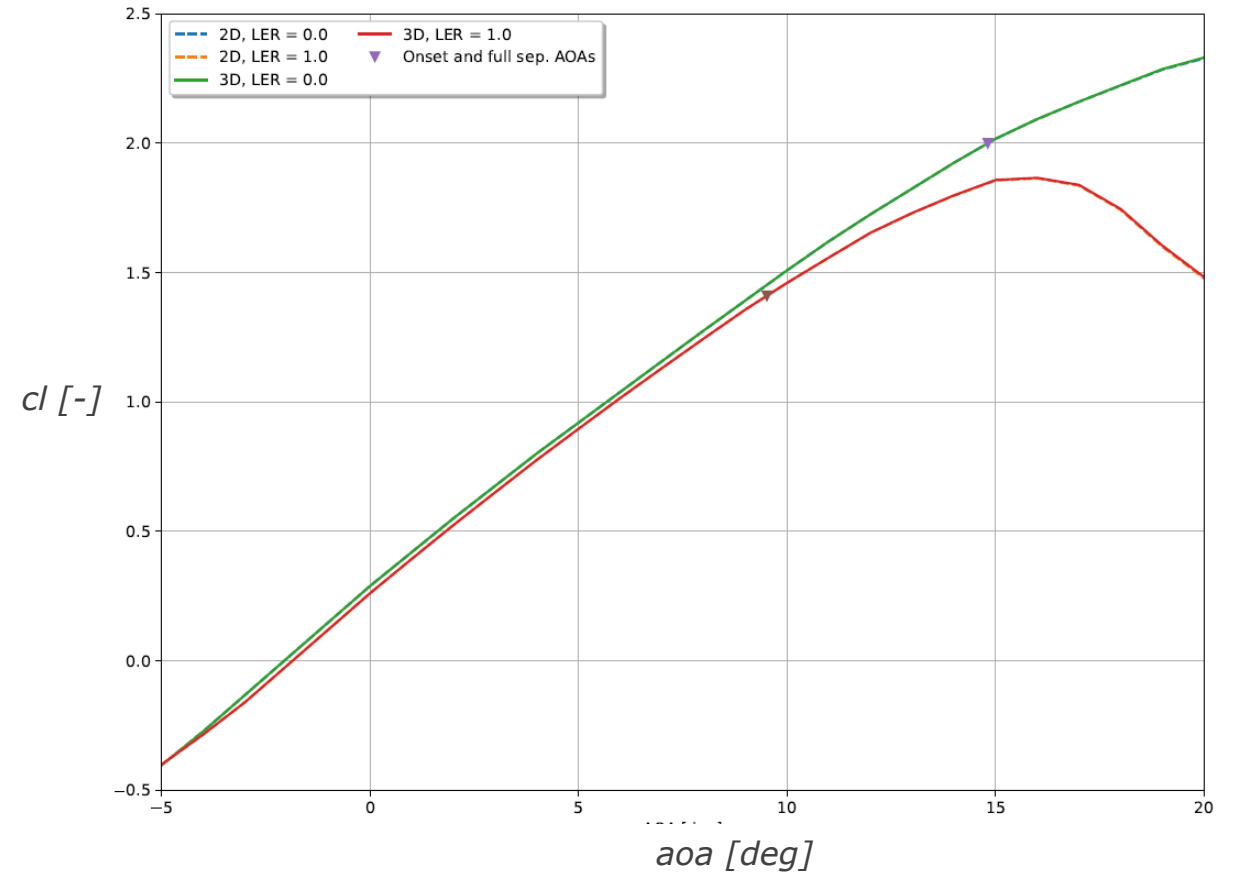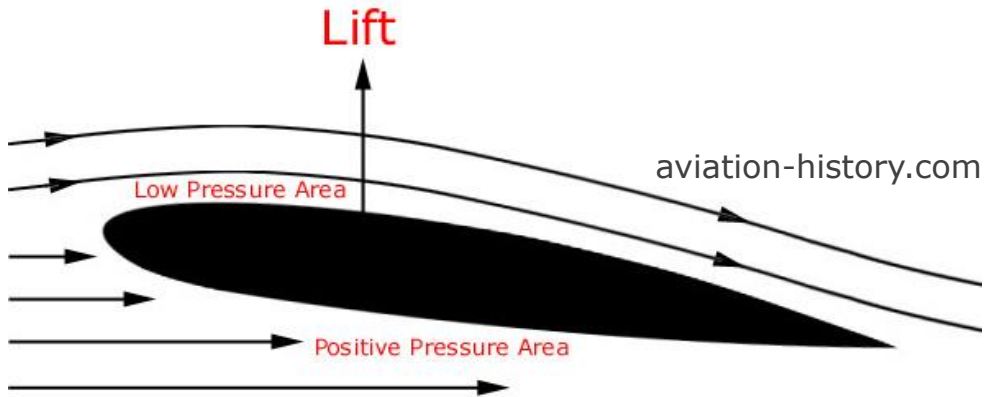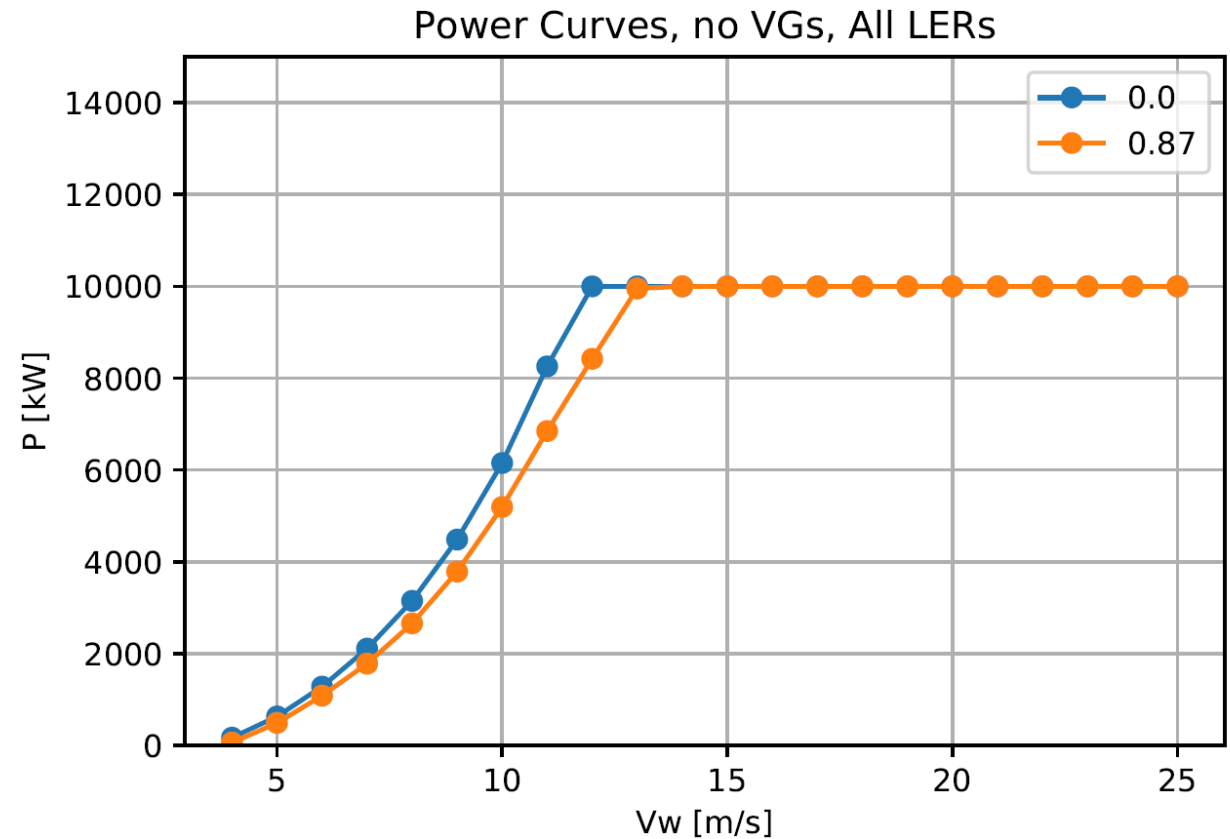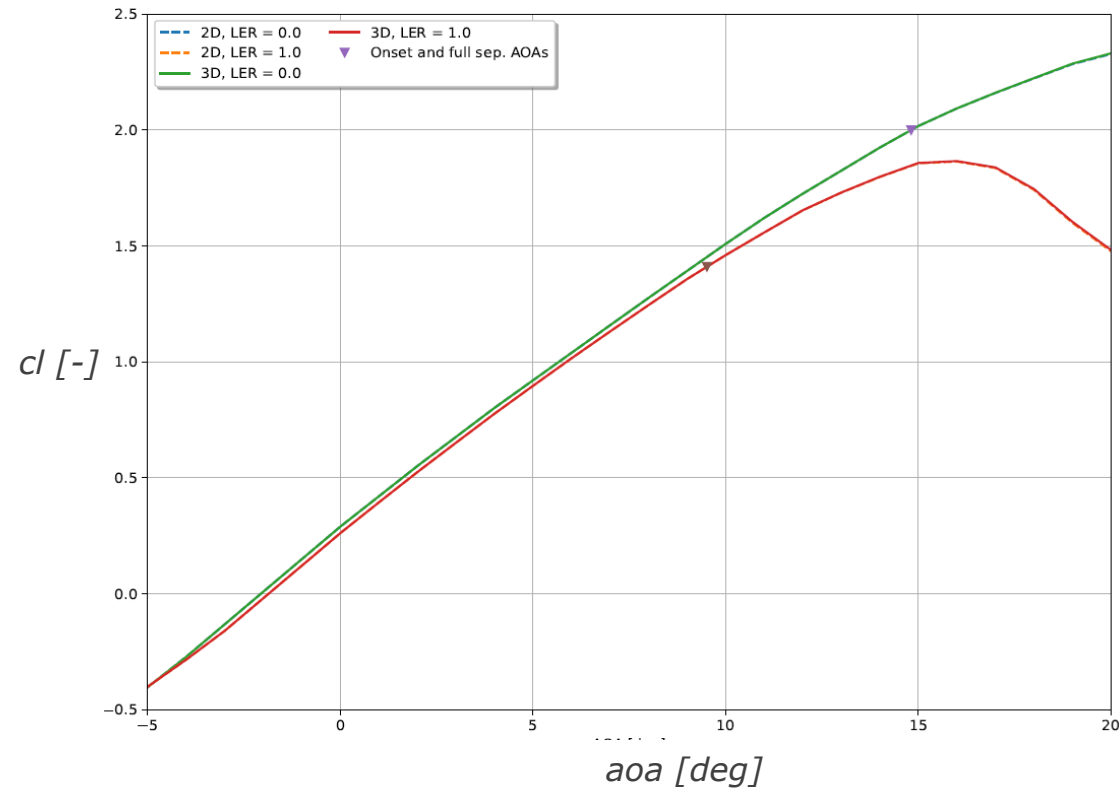Javier Ozores Arconada, Pierre-Elouan Réthoré,
Charlotte Bay Hasager, Jakob Ilsted Bech
Mikkel Friis-Møller, Mads Mølgaard Pedersen,
David Robert Verelst and Witold Skrzypiński (wisk@dtu.dk):

Blade erosion in wind farm layout and/or control optimization

What is <u>erosion</u> and **why** does it matter?

aviation-history.com

ref: armour EDGE

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

cl [-]

aoa [deg]

Power Curves, no VGs, All LERs

P [kW]

Vw [m/s]

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: Power Curve

ref: OTT Parsivel²

ref: AeroNORDIC
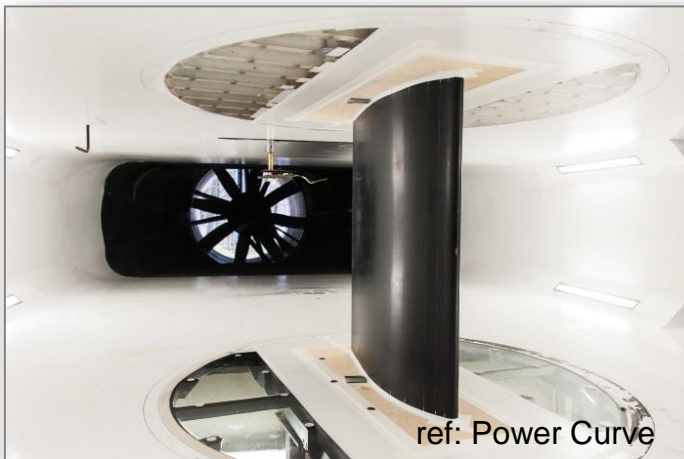
TopFarm Framework

- 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

https://gitlab.windenergy.dtu.dk/TOPFARM
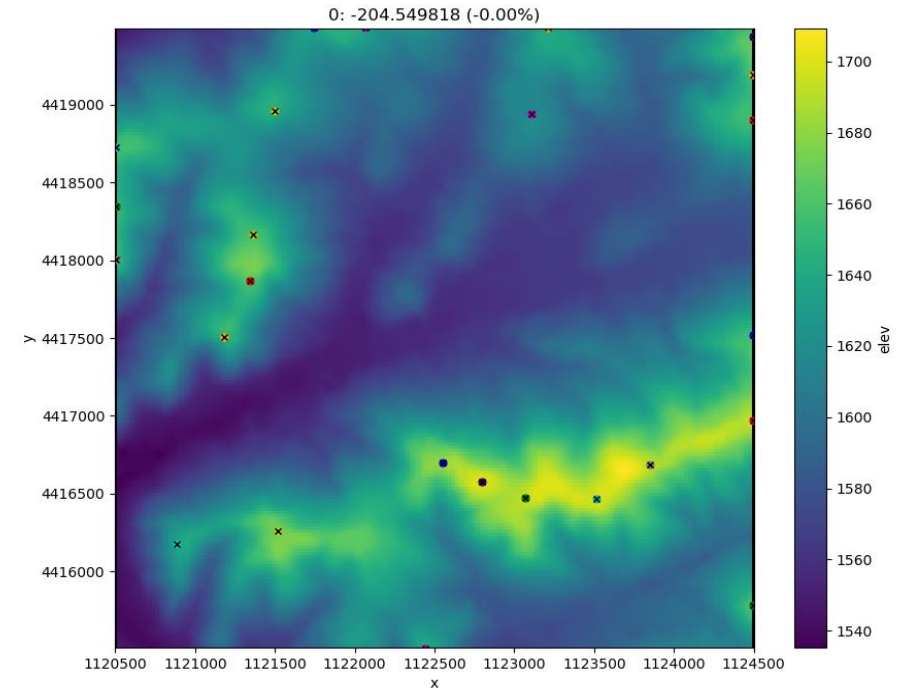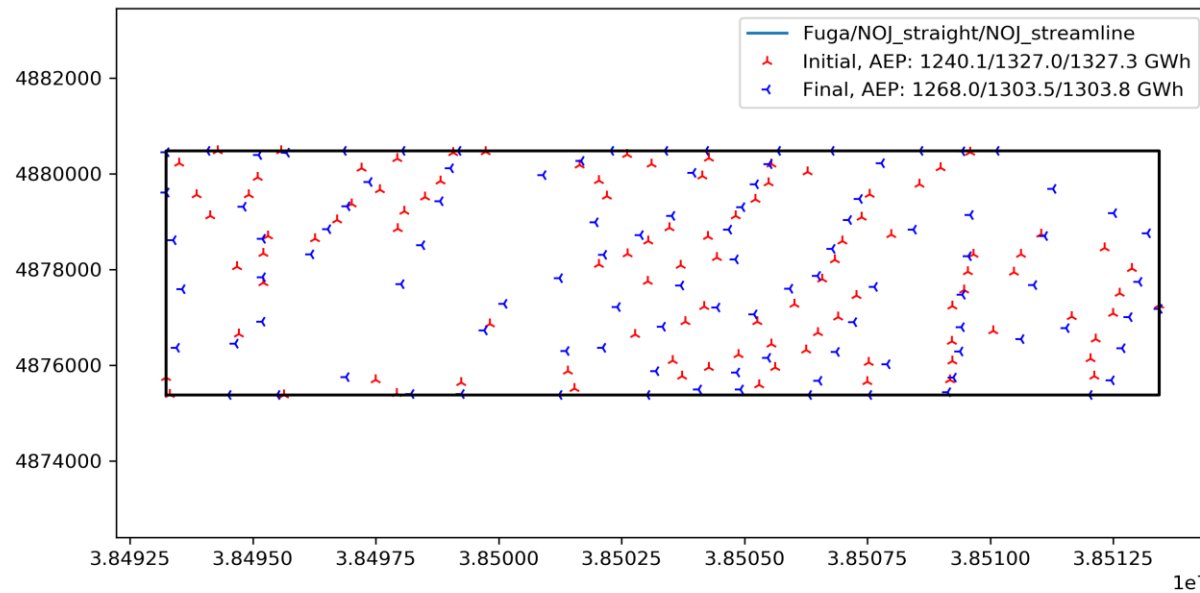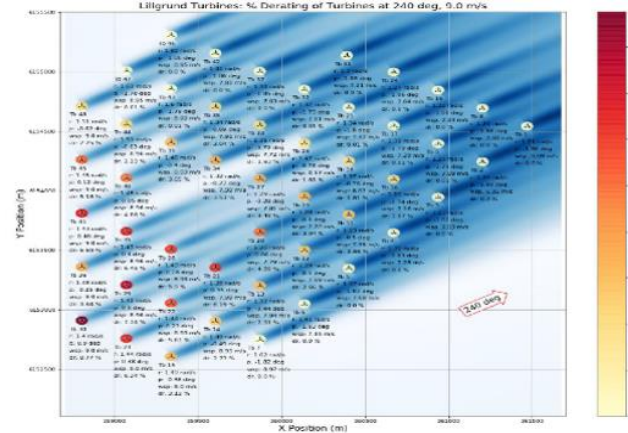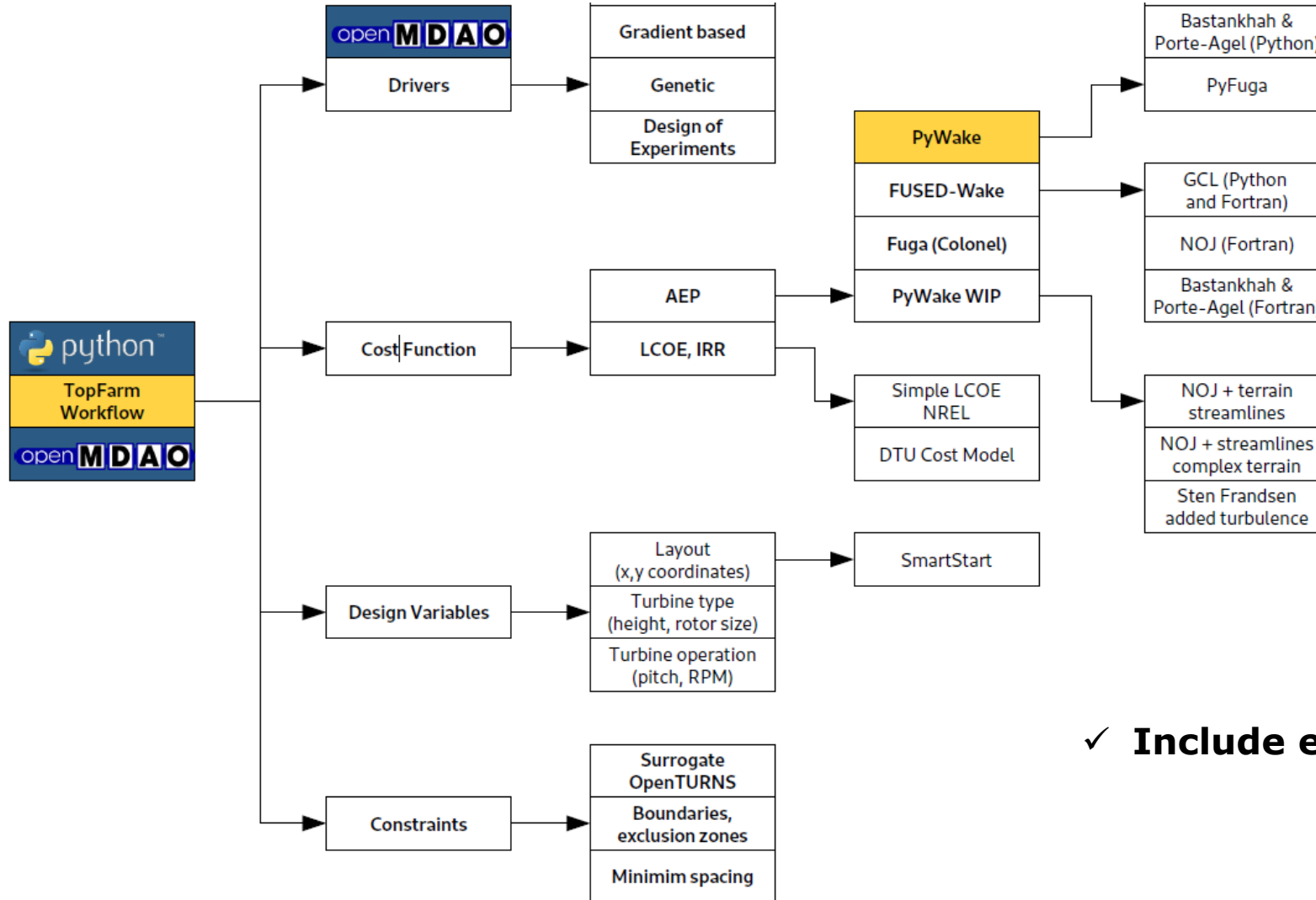
✓ **Include erosion features in TopFarm**

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*
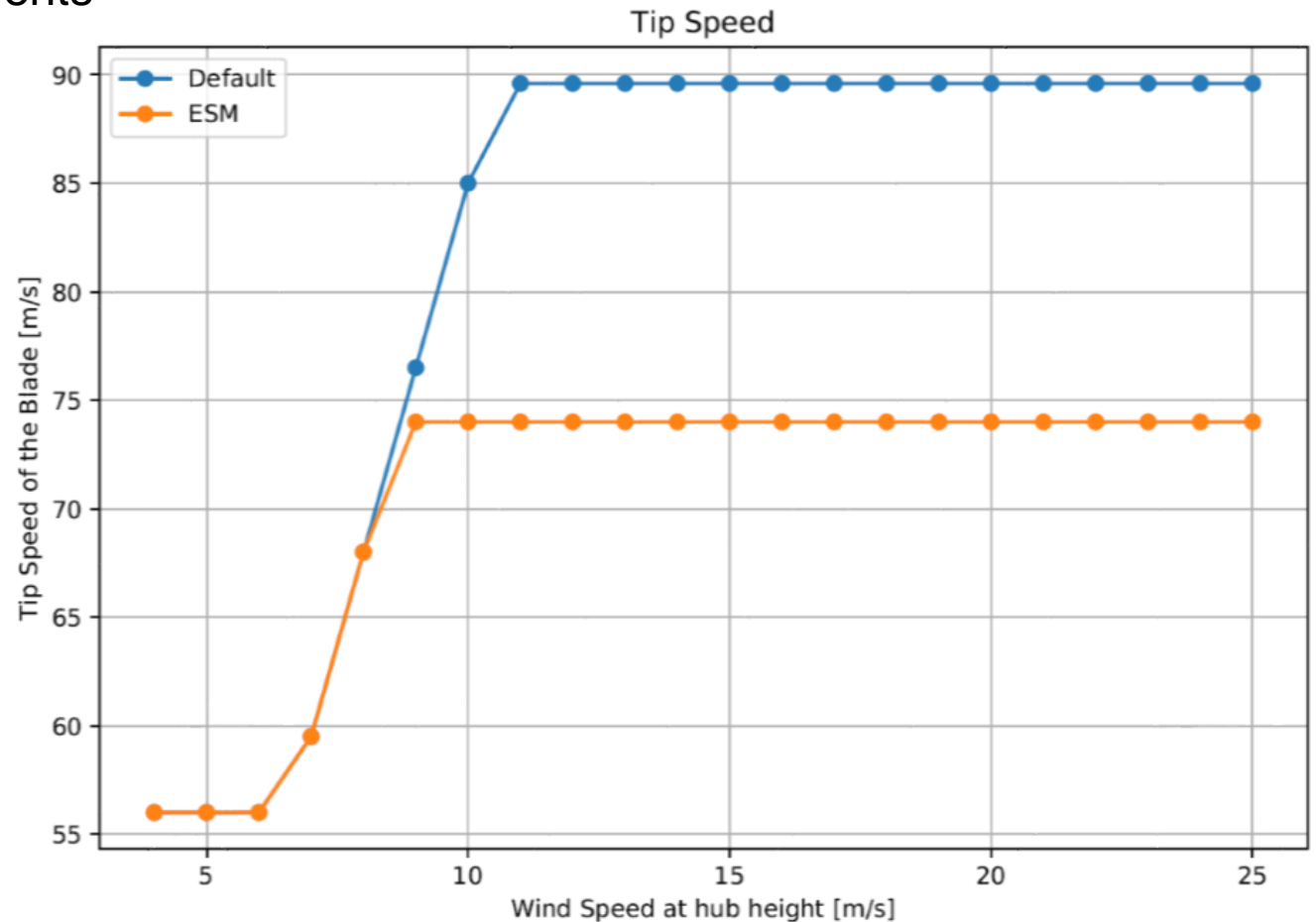

Rain rate on the ground [mm/h]

What is Erosion-Safe Mode (ESM)?

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- Increase energy production overall
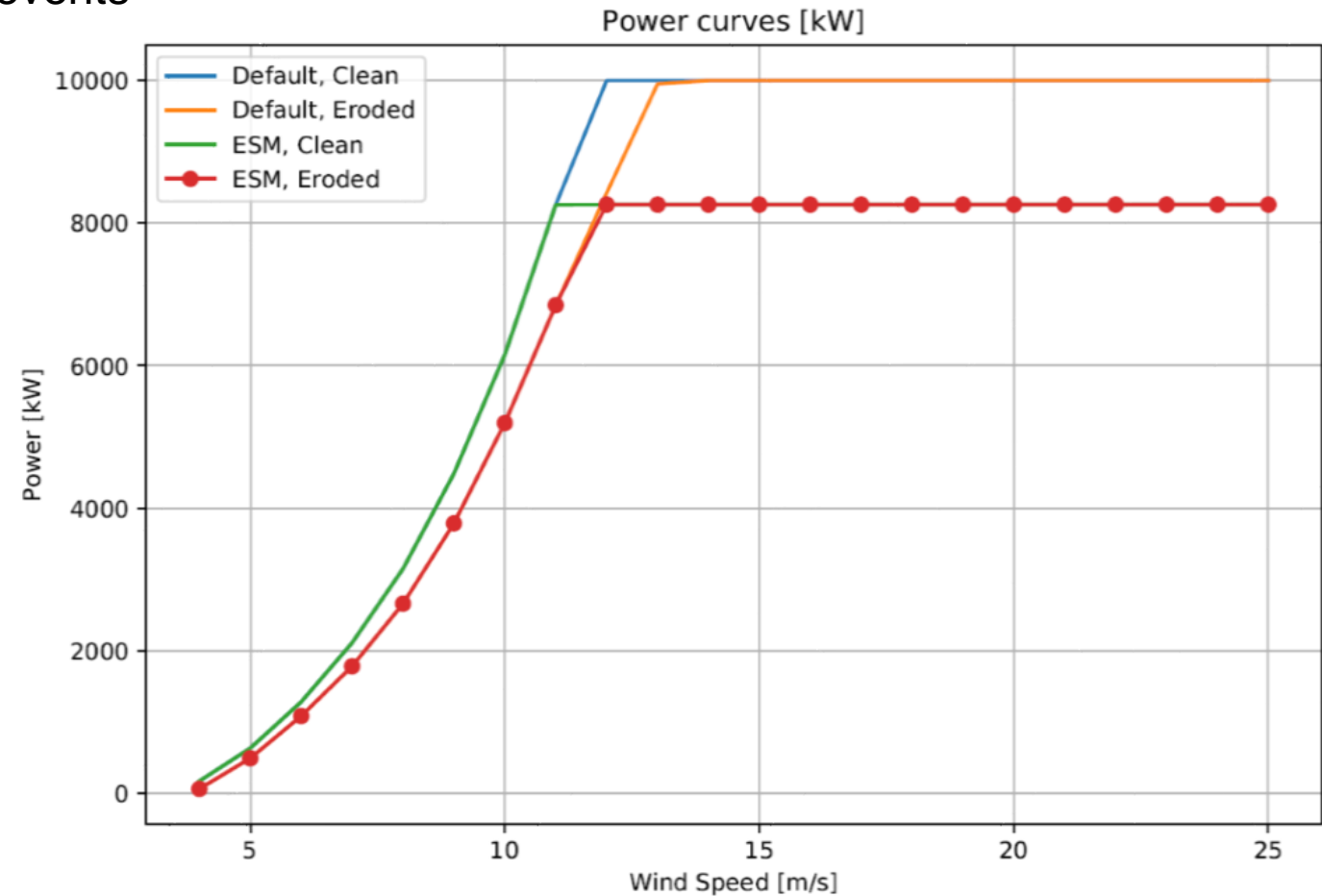
- *Most of the loss may be mitigated*
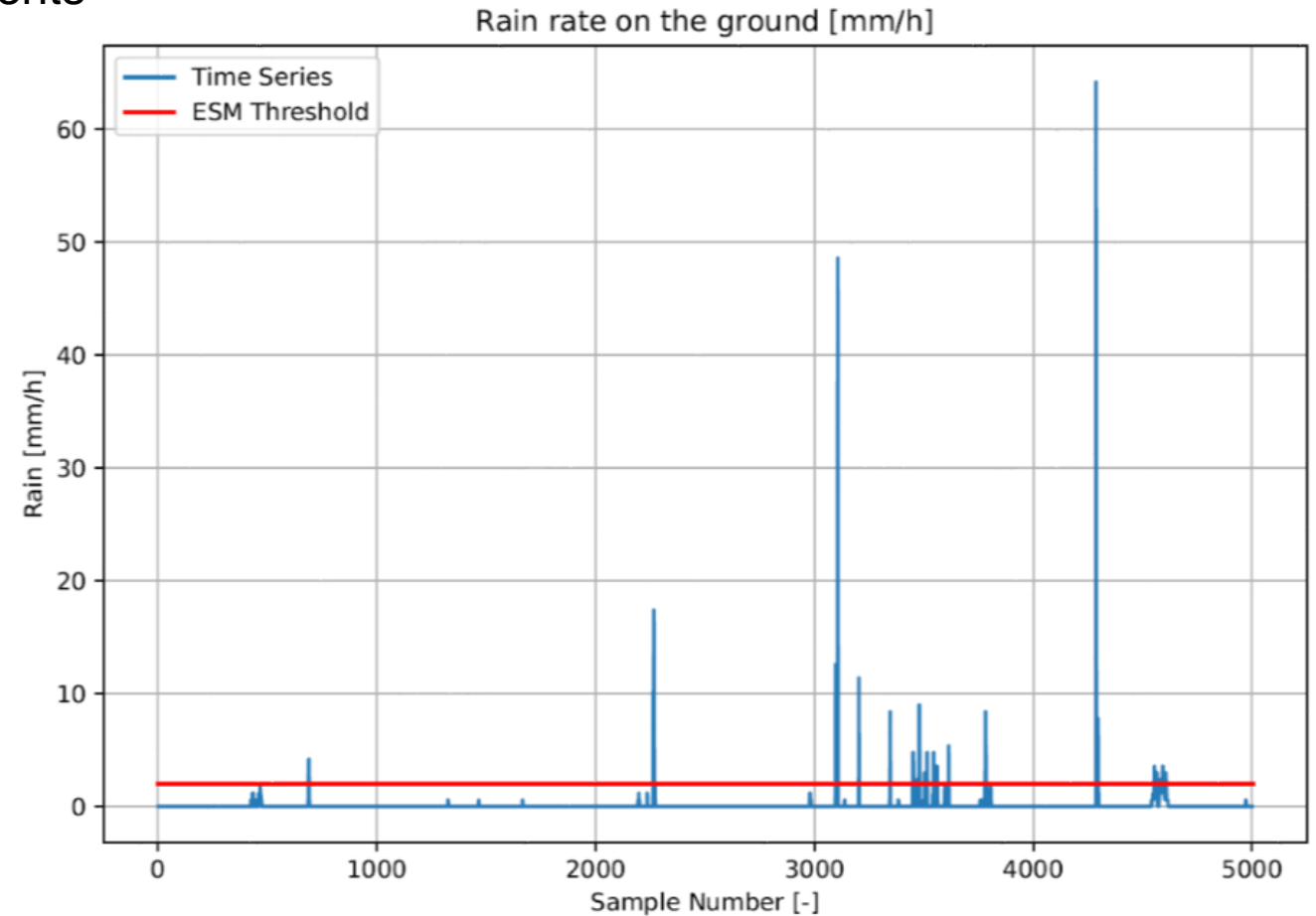
Tip Speed

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

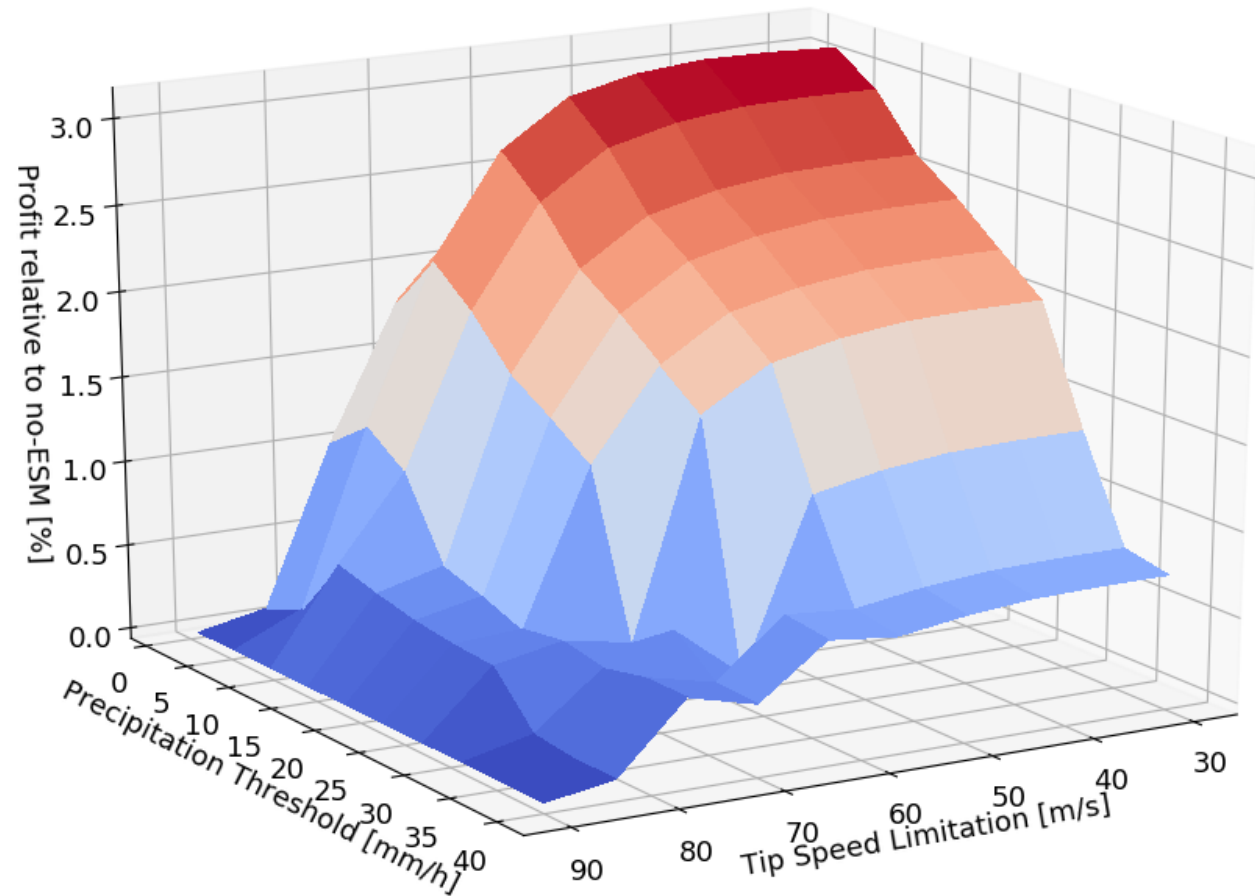- Increase energy production overall
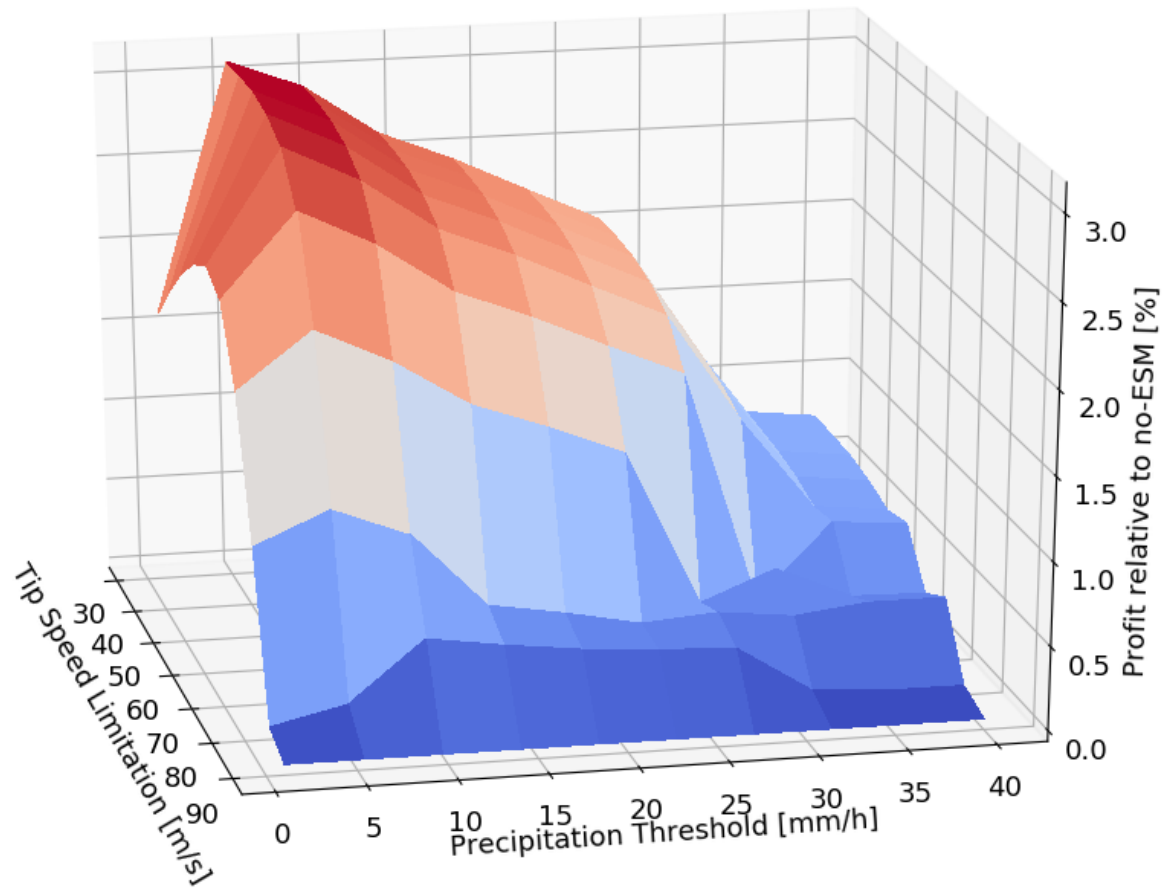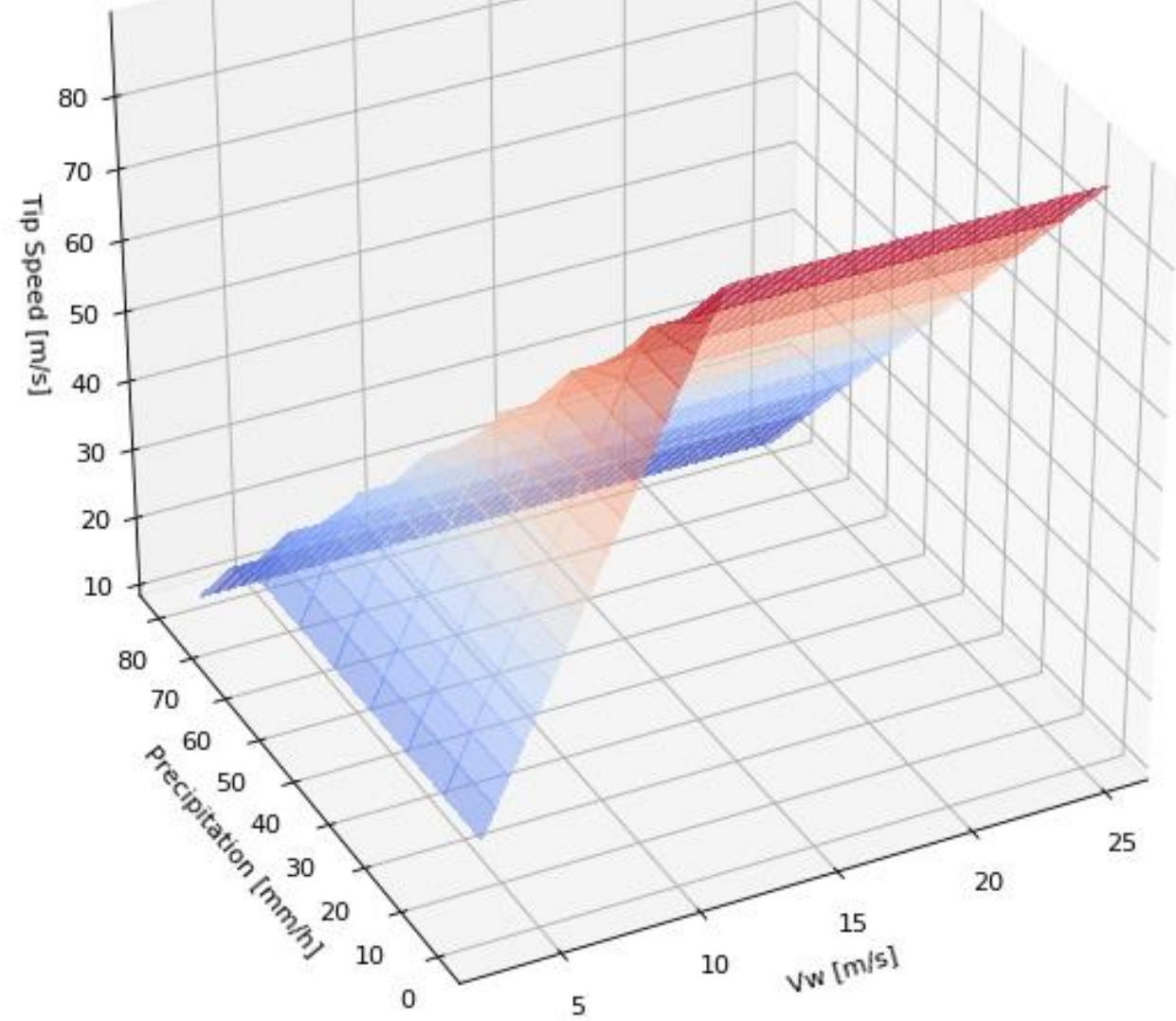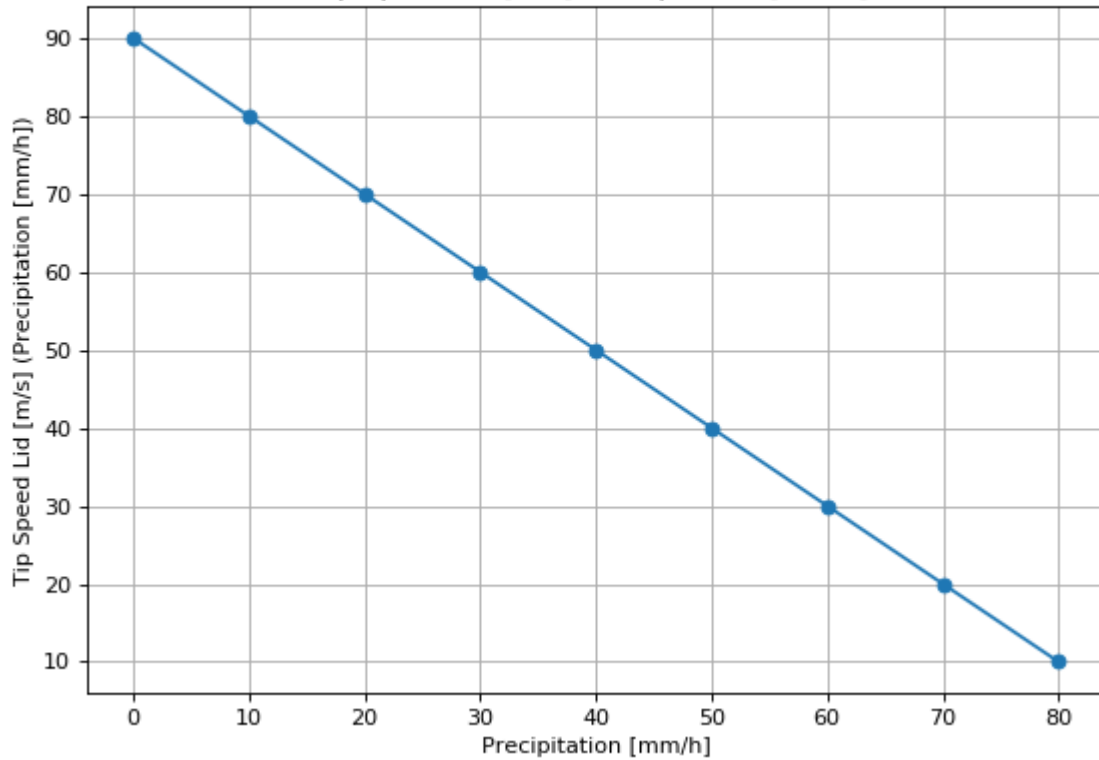
- *Most of the loss may be mitigated*

Power curves [kW]

*Constant **tip speed lid** and **precipitation threshold***

Tip speed lid(precipitation)

Variable price of electricity

Erosion in TopFarm

http://www.ict-aeolus.eu/images/horns_rev.jpg
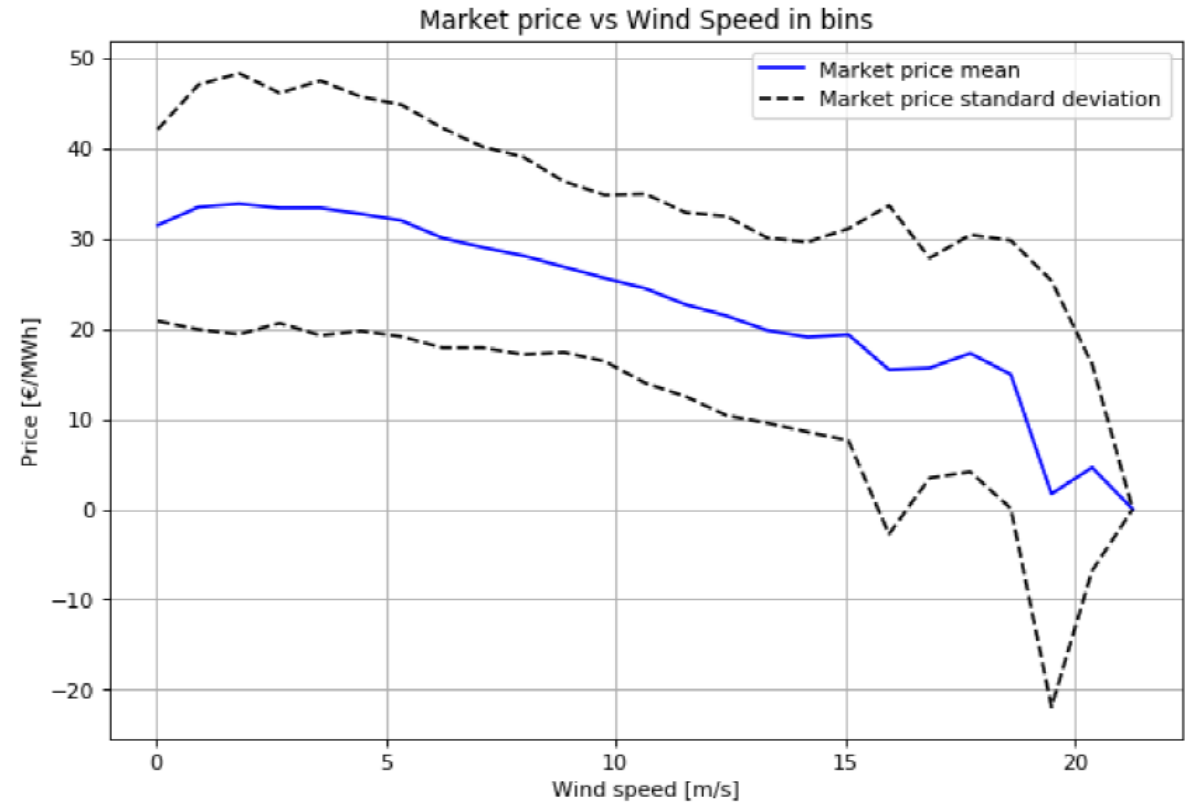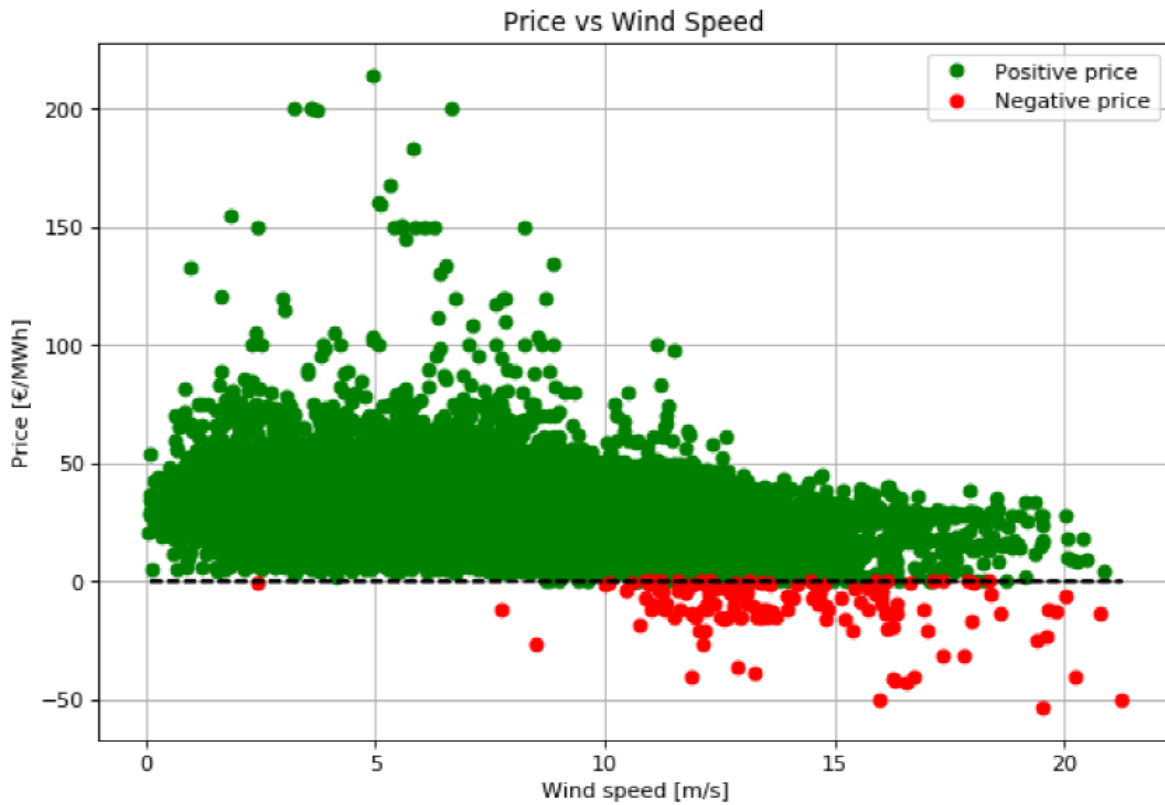
Exploratory study:

- *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