



Blade erosion in wind farm layout and/or control optimization

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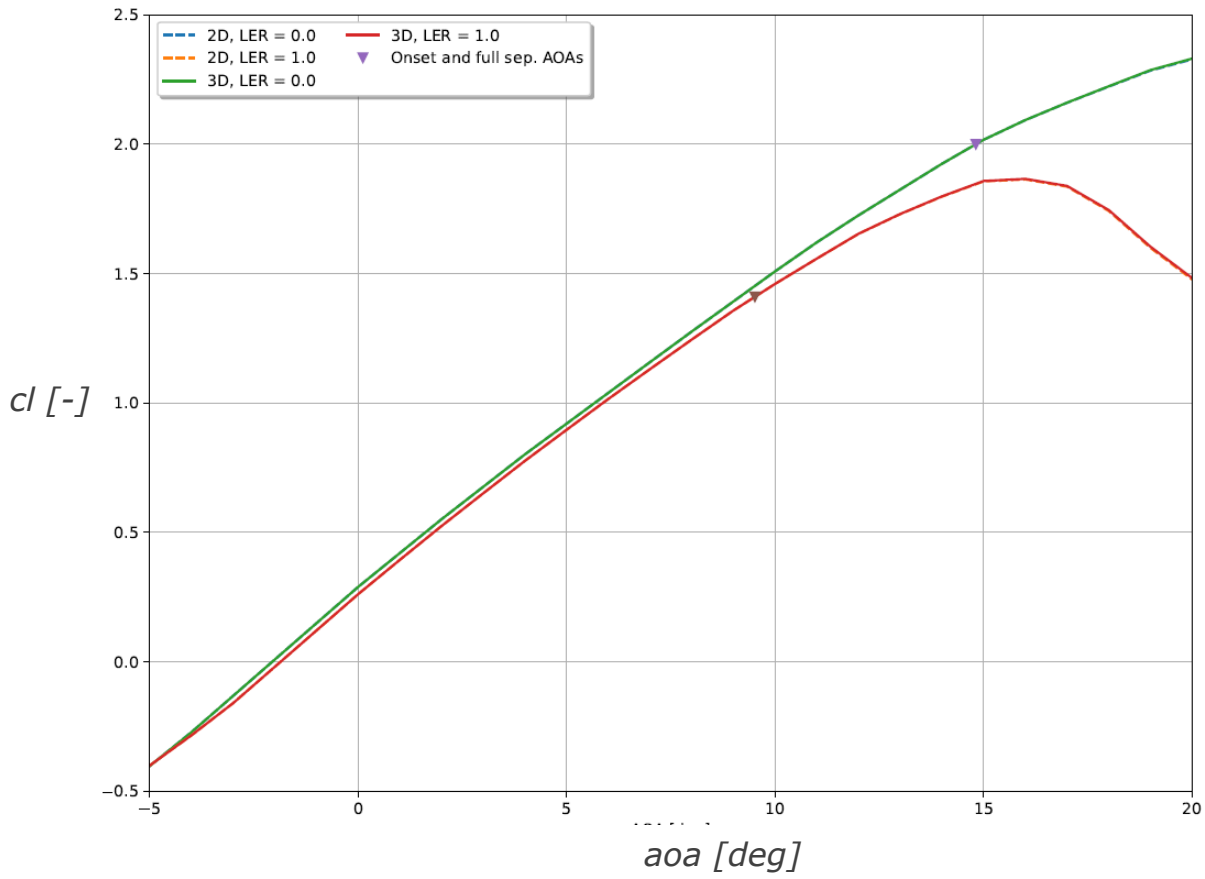
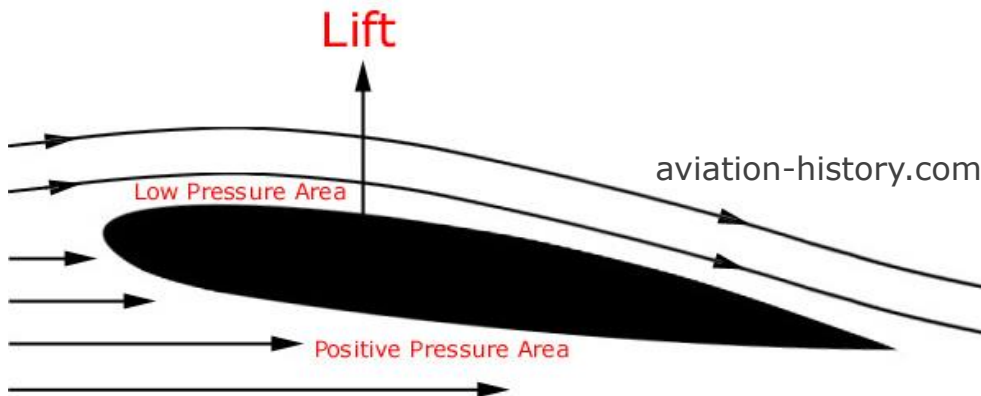
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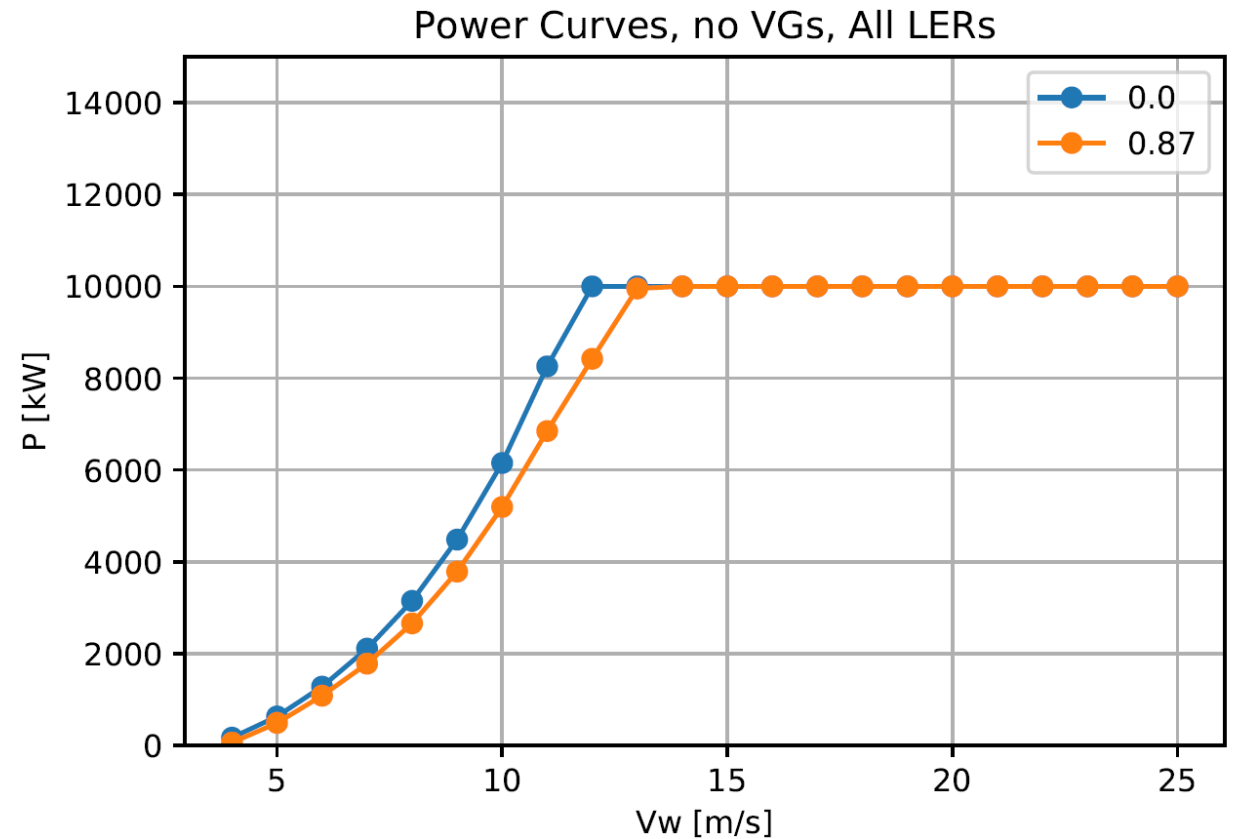
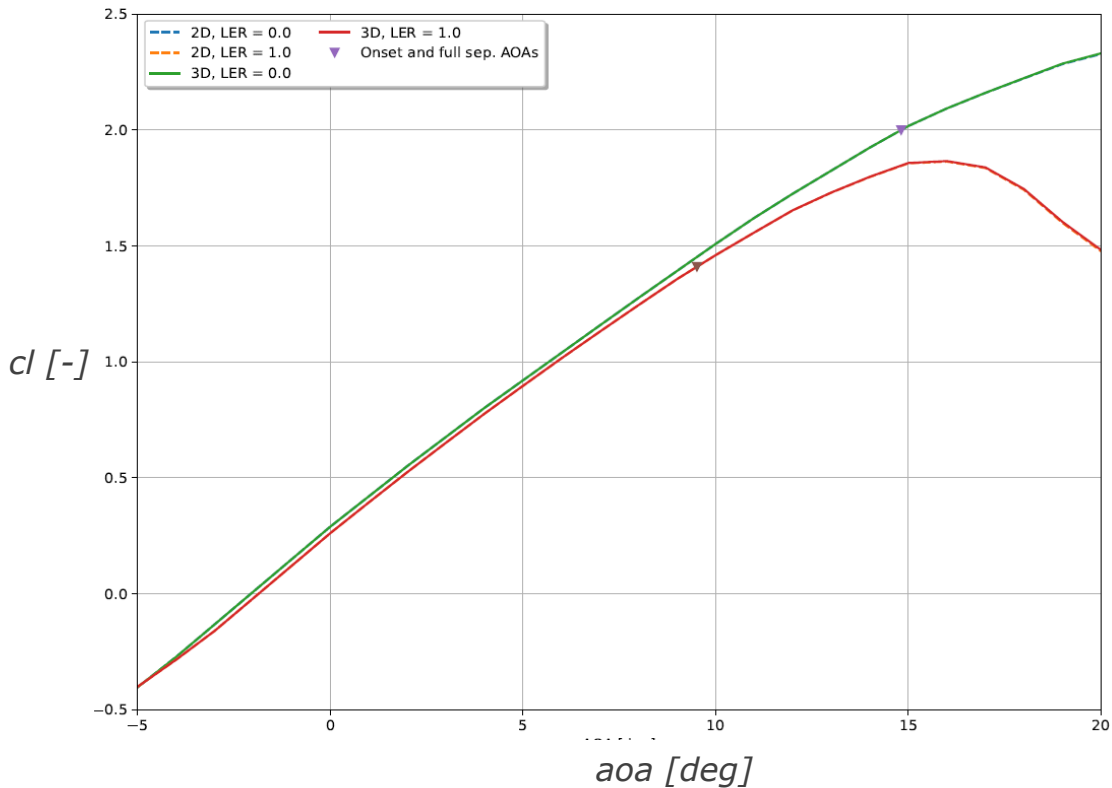
Javier Ozores Arconada, Pierre-Elouan Réthoré,
Charlotte Bay Hasager, Jakob Ilsted Bech
Mikkel Friis-Møller, Mads Mølgaard Pedersen,
David Robert Verelst and Witold Skrzypiński (wisk@dtu.dk):

Blade erosion in wind farm layout and/or control optimization

What is erosion and why does it matter?



What is erosion and **why** does it matter?



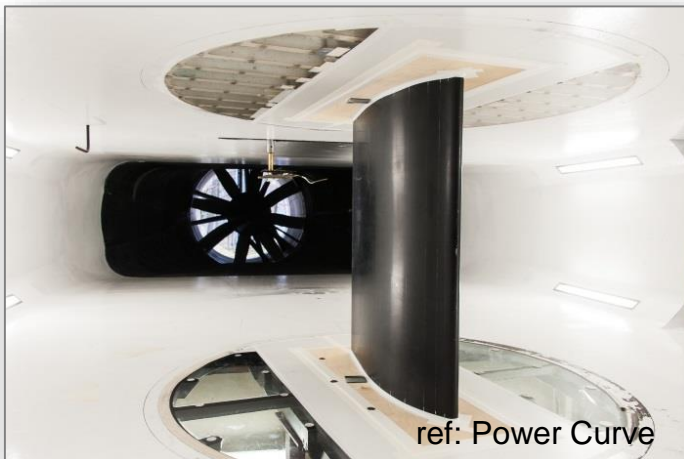
2-5% loss in the AEP

Introduction to the Erosion project

- Enable longer lifetime of wind turbine blades
- Accelerated tests in a rain erosion tester
- Wind tunnel tests
- Precipitation measurement by ground-based devices
- Radar precipitation forecasting
- Historical weather data
- *Engineering modelling of erosion on turbines + ESM
- Full-scale experimental validation

www.rain-erosion.dk

*Bech et al. doi.org/10.5194/wes-3-729-2018

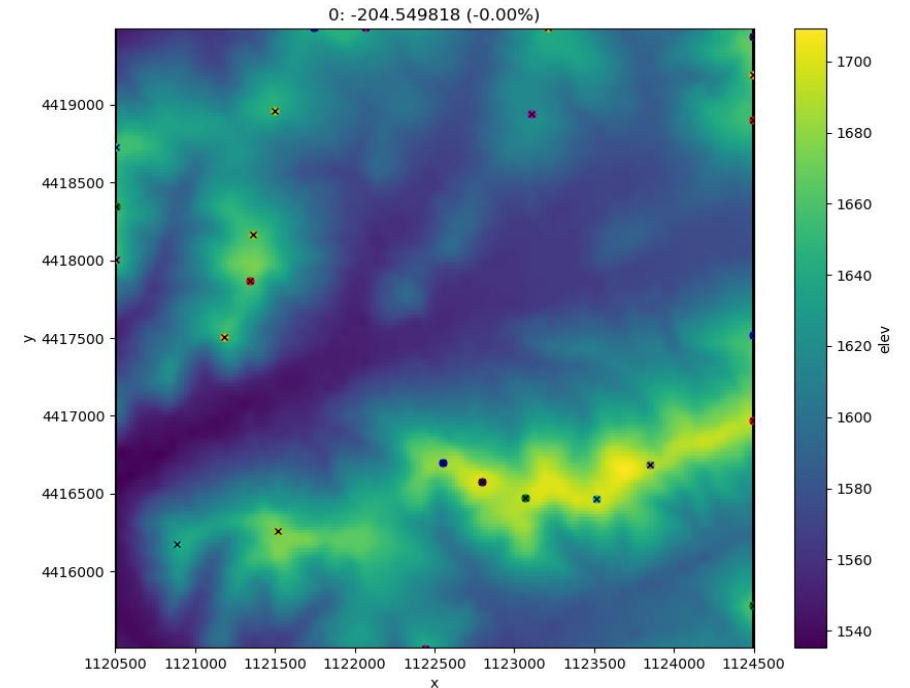
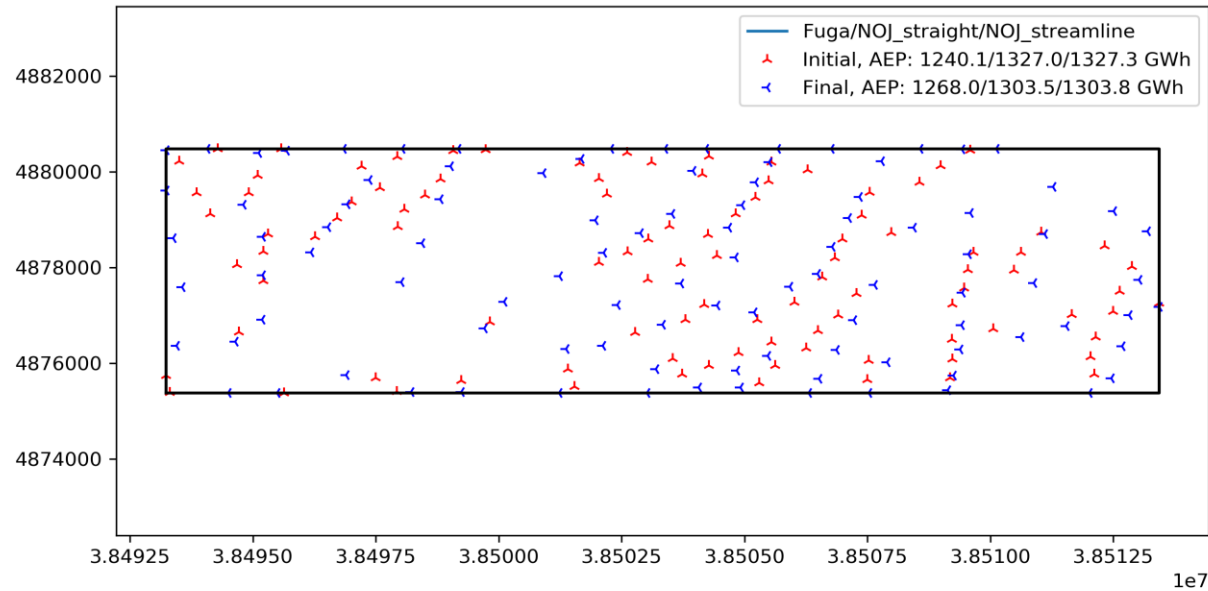
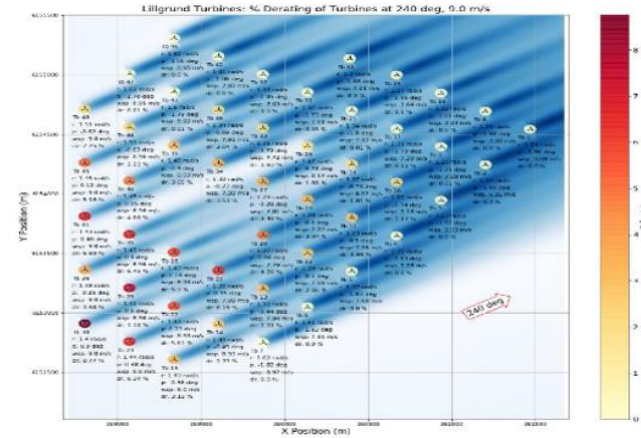


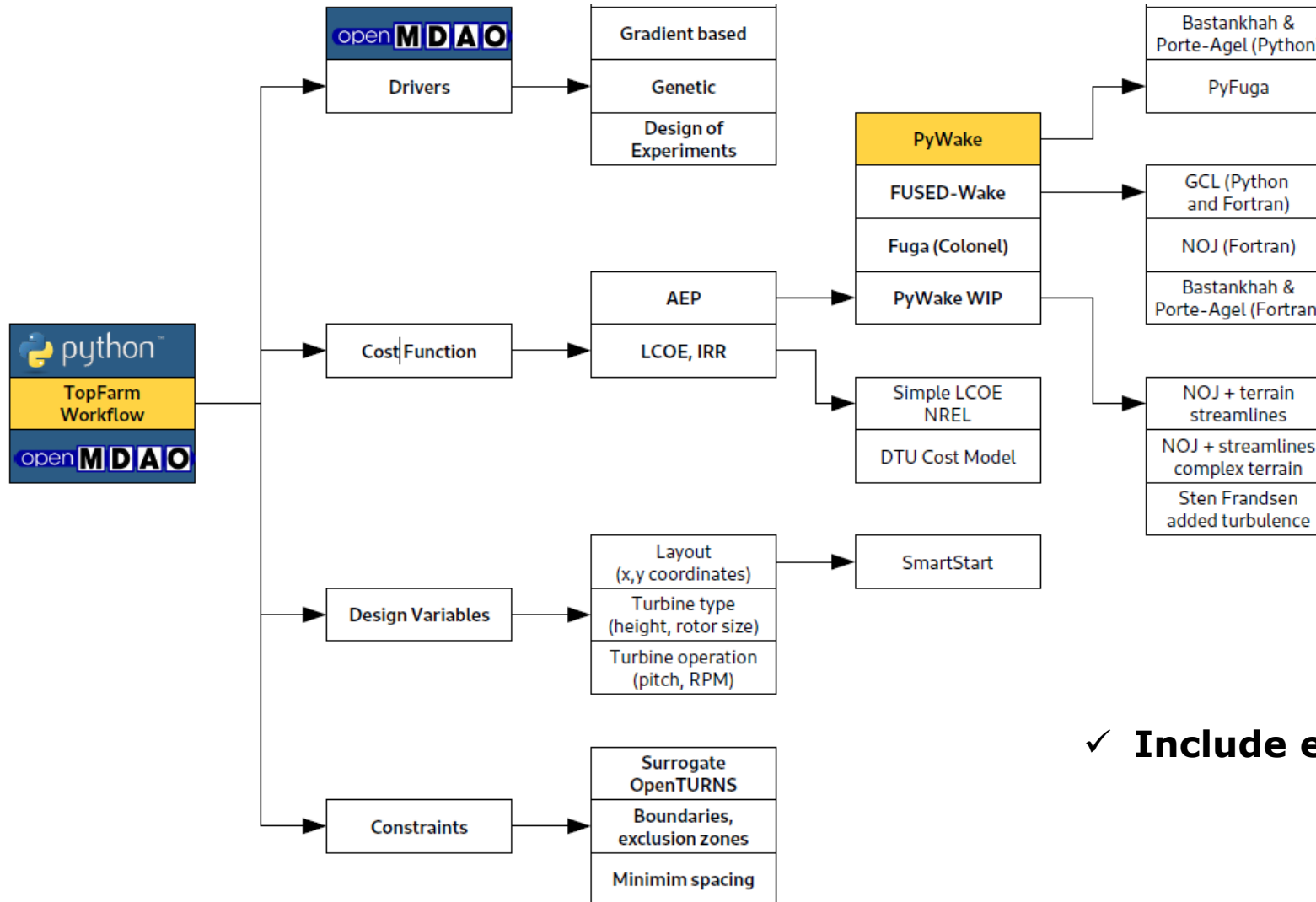
ref: OTT Parsivel²



TopFarm Framework

- Wind farm optimization framework:
 - Farm layout
 - turbine type, e.g. rotor size, hub height
 - operational parameters, e.g. RPM, pitch
- Open Source MIT license w/ propriety plugins

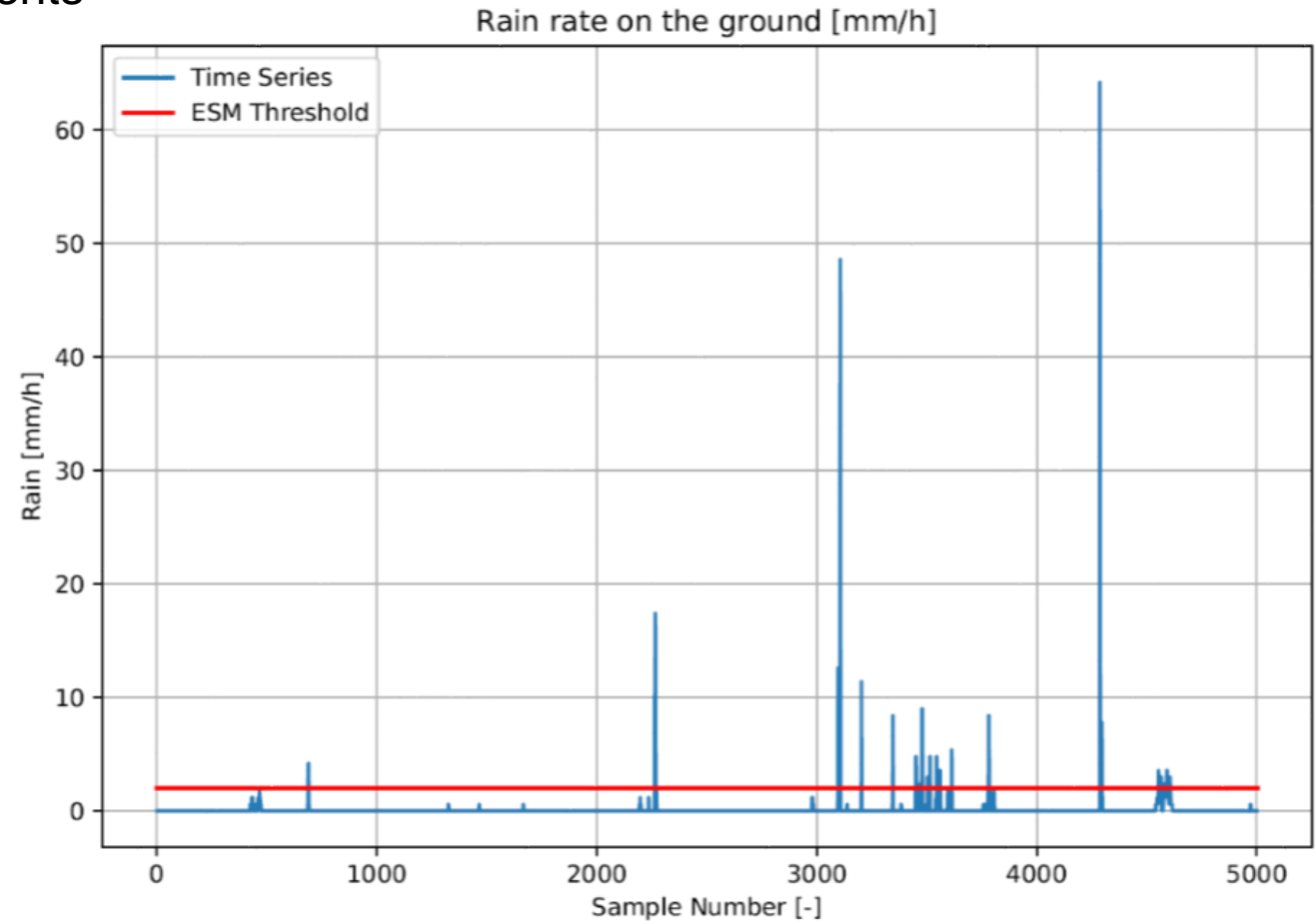




✓ **Include erosion features in TopFarm**

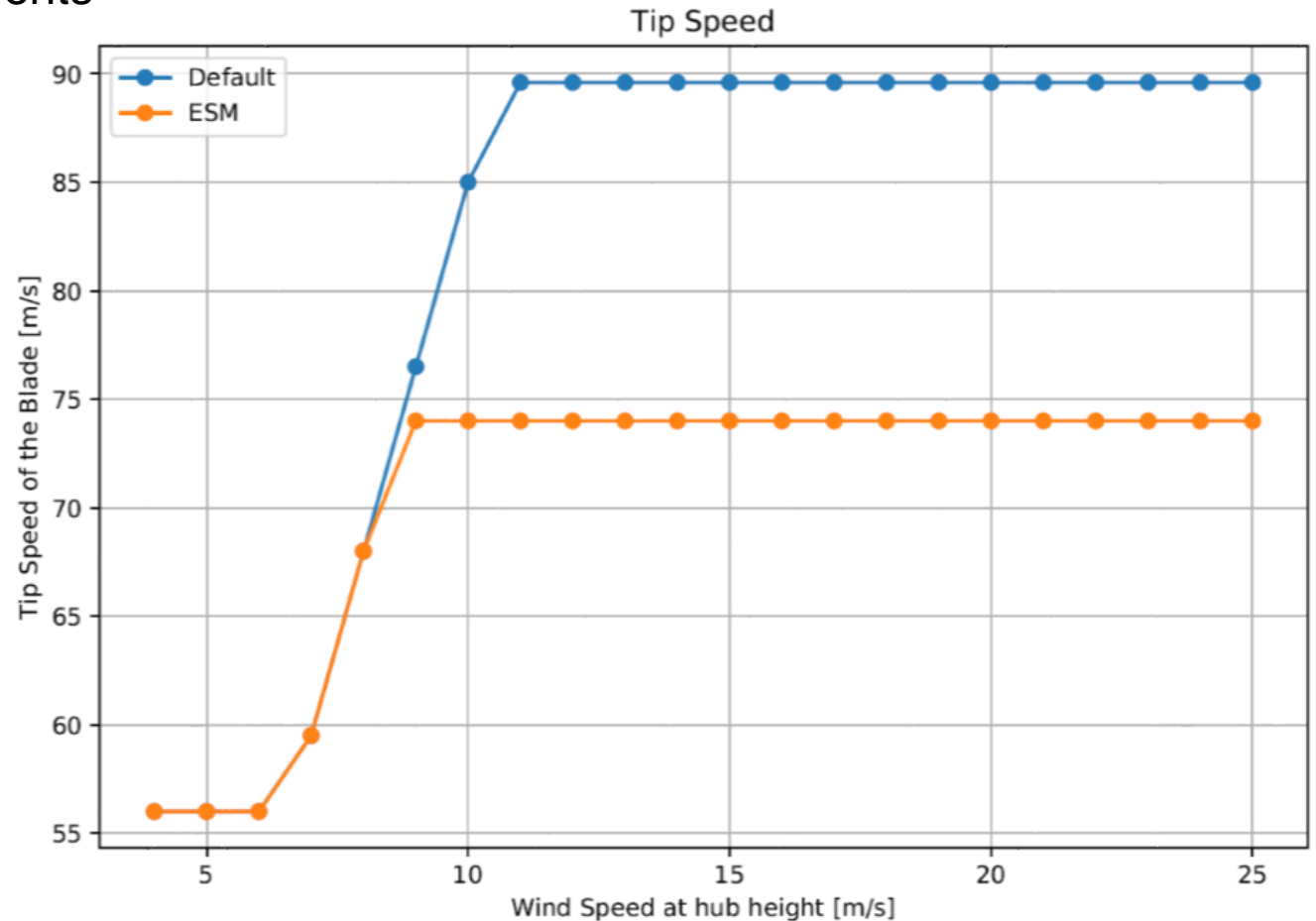
What is Erosion-Safe Mode (ESM)?

- Decrease tip speed during (rare and heavy) precipitation events
- Loose some energy production during those events
- Improve blade surface condition
- Save on repairs and maintenance
- Increase energy production overall
- Most of the loss may be mitigated



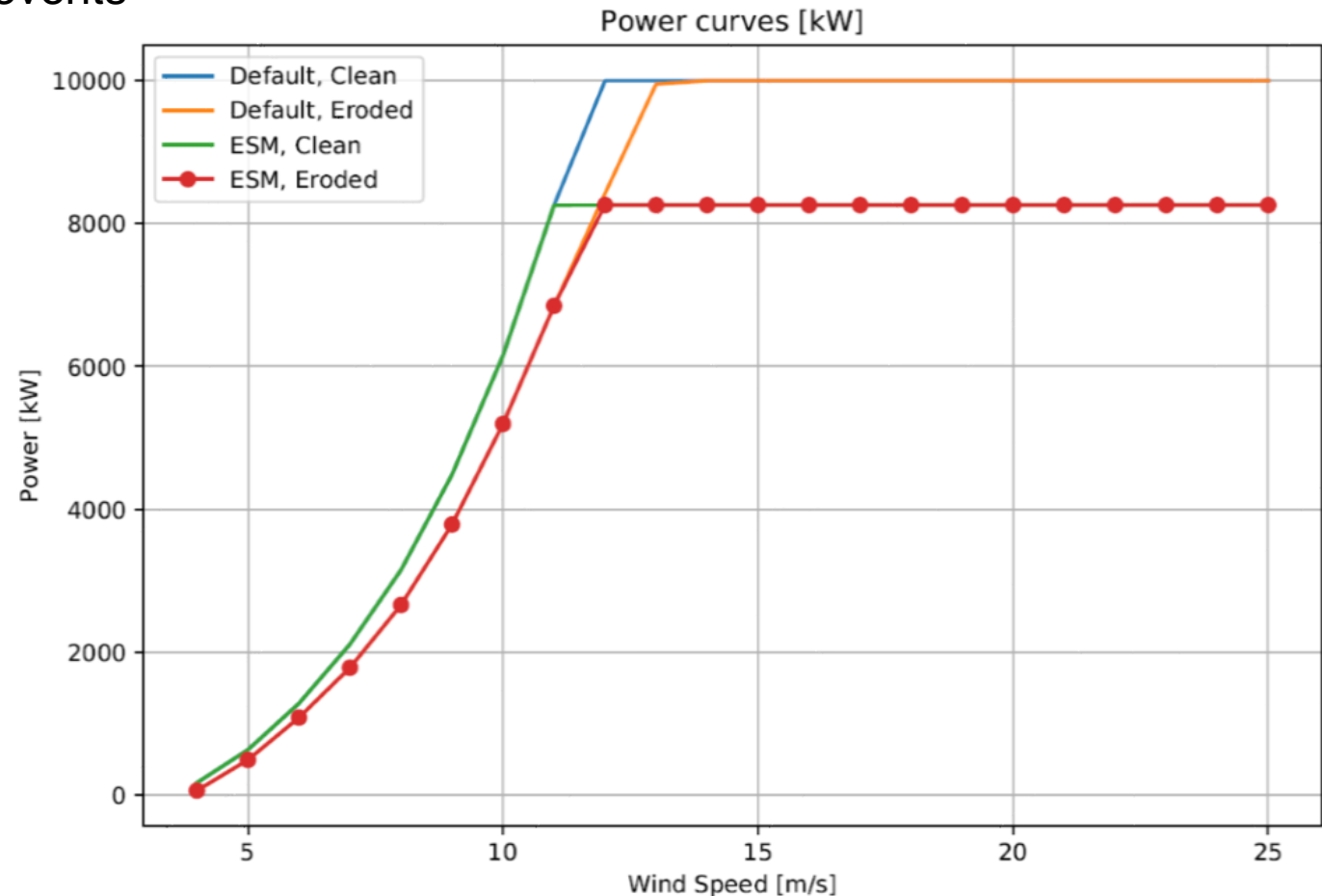
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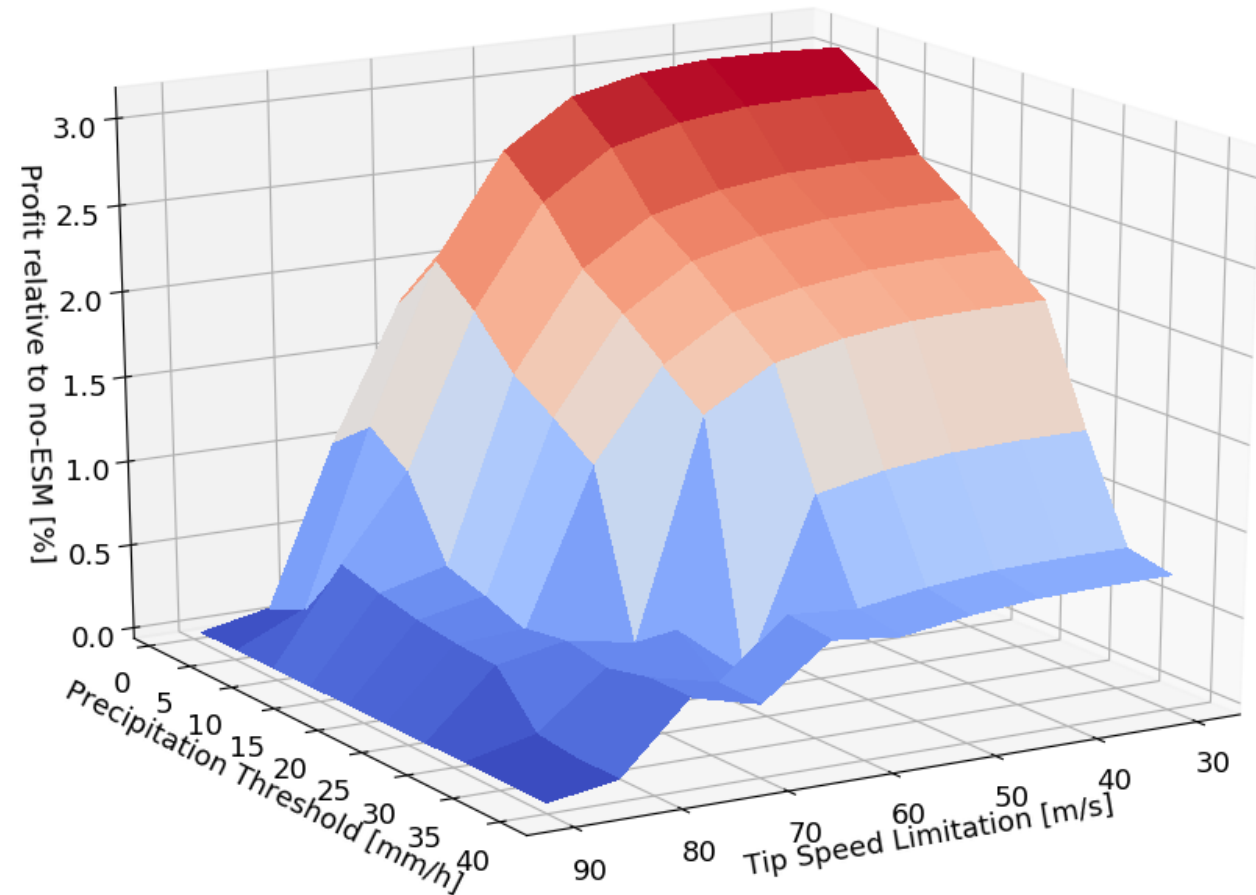
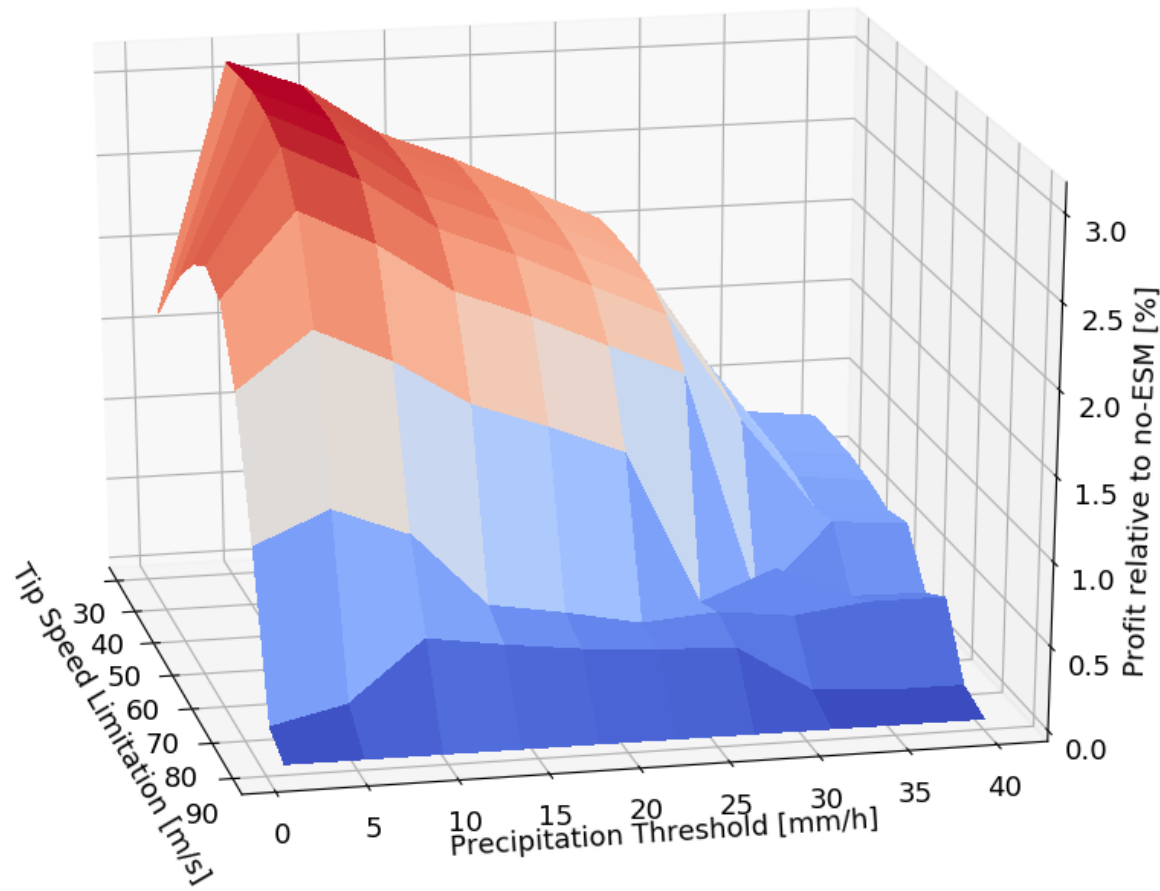


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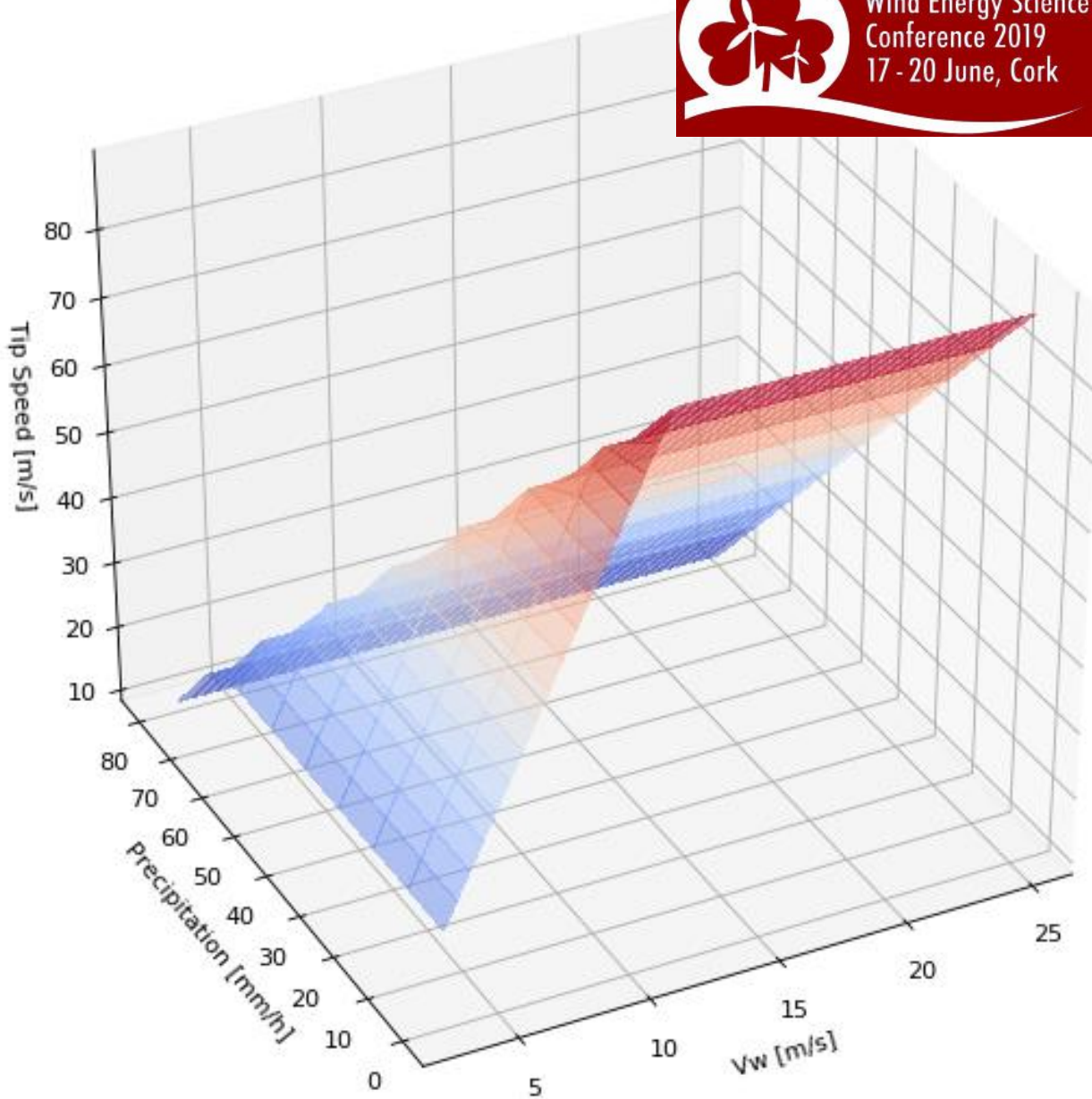
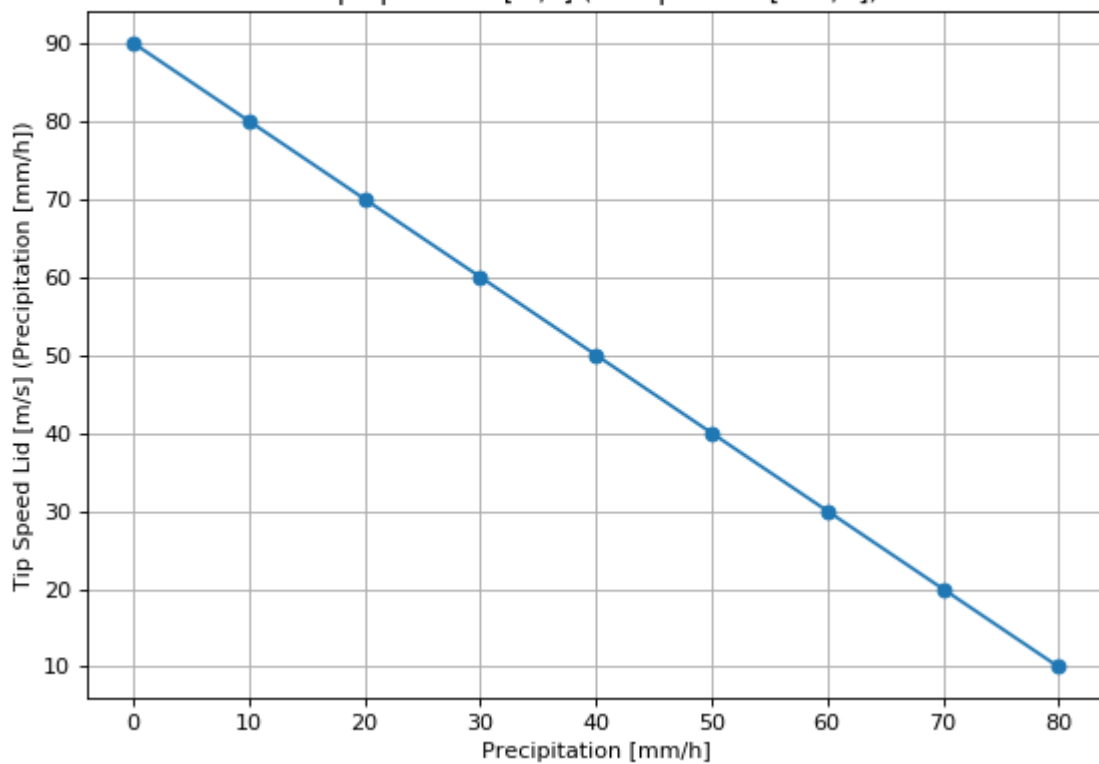


Constant *tip speed lid* and *precipitation threshold*

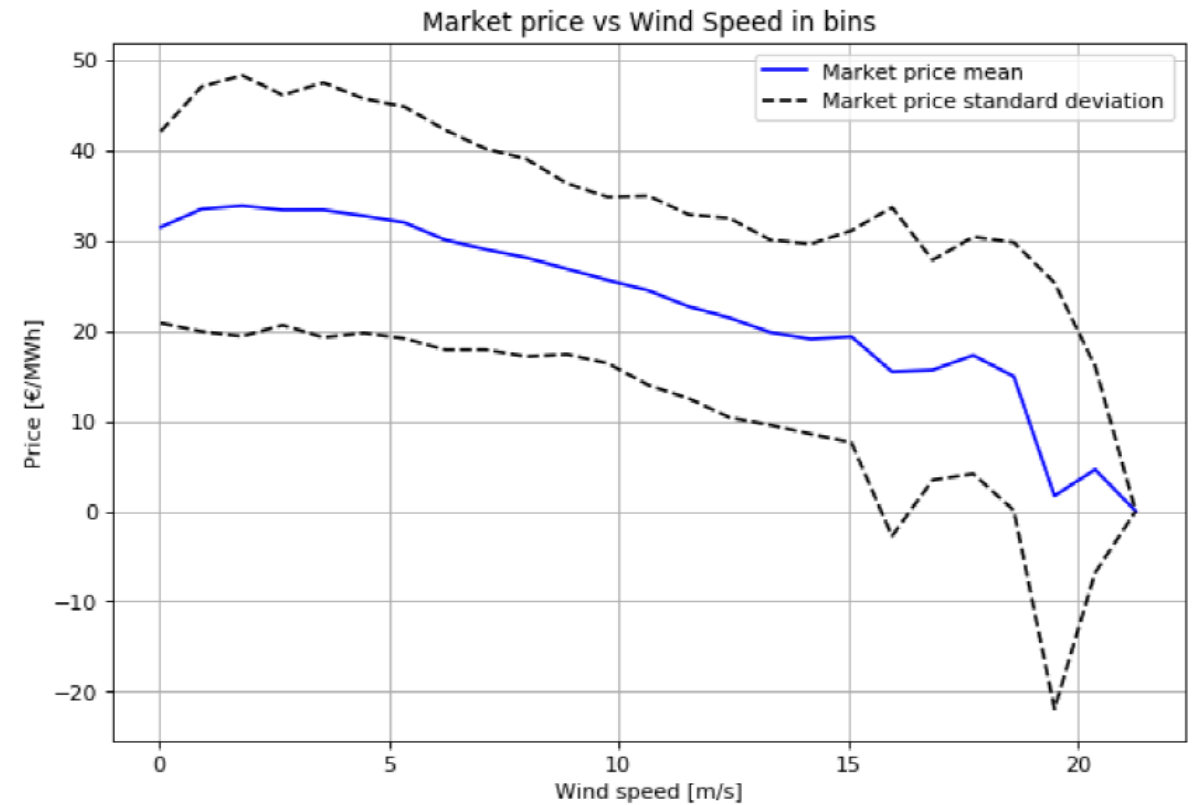
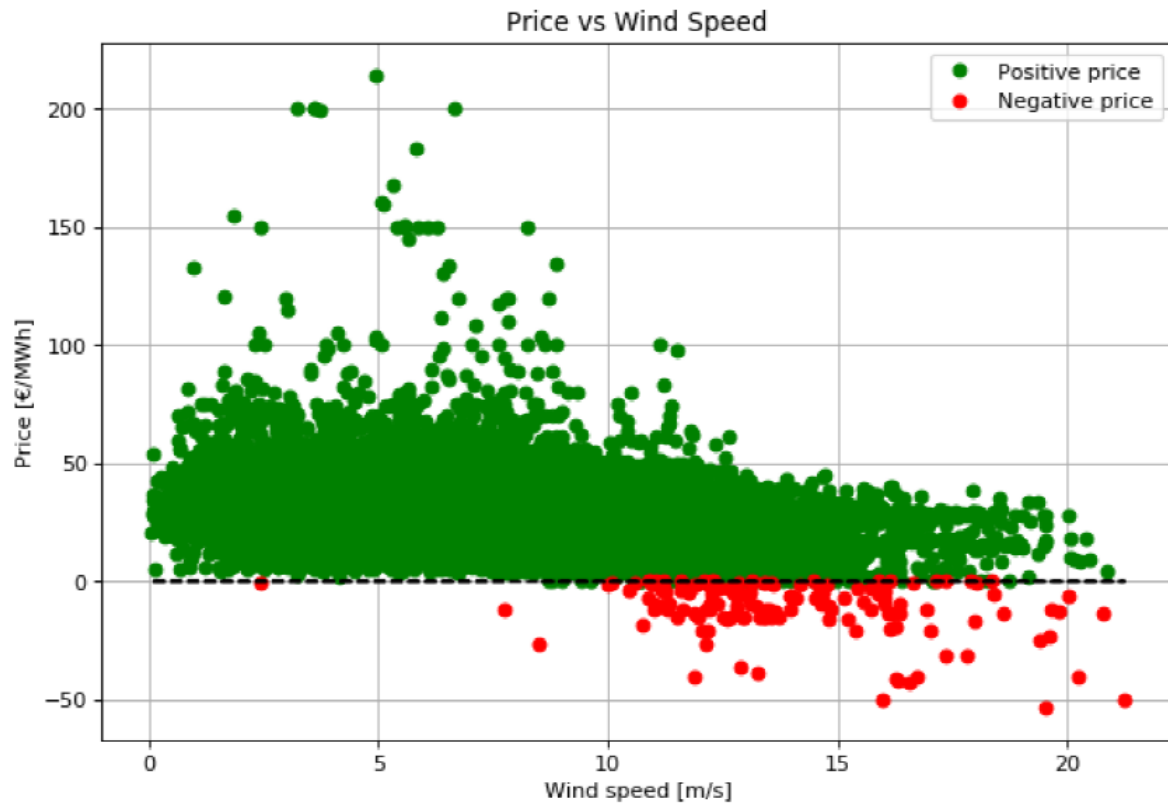


Tip speed lid(precipitation)

Tip Speed Lid [m/s] (Precipitation [mm/h])



Variable price of electricity



Erosion in TopFarm



Exploratory study:

- *Horns Rev 1 layout*
- *3 years of wind speed and precipitation TS*
- *28 €/MWh*
- *Penalty for repairs*
- *80 Vestas V80 turbines*
- *Assumed 90 m/s tip speed*
- *ESM parameters:*
 - *Same for each turbine*
 - *Constant lid (40 m/s)*
 - *Constant threshold (10 mm/h)*

-
- Individual increase in AEP: **1.6% - 1.7%**
 - Individual increase in profit: **2.9% - 3.0%**

Thank you