New concepts for solar collectors in 2030

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Abstract

In 2030, solar energy is expected to cover the full energy demand of newly built houses. In addition, increasing standards for quality of living require that newly built houses offer increased comfort, while still being affordable. Current collector technology will not be able to meet all these requirements; hence, new collector concepts are required. This paper develops new concepts for the capture, conversion, and storage of solar energy with a focus on future integration in newly built houses. Industrial design engineering was used in the concept development, including an analysis of the field as well as a series of workshops. Out of several concepts, two were selected and elaborated. The first concept (aimed at 2015) is based on a passive house, and is able to fully provide the domestic energy use of both the user and the building itself. The second concept (aimed at 2030) integrates energy production, energy storage, building insulation, and an indoor climate system in durable, modular construction elements; the total energy production of this concept exceeds the total domestic energy use. This paper illustrates the concept development process and its results.

Keywords: solar thermal collectors, built environment, zero-energy house, building integration.

1. Introduction

In 2030, the energy demand of newly built houses will be fully covered with solar energy, according to the vision of the European Solar Thermal Technology platform. Naturally, this should not interfere with the increasing demand for indoor comfort and the need for affordable accommodation. This creates a lot of requirements for future solar thermal collectors.

With the materials and production technologies that are currently being used, it is not possible to make the transition to a next generation of solar collectors with a strongly improved price/performance ratio. New collector concepts are required, based on new materials, new production technologies, and on increased intelligence of the collector system. In this paper we will illustrate how new concepts for solar collectors have been developed with a focus on implementation in 2030.

2. Approach

Within WAELS, a Dutch national long-term research project, a vision on the solar thermal collector of the future was developed. The explicit intention within this project was to develop a vision that was unbiased by the limits or benefits of existing collector technologies. Therefore, a backcasting method was used. This method starts by describing a vision of the future situation; from there, it deduced the developments needed to reach that situation.

As a first step, a series of three workshops was organised to get an overview of the developments in the various sectors related to solar thermal collectors. Experts from widely varying fields, such as construction, installation, materials science, and information technology, were invited to discuss the developments in their fields of expertise, and to share their expectations of the state of technology within their field in 2030. These developments were combined in order to define a set of opportunities (e.g. new materials, sensors, construction technologies, etc.) and boundary conditions (e.g. evolved energy demand, competing technologies, etc.) for solar thermal collectors in 2030.

3. Trends

In the workshops, many interesting ideas and combinations of new technologies were discussed. In general, these ideas can all be summarised in the following five expected trends, describing aspects that will become increasingly important for solar collectors:

- flexibility: both building and installation can easily adapt to newly added components or to changes in user demands;
- integration: building and installation components are fully integrated and interwoven;
- intelligence: the building can independently adapt its behaviour to the ambient conditions and the user's demands and behaviour;
- modularity: building and installation components are easily exchangeable;
- independence: the building can provide in its own energy needs.

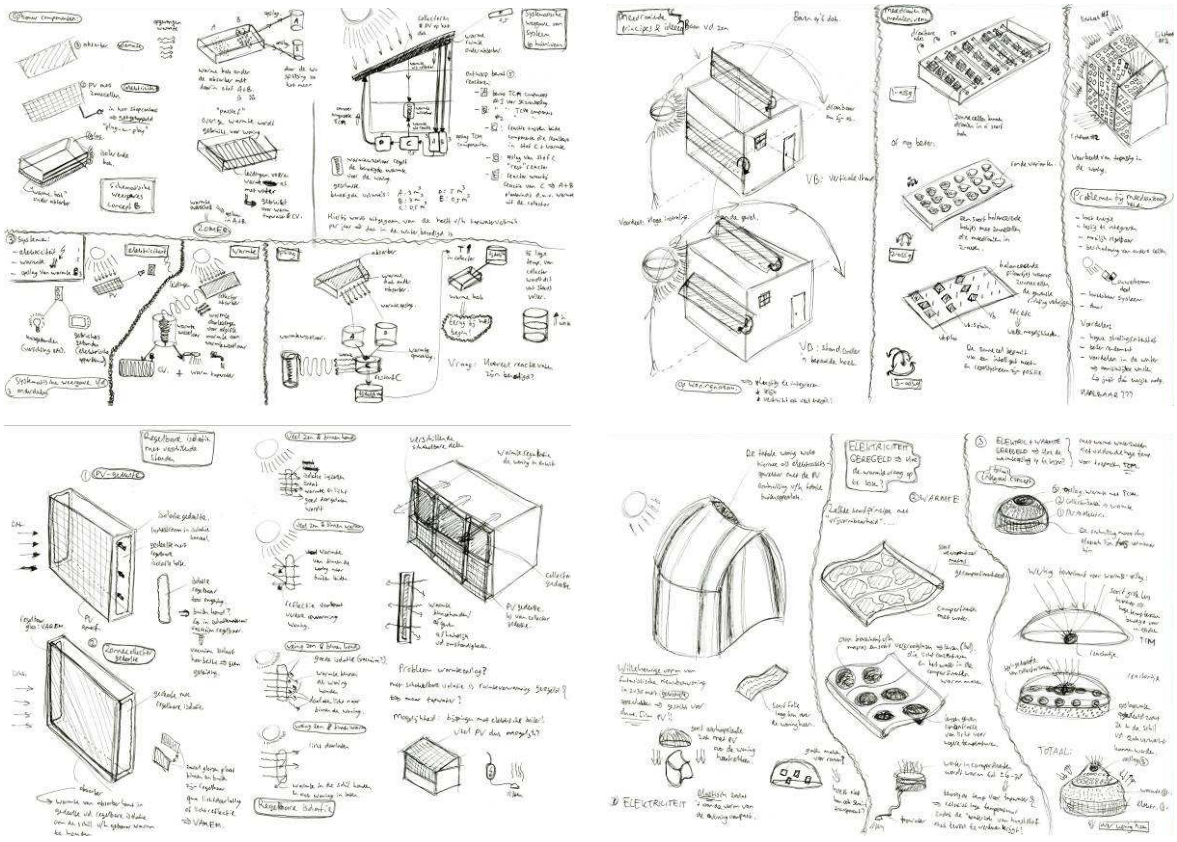

Figure 1 — Some rough sketches visualising some of the ideas from the workshops.

The trends and ideas resulting from the series of workshops were analysed by an industrial designer of the University of Twente and combined into twelve sketches of the solar thermal collector of the future. The purpose of these sketches was to visualise the outcomes from the workshop, and to get an impression of the consequences and feasibility of the realisation of these trends.

Next, a multi-criteria analysis was performed, in which the sketches were analysed and ranked. Aspects in this analysis were the requirement of energy neutrality, ease of installation and building integration, feasibility of large-scale production and realisation, renewability, economy, and aesthetics. The sketches with the highest score in the multi-criteria analysis were worked out into two primary concepts.

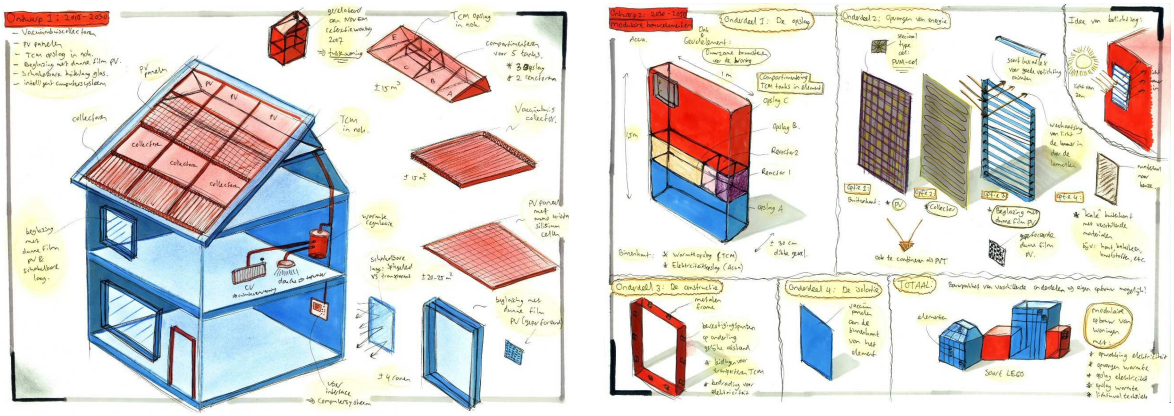

Figure 2 — Rough sketches of the two selected concepts.

4. Concepts

The first concept, aimed at 2015, is based on a passive house. The roof is covered with a roof-integrated side-by-side solar system with both PV panels and vacuum tube collectors (see Figure 3). The heat generated in the collectors is stored in a thermochemical seasonal heat storage. The energy flows, heat as well as power, are regulated by an intelligent energy management system. This system is able to fully provide the domestic energy use (assumed to be 6.5 GJ for space heating, 12 GJ for DHW, and 3,500 kWh for electricity), covering the energy demand of both the user and the building itself.

The second concept, aimed at 2030, is based on durable, modular construction elements, in which energy production, energy storage, building insulation, and an indoor climate system can all be integrated (see Figure 3). By choosing the appropriate construction elements, the building can be completely tweaked to the user's particular demands. Although the energy production of this concept is of course very dependent on the chosen configuration, many energy-producing configurations are possible, in which the total energy production exceeds the total domestic energy use.

Note that these two concepts should not be seen as design concepts for a future dwelling; they are only intended to visualise possible directions for the future development of solar thermal collectors, and to illustrate the possible consequences of the expected trends described earlier.

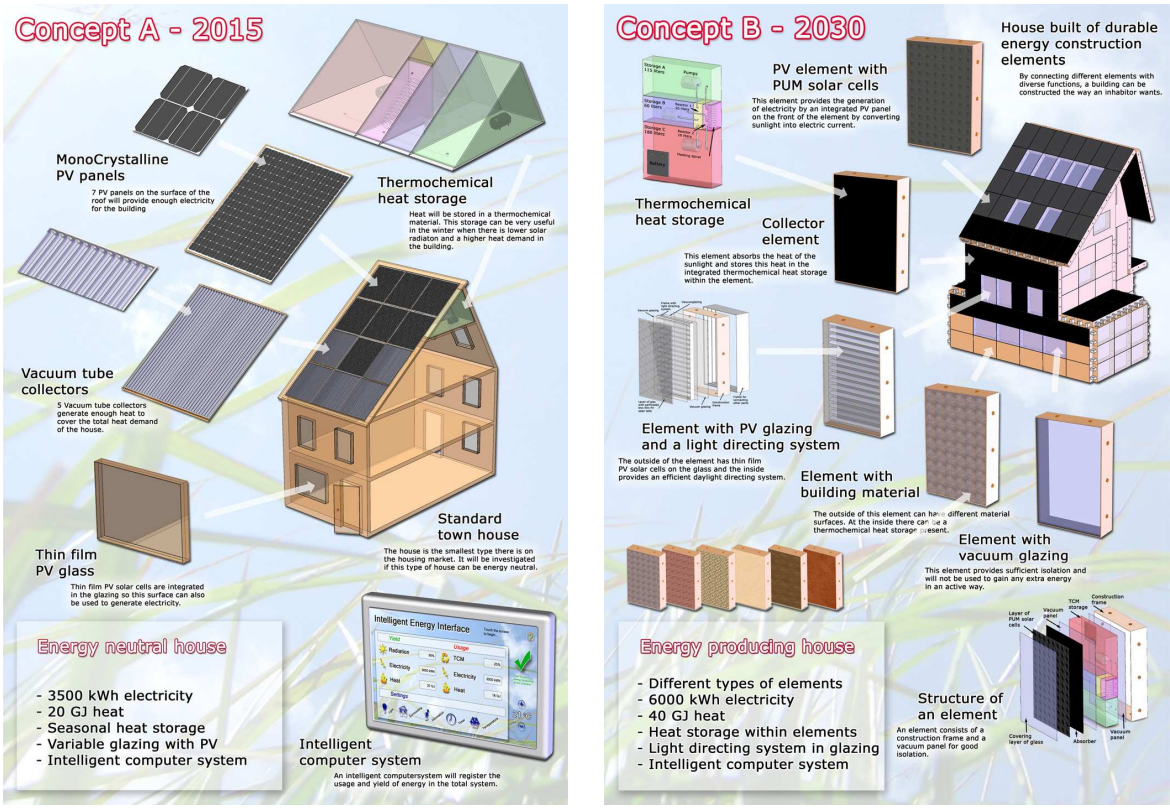

Figure 3 — The two selected concepts.

5. Acknowledgements

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