European Commission, Horizon 2020 Programme

MORE-CONNECT

Final selection of favourable concept based on LCA

Country:	The Netherlands
Author(s):	Ana Tisov, Peter Op' t Veld, John van Oorschot
Institution(s):	Huygen Installlatie Adviseurs, ZUYD University of Applied Science
Date:	26/10/2017

This document has been prepared within the framework of the EU Horizon 2020 project MORE-CONNECT, Work Package 6 "Market and Replication", Task 6.2.

Methodological guidelines and feedback on the selection of the favourable concept to be tested in the pilot were provided by Roman Bolliger and Walter Ott from econcept, Switzerland.

For more information about the MORE-CONNECT project see the project website:

http://www.more-connect.eu

This project has received funding from the European Union's H2020 framework programme for research and innovation under grant agreement no 633477.The sole responsibility for the content lies with the authors. It does not necessarily reflect the opinion of the European Communities. The European Commission is not responsible to any use that may be made of the information contained therein.

This work was supported by the Swiss State Secretariat for Education, Research and Innovation (SERI) under contract number 15.0001. The opinions expressed and arguments employed herein do not necessarily reflect the official views of the Swiss Government.

1 The reference building

1.1 Description of reference building

Figure 1: *Typical raw family house in the Netherlands (location De Bilt).*

The reference building presents a typical traditional raw family house in the Netherlands. Such houses have been built between 1965-1974 and nowadays represent 9 % of the Dutch housing stock (606 000) [1]. This type of residential house has typically 4 to 5 rooms spread over 3 floors (usage area 106,0 m^2). Built in 1965 this type of houses satisfied the thermal requirements valid at that time. However, according to the new building standards this type of building is typically under-insulated, therefore applicable for MORE-CONNECT renovation.

Buildings that have not yet been renovated, have traditionally a central heating system with the boiler type HR combi set (HR107 38 % and HR100 23 %). Some buildings have other boilers (CR 8 % and VR 25 %) or are still heated locally (1 %). In addition to boilers, electric boilers (5 %), gas boilers (4 %) and kitchen heaters are used for domestic hot water preparation. Houses are mostly ventilated, either with naturally supply and passive stack ventilation or with natural supply and mechanical exhaust in service rooms and kitchen.

The houses that went already through the renovation were mostly improved by changing the glazing and improving the façade insulation. The emphasis was on double glazing (60 % of the glass surface) and double glazed window with HR++ glazing (18 %). Regarding the building envelope, 35 % included renovation of the facade, 8 % of the floor area, 17 % pitched roof and 26 % flat roof.

As the pilot building, described in D6.1, is in fact the reference and standard for retrofitting in the 'Energiesprong program' in the Netherlands (i.e., also for the so called NOM retrofitting concepts; NOM is in Dutch Nul op de Meter or in English 'Zero on the Meter'), the pilot building can be considered as the final selected favourable concept in the Netherlands.

1.2 Dimensions and characteristics of the reference building

The following table summarizes the dimensions and characteristics of the reference building.

Parameter	Unit	Data	Parameter	Unit	Data
Building period		1965-1974	Typical indoor temperature	°C	20
Gross heated floor area	m^2	106	Average electricity consumption per year and m^2 (excluding HVAC)	kWh/ ($a*m^2$)	28
Wall area (excl. windows)	m^2	66	U-value wall	$W/(m^2*K)$	1.45
Roof area pitched	m^2	65.5	U-value roof pitched	$W/(m^2*K)$	0.89
Roof area flat	m^2	-	U-value roof flat	$W/(m^2*K)$	-
Attic floor (if attic is unheated)	m^2	-	U-value attic floor	$W/(m^2*K)$	-
Area of ground floor (no cellar)	m^2	52	U-value ground floor (no cellar)	$W/(m^2*K)$	2.53
Area of window to North	m^2	-	U-value windows	$W/(m^2*K)$	2.9
Area of window to East	m^2	13	g-value windows	factor	0.7
Area of window to South	m^2	-	Energy need hot water	kWh/m^2	45.41
Area of window to West	m^2	13	Energy need for cooling	kWh/m^2	-
Average heated gross floor area per person	m^2	35	Airflow rate	$m^3/(h*m^2)$	1.0

2 The MORE-CONNECT solution

The main MORE-CONNECT measure will include renovation of the existing building envelope above the ground (roof and walls) with MORE-CONNECT prefabricated modules and installation of an HVAC engine. First, to assess existing building conditions and to obtain accurate data about the existing surfaces 3D laser scanning should be conducted [2].

Figure 2: First MORE-CONNECT prototypes applied in a typical row-house in Heerlen, the Netherlands.

It is considered that typical Dutch row houses are to be renovated with the MORE-CONNECT modular prefabricated integrated roof and facade elements to a net zero-energy level (including lighting and appliances). The facades include integrated combined heating units (convectors) with decentral demand and CO_2 controlled mechanical ventilation units with heat recovery. The roof elements have 40.0 m^2 PV panels for 6.4 kWp. A fully prefabricated installation box (engine) contains an air-to-air heat pump, boiler, mechanical exhaust fan and PV converters. This box is placed in the roof and can be accessed and replaced from the outside. In case of maintenance or replacement no access or activities in the dwellings are necessary, thus minimizing the disturbance for occupants.

The prefabricated modular wall elements are between 306-345 mm: 30 mm wind barrier, 170/220/240/280 mm glass wool insulation (Knauf Naturoll) between timber frames with expected life-time between 40-50 years.

3 Investigated renovation packages

For the identification of favourable concepts, an assessment of various possible renovation packages is carried out. These renovation packages include the MORE-CONNECT solutions. The renovation packages are assessed with respect to greenhouse gas emissions, primary energy use, and costs.[1]

For the selection of favourable concepts, the investigated renovation packages are shown in the following table:

Renovation Package	Description
Ref1	In the reference case, the wall (masonry, joints) and the windows are repainted and the pitched roof is refurbished (replacing tiles and interface between roof slab and chimney)
M1	The wall is insulated with a MORE-CONNECT prefab element including 17 cm of mineral wool
M2	The wall is insulated with a MORE-CONNECT prefab element including 28 cm of mineral wool
M3	M2 + roof insulation with MORE-CONNECT prefab element including 22 cm of mineral wool
M4	M2 + roof insulation with MORE-CONNECT prefab element including 28 cm of mineral wool
M5	M4 + ground floor replacement with additional PUR insulation (U = 0.22 W/m^{2}K)
M6	M5 + new windows with U-value of 1.1 W/m^{2}K (double glazing)
M7	M5 + new windows with U-value of 0.8 W/m^{2}K (triple glazing)
M8	M7 + supply-exhaust ventilation system with heat recovery
M9	M8 + 40 m^2 PV panels (6.4 kWp)

The heating systems taken into account were:

- Natural gas
- Air/water heat pump
- Wood pellets

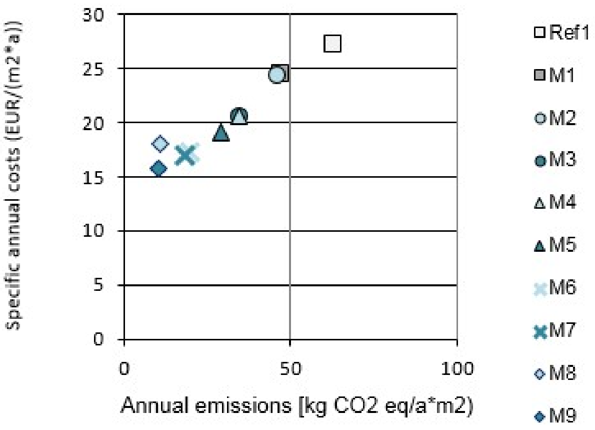
[1] For a description of the assessment methodology, a separate document is available entitled: «Methodological framework and instructions for the selection of favourable concepts for the pilot projects (Task 6.1 part 1)»

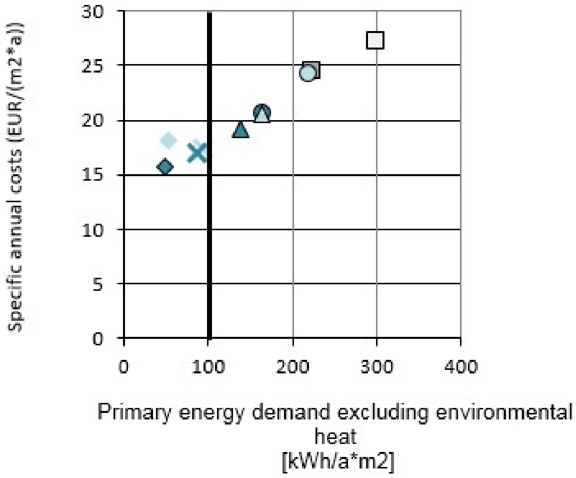
4 Assessment of investigated renovation packages and selection of favourable concept

4.1 Overview graphs

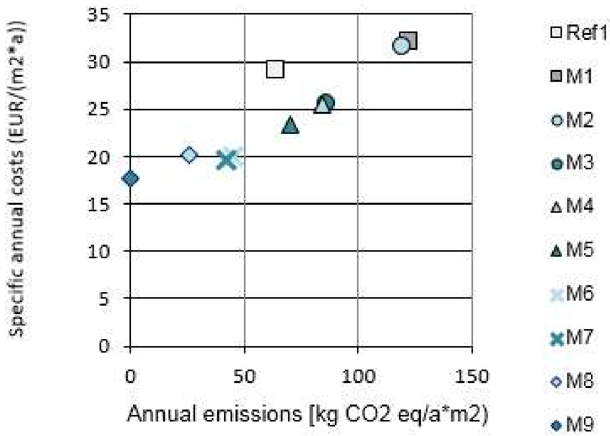
For the reference building, the expected impacts of the investigated renovation packages are shown in the following graphs.

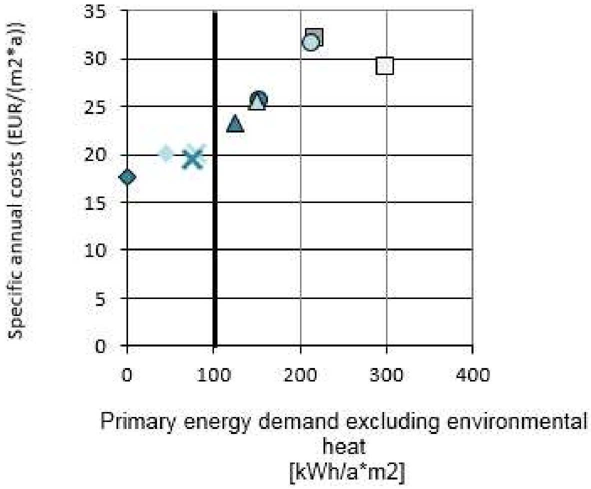
Heating system: natural gas



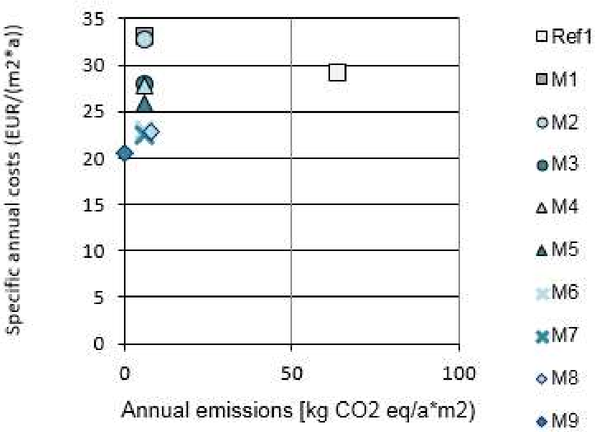


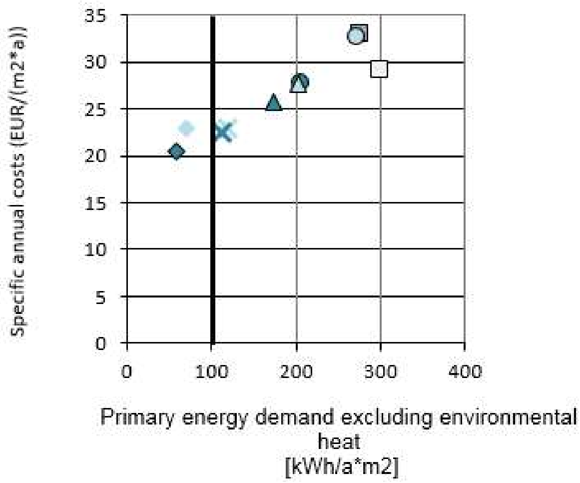
Heating system: heat pump





Heating system: wood pellets





4.2 Discussion of results from assessment

The first quantitative objective of the MORE-CONNECT project is reduction of primary energy consumption of at least 80 % compared to the original consumption. As it can be seen from the graphs, this is possible with the proposed renovation package M9 for all the three analysed heating systems. The comparison between heating with natural gas and with air water heat pump shows there are higher emissions once considering the heat pump. The electricity for the operation of heat pump comes from non-renewables (electricity), however, in reality this electricity for operation of the heat pump could be covered by PV panels. For the Netherlands for a long time a national primary energy mix factor for electricity of 2.65 has been used (using 3 for nuclear and 1 for renewables), however, it still needs to be updated with the latest development of renewable electricity production. In terms of emission, it seems that the last M9 renovation package with wood pellets is the most favourable option. However, there are some practical considerations in the Netherlands with the wood pellets. In general, the most favourable concept presents renovation of the building envelope, introducing ventilation with heat recovery and combining this with renewables on the site (PV panels). As seen due to low operation costs, the investment (capital investment) presents a cost-efficient solution. This also supports the already realized renovation case in Heerlen.

4.3 Aspects related to reuse of materials, embodied energy and indoor environment

As described in a separate report of the MORE-CONNECT project on material alternatives in relation to reuse and the combined energy and materials impact of prefabricated elements, the prefabricated panels can be disassembled in individual components where it is possible to reuse or at least recycle most of the components: wood and insulation. Therefore, most of the materials applied for the Dutch pilots are suitable for a reuse. As wood is used for the prefabricated façade panels, this shows a good opportunity for being reused after the first life cycle. Furthermore, the Pilkington glazing can be recycled.

It is assumed that by introducing the ventilation system with heat recovery also indoor air quality is improved. This is an important objective that is often neglected during the comprehensive energy conservation campaigns. In order to save energy, residents are encouraged to improve the airtightness of the buildings and reduce the ventilation rates – which might result in more damp homes. Damp homes are not only associated with increased house dust mites infestation, but also with increased concentration of many indoor-generated air pollutants [3]. It should be monitored whether there is a problem with the moisture in the building structure (panels) as this can degrade the building materials, creating favourable conditions for microbial growth (mould) and can become a source for bad indoor climate. Also, many new materials (polymers) can contribute to poorer indoor air quality, therefore it is important that users are aware what kind of materials are used in prefabricated panels: MORE-CONNECT panels not emitting any harmful particles.

5 Conclusions and lessons learned

For the selection of a favourable concept in The Netherlands, the more then 10 years of practice and experiences from the national ‘Energiesprong program’ are very important to take into account. Energiesprong was also the basis for H2020 projects as MORE-CONNECT and TransitionZero. Taking into account these experiences as well as the specific assessment carried out for MORE-CONNECT, the favourable concept for the Netherlands is chosen as follows:

- The wall is insulated with a MORE-CONNECT prefab element including 28 cm of mineral wool;
- Roof is insulated with MORE-CONNECT prefab element including 28 cm of mineral wool;
- Ground floor is additionally insulated with PUR insulation (U = 0.22 W/m^{2}K);
- There are new windows with U-value of 0.8 W/m^{2}K (triple glazing);
- Installation of HVAC engine: supply-exhaust ventilation system with heat recovery;
- On the roof are installed 40 m^2 PV panels (6.4 kWp).

As it can be seen from the investigated building and therefore a typical Dutch residential row house from the sixties, the average consumption is between 250 – 300 kWh/m^2. It can be seen that improvements of the energy performance (Step 1 – building envelope improvement) can reduce the energy consumption to 50 – 60 kWh/m^2 per year or even lower which shows a significant energy reduction. A further step in reaching nZEB goals is achieved with renewables on site where 50 – 70 % of this consumption is covered by RES (Step 2 – adopting renewables). When looking into reduction of CO_2 emissions and energy savings over a building’s life time, one can see that PV panels are a good solution for the Dutch market.

Improving buildings through life cycle optimization seems to be an indispensable step when adopting MORE-CONNECT renovation concept. The presented analysis for the Dutch demonstration case shows the necessity to go beyond energy evaluation and move towards the environmental assessment over a life cycle allowing comparison of the impacts due to different building components and possibilities for the generation of heat or electricity from renewable sources on site.

The selected MORE-CONNECT HVAC engine could still be optimized in terms of dimensions and weight (now about 1,5 x 1,5 x 1,5 m and 500 kg); both could be reduced by ca. 35%. This challenge has been taken for example by Factory Zero (https://factoryzero.nl , spin off of the Energiesprong program). Also a price reduction could be achieved, going from ca. € 25.000 for a traditional HVAC configuration to € 16.000 – 19.000 for the prefab platform 1.0 to € 12.000 for the version 2.0).

Figure 3 New developments for prefab platforms for building services from Factory Zero.

Another lesson learned after four years of MORE-CONNECT is that in the Netherlands the average break down of costs is now is:

- Prefab envelope: 1/3
- Building services and PV: 1/3
- Finishing, small works, failure costs: 1/3 (aim is < 5% hours spent on site)

Especially the last part is still a problem, both in terms of costs and quality. First of all, many contractors lack the skills for executing a smooth deep renovation process. But also. The earnings and earning models of traditional companies is often based on extra work and failure costs, which are often not offered in bids.

Finally, taking into account the latest development in both policy making, but also as a demand from the market, there is clear need for a further development towards circular renovation products and concepts.

References

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