**Research**

***Solar energy***

*Energy Grid North*

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| **Datum : 16 mrt. 2021** |
| **Versie : 1** |
| **Status : Start** |
| **Auteur : Krijgsman, N** |

# Introduction

This research is done to gather more insights on the possibilities of how to predict the production of solar energy.

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# Questions and methods

Main question: **How can we predict the amount of solar energy is going to be produced in the north?**

Sub questions:

* How is solar energy produced?
* Which factors influence the solar panel’s energy production?
* How is the energy production calculated?
* Which sources can be used to predict the weather?
* How much solar energy is on average being produced by the north?

Methods:

* Library
  + Literature study

# How is solar energy produced?

Solar energy is produced by solar panels. Solar panels need to be in the sun in order to be able to generate energy. The system used to create solar energy can also be called the photovoltaic (**PV**) system. This system exists of solar panels and an inverter. The current created by the solar panels is a direct current (**DC**). This DC needs to be converted to an alternating current (**AC**) because AC is needed for all household appliances. In addition if you want to feed your energy back to the grid that also has to be the AC because the entire grid runs on AC.

# Which factors have influence on the solar panel’s energy production?

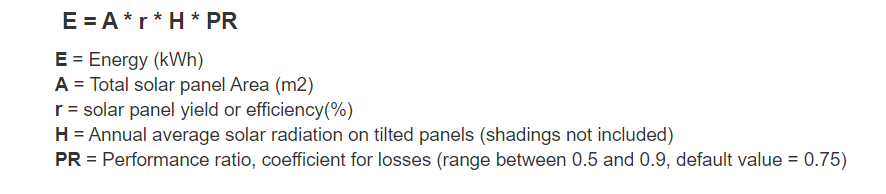
There are multiple factors that influence the efficiency of the solar panels.

* Location
  + Different parts of Earth’s surface receive different amounts of sunlight.
* Weather conditions
  + Air temperature
    - This one is interesting as it goes against how I thought it worked. The efficiency of the PV cell depends on its temperature, increases when the temperature drops and decreases when the temperature rises.
  + Precipitation
  + Snowfall
  + Relative humidity
  + Cloud cover
  + Sunshine duration
  + Solar radiation
* Dusty solar panels

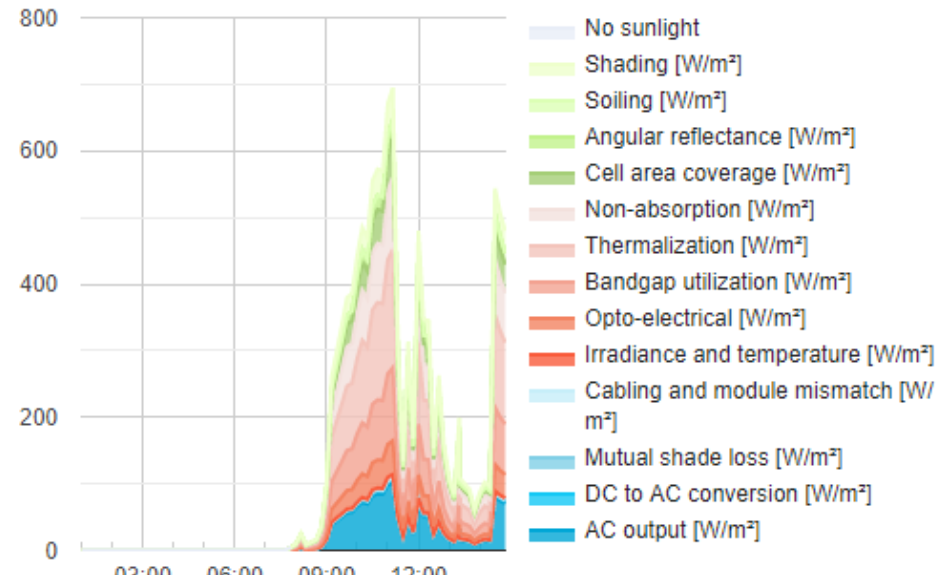
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# How is energy production calculated?

The formula to calculate the annual solar production is:

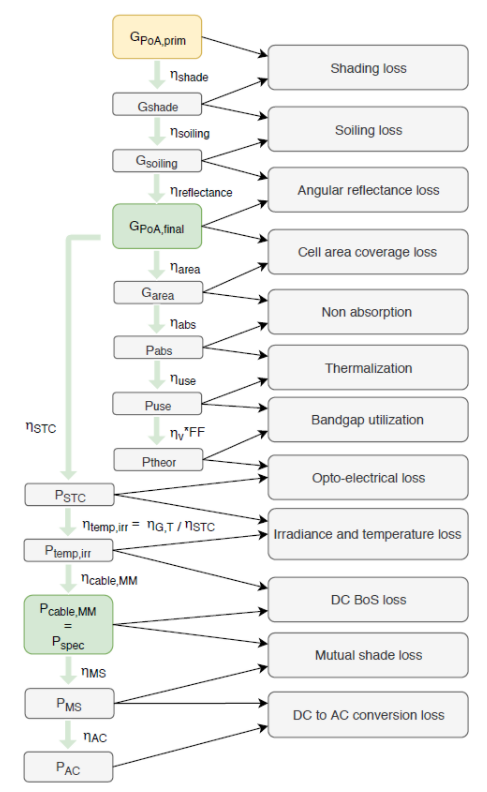


This is mostly useful for homeowners when they’re looking to invest in solar energy. This way they can calculate how much energy they will generate. Sadly this is not very useful for our daily prediction/real time predictions.



The figure above is a graph of how much energy could be generated at the given time and in which areas the energy is lost. The blue color represents the actual energy send to the grid.

In the figure below are all the steps, all with their own formulas, taken by the TU Delft to make an accurate prediction.



# Which sources can be used to predict the weather?

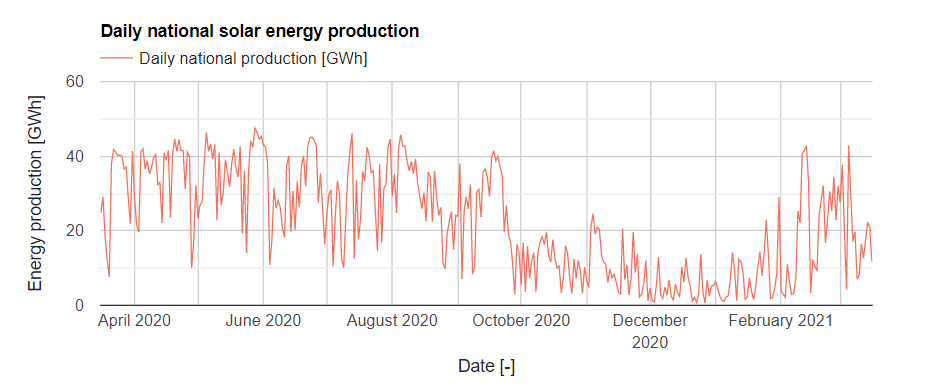
The best source to use in the Netherlands to predict the weather is the KNMI. This is an institution that has 46 weather stations around the country. They provide real time data for multiple variables that are useful for predicting solar production. Just a few things they measure that are useful are:

* Irradiance
* Temperature
* Clouds
* Rainfall
* Sun position

This data can be accessed by using the MeteoServer API. You can set your location and all the data you need.

# How much solar energy is on average being produced by the north?

The potential peak if all PV systems are fully working at maximum capacity is 1669 MWp. 575 MWp (Groningen) + 575 MWp (Friesland) + 519 MWp (Drenthe) = **1669 MWp**. This is the peak performance at which the PVs can operate. So for our model it would be rather strange if we can produce more energy than this number.



The graph above is the Dutch energy production of the last year. This energy is generated by all the PVs in the Netherlands, which has a peak of **9269 MWp**. If we apply some bold calculations that means that roughly 1669 / 9269 \* 100 = **18%** of all energy produced is produced in the north.

# The handmade formula

After studying the data sets and which values impact the production in the Netherlands. It is more simplistic and therefore will have a larger error margin. We are not specialists of math or in calculating energy production so we are happy with the results of our formula.

**MWp** is the peak production an area of solar panels can produce.

**Rcurrent** is the current radiation

**Rmax** is a constant that represents the radiation required to reach the maximum capacity of the solar panels. Currently calculated at 990. This number gave the best results and may vary.

**Production** is the output of the system in MW.

# Conclusion

**How can we predict the amount of solar energy that is going to be produced in the north?**

There are multiple answers to this question. It depends on the type of prediction. If you are a homeowner that wants to know how much energy your PV system is going to generate, that is easy, fill a formula and boom, you know your annual production.

In prediction for the upcoming moments or to predict a few days into the future it is a bit more complicated. The system built by the TU Delft is pretty good and well founded for predicting the energy in the future. The downside to this system is the amount of formulas that are not easy to understand for me. This will take its toll when implementing such formulas in the simulation.

# Recommendations

See what formulas are understandable and have the most impact on the prediction. Maybe discard the other parts of the calculations to save some time while implementing.

Another option to predict the generated energy is by using machine learning. For this you can use the data provided by the KNMI of the past in conjunction with the weather forecast. With these you can predict the energy production. Personally this might take a while to do, because I don’t have a lot of experience with machine learning.

# Appendix

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