

# INDIVIDUAL HOME-OWNERS, ENERGY-EDUCATION AND PV-PERFORMANCE GUARANTEE

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**Abstract** – A series of 15 individual owned houses at the Pieter Christiaanpark in Leeuwarden are designed to become energyneutral. All houses are furnished, amongst other energysaving measures, with large grid-connected photovoltaic systems and a solar domestic hot water system. The design is only potentially energyneutral. The ultimate success depends on the behavior of the occupants. Therefore a scheme is put up to inform and educate the home-owners. The goal is to learn the home-owners how to properly use new technologies needed in energyneutral houses without compromising their comfort. The scheme consists of several meetings and additional manuals to supply the occupants with the necessary information on the right moment. Two types of home-owner's manuals are discussed. The photovoltaic systems were sold with a guarantee on the energy-yield instead of a guarantee on electric power. This guarantee on energy-yield improves the acceptance of solar technologies. The accompanying protocol to establish the normalized yield overcomes the unpredictability of solar energy.

## 1. INTRODUCTION

Building energyneutral houses is not common practice. It still requires an initiative and support. Leeuwarden initiated many projects on saving energy over the past years and for this they received in 1999 the Energy-award of the Netherlands Agency for Energy and the Environment (Novem). The community of Leeuwarden initiated in 1998 two projects on energyneutral houses. One of the projects is called '15 Energyneutral houses Pieter Christiaanpark' in which a whole series of houses had to become energyneutral. There are several definitions of energyneutrality possible. In this project an energyneutral house is defined as a house in which the emitted CO<sub>2</sub> of the still needed energy from fossil fuels over one year equals the same amount of CO<sub>2</sub>-emission avoided by the production of sustainable energy, if produced conventionally.



**figure 1 – View on the rear side of the energyneutral homes Pieter Christiaanpark, Leeuwarden.**

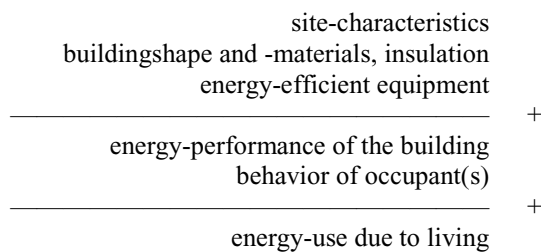
In the Pieter Christiaan-project a concept was put forward with mostly proven technology [1]. Only one new technology was introduced: a collective gasabsorption heatpump for all 15 houses. To produce the needed sustainable energy the south-orientated shed-roofs were furnished with a large grid-connected photovoltaic system with a guaranteed production of 3,700 kWh per dwelling. To guarantee electricity instead of electric power is quite unusual but advantageous for the buyer. The concept gained support among the projectdeveloper, the constructor, the local utility and Novem. Although the technologies were proven, that didn't mean that they were common. Because real energyneutrality is established during the use of the building, the support of the would-be home-owners themselves was essential for the success of the project.

## 2. ENERGYNEUTRAL HOMES FOR EVERYONE

The art of building energyneutral houses goes further than to realise a set of innovative technologies. The art is also to obtain the occupants' acceptance of these innovative technologies. Acceptance is more likely if it comes closer to what they are used to. People often resist change but can learn to live with changes provided they are not too extreme. The easy way out is to search for people who are interested in saving energy, people who are prepared to invest their time and energy in learning to live with all the new technologies. Although more people become conscious of the necessity to save energy, few are prepared to pay the price. And there are too few of them to solve the problem. To achieve significant energy savings, it is necessary that everyone can live in such a house without any problem. This was one of the presumptions of the project and lead to the demand of

using proven technology. As already put forward, proven is not the same as commonly accepted.

Energynutrality implies that not only energy-use closely related to the building itself is involved but also the energy-use closely related to the occupants. Although there's not a clear distinction between these two kinds of energy-use. Roughly speaking one can say that heating, lighting and auxiliary power are more related to the design and hot water, cooking and domestic equipment are more related to the occupants. A good design can only be potentially energy-neutral: a compact design, walls well insulated, windows put in the right place to catch the sun's energy in winter, etc. With enough support such a design can even be made economically feasible. Designers can do their best but their calculated energy-saving exist only on paper. The actual energy-use depends strongly on the behavior of the owners. Without the effort of the occupants it is not possible to actually become energynutral.



**figure 2 – Schematic view of the relation between site, building, occupants and energy-use.**

The new occupants of an energynutral house, who are used to the average existing house, have to learn to use the house according to the intention of the design and preferably have to learn to use less energy themselves also. Someone has to explain them how to use a house equipped with new technologies that makes a house potentially energynutral. Informing the home-owners will diminish the gap between their old and new situation so the change seems to be small. But who will explain all this?

The usual involved companies in the design- and building of the house are often not reluctant to inform the home-owner how to use their new home and to become energynutral. There is no incentive for these companies to inform the new home-owners what they need to know. It is simply not in their interest. They are not paid for the job, it is unlikely that those people will be their client again and they are also not trained in teaching. They are trained in designing or building houses. After the house is completed everyone involved moves to the next project and no one cares about the actual energy-use.

The energynutrality was also based on an assumption about the behavior of the occupants. So in this specific

project the home-owners had to be instructed not only on matters related to the specific building but also on matters related to daily live. Especially the use of electricity depends on behavior of the occupants and was estimated in total at 1,740 kWh per year. The assumption was conservative compared to the average use of electricity of a Dutch household 3,300 kWh per year [2]. A survey of the average use of electricity within the group of the new home-owners of Pieter Christiaanpark in their former houses in the previous year (1999) showed that the use of electricity varied between 1,193 kWh and 3,329 kWh with an average of 2,253 kWh. The difference with the assumption had to be solved by trying to adapt the behavior of the occupants. In comparison to the efforts of several involved companies and the community during the design and construction of the energynutral houses it is justified to also ask a contribution of the new home-owners to attain energynutrality.

**table 1 – Comparison of fossil energy-use of different types of houses.**

	Gas [m <sup>3</sup> ]	Electricity [kWh]
1. Average existing house (NL) <sup>1</sup> (tweekapper, build after 1982)	1,400	3,300
2. Novem reference new houses <sup>2</sup> (tweekapper, EPc <sup>3</sup> =1,2)	1,100	3,100
3. Energynutral <sup>4</sup> houses, Pieter Christiaan-park, EPc=0,6	570	1,740

**table 2 – Yearly CO<sub>2</sub>-balance of a energynutral house at the Pieter Christiaanpark.**

	Gas [m <sup>3</sup> ]	Electr. [kWh]	Energy [MJ <sub>Prim</sub> ]	CO <sub>2</sub> [kg]
Heating, Domestic hot water	705	40	22,822	1,232
Solar dom. hot water system	-200		-6,472	-342
Dom. equip. lighting, cooking	65	1,700	17,800	1,215
Photovoltaic system		-3,700	-34,150 <sup>5</sup>	-2,355

<sup>1</sup> 1997 [2]

<sup>2</sup> Includes domestic equipment 1.400 kWh.

<sup>3</sup> Energy Performance-coefficient mandatory for new houses with building-permit between January 1st, 1998 and January 1st, 2000.

<sup>4</sup> Excludes photovoltaic electricity, includes collective heating.

<sup>5</sup> Based on the average efficiency of the Dutch electricity-production.

### 3. INSTRUCTING THE OCCUPANTS ON USING AN ENERGYNEUTRAL HOME

If people don't understand their homes, they cannot make optimal use of the house and the new technologies. What is even worse, they probably blame the new technologies if discomfort arises. If, on the contrary, people notice the behavior of their house and are able to relate this to their own actions, they get the feeling they are in control and in time learn to use the new technologies to their advantage.

On behalf of the occupants the community of Leeuwarden and Ecofys, as her counselor, decided that informing the home-owners in energy-related matters had to be an issue in the project. The idea was simply to extend the usual home-owners manual with special attention to energy and sustainability. The manual would have to contain specific information on this subject, easy to use when needed. The content of most manuals however doesn't invite to read for fun and so people rarely read manuals. The quality of the average home-owners manual depends strongly on the motivation of the contractor for this part of his work. Two meetings with the home-owners were added. The advantage of a meeting is the possibility to bring forward the essence of the information and to involve the home-owners in the project of attaining energyneutrality. It also gives a better indication –by direct feedback– if the information has actually reached the home-owner. Ecofys organized both the meetings and also the manuals.

#### 3.1 Meeting the occupants

Informing home-owners that already have a lot on their mind asks for careful planning to give the right information on the right moment to increase the effectiveness. The right moment to inform occupants is when they immediately can use the information on energy and sustainability in their actions around the new house (ordering a kitchen, buying domestic equipment, decorating the house, starting to use the house or even when they start arranging the garden).

First of all it is important to be aware that the average home-owner lacks sufficient knowledge of the subject to fully comprehend an energyneutral home. It is therefore necessary to focus only on information about simple actions he or she can or has to take when living in an energyneutral house. Nevertheless a short and simple explanation on the interaction between climate, hvac-equipment, the house itself and their own behavior is unavoidable. This left the home-owners with a basic idea about the function of the (new) technologies and the effects on the interior climate so he or she was able to control his or her own comfort. This explanation was given in the first meeting in which also the background and reasons of building energyneutral were presented. Another purpose of the first meeting was to show that

energyneutral living can already be part of daily life. The second meeting focused on information on what to do and what not to do when living in an energy-neutral house in order to attain the desired comfort. The last meeting clarified all equipment in showing the home-owners in a life situation how to operate, to use and to maintain the house by demonstration. The purpose of the meetings was not only to teach the occupants on how to use an energyneutral house but also to prevent prejudices about new technologies due to incorrect use.

The information during the second meeting on what to do and what not to do was divided into (1) actions more or less independent of the specific building, i.e. information with a general value, and (2) actions related to the specific building. For the first kind of information there already exists several books. For this project we choose the book 'Hart voor uw huis' –[Have a] heart for your house– [3] (manual 1) because it uses simple language and illustrations and has a structured lay-out of subjects related to several aspects of living with separated discussions of examples and/or comparisons of alternatives. This general information included also information on how to decorate your house with environmentally sound materials. Information about actions related to the specific building focused on dealing with the high insulation and balanced ventilation-system with heatrecovery in relation to the interior climate and comfort and on making optimal use of the sun's energy. This information was also put in the home-owner manual (manual 2) which will be discussed later. In table 3 one can find the education-scheme used in the Pieter Christiaanpark.

#### table 3– Which information, when and how.

- Meeting 1: Background and motives of energyneutral houses – function of hvac-equipment (2-3 months before completion of the house).
- Meeting 2: Interaction between climate, hvac-equipment, the house and behavior to attain the desired comfort; instruction on using hvac-equipment; information about furnishing and decorating the house (6-8 weeks before completion of the house)
- Meeting 3: Demonstration at the site in operating, cleaning, maintaining and solving small problems of the hvac-equipment (shortly after completion of the house).
- Manual 1: General information on sustainable and energysaving living (2-3 months before completion of the house).
- Manual 2: Specific information on why and how to operate, clean, maintain and repair building materials and/or hvac-equipment (at completion of the house).

The meetings about energy and sustainability coincided with general meetings organised by the contractor to inform the new home-owners about the progress of the project and other general matters related to the project. It is safe to say that most home-owners appreciate the effort to inform them about their special houses. A survey among the new home-owners during the use of the homes must indicate whether the information served its purpose.

### 3.2 The PV-Performance Guarantee Protocol

The large photovoltaic system and the domestic solar hot water system are crucial for the CO<sub>2</sub>-balance of the houses. The home-owners of the energyneutral houses of the Pieter Christiaanpark bought, together with the house itself, a (subsidized) photovoltaic system with a guaranteed production of 3,700 kWh electricity in an average year. Guaranteeing electricity instead of electric power ( $W_p$ ) shifts the risks of a dysfunctional system from the buyer to the supplier. This improves the acceptance of photovoltaic technology by the new home-owners. With this guarantee they also got a familiar criterion (kWh) to check themselves what they had bought. A criterion closely related to their daily life. To facilitate this and to stimulate their interest for solar-power, the meter that indicates the production of electricity by the photovoltaic system was placed on a easily and readily accessible spot: the meter-cabinet next to the frontdoor in the central hall. The solar system received special attention during the meetings with the home-owners. Both systems were explained and an attempt was made to adapt their behavior to use the sun's energy when available (during the day and from early spring till late autumn).

Guaranteeing solar energy is easier said than done. It involves drafting a detailed contract to lay down exactly what is guaranteed and what will be done to verify the guarantee. Based on experiences in the 1 MW-PV-project of Nieuwland, Amersfoort, a performance guarantee contract was designed. At first, conditions under which the guarantee is made had to be stated clearly. For example, the PV-production was guaranteed on the insolation of the test-reference year of De Bilt (TRY De Bilt). Then, after commissioning of the PV-system and a test period, a measurement period is started to verify the performance guarantee. A one year measurement period was taken to get a good idea of yearly system performance without having to make detailed calculations to correct for climatic deviations in the measurement period. A simple performance check reduces risk of arguments on details of calculations later on. At the end of the measurement period it is evaluated whether the system has functioned according to the guaranteed level of performance. If the system performs correctly this is a very simple calculation. In more complex cases corrections for outages might have to be made. It is important to regularly keep track of system performance during the measurement year to detect outages at an early

stage. Agreements were made on a minimal measuring frequency. The owner/user is responsible to inform the supplier within 7 days if the system would fail or would not function properly. If production-loss is caused by not informing the supplier in time this loss is accountable to the owner/user. Finally, if the system doesn't meet the guaranteed results, the PV supplier has to pay for the lower yield of the system. The development of the Performance Guarantee Protocol for the CO<sub>2</sub>-balance homes was part of a European project for developing a model contract for PV-performance guarantees [4].

#### table 4 – The main aspects of the PV-Performance Guarantee Protocol.

1. Define the conditions on which the production of electricity is guaranteed (a/o. the irradiation).
2. Relate the actual situation to the conditions.
3. Correct the actual production for the actual situation to obtain the normalized production of electricity.
4. Compare the normalized production with the guaranteed production. Incorporate if desired a margin for (unnoticed) failure and/or repair of the system.
5. Establish agreement on when and how data is measured (actual production, actual or local irradiation) and when and who informs the supplier in case of failure or malfunction.
6. Establish agreement on fines if the normalized production differs from the guaranteed production.

Because of the extensive efforts attached to the protocol (measuring, informing) it is only economical in the case of large photovoltaic systems. Although not a guarantee on performance there are already other products on the market with which PV-owners can track themselves the performance of their system. For small photovoltaic systems there are special loggers/displays<sup>6</sup> available that register the cumulative amount of produced and used electricity as well as the momentaneous production of electricity by the sun.

### 3.3 Types of home-owner manual

Every house is unique in a way and needs its own specific manual. This can be solved in two ways. The first method is the modular approach in which standardized text and illustrations of building-elements or instruction on comfort are selected depending on its presence or relevancy to quickly compose a manual. An example of this approach is the recently issued WoonWijzerWizard [5]. The disadvantage of this kind of manual is that it results in global information because it has to be valid for a many types of houses. A manual of this kind can easily be outdated if no maintenance of the underlying database is carried out. Another approach issues a set of simple instructions to the contractor and subcontractor(s) which

<sup>6</sup> For example the Eclipse PV/E of Econergy BV.

information they have to collect and in which way they have to present this information. In this approach only the structure of information is specified, not the contents. The collected information in this structural approach is put together in a home-owners manual by the contractor or in order of the contractor by a specialized bureau. The advantage of this structural approach is that information is up to date and specific for the project. The disadvantage is that more effort is needed to collect the necessary information.

**table 5 – Qualitative assesment on two kinds of home-owners manuals.**

	MODULAR	STRUCTURAL
Method	Standard paragraphs of items	Instruction on what/how to specify
Information	Global, easily outdated	Specific, always up-to-date
Source	Central database	Contractor, sub-contractor
Effort (time, costs)	Limited <sup>7</sup> (product-based)	Extensive <sup>8</sup> (proces-based)
User-friendliness	Requires more basic knowledge and imagination	Step-by-step instruction on recognizable objects
Conditions	Ownership or license of database required	Agreement with contractor required in early stage, preferably part of tendering

In the Pieter Christiaanpark-project the structural approach is applied. The main structure consists of three parts. The first part repeats the specific information presented during the meeting on the interaction between the house and the actions by the occupants. The second part describes the cleaning, maintenance and repairing of the building that can be carried out by the occupants themselves and describes also the operating, cleaning, maintenance and repairing of hvac-equipment that can be carried out by the occupants. Finally, the third part describes the specifications of the building and the equipment for reasons of maintenance, repair and/or extension by professionals. Each paragraph ends with one or more bullets summarizing what to do or what not to do regarding the topic under discussion.

<sup>7</sup> Assuming a complete database with information is available.

<sup>8</sup> Information-gathering divided over several involved (sub)contractors.

**table 6 – Main parts of home-owner manual according to the structural approach.**

1. Daily use – understanding the interaction between climate, house and hvac-equipment to reach the desired comfort
2. Instructions: cleaning, maintenance, repairing – by home-owners themselves
3. Specifications: maintenance, repairing and extension – by professionals

Within the main structure the information of the second and third part are supplied by the contractor (or the sub-contractors). They receive the instruction to describe the following aspects of their product, if applicable:

- a. Functioning.
- b. Description of the main parts; main technical specifications.
- c. Operation.
- d. Cleaning and maintenance.
- e. Safety; What to do in case of malfunctioning.
- f. Guarantees, certificates, insurance.
- g. Hints in optimizing the use of the system.
- h. Data of services and suppliers.

### 3.4 Monitoring

The houses are recently completed. In order of the Netherlands Agency for Energy and the Environment (Novem) the effect of the structural approach will be monitored. The actual energy-use of the house will be measured. An inquiry will be set up to investigate their behavior and how they adapted following the information presented during the meeting and in the manuals.

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