Executive Summary

Overview
NGenTec have developed lightweight and highly reliable novel permanent magnet generators (PMG) for the wind energy sector.

A spin-out company from the University of Edinburgh, NGenTec was incorporated in 2009 and aims to become a leading UK supplier of generators and associated engineering services directly to wind turbine manufacturers and developers.

Market Opportunity
Gearbox reliability has been reported to be a significant reliability issue in wind turbines. NEG Micon, once a world leading wind turbine manufacturer, collapsed in the late 1990s due to worldwide gearbox failures. In addition, the Horns Rev wind farm (80 2MW wind turbines) had to repair all its gearboxes\(^1\). Kittiwake (a leading global provider of monitoring and testing technology solutions) have determined that the total cost of removing, overhauling and reinstalling a single gearbox could be up to €450,000 for a multi-MW offshore wind turbine\(^2\). Operating and Maintenance costs are even more important as the wind energy industry moves towards offshore locations and utility scale wind farms.

Direct drive generators eliminate the need for gearboxes in a wind turbine and wind turbine manufacturers are increasingly seeing this as the solution of choice for both the onshore and offshore environment. However, the supply chain for large scale direct drive generators has relatively few options available. NGenTec believe they have an ideal solution for this market with its novel generator design.

The Market
Global wind energy market:
- 38GW of wind energy capacity was installed worldwide in 2010, representing an investment in wind turbines of €50 billion\(^3\)
- €150 billion annual global wind turbine installation forecast by 2020\(^4\)

European offshore wind energy market:
- 308 new offshore wind turbines in 2010 totaling 883 MW and worth €2.6 billion (50% growth from 2009) in Europe\(^5\)
- Forecast 1200 (7GW) of new offshore wind turbine installations annually by 2020 in Europe (CAGR 21%)\(^6\)

The global offshore wind energy market is predominantly in Europe in coming years and NGenTec is ideally located in Scotland to supply this growing market place.

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\(^2\) Kittiwake, http://www.kittiwake.com/wind_power.htm

May 04, 2011

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Product

NGenTec generator technology is embodied in the companies C-GEN generator. C-GEN is an axial-flux machine with multiple benefits such as high reliability, fault tolerance, high efficiency at low loads, low number of parts and high power density. Each C-GEN machine has Inherent modularity and redundancy. Each C-GEN generator can be made up of several stator and rotor light weight modules, which simplifies craneage, transport and installation. C-GEN generators could be “stacked” back to back along the shaft of a wind turbine and in the event of a generating line failure, one generator unit could be isolated enabling the wind turbine to continue generating revenue whilst maintenance is scheduled and this is particularly relevant for the offshore market due to the remoteness and challenging conditions for access.

C-GEN also provides the following benefits over other direct drive PMGs:
• Elimination of large iron core potentially resulting in reduced weight of the machine, with an advantage to wind turbine structure and foundation
• Simple and standard components leading to cost effective manufacturing, installation and maintenance
• The generator arrangement also eliminates the undesirable magnetic forces between the rotor and the stator. Zero cogging torque.

The initial C-GEN generators are shown below. Figure 1 shows an initial C-GEN demonstrator that was used to validate NGenTec design tools and shows the simplicity of the machine. Figure 2 shows the C-GEN machine fitted to a commercially available wind turbine that demonstrated its full operating range and characteristics in real conditions.

Development Programme

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<tr>
<th>Development Activities</th>
<th>2011</th>
<th>MONTH</th>
<th>2012</th>
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<tr>
<td>1MW Demonstrator (Segment of 6MW C-GEN)</td>
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<tr>
<td>1MW Demonstrator Design</td>
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<td>1MW Demonstrator Manufacture</td>
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<td>1MW Demonstrator Assembly &amp; Rig Integration</td>
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<td>1MW Demonstrator Rig Testing</td>
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NGenTec have now completed (Q1/2011) the design of a 1MW generator segment of a 6MW C-GEN, where a “segment” is considered to be a stand-alone generator that can be stacked back to
back along the shaft of a wind turbine six times to create a 6MW machine. The 1MW demonstrator will be running at the rotational speed of a 6MW generator and producing the equivalent torque to prove many characteristics of a full 6MW generator.

NGenTec have signed an industrial partnership with global engineering company David Brown Gear Systems to provide manufacturing expertise and testing services for the 1MW demonstrator.

NGenTec are pursuing opportunities with wind turbine manufacturers to develop and prototype C-GEN generators to meet their wind turbine’s specific requirements.

**NGenTec Technology Status**
- Four C-GEN prototypes have been built and satisfactorily tested. The tests served to prove the mechanical, structural, electro-magnetic and thermal characteristics of the machine.
- Design modelling tools have been developed and verified to optimise generator designs.
- 2 patents for core technology have been filed internationally and are at the PTC stage.
- NGenTec are pursuing a comprehensive IP portfolio.

**Projected Revenues**

The sales activity for NGenTec will take a significant step up throughout 2011 in order to secure the engagement of an OEM for the development of a large-scale generator. These sales projections are based on NGenTec securing development projects with a number of wind turbine manufacturers between 2012 and 2015, with each customer moving towards volume manufacture of C-GEN generators by 2017 by which time NGenTec aim to have secured a 7% share of the global offshore wind energy market.

2017 allows sufficient time to manufacture, test and certify the prototypes.

**Investment Status**

NGenTec secured inward investment of £2 million from Amsterdam based SET Venture Partners and Scottish Enterprise’s Scottish Co-investment Fund (£1 million each) in December 2010. The investment followed a recent £800,000 grant from the Department of Energy and Climate Change’s (“DECC”) Environmental Transformation Fund.

In February 2011 NGenTec secured an additional £200,000 investment from Edinburgh Technology Fund.

NGenTec have signed an industrial partnership with global engineering company David Brown Gear Systems to provide manufacturing expertise and testing services for the 1MW demonstrator, in return for an equity stake.
NGenTec is seeking to raise an additional investment of up to £6 million to commercialise the C-GEN product and take the company through to volume manufacture and self-sustainable growth.

Management and Personnel

The board of NGenTec comprises: Dr Derek Shepherd (non-executive Chairman), Dr Makhlouf Benatmane (CEO) Dr Markus Mueller (Chief Technology Officer), Dr Derek Douglas CBE (non-executive Director), Wouter Jonk (Non-executive Director, SET VP), Gavin McCallum (Non-executive Director, Clyde Blowers).

Dr Derek Shepherd, Non-Executive Chairman, Founder, was Managing Director of Aggreko International and a main board Director of Aggreko plc for 11 years. In this role he grew the international business into a billion dollar business over 11 years. Previously he was responsible for the UK based assembly facility that supplies Aggreko generators to the worldwide market.

Dr Makhlouf Benatmane, CEO, is a highly qualified executive offering more than 20 years of accomplished experience in electrical engineering. A charismatic and inspirational leader Ben has extensive experience in building strong and prosperous relationships with stakeholders in the wind energy industry with a proven track record of creating and delivering complex technical and strategic programmes. Prior to joining NGenTec Ben led the Wind and Renewables sector for Converteam UK Ltd where he was responsible for strategic business planning, contributing to corporate strategy, product definition and delivering the renewables sector financial performance of the company.

Dr Markus Mueller, CTO & Founder, is the inventor of C-GEN technology and has extensive experience of developing novel generator technologies. A Reader at the University of Edinburgh, he is running a research team of 13 supported by £2m of funding, focused on the development of electrical machines for renewable energy.

Dr Derek Douglas CBE, Non-Executive Director, Fund Raiser and Founder, is CEO and Chairman of Adam Smith Ltd. (ASL) based in Edinburgh. ASL provides corporate financial advice to SMEs and particularly start-ups seeking investment. He has a long history of successfully raising finance for start-ups in Scotland.

Jim Boyd, CFO, is a Chartered Accountant with significant financial and general management experience including over six years within the renewables industry in Scotland, including major fund raising projects.

Dr Alasdair McDonald, Chief Engineer & Founder, is a Research Associate at the University of Edinburgh and is involved in several research projects related to C-GEN. His technical expertise combines electrical and mechanical engineering disciplines.

James Murray, Business Development Manager, has 7 years experience in project management and technical leadership for BAE Systems and Mott MacDonald. James is also a 2009 Saltire Fellow, a practical programme focused on creating and leading high growth ventures.

NGenTec also have an experienced and professional engineering team.