



# Prioritising Wind Energy Research

Strategic Research Agenda of the Wind Energy Sector

2020

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## Overview

The energy sector of today faces a triple challenge : how to tackle climate change and meet rapidly increasing demand for energy while ensuring the security of its supply? Wind energy can be a significant part of the answer if sufficient support and increased political will are applied to its development.

The European Commission's May 2004 Communication<sup>1</sup> neatly encapsulates the benefits of wind and other renewable energy sources :

*“ Developing Europe's potential for using renewable energy will contribute to security of energy supply, reduce fuel imports and dependency, reduce greenhouse gas emissions, improve environmental protection, decouple economic growth from resource use, create jobs, and consolidate efforts towards a knowledge based society”.*

IEA and European Commission estimates show that, in a business as usual scenario, world and EU electricity demand could double by 2030<sup>2</sup>. Including the replacement of aging infrastructure, a global investment of some €10,000 billion will be necessary to meet this demand.

Unlike conventional fuels, wind energy is abundant, clean and indigenous. In 1999, energy imports cost the EU €240 billion, equal to 6% of its total imports. The European Commission's Green Paper on Security of Supply suggests that, in twenty to thirty years time, the EU could be importing 70% of its energy, up from 50% today. It concludes that:

*“ Renewable sources of energy have a considerable potential for increasing security of supply in Europe. In the medium term, renewables are the only source of energy in which the European Union has a certain amount of room for manoeuvre aimed at increasing supply in the current circumstances [...]. Effectively, the only way of influencing [European energy] supply is to make serious efforts with renewable sources.”*

Wind energy is a provider of sustainable economic growth, high quality jobs, European technology and research leadership, and global competitiveness. Indeed wind energy can help significantly across

the whole range of goals in the Lisbon Strategy to make Europe the world's most dynamic and competitive knowledge based economy.

Installed wind power worldwide, mainly based on European technology, stands at some 47,000 Megawatts (MW). This is just the beginning. The Global Wind Energy Council scenario *Windforce 12* demonstrates that there are no technical, economic or resource barriers to the supply of 12% of the world's electricity needs from wind power in 2020. This would mean an annual business worth some €80 billion.

Europe is the cradle of the wind industry, and today Europe is the world leader. European manufacturers represent over 80% of global industry turnover. But essential research and development must be undertaken, and sufficient support provided at EU and Member State levels, if aggressive competition is to be prevented from taking this lead, and nascent markets developed by European companies.

### A Roadmap for Collaborative Research and Development

This Strategic Research Agenda (SRA) is a roadmap showing wind energy research and development milestones towards increased wind power penetration and benefit to the union. The SRA details the key priorities, as they are understood today, to be addressed in the development of wind resource assessment, turbine and wind farm design, and the integration of wind power into European electricity supply, as well as research related to public support, the environment, and standards and certification.

The research tasks identified fall into three main categories: 'showstoppers', 'barriers' and 'bottlenecks'. Most important, showstoppers are issues of such importance that failure to address them could potentially halt progress in wind energy altogether. As identified in Chapter Three, such showstoppers include:

- In terms of **resource estimation**: maximum availability of wind resource data, in the public

<sup>1</sup> COM(2004) 366  
<sup>2</sup> compared to 2002

domain where possible, to ensure that financiers, insurers and project developers can develop high quality projects efficiently, avoiding project failure through inaccurate data.

- With regards to **wind turbines**: the availability of robust, low-maintenance offshore turbines, as well as research into the development of increased reliability and availability of offshore turbines.
- For **wind farms**: the research and development of wind farm level storage systems.
- In terms of **grid integration**: planning and design processes for a trans-European grid, with sufficient connection points to serve future large-scale wind power plants. This task should be undertaken by the wider energy sector in close cooperation with the wind energy sector.
- With regards to **environment** and **public support**: a European communication strategy for the demonstration of research results on the effects

of large-scale wind power plants on ecological systems, targeted at the general public and policy makers. To include specific recommendations for wind park design and planning practices.

#### Funding for R&D

Wind energy is reaching closer and closer towards cost parity with competing conventional technologies. Yet, even as progress is made, public funding for R&D is waning. The wind energy sector calls upon the EU and its Member States to renew their support for wind energy R&D, and has proposed that a **European Technology Platform for Wind Energy** be established to gather together all wind energy sector stakeholders, public and private, at EU and Member State levels, and including the wider energy sector, to help Europe harvest the full benefits of wind power.

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## 0. Introduction

Despite the great progress made in the past 25 years, wind energy has a long way to go before it reaches its full potential in terms of the large-scale supply of electricity. While it can already be cost competitive with newly built conventional plant at sites with good wind speeds, significant further cost reductions are necessary through market development and R&D.

The objective of this document is to communicate to policy makers at EU and national levels the essential strategic R&D requirements of the wind energy sector: what it needs to attain its full potential and become the cheapest electricity generating option for the future; and to demonstrate the rewards such investment in R&D will bring, such as maintaining European leadership in one of the most exciting energy industries of the present day, and driving the Lisbon Strategy.

This Strategic Research Agenda (SRA) is aimed particularly towards the EU's Seventh Framework Programme for R&D (FP7), at present under development. FP7, to last from 2007 to 2013, will constitute a vital period in the development of wind energy. Collaborative R&D undertaken at the EU level must take into account activities at the national level, and vice versa, while both EU and national funding should be stitched together to provide steady and reliable support for the development of wind power technology.

But it is not enough to maximise public funding. This research agenda is also aimed at private industry, which must remain deeply involved in collaborative R&D efforts, such as the Integrated Project, UpWind, for which funding under FP6 has recently been confirmed. Private-public partnerships are essential to ensure steady progress in technology development and cost reductions, and to maximise the efficient use of overall funding.

The European Technology Platform for Wind Energy proposed by the industry aims to develop this collaborative approach. The platform would be steered

by a Strategic Advisory Board, with maximum transparency, representing and addressing the needs and activities of stakeholders from throughout the wind energy sector: private and public industry and research, Member States and the EU, and with strong links to the wider energy sector.

### **A Dual Approach to Wind Energy Cost Reductions**

Technology and other research and development are crucial in the attainment of full cost competitiveness with other power sources, but they must go hand in hand with the creation of adequate framework conditions for investments in new markets, such as effective payment mechanisms, the removal of grid related and administrative barriers to wind energy penetration, and public acceptance.

Taking grid integration as an example, basic research aims to develop new designs and system operation tools for the European grid system, and to conduct strategic grid planning, taking into account projected increases in distributed generation, including wind power. At the same time, framework issues such as grid accessibility and ownership must be addressed. In other words, valuable and costly R&D must not be allowed to evaporate without leading to concrete results - it will be of little value if the strategic and operational aspects of grid integration are not addressed.

Moreover, European grid redevelopment is an example of an area of research that is not the sole concern of the wind industry, but a task belonging to the wider electricity sector as a whole.

Taking into account these twin elements of a successful wind energy strategy, the activities of the platform would be arranged in two baskets: market development, including short-term and operational issues such as overcoming grid and administrative barriers (with the support of the Directorate General for Transport and Energy); and research and development (with the support of the Directorate General for Research).



This Strategic Research Agenda lays out the key R&D priorities of the wind energy sector, both in terms of tasks and necessary resources. At present, the SRA looks towards 2020. Pending the commitment of the European Commission, it will be developed by the proposed European Technology Platform for Wind Energy, to provide a technological roadmap to 2030 and beyond.

### Structure of the SRA

Section 0.1 of this introduction discusses the origins of this report, and Section 0.2 provides the key elements of European policy related to wind energy. The Lisbon Strategy, of particular relevance, is discussed in more detail in Chapter One, which asks why wind energy should be a priority for the Community. Chapter Two provides perspectives on R&D Priorities, from outside the industry.

The research priorities detailed in Chapter Three are broken down into a number of themes.

- Section 3.1: accessing the full technical potential of wind energy - wind resource.
- Section 3.2: how to build tomorrow's wind turbines, including issues related to design, manufacturing, transport, installation, operation and maintenance (O&M), offshore, complex terrain and cold climates.
- Section 3.3: running a wind farm as a single plant, i.e. issues arising from development of very large wind farms.
- Section 3.4: technology issues related to the grid penetration of wind power.
- Section 3.5: public support and environment.
- Section 3.6: standards and certification for reduction in uncertainty.

Chapter Four discusses the implementation and financing of the Strategic Research Agenda, and Chapter Five provides conclusions and recommendations.

## 0.1 The Wind Energy R&D Network

The SRA has been developed over a period of three years, with the collaboration of the European Commission and the wind energy sector, through the Wind Energy Thematic Network Project<sup>3</sup>.

In a series of six strategy workshops held around Europe, ending in a final meeting at the Joint Research Centre (JRC) in Ispra, Italy, experts from throughout the sector have discussed their R&D perspectives and needs in four groups: turbine and component manufacturers, end users (developers, utilities and owners), R&D Institutions, and financiers and insurers.

This process has seen remarkable collaboration, both within the industry, in the expression of common needs, and with publicly funded research bodies. It has thrown to light many issues and questions: what exactly are the roles of public versus private research (collaborative versus competitive)? How can the two be coordinated and integrated to some degree without encroaching on intellectual property rights? How can national and European research be better coordinated and integrated? How can sufficient funding for R&D be ensured to enable the sector to meet its potential?

In response to these questions, and partially as a result of collaboration through the network, the wind energy sector has proposed and obtained an integrated project under FP6. The UpWind Project looks towards the development of design tools for a new generation of wind turbines from 2010. It will last five years, ending in 2010. However, UpWind represents, to date, the only long-term funding available to wind energy from the Community under FP6.

The network has benefited from the opinions and expertise of over two hundred wind energy and wider energy sector specialists. It has demonstrated the vital importance of strong collaboration and the integration of R&D activities. The proposed European Technology Platform for Wind Energy, while a much broader entity than the network, can be seen as its direct descendent.

<sup>3</sup> Contract number ENK6-CT-2001-20401

## 0.2 European Policy Context

This section outlines some of the key policy milestones driving wind energy development. Note that the Lisbon Agenda is particularly important in the context of research and is dealt with in more depth in Section 1.3.3 “Driving the Lisbon Strategy.”

### The Renewables White Paper

In 1997, the European Commission White Paper on Renewable Sources of Energy<sup>4</sup> set the goal of doubling the share of renewable energy in the EU from the 1997 level (of less than 6%) to 12% by 2010. One of the targets of the white paper was to increase EU electricity production from renewable energy sources from 337 TWh in 1995 to 675 TWh in 2010. Within this target, the goal for wind power was 40,000 MW installed capacity by 2010, which could produce 80 TWh of electricity and save 72 million tonnes of CO<sub>2</sub> per year.

Development since 1997 and expectations of future development indicate that these targets for wind power will be exceeded, according to a May 2004 communication from the European Commission<sup>5</sup>.

### The RES-E Directive

Directive 2001/77/EC on the promotion of electricity from renewable energy aims to increase the share of electricity from renewable energy sources to 22.1% by 2010 (EU-15) from 14% in 2000. For the expanded EU, the target is 21% by 2010. Indicative targets for renewables' share of electricity vary among Member States. The Directive states:

*“(1) The potential for the exploitation of renewable energy sources is underused in the Community at present. The Community recognises the need to promote renewable energy sources as a priority measure given that their exploitation contributes to environmental protection and sustainable development. In addition this can also create local employment, have a positive impact on social cohesion, contribute to security of supply and make it possible to reach Kyoto*

*targets more quickly. It is therefore necessary to ensure that this potential is better exploited within the framework of the internal electricity market.”*

*“(2) The promotion of electricity produced from renewable energy sources is a high Community priority as outlined in the White Paper on Renewable Energy sources for reasons of security and diversification of energy supply, of environmental protection and economic cohesion.”*

Referring to these targets, and the effort required to reach them, the Energy Council concluded in November 2004, with regard to “sources of renewable energy with high potential such as wind offshore energy”:

*“In order [to meet] the EU-targets on renewable energy there is a need for [...] joint R&D efforts focusing on further cost reductions of supporting technologies.”*

The Commission's May 2004 Communication on the share of renewable energy in the EU shows that most Member States are not on track to meet their national targets. The Communication estimates that if current trends continue, a share of 18 or 19 per cent will be achieved in the EU-15, as opposed to the 22.1% (21% for EU-25) foreseen in the directive.

Only four of the EU-15 Member States assessed in the Commission's Communication look set to meet their targets: Germany, Denmark, Finland and Spain. The Commission estimates that additional investments of 10 to 15 billion Euros are required to achieve the 12% target the EU has set itself, to come from both public and private sectors.

### The Green Paper on Security of Energy Supply

According to the Commission's Green Paper on Security of Energy Supply, in two decades Europe will be importing 70% of its energy (up from 50% today). The Green Paper points out that renewable energy sources are indigenous and can be the force to counteract this trend:

<sup>4</sup> Energy for the future: renewable sources of energy - White Paper for a Community Strategy and Action Plan, European Commission, 1997  
<sup>5</sup> COM(2004) 366 final: Communication of the European Commission of 26/05/2004 on the share of renewable energy in the EU

*“Renewable sources of energy have a considerable potential for increasing security of supply in Europe. Developing their use, however, will depend on extremely substantial political and economic efforts. [...] In the medium term, renewables are the only source of energy in which the European Union has a certain amount of room for manoeuvre aimed at increasing supply in the current circumstances. We can not afford to neglect this form of energy.*

*Effectively, the only way of influencing [European energy] supply is to make serious efforts with renewable sources.”*

### **The Lisbon Strategy and Barcelona Objectives**

In March 2000, meeting in Lisbon, the European Council set out the ten-year Lisbon Strategy towards making Europe:

*“the most competitive and dynamic knowledge based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion.”*

The European Research Area (ERA) was proposed by the European Commission following its endorsement by the Lisbon European Council. ERA aims to boost competitiveness, sustainable economic growth, and employment, and is a key pillar of the Lisbon Strategy.

The “Barcelona Objectives” adopted at the Barcelona European Council in 2002 target an increase in R&D spending to 3% of GDP by 2010 (from 1.9% in 2000). It was also agreed that at least two thirds of total investment should come from the private sector. The Community’s Action Plan for Europe, resulting from the same summit meeting, highlights the potential of technology platforms to address major societal, economic and technological challenges on the road to achievement of the objectives, and to stimulate more effective and efficient R&D.

# 1. Why is Wind Energy Research Necessary for the European Union

Continued emphasis on wind energy R&D, both in the long-term to generate new knowledge, and in the short-term to apply it in today's electricity systems, is of paramount importance. Through R&D and market measures, the cost of wind energy will reduce to parity and below its cheapest competitors. At the same time it will provide secure and reliable power at nearly zero cost to the environment, and ensure European technology leadership, increased employment and economic growth.

At the launch of an earlier draft of the research agenda, in January 2004, then Commissioner for Research and Development Philippe Busquin, stated that:

*"Wind power is a prime example of how an ambitious European research effort can give Europe a very strong leadership. [...The R&D strategy] contributes both to our research policy objective of reaching 3% of GDP for research investment by 2010, and to our energy policy objective of reaching 12% of renewable energy by the same date."*

But it is not enough to rest on one's laurels. If the Union does not increase R&D funding to renewable energy, at least to a par with that given to conventional technologies, it will fail to meet its targets for renewable energy and greenhouse gas emissions, and to reduce its dependency on energy imports.

In an answer to a recent written question<sup>6</sup>, European Commissioner for R&D, Janez Potočnik stated:

*"The Commission is concerned by the decreasing trend of the RTD spending in the field of renewable energy sources these last twenty years both at the national and European levels. If this trend is not reversed by a substantial increase of funding in the future, it could hamper the progress of renewable energies in the EU energy mix."*

Although wind energy has grown at an average annual rate of 22% over the last six years, there is a huge gap to be bridged between present installed capacity and wind energy's potential for 2020. At present, in Europe, over 34,000 MW have been installed, of which some 640 MW are located offshore. In 2020, some 180,000 MW are projected to be installed<sup>7</sup>, of which 70,000 MW would be located offshore.

Many technological obstacles will emerge in this journey, and some of these can be pre-empted if dedicated, sufficient R&D funding is assured in the short to long term.

## 1.1 Increasing Demand for Electricity

In its Business As Usual (BAU) scenario, i.e. in the absence of intervention, or increased political efforts in the field of energy efficiency, the IEA estimates that the world's electricity demand could double between 2002 and 2030.

The European Commission estimates that EU-25 electricity demand has increased by an average of 1.7% per annum since 1990<sup>8</sup>. In EU-15 states, demand growth has reached up to nearly 1.9% annually. In the New Member States (NMS) demand initially exhibited limited growth (from 1990 levels) – around only 0.2% annually – but in the second half of the last decade, it rose again to around 1.5% per annum.

Looking into the future, in its Business As Usual scenario, the European Commission expects total electricity generation in the EU-25 to grow by 1.4% annually from 2000 to 2030 (see Table 1.1).

<sup>6</sup> Number E-2459/04, by Péter Olajos (PPE-DE) to the Commission

<sup>7</sup> EWEA: *Windpower Targets for Europe*, October 2003

<sup>8</sup> European Commission DG TREN, *European Energy and Transport: Scenarios on Key Drivers*, September 2004

**Table 1.1**  
**Electricity Demand in the EU-25<sup>a</sup>**

|              | TWh   |       |       |       |       | % Annual Growth Rate |       |       |       |       |
|--------------|-------|-------|-------|-------|-------|----------------------|-------|-------|-------|-------|
|              | 1990  | 2000  | 2010  | 2020  | 2030  | 90/00                | 00/10 | 10/20 | 20/30 | 00/30 |
| <b>NMS</b>   | 317   | 324   | 392   | 498   | 551   | 0.2                  | 1.9   | 2.4   | 1.0   | 1.8   |
| <b>EU-15</b> | 2,139 | 2,574 | 3,027 | 3,450 | 3,846 | 1.9                  | 1.6   | 1.3   | 1.1   | 1.3   |
| <b>Total</b> | 2,456 | 2,898 | 3,419 | 3,949 | 4,397 | 1.7                  | 1.7   | 1.5   | 1.1   | 1.4   |

The disparity between EU-15 and New Member State electrification levels as of 2000 is demonstrated in the table, reflected in the evolution of electricity demand up to 2030. While electricity demand increases by 1.3% per annum in EU-15 states between 2000 and 2030, decelerating throughout the period, the European Commission’s Primes Model projects pronounced growth in New Member States, averaging 1.8% per annum from 2000 to 2030, accelerating up to 2020 before also decelerating up to 2030.

The benefits this capacity has brought, in terms of sustainable economic growth, reduced energy imports, employment, sustainability goals, reduced pollution and the achievement of community targets for renewable energy, are only a first taste of what wind energy can do for Europe. Figure 1.1 shows the installed capacity of EU-25 countries today.

Overall then the amount of Terawatt hours (TWh) needed to supply EU-25 states by 2030 will increase by over 50% from 2000 levels.

**Figure 1.1**  
**Wind Power Installed in Europe by End 2004**

### 1.2 Wind Energy Tomorrow...

Wind power is a leading element in the European renewable electricity market. Much of this success is based on strong research and development. Today, wind energy capacity installed accounts for more than 2% of EU electricity consumption. In an average wind year the 34,200 megawatts of wind energy capacity installed in Europe (end 2004) can produce some 73 TWh of electricity.



9 Ibid

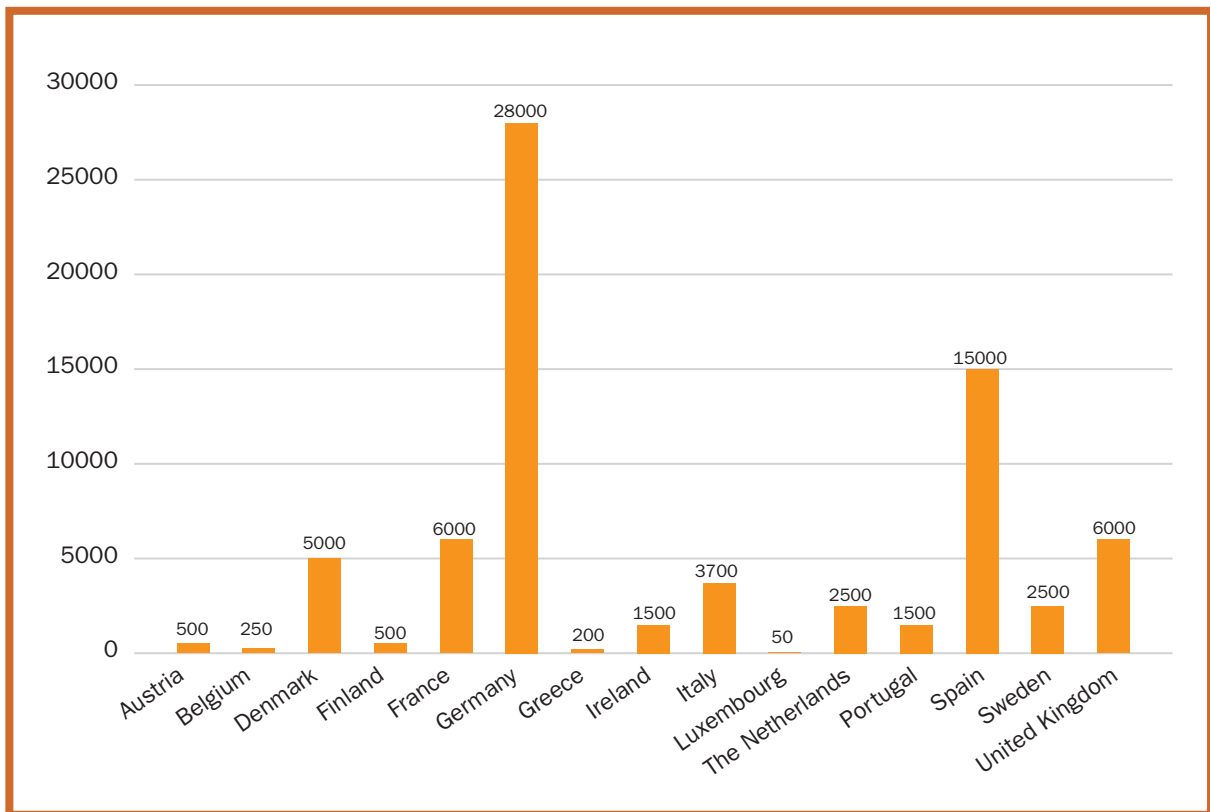
### 1.2.1 Wind Energy in 2010...

The RES-E Directive (see Section 0.2) targets the achievement of 22.1% (21% for EU-25) penetration by renewable energy of the overall electricity market in 2010, up from 14% in 1997. According to industry projections in 2003<sup>10</sup>, wind energy alone has the potential to meet half of this target. The Commission's 1997 White Paper on Renewable Sources of Energy targets the installation of 40,000 MW of wind power in 2010. While the industry initially adopted this target, it subsequently updated them in 2000, and again in 2003 to 75,000 MW, based on current growth trends.

EWEA's (2003) projection of EU-15 wind energy installed capacity for 2010 is presented in Figure 1.2. It shows that with continued political support and a strong R&D framework at Member State and EU levels, wind generating capacity by 2010 could reach 75,000 MW of installed capacity. In terms of overall capacity, Germany will continue as European leader, followed by Spain. Boosted significantly by around 50% of its total from offshore, the United Kingdom will take third place with France, followed by Denmark.

Every EU-15 Member State is expected to generate electricity from wind energy, and 10 states will have cleared the 1,000 MW level, marking their serious commitment to wind energy.

**Figure 1.2**  
**Projected Installed Wind Power Capacities in the EU-15 by 2010<sup>11</sup>**



<sup>10</sup> EWEA: *Windpower Targets for Europe*, October 2003

<sup>11</sup> Ibid

By 2010, in terms of capacity and power generation<sup>12</sup>, EWEA projects that wind power can provide:

- Annual electricity generation of 167 Terawatt hours (TWh), equivalent to 5.5% of European electricity demand, or the power needs of 34 million European households / 86 million people
- 28% of all new installed generation capacity over the period 2001 – 2010
- 10.6% of overall European installed generation capacity

In terms of sustainability and savings, successful development of wind power could:

- Deliver 50% of the EU Renewable Energy Directive target
- Meet more than 30% of the EU Kyoto Protocol commitment
- Save annually 109 million tonnes of CO<sub>2</sub>
- Cumulative CO<sub>2</sub> savings of 523 million tonnes (period 2001 – 2010)

And in terms of fuel and external cost savings, and investment in Europe, Wind power would mean:

- Cumulative avoided fuel costs of € 13.2 billion
- Annual avoided external costs of € 1.8 - 4.6 billion
- Cumulative avoided external costs of € 9.4 - 24 billion over the period 2001 – 2010
- An investment value of €49 billion over the period 2001 – 2010

### 1.2.2 ...And in 2020

EWEA figures from 2003 suggest that a target of 180,000 MW installed wind power capacity is feasible for 2020, including 70,000 MW offshore. The latter marks the paradigm shift that will take place in wind energy. For 2010, some 13% of capacity is envisaged offshore; by 2020 the proportion has risen to 39%.

Offshore wind energy is one of the new frontiers of the wind industry. While promising, able to take advantage of significantly higher offshore wind speeds, considerable research and development tasks remain to be carried out in offshore technology, and technological bottlenecks overcome.

An installed capacity of 180,000 MW in 2020 would deliver 12.1% of European electricity needs, with an annual electricity generation of some 425 TWh. This is the equivalent of the power needs of 85 million European households. Wind energy capacity would constitute 37% of total new generation capacity installed over the period 2010 to 2020, and 21% of total European installed generation capacity.

The European Renewable Energy Council (EREC), of which the European Wind Energy Association is a founder member, is calling for a 20% share for renewable energy technologies in gross inland energy consumption<sup>13</sup>.

The European Conference for Renewable Energy Intelligent Policy Options in Berlin, January 2004, also concluded that the EU should set the 20% target for 2020 without delay:

*"[...] new targets are needed to provide medium and long-term investment security [...] the institutions of the European Union should proceed without delay in setting new ambitious targets for 2020 [...] A target value of at least 20% of gross inland energy consumption by 2020 for the EU is achievable. Such targets shall be accompanied by a detailed action plan [to] maintain the European Union's role as driving force in the development of renewable energy markets."*

The European Parliament adopted the same target in 2004<sup>14</sup>. Subsequently, the European Parliament's Industry, Research and Energy (ITRE) Committee adopted on 27 June 2005 a report<sup>15</sup> calling for an increase in the share of energy from renewables by 2020 to 25% (from the current level of around 6%).

The latest edition of the Global Wind Energy Council and Greenpeace study Wind Force 12 shows that alternative paths to the Business As Usual scenarios referenced in Section 1.1 are possible. The report shows that with increased political will, global installed capacity of wind power could reach over 1,200,000 MW (1.2 Terawatts), supplying 12% of the world's electricity.

<sup>12</sup> EWEA: *Windpower Targets for Europe*, October 2003

<sup>13</sup> The methodology behind this figure was based on the Eurostat convention as this was the basis for the figures in the White Paper on Renewables and other relevant official documents. A calculation based on the substitution principal yields a target of 25%.

<sup>14</sup> *European Parliament Resolution on the International Conference for Renewable Energies (Bonn, June 2004)*, P5\_TA(2004)0276

<sup>15</sup> *Report on the share of renewable energy in the EU and proposals for concrete actions*, (2004/2153(INI))

## 1.3 The Role of Wind Energy

The benefits of wind energy are recognised and well summarised in the European Commission's May 2004 Communication<sup>16</sup>:

*"Developing Europe's potential for using renewable energy will contribute to security of energy supply, reduce fuel imports and dependency, reduce greenhouse gas emissions, improve environmental protection, decouple economic growth from resource use, create jobs, and consolidate efforts towards a knowledge-based society."*

The BAU scenario developed by the European Commission, and based on the Primes Model, does not count RES development through implementation of the RES-E Directive, perhaps because overall Member State implementation of the Directive to date has been poor. However, the model does demonstrate that, if renewable energy does not take up the new demand, traditional, polluting technologies will be the only alternative.

This would cause irremediable harm to the environment, reducing air quality still further, lead to substantial increase in greenhouse gas emissions; drastically increase European dependence of foreign energy imports; and neglect what is at present one of Europe's fastest growing industries, and potentially one of its greatest success stories.

### 1.3.1 Reductions in CO<sub>2</sub> Emissions

Under the Kyoto Protocol on climate change, the EU has committed to reduce its greenhouse gas emissions by 8% in 2010, compared to 1990 levels. However, greenhouse gas (GHG) emissions in the EU-15 have decreased by only 1.7% between 1990 and 2003, and last year increased by 1.3%, according to a recent inventory report from the European Environment Agency.<sup>17</sup>

Commissioner Piebalgs stated earlier in the year that:

*"It has been estimated that CO<sub>2</sub> emissions in the European Union [...] are likely to exceed their 1990 level by 14% in 2030. Such a development will make it even more difficult to achieve the objectives of the Kyoto Protocol."<sup>18</sup>*

Today, wind power installed in Europe is saving over 50 million tonnes of CO<sub>2</sub> every year. If current trends in growth continue, by 2010, wind energy will save 109 million tonnes per year, the equivalent of more than 30% of the EU's total Kyoto Protocol obligation<sup>19</sup>.

The key role of renewable energies like wind power in tackling climate change is already acknowledged. The recent European Environment Agency (EEA) assessment on greenhouse gas emission trends in Europe concluded that:

*"the promotion of renewable energy has the greatest impact on emissions in most EU Member States for both implemented and planned policies."*

The gravity of greenhouse gas emissions, and its consequent effects on global climate warming and instability witnessed by El Niño phenomena and others, often overshadows more microcosmic damage caused every day by continued reliance on fossil fuels and nuclear.

### 1.3.2 European Energy Independence

The 50% increase in European electricity demand predicted by the European Commission in their Business as Usual scenario<sup>20</sup> would be met in the main by conventional fuels. This would be unfortunate, ensuring that Europe's dependence on energy supplies from other, often unstable economies would increase from its present level of around 50% today to 70% by 2030.

<sup>16</sup> COM(2004) 366 final

<sup>17</sup> EEA, 21 June 2005. Due to a surge in electricity demand mainly met by coal-fired power plant

<sup>18</sup> Answers to Questionnaire for Commissioner Designate, Andris Piebalgs; Part B – Specific Questions; Spring 2005

<sup>19</sup> EWEA, 2004: *Wind Force 12: A blueprint to achieve 12% of the world's electricity from wind power by 2020.*

<sup>20</sup> European Commission DG TREN, European Energy and Transport: *Scenarios on Key Drivers*, September 2004



Oil and gas reserves are finite and the effects of their depletion will be felt long before the fields are actually drained, in the form of drastic price increases in energy supplies, and consequent economic distress. If measures are not taken today to prepare for the transition to an economy based on new indigenous energy technologies such as wind power, time pressures and oil prices significantly higher than the already high prices of today are likely to cause great economic and social upheaval.

Renewable energy sources are more evenly distributed over the world, unlike oil reserves, for example, of which 60% are located in only 40 oil fields, often in African, Arabian and Central Asian States, prone to socio-political disruption. Energy price volatility, caused by the insecurity this engenders, is best exemplified by current (June 2005) oil prices in excess of \$60 / barrel<sup>21</sup>.

By contrast, wind energy involves no fuel price risk, as there is no fuel. Wind is an endless resource that only requires increased research for its effective extraction, accurate prediction, and optimised and intelligent integration, and a market penetration large enough to 'absorb' weather systems (see Section 3.1). Wind energy is one of Europe's largest indigenous energy resources, bigger than oil, coal and gas together.

Wind can reduce energy import dependence as part of a more diverse and modernised European electricity supply. If Europe is to have secure electricity supply at stable prices, diversity, mitigating reliance on non indigenous energy sources, is essential.

In April this year, Energy Commissioner, Andris Piebalgs admitted that not enough progress was made regarding the objectives of the Green Paper on Security of Energy Supply:

*"The drive has not been too strong [...] There is now a real constraint on the security of supply of energy [...] the current emphasis placed on renewables and energy efficiency is insufficient."*

He also stated the "growing need for co-ordinated action at EU level" - a need that the proposed European Technology Platform for Wind Energy is poised to address.

<sup>21</sup> Light sweet crude. (June 28<sup>th</sup> 2005, Associated Press)

### 1.3.3 Driving the Lisbon Strategy

A strong wind power development does not only mean reduced CO<sub>2</sub>, as well as other environmental benefits. Sustainable economic growth, reduced energy import dependence, high quality jobs, technology development, global competitiveness, and European industrial and research leadership – wind is in the rare position of being able to satisfy all these requirements. Indeed wind energy can help significantly across the whole range of goals in the Lisbon Strategy to make Europe the world's most dynamic and competitive knowledge based economy.

Right now, Europe leads the world in wind: European manufacturers represent over 80% of global industry turnover; but foreign competitors are aggressively fighting for market share. And it is not only the benefits of a strong European wind industry that are at stake.

#### Wind is a Driver for Other Technologies

Since its inception, the industry has depended to a large degree on technology transferred from other industrial sectors, including aeronautics, shipping, steel and composites. Thus wind energy provided new markets for existing industries.

Today, while wind energy continues to provide such markets, the trend is reversing somewhat and advances in wind energy knowledge are increasingly spilling over into other industries. Wind energy research is increasingly driving other technologies, not only in manufacturing, but in installation, and operation and control, among others.

In other words, wind energy has become a driver for development and generation of new knowledge in other industries. However, wind energy lacks the strategic investment that was made in, for example, aeronautics and military equipment industries, from which it has borrowed technology.

#### Aggressive Competition from Outside Europe

Europe not only leads the present world market but also represents the centre of the manufacturing industry and technology innovation. Only with continued, strong political commitment and sufficient funding to R&D can this leadership be maintained.

Market assessments and industry analysis predict that Europe will be the most significant wind energy market over the rest of the decade. Danish wind energy consultancy, BTM Consult, expects two thirds of world new installed capacity between 2002 and 2006 will take place within the EU.

80% of today's capacity is located in just five countries - Germany, Spain, Denmark, the USA and India. Recently, The Netherlands and Italy have forged ahead to also break the 1000 MW barrier. The vast majority of the world market, then, in countries with a good resource but little or no capacity, is as yet unharnessed. Also, large export markets are emerging, for example, in the United States, India, China, Canada, Brazil and Japan. But how much European industry will profit from these markets, and how much of it will fall to competitors from outside the EU, remains to be seen.

## 1.4 Concluding Remarks

Wind energy is already providing and has the potential to provide greatly increased sustainable macro-economic benefit to the Community. The European Commission has set targets for renewable energy and electricity production, which are unlikely to be met without increased concentration on those renewable energies best placed to provide the additional capacity, such as wind power.

In order for wind power to become fully competitive with conventional power generating technologies, even without internalisation of external costs to society, or reform of the very large subsidies they

receive, it is up to the wind energy sector to make further cost reductions.

Some 60% of cost reductions in the last two decades are estimated to be the result of economies of scale brought about by increased market volume, in turn a result of market volume in a handful of Member States. The remaining 40% of cost reductions can be directly attributed to research and development (R&D)<sup>22</sup>. Thus R&D is a direct driver towards achievement of Union targets for renewable energy market penetration.

Increased R&D funding is in itself an objective established at the Barcelona European Council in 2003, which targeted an EU R&D spend of 3% of GDP. Without such an increase, Europe will not achieve the objective of the Lisbon Strategy to become the world's most powerful, knowledge based economy, and without sacrificing en route the sustainability pillar of the strategy.

Failure to provide sufficient support to R&D in wind energy would be to risk the loss of one of the key energy technology growth areas in Europe today. The Global Wind Energy Council and Greenpeace, in the latest edition of their joint report *Wind Force 12*<sup>23</sup> explain that - with significantly increased political will and the development of strong and beneficial policy frameworks - the global wind energy market could develop into an \$80 billion dollar annual market by 2020. If Europe is to provide for this market, and reap the benefits this would entail, it must focus on research and development today.

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<sup>22</sup> Ad Hoc Group Report to the Executive Committee of the International Energy Agency Implementing Agreement for Co-operation in the Research and Development of Wind Turbine Systems: *Long-Term Research and Development Needs for Wind Energy for the Time-Frame 2000 to 2020*; Approved By The IEA R&D Wind Executive Committee, October 2, 2001

<sup>23</sup> Wind Force 12: *A Blueprint to Achieve 12% of the World's Electricity Supply by 2020*

## 2. Perspectives on Wind Energy R&D Priorities

This report communicates the R&D priorities of the wind energy sector. Other international groups are involved in wind energy R&D strategic planning. This chapter lays out the perspectives of some of these organisations.

### 2.1 European Union Activities

#### 2.1.1 European Commission Advisory Group on Energy

The European Commission Advisory Group on Energy (AGE) has established two working groups: the Strategic Working Group (SWOG) which is dedicated to providing guidance on energy research agendas; and a European Energy Research Area Working Group (ERAWOG) which focuses on the analysis and assessment of opportunities for collaboration in energy research.

SWOG has recently released a report, *Key Tasks for Future European Energy R&D: A first Set of Recommendations for Research and Development*. In the report the group recognises the need for a dedicated wind energy research programme:

*“SWOG believes [...] that EU-wide, long term generic and scientific R&D in wind energy would be appropriate to support the sector. The necessary basic element will be the establishment in FP7 of a research programme dedicated to wind energy, with the aim of supporting R&D projects and facilitating the further development of European industry in the wind energy sector.”*

SWOG stresses the importance of providing support at a level that will stave off international competition from the US and Japan, for example.

*“[...] the days are over when the fledgling European wind energy industry could depend on wind R&D being performed in national laboratories. Their future success therefore relies on the existence in the EU of the necessary research, available to EU companies at costs [comparable to] US and Japanese competitors.”*

#### SWOG R&D Priorities

In its annex dedicated to wind energy<sup>24</sup>, the report continues to detail R&D tasks, summarised below.

- To develop better understanding of wind resources, particularly in complex terrain and offshore, including improved power output prediction, and increased reliability of short-term forecasting (6 to 48 hrs).
- ‘Fourth-generation’ wind turbine technology, i.e. novel rotor concepts using ‘intelligent’ materials; enabling computational fluid mechanics; and new generator concepts.
- Offshore: there is a need for an R&D programme encompassing modeling and prediction of ocean currents and wave-state, wave-structure interaction (internal waves and surface waves), sediment transport, and ice conditions, as well as operation and maintenance.
- Grid integration, i.e. radically different and better systems and techniques for dynamic grid management based on improved systems integration, systems analysis, and control technologies.
- Stand Alone and Hybrid Systems: integration of stand alone turbines with other power sources such as PV for use in small grids.
- Socio - Environment: understanding sound generation and transmission; sound reduction; potential ecological impacts; potential interference with telecommunications and radar.
- Testing, standardisation and certification: for the reduction of uncertainties.

#### 2.1.2 Framework Programmes

Prior to and during the present financial perspective the mistaken impression seems to have developed that wind energy is a mature industry which no longer requires long-term funding for fundamental research and development. This is not the case. Indeed, it is more critical than ever that the industry further develops technologically in order to maintain European leadership in line with the Lisbon Strategy. The research requirements for developing offshore wind energy and grid integration alone are substantial to warrant increased support.

<sup>24</sup> See [http://www.europa.eu.int/comm/research/energy/pdf/swog\\_en.pdf](http://www.europa.eu.int/comm/research/energy/pdf/swog_en.pdf)

With this in mind, research institutes from around Europe have gathered together under the new aegis of the European Academy of Wind Energy, to exchange information and develop new knowledge in matters related to wind energy technology and policy, and constituting a major step towards the establishment of a European Energy Research Area<sup>25</sup>. The proposed European Technology Platform will take this collaborative approach even further, integrating the activities of research institutes with those of other wind energy sector stakeholders.

### **The Seventh Framework Programme**

In November 2004, the Energy Council concluded, with regard to *"sources of renewable energy with high potential such as wind offshore energy:*

*'In order [to meet] the EU-targets on renewable energy there is a need for [...] joint R&D efforts focusing on further cost reductions of supporting technologies.'*"

In its June 2004 Communication, 'Science and technology, the key to Europe's future - Guidelines for future European Union policy to support research'<sup>26</sup>, the European Commission outlined 6 major objectives of EU action in the field of research, and FP7, including the launching of:

*"European technological initiatives in promising industrial sectors such as energy, transport, mobile communications, embedded systems and nano-electronics. Technology platforms are being set up to bring together stakeholders to define a common research agenda."*

Accordingly, The European Wind Energy Sector, together with national ministries is actively working towards the establishment of a European Technology Platform for wind energy. In preparation for the platform, the wind energy sector has produced this Strategic Research Agenda to demonstrate the need for strong support for wind energy R&D. At a recent event<sup>27</sup>, Commissioner for Research, Janez Potocnik stated that:

*"A challenge for FP7 is to support the implementation of these [Strategic Research Agendas] established by the Technology Platforms."*

The June 2004 communication raises the issue also of 'research infrastructures.' Addressed separately in chapter 3.7 below, research infrastructures are specific pieces of hardware, laboratories and the like, existing or conceptual, considered essential in the furthering of European research.

Much emphasis is placed on Small and Medium Enterprises (SMEs) in discussions on FP7, as these are where innovation can be strongest. The vast majority of wind energy companies fall into this category – highly innovative, technologically cutting edge companies, but lacking the reserves of larger companies, and therefore requiring the support of the EU institutions if they are to deliver their full potential.

### **FP7 is Still Under Development**

The FP7 programme will not commence until January 1<sup>st</sup> 2007, and the European Commission only made its formal proposal to the European Parliament on April 6<sup>th</sup> 2005. At the time of writing, the European Parliament is preparing its response to the Commission, and one of the key questions on the table is the funding that will be accorded to renewable energy. As Polish MEP and former Prime Minister, Jerzy Buzek, the Parliament's Rapporteur on the Commission's proposal, explained:

*"The European Parliament will put forward a few hundred amendments, some of which 'on very sensitive issues', such as the proportion of R&D allocated to nuclear and to renewables."*

The size and form of EU finance for R&D in wind energy will be decided by the Member State representatives in the Council together with the European Parliament<sup>28</sup>. The position taken by national ministries will be crucial in the winning of sufficient financing for R&D in the wind sector.

<sup>25</sup> See [www.eawe.org](http://www.eawe.org) for more information

<sup>26</sup> COM(2004) 353

<sup>27</sup> Closing Ceremony of the European BIC Network/International Association of Science Parks Nantes, 20 May 2005

<sup>28</sup> According to Article 166 of the Treaty Establishing the Community

National policy makers need to understand that R&D in wind energy is at the heart of achieving the objectives of the Lisbon Strategy. It is essential that the sector as a whole maintains the clear message that the great benefits offered by wind energy will only materialise if sufficient, long term support is maintained under FP7 and beyond. This message should be repeated right through the FP7 decision making process in the spring and summer of 2006.

## 2.2 The International Energy Agency

In Its Report *Long-Term Research and Development Needs for Wind Energy for the Time Frame 2000 to 2020*, the Executive Committee of the IEA Implementing Agreement for Wind Energy<sup>29</sup> stated that continued R&D is essential to provide the necessary reductions in cost and uncertainty necessary to realise anticipated deployment levels.

In the mid-term, the report describes the R&D areas of major importance for the future deployment of wind energy to be related to forecasting techniques, grid integration, public attitudes, and visual impact:

*“R&D to develop forecasting techniques will increase the value of wind energy by allowing electricity production to be forecast from 6 to 48 hours in advance. R&D to facilitate integration of wind generation into the electrical grid and R&D on demand-side management will be essential when large quantities of electricity from wind will need to be transported through a grid. R&D to provide information on public attitudes and visual impact of wind developments will be necessary to incorporate such concerns into the deployment process for new locations for wind energy [especially offshore].”*

In the long-term, the IEA Implementing Agreement on Wind Energy sees the focus of R&D on taking steps towards making the wind turbine and its infrastructure interact more closely:

*“Adding intelligence to the complete wind system and allowing it to interact with other energy*

*sources will be essential in areas of large-scale deployment. R&D to improve electrical storage techniques for different time scales [minutes to months] will increase value at penetration levels above 15% to 20%.”*

Since its inception the IEA Implementing Agreement on Wind Energy has been involved in a wide range of R&D activities<sup>30</sup>. The current research and development activities of the Implementing Agreement itself are organised into six tasks (referred to as “Annexes”), giving insight into its perceptions of current R&D priorities.

- Task II: “Base technology information exchange” - co-operative activities and information exchange in two areas: i) the development of recommended practices for wind turbine testing and evaluation, including noise emissions and cup anemometry; and ii) joint actions in specific research areas such as turbine aerodynamics, turbine fatigue, wind characteristics, offshore wind systems, and forecasting techniques.
- Task XIX: “Wind energy in cold climates”. The objectives here include i) to gather and share information on wind turbines operating in cold climates; ii) to establish a formula for site-classification, aligning meteorological conditions with local needs; iii) monitoring the reliability and availability of standard and adapted turbine technology; as well as the development of guidelines.
- Task XX: HAWT<sup>31</sup> Aerodynamics and models from wind tunnel tests and measurements. The main objective here is to gather high quality data on aerodynamic and structural loads for HAWTs, to model their causes and predict their occurrence in full scale machines.
- Task XXI: Dynamic models of wind farms for power system studies, of which the main objective is to assist in the planning and design of wind farms through development of models for use in combination with software packages for simulation and analysis of power system stability.

29 The Executive Committee of the International Energy Agency Implementing Agreement for Co-operation in the Research and Development of Wind Turbine Systems, at its 54th Executive Committee meeting in Oulu, Finland, in 2004, invited the European Wind Energy Association to join the Implementing Agreement, pending an amendment to the Agreement to enable this.

30 See [http://www.ieawind.org/iea\\_wind\\_pdf/PDF\\_2004\\_IEA\\_Annual\\_Report%20PDF/15-42%20ImpAgree.pdf](http://www.ieawind.org/iea_wind_pdf/PDF_2004_IEA_Annual_Report%20PDF/15-42%20ImpAgree.pdf) for more information

31 Horizontal Axis Wind Turbine

- Task XXIII: Off shore Wind Energy Technology Development – to identify and conduct R&D activities towards the reduction of costs and uncertainties and to identify joint research tasks among interested countries.
- Task XXIV: Integration of Wind and Hydropower Systems – to identify feasible wind/hydro system configurations, limitations and opportunities, involving analysis of the integration of wind energy into grids fed by a significant proportion of hydropower and opportunities for pumped hydro storage.
- Task XXV: "Design and operation of power systems with large amounts of wind power production" has recently been proposed as an additional task.

This brief overview of the activities of the Implementing Agreement can be compared with the R&D tasks outlined below in this Strategic Research Agenda. A predominantly common view on priorities is apparent. Through its pending membership of the IEA Wind Implementing Agreement (WIA) Executive Committee, and through the European Technology Platform for Wind Energy, to which the IEA WIA will contribute, this Strategic Research Agenda will be further developed, taking into account the findings of both bodies<sup>32</sup>.

## 2.3 G8 Perspective

At the Evian G8 Summit, in 2003, leaders agreed a Science and Technology for Sustainable Development Action Plan, including, in the context of accelerating the research, development and diffusion of energy technologies, to:

*“(2.2) Promote rapid innovation and market introduction of clean technologies, in both developed and developing countries [...]*

*(2.3) Support efforts aimed at substantially increasing the share of renewable energy sources in global energy use [including to] stimulate fundamental research in renewable energies, such as solar photovoltaics, off-shore wind energy, next generation wind turbines, wave/tidal and geothermal, biomass; collaborate on sharing research results, development and deployment of emerging technologies in this area; work towards making renewable energy technologies more price competitive.”*

<sup>32</sup> See <http://www.ieawind.org/>

The Evian Action Plan committed G8 countries to convene senior G8 policy and research officials and their research institutions to compare and to link programmes and policies. A follow up meeting was held in Oxford in May of this year, focusing on information on strategic research priorities, and to identify scope for closer collaboration.

In January 2005, the report Meeting the Climate Challenge – Recommendations of the International Climate Change Task Force stated:

*“A long term objective [should] be established to prevent global average temperature from rising more than 2°C above the pre-industrial level, to limit the extent and magnitude of climate change impacts.*

*“G8 Governments [should] establish national renewable portfolio standards to generate at least 25% of electricity from renewable energy sources by 2025, with higher targets needed for some G8 governments.*

*“Governments [should] remove barriers to and increase investment in renewable energy and energy efficient technologies and practice such measures as the phase out of fossil fuel subsidies.”*

### “Increased Commitment to Energy R&D”

At the Gleneagles Summit in Scotland, in July 2005, G8 leaders agreed an Action Plan including promotion measures for R&D in the field of energy:

*“18. We recognise the need for increased commitment to, international cooperation in and co-ordination of research and development of energy technologies. We will continue to take forward research, development and diffusion of energy technologies in all the fields identified in the Evian Science and Technology Action Plan.*

*“20. We take note of the Energy Research and Innovation Workshop held in Oxford in May 2005, and will [...] work with the IEA to:*

- *build on the work already underway through its implementing agreements to facilitate cooperation and share energy research findings;*
- *reinforce links with the international business community and developing countries;”*

### 3. R&D to Maximise the Value of Wind Energy

This chapter describes the R&D priorities of the wind energy sector, as identified through the Wind Energy R&D Network. They are broken down into a number of themes.

- Accessing the full technical potential of wind energy (wind resource).
- Building tomorrow’s wind turbines.
- Running a wind farm as a single plant.
- Technological issues related to the grid penetration of wind power.
- Public support and environment.
- Standards and certification for reductions in uncertainty.
- Research infrastructures.
- Perspectives of Network Working Groups.
- R&D tasks in the wider energy sector.

In each section, key technological elements are explained to provide the context of the priorities, which are shown at the end of each section, divided into three categories, each with a different colour code, reflecting a different ‘type’ and level of priority.

- **The key priority is presented as a potential “Show-Stopper” (in red), which is to say that it is considered to be an issue (technological / societal) of such importance that failure to address it could halt progress altogether. Thus it needs special and urgent attention.**
- **Orange represents a “Barrier”, defined as being a principal physical limitation in current technology, which may be overcome through the opening up of new horizons through generic / basic research over the medium to long term.**
- **Green represents “Bottlenecks.” Not to be confused with the above, Bottlenecks are problems which can be relatively quickly overcome through additional short or medium term R&D, i.e. through the application of targeted funding and / other resources.**

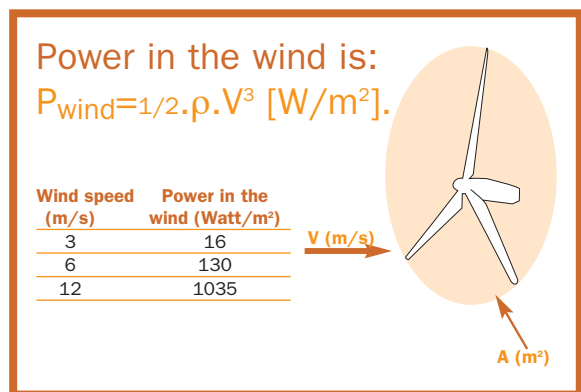
#### 3.1 Harvesting the Resource

The power in the wind is proportional to the cube of the wind speed, as demonstrated in Figure 3.1. A 20% higher wind speed means over 70% more energy content in the wind.

This means that the cost of electricity produced is very sensitive: the speed and distribution of the wind, and therefore choice of location – with the best resource – is key. Understanding the wind regime accurately, which is to say the average wind speed, the vertical wind gradient and the frequency distribution, is the most important factor when assessing the economic feasibility of a project. A 10% difference between measured and actual wind speed can make the difference between a “go” and “no-go” project.

**Figure 3.1**

**The power of wind is proportional to the cube of the wind speed. To calculate the power in the wind at a future wind turbine location, V should be the value of the undisturbed wind speed at hub height, A the rotor swept area and ρ the air density. On the basis of flow theory (Betz law) a wind turbine can never extract more than 16/27 (=59.3%) mechanical energy from the wind.**



Source: Jos Beurskens, ECN

**Figure 3.2**

Different systems to measure the wind characteristics. From left to right: an offshore mast equipped with i.a. classical cup anemometers, two experiments with SODAR (on land and offshore).

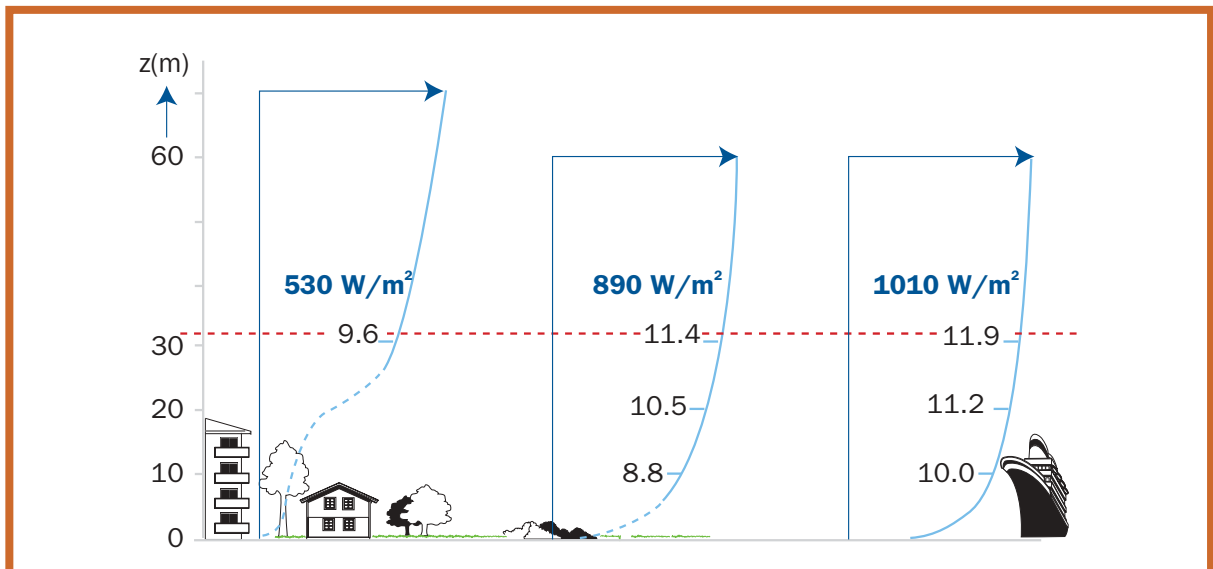


In the past, in order to facilitate site selection and assess the feasibility of possible projects, wind ‘atlases’ have been produced, containing not only wind speed characteristics at different locations, but

also methods to estimate wind speeds other than those used at a particular location, as well as methods to determine the vertical wind gradient for different levels of terrain roughness (see Figure 3.3).

**Figure 3.3**

The vertical wind gradient for different values of surface roughness (built up area, such as the centre of a city; area with scrub vegetation; open flat land or sea surface). Note that the wind power content of the wind at the same height (30 m) varies considerably.





The European Wind Atlas, developed under the European Commission's JOULE programme in 1989, has been an essential tool in the exploration of European wind energy potential, and in the selection of new high potential wind energy sites. However, the Atlas is not complete. Data from New Member States have not been fully verified or included, nor has the offshore wind resource in any real detail<sup>33</sup>.

It is essential that additional measurements of the wind resource around Europe be carried out. Recent measurements must be screened for reliability and included in the atlas database. Many additional field measurements have become available since the first issue of the Atlas, and consequently large amounts of data exist which could be used to verify meteorological models.

New observation, measurement and data communication technologies are enabling the wind energy community to explore potentially interesting areas more efficiently. One of these techniques is remote sensing. It is becoming possible to measure wind speed at high altitudes from measuring units at ground level by means of acoustic sound (SODAR) or light (LIDAR). But the reliability and accuracy of these methods is as yet far from sufficient. Further research into and development of such techniques will offer great possibilities worldwide, to map the total wind energy resource of the planet and thus identify the best sites to be developed to produce electricity at the lowest prices.

The offshore wind resource is not well mapped. The accuracy of many existing data is low and there are large areas that are not yet explored at all. Measuring wind characteristics at sea is needed, but very costly, mainly because of the high anemometry towers that are necessary (see Figure 3.2). Installation and removal of the towers adds to the cost considerably. Satellite observation can offer opportunities for measuring the offshore resource at an acceptable cost level. However such methods need to be further developed so they can meet minimum accuracy requirements for wind energy applications.

Such new methods are particularly relevant in exploring potentially interesting sites in complex terrain. Wind speed and turbulence characteristics in complex terrain can vary significantly over relatively short distances. The potential avoidance of a need for anemometry masts would make the exploration of such terrain types feasible, in terms of both investment cost and time saved.

New communications technologies, such as GSM (Global System for Mobile communication) and follow up systems like GPRS (General Packet Radio Services), GPS (Global Positioning System), satellite links, and glass fibre links will enable almost continuous analysis and display of data.

Measurement data could be made immediately available to customers in great detail and in various formats. This is particularly relevant for operators of large wind farms who have to specify the power that they will make available a few hours ahead. The forecasters which are required for such a service need geographically dispersed, accurate, synchronous wind data which can be provided through systems mentioned above. Not only operators need such data but also project developers, in the assessment of suitable wind energy sites.

#### R&D Priorities regarding Wind Resource Estimation and Mapping

**Maximum availability of wind resource data, if possible in the public domain, to ensure that financiers, insurers and project developers can develop high quality projects as efficiently as possible, and avoid project failure through inaccurate data**

**Resource mapping of areas with a high probability of high wind resource potential, but as yet unexplored, including the Baltic, North and Black Seas.**

**Development of cost effective measuring units, including communications and processing, and which are easily transportable, for the assessment of wind resource characteristics, such as LIDAR, SODAR and satellite observation.**

<sup>33</sup> Which is not to say that no attempt to map the offshore wind resource has been carried out.

## 3.2 Building Tomorrow's Wind Turbines

The long-term economic success of the European wind industry will primarily depend on its ability to penetrate the world market. Therefore, providing cost efficient and reliable turbines is a key factor for success.

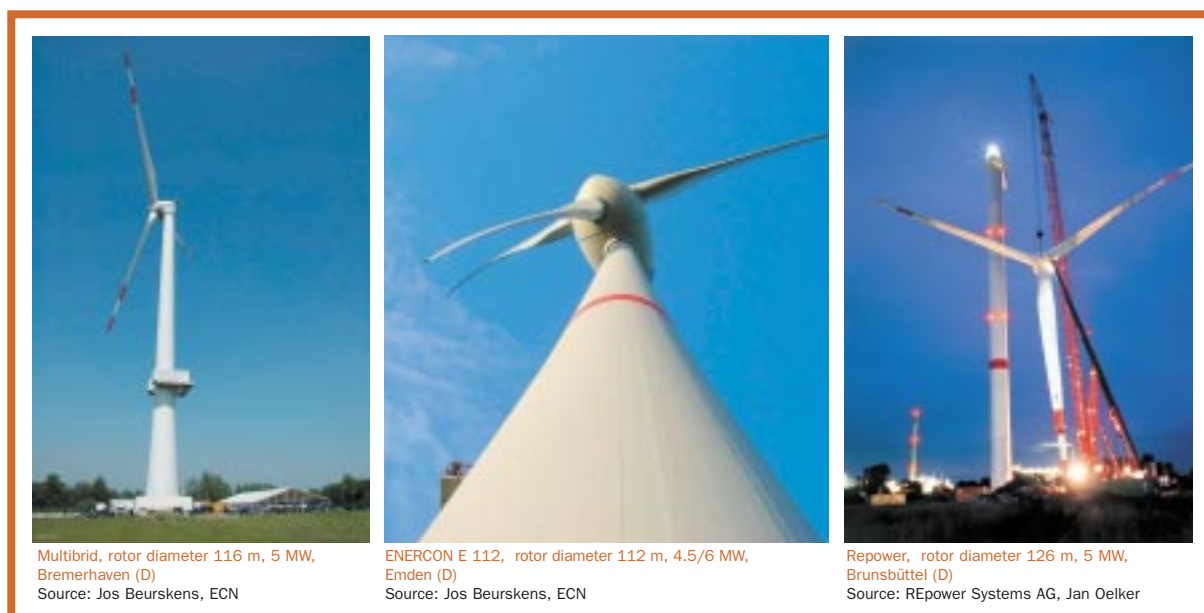
The bulk of wind energy capacity presently installed or under installation consists of wind turbines with rotor diameters between 60 and 90 metres, with rated installed capacity varying from 1 to 3 Megawatts (MW)<sup>34</sup>. The first examples of 5 MW turbines with a rotor diameter of around 120 m are at present in the prototype phase (see Figure 3.4).

The up-scaling of wind turbines during the last decade is unprecedented, and will likely continue as offshore installations become more economically attractive and common (see Figure 3.5).

There are a number of advantages inherent in this up-scaling, and which drive the trend:

1. Reduction in visual impacts. This is an interesting point as public perception may not always take into account that a small number of larger turbines can replace a larger number of small turbines (see Figure 3.6). Larger turbines also rotate slower, and thus tend to be less intrusive visually.
2. In 'Line-Clusters' the generating capacity per kilometre is more than proportional to the rotor diameter, which favours the installation of wind turbine as large as possible, see Figure 3.8.
3. The minimisation of the cost of offshore installations, a significant proportion of which is the cost of foundations, necessitates that the largest possible capacity be installed on each foundation unit. The same applies to the grid transporting the power from offshore to the shore.

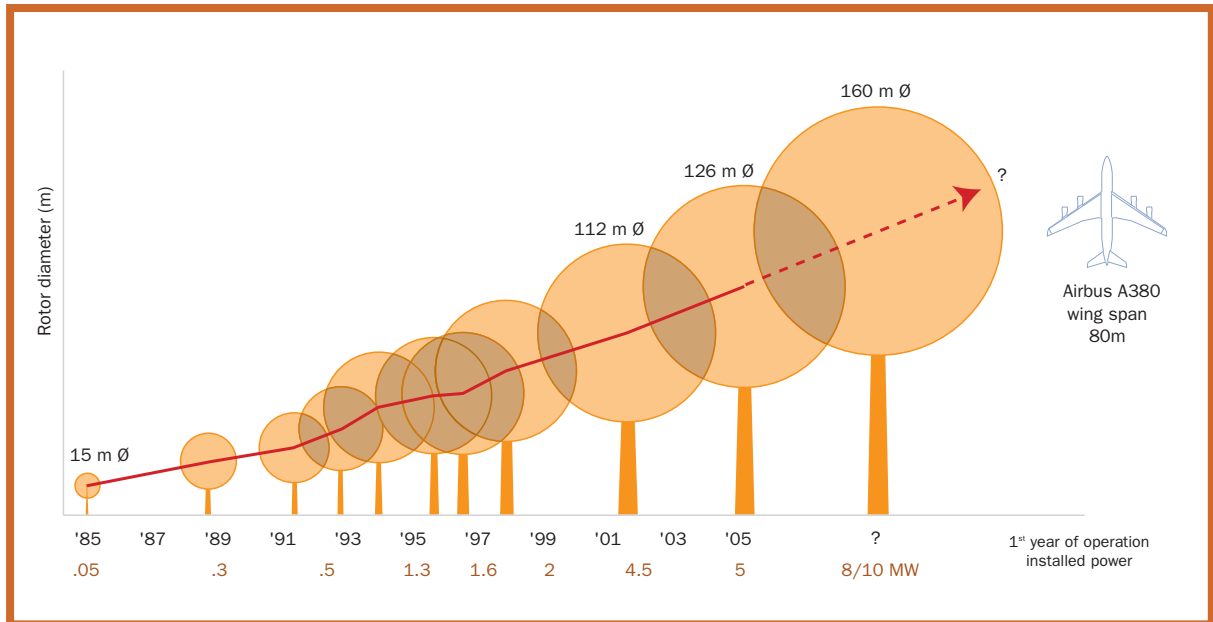
**Figure 3.4**  
The largest wind turbines of 5 MW and over.



<sup>34</sup> This is not to say that small and micro wind turbines are not of importance. See Section 3.2.1.

**Figure 3.5**

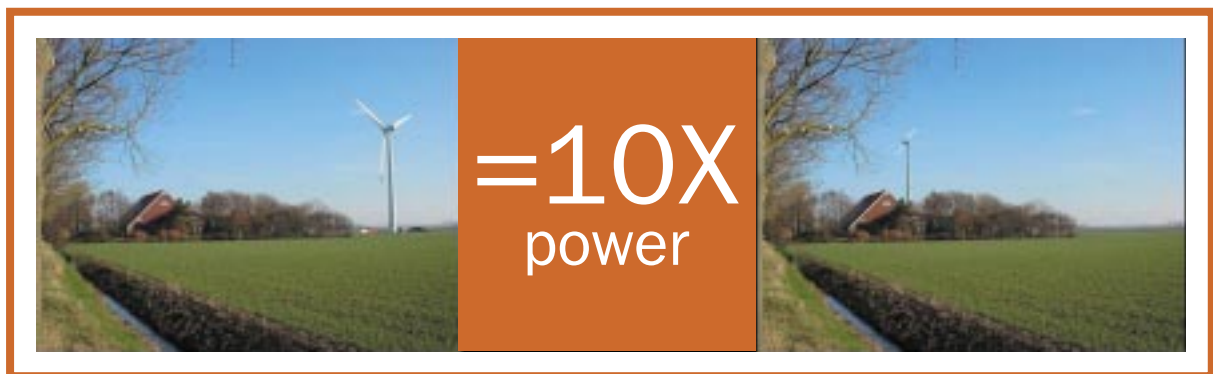
The size of wind turbines at market introduction. Mid 2005 the largest wind turbine had a diameter of 126 metres and an installed power of 5 MW.



Source: Jos Beurskens, ECN

**Figure 3.6**

The generating capacity of the wind turbine on the left is ten times that of the machine on the right. The visual impact hardly differs.



Photos: Jos Beurskens, ECN

Up-scaling, however, incorporates development risks. Up-scaling without radically changing design concepts and material properties, leads to higher internal material stresses. Such stresses can only be kept at acceptable levels if materials are used with higher strength to mass ratio or compliant components are incorporated in the design. If components bearing heavy, dynamic loads, such as blades, blade roots and yawing systems are made of flexible materials, then the forces acting upon them are not transferred to the supporting structure (see Figure 3.7). In this way dynamic forces are averaged out, leading to significantly lower fatigue loading of the relevant components.

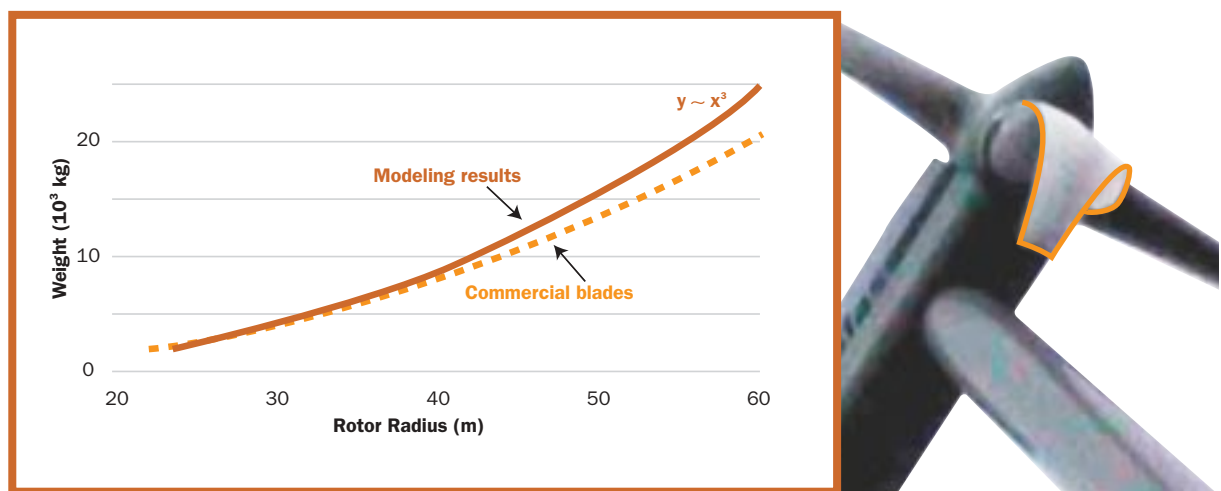
### Design Tools for Reduced Uncertainty

Currently used design tools are only partially suitable for the reliable design of very large wind turbines, and have been validated and verified by means of measurements on what are now only ‘medium size’ machines. However, some physical properties that are irrelevant in small and medium sized turbines cannot be neglected in the design of large, multi-megawatt turbines.

It is difficult to define a sharp upper limit for the machines to which existing design tools can be applied. However it is generally acknowledged by experts that the design risks increase considerably for machines with rotors of over around 125 metres in diameter.

Figure 3.7

This graph shows the calculated relationship between blade length and the development of commercial blades. Commercial blades are relatively lighter than calculated reference blades because new materials are being applied and design codes become more accurate. This leads to less conservative designs. Blades are made extremely flexible which avoids dynamic forces to be transferred to the hub construction. In the picture the deflection of a blade during normal operation can clearly be seen.



Source: NREL, USA

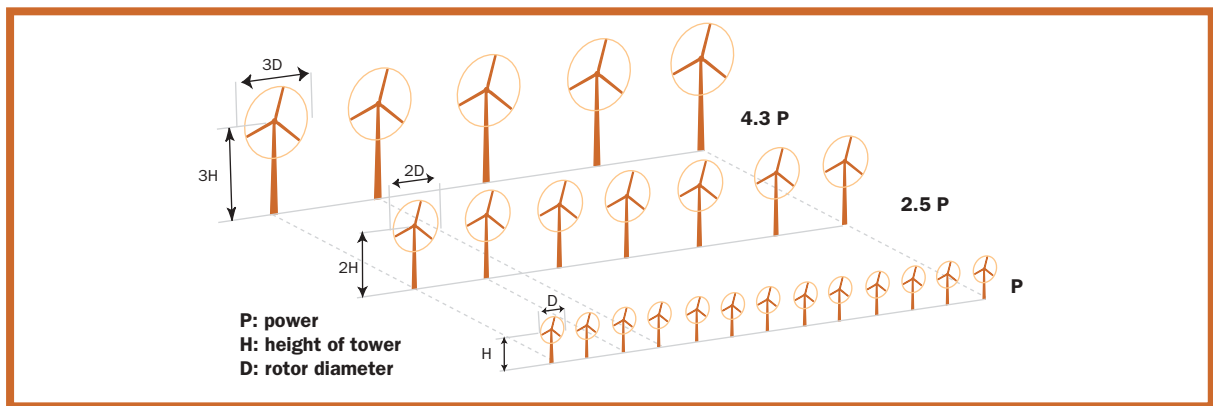
Photo: Jos Beurskens, ECN

For this reason, new design tools are needed, supplemented with new features taking into account such issues as extreme blade deflections, and wave loading of support structures, particularly in the case of offshore turbines. Such new tools will be essential if a new generation of wind turbines is to be designed and manufactured in a cost effective way.

If the elaborate and expensive testing of prototypes can be reduced by the availability of high quality design tools, the time to market innovative concepts will also be reduced, providing manufacturers with competitive advantage. The probability of failure of wind turbines newly introduced to the market will also reduce, so providing financiers and end users with a lower risk profile, and less uncertainty, and consequently lower electricity costs to the consumer.

**Figure 3.8**

**Depending on the roughness of the terrain, the total capacity of a line cluster is more than proportional to the size of the rotor. This is one reason to install wind turbines as large as possible.**

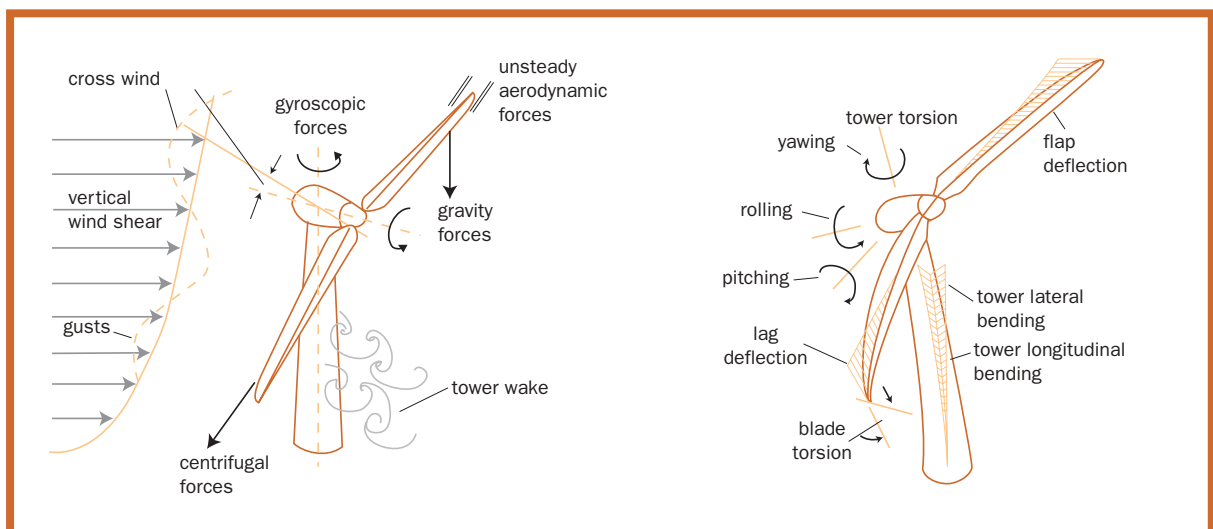


Source: Jos Beurskens, ECN

One of the key challenges in developing design tools suitable for very large wind turbines is to understand and model aero-elastic phenomena. Figure 3.9 gives an impression of the many dynamic external forces that act on wind turbines and the many ways the wind turbine structure may be distorted and may vibrate.

**Figure 3.9**

**On the left all external dynamic forces are indicated that expose a turbine to extreme fatigue loading. On the right the various vibration and deflection modes of a wind turbine can be seen. From the dynamic point of view a wind turbine is a complex structure to design reliably for a given service life time.**



Source: Kießling, F: Modellierung des aeroelastischen Gesamtsystems einer Windturbine mit Hilfe symbolischer Programmierung. DFVLR-Report, DFVLR-FB 84-10, 1984.

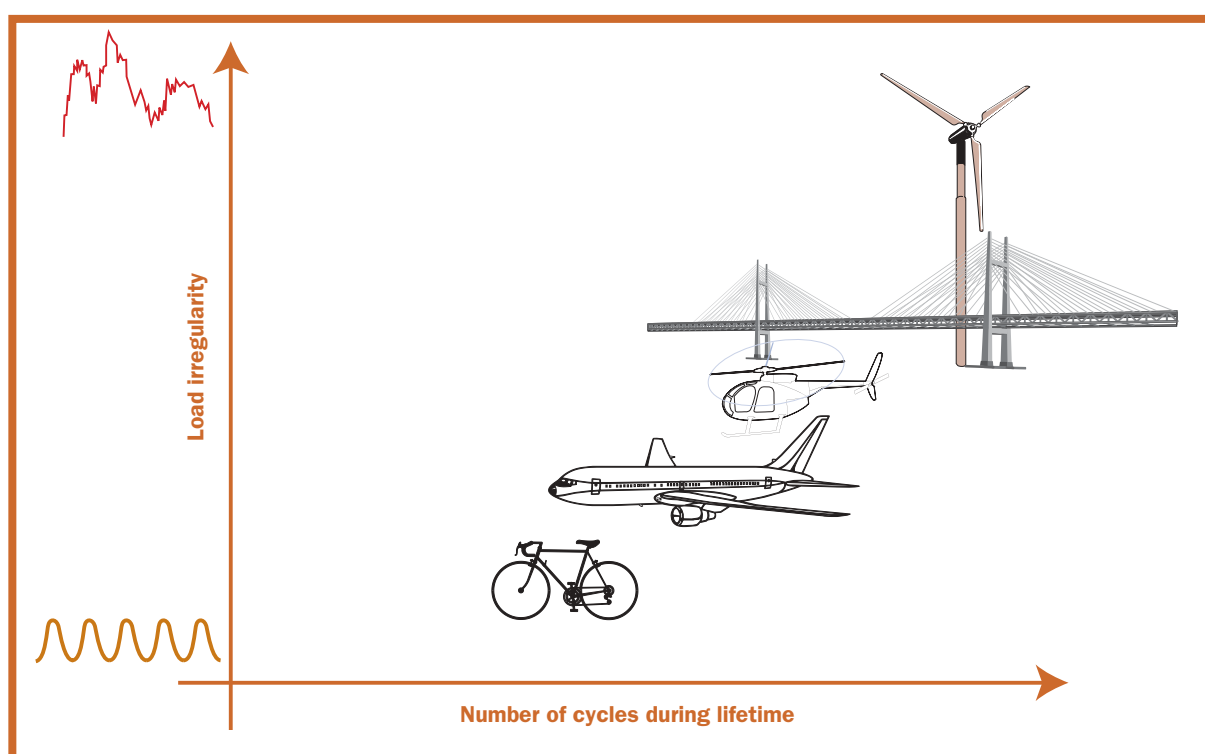
In fact, the fatigue loading of a wind turbine is more severe than that experienced by helicopters, aircraft wings and car engines. The reason is not only the magnitude of the forces but also the number of load cycles that the structure has to stand during its life time of 20 or more years (see Figure 3.10).

methodology, which can incorporate new findings, however, is not yet available and is urgently needed.

New materials and manufacturing methods are required to design and manufacture extremely large machines. For example, nowadays fibre reinforced plastics (FRP) rotor blades are designed according

**Figure 3.10**

**The fatigue loading of a wind turbine during its life time is large compared to examples bridges, helicopters, airplanes and bicycles.**



Source: WMC (TU Delft-ECN)

The larger the wind turbine becomes, the more extreme the phenomena become. To better understand the complex flow in the rotor area, computational fluid dynamics (CFD) need to be further developed. Large scale wind turbines can be equipped with sensors recording dynamic behaviour. Thus, system identification and inverse methods for providing the loads under real conditions are required. Comparing the loads with computational results will provide validated methods. Figure 3.11 illustrates the complexity of rotor flow.

A number of numerical codes exist to analyse and design components and subsystems such as drive trains, rotor blades, drive train dynamics, and tower dynamics. A state of the art integrated design

to regulations based on the very first principles of composite mechanics. Furthermore, equations describing material properties are considered linear, although it is common knowledge that this does not allow for some phenomena. Such shortcomings in state-of-the-art numerical tools and existing formulations of composite mechanics result in uncertainty levels that lead to rotor blades of unnecessarily high weight and cost.

Also new components are needed to control instabilities and reduce dynamic loads. Smart, passively controlled blades; and slow running, compact generators, are just two examples. Such components will have to be intensively tested in laboratories that

can also simulate extreme external conditions foreseen during their projected lifetime.

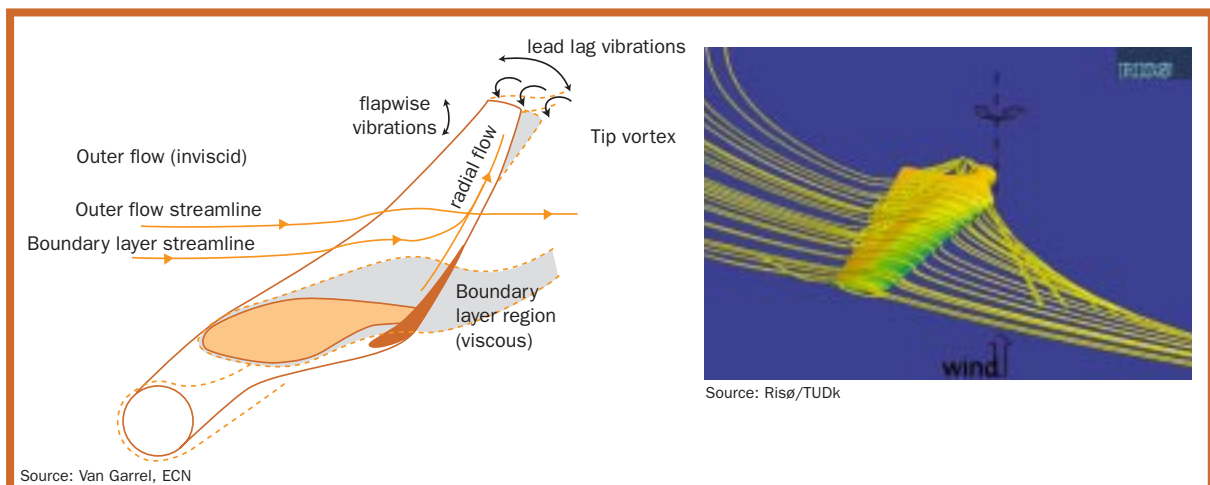
Insufficient facilities exist at present for such testing. Section 3.7 of this report addresses the research infrastructure.

In the absence of such testing facilities it remains unclear whether a complicated structure such as a very large wind turbine can operate with full reliability and security, under all operating conditions, throughout its lifetime, while producing electricity with maximum efficiency. Multi-parameter control strategies are needed to minimise mechanical loads, enable active vibration damping, and optimise energy output and load factors, to mitigate destructive loads, and ensure full grid compatibility.

**Figure 3.11**

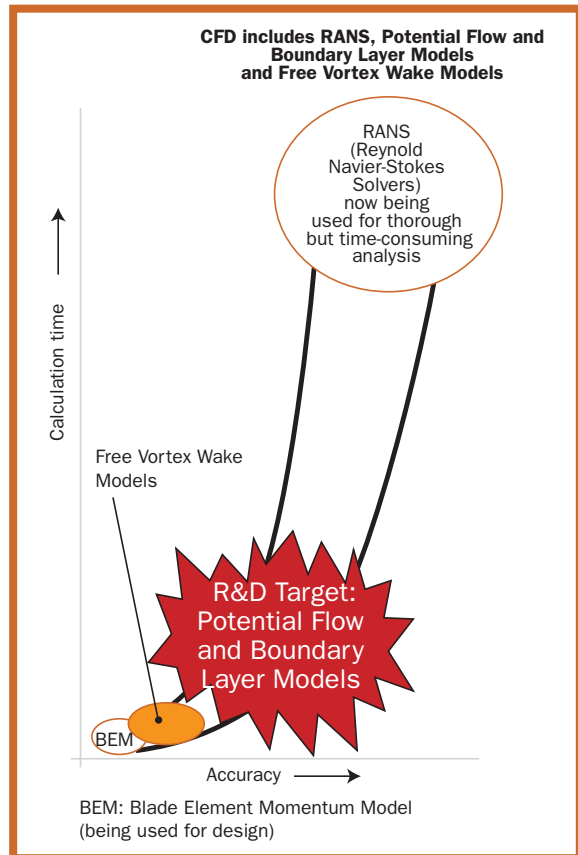
Sketch of 3-dimensional flow, stall induced vibrations and centrifugal effects on flow. The interaction between flow and blade deformation is very complex. 3-dimensional aspects (tip vortices), axial flow, flow detachment (stall) and flow induced vibrations all have to be taken into account in order to guarantee stable operation of the blade and accurate calculation of lifetime. CFD (Computational Fluid Dynamics) is likely to be used in the future for detailed flow calculations as the computing time is reduced and the non linear effects are better understood and modelled.

The picture on the right shows the result of a CFD calculation of the flow around a rotor blade. The future vision is that integral design of a wind turbine can be carried out so reliably that no extensive field tests are needed before market introduction.



**Figure 3.12**

Existing models (RANS and BEM) both are inadequate for industrial use and R&D purposes. RANS are accurate but the calculation times prohibit their use in the industry, and hamper R&D work. BEM is fast, but inaccurate. Modern research aims for fast calculation codes with accuracies approaching RANS, such as Potential Flow and Boundary Layer Models.



Source: Van Garrel, ECN

### R&D related to Minimising Operational Costs

The cost break down of wind electricity has no fuel component; it comprises mainly capital cost and operation and maintenance (O&M) costs. All of the R&D tasks mentioned above are concerned with minimising capital cost.

But to manage a valuable and high-tech asset like a wind turbine, dedicated O&M methods and transport and installation systems need to be developed. The need for tailored systems is particularly great in extreme locations such as offshore, extreme cold climates and mountainous terrain. To make this possible, the specific geographical and meteorological characteristics of such sites must also be explored and mapped. In particular, there is very limited access to offshore wind turbines in bad weather conditions. Currently no integrated health monitoring system for early diagnosis and assessment of damage (to machinery, supporting structure and blades) is available. This can be a show-stopper, since it leads to extremely conservative design, to long standstill times and severe problems with insurance.

#### 3.2.1 Small and Micro Sized Wind Turbines

As the world market is dominated by large wind turbines, the importance of small (50 kW < 500 kW) and micro (< 50 kW) wind turbines (figure 3.13) is often forgotten. Especially in remote areas, small isolated communities and sites connected to weak grids, the market perspective for those machines is considerable. As yet, the market is showing much less strength than its potential, for reasons such as a lack of quality control facilities for testing and certification, and lack of clear government policy and funding from national and EU levels.

A co-ordinated European R&D effort to provide the basis for technical quality for small and micro turbines, simultaneously to the development of large units, is greatly needed.

Figure 3.13

Application of a small wind turbine in a hybridised system consisting of wind, solar and diesel energy units.



Source : EU-Project HYBRIX, ISET/IBERINCO

### R&D Priorities Related to Wind Turbines

**The availability of robust, low-maintenance offshore turbines, possibly incorporating novel design concepts such as vertical axis machines. Research into the development of increased reliability and availability of offshore turbines.**

- 1. Integrated design tools for very large wind turbines operating in extreme climates, such as offshore, cold / hot climates and complex terrain.**
- 2. State of the art laboratories for accelerated testing of large components under realistic external (climatological) conditions.**

**Development of component level design tools and multi-parameter control strategies.**



### 3.3 Wind “Power Plants”

As wind farms grow in rated capacity, in quantity and in geographical dispersion, it is to be expected that they will be operated more and more as a ‘conventional’ power plant, in other words with more and more similar output characteristics as existing, conventional power plant.

This has as a prerequisite that the power output of the wind farm / plant be controllable and the output more predictable, in order to dispatch power as much as possible when it is needed and at maximum value. Of course, the controllability of wind farms will always be limited compared to fuel-fired plants as long as wind power plants are not supplemented with storage systems, and as long as they are too few in number and insufficiently widespread, with insufficient interconnection, to be able to ‘absorb’ weather systems - in other words, when the wind is not blowing in the North Sea, it may well be in the Baltic.

As the penetration of wind energy into European grids increases, further analysis of potential storage systems will be needed. Research and development in this area will not only target the type of storage system (for example, hydrogen, pressurised air, hydropower reservoirs, Redox-, Lead-acid and Lithium-Ion batteries, etc.), but also its location - where to integrate such systems into the electricity supply system - and its operation and management to maximise overall firm power output. High voltage high density storage even in the short term (up to 7 hours) would greatly improve the integration of wind into the electricity supply system.

To enable the operation of large wind farms in a comparable manner to conventional electricity plant, the following elements need to be developed further:

- Reliable output forecasting systems, for readings up to 24 hours in advance.
- Control systems for output control<sup>35</sup>.

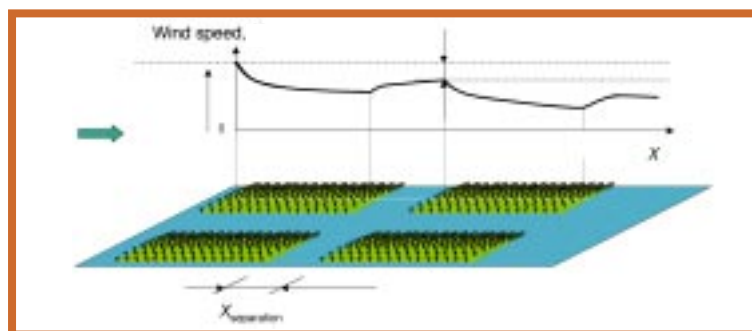
- Storage systems, as wind power penetration into grids rises above, for example, 20%, to balance electricity supply and demand.

Economic attractiveness in the development and operation of large wind farms will be further enhanced through the development of the below know-how and systems.

- Improved, long-term energy output calculations are of the utmost importance in the assessment of risk. The annual energy content of the wind may vary up to plus or minus 30% of the long term (10 - 20 years) average value. It is this long term average that financiers need to know in combination with the life time expectancy of the wind power plant.
- Understanding of the air flow in and around wind farms. Researchers expect to be able to increase the energy performance of a wind farm with greater understanding of the air flows around and through it. It is also necessary to gain further understanding of flow to assess the cumulative effects on the available wind resource of many wind farms installed in a given area (See Figure 3.14).
- Publicly available, site-specific data for planning and risk assessment, such as data on terrain types, ecology, competing activities for land / sea usage, climatological conditions including extreme events (waves [offshore], temperature, seismic activity, precipitation, wind speed, wind gradient, wind turbulence characteristics, and geology).

**Figure 3.14**

**The effect of a large wind farm on the wind resource of a nearby wind farm. The magnitude of the total available wind resource in a certain area will depend on the numbers of large wind farms to be installed and their relative distances.**



Source : Risø

<sup>35</sup> From an economics point of view it is not only necessary to maximise the energy output of a wind turbine or wind farm, but also the capacity factor. A high capacity factor leads to higher utilisation of the cable connection capacity and thus an overall higher penetration degree of wind power. However an optimal balance has to be struck between energy output and capacity factor as they are not independent of each other.

**Figure 3.15**

**Measurements in an atmospheric wind tunnel to determine the flow in and around a wind farm in order to optimise wind farm control.**



Source: Gustave Corten, ECN

The latter data are also essential in the full exploitation of the wind energy resource in a given area. Understanding of cumulative effects on, for example, bird migration routes, shipping safety, the transport of sand on the sea bottom, and the effects on wind flow of a large number of wind farms, is crucial in the strategic assessment of environmental impacts. Simple extrapolation of the effects of one wind turbine or one wind farm in order to assess the effects of many falls far short of sufficient, as saturation or unexpected phenomena may be observed on the crossing of certain thresholds.

#### **R&D Priorities Related to Wind Farms**

**Research into and development of storage systems for use at the wind farm level.**

- 1. Understanding the (wind) flow in and around large wind farms.**
- 2. Control systems to optimise power output and load factors at wind farm level.**
- 3. Development of risk assessment methodologies.**

## **3.4 Grid Integration**

In principle there is no absolute technical limit to wind power penetration. Based on studies it is considered feasible to realise penetrations of power consumption in a given area of up to 20 % without making large adjustments to the structure or operation of the grid, and the additional system costs are moderate.

A system with a much higher flexibility of generation mix, which is better interconnected, and with various demand side control options and storage, will be capable of accommodating high proportions of wind power. It is reasonable to expect that wind power integration costs will increase smoothly and gradually with increasing penetration and that they will not increase significantly beyond a certain threshold.

It is considered to be much more economically efficient to implement other measures to maximise both the penetration degree and security of supply. Such measures include:

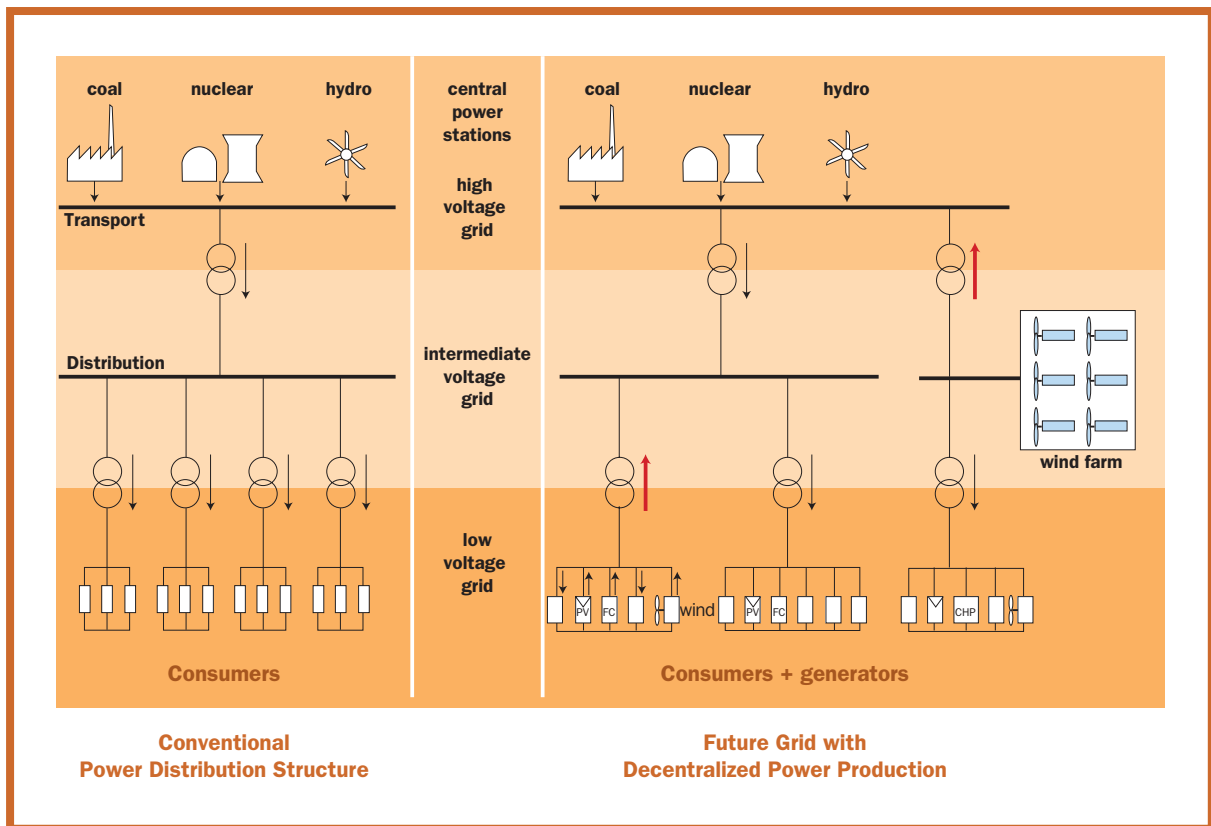
- Increase the ‘fault ride through’ capability of the electrical conversion systems of wind farms (whereby the wind farm is able to support the grid in cases of grid faults) in high wind penetration supply areas.

Generally a wind farm is disconnected from the grid when a significant voltage dip occurs, for instance as a result of a fault in the system, such as a sudden outage of large power plant or line faults. In such cases the quality of the grid is further restricted by the sudden loss of generation, which could initiate further grid instabilities. Equipping wind farms with ride through control capability based on modern power electronic systems could provide extra security.

Wind power plants could feature ‘virtual power plant’ operation characteristics, which mean that they fulfil grid code requirements with respect to active power control, reactive power and voltage control, and fault ride through capability.

- Active voltage control at wind farm sites. Voltage control is realised by reactive power control of the wind turbines (feasible with variable speed turbines with partial or full size frequency converters, and by the installation of static and dynamic voltage controllers in the grid near wind farm locations).
- Electricity output forecasting systems (as mentioned in the section above).

**Figure 3.16**  
 Wind turbines will be connected to a grid that is fundamentally different from the conventional grid, as a large variety of generators will be integrated. Thus the grid needs to become “intelligent”.



Source: ISET

R&D tasks related to the grid integration of wind energy fall into two categories: 1) Measures to be taken by the wind industry (bullets i – iii); and 2) Measures of a more general nature, to be taken by TSOs (Transmission System Operators) and wider energy stakeholders with the involvement of the wind energy sector (bullets iv – vii).

- i. Development of technology that provides wind plant with some of the capabilities of other types of plant, such as power control, voltage control, fault ride through capability and, if needed, primary control capability.
- ii. Advanced forecasting systems, at wind farm operator, DSO and energy supplier level.
- iii. Improved methods of assessing the interaction of wind farms and the electricity system.
- iv. Development of cost effective technologies for grid management and reinforcement, such as static and dynamic voltage control devices.
- v. Increased flexibility in the generation mix (future investment strategy), to enable the utilisation of distributed intermittent generation.
- vi. From a market development perspective, the planning of interconnection capacity as a function of the wind resource is important. R&D into the quantification of the interconnection capacity to be established for power exchange and balancing of intermittent generation is essential to enable this.
- vii. Demand side management and storage technologies.

On a European level the role of wind energy and other renewables can be maximised if strong interconnectors are available which are able to transport large amounts of electricity all over Europe. This is also needed to create real and undistorted competition in the Internal Electricity Market.

The large scale introduction of wind energy is, however, not the only reason for a ‘Trans-European’ grid. The increasing variety of a whole range of electricity producers can only be catered for if such a grid is developed or the current grid structure altered. Its realisation is a huge political and organisational challenge, which needs strong political and financial commitment and support from the European institutions, Member States and other stakeholders.

To enable decentralised units to operate efficiently, including small and stand-alone wind turbines, the grid must become more ‘intelligent’, which is to say that the power quality at all voltage levels of the grid should be maintained, for example, by electronically controlled transformers, and both generators and consumers similarly remote controlled. To that end the development of an international centre for control would enable all actors to bring their requirements: transmission system operators (TSOs), wind farm and other renewable energy and distributed electricity generation system operators, national regulators, etc.

#### R&D Priorities Connected with Grid Integration

**Planning and design processes for development of a Trans-European Grid, with sufficient connection points to serve future large scale wind power plants. This task should be undertaken in connection by the wider energy sector.**

**Control strategies and requirements for wind farms to make them fully grid compatible and able to support and maintain a stable grid.**

**Development of electric and electronic components and technologies for grid connection.**

### 3.5 Public Support and the Environment

Besides the positive effects of wind energy on the environment, especially in the replacing of fossil fuels and consequent reduction in CO<sub>2</sub> and other emissions, wind energy potentially has negative environmental impacts. These can be divided into impact on ecology, and visual and other-sense impacts.

Into the first category fall:

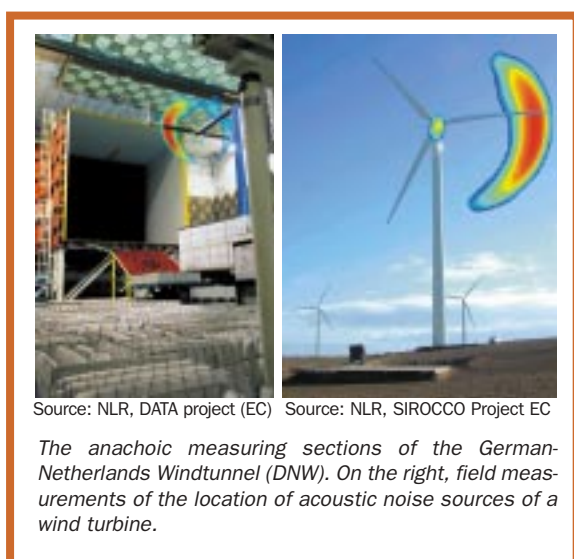
- Potential impacts on avian and bat populations, for example, collision, diversion, habitat disturbance, impact on migration routes
- Effects on benthic organisms and fish, and sea mammals for offshore applications.

The second category includes:

- Acoustic sound emissions (see Figure 3.17)
- Visual impact (See Figure 3.18)
- Shadow effects and ‘flicker’
- Safety

**Figure 3.17**

Measurements of acoustic noise emission of a rotor in an anechoic wind tunnel (left) and in the field (right). The visualisation of the acoustic noise source gives the designers to change the shape of the blades to reduce aero-acoustic noise emission.



**Figure 3.18**

Example of a well integrated wind farm in the landscape. The wind farm is located adjacent to large infrastructural elements.



Source: Jos Beurskens, ECN

These aspects constitute inputs for environmental impact assessments (EIA) carried out in project development, but also strategic environmental assessments (SEA) and screening which should be carried out at a governmental level. All these issues require further, in depth exploration, even if only to prove that some of the suggested potential impacts are perhaps not having the negative impacts sometimes perceived by the general public, politicians and the misinformed. The coming of large-scale offshore wind energy applications stimulates a great deal of research and is yielding a similarly great volume of new knowledge of a generic nature. It would not be fair to expect the industry to shoulder the burden of such a cost alone, when its benefits will be felt in other sectors also. A great deal of labour is involved in carrying out such research within an EIA, and they are therefore very expensive, the cost falling in the main on project developers.

An international exchange of research data is quintessential in having results available to all actors in Europe as soon as they come available. Communicating the findings of such R&D must be done with great care. Failure to communicate accurately and without delay may be to the detriment of public support for wind energy, thus becoming a potential showstopper.

### R&D Priorities Related to Public Support and the Environment

**European communication strategy on R&D results of effects of large scale wind power plants on the ecological system, targetted at the general public and policy makers. To include specific recommendations for the best wind park design and planning practices.**

- 1. Monitoring effects on ecology adjacent to wind energy developments.**
- 2. Development of automatic equipment to monitor in particular bird collisions, and sea mammals' reaction to underwater sound emissions. Equipment is needed to decrease cost of environmental monitoring during both planning and operational phase.**

**International exchange and communication of results of R&D into ecological impacts.**

## 3.6 Standards and Certification

Continuous effort is required in the translation of research and development findings into updated standards and certification procedures. Reliable standards are essential in the reduction of uncertainties or risk, particularly from the point of view of insurers and financiers of wind energy projects.

The International Electrotechnical Commission (IEC) standards currently in use in relation to wind energy technology (see Table 3.1) are maintained under the aegis of Technical Committee 88, which is dedicated to wind energy. The working groups charged with the maintenance require funding to ensure that the most suitable experts are available to examine the status of the standards, taking into account new knowledge. Such funding comes at present in the main from the Member States, but is limited.

Although standardisation and certification are basically different processes, they are often related to each other. Certification is to formally declare that a piece of equipment, a process, or software meets certain specific requirements.

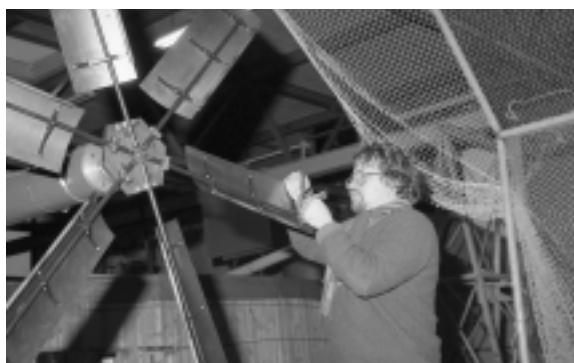
The requirements against which a wind turbine, wind turbine component, or wind energy project, is compared may be standards, but they may also be technical specifications or design criteria.

Generally, the availability of standards makes certification processes much easier, because nearly all relevant actors were involved in designing standards. The verification method may consist of a design evaluation, field testing and/or laboratory testing and checking of manufacturing quality.

For the mutual recognition of certificates, an international agreement must be concluded on certification and testing methodologies. For this reason, standards are under development for certification processes themselves.

Figure 3.19

Wind Energy R&D has come a long way since the 1970s.



Standards are often considered as the last phase of a research or development process in which the results are 'frozen' as state-of-the-art, until market players take the initiative to update them. Regular updating is essential to avoid their becoming bottlenecks on technical innovation, as new technical concepts and research results become available.

The objectives of both certification and standardisation processes are to set verified and independent minimum requirements for quality, reliability and safety. In the pioneering phase of a technology this might secure a successful market introduction. It could provide governmental authorities an instrument that guarantees that public funds are spent well in the case subsidies are available for market introduction. At a later stage, when the market is developed, certificates and standards are effective instruments in removing trade barriers and thus strengthening the integration of EU markets by allowing easy movement of equipment and investment within EU member states. They also provide quality standards for project developers and security for financiers and insurance companies.

The first activities to establish standards and design certification procedures started in the early 1980s on a national scale in countries like Denmark, the Netherlands and later in Germany. In the late 1980s and early 1990s, standardisation activities were incorporated into international frameworks. On a global level the International Electro-technical Committee (IEC), and on a European level CEN and CENELEC (1995) provide working platforms. All use the preparatory work car-

ried out within the framework of the IEA Wind Energy programme and EC wind energy research programmes as inputs. One of the very effective spin-offs of EC research is the MEASNET initiative, which is an important source for new standardisation actions.

A number of wind energy standards have been published, mostly under the TC88 Committee of IEC. Table 3.1 gives an overview of the publications as of mid 2005.

**Table 3.1**

**State of the art of Wind Energy Standards**

| Standardisation area | Title                                                                | Standard number                                              |
|----------------------|----------------------------------------------------------------------|--------------------------------------------------------------|
| Design Requirements  | Design Requirements for Wind Turbines                                | IEC 61400-1, ed. 2<br>IEC 61400-1, ed. 3<br>ballot procedure |
|                      | Design Requirements for Small Wind Turbines                          | IEC 61400-2, ed. 1<br>IEC 61440-2, ed. 2<br>ballot procedure |
|                      | Design Requirements for Offshore Wind Turbines                       | IEC 61440-3, CD being prepared                               |
|                      | Gear Boxes for Turbines from 40 kW to 2 MW and larger                | ISO/IEC 81400-4, ed. 1<br>ballot procedure                   |
| Measurements         | Acoustic Noise Measurement Techniques                                | IEC 61400-11, ed. 2                                          |
|                      | Wind Turbine Power Performance Testing                               | IEC 61400-12, ed. 1                                          |
|                      | Power Performance Measurements of Grid Connected Wind turbines       | IEC 61400-12-1 FDIS<br>ballot procedure                      |
|                      | Mechanical loads                                                     | IEC TS 61400-13, ed. 1                                       |
|                      | Declaration of Apparent Sound Power Level and Tonality Values        | IEC TS 61400-14, ed. 1                                       |
|                      | Power Quality Characteristics of Grid Connected Wind turbines        | IEC 61400-21, ed. 1                                          |
|                      | Full-scale Structural Testing of Rotor Blades                        | IEC TS 61400-23, ed. 1                                       |
| Other                | Lightning Protection                                                 | IEC TR 61400-24, ed. 1                                       |
|                      | Communication for control and monitoring                             | IEC 61400-25 CD<br>finalised                                 |
|                      | IEC System for Conformity Testing and Certification of Wind turbines | IEC WT 01, ed. 1                                             |
|                      | Protective Measures                                                  | EN 50 308, ed. 1                                             |
|                      | Electromagnetic Compatibility                                        | prEN 50 373                                                  |
|                      | Declaration of Sound Power Level and Tonality Values                 | prEN 50 376                                                  |
|                      | International Electrotechnical Vocabulary, Part 415                  | IEC 60050-415                                                |

This may appear comprehensive but many holes remain. “Black spots” need urgently to be covered, at least on an EU wide basis, and include standardisation in such areas as:

- Energy yield calculation
- Grid connection protocols and procedures
- Risk assessment method
- Requirements for component design certification, e.g. gearboxes
- Standardisation of O&M mechanisms

Other urgent issues have already been incorporated in new standardisation initiatives:

- Standardisation of certification and test procedures
- Design criteria for offshore wind turbines
- Project certification.

#### R&D Priorities related to Standards and Certification

##### Development of the following international standards:

- Energy yield calculation
- Grid connection protocols and procedures
- Risk assessment methodology
- Design Criteria for components and materials
- Standardisation of O&M mechanisms

Accelerated finalisation of ongoing standard development activities. (certification processes and test procedures, design criteria for offshore wind turbines, project certification)

### 3.7 Research Infrastructures

This section outlines some existing and desirable research infrastructures that should receive consideration for funding under FP7.

Only some of the major manufacturers of wind turbines and components have their own facilities to test their products. Testing in the industry usually serves the following purposes:

1. Verification of product performance specification
2. Industrial development
3. Quality control

R&D institutions use experimental testing for verification of design tools, analysis of relevant physical phenomena and to provide independent and normalised performance data of complete systems, components and materials.

For a sound development of the whole sector the experimental capabilities both in the industry and in R&D institutions must be state of the art, tuned to the short and medium term needs of the sector. This is of particular interest as the financial risks, as a result of the technical risks associated with the following development trends, continue to increase:

- Increasing size of the wind turbines (D>100m)
- Increasing capacity of wind farms (P>100MW)
- Wind turbine systems operating in extreme external conditions (offshore, cold/hot climates)
- Increasing occupation of existing grid connection capacity
- Increasing requirements of grid operators

Also the spectacular growth of the market and size of individual projects implies increasing financial risks. Introducing a new and failing type of wind turbine on the market might lead to unbearable cost, threatening the mere existence of companies. Extensive testing of components, sub systems and complete systems could avoid these problems.

Physical phenomena, which could be ignored in smaller wind turbines, require improved modelling and associated design tools. To fully understand these phenomena and to verify models and tools, facilities and basic research are needed.

A number of new facilities are required which are so expensive to realise and operate that it is worthwhile to investigate the possibility of their being shared among different actors in the wind energy sector. It is also very probable that the pooling of existing facilities such as test stations and blade test rigs offers more value to the sector than operating them as single units.

Below an inventory of existing and potential R&D facilities is presented, categorised according the system level.



Table 3.2

## R&amp;D Infrastructure

| Type of Facility                                                    | Description & Purpose                                                                                                                                                                                                                                                                                                | Remarks (present operators)                                                                                                                                                                                                                                                                                                            |
|---------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>System testing: Wind turbine and wind farm</b>                   |                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                        |
| Test stations for large wind turbines                               | Independent verification of loads, environmental characteristics and performance for different highest wind classes.                                                                                                                                                                                                 | Facilities already available in Denmark, Germany, the Netherlands. However capacity falls short compared with demand. Extension of European testing capacity needed. (Risø-DK, DEWI-D, ECN-NL, WINDTEST-D, ISET-D, CENER-E, ISET, etc.)                                                                                                |
| Test station(s) for offshore wind turbines                          | Independent verification of loads, environmental characteristics and performance for typical offshore external conditions.                                                                                                                                                                                           | No offshore test sites exist to date. (Initiatives exist in DE, DK, NL)                                                                                                                                                                                                                                                                |
| Full size offshore wind farm for performance evaluation             | Improving output by control systems which optimise output and load factor on farm level. Impact on mechanical loading and energy efficiency.                                                                                                                                                                         | Experimental verification will be carried out using an existing (commercial) wind farm, supplemented with experimental operational settings and measuring systems. Energy output lost through experimentation to be considered as operational cost of an R&D facility.                                                                 |
| Test stations for small wind turbines                               | Independent verification of loads and performance for licensing small wind turbines.                                                                                                                                                                                                                                 | The quality of available small machines varies considerably. Uncertainty of quality blocks market development. In order to improve quality, a certification system should be introduced based on obligatory system testing. (CIEMAT-E, SEPEN-F)                                                                                        |
| Test rigs for hybrid and autonomous systems                         | Performance and system reliability testing of systems for remote areas                                                                                                                                                                                                                                               | All earlier rigs are abandoned / not in use anymore / outdated. Reconsideration of state-of-the-art facilities is needed as the industry develops a market for those systems. Lack of confidence through absence of reliability is a major barrier for market development.                                                             |
| <b>Sub-Systems: Drive trains</b>                                    |                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                        |
| Rotational dynamics of drive train from rotor to grid connection    | Large, variable speed and torque simulating equipment driving a full scale drive train offers the possibility to fully verify the electricity conversion system, suppress vibrations, implement control strategies, etc.<br>A climate chamber is required to carry out accelerated duration tests of the rotor head. | As the industry already has advanced large-scale systems for components of the drive train, such as gearbox and generator systems, the need for an R&D facility should be investigated. However no systems are available for accelerated duration testing of the complete rotor head (excl. blades) under various external conditions. |
| <b>Components and Materials</b>                                     |                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                        |
| Fatigue testing rigs for very large blades and other GRP components | Facilities with testing capacities which exceed that of presently available laboratories.                                                                                                                                                                                                                            | Creating fewer large facilities, serving a larger market offers substantial cost and expertise advantages. (Risø/Sparkær-DK, WMC-NL (= ECN+TU Delft), CRES-GR, NAREC-GB, BTC-DK)                                                                                                                                                       |
| Materials development & testing                                     | For very large turbines new materials with higher strength to mass ratios are needed. For this kind of wind turbine dedicated labs are needed.                                                                                                                                                                       | Crucial question: are existing fatigue and environmental testing facilities in the universities and institutes adequate and fully available? (Danish institutes and industries)                                                                                                                                                        |

| <b>Analysis of Physical Phenomena: Aerodynamics, Waveloads &amp; Atmospheric Research</b> |                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                 |
|-------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Large wind tunnel, dedicated to wind energy applications                                  | To investigate 3-dimensional and non-linear flow around rotor blades, to be applied to design relatively compliant large turbine rotors                                                                                                                                                   | Present practice is that only a limited number of experiments can be carried out as the availability of large tunnels in the USA, China and Europe allow.                                                                                                                                                                                                       |
| Field facility for differential measurements                                              | Two rotors, one for reference and one for experiments, located at the same site permit the measurement of relatively small differences in performance.                                                                                                                                    | There are no other ways of determining small differences in performance, thus no other means to prove improvements, which will lead to more energy output during longer periods. (ECN-NL has design)                                                                                                                                                            |
| Test site for comparative testing of atmospheric parameters                               | A well defined site is needed to carry out comparative measurements of atmospheric parameters; wind speed and turbulence levels being the most important. By defining one site, a number of (external) parameters can be kept constant. Equipment to change turbulence might be feasible. | The energy production and lifetime of a wind turbine system is very sensitive to these parameters. Despite its importance, current measuring techniques are insufficient. New remote sensing techniques offer the possibility to match classical anemometry without the non linear behaviour. These techniques are much cheaper for high altitude measurements. |
| Wave-channel                                                                              | Influence of waveloads on supporting structures of offshore wind turbines (inclusive of geotechnical questions).                                                                                                                                                                          | There is Europe's largest facility of this kind available (ForWind group at University of Hannover, Germany). This needs to be adjusted to wind energy research.                                                                                                                                                                                                |
| <b>Power Quality and Grid Integration</b>                                                 |                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                 |
| Laboratory with simulated grid                                                            | Testing new electrical conversion system on its ability to meet grid requirements under various external conditions, such as wind speed fluctuations and grid events.                                                                                                                     | With an increasing degree of penetration, the requirements of grid operators on electrical conversion systems increase also (For small scale applications: ISET-D, TUDelft-NL, CREST-DK)                                                                                                                                                                        |

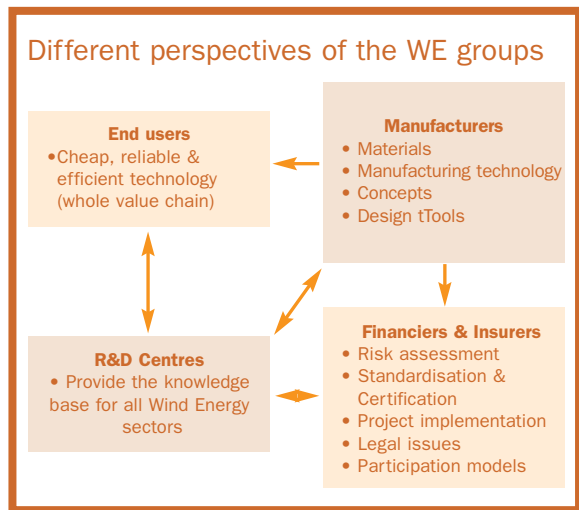
Source: Jos Beurskens, ECN

### 3.8 Perceptions of R&D Priorities within the Network

At the final Wind Energy Network R&D Strategy Workshop, which took place at Ispra in February of this year, each of the four R&D Network working groups presented their key R&D priorities. In Figure 3.20 these priorities are expressed graphically, showing their specific perspectives, according to their role in the market.

Figure 3.20

Perspectives and tasks of the four wind energy sector groups



These were discussed during the workshops with a view to i) identifying missing elements; and ii) identifying overlaps between their agenda, highlighting areas of common concern. It is remarkable that despite the different perspectives of the four groups, approximately 80% of the R&D tasks identified in the earlier draft of the SRA<sup>36</sup> were identified as priorities by all four groups.

Participants of the Ispra workshop were requested to assign a relative importance to R&D tasks in four areas that correspond to the core of this Strategic Research Agenda:

- Wind Turbines
- Wind Farms
- Grid Integration
- Cross-Cutting Tasks, including resource assessment, standards, and certification

Across all working groups, it is apparent from the data received<sup>37</sup> that, overall, the wind turbine itself is seen as being the priority in terms of R&D (see Figure 3.21). Grid Integration is considered the next important area, and participants again stressed that research in this area is not solely the burden of the wind energy sector, but should be undertaken with the involvement of TSOs and other stakeholders.

**Figure 3.21**  
Overall Perception of Importance of R&D Areas

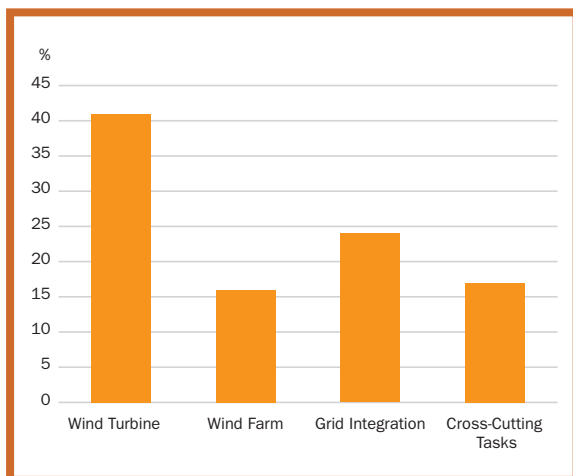
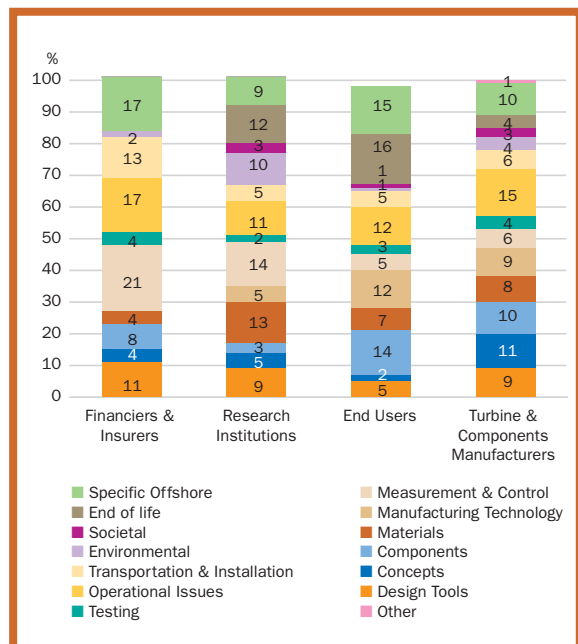


Figure 3.22, parts a-d, demonstrate the perspective of the four working groups on priorities within the R&D areas. The number of R&D tasks in the ‘wind turbine’ category makes for confusing data, but certain salient points emerge. Offshore is seen as an important priority by all four groups, particularly financiers and insurers, and end users, who are keen to develop where the resource is highest – offshore – with the potential to generate the most electricity per unit.

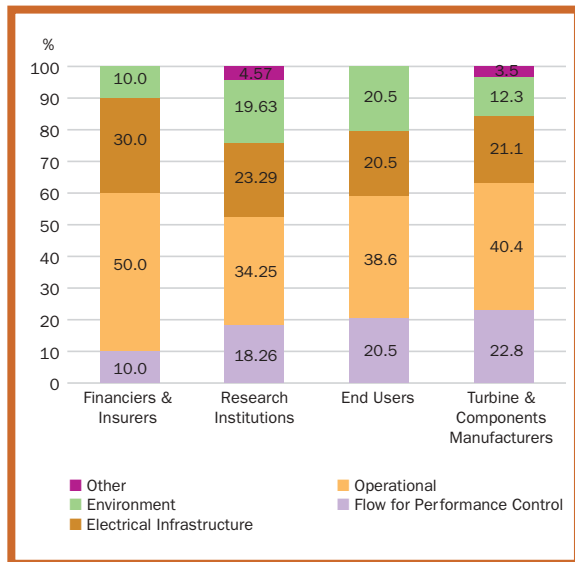
**Figure 3.22a**  
Relative Importance of Tasks in the “Wind Turbines” Research Area



‘Operational Issues’ and ‘Measurement and Control’ are similarly viewed as a high priority across the board. High priority also is accorded to standards and certification, output verification and risk analysis (see Figure 3.22d). It is essential that wind energy builds its reputation as a reliable source of energy, of benefit to the European grid. On a project level, the existence of reliable, up-to-date standards greatly increases the effectiveness of risk analysis, explaining the high priority accorded to it by financiers and end users. Design tools are also a priority across the four groups.

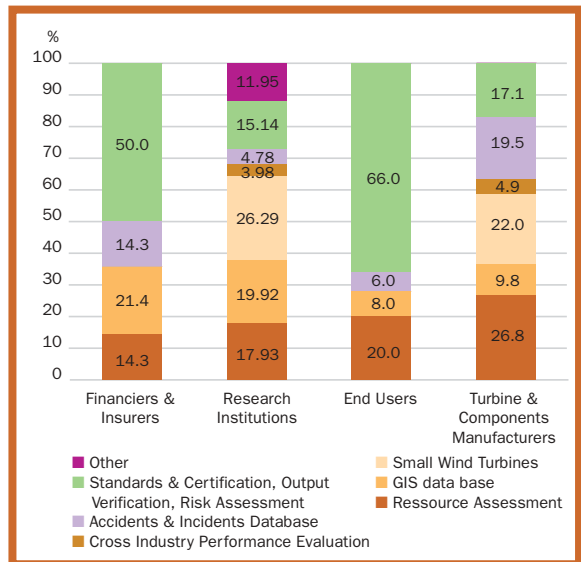
<sup>36</sup> Released in January 2004. See [www.ewea.org](http://www.ewea.org)  
<sup>37</sup> Participant response rate was 44%

**Figure 3.22b**  
Relative Importance of Tasks in the “Wind Farm” Research Area

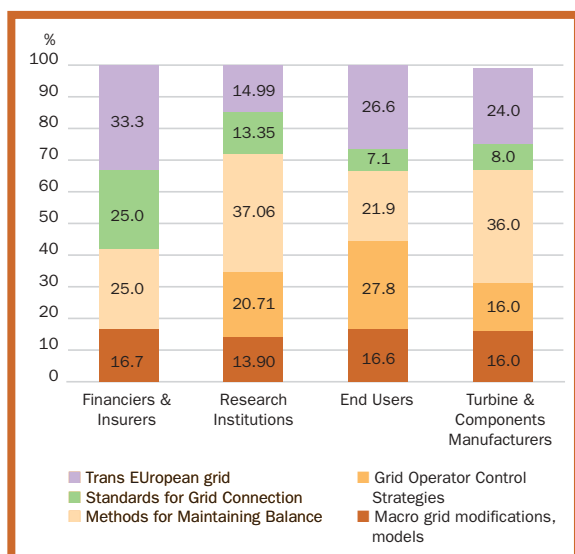


In the Wind Farm Research Area, operational issues are seen as the priority across the board. Operational issues include such research tasks as development of accurate short and long range forecasting, estimation of operation and maintenance requirements prior to installation, and access technology, particularly with regards to offshore installations.

**Figure 3.22d**  
Relative Importance of Tasks in the “Cross-Cutting Tasks” Research Area



**Figure 3.22c**  
Relative Importance of Tasks in the “Grid Integration” Research Area



## 4. Implementation of the SRA

### 4.1 European Technology Platform for Wind Energy

The Commission's April communication 'Science and Technology, the Key to Europe's Future' has emphasised the key role to be played by European Technology Platforms in the implementation of the European Research Area. European Commissioner for Research, Janez Potočnik recently referred to an apparent "European Paradox", wherein high quality EU research is not being translated into innovative output.

In a recent working document<sup>38</sup>, the Commission states:

*"to ensure a solid industrial fabric throughout the European territory, a stronger link between research and industry is particularly important. Industry has, clearly, a key role to play in this endeavour."*

With this in mind, and in response to the expression of the needs of the wind energy sector, the European wind industry, together with national ministries and other stakeholders in the development of wind energy has proposed to the European Commission that a European Technology Platform for Wind Energy be established.

Historically, the majority of overall wind energy cost reductions can be traced to two essential drivers:

- Increasing economies of scale – for around 60% of reductions
- Research and development – for around 40%

Thus, as the conceptual diagram (Figure 4.1) below demonstrates, the proposed wind platform will be based on two central pillars, corresponding to these drivers. The platform aims to be:

- A clear, single voice for European market development and collaborative research needs, able to establish clear priorities to best preserve and enhance European leadership in the wind energy sector. At present there are many actors working in the sector with limited interaction and consensus on R&D priorities. Actions like the Wind Energy Network, and organisations such as the European Academy of

Wind Energy can only achieve a degree of coordination. The technology platform on the other hand would seek to bring together all stakeholders, for a minimisation of duplication of effort.

- Able to steer long term R&D while harvesting the 'low hanging fruit' – short term activities to increase market volumes and generate cost reductions through economies of scale.
- A transparent forum, open to all stakeholders, flexible enough to respond to evolving needs.
- A facilitator to turn new knowledge into innovative output as quickly as possible.
- A driver for maximising, steady, transparent funding for wind energy research, development and demonstration from EU and national levels.
- A facilitator for interactive policy making among European, Member State and local (provincial) levels.
- The single point of contact for all R&D issues related to the wind energy sector, and cross cutting R&D issues involving interaction with the wider energy sector, including, among others, other electricity generation technologies, TSOs, and their technology platforms.

In July 2004 by the Chairman of the Informal Competitiveness Council, Dutch Economy Minister Laurens Brinkhorst took the opportunity to call for the establishment of a European Technology Platform for Wind Energy to focus wind energy development. He expressed the need for:

*"a limited number of platforms for precisely those areas in which Europe is successful, such as nanotechnology and wind power."*

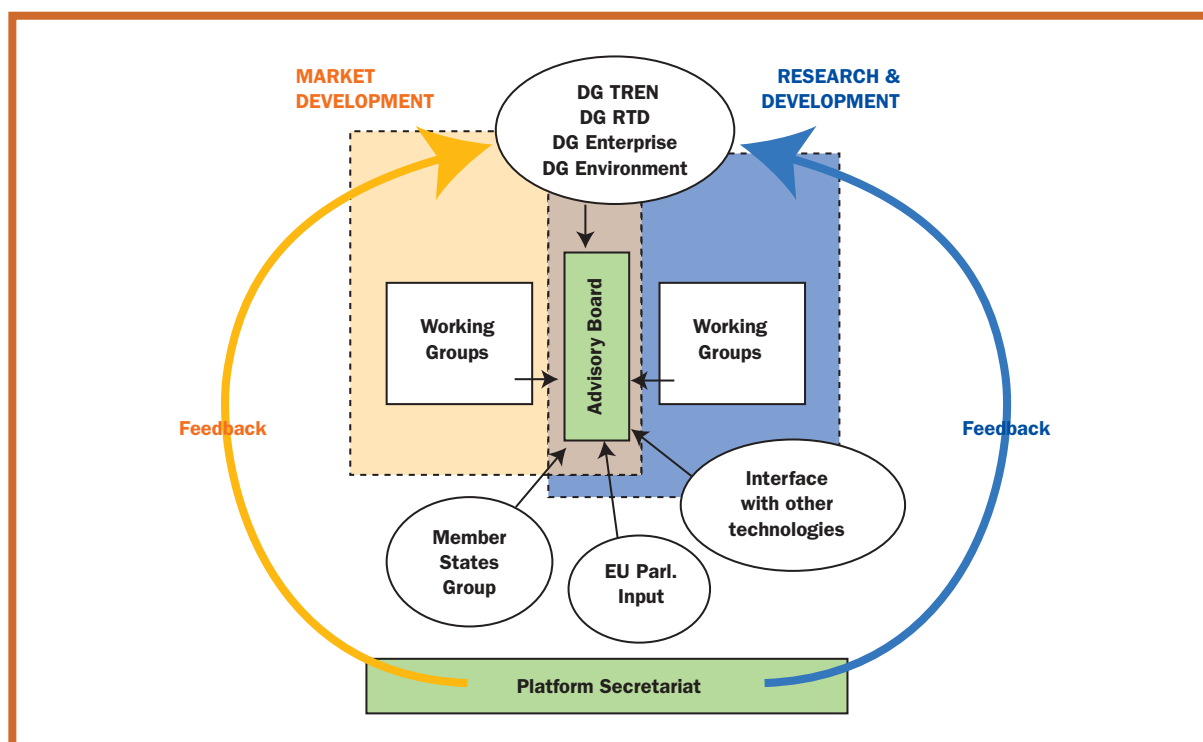
Participants of the Dutch EU Presidency's Policy Workshop on the Development of Offshore Wind Energy, in Egmond, Holland agreed that:

*"[Offshore] wind energy will contribute significantly to the Lisbon Strategy and EU objectives on technological development, exports, employment and regional development."*

*"Participants emphasise the need for setting up a Wind Energy technology platform within the framework of FP7, as proposed by the Informal Competitiveness Council (Maastricht, July 2004)."*

38 SEC(2005) 800, Commission Staff Working Document: Report on European Technology Platforms and Joint Technology Initiatives: Fostering Public-Private R&D Partnerships to Boost Europe's Industrial Competitiveness

**Figure 4.1**  
A conceptual diagram of the proposed wind energy platform



## 4.2 Financing the Strategic Research Agenda

The IEA notes that between 1974 and 2001 only 8.2% of total energy R&D funding in OECD countries was allocated to RES. In its recent report, *Technology Perspectives for Energy Policy*, the Governing Board and Management Committee of the IEA affirmed that more research funding is needed for renewable energy sources.

*“The newest renewables technologies, such as those for wind and solar energy, as well as [...] bioenergy technology, hold the promise of the greatest cost reductions [...]. If ambitious but practical goals are to be met for expanding renewable energy’s share in the fuel mix, then the issue of increased R&D funding must be addressed.”*

Coming soon after warnings (at the time of writing) that the European Council may block the Commission’s and Parliament’s call for increased support for wind energy R&D under the coming FP7 programme, the report continues:

*“Policies must support R&D and stimulate market demand [...] policy makers can reduce the added investments needed to bring renewables into the competitive mainstream by establishing a policy environment recognising the mutually reinforcing impact of policies to support R&D and policies to stimulate market demand.”*

Long-term commitment from national as well as EU R&D programmes, combined with close cooperation between industry and research institutions, has been a principal contributor to Europe’s global leadership in wind turbine and component manufacturing and wind energy capacity building in general.

Failure to support short to long term funding for wind energy R&D will threaten EU leadership in wind energy at the same time as new markets begin to open up around the world, markets from which EU industry and the EU as whole could benefit, and which are attracting interest from the EU’s competitors.

Since the early 1980s, when public renewable energy research funding was at an all-time high, direct spen-

ding by the Member States of the EU-15 has dropped by 40-50% in real terms. It now accounts for about 15% of total energy research. On the other hand, fossil and nuclear energy research accounts for approximately 60% of the total spend. The Bonn Conference<sup>39</sup> political recommendations point out that:

*“governments have an opportunity to strengthen renewable energies by reversing the ratio of funds allocated for renewables versus those provided for conventional energy R&D.”*

### 4.2.1 EU Funding under Previous Framework Programmes

#### Funding for Overall Energy Research

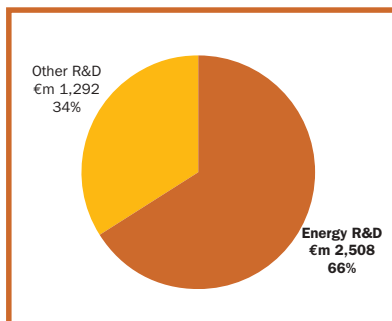
The European Commission’s Advisory group on Energy (see Chapter 2.2.1) has recently released a report which shows the full extent of the reduction in European Union funding for energy R&D through its Framework Programmes.

The figures below (4.2a - f) demonstrate that energy research funding as a percentage of all EU R&D funding has reduced to around 18% (in FP6) of the level it was at twenty years previously when the First Framework Programme began.<sup>40</sup> The Strategic Working Group of the Advisory Group on Energy points out:

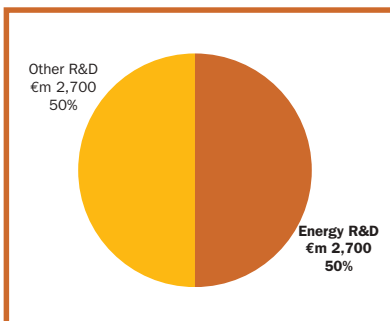
*“in face value terms, expenditure is now less than it was 25 years ago, in real-value terms it is very much less and, as a percentage of the total Community R&D it is roughly six times smaller.”<sup>41</sup>*

The oil crises in the years preceding FP1 caused energy research to be viewed with a level of urgency not seen before. The rocketing oil prices of today, and the concomitant importance of sourcing indigenous energy supply such as wind power and other renewable energies, should provide sufficient impetus to policy makers to once again bring energy research and development to the top of the agenda.

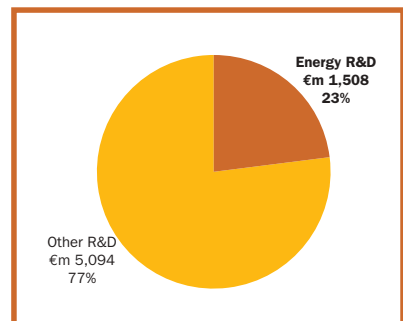
**Figure 4.2a**  
Energy Spending in FP1 (1983 – 1986)



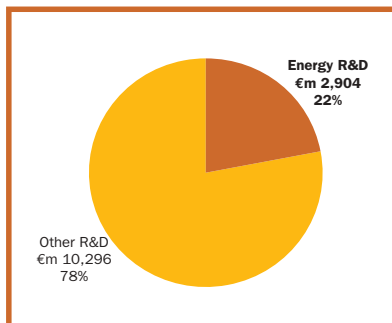
**Figure 4.2b**  
Energy Spending in FP2 (1987 – 1990)



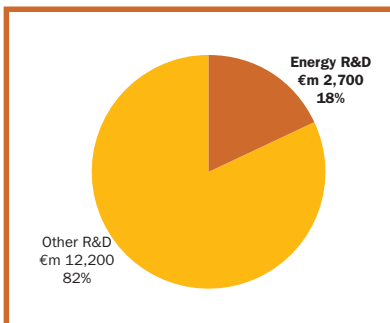
**Figure 4.2c**  
Energy Spending in FP3 (1991 – 1994)



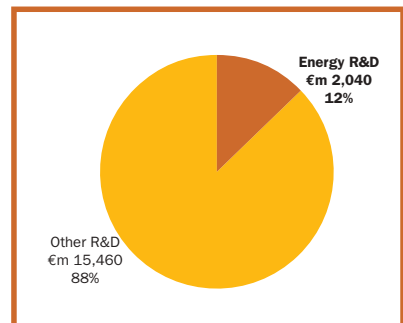
**Figure 4.2d**  
Energy Spending in FP4 (1995 – 1998)



**Figure 4.2e**  
Energy Spending in FP5 (1999 – 2002)



**Figure 4.2f**  
Energy Spending in FP6 (2003 – 2006)



39 International Conference for Renewable Energies, Bonn, 2004 <http://www.renewables2004.de/>

40 Source: SWOG, 2005: Key Tasks for Future European Energy R&D: A first Set of Recommendations for Research and Development

41 Key Tasks for Future European Energy R&D: A first set of recommendations for research and development by the advisory Group on Energy: Directorate-General for Research Sustainable Energy Systems: EUR 21352, 2005

The Advisory Group on Energy's Strategic Working Group (SWOG) continues to call for an increase of a factor four in the amount of funding dedicated to energy R&D. It expresses well the energy challenges that the EU now faces:

"[SWOG] deplores the relentless erosion of energy R&D expenditure over the last 25 years. This has led to a level of funding which is neither commensurate with the importance and severity of the energy challenge nor with the conclusion that a wide range of technologies must be pursued to be sure that the challenge can be met."

"SWOG believes that, for the enlarged European Union (EU-25) the present level of EC energy R&D expenditure should be increased by at least a factor of four."

#### Funding for Renewable Energy Research

Under FP6, €810 million was dedicated to R&D under the "Sustainable Energy Systems" Chapter.<sup>42</sup> Even before an assessment is made of where the money is applied specifically, which depends on the tendering process, this already represents a reduction of some 20% over its predecessor programme, FP5.

The name of the chapter or budget-line "Sustainable Energy Systems" engenders a lack of transparency in the funding process. The chapter includes so-called "clean coal" technologies, revolving mainly about the sequestration of CO<sub>2</sub>. It also includes hydrogen, which is not an energy source in itself as it does not occur naturally and has to be produced. Thus it is only as clean as the technology used to produce it, which at present is predominantly conventional. Nonetheless these technologies are included in the same budget line as clean, renewable, everlasting energy technologies. More seriously still, a large amount of funding that should be dedicated to renewable energy technologies is diverted to effectively conventional fuels.

The status of renewable energy R&D funding is cause for concern. EU funding for RES has dropped from €400 – 450 million in FP4 and FP5 to approximately €380 – 410 million in FP6. Table 4.1 shows the funding actually accorded (following tendering) to renewable energy and energy efficiency R&D under The Fifth Framework Programme (FP5) and in the first half of FP6<sup>43</sup>. Beneath these figures are shown those for conventional energy technologies, not including nuclear.

**Table 4.1**  
Funding for renewable energy under FP5 and FP6 (first half only)

| Technology                              | FP5 - Non nuclear energy (€m) | FP6 (first half) Sustainable Energy Systems (€m) |
|-----------------------------------------|-------------------------------|--------------------------------------------------|
| PV                                      | 105                           | 45                                               |
| Biomass                                 | 140                           | 30                                               |
| Wind Energy <sup>44</sup>               | 70                            | 10                                               |
| Other (geothermal, solar thermal, etc.) | 65                            | 40                                               |
| Hybrid, Energy Efficiency, Integration  | 170                           | 90                                               |
| Total Renewables and Energy Efficiency  | 550                           | 215                                              |
| Fuel Cells, Hydrogen, Energy Storage    | 140                           | 90                                               |
| Fossil Fuels                            | 200                           |                                                  |
| CO <sub>2</sub> Sequestration           | 25                            | 40                                               |
| Socio-economic research                 | 20                            | 10                                               |

Source: Response to Written Question from MEP Mechtild Rothe, April 2005

42 €405 million to long-term R&D, administered by DG Research, and €405 million to short to medium-term research, administered by DG TREN.

43 As FP6 will continue to run until the end of 2006, a final full figure is not available.

44 The table does not include what will be received by the Upwind Project mentioned above.



The EU is crucial, along with the Member States, in the development of wind energy technology. Yet support for wind energy R&D under the EU's Sixth Framework Programme (FP6) has been severely restricted.

The €10 million on wind energy R&D in the first half of FP6 have been dedicated to short term and demonstration projects, administered by the Directorate General responsible for energy, DG TREN (rather than DG Research). While essential, such activities must have as their principal objective the demonstration of long term research findings. For the same period of FP6, the funding long term research in wind energy was zero. In the same period the funding received by "clean" coal (CO<sub>2</sub> sequestration) was four times the total funding for wind energy.

Only in the third call for proposals (not included in the above table), when specific text was included for a wind energy Integrated Project (IP), and following an industry-wide effort, was the long-term R&D UpWind Project accepted. Thus, the total funding to date for wind energy under FP6, including this substantial project, is therefore only some €24 million.

The reduction in funding for wind R&D appears to be the result of the mistaken impression that wind energy is sufficiently mature, that it no longer requires significant support for R&D. While wind energy has indeed made great progress during the period of the framework programmes, further work remains in both the short and the long term if wind energy is to achieve its potential to become Europe's cheapest energy source. If the EU does not consecrate significant and sufficient funding to wind energy research, it risks losing its lead in one of the great technologies of the future.

#### 4.2.2 The Seventh Framework Programme

In his answer to a recent written question<sup>45</sup>, European Commissioner for Research, Janez Potocnik stated his concern about the reduction in funding for R&D, and the need to reverse the trend:

*"The Commission is concerned by the decreasing trend of the RTD spending in the field of renewable energy sources these last twenty years both at the national and European levels. If this trend is not reversed by a substantial increase of funding in the future, it could hamper the progress of renewable energies in the EU energy mix."*

On April 6<sup>th</sup> of this year, the European Commission made its official proposal for FP7<sup>46</sup>. Unlike its predecessors, which lasted four years, FP7 will last seven years, from 2007 to 2013. In its proposal, the Commission calls for an increase of 90% in the budget of non-nuclear energy research. This would raise the annual budget to approximately €420 million per annum, totaling €2.9 billion over the lifetime of the programme.

The European wind industry welcomes the Commission's proposal for a substantial increase in non-nuclear energy research. However, it has been proposed to increase nuclear energy research significantly more, particularly in the realm of fusion technology, for the ITER experimental reactor. Nuclear energy actions have been proposed to receive an increase of 130% in funding.

Final figures for renewables funding are not available for FP6 as the programme is still ongoing (unlike nuclear, it is impossible to know how much funding RES has received until the end of the programme).

But under FP5, nuclear energy research received approximately 80% more EU funding than all renewable energies and energy efficiency combined; and fourteen times that received by wind power.

45 Number E-2459/04, by Péter Olajos (PPE-DE) to the Commission

46 COM(2005) 119 Final: Proposal for a Decision of the European Parliament and of the Council Concerning the Seventh Framework Programme of the European Community for Research, Technological Development and Demonstration Activities (2007 to 2013)

**Table 4.2**

**Average Annual Euratom Spending on Nuclear Research 1995 – 2006 (€million)<sup>47</sup>**

| Framework Programme N° | 4<br>1995-1998 | 5<br>1999-2002 | 6<br>2003-2006 | 7<br>2007-2011 <sup>48</sup> |
|------------------------|----------------|----------------|----------------|------------------------------|
| Fusion                 | 895            | 788            | 824            | 2159                         |
| JRC                    | 441            | 49             | 319            | 539                          |
| Fission                |                | 142            | 209            | 394                          |
| <b>Total</b>           | <b>1,336</b>   | <b>978</b>     | <b>1,352</b>   | <b>3,092</b>                 |

### Transparency and Funding

Transparency issues may make it impossible to know in advance how much funding will be awarded to renewable energy technologies, as opposed to other technologies included along side them, as is the case under the FP6 Sustainable Energy Systems budget line (see above). Such a lack of transparency would make it difficult for the (proposed) European Technology Platform for Wind Energy to schedule R&D tasks according to the funding on offer.

The European wind energy sector has in this report identified a large body of work to be undertaken in private public partnership. If the sector can know in advance the level of funding to be provided by the EU, it can establish the best methods, in advance, of raising its own contribution. MEP Claude Turmes, in his draft report to the European Parliament’s Energy Committee (ITRE), on the Share of Renewables in the EU and Proposals for Concrete Actions stated:

*(§27) “in the upcoming FP7 programme a minimum of €300 million a year should be dedicated to renewable energies [...] to compensate the historical bias in EU energy research programmes”*

While the European Parliament strongly supports this increase, the proposal for FP7 as a whole has caused disagreement in the European Council, which has joint decision making powers with the Parliament over the future of the programme.

Following the expression of the European Council under the Luxembourg presidency that the proposed 90% increase in funding might be drastically reduced, Giles Chichester, Chairman of the European Parliament’s Industry, Energy and Research Committee (ITRE) stated:

*“The European Council has repeatedly emphasised since its meeting in Lisbon in 2000 the crucial role of research and technological development policy in the context of the Lisbon Strategy [...] Nevertheless, the proposal of the Luxembourg Presidency would imply a substantial reduction (of the order of 30% or more) in the budgetary resources for [FP7] compared to those proposed by the European Commission in April.”*

*“An FP7 budget at the level proposed by the Commission is an essential prerequisite for the attainment of the 3% target for European R&D investment set by the Heads of State and government themselves in Barcelona.”*

### Joint Technology Initiatives

Funding under FP7 would be delivered either through existing mechanisms such as Integrated Projects (IP) and Concerted Actions (CA), or, in a limited number of cases where the Commission deems the need and potential added value to the EU are greatest, through the (as yet untried) Joint Technology Initiative mechanism (JTI).

The Spring 2005 European Council referred to the potential role of the JTI, based on the development of technology platforms. At present the European Commission is identifying platforms where the mechanism may be implemented. The hydrogen and fuel cells platform, established as a prototype under FP6, is set to operate under the JTI mechanism.

In its recent working document on the subject<sup>49</sup>, the Commission has shed new light on the previously little known JTI. Each will involve the establishment of a dedicated legal structure designed to implement a clearly defined objective. A JTI can be used to implement a specific part or the entirety of a European Technology Platform and will combine funding from FP7 with other sources of public funding including the Structural Funds.

According to the Working Document, the key criteria for establishing whether or not a Joint Technology Initiative is applicable or not to a given sector are as follows:

<sup>47</sup> Source: <http://www.cordis.lu/en/sitemap.htm#eu-research>; Anthony Frogatt 2005; COM(2005) 119 Final

<sup>48</sup> FP7 will last from 2007 – 2013, but the figures in the Commission’s Proposal (COM(2005) 119 final) are based on the shorter duration of the programme previously foreseen

<sup>49</sup> SEC(2005) 800, Commission Staff Working Document: *Report on European Technology Platforms and Joint Technology Initiatives: Fostering Public-Private R&D Partnerships to Boost Europe’s Industrial Competitiveness*

- Strategic importance of the topic and presence of a clear deliverable
- Demonstration of market failure
- Concrete evidence of potential added value to the EU
- Evidence of substantial, long-term industry commitment
- Clear inadequacy of existing instruments

In the light of these criteria, the renewable energy sector as a whole could be a suitable candidate for the application of an “umbrella” Joint technology Initiative, ensuring that sufficient funding is channeled to where it is most needed.

#### 4.2.3 Private Sector Commitment

Research and development take many forms, but an essential distinction exists between private and public work. Public R&D tends to take the form of basic / fundamental long-term and pre-competitive work that has a shared outcome and is of benefit to all parties. The Integrated Project Upwind falls into this category, for example. Private R&D, on the other hand, tends to address shorter term work, through the development of prototypes for example, which can give the competitive edge to one company over another.

It is difficult to quantify the costs of the collaborative R&D tasks described in this Strategic Research Agenda. Ideally, a figure might be extrapolated from R&D needs, to be requested from the public purse. This has not proved possible to date. While the scope of some research priorities has been identified, it can not be thought of as definitive, as newly emerging technologies and as yet unforeseen technological barriers will always provide new opportunities and present new challenges.

Thus, this edition of the Strategic Research Agenda should be seen only as the ‘present view’ on what needs to be done.

#### EU Seeks Greater Contribution from the Private Sector

Whether or not EU and national funds are channeled through a JTI, or through the existing mecha-

nisms, the ratio of private to public funding for collaborative R&D is of the essence.

In a recent statement<sup>50</sup> Commissioner for Energy, Andris Piebalgs, called for a greater contribution to R&D from the private sector:

*"As long as we keep thinking that the 3% allocated to research comes through taxpayers money, we will fail. We should have considerable contributions from industry."*

According to the European Commission funded REDS project<sup>51</sup>, in 2001 approximately half of all renewables related R&D at national and EU levels was carried out by the private sector. This is in line with the general pattern of FP6, wherein the ratio of private to public funding has been 1:1.<sup>52</sup>

Private industry intends to continue to provide consistent financial support to research and development activities. However, taking a wider view than merely the renewable energy sector or even the energy sector as a whole, it was envisaged at the Barcelona Summit that the ratio of private to public funding for R&D in all sectors should increase to 2:1, in order to meet the objectives of the Lisbon Strategy, and to bring EU practice closer in line with that of competitors such as Japan and the USA.

While this pattern may be applied across the research sector as a whole, it could prove disastrous for small and medium-sized enterprises (SMEs) such as the majority of wind energy companies.

German MEP Rolf Linkohr estimated, in 2004, that in order to reach the 3% Barcelona objectives by 2010, private research would have to increase by 9% annually. SMEs by their nature have limited resources to tie up in long term research activities, as a fast return on their investments is essential to maintain revenue. This accounts in part for the fact that private enterprise in the wind industry tends to focus on short term research – to pluck the ‘low-hanging fruit’.

In its preparations for FP7 the European Commission has stated its intention that SME par-

<sup>50</sup> Euractiv, June 2005

<sup>51</sup> *Research & Development Spending - A survey of R&D spending for renewable energies in EU countries*. Fraunhofer Institute, PricewaterhouseCoopers and Brocconi University, 2005. See <http://www.eu.fraunhofer.de/reds/> for full information

<sup>52</sup> Ibid

ticipation in the programme should be encouraged. However, pressure to increase the industry contribution up to two thirds is unlikely to boost wind industry SMEs' participation. If such companies are to be encouraged to take part in the funding of longer term R&D, the chosen ratio of public to private funding must take their resources and the relative size of the sectors into account in a flexible manner.

### **Industry R&D Intensity Is Already Greater than Called for at Barcelona**

This flexibility is doubly important when one considers the present R&D intensity – the amount spent on R&D over revenue - of the wind industry.

The 2:1 private to public ratio proposed for FP7 is intended to invigorate those sectors where limited new knowledge is being developed. To catch up with international competition, the EU private sector is being encouraged to increase its R&D spending to around 2% of its revenue, while the other 1% is to be provided from public funds.

EWEA data reveals that the R&D intensity<sup>53</sup> of private industry in the wind energy sector is already well in excess of 2%, at approximately 3.2% - and in some cases considerably higher.

Thus, on a case by case basis, to provide €1 for every €2 provided by the industry (instead of a 50:50 split) would not encourage progress towards the Lisbon Objective, but rather starve of vital support to one of the very industries that can help achieve it.

The question remains: from where exactly should public funds be sourced? According to the REDS project, a quarter of public spending on R&D has come from the EU budget, but several sources are feasible. The proposed European Technology Platform for Wind Energy would assess the alternatives, including collaboration among Member States, the European Investment Bank and the Structural Funds.

### **The Private Sector Must Submit High Quality Projects**

When questioned recently as to why the FP7 proposed budget for energy has only increased to €2.9

billion while, for example, the budget for Information and Communication technologies has shot up to 12.6 billion, Commissioner Piebalgs, said:

*“You can allocate a lot of money to one particular policy area but you must also take consumption capacity into account. [According to] my services I believe that, considering consumption capacity, a 60% increase is sufficient to accommodate all the projects that will come up.”*

Consumption capacity refers to whether or not a sufficient number of projects have been submitted to justify the budget. The fact that little funding has to date been obtained for wind energy research under FP6 may then be in part due to insufficient receipt of high quality proposals, which is to say that you can lead a horse to water, but you can not make it drink.

The research sector must make it a priority to maintain the generation of high quality project proposals, covering such tasks as laid out in this Strategic Research Agenda. Failure to do so will risk undermining chances of increased research support for wind energy,

### **4.2.4 Member State Financing**

The Political Declaration of the Renewables 2004 Conference in Bonn last year states:

*“Ministers and Government Representatives emphasise the need for additional targeted research and development [...] Emphasis should be on affordability and cost reduction [...] recognising that different renewable technologies offer different opportunities and face different constraints.”*

It is particularly important that Member States demonstrate real commitment to wind energy R&D. In contrast to US federal spending for example, the EU's total R&D spend (in all sectors) is only a fraction of what Member States spend, as noted recently by R&D Commissioner Janez Potočnik :

*“In the United States, 95% of public research is in one way or another under federal control, whereas in the European Union the present Community Framework Programme represents scarcely 5% of total public expenditure [...]”*

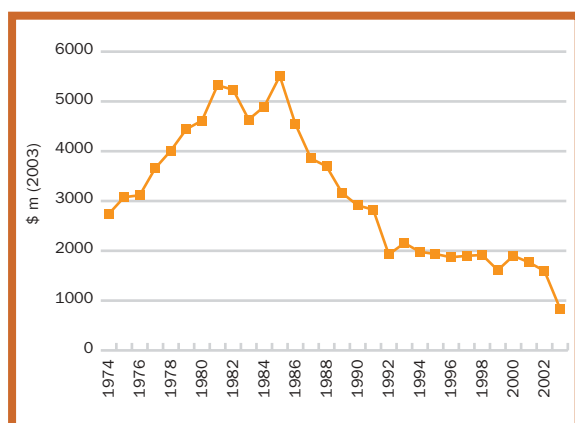
53 R&D intensity in this case is defined as EU turbine manufacturers total R&D spending, over their gross revenue.

It is difficult, however, to assess member state funding for renewables or wind energy R&D spending in real terms. The data discussed below have been sourced from the International Energy Agency's Energy R&D Statistics Database<sup>54</sup> and the European Commission funded REDS Project.<sup>55</sup> While invaluable, they can only provide a general picture of trends in spending, as incomplete data for one reason or another, differences in definitions, and the fact that the data may not take into account the entire and diverse range of funding sources, mean that the below should not be taken to reflect the complete picture. The Wind Energy R&D Network has also revealed up to date but more qualitative data on R&D funding in the EU-15.

Research, development and demonstration budgets related to energy as a whole increased after the oil shocks of the 1970s, yet IEA figures show that from 1974 to 2001, energy technology research accounted for only 8.2% of total OECD member state government funding for R&D.

Figure 4.3 demonstrates the steady downward trend in energy R&D spending since 1985. In 2003, public R&D spending by EU-15 governments amounted to a little under \$1 billion. By comparison, in the United States, the figure stood at \$2.7 billion.

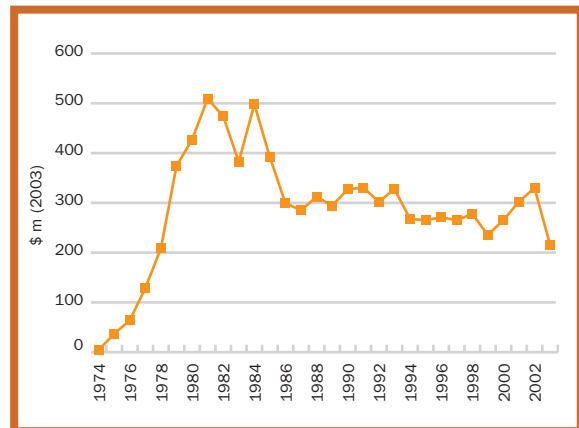
**Figure 4.3**  
EU-15 State Spend - All Energy R&D



By 1987, RES R&D budgets had declined to around 60% of their peak levels, after which the overall trend was relatively stable into the new millennium

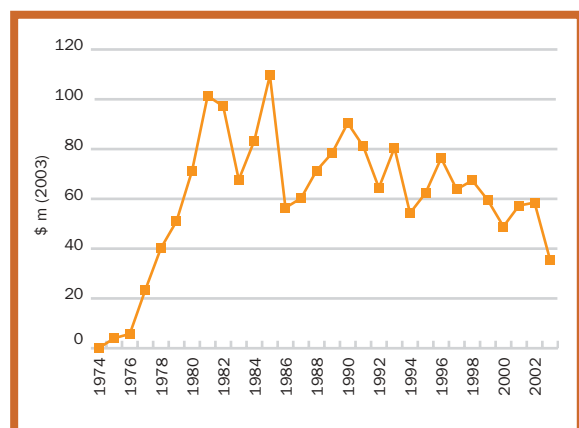
(See Figure 4.4). In other words, RES R&D funding over the last decade or so is around two thirds what it was in the early 1980s.

**Figure 4.4**  
EU-15 State R&D Spend - All RES



Funding for wind energy R&D in EU Member States has followed a similar overall pattern to RES funding, peaking in the 1980's and reducing, albeit erratically, up to 2003 (see Figure 4.5). Varying from year to year by as much as 30%, the data provide a strong argument for steady, reliable R&D funding from the European Level – to 'iron out' some of the variability in national funding, and to provide a sure resource for long term strategic planning of R&D tasks. The 2003 level of financing was approximately one third of its peak in the mid 1980s.

**Figure 4.5**  
EU-15 State Wind Energy R&D Spend



54 <http://www.iea.org/Textbase/stats/rd.asp>

55 European Research Spending for Renewable Energy Sources <http://www.eu.fraunhofer.de/reds/>

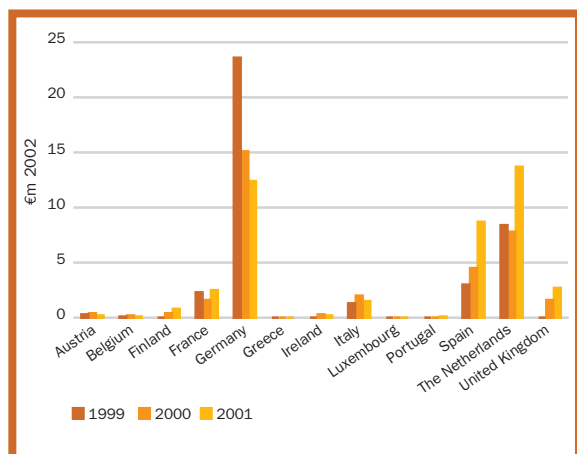
National emphasis on renewable energy technologies varies according to national resources and general preference. For example, in Germany, a little less than 11% of the total budget for Renewables R&D is spent on wind related activities. Belgium on the other hand, according to the data available, spent a little under 1% on Wind energy R&D in 2001. At the other extreme, in the same year, Ireland spent 66% of its RES R&D budget on wind energy.

According to REDS Project data:

*“one third of the EU-15 Government research spending and half the personnel working on research for renewables are from Germany.”*

Figure 4.6 demonstrates the extent of Germany’s spending on wind energy R&D, relative to other member states, although in the three years of data shown, this has reduced by almost half. Germany leads the world in wind energy installed capacity. The data here suggest that this may be – at least in part - due to forward thinking and understanding of the value of investment in long term research.

**Figure 4.6**  
Selected EU Government R&D Spend on Wind R&D

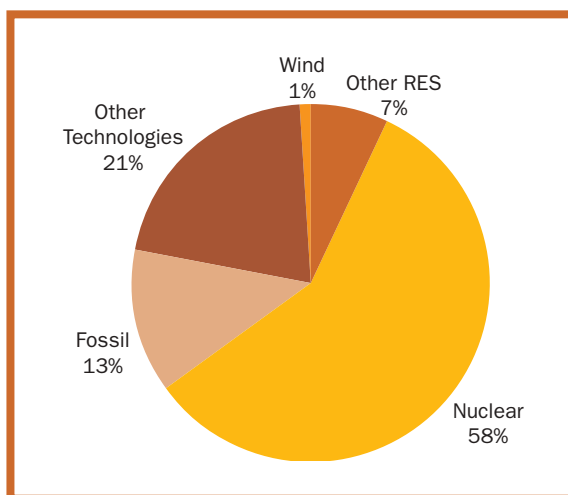


Source: REDS database at <http://www.eu.fraunhofer.de/reds/>

### Conventional Energy Research

Levels of Member State funding to renewable energy sources overall, and to wind energy, are only a fraction of the funding accorded to conventional energies. Over the period from 1994 – 2002, nuclear energy research financing was approximately three and a half times greater than that dedicated to renewable energy<sup>56</sup>. Figure 4.7 demonstrates the overwhelming disparity in the level of funding accorded to renewable and conventional technologies in IEA countries.

**Figure 4.7**  
Total Energy R&D Shares in IEA Countries from 1974 to 2002 (US\$)<sup>57</sup>



Over the last three decades, 92% of all IEA country R&D funding, some \$268 billion, has gone to the non-renewable energy sector, chiefly fossil and nuclear technologies, while a mere 8% has been spent on all renewable energy technologies combined (\$23 billion). Wind Energy has received just 1% of all funding, some 2.9 billion over twenty nine years.

Just three countries, Germany, Japan and the USA, accounted for 70.4% of this spending. If the EU is to maintain its membership in wind energy technologies, its Member States must follow the example of the market leader.

<sup>56</sup> IEA R&D Statistics Database  
<sup>57</sup> Source: *Renewable Energy, Market and Policy Trends in IEA Countries*, OECD / IEA, 2004

## 5. Conclusions and Recommendations

This Strategic Research Agenda has been developed with the active participation of a broad and deep cross-section of the wind energy sector, and with the support of the European Commission. It highlights the key R&D priorities that must be undertaken if the European electricity system is to benefit fully from wind energy. The Priorities listed below are divided into three categories: showstoppers, barriers and bottlenecks.

### 5.1 Priorities for Research and Development

While the below tasks represent the accumulated knowledge of the R&D tasks to date, they can not be considered as a definitive list of tasks that, once completed, will ensure the complete satisfaction of all needs. Research by its very nature, discovers new challenges, even as it provides new knowledge to overcome the old.

This agenda for research should be seen therefore as only the first edition of an ongoing identification process, which would be updated through the proposed European Technology Platform for Wind Energy.

#### 5.1.1 Showstoppers

These are the key priorities, which is to say that they are considered to be issues of such importance that failure to address them could halt progress altogether. Thus they need special and urgent attention.

1. In terms of **resource estimation**: maximum availability of wind resource data, in the public domain where possible, to ensure that financiers, insurers and project developers can develop high quality projects efficiently, avoiding project failure through inaccurate data.
2. With regards to **wind turbines**: the availability of robust, low-maintenance offshore turbines, as well as research into the development of increased reliability and availability of offshore turbines.

3. For **wind farms**: the research and development of wind farm level storage systems.
4. In terms of **grid integration**: planning and design processes for a trans-European grid, with sufficient connection points to serve future large-scale wind power plants. This task should be undertaken by the wider energy sector.
5. With regards to **environment** and **public support**: a European communication strategy for the demonstration of Research results on the effects of large-scale wind power plants on ecological systems, targeted at the general public and policy makers. To include specific recommendations for wind park design and planning practices.

#### 5.1.2 Barriers

Barriers are defined as being principal physical limitations in current technology, which may be overcome through the opening up of new horizons through generic / basic research over the medium to long term.

1. **Wind Resource**: Resource mapping of areas with a high probability of high wind resource potential, but as yet unexplored, including the Baltic, North and Black Seas.
2. **Wind Turbines**: **i)** Integrated design tools for very large wind turbines operating in extreme climates, such as offshore, cold / hot climates and complex terrain; **ii)** State of the art laboratories for accelerated testing of large components under realistic external (climato-logical) conditions.
3. **Wind Farms**: **i)** Understanding the flow in and around large wind farms; **ii)** Control systems to optimise power output and load factor at wind farm level; **iii)** Development of risk assessment methodologies.

4. **Grid Integration:** Control strategies and requirements for wind farms to make them fully grid compatible and able to support and maintain a stable grid.
5. **Environment and Public Support:** **i)** Effects on ecology adjacent to wind energy developments; **ii)** Development of automatic equipment to monitor in particular bird collisions, and sea mammals' reaction to underwater sound emissions.
6. **Standards and Certification:** development of the following international standards: **i)** Energy yield calculation; **ii)** Grid connection protocols and procedures; **iii)** Risk assessment methodology; **iv)** Design Criteria for components and materials; **v)** Standardisation of O&M mechanisms

### 5.1.3 Bottlenecks

Not to be confused with the above, bottlenecks are problems which can be relatively quickly overcome through additional short or medium term R&D, i.e. through the application of targeted funding and / other resources.

1. **Wind Resource:** Development of cost effective measuring units, including communications and processing, and which are easily transportable, for the assessment of wind resource characteristics, such as LIDAR, SODAR and satellite observation.
2. **Wind Turbines:** Development of component level design tools and multi-parameter control strategies.
3. **Grid Integration:** Development of electric and electronic components and technologies for grid connection.
4. **Environment and Public Support:** International exchange and communication of results of R&D into ecological impacts.
5. **Standards and Certification:** Accelerated finalisation of ongoing standards development activities (certification processes and test procedures, design criteria for offshore wind turbines, project certification).

## 5.2 Enabling R&D

The European wind industry, together with national ministries and other stakeholders in the development of wind energy, has proposed to the European Commission that a technology platform for wind energy be established. The overall objective of the platform, in R&D terms, is to increase cooperation and research into European wind energy, thus maintaining and further develop Europe's position as the world's undisputed leader in wind energy.

At present there are many actors working in the sector with limited interaction and consensus on R&D priorities. Actions like the European Commission funded project *Wind Energy Thematic Network*, and organisations such as EWEA, and the European Academy of Wind Energy can only achieve partial coordination. The technology platform on the other hand would seek to bring together all stakeholders, to minimise duplication of effort. In summary, the platform aims to be:

- A clear, single voice for European market development and collaborative research needs, able to establish clear priorities to best preserve and enhance European leadership in the wind energy sector.
- Able to steer long term R&D while harvesting the 'low hanging fruit' – short term activities to increase market volumes and generate cost reductions through economies of scale.
- A transparent forum, open to all stakeholders, flexible enough to respond to evolving needs.
- A facilitator to turn new knowledge into innovative output as quickly as possible.
- A driver for maximising, steady, transparent funding for wind energy research, development and demonstration from EU and national levels.
- A facilitator for interactive policy making among European, Member State and local (provincial) levels.
- The single point of contact for all R&D issues related to the wind energy sector, and cross cutting R&D issues involving interaction with the wider energy sector, including, among others, other electricity generation technologies, TSOs, and their technology platforms.



### 5.2.1 Funding

EU level funding for overall energy R&D through the framework programmes is just a sixth of what it was two decades ago. Member State financing, according to IEA figures, is approximately one third of its peak in 1986. And yet public R&D funding, even as it has reduced, has been undoubtedly essential in the development of wind energy. Private enterprise will continue to match public funds, and to maximise its output, within the limits of its capabilities.

The wind energy sector adds its voice to that of the European Commission, its Advisory Group on Energy, and the European Parliament, in calling for the increase of funding for renewable energy; not only to make up for its neglect in recent years, and not only to bring it up to a level with

its conventional competitors, but to provide funding commensurate with the benefits it offers Europe.

A strong wind energy sector does not only mean reduced CO<sub>2</sub>, as well as other environmental benefits. Sustainable economic growth, reduced energy import dependence, high quality jobs, technology development, global competitiveness, and European industrial and research leadership – wind is in the rare position of being able to satisfy all these requirements.

Commitment through the European technology platform for wind energy in the form of active collaboration as well as funding, at national and EU levels, from private and public organisations, can ensure that these benefits be fully realised.

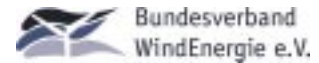


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Please note: this report is based on inputs from a variety of authors and information sources.  
EWEA does not accept responsibility for the accuracy of the data included.  
This report does not reflect the formal position of the European Commission.

## About EWEA

**EWEA is the voice of the wind industry - actively promoting the utilisation of wind power in Europe and worldwide.**

EWEA members from over 40 countries include 230 companies, organisations, and research institutions. EWEA members include manufacturers covering 98% of the world wind power market, component suppliers, research institutes, national wind and renewables associations, developers, electricity providers, finance and insurance companies and consultants. This combined strength makes EWEA the world's largest renewable energy association.

The EWEA Secretariat is located in Brussels at the Renewable Energy House. The Secretariat co-ordinates international policy, communications, research, and analysis. It co-ordinates various European projects, hosts events and supports the needs of its members.

EWEA is a founding member of the European Renewable Energy Council (EREC), which groups the 6 key renewables industries and research associations under one roof.

