Ingham Consult

- Independent Danish Wind Consultants since 1990

Our clients:

Developers

Governments and EU

Banks and Investors

Utility Companies

Ingham Consult services:

Wind Measurements incl. SODAR
Wind Resource Assessment
Micro-siting
Power Performance Measurements
Energy Production Estimates
Project Proposal and Presentation
Feasibility Studies
Environmental Studies
Tender Preparation
2nd opinion & Due diligence

SELECTED PROJECTS WORLD-WIDE

SELECTED CLIENTS - COMMERCIAL PROJECTS

DENMARK Danwin Nordtank Energy Group Micon NEG Micon Vestas NESA/Elkraft Topdanmark Insurance Company Nordea Bank **NORWAY** Norsk Miljøkraft Tromsø Norsk Miljøkraft Måsøy Norsk Miljø Energi Bergen Kommunale Kraftverk Havgul Andmyran Vindpark Norsk Hydro		**GERMANY** Thyssen Rheinstahl Technik Thyssen-Krupp EtaPlan Renerco General Electric **UK** Energy Parks UK/Wales Shell International **THE NETHERLANDS** NUON Koop Durzaame Energie **SPAIN** Parque Eolica La Caracha Parque Eolica Plane de Jarreta

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Key factors for the *SUCCESSFUL* Development of a *Wind Power Plant*

Wind Energy as a competitive renewable energy source

...thanks to the development of the modern wind turbine

The Gedser wind turbine 1940's

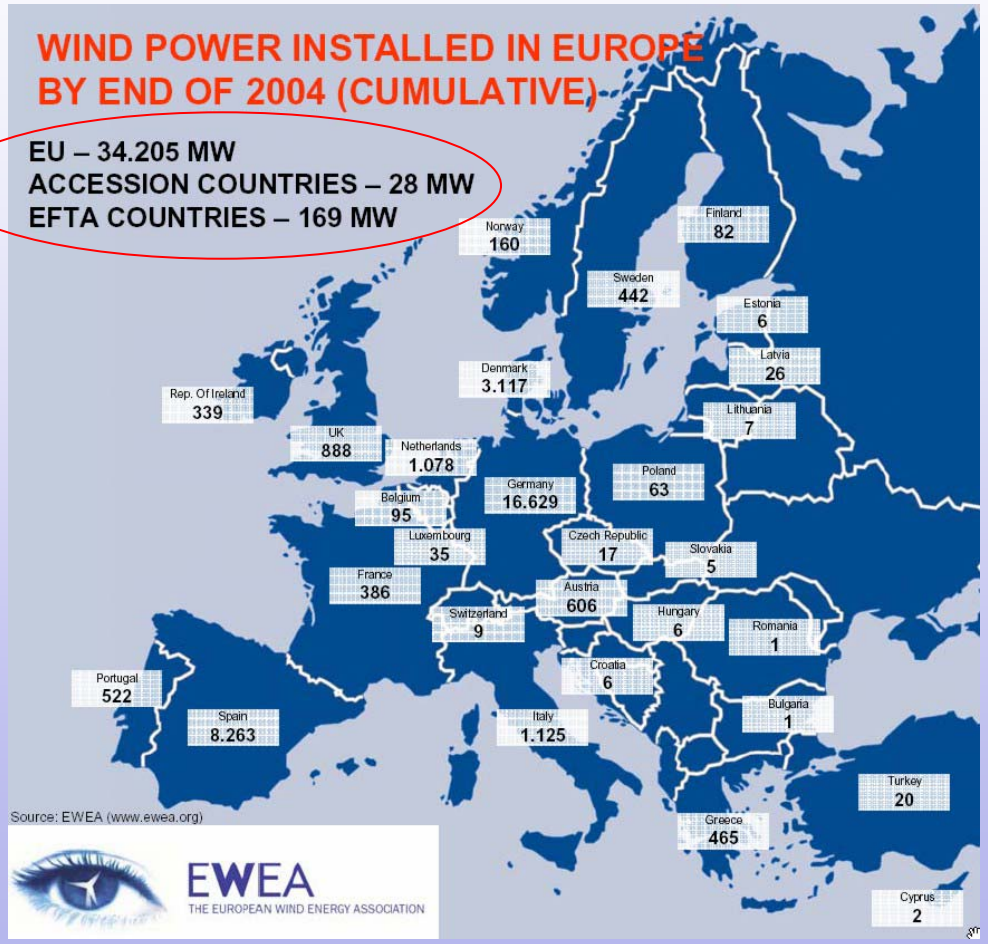
The Riisager wind turbine 1970's

Horns Rev (DK) 80x2MW installed 2002

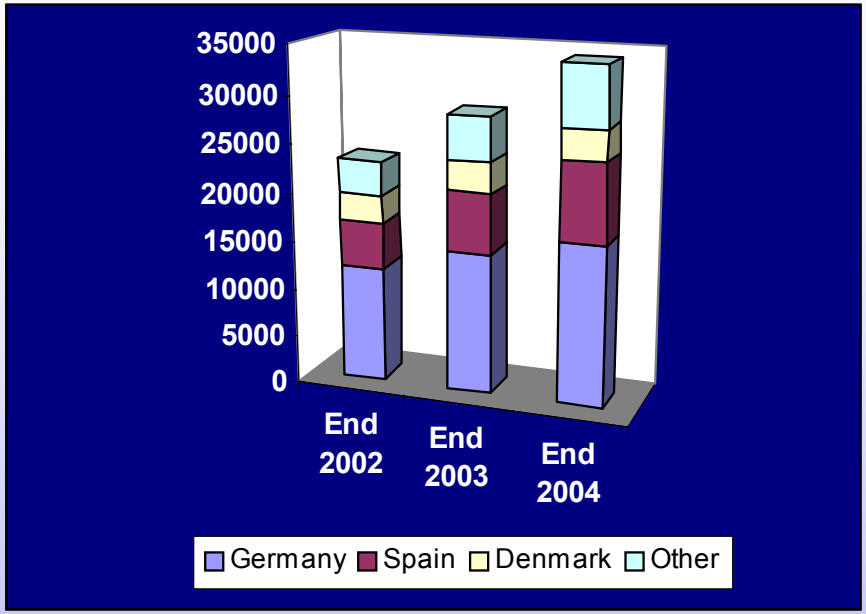
Today, wind power is a well established renewable energy source

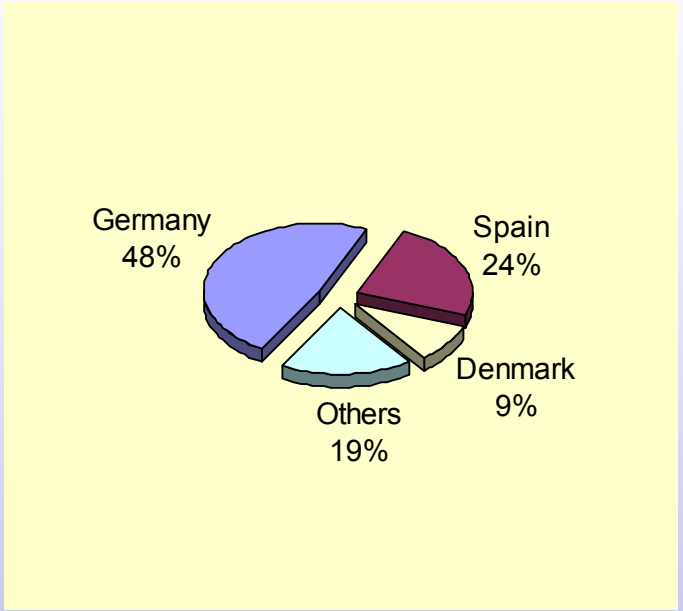
Installed Wind Energy in Europe Dec. 2004

Country	MW
Germany	16629
Spain	8263
Denmark	3117
Italy	1125
Netherlands	1078
UK	888
Austria	606
Portugal	522
Greece	465
Sweden	442
France	386
Ireland	339
Norway	160
Belgium	95
Finland	82
Poland	63
Luxembourg	35
Latvia	26
Turkey	20
Czech Rep.	17



Development in Total Installed Wind Power in Europe





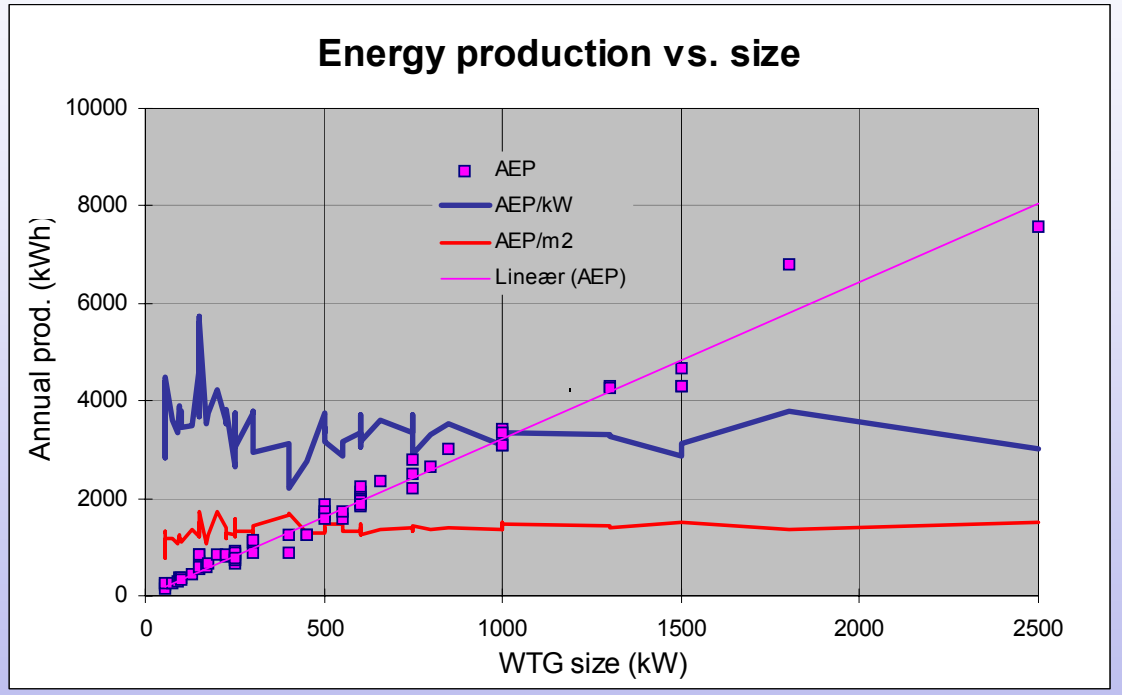
The 3 largest contribution countries are

GERMANY

SPAIN

DENMARK

Are large WTGs more effecient than small ones?

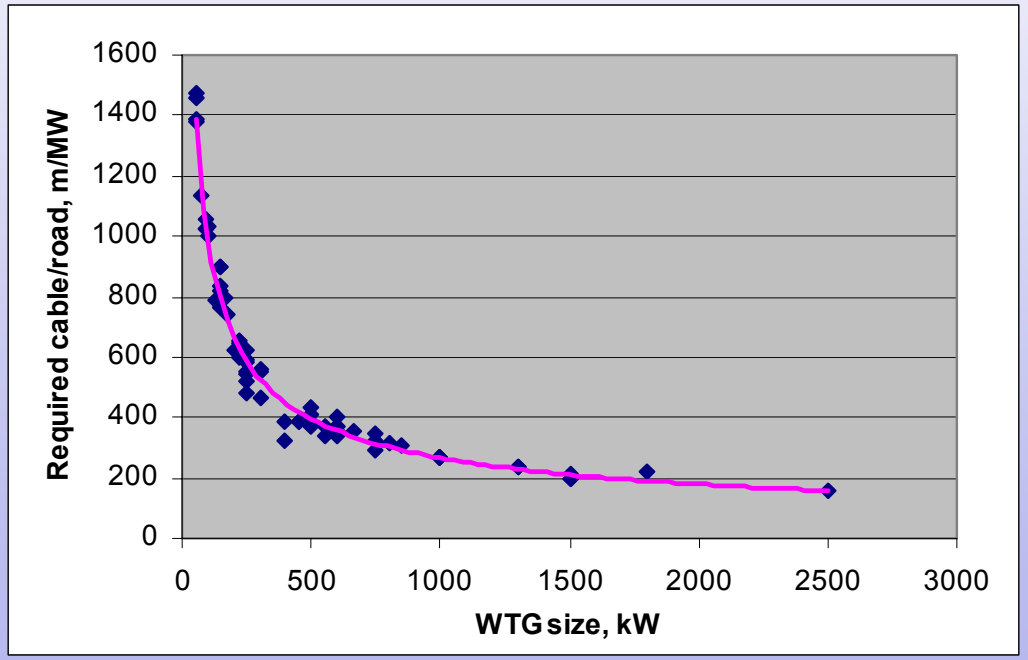


In general, the answer is NO!

Why large WTGs then??

Typically, a project will benfit form larger WTGs because:

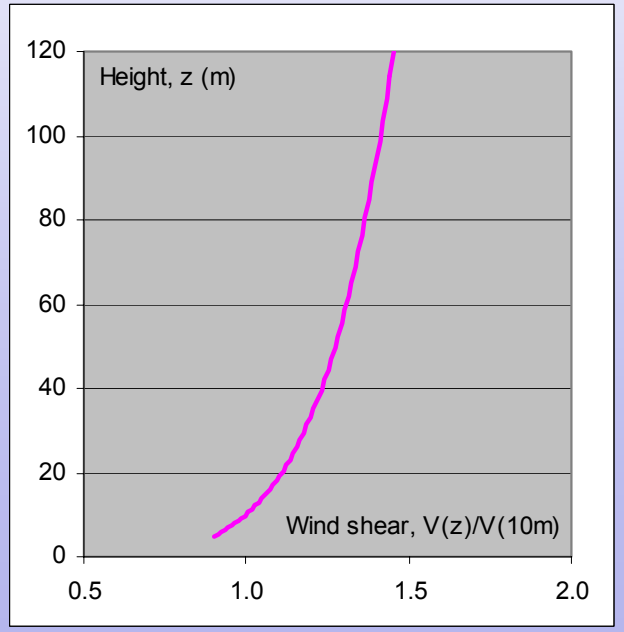
1. You need less km of roads and cables per MW

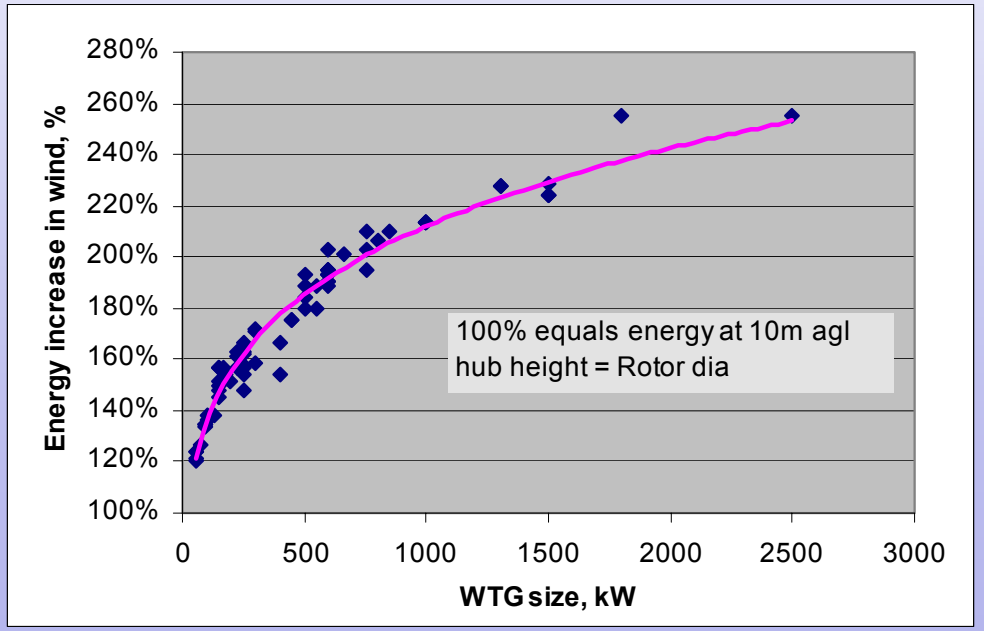


Why large WTGs then??

Typically, a project will benfit form larger WTGs because:

2. The wind energy increases with WTG hub height
   (due to wind shear.
   Hub height increases proportional to the square root of the WTG size)





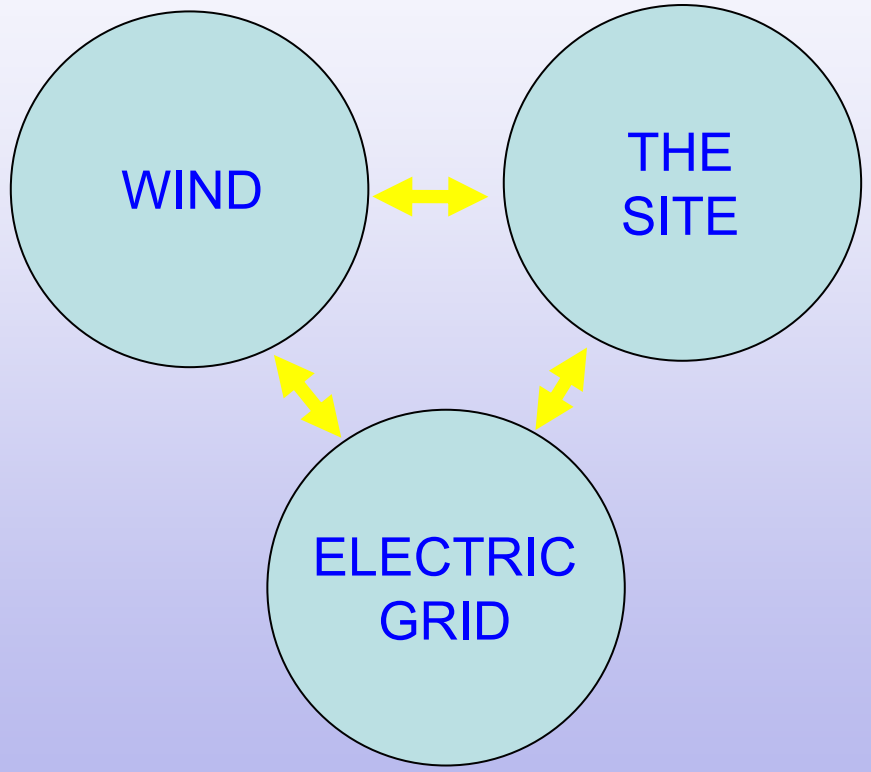
Why large WTGs then??

Typically, a project will benfit form larger WTGs because:

3. Newest technology, e.g. on power quality control

   By controlling the power quality and the reactive power it is possible to connect larger WTGs at the same grid interconnection point

Key Factors in Wind Power Plant Development



The Wind Resource

Important properties:

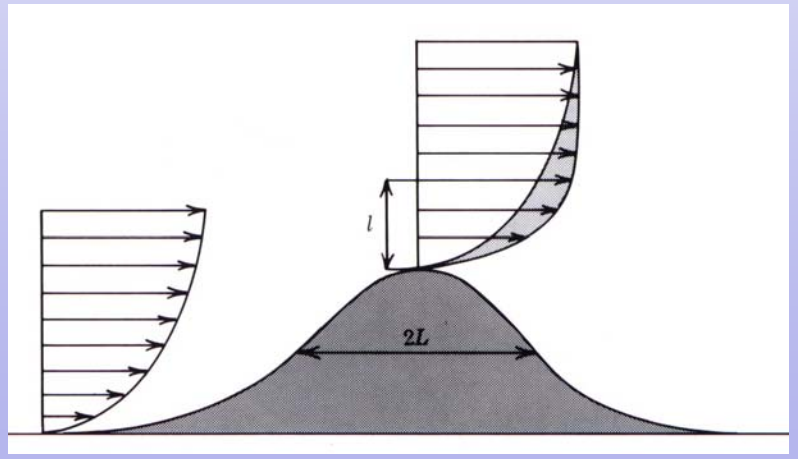
1. The power of the wind is proportional to the cube of the wind speed

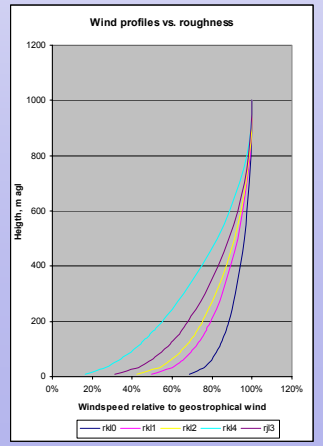
$$P = \tfrac{1}{2} \cdot \rho \cdot V^3 \cdot A$$

1. The wind speed increases with height (wind shear)

1. The wind speed increases over a hill

1. The wind speed at a given height is reduced over rough terrain





The Wind Study

A reliable and professional carried out wind study including high quality wind measurements is a crucial requirement when developing larger wind projects. Such work should be carried out by an independent consultant or institute with the necessary expertice. The wind study should include the following:

1. Identification of candidate sites and fact-finding work
2. Detailed assessment and roughess classification of the site
3. On-site quality wind measurements with calibrated equipment
4. Correlation to long term reference station(s) for long term scaling
5. Establishment of a long term wind atlas for the site based on a recognized flow model

The Site

The final selection of a site for a wind power plant is not only based on the wind study. Other important parameters are:

1. Sufficient land area available for a feasible project size
2. Access roads including roads for transportation to the site
3. Grid interconnection possible
4. Environmental constraints, e.g. wild life, recreative areas, noise etc.

It has become a standard requirement in most countries to submit an environmental study that includes both noise calculations and photorealistic visualisations of the wind turbines seen from different selected view points.

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Environmental Impact Study - noise

Case Study:

Ingham Consult has carried out an environmental study on noise for the Andmyran 200 MW wind farm (Norway). Based on the noise emmision data for the WTGs and the micro-siting, a noise level map was established for the planning application process.

Client: Andmyran Vindpark A/S.

Noise level map
Andmyran 200MW Wind Farm

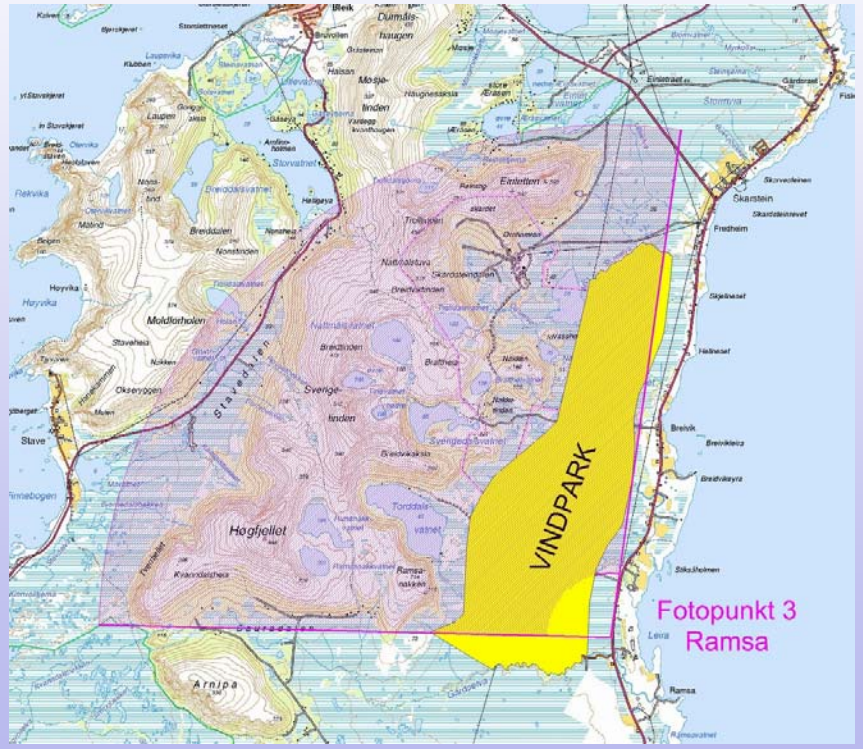
Environmental Impact Study – Visual impact

Case Study:

Ingham Consult has carried out a complete visualization study for the Andmyran 200 MW wind farm (Norway). For each of 5 view points selected for the planning application a visualization was carried out showing the WTGs

Client: Andmyran Vindpark A/S.

Andmyran Wind farm
camera position and sector



Generating the visualisation

First, the 3D-modelling is checked against the photo

200MW Wind Farm, Andmyran, Norway

Generating the visualisation

Then the WTGs are mounted in correct scale into the photo

200MW Wind Farm, Andmyran, Norway

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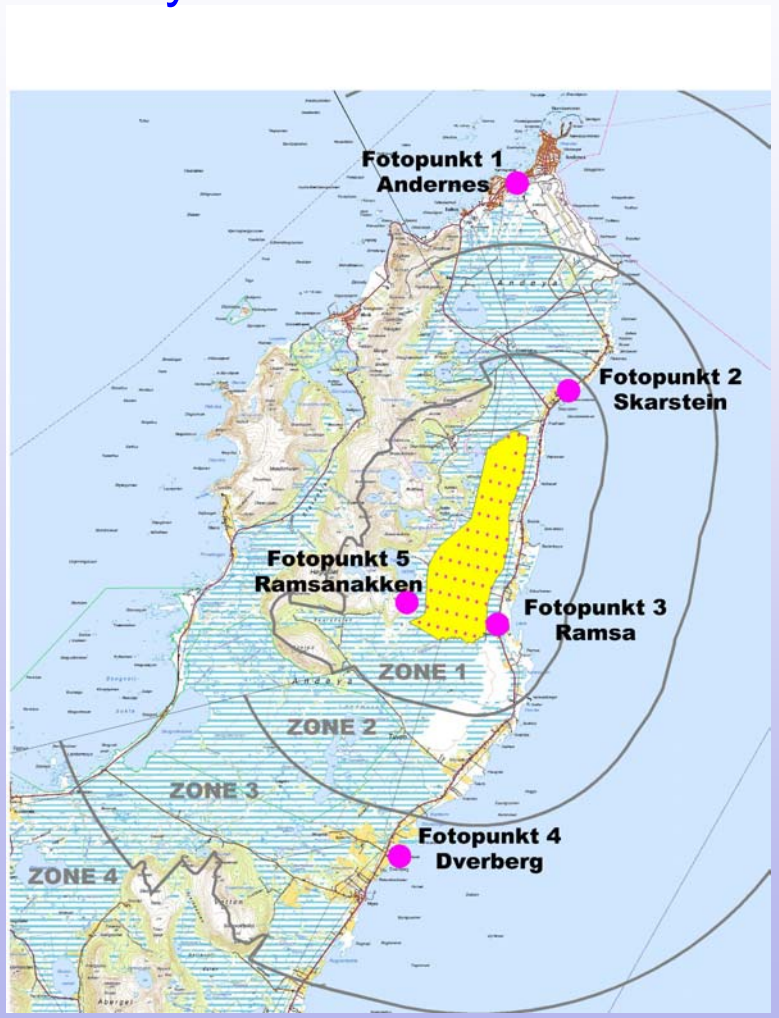
Zones of visual influence for Andmyran wind farm

Case Study

Ingham Consult has established a map showing zones of visual impactfor the Andmyran 200MW wind farm (Norway). The map was constructed based on the digital topography, the size of the WTGs and the micro-siting.

4 zones of visual impact were identified within 20 km from the project:

Zone 1: Dominant influence
Zone 2: Large influence
Zone 3: Small influence
Zone 4: Marginal influence



Electric Grid Interconnection

It is important at an very early stage of development to investigate the possibilities and requirements for interconnection of the wind farm to the grid. Even if a high voltage line is available close to the site, there might not be sufficient free capacity for the project. This has to be analysed by the client's electrical engineer in cooperation with the grid owner/operator. Losses have to be included in the net production calculations.

Total output and losses

Total gross Annual Energy Production (AEPgross):			139204.6 MWh/yr
Losses			
	Array losses	6.3 %	
	WTG performance (power curve)	2.0 %	
	WTG downtime	3.0 %	
	Losses in MV/HV grid and trafos	2.5 %	
	O&M downtime outside contract	1.0 %	
	Misc. Other losses	1.0 %	
	Total losses (by multiplication)	14.9 %	-20718.9 MWh/yr
Total Net Annual Energy delivered to the grid			**118486 MWh/yr**

Average net annual energy delivered per WTG	2236	MWh/yr
Average equivalent full load hours	1490	hours/yr
Average equivalent capacity factor	0.17	

END OF SESSION

THANK YOU FOR YOUR ATTENTION !

For further information or request for our assistance on wind energy projects,

please contact:

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phone: (+45)3066-0120 *mail@ingham.dk*