

Executive Summary:

**Ten-Year Review of the International Wind Power Industry
1995-2004**

Forecast for 2015 & Long Term Scenario to 2025

BTM Consult ApS -September 2005

This is a summary of BTM Consult ApS latest report encompassing a Ten Year Review of the international wind power industry. In the following are listed highlights from the past decade, new angles are analysed and results are recorded. Furthermore two special topics dealing with *requirements to large wind farms in today's utility system* and review on the *technological development* and trends in the design of modern WTG's are described.

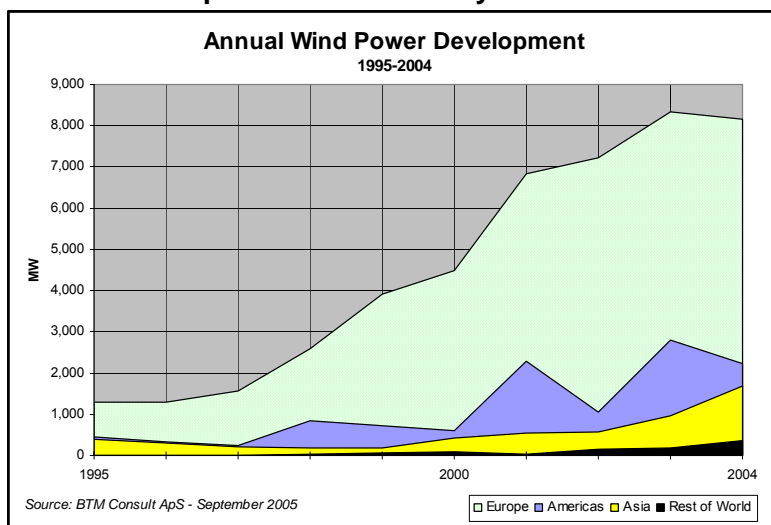
The aim of the publication is to give an *overview of the last decade*. The period from 1995 to 2004 represents the *maturing era* of the modern wind power industry. Furthermore, in view of this past development, the likely prospects for the future are presented in the form of a ten-year forecast up to 2015 and a long-term scenario up to 2025. The findings and highlights referring to the chapters in the report are:

Market development (Chapter 3):

The aggregated installed wind power capacity has increased from 3,500 MW by end of 1994 to nearly 48,000 MW by end of year 2004 – a growth by a factor 13.5. More detailed figures for the decade are:

- Annually new installed capacity is increased with an average growth rate of 27.3 % p.a. since back 1995. In 2004 8,154 MW of new capacity was installed.
- Aggregated wind power in the world is increased by an average growth rate of 29.1 % p.a. The end of 2004 recorded 47,912 MW capacity recorded in operation worldwide.

Installed wind power distributed by continent 1995 to 2004



Wind Turbines increases in size from 1995 to 2004

In 1995 the average size of WTG's delivered to the market had a capacity of 400 kW. By end of 2004 this figure is increased to 1,248 kW. The report lists the total deliveries by size segment. The table hereafter shows the development in size segments over the past five years:

Distribution of total MW by size segment 2000 to 2004

Year	2000	2001	2002	2003	2004
Total MW supplied	3,961	7,056	7,416	8,304	8,508
Product (Size range)	% of total MW				
"Small WTGs" <750 kW	49.3%	32.3%	13.7%	7.4%	5.4%
"Mainstream" 750-1500 kW	37.7%	50.8%	55.7%	56.4%	50.9%
"MW-class" 1501-2500 kW	13.0%	16.9%	30.0%	35.3%	42.8%
"Multi-MW Class" >2500 kW	0.0%	0.0%	0.6%	0.9%	0.9%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

Source: BTM Consult ApS – September 2005

High penetration of wind power in Europe

The penetration of wind power in Europe has reached 2.3 %, meaning that 2.3 % of the total electricity consumption in Europe is delivered from wind power. A few countries have reached a remarkable high penetration, those are: Denmark with 19.7 %, Spain with 7.7 % and Germany 5.4 % as the leading nations in wind power utilisation.

Developments on the supply side & Consolidation in the Industry (Chapter 4 & 5)

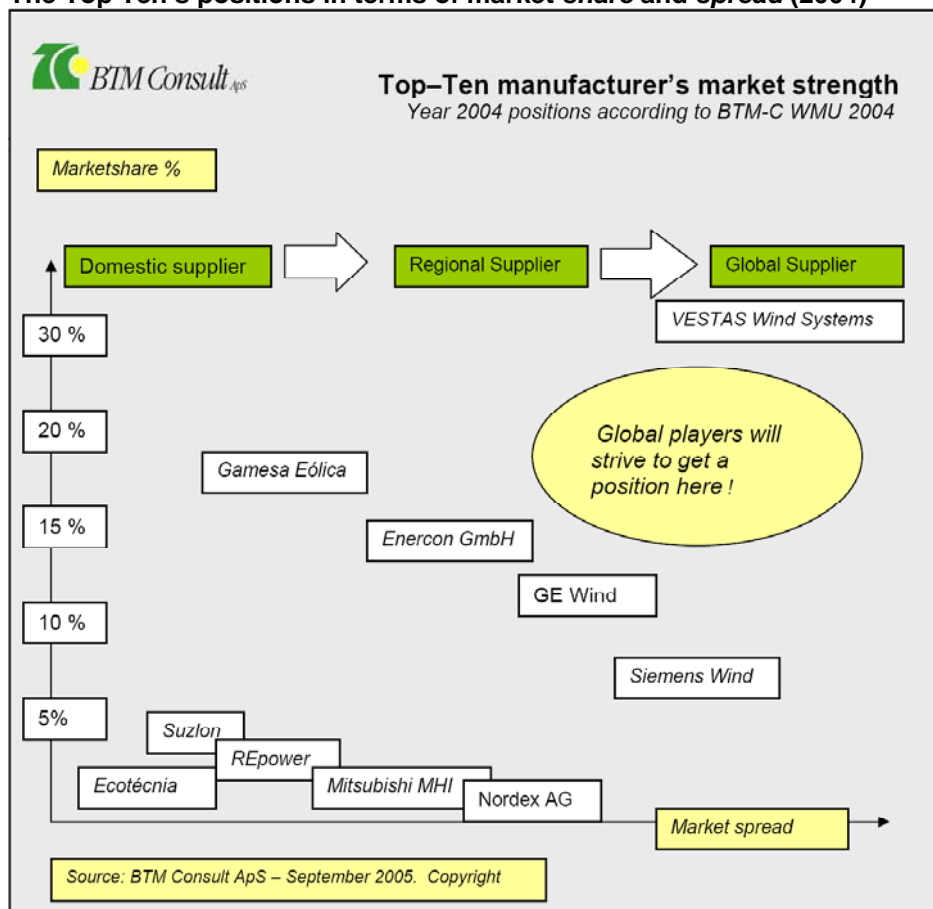
The total supply of wind turbines is shared among a group of some 25 companies, of which the ten leading are ranked as the Top-Ten Suppliers. The Top-Ten has during the decade counted for typically 90-96 %. The upper 5-6 suppliers remain the same (same technology) in the whole period, even though some have changed name as result of a merger and/or acquisition. Down the list, there have been changes from time to time. 25 companies have been represented on the Top-Ten list during the past decade. The six leading during the ten years period is VESTAS, Gamesa, NEG Micon (now part of VESTAS), ENERCON GmbH, GE Wind (former ENRON Wind) and Siemens (former Bonus Energy). The highest market share for a single company is VESTAS', with 34.3 % in 2004 after they acquired NEG Micon.

Consolidation in the industry

The consolidation in the industry has been traced and the most remarkable merger/acquisitions are described. Also a brief review of the time up to 1995 is done.

The assessment ends up with grouping the major players into three categories, based on present situation and past track records. The group of minor players are also identified, as they might candidate for later entry between the Top-Ten. In the following graph, the market positions of the Top-Ten companies are illustrated in terms of market share and – spread. It is based on the situation as it was in 2004.

The Top Ten's positions in terms of market share and spread (2004)



Even though there are four companies in the “emerging global player’s” group, all candidates for entry into the “global players” groups, there will, obviously, not be room for five players with a 25% market share each! A more likely scenario in the medium term is that there will be a small group of 3-4 companies at the top sharing 80% of the market.

Development of Wind Turbine Technology (Special Topic 1 -Chapter 6)

The development in the past decade is reviewed from the market and from an R&D view. The most spectacular progress is the size of the wind turbines. In 1980 the typical turbine was a 50 kW turbine with a rotor diameter of 15 m. In 1995, where this reports review starts, the size was increased to 500-600 kW and with 40-50-metre rotor diameter. In 2004 the commercial turbines have reached 2-3 MW with 90 – 100 meter rotor diameter. The “invisible” improvements are better design codes, optimised use of materials control strategies and devices, which reduce loads and improve electric quality of the output. The review has also analysed the records in the market, to answer the question: **What is actually sold with success in the market?** The most sold turbines in during the past decade are listed in the report (the Top-Ten products). The three most sold turbines are VESTAS V47, Gamesa G52 and GE Wind’s 1.5 MW.

Along with the basic design and the up scaling, the evolution of the concepts regarding the power conversion from rotor to the grid is assessed comprehensively. Topics treated in the report are: Power control ability and methods used, from **stall regulated fixed pitch** to **variable speed with full span pitch**.

A review of offshore, lists the operational projects in the world, and the candidate-products for future offshore, meaning turbines in the range 3 – 5 MW are identified. Most of these types are in operation as prototypes on land sites.

Wind Power joins the mainstream (Special Topic 2 – Chapter 8)

There is 10 years (or more) of product development and improvements, from the stages of manufacturing of a **single turbine**, which can produce electricity to a stiff grid, to the supply of **complete wind power plant**. The latter must comply with utilities and Transmission System Operator’s requirements – and their desire for even more system compatibility. It is no longer a matter of 50 to 100 kW on and off at low voltage level. It is a matter of several hundreds of MW wind farms, which are required actively to contributing to the stability of the whole system – a huge challenge to be met.

Forecasting – an exercise in uncertainty (Chapter 7)

BTM Consult has made an evaluation of previous forecasts presented in the annual World Market Update publication, published since 1995. The first five “five year forecast” has been surpassed by real life. The basic conclusion is that the dynamics of the wind turbine industry has been far stronger than expected by us (and other analysts as well) ten years ago. However, there seems to be a broader consensus about short term forecast for the industry to day, as it has become mainstream technology and therefore behave more predictable. The table following shows previous BTM-C forecasts reflected in actual development:

Predicted cumulative installation five years ahead from BTM Consult ApS

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004
Forecast’s from previous BTM-C World Market Updates (Cum. MW by end of the year):									
Summary by 1995	6,125	7,625	9,520	11,615	13,710				
WMU '96		7,724	9,739	12,044	14,524	17,514			
WMU '97			9,583	11,563	13,763	16,713	20,283		
WMU '98				13,358	17,028	21,163	26,243	31,833	
WMU '99					18,817	24,642	30,737	38,337	47,512
WMU '00						24,704	31,589	39,604	48,084
WMU '01							32,447	42,352	52,757
WMU '02								41,002	50,262
WMU '03									48,336
Actual cumulative installation , as recorded by BTM-C (MW capacity):									
Cum. Installed MW	6,104	7,638	10,153	13,932	18,449	24,927	32,037	40,301	48,394

Source: BTM Consult ApS – World Market Update 1996-2003

The same chapter include a review of past estimates and/or projections from institutions as IEA/WEO (IEA’s World Energy Outlook), EWEA (European Wind Energy Association), WEC, (World Energy Council). Also this organisation has been “surprised” by the actual pace in the Wind Power Industry. IEA has been more conservative in its view on the role of wind power in the future. However, the IEA

report (WEO) has become a most important reference for BTM-C's, when "looking forward", as it covers the energy industry as a whole.

Long-term development of Wind Power – two scenarios (Chapter 9)

There are made two scenarios for wind power development, different from what is normally done in BTM-C's World Market Update – forecasts. It is first time BTM-C makes a long-term scenario (2025), and the short-term scenario is turned into a forecast with a time horizon five years longer than usually. The forecast for 2015 is broken down by continent, and by country and the figures shown year by year to 2015. The Forecast and Scenario 2 respectively are presented as,

1. **Business as Usual**
2. **Environment and Security of Supply focused Policy**

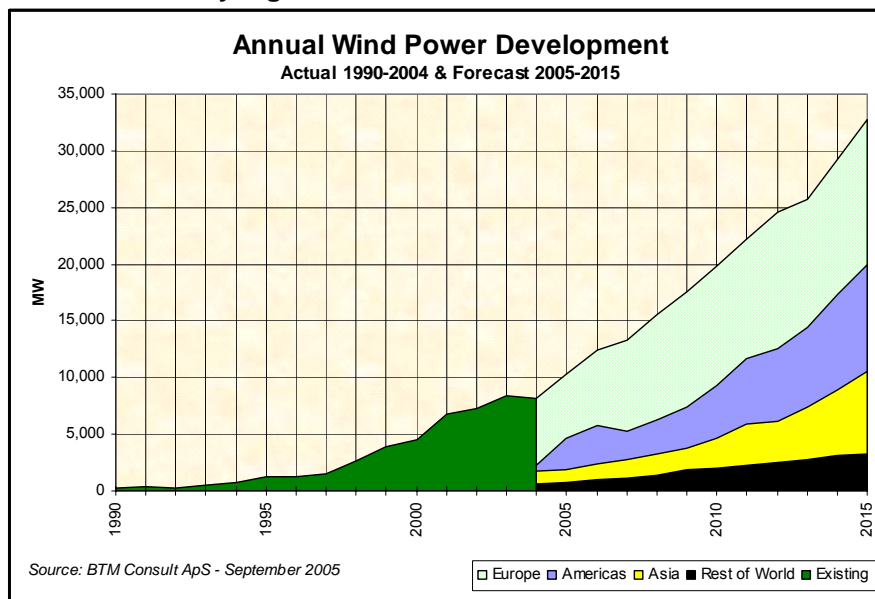
An important part of the task has been to estimate the expected share to be taken by wind power compared to other generation technologies. This has involved an assessment of the competition in terms of cost-effectiveness, reliability and the environmental impacts, whether positive or negative. Included in the process has been an evaluation of wind power technology and its potential for further improvements, along with progress among competing technologies. The higher oil/gas prices seen recently are suggested to be maintained at a level of US\$ 40 – 50 for long time.

Forecast to 2015

Overall figures for the forecast to 2015:

- Annual installation will increase from 2004's figure of 8,152 MW to **32,720 MW in 2015**
- Cumulative capacity will increase from 2004's figure of 48,000 MW to **271,512 MW**
- The average growth in **annual installation** for the whole period is **13.5% p.a.**
- The average growth in **cumulative installation** for the whole period is **17.1% p.a.**
- The fastest growing regions will be America and Asia
- Europe will show more moderate growth than in the past. However, even with an 8.4% average increase in annual installation, Europe will maintain its position as the largest regional market for wind power up to 2015
- Wind power plants are expected to produce **620 TWh** per year in 2015, equal to a **penetration rate of 2.7%** of the world's electricity production.
- **Europe's share** of the cumulative installation in 2015 **will drop** from today's 72.5% to 53%. The **American share will grow** from today's 15.4% to 23.6%.

Global forecast by region to 2015



This Executive Summary reflects the main findings in recent BTM Consult ApS report: **Ten-Year Review of the International Wind Power Industry – Sept. ISBN 87-987788-7-0**
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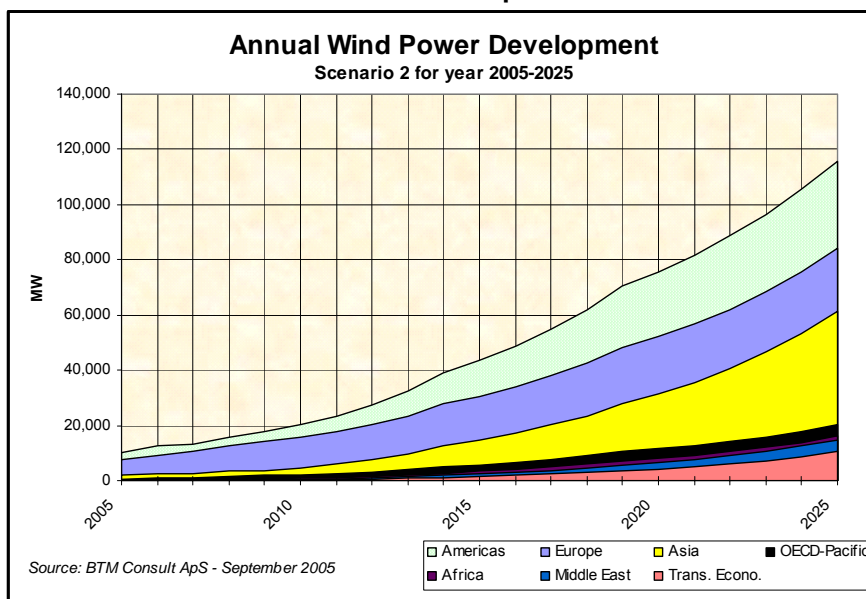
Cost estimate of the Forecast to 2015:

The additional **224,000 MW** to be installed in the next eleven years according to the Forecast represents a **total investment cost around US\$ 224 billion**, based on today's key-price of approximately US\$ 1,000 per kW wind power capacity. Notice that future price development has not been assessed for this forecast study!

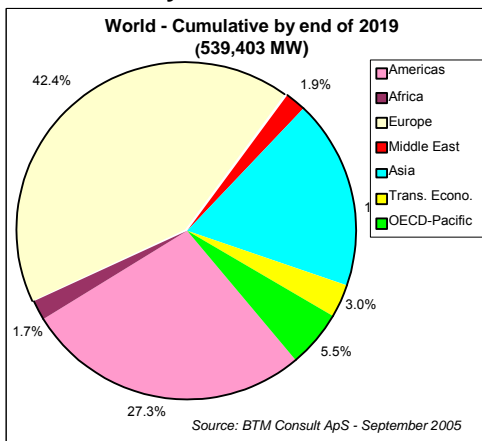
Scenario for 2025

The scenario is built under a set of assumptions about the global progress concerning awareness of “global warming” and “security of supply”. Based on these considerations along with development patterns likely to be replicated in the future and finally the actual size of physical resources and grid- or load conditions, the scenario is quantified by region and year-by-year to 2025. The aggregated installed capacity will reach 1,000,000 MW (or 1,000 GW). It is a factor 20 more than to-days installation. The annual demand for new wind power capacity will grow to some 70,000MW per year in 2020, and 118,000 MW per year in 2025. Europe will end up as a saturated market with a wind power penetration close to 20 % (As actually reached in Denmark in 2004!). Other regions/continent are still on the route of further growth. The development in Scenario 2 is shown in the following graphs:

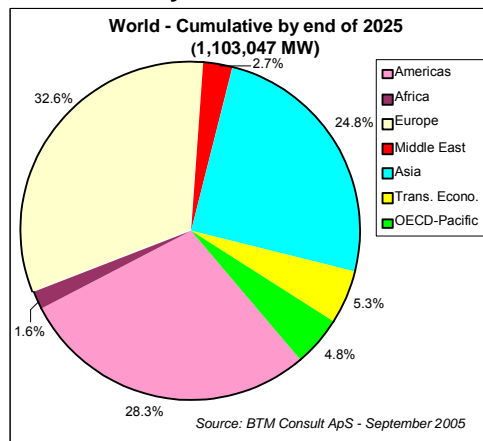
Scenario 2 – Global wind Power development to 2025



Scenario 2 by 2019



Scenario 2 by 2025



The impact of the scenario is calculated in terms of penetration, with reference to the IEA, reference projection for 2030 (adjusted to 2025 via interpolation in the WEO 2004 – data)

- The global penetration of wind power has reached 8.6%.
- The highest penetration is in Europe, reaching almost 20% and a full-saturated market. From then on it will need to install some 18 GW per year just to maintain its installed capacity.
- All the remaining regions/continents still have a potential for further expansion, as they are far from the “20% penetration” limit. Most countries belonging to the Transition Economies are not likely to take off before the end of the scenario and do not have a huge potential ahead of them.