# Occupant-owners preferences in deciding about innovative renovation concepts

## Arjan Bogerd, Clarine van Oel, PhD, Guus de Haas, MSc,

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**Abstract**
To attain the new European mandate on $CO_2$ reduction, the Dutch government set an ambitious 2% $CO_2$ reduction per year for all sectors. Currently 19% of the $CO_2$ emission in the Netherlands is from households. To date, occupant-owners own about 56% of the Dutch housing stock, and this is thought to increase up to 70% of the housing stock in near future. Therefore, such an ambitious level of $CO_2$ reduction might be only reached if there is sufficient commitment among owner-occupiers to engage in ambitious renovation measures directed at energy savings.

The highly ambitious aims in $CO_2$ reduction require a renovation approach that goes far beyond the standard renovation practice at this very moment. Current renovation yields up to 35% fossil energy saving, whereas a reduction of about 75% is required to meet set goals. The kind of measures that are considered to attain the set aims, compare to the technical measures for energy reduction applied in the 'passive house concept'. However, applying this kind of measures in existing housing stock would impose high constraints on the occupant-owners. The implementation of high ambitious innovative renovation concepts therefore require more information about occupant-owners preferences in deciding about such concepts.

The here reported study used a discrete choice experiment with images to evaluate the preferences of the occupant-owners in deciding about innovative renovation approaches. Results were analyzed with Non Linear Regression modeling. The questionnaire was first piloted with 83 participants. The final questionnaire was submitted to all members of the Dutch Association for occupant-owners who received their electronic newsletter. A total of 1565 respondents, mainly occupant-owners, filled out the questionnaire. They were asked to choose between two images representing a terrace house built between 1946 and 1976. Every image had six attributes, namely 1) insulation of the outer wall, 2) innovative sustainable technical measures, 3) simple payback time, 4) inconvenience during the works, 5) attitude/ behavior of occupant-owner, and 6) increase of comfort.

Results showed that all factors significantly influenced the decision process of occupant-owners. Regarding insulation, people preferred a light insulation to medium or high levels of insulation. At the highest level of insulation, the façade of the dwelling was completely replaced, whereas light insulation did not change the appearance of the dwelling. The difference between the utilities of medium and high insulation was very small.
For the attribute "technical measures" respondents preferred a solar boiler and heat pump to a package of measures that would result in a colder indoor climate at the first and second floor in winter time. For the attribute "simple payback time" respondents clearly preferred a payback time of 3-7 years. The attribute level 14-21 seems to be not acceptable. Increase of comfort leads to a significant improvement of utility and thus a higher appreciation of the respondents. Respondents were very negative about the option that they have to leave their home. The attribute level "1 month out of home" had a very negative utility compared to the

option of staying for 1 month in a mess. Regarding their willingness to change their behavior, financial solutions such as replacement of fridge, washing machine etc by ones with A++ energy labels was preferred to making no changes at all. However, respondents clearly indicated that they were not willing to refrain from this kind of household appliances. The option of refraining from a dryer was not acceptable to them.

**Introduction**

In order to meet the new CO2 reduction guidelines by the EU, the Dutch government has set a target of 2% reduction of CO2 emission per year. The CO2 reduction should be achieved in all sectors. Reduction of energy consumptions of residential dwellings is important in achieving these targets, as about two third of the energy use in the Netherlands is used in urban surroundings.

This study is about terrace houses build from1946 to 1976. These terrace houses represent approximately 10% of the total Dutch housing stock. About 50% of the Dutch property owners are occupant-owners, so the occupant-owners are an important target group to realize the high set ambitions. This might only be realized, if there is sufficient support from occupant-owners to do major renovations directed at energy reduction. Thus far, preferences of occupant-owners are not often considered in the development of new renovation concepts. This might add to a low acceptance of innovative measures among occupant-owners, as the kind of renovations measures proposed to them might not fit their preferences. To evaluate the preferences of occupant-owners, we used the Discrete Choice Method to evaluate their preferences in innovative renovation approaches. The respondent was asked to choose between two hypothetical houses differing in several characteristics. These characteristics included both technical and non-technical issues and are referred to as attributes.

**Method**

There are several methods to investigate consumers` utility (preferences) for a product. In measuring the utility for a product, one can distinguish between revealed preference methods, stated preference methods and non-preference methods (Van Beukering et al. in Van Kempen, 2001). The revealed preference method is based on the observation of actual made choices of households and individuals and it assumes that people show their preferences by their actions. The Stated Preference method is based on information extracted from interviews or choice experiments. Because the renovation concepts are still under construction, stated preference techniques are the single one method that are of use to this study. A mere advantage is that these techniques also allow for the measurement of peoples opinion to non-economic goods, e.g. comfort, behavior.

Within the stated preference methods, there is a direct and an indirect method to investigate consumers` utility. The direct method is known as the contingent valuation method (CVM). The most important problems of CVM are related to cognitive stress and strategic responses (Geurs et al. 2006). People experience difficulties in assigning a value to a product or service. There is also the risk of strategic bias as people might think they can influence the situation like the price of a house. Because of these problems, we employed the indirect or the conjoint analysis method (CAM), more specifically the discrete choice method (DCM). The respondent is asked to assess two hypothetical houses that differ on several characteristics (called attributes) and express his/her preference for either of these two.

The DCM is based on efficiency in choice designs using the multinomial logit model. This model assumes that consumers make choices among alternatives that maximize their perceived utility. This is expressed in the formula below:

$$u = x_i\beta + e$$

u= utility
$x_i$= is a row vector of attributes characterizing alternative i
β = is a column vector of K weights associated with these attributes
e= is an error term that captures unobserved variations in utility (Kuhfeld, 2005, p122)

The multinomial logit model assumes that the probability that an individual will choose one of a number of alternatives from the choice set.

$$p(c_i|C) = \frac{\exp(U(c_i))}{\sum_{j=1}^{m}\exp(U(c_j))} = \frac{\exp(x_i\beta)}{\sum_{j=1}^{m}\exp(x_j\beta)}$$

| | |
|---|---|
| m | number of alternatives |
| $c_i$ | alternative |
| C | choice set |
| $x_i$ | vector of alternative attributes |
| β | vector of unknown parameters |
| $x_i\beta$ | utility of alternative $c_i$ (Kuhfeld, 2005, p144) |

Development of an efficient design and further statistical analyses were conducted in SAS 9.2 (Discrete Choice Modeling). SPSS was used in additional analyses. Generally, a threshold of $p < 0.05$ was used in significance testing of the main effects.

**Pilot study**
The discrete choice method was used as part of a larger questionnaire and was first piloted (n=83). The questionnaire consisted of three main parts, the first part consisted of general questions in the usual format. The second part covered the here reported discrete choice experiment. The third part of the questionnaire was the closure and people were asked to give there remarks about the questionnaire.
From the pilot study, it was learned that the questionnaire were too long and that there were too many questions. The initial questionnaire took about 25 minutes. A part of the direct questions were removed to reduce the time respondents needed to fill out the questionnaire. Furthermore, respondents stated that the differences between the images in the discrete choice experiment were not very clear. The attributes on the images were also too technical. Some attributes and the layout of the images were changed to clarify the discrete choice experiments.

**Final questionnaire**
The final questionnaire was distributed among all members of the Dutch Association for occupant-owners who subscribed to the electronic newsletter. A total of 1565 respondents, mainly occupant-owners (97%), participated in the research. The questionnaire consisted of three parts. The first part investigated people's current opinion and actions towards energy saving (direct questions). The second part consisted of the in this paper reported discrete

choice experiment. The third part of the questionnaire was the closure and people were asked to leave their address if they would like to participate in a lottery for one out of five prices. Each respondent did 12 choice experiments in which he or she was asked to choose between two images representing a terrace house build from 1946 to 1976. The images were composed out of 6 attributes according to a prespecified design. The six attributes were insulation of the outer wall, technical measures, simple payback time, inconvenience during the work, the attitude / behavior of the owner, and the increase of comfort. The attribute levels were designed according to table 1.

| Attributes | Level 1 | Level 2 | Level 3 |
|---|---|---|---|
| Insulation of outer wall | Light | Medium | High |
| Technical measures | Solar boiler | Zoning | Heat pump |
| Simple pay back | 3 - 7 years | 7 - 14 years | 14 - 21 years |
| Comfort | No expansion dwelling | Roof dormer | 2 floors expansion |
| Inconvenience during work | 1 month in mess | 1 month out of house | |
| Behaviour owner | No change | A++ appliances | dryer out |

Table 1: attributes and attribute levels

*Insulation of outer wall*

- **Light**: cavity wall insulation, no change of the appearance of the dwelling
- **Medium**: The outer leave will be removed and replaced by a new outer leave and finish of plaster work. The roof will be insulated on the inside.
- **High**: The façade will be removed and replaced by a complete new prefabricate façade. Also the roof will be replaced by a new insulated prefabricated roof.

*Technical measures*

- **Solar boiler**: A technique that absorbs the sun's infrared radiation and transfers this to the water that is running through a tube in the center of the absorber. A flat collector will be placed on the roof.
- **Zoning**: The dwelling will be split up in different sections with differences in temperature. In this case the living room will be insulated. The temperature in the living room will be about 21 °C, the rest of the dwelling at about 17 °C.
- **Heat pump**: Ground source heat pump withdraws heat from the ground or groundwater which is at a relatively constant temperature during the year below a depth of about eight feet (2.5 m). In winter, the pump will be used to heat the dwelling, in the summer it could be used for cooling. The measures of the installation in the dwelling are 60 cm, 60 cm, 200 cm (width x depth x height).

*Simple payback time*

Simple payback is the amount of time it takes to recover installation costs based on annual energy cost savings. If annual cash flows are equal, the payback period is calculated by dividing the initial investment by the annual energy cost savings.

$$\text{Payback period (in years)} = \frac{\text{Initial investment cost}}{\text{Annual energy cost savings}}$$

Three levels of simple payback time were distinguished:

- **3-7 years**
- **7-14 years**
- **14-21 years**

*Comfort*
If the dwelling will be extended, this can be seen as an increase of the comfort. In the discrete choice experiments this will be used to investigate the acceptation for radical measures in combination with an increase of comfort.

- **No expansion dwelling**: no changes.
- **Roof dormer**: A roof dormer will be placed for additional space and light in the attic.
- **2 floors expansion**: On the backside of the dwelling an extension will be build. This extension yields 1.5 meter extra space on the ground floor and the first floor.

*Inconvenience during work*
The highly ambitious aims in $CO_2$ reduction require a renovation approach that goes far beyond the standard renovation practice at this very moment. But how is the acceptation of the owner-occupier for inconvenience during the work? This attribute gives two options:

- **1 month in mess**
- **1 month out of house**

*Behavior owner*
In addition to technological measures, it might be necessary to address the possibilities of behavioral changes in order to reduce energy consumption. Three different options were considered:

- **No change**
- **A++ white-line household appliances**: replacing the washing machine, fridge, dryer, etc by appliances with A++ energy saving labels
- **Dryer out**: reduction of energy consuming household appliances reflected by dismissal of a dryer

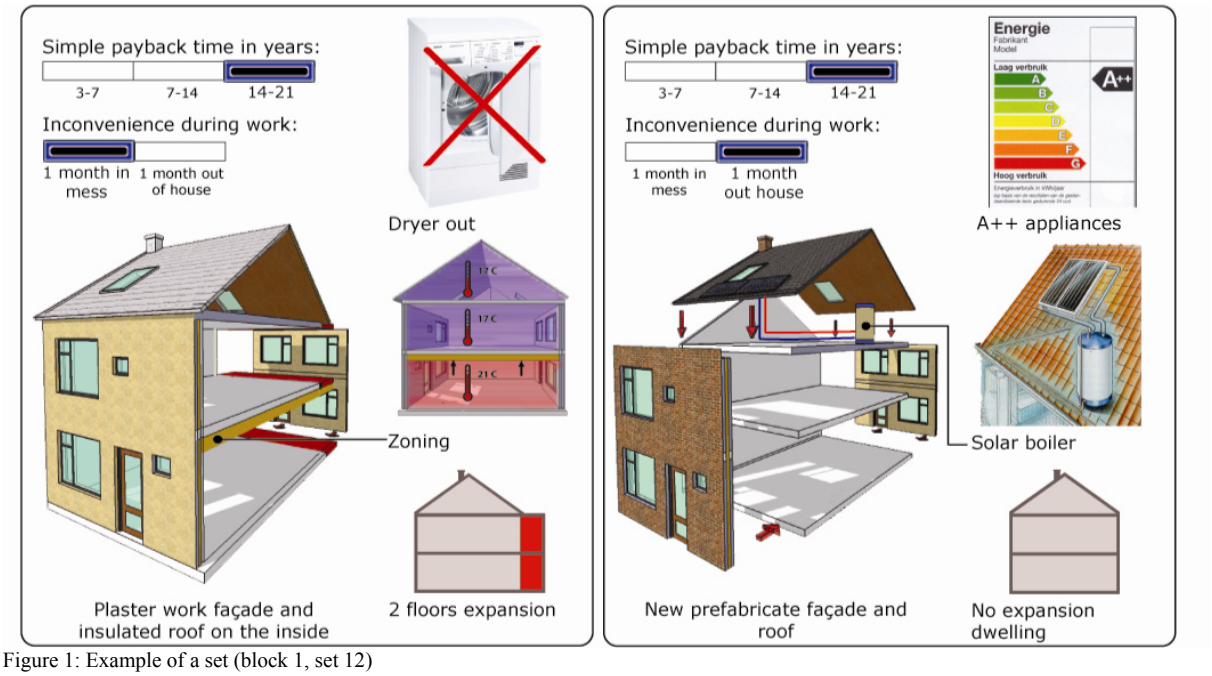

Figure 1: Example of a set (block 1, set 12)

These attributes and category levels were all combined into 72 different combinations. The combinations are made in the software program SAS and reflected a fractional factorial

design. This means that not all the combinations are used, but that optimal combinations were calculated using SAS. These 72 combinations were split in three blocks of 24 different combinations. Each respondent got one block of 12 sets; each set has two different combinations (2x12). See figure 1 for an example of a set. The different combinations are represented in an image.

Before the actual start of the choice experiment, respondents got an introduction of the hypothetical situation. They were asked to imagine that they live in a terrace house build from 1946 to 1976. The respondents were asked to choose between two images representing a terrace house build from 1946 to 1976. The images were constructed as specified before. An example of a set of two images is presented in figure 1.

**Results**

Results showed that all attributes significantly influenced the decision process of occupant-owners.

*Insulation of outer wall*

Regarding insulation, people preferred a light insulation to medium or high levels of insulation. Light insulation had a utility of 0.26 compare to a highest level of insulation. At the highest level of insulation, the façade of the dwelling was completely replaced, whereas light insulation did not change the appearance of the dwelling. The difference between the utilities of medium and high insulation was very small (medium over high insulation had utility of 0.07).

*Technical measures*

For the attribute "technical measures" respondents preferred a solar boiler and heat pump to a package of measures that would result in a colder indoor climate at the first and second floor in winter time. This latter concept is referred to as "zoning". Compared to "zoning" a solar boiler has a utility of 0.24 and the heat pump a utility of 0.52.

*Simple payback time*

Respondents clearly preferred a payback time of 3-7 years over a simple payback time of 14-21 years with a utility of 1.09. A payback time of 7-14 years has a moderate utility of 0.76 comparing to 14-21 years. The attribute level 14-21 seems to be not acceptable.

*Comfort*

Increase of comfort leads to a significant improvement of utility and thus a higher appreciation of the respondents. The utility for a roof dormer is 0.37 and for a 2 floors expansion 0.43, compared to the possibility of no expansion of the dwelling.

*Inconvenience during work*

Respondents were very negative about the option that they have to leave their home. The attribute level "1 month out of home" had a very negative utility (-0.44) compared to the option of staying for 1 month in a mess.

*Behavior*

Regarding their willingness to change their behavior, financial solutions such as replacement of fridge, washing machine etc by appliances with a A++ energy label was preferred to making no changes at all. The attribute level "A++ pack apparatus" had a remarkable high utility with 0.72, more then "doing nothing" with 0.33. However, respondents clearly

indicated that they were not willing to refrain from these household appliances. The attribute level "dryer out of home" was not acceptable to them.

**Discussion**

This study addressed the occupant owners' preferences in deciding about innovative renovation concepts. Respondents were asked to choose between two images representing a terrace house build from 1946 to 1976. Every image consisted of six attributes, namely insulation of the outer wall, technical measures, simple payback time, inconvenience during the work, the attitude and behavior of the owner, and the increase of comfort.

The results showed that occupant-owners do prefer renovation concepts that do not change the façade (light insulation). However, as there was only a small difference in their preference of higher levels of insulation; one might consider developing renovation concepts with either light or high insulation. Respondents did not appreciate the idea of zoning. They preferred technological measures like solar boiler or heat pump. Higher levels of comfort, i.e. more functional floor space, might significantly contribute to higher acceptance of ambitious renovation concepts. This might be one way to compensate for disadvantages such as investments and inconvenience during the works. Simple payback time seems to become unacceptable when it exceeds the threshold of about 14, 15 years. Regarding inconvenience, respondents clearly preferred to stay at home during the works. Finally, this study clearly shows that respondents in some way are willing to make behavioral choices by preferring white-line household appliances with A++ labels. However, it seems unacceptable to them to adjust their behavior such as that they refrain from using household appliances.

**References**


- Breidert, C., Hahsler, M., Reutterrer, T. (2006), *A review of methods for measuring willingess-to-pay*, Innotive marketing
- Berkhof D. van den, 2008, *Belevingsonderzoek lounges Amsterdam Airport Schiphol*, *welke vormgevingsaspecten hebben invloed op de beleving van de reiziger*, Delft
- Donkervoort, R.D., Knoll B., Zundert K. van, et al. (2008), *Rigoureus WP 4, Uitwerking basismaatregelen* (concept)
- Eck, A. van (april 2008), *De "willingness to pay" voor een energiezuinige nieuwbouw woning*, Delft
- Geurs, K.T. en Haaijer, M.E. (2006), *De optiewaarde van het spoor, de waardering van de aanwezigheid en het gebruik van regionale spoorlijnen*, Rapport
- Haas, G.J. de (juni 2008), *Reductie $CO_2$-uitstoot in de bestaande woningvoorraad*, Delft
- Kempen, E.E.M.M. van (2001) *Een schatting van de baten van geluidmaatregelen,* Bilthoven: RIVM
- Kuhfeld, W. F. (2005), *Marketing research methods in SAS, experimental design shoice, conjoint and graphical technique*, USA, North Carolina, SAS Institute Inc.
- SenterNovem, Rigoureus WP 1, *Verkenning nationale en internationale ontwikkelingen* (concept)