

# BIPV Pricing in The Netherlands

2014 Price Benchmark Report



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## 1 Preface

With pleasure we present the results of a Building Integrated Photo-Voltaics (BIPV) price benchmark study for the Netherlands. The study was conducted in the first quarter of 2014, as a topic in the M.Sc. project of Guus Verberne. Since that time, the results already attracted a lot of attention from the SEAC project partners. The results were also used in a conference paper concerning a market analysis for BIPV façade and roof products<sup>1</sup>. The results will also be used in an up-coming report by the SEAC and the SUPSI on the availability of BIPV solutions in The Netherlands and Switzerland. The popularity of the results made us decide to make a full report from the results that is free to download for the solar energy community.

We want to thank all participants for their contribution to this benchmark study:

- ABG Solar bv
- AERspire bv
- De Solarshop
- Dijkman elektrotechniek bv
- Direct Solar
- Ennova
- Eternit
- Heijmans
- Green Power Systems
- M2bouw
- Mijn Energiefabriek
- Monier
- Nederlands Bouwkosten Instituut
- New Energy Systems
- SCX Solar
- Smartroof
- Solar Today
- Solar-Systemen
- Solus Engineering
- Stafier
- Synroof
- Van der Sanden dakbedekkingen
- Zonnefabriek
- Zonnepanelen-parkstad

Last but not least, we would like to thank *you* for downloading and reading the report. We hope the results will bring you new insights and will allow you to better understand the cost build-up and market potential of BIPV systems.

With kind regards,

The Authors

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<sup>1</sup> G. Verberne *et al.*, "BIPV Products for Façades and Roofs: A Market Analysis", Proceedings of the 29<sup>th</sup> EU-PVSEC held in September 2014 in Amsterdam, The Netherlands. On-line available at <http://www.eupvsec-proceedings.com/>

## 2 Summary

In this benchmark we investigated the price levels of the Building Integrated Photo-Voltaics (BIPV) market in the Netherlands. There is a broad scope of different BIPV applications (e.g. roofing, façades, skylights, glazing, etc.). This study limited itself to the applications for pitched roofing in the Dutch residential sector. Two types of BIPV applications (tiles, in-roof systems) were compared to conventional roofing and conventional Building-Attached Photo-Voltaic (BAPV) roofing solutions.

Suppliers of BIPV systems were invited to quote on a virtual home with the target to make the house net electricity zero. Two virtual homes were defined. The first virtual home was a terraced house with 60 m<sup>2</sup> roof area and 3300 kWh/a electricity usage. The second virtual home was a detached house with 125 m<sup>2</sup> of roof area and 4600 kWh/a electricity usage. The quotes were split up in various categories including electrical connection costs (cables, inverter, AC connection), PV installation costs, PV fastening system costs, PV panels costs, Installation costs, and conventional roofing materials costs.

In total, 11 quotes for BIPV systems were received. These were well-distributed over the two categories of BIPV in-roof systems and BIPV tiles. In addition, 8 quotes on conventional BAPV systems were gathered for price comparison. It was chosen to report the turn-key prices for the full roof upgrade rather than the common unit of €/Wp, because only in this way a clean comparison between the various solutions to make the house net electricity neutral could be made. From the analysis of the prices, the following key conclusions can be drawn:

- Turn-key prices for retrofitting a BAPV system and make the house net electricity neutral are €6,000 for a terraced and €8,000 for a detached house. BIPV in-roof mounting systems add €2,500 to these costs, due to three main effects:
  - Additional labour is required due to the removal of the existing roof tiles.
  - Suppliers of BIPV in-roof mounting systems tend to choose high quality European brand PV panels in their systems, whereas BAPV system suppliers tend to choose low-cost Asian brand PV panels.
  - More costs are made in the installation process, due to a more complicated and slower installation process than BAPV systems.
- Turn-key prices for renovating a full roof and then adding a BAPV system to make the house net electricity neutral are €10,000 for a terraced and €16,000 for a detached house. BIPV in-roof mounting systems add €1,000 to these costs. Cost savings are made for requiring less roof tiles, but additional expenses are needed for the use of more expensive high quality brand PV panels and longer installation times required.
- Several suppliers of BIPV tiles are active on the Dutch market. Their products are meant to blend better into the roof's optical appearance and consequently improve the overall aesthetical quality of the house. A large price spread within the products that are offered exists. The cheapest BIPV tile solution for a turn-key roof renovation was €14,000 euro for a terraced and €21,000 euro for a detached house. The most expensive solution was €23,000 euro for a terraced and €35,000 euro for a detached house. The large price range suggests a proto niche market or sub-segmentation within this product group.
- Comparing the dwelling types with each other we see an overall price advantage in favour for larger roof systems. The electricity producing roof on a detached house was approx. 20% cheaper per m<sup>2</sup> than the same system on a terraced house, for all three system types of BAPV, BIPV in-roof systems and BIPV tiles.

### 3 Method

#### Outline benchmark study

As mentioned in the introduction the focus of this report lies on the residential pitch roofing applications, where we have 3 main categories. First, the Dutch conventional roofing which represents the most common roofing solution and consist mainly of different types of tiles. The second category is BAPV (See Figure 6) solutions for pitched roofs, by far the most common PV pitched roof solution. The last category is BIPV and can be sub-divided into two different roofing solutions, namely in-roof mounting systems (See Figure 7) and BIPV tiles (See Figure 8). We discuss these categories into more detail later in this chapter.

#### Reference roof

A survey was conducted to gather all the data regarding the three different roofing solutions. In order to make the results of the survey comparable, two reference roofs were determined. The two chosen roofs represent the largest share of dwellings in the Netherlands. For the exact dimensions of both roofs see Figure 1 and Figure 2. One is an average terraced house (NL: rijtjeshuis) with a total roof area of  $\pm 60 \text{ m}^2$  (source: AgentschapNL). The second roof is that of an average detached house (NL: vrijstaand huis) with a total roof area  $\pm 125 \text{ m}^2$  (source: AgentschapNL).

#### PV system size

The PV system size is determined based on the net electricity neutral requirement. The requirement implies that the annual electricity production of the PV system equals the annual electricity consumption of the household. The specific annual yield of the PV system varies between 600 and 1000 kWh/kWp depending factors such as location, azimuth, tilt and horizon pollution. In this report 900 kWh/kWp is assumed, which is typical for south facing systems in The Netherlands. The average electricity consumption of a terraced house is 3300 kWh/year (source: CBS). The required south facing PV system is 3650 Wp. In some rare cases of low efficiency BIPV tile solutions, the south facing roof of the terraced house was not large enough to fit the PV system. In these cases we fitted a part of the system on the north side of the roof, and assumed 540 kWh/kWp for these panels. The average electricity consumption of the detached house is 4600 kWh/year (source: CBS). The required south facing PV system is 5100 Wp.

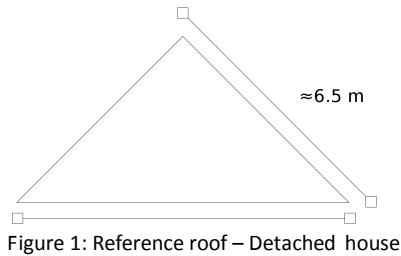
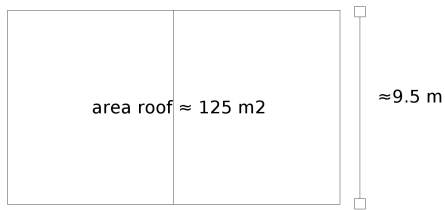


Figure 1: Reference roof – Detached house

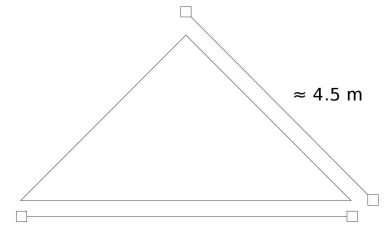
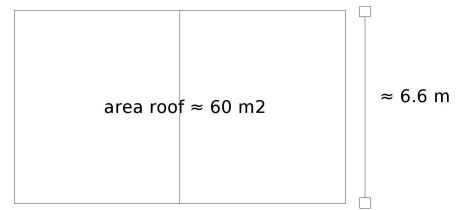


Figure 2: Reference roof – Terraced house

### Roofing solutions

Gathering the required data for the benchmark is differently done for the three categories (conventional roofing, BAPV and BIPV). First actors which are involved in the execution of conventional roofing were determined. The data from NBI - Bouwprijzen Gebouwelementen Renovatie (2013) is used to determine the prices for roofing a conventional roof, both terraced and detached. Moreover, three roofing materials are included for the conventional roofs. Concrete tiles (See Figure 3) which are often used today because of their low costs and easiness to install. Next, ceramic tiles (See Figure 4) which represent the most common roofing material for existing Dutch pitched roofs. The ceramic tiles are more expensive than concrete tiles but less expensive as slates (See Figure 5) which is the third roofing material. Slates are not very common in the Netherlands and mostly known from historical buildings such as churches and town halls. The turn-key prices of these conventional roofing solutions are checked and compared for validity with the prices of roofer contractors and a construction company.

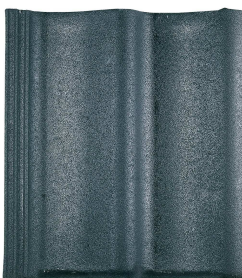


Figure 3: Concrete tile



Figure 4: Ceramic tile

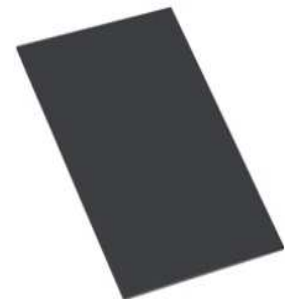


Figure 5: Slate

For the second and third category (BAPV and BIPV roof solutions) a survey was conducted. Quotes were gathered for the two described roofs. In order to reduce the bias in the responses it was important to only gather the data from a quote which is related to the PV part of BAPV installation. For the BAPV and BIPV roofing solutions, the quote was divided into 3 material components; PV panels, BAPV fastening system and

the inverter together with other electronic components. Furthermore, 2 labour costs were determined, the installation costs for installing the mechanical part (PV panels and fastening system) and the installation cost for the electrical part of the PV system. Due to the earlier described aim of this study, the BAPV panels, fastening systems and the installation of the mechanical part of the PV system are variable per quote. For the electrical components and the installation of these components fixed prices are used for all the quotations, this applies for both BAPV as well as for BIPV. Additional information was needed for BIPV roof tile solutions. Here we can distinguish PV tiles, Non-PV tiles (custom made conventional tiles) and the inverter and other electronic components. Furthermore, two labour prices were determined, the installation costs for installing the mechanical part (PV tiles and non-PV tiles) and the installation costs for the electrical part of the PV system. The defined material components for the BIPV in-roof mounting systems are similar to those of the BAPV only the fastening system is a special in-roof frame instead of an on-roof frame.



Figure 6: BAPV



Figure 7: BIPV in-roof mounting system



Figure 8: BIPV tiles

### Type of project

At which moment in the building phase one should integrate a roofing solution? The moment of integration plays a big role to determine which roofing solution is more or less suitable. Here three types of integration are determined and discussed: retro-fit, renovation and new built.

- Retro-fit refers to the addition of new technology or features to older systems. Here this means improving the existing buildings with energy efficiency equipment. In the case of retro-fit for pitched residential houses, all three suggested PV roofing categories could be used for retro-fit, although for BIPV tiles this depends on the compatibility of the PV tile with the existing roofing material. For BAPV this means adding the BAPV system to the original roof. When an in-roof mounting system is applied a part of the old roof will be removed. When necessary water-resistant foils are added and the in-roof mounting system is installed. Also here a distinction is made between material costs and labour costs.
- Renovation refers the process of improving an existing structure, in this case a pitched roof of a house. Included in the renovation is the removal of counter battens, tile battens (dutch: tengels en panlatten) and tiles. Installing new battens, tiles and a roofing or combination of roofing solutions are included in the renovation process. Also here material costs and labour costs are taken into account separately. All roofing categories are investigated regarding to renovation.
- New built refers to the construction of new infrastructure, in this case pitched roofs for residential purposes. The construction activities which are taken into account are similar to the ones of renovation, the only difference here the removing part which is excluded.

### **Participants of this benchmark study**

This benchmark is made possible by the input of the participants, from 31 companies who were asked to participate in this benchmark 23 actually did. The high attendance of 75% demonstrates the interest in a rapidly evolving PV market. Producers and installers see the possible prospects and want to stay up to date regarding the developments in the BI(PV) residential market. If we divide the participants in the different categories and sub-categories the distribution is the following;

- Conventional roofing: 3 participants
- BAPV roofing solution: 8 participants
- BIPV in-roof solution: 6 participants
- BIPV tiles: 5 participants
- BIPV full roof solution: 1 participant (category not further explained and results not further reported due to lack of statistics in this category)

### **Figure of merit**

The standard figure-of-merit to describe a PV system's financial performance is the €/Wp, in which the Capital Expenses (CapEx) of the PV system is divided onto its power generation capacity expressed in Wp. This may be convenient for BAPV systems as the CapEx is made to achieve one function, namely producing electricity. In contrast, we are investigating the price of a roof with multiple functions. A significant share of the price is attributed to non-PV functions, such as rain tightness, weather proof, constructional safe, aesthetics. In order to still be able to compare the various systems we have chosen to use the total consumer price per household as the figure-of-merit. This total price includes the VAT of 21%.

In some figures, we divide the total price of the roof over the total area of the roof, in order to arrive at a typical price/m<sup>2</sup>. All turn-key prices are average prices calculated per roofing category. To give more insight in the price range of a particular roofing category box-and-whisker plots are used. These graphs depict the range of all the participating companies in a category.



## 4 Results

This chapter provides an overview of the results from the benchmark study. The results are separately displayed per project type: retro-fit, renovation or new built.

### Retro-fit

As discussed in the previous chapter retro-fit solely fits BAPV, BIPV in-roof mounting systems and to a smaller extent it fits to BIPV tiles (depends on the compatibility of the BIPV tile). For this reason we have chosen to only include BAPV and BIPV in-roof mounting systems as viable options for retro-fit. Retro-fitting a detached house with BIPV in-roof mounting system is on average 35-40% more expensive than when applied with a BAPV system.

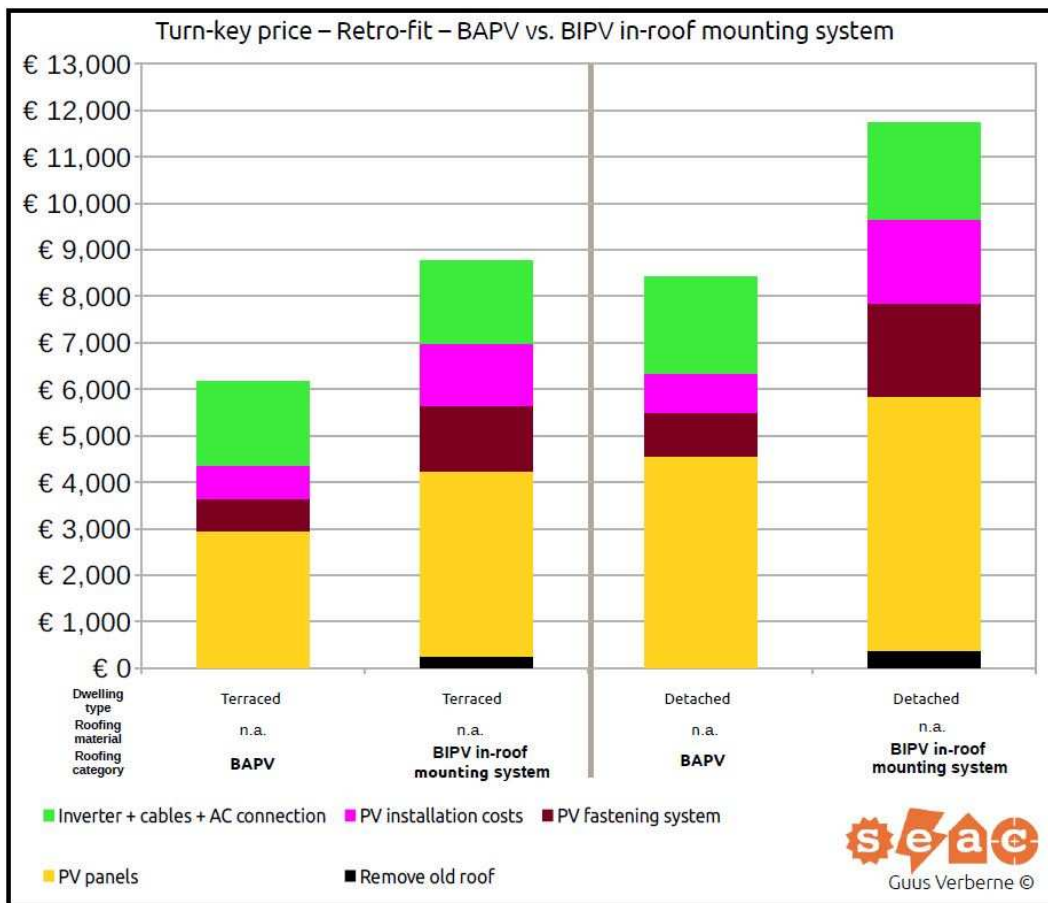


Figure 9: Average turn-key price – Retrofit – BAPV vs. BIPV in-roof mounting systems.

Figure 9 displays the average price for two different roof solutions namely BAPV and BIPV in-roof mounting systems. The left two stacked bars represent the terraced house where the right two represent the detached house. However, due to the price differences within the two roofing categories we also included the box-and-whisker plot for a retro-fit integration (See Figure 10). A box-and-whisker plot is a convenient way of graphically depicting groups of numerical data through their quartiles. The body of one box plot represents 50% of the turn-key prices. The upper horizontal line represents the highest turn-key price, furthermore, the area between the body and the upper horizontal line is containing 25% of the turn-key

prices. This is similar for the lower part of a box plot. We see there is no overlap between the two solutions, not for the terraced house nor for the detached house. Note that the gap between the two roofing solutions is larger for the terraced house than the detached house.

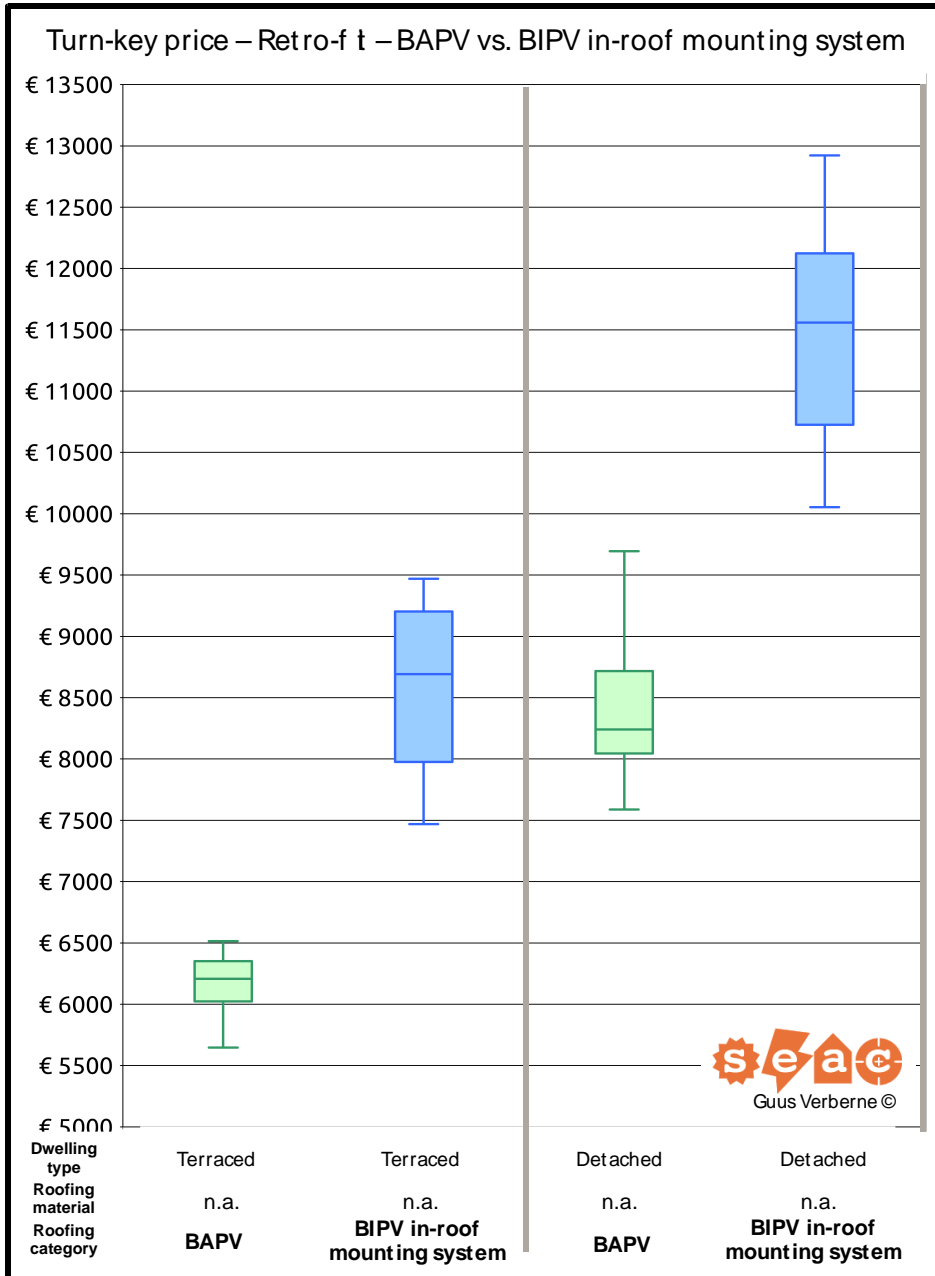


Figure 10: Box-and-whisker plot of turn-key price – Retro-fit – BAPV vs. BIPV in-roof mounting system.

## Renovation

To discuss the renovation 3 types of figures are used. The first figures explain the average prices of the different roofing categories. Next, multiple figures are displayed as the turn-key prices in €/m<sup>2</sup> for each system component. At last, figures explain the price ranges between the different products and roofing categories using box-and-whisker plots.

The next figures show how an average roofing category is composed. All the different components of a roofing solution together form the total turn-key price. First, the conventional roof is discussed, including all three roofing materials. Next BAPV is considered, the BAPV category is integrated with concrete tiles. Other conventional roofing materials are not included due their higher costs. Regarding the BIPV in-roof mounting system all additional roofing materials are considered. Another roofing category which is discussed are the BIPV tiles. We an overview.

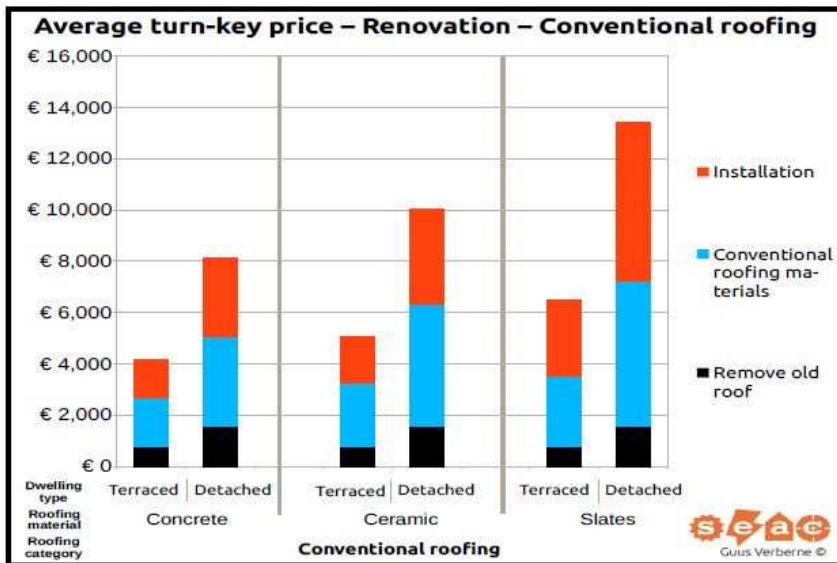


Figure 11: Average turn-key prices conventional roofing – Terraced vs. Detached.

Figure 11 shows the average turn-key prices of the conventional roofing category with different roofing materials. The stacked bar includes removing the old roof, the material costs of the new roof and the installation of the new roof. Included in the roofing materials are battens, different kind of roof tiles (e.g. tiles, ridge tiles, wall tiles, etc.) and tile hooks.

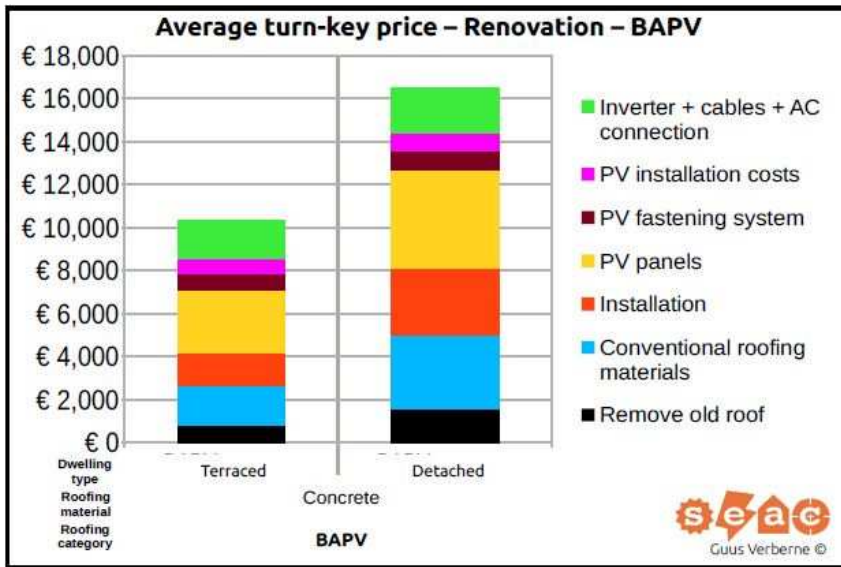


Figure 12: Average turn-key price BAPV - Terraced vs. Detached.

Figure 12 displays the graph of the average turn-key price of the BAPV roofing category. Here the roof is renovated and after installing the new concrete tiles a BAPV system is applied. The number is obtained as the average of the 8 BAPV quotations. The turn-key price difference between the cheapest and most expensive solution is 9% (See Figure 10).

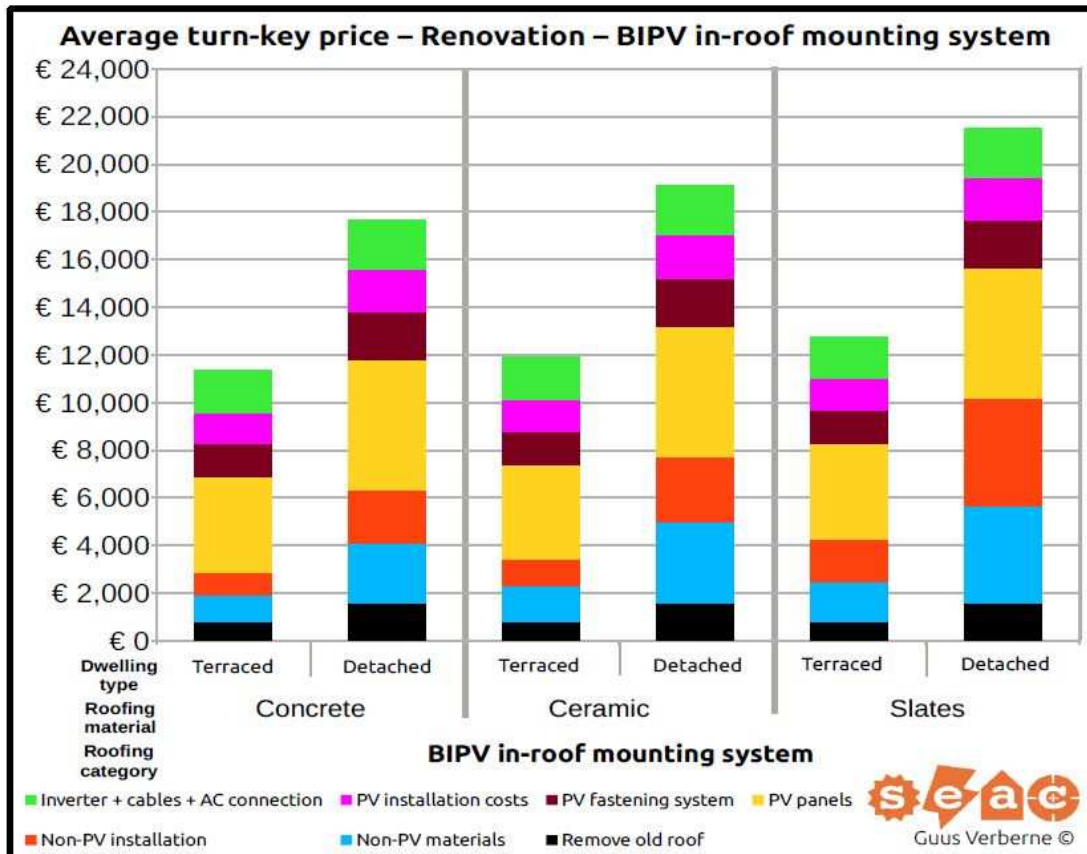


Figure 13: Average turn-key price BIPV in-roof mounting system - Concrete/Ceramic/Slates - Terraced vs. Detached.

Figure 13 gives an overview of the average prices of in-roof mounting systems applied with different conventional roofing materials. The turn-key price difference between the cheapest and most expensive solution is in these categories between 17% and 20%, depending the roofing material that is used (concrete, ceramic, slates).

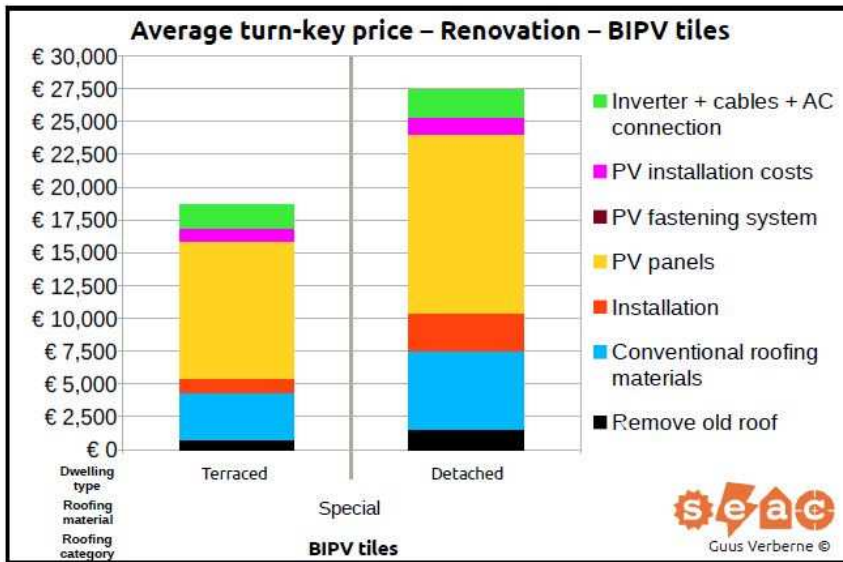


Figure 14: Average turn-key price BIPV tiles - Terraced vs. Detached.

Note that for the BIPV tiles we defined “non-PV materials” which refer in most cases to custom made tiles (See Figure 15). Furthermore, no fastening system is used in a BIPV tile roofing solution. A last remark, this is the average price over the 5 different BIPV tile roofs and due to the broad range in turn-key prices we suggest to also look to Figure 18 and Figure 19, where a box-and-whisker plot shows the price range of the BIPV tile turn-key prices. The difference between the different quotes within the BIPV tile category shows a big difference; we see a price range from about €21,000 up to €35,000 for a detached house. The turn-key price difference between the cheapest and most expensive solution is in this category almost 70%.

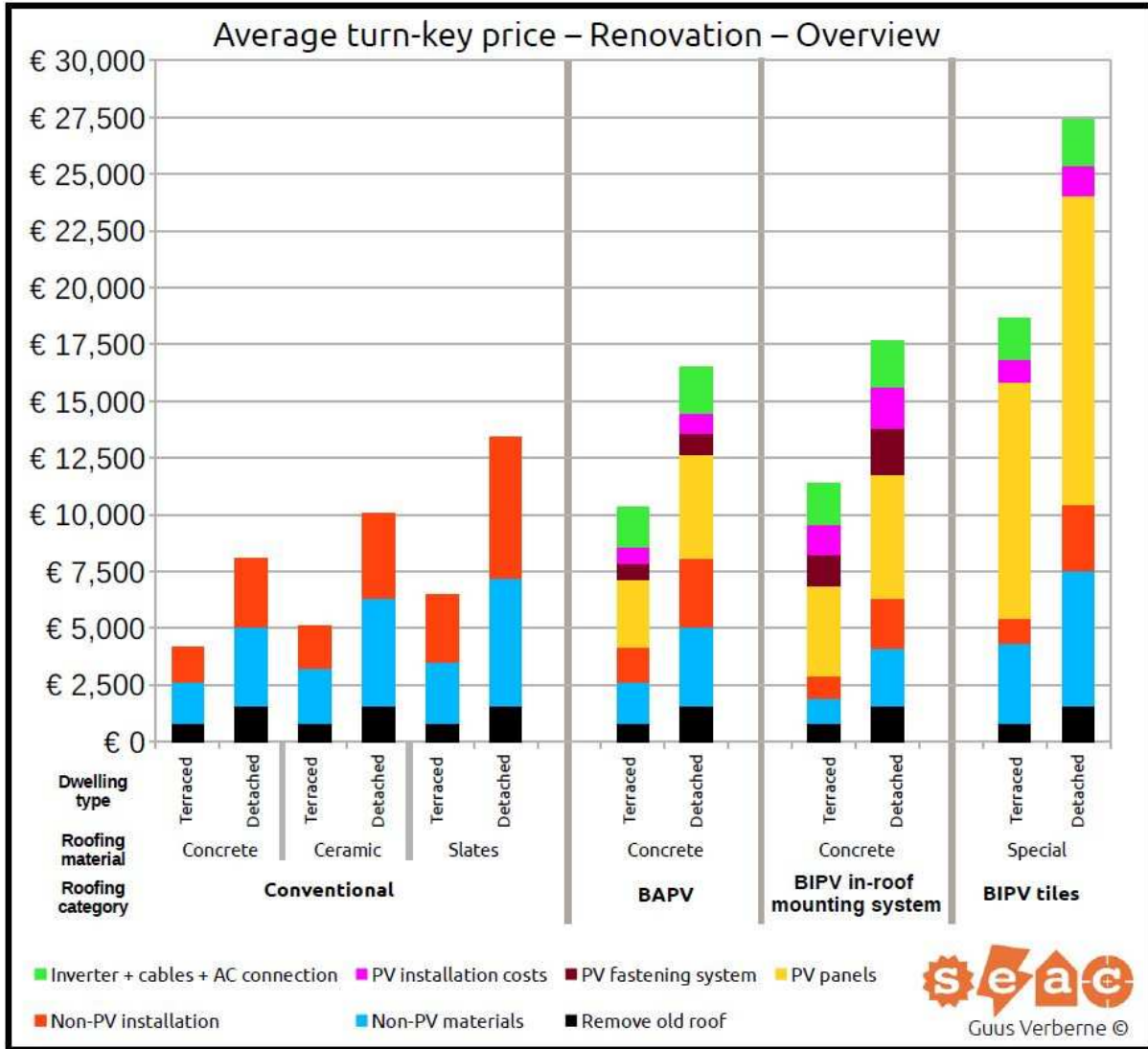


Figure 15: Average turn-key price - Multiple roofing solutions - Terraced vs. Detached.

An overview of all roofing categories is depicted in Figure 16, average turn-key prices for both the detached and terraced houses. Although, due to the limited space, two of the roofing material possibilities in the BIPV in-roof mounting system category are excluded in this figure. The excluded solutions are displayed separately in Figure 14.

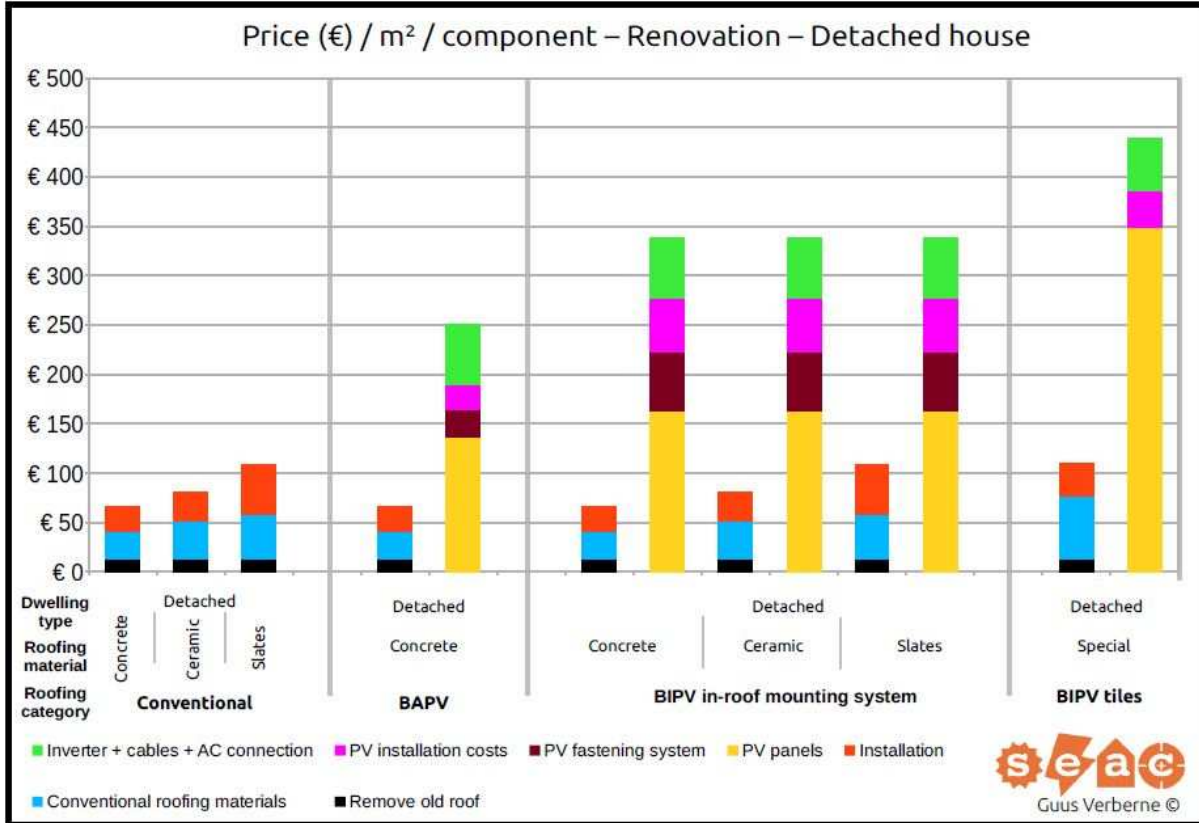


Figure 16: Average turn-key price as €/m² per component - Renovation of a detached house

Note that in Figure 17 we make a distinction between the PV and non-PV part of a roof. The prices of the different components are divided over the two different area sizes. For example, the price of the electrical equipment is divided over the roof area which produces electricity and is the PV area. The costs of conventional tiles or non-PV tiles are divided over that area of the roof which does not produce electricity. When calculating with these prices one needs to know how many m² of the roof is covered with PV panels and how many is covered with a non-PV roofing material. The m² prices of the PV panels are on average 140 €/m², 160 €/m² and 350 €/m² for respectively BAPV, BIPV in-roof mounting system and the BIPV tile solution. Furthermore, we see a higher price per m² for the conventional roofing materials (special) of the BIPV tile solution.

The next two figures explain the range of turn-key prices within every category. Where Figure 18 and Figure 19 represent the ranges for renovating detached and terraced roofs, respectively. The gap difference between the different roof sizes can be explained by the fixed costs (inverter + cable + AC connection and the PV installation costs) these are in general relatively higher per m² for smaller roof size. Furthermore, the large price spread in the BIPV tiles solution for terraced houses is influenced by the occurrence of a few low-efficiency solutions that require the installation of PV on the north side of the roof in order to meet the net electricity neutral requirement. The average turn-key price for renovating a complete roof of a detached house using BAPV as the PV roofing solution and compare this to the cheapest turn-key price using BIPV tiles as roofing solution results in a €4800 or 30% price difference. Where the average turn-key price difference between a BAPV roofing system and a BIPV in-roof mounting system is just over 20%.

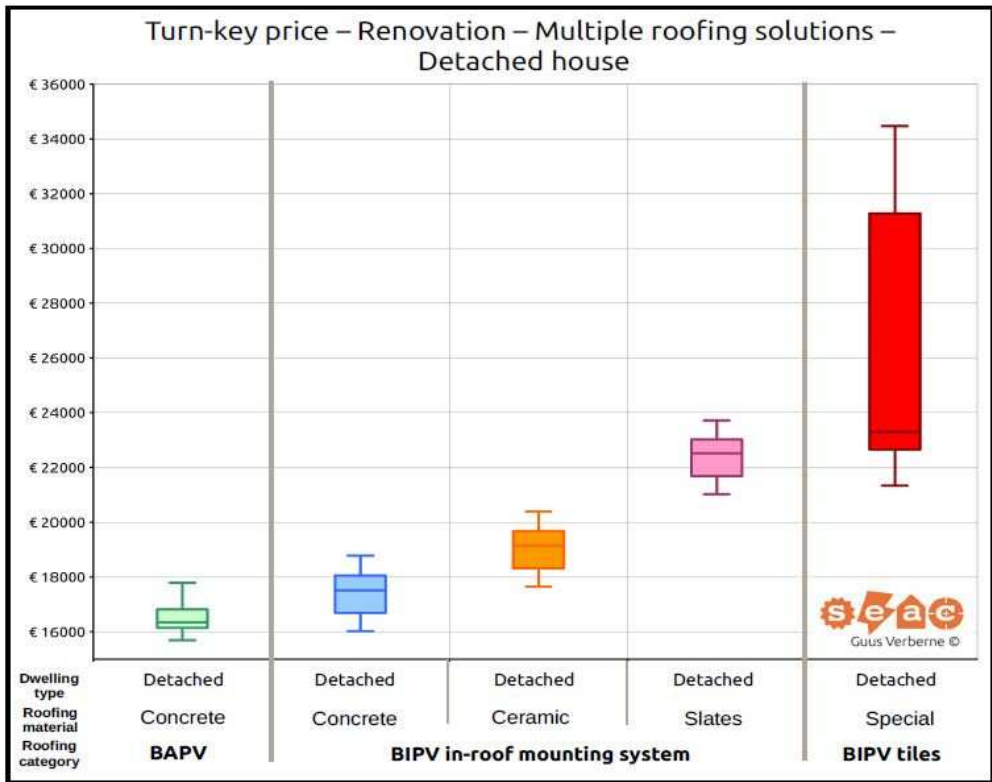


Figure 17: Box-and-whisker plot of turn-key prices of multiple roofing solutions for renovating a detached house.

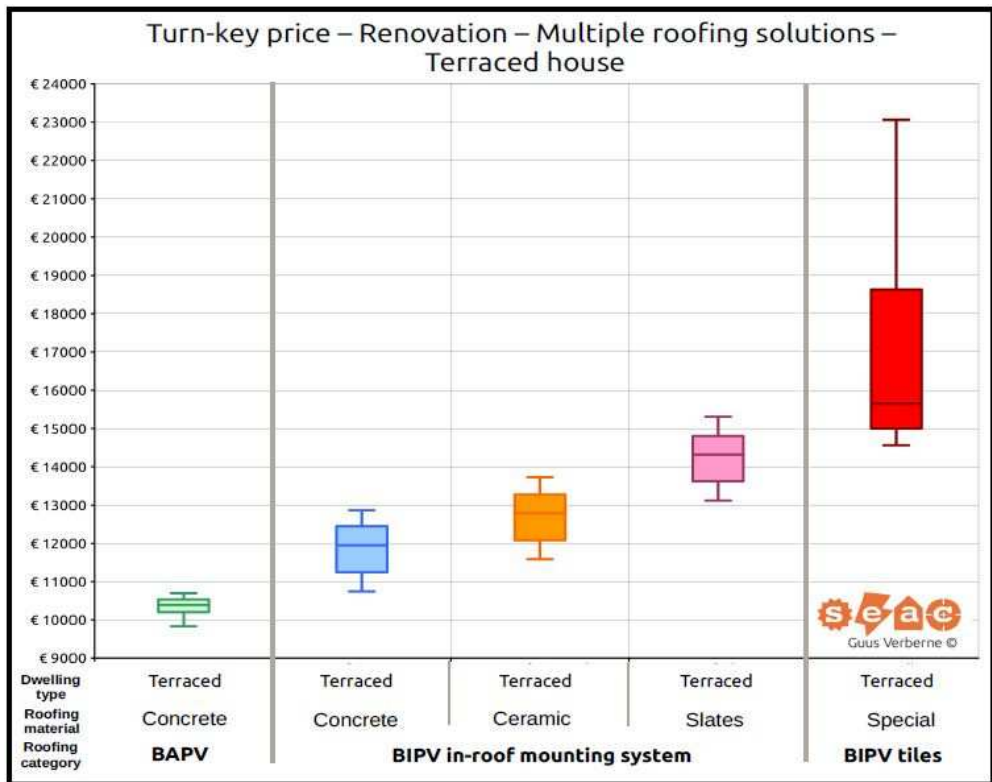


Figure 18: Box-and-whisker plot of turn-key prices of multiple roofing solutions for renovating a terraced house.



**New built**

The new built integration level is very similar to the renovation integration level, the only difference is the component category “removing old roof”. Due to the similarity of these integration levels not all figures are included in this report. Only an overview of the different roofing categories per dwelling type are displayed below (See Figure 20 and Figure 21).

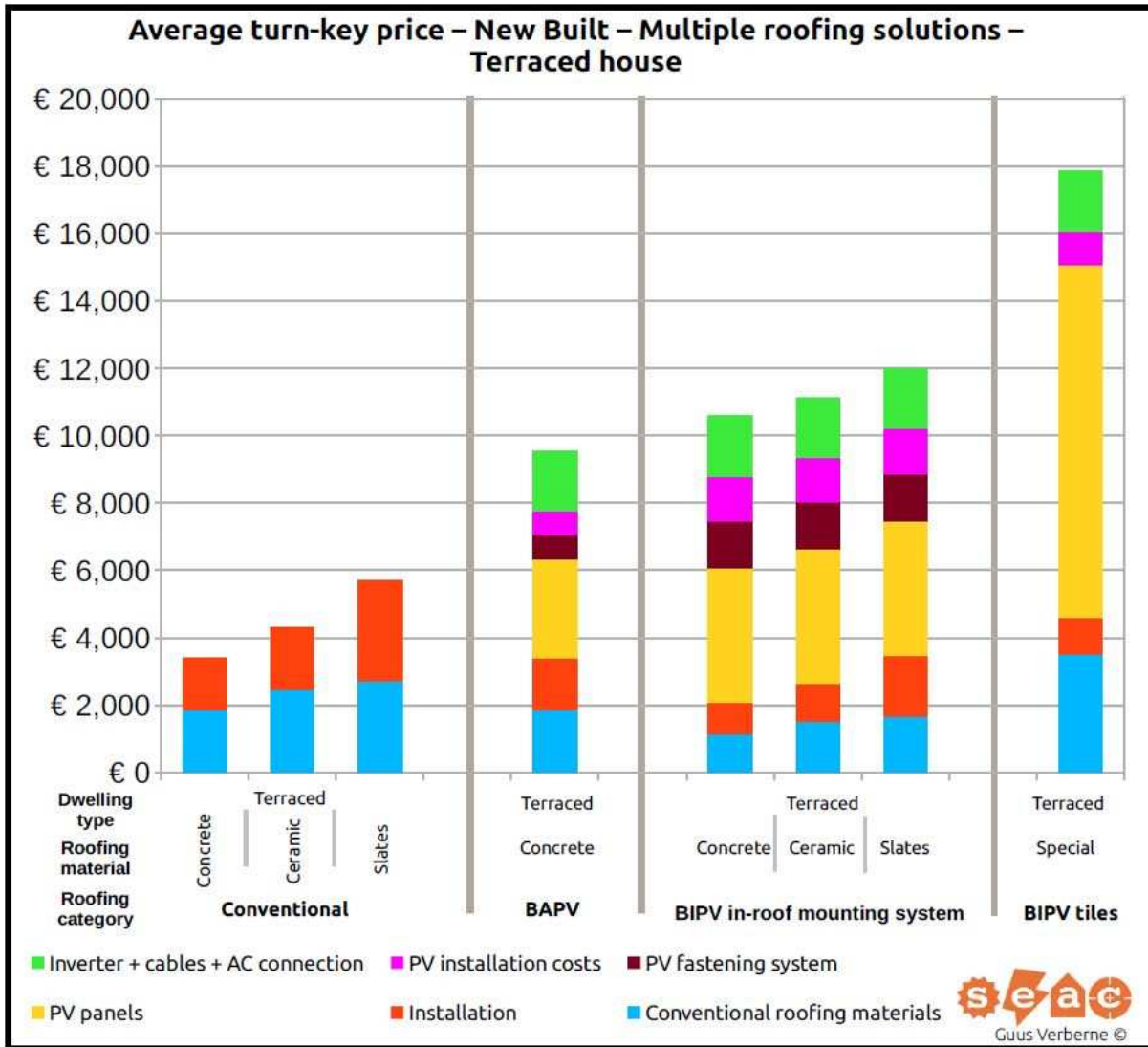


Figure 19: Average turn-key price - New built - Multiple roofing solutions - Terraced house.

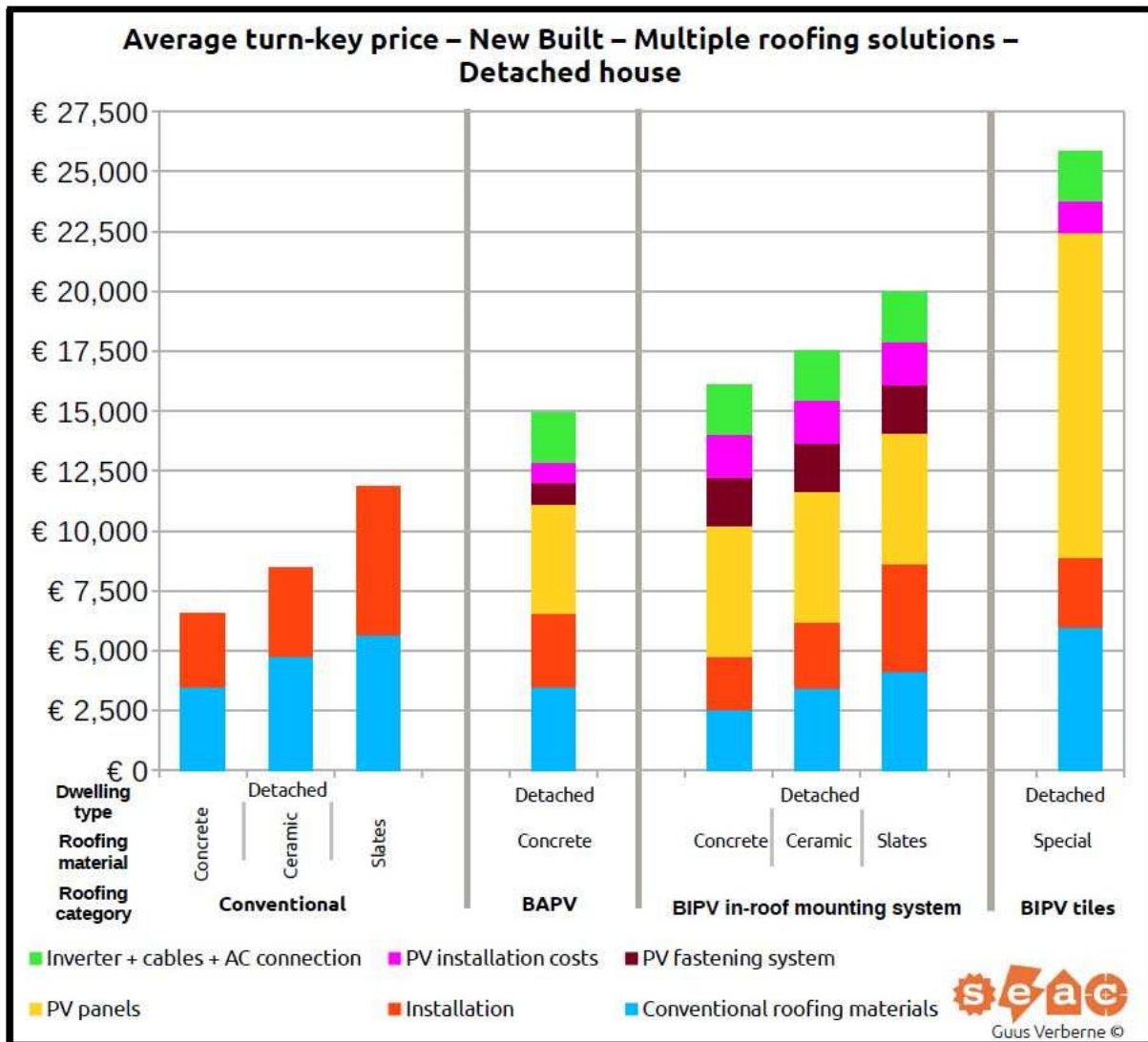


Figure 20: Average turn-key price - New built - Multiple roofing solutions - Detached house.

## 5 Conclusion and discussion

The main goal of this report is to provide the solar community with more insight on the subject of the Dutch BIPV market. Provide an overview of the turn-key prices within BIPV market and compare those prices to BAPV and conventional roofing solutions. First, the conclusion per category is discussed individually. Next, the categories of the different roofing solutions are compared with each other.

When analysing the category of BAPV and compare these quotes we can conclude that in the competitive market of BAPV the price differences are small. The turn-key price difference between the cheapest and most expensive solution is in this category 9%. Analysing the BIPV in-roof mounting systems gives a slightly bigger variation, this has to do with the type of solar panels used and the different in-roof fastening systems. European panels which are more expensive in comparison to Asian panels are often used in this BIPV roofing category. Furthermore, the fastening systems are more complex and therefore more expensive than those of BAPV roofing solutions. Moreover, they cannot benefit from the economies of scale where BAPV can. The turn-key price difference between the cheapest and most expensive solution is in these categories between 17 up to 20% depending on the roofing material that is used (concrete, ceramic, slates). Comparing the different quotes of the BIPV tiles shows a big difference; we see a price range from about €21,000 up to €35,000 for the roof of a detached house. The turn-key price difference between the cheapest and most expensive solution is in this category almost 70%. These higher prices suggest there is a proto niche market within the residential PV market, certainly because the number of available products is limited. Reasons for this relatively big price difference are the higher development costs due to its higher complexity and pioneering (the standard panels are more mature in their development, BIPV tiles are not yet benefiting from the economies of scale). Furthermore, where the BAPV market is standardized in types of panels and fastening systems we see a wide range of completely different products in the BIPV tile segment.

When comparing the results for retro-fitting a detached house we can conclude that on average BAPV systems are 35-40% cheaper than BIPV in-roof mounting systems, depending on the roof type (detached or terraced). The reason for the price gap between the two roofing solutions are the costs for removing a part of the old roof, the use of more expensive PV panels, a more expensive fastening system and higher installation costs for the fastening system. By looking at the box-and whisker plots of Figure 10, we can conclude that the cheapest BIPV in-roof mounting systems do fall within the common price range of BAPV systems. Analysing the renovation of a roof we see a more positive development. When one renovates a complete roof, a large share of the BIPV in-roof mounting system falls within the price range of a BAPV solution (See Figure 18). Here we see a price difference between the detached and terraced renovation. A larger PV system size positively influences the relative price difference of the turn-key price of the two discussed roofing solutions. On average a BIPV in-roof mounting system is 7% to 10% more expensive than a BAPV system depending on the roof type and assuming for both roofing solutions concrete tiles are used as the roofing material. The last integration level which is discussed is the new built houses. Also here we see that on average the prices of BAPV and BIPV in-roof mounting systems overlap each other.

Analysing the BIPV tiles category we can conclude that the largest part of the price can be devoted to the mere BIPV panels. Where one pays on average around € 140/m<sup>2</sup> for BAPV panels, the BIPV tiles cost € 350/m<sup>2</sup> which is around 155% more. Furthermore, note that the price differences within the BIPV tile segment are relatively high (See Figure 18 and Figure 19). The average turn-key price for renovating a complete roof of a detached house using BAPV as the PV roofing solution and compare this to the cheapest turn-key price using BIPV tiles as roofing solution results in a €4,800 difference. In summary, one can pay only 30% more when renovating his roof using BIPV tiles. Of course the question here will be, what is the customer is willing to pay more for aesthetics.

From the results and discussion above, the following list of concrete conclusions can be drawn:

- Turn-key prices for retrofitting a BAPV system and make the house net electricity neutral are €6,000 for a terraced and €8,000 for a detached house. BIPV in-roof mounting systems add €2,500 to these costs, due to three main effects:
  - Additional labour is required due to the removal of the existing roof tiles.
  - Suppliers of BIPV in-roof mounting systems tend to choose high quality European brand PV panels in their systems, whereas BAPV system suppliers tend to choose low-cost Asian brand PV panels.
  - More costs are made in the installation process, due to a more complicated and slower installation process than BAPV systems.
- Turn-key prices for renovating a full roof and then adding a BAPV system to make the house net electricity neutral are €10,000 for a terraced and €16,000 for a detached house. BIPV in-roof mounting systems add €1,000 to these costs. Cost savings are made for requiring less roof tiles, but additional expenses are needed for the use of more expensive high quality brand PV panels and longer installation times required.
- Several suppliers of BIPV tiles are active on the Dutch market. Their products are meant to blend better into the roof's optical appearance and consequently improve the overall aesthetical quality of the house. A large price spread within the products that are offered exists. The cheapest BIPV tile solution for a turn-key roof renovation was €14,000 euro for a terraced and €21,000 euro for a detached house. The most expensive solution was €23,000 euro for a terraced and €35,000 euro for a detached house. The large price range suggests a proto niche market or sub-segmentation within this product group.
- Comparing the dwelling types with each other we see an overall price advantage in favour for larger roof systems. The electricity producing roof on a detached house was approx. 20% cheaper per m<sup>2</sup> than the same system on a terraced house, for all three system types of BAPV, BIPV in-roof systems and BIPV tiles.