VIPV shading model approach based on land use type

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Introduction

As the number of electric vehicles (EVs) increases, the dependency on charging from the electricity grid increases. To be less dependent on the charging infrastructure, there is an increasing interest in innovative technical solutions that enhance the driving range of EVs without the need for grid charging. Vehicle integrated PV (VIPV) is one of the solutions. To estimate the impact of VIPV on the reduction on grid demands, yield models are needed that accurately describe the effect of shadow on the PV yield.

Shading

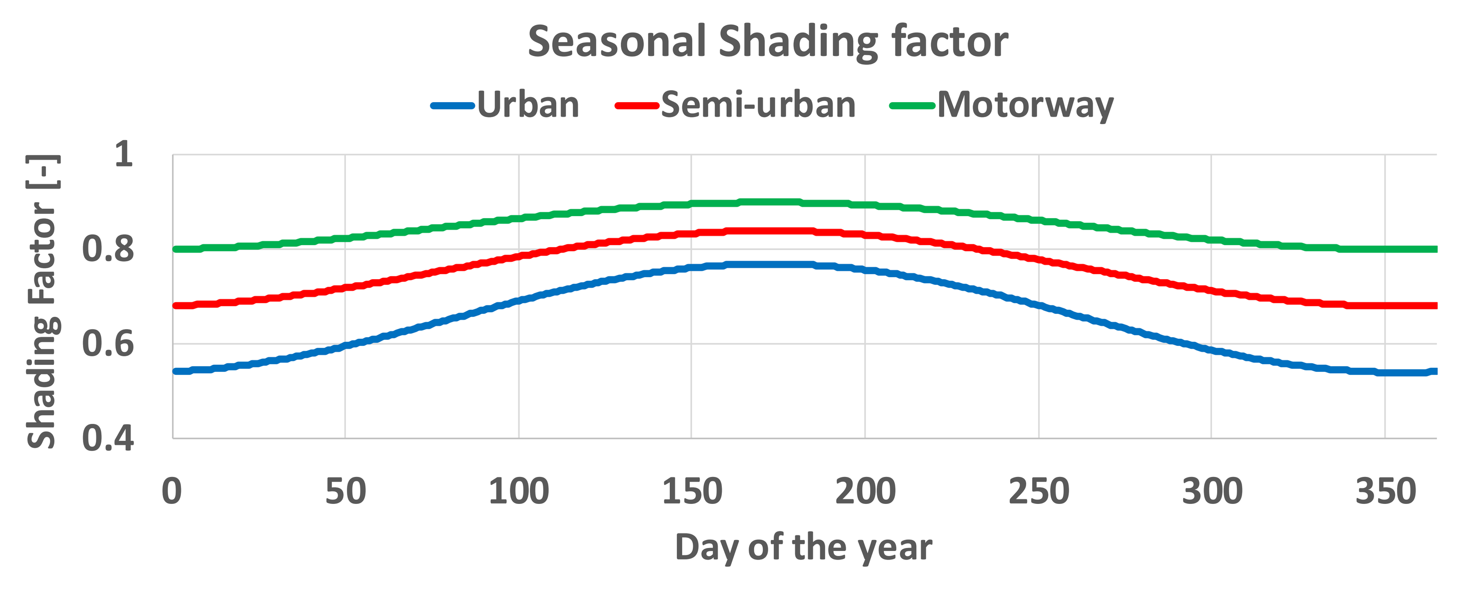
The first step in predicting the yield is to determine the irradiance on the vehicle using:

- Location
- Meteorological conditions
- Global Horizontal Irradiance (GHI)
- Shading on the vehicles.

Determine the shading on the vehicle is difficult due to:

- The dynamic behavior resulting from the movement of the vehicle and the varying vehicle's surroundings

Often a general shading model is used to calculate the effect of shading losses on the irradiance for different road types.



Model verification

Within the SolarMoves* project 27 vehicles with 37 sensors are driving around Europe

- They measure the irradiance on the vehicle which is then compared to satellite irradiance data along the route
- The ratio gives the shading factor

Analysis showed that many specific situations affect the measurement results:

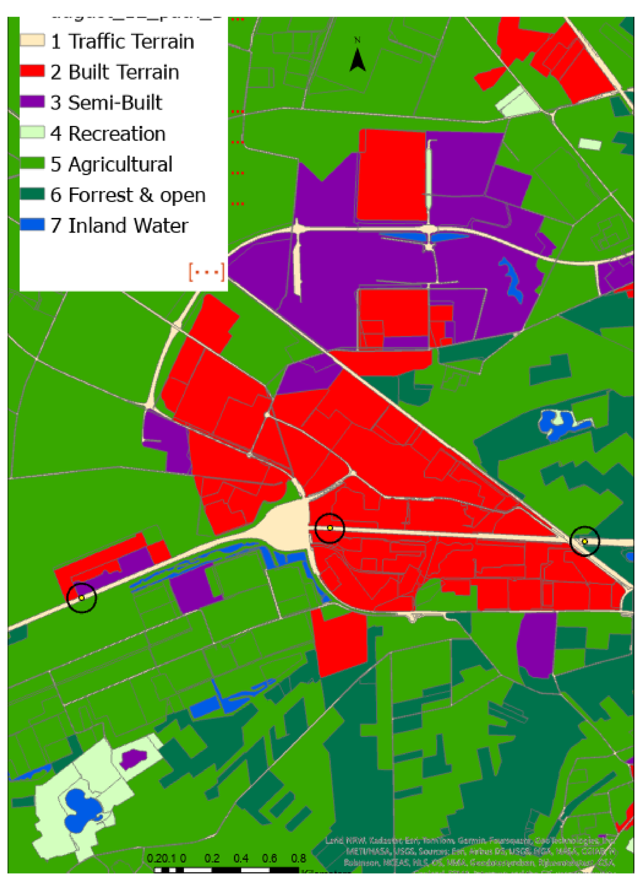
- Parking in the shade
- Time difference in cloud impact due to geographic difference between satellite data and exact measurement location
- Very different environments during the trips, impossible to assign a single road type

Below we show an improved model to derive more accurate road type specific shading factors based on the land use distribution along the trip.

* https://www.tno.nl/en/sustainable/energy-supply/solar-applications/solar-powered-cars/solar-potential-electric-vehicles/

Approach

- Divide the route into route points
- Overlay route points on land-use map Using ArcGIS
- Use a radius approximating the location uncertainty
- At each point determine the fractions of land type using the following 7 land types:
  - Traffic Terrain
  - Built
  - Semi-built
  - Recreation
  - Agricultural
  - Forest and open
  - Inland Waters



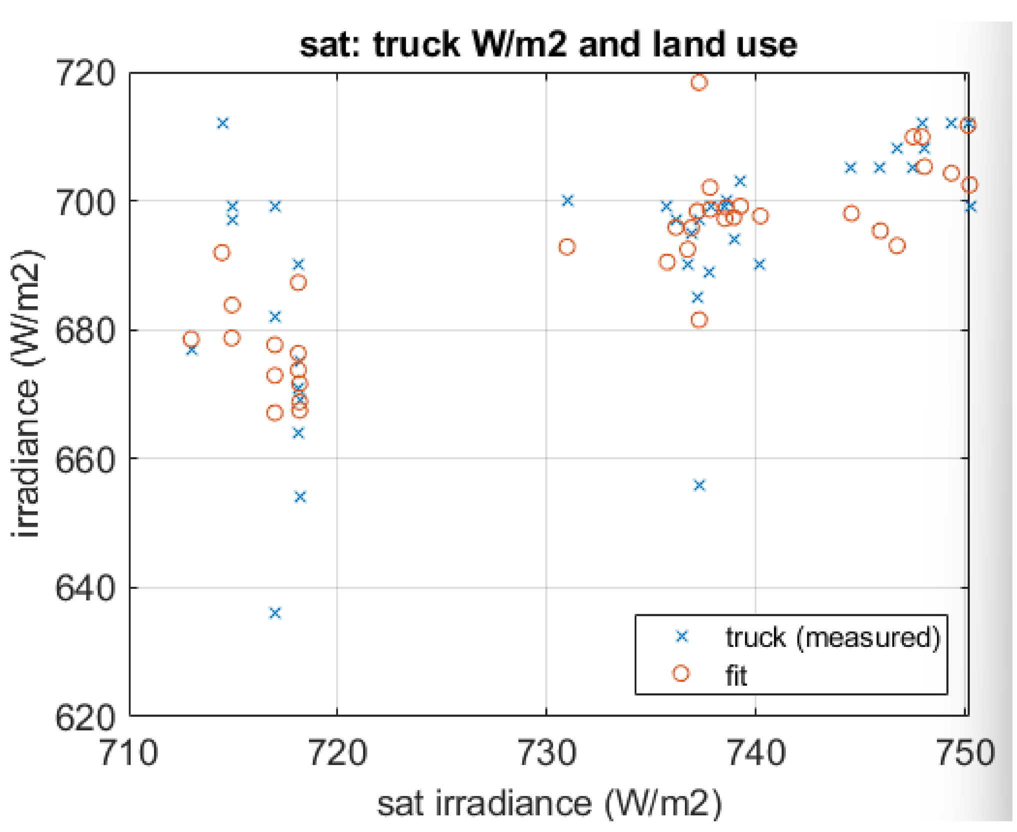
Fitting

Fit the following equation to the measured and satellite data to determine the shading factor per land type

$$Irr(truck)_j = Irr(Sat) * \sum_{i=1}^{7}(a(j,i) * sf(i)) \quad \textbf{Eq.1}$$

Irr(truck), measured truck irradiance
Irr(Sat), satellite irradiance data
a(j,i), fraction of land type i at route point j
sf(i), shading factor for the specific land type

Results



The resulting fit gives a correlation factor of 0.70

The following numbers for the shading factor are found:

Traffic Terrain	0.91
Built	0.94
Semi-built	0.97
Recreation	0.94
Agricultural	0.96
Forest and open	0.96
Inland Waters	1.02

Conclusions & Outlook

- A first attempt has been made to define the measured irradiance loss on a truck at several route points and correlate that to the shading factor of 7 different land use types
- A linear model fit resulted in a correlation factor of 0.7 and a nonphysical shading factor for Inland waters of 1.02
- This data set was limited and might contain route points which deviate from the typical land types due to overpasses or tunnels
- A more detailed data analysis will be performed on a more extensive dataset to improve the parameter fit

Acknowledgements

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