Cabling for Windpower
White Paper

Reaping the whirlwind

"For they have sown the wind, and they shall reap the whirlwind,"
Hosea (8:7)

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Synopsis

This report is intended to give a general overview of the global windpower market, and provide information about how Nexans is serving this market.

It opens with a review of the pros and cons of windpower and its future development, and concludes that despite some skepticism, windpower is an inevitable trend and an opportunity for those who can serve its multiple needs worldwide. The paper then focuses on several challenges facing developers, and concludes with the expectations they have of cable suppliers. Finally, the third section presents Nexans' overall solutions for both Original Equipment Manufacturers (OEMs) and infrastructure installers and explains Nexans' service approach.

This report is followed by an Appendix containing a list of recent Nexans success stories, innovations and references.

I. INTRODUCTION: WINDS OF CHANGE, WINDS OF OPPORTUNITY

"Wind energy is the first of the 'new renewable' technologies to have penetrated the energy markets in some parts of the developed world in a serious way with the right kind of policy support. The wind industry can lead the way for other renewable energy technologies: as it matures and penetrates markets worldwide, it drives costs down which will make this technology competitive worldwide, including developing countries."

Prof. Jose Goldemberg, Secretary for the Environment of the State of São Paulo, Brazil

1. With the wind: the optimists

The basic assumption of both pro and anti-wind advocates is that there is a growing **need for electricity** in a world that is growing by 2.4% annually.
At present, the World Energy Council estimates that there are 1.6 billion people throughout the world who do not have access to electricity, and this number is unlikely to decrease by 2020.
Meanwhile, electricity consumption is predicted to increase by 58% by 2020. For Professor Goldemberg, cited above, "energy is fundamental to economic and social development, both North and South," and that is why he, and many others, including political opinion leaders like Tony Blair, are looking to wind as a solution.

A - One of the strongest arguments of proponents is **availability**.

Recent assessments show that the world's wind resources are very large and well-distributed across all world regions and countries. The total resource that is technically recoverable is estimated to be 53,000 Terawatt hours (TWh)/year. This is over twice as large as the projection for the world's electricity demand in 2020.
Therefore, not only can countries which totally lack oil & gas or coal reserves avoid the burden of that expense, but also, once infrastructure is installed there is no fuel bill to pay. Moreover, the resource is not likely to run out.

B - A second argument is **renewability or sustainability**, which has been a wide concern since the publication of the Bruntland Report ("Our Common Future," 1987).
Renewable electricity can be generated from several sources: wind power, wave, tidal, solar photovoltaics , hydro generation, geothermal and biomass (energy from forestry or crops).

Apart from hydropower, which accounts for 16.6% of the world's energy, windpower is the only serious contender in this field, and that explains its recent expansion in Europe and elsewhere, often with government support. In fact, industry experts estimate the average growth for new installations at 25% per annum over the next seven years.

C - Thirdly, supporters of windpower claim that **pollution reduction** is one of the prime benefits from windpower.

The Kyoto Protocol (1997) stipulates that industrial countries must reduce greenhouse gas emissions from 1990 levels by an average of 5% between 2008 and 2012. To date, 84 countries have signed and 122 countries ratified the Protocol, despite the pullout of the US.
Proponents of windpower claim that windpower will remove a significant amount of carbon dioxide from the atmosphere, CO2 being the gas largely responsible for the greenhouse effect which leads to global climate change.
In the US, it is claimed that 30,000 Americans die yearly due to emissions from coal burning power plants. Windpower could effectively remove 10,771 million tones of CO2 by 2020, and nearly 89 million tonnes by 2040.

D - The fourth advantage of windpower is **the reduction of fuel imports**, both for developed and developing countries.

A recent European study, the "ExternE" project, spent a decade examining the fuel costs for the then 15 EU states and found that "the cost of electricity from coal or oil would double, and that from gas increase by 30%, if their external costs associated with the environment and health were taken into account".
Moreover a recent European Commission Green Paper on Security of Energy Supply states that in two decades Europe will be importing 70% of its energy (up from 50% today) unless windpower can bridge the energy gap.

Moreover, it has been pointed out that conventional energy sources have received an estimated $250–300 billion in **subsidies** per year worldwide, largely distorting markets. Subsidies artificially reduce the price of power, keep renewables out of the market, and prop up uncompetitive technologies and fuels. The 2001 report of the G8 Renewable Energy Task Force strongly urges that "G8 countries take steps to **remove incentives** and other supports for environmentally harmful energy technologies, and develop and implement market-based mechanisms that address externalities…"

E - The final argument in favor of windpower is its **job creation**, many of them of high quality. With an **expansion** over the past five years of an average cumulative rate of 32%, global employment in the wind industry has given work to nearly 100,000 people. If the expansion of windpower continues at past rates, it is estimated that a total of 2.3 million jobs will be created around the world by 2020 in the manufacture, installation and other work associated with the windpower industry.

2. Against the wind: the pessimists

To give a complete picture, it is necessary to consider some of the arguments against **windfarms.**

The Country Guardian is a UK conservation group concerned about the environmental and social damage caused by commercial windfarms. It is not opposed to wind energy as such, but claims that all sites that are windy enough for commercial windfarms are environmentally sensitive in one way or another.

Among the arguments in their regularly updated document, "The Case against Windfarms," they argue the following points:

- **Emissions from cars** are the fastest growing source of CO2, and efforts to control greenhouse gases should be focused there, not on generation
- Windfarms provide **intermittent energy**, which must be complemented by conventional sources
- Onshore wind **costs 2.5 times the cost of gas**, and offshore even more
- Wind turbines are **ugly, noisy and destroy bird life**
- Offshore windfarms **disrupt shipping lanes**
- Turbines **interfere with television and microwave communication links**
- Because the best windspeed sites are in the areas with the finest landscapes, they will **destroy the tourist industry**
- Proximity of wind turbines lowers **real estate values**
- Windfarms are **industrial and commercial developments** unfitted for natural landscapes

Another set of arguments, from the corporate world this time, comes from an **Executive Intelligence Review**[1] article where the author, Lothar Komp, argues that wind power is expensive and unable to meet Germany's energy needs. Given the fact that electric current cannot be stored, and that a continuous current must be fed into the grid at all times, he maintains that the only sensible solution to rising power needs is a **nuclear** one.

In Germany nuclear power plants handle one-third of the nation's electrical production, and one-half of the country's base load. Despite this, since 2000, the government has agreed on a moratorium on any new nuclear energy capacity. Komp calls the moratorium **"economic insanity"** and urges the building of smaller "pebble bed" high-temperature reactors (HTRs) to guarantee cheap, carbon-free and secure electricity. He adds that superconducting rings can resolve the problem of storing electricity for long periods of time.

Strangely, this second view was recently echoed by the renowned environmentalist **Dr James Lovelock**, inventor of the "Gaia theory," and to the surprise of many, an avid supporter of Environmentalists for Nuclear Energy (EFN).

(1) See EIR, 10 Oct 2003 issue: "How will Europe Fill its Huge Energy Gap in the 21st century." www.larouchepub.com/other/2003/3039eur_energy.html

Although he fully agrees with **the pro-wind energy lobby** that climate change is an immediate and urgent threat, he feels that wind cannot deal with the speed of global warming and its devastating effects, like the 30,000 heat-related deaths in Europe in the summer of 2003. He, too, believes that nuclear power is the only form of energy that will not contribute to **global warming** and could supply enough power for the planet[2].

3. The way the wind blows: current trends and opportunities

Despite the **skepticism** of the anti-wind faction (and this includes both concerned communities and a fraction of the "green" movement), those in favor of further wind development can point to a number of important **irrefutable facts** and faits accomplis that suggest that whatever one's opinion the markets for wind turbines and windpark infrastructure will continue to flourish and expand worldwide.

Since 1999, the European Wind Energy Association (supported by its national counterparts, like the American Wind Energy Association) has continued to publish a series of "feasibility" studies, aimed at encouraging governments to formulate **policies to favor wind power development**.
The latest study (published in May 2004) confirms that windpower has maintained its status as **fastest growing energy source**, stating that installed capacity worldwide has continued to grow at an annual rate of over 30%.
Last year alone, more than 8,300 MW of new capacity was added to the world electricity grid, an investment that was worth more than € 8 billion.

The EWEA's assessment of the **current situation** is optimistic: "*By the beginning of 2004, global windpower installations had reached a level of 40,300 MW. This provides enough power to satisfy the needs of around 19 million average European households, close to 47 million people. Although Europe accounts for 73% of this capacity, other regions are beginning to emerge as substantial markets. Over 50 countries around the world now contribute to the global total, whilst the number of people employed by the industry is estimated to be around 90–100,000.*"[3] .

(2) See "Wind Power Just a Gesture" from the Western Morning News, at www.countryguardian.net/lovelock.htm
(3) See Wind Force 12, published May 2004, page 10: www.ewea.org

In addition, the study affirms a number of other current trends that seems to secure a **bright future for windpower:**

- If national and international policy shifts can create a **"level playing field"** for wind, 12% of the world's electricity could be wind-based by 2020, meaning a capacity level of 1,200 GW
- Over **2 million jobs** would be created
- 10,700 million tonnes of **carbon dioxide would be saved** from the atmosphere
- Windpower has shown a dramatic **fall in cost** (with production costs having fallen by up to 50% over the past 15 years)
- **Unit costs** for electrical output has also fallen steadily in recent years: today 3.79 € cents/kWh; 3.03 € cents/kWh by 2010 and 2.45 cents/kWh by 2020
- At optimum sites, wind can **compete with new coal-fired plants** and even challenge gas
- Individual wind turbines have **increased in capacity**, with the average size at 1,200 kW and the largest now reaching 3,600. 5,000 kW prototypes are underway, which will favorably change the investment/output equation
- The windpower boom is **attracting banking and investment**, and new players from oil & gas and power utilities are now entering the market
- A string of **success stories** around the world are driving the market (Germany, Spain, Denmark, the US and India)
- The offshore wind market is poised for a strong **breakthrough,** due to minimal public disruption and higher output due to stronger and more constant wind speeds
- **Nuclear power** is definitely being phased out in many countries

In short, indicators imply that wind energy is capable of becoming a **mainstream power source** in its own right by 2020, capable of unseating many traditional sources which are bound to become more expensive.

Wind's strongest argument is simple: **no fuel bill**.
Once infrastructure is in place, operating and maintenance costs are the only overhead. Since most installations are good for twenty years and more, this offers an **attractive investment** for major operators.
In addition, because of variable size and modular **flexibility**, wind is an interesting investment for communities, small factories, and individuals as well.
In some parts of the globe, especially the United States, farmers have been the most enthusiastic investors in wind turbines, with sales of electricity to utilities and merchant power companies providing an important addition to their income.
Opportunities in the third world are definitely a factor, too, since this is where demand for new energy is highest.

However, EWEA's strongest claim is that the *"the total available global wind resource that is technically recoverable is more than twice as large as the projection for the world's entire electricity demand."*

4. Success stories worldwide

If arguments on both sides of the windpower question can sound utopist, biased or wishful thinking, one simply has to assess current and future wind energy projects to realize that a movement is indeed underway, and that one better get aboard or be left behind.
In its May 2004 issue, the Windpower Monthly, the voice for pro-wind advocates, claims that a flurry of recent **positive political activity** is driving a range of markets in Denmark, Brazil, Spain and Germany[4] which will probably mean a rise of sales in those four markets in the coming years. This positive news simply confirms the **worldwide "success stories"** discussed at some length in AWEA's Wind Force 12:

- **Germany** is still **the world leader** in the market, with more than 14,600 MW of installed wind power capacity.
  Already, these turbines produce enough electricity in a normal wind year to meet nearly 6% of demand in a country of 82 million people. This should reach 10% by 2010. In one northern state, Schleswig-Holstein, 34% of electricity demand is now satisfied by windpower. Last year more than 1,700 new turbines were connected to the national grid (average annual increase is 34%). This new industry was worth some € 4.8 billion in 2003.

- In **the USA**, there are now utility-scale wind power installations in 30 states, generating enough electricity to serve more than 1.6 million households.
  Double-digit growth is expected through the rest of the decade. Increasingly farmers are earning extra income from leasing their "wind rights," while continuing to grow crops around the turbine bases. Bulk transmission capacity is being considered between windy, distant rural areas to major cities. Federal studies estimate that the **US has enough windpower to meet more than twice the nation's electricity demand**. North Dakota alone has about 50 times the wind resource of Germany.

- In **Canada** (according to the Canadian Wind Energy Association, CanWEA) the industry is gearing to respond to requests for proposals totaling some 1,000 MW of new wind.

- **India** installed over 400 MW of new capacity in 2003. With 2,125 MW of total capacity, it is **the fifth largest producer of windpower** in the world. The total potential is around 45,000 MW. In a country where power cuts are common, wind allows businesses and factories to supply themselves autonomously. That is why windfarms in India often consist of clusters of individually owned turbines. The windpower supply industry is booming, too, with some 80% of turbine components being manufactured locally.

(4) See "Four big wind markets on the make" in Windpower Monthly, May 2004 at www.windpower-monthly.com/cont.htm

- **Denmark's wind sector** has grown faster than any other, and is now bigger than the Danish cement or steel industries, employing some 20,000 people. 40% of wind capacity being stalled globally today is of Danish origin. This is hardly surprising since the first wind-powered electric generator was built in Denmark in 1890. Since the Danes have rejected both nuclear energy and coal as an option, wind seems to be the publicly-approved alternative. Following a new agreement in parliament, by 2010 Denmark should obtain over 25% of its electricity from wind. As in India, most turbines erected are owned by individuals or cooperatives.

- **Spain**, with its mountainous, sparsely populated countryside has seen phenomenal growth recently. By 2001, total installed capacity had reached 3,550 MW, 30% of which was installed in a single year. Three Spanish manufacturers – Gamesa, Made and Ecotècnia – account for 75% of wind turbines installed, and they are closely eyeing the potentially **lucrative South American market** (including Brazil). **Regional governments** have played a key role in development, with Galicia planning to install 4,000 MW by 2010, which will satisfy 55 % of its power demand.

Offshore has been called the "new frontier" of the international wind industry, and in northern Europe many thousands of megawatts of capacity are being planned off the coasts of a dozen countries.

Two important benefits are stronger winds that can deliver up to **40% more energy**, and **low visual and noise impact**.
Also 5 MW turbines are now being considered for offshore applications. Germany is planning 25,000 MW of coastal capacity. Also, Denmark and the UK have ambitious offshore construction programs of sites with up to 600 turbines each. Possessing over one-third of Europe's entire potential for offshore wind energy, the UK may soon be providing one in six of its households with wind generated electricity.

II. CHALLENGES AND CUSTOMER EXPECTATIONS

Onshore wind turbines are still playing an important role in countries with a large landmass, like the US and Canada, or extensive upland areas, like Spain, or in countries with numerous coastal islands, like Norway.
However, **offshore windpower** has increasingly become an alternative in land-scarce Europe and the developing world. Each kind of wind turbine and windpark infrastructure has its own demands in terms of cabling. Factors like nacelle design, size, and customization are bound to affect the kinds of cables chosen by Original Equipment Manufacturers (OEMs), while location, land versus water installation, distances, or connection to a local or distant grid affect the kind of cable used, as well. Since so many, windparks are remotely controlled, the skillful integration of energy and telecom cables are a must.
Manufacturers, installers, operators, and merchant power companies face numerous **challenges** in meeting their 2020 objectives

1. Cost reduction

If windpower is going to successfully compete with other forms of power generation (like coal, or oil & gas) **costs have to be reduced** to make them financially attractive.
One definite advantage they have over most other sources is **no fuel bill**.
Thus, cost reduction must come from using **standard, interconnective solutions** wherever possible in tower and nacelle construction, and in inter-turbine links and grids. Wind turbines represent 75% of the capital cost of an onshore project, but already costs are falling: some 50% since the mid-eighties, making wind competitive with some new coal-fired plants.
Since the **size of windparks** is increasing, with recent offshore projects envisaging up to 600 wind turbines, a certain **economy of scale** is guaranteed during turnkey construction.
Also, in places like India, costs are lowered and import replacement objectives are met by setting up **local plants for equipment**, and using local producers wherever possible. Today, a dictum circulating in the energy business is that low-voltage and medium-voltage cables are definitely "commodity" products, and it is assumed that quality is more or less the same, with cost as the determining factor. Real product differentiation occurs with high-voltage products which are harder to produce and complicated to install, and special products (like fire-performance cables).
Since most of the windpark developers are **global,** they are often comparing cable types between countries, and are centralizing purchasing.
Above all, they want to pay **one price for a given product everywhere**, so as to obtain savings from bulk purchasing.

2. Global supply and turnkey capability

As mentioned above, **windpark developers are increasingly global**. So are the original equipment manufacturers and grid installers.
Nine out of ten of the world's suppliers of wind turbines and windmill structures are based in Europe; however, they are responsible for over 90% of the total supply in the international market.
All major players are aware that if windpower is going to be **a "universal" technology**, it must be applicable anywhere, and that means assuring a supply of all equipment, cables and components worldwide.
50 countries are now actively involved in wind projects, many of them in the developing world.
Although they usually have numerous cable suppliers available locally, it is evident that the windpower market takes **special expertise**. Cables must be able to withstand torque, prolonged vibration, sea-water corrosion, and continue to operate under fire conditions. That is why cable suppliers must aim at important niche-markets, where proven expertise can be brought into play. They must also be able to assure delivery anywhere in the world on short notice.
Given the fact that wind turbines and infrastructure are often difficult to access (in remote mountainous areas or offshore), logistics is a key concern as well, with sequential delivery as priority.
Finally, few modern industries combine such a **diverse number of needs**: onshore/offshore, OEM/infrastructure, energy/telecommunications.
To eliminate the complexities of multiple sources of supply, windpower players ideally look for **one cable company** that can satisfy all of these needs worldwide, from initial feasibility studies and design, through construction and installation, final commissioning and maintenance.

3. Innovation and upscaling

Few recent industries have shown such a **vertical learning curve** and rapid development as windpower.
Indeed, one of the reasons for the **skepticism** noted at the beginning of this paper, may lie in the fact that many observers are still focused on the industry as it stood in the mid-eighties, and failed to note the **leaps and bounds** that have occurred since, making it a genuine contender in the area of renewable energy.
The most dramatic improvement is in **size and performance**.

Twenty years ago, wind turbines generated 25 kW each. Today's models generate on average 1.3 MW, with 2 MW projected for 2013. Depending on the site, a 1 MW turbine can produce enough electricity for 650 households.
Innovation is making it possible to capture more energy through larger blades, improved power electronics, composite materials and taller towers. Much of this innovation is driven by **offshore**.

Key figure:
1 MW turbine can produce enough electricity for 650 households.

Today's largest turbine is 3.6 MW with a rotor diameter of 104 meters; German Enercon has erected a prototype of 4.5 MW, and a 5 MW turbine is under development. This means that fewer turbines can be used.
The International Energy Agency (IEA) estimates that the **price of wind turbines** is reduced by 16% each time their average size doubles. Also, the industry has developed turbines to work efficiently at lower wind speeds.
Since the building of towers is the biggest investment, **re-powering** (i.e. installing larger generators on existing towers) is going to be a major challenge. In fact, upscaling will account for all new installed capacity by 2040. For the cable business, this kind of growth requires cabling with adequate "headroom" to accommodate change, both in the towers and nacelles, and also in the windpark infrastructure.

4. Upgrading transmission, distribution and grid interconnectivity

Variability of wind supply produced fewer problems for grid management then skeptics had anticipated.
On windy winter nights, wind turbines account for up to 50% of power in Denmark. Since wind power is often located at the edge of the grid, close to local demand, there is a **problem of access**, exacerbated by vertically integrated power utilities who refuse to open the doors to transmission/distribution.
Spain has poor grid infrastructure, and in the US there are transmission barriers, especially from distant rural area to the cities. In coastal areas, there is often a total absence of grids to bring offshore wind power deeper inland.
The quantity of windpower electricity which can be integrated into a country or region's electricity grid depends on the system's ability to respond to fluctuations in supply. However, no technical problems occur when **running wind capacity** together with the existing grid when the penetration level of wind is around 20% (especially combined with complementary hydro sources).

In Europe, the already planned **new supergrid** would solve problems of under and overcapacity. There is a pressing need to **upgrade transmission/distribution**, and to **improve grid interconnectivity** so that electricity can be widely shared and traded. There is also an obvious need for **higher voltage lines** for long-distance connections onshore, and for bringing offshore production to the mainland and further.
For cable suppliers, the main customers are now a whole range of different players: from thousands of small investor-owned windparks to large giants who do complete installations. What is needed is long-term vision, based on interconnective cabling, to bring embedded renewable generation/distribution into the mainstream grid.

5. Meeting offshore opportunities

In several European countries, available **land sites are saturated**, and there is also growing concern (in England, especially) about **visual and noise nuisance** for residential areas, designated land, national parks, uplands of outstanding natural beauty, etc.
Thus, there is underway an inevitable **move offshore**, and sometimes considerably offshore – 50 to 200 km – for new facilities.
The **advantages** are stronger, more stable winds, and the possibility of installing much larger wind turbines. Within the European context alone, it is estimated that a sea area of 150,000 square kilometers with a water depth of less than 35 meters could be available for offshore schemes.

If fully exploited, this would, provide **enough power to satisfy all of Europe's current and future electricity demands**. Since Germany has already voted to shut down its 19 power plants, it has set a goal of obtaining 25% of the country's electricity from windparks in the North and Baltic Seas by 2025, meaning the construction of some 25,000 MW of windpower in the sea by 2025.
From the cabling point of view, this will require submarine cables, maritime installation expertise, and a mastery of long-distance transmission techniques. The ability to install equipment and cabling infrastructure in brief "weather windows" is a must, often requiring special installation vessels and Remotely Operated Vehicles (ROVs). Cables must be resistant to salt-water corrosion and abrasion caused by sea currents and waves.

6. Customer expectations of cable suppliers

Whether it is in the area of generation or infrastructure (transmission and distribution), onshore or offshore, **cables play a central role** in the provision of windpower. Not only do they carry an invisible "commodity" that is difficult to store, they also serve important communications and control functions, at every stage critical for reliability, safety and performance.

Manufacturers, power utilities, engineering contractors, installers, and merchant power companies, all have high expectations of a cable manufacturer for their turbines and windparks:

- **Comprehensive range** of high-quality wind turbine and infrastructure cables and accessories from **one supplier**
- **Light, flexible cables** that can handle vibration, extreme temperatures, torque, sea-conditions
- **Customized products**, pre-cuts, connectivity and special palletizing
- **Innovative materials and production procedures** for easy assembly and installation
- Strong **worldwide presence** to serve national projects
- **Expertise and engineering assistance** at the infrastructure design stage, including feasibility studies
- **Onshore and offshore turnkey capability** for transmission and distribution; this includes full mastery of installation, both in remote land-based and offshore sites
- **Constant innovation** to meet evolving technologies and standards
- Familiarity with both the **energy and the telecom side of cable**, since the latter is an important part of windpark management
- **Advanced connectivity solutions**, since joints, terminations are critical to infrastructure and grid reliability
- The ability to meet **rigorous safety standards** and handle harsh environments, which can range from desert to arctic conditions, marine and land-based.
- **Fast delivery and high reactivity** in the case of accidents breakdowns, blackouts, line failures, etc.

III. NEXANS: A GLOBAL LEADER IN WIND TECHNOLOGIES

Nexans' global offer is an important one for the windpower industry. Unlike many of its competitors who provide only niche items to separate suppliers and sub-contractors, Nexans has the **capacity to produce virtually every type of cable** used in wind turbines and infrastructures worldwide, often dealing directly with the energy authority or entrepreneur on major turnkey projects.

1. From standard products to custom-designed cabling

To meet the "commodity" nature of the windpower market, Nexans supplies an **extremely wide range of standard products**, especially in the area of low and medium voltage.

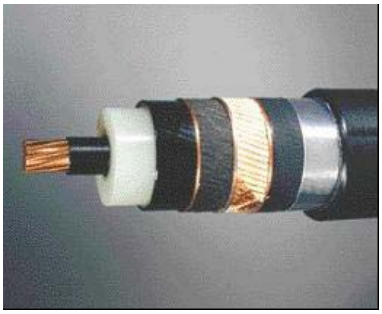
In the area of high voltage, there are no off-the-shelf products. All cables are **custom-designed** for the client, especially as a part of important turnkey projects both onshore and offshore.

In addition to supplying an extremely wide range of cables to the world's leading OEMs, Nexans is an **expert in both underground and submarine cables** for inter-turbine infrastructure (including both land and marine "export" cables) and beyond to the national grid. This not only includes cables, accessories, joints and terminations (which are extremely demanding in the HV environment) but also system design, installation, civil engineering, and testing.

Since **standards** are so important to this international, yet highly regulated industry, Nexans is compliant with most of the world's electrical standards: IEC, NF, BS, CSA, ASTM, EDF, ICEA, IEEE, NEK 606, ISO 9001 quality, Qualified Products List (QLP), advanced fire performance specifications, etc.

2. Solutions for Original Equipment Manufacturers

Nexans produces **low-voltage cables** up to 1kV in rubber-insulated or rigid designs which run between the generator and the transformer, whether it is located at the base of the tower, or high above in the nacelle. These cables provide energy for the various wind turbine motors and electronic devices, including coolers and heaters, the breaking system, lighting, the service crane, and the various steering and switching devices.

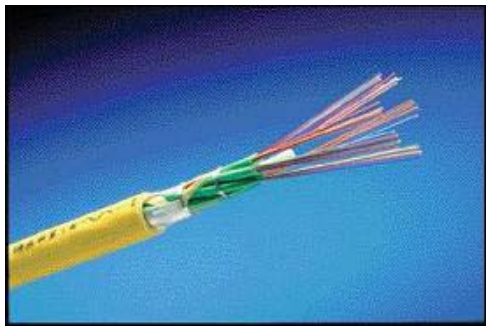


It also manufactures **medium-voltage cables** up to 18–35 kV. These cables run between the generator and the transformer in larger turbines (2- 5 MW), often located offshore. They also power steering and switching equipment.

Control cables are flexible shielded cables containing from 2 to 100 cores used to carry both the energy (usually 300-500 volts) and low-frequency signals to control the motor drive or the generator for breaking, positioning or optimizing rotor RPMs.

Sensor cables are used to measure windspeed, temperatures within the nacelle, and various performance parameters, while fieldbus cables are used in parallel with energy cables to digitally control all electronic and mechanical devices over an extensive area. Nexans sensor and fieldbus cables have already proven their reliability on ships and in the oil & gas industry. Fieldbus technology uses only two cores, gaining precious space, while delivering the kind of complexity needed to handle a large wind park.

Based on Nexans **long experience in telecommunication**, Nexans fiber optic data cables allow manufacturers to meet the need for higher data transmission capacity within the wind turbine structure, mainly for remote control and monitoring purposes. Nexans supplies both **traditional silicon and a new generation of Plastic Optical Fibers** (POFs) for this purpose. By replacing copper data wires, fiber optic cables achieve important weight and space savings, and are immune to the intense EMI in the immediate environment.



Also, Nexans produces a **full range of fiber optic accessories**, including access routing technology. Nexans' FiberArt™ splicing frame optimizes fiber routing through the nacelle's physical cabling network, thus guaranteeing network integrity. Nexans **modular distribution frames** provide a complete architecture for main exchange nodes or point-of-presence, including water-resistant dome structures, located at the tower base.

Nexans produces a **complete family of winding wires** for motors and rotor generators, including specialty winding wires, and fine and ultra-fine wires for timers, valve relays and small transformers, and self-bonding wires for electrical motors of all sizes. Nexans winding wires offer specialized characteristics in terms of solderability, heat-resistance, insulation properties to achieve performance gains.

Continuous Transposed Cables (CTC) wires for transformers are easier to wind, and more efficient for medium-voltage transformers. They are extremely durable, with a lifespan of over 25 years. They allow transformer dimensions to be reduced considerably, especially for low-voltage.

As a self-powered entity, wind turbines not only contain cables, they also house numerous types of terminations and connectors. Nexans provides **"safe-to-touch" separable connectors**, and a whole range of modular terminations and joints. Since several suppliers can be involved in wind turbine construction and installation, Nexans offers interconnective solutions to guarantee system integrity and ease-of-installation and maintenance, with no risk to personnel.

To protect sensitive onshore and offshore equipment all Nexans wind turbine cables are available in **halogen-free versions**, being flame or fire retardant, while providing low toxicity, corrosion and smoke density.

Moreover, since manufacturers want to produce more efficiently, Nexans has prepared **two special cabling production "kits"**, one for energy and the other for control cables. The kits contain a wide variety of pre-cut and often pre-fitted cables for easy installation per unit. These kits not only eliminate waste, they provide advanced color-coding, reduce need for multiple orders, and offer a guaranteed, one-supplier product.

Solutions for Windpark Infrastructure

Nexans provides a full range of medium-voltage cables for inter-turbine connections. Onshore underground single-core cables (typically 33 kV) connect the rows of wind turbines, and in parallel link them to an onshore substation. There are also offshore cost-efficient submarine 3-core copper cables with integrated fiber optic elements and customized armor designs to link the turbines

In addition Nexans provides **high-voltage cables** for transmission. This includes onshore AC transmission, i.e. cables ranging from 60kV to 500 kV, XLPE insulated, for power transmission from the onshore windpark substation to the central grid; offshore AC transmission, i.e. submarine cables ranging from 60kV to 500kV with various designs available: 3-core XLPE cables (60−225 kV), and single core XLPE up to 400 kV; and onshore and offshore DC transmission up to 500 kV applicable for high transmission requirements and long distances, i.e. mass-impregnated cables with an Integrated Return Conductor, and Polymer-based insulated DC cables

Overhead MV and HV conductors are also available. Although most inter-turbine connections (MV) are underground for land-based windparks, overhead aluminum-alloy conductors are used to move power from a distant location to the domestic grid. Nexans provides a wide range of sizes and alloys according to customer needs, with various alloys adapted to each country's standards, climate and terrain.

Unlike its competitors, Nexans manufactures all MV and HV accessories. Normally, subsea cables should not have joints. However, Nexans supplies purpose-designed joints and terminations for XLPE insulated cables, as well as transition joints between various cable types. Nexans terminations and joints make splicing quick, easy and long lasting.

Auxiliary equipment and systems are an important part of any windpark infrastructure, especially in harsh sea conditions. Nexans provides **corrosion protection systems**, and **mechanical support** and **protection systems** (hang-off and clamping systems, protective shells/slabs/mattresses). Nexans hang-offs securely fasten heavy energy cables on top of the J-tubes well above sea level. They are easy to install, and fully relieve any pulling force on the sealing ends.
Whether onshore or offshore, optical fiber cables are increasingly being twinned with MV and HV energy cables to provide remote control of rotor speed, blade angle, braking, temperature, hydraulic levels, etc. via distant Programmable Logic Controllers (PLCs) which have now replaced sequential relay circuits for machine control.

To match the above, Nexans also produces a full range of fiber optic accessories, including a full range of fiber access routing technology, and splicing and modular distribution frames. Nexans' FiberArt™ splicing modules optimize fiber routing in towers and substations. In addition, to make the connection between submarine cables and terrestrial networks, Nexans has an entire range of waterproof closures.

Local Area Networks assure high levels of windfarm and local infrastructure security. Nexans has both advanced fiber and copper LAN solutions for complete monitoring, control and communications/ surveillance functions. The kind of data speeds previously available onshore are now available offshore, which means that power utilities can now plan a decade ahead without expensive retrofitting.

5. The service dimension

Nexans does more than just sell cables and accessories to the growing windpower industry; it is always investing heavily in **research & development** to find ways to improve wind generation, transmission/ distribution and grid interconnectivity. The presence of Nexans in over **65 countries** gives it a full mastery of both national and international standards. Its **10 Competence Centers** and **International Research Center** work closely with customers to constantly improve its standard range of products and technologies, and to develop customized, industry-specific solutions.

Increasingly, customers delegate their technical studies to preferred suppliers so that they can make the necessary calculations and recommendations, and then cooperate closely in engineering and installation. Nexans has a proven background in installation. Nexans developed special reels and drums for **easy and safe delivery**, and is adept at handling exceptionally long lengths of cables, including pulling operations. To meet the submarine challenge, Nexans operates dedicated cable laying vessels, "spider" trenchers, excavators, Remote Operated Vehicles and other specialized underwater equipment.

Navigation, positioning and tracking equipment has been developed to make sure that cable is safe and secure at touchdown. Nexans Norwegian-designed **CAPJET** has buried over 3,500 km of cable in seas around the world. For aerial positioning, Nexans uses PLS CAD software for transmission line design. After choosing a specific conductor type, the terrain profile and the desired power capacity is entered. The program calculates where the best position for the towers would be, the distance of the span, the safest height of the towers, etc.

Since today's windpark developers come from a diverse background, Nexans is increasingly called upon to **give its considered opinion** regarding cable type, configuration, and so on. This kind of technical support, especially at the project design level, allows power providers to choose the best solution for projected use. Increasingly, Nexans is taking a turnkey approach, especially on new offshore projects. Nexans considers that it is not just selling a product but an **"energy solution"** that includes cables, accessories, joints, terminations, installations, connections, civil engineering (through subcontracting), testing and commissioning. Line design and compatibility to meet the demands of grid configurations are always an overriding concern.

By offering **complete solutions**, based on a long experience, not only within the world of energy, but also from the world of telecommunications, Nexans provides the resources needed to help the windpower industry achieve the ambitious objective of providing 12% of the world's electricity from wind power by 2020.

IV. APPENDIX:

Some recent Nexans success stories, innovations and references

- Nexans delivered and installed a composite 145 kV three-phase AC high-voltage cable and fiber optic communications and control cables for a wind farm on the island of Smøla in Norway. When completed it will be one of Europe's largest. Its 68 wind turbines will produce enough electricity to power some 90,000 households.

- Nexans was awarded an order to supply 23 km of 35 kV submarine power cables to transport the power generated by wind turbines of the Arklow, Ireland, windfarm to an onshore cable station, as well as the links between the turbines.

- Nexans provided MV interconnections between turbines and the composite 170 kV three-phase power cable with integrated fiber optic elements between land and the world's largest offshore wind park, Horns Rev, Denmark. The service voltage of 170 kV for a three-core XLPE represents at present a world record for submarine cables.

- At Bohain, France, Nexans has invested in test equipment to make our cables more reliable. To develop a new flexibile core LV and MV cable, a test bench was used to reproduce the way cable moves in a wind turbine.

- Nexans supplied NEG Micon with 40 km of precision-cut control cables that were capable of withstanding four complete twists per 15 meters of cable, while exhibiting minimum mobile bending radius for the untwisted part.

- Since the Danish manufacturer, Vestas, uses HFFR cabling so as to protect the environment and to avoid corrosion of electrical devices in case of a fire, Nexans provides a complete range of halogen-free, fire-retardant solutions, many of them developed in-house.

- During the 2003–4 period, Nexans was and is currently involved in dozens of projects in Portugal and Spain, involving well over 300 new wind turbine installations.

- In the province of Galicia, (Spain), Nexans delivered 180 km of a 30kV XLPE cable to the La Cañiza windpark for the distribution of wind energy to the local grid.

- To GE Wind, Nexans delivers complete cable kits for wind turbines, including control cables, optical fiber, and energy cables from the generator to the transformer (H07 RNF type). The client appreciates the fact that the kits make installation rapid and easy. The cables themselves are very clean and well-identified. For some cables connectors are pre-installed, avoiding waste and reducing accidents in cable preparation.

- Nexans manufacturers and cuts ready-to-install cables for virtually 95% of Ecotècnia of Spain, a leading wind turbine producer. With one purchase order, Ecotècnia can thus assure a high level of control and logistics during turbine assembly and installation.

- For the Spanish market, Nexans created a specialized windpower workshop to assure that all cables can be cut and conditioned to strict customer needs. For example, no cable ever touches the ground, which means unsurpassed levels of cleanliness, which is important in the nacelle environment. Special packaging and labeling (readable at six meters) were also provided.

- In addition to providing standard "commodity" cables, Nexans has developed a whole range of customized cables to meet every OEM's specific wind turbine and windpark infrastructure specifications.