



Center for
Big Data Statistics

From Experimental to Official Statistics: *The Case of Solar Energy*



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Energy Statistics Working Group

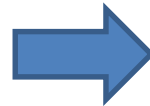
Luxembourg, 7 November 2019

Towards smart statistics

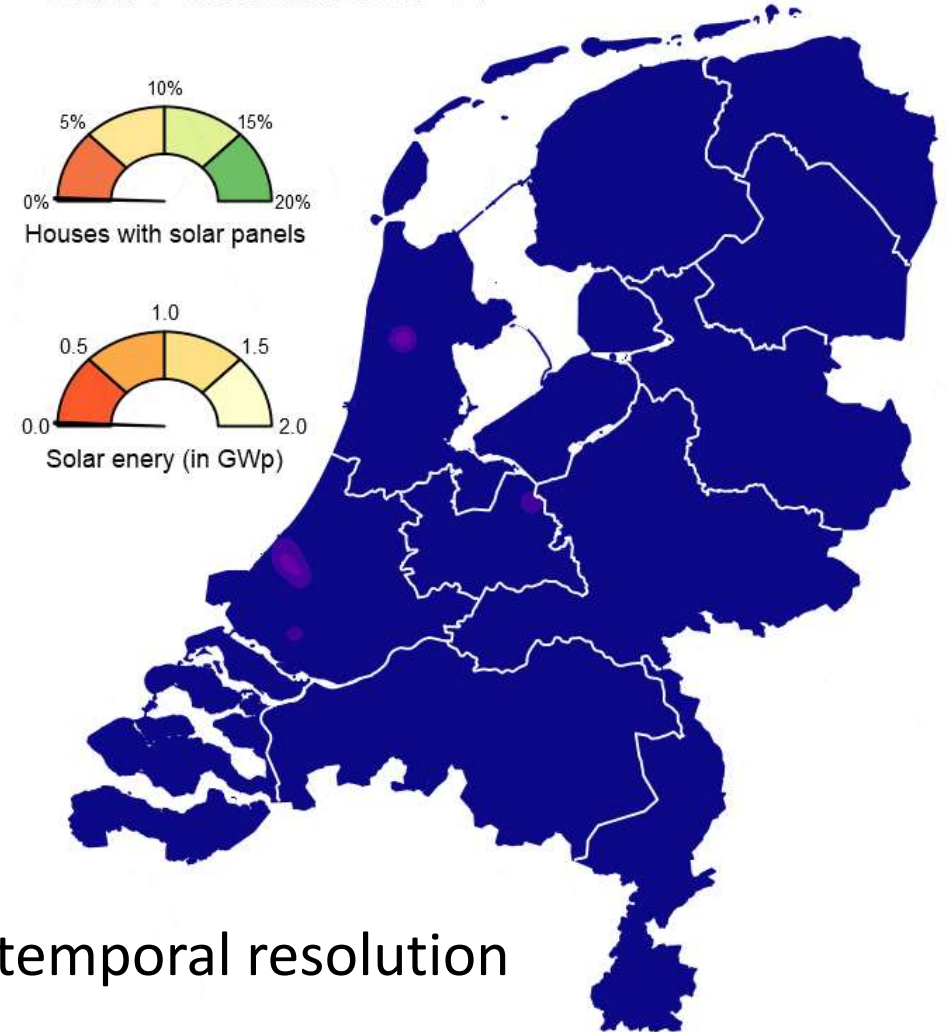
Desired Output?

Solar energy

year	total installed power [MW]
2010	90
2011	149
2012	287
2013	650
2014	1.007
2015	1.526
2016	2.135
2017	2.903
2018	4.414

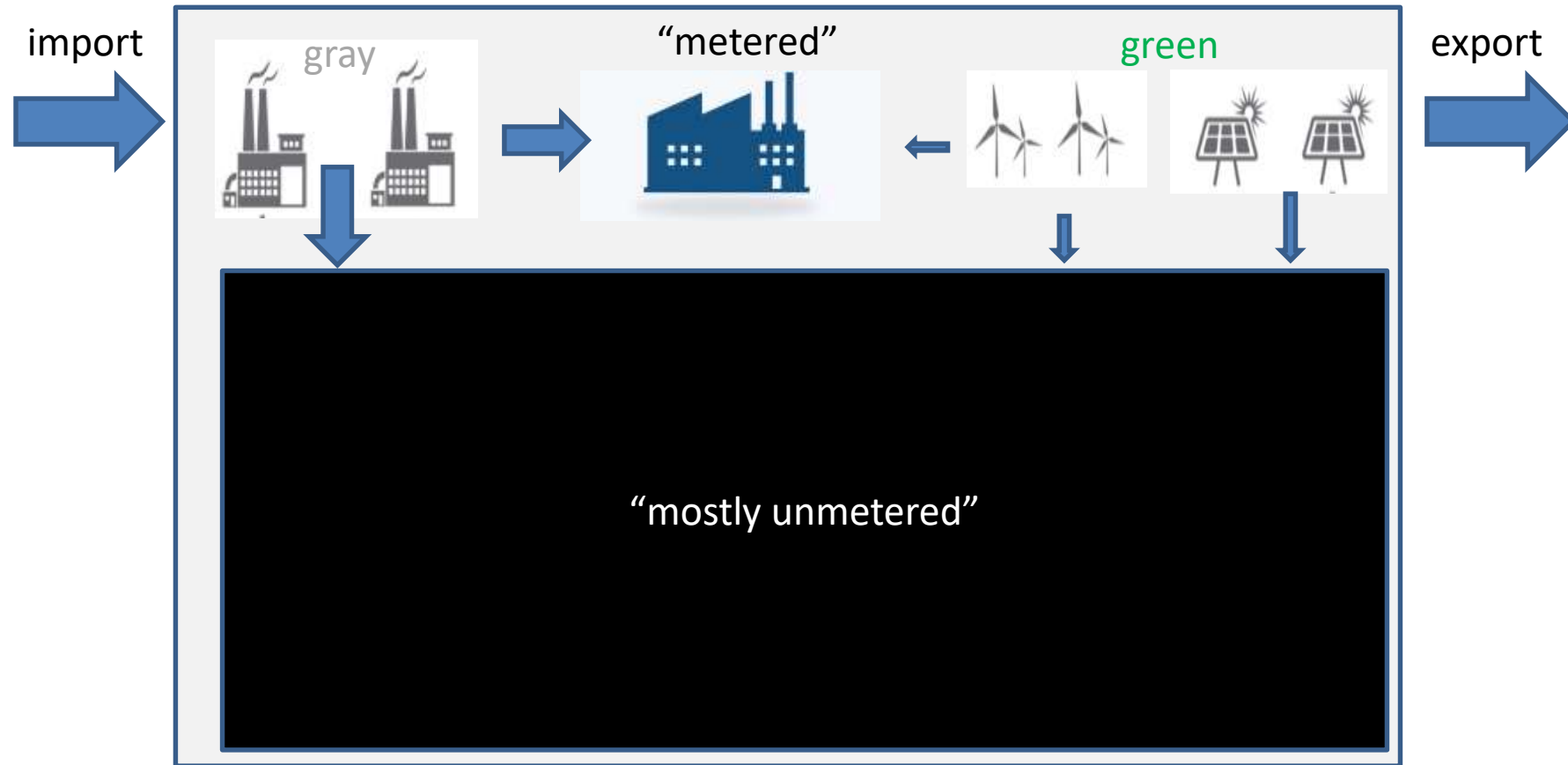


Solar Panels in 2010-01



- High spatial & temporal resolution
- Fast results

The challenge



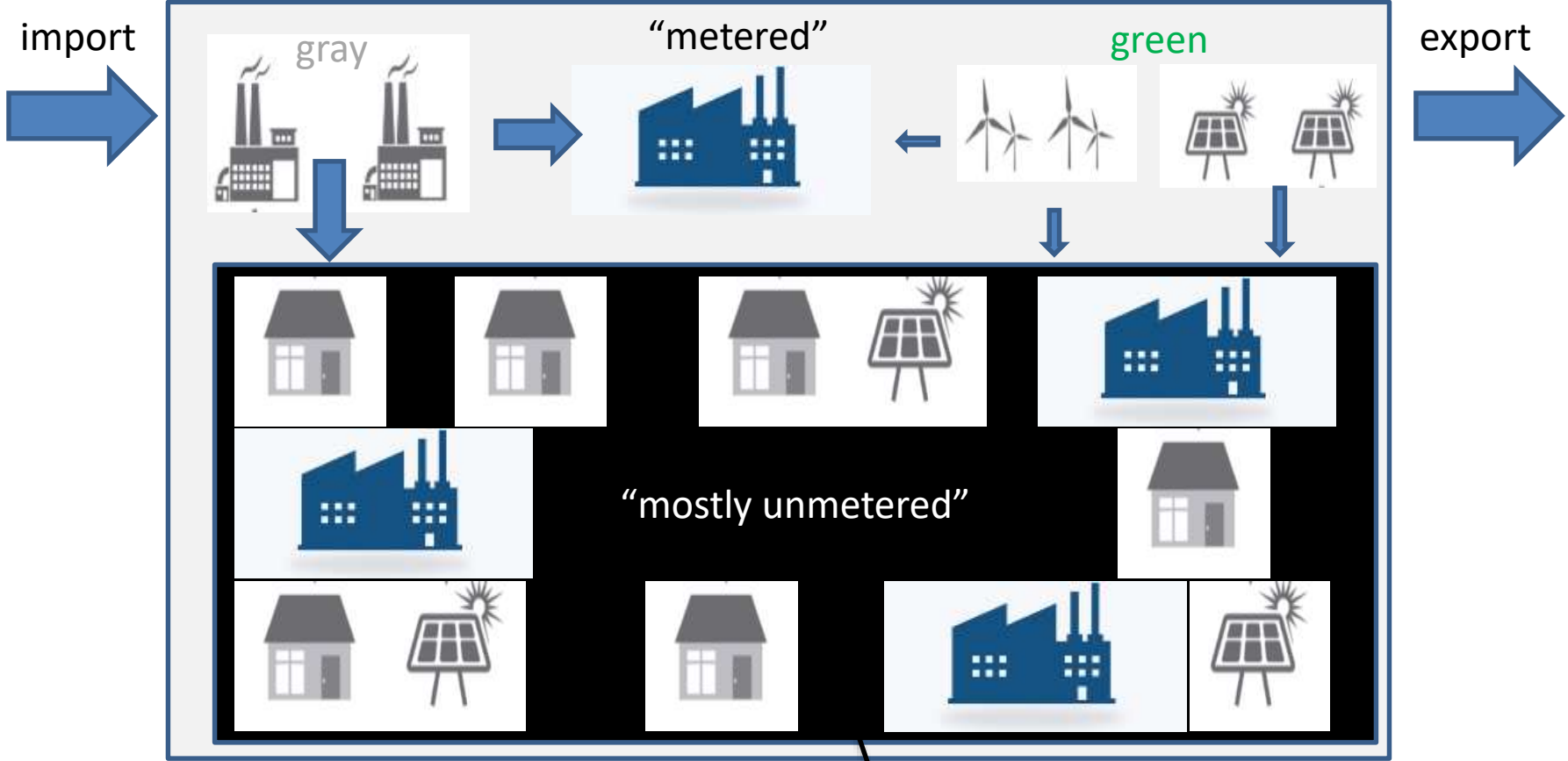
Dutch grid

Balancing supply & demand!

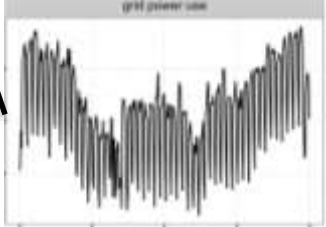


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Inside the "black box"



Dutch grid



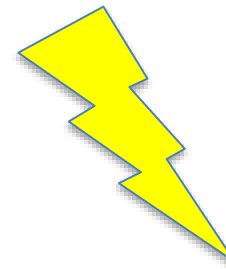
Life could be easy: smart meters



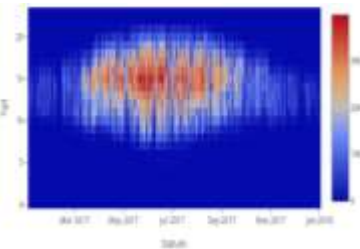
- + Direct measurement
- ? Quality sensor measurement





- Coverage
- Access



Evaluate different data sources



	Survey (import)	Admin data (register)	Tax refund / subventions	Aerial images	Measured data
	<ul style="list-style-type: none"> • Direct • Type 	<ul style="list-style-type: none"> • Direct • Location • Type 	<ul style="list-style-type: none"> • Incentive • Location • Frequency 	<ul style="list-style-type: none"> • Coverage • Location • Frequency 	<ul style="list-style-type: none"> • Coverage • Location • Concept
	<ul style="list-style-type: none"> • Burden • Coverage • No location 	<ul style="list-style-type: none"> • Coverage? 	<ul style="list-style-type: none"> • Started 2013 • Type & power just estimate 	<ul style="list-style-type: none"> • Type? • Integrated panels? • Effort 	<ul style="list-style-type: none"> • Advanced models needed

Aerial images: extract solar panels



Possible first step: extract buildings



Admin data → Machine vision

ESSnet DeepSolaris:

+ Location

+ Number

? Type

?



Tesla solar roof



'positive'

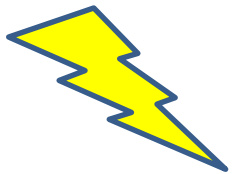
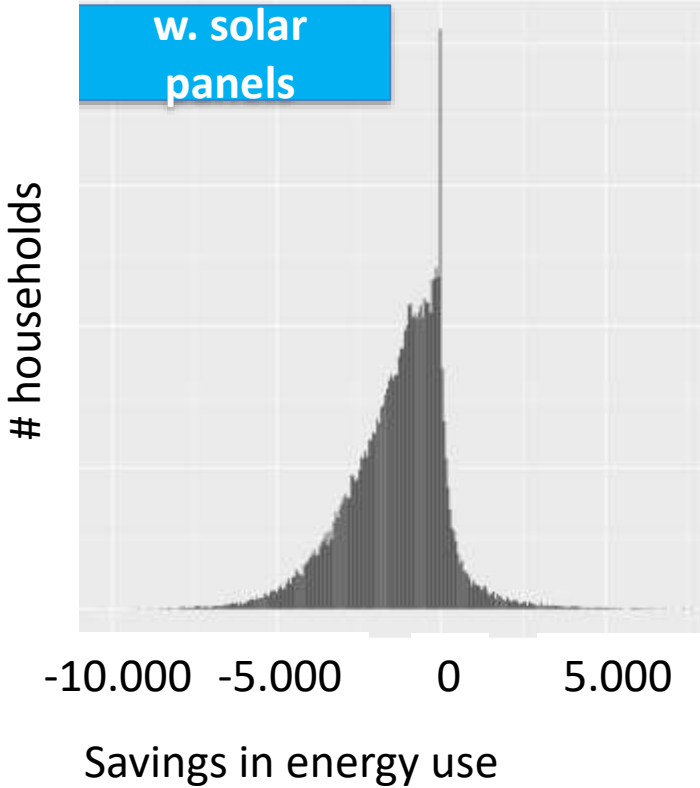
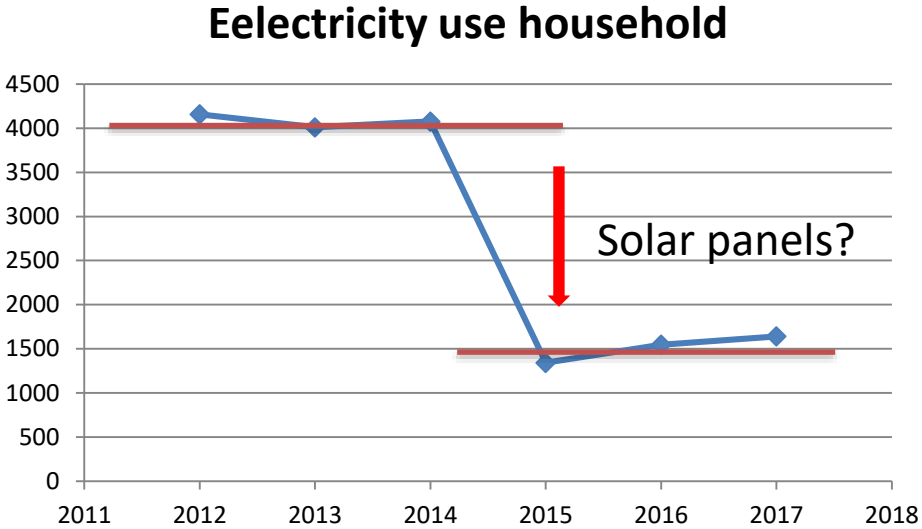


'negative'

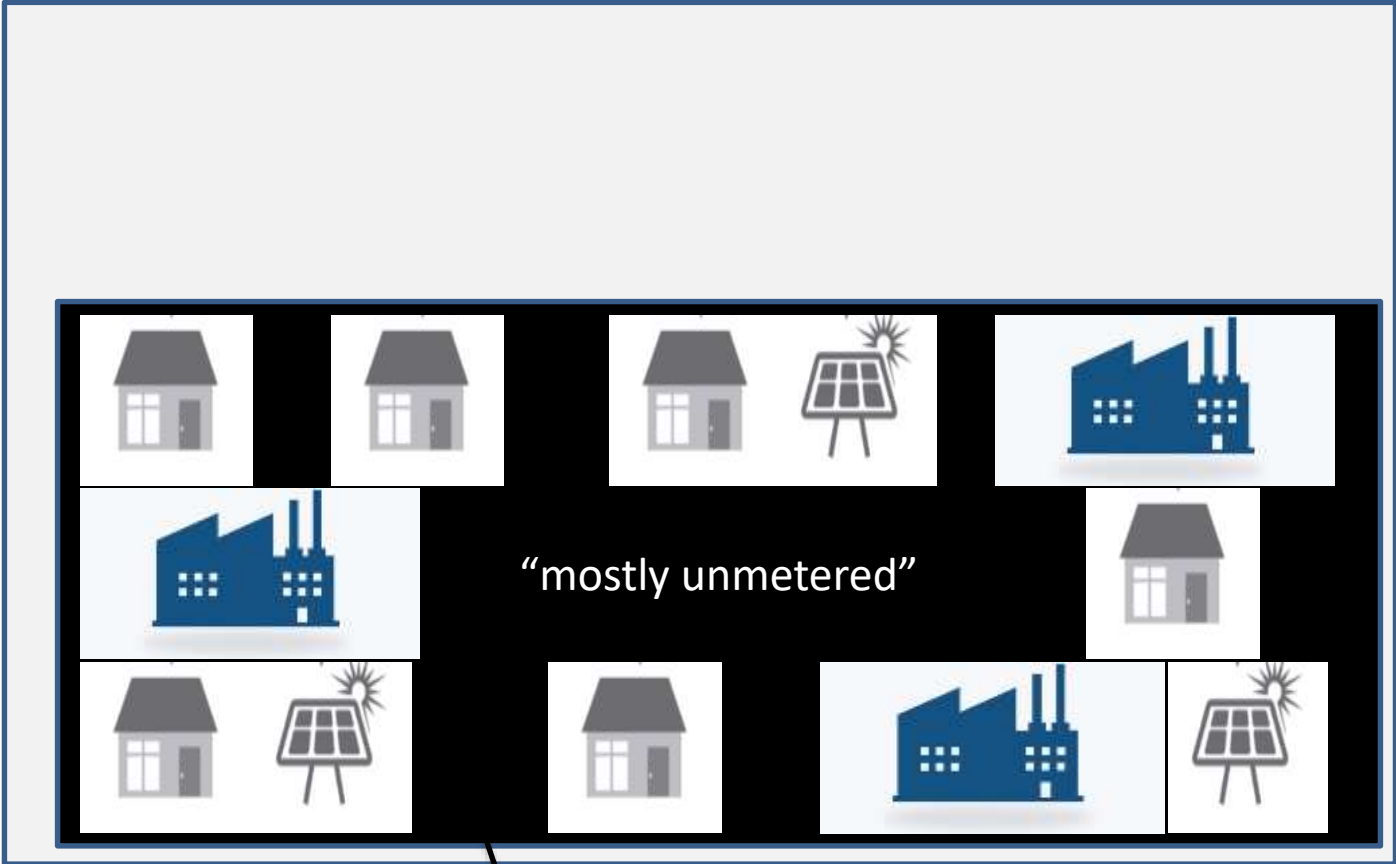


Energy savings (solar panels)

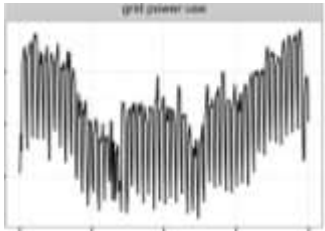
- Yearly electricity consumption household
- No household dynamics



Back to the “black box”

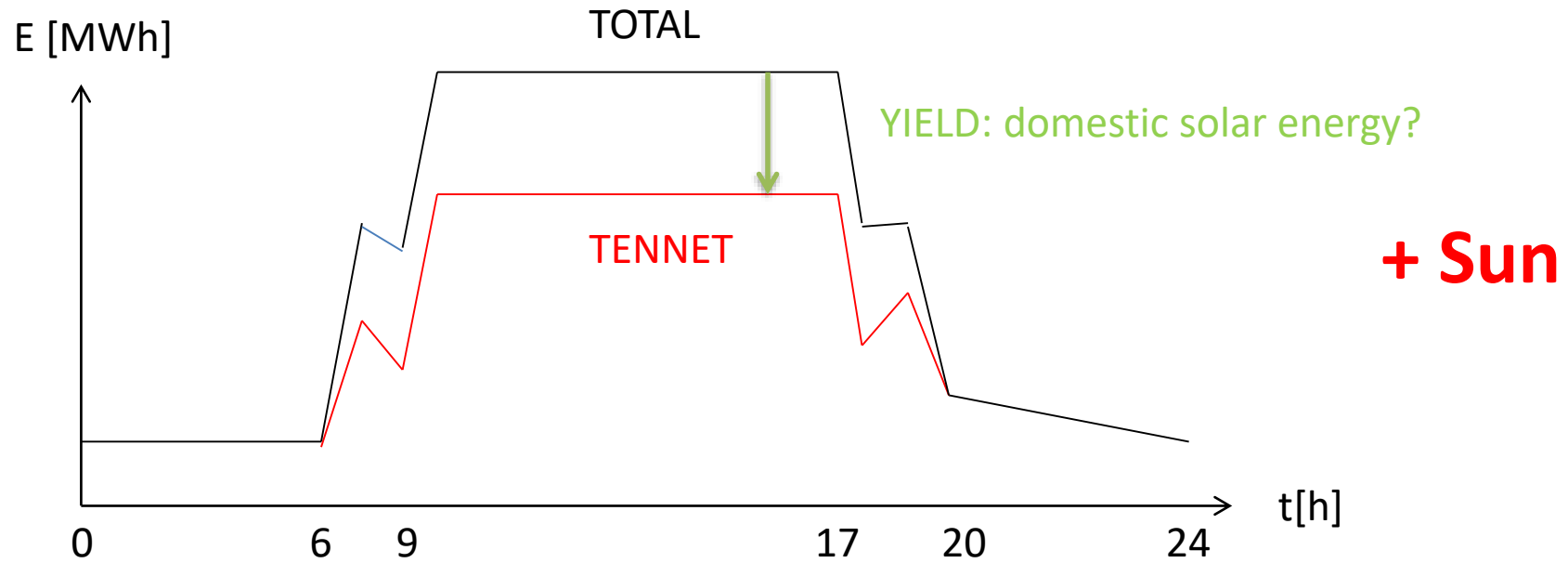


Dutch grid



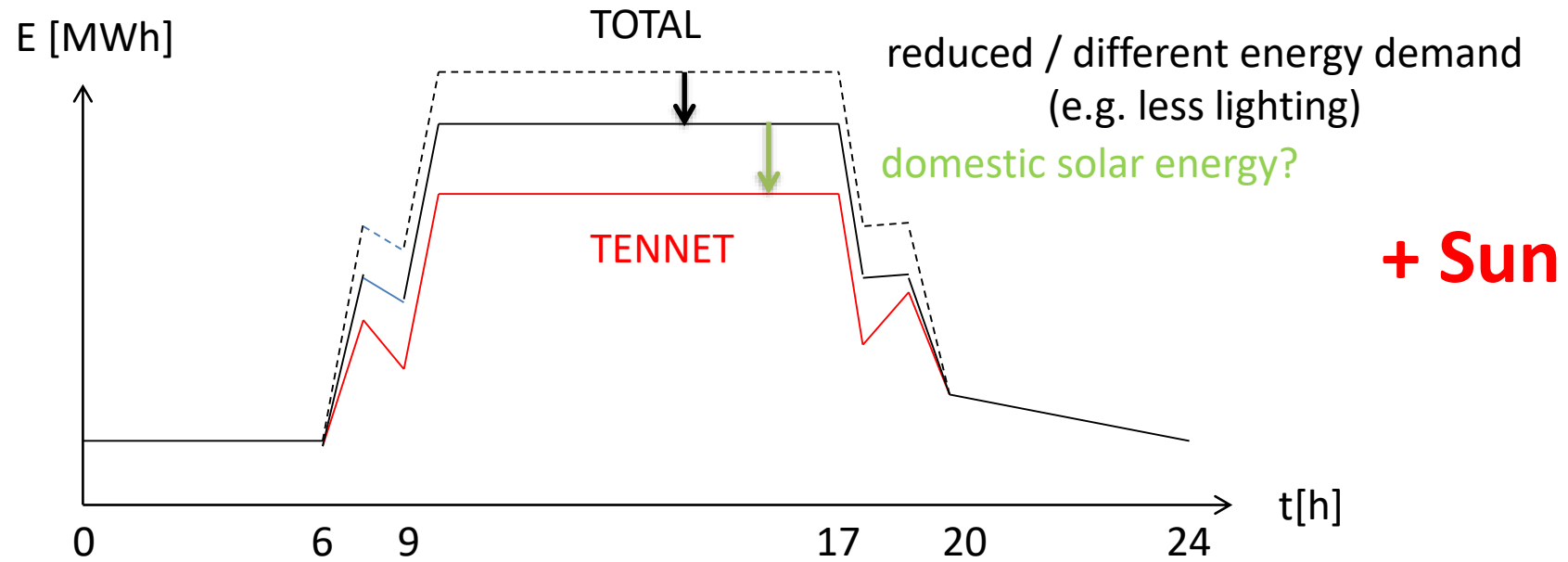
The basic idea

Schematic electricity demand during 1 day (unmetered part)

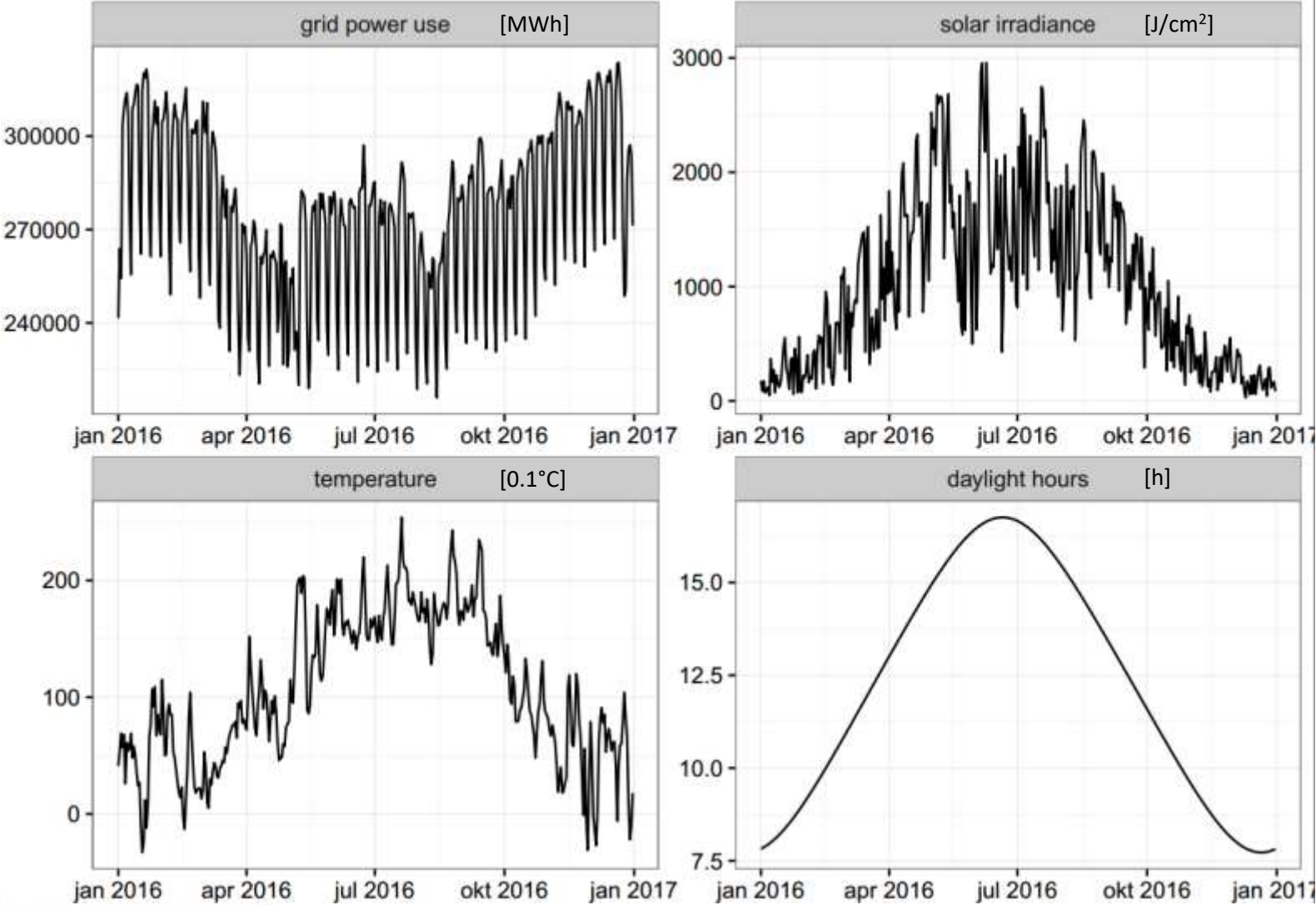


The basic idea

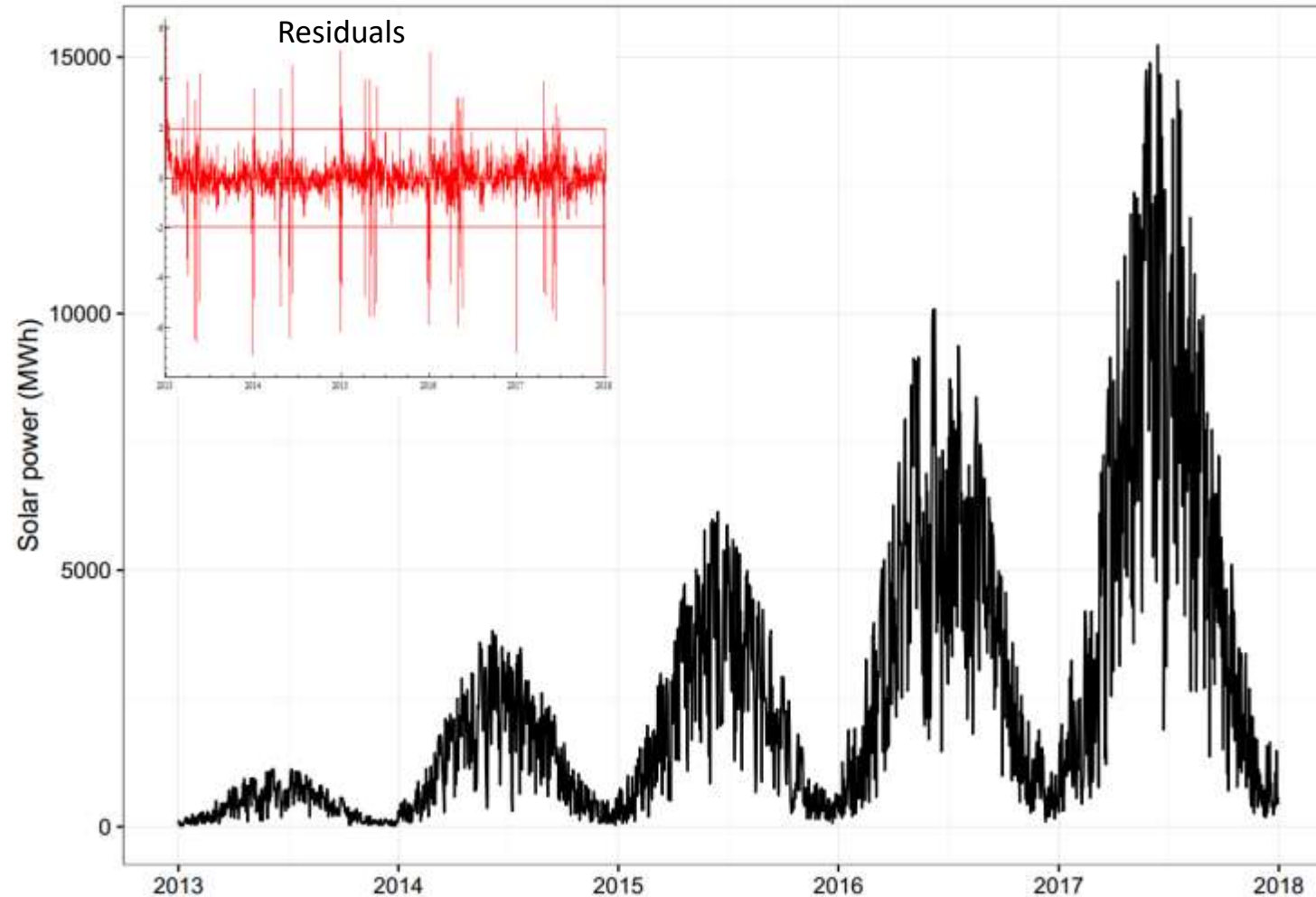
Schematic electricity demand during 1 day (unmetered part)



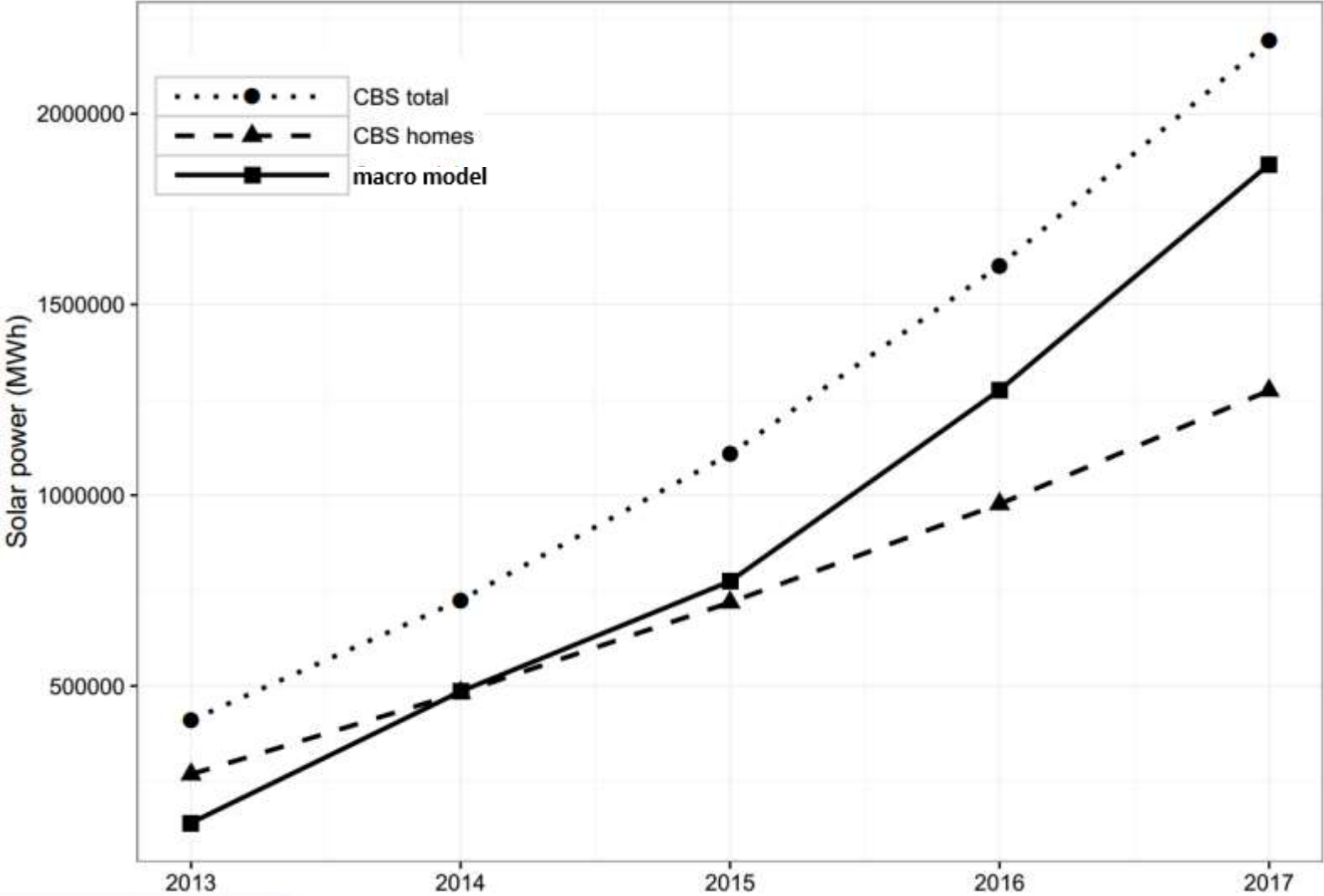
Input to the model



Output: estimated solar power



Output: compare methods



Estimating solar energy from new data sources



← We have good data on solar farms

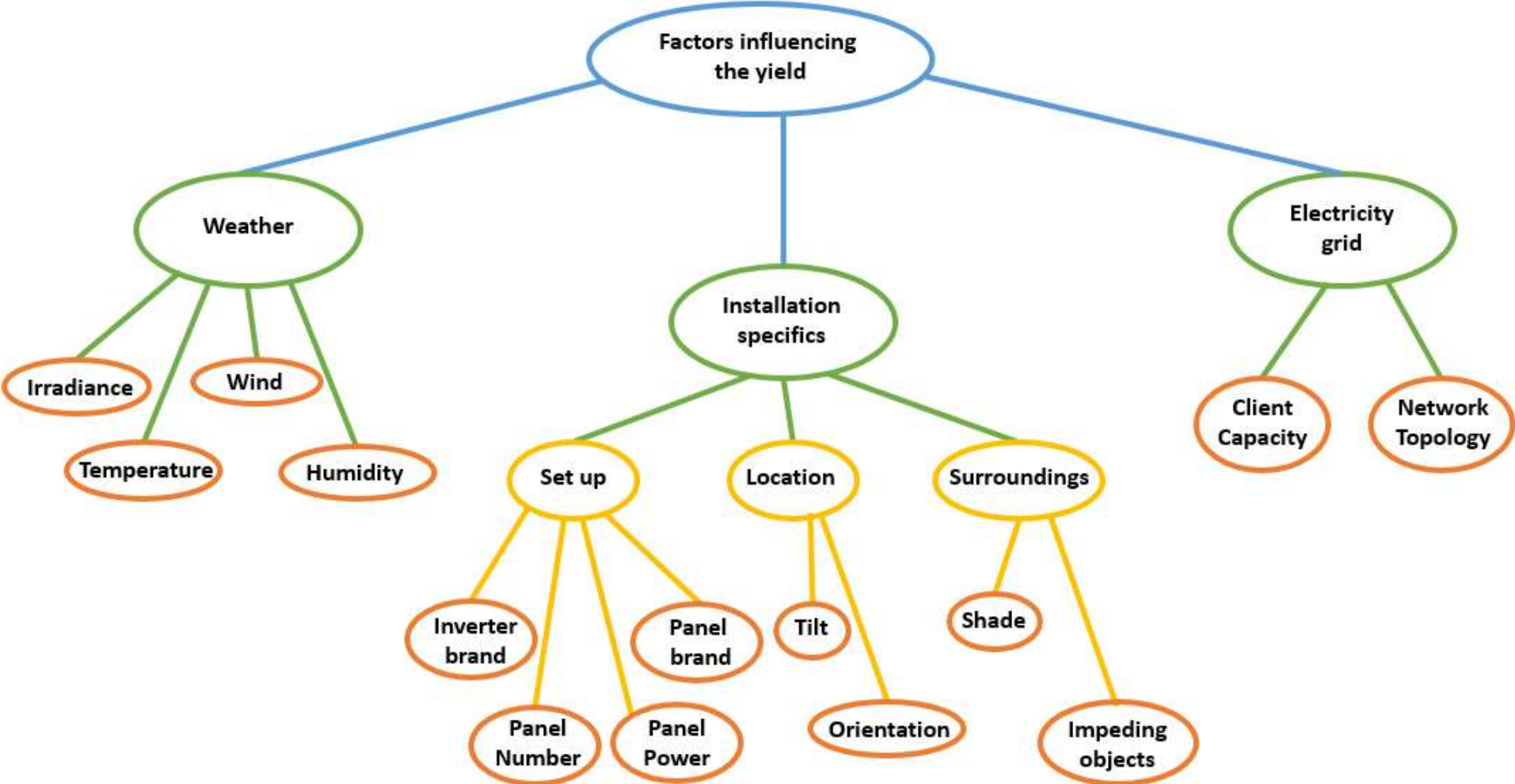
But what about those? →



and their number is increasing ...



Factors influencing yield of PV installations



Estimating solar energy: current method

- Yearly estimate for the whole of NL based on #panels in register
- Uses a **scaling constant** from the *Dutch Protocol Renewable Energy (2015)*
- Produced solar power calculated as:

$$P_{year} = \left(\frac{\sum_{n=1}^{N_1} W_n + \sum_{n=1}^{N_{365}} W_n}{2} \right) \frac{875 \text{ kWh}}{\text{kWp}}$$

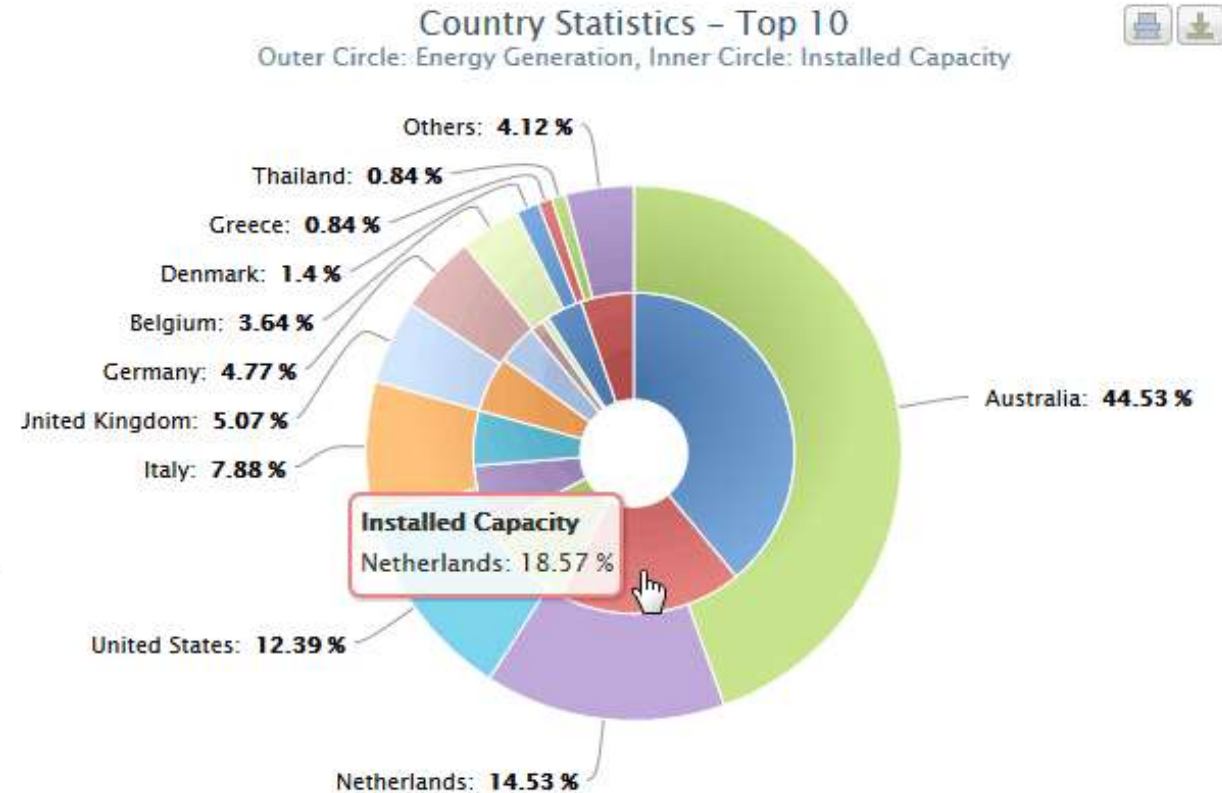
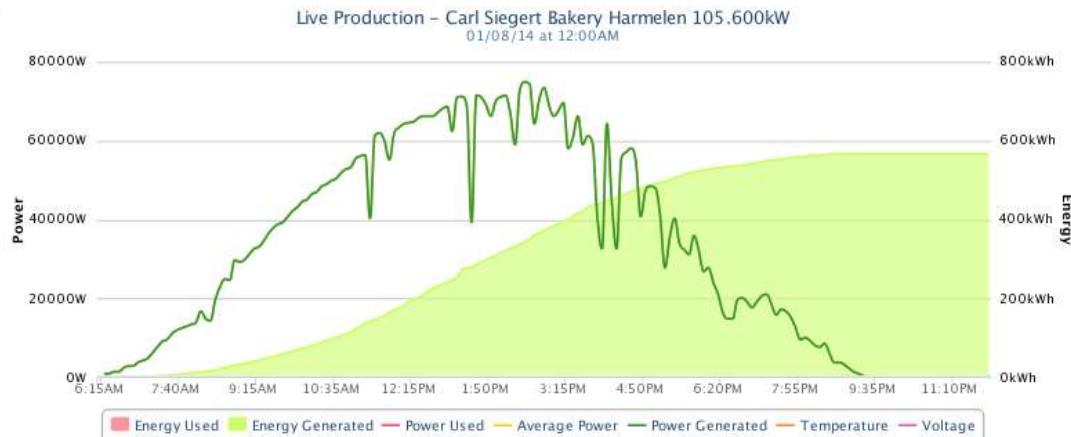
Can we do better?

using new data sources ...



Data source 1: PVOutput.org

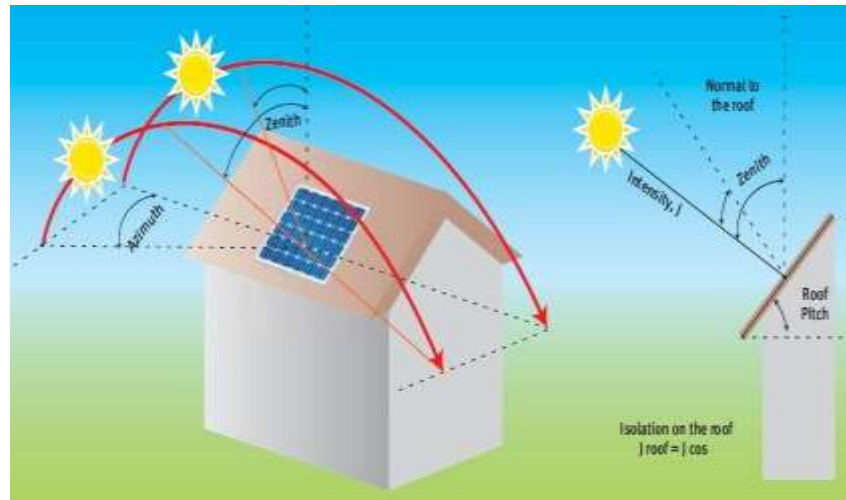
- A free service hosted in Australia containing detailed ***pv output data***
- People connect their panel to the ***data portal*** (citizen science)
- Can we use this to calibrate a ***model*** for detailed regional solar energy production?



- About 5700 installations in NL

PVOutput Data

- Output power (W) and energy (kWh) per 5 minutes
- Number of panels and panel capacity (W)
- System size (W)
- Orientation (NE, E, SE, S, SW, W, NW, N)
- Tilt (0-90 degrees)
- Inverter size
- Inverter brand
- Installation date
- Lat/lon + pc4



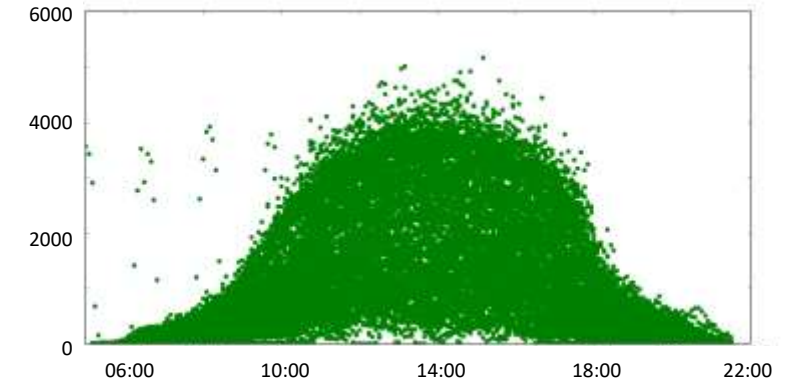
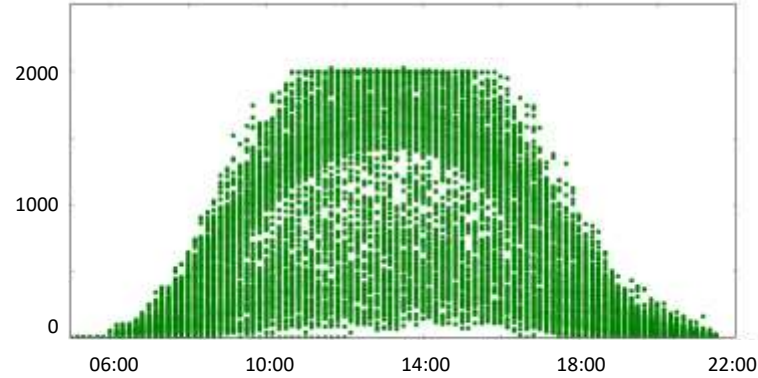
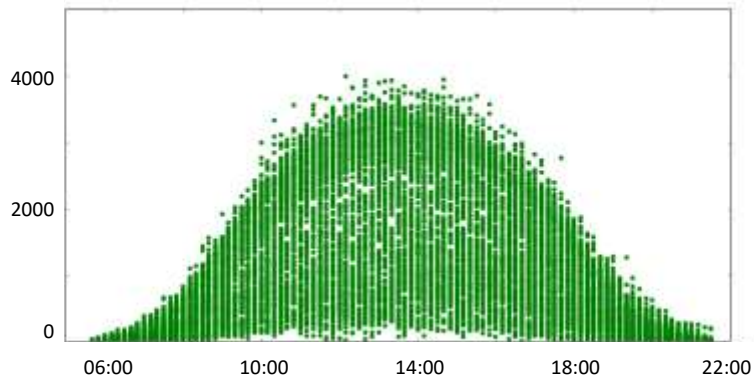
Tilt and orientation



Installations with continuous data for whole year

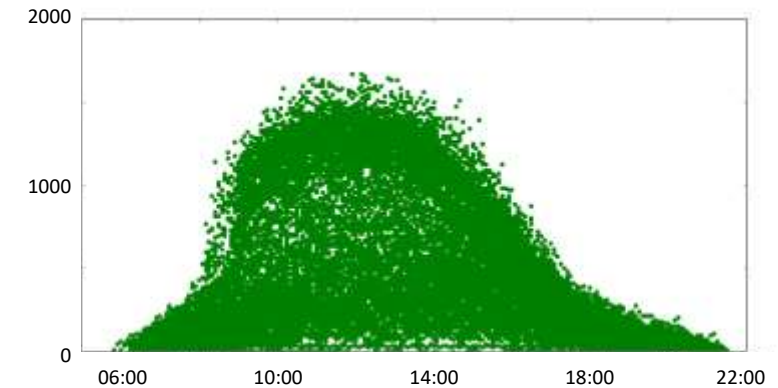
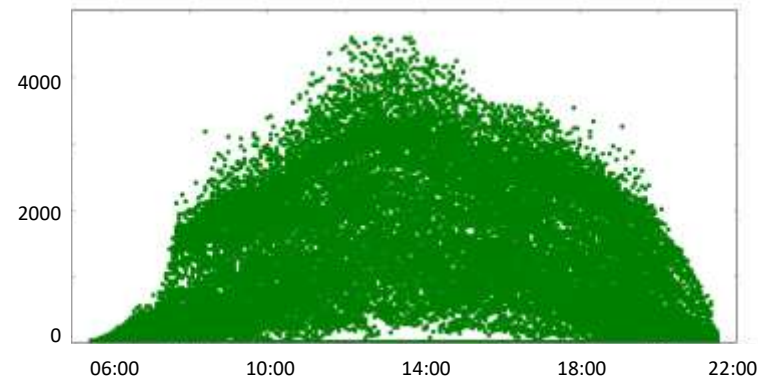
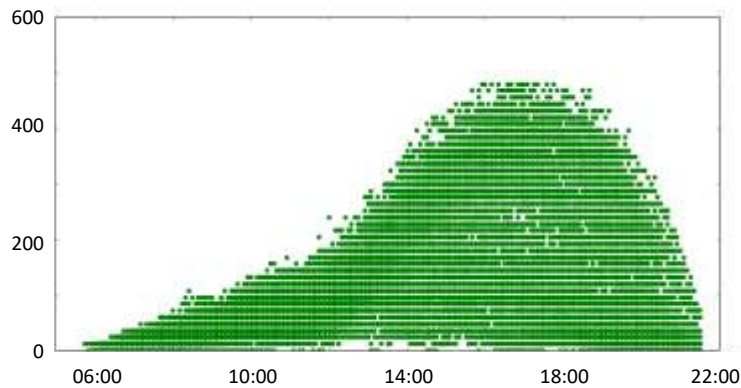
PVOutput Daily Profiles

- Different yield patterns caused by several factors, e.g.:



Max Inverter Size

Software issues



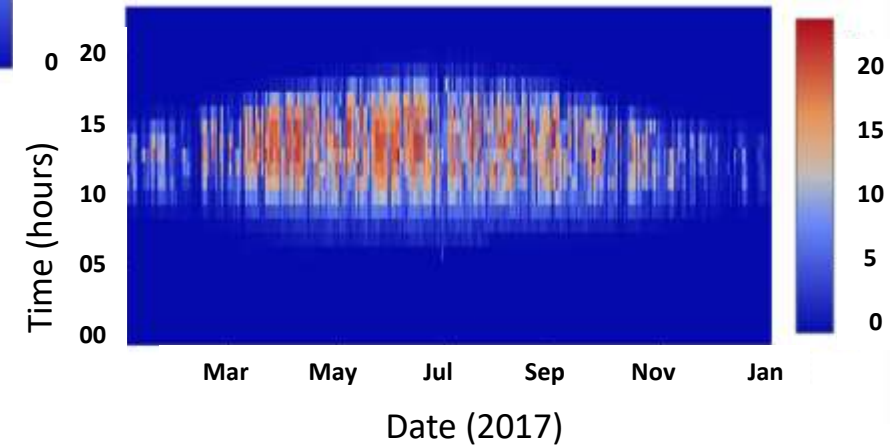
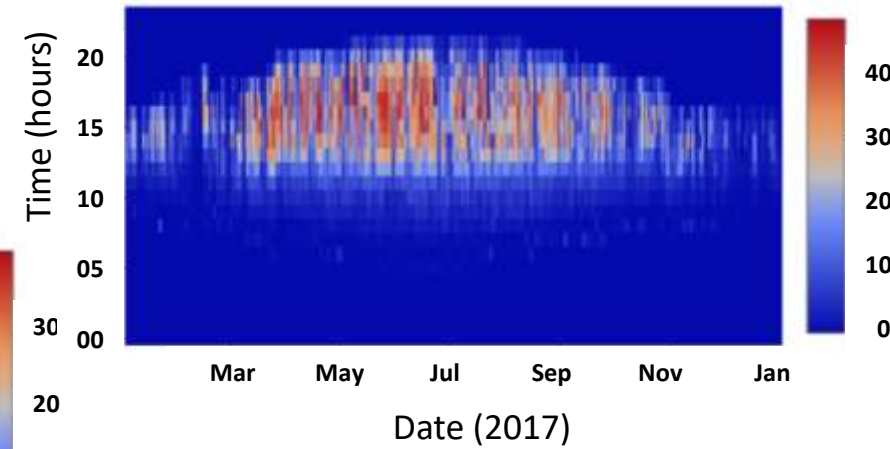
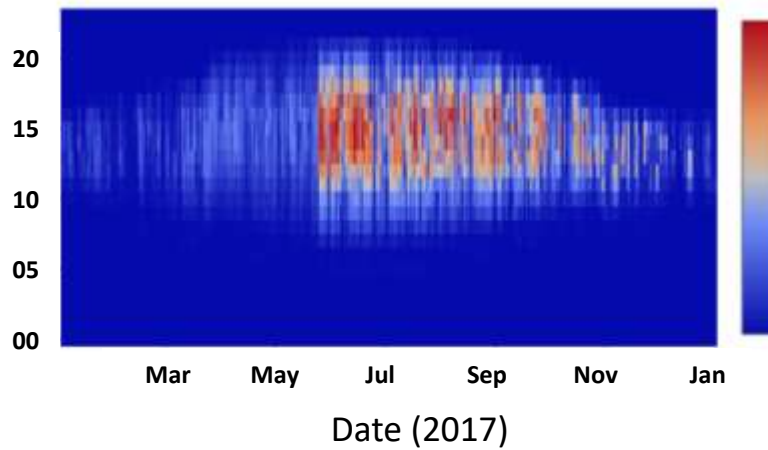
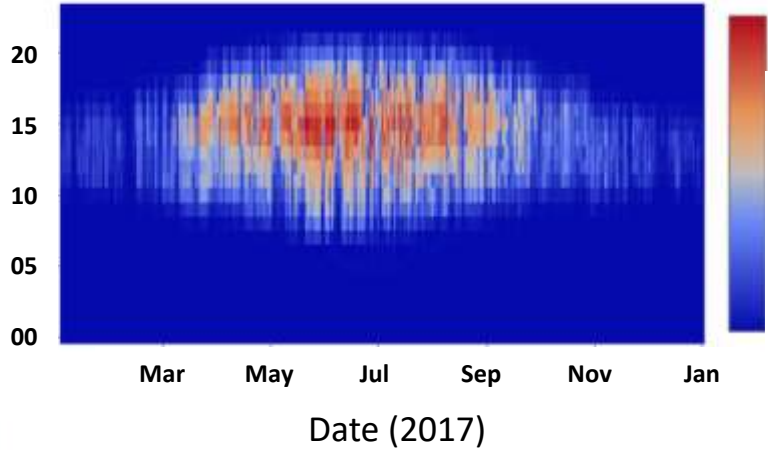
Orientation

Surrounding Objects (e.g. chimneys, trees, buildings etc.)



PVOutput Annual Profiles

Time (hours)



Data cleaning

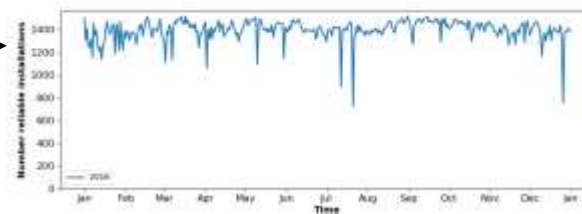
PVOutput yields shows:

- healthy patterns
- but also
- mixed data quality

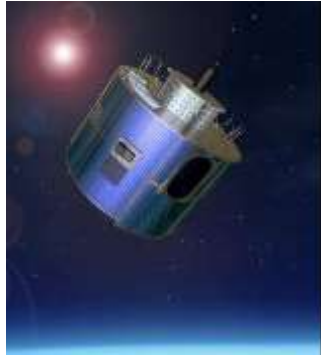


Daily set of reliable pvoutput installations based on 4 criteria

1200



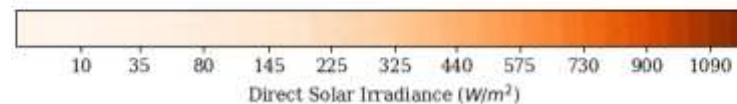
Data source 2: modelled irradiance data (KNMI)



- Meteosat 2nd
- Every 15 min.
- Grid 3 km x 5 km
- Available when Sun is more than 12 degrees above the horizon

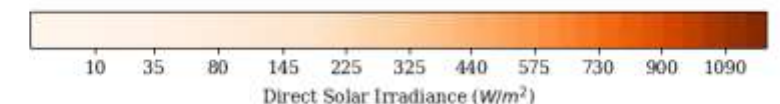
Direct Solar Irradiance in the Netherlands on 22-06-2017

t=05:15 (GMT)



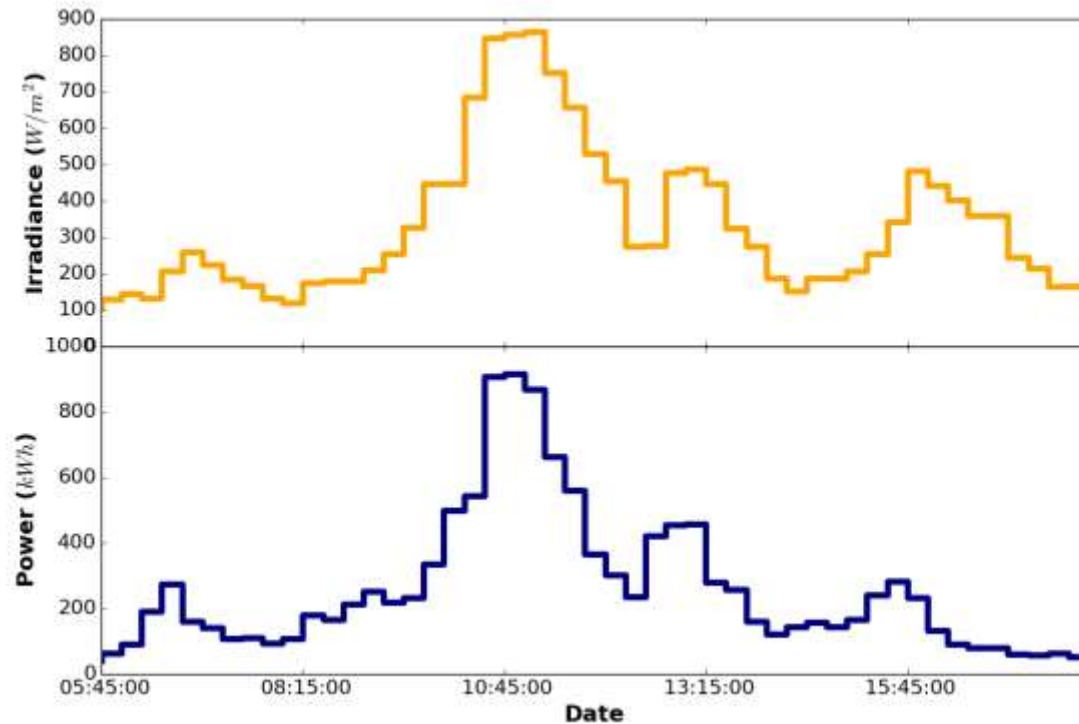
Direct Solar Irradiance in the Netherlands on 21-06-2017

t=05:15 (GMT)

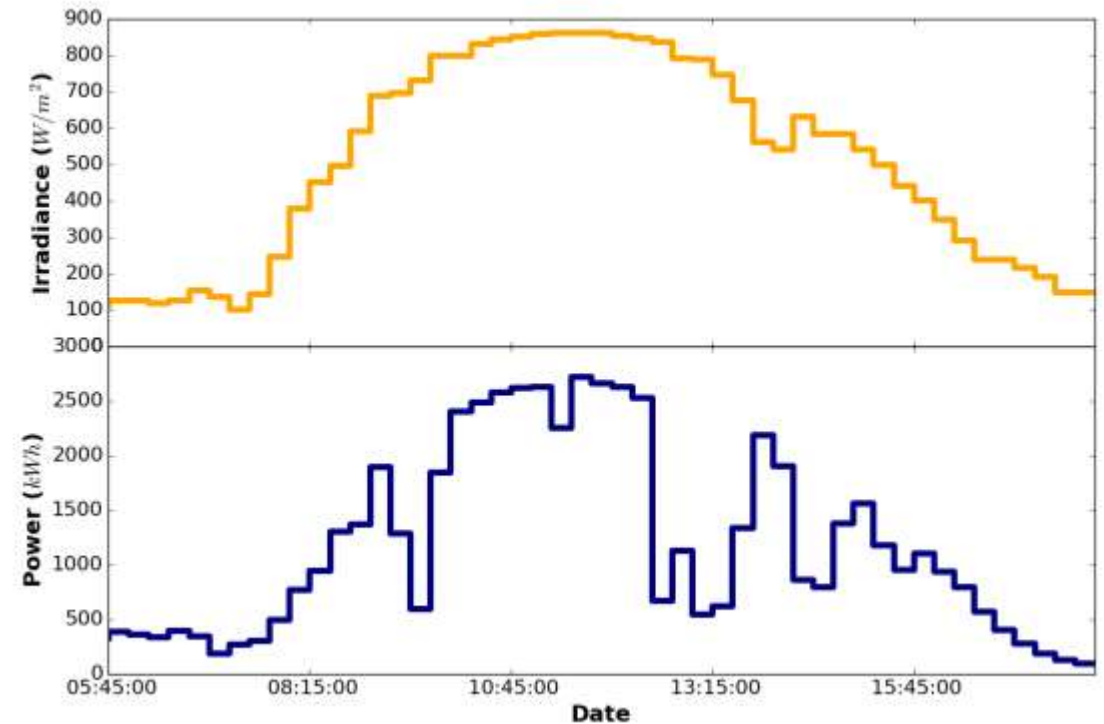


Combining the two data sources (1)

- Irradiance versus power on 2 different locations:



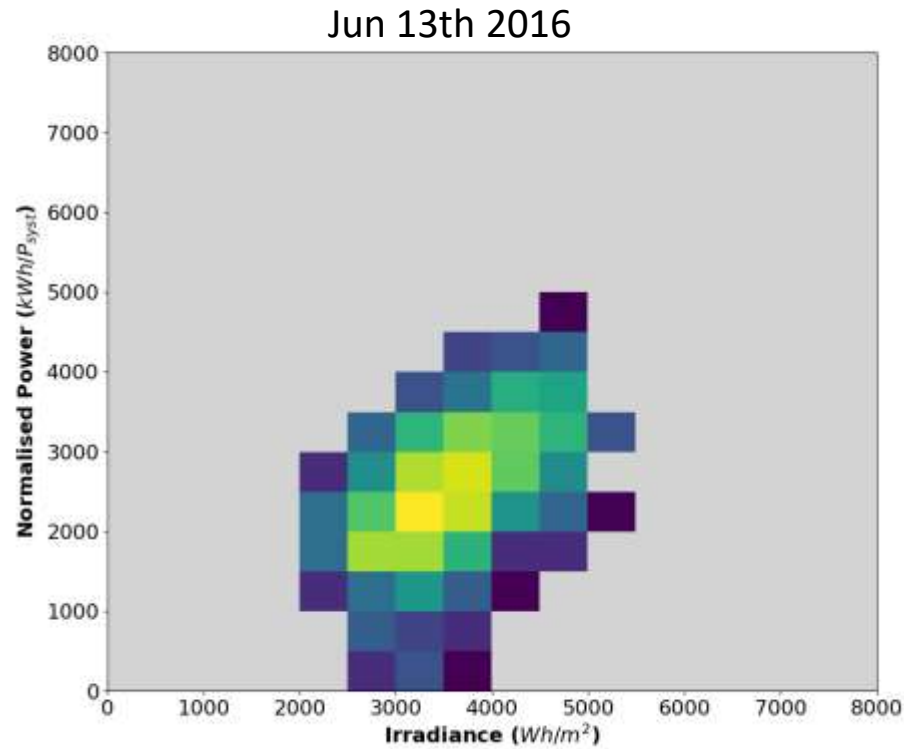
Power follows irradiance closely



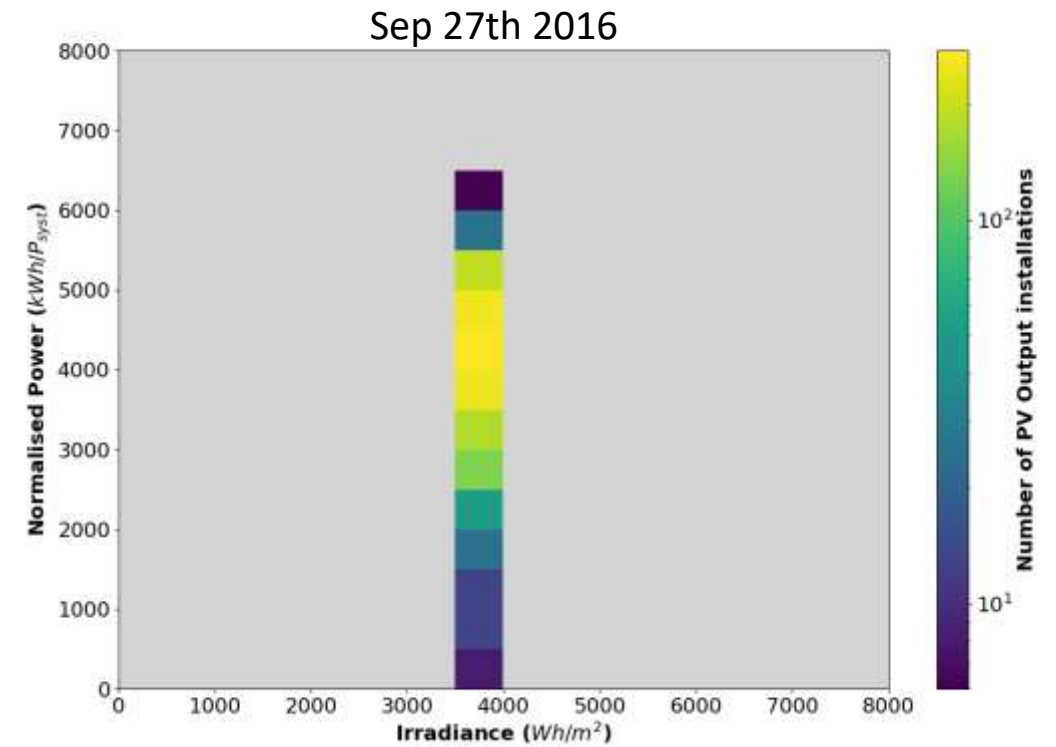
Some local effects

Combining the two data sources (2)

- 2D plane of irradiance and normalised power for 2 different days:



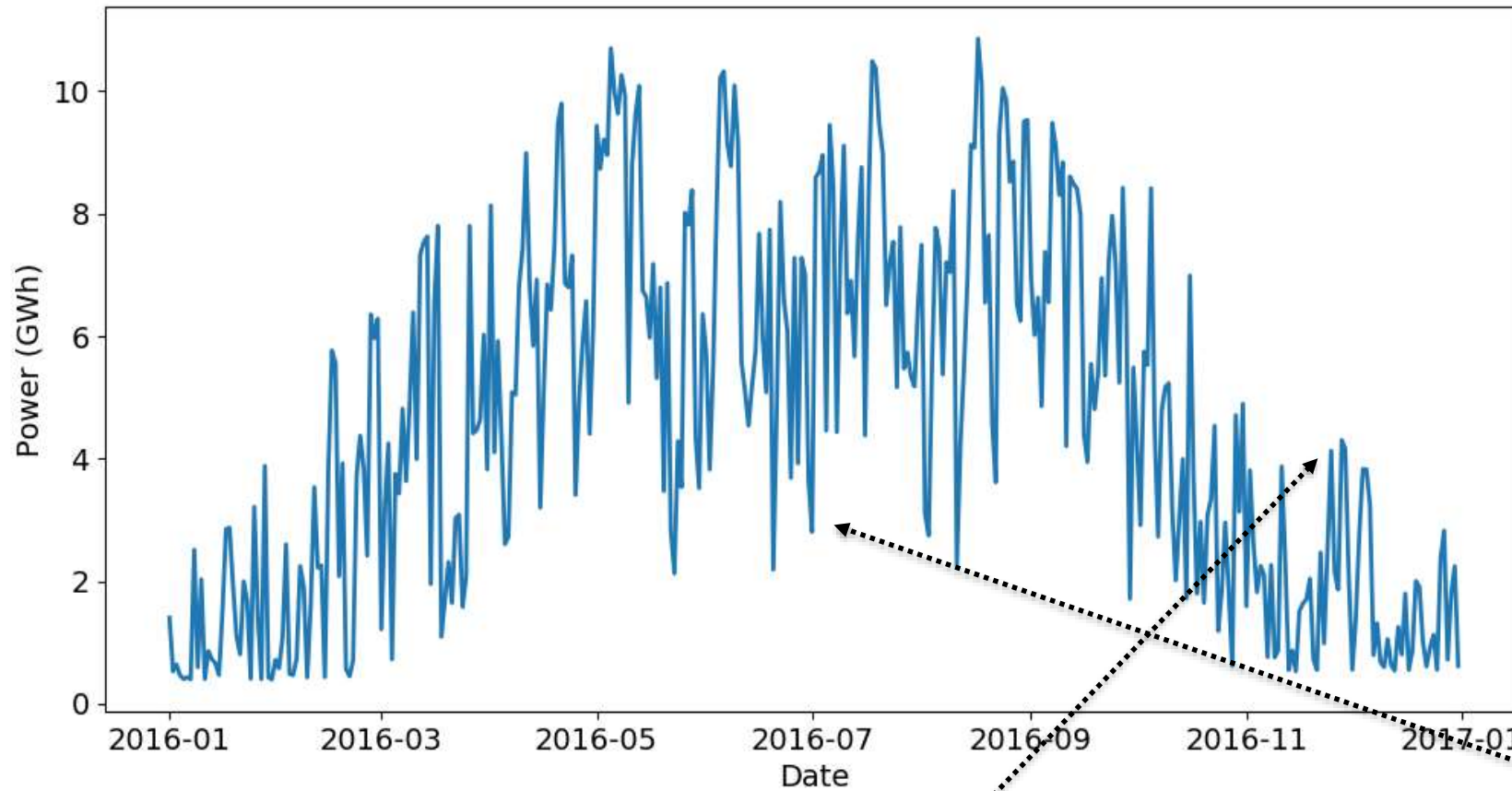
Day with varying irradiance over NL



Exceptionally clear day over whole NL

Total daily solar power 2016

Paper in preparation, B. Laevens:
Towards an observational daily and regional
solar energy statistic for the Netherlands



A good Winter's day is quite good when considering a bad Summer's day



Conclusions

- **Smart meter data** is not yet available widely in NL, we use **other data sources**
- In the case of solar energy we use multiple approaches:
 - Register improvements using data on **tax refunds**
 - Analysis of **aerial data** for improving the solar panel register
 - Using **irradiance grid data** and **measured yields** from solar panels for building a model to determine detailed solar energy statistics
 - Building an experimental **macro model** from the high power grid and climate data to estimate the total domestic solar power generated in NL
- EU: please put **Bucharest memorandum** into work by releasing new **fundings** for **modernisation of statistics** based on new data sources, new skills and methodologies and new models
- NSIs: let's work **together** on innovation!



More info

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