LPVO Laboratory of Photovoltaics and Optoelectronics

solartrain
PV MODULE LIFE TIME FORECAST AND EVALUATION

Energy forecast tracking and modelling of electromobility: Solar-Powered eBikes

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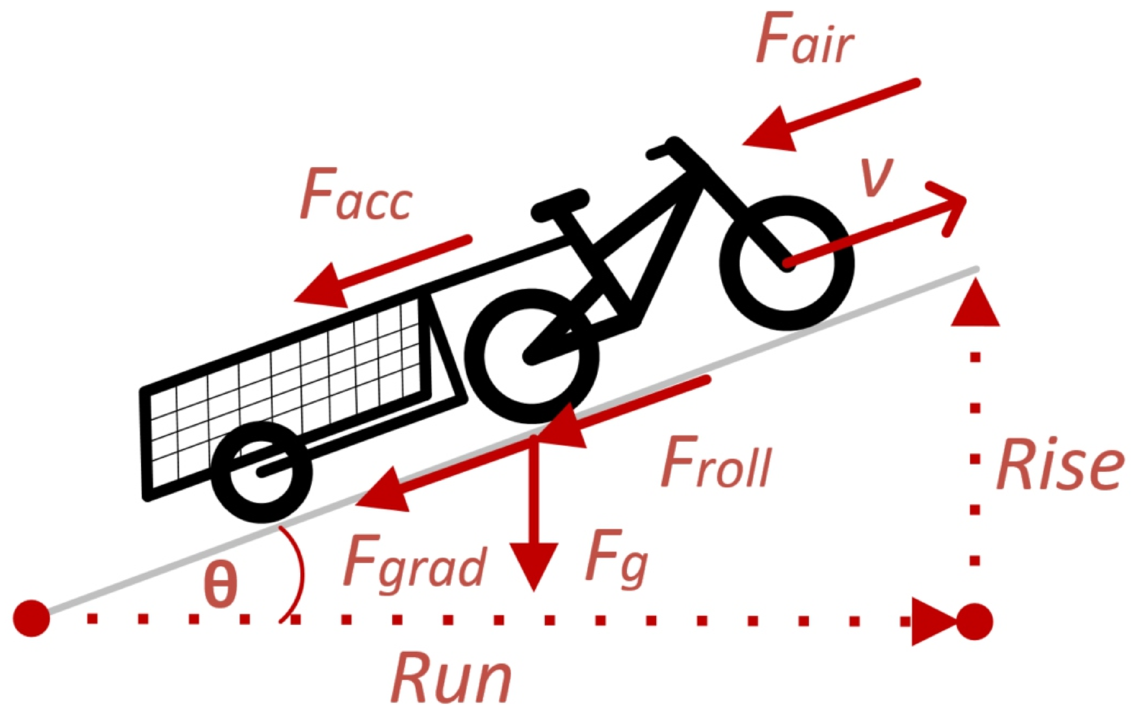
Introduction

New ways of transportation are being studied to support the energy transition worldwide. The electromobility is being introduced in public and private transportation, but still the need for electricity to charge the batteries of such a vehicles is remaining. One viable option in some cases is the installation or integration of solar photovoltaic cells onto the roof or exposed surfaces. In this paper, we present preliminary results of the weather and energy forecast tracking and further modelling of electromobility. As case study, the data recorded by a cyclist during the Marathon Franja Ljubljana 2019 is processed and then several hypothetical cases of electromobility and integration of solar PV panels are compared.

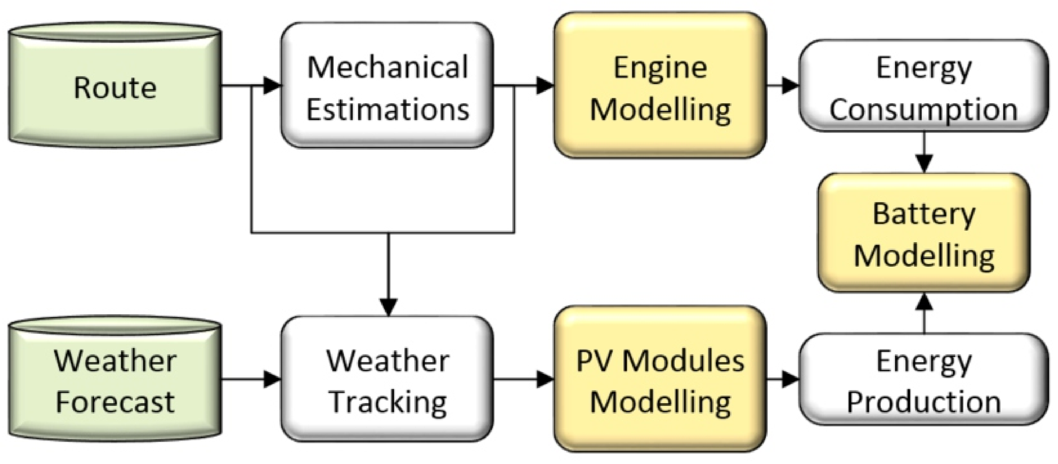


Basic forces involving a moving object (representation of a solar e-bike, befree-solarbikes.com)

Tracking and modelling: Solar-Powered eBike

Methodology

The climate data, such as irradiance, temperature, wind speed and direction, etc. can be extracted from climate reanalysis models. Routes in specific timeframe including geographical coordinates, elevation and estimated EV speed can be obtained from Google Maps, Strava or any similar service.

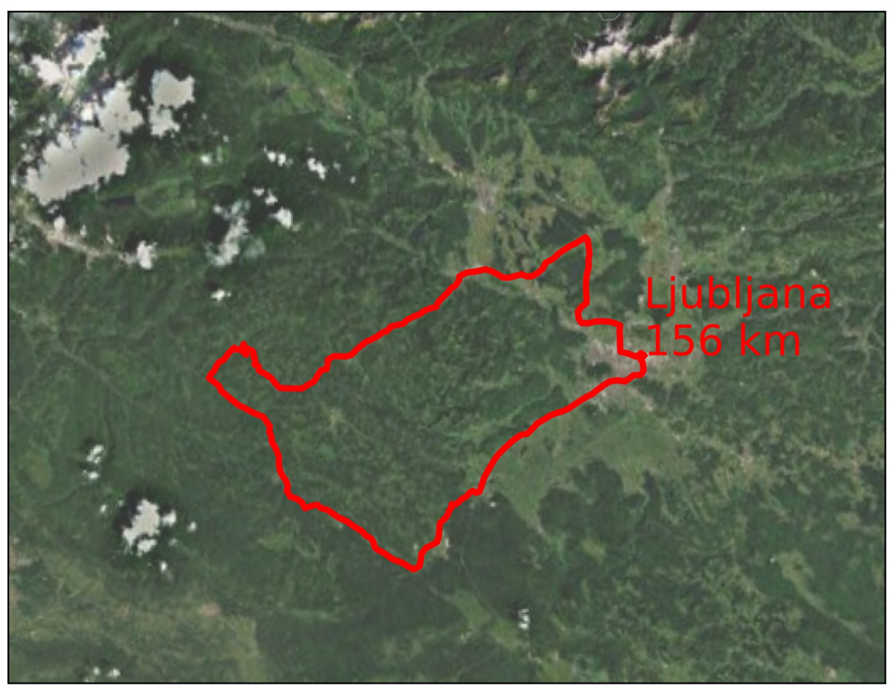


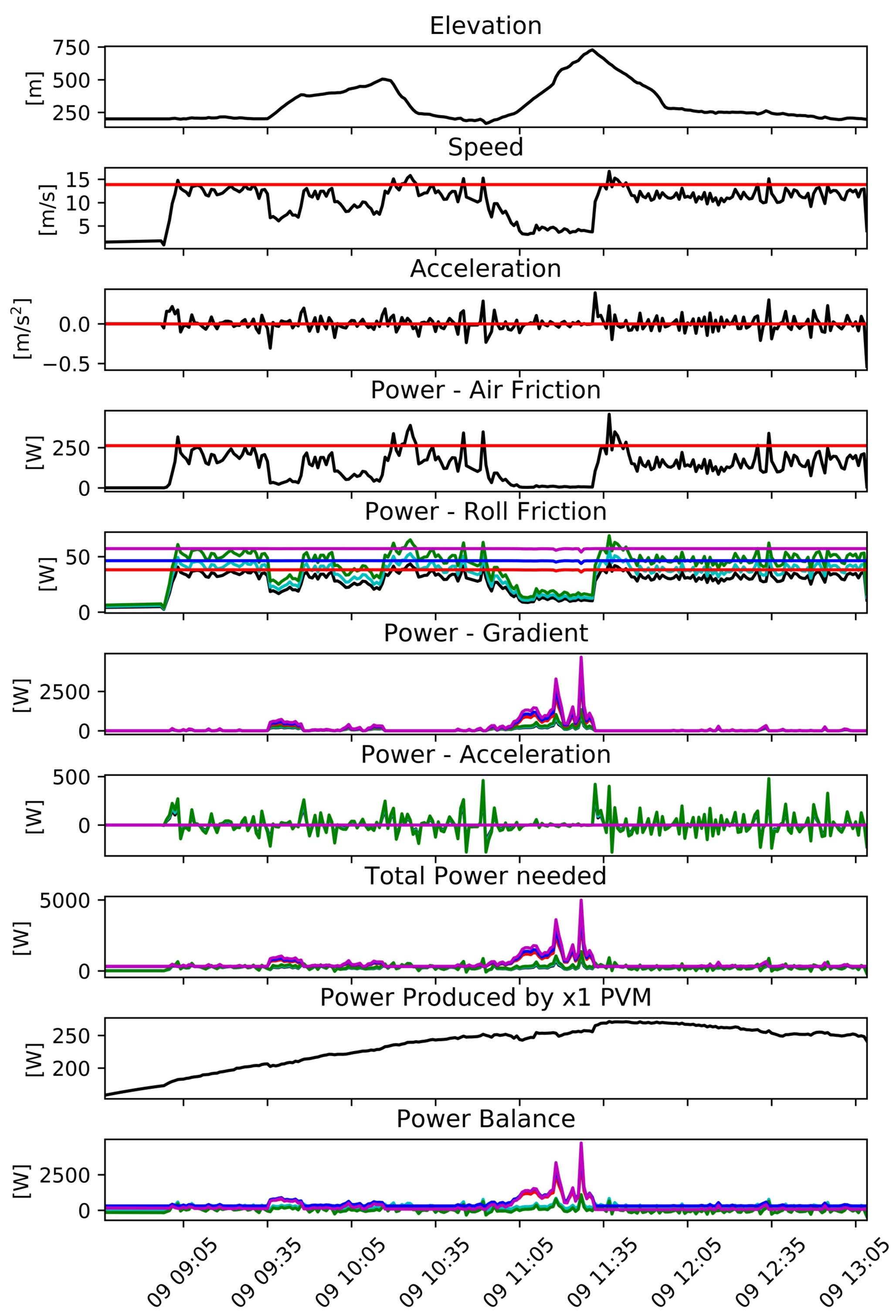
$$P_{air} = v \cdot 0.5 \cdot \rho_{air} \cdot A_{EV} \cdot c_w \cdot v^2$$
$$P_{roll} = v \cdot c_r \cdot g \cdot m_{EV} \cdot \cos(\theta)$$
$$P_{grad} = v \cdot g \cdot m_{EV} \cdot \sin(\theta)$$
$$P_{acc} = v \cdot f_m \cdot m_{EV} \cdot \alpha$$
$$P_{total} = P_{air} + P_{roll} + P_{grad} + P_{acc}$$

Variable	Name	Unit
ρ_{air}	Air density	Kg/m^3
A_{EV}	EV frontal area	m^2
c_w	Drag coefficient of EV	-
v	Effective Speed – EV/Wind	m/s
c_r	Roll resistance tires/surface	-
g	Acceleration of gravity	m/s^2
m_{EV}	Total mass of the EV	Kg
θ	Angle of the road	rad
δ	Direction of the EV	rad
α	Acceleration of EV	m/s^2
f_m	EV mass factor	-
P_{air}	Power due to Air friction	W
P_{roll}	Power due to Roll friction	W
P_{grad}	Power due to Gradient	W
P_{acc}	Power due to Acceleration	W
P_{total}	Total Power	W

Flowchart and equations for simple modelling of a solar-powered EV, climate tracking and energy balance.

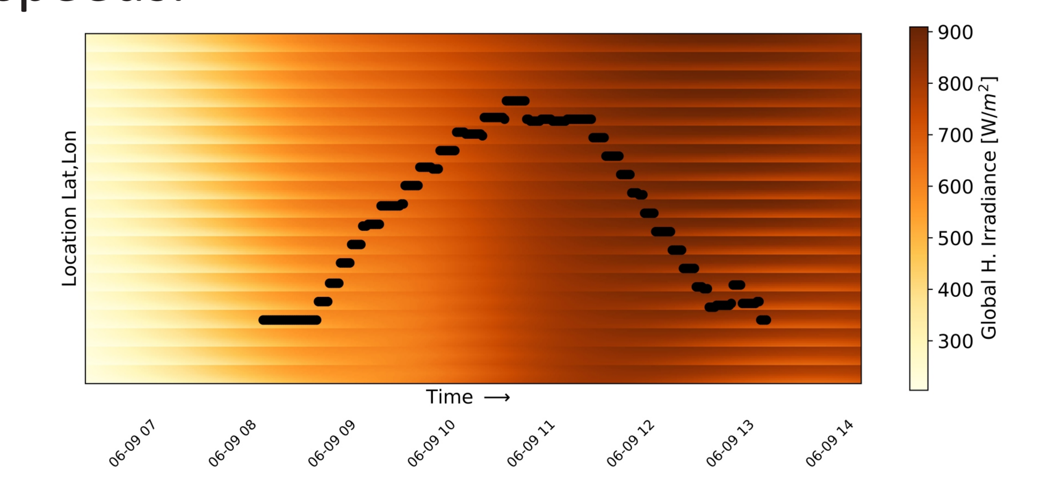
Case Study: Marathon Franja Ljubljana



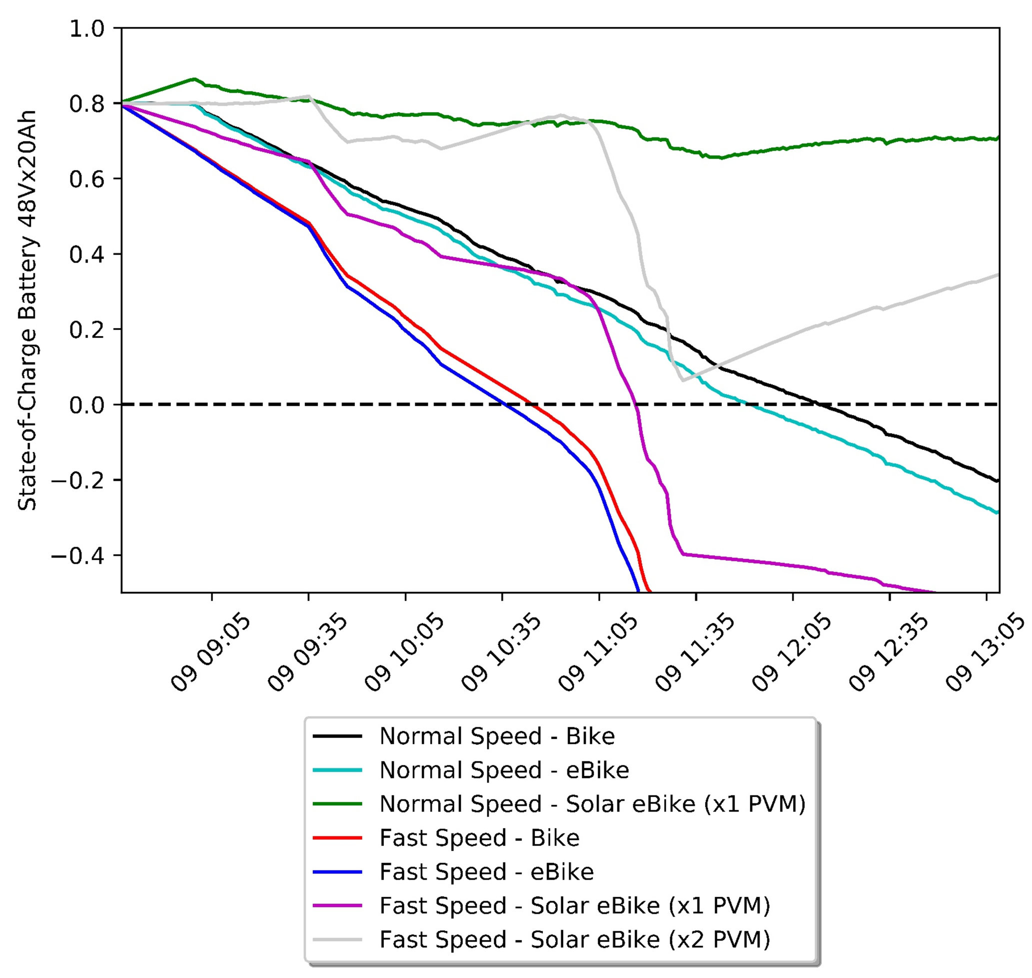


Simulation of energy needed for different cases (bike, ebike and solar ebike) considering the route of Marathon Franja Ljubljana.

The Marathon Franja Ljubljana covers a bike route of 156km. Power and temperature were measured during the race of approximately 5 hours. Hereby, we model and compare the real case to different case scenarios at different speeds.



Representation of the available climate data (example for *GHI*) in terms of geographical location and time. Each dot considers a latitude, longitude, timestamp and climate value.



State of Charge of a 48Vx20Ah battery for normal and fast speed, normal bike or ebike, with mounted PV panels.

Conclusion

- Climate variables were extracted and modelled using the ERA5-Land reanalysis dataset.
- The consumption of an EV was modelled considering a desired path. In this case study we evaluate the performance of bikes during the Marathon Franja Ljubljana - 156km.
- Further studies will cover the validation of mechanical modelling and the moving module operating temperature and energy production.

Acknowledgment

The authors would like to thank Marko and Matevž Bokalič for providing the bike measurements, and the ECMWF for providing the climate datasets.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement N° 721452 and research programme P2-0197 funded by Slovenian Research Agency.

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