Shadow flicker – The European view and practical mitigation methods
Agenda

1. Overview K2 Management
2. Shadow flicker –the European view
3. Permitting examples
4. Planning and siting to mitigate shadow flicker
5. Technical mitigation
6. Aftermarket solutions
300+ years of experience in wind
>45 offshore projects
>620 onshore projects
55+ employees all in all
8 customers (active)
6 years in operation
7 worldwide offices
K2 Involvement

Our office locations and countries of activities

- Boston, US
- Arhus DK
- Hamburg DE
- London, UK
- Sao Paulo, BR
- Taipei, TW
- Seoul, KR
Engineering and management services to the onshore and offshore wind industry:

- Wind & Site
- Project Planning & Management
- Foundation Design
- Project Engineering & Development
- Project Implementation

- Risk & Interface Management
- Quality and Health & Safety Management
- Operation & Maintenance
- Supply Chain Support
- Due Diligence
K2 Management serves these main customer groups:

- Project developers
- Lenders/Banks/Insurances
- Supply chain companies
- Planning boards
The European wind market

• Main countries: Denmark, Germany, France, Poland, Spain, Sweden, Romania, Bulgaria

• Densely populated areas similar to New England

• Large industrial WTG over 2MW (US: 1.94 MW)

• High share of 3MW class, e.g. in Germany:
  • 2 MW- 3 MW class 38%; 3-3.6 MW class 33%

• Hub heights: av. 113m (370ft) (US 93m), usually 100m to 140m (328 – 460ft)
Shadow Flicker – the European view

- Shadow flicker is well known, but not an issue for developers, residents or permitting authorities.
- Why?

  - Federal / State laws regulate emissions of wind turbines and their immissions on persons, buildings and nature
  - Regulates siting approval of local authorities
  - Developers have to prove mitigation based on software in permitting
- Shadow flicker is effectively mitigated
Permitting examples - Europe

- Local authority permits wind turbine under consideration of applicable immission protection law
- Sometimes “Limited shadow flicker has to be accepted”
- Typical limit is 30 hours per year and/or 30 minutes per day
- Essential is the actual value, not the theoretical possible value
- Requirement to either site turbine to avoid exceeding shadow flicker limit or to use “technical measures” to avoid flicker
Planning and Siting

- Siting with software tools e.g. WindPro
- Shadow flicker is simulated based on solar altitude and WTG size
- Receptor points can be defined in software and calculated
- Need for re-siting or technical measures can immediately be determined
- Permit can be filed as needed by developer

![Image of software interface for siting calculation]
Planning and Siting

COMMITMENT TO PROJECT LEADERSHIP
Technical Mitigation

- If re-siting cannot be done or creates other concerns (e.g. noise), technical mitigation of shadow flicker is the preferred solution
- Calculate shutoff times and annual production loss to determine impact on project

**Shadow impact module**

- Software solution tracks course of sun
- Sensor tracks actual sunlight
- Automatic shutoff and startup of wind turbine
Aftermarket solutions

Pending SCADA ports accessibility

Either

- Integrate shadow stop module into existing system

Or

- Software based control w/o sensor

- Can control up to 50 turbines

- Integration into SCADA system

- Effective elimination of shadow flicker
Summary

Legislative
- Clear shadow flicker guidelines would provide security to developers, investors, authorities and residents

Siting
- Effective shadow flicker mitigation can be achieved
- Needs to be considered before permitting and while siting
- Use technical shadow mitigation system if simulations shows exceedance
Thank you for your attention!

Questions?

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