

STOCKHOLM SEPTEMBER 21 2021

SUSTAINABLE ELECTRIFICATION MAKING CLIMATE VISION A REALITY

NEXANS CLIMATE DAY

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Welcome message

One year ago, we brought together experts from across the energy sector at the first Nexans' Climate Day in Paris. This event aimed to open discussion and structure collective industry thinking to assess the opportunities and risks to the global transition to sustainable electrification. With demand for electricity expected to increase dramatically over the next two decades, we enjoyed valuable discussion and debate over the path forward for our industry.

A year on, the stakes surrounding this transition are higher than ever. The rolling blackouts we saw in Texas were just one stark reminder of the need to work together to tackle the challenges in front of us. What will our new energy systems look like? What roadblocks are in our way? How can we transition safely without any stops in services for consumers? Will resources for materials last?

Today, I am very excited to welcome you to the second Nexans' Climate Day with the same ambition: an open debate between those who will design the electrification of the future.

Nexans' Climate Day aims to open the stage to key stakeholders, different visions to debate and open new gates, and design new solutions.

The Nordics are at the forefront of the transition to sustainable electrification, therefore it is only right that we are here in Stockholm today. I am honored to welcome and learn from experts, global companies, influencers, regulators gathered together to make a climate vision a reality through sustainable electrification.

The event will bring together global energy experts to discuss:

The challenges of sustainable electrification of the world and its key role in the fight against climate change:

- From oil and gas to offshore wind – how big will offshore wind become?
- The risk of electricity shortages and growth of solar energy in the Nordics
- The Swedish regional strategy on electrification

The keynote speech will be delivered by Tomas Kåberger, Professor of Industrial Energy Policy at Chalmers University of Technology, and former Director General of the Swedish Energy Agency. Other speakers include myself, alongside:

- Ulrik Stridbaek, Vice President and Head of Group Regulatory Affairs: Ørsted
- Ragnhild Kattelund Executive Vice President, Subsea & Land Systems Business Group, Nexans
- Håkon Borgen, EVP Head of Technology and Development, Norwegian TSO Statnett
- Vincent Dessale, Chief Operation Officer and Senior Executive Vice President of Building & Territories Northern Business Group, Nexans

The morning session will be followed by a work luncheon between the speakers and the Nexans Executive Committee members to explore further the solutions put forward during the event.

I very much look forward to meeting and speaking with many of you here today. I am sure it will serve as a vital touchpoint as we all look toward a more sustainable, greener future. Thank you for attending, and enjoy the day ahead.

Christopher Guérin,
CEO, Nexans

Speakers

CHRISTOPHER GUERIN CEO NEXANS

Christopher Guerin was appointed Chief Executive Officer of Nexans in 2018. He has spent most of his career with this company, where he has held the position of Senior Executive Vice President, Europe industry since 2014. Prior to this date, he was in charge of the Industry Market Line, which he took over in 2013 after having held, for six years, various Sales and Marketing functions in France and Europe. Between 2005 and 2007, he held the position of Sales Director Europe. After working at Fenwick Linde in the UK, he joined Alcatel Cables in 1997, which became Nexans in 2001, in the Metallurgy division where he was in charge of various management functions. Christopher Guerin is a graduate of ESDE and INSEAD.

TOMAS KÅBERGER KEYNOTE SPEAKER - MODERATOR

Tomas Kåberger is currently an affiliate professor at Chalmers University of Technology in the area of industrial energy policy. He was Director General of the Swedish Energy Agency between 2008 and 2011. He is a board member of Vattenfall, Chairman of Renewable Energy Institute in Tokyo, Senior Advisor to the Global Energy Interconnection Development and Cooperation Organization in Beijing, and a board member of the Research Council of Norway. Tomas is an Advisor to Vaasa University in Finland.

ULRIK STRIDBAEK VICE PRESIDENT AND HEAD OF GROUP REGULATORY AFFAIRS, ØRSTED

Ulrik Stridbaek is responsible for managing Ørsted's stakeholder engagement on regulatory and policy issues. He has worked at Ørsted for 12 years. Before joining Ørsted, he was a senior policy advisor at the International Energy Agency, where he was responsible for electricity sector analysis, giving policy advice to member governments. He worked at the IEA for four years. Ulrik Stridbaek has worked in the energy sector on energy sector analysis, regulation, and policy for more than 20 years. Power market design, transmission regulation, energy economics, and the green transition have been the focus areas. He holds a Master's degree in Economics. (Source: <https://futureoffshorewind.live.ft.com/agenda/speakers/872391>)

RAGNHILD KATTELAND EXECUTIVE VICE PRESIDENT, SUBSEA & LAND SYSTEMS BUSINESS GROUP

Ragnhild Kattelund has held various management positions in Engineering, Sales, Purchasing, and Projects Management since she joined Nexans (previously Alcatel) in 1993. In 2011 she was appointed Project Director for the Submarine High Voltage Business Line. Since then, she has held Vice President roles in Technical & Project operations and Subsea Energy Systems Business Line. Since March 2018, Ragnhild has been Vice President of Subsea & Land Systems Business Group, and CEO of Nexans Norway since September 2019.

VINCENT DESSALE CHIEF OPERATION OFFICER AND SENIOR EXECUTIVE VICE PRESIDENT OF BUILDING & TERRITORIES NOR- THERN BUSINESS GROUP

Vincent Dessale joined Nexans in 2001. He held various key positions in Supply Chain in Europe before heading Operations in South Korea in 2006, and extending his responsibilities to the Asia-Pacific region in 2009. In 2012, he was appointed Chief Operating Officer of the Submarine High Voltage Business and, then in 2014, Executive Vice President of the Subsea Energy Systems Business Line before being appointed Senior Executive Vice President, Subsea & Land Systems Business Group in February 2018.

ANNIKA VIKLUND SENIOR VICE PRESIDENT AND HEAD OF BUSINESS AREA DISTRIBUTION VD VATTENFALL ELDISTRIBUTION AB

Annika has been with Vattenfall Distribution since 2006, joining as Marketing Manager and has since 2010 been Managing Director for the Swedish distribution business, and in 2015 Business Area Manager for the electricity distribution operation in Vattenfall.

She represents Sweden energy in the industry associations Eurelectric Distribution & Market Facilitation Committee and member of The Commission for Electrification, an advisory body chaired by the Swedish Minister for Infrastructure. Before she joined Vattenfall, she was Manager, Consultant and held Technical positions with IBM for 20 years.

She is a frequent speaker in the Swedish energy sector and was awarded "Diversity Manager of the Year" in 2017 by the Swedish Management Magazine Chef and "Power Woman of the Year" in 2019 by the female network "Kraftkvinnorna" (Power Women).

JOHAN GERKLEV

Sustainability Manager at Skanska in Sweden and Head of Sustainable Business Development, a unit with about 50 sustainability specialists. Since 1995, Johan has been part of Skanska's sustainability journey, from crisis and risk to future, opportunity, and business.

KENNETH JOHANSSON

HEAD OF ELECTRICAL NETWORK, STOCKHOLM, ELLEVIO

Kenneth has more than 20 years of experience in the cable industry, where he has had a number of different positions. From 2012 to 2013 he was CEO of Seabased Industry AB, a development company in Wave Power. From 2014 he has been working as Head of Regional Network Stockholm, responsible for the network between 33kV to 220kV. He is currently chairman of the Swedish Standardization Committee for electrical cables TK 20.

ANNA WERNER

CEO SOLAR ENERGY ASSOCIATION OF SWEDEN

Anna has been with the company since 2019. Before that, she worked for five years at Villaägarna, responsible for energy issues, and spent seven years as a technical consultant at Afry.

LARS JOSEFSSON

CEO NEXANS SWEDEN/GM BU NORDIC

Lars has been with the company since 1998 and has held various positions as Director of Marketing D&I and Utilities Europe before returning to the Nordics in 2018. Lars has also been Chairman CPR Europacable.

ANNA GRAAF

DIRECTOR OF SUSTAINABILITY, WHITE ARKITEKTER

Anna has been Director of Sustainability at White Arkitekter since 2012. During the last 25 years, she has gained extensive experience in sustainability management and energy-efficient design, from early stages throughout construction for buildings as well as urban planning. Anna is also a board member of NMC, the Network for Sustainable Business, and member of the steering group for Circular Sweden and Center for Circular Buildings. Anna holds a master's degree from Chalmers University of Technology.

NICLAS DAMSGAARD

CHIEF STRATEGIST SVENSKA KRAFTNÄT (SWEDISH TSO)

Dr. Niclas Damsgaard is Chief Strategist at Svenska Kraftnät (the Swedish TSO). Previously at Svenska Kraftnät, he served as Senior Vice President for Market and System Development and Acting Executive Vice President for the System Operator Division. He has previously had close to 15 years of experience in consultancy, most recently as Director and Head of Energy Markets and Strategies at Sweco. He holds a Ph.D. in economics from the Stockholm School of Economics and is specialized in deregulation and regulation of markets with a focus on the electricity market.

THOMAS LINDERHOLM

ENERGY SPECIALIST FABEGE

Thomas has an MSc degree in Energy Systems and is a certified passive house expert. At Fabegé, a property developer in Stockholm, Thomas works as an Energy Specialist, focusing on developing sustainable and attractive city districts and making the buildings run as energy efficiently as possible. Before that, he worked as energy coordinator in building projects, specializing in building simulation and passive house design.

HÅKON BORGEN

EVP HEAD OF TECHNOLOGY AND DEVELOPMENT, NORWEGIAN TSO STATNETT

Håkon Borgen works as EVP Head of Technology and Development for the Norwegian TSO Statnett in Oslo. Håkon also chairs the Research & Development and Innovation (RDIC) committee in ENTSOE. Borgen holds an MSc from Norwegian University of Science and Technology (NTNU) in Electrical Engineering with his final master's thesis written at Technische Universität Darmstadt in Germany.

Borgen has more than 25 years of experience in the energy sector from both Grid operations, Grid development, Engineering, Licensing, Technology, R&D, and Construction works in large projects onshore and offshore.

Today he is responsible for the TSO Planning function, Market Analysis, Technology Development as well as Research and Development (R&D). This position also includes the planning and execution of the two ongoing large submarine interconnectors from Norway to neighbouring countries in Germany (Nordlink) and the UK (North Sea Link).

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Agenda

09:00

WELCOME

CHRISTOPHER GUÉRIN, CEO NEXANS

THE ELECTRIFICATION OPPORTUNITY

TOMAS KÅBERGER, KEYNOTE SPEAKER

10:00

A SESSION DEDICATED TO GENERATION

FROM OIL & GAS – HOW BIG WILL WIND BECOME?
WILL OFFSHORE GRID CONNECTION BE TOO COSTLY?
IS SWEDEN'S SOLAR INDUSTRY READY TO SCALE UP?

ULRIK STRIDBÆK, VP AND HEAD OF REGULATORY AFFAIRS ØRSTED
RAGNHILD KATTELAND, EVP NEXANS
HÅKON BORGES, EVP NORWEGIAN TSO STATNETT
ANNA WERNER, CEO SOLAR ENERGY ASSOCIATION OF SWEDEN
TOMAS KÅBERGER

10:30

A SESSION DEDICATED TO TRANSMISSION & DISTRIBUTION

Transmission and distribution – key to fast, industrial electrification

HOW WE WILL MAKE IT WORK?
WHO ARE THE KEY STAKEHOLDERS AND WHAT ROLE DO THEY PLAY?
WHERE WILL THE REQUIRED INVESTMENTS COME FROM?

KENNETH JOHANSSON, HEAD OF REGIONAL NETWORK STOCKHOLM, ELLEVIO
NICLAS DAMSGAARD, CHIEF STRATEGIST SVENSKA KRAFTNÄT (SWEDISH TSO)
ANNIKA VIKLUND, CEO VATTENFALL DISTRIBUTION
VINCENT DESSALE, SEVP NEXANS
TOMAS KÅBERGER

11:30

A SESSION DEDICATED TO USAGE

INTELLIGENT BUILDING DESIGN –
HOW TO MIX MINDSET AND TECHNOLOGY TO STIMULATE ENERGY
EFFICIENCY AND POWER CONSUMPTION

ANNA GRAAF, HEAD OF SUSTAINABILITY WHITE ARKITEKTER
JOHAN GERKLEV, HEAD OF SUSTAINABILITY SKANSKA SWEDEN
THOMAS LINDERHOLM, ENERGY SPECIALIST FABEGE
LARS JOSEFSSON, GM NEXANS SWEDEN
TOMAS KÅBERGER

11:50

WRAP UP & SUMMARY

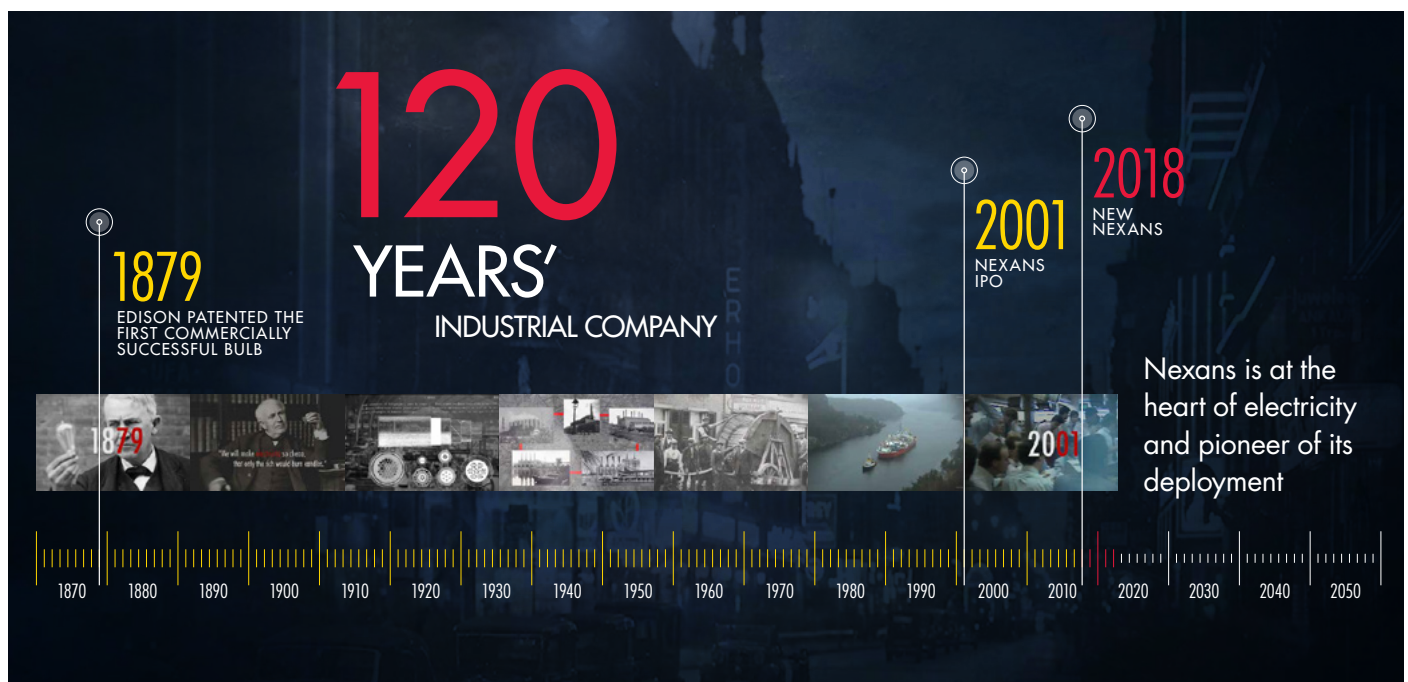
CHRISTOPHER GUÉRIN, CEO NEXANS
TOMAS KÅBERGER

About Nexans and the electrification value chain

OUR PURPOSE ELECTRIFY THE FUTURE

ELECTRIFICATION IS IN OUR DNA.

It is at the heart of our existence. It's the reason why we give the best of ourselves to build a better future for the world.



Nexans is part of the living history of electricity. Ever since Edison first discovered electricity, we have been electrifying the world around us. Now, we are entering an era of sustainable electrification for everyone.

We are leading the charge to the new world of electrification – safer, sustainable, renewable, decarbonized and accessible to everyone – connecting us all to new opportunities, technologies and behaviors that will build a better future.

SIMPLIFY TO AMPLIFY: OUR PATH TO **ELECTRIFY THE FUTURE**

For over a century, we have played a crucial role in the electrification of the world. Now, it is time for Nexans to simplify to amplify its role: simplify the number of businesses covered and amplify the electrification sectors, by becoming a real pure player in electrification.

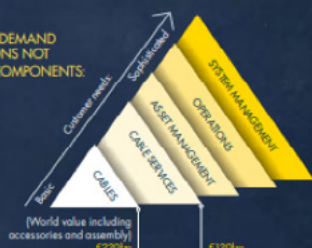

From energy production and distribution to usage, our passionate teams design dedicated, systematic answers to our customers' unique requirements. Nexans' innovative, connected electrification solutions generate sustainable profits for all of our stakeholders, and enable progress for people and the planet.

NEXANS PURPOSE ELECTRIFY THE FUTURE

Electrification is in Nexans DNA, and has been for the last 120 years. Nexans has never stopped building the future of electricity and will continue for the years to come.





The €7 trillion to be invested in electrification worldwide by 2030 are a huge opportunity. However, staying a generalist would be a risk as customer demand is migrating to solutions, requiring a deeper understanding of this ecosystem.

Our 2021-2024 sequence will simplify our business by rotating our core as pure electrification player while amplifying our system, solution and software offer, beyond hardware.




OUR BUSINESS – A PURE ELECTRIFICATION PLAYER IN 2024


Nexans provides end-to-end solutions to its clients alongside the electrification chain; from generation, to transmission, to distribution, to usages of energy.

GENERATION	TRANSMISSION	DISTRIBUTION	USAGES
 Turnkey Offshore Windfarms connections to the shore	 Turnkey Submarine & land interconnections	 Turnkey : <ul style="list-style-type: none">– Electrification projects– Superconductor systems– Connection of utility scale renewable farms to the grid	 <ul style="list-style-type: none">– Electrical vehicles charging stations– End-to-end supply chain services– Product innovations to ease installation, enhance safety and installer productivity
Asset monitoring & management			Smart cables & accessories

OUR METHODOLOGY SIMPLIFY TO AMPLIFY



Nexans deploys a standardized transformation sequence built on more than 40 levers to optimize performance, duplicate successful units DNA and manage risks.



We are focusing our +€100m R&D expenses and 800 experts on electrification segments. We have joined our forces with a strong network of partners to amplify our impact.

PORTFOLIO MANAGEMENT

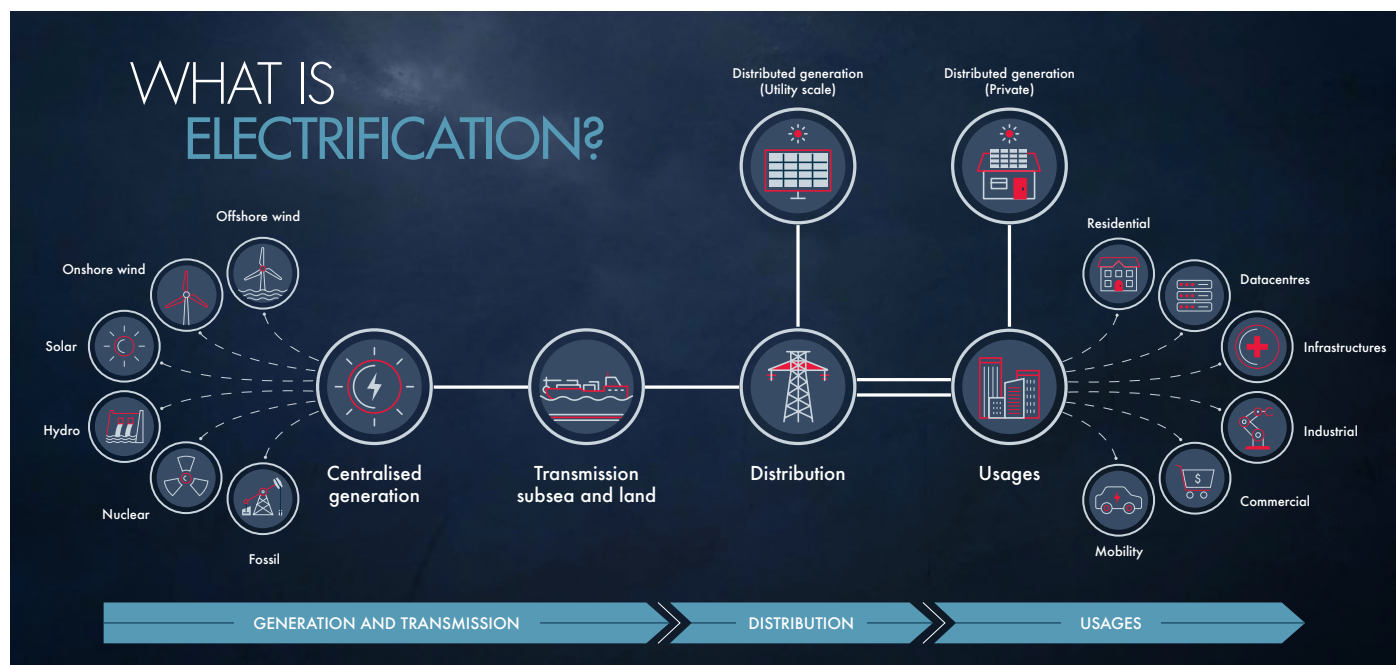
Our business units are managed through a portfolio approach based on financial KPIs. They follow a standardized transformation process to maximize value creation and reach upper-range financial ratios.

OUR COMMITMENT IN 2024

- €6-7bn SALES⁽¹⁾
ELECTRIFICATION PURE PLAYER
- 10-12% EBITDA⁽²⁾
IN % OF SALES
- ≥40% NCCR⁽³⁾
GROUP CASH GENERATION
- >20% PAY OUT⁽⁴⁾
PROGRESSIVE DIVIDEND

(1) Standard sales at constant metal prices
(2) Integer on sales at standard metal prices
(3) Normalized Cash Conversion ratio defined as Normalized Free Cash Flow / EBITDA. NCCF excludes strategic CAPEX, PPE investment, one-off change in working capital and material restructuring plans cash-out
(4) Of recurring net income

WHAT IS ELECTRIFICATION?



Electrification markets represent more than 70% of world cable demand today, and the growth per annum for electrification is +5,6% for the next ten years, higher than all others.

Because of the convergence of world electrification and the demand it will require on raw materials, specifically copper, Nexans will reinforce its autonomy through metallurgy. We are the only player in the world still vertically integrated and prepared for the future shortage of copper.

ELECTRIFICATION IS BASED ON FOUR MAJOR PILLARS:



generation of energy: offshore and onshore wind turbines, solar power plants, hydropower, nuclear;



transmission to countries interconnection;



distribution that requires infrastructure modernization to sustain future demand of electricity;



usage then drives the demand of electricity, and that is everywhere there is human activity: either construction, data-centers, infrastructures, industrial activities, commercial businesses, etc.

ELECTRIFICATION VALUE CHAIN: GENERATION AND TRANSMISSION



The core business is both interconnectors facilitating the exchange of renewable energy between and within countries and continents as well as cable solutions for offshore wind farms. It begins with generation and transmission. The clients are offshore wind developers, national transmission system owners, grid owners, and more and more infrastructure investors. Renewable energies amongst which offshore wind farms are a keystone of the sustainable energy transition.

The offshore wind market represents an incredible annual growth: about 200 GW will be installed worldwide in the next decade. While Europe will remain the main market, Asia and the US are to follow closely. It is about an 11.5% annual growth of Nexans' cable and installation market, reaching an €8 billion annual market size in 2030.

The company is already very well positioned and engaged in this booming market. For instance, it is working on a wind farm of up to 1,5 GW, the Seagreen offshore wind farm outside Scotland. This unique offshore wind farm will supply more than 600,000 Scottish households with clean energy. As its cost has been divided by more than five times in the last ten years, offshore wind is now increasingly profitable compared to other renewable technologies. This industry will be the major enabler of the sustainable energy transition needed to achieve the Paris Agreement goals.

The offshore wind farms cannot – by nature – always be placed close to the consumption areas. This is why Nexans is linking renewable energy sources to every electricity grid, by installing energy highways. The Interconnector market, subsea and land HV corridor, will have an annual growth rate of 14.3%. More than 70,000 km of cables are to be installed. Nexans has a unique HV cable facility, based in the US in Charleston, South Carolina. The company is the only local supplier able to answer the future US sustainable energy needs. Currently, it is installing the North Sea Link interconnector between Norway and the UK and the interconnection between Mindanao and Visayas in the Philippines.

Nexans has invested more than €500 million in the energy transition. It already owns one purpose-built cable-laying vessel: Nexans Skagerrak. Nexans took delivery of a new cable laying vessel Nexans Aurora. This unique vessel is equipped with a 10,000 tons dual turntable and high-tech cable installation equipment. This vessel will be able to install cables at 3,000 meters of water depth. Today, Nexans owns cutting-edge technology for cable material choices, long distances, deep water and dynamic application. The company delivered the first high voltage dynamic cables for Hywind, the first commercial floating offshore in 2017. Its capacity will increase by more than 30% by 2024.

ELECTRIFICATION VALUE CHAIN: DISTRIBUTION



Distribution is the fundamental link between generation and transmission and usages. It is mainly about Medium Voltage hardware and turnkey solutions.

Three figures are to be considered for the coming decade:

- 1.8 billion habitats will need access to electricity
- 17% additional power generation
- Growth in renewables will be 2.6X

And projections just in the cable market are +4.2% CAGR

There's an increased blackout risk as the network is aging. Today, grids in Europe and the US are some of the oldest, and they have exceeded the average life expectancy of cables.

€4.4 trillion will be spent on distribution for improving access and reliability — Nexans is well positioned with its unique solutions. Being a solution provider, Nexans addresses the electrification challenges:

- turnkey solution to connect renewable farms to the grid and making green energy more accessible and competitive;
- Neo Grid solution, for electrifying villages: at this time, 32 villages have been connected in Ivory Coast;
- superconductivity and asset management are helping to reduce outages, improve reliability, and optimizing cost: for the Stockyard Hill Project in Australia, Nexans delivered a 9 % reduction in the total cost of ownership by cable design, layout optimization, and architecture solution for a reliable green power output in addition to lowering Capex.

ELECTRIFICATION VALUE CHAIN: USAGE



Where you have human activity, you have the usage of electricity. In all buildings, all means of transportation and emerging hyper-scale data centers, for which electricity supply is as critical as data connectivity. The building market is full of dynamism, with significant growth of cable demand of 50% in the next ten years, which represents a €27 billion increase. This major growth is driven by megatrends worldwide: growing population and urbanization, increasing access to electrification in rural areas, etc.

Plus 30 million EV charging stations will be installed in Europe alone by 2030, and Nexans is at the heart of the e-mobility development.

Being a local player will be a key enabler to reduce carbon emissions. Environmental impact and digitalization capabilities are becoming a criteria of choice by our customers.

Safe electrical power usage is and will be at the heart of our lives: 80% of building fires are due to counterfeit cables in emerging countries. And in Europe, one fire that happens every 6 minutes is due to electrical failures, accounting for 273,000 fires per year.

In many countries, we have been able to launch on the markets the Halogen-Free Flame Retardant technology, replacing the old-fashioned PVC technology. Such a cable can withstand 1,000 degrees Celsius for more than 2 hours while still transmitting the electric power, allowing safer conditions for people to exit in case of emergency.

Insights from our experts

EQUIPPING EUROPE'S FUTURE ENERGY GRID WITH SUPERCONDUCTORS

JEAN-MAXIME SAUGRAIN AND FREDERIC LESUR

Europe's "Best Paths" project was the hotbed where the first 3-gigawatt-class superconducting cable system was designed, optimized, fabricated, and tested. Frédéric Lesur, Senior Engineer High Voltage Cable Systems and Power Grids, and Jean-Maxime Saugrain, VP Machines, Cryogenics & Superconductors at Nexans, take us behind the scenes.

When carrying high currents, the resistance of conventional high-voltage power cables with copper or aluminum conductors causes them to produce heat. This heat translates to lost energy, which can be nearly 10 percent over long-distance transmission projects. The waste represents the equivalent output of several of Europe's largest power plants.

This sparked interest in superconducting cables since they offer electrical transmission with zero resistance. To put it in perspective – within a compact footprint, a single superconducting cable could carry several nuclear reactors' joint output over long distances with no losses.

When cooled below a critical temperature, superconductors have no electrical resistance. This temperature varies from nearly absolute zero (-273°C) to -135 °C, depending on what material is being used.

Although superconductors were discovered in 1911, the technology's potential for perfect power transmission remained untapped for decades, mainly because of the commercially available superconductors' extremely low operating temperatures. In 1987, however, the discovery of high-temperature superconductors (HTS) created new possibilities for superconducting power applications. This turned the focus to energy storage, cables for power grids, and fault current limiters.

In recent years, the high efficiency, compact size, and reduced environmental footprint of superconductors have sparked renewed interest. Grid operators are taking note of these advantages as they prepare for the transition to renewable energy.

HVDC SUPERCONDUCTING CABLE SYSTEMS

The future need for multi-gigawatt links was the key motivation to study HVDC superconducting cables in the Best Paths project. The cable system is designed to operate at high voltage with a range of possible currents exceeding 3 kA. Conventional resistive cable technology is more capable of meeting grid requirements below this current level.

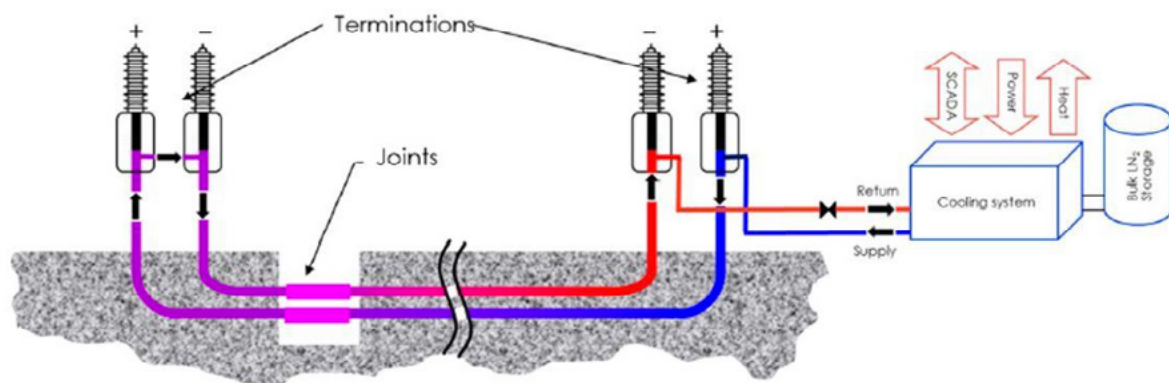


Figure 1 -
Schematic of an HVDC superconducting cable system with a length of approximately 10 km.

Figure 1 indicates that the HVDC cable system is bipolar, allowing electricity to flow in both directions. The system comprises five key elements:

- Superconductor
- Cryostat (cryogenic envelope), which stores the cooling fluid required to maintain the superconductor temperature
- Cryogenic terminations and joints
- High-voltage insulation
- Sufficient cooling devices attached to associated power and fluid supplies for auxiliary equipment

Along with the cable, the system comprises two terminations to connect to the grid and joints. The cable length determines the number of cooling systems needed to maintain the operating temperature along the link.

EUROPEAN-FUNDED BEST PATHS PROJECT

The four-year project (2014-18) featured a full-size cable system demonstrator operating at 320 kV and 10 kA. The 320 kV operating voltage was selected to facilitate insertion into the transmission grid, while the 10 kA-current was the maximum amount the AC/DC converters could carry.

An extensive preparatory phase – involving the specification, development, and optimization of the main system components – preceded Best Paths. Selecting MgB₂ as the superconductor material had a significant impact on the cable design and remaining system components' choice.

A cryogenic envelope houses the superconducting cable to maintain the operating temperature along the link's length. Flexible cryogenic lines – with proven reliability obtained over more than 50 years – were used to simplify the cable laying.

Figure 2 shows the final design.

Figure 2 -
Final demonstrator design successfully tested in Best Paths.



Although operating at 320 kV, the HVDC superconductor cable system was tested at nearly 600 kV to meet Cigré recommendations. Future development could include reducing the operating voltage to keep the cable's overall diameter to a minimum while minimizing its footprint. The current would then be increased correspondingly to maintain the GW power levels.

A VIABLE OPTION FOR BULK POWER TRANSMISSION

Successfully designing, manufacturing, and testing a 3-gigawatt-class HVDC superconducting cable system in the Best Paths project has widened the field of applications for superconductors. It proved that they represent a realistic solution for bulk power transmission. They also contribute to global decarbonization by reinforcing and increasing electricity grids' efficiency, with minimal environmental impact.

Robust and reliable superconducting cables also open the promising possibility of the simultaneous transportation of two energy carriers – hydrogen and electricity – if hydrogen was to replace helium gas as the cooling medium.

THE SUPERCONDUCTING WAY TO **PROTECT SMART CITY GRIDS**

JEAN-MAXIME SAUGRAIN



Superconducting cables carry electricity at exceptionally high currents, reliably and with minimal losses. That makes them an attractive option for meeting the fast-growing power needs of smart cities. However, superconducting properties can also be used to stop current dead in its tracks, almost instantaneously. This enables an ingenious device known as a superconductor fault current limiter (SFCL) to provide vital protection against the increasing threat of fault currents.

Increasing fault currents caused by short circuits are an inherent risk in smart cities. They result from factors such as higher loads, more distributed generation, and more complex load flows. The consequence is that the safety rating of transformers and switchgear in distribution networks may be exceeded. Without suitable protection, vital infrastructure can be damaged, causing outages with consequent impact on business and society.

Fortunately, an answer is in hand in the form of the SFCL. It is based on high temperature superconductor (HTS) material that is cooled to its operating temperature of -200°C by liquid nitrogen, a fluid that is both readily available and inexpensive. The concept behind the device is beautiful in its simplicity.

In normal operation, the SFCL allows current to flow easily and with no losses. But should a fault current start to flow the superconductor heats up above its critical temperature and it transitions from a perfect conductor to having a very high resistance. The transition takes place in less than 2 milliseconds (ms) – about 50 times faster than the blink of an eye. The result is that the fault current is limited immediately, protecting equipment such as transformers, switchgears and busbars on the same circuit.

A key advantage of the SFCL, unlike some fault current limiters that rely on explosive devices to break the circuit, is that it does not need to be replaced or reset after use. As soon as the fault current is cleared and the superconductor is cooled back down, the SFCL can return to operation. That makes SFCLs ideal in case of frequent fault currents or for installation in hard to access parts of the network.

The SFCL can be deployed to protect critical parts of the network infrastructure in smart cities where it offers a very cost-efficient way of stabilizing and optimizing grids as power demand increases.



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