PROFESSIO ENERGIA
ENERGY TO DO THE BUSINESS

The challenge of extreme weather for renewable/wind energy production

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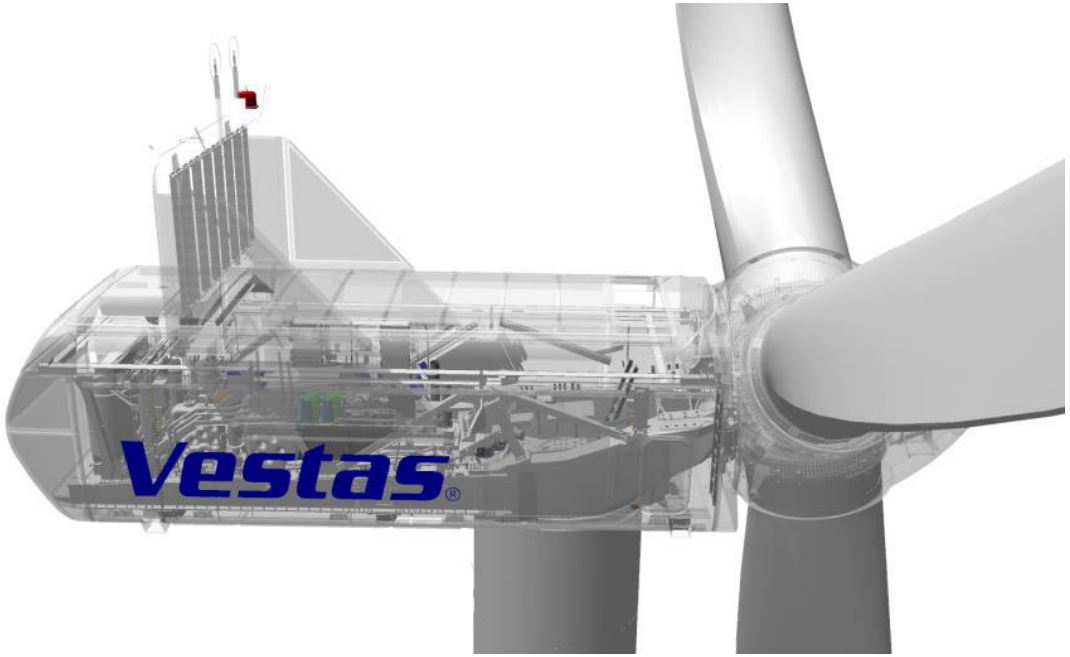
Introduction

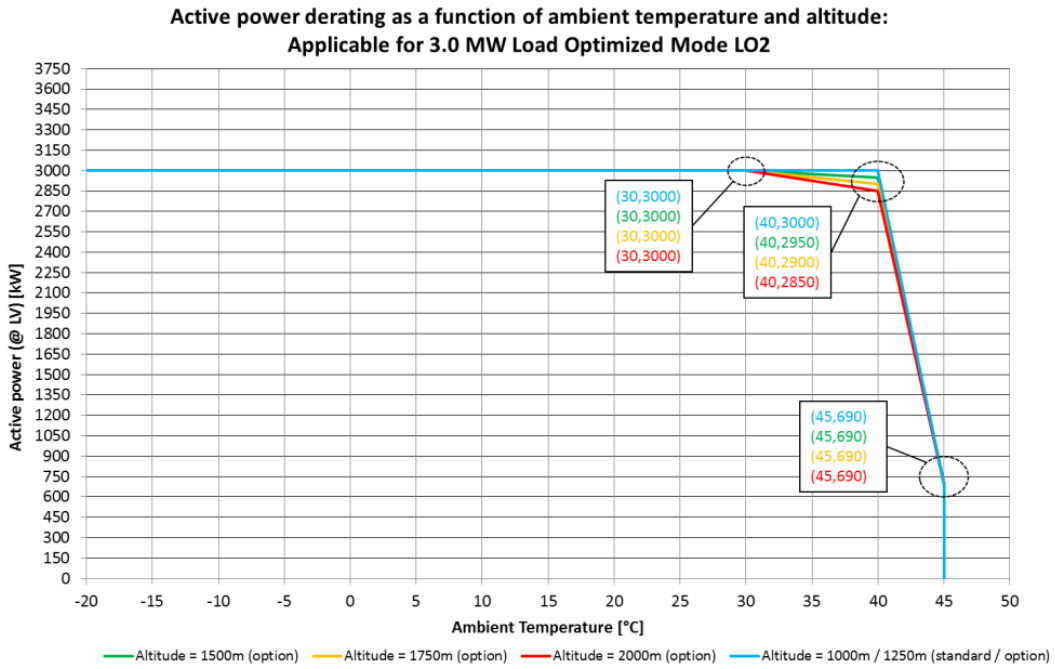
Professio Energia PLC is public listed, pure play renewables company.
Owners are largest croatian institutional investors, pension funds and insurance company
Oriented towards large wind, large solar and energy storage systems projects.

122 MW → 300 GWh/a → 100000 households

Operational envelope for the wind turbines

Temperature -20°C to +45°C extreme -40°C to +50°C
Altitude up to 1000 m a.s.l., optional up to 2000 m a.s.l.





Source: Vestas

Operational envelope for the wind turbines – must be proven safe under a set of predefined load cases

IEC 61400-1

Edition 4.0 2019-02
REDLINE VERSION

INTERNATIONAL STANDARD

Design lifetime 20 years!

Wind turbine class		I	II	III	S
V_{ref}	(m/s)	50	42,5	37,5	Values specified by the designer
A	I_{ref} (-)	0,16			
B	I_{ref} (-)	0,14			
C	I_{ref} (-)	0,12			

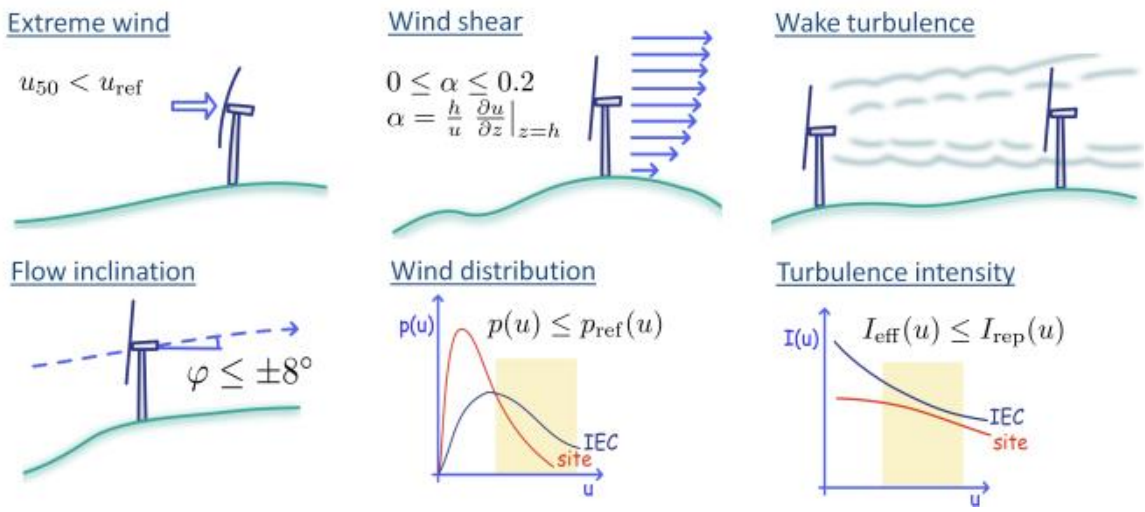
V_{ref}	reference wind speed average over 10 min
I_{ref}	expected mean value of the turbulence intensity at 15 m/s
V_r	rated wind speed defined as minimum wind speed at hub height at which a wind turbine's rated power is achieved in the case of steady wind without turbulence
V_{hub}	wind speed at hub height
V_{out}	highest wind speed at hub height at which the wind turbine is designed to produce power in the case of steady wind without turbulence (cut-out wind speed)

Operational envelope for the wind turbines

Wind conditions are specified by extreme wind speed, vertical wind shear, flow inclination, turbulence and rare gust-like events.
The load type is either an ultimate load, which might instantly damage the turbine, or a fatigue load.

Wind turbine set of design requirements- standard IEC 61400-1 4th edition Wind turbines

- Location specifics
  - terrain complexity
- Site wind conditions
  - average vertical wind profile exponent α should be between 0 i 0.2;
  - average air density should be lower than 1,225 kg/m^3 for wind speeds greater or equal to V_r
- Flow inclination should be less than 8°
- Site estimate of extreme 10-minute average wind speed at hub height with a recurrence period of 50 years should be less than V_{ref} for a given IEC class
- Site value of the probability density function of V_{hub} should be less than the design probability density function at all values of V_{hub} between the wind speed 0.2 V_{ref} and 0.4 V_{ref}
- The representative value of the turbulence standard deviation (σ1) should be greater or equal than limitations defined by the norm at all values of V_{hub} between the wind speed 0.2 V_{ref} and 0.4 V_{ref} (or when the turbine properties are known, between 0.6 V_r and V_{out}).



Source: wasp.dk

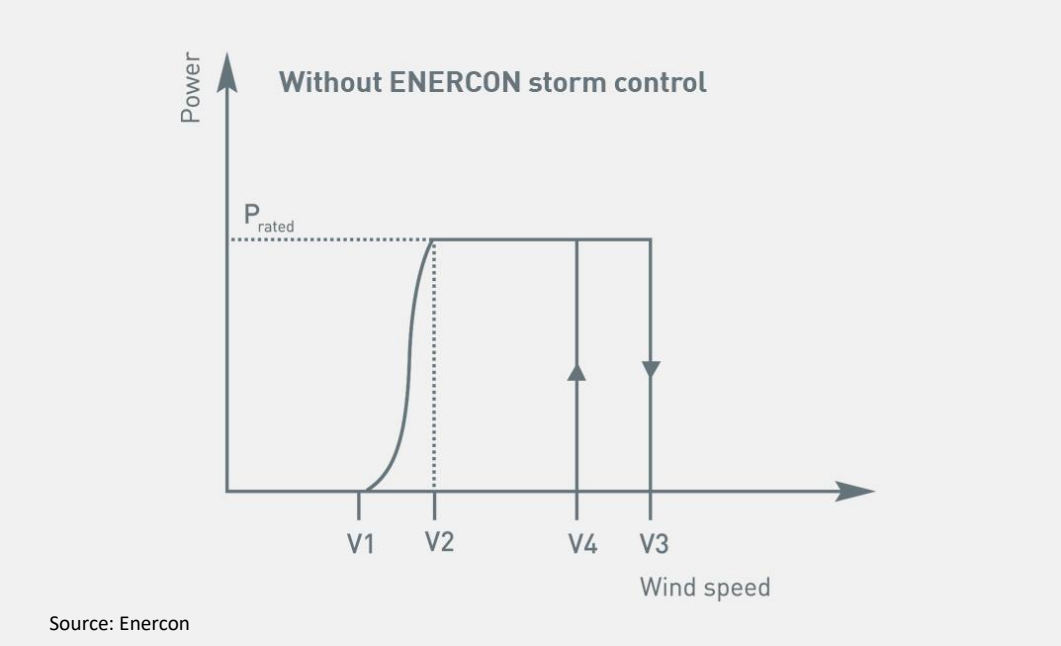
Extreme weather - direct effects

Wind speed control – extreme wind speeds, when is to much wind, ride through?

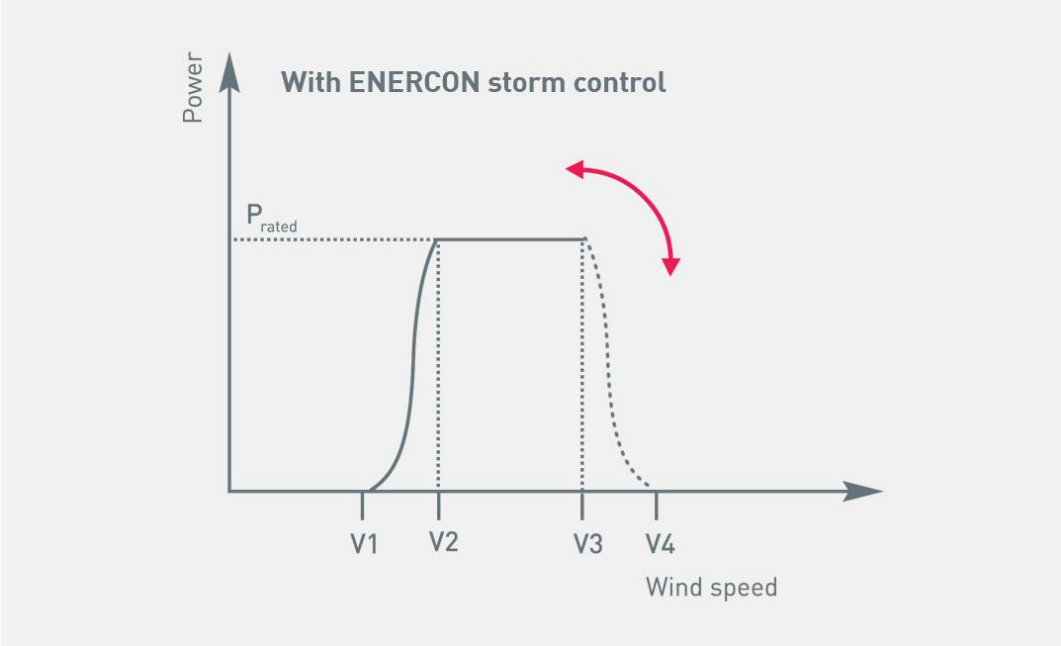
- Cut-out wind speed 25 m/s different criteria (temporal and by wind speed)
- Wind turbine turns into the wind
- pitch mechanism turns the blades minimising the surface, decreasing drag on a blade – stop spinning
- Mechanical disc brake applied

Extreme weather - direct effects

Storm protection - Storm control/High wind operation functionality.
Different commercial names, but they all enable machine to ride through rough wind regime without significant energy production loss. This slows the wind turbine down so that it can continue to operate even at high wind speeds, beyond cut-out wind speed.



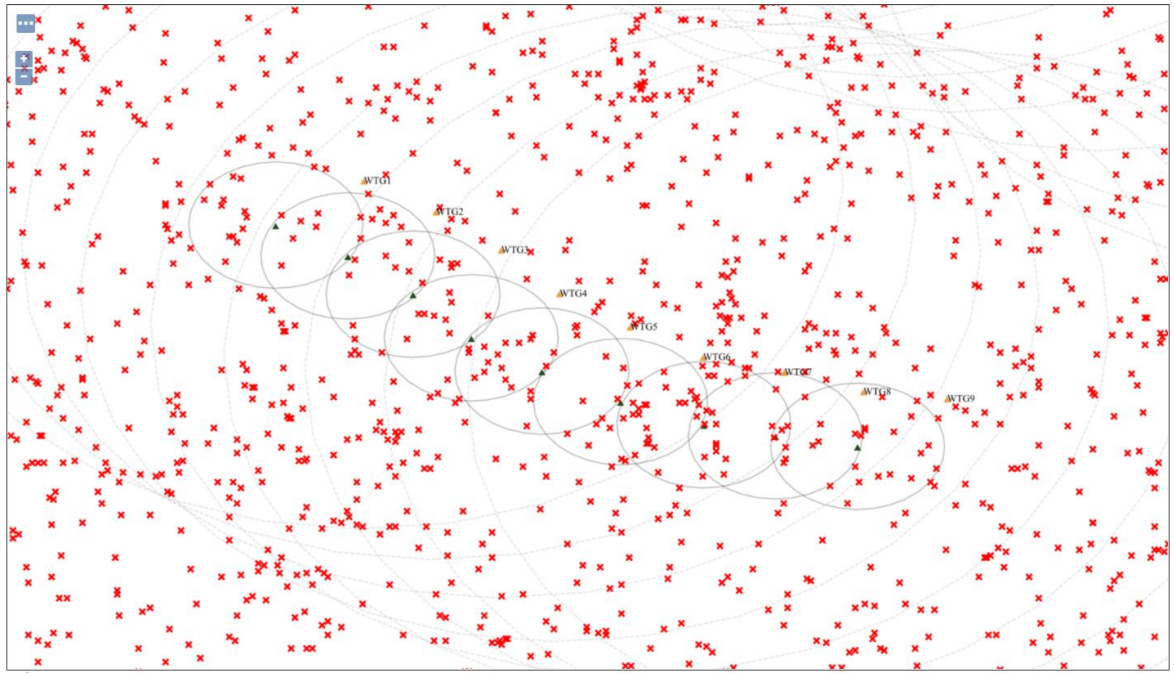
Source: Enercon

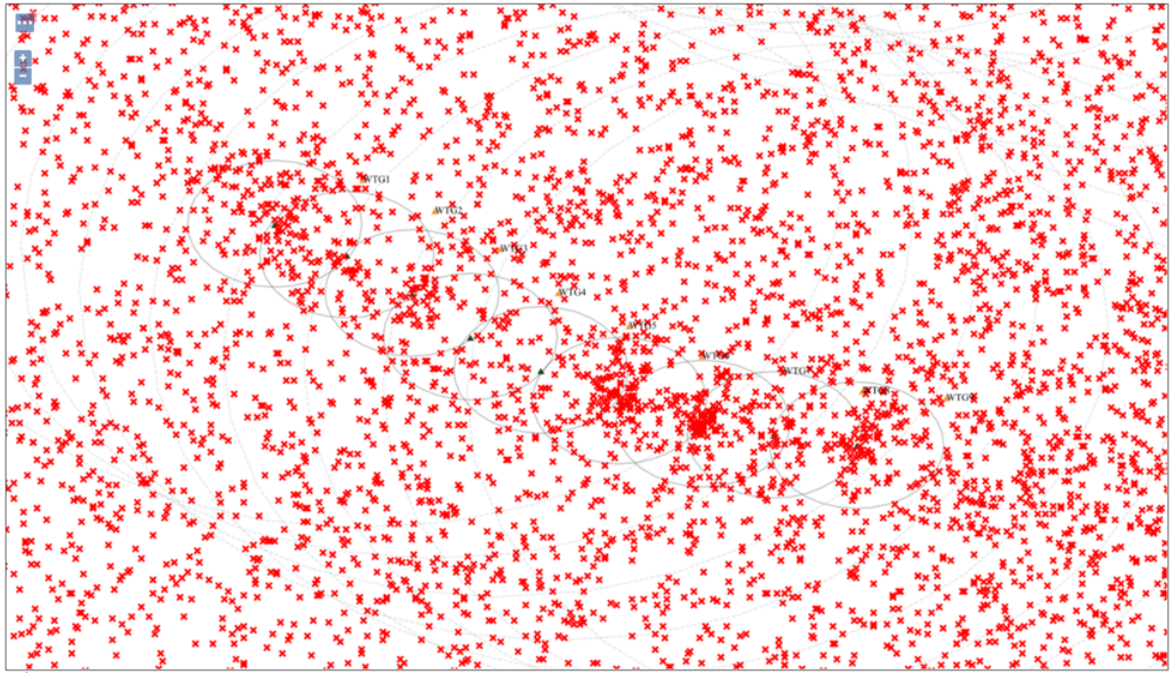


This system enables fewer hysteresis related stop-and-start operations due to a cycle moving to a higher wind speeds, also limiting the strain on a wind turbines.

Extreme weather - direct effects

Lightning – is it a problem for a wind turbine?

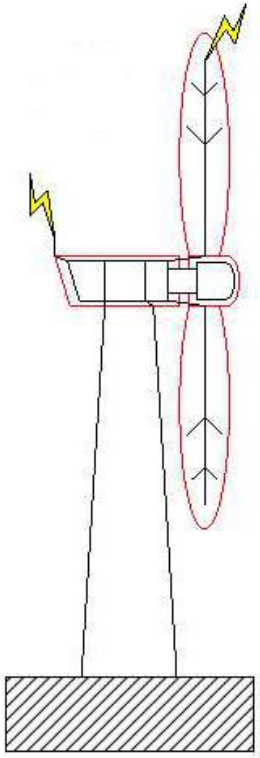




Lightning stike density increased 2-3 times after installation of the wind turbines.

Extreme weather - direct effects

The wind turbine is systematically designed to withstand direct lightning strikes.
LPS installed in accordance with IEC 61400-24:2010



- Blade tips, weather station and aviation obstruction lights at the rear top end of the nacelle are the areas with the highest risk of lightning strikes.
- The blades are the most vulnerable components exposed to lightning strikes.
- The blades are designed to withstand this extreme lightning strike environment, but despite that damages occur, and consequently downtime.

Extreme weather - direct effects

Lightning – in a real life of the wind turbine

Photo 1: Damaged laminate by lightning strike. SS. Z47,2m

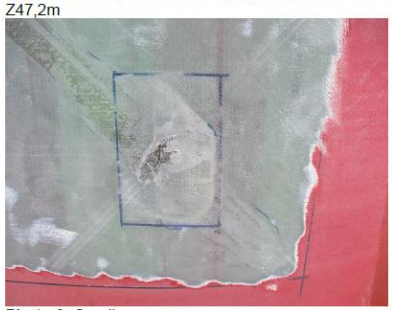


Photo 3: Sanding process

Photo 5: Internal inspection

Photo 7: Laminate

Photo 9: Laminate

Photo 11: After postcure

Photo 13: Finish

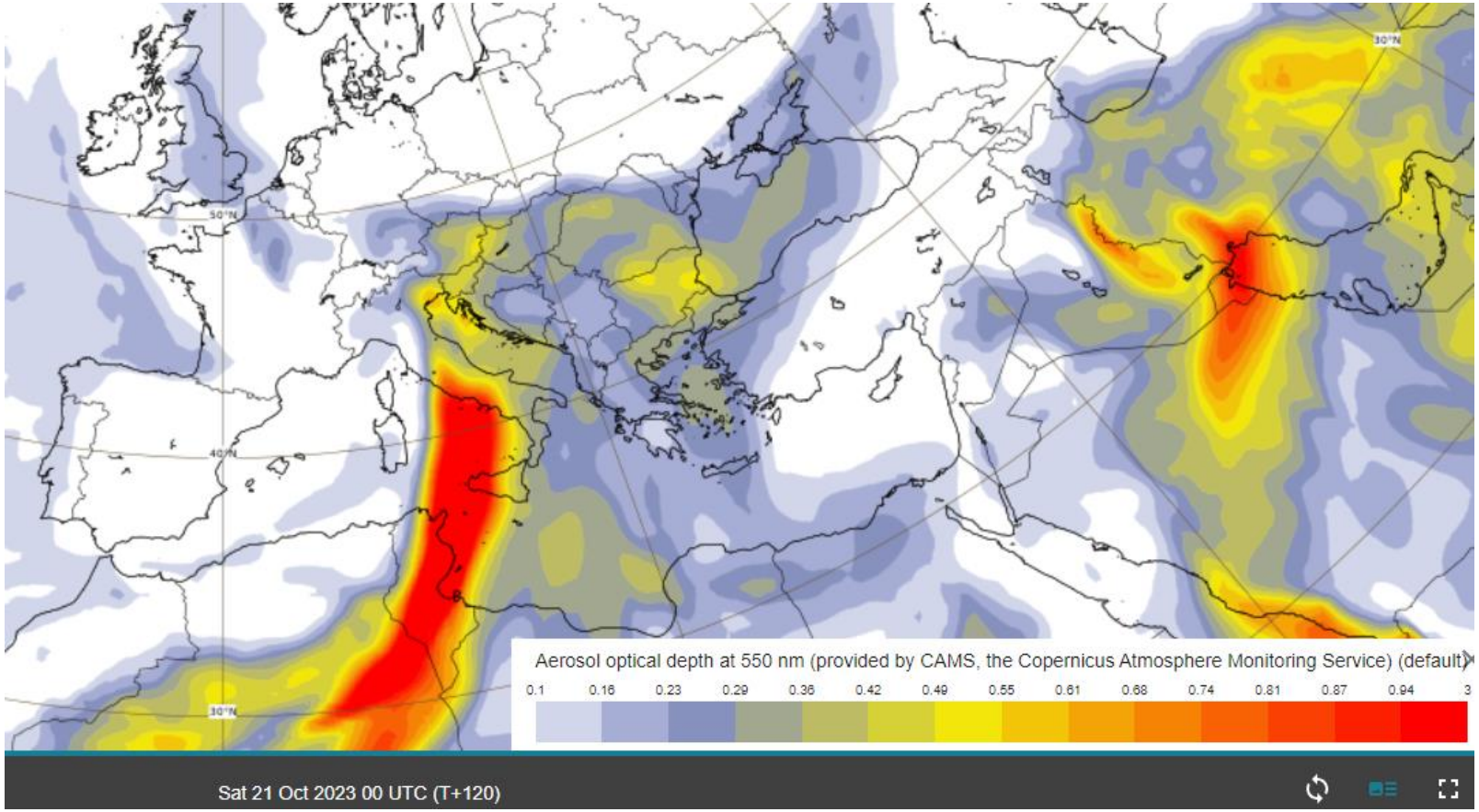
Photo 15: Drain

Photo 14: Conductivity

407 MWh ~ 43 k€

Extreme weather - direct effects

Hail, sandstroms, rainfall and dust cause erosion damage – key contributor to a blade profile deterioration.



Source: https://atmosphere.copernicus.eu/

Extreme weather - direct effects

Photo 1: Erosion LE. Z33 and 35,2m

Photo 2: Erosion LE. Z33 and 35,2m

Photo 3: Erosion LE. Z33 and 35,2m

Photo 4: Erosion LE. Z33 and 35,2m

Photo 5: Erosion LE. Z33 and 35,2m

Photo 6: Erosion LE. Z33 and 35,2m

Hail, sandstroms, rainfall and dust cause erosion damage – key contributor to a blade profile deterioration.

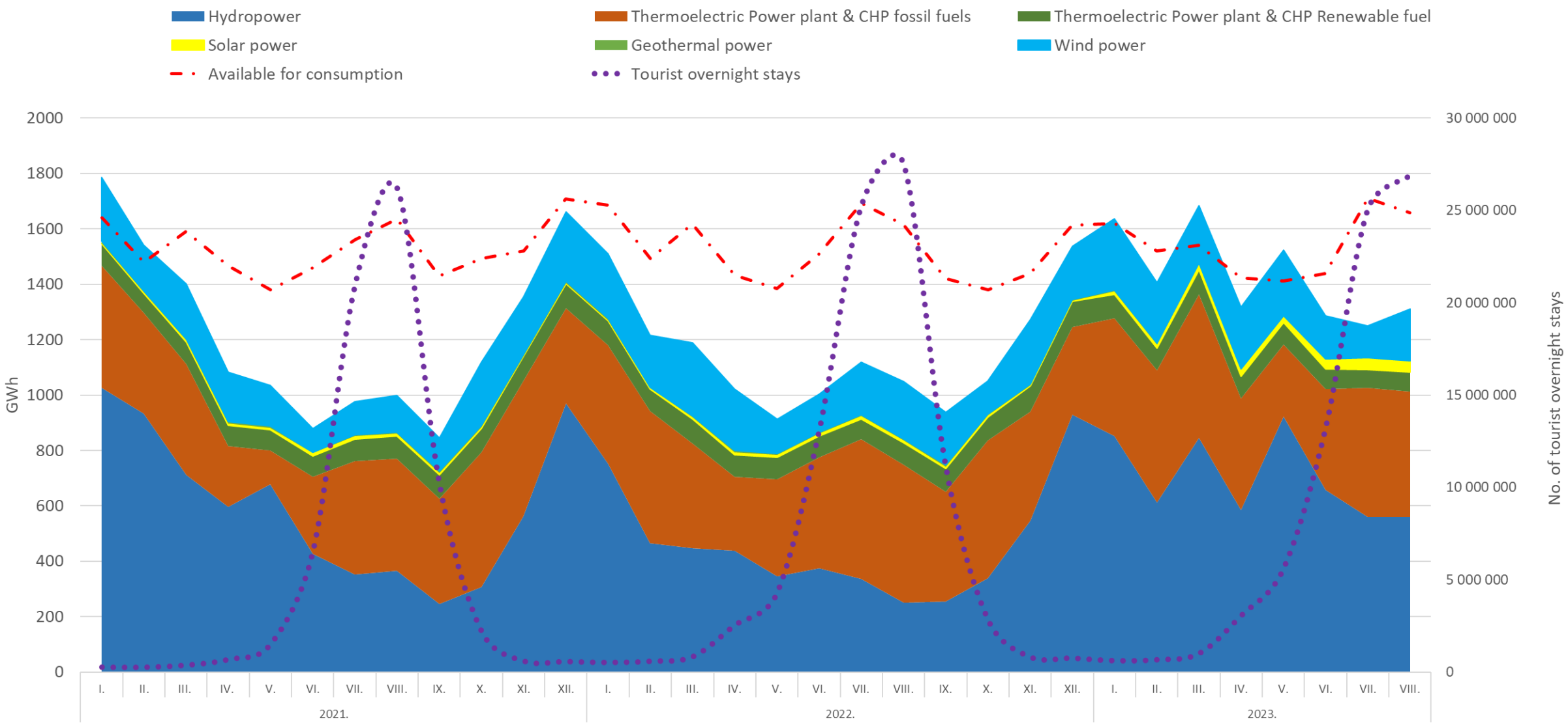
- Increase in drag & decrease in lift – lower AEP
- Rotor vibrations
- Maintenance strategies

Extreme weather - indirect effects

- Power demand increases during summertime, higher air temperatures, tourism – low wind season
- Draughts and heat make less water available for the hydro power plants, and cooling of the thermal/nuclear power plants, pushing the infrastructure down to its limits.
- Historical change and flip of peak power demand from winter (heating) to summer (cooling).
- Extreme weather - power demand forecasting challenge

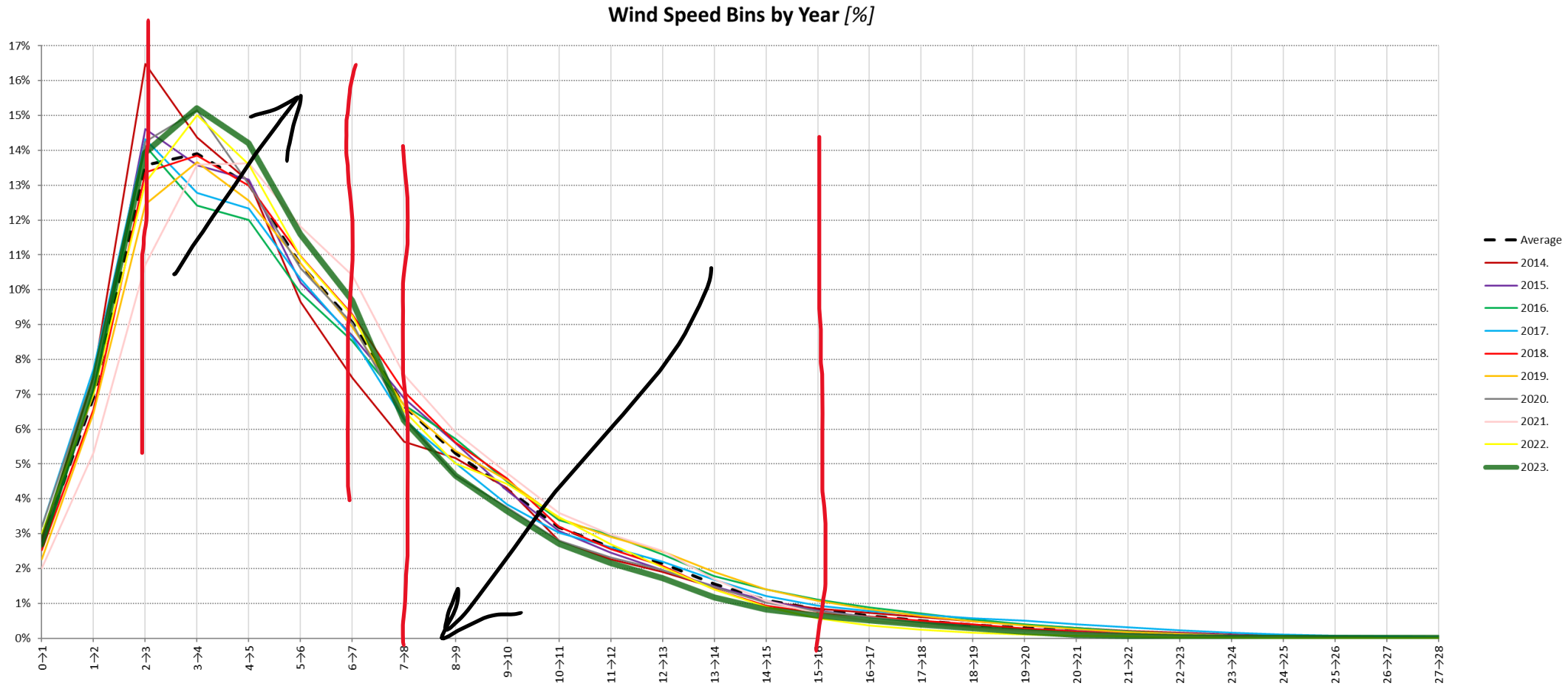
Source: Public Fire Brigade Town of Senj https://www.jvp-senj.hr/

Extreme weather - indirect effects



Extreme weather - indirect effects

Wind is slowing down?
Electricity production lack compared to planned – repercussions to financial models



Conclusions

- Higher risk related to wind power (renewables) operation due to unpredictable changes in weather patterns in years to come – „fuel” direct link to natural forces and weather
- Wind patterns are not constant, weather patterns are variable
- Location and site selection extremely important, where and when to utilise natural resources
- Appropriate wind turbine class selection – design
- Additional protective systems
- O&M – extremely important to keep the machinery in the best possible condition
- R&D – future will bring us better options to satisfy our energy demand using renewable resources in sustainable manner

THANK YOU!

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