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Towards Sustainability: A Power Cable Industry Supplier's Perspective

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SUMMARY

Polyolefins are an important component of power cables. As the cable industry is considering how to improve in sustainability, the paper provides an overview of the various options and considerations that polyolefin suppliers can bring to the discussion. The paper covers the full lifecycle: selection of raw materials manufacture the polyolefin; design and manufacturing of polyolefin solutions; incorporation into the cable design and manufacturing process; use phase, which by far represents the longest time period in said polyolefin's lifecycle and has the largest impact due to the particular application that is power cables; and lastly, end-of-life. The paper calls for a dialogue across the value chain, including cable manufacturers and end-users, to jointly identify the most efficient actions and paths towards sustainability.

KEYWORDS

Polyolefins – Sustainability – Circular Economy – Lifecycle Analysis – LCA – XLPE – Recycling

1 INTRODUCTION

Polyolefins are the most widespread group of plastic materials [1] and can be found in a wide array of applications. For instance, polyethylene is employed in short-term applications, such as e.g. packaging material, as well as in long-lasting applications, such as insulation or jacketing materials for power cables [2].

Sustainable development, defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [3], is a global topic. The polyolefin industry is involved in sustainability discussions with various value chains and stakeholders. For example, when it comes to packaging, there is high focus on proper design, use and disposal of the products in order to reduce their impact on the environment and health as well as how to ensure collection and reuse. In the automotive world, polyolefins is an alternative to heavier materials to make the parts lighter, resulting in reductions in fuel and energy consumption.

The cable industry, is supporting many of the changes the power industry is undergoing to deliver a more sustainable power system. Power cables enable integration of remote, offshore renewable energy sources through subsea cable technology or efficient interconnections via high voltage, direct-current (HVDC) cable transmission.

This paper presents various contributions of polyolefins along their lifecycle and how they can contribute to sustainability in the wire and cable industry.

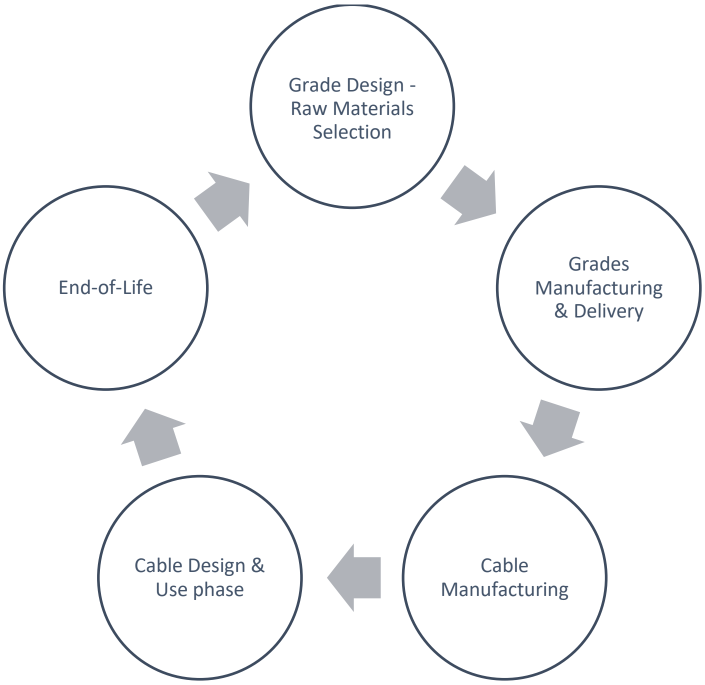

Figure 1: overview of the PO grades lifecycle for cable applications

2 RAW MATERIAL SELECTION

A first element for improved sustainability in the polyolefin industry lies in decoupling the production of products from the systematic use of fossil fuels as much as possible. Indeed, the use of these raw materials can result in an unsustainable depletion of natural resources. Currently – besides alternative economic models, which could include e.g. reuse – three major options available to reduce the need for fossil-fuels as raw material to the polyolefin industry are: (i) mechanical recycling; (ii) chemical recycling; and (iii) renewable feedstock.

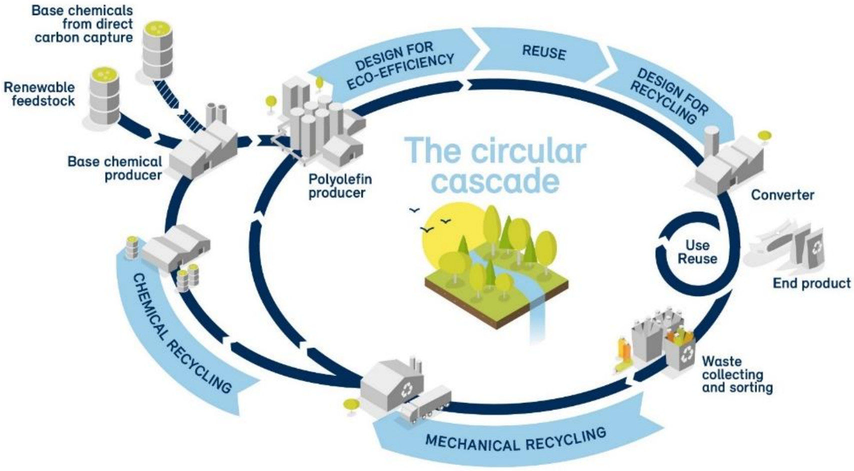

Figure 2 Representation of a circular economy model for polyolefins

2.1 Mechanical recycling

Mechanical recycling is the main portion of all recycling processes available today. Mechanical recycling means normally that the plastic parts are milled or shredded to finer parts/particles. These "flakes" can then be molten and compounded into new pellets. These can be reused in a plastic product, which can be recycled several times.

Mechanical recycling is attractive from a carbon footprint perspective, as it enables reuse of valuable resources, for the manufacturing of which energy was consumed. It is estimated the benefit of using mechanically recycled material over virgin (i.e. made from fossil feedstock) plastic is around 1.8 tons CO2eq [4] for every ton of material.

Mechanical recycling of plastics is, however, subject to various challenges. Today only a small fraction of the plastic waste is recycled. In the EU, about a third (32.5%) of the 29.1 million tons of plastic post-consumer waste that was collected in 2019 was recycled [5]. Globally, the proportion of recycled plastic packaging is around 14% [6]. A first key element for efficient plastic recycling is an efficient waste collection system. Once collected, the waste also needs to be sorted and properly recycled. Today the capacity for recycling and sorting is limited. Further challenges are linked to the mix of "raw material" plastics. The key here lies in sorting technologies, but also in designing products so that such sorting can actually happen. Besides, contamination through prior use (e.g. food contained products) may affect the quality of mechanically recycled plastics or impacts the cost of "pre-processing". These challenges need to be addressed, as users of plastics materials, such as the cable industry, depend on a steady and reliable supply chain that can deliver consistently at the right quality and in the right quantity.

Significant efforts are invested into improving the quality and quality consistency of mechanically recycled materials. Sorting technologies are improving. The future of high quality mechanical recycling includes odour reduction and cleaner materials, free of impurities. A paradigm change is occurring where recyclates are no longer considered in terms of waste that need to be managed, but rather materials that need to meet certain characteristics in the frame of product design and development. This leads to the possibility to consider the use of these high-quality mechanically recycled plastics even in high-end applications (3). In applications such as e.g. high-voltage insulation, where purity and cleanliness are extreme and even the smallest contaminants can lead to failure, use of mechanically recycled material appears unfeasible for the foreseeable future. However, jacketing materials produced with mechanically recycled products are considered to be within reach and constitute the most promising, short-term applications for such recyclates.

2.2 Chemical recycling

Another option to be used as alternative raw materials to fossil fuel are product streams resulting from chemical recycling [7]. This is a process in which low quality mixed plastic waste not suitable for mechanical recycling due to sorting complexity, mixed plastic streams or high contamination, could be processed as feedstock again. Another benefit of this recycling process is the potential to capture and separate out so-called legacy chemicals and substances of very high concern from plastics that could be present in end-of-life plastic. Provided that the energy needs and related greenhouse gas emissions can sustainably be handled, chemical recycling represents a great potential for such plastic waste in comparison to incineration or landfilling of plastic, which both are options that do not contribute to circularity. Chemical recycling breaks down the plastic waste into chemical building blocks such as feedstocks or monomers that could be used for the production of new chemicals and plastics with an equivalent quality to those produced using virgin feedstock. Available technologies include gasification, pyrolysis, solvolysis and depolymerisation. Several technologies are technically ready and proven at first industrial scale already today[8].With this technology, recycled plastics could be used in high quality applications such as food packaging [9]. The potential reduction of carbon footprint for plastics made with such technology is estimated to be up to 45% compared to plastic waste going into incineration.

2.3 Bio-based feedstock

A third sustainable stream of feedstock available for the polyolefin industry is from renewable sources (biomass) and – when the technology & processes further mature – also from CO_2 capture and utilisation (say artificial photosynthesis). Currently, the state-of-the-art consists of renewable feedstock coming from biogenic waste and residues from e.g. vegetable oil refining. This avoids competition with the food industry and the adverse effects this could have on food supply. The CO_2 absorbed by the plant during its growth is “captured” in the biomass used as feedstock. This captured carbon is considered a carbon storage in a lifecycle analysis (LCA). In the “cradle-to-gate” LCA for polyethylene (PE) production, it is evaluated that using bio-based feedstock instead of fossil feedstock reduces the carbon footprint by 1.9 tons of CO_2-eq per 1 ton of PE.

One benefit of feedstock from chemical recycling and bio-based feedstock is that the material is compatible with existing assets in the polyolefin industry. Given the scale and complexity of the polymerisation process and associated assets, an ‘overnight’ transition from fossil–based feedstock materials to a fully circular economy is not realistic. Using sources that can be incorporated into the existing production stream and production assets is an opportunity to immediately initiate a transition towards circularity and use of such non-fossil, alternative raw materials as of today. As feedstock becomes more available and the market demand grows, the carbon footprint savings will increase.

Another attractive feature for these alternative types of feedstock is that they can both be used in high-quality applications, e.g. in the cable industry, insulation materials for power cables.

In order to account for their usage, and to track the respective share of virgin vs. bio-based or chemically-recycled feedstock, the mass balance approach is used. Mass balance is “a method to match output (i.e. products with recycled content) with input (i.e. quantity of recycled feedstock) within a predefined system boundary and within a given booking period” [10]. An analogy is the tracking of the share of electricity generated from renewable energy sources.

Table 1: Overview of circular options for polyolefins:

	Emissions reduction	Plastic waste use	Virgin-like Quality	Perspective/further improvement efforts
Mechanical recycling	++	Yes	No	Improved collection/ sorting/cleaning for better output quality
Chemical recycling	+	Yes	Yes	Energy efficiency and CO2 balance in chemical reaction
Bio-based feedstock	++	No	Yes	3rd generation bio-feedstock from e.g. algae [11]

2.4 Other environmental, Health & Safety aspects

Additional to greenhouse gas emissions reduction and plastic waste management, another important step in the sustainability of polyolefins is the use of non-hazardous raw materials and additives. Besides the "raw" polyolefin base resin, plastics for cables require for example additives to stabilise the materials and ensure long lifetime. These additives can have environmental and health impact and are monitored by regulations, such as REACH in Europe. It is of course essential for the polyolefin industry to follow and comply with such regulations. Beyond such regulatory frame, voluntary initiatives such as the Responsible Care® Global Charter from the International Council of Chemical Associations (ICCA) are taken by the chemical industry, that drive for continuous improvement in health, safety and environmental (HSE) performance. This impacts the design of polyolefin materials and products, during which thorough analysis are conducted to proactively reduce or remove substances of very high concern (SVHC), following the updates in the regulatory framework of hazardous substances. Thus, a polyolefin supplier has to not only fulfil legal requirements, but also monitor the development of regulations and standards for its materials in all the applications, or end-uses for which it is considered.

3 GRADE MANUFACTURING PROCESS

The greenhouse gas protocol initiative has developed a standard to measure and report greenhouse gas (GHG) emissions [12]. It defines three "scopes", in an effort to make this measurement essentially more clear, transparent and practical. The standard prescribes that companies "report on scopes 1 and 2, at a minimum". Besides the choice of raw materials, which would fall under scope 3, a key contribution of the polyolefin industry to sustainability lies in making its operations more sustainable. Here scope 1 and scope 2 emissions are considered.

Polyolefins manufacturing consists typically of hydrocarbon cracking followed by polymerisation. Steam crackers convert naphtha or natural gas liquids into monomers such as ethylene or propylene, which are then polymerised in "reactors". In particular, steam cracking is conducted in furnaces at about 850°C, typically achieved by the combustion of fossil fuels. Therefore, this energy-intensive process represents the principal opportunity for reducing the industry's greenhouse gas emissions.

A mere energy efficiency measure (while not addressing the scope 1 own emissions) is to maximize the usage of residual process heat. In some areas, heat generated by the process is used in local communities to supply district heating. The energy is thus used beyond the sole manufacturing process and has a sustainability impact by avoiding the need of additional energy consumption by individuals heating their homes.

A first genuine GHG emissions mitigation route is, electrification of the cracking process. The "Cracker of the future" consortium which gathers several European chemical industry members [13] is investigating this. This is also dependent on, or combined with a decrease in carbon intensity of the electricity mix and an abundance of renewable power, which goes along the increase in renewable energy sources that the power cable industry is supporting.

Another mitigation route for steam crackers (as building block just before polymer manufacturing operations) lies in performing "carbon capture". This technology allows to prevent emissions and safely store the captured CO_2, while in the longer run one could envisage reusing carbon "waste" from the cracking or polymerisation process into a valuable element of another value chain. One considers the capture of "waste" CO_2 to either store emitted carbon or, even better, reuse it in the process to manufacture synthetic gases. A multitude of efforts are underway within the industry; one example is the consortium involving companies in the port of Antwerp, Belgium, to organize management of CO_2 emissions [14]. As polyolefins are hydrocarbons, i.e. the combination of carbon and hydrogen atoms, carbon capture can represent an attractive potential in combination with the development of a hydrogen supply chain.

Besides changes in operations (scope 1), the emissions from the generation of the electricity needed for the manufacturing operations are scope 2 emissions. These can be reduced in two ways. First, more efficient machinery and equipment can lead to a reduction of the need for energy. Second, using electricity from "clean" sources leads to a lower or a neutral carbon impact. Sourcing of clean electricity is achieved by entering into Power Purchase Agreements with renewable energy suppliers and contributes to the development of renewable energy generation.

Other important areas to minimise the impact comprise the products´ packaging and the logistics process, which can be adapted to minimise emissions. These encompasses, for example, supplying products with packaging enabling a lower carbon footprint and/or able to reduce handling and scrap level at customer side, or boosting possibilities related with recyclability streams. These actions and the above mentioned raw material options can reduce the scope 3 emissions of companies, where cooperating with the value chain is key.

4 MANUFACTURING AT THE CABLE PRODUCER

As already stated, in the wire and cable industry polyolefins are used essentially for :

- Electrical Insulation in power cables, from low to extra-high voltage. In power cables with a higher electrical field, a three-layer insulation system is composed of an insulation layer, in between two layers of semi-conductive material to homogenize the field. The insulation and semi-conductive layers are often made of Crosslinked Polyethylene (XLPE) or XLPE copolymers. They are applied over the conductor via an extrusion process followed by vulcanisation.
- Mechanical protection jacketing or outer sheath - also including in some cases fire resistance properties. The sheath is often made out of HDPE (High Density Polyethylene).

One essential dimension is the focus on yield and quality: ensuring polyolefin grades with the right quality level are used (e.g. "cleanliness" pertaining to contaminants, for power applications). This will result in "first time right" cable manufacturing, eliminating the need for corrective actions, reprocessing and low production waste levels.

Properties of polyolefins can be optimised to enable more efficient cable manufacturing. For instance, a material enabling extrusion at lower temperatures while delivering the same performance will positively impact the sustainability profile of said cable.

XLPE is currently the material of choice for power cable insulation since it offers a combination of thermal, mechanical and electrical properties that are particularly suited for the application, made via an inherently clean process (high-pressure polymerisation without catalyst). A highly important step in XLPE power cable production is the degassing process. It is the step where the peroxide decomposition products generated as a result of the peroxide-initiated crosslinking are either reduced, removed or redistributed. The main decomposition products are methane, acetophenone and cumyl alcohol. Methane is considered the primary by-product to be removed.

Great care is taken to the conditions and parameters for the degassing process, such as duration and temperature at which it is performed. These depend on the cable design and various other factors [15]. The peroxide decomposition products are reduced with time and affect the electrical performance of the cable. This thermal treatment is performed in large, heated chambers. The heated chambers are ventilated, ensuring there is sufficient air flow around the cable, to ensure methane is removed. Without proper degassing, the methane could be released during the jointing and installation of the cable leading to installation safety issues, or during cable service, leading to potential failures.

Degassing XLPE cables contributes greatly to the quality of power cables by improving the performance in electrical testing and the dielectric properties. The degassing step ensures the stability of the electrical properties. However, it contributes to the emissions at cable production site. There is thus a need to find optimal degassing conditions that minimize the duration while maintaining safe limits of methane. Solutions are developed that reduce the degassing burden compared to the first generation of XLPE for wire and cable. Models have been proposed to optimise the degassing step in cable manufacturing, and ensure it contributes to a more sustainable process.

Recently, thermoplastic solutions are promoted on the basis that they offer benefits in emissions reduction during cable manufacturing due to the fact that they do not require degassing. It remains critical that benefits in manufacturing are balanced with other material characteristics in order to offer the best sustainability profile for the cables while maintaining cable performance over the complete lifecycle of the product. This aspect will be developed in the next part of this paper.

In general terms, the handling of the polyolefin products at the cable manufacturers is part of the responsibility of the supplier. Suppliers need to assist the cable industry to achieve minimum compliance with regulations such as supplying relevant data/information for safe handling. This requires good organization at the polyolefin manufacturer to provide reliable and accurate data as well as monitoring evolving regulations. The sustainability impact of polyolefins in cable manufacturing is multi-dimensional and needs to be assessed.

5 IMPACT ON CABLE DESIGN AND USAGE

While in other industries reducing the amount of polyolefin materials (e.g. lighter packaging) may represent a path towards a more sustainable design, for power cables other paths may prove more beneficial to increase the sustainability performance. For instance, operating a cable at higher voltage would typically involve more polyolefin materials, but would also result in lower conductor size, reducing the amount of metal required.

The cable design phase is thus probably the most important and impactful since it is the key phase to determine the features, properties, and performance capability that the new cable will embed and release over the life cycle. Indeed, the cable once produced will operate for decades, and the sheer duration of this “use phase” shows the criticality of the sustainability profile of the power cable. This is for example illustrated in the life cycle analysis presented in [16] for AC cables ranging from 20 kV to 220 kV, assuming a 40 year life time for the cables at a typical maximum conductor temperature of 90°C. The generated CO_2 emissions per km cable in different phases of the cable life cycle was studied, using varying degrees of utilisation of the grid from 20% to 110% of the maximum load.

One outcome of that study is that, for all evaluated cable types, the thermal losses during the use phase resulted in much higher CO_2 emissions than during any other phase during the life cycle of the cable. This is consistent with the findings in CIGRE brochure TB689 [17]. The emissions depend largely on the electricity source as well as on the grid utilisation rate. It is clear that based on the carbon-emission reduction targets worldwide, there will be an increase of the portion of renewable energy, leading to a reduction of the CO_2 emissions over time during the use phase. However, even if 100% renewable energy usage levels are reached, the CO_2 emissions will be reduced but the cost of energy losses during the use phase will remain.

That is why it is of foremost important to have people in the polymer industry with high level of expertise and experience in the end application industry, working together with the polyolefin user (e.g. cable manufacturer) so that they together can assess and generate new ideas and possibilities in a cross-functional set up. In the power cable industry, this is particularly relevant as the performance of the polymer can have huge impacts in the power cable design and sustainability profile.

Designing for sustainability, for circularity, or eco-design is becoming the new standard way of doing grade design at the polyolefin supplier. This encompasses a series of aspects which are different depending on the final application of the grade. A deep understanding of the application, the end user need, and related technical standards (when available), are important to consider. With respect to cable applications, it is fundamental to have a strong link and open, cross-industry collaboration and dialogue between the polyolefin supplier, the cable manufacturer, and other members of the power cable value chain (including transmission system or offshore grid connection designers) so that each idea can be assessed and considered in the broader supply chain context and potential impacts are evaluated before becoming alive in a new grade.

Power cables are ‘enablers’ for the transformation of our energy system from fossil-based generation to the integration of renewables such as onshore and offshore wind as well as solar energy. This in itself is a significant contribution of the industry to sustainability. Since these energy sources can be located far away from the main energy consumption areas, there is a need for efficient transmission of large amounts of electrical power for long distances. This can be achieved by utilising for example HVDC transmission using polymer insulated cables. In Germany, the technology has been used to connect offshore wind projects with a transmission capacity of around 900 MW using single circuits of 320 kV cables. As the polyolefin technology [18] has been further developed and enhanced to enable transmission of power at higher voltages (> 600 kV), the amount of power that can be carried by a single circuit will increase to 2 GW and beyond. This means a reduced impact for installation, and the higher voltage also implies lower transmission losses.

Another example where polyolefins may contribute in cable sustainability performance is materials used for distribution cables, where so-called wet designs are used. A regular power cable design includes a metallic water (or moisture) barrier over the cable core to prevent water ingress. A wet design results in that no such moisture barrier layer is needed. If the cable is a so-called wet design cable, the cable construction allows migration of water or moisture into the interior parts of the cable core. This enables the use of a ‘simpler’ cable design (elimination of one layer and corresponding manufacturing step), thus reducing material consumption. However, letting water migrate inside a power cable is not trivial. It is known that the combination of electrical field and water can lead to water tree degradation of the insulation. The growth of water trees may result in breakdown if they initiate an electrical tree. Therefore, special water-tree-retardant materials have been developed that either reduce the start of growth of water trees and/or slows down the water trees growth so it does not affect the cable during its design life. One proven water-tree retardant (WTR) technology is so-called Copolymer WTR XLPE. The contribution of Copolymer WTR XLPE regarding increase of reliability in a cable network is given in [19].

Cable design can also make the cable installation process more sustainable. Different aspects are currently considered and can lead to an improved footprint. For example designing insulation and jacketing grades which help optimise cables’ mechanical performance during installation. Limiting the need for excavation works or for pipes, conduits, or different protective layers (sand/ rock/ other material...) to be installed around or on top of cables could prove beneficial from a sustainability angle. Beyond limiting emissions, this can benefit significantly the total installation time and cost, and also lead to reduce the overall failure rate.

In view of the outcome of the LCA analysis referred to above, this highlights the fundamental importance of the optimal dimensioning of the cables, to be able to run them at lower temperatures for the same transmitted power. Here the contribution of the polyolefin material is that the generated heat losses need to dissipate to the surroundings, making the thermal conductivity of the insulation layer an important parameter. The thermal conductivities on the materials surrounding the cables (soil or backfill), are also important to minimise the temperature increase of the conductor. It is really a key need to design materials to be used for power cables with circularity in mind and really focus on whether there are possibilities to facilitate the handling of the cables when they have reached end-of-life (EOL). However, this cannot be made by compromising on performance of the materials since a reliable operation of the cables is a must. Cables used for the higher voltages all have very stringent performance requirements and demanding cable standards needs to be fulfilled.

6 END-OF-LIFE; CURRENT TRENDS IN THE RECYCLING OF POLYOLEFINS FROM CABLES

Cables are complex products including several layers with different materials including metals, plastics, tapes and yarns. Cables are probably among the longest lasting products, with design life lasting several decades. Some TSOs even see beyond: RTE indicates in its 10-year network development plan that life expectancy of synthetic insulated cables ranges from 85 to 100 years [20].

In this perspective, the recycling of polyolefin materials in cables is not comparable to that of plastic packaging. The risk of polyolefins in power cables ‘leaking’ into the environment is non-existent as compared to packaging. It is assumed that grid owners today can locate their assets. End-of life of cables must still be envisaged, and what to do with the recovered cable. When considering recycling, the cable industry is currently recycling cables due to the metal value [21] and metal recyclers are not considering the plastic materials on the cable as a valuable raw material. Plastic is waste to get rid of either as incineration and energy recovery or in worst case as landfill. Cost of landfill and even regulations will hopefully change this behaviour.

Grinded XLPE waste could be blended with HDPE and PP with improved properties like impact strength, giving a value added as a "new" raw material. In ref [22] mechanical recycling of plastics from cables were studied and sorting and separation methods were developed. It was also shown the environmental benefits of increased sorting and recycling of plastic materials in cables. XLPE waste from manufacturing of cables as well as XLPE from end-of-life (EOL) cables could be recycled into a cable drum and other products, up to 60%. It was also demonstrated that the XLPE waste containing products could be reused and compounded several times.

In [2] it is reported that the quality of the XLPE waste from different recyclers are varying and that the impurity level needs to be improved in most cases. The main process today in mechanical recycling of cables are the shredding process where the whole cable is chopped into pieces and then size reduction is gradually performed. In this case metal contaminants in the plastic waste are not possible to avoid, as well as a mix of plastic materials depending on the design of the cable and its layers. It is important that the cable and recycling industry together develop other methods of recycling cables, also considering recovery of the polymers. In the article, such a method of stripping the cable of the different layers is mentioned, where the waste will be cleaner, and most likely more usable into products with higher demands.

In a recent study June 2021 [23], two similar cables with different insulation (cores) systems where compared. Both the plastic core (including inner and outer semi-conductive layers and the insulation layer) and plastic jacket where stripped off of the cable and blended with virgin materials. All plastic waste from the cables where recyclable and have high reuse value. The processing performance was good and offered good end-properties like mechanical performance and toughness as well as ageing properties. All mixed compounds where black, coming from the semi-conductive layers. Again it was shown that XLPE waste from cables is mechanically recyclable, mixed with HDPE or PP a new polymer material with especially improved impact resistance was obtained. The environmental saving is around 1.4 – 1.6 kg CO_2 for each kg of cable plastics.

Another challenge is the value of recovering cables at their end of life. Today we see no trend to actually dig up end-of-life (EOL) cables and perform “urban mining”. One reason why we see little recycling of EOL cables could be that cables are long lasting products and are still in use. Different methods and challenges are studied in [24]. Digging up cables in an urban environment is another challenge. Even from an environmental standpoint, the net benefit of retrieving end-of life assets must be balanced with the emissions cost through the works required to extract cables off the ground. However, as regulations are being implemented to ensure sustainability, the situation is likely to evolve. There could be a benefit to actually dig up the EOL cables and reuse the materials instead of using new materials.

Besides mechanical recycling, chemical recycling as introduced earlier in this paper offers very attractive perspectives for “complex” materials, which 3-layer bonded insulation and semi-coducting material, or jacket found in power cables could qualify for. More research and investigations are required to develop the application of chemical recycling to cable polyolefin at the end of life, but such technology has the potential to make whole the transition of polyolefins in cables to a fully circular economy model.

7 CONCLUSION

Throughout this paper, the authors have attempted to provide a complete overview of the sustainability topic for polyolefin suppliers when considering power cable applications. Such applications represent an excellent case for polyolefins usage, where the materials’ durability, flexibility and overall characteristics can be fully exploited and deliver value to society for a number of years. From the selection of raw materials to disposal at the end-of-life, through a use phase that is one of the longest for polyolefin applications with a particular impact on energy consumption and therefore sustainability, there are multiple aspects to sustainability of polyolefins in power cables. These need to be balanced and properly evaluated, so that the necessary pathway to fully sustainable power cable polyolefin solutions does not compromise with other key aspects of quality and reliability, which the power industry and society at large depend on for a reliable and secure supply of energy. To that effect, tools such as LCA, as already identified in CIGRE Brochure TB689, are available to guide the industry. The authors believe that an analysis that covers the full value chain, from polyolefin solution design and development to grid operation and management (and the challenges conversion to a system dominated by intermittent, renewable energy sources entails), with power cable design at the centre, would provide the holistic view required to make the best and most efficient choices in terms of future development and process improvements. A close cooperation across industry stakeholders is thus welcome to deliver a sustainable power cable industry as early as possible.

BIBLIOGRAPHY

[1] https://www.polymersolutions.com/blog/top-types-of-polyolefins-the-most-common-kind-of-plastics/

[2] Huuva, Ribarits, "Recycling XLPE from cable waste" Jicable 2019

[3] UN World Commission on Environment and Development, " Report of the World Commission on Environment and Development: Our Common Future", 1987

[4] Materials Economics (2019) Industrial Transformer 2050- Pathway to Net Zero emission from EU Heavy industry

[5] PlasticsEurope, "Plastics – the Facts 2020 - An analysis of European plastics production, demand and waste data"

[6] Ellen MacArthur Foundation, The new plastics economy: rethinking the future of plastics (2016)

[7] Cefic, https://cefic.org/policy-matters/innovation/chemical-recycling/ retrieved 21/01/2022

[8] https://www.plasticsrecyclers.eu/chemical-recycling

[9] Cefic-Position-Paper-on Chemical-Recycling

[10] Ellen McArthur Foundation CE 100 Network, "Enabling a circular economy for chemicals with the Mass balance approach", White Paper,

[11] https://www.futurebridge.com/uncategorized/algae-future-feedstock-for-biofuels/, retrieved 07/01/2022

[12] The Greenhouse Gas Protocol – A Corporate Accounting and Reporting Standard (Revised Edition), World Resources Institute and World Business Council for Sustainable Development, March 2004

[13] https://www.trilateral-chemical-region.eu/cracker

[14] Gasworld, "Antwerp@C investigates potential for halving CO_2 emissions in Port of Antwerp by 2030", Joanna Sampson, 28 May 2020

[15] N. Hampton et al. "The Role of Degassing in XLPE Power Cable Manufacture", IEEE Electrical Insulation Magazine — Vol. 22, No. 6, November/December 2006

[16] D. LeRoux, 'Life Cycle Assessment (LCA) and losses due to thermal resistivity of insulation materials' (Cigre 2016, B1 Discussion, PS2 Q4, Paris, France)

[17] CIGRE TB689 "Life cycle assessment of underground cables" WG B1.36, May 2017.

[18] R. Huuva, 'High Voltage DC : From Innovation to Operation' (Jicable HVDC 2021, Liege, Belgium)

[19] D. Wald and A. Smedberg, 'Performance of Modern Cables in Central Europe' (Jicable 2007, Paris, France)

[20] RTE, « Schéma décennal de développement du réseau », 2019, table 2.3, p. 46

[21] M. Zackrisson and Boss "Recycling production Cable waste – environmental and economic implications".

[22] Boss et al "Resource efficient cable plastic recycling" Report Swerea IVF 24241

[23] RISE Report P102768, "Recycling and Circularity in Power Distribution Cables: A fact-based study comparing market sourced MV XLPE and PP-TPE insulated cables", 2021

[24] Henric Larsson, Master thesis 2013 Linköpings University; "Economic and environmental conditions for extraction and recycling of ground power cables"