Sustainability of Dutch Home Automation Projects, Evaluation and Recommendations.

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Abstract

In the Netherlands, in the years 2002 to 2004 a national programme has been implemented by NIDO and ECN to evaluate the sustainability of the application of Home Automation for independently living elderly people.
Evaluation of 12 projects in the Netherlands, Belgium and Germany showed that:

- There are good prospects for improving independence and quality of life for the elderly by using home automation applications. A prerequisite is that the users are well involved in the design process. However, this is not current practice.
- In theory, there are good opportunities for combining social and healthcare applications with applications that improve thermal comfort and energy efficiency. In practice this is not applied, for a variety of reasons.
- Energy consumption of the equipment itself is usually unknown. Suppliers and consultants estimate it as being low. In two known cases the energy consumption has been measured. In these cases the energy consumption was significant: 10 to 40 % of the normal annual electricity consumption of the households concerned. With increased attention to low-power ICT-appliances this percentage is expected to be decreasing.
- Current applications are still too expensive and difficult to organise and maintain.

Simulation studies performed by ECN showed that home automation could be a good tool for supporting energy savings, especially for a target group of high income customers that are not themselves very much oriented towards energy efficient behaviour and that are living in larger and older buildings.
Recommendations are formulated for effective and sustainable application of home automation. If these recommendations are implemented, there are good opportunities for successful and sustainable application of home automation to assist elderly people living independently.

Dutch national programme for sustainable Home Automation applications

In the Netherlands in the years 2002 to 2004 a national programme was implemented by NIDO and ECN for sustainable Home Automation applications[1] [1]. NIDO was a Dutch government initiative for promoting sustainable practices across society[2]. Programme management of the NIDO programme for sustainable Home Automation was performed by ECN (Energy research Centre of the Netherlands). ECN also was delivering the technical expertise concerning energy efficiency of home automation applications.
The aim of the programme was to evaluate the sustainability of the application of Home Automation for independently living elderly people. This is an attractive market in view of the increasing number of elderly people in the Netherlands and across Europe in the coming decades. Home Automation applications can support elderly people to live independently and at the same time relieve the work load of care services, if provision is made, that the applications are properly installed and operated and the services are well organised. The focus of the programme was on how these social and financial benefits could be combined with environmental benefits, like energy and carbon savings.
For this purpose, activities were organised like project evaluations, desk research, a conference, workshops, several publications and a website [1]. To give more attention to the residents - the users of the home automation applications - joint workshops were organised with both professionals and

[1] The name of the programme is 'In eigen omgeving oud worden' (Ageing in one's own surroundings)

[2] The full name of NIDO is 'Nationaal Initiatief Duurzame Ontwikkeling' (Dutch National Initiative for Sustainable Development.) It operated from 2000 to 2004. From 2005 the activities of NIDO were taken over by the Competence Centre for Transitions [2]

elderly people. In total, over 100 organisations active in the field of housing, care and home automation participated in the programme.

ECN research on Home Automation and Energy Efficiency
Over the last seven years ECN has conducted several projects in the field of Home Automation and Energy Efficiency. These projects ranged from designing ICT architectures, developing business models to implementing laboratory tests and performing field experiments [3,4].
ECN has 4 research dwellings. One of these is equipped as an ICT research dwelling (see figure 1). In this ICT research dwelling ECN has conducted tests with energy efficient ventilation controlled by a home automation system [5]. The other three research dwellings are used for performing tests with building integration of comfort installations.

Figure 1. Research dwellings at ECN. At the right, the ICT research dwelling.

Evaluating sustainable Home Automation applications in the Netherlands

12 projects in the Netherlands, Belgium and Germany were evaluated, including:

- **Development of service flats across Flanders (Belgium)**: In the period of 1998 to 2003 Service Flats Invest NV, Antwerp (Belgium) built 700 low cost service flats in several towns in Belgium. Typical for these projects is cost reduction. This was achieved through the combination of a standardized building concept and large contracts with suppliers. Some home automation functions are included in the concept. Attention has been paid to design and ease of use. However, a disadvantage of this project was that residents have limited control over the internal arrangement of their house and the settings of the home automation system. [6]
- **Renovation project Lidwinahof, Best (Netherlands)**: In 2002 housing association Domein renovated 49 apartments for elderly people. In this renovation project home automation applications were installed for safety and security, care and comfort. Typical for this project was an extensive survey among the residents, both before and after the renovation. [7]
- **Demonstration project Moerwijk, The Hague (Netherlands)**: From 2001 to 2004 a home automation installation was designed and installed in a test apartment by expertise and consultancy centre ILSE (Independent Living for SEniors). Typical for this project was a heavy involvement of elderly people from the target group as well as care professionals, both in the design phase and in the demonstration and evaluation phase. [8, 9]

Evaluation of these projects showed that:

- There are good prospects for improving independence and quality of life for the elderly by using home automation applications. A prerequisite is that the users are well involved in the design process. However, currently in the Netherlands this is not common practice.
- In theory there are good opportunities for combining social and healthcare applications with applications that improve thermal comfort and energy efficiency. In practice this is not applied, for a variety of reasons.
- Energy consumption of the equipment itself is usually unknown. Suppliers and consultants estimate it as being low. In two known cases the energy consumption has been measured. In these cases the energy consumption was significant: 10 to 40 % of the normal annual electricity consumption of the households concerned.
- In the Netherlands home automation was (and is) still in the phase of pilot projects.
- Current applications are still too expensive and difficult to organise and maintain.
- The Dutch healthcare sector is organised with a lot of (financial) regulations. These regulations do not reward the benefits of home automation applications.[3]
- A long term policy for providing services is crucial for the long term success of suppliers of (houses with) home automation applications. A basis for this long term policy should be the future demand for housing and residential services of elderly people and other target groups. Important aspects of the long term policy are a definition of the service package provided by the own organisation and a long term cooperation with external partners in delivering residential services.

Improving Independence and Quality of Life for the Elderly

An important lesson from the programme is that for a successful supply of home automation applications it is important that the future users can choose their applications themselves ('demand-controlled supply'). Although this goes without saying for most home appliances, in the market for home automation in the Netherlands this is not evident so far. As a result, there are more negative examples to illustrate the importance of this, than there are positive examples.
The following examples illustrate the kind of problems that can arise when home automation applications are developed without proper interaction with the future residents:

- Automated corridor lighting (when there is movement in the corridor and the natural light level is below a certain threshold the lamp automatically turns on): As the resident didn't want the lamp to be lighted all the time, he turned the light off permanently.
- Automated door alarm (when the door is opened for longer than 5 minutes an alarm sound is given, to warn the resident that he has not properly locked the door): In practice, residents liked to stand in the doorway talking to their neighbours. This gave rise to alerts as well...

Positive examples to show the value of demand-controlled supply are scarce. Three Dutch examples are the following projects:

- Demonstration project Moerwijk (Expertise and Consultancy Centre ILSE, The Hague)
- Domotel (Expertise and Consultancy Centre ILSE, The Hague) [10]
- Project Berkenstede (Housing corporation De Key, Amsterdam)

These projects show that it is feasible to involve elderly people in the design of home automation appliances. It does require a lot of attention and time in the development phase of the project, but doing this eventually leads to a greater user satisfaction and to a more effective use of resources.
A final confirmation of the importance of a demand controlled supply approach comes from the renovation project Lidwinahof, Best. In this pilot project - as a test - a lot of functionalities were provided, without any choice for the residents. In practice half of the residents had their system partially or completely turned off within a year after installation. [7]
However, the same project Lidwinahof, in the city of Best, shows that home automation applications can help to improve the independence and quality of life of elderly. In the project survey many of the inhabitants confirmed that they expect to live independently longer because of the home automation

[3] As an example, consider a case in which a healthcare alarm system reduces the number of hours spent by care professionals. This would be good for the overall efficiency of the care process. However, in such a case an organization for home care gets a reduction in income equivalent to the reduction of the number of hours spent. This means the organization is punished, instead of rewarded, for increasing the efficiency of the care process.

appliances[4]. In general the people were satisfied with the home automation applications. People were more positive about safety and healthcare functions (like the burglary alert and the care phone) than about functions they regarded as luxury functions (like images from a front door camera on their TV screen and automatic lighting control.)

Combining Social and Healthcare with Energy Efficiency Applications

For the target group of elderly people the main applications of a home automation system are social and healthcare applications. If these functions are installed, it is possible to add energy efficiency functions to the system.

Opportunities for energy efficiency applications
A whole range of energy efficiency applications is possible in home automation systems. On one hand one can think of energy efficient lighting, heating, ventilation and cooling control. On the other hand experiments have been done with applications that stimulate energy efficiency measures through user feedback on energy consumption. In addition, control applications are conceivable that focus on optimising indoor climate, like solar shading control to prevent overheating and weather dependant indoor climate control.
A special type of application is automated residential demand response. Demand response is defined as "a tariff or program established to motivate changes in electricity use by end-use customers in response to changes in the price of electricity over time, or to give incentive payments designed to induce lower electricity use at times of high market prices or when grid reliability is jeopardized." [11] Directly, this does not lower the electricity consumption. However, it can be used to compensate imbalance between electricity demand and supply. In this way demand response can foster large scale integration of intermittent renewable energy sources. Indirectly, application of demand response has been shown to contribute to reduction of the electricity consumption as well.[5] [12]
In practice these applications for energy efficiency, demand response and indoor climate control should be combined into one, comprehensive, energy efficient indoor climate control system. Of course it is very advantageous to use a home automation system not only for energy efficiency applications, but to use one system for several other applications simultaneously. In any case one should take care that the energy savings of the energy efficiency applications are not cancelled by the energy consumption of the home automation system itself.

Estimating the energy efficiency increase due to home automation applications
An estimation of the energy efficiency increase that can be achieved when adding energy efficiency applications to an *existing* home automation system for healthcare and social services has been calculated with the dynamic building simulation package TRNSYS. As a reference case a typical Dutch apartment from the beginning of the 1980s inhabited by 2 elderly people was taken. Three behaviour patterns were defined: an energy efficient behaviour pattern, an average behaviour pattern and a wasting behaviour pattern. Calculations were made for two types of energy efficiency applications added to the existing home automation system. The first type was a relatively simple one, based on current technology, with the following services: shutting down space heating, ventilation and lighting during absence of the inhabitants. The second type was an advanced type of energy efficiency application that also includes weather prediction based control. The results of these calculations are shown in table 1, 2 and 3 below. [13]

Table 1. Calculated energy consumption per household in reference case.

Behaviour pattern	Natural gas use [m^3/year]	Electricity use [kWh/year]
Energy efficient	925	2532
Average	1099	2576
Energy wasting	1500	2620

Source: [13]

[4] 88% of the respondents gave a positive answer to that question (equal to 63% of residents).

[5] One way to understand this is that delaying electricity consumption in the end can lead to canceling it. Another way to understand it is that as the marginal price of electricity increases at peak moments, consumers will have a bigger incentive to disconnect lower value appliances.

The numbers given for natural gas and electricity are totals for the household (domestic hot water and household appliances are included).

Table 2. Calculated energy savings by current technology energy efficiency applications.

Behaviour pattern	Natural gas savings [m^3/year]	Electricity savings [kWh/year]
Energy efficient	33	20
Average	44	63
Energy Wasting	105	107

Source: [13]

Table 3. Calculated energy savings by advanced energy efficiency applications.

Behaviour pattern	Natural gas savings [m^3/year]	Electricity savings [kWh/year]
Energy efficient	35	-16
Average	67	28
Energy wasting	166	72

Source: [13]

The following conclusions can be drawn from the simulation results for a 2-person household in an apartment:

- The less energy efficient the behaviour pattern, the higher the potential savings of energy efficiency applications.
- Advanced energy efficiency applications including weather prediction based control can not only provide better indoor climate but also have a higher energy savings potential.

When interpreting these figures it should be noted that the energy savings that can be accomplished in reality will depend to a large extent upon the following factors:

- The number of inhabitants and their behaviour patterns, including the amount of time they are present at home[6]
- The size and quality of the house involved.[7]

In general there are more opportunities for energy savings in larger and older buildings with high-income customers that are not themselves very much oriented towards energy efficient behaviour. Especially for this target group, home automation could be a good tool for supporting energy savings, provided the home automation system does succeed in combining additional comfort with energy savings.

Energy Efficiency of Equipment

Energy consumption of home automation systems

A trivial prerequisite for sustainable application of home automation is a very low energy consumption of the home automation system itself. However, in the current practice of home automation in the Netherlands the energy consumption of the equipment itself is usually unknown. When asked, suppliers and consultants usually estimate this consumption as being low, 'nothing to worry about'. However, the suppliers and consultants do not give exact numbers of the yearly energy consumption. And buyers do not always ask for the figures.

In one known Dutch case the energy consumption was given attention: in the case of the retrofit of an apartment building for elderly people in the town of Best by housing corporation Domein. During the preparations for the project the inhabitants were asked about their preferences and informed about the plans. At that stage, the inhabitants themselves raised the question of what the electricity consumption would be. The consultant involved answered that people were not to worry as 'it is only

[6] In the reference case in the calculation the inhabitants were present over 90% of the time. This is more than average, meaning that for average Dutch households the energy savings potential is higher than calculated here

[7] In the reference calculation the house was relatively small and of moderate building quality. This results in a below average reference gas and electricity consumption, meaning that for average Dutch households the energy savings potential is higher than calculated here.

low voltage, so the energy consumption will be negligible'. However, after completion, the energy consumption turned out to be approximately 190 kWh per year. For the households concerned this was significant, as it was an increase of their annual electricity consumption of over 10%.[7]
In another case - in which no attention was paid to reduction of the energy consumption of the home automation system - the annual electricity consumption of a very extensive home automation system was found to be as high as 1300 kWh. For an average Dutch household this would mean an increase of the electricity consumption of over 35%.

Recommendations
The following recommendations can be given for improving energy efficiency of home automation systems:

- Reduce the standby electricity consumption of the equipment.
- Reduce the number of power supplies and their number of operational hours.
- Pay special attention to the electricity consumption of equipment that operates continuously, like the communication infrastructure.
- Switch off all equipment with a stand-by electricity consumption from the power supply when it is not operational. Reduction of stand-by electricity consumption can be introduced into the home automation system as an extra function - not only for home automation components, but also for domestic appliances.

Recommendations

For effective and sustainable application of home automation the following recommendations are formulated:

- Supply in a demand controlled way, offering differentiated packages;
- Involve residents from the target group in the composition of these packages;
- Give tailor-made assistance to users during design, installation and (before the) use;
- Give attention to reduction of the energy consumption of the equipment itself;
- Include applications that improve indoor climate and energy efficiency;
- Make sure to include the whole future service chain when developing offers;
- Apply standardised equipment and communication protocols to reduce costs and prevent supplier dependence.

If these recommendations are taken into account, there are good opportunities for the successful and sustainable application of home automation to assist elderly people living independently.
However, current developments in the Netherlands do not fully take into account the recommendations mentioned above. It will depend upon combined action from the industry and the research community in the next couple of years whether or not the development of home automation applications for this growing market will be succesfull and sustainable.

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