K2 Management

COMMITMENT TO PROJECT LEADERSHIP

Shadow flicker – The European view and practical mitigation methods

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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

Snapshot

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- 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

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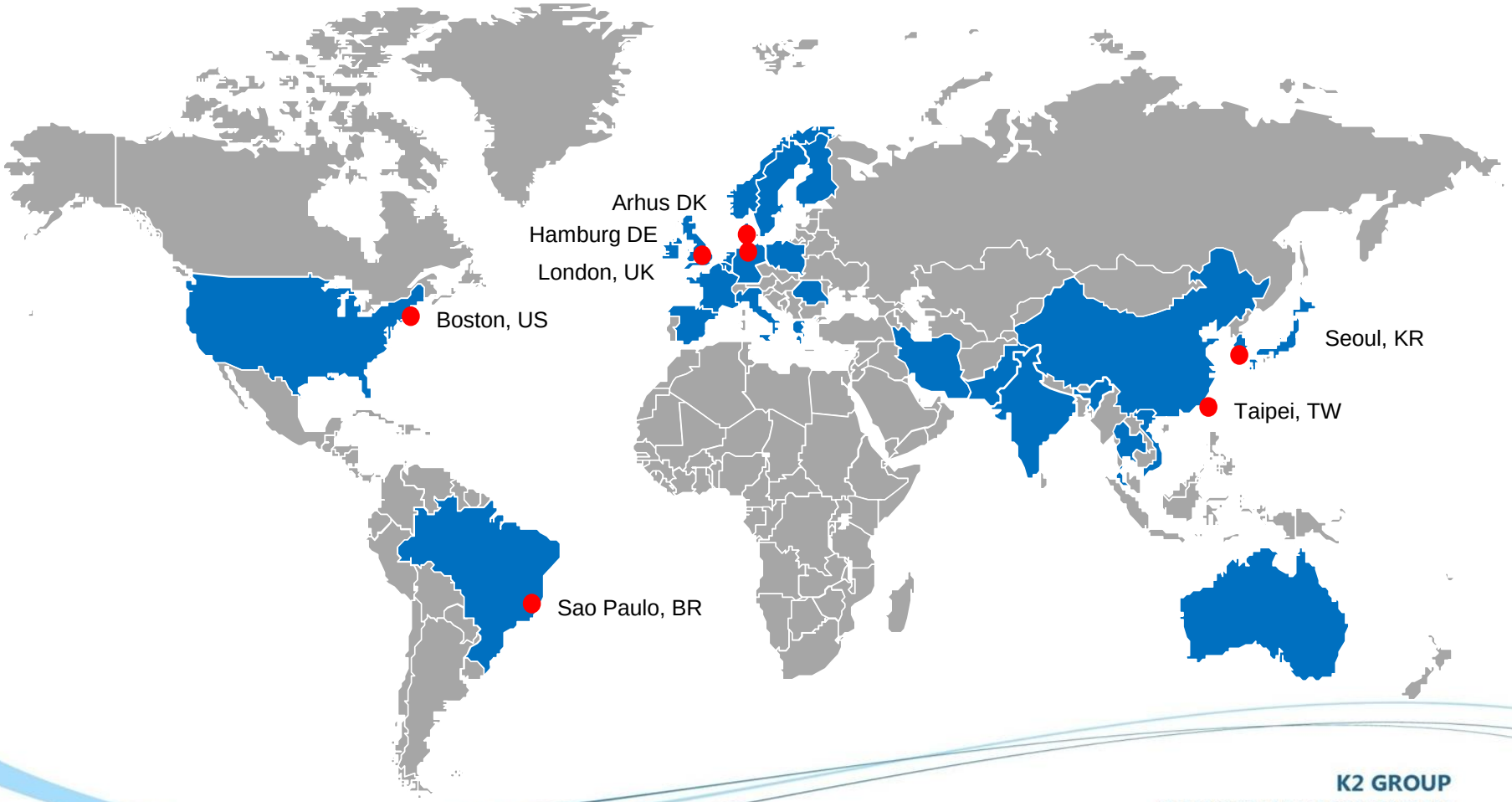
Our office locations and countries of activities



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K2 Services

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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 Clients

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K2Management serves these main customer groups:

- Project developers
- Lenders/ Banks / Insurances
- Supply chain companies
- Planning boards

Shadow Flicker – the European view

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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)

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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

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- 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

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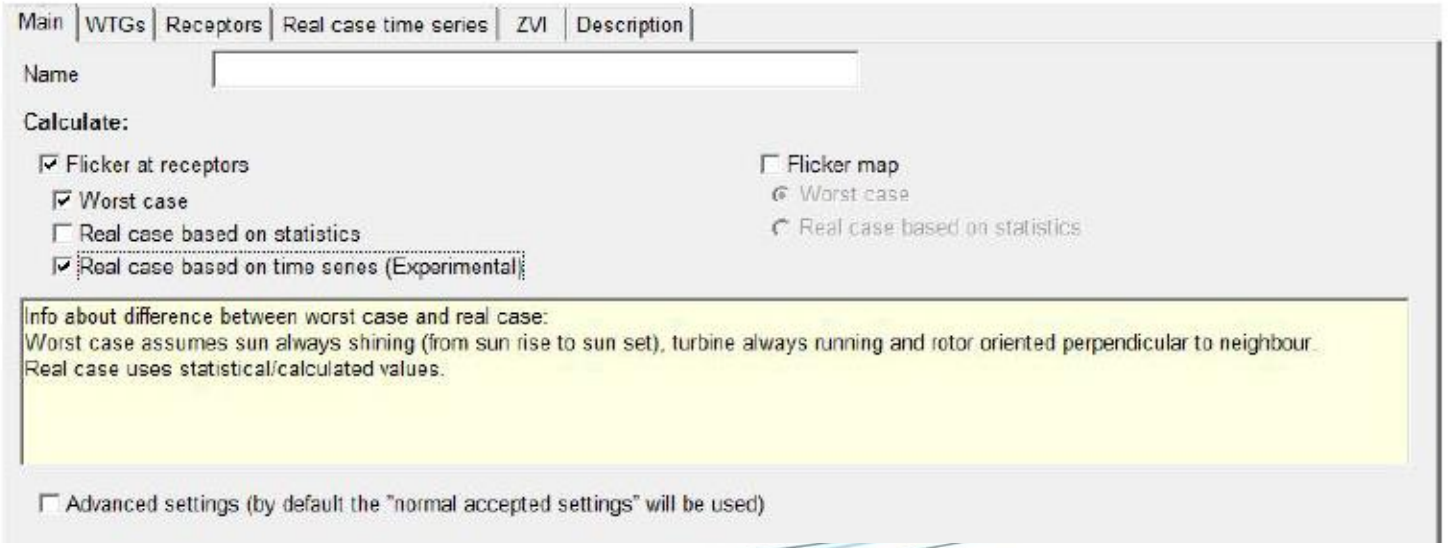
Planning and Siting

- 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



Planning and Siting

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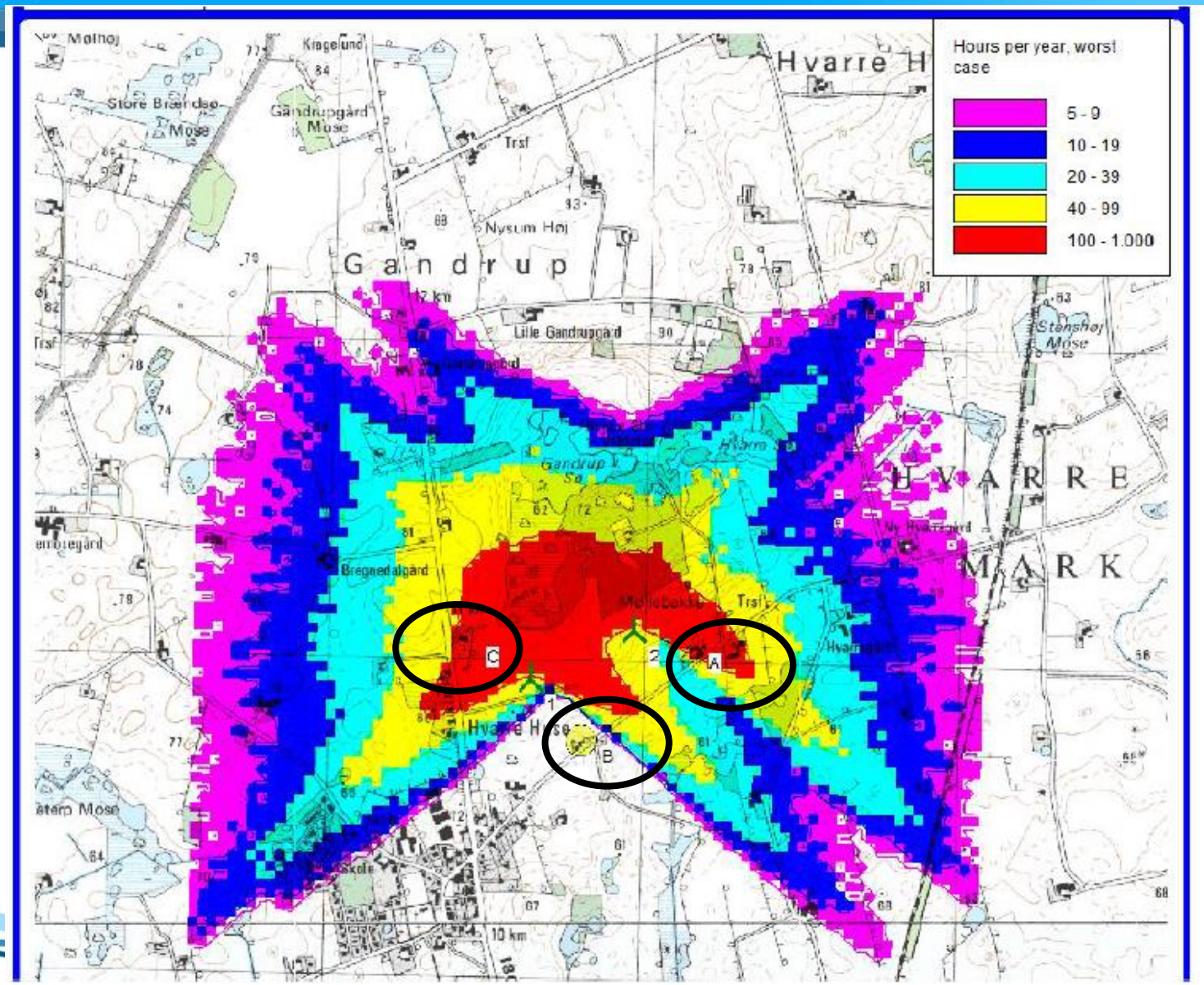

Technical Mitigagtion

- 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

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- Pending SCADA ports accessibility

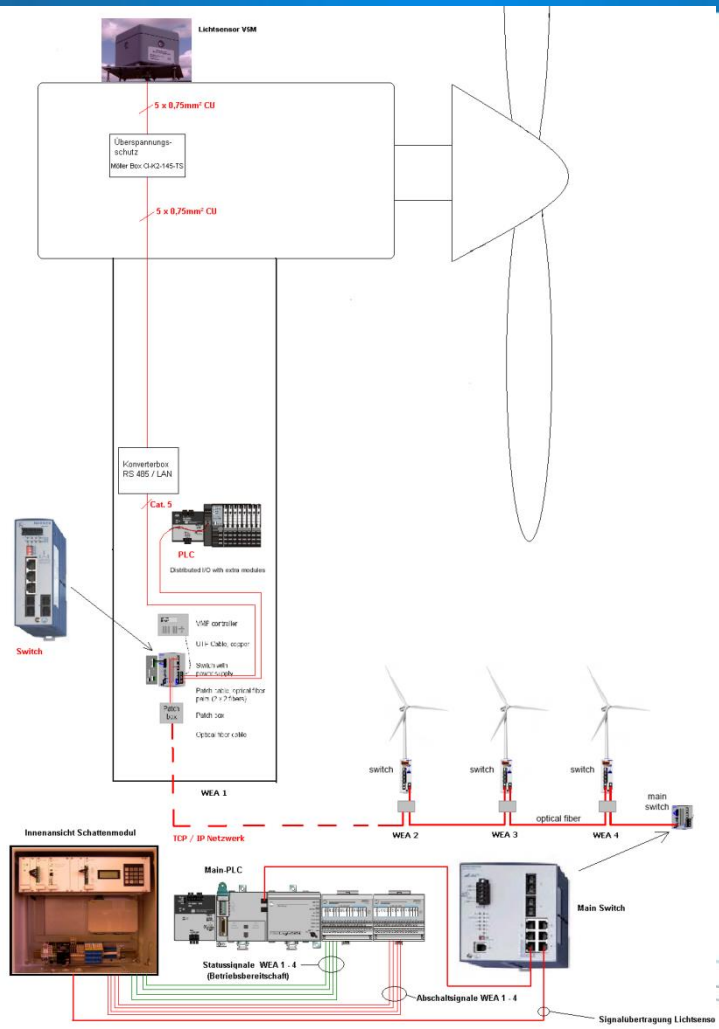
Either

- 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



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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!

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Questions?

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