the other wall finishing.

As the implementation of the technologies is carried out in the period from October 2017 to May 2018 it is still to early to make conclusions and note any experiences.
This part will be written in 2018 and added to the final book publication.

5.1.2 ESTONIA

1 housing type chosen and why

Building type chosen is representing a typical multi-storey apartment building, made of prefabricated concrete large panels and constructed during the 1960-90 period in Estonia, where about 65% of people live in this type of apartment buildings. The designed service life of these buildings was 50 years, which is almost over for formerly constructed buildings, therefore the anyway renovation need is actual in these buildings. Typical to many other older buildings problems are: serious thermal bridges, mould growth at the external intersections of roof-wall, high energy consumption, insufficient ventilation, overheating during winter, unsatisfactory thermal comfort. Fresh air inlet was initially designed through the slits around untightened window wooden-frames and natural exhaust via kitchen and sanitary rooms to central shaft. The building had a one-pipe radiator heating system without thermostats and the room temperature for the whole building was regulated by a heat substation depending on the outdoor temperature.

The pilot building is a 5-storey TUT dormitory building with total area 4318 m^2, constructed in 1986

Existing 250mm concrete panel exterior wall consists of 2 concrete sections and insulation layers: 60mm external reinforced concrete slab + 70mm wood-chip insulation layer + 50mm phenolic foam insulation layer + 70mm internal reinforced concrete slab. The existing flat roof with parapet is covered with bitumen felt and insulated with wood-chip boards. The thermal transmittance of the existing envelope is U=0.9 - 1.1W/(m^2·K).

Therefore, the results of conducted pilot renovation within a framework of MORE-CONNECT project at Tallinn University of Technology campus, in student dormitory building in 2017, gives opportunities very easily to disseminate the results to the existing (and quite large) similar building stock and gives an input to the further development of nZEB design of integrated and multipurpose renovation of living houses with modular external envelope panels.

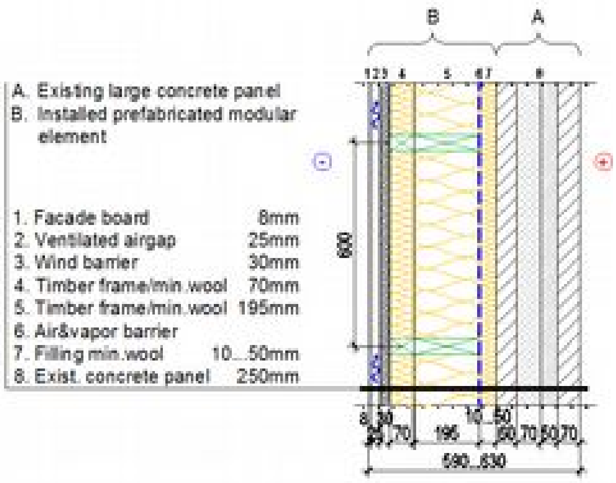


Fig. 1 Location of pilot building at TUT campus in Tallinn, Estonia (left) and basic design of wall insulation modules, placed onto the existing concrete wall (right)

2 general strategy chosen, to renovate housing type

The general decision of renovation was that light-weight modular prefabricated panels will be installed onto the existing envelope (roof and walls), without demolishing of existing loadbearing structures. The living spaces of flats will be enlarged with help of closing open balconies with the same modular panels and will be closed with glazing and thus will be as a part of living space. The basement walls were insulated in-situ with an external thermal insulation composite system.

Fig.2 Pilot building at the renovation stage in summer 2017 (left) and final overview after the renovation in autumn 2017 (right)

The current aesthetic state is not very requiring as it represents widely used soviet-time concrete multi-storey house building traditions from last century 60’s to 90’s. The value of a property could be raised via renovation according to the MORE-CONNECT principles (placing a prefabricated facade and roof panels). The quality and time schedule could be optimized thanks to the controlled preliminary installations made at the insulation modules factory (preinstalled windows, facade boards, mold drips, flashings etc) and shortened installation period at the building site. The installation of the modules was intended to realize with help of pulleys (for workers) and with crane (panels lifted directly from the transport vehicle to the installation place).

Fig 3 Installation of the module panels of walls (left) and onto the roof (right) at the pilot building in Tallinn, Estonia in summer 2017

3 technical concepts chosen for renovation:

In the pilot project, the building envelope will be insulated and rendered with the help of prefabricated modular renovation elements. To get accurate information about the unevenness and roughness of the existing surfaces of external envelope and inhomogeneity of windows location, 3D laser scanning of the envelope was conducted before the design. Self-supporting modules were hanged onto the existing wall surface with the help of designed fixings, allowing adjustment of modules in all three directions. Therefore, there was no need for additional foundation for the wall module panels.

The total thickness of modular element in the current project is 340-380 mm, depending on the surface flatness of the existing wall. To fill the unevenness and roughness of the existing surface, 10-50 mm light mineral wool as filling layer is intended to be added onto the inner side of the modular element. The timber-frame structure is filled with 265 mm mineral wool in two layers and covered with 30 mm dense mineral wool wind barrier. The 25 mm ventilated airgap is covered with 8 mm finishing hardboard, which also provides a firm rain screen to the structure beneath. For protection from weather impacts during the construction process and from constructional moisture, the inner side of the module is designed to be protected with air&vapor barrier layer. The designed thermal transmittance of the external wall is U_{wall}=0.11 W/(m^2·K) and the airtightness of the entire building envelope q_{50}<2 m^3/(h·m^2). To avoid the thermal bridges and minimize the impact of air leakages, smart connectors and innovative fixings, also sealants and polyurethane (PUR) foam will be used at critical joints.

Fig 4 Steel corner brackets for mounting of wall modules

Designed roof elements were installed on the specially built timber structure because the original roof has an inward slope and parapet. Therefore, under the formed slope roof, in 0.6-1.2m high attic between old and new roof technical appliances were placed (e.g. heat exchangers, duct dispensers, automatics etc.). The total thickness of the thermal insulation in the roof modules is 340mm, U_{roof}=0.10 W/(m^2·K).

In solution with highly-insulated modular panels, installed onto the existing concrete wall, it prevents the moisture dry-out and could pose a higher risk of mold growth. One of the most critical hygrothermal design tasks was the selection of a vapor barrier for the wall module. The most influential parameters here are a built-in moisture dry-out after the installation of the insulation modules (requires a relatively permeable vapor barrier) and the long-term performance where a vapor tightening barrier is required because the joints of the original wall would not be air- and vapor tight. Cracks and openings in the walls contribute to the uncontrolled moisture flux into the structure. With hygrothermal analysis it was found that in our region the south-west oriented wall has about 20% higher moisture content than other sides of the building envelope and with the consideration of impact of wind-driven rain, the wall has almost 50% higher moisture content. Analysis showed that the moisture content in the whole external concrete slab is about w=110kg/m^3 in the most critical periods, at the last quarter and the first months of the year. Required hygrothermal performance of studied solutions was ascertained with a smart vapor retarder with changing vapor tightness 0.2m<S_d<5m when the initial moisture content of existing concrete large panel was w≤110kg/m^3 or with 22mm OSB as vapor control layer when the initial moisture content of the existing concrete large panel was w≤75kg/m^3 or with PE-foil as air and vapor barrier when the initial moisture content of the existing concrete large panel was $w \leq 55 kg/m^3$.

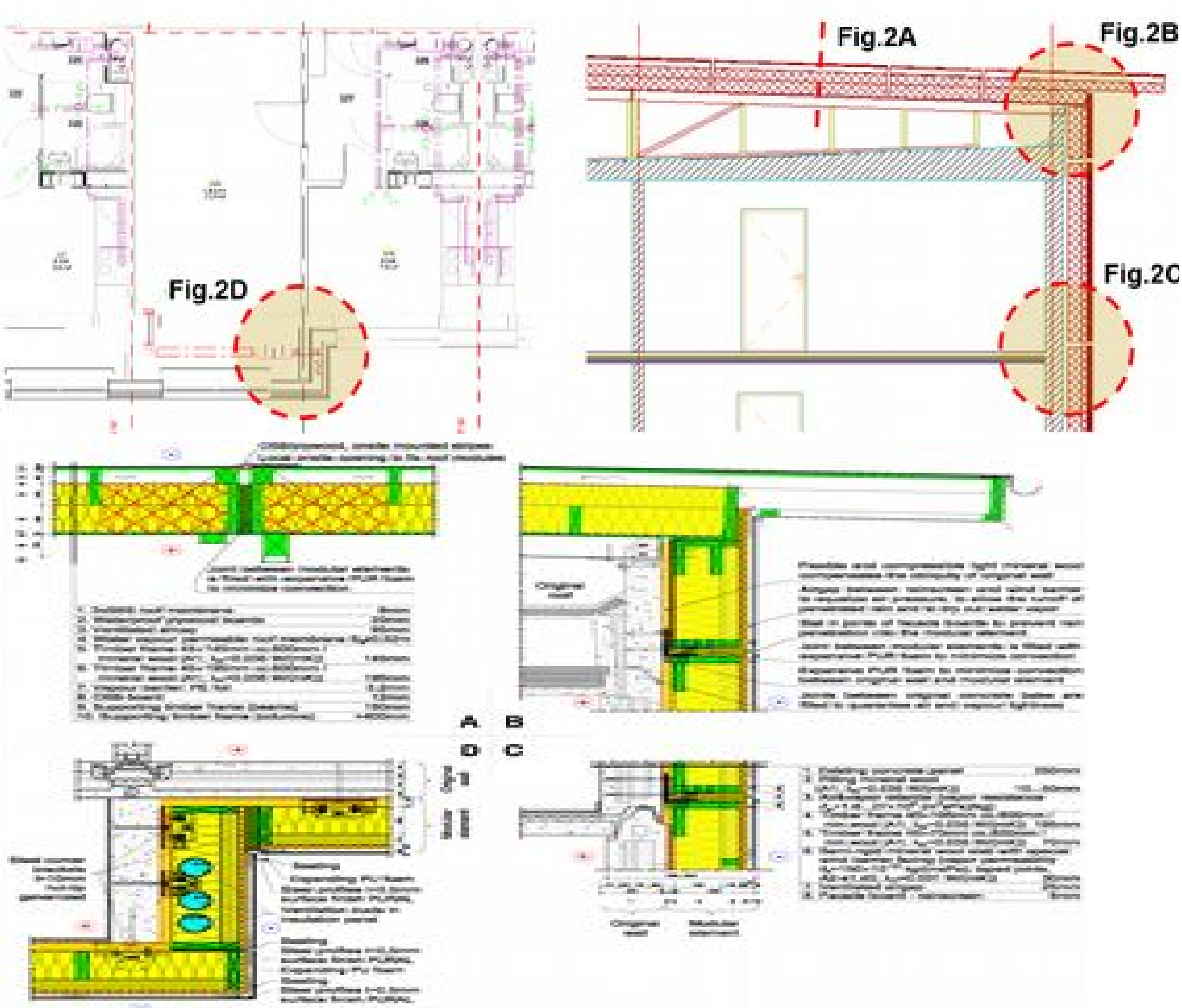


Fig 5 Designed solutions at the different structural points of nZEB pilot

4 Conclusions:

A pilot nZEB renovation of a typical concrete large panel apartment building was conducted in Estonia. This is one of the first deep energy renovations that has been designed to correspond to the nZEB target of new buildings. In addition to the use of prefabricated modular panels for building envelope insulation, the design solution includes many other tasks to be researched: parallel comparison of two different ventilation solutions: apartment based balanced VHR and centralized balanced VHR; parallel comparison of heating of DHW by solar collectors and sewage heat recovery.

The analysis and the whole process of design itself showed that it is essential to consider the initial state of the building when highly-insulated module panels are intended to be used for a nZEB renovation. The installation of the wooden modular elements indicated that a substantial thorough initial work (“measure twice and cut once”) and deeper concentration of moisture safety issues are needed. Roof elements must be installed before the wall elements to prevent the wetting of original external wall due to diving rain and rain from temporary roof.

One of the challenges in this process is the decisive importance of the interaction between the design process and the construction work at the building site. Engineers and designers should include hygrothermal modelling into design practices to assure the moisture safety of structures and sustainability in the long term. The analysis, design and other preparation activities of the integrated nZEB design process gave us a unique experience, showing weak links in the chain and helping to prevent major faults in the construction of the pilot and in the further processes of design.

Fig 6 Well insulated building envelope with onsite energy production is needed for nZEB

5.1.3 LATVIA

1 housing type chosen, and why.

Latvian pilot building is typical brick multi apartment building built in 1967. The pilot building is silicate brick residential house with a lateral bearing system. The house has a wooden roof structure with slate covering. The building has simple, rectangular floor plan. It has two floors with similarly designed flats. The house has a hip roof with a number of chimneys. All old wooden windows are replaced by PVC windows 7 – 10 year ago.

Building represents typical building constructed in 50ies – 60ies last century. This type of building is very common in rural areas and small cities. Selected building type has a high replication potential.

Figure 1. Demo Building before renovation.

Building 3d model before renovation is available here http://demo.mikrokods.lv/Saules_iela_4a_3mx/App/index.html#%2F .

2 general strategy chosen, to renovate housing type

All initial data for technical project development was gathered during the first part of work package. At the early beginning, the agreement between homeowners, housing company and Riga Technical University was signed. Before the preparation of the technical project the IAQ measurements, thermography and Blowerdoor test were performed. According to the measurements air tightness of building envelope was 4.5 m^3/m^2h. U-values of external building envelopes were around 0.3 $W/(m^2 \cdot K)$ for ceiling, 0.95 $W/(m^2 \cdot K)$ for walls and 1.9 $W/(m^2 \cdot K)$ for windows. Quality of construction work is very poor. The extra ceiling thermal insulation has a lot of air gaps between mineral wool mats. Windows/walls connections are not insulated and

Figure 2. Demo Building technical conditions

sealed properly.

3 technical concept chosen for renovation:

Taking into account building poor technical conditions it was decided to focus modular retrofitting on improvements of external building envelope. The general strategy included development and installation of prefabricated modular thermal insulation panels. Modular solution is based on wooden frame. Extra attention is paid to air-tightness of panel joints.

The main target was to get wall below 0.18 $W/(m^2 \cdot K)$, windows below 1,1 $W/(m^2 \cdot K)$ and ceilings below 0.11 $W/(m^2 \cdot K)$.

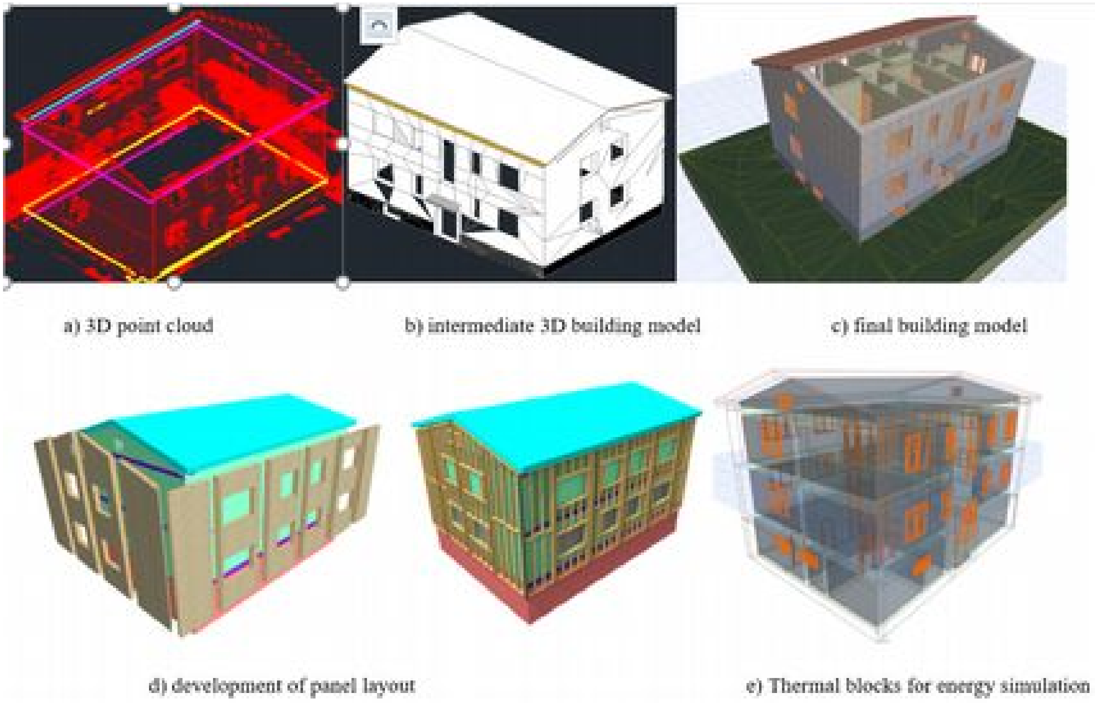
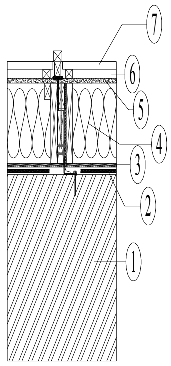


Figure 3. Demo Building retrofitting process

4 prefab panels:



1 – existing wall;

2 - Connection layer between existing wall and modular panel - low density mineral wool;

3 – OSB;

4 – Thermal insulation, λ – 0.033W/(m·K);

5 - Wind protection, plasterboard;

6 – ventilated air cavity;

8 - External finishing - wood planks;

Figure 3. Final layout of modular prefabricated thermal insulation panel

The moveable scaffolding was used to prepare buildings for panel installation and crane lifting was used for panel mounting (Figure 4).

Figure 4. Use of scaffolding or crane lifting for retrofitting

In total panel mounting took 5 working days and 6 workers. 5 days included also some problems with some panels replacement. Taking into account gained experience the panel mounting time can be reduced up to 3 working days for the similar buildings.

5 Preliminary conclusions

Installation of renewables wasn't taken into consideration due to bad condition of roof supporting structure and absence of central hot water supply system. Installation of PV also was limited by home ownership specifics. There are four owners. Thus calculation of supplied to the grid and received back electricity would require extra effort to implement complicated metering system.

5.1.4 PORTUGAL

1 housing type chosen, and why.

The Portuguese pilot building is a building located in Vila Nova de Gaia, Porto Metropolitan Area, in the North region of Portugal. It is a social housing neighbourhood, built in 1997, and managed by Gaiurb (a municipal company). It is a multifamily building with three separate blocks, each with three floors, corresponding to six apartments (a two-bedroom apartment and a three-bedroom apartment per floor). In total, eighteen apartments constitute the building, which has a gross heated floor area of 1265 m^2 (Figure 1).
The building, in terms of typology and building characteristics, is representative of about 40% of the Portuguese multifamily buildings, which justified its choice. It also presents additional common characteristics typical of this important parcel of the Portuguese built environment. For example, as the majority of the Portuguese residential building stock, the building is not equipped with a central heating system. Some of the apartments have portable electric heaters, although the majority does not have any heating system installed. Additionally, building envelope presents some signs of deterioration, although in small scale. The common parts of the building (stairs, halls and walls) show signs of mould and are in a higher state of deterioration. Inside the apartments, thermal discomfort has been reported – both in winter and summer - and mould is clearly visible in the corners of the walls and near the windows. Extensive mould areas can also be found in some of the ceilings of the rooms and bathrooms. All these issues highlight the need for renovation.

Figure 1 - General view of the Portuguese pilot building

2 general strategy chosen, to renovate housing type

The general strategy is based on a modular approach to improve the overall performance of the façade. In that way, prefabricated modules will be added to the existing façade, using crane lifting as a working method. Calculations indicate that an estimated 25% reduction in primary energy use is possible just with the application of the prefabricated modules alone. However, as the project has as main objective the reduction of at least 80% of the primary energy use, other measures had to be considered in addition to the application of the prefabricated modules. In this context, additional layers of insulation are planned to be placed in the roof and in the cellar. Existing windows are already double glazed and therefore, their replacement is not being considered at this stage. Additionally, the building manager chose not to implement solar panels for domestic hot water (DHW), but after the renovation, as part of a second phase, a biomass boiler is planned to be installed, improving significantly the building systems performance for both heating and DHW preparation.

Considerations:

Adding modular, prefabricated elements to the existing façade will allow faster interventions, as well as will avoid disturbing the occupants.

3 technical concept chosen for renovation:

The module was designed to reduce operational energy demand and increase hygrothermal comfort inside the apartments. Additionally, there was a concern in the choice of materials that constitute the façade panel, which includes a wood frame and a cladding based on a recycled material in order to reduce embodied energy and carbon emissions.

The modules will be vertical oriented (10 m height)and will use standard metal connectors to be assembled to the exterior wall . The renovation solution includes the application of an additional insulation layer of mineral wool to be put between the existing façade and the prefabricated modular system.

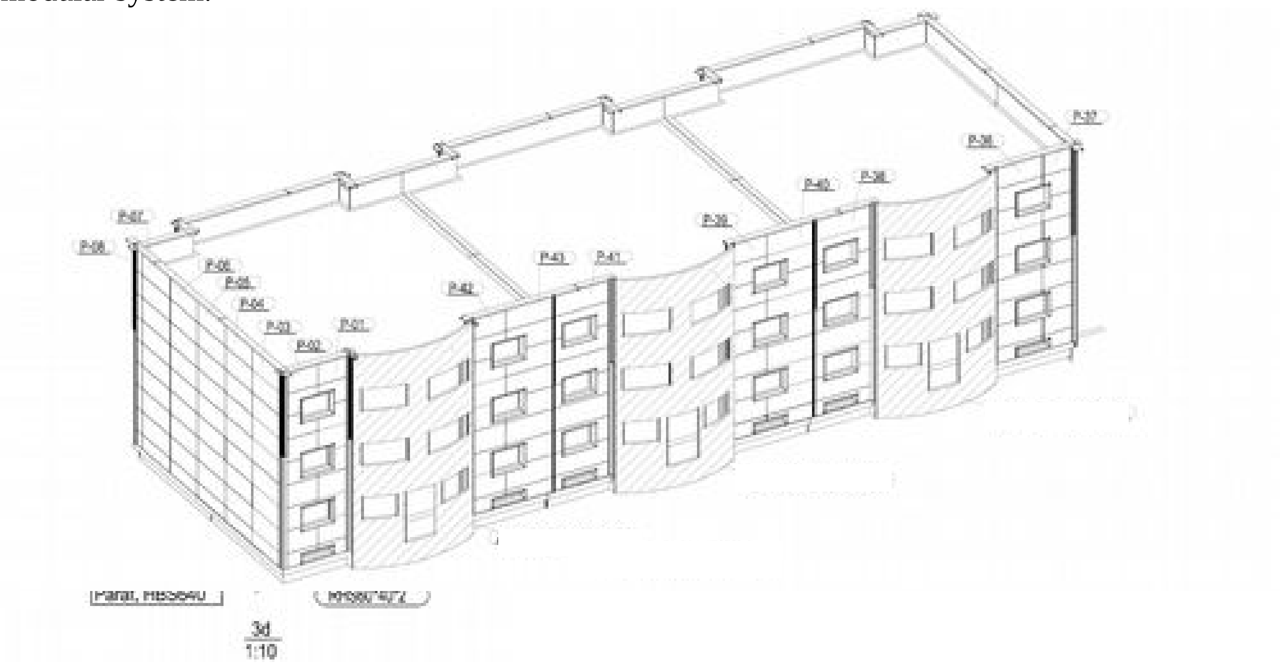


Figure 2 - Detail of panel fixation

4 prefab panels:

The developed MORE-CONNECT prefabricated modular solution comprises a wood frame, an internal/external cladding made of Coretech® sheets and a filling material of polyurethane foam . During the development process, both aluminium and wood were considered for the module structure (frame). The initial structure was considered to be in aluminium because it is a widely used material in Portugal in this type of prefabricated structures and in the construction sector in general. Nevertheless, wood presents a higher thermal performance than aluminium, allowing

reducing thermal bridges, particularly in the connection between modules.
Coretech® is a recycled material made from waste components of the car industry such as kraft and cellulosic paper, polyurethane foam, fabrics and fiberglass. It presents attractive characteristics such as high durability, water and fire resistance and a very good thermal performance. Although it is not widely applied in the Portuguese construction sector, there are already several applications of Coretech®, both in building envelope insulation and external cladding of buildings. Other advantage of this material is the possibility of applying any material as external coating/cladding (paint, ceramic, plaster, etc.).
Polyurethane foam was choosen as filling material of the prefabricated elements given its high thermal performance and high durability.
The Coretech® panel is 8 mm thick, the wood frame 100 mm and polyurethane foam 100 mm. In total, the prefabricated module has a thickness of 120 mm. The connection between the modules is a male-female connection in the wood frame.

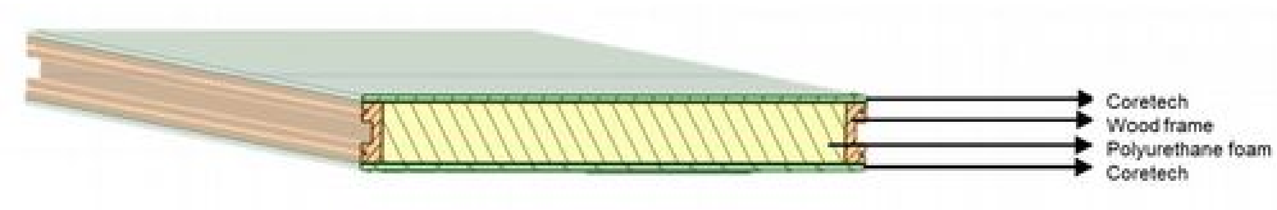


Figure 3 - Illustration of the prefabricated module

In order to be tested in laboratory facilities, the prefabricated modules were produced with 2.55 m of height and 1.00 m width. Nevertheless, the solution can be applied in different sizes, depending on the characteristics of the building. In the Portuguese pilot building the dimensions of the panel are 10.0 m high and 2.4 m width.
Due to the stiffness of the prefabricated element, there was the need to create an interface between the existing building wall and the prefabricated element, capable of absorbing the irregularities of the surface, guaranteeing a continuous insulation. This interface would efficiently avoid the occurrence of thermal bridges and improve the energy performance of the solution. The chosen material to act as interface was mineral wool (MW) with a density of 25 kg/m^3.

Considerations: Planned optimization of the industrial production line and mass production of the prefabricated panels are expected to significantly reduce the final costs of the modules and make them more cost-effective.

5 Preliminary conclusions
The process, so far, has faced several challenges. Consideration of life cycle and embodied energy in the choice of materials led to frequently non-consensual discussions regarding the need for balance between technical and structural features and sustainability concerns, which calls for a more integrated perspective from all the stakeholders in the process.
In addition, planned (and functionally adequate) dimensions for the prefabricated module are not usual for Portugal, which are expected to cause difficulties regarding both transport and installation.

5.1.5 THE NETHERLANDS\

1 housing type chosen , and why.
In the Netherlands a dominant type is row houses with tilted or flat roof. There is more then 4 million homes that are build between 1950 and 1985 which are in need for renovation in order to be suitable for the next 40 to 50 years.
The repetitive aspect of the builds makes them very suitable for an industrialized renovation approach.

2 general strategy chosen , to renovate housing type
We chosen to remove front and back walls and replace those with prefabricated wall elements that close the opening on a high level of airtightness. Fixing the elements from the inside makes it possible to place the elements without scaffolding.
The elements are completely finished in and outside so no manual labour on the building spot is needed apart from fixation to the existing concrete walls.
Elements also contain ventilation ducts; replacing the old walls makes it easy to reach all rooms without the need to work inside the building. Good ventilation is essential since good isolation and good airtightness brings the need for good ventilation.
In order to reach very low level of energy use also the ventilation is combined with a heat-exchange installation.
Hot water with aims for household use and for heating is generated using a water/water heatpump.
Electricity is generated by PV panels. Around 28 panels generate year over enough kW to facilitate all electricity needed.

3 technical concept chosen for renovation:
The basis elements build up is wood skeleton. Rockwool insulation is added to the panels which closed by OSB and gypsum plates. On top of the OSB a EPS insulation layer is added in order to reach Rc 6,5 or better. This is the same for the roof.
Outer side is finished with either putz or StoThermBrick. The inner side is wallpaper included.
In order to reach low energy use level the windows are triple glazed HR++.
This measure also brings more comfort in the rooms since cold-fall is not happening with the use of HR++.
The elements are horizontal and element bearing is done at fundament level. Elements are stacked on top of each other. The connection with the existing walls is only for wind draw.
For airtight connections foil flaps are combined with compri-tape. This tape closes gaps of up to 2 centimeter.

4 Installation strategy
All installations are combined in a skid. When placed in the attic the installation is placed in one run when the roof is open. The prefabrication leads to less failure and less labour time especially when produced in larger series.
The design is such that there is only one way to fix the different installation parts.
This installation engine contains; heatpump with vessel, ventilation, heat-exchange, converter and monitoring hard and software. And is connected to 2 thermostats ; in the living room and the master bed room. The home will have a very steady temperature of 21 in the living room and 19 in the sleeping rooms.
All rooms are reached with ventilation ducts coming from the attic. Moisture sensors are placed in the kitchen and the bathroom which regulate the need for extra ventilation in case of use.

Conclusions and guidelines
Monitoring data is used to manage the systems as well as prove the correct working of the combination of renovation elements and the installations.
The monitoring proves that calculations where correct for energy use as well as comfort and healthy indoor climate.

5.1.6 CZECH REPUBLIC

1 housing type chosen , and why.
Based on statistic research, the most frequent multi-family residential building in the Czech Republic is a 3-story building built in the period from 1946 to 1960. Such typology covers about 5% of the complete Czech multifamily housing stock. As a reference building was chosen post-war residential block in Milevsko, which by its typology and material basis represents a significant part of the residential housing stock of Czechia due for retrofitting.

This particular building, used as social housing, has 24 studios (room, kitchen, bathroom, hall), 31 m^2 each, in three stories (see Figure 1). Technical or housing facilities and cellars were put in the basement, which is partially under the ground. Entrance to the building is on the northern façade, leading to the wide central hall with north-south orientation. At the southern façade, central hall is ended with a loggia. Each flat has two windows oriented either to the east or to the west. The building has a gable roof (33°), attic space is currently unused. Building has longitudinal wall structural system made of bricks (450 mm), ceilings are made of reinforced concrete. Façades are plastered, windows and exterior doors are partly original, partly (3 of 24 studios) replaced with insulating double-glazing, both with wooden frame.

Figure 1: Typical representative of the typology in qeustion in Czechia

In the time the reference building was build, usual U-values varied (there were no standards then): 0.76–1.72 W/(m^2K) for the roof, 1.07–1.70 W/(m^2K) for the wall, 0.76–1.22 W/(m^2K) for floor and 2.18–3.44 W/(m^2K) for windows and doors. The total heat loss of the building is 2,037 W/K from which ventilation is responsible for 12 % and remaining 88 % is accounted to heat flow by transmission. The annual energy consumed by one reference building is around 1050 GJ.

2 general strategy chosen , to renovate housing type

The general strategy came out from the analysis of the typical representatives of the select typology, their technical shape and needs, and from the SWOT analysis of typical common retrofitting interventions that are offered on the market nowadays.

The limitations given by the building typology are given by the fact that the major part of the building envelope is at the same moment the load bearing structure – typically the masonry walls of 450–600 mm form the supporting structure for the concrete floor structures. Therefore, there is no option for replacements, the only way is to make an addition upon the existing walls.

Czech industrial partner of the project is company RD Rýmařov, the largest national producer of prefabricated family houses made from panels with timber structural system. Therefore, the technology development started from the company's existing portfolio of panels and installation practices (direct installation of the elements by mobile crane from trucks that come just in time).

3 technical concept chosen for renovation:

There was developed a new system of anchors that enable fixing of panels on the existing façade (panels are hanged – no new foundation needed). On the long facades with windows, the standard panels will be installed in horizontal position on height of one floor. Their length will be up to 8 m for ease of manipulation on crane. On gable walls, some panels might be installed also in vertical position.

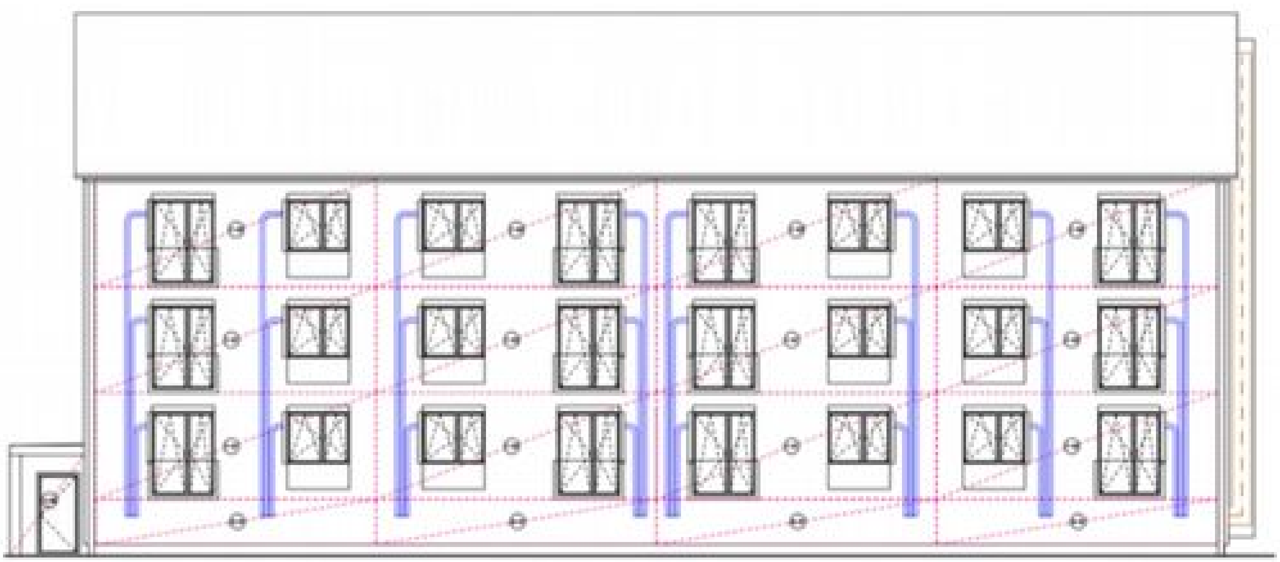


Figure 2: Set of 12 standard panels and 4 plinth panels on the east façade. New prefabricated entrance on the left, new "chimney" encapsuling new HVAC ducts on the right.

At the plinth part, there will be set of special panels that provide connection from horizontal airducts (led under the ceiling in basement) to the vertical airducts in the standard wall panels. Thus, the fresh air is distributed from the central HVAC unit in the basement through the wall panels to the air inlets that are attached just between the new windows in panels' cores and the existing walls.

At roof, the old layers of ceramic tiles on lathes are removed and onto the existing rafters are attached new roof panels finished by preparation for integrated PV system, which comes separately afterwards. There are special elements that provide closing the gap between wall and roof panels.

There are developed also special modules to be attached at one side wall, that create a new "chimney" which includes air inlets and outlets to and from the central HVAC unit with heat recovery.

4 prefab panels:

Each standard panel consists of a structural core made from timber frames which are filled with thermal insulation and decked by fire resistant boards from both sides and windows are fixed to the structural elements. On the outer side of the core is made plaster finishing on wood fibreboards (see Fig. 3).

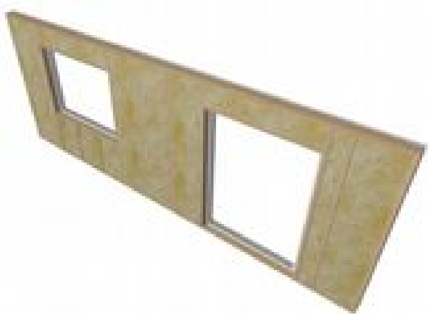


Figure 3: Structural core of a wall panel made of timber elements, fire-resistant boards from both sides and filled with mineral wool.

From the back side of the core is a layer of soft thermal insulation of width 120-140 mm. In this soft layer are integrated air ducts for mechanical ventilation of each flat, new wiring for sensors and internet distribution and piping for the cases a new heat distribution system is needed (see Fig. 4). In the same layer are also integrated outlets of the ventilation air, which are attached to the frame adjacent to windows.

Figure 4: Soft layer from the back of the core, which will be in contact with the wall of existing building.

The prefab wall panels are attached to the existing masonry wall, usually 450 mm wide. Additional extension of openings (after dismantling the old windows) for larger windows is possible and the finishing. The window sills and jambs are finished by caldding from furnituring boards. The wiring and piping is accessible through small doors in the window jambs; the design of all technological boxes is airtigt. The final setting is presented in Fig. 5 bellow.

Figure 5: Final setting of the external wall module on the existing wall structure.

6 (11) **conclusions and guidance** from experiences so far:

Europe is facing a major challenge in bringing CO_2 emissions from 250 million+ houses down, to 0 or near-0 . One of the major options is to retrofit this stock, and add prefab panels to roofs and facades, and add solar panels to produce the remaining (reduced) need for operational energy. This is a challenge in itself, since housing stock greatly differs, as well as available roof surfaces, and production potential in the different climate zones.
The research so far shows that retrofitting with prefab panels is a viable option all over Europe. And the geoclusters can learn a lot from each other as well as co-innovate: many technical solutions are applicable in all regions, as well as the production process. In The MORE Connect project these will be developed and documented, in the final deliverables. However, the devil is in he details: for each project it has to be decided what is the optimal configuration, from panels and installations as well as potential for solar power generation. Optimal configuration depend mainly on the starting situation: What is the need for heating (cooling) , what are the options to reduce demand before the retrofit, in the use and behavior in and of the house. The more connect project assumes there is no adaptation before hand. The project concentrates on reduction on building level, and production of building level. Even then a few concept studies have to be made, for the optimal detailing of the prefab panel, in order to limit the rebound effect in embodied energy for the materials.
A major difference found is also in financing the retrofit: It depends a lot on how energy bills are settled, if there is a feed in tariff , and not the least how pay back periods for investment loans are calculated.
An important issue is also upscaling the whole process, for which blue prints for production facilities are needed that can be multiplied throughout Europe. Development of basic configurations will be part of the second period in More Connect .

Overall it seems that the most important part of retrofitting in the More Connect approach is preparation of the project: Many difficulties can be avoided by a detailed and cyclic design process. For the building sector, used to solve many small issues at the building site, that is a challenge in itself, especially when the whole retrofit should taken place in a few days, to avoid disturbance for the inhabitants and reduce cost at the building site. (“measure twice and cut once”)

The general experience from partners is summarized in the “ keep it as simple as possible! “ Which applies even more in prefab- retrofit approaches as in general construction.

7 (12) looking forward

During the remaining period of the More Connect project, improvements will be made, and experiences gained. This is expected to lead to further insight and knowledge on how to apply the more Connect approach in the different geoclusters, in a way that further projects can have a kick start applying the same methods. This will be reported and extensively described in the follow up reports and publications of the More Connect project.

MORE Connect WP3 Del 3.8 Oktober 2017

Annex I

The “Gas phase out” concept

In some countries gas is a major source to heat houses directly. In the Netherlands nearly all houses have a gas connection, for heating and cooking. The main trend now is to go for all electric and disconnect from the natural gas. For two reasons: eliminate fossil fuels, but also to reduce gas extractions in Groningen and prevent further soil setting, in terms of regular small earthquakes.

There is two ways to reduce gas : disconnect from the gas with every retrofitted house (the current trend) . Or to provide every house with a small Heat pump in hybrid mode, driven by PV.
The first option, will take decades before all houses are retrofitted, the second option can be realized in a few years, since this requires no substantial work, and is a matter of adding a small heat pump. The advantage is, that in short time all houses can reduce gas consumption (and CO_2 emissions) significantly, gas will only be needed for the coldest period when the Heat pump is not sufficient. With the climate getting warmer, the real cold periods will decrease, and less and less gas is required. This has a few advantages: 1: fast reduction overall,: 2 less rebound effect in material investments in , 3 no disruption for inhabitants (easy installation) , 4 no capital destruction creating a large waste dump from gas equipment (and relatively cheap compared to a total make over), and 5 no sub optimizations: a major renovation might take place later, when the investments in gas infrastructure are written of, with by then new innovative appliances.

Its even easy adaptable for further reductions, for instance If combined with reduced heating area, or (electric) infrared heating devices for less used rooms (only functioning when people are present) a further improvement can be made. Of course easy basic measures like double glazing, and cavity wall insulation can be applied as well.
This option has not been calculated in detail, it results fro analyses of other options as a possible and interesting route, but is mentioned for completion and should be studied.