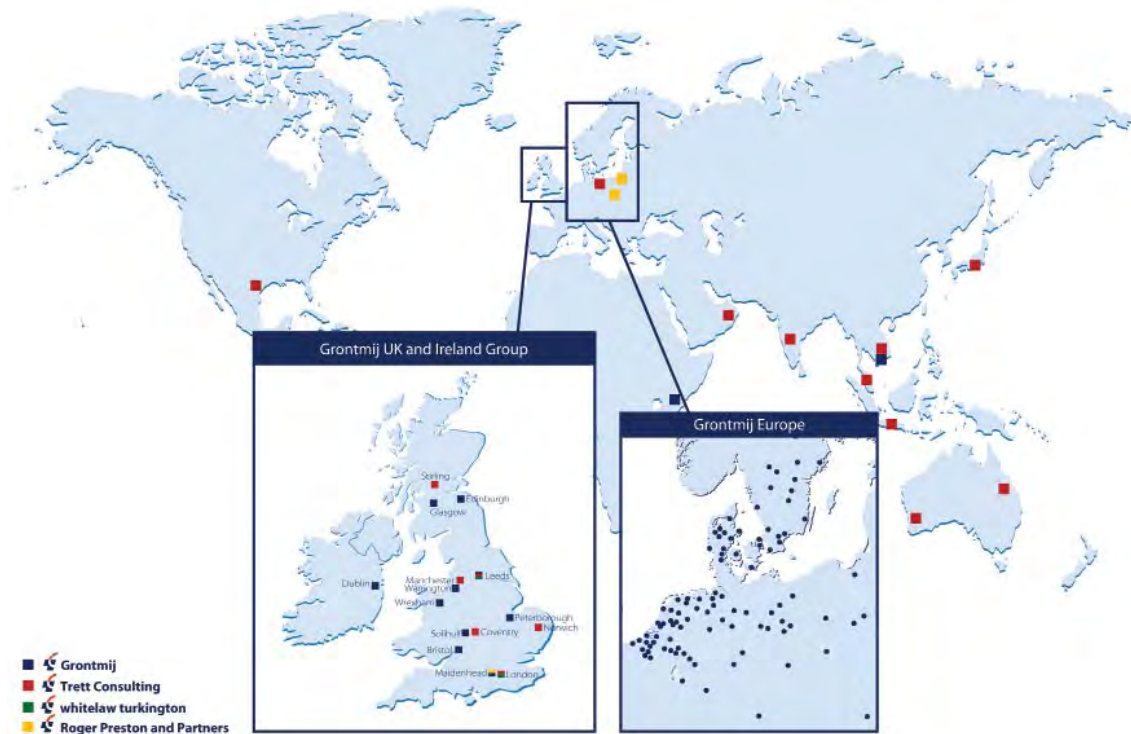


# Wind Power



# Introduction



**Grontmij is one of the leading engineering consultancies in Europe. The Group has offices located in the UK and Ireland, Holland, Denmark, Sweden, Belgium, Germany and Poland.**

## Structure

We provide consultancy services in the fields of water, built and natural environment, transportation, systems and energy and employ over 1,000 people in established offices throughout the UK and Ireland. This is complemented by access to a worldwide skills base as part of a group that employs 8,000 people. Our breadth and depth of knowledge across a number of market places and expertise areas enables us to provide a fresh approach and innovative solutions to common problems. Our structure, size and strength mean that we can deliver solutions

to your challenges on a local, national and international level.

## Acquisitions

We have expanded our portfolio of services in the UK through three important acquisitions. Whitelaw Turkington brings best-in-class landscape architectural capabilities to Grontmij. Leading commercial and contract consultancy Trett Consulting strengthens our core capabilities with high level expertise in dispute resolution and commercial and contractual advice. Also, Roger Preston & Partners, brings over 75 years of experience in sustainable building consultancy to the Grontmij group.

## Operation

Grontmij works with both public and private sector clients. The majority of our clients are

large undertakings with a statutory duty to provide high levels of service to their customers. This can include the provision of continuous improvements in efficiency and return on investment, achieving programmed targets set by regulatory authorities, and working to budget constraints imposed by regulators. An important aspect of our solutions is our ability to think of projects as a whole.

We believe that better results are obtained by going beyond narrow interdisciplinary boundaries and considering projects in a wider context. We work with our clients to ensure that the service we provide is tailored to meet their needs in the widest sense, providing the right technical solutions in the most cost effective manner.

# Culture

**At Grontmij, it's not just about what we can do, but how we do it. We place our clients at the very heart of what we do, and invest in our culture to support our client focussed approach to projects. We see this as an area which differentiates us in the industry.**

## Culture

We consider our most valuable assets to be our people and our clients, and the opinions of both groups are continually monitored and reported. We monitor our progress and

ensure that all views are listened to and understood. This produces an empowered and motivated team culture. As a result, putting the customer first is a way of life.

Many of our clients have come to rely upon us because of our quick response times, our flexible approach to problem solving, and willingness to work within integrated teams where each party can apply different and specific skills to the project at hand.

## Mission Statement

Grontmij always strives to be the best local service provider for consultancy, management, engineering and contracting in the building, infrastructure and environment sectors.

We create value for our clients and shareholders, and help to build sustainable living and working environments.



## Project feasibility and implementation

### Project development

Identification of the optimum site is a key parameter for successful wind farm development. Drawing on vast wind power experience and resources, Grontmij undertakes site selection investigations for both onshore and offshore projects.

Numerous technical parameters are evaluated to identify an ideal wind farm site. Grontmij provides an expansive range of services to optimise wind project development including feasibility studies, review of wind data and production estimates, site investigation evaluation of geotechnical properties and civil works. In addition, Grontmij can undertake the necessary reviews of interconnection to electrical transmission systems, evaluation of finance and compliance to joint implementation and clean development mechanisms.

### Project implementation

Grontmij has established a wealth of experience within energy and environmental planning. In recent years, Grontmij has focused on wind power and has developed an extensive portfolio.

With a vast range of competencies, Grontmij can provide clients with the essential services of project management and procurement planning. The consultancy can handle processes for prequalification, tendering, contracting and contract management. Services also cover the establishment and

management of training programmes and performance evaluations for personnel in operation and maintenance organisations.

Grontmij has project managed design and site supervision of various onshore and offshore wind farm developments.

### Incentive Mechanisms

Grontmij has extensive experience in identification and facilitation of grant aid assistance from the various government funding streams. In addition we identify and provide technical guidance in regards to the various incentive mechanisms available for the generation of renewable energy including the Renewables Obligation (RO) and feed in tariffs (FITs).

### Due diligence

Grontmij has been undertaking Technical Due Diligence (TDD) for several years for both onshore and offshore wind farm projects.

Vast technical know-how, extensive networks and local presence enable Grontmij to conduct TDD assessments at short notice and in accordance with local standards and regulations. Central to the TDD services is our combination of technical know how, regulatory insight and ability to quantify risks.

Grontmij's multi-disciplinary team consists of people from various professional backgrounds that can provide a high quality and professional wind power TDD service. In addition to engineers, we employ economists, biologists, geologists, computer scientists and legal experts.

## Foundation engineering and geotechnical investigations

### Technical basis

Each wind farm has specific geotechnical characteristics that provide unique challenges. Grontmij undertakes a technical site evaluation and thorough analysis to establish a basis for design of all structural works. Grontmij has leading expertise in evaluating loads from wind and additional load combinations from waves and ice on offshore units.

Grontmij established the design basis for the world's first large-scale offshore wind farm situated off the coast of Denmark. As a result of the knowledge gained from this, Grontmij was appointed by the Danish Energy Agency to specify the design rules for offshore wind farms.

### Structural design

Grontmij has leading expertise in wind turbine support structure engineering and soil mechanics. The consultancy can determine and evaluate loading from large wind turbines on foundations for onshore and offshore installations.

Drawing on extensive experience to develop innovative support structure solutions, Grontmij's resources include the latest computer technology which is utilised to analyse foundation designs.



### Geotechnical investigations

Grontmij has extensive experience within the design, procurement and management of intrusive investigation works and the preparation of factual and interpretative reports. The consultancy provides specialist services such as peat slip risk hazard assessments, turbine base geotechnical reviews, ground improvement advice and inspection / testing, earthworks slope stability assessment and stabilisation, mine working assessments and the development of remediation measures. Throughout these investigations, Grontmij applies a flexible approach ensuring the lowest possible cost without compromising quality. This is implemented by comprehensive supervision and continuous data evaluation followed by project adjustments. This allows Grontmij to control the investigations in detail and secure only the necessary information.

### Environment and authorities

#### Environmental impact assessment

Grontmij provides the full range of services for Environmental Impact Assessments (EIA) for single turbines and large wind farms. This is underpinned with experience in producing EIAs for both onshore and offshore installations in accordance with UK regulations, EU directives and recommendations made by the OECD / World Bank.

Grontmij's experience also includes the evaluation of noise and shadow flicker and biological studies to survey, analyse and monitor flora and fauna.

The consultancy's wind farm EIA team has specialist knowledge in undertaking modelling and evaluation of impacts of all hydraulic elements.

#### Noise and vibration issues

Grontmij undertakes noise prediction calculations, verifying measurements and noise declarations according to international standards. Based on years of practical experience, Grontmij has developed a dedicated system for the measurement and analysis of wind turbine noise.

### Wind power optimisation

#### Review of wind data and reduction estimates

By utilising Grontmij's vast experience and the latest computer modelling technology, the wind energy potential can be maximised by optimising wind farm layouts for both onshore and offshore projects.

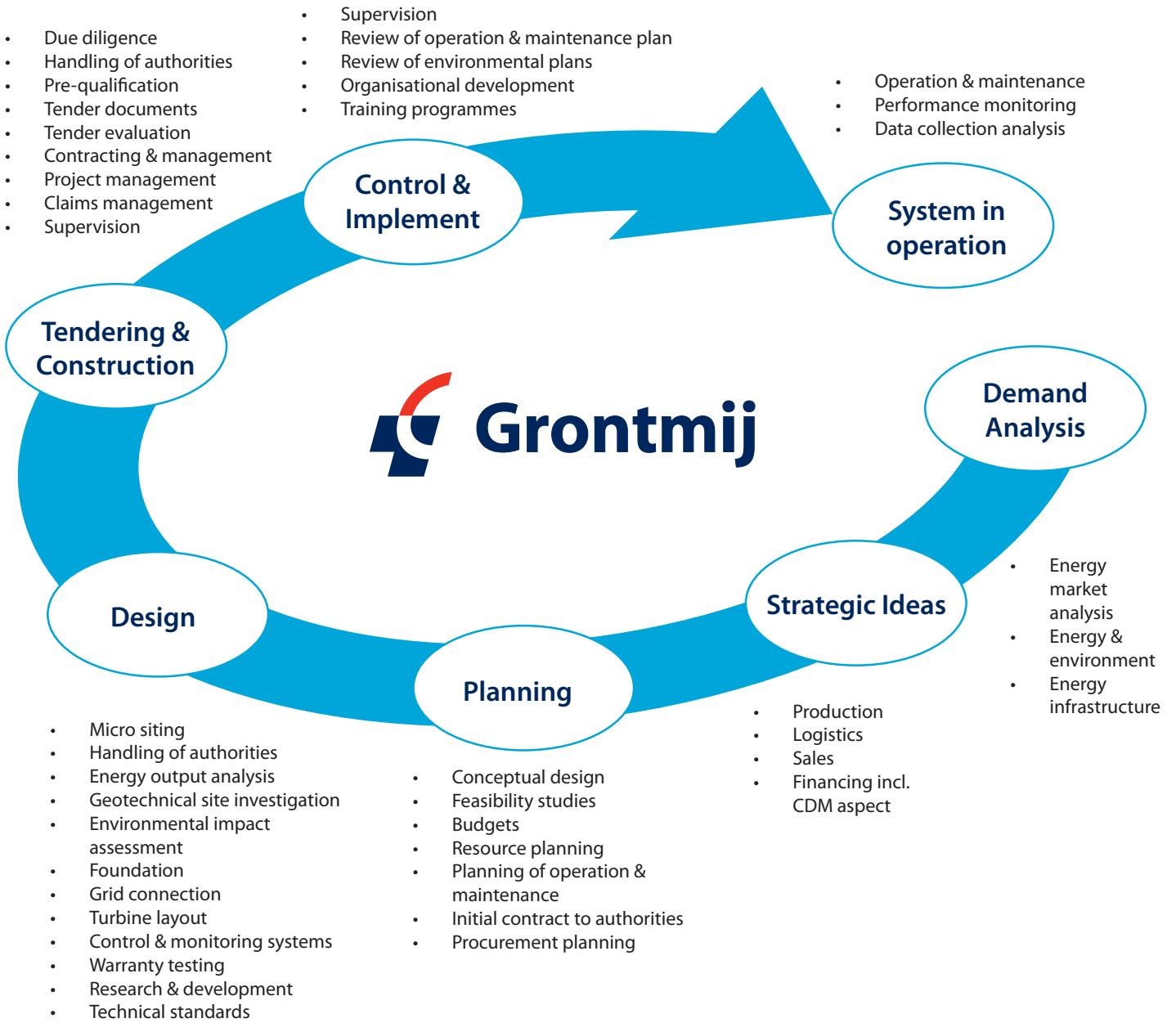
#### Grid connection

Achieving a wind farm's ultimate goal of generating and exporting renewable electricity requires careful network planning design and verification. Grontmij performs analysis of static and dynamic interactions between wind farms and power grids to establish the requirements of new plant.

Grontmij has many years of experience of power plants, installations and long distance onshore and offshore grid connections. The consultancy's comprehensive experience in the specification and tender document production for wind farm power equipment includes transformers, switchboards, cables and control equipment. Grontmij also evaluates hybrid and off-grid power systems for small scale wind farms and single turbines in remote areas.

#### Evaluation of turbines and warranties

Development, design, and manufacturing of wind turbines are influenced by the characteristics of the wind farm site. Grontmij participates in design and product development from manufacturing facilities to enable evaluation of vibrations of rotors and complete turbines in operation. The consultancy can advise on operational conditions and maintenance programs and conduct control, monitoring and warranty reviews of turbines prior to final commissioning and end of liability.



# Wind Energy Consultancy – Approach

Grontmij's approach to wind energy projects is to view the project in the context of a full project cycle, meaning that we look ahead to subsequent phases of the project whilst setting up the important milestones with corresponding success indicators and check-lists based on previous experience.

When we become involved in renewable energy projects, we recommend identifying and addressing the various risks involved throughout the project cycle. We will consequently put strong emphasis on this aspect in our approach and methodology for the execution of such projects.

The simplified project cycle below illustrates the various logical steps of the project from idea to commissioning and commercial operation with the appropriate milestones for control and re-consideration.

This model is simplified and does not illustrate important aspects such as authority permission processes and environmental impact assessments. It does however illustrate a number of important points concerning controlled project development.

The technical feasibility is an essential factor in the decision to proceed with the project whilst the financial viability

is highly dependent on the regulatory framework governing wind energy, and thus an issue. Compared with conventional power generation the financial cost of producing electricity from wind power systems is relatively high, but the resulting economic and environmental benefits are correspondingly high. The political issue is how to include the economic benefit in the power purchase agreement between the owner of the wind energy installation and the purchaser of the produced power.

A pre-feasibility study will give an overview of the technical feasibility and financial viability of the wind energy project in order to make a decision on how to proceed. If the pre-feasibility study indicates that wind energy could be utilised, it will be necessary to examine the feasibility of the project in detail with emphasis on the barriers identified during the pre-feasibility study.

The main issues to be addressed in a wind energy assessment (point one and two in the project cycle) are:

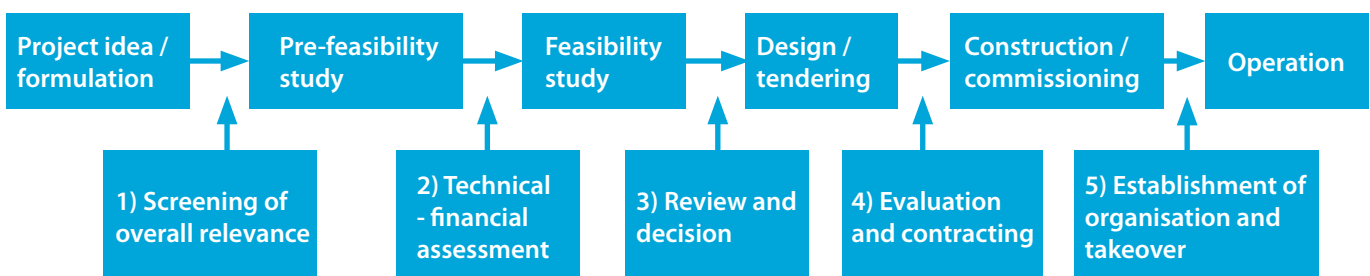
- Whether wind conditions are suitable for wind turbines with sufficient production potential for commercial exploitation
- Whether local infrastructure

components, such as grid connection and access to the site, are suitable for the erection of an on-shore wind energy system

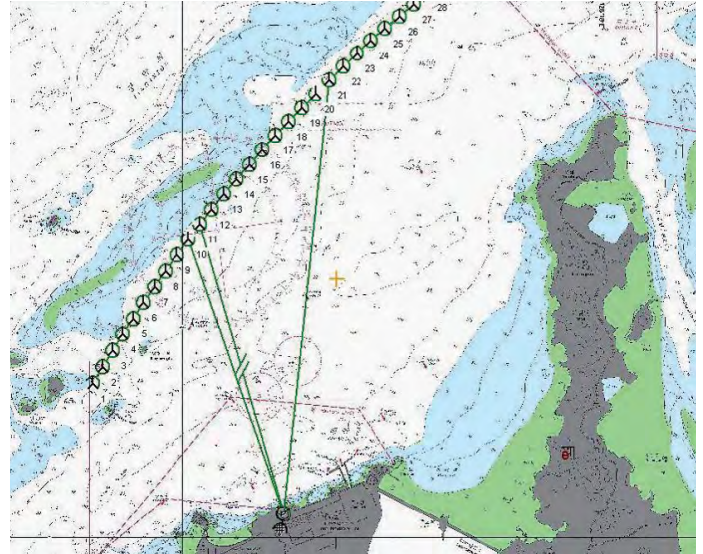
- Whether the project represents a favourable investment opportunity based on present tariffs and known financial conditions together with experience from similar projects
- Project potential as a CDM-project thus benefitting from the sales of certified emissions reductions such as Renewable Obligation Certificates (ROCs)

Based on the outcomes of this assessment, the project owner should decide whether to proceed with supplementary studies and / or a specific feasibility study comprising the design of turbines, detailed cost estimates, financing etc.

## The project cycle



# Electrical Power Management



The contentious interest in climate change and renewable energy has created exciting challenges regarding the preparation, planning and implementation of renewable energy sources and sustainable development. High level knowledge and experience in electrical power integration and how new sources influence the grid system and energy markets has an essential role to play for completing sustainable, energy efficient solutions.

Grontmij provides consulting in the fields of power and energy.

- Electricity planning
- Operation and design
- Wind power
- Energy markets

- Energy efficiency
- Power generation

Our know-how includes all phases of a wind energy project from planning to implementation, detailed design, inspection and supervision. Our client base includes energy producers and suppliers, industrial users and authorities from all over the world. We have completed international projects for the World Bank, European Bank for Reconstruction and Development, Sida, EU-Phare, EU-Tacis, EU-ALURE, EU-ALA, etc.

We combine the latest tools, experience and knowledge to find the most suitable solution for our client. We provide consulting services within the following areas:

- Rural and urban power distribution systems
- Grid connection of wind farms, onshore and offshore
- Hybrid systems, off-grid solutions such as combined wind and diesel power systems.
- Power transmission networks and substations
- Power system analysis and operation
- Power generation plants
- Energy market analysis, including analysis of electricity and load forecasting.
- Energy utilisation, including energy savings
- Energy system analysis
- Operation and maintenance

## Grid Connection Study of Wind Farms



Grontmij is one of the leading consultancy companies within wind power offering professional services in all aspects of planning design and implementation. When establishing a wind farm, a series of network planning, design and verification must be performed. It is important to perform the necessary preliminary studies and simulations, before connecting wind farms to the grid system. The simulation of the wind farm interaction with the grid system provides valuable information on the wind farm's influence on the grid system and identifies suitable electrical components for the grid connection. This is essential to determine the optimal grid connection and also lowers costs.

We have a wide range of experience in the different simulation tools for grid analysis widely used by power system utilities and operators. Our simulation tool experience includes Digsilent Power Factory, PSS/E, NEPLAN and E-Grid Wind Pro allowing us to determine the following:

- Basic design and concepts for grid connection
- Load flow calculations
- Short circuit calculations
- Power quality and stability analysis



The purpose of Environmental Impact Assessments (EIAs) is to generate the information required in the decision making process. This allows for the adaptation of the original wind energy project plans and designs as well as the identification of potential additional measures to mitigate and compensate for negative environmental consequences.

Though national variations exist, the legislative framework of EIAs is based on the EU EIA-directive in most European countries. The principle topics that need to be examined in an EIA are therefore usually well-defined. However, the physical characteristics of wind turbines and wind farms traditionally result in the EIAs focusing on certain topics. These usually include:

- Visual impacts
- Fauna - mainly disturbance/collisions in relation to birds/bats
- Noise
- Shade flickering

The full EIA includes screening and scoping phases, EIA, environmental impact statement and monitoring programmes.

For most countries, the screening phase involves a brief enquiry by the authorities to determine whether an EIA is required. The remaining issues are usually work delivered by the project makers and their consultants, although prepared in close co-operation with the authorities.

## EIA - a Multi-Disciplinary Task

Grontmij has many years of expertise in EIAs for both offshore and onshore wind farms. We have been engaged in work ranging from the development of manuals for EIAs for wind turbines on behalf of the Danish Energy Agency to highly specialised research and monitoring programmes to determine the risk of collision with birds.

We have leading expertise within:

- Noise evaluation
- Advanced laser and radar studies of migrating birds
- Assessing impacts on fauna, in particular in relation to effects on fish, mammals and benthic fauna and disturbance and risks of collision with birds. This includes defining terms of reference for the EIA and monitoring programmes as well as conducting and reporting field work
- Assessment of visual impacts of wind farms including visualizations
- Hydraulic modelling and evaluation including spill and impacts on current flow during construction phases

From our engagement in many different projects and at various levels, Grontmij has gained extensive experience in managing the dialogue on EIAs and related issues concerning wind farms with the aim to promote the interests of both authorities and project makers.

## Selected References (full EIAs)

### Onshore projects

- Egypt, EIA and advanced laser and radar bird migration studies for 120–360 MW onshore wind farm
- National test station for large wind turbines (EIA)
- Aeroe wind farm, EIA on a 5-10 MW project
- Vognkær, EIA on a 10-13 MW project

### Offshore projects

- Avedøre Holme, offshore test wind farm
- Frederikshavn, offshore test farm (compiling EIA)
- Rødsand 2 wind farm compiling EIA on a 215 MW project
- Horns Rev 2 wind farm, compiling EIA on a 215 MW project
- Rønland wind farm, EIA and following 2-6 years' surveillance programmes on impacts on flora and fauna – 20 MW project
- Grenå wind farm, EIA on a 5-16 MW project
- Nysted wind farm, compiling EIA on a 150 MW project.
- Omø Stålgund wind farm, compiling EIA on a 155-240 MW project

# Operation and Maintenance



Our team of experts have decades of experience with operation and maintenance of wind farms worldwide. Grontmij performs independent review and inspections of wind turbines and wind farms in order to:

- Identify potential technical problems.
- Optimise operation of the wind turbines.
- Technical due diligence inspections.

Selling and purchasing plants as well as insurance conditions may call for a detailed determination of the plant condition.

Our team handles foundation, electrical and mechanical parts of the plant with an experience based on numerous inspections of wind power plants in Denmark, UK, China and Sweden.

We can identify possible operational problems in wind turbines and assess performance of the wind turbines and the Operation and Maintenance (O&M) organisation.

We also perform planning and tendering of O&M in offshore wind farms. We provide consulting services within the following areas:

## Consultancy Services

- Warranty operation and maintenance agreement (WOMA)
- Service agreement – tendering and negotiations
- Gearbox inspection and analysis
- Review and inspection
- Boat service planning and contracting
- Technical due diligence inspections
- Investigations, analyses and troubleshooting

## References:

- Post construction evaluation of six wind farms in China 2009
- Middelgrunden offshore O&M expert assistance 2001-2009 – including management of 5-year review on foundation and offshore transformer exchange
- Middelgrunden 20 x 2 MW
- China 80 x 850 kW and up to 1500 kW
- Sweden 100 x 600 kW and up to 1500 kW



## Project References

## Offshore Wind Accelerator Foundations in Deeper Water, UK



**In 2009 the Carbon Trust is launched a major new Technology Accelerator initiative focused on reducing the cost of energy (£/MWh) from offshore wind energy by 10%+. The Offshore Wind Accelerator (OWA) and will fund large-scale Research, Development and Demonstration (RD&D) projects to unlock technological barriers to advance the industry and thereby accelerate its development so that significant carbon emissions reductions are achieved.**

Offshore wind farms to date have been predominantly constructed using either concrete gravity bases or monopile foundations. These structures are considered too expensive for the deeper water projects, particularly those which The Crown Estate will offer in Round 3 (and beyond). Project Beatrice is the first UK wind farm installed in 40m water depth and uses a steel jacket quadrupled foundation which is not commercially viable at present. The development of cost effective foundations, suitable both technically and commercially for the physical conditions likely to be encountered on Round 3 projects, is therefore needed in order to improve the economic viability of large scale offshore wind projects.

This OWA project will demonstrate the viability of (a number of) deployable new generation foundation(s), that will enable economic operation of deeper water wind farms at depths of both 30-45m and 45-60m. Viability will be judged in terms of potential for volume fabrication, installation, maintainability, supply chain opportunities and operability.

### Services

Project manager on the program Offshore Wind Accelerator (OWA), offshore foundations.

Foundation concept competition

Development of 5-8 new platform concepts on 30-60 meter water depth

Review of foundation concepts from 5-8 consultants / contractors

Make plans for tests of some of the concepts

Development of site assessment and design basis

Confirm and detail the work plan / Gantt

Advise customer on eliminating / proceeding with designs

Advise customer on issues that might arise with concept verification

Negotiate with Crown Estate on the provision of a Round 3 demonstration site

Ensure project is run on time and budget

Develop and run the concept competition

Create a standard response format and criteria for the design competition

Develop and apply generic site data for initial concept screening

Contract development support for concept designs where required

Provide funding to designers where required

Gather and synthesise data on OWA sites selected from OWA partners

Advise customer on final selection process

### Client

Carbon Trust in corporation with Airtricity, DONGEnergy, RWE Innogy, Scottish Power and Statoil/Hydro.

### Date

2009 - 2010

## Ardrossan On-Shore Wind Farm Extension



**Grontmij with RJ McLeod Contracting Limited prepared an integrated and robust range of civil and structural engineering solutions to address the variable site constraints.**

With an extra three turbines, bringing the total to 15, the extended Ardrossan Wind Farm will generate 30MW of green electricity, enough power for 18,750 homes. This will help to tackle climate change by reducing carbon dioxide emissions by approximately 85,000 tonnes per annum.

Grontmij as design partner to RJ McLeod contracting undertook detailed geotechnical and structural assessment and modeling works to optimise turbine foundation arrangements, allowing more conventional gravity foundation solutions to be developed.

Through working closely with our contractor, client optimised access track and erection platform arrangements are being developed to suit the underlying ground conditions and topographical constraints.

Grontmij's geotechnical engineers will be working closely with the site construction team to advise, inspect and test turbine formation levels prior to base construction as part of construction quality assurance works.

Through liaising with Airtricity's wind farm operator and our contractor clients electrical sub-contractor, the sub-station extension arrangement was configured to suit the specific operational requirements of the wind farm developer. Whilst minimising interfaces with the existing wind farm, this will remain operational during the construction of the extension works.

### Services

Detailed geotechnical assessment works

Design & detailing of turbine foundations

Design & detailing of sub-station extension

Obtaining building warrant

Catchment assessment and culvert crossings

Formation inspection and testing works

Development of internal access track and erection platforms

Technical support during construction

### Client

RJ McLeod Contracting Limited

### Date

2008 - Ongoing

## Earlshaugh On-Shore Wind Farm



**Grontmij offers a full spectrum of multi-disciplinary skills to deliver to the specific requirements of the client, the detailed development of on shore wind farm site arrangements from planning application design to detailed design and construction.**

Earlshaugh wind farm is a proposed 108MW wind farm potentially featuring up to 363MW turbines located within the Tweedsmuir Hills near Moffat within the Scottish Borders.

Grontmij worked in a technical advisor capacity as part of a large multi-disciplinary team providing infrastructure design and construction advice. This was as part of the projects Environmental Impact Assessment (EIA) and planning application submission.

Grontmij's early involvement allowed us to work closely with the wind farm developer to initially refine turbine locations to avoid areas of 'significant' peat slip risk hazard and also ease construction whilst maximising power generation. Access track geometrical arrangements and a suite of solutions were developed through extensive field works and liaison with the construction and environmental team.

Geomorphological and topographical survey works allowed borrow pit locations to be identified and sized following earthworks quantification and construction operation sequencing. Restoration profile arrangements were developed with the landscape and visuals team.

Access tracks were positioned to minimise the number of water-course crossings across the highly sensitive water course tributaries. Bridge and culvert crossing arrangements were developed with special consideration to the sensitive nature of these receptors.

We attended public consultations and various design team workshops in a technical advisor capacity.

Grontmij used its extensive experience in design and construction within the wind farm industry to prepare a detailed 'design and construction method statement' document with supporting detailed arrangement and drawings to compliment the planning application document.

### Services

- Peat slip risk hazard assessment works
- Development of site access track arrangements
- Borrow pit identification, sizing and restoration profiles
- Turbine foundation and erection platform configurations
- Earthworks material quantification
- Catchment assessments
- Water-course bridge and culvert crossing proposal
- Design and construction method statement preparation

### Client

Wind Energy Limited

### Date

2007 - 2008

## Kilbraur On-Shore Wind Farm



**Grontmij with RJ McLeod Contracting Limited prepared an integrated and robust range of civil & structural engineering solutions to address the variable site constraints.**

Kilbraur Wind Farm is a 47.5MW wind farm featuring 19 2.5MW turbines, which, when constructed, will supply electricity for 27,000 homes and displace up to 107,000 tonnes of carbon dioxide each year.

Grontmij as design partner to RJ McLeod and Nordex Energy AG, provided detailed design and technical support during construction, which involved the reinforced concrete gravity foundations for submerged and drained ground conditions, developed internal access track and optimised erection platform configurations considering the underlying ground conditions and site topography.

Through working closely with our contractor client, we undertook detailed geotechnical assessment works and turbine base formation inspection and testing works as part of construction quality assurance works required by Nordex Energy AG, the wind turbine supplier.

In addition, Grontmij provided reactive peat slip risk hazard assessment and mitigation solution works as construction works proceeded.

Turbine erection works progressed in late 2007 with the wind farm feeding electricity into the National Grid during early 2008.

### Services

Design / detailing of RC turbine foundations.

Development of access track & erection platform arrangements

Peat landslide hazard assessment

Turbine base formation inspection / verification

Water-course catchment assessment & culvert sizing

Providing technical / geotechnical support

Preparing as-built drawings / inspection records

### Client

RJ McLeod Contracting Limited

### Date

2007 - 2008

# Pates Hill On-Shore Wind Farm



**Grontmij has significant experience within the design, procurement and management of ground investigation works for wind farm applications. We cover a full spectrum of skills to meet the specific requirements of the site.**

Pates Hill wind farm is a proposed 14MW wind farm featuring 7 2MW turbines located approximately 1.4km to the north of Woolfords in West Lothian, Scotland.

The site is situated within the commercial spruce forest which once formed parts of land occupied by the now abandoned Harwood mine.

Low pressure, tracked rotary core drilling plant was used to gain access across the site to the seven turbine locations.

Grontmij's mining desk study identified the presence of recorded deep mine working and the potential for un-recorded shallow workings in coal and limestone seams, as well as recorded mine entries on the site.

Grontmij's field work was targeted to investigate the potential of shallow mine workings beneath the seven turbine locations, confirm rock head levels and assess rock quality for foundations.

In addition, colliery waste on site was investigated for re-use within the proposed internal access track construction and as a founding medium for control building foundations. Peat probing was undertaken to characterise the thickness and extent of peat deposits.

A suite of geotechnical and chemical testing was undertaken to obtain geotechnical parameters for design to assess the potential aggressive nature of colliery spoil ground and water quality across the site.

Grontmij prepared interim, final interpretative and factual ground investigation reports, including; recommendations for additional ground investigation works given presence of recorded mine-workings and at some locations a high risk of un-recorded workings.

Also provided were outline design guidance for internal access tracks, turbine foundations and control building.

## Services

Mining desk study

Geo-environmental desk study

Design, procure and manage ground investigation works

Preparation of interpretative mining report

Preparation of interpretative geotechnical report

Preparation of contamination assessment report

Provide advice of WTG foundation solutions and site earthworks

## Client

Your Energy / New Lives  
New Landscapes

## Date

2007 - 2008

## West Durham On-Shore Wind Farm



**Grontmij with Hanson Contracting Limited, prepared an integrated range of robust and flexible foundation solutions to address the variable ground condition constraints within this former open cast mine site.**

West Durham wind farm is a 24MW wind farm featuring twelve 2MW turbines, which, when constructed, will supply electricity for 13,400 homes, making a significant contribution to the North East's green electricity targets.

The wind farm is located near the village of Tow Law; in an area where both open cast and underground mining have been undertaken in the past, creating interesting foundation design challenges for Grontmij's design team. Through working closely with our contractor client, turbine supplier and pile foundation sub-contractor, Grontmij has developed innovative foundation solutions which feature the use of driven steel tubular piles. These will be installed to depths of 20m through the open cast back fill.

Cost effectiveness, robustness and buildability in such variable conditions were key considerations within the foundation designs.

A folio of typical access track construction and turbine erection / piling platform details to facilitate construction traffic and turbine component delivery and erection, were also developed for the variable ground conditions.

Through a detailed mining study and additional ground investigation works, Grontmij was able to propose micro re-siting of turbines to effectively move some turbines away from the open cast mining back-fill; simplifying the design and detailing of wind turbine generator foundation design works.

Grontmij has maximised value for money by producing the optimum civil and infrastructure design solutions for our contractor client.

### Services

- Mining study
- Ground investigation design and supervision
- Shallow mine-working grouting works
- Gravity and piled turbine base design
- Control building design and detailing
- Public highway access junction designs and approvals
- Internal access track and erection platform configurations
- Turbine base formation inspection and testing works
- Technical support during construction

### Client

Hanson Contracting Limited

### Date

2007 - Ongoing

## Earlshaugh Wind Farm: Peat Landslide Hazard Assessment



### **The detailed assessment of peat slope behaviour is considered an essential element of the environmental statement for wind farms in the United Kingdom.**

Earlshaugh wind farm is a proposed 108MW wind farm located within the Tweeddale Hills, near Moffat within the Scottish Borders. If constructed, the 36 wind turbine site will supply electricity for over 70,000 homes.

The detailed assessment of peat slope behaviour is considered an essential element of the environmental statement for wind farms in the United Kingdom.

Grontmij undertook a qualitative site specific assessment of peat slope stability at each of the 36 proposed turbine locations, at all access track corridors and at the proposed borrow pit locations.

The assessment considered the impact of likely earthworks and construction operations on existing peat slope stability. In addition, key consideration was given to the potential effects of a peat landslide event on the environment across the site.

The 'hazard ranking' approach proposed within the Scottish Executive (2006) guidelines was used within the assessment.

Through Grontmij's approach and through consultation with Wind Energy (services) Ltd, the targeted relocation of turbines and modifications to internal access track routes was undertaken to reduce localised hazard rankings and allow the development of targeted design mitigation measures.

### Services

Desk study

Qualitative site specific assessment

Design, procure & manage intrusive investigation works

Slope stability analysis

Review of construction impacts

Hazard and risk ranking works

Development of mitigation measures

Preparation of peat landslide hazard assessment report.

### Client

Wind Energy (Services) Ltd

### Date

2007

## Rødsand 2 Off-Shore Wind Farm



**Rødsand 2 Offshore Wind Farm is situated in Denmark, south of the island Lolland , approximately 3 km west of Nysted Offshore Wind Farm. Grontmij is consultant to the site owner E.ON.**

The project consists of:

- 90 pcs. SWP 2.3MW, total 207MW
- Gravity based concrete foundations from Aarsleff Bilfinger JV
- Internal MV electrical grid is supplied by NSW
- Wind turbines installed by A2SEA
- Substation and grid to coast contracted by Energinet.dk

Sea depth is 6-12m sea bed consists of clay till. Offshore works were initiated in August 2008 with pre-trenching for cables. Foundation manufacture in Poland started in January 2009. Dredging for foundations started January 2009. Commissioning of wind farm with 207 MW in operation will be the end of 2010.

### Services

Consultancy and basic design for wind farm owner during tender and production period. The services include:

EIA presentation at public meeting and assistance in adapting project to public comments on EIA

Preparation and initialization of compensation negotiations with Danish Fishermen's Association

Layout optimization of wind farm including production prediction, screening of geotechnical information and grid cost evaluation

Basic design of inter turbine grid connection

Offshore sub station:  
Interface planning and negotiation between owners of 36KV system and 132KV system

Planning and supervision of complete geotechnical investigations including laboratory testing for 90 wind turbines

Tender assistance for wind turbines, foundations and grid

Site assessment and design basis for foundation (incl. DNV certification)

Study of collision friendly foundation design

Planning of construction site in Rødby and Nyborg

Review of contractors detailed design of foundations

Interface management

### Client

E.ON Vind AB

### Date

2007- Ongoing

## Taeon Off-Shore Wind Farm, Korea Feasibility Study



### **Taeon Offshore Wind Farm is located 6km off the western coast of South Korea.**

The republic of South Korea has a long developed onshore wind farm program, and the first offshore wind farms are now under preparation. The company IREE has been awarded consent by the ministry to prepare a 200MW offshore wind farm off Daesan Hang, in southwest of Seoul.

During 2008, Grontmij prepared a feasibility study. This included assessment of possible tidal power technology and suction-bucket technology. Meteorological masts were installed. Preliminary wind farm layouts and production estimates were provided. The layout considered production, visual aspects, geotechnical situation, grid connection, environmental issues and navigation.

### **The wind farm area**

The area is a scenic cliff coast with resort areas. The whole coastline suffered under an oil tanker spillage in Autumn 2007, but there is strong local political support for a wind farm project. Wind and wave conditions in the area are modest.

### **Foundations**

Geotechnical properties are challenging with water depths of 10-30m and additionally 10-20m of mud or soft clay. Feasible foundation types are concrete gravity based or steel mono-piles, though there is also a local know-how with suction-buckets for bridge construction.

### **Electrical interconnection**

There is a 3500MW coal-fired thermal power plant located at the shore with interconnection to the national 345KV transmission system. Interconnection to the electrical transmission system is therefore feasible, even without an offshore transformer platform.

### **Environmental study**

The primary areas of possible concern are related to: fishing, navigation, resting birds, visual impacts and recreational activities.

Planned installation: After 2010.

### **Services**

Feasibility study, including:

EIA-input and authorities issues

Wind farm layouts for different site locations and installed capacity

Assessment of geotechnical properties

Assessment of design basis

Grid connection

Assessment of foundation concepts, including suction type designs

Types of wind turbines

Operation and maintenance aspects

Economics and risks

Assessment of a hybrid tidal power system

### **Client**

I'REE

### **Date**

2007 - 2008

## Kriegers Flak Offshore Wind Farm, Sweden



### Services

Foundation design basis

Sediment spill assesment  
for concrete foundations

Tender preparation for  
geotechnical investigations

Contract preparation for  
geotechnical investigations

Supervision of geotechnical  
investigations

### Client

Vattenfall

### Date

2006 - 2010

**On the Swedish part of the site "Kriegers Flak" the power company Vattenfall is planning a 640 MW offshore wind farm constituting 128 pieces of 5MW turbines. The water depths on the site vary between 15 and 42m.**

Grontmij has provided permanent staff for preparation of design basis for foundations of the offshore wind farm. The services provided include evaluation of wave, current, tide and surge as well as evaluation of ice. Further load combination evaluations including wind turbine loads were carried out. The evaluations lead to prediction of loads for different foundation structures. Grontmij also provided assistance to writing of the design basis according to IEC61400-3 and DNV-OS-J101.

A spill assessment for possible future implementation of concrete foundations was prepared as an amendment of the environment impact assessment in order to open the possibility of using concrete foundations.

For the offshore geotechnical investigations, Grontmij has provided several services. Initially a geotechnical baseline had to be provided in order to plan and optimise the future geotechnical investigations that would be deemed necessary. Grontmij evaluated existing geophysical and geotechnical data and planned an additional geophysical investigation and the full geotechnical investigation. The detailed geophysical and geotechnical evaluation planned by Grontmij resulted in a substantial reduction of the initially planned necessary number of borings and CPT – and a substantial reduction of the budget.

In order for the client to tender for contractors for the geotechnical investigations, Grontmij prepared pre-qualification and tender documents for international tendering in accordance with EU rules and based on FIDIC. Following the evaluation, Grontmij (on behalf of Vattenfall) managed negotiations with all tenderers and prepared a contract.

During the summer of 2007, Grontmij supervised the geotechnical investigations. Grontmij has also been project manager of a foundation concept study where a consortia of 5 consultants and associated contractors have developed new or improved foundation concepts including steel monopile, optimized jacket, drilled concrete monopile, gravity concrete tripod and gravity concrete cone. The results were presented at a seminar in Stockholm March 2009.

## Wind Farm in El-Zayt, Egypt



**Based on the findings of the pre-feasibility study for a large wind farm in Egypt, Grontmij was requested by the client, Italgem, to prepare a more detailed feasibility study of a 120-360MW wind farm in El-Zayt, Egypt.**

The study included a comprehensive assessment of potential sites, taking into account issues such as bird migration, orography and flooding. Further the potential production and thereby income were assessed taking into account different potential WTG set-ups.

The technical feasibility of establishing the wind farm was then assessed. This included construction issues (foundations, cables, internal roads, flood protection) and operational issues including assessment of set-up of an O&M organisation.

Based on the above findings, investment and operation costs were estimated. With the income and cost side estimated, a financial analysis was prepared to calculate NPVs, pay back periods and IRRs.

Finally, Grontmij prepared a plan for how the client could go through the final planning phase, tender phase and execution phase in order to get the wind farm in operation when required.

A pre-requisite for initiating this was that the environmental impact study, also prepared by Grontmij, was issued by the client to the authorities in Egypt.

### Services

- Site assessment including investigations
- Detailed wind resource estimations
- Production estimation
- Selection of WTGs
- Grid connection assessment
- Investment estimate (turbines and balance of plant)
- Technical feasibility
- Preparations for inclusion of CDM option
- Financial feasibility
- Environmental impact assessment

### Client

Italgem / Italcementi group

### Date

2006 - 2007

## Wind Farm in El-Zayt, Egypt



**Marsa Alam Wind Farm (indicated with an "X" on the figure) is located near the Red Sea coast, about 200km south of Hurghada.**

Main components of the planned project include:

- 20MW Wind Farm, consisting of 20 - 24 turbines, cooperating with an existing diesel power plant.
- Gravity based concrete foundations
- Electrical interconnection to nearby power plant

Marsa Alam Tourist Development Area is not interconnected to the national grid but has its own electrical power supply from a local diesel power plant. The wind farm is meant to save diesel consumption. Current installed diesel capacity is 30MW, which is planned to increase to approximately 200MW during the next 20 years of development of the area. The wind farm will operate as an ordinary grid connected wind farm, however a central regulation of the power output will be possible in order to keep wind power production below certain limits of the total electrical production.

Planned installation: After 2010.

### Services

EIA-input and authorities issues

Wind farm layouts for different site locations and installed capacity

Assessment of geotechnical properties

Electrical connection

Foundation

Modelling of electrical production and consumption

Types of wind turbines

Operation and maintenance aspects

Economics and risks

Assessment of CDM option

### Client

Italgen/Italcementi group

### Date

2006 - 2007

## Clogher Head Offshore Wind Farm



**Grontmij provided a deskbased pre-feasibility study of foundation works through a marine and civil engineering assessment. Site at 20-50m water depth and envisaged for a Phase 1 of 100MW and Phase 2 of 400MW were included. 3-4MW wind turbines were proposed.**

In connection with the studies, new advanced models for determining the wave loads from steep waves to various foundation concepts (tripod, monopile, gravity foundation) were used. Furthermore, a new methodology for determining the dynamic interaction between the wind load and the wave load depending upon the flexibility of the foundation and the ration between the wind load and the wave load was utilised for extreme loads as well as fatigue.

### Services

Screening of existing information on especially geology / geotechnics and climate

Concept evaluation of floating foundation structure

Outline design of bottom mounted structure

Indicative estimated cost

Preliminary risk assessment

Recommended additional geotechnical and hydrographical site investigations

Evaluation of overall suitability

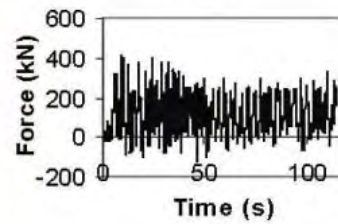
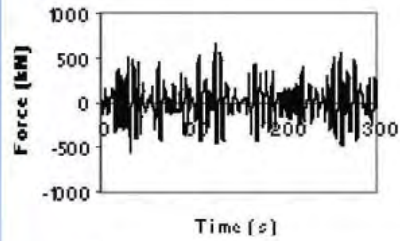
### Client

Airtricity

### Date

2002-2003

## Nysted Offshore Wind Farm



**One of Denmark's large-scale offshore wind parks, with a rated power capacity of 158MW (72 wind turbines of 2.2MW each), went into production in 2003 at Nysted / Rødsand. Rødsand is located southwest of Rødby in the Baltic Sea, south of Denmark.**

With expert and editor assistance from Grontmij, the environmental impact assessment was concluded. Design basis for all types of foundation concepts, has been set by Grontmij including physical model tests to determine ice loads and wave loads on conical structures.

Based on earlier conceptual evaluations, Grontmij performed detailed design of gravity-based foundations and input to tender documents for a design & construct contract. We assisted in tender evaluation and provided expert assistance to the supervision during construction.

### Services

Member of the leading team for planning and designing, with special focus on establishing a design basis

Assistant editor of EIA

Assistance on construction issues

Conceptual design for gravity foundation of either concrete, composite or mono-piles

Detailed design of gravity based foundation

Preparation of Tender Documents

Tender evaluation

Assistance during follow up and supervision

### Client

SEAS / Energi E2

### Date

2000 - 2003

# Middelgrunden Offshore Wind Farm



**The offshore wind farm at Middelgrunden consists of 20 x 2MW Bonus turbines (hub height 64m, rotor diameter 76m).**

The foundation water depth is 4m to 8m at an old dump site. Foundation weight is 1,800 tonnes. Average wind speed at 50m height is 7.2m/s. The expected production is 100GWh / year. The farm was constructed in year 2000. The investment amounts to €48m

Middelgrunden offshore wind farm represents the start of Denmark's large offshore wind farm development. The project should create the required technical knowledge for the coming 150MW wind farm.

First estimates for combined forces from wind, waves and ice were developed during the project. This formed the basis of Denmark's first technical design recommendation for offshore wind farms.

## Services

### Conceptual design

Feasibility study of the foundation for 27 1.65MW wind turbines

The services include:  
Assessment of environmental conditions including blockage of current in Øresund, ship impact, wave load, ice load, geotechnical conditions and technical feasibility study of the foundation for 27 1.65MW wind turbines

### Detailed design

Establishment of an offshore wind farm consisting of 20 2MW wind turbines

The services include:  
Preparation of a design basis including determination of combined loads from ice, currents and waves

Conceptual design gravity concrete foundation detailed for tendering

Tender documents and contracting

Detailed design of a composite concrete foundation incl. FEM modelling

Documentation for certification by DNV

Evaluation of spill from dredging works

Project management

Supervision

## Client

Work-group for wind turbines at Middelgrunden

## Date

1997 - 2001



## List of Selected References

## References - UK

Scheme title / location	Client / developer	Dates	Description of services
North Rhins wind farm, Dumfries & Galloway, Scotland	RJ McLeod / AES	2008 - Ongoing	<p>North Rhins Wind Farm is a 22MW wind farm located near the village of Portpatrick in South West Scotland. The site, featuring eleven 2MW Vestas wind turbine generators, started exporting power to the national grid at the end of 2009.</p> <p>Grontmij was commissioned by RJ McLeod to provide multi-disciplinary tender stage design / technical advisor support and is now providing detailed design and support services during the construction of the scheme. The following services are being provided:</p> <ul style="list-style-type: none"> <li>• Through detailed additional ground investigation and foundation analysis, Grontmij developed gravity reinforced concrete turbine foundations in place of a potential piled turbine foundation at one of the turbine locations with construction cost and programme savings.</li> <li>• Design and detailing of gravity reinforced concrete turbine foundations for drained and submerged turbine foundations including preparation of design statements and calculations for Vestas' approval.</li> <li>• Design and detailing of sub-station building and related infrastructure.</li> <li>• Design and detailing of site access junction arrangement including technical approvals with Dumfries &amp; Galloway highways department.</li> <li>• Design and development of internal wind farm site infrastructure including site access tracks and turbine erection platforms.</li> <li>• Turbine base formation testing / inspection and QA reporting.</li> <li>• Technical support during construction phases.</li> </ul>
Lochhead Wind Farm, Strathclyde, Scotland	Hanson Contracting Services / A7 Energy Limited	2008 - Ongoing	<p>Lochhead wind farm is a 6MW wind farm featuring three REPower MM82 wind turbine generators, which, when constructed, will displace 65,000 tonnes of carbon dioxide from fossil power stations. Supermarket giant Sainsbury's has signed a deal to purchase power directly from the wind farm project in South Lanarkshire.</p> <p>Grontmij was commissioned by Hanson Contracting to provide multi-disciplinary civil, structural and geotechnical engineering services for the design and construction of the wind farm. Grontmij provided the following services:</p> <ul style="list-style-type: none"> <li>• Design, procurement, management of ground investigation works including preparation of factual and interpretative ground investigation reports.</li> <li>• Design and detailing of gravity reinforced concrete turbine foundations including preparation of design statements and calculations for REPower approval.</li> <li>• Design and detailing of sub-station building and related infrastructure.</li> <li>• Design and detailing of site access junction arrangement including technical approvals from South Lanarkshire Council highways department.</li> <li>• Development and design of major water supply main protection works including full technical approvals from Scottish Water.</li> <li>• Design and development of internal wind farm site infrastructure including site access tracks and turbine erection platforms.</li> <li>• Turbine base formation testing / inspection and QA reporting.</li> <li>• Development of off-site cabling arrangement from Scottish Power sub-station down to wind farm including cabling route arrangement / construction details and consultations with affected utility providers.</li> </ul>

## References - UK

Scheme title / location	Client / developer	Dates	Description of services
Little Raith Wind Farm, Loch Gelly, Fife, Scotland	West Coast Energy Limited	2008 - 2009	<p>West Coast Energy Limited intends to construct and operate Little Raith Wind Farm, which will comprise up to nine wind turbine generators generating up to 3MW of electricity.</p> <p>Grontmij was commissioned to develop eastern and western wind farm access arrangements through third party lands to the main wind farm site producing the necessary design drawings to allow West Coast Energy to enter into land lease agreements. Our involvement included identifying access points off the public highway network, designing access track earthworks through adjacent lands minimising the impacts on farming operations, designing access junction arrangements obtaining approvals in principal from Fife Council highways department.</p>
Edinbane Wind Farm, Isle of Skye, Highlands, Scotland	RJ McLeod / AMEC	2008 - Ongoing	<p>In the first instance, Grontmij was commissioned to provide multi-disciplinary civil / structural and geotechnical engineering services to RJ McLeod on enabling works. We then undertook the main wind farm infrastructure works for the 18 turbine wind farm located approximately 8km east of Dunvegan on the Isle of Skye. Grontmij provided the following services:</p> <ul style="list-style-type: none"> <li>• Detailed design of new bespoke wind farm access bridge as part of enabling works. Structure designed in modular form to ease construction in remote area; pre-cast concrete bankseats, steel super-structure and timber deck arrangement.</li> <li>• 4.5km of public highway and forest access track improvements to facilitate turbine component delivery.</li> <li>• Detailed Design of 1.8m diameter replacement culvert on A83 public highway including water-course training works, liaisons and consultations with SEPA and technical approvals from Highland Council structures department.</li> <li>• Detailed design of 1.8m diameter culvert extension and carriageway curve widening to facilitate turbine component delivery.</li> <li>• A863 / Balmeanach road junction improvements to facilitate turbine component delivery.</li> <li>• Earthworks design of internal wind farm access track / turbine erection platform infrastructure.</li> <li>• Turbine base formation inspection / testing works and construction quality assurance reporting.</li> </ul>
Long Park Wind Farm, Scottish Borders, Scotland	Hanson Contracting Services	2008 - Ongoing	<p>Grontmij was commissioned by Hanson Contracting to provide civil engineering services in relation to off-site cabling works from an existing sub-station in Galashiels to the new wind farm site currently under construction. Works involved:</p> <ul style="list-style-type: none"> <li>• Collating detailed service information along the route corridor to inform the options for positioning the new wind farm cabling works.</li> <li>• Detailed route walkover with electrical sub-contractor / Hanson Contracting to identify cable positioning within public highway / verge, investigate bridge crossing arrangements and other constraints for consideration.</li> <li>• Detailed consultation with affected utility providers, especially Scottish Water.</li> <li>• Preparation of route alignment designs and typical construction details.</li> <li>• Preparation of specific designs / details for areas of specific engineering difficulty (bridge / structure crossings).</li> </ul>

## References - UK

Scheme title / location	Client / developer	Dates	Description of services
Ardrossan Wind Farm Extension, North Ayrshire, Scotland	RJ McLeod / Airtricity	2008	<p>With an extra three turbines bringing the total to 15, the extended Ardrossan wind farm will generate 30MW of green electricity, enough power for 18,750 homes.</p> <p>Through working very closely and harnessing the expertise of the contractor / client, Grontmij's wind farm infrastructure team undertook detailed additional ground investigation and foundation analysis. This led to the use of gravity reinforced concrete turbine foundations in place of piled turbine foundations with construction cost and programme savings.</p> <p>Grontmij provided the following additional services:</p> <ul style="list-style-type: none"> <li>• Design / detailing of granular access tracks and turbine erection platforms.</li> <li>• Checking / verifying / inspecting turbine formations including undertaking significant in-situ geotechnical testing of ground conditions and construction works proceeded.</li> <li>• Design and detailing of sub-station building extension with related external works.</li> <li>• Undertaking water-course catchment study and sizing culverts; liaising with SEPA.</li> <li>• Providing technical / geotechnical support during construction.</li> </ul>
Fairburn, Achany & Gordonbush Wind Farms, Highlands, Scotland	Scottish & Southern Energy / RJ McLeod	2008 - Ongoing	<p>Scottish &amp; Southern Energy has submitted planning applications for Fairburn, Achany &amp; Gordonbush wind farms, which are 35MW &amp; 41.4MW sites located near Muir of Ord &amp; Lairg in the Scottish Highlands.</p> <p>Grontmij is currently providing pre-construction services for the contractor / wind farm developer client allowing planning conditions to be closed off and enabling on-site construction works to proceed. Grontmij is undertaking the following services:</p> <ul style="list-style-type: none"> <li>• Review / development of public highway enhancement works to facilitate turbine component delivery and road safety during construction works including extensive liaison with local highways authority.</li> <li>• Supervision of intrusive ground investigation works progressing on both site's providing recommendations for further Intrusive site investigation works.</li> <li>• Liaison with local authority on abnormal load delivery routes, potentially affected structures and bridge assessment work requirements. Structural assessments.</li> <li>• High level water-course catchment assessments.</li> <li>• Development of sub-station and internal access track arrangements.</li> <li>• Geotechnical and gravity foundation assessments.</li> </ul> <p>Grontmij is now undertaking and providing detailed design and technical support services within the design and construction of Fairburn wind farm for RJ McLeod.</p>
Pates Hill Wind Farm, West Lothian, Scotland	New Lives New Landscapes / Your Energy	2007 – 2008	<p>Pates Hill wind farm is a proposed 14MW Wind Farm Featuring seven 2MW turbines located approximately 1.4km to the north of Woolfords in West Lothian. The site is situated in a commercial spruce forest that once formed parts of land occupied by the now abandoned Harwood Mine.</p> <p>Grontmij is providing geotechnical engineering services encompassing:</p> <ul style="list-style-type: none"> <li>• Mining desk study identifying the presence of recorded deep mine workings and the potential for un-recorded shallow mine workings in coal and limestone seams.</li> <li>• Geo-environmental and contaminated land studies.</li> <li>• Design, procure and manage intrusive ground investigation works.</li> <li>• Preparation of factual and interpretative mining and geotechnical reports.</li> <li>• Provide wind turbine generator foundation / access track earthwork solution advice.</li> <li>• Recommendations for grouting / remediation of shallow mine workings.</li> </ul>

## References - UK

Scheme title / location	Client / developer	Dates	Description of services
Aitkengall Wind Farm, East Lothian, Scotland	RJ McLeod Contracting Limited	2007	<p>Aitkengall community wind farm is a proposed 48MW wind farm being developed by Community Wind Power. The wind farm features sixteen 3MW Vestas V90 wind turbine generators, which, when constructed, will supply electricity for over 31,000 homes and will displace approximately 126,000 tonnes of carbon dioxide. The wind farm is located near the village of Innerwick, approximately 9.5km south of Dunbar in East Lothian.</p> <p>Grontmij provided the following tender stage design services for our contractor client:</p> <ul style="list-style-type: none"> <li>• Review of public highway enhancement works to facilitate turbine component delivery.</li> <li>• Review of site access strategy with development of enabling access track works solution with significant earthwork embankment and cutting works within environmentally sensitive and topographically difficult conditions.</li> <li>• Detailed geotechnical and foundation assessment works with recommendations for further intrusive site investigation works.</li> <li>• High level water-course catchment assessment works to allow development of principle water-course crossing solution.</li> <li>• Preparation of detailed design statement to support design works.</li> </ul>
West Durham Wind Farm, Tow Law, England	Hanson Contracting Limited / Banks Developments	2007 – Ongoing	<p>West Durham wind farm is a 24MW wind farm featuring twelve 2MW turbines, which, when constructed, will supply electricity for 13,400 homes.</p> <p>The wind farm is located near the village of Tow Law, with part of the site underlain by lower coal measures that have been worked in the form of backfilled open cast and shallow mine workings, presenting interesting challenges for foundation design works.</p> <p>Grontmij provided tender stage and are now providing detailed design services to the contractor / client:</p> <ul style="list-style-type: none"> <li>• Detailed geotechnical assessment works and mine working grouting works.</li> <li>• Gravity and piled foundation base designs including detailed liaisons with piling contractors and wind turbine supplier (REPower).</li> <li>• Development of granular access roads and turbine erector platform configurations.</li> <li>• Liaise with Derwentshire District Council highways department regarding site access proposals from the public highway.</li> </ul>
Earlshaugh Wind Farm, Near Moffat, Scotland Peat Slip Risk Hazard Assessment	Wind Energy (Earlshaugh) Ltd	2007 – 2008	<p>Technical advisor undertaking peat slip risk hazard assessment as part of a planning application proposal. Works being undertaken include:</p> <ul style="list-style-type: none"> <li>• Office based desk study review: topographical mapping / BGS.</li> <li>• Site walkover works to assess / review; peat features and exposures, existing drainage paths and geomorphological mapping.</li> <li>• Intrusive ground investigation works; peat probing and sampling; trial pitting works and technical soil testing works.</li> <li>• Slope stability analysis.</li> <li>• Hazard and risk ranking and review of construction impacts.</li> <li>• Development of mitigation measures.</li> </ul>
Kilbraur Wind Farm, Golspie, Scotland	RJ McLeod Contracting Limited / Nordex UK Limited	2007	<p>Kilbraur wind farm is a 47.5MW wind farm featuring nineteen 2.5MW turbines, which, when constructed, will supply electricity for 27,000 homes and displace up to 107,000 tonnes of carbon dioxide. The wind farm is located within the Kilbraur area of Strath Brora, Sutherland approximately 10km north west of Golspie.</p> <p>Grontmij is currently providing the following services to the contractor / wind turbine generator client.</p> <ul style="list-style-type: none"> <li>• Design / detailing of reinforced concrete gravity drained and submerged wind turbine generator bases.</li> <li>• Detailed geotechnical review and wind turbine foundation assessment works.</li> <li>• Design / detailing of granular access tracks and turbine erection platforms.</li> </ul>

## References - UK

Scheme title / location	Client / developer	Dates	Description of services
			<ul style="list-style-type: none"> <li>• Checking / verifying / inspecting turbine formations undertaking plate bearing testing where necessary.</li> <li>• Undertaking water-course catchment study and sizing culverts; liaising with SEPA.</li> <li>• Providing technical / geotechnical support during construction.</li> </ul>
Dunan Wind Farm, Perthshire, Scotland	Wind Energy Ltd	2007	Technical advisor as part of a multi-disciplinary team providing high level advice on wind farm access strategy and earthworks access track solutions as part of planning application submission package for a 22 turbine site.
Earlshaugh Wind Farm, Near Moffat, Scotland	Wind Energy (Services) Ltd	2007-2008	<p>Technical advisor as part of large multi-disciplinary team developing configuration for a proposed 72MW wind farm within the Scottish Borders, as part of planning application and environmental impact assessment works.</p> <p>Grontmij is currently providing the following technical advisory services:</p> <ul style="list-style-type: none"> <li>• Development of internal access track configurations and construction methodologies to facilitate turbine component delivery within environmentally sensitive peat and upland heathland environment and visual impacts restrictions.</li> <li>• Water-course catchment assessment works and development of culverted and bridge structure water-course crossing arrangements with detailed consideration of environmental best practice and construction methodologies.</li> <li>• Quantification of earthworks materials for construction works, identification and intrusive investigation of suitable borrow pit locations and development of borrow pit configurations and restoration profiles.</li> <li>• Development of turbine foundation and component erection platform configurations.</li> <li>• Preparation of detailed construction method statement as part of planning application.</li> <li>• Attendance to team workshops and public exhibitions including extensive liaison with the land-owner.</li> </ul>
Drumderg Wind Farm, Alyth, Scotland	Holequest Limited (Scottish & Southern Energy)	2006	<p>Grontmij was commissioned by Holequest Limited to prepare a ground engineering report for Drumderg Wind Farm Near Alyth, in Perth and Kinross.</p> <p>The commission included:</p> <ul style="list-style-type: none"> <li>• Site walkover.</li> <li>• Desk based review of site geology, hydrology, hydro-geology and a review of the findings of historical site investigation works undertaken by Scottish &amp; Southern Energy.</li> <li>• Summary of ground conditions identified within current intrusive investigation works through a review of the soil mechanical and chemical test results.</li> <li>• Design recommendations / guidance to allow the design of wind farm infrastructure elements; WTG foundations, access tracks, turbine erection platforms, control building and anemometer masts.</li> <li>• Identification of potential borrow pit locations and review on acceptability of site won rock for use within aggregates for concrete production.</li> </ul>
Greengairs Landfill Site	WRG Ltd	2007	Design of investigation for proposed eight turbine development at Greengairs landfill site - has issues with mining, deep peat and unconsolidated open cast backfill .
Garracummer Windfarm, South Tipperary, Eire	South Tipperary Council	2005	Technical review of EIA with respect to peat slope stability on behalf of planning authority for proposed 13 turbine development

## References - UK

Scheme title / location	Client / developer	Dates	Description of services
Various water treatment sites	Scottish Water Solutions	2004	Initial feasibility study for single turbine installations at several water treatment works in Scotland, including review of baseline ground conditions, and appraisal for access / buildability.
Crystal Rigg Wind Farm East Lothian	Nordex UK Limited	2004	Grontmij was commissioned by Nordex UK Limited to provide geotechnical engineering services relating to the design of turbine erection platforms within difficult ground conditions. Grontmij was responsible for verifying bearing capacity at formation and top of erection platform levels. Providing technical support during construction works.
Wind Farm & Associated Access Construction Techniques	Scottish Natural Heritage (SNH)	2003	<p>Technical advisor to SNH undertaking a study into the methods upon which onshore wind farm access track construction, and associated on site construction works could be reduced or implemented in a manner which is less damaging to the natural environment.</p> <p>The advice and recommendations within our report facilitated the development of SNH's good practice guideline 'Constructed Tracks in the Scottish Uplands'.</p>
Whitelee Wind Farm Near Glasgow Scotland	Scottish Power / Morrison Construction	2002-2006	<p>Grontmij was commissioned by Morrison Construction to prepare tender stage designs for the development of Europe's largest wind farm, featuring 140 turbines and approximately 84km of access tracks in Whitelee forest, near Glasgow.</p> <p>Design services Included:</p> <p><b>Geotechnical engineering</b> encompassing drift geology review and desktop study, geological assessments, review of site investigation information, technical support on location, use, handling and volume quantification of site won earthworks materials, peat depth identification, turbine foundation design, slope stability analysis, and geotechnical support within access track design works.</p> <p><b>Granular access track design</b> encompassing horizontal and vertical alignment design of new access roadways for turbine delivery and earthworks construction plant, geogrid reinforced granular floating track design over deep / shallow peat wetlands, peat replacement construction taking cognizance of existing hydrological regime and environmental impacts, circulatory systems to improve earthworks operation efficiencies, optimised earthworks quantification for pricing purposes.</p> <p>Grontmij, through working closely with the contractor / client, undertook full scale testing of various forms of geo-grid reinforced granular access tracks using fully laden articulated dump trucks, to assess and optimize an access track construction arrangement.</p> <p><b>Turbine erection platform design</b> encompassing development and optimization of three erection platform arrangements for use within given topography and under-lying ground conditions, earthworks quantification and optimization through working closely with Morrison Construction / Scottish Power.</p> <p><b>Turbine foundation design</b> encompassing review of gravity base foundation options, earthworks quantification and bearing capacity checks. Segmental, pre-cast concrete foundation solutions were also explored through working closely with the contractor / client.</p> <p><b>Drainage works</b> encompassing site visit, review and development of gully crossing arrangement and related pollution prevention measures working closely with project ecologist and environmentalist.</p>

## References - UK

Scheme title / location	Client / developer	Dates	Description of services
Black Law Wind Farm, Forth, Scotland	Scottish Power / Morrison Construction	2003	<p>Scottish Power planned to install 70 turbines on a former open cast coal-mine site at Black Law near Forth in Lanarkshire. When completed, the wind farm would have a capacity of 120MW and generate sufficient power for 70,000 homes.</p> <p>Grontmij was commissioned by Scottish Power / AWG Construction Services to provide the following services :</p> <ul style="list-style-type: none"> <li>• Through a detailed geotechnical review, prepared a portfolio of typical access track solutions to facilitate earthworks construction plant movements and turbine component delivery operations.</li> <li>• Development and earthworks optimisation of erection platform arrangements given underlying ground conditions and site topography.</li> <li>• Sizing and design of gravity reinforced concrete WTG foundations.</li> <li>• Preparation of water-course catchment assessment works and thus sizing of culverts at water-course crossings taking cognizance of Scottish Natural Heritage and SEPA's requirements for water-course crossings.</li> </ul>
Clogher Head Offshore Wind Farm - Pre-feasibility, Marine and Civil Engineering	Airtricity	2002 - Ongoing	<p>Desk-based pre-feasibility of foundation works through marine and civil engineering assessment. Site at 20-50m water depth and envisaged for a Phase 1 of 100MW and Phase 2 of 400MW. The services included:</p> <ul style="list-style-type: none"> <li>• Screening of existing information on especially geology / geotechnics and climate.</li> <li>• Concept evaluation of floating foundation structure.</li> <li>• Outline design of bottom mounted structure.</li> <li>• Indicative cost estimated.</li> <li>• Preliminary risk assessment.</li> <li>• Recommended additional geotechnical and hydrographical site investigations.</li> <li>• Evaluation of overall suitability.</li> </ul>
Bindoo Wind Farm (Tender), Ireland	Airtricity	2002	<p>Review of options and preparation of contract documents to FIDIC standards for 35 turbines, 77.5MW onshore farm in a remote part of Ireland.</p>
Screening of potential sites for wind power Italy	EOS Energia	2002 – Ongoing	<p>Screening and evaluation of 60 different locations for wind power potential. In 15 municipalities covering an area of about 300km<sup>2</sup> of the mountainous Basilicata, Southern Italy, the site evaluation encompassed:</p> <ul style="list-style-type: none"> <li>• Physical inspection and assessment.</li> <li>• Recording of geographical, meteorological and technical features and site-specific properties.</li> <li>• Processing of maps and other technical legal and financial information.</li> <li>• Pre-feasibility analysis.</li> <li>• Visualisation of potential wind farms.</li> <li>• Proposal for a site specific one-year measuring programme covering four sites.</li> </ul>
Ebeltoft Wind Farm Denmark	Jysk Vindkraft A/S	2002	<p>Establishing wind farm comprising four wind turbines (1.3MW) on breakwater, west of Ebeltoft Port, situated on the east coast of Jutland, Denmark. Wind farm in operation in 2002. The services include:</p> <ul style="list-style-type: none"> <li>• Expert assistance on foundation concepts</li> <li>• Geotechnical site investigation</li> <li>• Development of design basis</li> <li>• Detailed design of pile supported foundations</li> <li>• Preparation of technical specifications</li> <li>• Supervision</li> </ul>

## References - UK

Scheme title / location	Client / developer	Dates	Description of services
Arklow Bank (Tender) Ireland	Airtricity	2001	Preparation of a tender for 60MW wind farm, 5km offshore. Development of methodologies, programme and outline costing.
Orestad Offshore Wind Farm Ligggrunden	Orestads Vindkraftfarm AB	2001 - 2002	Establishing an offshore wind farm comprising 48 min. 2MW wind turbines. Lillgrunden is located in Oresund south west of Malmo, Sweden. The services include: <ul style="list-style-type: none"> <li>Initial expert advise on tender strategy.</li> <li>Development of design basis.</li> <li>Expert evaluation of programme for geotechnical site investigation.</li> <li>Conceptual design of wind farm.</li> <li>Detailed design of gravity based foundation.</li> <li>Preparation of technical specifications for tender, design and construct.</li> <li>Project management in owners organisation for all electrical works.</li> </ul>
Irish Sea, Offshore Wind Farm Off Barrow UK	ETOC	2001	Expert assistance in preliminary evaluation of concept for foundation of wind farm with 30 turbines (3-5MW) in water depths of 20-30m 20km offshore. Seabed of sandstone with up to 7m overburden of soft silt / sand.
Wind Tower Production Facility at Machrihanish UK	Vesta's	2000	Appointed as building and civil engineering design consultants for the proposed new facility for the Danish Company, Vestas Wind Systems A/S at the old RAF Station at Machrihanish, Mull of Kintyre. The project is sponsored by the local enterprise body, Argyll and the Islands Enterprise.
National Framework (Tender)	National Wind Power		Three year framework consultant to major renewable energy company developing on and offshore sites. Responsible for site screening, planning management civil, structural, marine, electrical SCADA and grid connection.
Bowbeat Windfarm (Tender) Scottish Borders	Powergen Renewable Developments	2000	Tender designs for 24 turbine wind farm. Work package included geotechnical appraisal of wind farm site, including access roads designs, substructure design for turbine masts and anemometers.
Mull of Kintyre	Raynesway Construction	1999	Tender design for 12 turbine wind farm. Services included in particular: access roads and geotechnical designs for optimal placement of bases in-line with rock quality assessments.
Mull of Kintyre	Scottish Power	1995	Computer analysis of 30 turbine wind farms on west coast of Scotland to support EIS and planning stipulation.
Caithness Wind Farm	RPS Cairns	1994	Topographical analysis and zone of visual influence population analysis as part of a site selection for three wind farms giving a total of 46 1.5MW turbines.

## References - International

Scheme title / location	Dates	Description of services
Consultancy for Rødsand 2 Offshore Wind Farm, Denmark	2007 - 2010	<p>Consultancy for wind farm owner E.ON during tender and production period. The project consists of 90 2.3 MW SWP wind turbines on concrete gravity foundations from Aasleff Bilfinger JV with internal grid from NSW. Commissioning of 207 MW by end of 2010.</p> <p>The services include:</p> <ul style="list-style-type: none"> <li>• EIA presentation at public meeting and assistance in adapting project to public comments on EIA</li> <li>• Preparation and initialisation of compensation negotiations with Danish Fishermen's Association</li> <li>• Layout optimization of wind farm including production prediction, screening of geotechnical information and grid cost evaluation</li> <li>• Basic design of inter turbine grid connection</li> <li>• Offshore sub station: interface planning and negotiation between owners of 36kV system and 132kV system</li> <li>• Planning and supervision of complete geotechnical investigations including laboratory testing</li> <li>• Tender assistance for wind turbines, foundations and grid</li> <li>• Site assessment and design basis for foundation (incl. DNV certification)</li> <li>• Load calculation, documentation and certification</li> <li>• Study of collision friendly foundation design</li> <li>• Planning of construction site in Rødby and Nyborg</li> <li>• Review of contractors detailed design of foundations</li> <li>• Interface management</li> <li>• Supervision of foundation manufacture on sites in Denmark and Poland</li> </ul>
Offshore Wind Accelerator (OWA), UK Round 3 Offshore Foundations, UK	2009	<p>Project manager on the program Offshore Wind Accelerator (OWA). The aim is to develop between five and eight new platform concepts on water depth 30-60m water for multi-MW turbines with participation of Airtricity, DONGEnergy, RWE Innogy, Scottish Power and Statoil / Hydro. Phase 2 plans for tests of some foundation concepts. Development of site assessment and design basis. Review of foundation concepts from 5-8 consultant / contractors.</p>
Civil Works Consultancy, Nørrekær Enge 30 MW Wind farm, Denmark	2009	<p>Engineering and tender on:</p> <ul style="list-style-type: none"> <li>• Removing old concrete foundation</li> <li>• New 2.3MW foundation in difficult soil</li> <li>• New roads for wind farm</li> </ul>
France, Offshore Wind Farm, France	2008 - 2009	<p>Conceptual foundation design was made for a 5MW turbine on water depths in range of 21-28m including:</p> <ul style="list-style-type: none"> <li>• Concrete gravity based structure (GBS)</li> <li>• Manufacturing site evaluation</li> <li>• Installation evaluation</li> <li>• Cost evaluation</li> </ul>
Krieger's Flak 1 Offshore Wind Farm, Germany	2008 - 2009	<p>Site assessment inclusive estimate of design soil conditions, design basis for 4 different foundations and 4 different turbines (3MW- 5MW), feasibility study of 80 positions with water depth of 20 to 45m and varying soil conditions, risk assessment.</p>
Foundation concepts. Krieger's Flak 640 MW Offshore Wind Farm, Sweden	2008 - 2009	<p>Project management of and technical assistance to 0.6MEUR study on development of foundation concepts for Krieger's Flak 640MW offshore wind farm in Baltic Sea 40km off the coast.</p> <p>The services include validation and recommendation of:</p> <ul style="list-style-type: none"> <li>• Project management</li> <li>• Wind-wave load analysis on 3.6 and 5MW turbines (FLEX5)</li> </ul>

## References - International

Scheme title / location	Dates	Description of services
Bornholms Offshore Wind Farm, Denmark	2009	Application for Danish Energy Agency for 90MW offshore wind farm close to Bornholm: <ul style="list-style-type: none"> <li>Layout, design, and application</li> <li>Technical and financial risk assessment</li> </ul>
Due Diligence on 23 Wind Farms, Europe	2009	Review of 23 planned wind farm with a total capacity of 800MW including: <ul style="list-style-type: none"> <li>Civil work</li> <li>Electrical interconnection</li> <li>Implementation schedule</li> <li>Project economy (CAPEX/OPEX)</li> </ul>
Suurhiekkä Wind farm, Finland, Offshore Wind Farm, Finland	2009	Input for planning of wind farm including: <ul style="list-style-type: none"> <li>Optimisation of layout with respect to accessibility due to shallow water</li> <li>Conceptual foundation design with due respect to heavy ice loading</li> <li>Defining installation vessels and methodology</li> <li>Preliminary project programme</li> </ul>
Post Construction Evaluation of Six Operating Wind Farms, China	2007 - 2009	Evaluation of condition of six operating Chinese wind farms compared to original feasibility reports. The task will be carried out for the authority China Hydropower Engineering Consulting Group with subsidy from DANIDA. The services include: <ul style="list-style-type: none"> <li>Desk study of background of investment decision</li> <li>Planning of evaluation program</li> <li>Data collection in the wind farms – technical and other</li> <li>Analysis of results</li> <li>Reporting to relevant parties in China</li> </ul>
Dan-Tysk Offshore Wind Farm, Germany	2008 - 2009	Review of site assessment, soil program and foundation concept studies.
Offshore Transformer Assistance, Denmark	2008 - 2009	Optimizing cost and use of equipment when shifting transformers on Middelgrunden Offshore Wind Farm: <ul style="list-style-type: none"> <li>Planning of the installation process</li> <li>Optimal use and hiring of offshore equipment</li> </ul>
Operation and Maintenance, Middelgrunden Offshore Wind Farm, Denmark	2009	<ul style="list-style-type: none"> <li>Technical assistant for owner of wind farm</li> <li>New service agreement with service boat and manufacture.</li> </ul>
Finngrunden, Offshore Wind Farm, Sweden	2009	Analysis of ice conditions and design ice loads for selected foundation concepts in areas with ice ridges and rubbles: <ul style="list-style-type: none"> <li>Conceptual foundation drawings</li> </ul>

## References - International

Scheme title / location	Dates	Description of services
Modal Testing of Wind Turbine Blade, Denmark	2009	Evaluation of modal structural dynamic parameters for blades of 37m to 53m, mounted in a horizontal test rig. Performed for LM Glasfiber. The service included: <ul style="list-style-type: none"> <li>• Measurement applying operational modal analysis</li> <li>• Evaluation of natural frequencies, damping ratios and 3D mode shapes</li> </ul>
Offshore Wind Farm, UK Round 3, Design Basis, UK	2009	Rough design basis for offshore wind farm including: <ul style="list-style-type: none"> <li>• Operational weather for Installation</li> <li>• Conceptual foundation design</li> <li>• Installation vessels and methodology</li> </ul>
Baltic 1, Offshore Wind Farm, Germany	2008	New improved ice design conditions and design ice loads to monopile
Shanghai Donghai Bridge Offshore Wind Farm, China	2008	Technical review of foundation design
Conceptual Foundation Design, Netherlands	2008	Conceptual design of foundations for WTGs and Offshore Transformer for two Dutch offshore wind farms of 200MW and 300MW including: <ul style="list-style-type: none"> <li>• Draft offshore transformer unit design</li> <li>• Draft design of monopile foundations</li> </ul>
Due diligence of 2 Wind Farms, Romania	2008	Review of two wind farm projects of 20MW and 90MW including: <ul style="list-style-type: none"> <li>• Electrical interconnection</li> <li>• Implementation schedule</li> <li>• Project economy</li> </ul>
Conceptual Offshore Foundation Design, USA	2008	Foundation feasibility study for four offshore wind turbines for Hull. <ul style="list-style-type: none"> <li>• Geotechnical data evaluation</li> <li>• Manufacturing facility assessment</li> <li>• Technical and economical feasibility</li> </ul>
Pre Feasibility Study for Wind Farm, Vietnam	2008	Review of options for installation of 20MW wind farm near cement plant in southwest of Vietnam including: <ul style="list-style-type: none"> <li>• Estimate of wind resources</li> <li>• Draft wind farm layout</li> <li>• Electrical interconnection</li> <li>• Environmental and authority related issues</li> <li>• Implementation schedule</li> <li>• Project economy</li> </ul>
Geotechnical Investigation for Baltic 1 Offshore Wind Farm, Germany	2008	Tender and contract preparation as well as implementation supervision for offshore geotechnical investigations for the offshore wind farm. The services include: <ul style="list-style-type: none"> <li>• Planning of full geotechnical investigation</li> <li>• Contract preparation and negotiation</li> <li>• Implementation supervision of offshore geotechnical investigations</li> </ul>
Bird Studies for Large Onshore Wind Farm, Egypt	2008	Preparation and implementation of bird studies including: <ul style="list-style-type: none"> <li>• Radar and laser-optical studies of soaring and nocturnal migrants at the Red Sea coast</li> <li>• Data-analysis and reporting</li> <li>• Application of findings from migration studies into EIA of a 120 - 400MW wind farm</li> </ul>

## References - International

Scheme title / location	Dates	Description of services
Geotechnical Investigation and Design Basis, Krieger's Flak 1 Offshore Wind Farm, Germany	2008	Tender and contract preparation as well as implementation supervision for offshore geotechnical investigations for the offshore wind farm.  The services include: <ul style="list-style-type: none"> <li>• Planning of full geotechnical investigation</li> <li>• Contract preparation and negotiation</li> <li>• Implementation Supervision of offshore geotechnical investigations</li> <li>• Review of site assessment and design basis</li> </ul>
EIA, Avedøre Holme Offshore Test Wind Farm, Denmark	2008	Environmental Impact Assessment (EIA) of project for establishment of Avedøre Holme offshore test wind farm (3 turbines, 3-5MW) for DONG Energy.  The services include: <ul style="list-style-type: none"> <li>• Review of and commenting on sub-consultants reports on different environmental impacts</li> <li>• Writing and editing of EIA-report for public commenting</li> </ul>
Walney Offshore Wind Farm, UK	2008	Assistance to owner's engineering team: <ul style="list-style-type: none"> <li>• Management of metocean study</li> <li>• Preparation of hydrologic part of site assessment</li> <li>• Calculation of wave and current loads</li> <li>• Calculation of combined wind turbine and wave loads</li> </ul>
Wind Farm in Forest Area, Sweden	2008	<ul style="list-style-type: none"> <li>• Calculation/Estimation of production</li> </ul>
Proposal for 350 MW Offshore Wind Farm, USA	2008	Technical assistance to major North American energy utility on preparation of proposal for concession of 350MW offshore wind farm 30km off the coast.  The services include validation and recommendation of: <ul style="list-style-type: none"> <li>• Foundation engineering</li> <li>• Construction schedule</li> <li>• Wind resources</li> <li>• Environmental scoping</li> </ul> And preparation of: <ul style="list-style-type: none"> <li>• Loads analysis</li> <li>• Operation and maintenance plan</li> <li>• Decommissioning plan</li> </ul>
Greater Gabbard Offshore Wind Farm, UK	2008	Assistance to owner's engineering team: <ul style="list-style-type: none"> <li>• Review of site assessment</li> <li>• Calculation of wave loads and combined wind turbine and wave loads</li> </ul>
Trolleboda Design Basis, Offshore Wind Farm, Sweden	2008	Assistance to owner's engineering team

## References - International

Scheme title / location	Dates	Description of services
Alfa Ventus Offshore Wind Farm, Germany	2007 - 2008	Assistance to owners engineering team: <ul style="list-style-type: none"> <li>Review of site assessment, design basis and</li> <li>Tender design</li> </ul>
EIA, Frederikshavn Offshore Test Wind Farm, Denmark	2007 - 2008	Environmental Impact Assessment (EIA) of project for establishment of Frederikshavn offshore test wind farm (six turbines) for DONG Energy. The services include: <ul style="list-style-type: none"> <li>Review of and commenting on sub-consultants reports on different environmental impacts</li> <li>Writing and editing of EIA-report for public commenting</li> </ul>
Feasibility Study for Offshore Wind Farm at Taeon, Korea	2007 - 2008	Feasibility study for 300MW offshore wind farm at Taeon in South Korea. The services include: <ul style="list-style-type: none"> <li>EIA assistance</li> <li>Input for authorities</li> <li>Wind Turbine Technology assistance</li> <li>Foundations study</li> <li>Grid assessment</li> <li>O&amp;M assessment</li> <li>Budget assistance</li> </ul>
EIA Vonå 10 MW Wind Farm, Denmark	2007	EIA of a 10MW Wind farm west of Ringkøbing, Jutland, Denmark. Client: Østjysk Vindenergi Aps. <ul style="list-style-type: none"> <li>EIA on environmental aspect</li> <li>Bird migration field studies</li> <li>Impact assessment in relation to nearby EU-bird protection site</li> </ul>
EIA Nørrekær Enge 30-40 MW Wind Farm, Denmark	2007	Writing of EIA for a 30-40MW Wind farm to be implemented at Nørrekær Meadows, Jutland, Denmark. Client: Vattenfall. <ul style="list-style-type: none"> <li>EIA on environmental aspect</li> <li>Bird-migration field studies</li> <li>Impact assessment in relation to nearby EU-bird Protection site.</li> </ul>
Geotechnical Investigation Store Middelgrund Offshore Wind Farm, Sweden	2007	Supply of crew, drilling rig and performance of geotechnical offshore drilling for met mast as well as geotechnical expert back-up.
Feasibility Study, Wind Farm for Marsa Alam, Egypt	2007 - 2008	Feasibility study for Mohammed Abdulmohsin Al-Kharafi & Sons, Kuwait. Study included: <ul style="list-style-type: none"> <li>Wind resource assessment</li> <li>Location and evaluation of site proposals</li> <li>Elaboration of farm layout</li> <li>Grid connection assessment</li> <li>Evaluation of potential wind turbines</li> <li>Budgeting and financial analysis</li> <li>Assessment of potential CDM contribution to project output</li> </ul>

## References - International

Scheme title / location	Dates	Description of services
Site Screening Guide for Offshore Wind Farm Developer, Sweden	2007	Developing and editing screening note which ranks offshore sites according to cost implications of sea bed conditions
Due Diligence Wind Power Portfolio	2007	Due diligence for major European energy company on potential purchase of a renewable energy developer with portfolio of 1,400MW onshore wind power in the United Kingdom, Norway and Poland.
EIA, Krieger's Flak 640 MW Offshore Wind Farm, Sweden	2007	The services include: <ul style="list-style-type: none"> <li>• Desk study on spill assessment for concrete foundations</li> <li>• Grab tests: planning, boat and equipment contracting, offshore field works managing, laboratory contracting, result evaluation</li> </ul>
Basic Design, 250 MW El-Zayt Wind Farm, Egypt	2007	Carrying out owner's pre-tender basic design for a large wind farm in Egypt. The study included: <ul style="list-style-type: none"> <li>• Contracting supply and installation of 2 met mast</li> <li>• Preparing mine clearance of site</li> <li>• Wind resource study</li> <li>• Planning and contracting on site soil investigation campaign</li> <li>• Basic design covering layout, cabling, grid connection, foundations and O&amp;M facilities</li> </ul>
Design Basis, Borkum West Offshore Wind Farm, Germany	2007	Support for owner in development of design basis to be used for foundation design. The services include: <ul style="list-style-type: none"> <li>• Review of site assessment</li> <li>• Prediction of wave loads and combined wind and wave loads on monopiles as well as concrete gravity structures</li> </ul>
Design Basis, Greater Gabbard Offshore Wind Farm, UK	2007	Support for owner in development of design basis to be used for foundation design. The services include: <ul style="list-style-type: none"> <li>• Review of site assessment</li> <li>• Prediction of wave loads and combined wind and wave loads on monopiles as well as concrete gravity structures</li> </ul>
Geotechnical Investigation, Krieger's Flak 640 MW Offshore Wind Farm, Sweden	2007	Tender and contract preparation as well as implementation supervision for offshore geotechnical investigations for the huge offshore wind farm of power company waterfall. The services include: <ul style="list-style-type: none"> <li>• Evaluation of existing geophysical and geotechnical data</li> <li>• Planning of additional geophysical investigation</li> <li>• Planning of full geotechnical investigation</li> <li>• International pre-qualification after EU rules</li> <li>• International tender preparation after EU rules</li> <li>• Contract preparation and negotiation</li> <li>• Implementation supervision of offshore geotechnical investigations</li> </ul>
Foundation Design, Utgrunden II Offshore Wind Farm, Sweden	2006 - 2007	Tender design of foundations for tendering contractor. The services include: <ul style="list-style-type: none"> <li>• Conceptual investigation</li> <li>• Tender design of drilled monopile foundation for installation in rock in sea bed</li> <li>• Tender design of concrete gravity foundation for installation on piles</li> <li>• Contact to sub-contractors for pricing of supplies</li> </ul>

## References - International

Scheme title / location	Dates	Description of services
Design Basis, Krieger's Flak 640 MW Offshore Wind Farm, Sweden	2006 - 2007	<p>Permanent staff for preparation of Design Basis for foundations of the huge offshore wind farm of Power Company Vattenfall.</p> <p>The services include:</p> <ul style="list-style-type: none"> <li>• Wave, current, tide and surge evaluation</li> <li>• Ice evaluation</li> <li>• Load combination evaluation including wind turbine loads</li> <li>• Load prediction for different foundation structures</li> <li>• Assistance to writing of design basis according to IEC61400-3 and DNV-OS-J101</li> </ul>
EIA, Rødsand 2 Offshore Wind Farm, Denmark	2006 - 2007	<p>Environmental Impact Assessment (EIA) of project for establishment of 215MW Rødsand 2 offshore wind farm for DONG Energy (former Energi E2).</p> <p>The services include:</p> <ul style="list-style-type: none"> <li>• Review of and commenting on sub-consultants reports on different environmental impacts</li> <li>• Writing and editing of EIA-report for public commenting</li> </ul>
Feasibility Study, 120 MW El-Zayt Wind Farm, Egypt	2006 - 2007	<p>Feasibility study for Italgel / Italcementi Group, Italy.</p> <p>Study included:</p> <ul style="list-style-type: none"> <li>• Site assessment including soil investigations</li> <li>• Catalogue and short listing of preferred WTGS</li> <li>• Wind data analysis, energy calculations and loss/uncertainties</li> <li>• Estimation of costs for connection to grid</li> <li>• Financial analysis including sensitivity analysis</li> <li>• Environmental Impact assessment ready for submittal to authorities</li> </ul>
Pre Feasibility Study, Laayoune, Wind Farm, Morocco	2006	<p>Study carried out for large international private investor. The wind turbine project covers a two phase project of 10 MW to be installed in 2007, and 40MW to be installed in 2008.</p> <p>The services include:</p> <ul style="list-style-type: none"> <li>• Site visit</li> <li>• Visualisation</li> <li>• Wind data evaluation</li> <li>• Wind resource prediction</li> <li>• General feasibility study of environment, grid, wind resource, economy, installation, transport, soil</li> <li>• Wind turbine market survey</li> </ul>
Operation and Maintenance, Contract Negotiations for Middelgrunden, Denmark	2006	<p>Support for owner in re-structuring and contracting operation and maintenance setup to reduce costs on the basis of five years operation.</p> <p>The services include:</p> <ul style="list-style-type: none"> <li>• Evaluation five years continued and successful O&amp;M</li> <li>• Identifying potential alternative suppliers</li> <li>• Setting up tender call</li> <li>• Negotiating with tenders on turbine O&amp;M as well as boat-supply</li> </ul>
Sound Power Measurement Software, Denmark	2006	<p>Specialised software for in-situ measurement of wind speed and direction, suitable for use in connection with sound power determination</p>
EIA, Horns Rev 2 Offshore Wind Farm, Denmark	2006	<p>Environmental Impact Assessment (EIA) of project for establishment of 215MW Horns Rev 2 offshore wind farm for DONG Energy (former Energi E2).</p> <p>The services include:</p> <ul style="list-style-type: none"> <li>• Review of and commenting on sub-consultants reports on different environmental impacts</li> <li>• Writing and editing of EIA-report for public commenting</li> <li>• Baseline and impact studies dealing on fish, marine mammals and benthic fauna</li> </ul>

## References - International

Scheme title / location	Dates	Description of services
Pre-feasibility Study, Wind farm for Marsa Alam, Egypt	2006	<p>Study included:</p> <ul style="list-style-type: none"> <li>• Wind resource assessment</li> <li>• Location and evaluation of site proposals</li> <li>• Elaboration of farm layout</li> <li>• Grid connection assessment</li> <li>• Evaluation of potential wind turbines</li> <li>• Budgeting and financial analysis</li> <li>• Assessment of potential CDM contribution to project output</li> </ul>
Sound Power Measurements for Vestas Asia Pacific, Denmark	2006	<p>Noise measurements carried out for the wind turbine manufacturer Vestas on four V80 wind turbines in South Korea:</p> <ul style="list-style-type: none"> <li>• Measurement and analysis according to standard IEC 61400-11</li> <li>• Measurements of sound power for on-shore and off-shore gear</li> </ul>
Foundation Design, SIWT EU-supported Offshore Wind Demo Project, Denmark	2006	<p>Contract Preparation of Offshore Wind Farm project for Energy Company. The project consists of joint installation of foundation and 3.6MW wind turbine at Nysted Wind Farm for up to four wind turbines. The actual services include:</p> <ul style="list-style-type: none"> <li>• Revision of project budget</li> <li>• Review of contract with EU on demonstration support</li> </ul>
Foundation Design, Lynn and Inner Dowsing Offshore Wind Farm, UK	2006	<p>Tender design of foundations for a tendering contractor.</p> <p>The services include:</p> <ul style="list-style-type: none"> <li>• Screening of geotechnical information</li> <li>• Prediction of combined wind and wave design loads</li> <li>• Tender design of monopile foundations</li> <li>• Tender design of concrete foundations</li> </ul>
Pre-feasibility Study, El-Zayt Wind Farm, Egypt	2006	<p>Pre-feasibility study for Italgem / Italcementi Group, Italy.</p> <p>Study included:</p> <ul style="list-style-type: none"> <li>• Wind resource assessment</li> <li>• Site location assessment</li> <li>• Grid connection assessment</li> <li>• Preliminary wind turbine proposals</li> <li>• Budgeting and financial analysis</li> <li>• Assessment of potential CDM contribution to project output</li> <li>• Screening of potential areas in Egypt</li> </ul>
Foundation Design, Robin Rigg 200 MW Offshore Wind Farm, UK	2006	<p>Tender design of foundations for a tendering contractor.</p> <p>The services include:</p> <ul style="list-style-type: none"> <li>• Screening of geotechnical information</li> <li>• Prediction of combined wave and wind turbine design loads</li> <li>• Tender design of monopile foundations</li> </ul>
Wind Energy Potential Study, Indonesia	2006	<p>Study for DANIDA on potential implementation of wind farms in Aceh, Indon.</p> <p>The services include:</p> <ul style="list-style-type: none"> <li>• Power sector study</li> <li>• Site Screening</li> <li>• Wind Resource assessment</li> <li>• Grid Connection, Civil Works and Electrical Works assessment</li> <li>• Financial Assessment</li> <li>• Dissemination of wind energy technology</li> </ul>

## References - International

Scheme title / location	Dates	Description of services
Condition Monitoring and Evaluation of Middelgrunden Foundations, Denmark	2006	After five years of operation a visit and technical review on all 20 Middelgrunden foundations to control condition of foundations was carried out.
Project Development, Holmön 126MW Wind Farm Development, Sweden	2006	Project development consultancy for a consortium consisting of a power company, the local authority and a cooperative of local citizens. The 42 turbine project is to be constructed along the coast-lines of two islands. The services include: <ul style="list-style-type: none"> <li>• Budgeting for wind farm project</li> <li>• Wind resource estimation</li> <li>• Wind turbine technology assessment</li> <li>• Micro siting</li> <li>• Pier sketching</li> <li>• Production estimation</li> <li>• Civil and electrical engineering evaluation</li> </ul>
Commenting on International Offshore Wind Farm Standard, Denmark	2006	Review and commenting on committee draft for new edition of IEC61400-3 on behalf of danish power company.
Foundation Design, Utgrunden II 86 MW Offshore Wind Farm, Sweden	2006	Conceptual foundation design for power company. The services include: <ul style="list-style-type: none"> <li>• Assessment of geotechnical data and input for supplementary investigation</li> <li>• Structural design</li> <li>• Installation investigation</li> <li>• Budgetary estimation</li> </ul>
Tender Manager, Utgrunden II 86 MW Offshore Wind Farm, Sweden	2006	Provision of expertise for the first offshore wind project for E.ON Sweden. The services include: <ul style="list-style-type: none"> <li>• Foundation tender manager to prepare tender, evaluate tenders, prepare contract and supervise project implementation of design and construct foundation contract.</li> <li>• Electrical tender manager to prepare tender, evaluate tenders, prepare contract and supervise project implementation of design and construct cable and grid connection contract.</li> </ul>
Capacity Building, SIDA-Course "Management of Wind Power Dev.", Sweden	2003 - 2006	Every year SIDA sponsors an international four weeks course on management of wind power development. The course is carried out in different locations in Sweden. In 2003, 2004, 2005 and 2006 Grontmij supplied teachers for the course.
IEC 61400-3, Technical Standard for Offshore Wind Turbines, UK	2003 - 2006	Expert member of working committee

## References - International

Scheme title / location	Dates	Description of services
Foundation Design, Lillgrund 110 MW Wind Farm, Sweden	2005	<p>Tender design of foundations for NCC Construction Sverige AB in tendering to supply 48 foundations for 2MW wind turbines.</p> <p>The scope of work included:</p> <ul style="list-style-type: none"> <li>• Screening of geotechnical information</li> <li>• Prediction of combined wind and wave design loads</li> <li>• Development of design basis for the foundations</li> <li>• Tender design of concrete foundations including dimensions and geometry, reinforcement principles and concrete requirements.</li> <li>• Design of scour protections</li> <li>• List of quantities such as concrete and reinforcement</li> <li>• Lightning protection and secondary steel as well as formwork</li> <li>• Sketched maintenance manual</li> </ul>
Design Basis, London Array and Scarweather S. Offshore Wind Farms, UK	2006	<p>Supply of permanent staff for Danish Power Company Energi E2's design team for offshore wind farms. During 2005 work was concentrated on preparation of London Array West where first project phase shall consist of around 86 wind turbines of 3-5MW at water depths ranging from 0-30m, and on Scarweather Sands, where 30 3-4MW turbines shall be installed at water depths ranging from 5-25m.</p> <p>The tasks included:</p> <ul style="list-style-type: none"> <li>• Evaluation of met-ocean conditions</li> <li>• Evaluation of optimal foundation concept</li> <li>• Determination of wave forces on monopiles and gravity base foundations</li> <li>• Combination of nature loads with advanced load model</li> <li>• Development of design basis for foundations</li> </ul>
Elforsk, Sweden	2005	<p>Building and reporting of joint standard for naming of components and systems in wind plants.</p>
Capacity Credit Analysis and Performance Study for Wind Farms, Egypt	2004 - 2005	<p>The analysis was carried out for the Egyptian Ministry of Energy &amp; Electricity, New &amp; Renewable Energy Authority (NREA)</p> <p>The services included:</p> <ul style="list-style-type: none"> <li>• Selection of model for analysis of large-scale incorporation of wind power into existing grid</li> <li>• Training staff in use of load carrying and power production simulation models</li> <li>• Power capacity load / power production analysis</li> <li>• Evaluation of yearly productions compared to simulations</li> <li>• Evaluation of wake effects through the wind farms</li> <li>• Recommendations regarding optimal spacing in wind farms</li> <li>• Training in wind resources and wind power production analysis</li> </ul>
Design Basis, Borkum Riffgrund Offshore Wind Farm, Germany	2004 - 2005	<p>Assistance to owners engineering team:</p> <ul style="list-style-type: none"> <li>• Review of site assessment</li> <li>• Calculation of wave loads and combined wind turbine and wave loads</li> </ul>
EIA, Horns Rev 1 Offshore Wind Farm Denmark	2004	<p>Fishery acoustics expert</p> <p>Services include:</p> <ul style="list-style-type: none"> <li>• Assessment of fish attraction to artificial structures</li> <li>• Horizontal hydro-acoustical surveys on fish distribution</li> </ul>

## References - International

Scheme title / location	Dates	Description of services
Sound Power and Tonality Evaluation, Germany	2004	Noise measurements carried out for the wind turbine manufacturer Enercon on the wind turbine E-33 in northern Germany. Measurement and analysis according to standards IEC 61400-11.
COD-NNE5-2001-00633, Sweden	2004	Support of the European Energy Authorities in an EU-project with the objective to develop policy and requirements for identification and implementation of offshore wind power in S, DK, D, Ire, GB, NL and B. Energy Authorities from all these countries participated in the project.
Capacity Building, Small Scale Energy, Sweden	2003 - 2004	Capacity Building for African and Asian managers in two SIDA financed projects regarding small-scale energy. Training in development of wind turbines, aerodynamics, rotors, tender processes, environmental impact, economy and financing.
Research, Ice Loads on offshore Wind Turbine Foundations, Denmark	2001 - 2004	Research project carried out in cooperation with Risø, DHI, Elsam, SEAS and wind turbine manufacturer Bonus. The research included physical model tests of ice loads and improved methods for defining the determining load combination for offshore wind turbine foundations.
Research, Load Measurement, Middelgrunden Offshore Wind Farm, Denmark	2001 - 2004	Participation in research project on loads on a wind turbine and the foundation at Middelgrunden offshore wind farm. Work done in cooperation with Risø National Laboratory, DHI Water&Environment, Bonus Energy A/S and Workgroup for Wind turbines at Middelgrunden and SEAS A.m.b.A  The services included: <ul style="list-style-type: none"> <li>• Load monitoring, including measuring and analysis</li> <li>• Reanalysis / comparison to assumed design loads from wind, waves, current and ice.</li> </ul>
Specialised Measurement System for Wind Turbine Noise, Spain / DK	2003	For the wind turbine manufacturer GAMESA Eólica a user-friendly system for field measurements was developed for sound power measurements and tonality analysis based on 15 years of experience and according to Danish and international noise measurement standards.  The system features: <ul style="list-style-type: none"> <li>• Compact, portable equipment based on laptop computer</li> <li>• User-friendly graphical user-interface</li> <li>• Continuous on-screen evaluation of measurement parameters and sound power results</li> <li>• Choice between several standards</li> <li>• Automatic chart generation in several languages via the Windows clipboard for direct insertion into other applications</li> <li>• Handling of various user-defined channels</li> <li>• Measurement of turbulence intensity</li> </ul>
Specialised Measurement System for Wind Turbine Noise, Spain / DK	2003	Noise measurements carried out for the wind turbine manufacturer NEG Micon on a wind turbine of the type NTK 600/43 in north-western Spain. Measurement and analysis according to standards IEC 61400-11 and FGW-1.

## References - International

Scheme title / location	Dates	Description of services
Screening of Potential Sites for Wind Power, Italy	2002 - 2003	<p>Screening and evaluation of 60 different locations for wind power potential for the power company EOS Energia. An area of about 300km<sup>2</sup> of the mountainous Basilicata, Southern Italy, was covered.</p> <p>The services included:</p> <ul style="list-style-type: none"> <li>• Physical inspection and assessment</li> <li>• Recording of geographical, meteorological and technical features and site-specific properties</li> <li>• Processing of maps and other technical, legal and financial information</li> <li>• Pre-feasibility analysis</li> <li>• Visualization of potential wind farms</li> <li>• Proposal for a site specific one-year measuring program covering four sites</li> </ul>
Project Implementation, Wind Farms, Cape Verde	2001 - 2003	<p>Establishing for World Bank and Government of Cape Verde of three wind farms on sites of existing wind farms (1.2 - 4.8 MW for each farm). Services are carried out as sub consultant to Risoe National Laboratory.</p> <p>The services included:</p> <ul style="list-style-type: none"> <li>• Meteorological measurements</li> <li>• Power systems analysis</li> <li>• Performance design</li> <li>• Prequalification</li> <li>• Tender documents (World Bank, EPC)</li> <li>• Tendering, including evaluation of wind turbines and contracting</li> <li>• Contract management</li> <li>• Supervision</li> <li>• Performance evaluation</li> <li>• Operation and maintenance assistance</li> </ul>
Composition of Proposal for a Wind Farm, Sweden	2002	Composition of proposal for Kuling Energi AB for four wind turbines outside Falkenberg.
Krieger's Flak Offshore Wind Farm, Sweden	2002	Expert assistance to Eurowind AB in preliminary evaluation of concept for foundation of wind farm comprising 150-200 turbines (4.5MW) at water depths of 17-35m 40km from the shore. Seabed of sand / clay till over chalk.
Environmental Reports for Wind Projects, Sweden	2002	Annual reports to environmental authorities for the three wind farms 1) Vindön Wind Farm, 2) BO 01 wind turbine Boel and 3) the wind farm at Trelleborg, Solvik. Client was Sydkraft Vind AB
Design Basis, Nysted Offshore Wind Farm, Denmark	2001 - 2002	<p>The design basis engineer was stationed with the owner.</p> <p>The services included:</p> <ul style="list-style-type: none"> <li>• Evaluation of site assessment concerning waves, currents, sea state and ice conditions</li> <li>• Development of design basis covering, wave loads, wind loads, ice loads and combined loads as well as relevant load combinations for monopiles and concrete gravity foundation</li> <li>• Scour protection design</li> </ul>
Örestad Offshore Wind Farm, Lillgrund, Sweden	2001 - 2002	<p>Eurowind AB prepared to establish an offshore wind farm comprising 48 wind turbines of 2MW or larger at Lillgrund in Øresund.</p> <p>The services included:</p> <ul style="list-style-type: none"> <li>• Initial expert advise on tender strategy</li> <li>• Development of design basis including wave and ice loads</li> <li>• Expert evaluation of program for geotechnical site investigation</li> <li>• Conceptual design of wind farm</li> <li>• Detailed design of gravity based foundations</li> <li>• Preparation of technical specifications for tender, design and construct</li> <li>• Project management in owners organisation for all electrical works</li> <li>• Analysis and specification for grid connection to existing grid</li> </ul>

## References - International

Scheme title / location	Dates	Description of services
Fladen Grund Offshore Wind Farm, Sweden	2001 - 2002	Expert assistance to a joint venture of Göteborg Energi AB, Nordex and ABB in preliminary evaluation of tripod concept for foundation of wind farm comprising 150 turbines at water depths of 12-17m.
Roeland Wind farm, EIA and Foundation Tendering, Denmark	2001 - 2002	Establishing for the wind project developer Dansk Vindenergi ApS, the near shore wind farm comprising of 8-16 wind turbines (2.0-2.5MW) at Roeland in NW Jutland, Denmark. The wind farm was erected in 2002. The services included: <ul style="list-style-type: none"> <li>EIA regarding ornithological investigations and marine benthic fauna, impact on fishing, bottom flora, risk of ship collision, hydraulics, sedimentation and marine archaeology.</li> <li>Establishing design basis</li> <li>Conceptual and detailed design of gravity based foundations</li> <li>Preparation of tender documents</li> <li>Supervision</li> <li>Design of and negotiations with authorities on the development of ornithological and marine monitoring programmes for operational phase</li> </ul>
Manual for EIA's on Land-based Wind Farms Denmark	2001 - 2002	For the Danish Energy Authority writing of manual for reporting of EIAs on land based wind farms. The manual is a description of the administrative processes, legislative background, tools for the process, and formal demands for reporting EIAs on land based wind farms and is exemplified with text and figure from various EIA-reports on wind-farms.
Malmö, BO-01 conference, 2 MW Wind Power Plant Sweden	1999 - 2002	Establishment for Sydkraft Vind AB of a 2MW Wind turbine in connection with the BO-01 conference. The services included: <ul style="list-style-type: none"> <li>Risk analysis</li> <li>EIA and approval from authorities</li> <li>Technical specification</li> <li>Tender documents</li> <li>Tender evaluation</li> <li>Yearly environmental reports to authorities</li> </ul>
Due Diligence, Sun 'n' Sand Beach Hotels Ltd, Kenya	2001	The project was carried out for IFC / African Project Development Fund as part of a technical / financial due diligence in connection with a loan application. The services included: <ul style="list-style-type: none"> <li>Wind resources, present and future power capacity demand and consumption, and energy pricing</li> <li>Technical / financial analyses</li> <li>Environmental impact assessment</li> </ul>
Owners Tender Design Foundation Nysted Offshore Wind Farm, Denmark	2001	Conceptual design of concrete gravity foundation from Middelgrunden design to a safer and more cost effective foundation for the more offshore site of the 72 wind turbine wind farm. The services include: <ul style="list-style-type: none"> <li>Geotechnical design</li> <li>Structural design based on FEM and other tools</li> <li>Specification of lab tests of wave-loads, scour and ice-loads as well as analysis of this</li> <li>Cost optimization to reduce owners eventual foundation costs taking into consideration also manufacture and installation</li> <li>Development of design procedures outside existing standards to approach, what was afterwards included in IEC61400-3</li> </ul>
Grid-control for Grid-connection of two Wind Turbines, Sweden	2001	Grid-control for grid-connection of two wind turbines to distribution grid for Södra Hallands kraft.

## References - International

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Research, Wind Turbine Communication Protocol, Sweden	2001	Participation in Elforsk financed research project regarding test and evaluation of a communication protocol for wind turbines.
Utgrunden, Sweden	2001	Preliminary design of grid connection for Utgrunden offshore wind farm for wind turbine manufacturer Enron Wind AB, and evaluation of insurance conditions for Utgrunden offshore wind farm.
Power System Stability Studies, Sweden	2001	Power system stability studies carried out for Sydkraft Elnät.
Task Management for Grid-connection Engineering for Lillgrund, Sweden	2001	Task Management for grid connection onshore for Eurowind on the offshore wind farm Lillgrund as well as SCADA and electricity in the project.
EIA, Nysted Offshore Wind Farm, Denmark	2000 - 2001	The EIA editor was stationed with the owner. The services include: <ul style="list-style-type: none"> <li>• Review meetings with all sub-supplying environmental experts producing for the EIA</li> <li>• Participation in redefinition of sub-suppliers tasks</li> <li>• Writing parts of the EIA on the basis of expert inputs</li> <li>• Fisheries and acoustics surveys on fish</li> </ul>
Middelgrunden Offshore Wind Farm, Denmark	1999 - 2001	Establishment of an offshore wind farm consisting of 20 wind turbines of 2MW from the wind turbine manufacturer Bonus. The services included: <ul style="list-style-type: none"> <li>• Preparation of a design basis including determination of combined loads from ice, currents and waves.</li> <li>• Conceptual design gravity concrete foundation detailed for tendering</li> <li>• Tender documents and contracting</li> <li>• Detailed design of a composite concrete foundation incl. FEM modelling</li> <li>• Documentation for certification by DNV</li> <li>• Evaluation of spill from dredging works</li> <li>• Project management</li> <li>• Supervision</li> </ul>



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