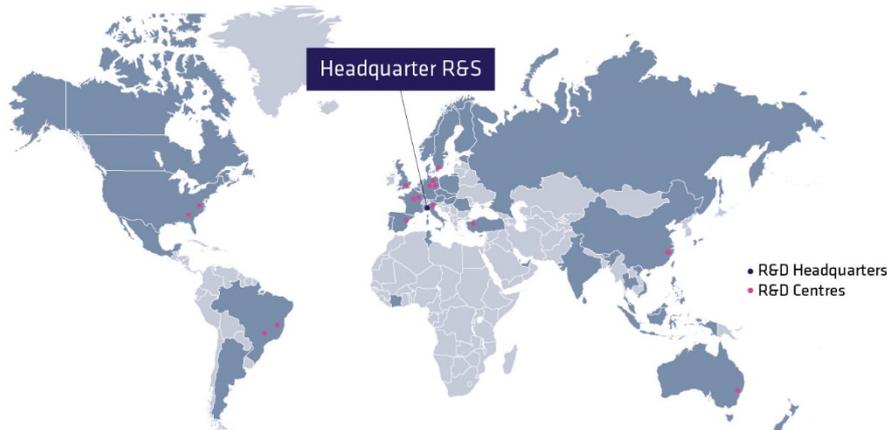


RESEARCH AND DEVELOPMENT

In 2017 the resources devoted to Research, Development and Innovation amounted to some Euro 84 million, confirming the ongoing commitment to and focus on sustainable long-term growth.



€ **84** million (1% of sales) invested in R&D

17 R&D Centres

Over **500** professionals

Over **4,850** patents

Over the course of the year Prysmian worked on numerous Research and Development projects. This section presents the most significant ones also from a sustainability point of view.

Work also continued to optimise costs through the Design-To-Cost (DTC) program, a methodology used to lower production costs, both when developing new products and when re-engineering existing ones. Prysmian's aim therefore is to reduce the quantity of materials used in cable manufacturing through product redesign. Thanks to this program, Prysmian achieved cost savings of more than Euro 13 million in 2017, with over 1,050 projects feeling the benefit. The cost savings were a direct result of reducing the quantity of material used in cable manufacturing with a consequent reduction in the associated environmental impacts.

ENERGY

Submarine Cables

The development of new diametrical splicing techniques for large aluminium conductors (with the possibility of gathering them on fixed platforms) was completed during the year, as was production of a large part of the 320 kV DC cable for the COBRA project to link the Netherlands to Denmark.

Work on splicing conductors in different materials continued with a series of mechanical tests in order to use the solution in three-core 220 kV AC cables. The geometric configuration of three-pole cables places higher mechanical stress on conductors and the related joints, particularly on bending. Full qualification and production are scheduled for 2018. Other important projects were:

- The development of **bimetallic joints** to optimise power transmission efficiency of submarine power lines, using the best conductor design for each section of the line according to its depth, thus ensuring greater sustainability of the line itself.
- With reference to **MI cables** (Mass Impregnated), catch-up work for the WesternLink project reached an end and voltage testing was completed following installation of the DC section to guarantee efficient transfer of energy between the north and south of the United Kingdom.
- In the area of **deep water cables**, having completed all the trials to confirm the mechanical feasibility of the cable solution developed, work was started and partly completed on developing installation and repair technologies entailing the use of innovative techniques in view of the great depths involved. These future ultra-deep submarine systems (for depths up to 3.000 metres) will therefore permit the development of new previously unviable interconnectors and power transmission links, also ensuring more efficient and sustainable energy.
- With reference to the **600 kV DC extruded cables** project, tests continued to fine-tune XLPE and P-Laser technologies. In particular, new prototypes were produced in both XLPE and P-Laser with copper conductor sectional areas of up to 2500mm² and aluminium conductor sectional areas of up to 3500mm².
- In the case of extra high voltage P-Laser cables using solid insulation, work continued on developing the **flexible "P-Laser"** joint with a new so-called intrusion technology, whereby the insulation is extruded to fill in the area of the joint. This technology has been patented and the first internal tests carried out on a full-size prototype, with decidedly encouraging results. Cables with P-Laser technology are made using recyclable, eco-friendly materials, which help reduce the environmental impact of electricity grids while increasing their efficiency and transmission capacity.
- Work was completed to fine-tune "**Lead Less**" technology for the production of lead-free metallic sheaths, using a tube-shaped longitudinally welded copper sheet. Over the next year, this technology will undergo industrialisation at the Pikkala plant in Finland. The removal of lead from HV and EHV submarine cables is an extremely important breakthrough for the environment. Furthermore, this technology will also make it possible to develop dynamic connections for offshore platforms, thus expanding the range of wind systems to even the deepest seas.

- Lastly, work continued on developing **monitoring systems** (of partial discharges) for **long distance EHV, AC or DC** submarine systems, using Prycam Gate technology. Research has begun into diagnostic systems allowing real-time identification of the position of any problems during cable operation, thus minimising repair times. Diagnostics and monitoring help reduce transmission system downtime, while ensuring better energy distribution and making the system more sustainable.

Underground Cables

- Product development for EHV cable systems saw the production of new prototypes insulated with P-Laser proprietary technology for **525 kV HVDC** systems. The 3500 mm² conductor section is the largest ever made by Prysmian, while the chosen conductor material (aluminium) has helped limit cable weight. Thanks to P-Laser technology, the system can operate at a conductor temperature of 90°C (instead of 70°C as is normally the case for HVDC XLPE cables) ensuring the same transmission capacity as that of a cable with like voltage but a 2500 mm² XLPE insulated copper conductor.
- Work continued on industrialising the production technology for the new generation of accessories serving **EHVDC applications**.
- In the area of future UHV AC applications, work started on developing suitable materials and technologies applicable to voltages of up to **800 kV**. The cables produced have allowed a preliminary evaluation of existing and new generation materials, with new technological solutions for insulation.
- The Abbeville plant in South Carolina has produced a 500 kV (AC) prototype with a 2500 mm² conductor (pre-qualification tests will be carried out in accordance with IEC62067), while the Mudanya plant in Turkey has started production of HV cables with longitudinally welded aluminium sheaths.

T&I (Trade and Installers)

The T&I business saw the European Construction Products Regulation (CPR) enter into full force in 2017, requiring cables to meet specific performance standards in terms of reaction and resistance to fire. The intense development work carried out in previous years to make its products compliant with the new European standard has allowed the Group's various companies to secure an edge in the different local markets right from the outset. Intensive work to complete the range and optimise costs will nonetheless continue throughout 2018. Several product families for applications not regulated by the CPR are also being required to comply with the same safety standards, intensifying the R&D focus in this regard. The imminent extension of the CPR requirements regarding reaction and resistance to fire has already spurred Prysmian into starting the testing and fine-tuning of products for this category even if the final requirements have not yet been clearly defined. The focus on sustainability has also become of primary importance for products in the T&I market.

Oil&Gas and Surf

The Group offers products and services for offshore oil & gas exploration and production activities, known in the market as "SURF" (Subsea Umbilical, Riser and Flowline). The Group added a new technology in 2017 to produce steel tube umbilicals for dynamic applications.

The O&G market crisis has oriented all "Core" cable development activities towards design and production cost optimisation, also by introducing alternative products to the market. The introduction of the CPR in the T&I market is also arousing the interest of oil companies, requiring specific developments also for products in this family.

In the area of electrical submersible pumps (ESP), oil exploration and production companies are now seeking technological solutions that simplify installation and maintenance as well as limit the related costs.

This involves developing extremely innovative solutions that require new generation cables with very specific additional performance characteristics. This trend is also leading to ever greater synergy between ESP and Downhole Technology systems, making it strategic to combine KH for both technologies.

OEMs

Intense activities continued in 2017 to develop and improve products for the industrial market, covering a vast and varied number of applications. The specialisation in some of these sectors, developed by some of the Group's units, is often required to be transferred to other units due to increasingly frequent requests for localisation in emerging country markets. It has therefore been necessary to equip local plants to manufacture part of the product portfolio, making it possible, also thanks to transfer of the Group's proprietary know-how and technologies, to penetrate new markets.

Monitoring systems

The development of monitoring systems has assumed ever increasing importance insofar as constant network monitoring helps manage, optimise and identify any network problems and so minimise the risk of default. This led in 2017 to a greater focus on systems to measure not only partial discharges but also other parameters, such as temperature, strain, vibration and radiation, with the development of sensors and monitoring systems and devices. As part of the PRYCAM services, whose purpose is to obtain real-time information on the conditions of cables or network components in their respective systems or circuits, the Group has developed PryCam Cable, to create a power source and data collection device for distributed systems of this kind.

TELECOM

Optical Fibre

As for optical fibre, 2017 marked further improvements in the fibre manufacturing process at the US and Brazilian factories, where an autonomous production process is now in operation.

During the year, production capacity was increased for BendBrightXS fibres (single-mode completely bend-insensitive fibre for FTTH applications), also thanks to process improvements. This fibre is very popular with the market thanks to its great flexibility and ductility, especially since the G657.A1 standard came into force. As a result, the Group is converting much of its capacity in this direction, favouring the production of multimodal bend-insensitive fibres for use in FTTH applications.

Since the standard for OM5 fibres has been ratified by the IEC and ISO/IEC, this platform is now used in IEEE to develop the specifications of the physical interfaces of transceivers that will operate at 25/50Gbit/s using up to four wavelengths. This will allow an 8-fibre cable, for example, to transmit from 40G to 100G up to 400G. Another important innovation concerns the use of "**Few Mode**" fibre technology, which allows digital information to be transmitted using a limited number of "modes", unlike, until now, when this has been possible using only single mode fibres. While information is encoded in single-mode fibres and travels in a single *light mode*, "Few Mode" fibre allows different *modes* to transmit digital information (with a consequent advantage for information capacity). The first "Few Mode" fibres, in so-called "4-LP mode", are still being tested.

Optical Cables

In the optical cables field, the Group's activity mainly involves three types of products (Flextube, Blowing, Ribbon).

Flextube cables have proven suitable for many international markets, and their production has been extended to several Group factories. Prysmian continues to work to increase the number and density of fibres contained in a single cable: the latest design houses **3,456 fibres**, organised in 6 elementary cores of 576 fibres each in a single cable (BendBrightXS fibres with a 200 µm diameter were used for this cable to help miniaturisation without compromising bend sensitivity).

Increased fibre density is also the main development goal of "Mini" and "Nano" cables installed using the **Blowing** technique. This family includes drop cables with up to 24 fibres and a maximum diameter of 3 mm and multi loose cables with up to 288 fibres and a maximum diameter of 8 mm. A blowing technique called "overblowing" has also been developed, allowing new cables to be "blown" into the space of the tube not occupied by previously installed cables, representing a clear benefit in terms of environmental impact.

As far as classic **Ribbon** cables for internal and external use are concerned, further improvements and additions to the portfolio were made. Totally Dry Ribbon cables up to 864f have been developed in a Low Smoke Zero Halogen version, while a new generation of Ribbon cables is under development with loose-connected fibres to allow greater packing density while maintaining the benefits of mass fusion splicing.

In collaboration with the University of Applied Science Südwestfalen, the Group has studied the impact of choice of broadband access technology on CO₂ emissions. The comparison between xDSL, Hybrid-Coax, GPON and Point-to-Point showed the advantage of full FTTH implementation, although it was noted that the impact on power consumption by customer modems offered room for improvement.

Connectivity

In terms of Connectivity, Prysmian has continued to develop new accessories for FTTH use (ultra broadband access networks). The Group's focus has been on "cabinets", with the development of optical distribution frames (MDFs), joints for splicing cables and termination solutions involving wall-mounted cabinets. The family of multi-function joints has also been launched in several countries, with specific characteristics for adaption to the various platforms.

The main innovations have involved:

- the development of a new range of **customer termination boxes**, under industrialisation at the plant in Menzel (Tunisia);

- the development of other **joint components**, making it possible to extend their use in the network, thus increasing Prysmian's market share;
- the development of **multiple components** and the launch of an extensive testing program to qualify the joints. These components are currently in production, with sales expected to start in the second quarter of 2018.

OPGW (special optical and submarine cables).

OPGW technology, in stainless steel with an aluminium coating, has been developed up to 96fo, while spiral space technology has been added to the product portfolio. Cables using these technologies have been qualified for various projects in the special cables field, for example cables for 500-vertical-metre dams.

Further developments have taken place in the family of optical cables offering high mechanical strength and high chemical resistance (ALPA) or fire resistance (ALPAM). Production of Subaqua cables has started at the Vilanova plant in Spain. As for submarine cables, a 330-km optical core has been successfully produced for the COBRA project.

Multimedia and Data Centre Solutions

Improvements have been made to the discontinuous ribbon-based Cat.6A U/UTP solution for structured cables with copper conductors.

PoE technology (Power over Ethernet) continues to be the main driver of product range extension and use in the field. This technology allows wireless access points, cameras, sensors and other IoT devices (Internet of Things) to be connected to one another. Even the new Reduced-Twisted-Pair technology is catching on: the first projects have been qualified to allow 1 Gbit/s transmission channels on a single pair, also allowing us to support current standardisation work.

Hybrid combined optical fibre and copper cabling solutions have been further developed for data centres. The first complete cat 8.2 connection has been qualified in collaboration with an industrial partner and is now on sale, offering 40 Gb/s transmission over a 30 m long copper channel. The IEEE transition to a speed of 25 Gb/s allows possible solutions using the Cat.7a product range. New multimode optical fibre cables have been developed for high speed data transmission (40/100 Gb/s); these cables are based on 8 or 12 fibre modules terminated with multi-fibre MPO connectors. The optical modules used can either be of a Flextube micro-module kind, or 3 mm micro-cables, that are assembled to cover the 72 to 144 fibre range. These cable families are available in a version with low smoke and toxic gas emissions and in a Plenum/Riser version.

During 2017, all the product families were qualified according to the Construction Products Regulation: tests were carried out on existing products, designs adapted and materials modified, in order to propose a product portfolio that covers all the necessary performance classes on the market. Most existing products will be classified according to the new fire-performance classes, but new solutions are also being studied and developed for classification in the very top categories.

INNOVATIVE MATERIALS

Prysmian is intensifying exploratory research to find innovative materials for new cable and accessories technology. The main achievements in the year are described below.

- Creation of an elastic sheath for overhead cable accessories (currently under industrialisation), also evaluating new forms for the elastic joint that it serves.
- Studies to understand how to eliminate lead from insulating compounds for medium and high voltage accessories and cables (still in progress).
- Development of semiconductive compounds for medium voltage disconnectable joints used by a subsidiary in France.
- Collaboration with an external partner to develop a coating able to reduce the flame propagation of crosslinked polyethylene, in order to improve the performance of low voltage CPR compliant cables and enhance their characteristics in the future.
- Collaboration with the University of Padua for a preliminary study with the purpose of starting a joint project on fire-resistant materials.
- Study of substances that absorb water without subsequently releasing it, showing the feasibility of a material with superior impermeability. By putting this material into high density polyethylene compounds, impermeability increases by a measure of at least one. In the area of lightweight submarine armouring, a collaboration was started with a producer of UHMW-based polyethylene fibre.
- Successful completion of tests using by-product absorbers in HVDC cables to confirm the reliability of the proposed solution.
- Collaboration with an external supplier for the development of a new tensioner. Experiments are underway to understand how to improve catalyst structure in order to have a cleaner polymer that absorbs gas better.
- Development of a method to study the electrical properties of mica glass tapes at high temperatures (up to 800°C) to evaluate the performance of tapes currently in use.
- Collaboration with the Polytechnic University of Milan to study and make oil-resistant polymers, leading to the creation of a material based on unsaturated polymers that react with each other to generate a crosslinked product with good properties. If the validity of this technique is confirmed, it will be possible to make oil-resistant sheaths consuming much less energy than at present.
- Experiments have been initiated to evaluate and approve materials suitable for the production of small optical cables, which are becoming more and more important in the marketplace.

- Studies were completed with the University of Salerno of a polypropylene used to make the diameter joints in PLaser cables, which showed totally unexpected anomalous behaviour.

Intellectual property rights

Protecting its portfolio of patents and trademarks is a key part of the Group's business, particularly in view of its strategy of growth in high-tech market segments. During the year, the Group continued to add to its patent portfolio, especially in high value-added segments and in support of the major investments made in recent years.

As at 31 December 2017, Prysmian Group had **4,871 patents** - including patents granted and pending applications - throughout the world, covering 746 inventions (of which 211 in the Energy Projects and Energy Products segments, 15 in the Oil&Gas segment and 520 in the Telecom segment). During 2017, 28 new patent applications were filed, of which 18 in the Telecom area, 8 in the Energy area and 2 in the Oil&Gas area, while 187 patents were granted after examination, of which 52 by the European Patent Office (EPO) and 33 in the United States.

The most important products, typically distinguished by particular characteristics or a specific production process, are protected by trademarks that allow them to be identified and guarantee their uniqueness. As at 31 December 2017, the Prysmian Group owned **586 trademarks**, corresponding to 2,514 trademark registrations in its countries of operation, covering the names and identifying symbols of its companies, activities, products and product lines.