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State of the State report

Solar panels could provide half of Dutch electricity demand

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“892 km^2 of roof surface in The Netherlands is suitable for solar panels. This is the equivalent of 125,000 soccer fields”

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Data analysis of public data provides insights on the potential of solar energy. What if every suitable roof in The Netherlands would have solar panels installed? Even in The Netherlands, with its cloudy and rainy climate, solar power has great potential. A total of 892 km^2 of suitable roof area is available for installation of solar panels, which could provide 50% of the Dutch electricity demand. This finding is based on research that is part of Deloitte's State of the State program.

This research answers the question: how much electricity would be generated if we installed solar panels on every suitable roof surface in The Netherlands? This detailed calculation of the virtual total yield of solar panels on all suitable roof area in The Netherlands has been performed in close collaboration with Object Vision and MapGear, based on publicly available data. Object Vision is a software company linked to the Vrije Universiteit, which developed GeoDMS, a big data geospatial modelling framework that can be used to calculate the total size, angle and wind direction of roof surfaces based on height data. MapGear develops geo apps and has extensive experience calculating the effectiveness of solar panels.

Total solar energy yield

The Netherlands currently has a total of 9 million buildings of which only 4.4% have solar panels on their roofs; a total installed base of 3 million solar panels in 2017. According to the National Solar Trend Report , this current installed base of solar panels provides for a total yearly yield of about 6 petajoule in 2016. This amount of solar energy accounts for less than 2% of total Dutch electricity demand. However, in potential, the contribution of solar energy is far greater.

The conclusion of our analysis is that 892 km^2 of roof surface in The Netherlands is suitable for solar panels; the equivalent of 125,000 soccer fields. In this optimum scenario of 270 million panels, a maximum yield of 217 petajoule could be achieved (an average of 139 kWh/m^2). In that scenario, solar energy could provide for up to 50% of the total Dutch electricity demand, while currently only 2% of Dutch electricity demand (434 petajoule in 2016) is generated through solar energy.

Electricity demand accounts for 20% of total household energy demand. When only considering roofs of houses for solar panel installation, nearly every household in The Netherlands could become virtually self-sufficient for electricity demand. Covering home roofs with solar panels would supply nearly 80 petajoule, which equals 98% of total Dutch household electricity demand.

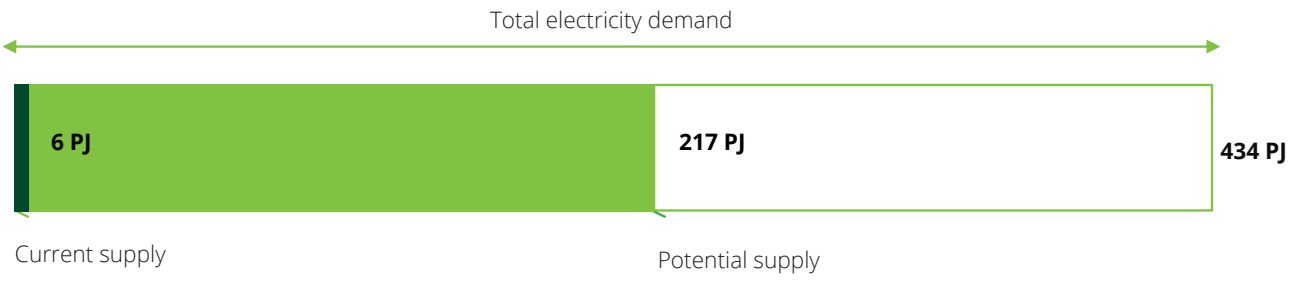

Figure 1: Current and potential electricity supply generated by solar energy

Suitable roof surface and potential yield solar panels

One map shows the roof surface suitable for solar panels per municipality and the other map shows the potential per inhabitant for each province.

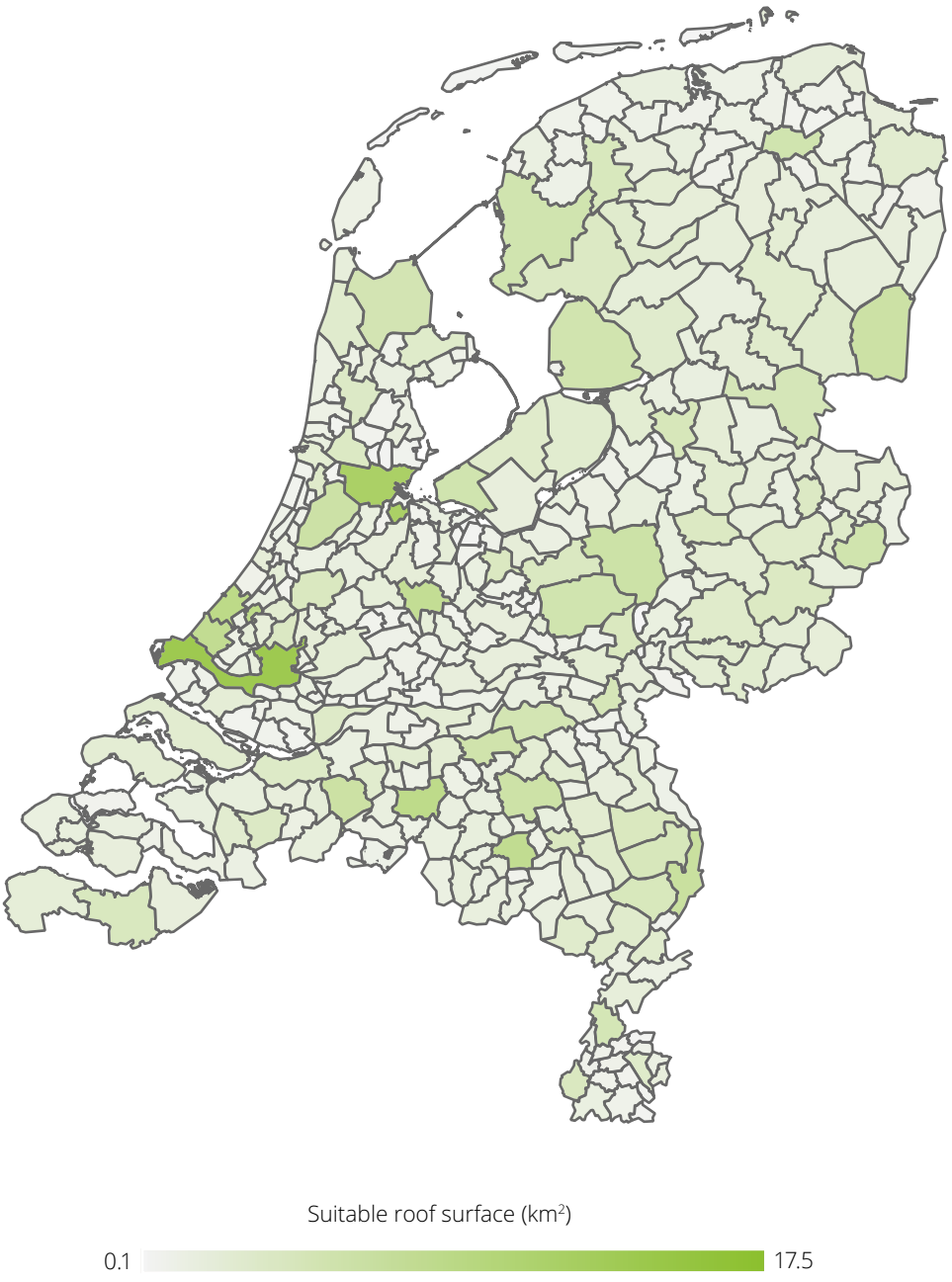

Figure 2: Suitable roof surface for solar panels

Figure 3: Potential yield by solar panels per inhabitant (MapGear)

Carbon reduction and economic benefits

The Dutch goal for carbon emission reduction is 49% by 2030. Installing solar panels on every suitable roof in the Netherlands can reduce the electricity production-related CO2 emission by 63%, which, as a result, would reduce the total carbon emissions by 20% . Based on the current Dutch energy consumption and production, the share of energy from renewable sources will be 16% .

Next to carbon emission reduction there are other benefits. A total of 270 million solar panels could be placed on 892km2 of roof surface. According to MilieuCentraal, each solar panel -including a transformer and installation- costs 365 euro on average. The total impulse for the Dutch solar industry could be as much as 100 billion euro. In addition, solar panel installation could create extra jobs on top of the current 9,000 FTE working in this industry already.

Figure 4: Facts potential of solar energy

Challenges for realization

This outcome of this data calculations does not result in solar panels on every roof next year. The potential of the industry is to grow from the current amount of 6 petajoule to 217 petajoule. With an assumed growth rate of 40% year on year (based on the growth of solar power from 2014-2017, see figure 5), installation of the total amount of solar panels would take 10 years to complete.

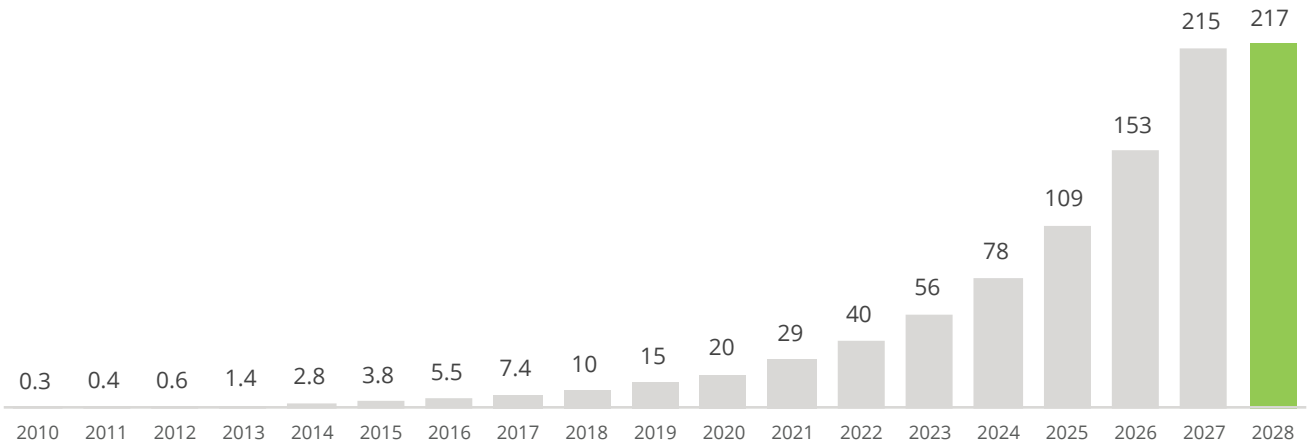

Figure 5: Growthpath solar panel energy supply on roofs (PetaJoule)

Next to the growth rate and the installation capacity of solar panels, we discuss three additional challenges to accelerate the speed of implementation: government incentive programs, energy grid surplus, and energy storage.

Government incentives have proven to be important to grow and accelerate the number of solar panels on rooftops. The Solar Trend Report 2018 provides an overview of all incentive programs . In general, a higher yield for consumers and businesses accelerates the growth rate of solar. The challenge in future years will be to encourage adoption of solar while keeping subsidy cost of the increased base at a manageable level.

A major challenge to consider is the current capacity of the Dutch energy grid and its means of electricity storage. Solar energy is generated during the day when there is already a surplus of energy. Adding this amount of solar energy to the energy system will lead to severe challenges to the grid to balance demand and supply. Not only the capacity to transport the additional amount of electricity would require a significant investment, but the grid is also currently insufficiently equipped for energy storage– both from a central and decentral perspective.

Means of electricity storage are still in development and maturing. Batteries are expensive and new storage solutions (like power to gas) are not mature enough. More decentral means of power storage are necessary to utilize a high solar yield without being limited by the capacity of the central electricity grid. Higher adoption of electric cars and connected battery storage in households are two means of decentral storage that would increase the storage of solar energy for later use. The increase in solar panels might act as a driver for innovation and further development of these technologies.

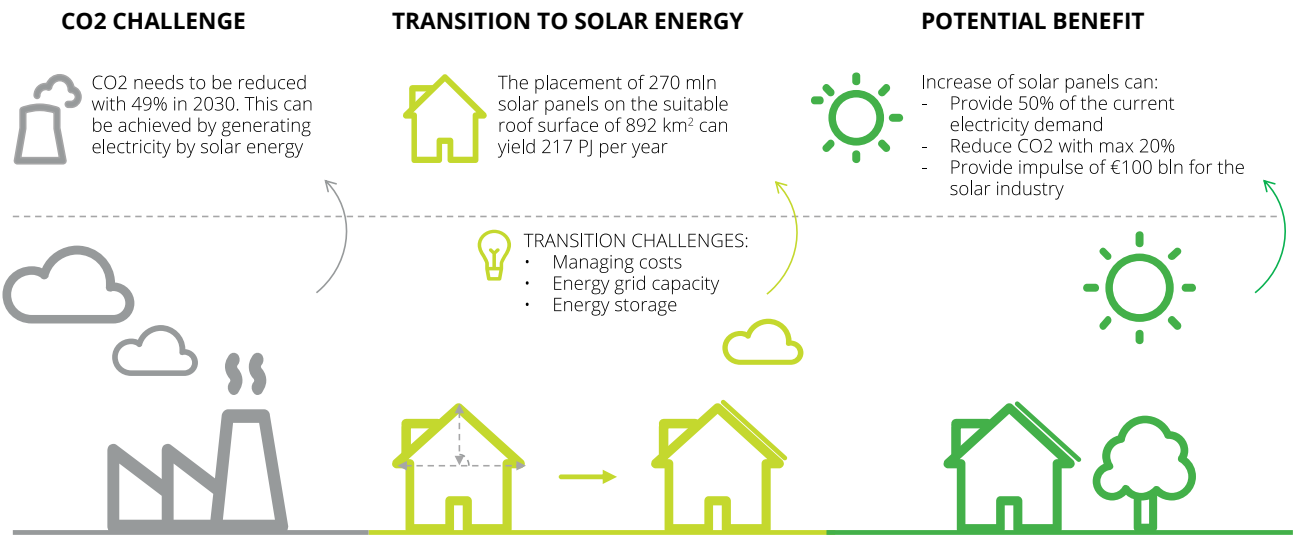

Figure 6: Making the most out of solar energy

State of the State

This solar panel research is part of Deloitte's State of the State program – providing data analysis of our country - intended to provide policy makers and organizations with useful insights on various social themes (e.g. education, care and safety). State of the State is part of GovLab, Deloitte's platform for social innovations. Please visit www.stateofthestate.nl for more studies.

The aim of this research

The aim of this research is to show the potential of solar energy when leveraging the total rooftop surface available in The Netherlands. Based on the average solar panel price and yield we have calculated the potential of solar energy for every municipality. The national government in conjunction with its provinces and municipalities can use our research to decide how to accelerate the growth of solar capacity in The Netherlands.

Method of data analyses

To calculate the potential of solar energy yield in the Netherlands, we needed to determine the total square meters of roof area and the appropriate share suitable for solar installation. The calculations were done using publicly available data of the 'Basisregistratie Adressen en Gebouwen' (BAG) made available by the Kadaster (the Dutch Land Registry and Mapping Agency). Combined with the digital elevation map of the Netherlands, AHN2 and AHN3, we were able to derive the elevation and surfaces of all roofs.
Not all roofs were included. We disregarded roofs and parts of roofs unsuitable for solar panels, like small dormers and ridges and determined the orientation and steepness of the roof surfaces. The roof surfaces suitable for solar have been identified based on a minimum amount of sunlight energy per m2 per year of 690 kWh. This has been determined based on the orientation and steepness of the roofs, which affect the yield of a solar panels. If the roof surface received too little sunlight for a profitable solar yield, it was excluded.

For calculating the number of solar panels per roof and total solar panels in The Netherlands, we used a validation dataset of MapGear for the city of Utrecht. MapGear is the owner of the 'Zonnekaart' (Sunmap) which is among the most detailed datasets on this topic available. After the number of solar panels per roof was known, it was multiplied by the rated power of a basic single solar panel of 270 watt peak, corrected for the impact of the orientation and steepness of the roof it is on. Various validations and checks were performed to account for local variations, which were subsequently included in the data analysis.

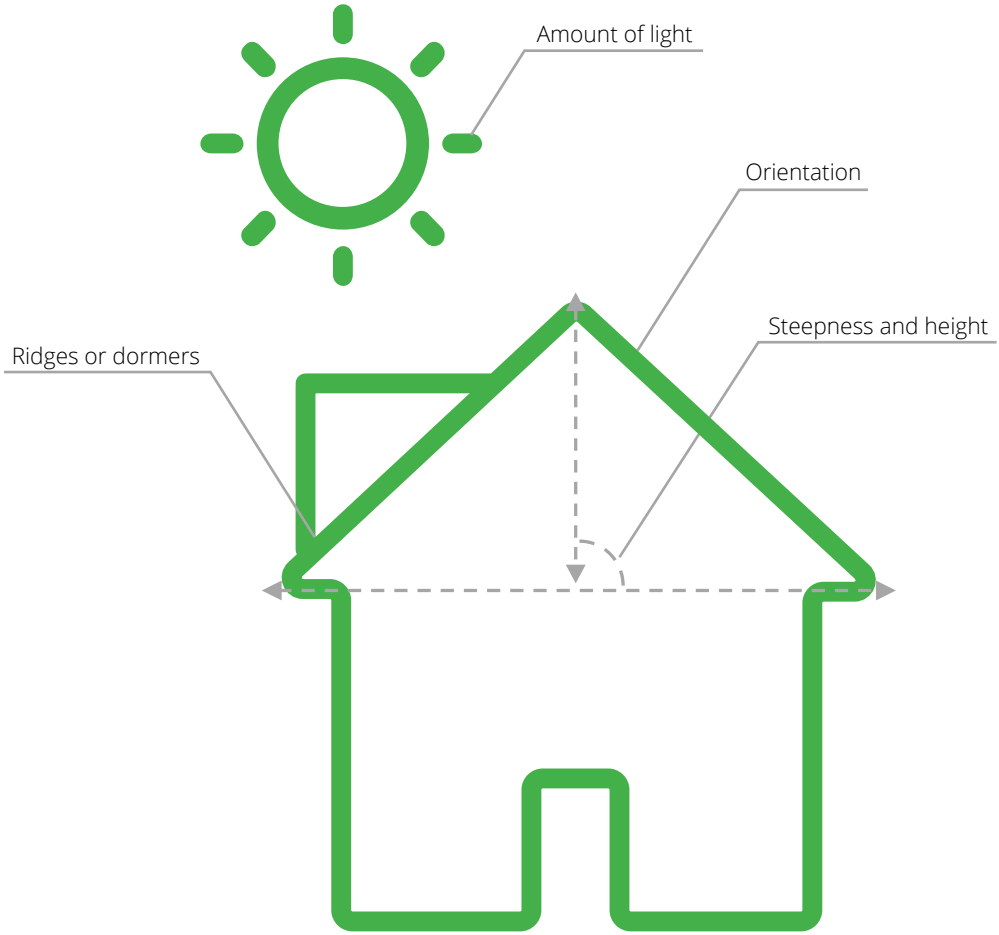

Figure 7: Indicators to determine suitability of the roof surface for solar panels

Assumptions & Sources

Assumptions we used for the analysis

- All buildings in the Netherlands that are in the BAG are part of the analysis.
  We excluded only buildings with a surface larger than 2500 m2 in the Westland in South
- Holland, where there are many greenhouses, to remove greenhouses.
  Greenhouses in other parts of the Netherlands are still included and may skew the result with at maximum few percent.
- Buildings created after the release of AHN2 were not included. This may create a deviation of a few percent.
- When calculating potential of solar panels on house roofs we included any building tagged with a housing function in the BAG, even if it was also tagged with an office function.
- When there was no housing function for a building but an office function was present, the building was determined as an office.
- Via the same approach, industrial and other functions are determined (in that order).
- Roof surfaces were only included if they receive enough sun hours within a year. The ROI time of a solar panel on such a location is at maximum of 11.1 years for consumers, depending on subsidies, electricity price and the net return policy
- Solar panels are assumed to have a nominal power of 270 watt peak. This number is based on data of Kenniscentrum Zonnepanelen VoltaSolar , which in turn is based on the Photovoltaic Geographical Information System (PVGIS) of the European Union.
- Solar radiation is assumed to be equal for the whole of the Netherlands. In addition, no distinction was made between the number of solar panels which can be placed on a flat surface and a surface with a slope. In addition, the shadow effect of surrounding buildings is not included. These factors are taken into account in the MapGear calculations.
- Declining yield of a solar panel over the years is not included in the calculation.
- Policies that forbid placements on certain roofs, like that of monuments, were not taken into account.
  These may lower the total amount a few percent for the whole of the Netherlands. This deviation will be larger in municipalities that apply these policies.
- In our research we only looked at the possible yield of solar panels on roofs. The potential yield of solar farms was not taken into account
- For the growth figure, a factor of 1 kWh / Wp / Year was taken to convert from Wattpeak to petajoule. Due to this average factor, the numbers deviate slightly for the numbers mentioned earlier in the text.

Bronnen

CBS: https://opendata.cbs.nl/#/CBS/nl/dataset/81955NED/table?ts=1518510853155
CBS: http://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=80324ned&D1=01&D2=a&D3=373&HDR=G2&STB=T,G1&VW=T
CBS: https://opendata.cbs.nl/statline/#/CBS/nl/dataset/82375NED/table?ts=1511882840671
CBS: http://statline.cbs.nl/Statweb/publication/?VW=T&DM=SLNL&PA=70946ned&D1=a&D2=0-1,5,15,18&D3=a&HD=160823-1750&HDR=G1&STB=T,G2
CBS: https://opendata.cbs.nl/statline/#/CBS/nl/dataset/82610NED/table?ts=1518511831914
CBS: https://opendata.cbs.nl/#/CBS/nl/dataset/80324ned/table?ts=1518510986807
Milieucentraal: https://www.milieucentraal.nl/nieuwsbrieven/professionals/juli-2016/400000-huizen-met-zonnepanelen-hoe-kom-je-er-bij/
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Nationaal Solar Trendrapport 2018: http://www.solarsolutions.nl/download/
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Bespaarbezaar: https://www.bespaarbazaar.nl/kenniscentrum/financieel/zonnepanelen-opbrengst/

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