Module 2: Customer request for a photovoltaic system

General description: Target groups for this learning module are electricians, roofers and basically every trade that deals with photovoltaic systems. The aim of the module is to get a better understanding of the potential for reducing carbon emissions with the help of photovoltaic systems. Hereby, it is also mandatory to understand the principles of photovoltaic systems and to know about components, their functions and their assembly in such systems. To successfully complete the learning module, skills from different professions are required. For this reason, the traditional skills of one trade are supplemented by skills from other trades.

These are specific to this module:

Roofers:

- Working with hazardous voltages.
- Components of a pv-system and their functions.
- Assembly of electrical components.

Electricians:

- Working at heights with regards to safety and protection gear.
- Roof construction and where to move safely.
- Assembly of pv-panels on roof tiles.

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Teaching Sequence	Description and Material	How to use?
Introductory scenario	A customer would like to receive information on photovoltaic systems. She has read a newspaper article about green energy and wants to get information on how she can reduce her carbon emission footprint and if it is possible at the same time to reduce her energy cost at home. She owns a house in the city of Basel, Switzerland which has a gable roof. One side of the roof is directed towards the north, the other side faces the south. Each side is eight meters long and six meters high. Your boss wants you to talk to the customer and convince her about the possibilities of energy savings and carbon emission. You should also outline which components are needed for the photovoltaic system and what the installation process looks like to have the customer informed about all the work that needs to be done. You can decide if you prepare a presentation, a podcast, a video or provide any other informative material for the customer.	The scenario is designed to create a real-life situation in which the student must act to succeed. Therefore, he/she needs to inform himself, make a workplan, decide on different possible solutions, come up with an idea for a pitch and create the needed materials and finally act and conduct the pitch with the customer. The scenario is flexible in the way that it can easily be adapted to national standards and requirements or depending on the institution it is taught at. For example, you can choose the location of the customer building or its size and orientation. You can also alter details of the building and the surroundings to create a scenario that fits your specific requirements. You can also omit single lessons if the content does not fit to your training program or if you cannot provide materials and rooms for practical approaches. Take the lesson structure as a basic idea and adapt it to your individual needs.

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<td>Lesson 1:</td>
<td>
Introduction to the Scenario
Objective:
Students will gain insight into the assignment and the client’s expectations. They will learn why solar energy, sustainability, and safety are essential.

Preparation by the Instructor:
• Study the scenario and ensure you understand the basic principles of solar energy.
• Prepare a brief presentation on solar energy and sustainability.

Assignment for the Student:
1.1 Clearly describe the assignment and the client's expectations.

1.2 Identify three reasons why solar energy and safety are important.

1.3 Explain how a photovoltaic system affects costs and environmental impact.

<table>
<tr><th>Assessment criteria</th><th>0 points (insufficient)</th><th>1 point (sufficient)</th><th>2 points (good)</th></tr>
<tr><td>Clear analysis of the client’s request.</td><td></td><td></td><td></td></tr>
<tr><td>Well-founded identification of three reasons why solar enery and safety are important</td><td></td><td></td><td></td></tr>
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<td>
The teacher should introduce learners to this topic making a small informative power point or by showing pictures concerning energy consumption, problems of fossil fuels and introduce the idea of green power.

Students then should get into the scenario and define their expected outcome. Also, they should think of all the aspects they would need to do and to learn to successfully create the expected outcome.

After this, students can work on the assignments. We recommend social methods like a group work, placemat method or the like.

For example material see ‘Material 1’
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	Clear explanation of how a photovoltaic system affects costs and environmental impact.				
	Total score				

Lesson 2:	**Roof Orientation and Yield Calculation** **Objective:** Students will learn how roof orientation affects energy yield and how to estimate energy production. **Preparation by the Instructor:** • Gather visual aids (e.g., diagrams of roof orientations and solar panel yields). • Prepare a sample calculation. **Assignment for the Student:** 2.1 Analyse the roof orientation and determine the optimal placement for solar panels. 2.2 Calculate the potential power output based on the available roof surface and tilt angle.	Introduce the class to a building with a PV-system maybe based on pictures or a short film if possible. Start a discussion of which factors contribute to the overall output power of a PV-system and collect those arguments for later falsification/verification. Show an example for an output power calculation of the introduced system and let students work on the assignments. We recommend tandems or groups of not bigger than three students. Each student must create their own documents. At the end of the lesson, you can look back at the collected contribution factors of power outcome and verify/falsify them together with the students.

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<td>2.3 Describe how weather conditions and shading affect solar panel performance.

<table>
<tr><th>Assessment criteria</th><th>0 points (insufficient)</th><th>1 point (sufficient)</th><th>2 points (good)</th></tr>
<tr><td>Correct analysis of roof orientation and placement.</td><td></td><td></td><td></td></tr>
<tr><td>Accurate and well-supported energy yield calculation.</td><td></td><td></td><td></td></tr>
<tr><td>Understanding of external factors and their impact.</td><td></td><td></td><td></td></tr>
<tr><td>Total score</td><td colspan="3"></td></tr>
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</td>
<td>For example material see ‘Material 2’</td>
</tr>
<tr>
<td>Lesson 3:</td>
<td>Components of a Photovoltaic System

Objective:
Students will learn about the key components of a PV system and understand their functions.

Preparation by the Instructor:</td>
<td>Introduce the class to this lesson maybe by showing a picture of a building with a PV-system and its components (inverter, fuses etc.) Ask what these components do within the system.

Let the students work on the assignments with the aid of information materials. Provide posters and pens or the like</td>
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- Gather images and physical examples (if available) of solar panels, inverters, and mounting systems.
- Prepare a brief explanation of how the components work together.

Assignment for the Student:

3.1 Create a poster or visual overview of the components (panels, inverter, mounting system, cabling, and connection to the electrical panel).

3.2 Describe the function of each component and how they work together in the system.

3.3 Explain which components are required for the scenario and why.

Assessment criteria	0 points (insufficient)	1 point (sufficient)	2 points (good)
Clear and informative visual representation.			
Correct and complete description of components.			
Application to the scenario with justification.			
Total score			

for the students to create a visualization of the whole PV-system and its components.

We recommend groups of 3-4 students per group during the working phase and a gallery walk at the end of the lesson. Students can use the gallery walk to compare own findings with the findings of other groups and ask questions with the aid of sticky notes which can be put on the posters of each group.

For example material see ‘Material 3’.

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<tr><td>Lesson 4:</td><td>Working Safely on Roofs

Objective:
Students will learn to identify and manage risks when working at heights, with a specific focus on a gable roof, as in the scenario.

Preparation by the Instructor:

• Gather safety guidelines and videos on safe roof work.
• Create a list of common risks and corresponding preventive measures.

Assignment for the Student:

4.1 Identify and describe at least three risks associated with working at heights.

4.2 Develop a plan with appropriate safety measures and required protective equipment.

4.3 Explain how the use of sustainable materials can enhance safety.

<table><tr><td>Assessment criteria</td><td>0 points</td><td>1 point</td><td>2 points</td></tr></table></td><td>Firstly, it is important to check local regulations and professional associations’ regulations to know about the regulations in your own country.

The lesson could start with a report or a photo of an accident at work which lets students focus on the possible risks and dangers while at work. Then we suggest having a think-pair-share phase in which students work on the assignments based on the given accident.
During the share-phase an open discussion should evolve among students.

For example material see ‘Material 4’.</td></tr>
</table>

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<table>
<tr><th></th><th>(insufficient)</th><th>(sufficient)</th><th>(good)</th></tr>
<tr><td>Accurate and Complete identification and description of at least 3 risks.</td><td></td><td></td><td></td></tr>
<tr><td>Accurate plan with appropriate safety measures and required protective equipment</td><td></td><td></td><td></td></tr>
<tr><td>Clear and accurate explanation of how the use of sustainable materials can enhance safety</td><td></td><td></td><td></td></tr>
<tr><td>Total score</td><td colspan="3"></td></tr>
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<tr>
<td>Lesson 5:</td>
<td>Solar Panel Installation Process

Objective:
Students will learn how to correctly install solar panels.

Preparation by the Instructor:

Gather information and visual materials on the solar panel installation procedure.

Prepare a practical example.</td>
<td>This lesson is optional or at least very flexible in the way it is held. If you have the possibilities to have students install and assemble real PV-panels that is an optimal way of training. If you do not have the materials, facilities etc. You could at least do a theoretical training on how to correctly assemble PV-panels. We recommend looking out for manufacturer materials and handbooks as they usually provide good visual materials and are usually free to use for educational purposes.

If you have the capabilities of a real material training, we suggest showing students once the correct way of</td>
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<td>
Assignment for the student:

5.1 Describe step by step how to install a PV system.
5.2 Use terminology correctly
5.3 Specify which materials and tools are required.

<table>
<tr><th>Assessment criteria</th><th>0 points (insufficient)</th><th>1 point (sufficient)</th><th>2 points (good)</th></tr>
<tr><td>Clear and logical step by step description of PV system installation</td><td></td><td></td><td></td></tr>
<tr><td>Correct use of terminology.</td><td></td><td></td><td></td></tr>
<tr><td>Appropriate material selection and justification.</td><td></td><td></td><td></td></tr>
<tr><td>Total score</td><td colspan="3"></td></tr>
</table>
</td>
<td>assembling and then let them try with the aid of manufacturer’s handbooks.

If that is not the case, we suggest for students to develop an assembly explanation on their ow with the aid of manufacturer’s handbooks.

For example material see ‘Material 5’.</td>
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<tr>
<td>Lesson 6:</td>
<td>
Electrical Connection and Grid Integration

Objective:
Students will learn how to connect a solar panel system to the electrical grid.

Preparation by the Instructor:

• Gather an example of an electrical diagram and safety regulations.
• Prepare an explanation of grid integration.
</td>
<td>This lesson has a practical approach. If that is not possible in your institution you can omit this lesson or turn it into a theoretical lesson.

It is also possible to combine the contents of lessons five and six if you work on the theoretical aspects.

It is important to check local regulations and professional associations’ regulations to know about the regulations in your own country.</td>
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Assignment for Students:

6.1 Design a correct and complete electrical diagram for grid integration.
6.2 Describe the safety regulations and procedures.
6.3 Give a clear explanation of the grid connection

<table>
<tr><th>Assessment criteria</th><th>0 points (insufficient)</th><th>1 point (sufficient)</th><th>2 points (good)</th></tr>
<tr><td>Correct and complete diagram.</td><td></td><td></td><td></td></tr>
<tr><td>Description of correct safety procedures.</td><td></td><td></td><td></td></tr>
<tr><td>Clear explanation of the grid integration.</td><td></td><td></td><td></td></tr>
<tr><td>Total score</td><td colspan="3"></td></tr>
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<td>

With the knowledge of all the components of the PV-system and the assembly of the PV-panels it is necessary to get an understanding of how to connect the system to the grid. The extend of the importance or even the allowance for students to work on the grid needs to be vetted before conducting this lesson.

We suggest starting the lesson with a brainstorming session on what is needed and what needs to be considered when we want to connect the PV-system to the grid.

Information materials regarding breakers, fuses, switches can come in handy here for students to inform themselves. We would recommend collaborative group work of 2-4 people with split areas of responsibility.

For example material see ‘Material 6’.

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<td>Lesson 7:</td>
<td>

Financial Aspects and Payback Period

Objective:
Students will learn how to calculate the costs and payback period of solar panels.

Preparation by the Instructor:

- Gather up-to-date data on solar energy and energy prices.
- Prepare a sample calculation.

</td>
<td>

An introductory presentation with a representation of rising energy consumption and cost could be used to introduce students to financial aspects.

After that they can work individually on the assignment, if possible, with the aid of mobile devices or computers and the internet to gather facts and figures on PV-systems and the cost of these systems to calculate the time it takes for a PV-system to amortise.

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<td>
Assignment for Students:

7.1 Calculate the total costs and payback period of the customer's PV system.
7.2 Describe a logical financial justification of the total costs
7.3 Present a clear presentation of the calculation

<table>
<tr><th>Assessment criteria</th><th>0 points (insufficient)</th><th>1 point (sufficient)</th><th>2 points (good)</th></tr>
<tr><td>Accurate and correct calculation.</td><td></td><td></td><td></td></tr>
<tr><td>Logical financial justification.</td><td></td><td></td><td></td></tr>
<tr><td>Clear presentation of the calculation.</td><td></td><td></td><td></td></tr>
<tr><td>Total score</td><td colspan="3"></td></tr>
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</td>
<td>Student findings should be presented individually and discussed with the class.

For example material see ‘Material 7’.</td>
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<tr>
<td>Lesson 8:</td>
<td>
Sustainability Impact and Environmental Effects

Objective:
Students will analyse the ecological benefits of solar panels.

Preparation by the Instructor:

• Find comparative studies on solar energy, CO_2 reduction, fossil fuels, and environmental effects.
</td>
<td>Introduce the lesson with pictures and/or videos of recent natural disasters like floods, draughts, earthquakes and the like to raise students’ awareness.

Start with an open discussion on why these catastrophes have come up and why they are so severe and why their occurrence is on the rise.

Students should come up with the concept of global warming and its effects on nature. With that established,</td>
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Check the UN sustainable development goals for a deeper understanding of sustainability.

Assignment for Students:

8. Compare the CO_2 savings of solar panels with fossil fuels and explain why it might be useful to use regenerative energies like PV.
Be sure you:
8.1 Use correct and relevant data
8.2 Make a clear comparison and justification
8.3 Use convincing argumentation
<table>
<tr><th>Assessment criteria</th><th>0 points (insufficient)</th><th>1 point (sufficient)</th><th>2 points (good)</th></tr>
<tr><td>Correct and relevant data.</td><td></td><td></td><td></td></tr>
<tr><td>Clear comparison and justification.</td><td></td><td></td><td></td></tr>
<tr><td>Convincing argumentation.</td><td></td><td></td><td></td></tr>
<tr><td>Total score</td><td colspan="3"></td></tr>
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</td>
<td>introduce the concept of sustainability and gather aspects and definitions in a short brainstorming.

Then give the student the assignment together with informative texts or if possible, give students the chance to do web research on this topic.

Students can then exchange their findings individually and discuss them in small groups.

For example material see ‘Material 8’.</td>
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<tr>
<td>Lesson 9/10:</td>
<td>Presentation and Customer Advice

Objective:
Students will learn how to deliver a professional and persuasive customer consultation.</td>
<td>To start the lesson, gather students’ ideas on what makes a good pitch/presentation.</td>
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Preparation by the Instructor:

- Guide students in creating a customer-oriented presentation.
- Gather examples of effective customer advice and presentation techniques.

Assignment for Students:

9.1 Prepare a professional presentation, in an appropriate format (e.g., video, brochure, conversation) that convinces the customer of the benefits of solar energy.

9.2 Justify the proposed solution with calculations and scenario-specific data.

9.3 Respond to potential customer questions or objections.

Assessment criteria	0 points (insufficient)	1 point (sufficient)	2 points (good)
Professional and appropriate presentation.			
Strong argumentation and persuasiveness.			
Appropriate respond to potential customer questions or objections.			
Total score			

Usually, students can already go into detail. Sometimes it is advisable to talk to colleagues if students have already dealt with this topic.

After establishing what a good pitch or end-product should look like, students can go into preparation phase and create their final pitch/product. (Cf. 'Presentation' for more details)

You could create evaluation forms together with the students to let students assess other students pitches and products.

Or you evaluate the pitch and products based on given criteria yourself.

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***Lesson 11:**	** Final Exam*	**This is optional.* If your training program and/or legal regulations require a formal final exam you can do that at the end of the unit. It might be advisable to include a couple of practice lessons with smaller tasks to prepare for an exam. However, you are not obliged to do an exam. The modules idea is to have the students create a portfolio which is the document for the final assessment (cf. ´Assessment' down below)
Presentation	The students must conduct a customer pitch and provide accurate and appropriate information on the request. The way in which the customer receives the information is completely up to the student's creativity. It can be a leaflet/brochure with all aspects together with a formal presentation. It can also be a videocast or podcast which contains all the information.	The style of the presentation is very flexible with this module. It can be adjusted to the learners' needs and aims. If for example you find a class that struggles with the openness and creative approach of the pitch you can also alter the scenario and specify the outcome product. You could for example specify that the customer requests informational material via E-Mail (brochure) for everyone to create a uniform product. It is very important to have the criteria very clear before starting the learning situation with students. It is also advisable to share these criteria to create transparency.

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Assessment

Assessment is based on a portfolio which contains tasks from every single lesson. This means that after each lesson, students have to hand in an assignment which is rated.
At the end, all ratings are added to calculate the overall result.
See the table below:

Lesson	Title	Criteria	Max. points
1	Introduction to the Scenario	3 criteria × 2 points	6
2	Roof Orientation and Yield Calculation	3 criteria × 2 points	6
3	PV System Components	3 criteria × 2 points	6
4	Working Safely on Roofs	3 criteria × 2 points	6
5	Installation Process	3 criteria × 2 points	6
6	Electrical Connection	3 criteria × 2 points	6
7	Financial Aspects	3 criteria × 2 points	6
8	Sustainability Impact	3 criteria × 2 points	6

Learning is a process. Thus, the assessment should not only take one point of time into account but should be a process as well, which is reflected in a portfolio. A portfolio which is continuously monitored and rated guarantees continuous control of the learning process and gives the chance to interfere and readjust in time.

The assessment based on the criteria for every lesson can be done by the teacher after every lesson but can also be done using peer review, which means that you can discuss the criteria at the start of every lesson and then have work tandems exchange their products and assess them for the other person. This does contribute to the learning effect and deeper understanding when going through other products.

Additionally, a final assessment, like a test or exam, can of course be added to adhere to national curriculums and legal frameworks. (cf. ‘Lesson 11’)

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	9	Presentation and Customer Consultation	3 criteria × 4 points	12
	Total	60		
Reflection & Evaluation	At the end of every lesson, there should be a little room for reflection on the student's learning process. The effectiveness of the learning module is evaluated at the end with a "Can-do-checklist".			During wrap up of every session, students should be encouraged to reflect on their learning process. This can be achieved by talking about the assessment criteria and reflecting if these are clearly shown in the individual learning products.

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		The Can-do-checklist (cf. ‘Material 11’) summarizes all competences and contents which are part of the learning module. The student self-evaluates his/her learning process by assessing own learning outcomes. It might be helpful to include a think-pair-share phase in which students can check their own skills, then talk to a neighbor about what they have learned and what they want to learn more and finally to share these thoughts in class. The reflection/evaluation process can be conducted during a whole lesson of its own but can also be conducted in a small slot of maybe 20 minutes, depending on your training programs needs and aims.

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Lesson 1:
A global description in which all the customer's wishes are included and all safety aspects and sustainability considerations to be taken are discussed. This can be done by means of a presentation or an oral explanation supported by photos and videos if necessary.

Thank you for your request to look into the possibilities for PV panels on your home. Below you can find information to arrive at a suitable solution.
The quality of PV panels is very good in 2025, this means that the payback period is around 5/8 years. In addition, your energy consumption and therefore CO2 emissions are significantly reduced. With the possible extension with a heat pump you can reduce gas consumption to 0. This means that your monthly costs are significantly reduced.

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Lesson 2:

2.1 Analyze the roof orientation and determine the optimal placement for solar panels.

After a thorough roof inspection, we came to the conclusion.

Step 1

Provide the entire roof construction because the quality of wood is very poor and it cannot carry the weight of the construction of the PV panels. This is very important to ensure quality and safety.

Step 2

Attach the PV panel rails to the renewed roof construction.

Step 3

Install 18x PV panels portrait position.

2.2 Calculate the potential power based on the available roof surface and the angle of inclination.

After measuring the roof surface, we came to the conclusion that 18 PV panels can be installed. A solar panel contains 450 Wp. In total, 18 solar panels have a maximum peak power of 8,100 Wp.

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2.1 Describe how weather conditions and shade affect the performance of solar panels.

We will install the entire installation including optimizer, this means that this has no negative effects on the yield of PV panels. Shade and clouds therefore have minimal negative effects on the yield.

Below you will find photos of the entire process.

Pictures: RijnIJssel Nagels

Build scaffolding to work safely.

Pictures: RijnIJssel Nagels

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Pictures: RijnIJssel Nagels

Inspection, roof construction is very bad and the tiles are no longer of the right quality. This must be replaced.

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Remove roof tiles.

Remove roof tiles. Entire roof provided with new woodwork.

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Laying new roof tiles ready.

Installing New Roof Tiles.

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Entire roof fitted with rails to install the PV panels

Installing 18 PV panels.

Pictures: RijnIJssel Nagels

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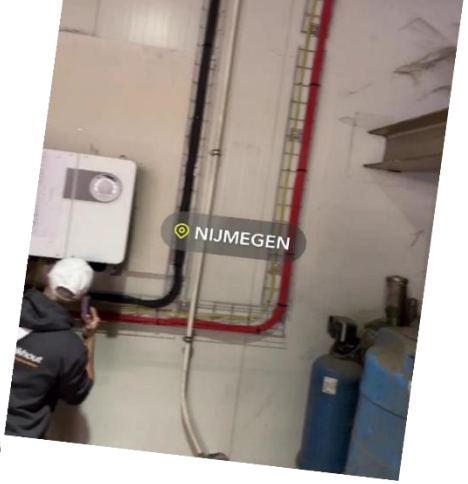
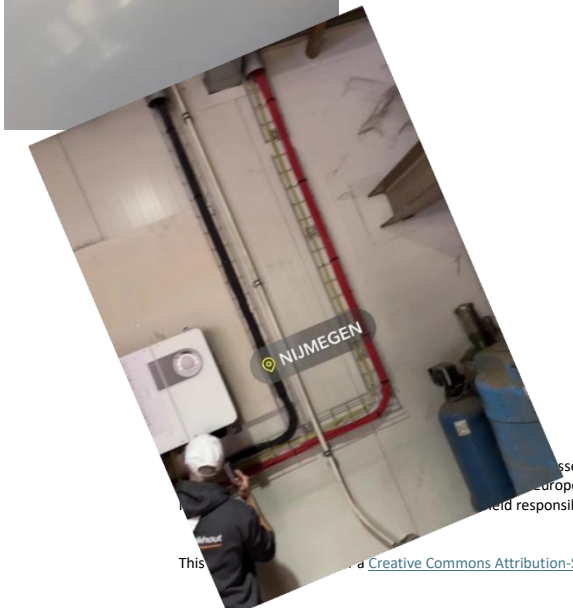
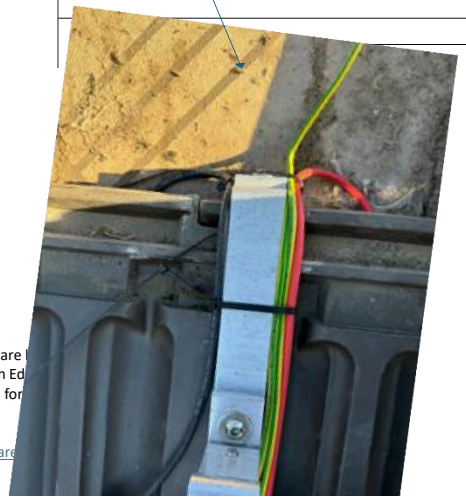


1. Solar Panel
2. Connector Male
3. Connector Female
4. Distribution equipment
5. Roof duct
6. Inverter
7. Provision for grounding





1. **Solar Panel**
   These are the panels that generate energy from the sun. This is done with direct current

2. **Male connector**
   This allows you to connect PV panels to each other and bring them to the inverter.

3. **3. Female connector**
   This allows you to connect PV panels to each other, this can be done by means of series or parallel connection.

4. **Distributor**
   Distribution device, this is where the power cable must go to the inverter, to supply the inverter with voltage and to be able to supply the returned energy.

5. **Roof duct**
   This is necessary to create a waterproof duct to install cables and the like from the roof to the inside.

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6. Inverter

A converter is necessary to convert direct current generated on the roof through the PV panels to alternating current supplied by our grid operator.

7. Provision for earthing.

The entire installation on this roof must be provided with earth to ensure safety.

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Picture: AI generator

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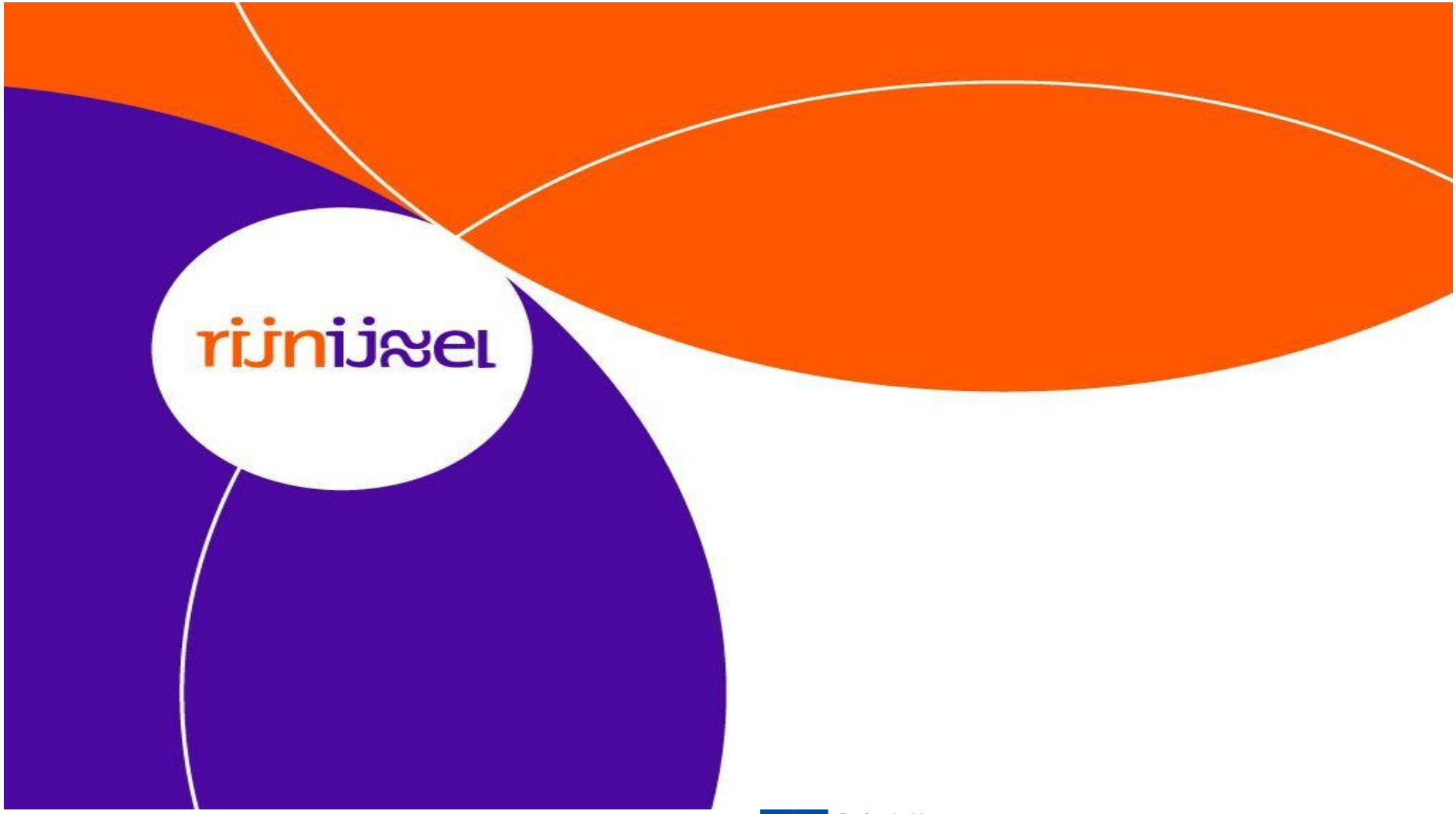

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Introduction

A rolling scaffold is a wheeled scaffold with one or more work floors. The mobile scaffold is commonly used in assembly and maintenance work.

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Basically, they are used for the same work as regular scaffolding, but they are easier to move and mostly lighter. But remember.....

Basically, they are used for the same work as regular scaffolding, but they are easier to move and mostly lighter. But remember

good.....

"If the rolling scaffold is incorrectlyused , there is a risk

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of tipping over or overloading, which can result in serious accidents."

This is because a rolling scaffold is much less stable than an ordinary scaffold. Hence, supports present to stability.

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Building

3 Rolling scaffolds should only be erected and dismantled by an expert. If materials are damaged they must not be used. Only original parts may be used.

4 Installation of a mobile scaffold should be on a level and load-bearing surface to happen.

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Example

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Move

4.1 Rolling scaffolds should only be erected and dismantled by an expert. If materials are damaged must they not be used. Only original parts may be used.

4.2 Installing a rolling scaffold should be done surface.on a level and load-bearing

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Some Rules

- If the work floor is higher than 2 meters above the ground

  , the minimum width of the

  work floor are ;0.6 meters

- Work floors shall be providedwith an all around fencing at least 1 meter above the work floor.

  An intermediate rail must be installed 0.5 meters

  above the work floor;

- **Always on the brake entering;put the wheels of the rolling scaffold before**

- **The rolling scaffold may be used only from the *inside***

- **Close shutters of work floors when you have reached the top;**

- **Temporary repairs to a mobile scaffold may be expertperformed ;only by an**

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- **No hoisting equipment shall be attached or used rolling scaffold;on a**

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No work should be performed on a rolling scaffold above wind force 6!!!

- *Clean* the rolling scaffold in the event of freezing or snow before work can begin;
- No work may be performed from a ladder or auxiliary scaffolding in the workplace;
- If thereis a risk of collisions, must the rolling scaffold be all around

  marked, such as by fencing or cones.

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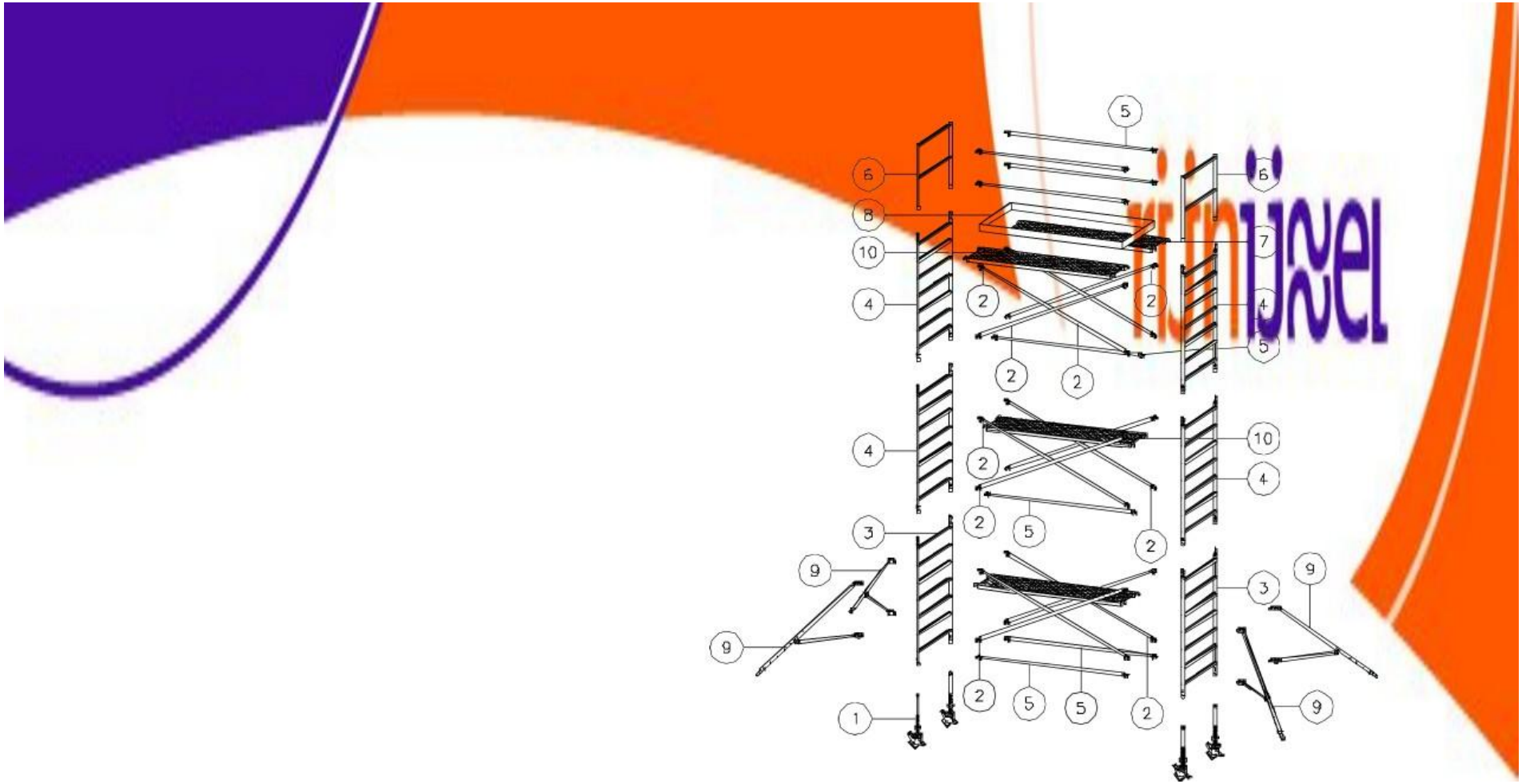

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1. Adjustable inner leg with wheel
2. Diagonal brace
3. Construction frame without locking
4. pins Construction frame (7 rungs)
5. Horizontal strut
6. Handrail frame Work
7. floor with hatch
8. Shovel edge
9. Stabilizer (adjustable)
10. Intermediate floor

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Installing a photovoltaic (PV) system (solar panel system) requires careful planning and execution. Here is a step-by-step guide to installing a PV system, including the materials and tools needed.

Materials Needed:

5 **1. Solar panels (PV modules)**

6 **2. Inverter**

7 **3. Mounting system (rails, brackets, screws, nuts)**

8 **4. DC cables (for connection between solar panels and inverter)**

9 **5. AC cables (for connection between inverter and electricity grid)**

10 **6. Earth cable (for grounding the system)**

11 **7. Cable clips and cable ties**

12 **8. Fuse box (for protection)**

13 **9. Earthing material (e.g. earth rods)**

14 **10. Fuses and earth leakage circuit breakers**

Tools Required:

14.1 Screwdriver (crosshead and flathead)

14.2 Drill with drill bits (depending on the type of roof)

14.3 Allen keys or torx keys

14.4 Saw (if necessary to cut the mounting rails to size)

14.5 Voltage and current testers

14.6 Multimeter

14.7 Spirit level

14.8 Tape measure

14.9 Stepladder or scaffolding

14.10 Screwdriver (for connecting the cables)

14.11 Pliers (for securing the cables)

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Installation Step-by-Step Plan:

Step 1: Preparation and Planning

8. **Location determination:** Choose the location for the solar panels (for example, the roof). Make sure that the roof has sufficient load-bearing capacity and is optimally oriented for sunlight (usually facing south in the Netherlands).

9. **Choose inverter location:** The inverter should be placed in a well-ventilated area, for example, a garage or basement. Make sure that the location is dry and easily accessible for maintenance.

10. **Check restrictions:** Check local regulations for installing solar panels (for example, permits or building codes).

Step 2: Install mounting system

1. **Attach mounting rails:** The mounting rails are attached to the roof, either on the roof boarding (for wooden roofs) or on the roof tiles (for tiled roofs). Use drill holes to firmly secure the rails.

2. **Install solar panel brackets:** Attach the brackets to the rails so that the solar panels can be mounted at the correct height. Make sure that they are firmly attached and watertight.

Step 3: Installing solar panels

1. **Install solar panels:** Place the solar panels on the attached brackets. Start with the first row and work from left to right (or top to bottom). Use a level to ensure that the panels are straight and horizontal.

2. **Secure panels:** Attach the panels to the mounting system brackets using the included screws and nuts. Ensure that the panels are firmly secured, but avoid excessive force as this may damage the panels.

Step 4: Electrical wiring

1. **DC wiring:** Connect the solar panels to each other using the DC cables. Each row of solar panels is connected in series to increase the voltage, after which the cables are routed to the inverter. Use cable clips to neatly secure the cables along the rails.

2. **Connecting the inverter:** Connect the DC cables from the solar panels to the

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inverter according to the inverter manufacturer's manual. The positive and negative cables must be connected correctly.

3. **AC wiring:** Connect the inverter to the mains using the AC cables. This must be done by a qualified electrician, as this poses a safety risk.

4. **Earthing systems:** Make sure that the inverter and the solar panels are properly earthed to prevent the installation from being dangerous in the event of a short circuit or lightning strike. Connect the earth cable from the solar panels and inverter to the building's earthing system.

Step 5: Safety and Test Checks

1. Install fuses: Install the necessary fuses and earth leakage circuit breakers in the fuse box to protect the system from overload or short circuit.

2. Test the system: Turn on the system and check with a multimeter that everything is working properly. Measure the voltage and current at the inverter and solar panels to see if the system is working properly.

3. Check the operation of the inverter: The inverter must have a display that shows the production of the solar panels. Make sure that the inverter shows the generated power and that no errors are displayed.

Step 6: Aftercare and monitoring

1. Monitor: After installation, you can monitor the performance of the system with a monitoring app or via the inverter (depending on the model). This will help you to track the operation of your system.

2. Maintenance: Regular maintenance is important to ensure that the system continues to work properly. Clean the panels periodically and check the wiring and inverter for wear.

Look out!

- Make sure to follow all safety precautions, such as turning off the power before working with electricity.
- Always consult a professional for connecting the inverter to the grid and for grounding the system.

This step-by-step guide provides an overview, but specific installation may vary depending on the size and type of system, as well as the roof type and environmental conditions. It may be helpful to use a certified installer to ensure a safe and efficient installation.

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Pictures: RijnIJssel Jonkers

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Here is a helpful method to make a design.

General diagram:

15 PV panels:

15.1 18 solar panels, usually divided into a matrix of 6 rows of 3 panels (depending on the available space). The panels must be electrically connected in parallel or in series, depending on the specifications of your inverter.

15.2 Each panel has positive and negative connections, and these must lead to the inverter via cables.

16 **Inverter:**

16.1 The inverter is the device that converts the direct current (DC) from the solar panels to alternating current (AC). The inverter must have the right capacity to process the generated current from 18 panels.

16.2 Connections from the panels go to the inverter, and the AC output of the inverter goes to the distribution board.

17 Distribution board:

17.1 The distribution board receives the AC current from the inverter. This can be a fuse box in which the current is further distributed to the rest of the house or building.

17.2 It is important to ensure proper grounding and protection measures (such as an automatic circuit breaker) to ensure the safety of the installation.

Steps to make a drawing:

11. Draw the panels:

- Place 18 panels on a grid layout (e.g. 3 rows of 6 panels) and connect them with lines to indicate the electrical connection.

12. Draw the inverter:

- Place the inverter after the solar panels. Connect the positive and

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negative wires from the solar panels to the input of the inverter.

13. Connection to distribution board:

- Draw a line from the output of the inverter to the distribution board. This is the cable that carries the converted alternating current (AC) to the distribution point.

14. Protection and grounding:

- Do not forget to indicate safety devices such as fuses, ground wires and surge protection on the drawing.

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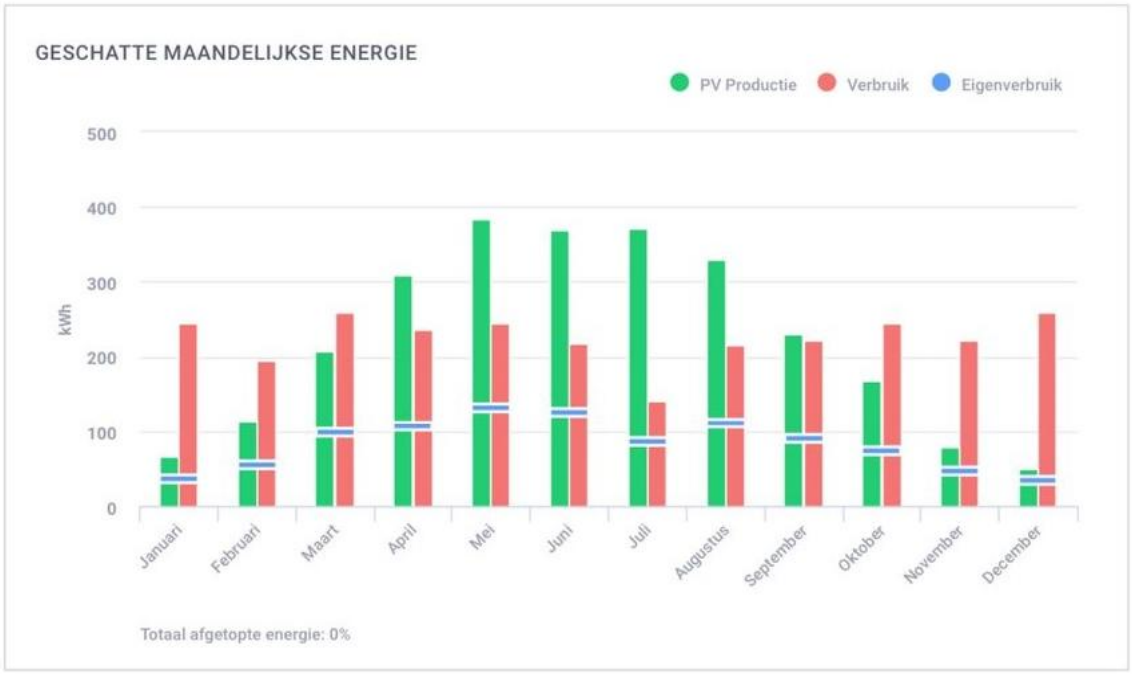

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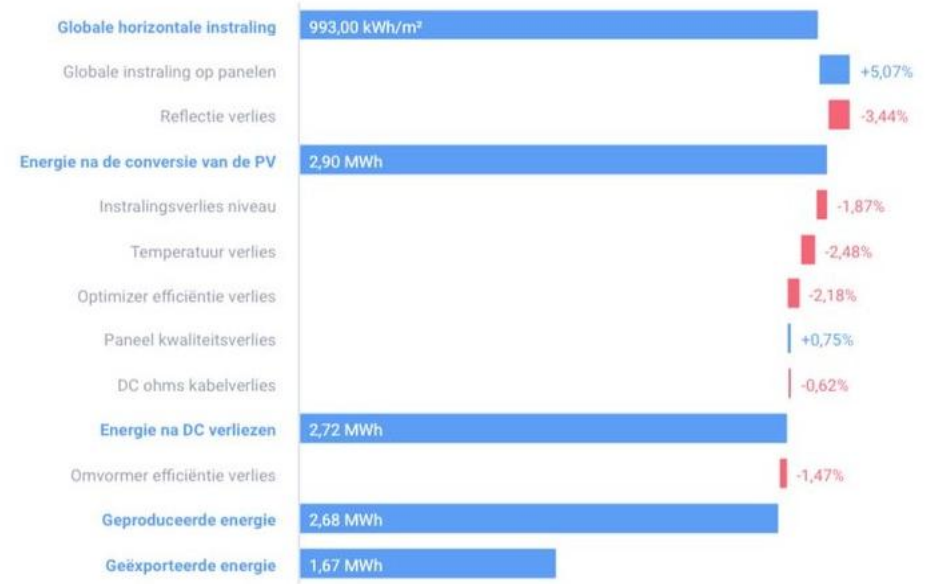
ELEKTRISCH ONTWERP

Omvormers & Opslag	Strings per omvormer	Optimizers per string	Panelen per string
1 x SE3000H 2.78kW | 93%	1 x string	8 x P401	8

SYSTEEMVERLIES DIAGRAM



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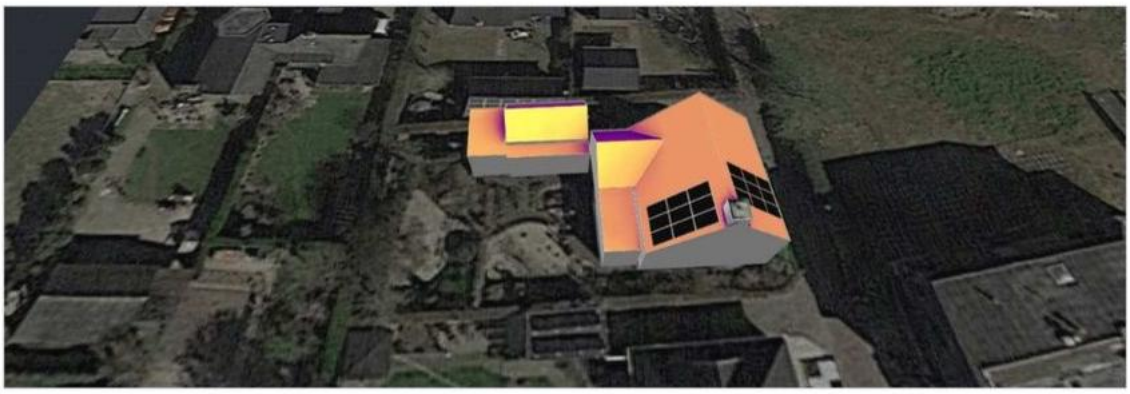

SYSTEEM OVERZICHT | 18 Panelen | 1 Omvormers | 18 Optimizers

SIMULATIERESULTATEN

Geïnstalleerd DC Vermogen	Maximaal Te Behalen AC Vermogen	Jaarlijkse Energieproductie	CO2-Uitstoot Bespaard	Aantal Geplante Bomen
7,20 kWp	4,00 kW	5,76 MWh	2,91 t	134

SIMULATIE PARAMETERS

LOCATIE & NET

Tijdzone	6-5-2021 CEST (Amsterdam)
Weerstation	Rees (24,39 km weg)
Weerstation hoogte	16 m
Weerstation gegevensbron	Meteonorm 7.1
Elektriciteitsnet	400V L-L, 230V L-N

VERLIESFACTOREN

Schaduw Dichtbij	Ingeschakeld
Albedo	0,20
Vervuiling & sneeuw	0%
Invalshoek wijziging (IAM), ASHRAE b0 param.	0,05
Thermische verliesfactor Uc (const) parallel	20
Thermische verliesfactor Uc (const) Schuin	29
LID verliesfactor	0%
Systeem onbeschikbaar	0%

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GESCHATTE MAANDELIJKSE ENERGIE

Totaal afgetopte energie: 0,01%

PANELEN

# Paneel	Model	Piekvermogen	Type montagemateriaal	Oriëntatie	Oriëntatie	Hellingshoek
9	Astronergy Co. Ltd. (Chint Solar), CHSM54M(BL)-HC-400 (182) Astro 5 Semi	3,6 kWp			274°	40°
9	Astronergy Co. Ltd. (Chint Solar), CHSM54M(BL)-HC-400 (182) Astro 5 Semi	3,6 kWp			83°	36°
Totaal: 18		7,2 kWp				

MATERIAALLIJST (BOM)

Artikelen	Aantal	Prijs (€)	Totaal (€)

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ELEKTRISCH ONTWERP

Omvormers & Opslag	Strings per omvormer	Optimizers per string	Panelen per string
1 x SE4000H 5.04kW | 126%	1 x string	18 x S440	18

SYSTEEMVERLIES DIAGRAM

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Number of solar panels	Total material costs	Installation costs	total cost	Savings per year
8 Solar panels (1.700 kWh/ jaar)	€ 1.900 tot€ 2.400	€ 750 tot€950	€ 2.650 tot€3.350	€ 375,-
12 Solar panels (2550 kWh/ jaar)	€ 2.600 -€ 3.000	€ 950 tot€1.100	€ 3.550 tot€4.100	€ 550,-
16 Solar panels {3400 kWh/ jaar)	€ 3.400 -€ 4.000	€ 1.100 tot€1.350	€ 4.500 tot€5.350	€ 700,-
20 Solar panels (4250 kWh/ jaar)	€ **4.200** -€ 4.700	€ 1.300 tot€1.500	€ 5.300 tot€6.200	€ 950.-
28 Solar panels (6000 kWh /jaar)	€5.700 tot€6.500	€ 1.700 tot€2.000	€ 7.400 tot€8.500	€ 1.300.-

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PV Solarysteem

Aantal	Omschrijving	Amount	Total
14,00 st.	Panel TW Solar 435W N-Type Mono 108 Halfcells All Black warranty 25 years	€ 95,00	€ 1.330,00
6,00 st.	Underframe roof tiles	€ 75,00	€ 450,00
8,00 st.	Underframe flat roof incl. ballast	€ 105,00	€ 840,00
1,00 st.	Electrical Internals Standard	€ 500,00	€ 500,00
1,00 st.	Inverter Solis S5 4k Three Phase 2 MPPT DC warranty 10 years	€ 1.048,00	€ 1.048,00
1,00 st.	Solis Wifi Stick	€ 35,00	€ 35,00
14,00 st.	Laying per panel and connecting	€ 85,00	€ 1.190,00
		Subtotaal:	€ 5.393,00

Distribution box

Aantal	Description	Amount	Total
1,00 st.	replace fuse box, main switch 3 phases, 4 earth leakage circuit breakers, 12 groups, cooking group, power group for solar panels and charging station, 230v socket	€ 626,00	€ 626,00
1,00 st.	hours first technician for fuse box	€ 340,00	€ 340,00
		Subtotaal:	€ 966,00

Charging stations

Aantal	Description	Amount	Total
1,00 st.	Zaptec GO charging station complete, €1238,-. Reduction due to existing cable and machine in fuse box Complete: Zaptec charging station with wall socket for charging cable, incl. machine, 10 meters 3 phase cable to the meter box, delivered working, without digging Station is suitable for up to 22kW for the most	€ 998,00	€ 998,00

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Gegevens

a.	Aantal zonnepanelen	Geïntegreerd	< selecteer	18	stuks
b.	Capaciteit per paneel in Wattpiek (Wp)			450	Wp
c.	Schaduw **(0% =** Geen schaduw, **50% =** Halve dag schaduw)			15,00%	pc.
d.	Orientatie (Zuid **= 0)** (Oost= **-90)** (West= **90)** zie tabel			35	< selecteer
e.	Hellingshoek dak (graden)			20	< selecteer
f.	Kosten per paneel inclusief btw			€ 385,00	euro
g.	Totale (bijkomende) kosten incl. btw			€ 500,00	**euro**
h.	Kosten vervangende omvormer (na 12 jaar) inclusief btw			€ 725,00	euro
	Btw terugvragen			nee	< selecteer
j.	Elektriciteitstarief (per kWh)			€ 0,260	per kWh
k.	Teruglevertarief zonder saldering (per kWh)			€ 0,065	per kWh
	Stroomverbruik per jaar			4.500	kWh
m.	Eigen gebruik opgewekte stroom			45,0%	pc.
n.	Jaarlijkse verhoging elektriciteitstarief (%)			4,0%	pc.
m.	Gemiddelde afname vermogen zonnepanelen per jaar (jaar 1 t:m 10)	Vermogen na 10 jaar:	88,0%	1,20%	per jaar
o.	Gemiddelde afname vermogen zonnepanelen per jaar (jaar 11 t:m 25)	Vermogen na 25 jaar:	81,6%	0,43%	per jaar
p.	Gemiddelde vermogensopbrengst (% van maximale capaciteit)			87,5%	PC.
q.	Investeringsjaar			2022	< selecteer
r.	Investering thuisbatterij inclusief btw			€ 4.250,00	euro
s.	Toename eigen gebruik opgewekte stroom door thuisbatterij	Van 45% naar 105%		60,0%	pc.

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Gegevens

t.	Eigen verbruik opgewekte stroom		5.981 kWh
u.	Totale investering		€ 12.405,00 incl.
v.	Maximale capaciteit zonnepanelen	18 x 450 kWh	8.100 kWh
w.	Gemiddelde rendement per jaar (25 jaar)		5.099 kWh
x.	Gemiddelde besparing (12 jaar)		€ 1.530,86 per jaar
y.	Terugverdientijd in jaren		**8,2** jaar
	Gem. rendement op investering (12 jaar)	**€ 1.530,86 / € 12.405,00**	

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Lesson 8

CO2 saving

Electricity from solar panels not only saves you a nice amount of money, but solar panels also save quite a lot of CO2 emissions. Gray electricity that comesfrom the grid has about 556 grams of CO2 emissions per kWh. with an average set So 10 solar panels, you save about 1,500 kg of CO2 per year. That is about 50% what an average car per year emits when it has driven 15,000 km in a year.

You also save a lot of CO2 by heating your home with a heat pump. By an average home (120m2) with natural gas, you emit +- 1,900 kg of CO2 per year. Heating the exact same home with an average heat pump requires 2,280 kWh of electricity per year.

The amount of CO2 emitted in making that power depends on its origin, and in the worst case, fossil fuels (gray power) are used for that purpose. But even in that , situationthe heat pump can an excellent reduction the inof CO2.

2 **Assuming use of gray electricity, the emissions are equal to 2,280 kWh x 0.556 kg= 1,268 kg C02 per year. This is 637 kg CO2 less than the central heating boiler, and thus a 33% reduction.**

3 **With the assumption of green power, emissions are equal to 2,280 kWh x**
0.400 kg= G12 kg C02 per year. So the decrease in emissions is about 52%.

So when youa heat pump and solar panels, your power comes from your own solar panels (provided they generate enough). As a result, therefore you will emit almost no CO2 heating your home!for

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Can-do-checklist – Customer request for a photovoltaic system

I can now …	- -	-	+	+ +
Analyse roof orientation and determine optimal placement foor solar panels.				
Calculate the potential power output of a PV-system based on the available roof surface and tilt angle.				
Describe how weather conditions and shading affect solar panel performance				
Name and explain the components needed for a Photovoltaic system.				
Identify risks associated with working at heights and take protective measures.				
Identify risks associated with working on hazardous voltages and take protective measures.				
Explain how the use of sustainable materials can enhance safety.				
Assemble PV-panels and connect components aproppriately.				
Connect a PV-system to the public grid.				
Calculate cost of a PV-system and amortisation time.				
Compare CO2 savings of solar panels and explain the environmental impact				
Conduct a professional pitch.				

Because I don‘t feel confident in this aspect, I need to work on this:

Because I like this aspect, I would like to work on this in depth:

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