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REPORT ON BEST PRACTICES IN SUBSEA TELECOMMUNICATIONS SUSTAINABILITY

Sustainable Subsea Networks, a research initiative of the SubOptic Foundation, is an academic-industry collaboration to enhance the sustainability of subsea telecommunications cables. This report is the culmination of two years of research conducted between 2021 and 2023 on the subsea cable industry's best practices in sustainability.

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Contributions
This report reflects sustainable contributions of the following companies:

A-2-Sea
Alcatel Submarine Networks/Nokia
Aqua Comms
BT Group
Bulk Infrastructure
Ciena
Cisco
Colt
Corning Incorporated
Digital Realty
E-marine
EGS Survey
EllaLink
Equinix
Fugro
Fujitsu
Global Marine
Globe Telecom
GlobeNet
Google
Hexatronic
HMB-IX
Indigo TG
Infinera
IT International Telecom
KDDI
Keppel Corporation
Makai Ocean Engineering
Mertech Marine
Meta
Microsoft
NEC
Nexans
NJFX
Nokia
NTT Group
Orange
Orange Marine
PICS Telecom
R&G Telecom
Red Penguin Marine
Route Position
Saildrone
Solomon Islands Submarine Cable Company
Southern Cross Cable Network
Subsea Data Systems
Subsea Environmental Services
Tata Communications
Telecom Egypt
Telstra
Telxius/Telefónica
Vodafone
WFN Strategies
Xtera

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EXECUTIVE SUMMARY

Executive Summary

Over the past ten years, there has been a growing awareness of Internet infrastructure and its impacts on the planet. Researchers, policy-makers, and companies have all sought to assess and reduce the carbon emissions produced by Internet infrastructure, largely focused on data centers. Subsea telecommunications cables, which transport over 99% of all transoceanic data traffic via 1.4 million kilometers of cable globally, have remained almost entirely absent in these discussions. This omission is in part due to the relatively small carbon footprint of subsea cable systems. Indeed, subsea telecommunications cables have long been recognized as enabling a more sustainable future, providing opportunities for reduced travel, more efficient access to information, and enabling international climate-related science, in addition to underpinning the social and economic fabric of our world through global communications.

Even with their marginal footprint (a subsea telecommunications cable being only about the size of a garden hose) and climate benefits, many individual companies and organizations in the subsea cable industry have been developing their own approaches to assessing sustainability and implementing best practices. Up until 2021, however, these efforts remained ad-hoc and were pursued largely independent of one another. By conducting research, convening events, and facilitating discussions on sustainability, the SubOptic Foundation's Sustainable Subsea Networks (SSN) project has been working to facilitate industry-wide cooperation to bring awareness to and enhance the sustainability of the subsea cable network.

The following report, **Best Practices in Subsea Telecommunications Cable Sustainability**, synthesizes two years of investigation by the SSN research team into ongoing sustainability work across the subsea telecommunications cable industry, compiled between 2021 and 2023. This initial report offers a wide-ranging guide to the existing carbon emissions mitigation efforts of subsea telecommunications cable companies, including not only owners and operators of cable systems, but those providing services across the supply chain, from cable installers to marine survey companies. The report also describes potential approaches to reducing carbon emissions going forward.

Drawing from materials provided by twenty-seven companies and public disclosures by members of the SubOptic Association, the report documents examples of best practices in accounting and disclosing carbon emissions, setting targets, sustainable design and operations, purchase and installation of renewable energy, and recycling, among other areas. The report concludes with a discussion of the major drivers of sustainability: customer demand, future regulatory change, green finance, parent companies' climate values, and the commitment of individuals. Building on existing efforts, the report concludes with a discussion of the need to work in collaboration to harmonize metrics across the sector that can be used internally to audit and track performance, as well as to identify opportunities for future enhancement.

The information compiled here offers a striking picture of an industry in transition—moving towards a more efficient and sustainable future across the lifecycle of a cable. By centralizing information on these efforts, the report provides insight into sustainability initiatives that can be scaled and replicated across many parts of the industry worldwide.

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TOP TAKEAWAYS

Top Takeaways

1 **Account and Disclose**
Measurement is the first step to effective management of carbon emissions. There is a growing trend toward carbon accounting in the subsea cable industry—but transparency and standardization is also key. Leading companies are disclosing their emissions to drive change.

2 **Embrace Shared Metrics**
Climate targets, standards bodies, and green certifications offer frameworks to structure effective action. While adoption of existing frameworks provides one pathway for sustainable development, there remains a need to collaborate to integrate and harmonize metrics across the industry, although we do not recommend these become formal standards. Metrics for sustainability should be compatible with other aspects of industry practice.

3 **Design for Sustainability**
Considerations for future networks include the use of sustainable materials such as zero-carbon steel, contracting with manufacturers running on carbon neutral energy, route planning that minimizes a cable's carbon footprint, and resilient network design that emphasizes connecting to clean-energy landing stations and hubs.

4 **Protect Cables**
One important action that can be taken to reduce emissions is to minimize repairs. An adequately-protected cable requires fewer repairs, less utilization of ships, and the emission of significantly lower levels of CO_2. Such protection can be achieved through physical means as well as improved understanding of external threats and engagement with stakeholders, including governments. The International Cable Protection Committee's Government Best Practices outlines the steps governments can take to better protect cables in their jurisdiction.

5 **Efficiency, Efficiency, Efficiency**
Energy efficiency initiatives are being undertaken at factories, on cable ships, and in cable landing stations. Marine operators can consider optimizing transit time, fuel efficiency, plough depths, and introducing new technologies. Effective project management is also an important step in sustainability.

6 **Support Renewable Energy**
Companies can support decarbonization by purchasing or installing renewable energy at their facilities. Marine operators can plug into shore power and look towards future transition in fuel sources. Several manufacturers and cable owners have invested substantially in carbon neutral and renewable forms, but this is far from the norm in the industry.

7 **Upgrade Systems and Extend Cable Lifetime**
Upgrading Submarine Line Terminal Equipment at the cable landing station has multiple contributions to sustainability: new equipment is more energy efficient, the energy per bit is dramatically reduced, and the lifetime of a cable is extended.

8 **Recover, Recycle, and Redeploy Cables**
A potential way to mitigate impact is through cable recovery, recycling, and the re-introduction of equipment and materials into the circular economy.

9 **Get Ahead of the Curve**
Sustainability is becoming a priority on many fronts. The primary drivers of this shift include customer demand, increasing regulation, green finance, and a cultural shift to prioritize green development. The subsea cable industry will benefit greatly by collaborating with governments to co-design policies and laws ahead of regulation, especially in tandem with considerations of sustainability beyond the reduction of greenhouse gas emissions.

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BACK-GROUND

Background

Over the past several years, subsea cable companies have put forward green agendas and initiatives. Cable supplier NEC, who has committed to science-based targets since 2017, formulated "Eco Action Plan 2025" to increase the company's sustainability.[1] Cable supplier Alcatel Submarine Networks developed a Green Charter to address climate change and to take a leadership role on environmental matters, documenting their work in the first video on the topic.[2] The consulting company WFN Strategies developed an environmental roadmap and a set of internal policies. Red Penguin Marine, another consultant, convened an environmental group within the company to discuss how they could move toward net zero. Corning focused their bi-annual summit in 2023 on the topic of sustainability and challenges facing the glass industry. Ciena created an Environmental Steering Committee in 2020 to manage its environmental programs, plans, and policies.[3] Such efforts—which intensified from 2021 to 2023—mark a transition period in the industry to developing sustainability initiatives and goals.

While some companies, such as Bulk Infrastructure, Hexatronic, and Telxius, have official employee positions dedicated to sustainability, others lack a coherent sustainability plan and dedicated sustainability officers. A few companies that we interviewed had no sustainability initiatives or policies in place. There are several reasons for this variation. Economic margins are not high in the industry, especially in the marine sector, and there are not excess resources to funnel into sustainability. The low carbon footprint of the industry as a whole has generally kept this from being as pressing a concern as it is for the data center industry. The subsea cable industry is also global, stretching across diverse geographic and environmental contexts where sustainability is more or less of a concern. Although there are companies dedicated to subsea cable development, in many organizations subsea systems are merely one part of a broader set of telecommunications operations, and other more energy-intensive infrastructures take precedence in sustainability work.

Nonetheless, even without coordinated effort, sustainability initiatives abound in the subsea cable industry. For a few companies, these initiatives are seen as a competitive advantage and contain knowledge to be safeguarded. Aside from these outliers, we found that most companies in the sector see more value in a collaborative approach. We are in the early years of the subsea cable industry's sustainability movement, and initiatives remain largely independent of one another and driven by a variety of influences.

We found that, while substantial coordination has occurred across the industry in marine sustainability—in part facilitated by the International Cable Protection Committee (ICPC)—many of our interviewees remain unaware of what others are doing specifically to mitigate carbon emissions.

Across the board, many of our interviewees acknowledged that sustainability had not even been on the radar when they joined the industry in the 1980s and 90s. At that time, "environmental factors just weren't on the agenda." Cable landing stations were constructed that consumed much electricity to cool the telecommunications equipment and, as one industry member recounts: "We gave no thought to where the electricity came from; it was just there, so no need to look for it from 'green' suppliers." But as another stated, "the environmental agenda twenty years ago was secondary and now it's not."

This catalog of best practices offers organizations an opportunity to learn about the many avenues being pursued across the industry. Communicating and sharing best practices is an essential first step for future development. In the following pages, we chart current sustainability work as well as potential directions for improvement. This can provide actionable guidance for companies in developing their own sustainability initiatives.

Notably, this report is not intended to outline a formally standardized approach or industry-wide recommendation, in recognition that there are many aspects of cable development that require consideration, especially in light of globally-disparate jurisdictional requirements. It is important to place this report, which deals primarily with CO_2 emissions, within 'sustainability' that extends beyond solely the carbon footprint (and which falls outside the remit of this present study). These may include aspects such as minimizing impacts on the marine environment, ensuring environmentally-considerate marine spatial planning, limiting loss of marine natural capital, biodiversity net gain, and the use of nature-inclusive designs for cable protection structures, among others.

> **"The environmental agenda twenty years ago was secondary and now it's not."**

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BEST PRACTICES IN SUBSEA CABLE SUSTAIN-ABILITY

Best Practices in Subsea Cable Sustainability

Methodology

To compile this report, SSN team members conducted interviews with cable owners, operators, suppliers, and recyclers, as well as vessel owners and those involved in marine operations. The team spoke with numerous personnel involved in the design and operation of subsea systems across cable's lifecycle. We solicited their input on potential avenues for—and obstacles to—making the network more sustainable. The below summary represents information from detailed interviews with members of twenty-seven companies. We have supplemented this with information drawn from the public websites and disclosures of additional companies that are members of the SubOptic Association. Their committed initiatives, boosted by growing investments, reveal a dedication to reducing the industry's environmental impact and coordinating with international sustainability goals.

Sustainable Subsea Networks Map

In collaboration with TeleGeography, we developed a Sustainable Subsea Networks Map (Figure 1). This map represents the best practices of twenty companies involved in the construction, operation, maintenance, or recovery of subsea cables. It offers a snapshot of the diverse contributions of this global industry.

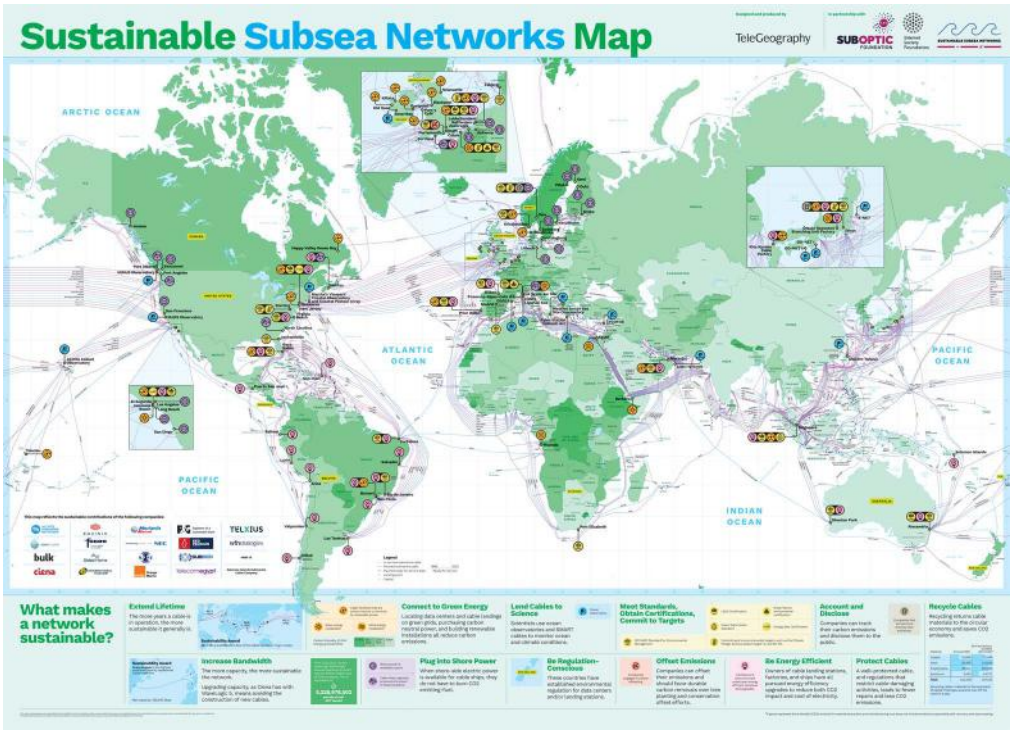

Figure 1. Sustainable Subsea Networks Map.
Graphic by Sustainable Subsea Networks (https://suboptic.org/page/sustainability-map)

Account and Disclose Emissions

The first step any company can take in a commitment to sustainability is to track their CO^2 emissions. Knowing where emissions are concentrated leads to more effective action. Public disclosure, audits, and external accreditation of these records then ensure accountability.

There are several global frameworks that facilitate accounting and disclosure. The Greenhouse Gas (GHG) Protocol is a comprehensive global standardized framework for measuring and managing GHG emissions.[4]
There are two global initiatives that use the GHG Protocol to facilitate disclosure that are highly relevant for the subsea cable industry. The CDP (formerly known as the Carbon Disclosure Project) is a not-for-profit organization that runs a global disclosure system for investors, companies, cities, states, and regions to manage their environmental impacts.[5]
The Task Force on Climate-related Financial Disclosures (TCFD) , although now disbanded, was created by the Financial Stability Board in order to increase transparency and to inform financial markets and investors about companies' commitment to mitigating climate change.[6]

The CDP and the TCFD, building on the GHG Protocol, aligned their goals in order to develop a comprehensive, high-quality, and comparable form of disclosure.[7] Alongside these frameworks, we review several popular Sustainability Indexes below. In addition, ISO 14064, not covered in depth here, specifies requirements for quantifying and reporting GHG emissions and removals at the organizational level.

Four pillars for accounting and disclosing emissions

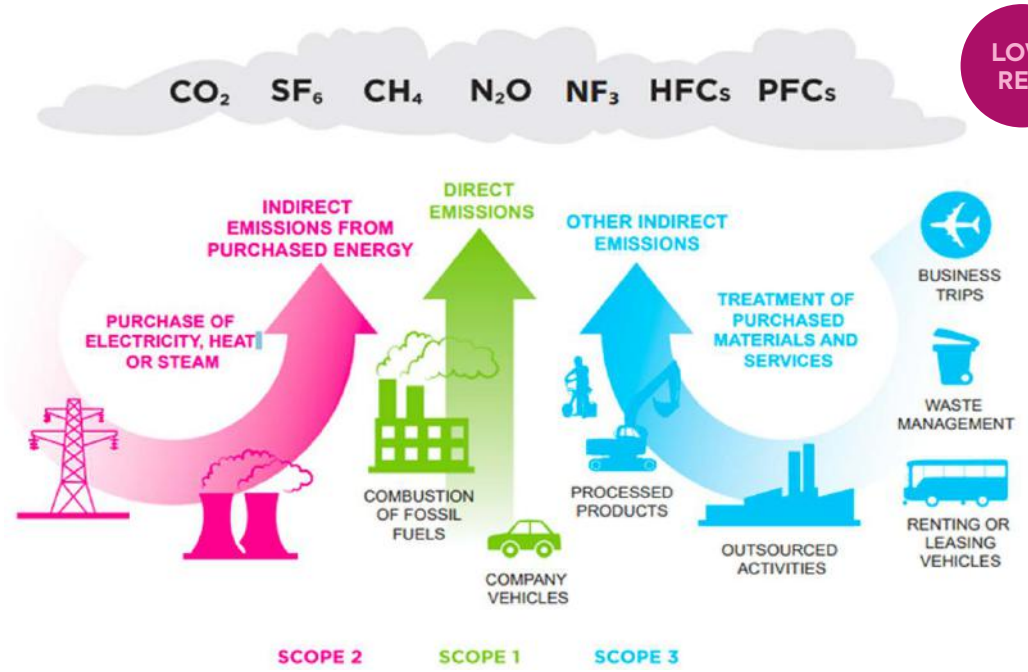

Figure 2. Overview of GHG Protocol scopes and emissions across the value chain. Graphic by Greenhouse Gas Protocol, "Corporate Value Chain (Scope 3) Accounting and Reporting Standard", p.5 (https:/ghgprotocol.org/sites/default/files/standards/Corporate-Value-Chain-Accounting-Reporing-Standard_041613_2.pdf)

Greenhouse Gas (GHG) Protocol

The practice of accounting and disclosing emissions is increasing within the subsea cable industry. Most companies who do so follow the GHG Protocol, which supplies the world's most widely used greenhouse gas accounting standards. It provides a foundation to assess private and public sector operations, a shared process for companies to ensure they are meeting their sustainability goals, and a framework to determine the best mitigation options to pursue. The most common mitigation instruments, discussed later with some caveats, include Energy Attribute Certificates (EACs) and carbon offsets.

According to the GHG Protocol's Corporate Accounting and Reporting Standard, a company's emissions impact can be categorized into three scopes. Companies who follow the metric must report the first two scopes.[8] The third is optional, as it is the hardest to measure. Scope 1 emissions comprise those that result from firm-level activities: stationary combustion, mobile combustion, fugitive emissions, and process emissions. On the other hand, scope 2 and 3 emissions account for indirect emissions. Scope 2 emissions result from the consumption of energy from electricity and other means. Scope 3 emissions are the most difficult to measure because they include all emissions within the value chain or operations of the company. This includes travel, commuting, waste, distribution, and more (Figure 2).

Companies who wish to follow the GHG Protocol must have clear documentation for internal reviewers and external verifiers to attest their credibility. Most companies in the telecommunications sector and subsea cable industry that report through the GHG Protocol account for all three scopes: BT Group, Bulk Infrastructure, Ciena, Corning, Digital Realty, Equinix, Fugro, Fujitsu, Globe Telecom, Google, Infinera, Meta, Microsoft, Nexans Norway, Nokia (Alcatel Submarine Networks), Orange, Southern Cross Cable Network, Telstra, Telxius, and WFN Strategies. Some companies report scope 1 and 2 emissions: Keppel Corporation and Tata Communications. Many companies that report following the GHG Protocol have also committed to reduce their emissions in relation to science-based targets, discussed below.

CDP

CDP Global is an international not-for-profit charity that works with investors, companies, cities, and governments to manage their environmental impacts. Over the last two decades, they have developed a global standard for climate environmental reporting. In order to disclose through the CDP, companies must access their Online Response System, select and review their Activity Classification System, and answer a set of questionnaires. The CDP's scoring methodology and approach is available in the Scoring Introduction 2023.[9]

The demand for environmental disclosure is only growing. The CDP website reports that 746 investors, with over US$136 trillion in assets, and over 280 large purchasers, with over US$6.4 trillion in procurement spend, are requesting that thousands of companies disclose their data using CDP. In addition to providing resources for disclosing data, CDP enables companies to protect and improve their reputation through transparency, to boost their competitive advantage when it comes to performance on the stock market, and to track and benchmark progress against industry peers. Furthermore, accounting and disclosing uncovers risks and opportunities that may otherwise be overlooked and allows companies to get ahead of regulation as mandatory disclosure becomes more widespread. Disclosing its emissions through CDP, marine surveyor Fugro reports, "demonstrates the transparency and accountability vital to tracking progress toward a sustainable future."

> **Accounting and disclosing uncovers risks and opportunities that may otherwise be overlooked.**

Most companies who use the CDP to account and disclose emissions have long-term plans in place to significantly or completely reduce carbon emissions. Companies who report their emissions through the CDP include: Ciena, Cisco, Corning, Digital Realty, Equinix, Fugro, Fujitsu, KDDI, Microsoft, NEC, Nokia (Alcatel Submarine Networks), Orange, Telefónica, Telstra, and Vodafone. Some companies, such as Google, have disclosed their emissions through CDP, but disaggregated numbers are not available and thus it is unclear how emissions are produced by subsea cable networks specifically.

While large companies tend to make use of such global frameworks, smaller companies more often disclose independently. For example, in 2021, the subsea cable company Aqua Comms carried out a full review of scope 1 and 2 emissions, and disclosed that its emissions intensity was 217 CO_2e/GWh.

Some companies not only conduct carbon footprint analyses for their operations as a whole, but for their individual products. Hexatronic has calculated the carbon footprint for 60% of the volume of ducts and cables produced in house, including its subsea telecommunications cables, and has set a target to calculate 80% of its products this year. Hexatronic's targets include climate intensity, energy intensity, and carbon footprint calculations. By 2025, the company reports, all of its in-house produced products will meet these targets.

> By providing a clear understanding of the financial risks and opportunities associated with climate change, TCFD enables Bulk's management team to make informed decisions and set strategies that are both financially and environmentally sustainable.

Task Force on Climate-related Financial Disclosures (TCFD)

The Task Force on Climate Related Financial Disclosures (TCFD) was adopted by many companies in the disclosure of their carbon footprint. Although disbanded in 2023, the TCFD focused on four areas: governance, strategy, risk management, and metrics and targets, in order to help companies provide better information to support informed capital allocation. Established in 2015, the goal of the TCFD was to ensure a widespread adoption of market transparency for climate related risk management and strategic planning.

The Task Force released recommendations that included climate-related risks, opportunities, and financial impacts.[10] In terms of metrics and targets, it recommended disclosing the metrics used by an organization as well as scope 1, 2, and 3 GHG emissions. It identified seven principles to enable effective disclosure: relevance, specificity and completeness, clarity, consistency, comparability, reliability, and timeliness.[11] Describing its decision to align with TCFD, Bulk Infrastructure reports, "by providing a clear understanding of the financial risks and opportunities associated with climate change, TCFD enables Bulk's management team to make informed decisions and set strategies that are both financially and environmentally sustainable." In turn, its board considered climate-related issues when reviewing Bulk's strategy.

Companies who aligned with the TCFD included: BT Group, Bulk Infrastructure, Ciena, Cisco, Corning, Digital Realty, Equinix, Fugro, Fujitsu, Google, Infinera, KDDI, NEC, Nexans, NTT, Microsoft, Telstra, Vodafone, and Xtera.

Sustainability Indices

In addition to the frameworks offered by the GHG Protocol, the CDP, the TCFD, and ISO 14064, sustainability indices offer evidence that companies are investing in making their operations more sustainable.

The MSCI World ESG Leaders Index is a capitalization-weighted record of companies with high Environmental, Social, and Governance (ESG) performance.[12] This index measures companies in relation to their sector peers and awards them grades including leader (AAA, AA), average (A, BBB, BB), and laggard (B, CCC). Some companies are engaging in accounting practices and disclosing to parent companies, who then report aggregated numbers. Such is the case for Alcatel Submarine Networks, whose carbon emissions are represented in Nokia's ESG reports.[13] The following companies also have an ESG score: Ciena, Cisco, Corning, Fugro, Fujitsu, Globe Telecom, Infinera, Keppel Networks, NEC, NTT, Orange, Telefónica, Meta, Microsoft, Nexans, and Vodafone.

The Dow Jones Sustainability World Index (DJSI) measures and represents the top 10% of the biggest 2500 companies in the S&P Global Broad Market Index based on long-term environmental, social, and governance criteria. The Dow Jones Sustainability Index is composed of ten different qualities to measure the performance of companies.[14] BT Group, Cisco, Fujitsu, Keppel Networks, KDDI, Microsoft, NEC, Nokia (Alcatel Submarine Networks), NTT, Orange, and Telxius are all listed in the DJSI.

The S&P/JPX 500 ESG Score Tilted Index Series measures the performance of constituents in the TOPIX 500 that meet sustainability criteria.[15] KDDI and NEC are listed in this index. Additional indices of interest include the Institutional Shareholder Services group of companies (ISS), Morningstar Sustainalytics, and EcoVadis.

> **Indices offer evidence that companies are investing in making their operations more sustainable.**

Commit to Carbon Emissions Targets

Many companies across different sectors of the subsea cable industry have committed to climate targets. These targets offer companies a framework for determining actions, measuring progress, and promoting positive public engagement.

Science Based Targets Initiative

Most companies in the telecommunications sector and subsea cable industry who have committed to targets have done so using the Science Based Targets Initiative (SBTi) Net-Zero Standard.[16] A partnership between the CDP, the United Nations Global Compact, the World Resources Institute, and the World Wide Fund for Nature, the SBTi framework offers guidance for companies to reach net zero emissions on a time scale that limits global temperature rise to 1.5 degrees Celsius.

By facilitating uptake of their Corporate Net-Zero Standard, the SBTi aims to cut emissions by half before 2030 and achieve net zero by 2050.[17] The SBTi sets four key standards in place: near-term and long-term science-based targets, neutralization of residual emissions, and beyond value chain mitigation. This SBTi standard is targeted for companies with more than 500 employees. Aligning a company's plans with the SBTi is an iterative and relatively resource-intensive process, which can make it difficult for smaller companies to participate. To encourage small- and medium-sized enterprises (SMEs) to also set reduction targets, the SBTi has streamlined the approval process.[18]

Many companies across different sectors of the subsea cable industry have committed to climate targets.

Near-term Targets (2030)

Most companies involved in the subsea industry that have adopted the SBTi framework have committed to near-term targets, adopting greenhouse gas reduction goals in line with limiting temperature rises to 1.5 degrees Celsius or halving emissions by 2030. Companies who have committed to net zero through SBTi are listed in the organization's target dashboard.[19] As of January 31, 2023, the following companies are all in compliance with the standard and have publicly shared their targets on the SBTi website.

- **Alcatel Submarine Networks**' parent company **Nokia** has committed to reduce absolute scope 1, 2, and 3 emissions by 50% from a 2019 base year.
- **BT Group** plans to reduce their scope 1 and 2 emissions by 87% and all three scopes by 29% from a 2016-17 base year.
- In 2020, **Ciena** set a goal to be carbon neutral across "reported operational emissions by the end of 2023" and are on track to achieve this goal. In 2022, the company submitted near-term science-based targets for scope 1 and 2, and scope 3 emissions for validation.
- Since 2006, **Corning** has reduced the energy intensity of its global fiber and cable manufacturing facilities by over 50%. Corning has committed to reduce absolute scope 1 and 2 GHG emissions 30% by 2028 and absolute scope 3 GHG emissions, covering purchased goods and services, capital goods, fuel- and energy-related activities, and upstream transportation and distribution 17.5% by 2028, both from a 2021 base year. These goals reflect Corning's commitments, which are undergoing the validation process with SBTi.
- From their 2018 data, **Digital Realty** will reduce its scope 1 and 2 emissions 68%. The company's scope 3 emissions include purchased goods and services and fuel- and energy-related activities, and it has committed to reduce this 24% per square foot.
- Based on its 2019 metrics, **Equinix** has committed to reduce its absolute scope 1 and 2 emissions by 50% and its absolute scope 3 emissions from fuel- and energy-related activities by the same percentage by 2030. Equinix's SBTi target also includes an increase in annual sourcing of renewable electricity to 100% by the same year. The company has also agreed to have 66% of its suppliers, by emissions covering purchased goods and services as well as capital goods, committed to science-based targets by 2025.
- **Fugro** has formally committed to reaching net zero by 2035 in both direct and indirect emissions from its operations (scope 1 and scope 2). It has intermediate targets of lowering vessel emission intensity by 20% and sourcing 80% of its electricity from renewable energy, both by 2025. With an extreme low-emission fleet of unmanned surface vessels (USVs) and boats with low or zero emissions anticipated by 2035, this ambitious aim necessitates large multi-year expenditures. Supported by these measures, Fugro was able to reduce its emission intensity of its own vessels by 10% to 13.3 tonnes in 2022 per operational day, compared to 2021.
- **Fujitsu** has committed to reduce scope 1 and 2 emissions 71% and scope 3 emissions 30% from a 2013 base year.

> **Most companies involved in the subsea industry that have adopted the SBTi framework have committed to near-term targets.**

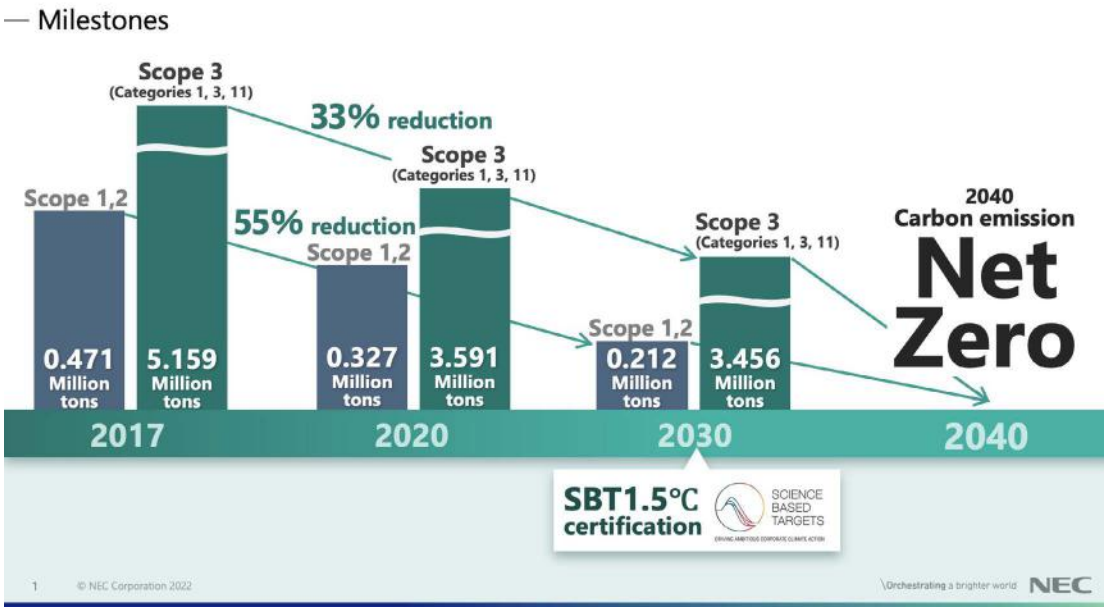

Figure 3. Net Zero Milestones. Graphic by NEC.

- **KDDI** uses 2019 as its base year and has committed to reducing scope 1 and 2 emissions by 50% as well as scope 3 emissions by 14%.
- In order to avoid growth in absolute scope 3 emissions, **Microsoft** has committed to reduce that particular emission type by 30%.
- **NEC Corporation** uses 2017 as its base year and has agreed to reduce scope 1 and 2 emissions by 55% and scope 3 emissions from purchased goods and services, fuel- and energy-related activities, as well as use of sold products by 33%. NEC has signed the Business Ambition for 1.5° (BA1.5°), a SBTi campaign, targeting net-zero CO_2 emissions by 2050.[20] (Figure 3)
- **Nexans** also uses 2019 as its base year for its targets. They will reduce scope 1 and 2 emissions by 46.2% and scope 3 emissions by 24%.
- Unlike other companies with short-term SBTi targets, **Orange** has 2025 goals as well. The company has committed to reduce scope 1 and 2 emissions by 29.6% and scope 3 emissions by 14% from their 2018 data.
- **NTT Group** has committed to reduce its scope 1 and 2 emissions by 80% from a 2018 base year. In addition, the company will reduce absolute scope 3 emissions by 15% within the same timeframe.
- **Telstra** brought its operations to net zero in 2020, certified by Climate Active in Australia. It has committed to reduce its absolute scope 1, 2, and 3 emissions by at least 50% by 2030 from a 2019 base year.
- **Vodafone** has committed to net zero emissions from operations by 2030 and across its value chain by 2040.

The following companies are also listed as committed in the SBTi dashboard, demonstrating their intent to develop targets and submit them for validation within twenty-four months: Globe Telecom, Google, Meta, Telxius, and Tata Communications.

Long-term Targets (2050)

The SBTi also offers support in setting long-term targets. These companies must abide by the Corporate Net-Zero Standards by achieving their targets no later than 2050. Whereas near-term science-based targets require a 95% reduction across scope 1 and 2 emissions, long-term goals must do this as well as reduce scope 3 emissions by 90%. Most companies have set short-term targets because of the difficulty of reducing scope 3 emissions.[21]

Cisco is one company that has set both short- and long-term targets. According to the SBTi's dashboard, the company commits to reach net zero greenhouse gas emissions across the value chain by fiscal year 2040 from a 2019 base year. To do so, it has set near-term targets to reduce scope 1 and 2 emissions 90% by fiscal year 2030, and to reduce scope 3 emissions from purchased goods and services, upstream transportation and distribution, and use of sold products 30% by the same year. Cisco's long-term SBTi target is to reduce all emissions 90% by 2040.

We recommend companies work towards long-term reduction goals in order to ensure that sustainability becomes a foundational facet of their operations.

Climate Pledge and SME Climate Commitment

Beyond the SBTi, the Climate Pledge[22] and the SME Climate Commitment[23] may be relevant for medium and small companies in particular. The Climate Pledge was founded by Amazon and Global Optimism in 2019 and currently has over 400 signatories. Those who commit to the Pledge agree to regular reporting, carbon elimination, and credible offsets. Any offsets must "neutralize any remaining emissions with additional, quantifiable, real, and permanent, and social beneficial offsets to achieve-net zero annual carbon emissions by 2040." The SME Climate Commitment is another global framework that helps small and medium enterprises achieve sustainability targets. The minimum levels of action are: "halving emissions before 2030; achieving net zero emissions before 2050; and disclosing progress every year."[24]

WFN Strategies is a subsea cable consulting company and has committed to targets through the Climate Pledge and the SME Climate Commitment to achieve net zero by 2040.

Other Targets

Other companies have set net zero goals but without the SBTi. Bulk Infrastructure's goal is to achieve net zero emissions across all scopes (1, 2, and 3) by 2050. Additionally, the company has committed to reducing its scope 1 and 2 emissions by 50% and decrease its emission intensity by 30% for scope 3 by 2030. According to their 2022 Sustainability Development Report, Tata Communications is "working towards decarbonisation initiatives to transition towards net zero."[25] Keppel Corporation is setting targets according to SBTi even though the company has not registered with the organization. On October 6, 2021, "the Keppel Corporation announced their commitment to halve the Company's scope 1 and 2 carbon emissions by 2030, compared to 2020 levels."[26] The company has been tracking its scope 3 emissions since 2019 and has committed to working with its supply chain.

Commit to Energy Targets

As part of their emissions accounting and target-setting, many companies have begun to track carbon neutral and renewable energy usage. The most popular formal commitment in this area is the RE100, although companies are also beginning to report the percentage of their operations powered by renewable energy. For example:

- Aqua Comms reported that 42.15% of its energy consumption was from renewable sources (2021).
- Ciena has a goal to use 100% renewable energy in its facilities by the end of 2023, through utility sourced renewables, an on-site solar PV plant at one of its facilities, and renewable energy credits.
- Cisco reported consumption of 1.321 million MWh[27] of renewable electricity, 89% of the company's total global electricity demand (fiscal year 2022).[28]
- As of 2022, around 49% of Fugro's energy consumption was from renewable sources. The company aims to reach 80% renewable energy consumption for its offices and its facilities worldwide by 2025.
- According to Orange's Integrated Report, 37.8% of the company's electricity comes from renewable sources, including grid-connected systems (2022).[29]
- In their Sustainable Development Report, Tata Communications reported that 14% of its electricity is sourced by wind or solar energy, approximately 23,000 MWh of power sourced for both Indian and international operations (2021).[30]
- Telstra has set a target to achieve renewable energy generation equivalent to 100% of its consumption by 2025.

To achieve carbon neutral and renewable energy targets, we recommend a case-by-case evaluation of strategies that may include installing on-site renewable energy, signing power purchasing agreements (PPAs) with renewable energy suppliers, or purchasing Energy Attribute Certificates (EACs) from providers that are geographically proximate—especially from recently installed energy generation projects. Each of these is discussed below.

> **The most popular formal commitment in this area is the RE100.**

RE100

The most popular renewable-energy commitment of companies in the subsea cable industry is the RE100 standard.[31] RE100 is led by the Climate Group and in partnership with the CDP has the goal of scaling zero-carbon grids. Launched in 2014, RE100 has been adopted by many companies worldwide. RE100 stimulates change at the global level through a set of policies that support the sourcing of renewables.[32] This standard defines which energy resources are renewable and requirements for effective use of renewables by market. Because electricity markets vary from country to country, the standard also sets boundaries for targets on renewable energy consumption and calls for third-party verification of renewable energy use. According to their Technical Criteria, wind, solar, geothermal, sustainably sourced biomass, and sustainable hydropower are recognized as renewable energy.[33] Hydrogen and energy storage are not considered renewable energy.

RE100 members:[34]

- BT (joined 2014, target 2020), 100% renewable (2023), 3.32 million MWh (2021)
- Equinix (joined 2016, target 2030), 96% renewable (2022), 7.43 million MWh (2022)
- NEC Corporation (joined 2021, target 2050), 9.5% renewable (2022), 71,714 MWh (2022)
- Nokia (joined 2022, target 2025), 63% renewable (2022), 573,000 MWh (2022)
- Southern Cross Cable Network
- Telefónica (joined 2017, target 2030), 82.3% renewable (2022), 5.03 million MWh (2022)
- Vodafone (joined 2018, target 2025), 75% renewable (2023), 4.72 million MWh

RE100 also has Gold Members who "must show demonstrable and significant progress in aligning their portfolio impacts/financed emissions with a 1.5-degree world."[35] In doing so, they must also demonstrate that they are "phasing out financing of projects/companies involved in coal-fired power and thermal coal mining by 2030 in advanced economies and by 2040 in emerging markets and developing economies."[36]

Gold Members of RE100:

- Fujitsu (joined 2018, target 2050), 20% renewable, 242,000 MWh (2021)
- Google (joined 2015, target 2017), 100% renewable (2023), 18.3 million MWh
- Meta (joined 2016, target 2020), 100% renewable (2023), 9.42 million MWh (2021)
- Microsoft (joined 2015, target 2014), 100% renewable (2023), 18.2 million MWh (2022)
- Nexans (joined 2020, target 2030), 19.2% renewable (2021), 211,731 MWh (2021)

> **"RE100 also has Gold Members who must show demonstrable and significant progress in aligning their portfolio impacts/financed emissions with a 1.5-degree world."**

Energy Attribute Certificate (EAC)

Energy Attribute Certificates (EACs) are the tradeable, market-based, legal documents that companies use to claim any use of renewable energy. An indication of how, when, and where energy was generated, EACs are needed to verify that end-users are consuming renewable energy, since electric grids do not trace the location of an electron as it travels from source to user. They function as contractual instruments with information about the way the electricity has been (or will be) produced, including from hydropower, wind power, or solar. EACs also convey information about where the energy was produced and the amount of electricity produced in megawatt hours of renewable electricity. EACs are then sold by renewable energy producers to companies that can then claim "use" of this energy, regardless of whether the source is on-site, off-site, or in a completely different region.

EACs are convenient and cost-effective solutions to achieve climate goals and reduce a company's energy-related carbon footprint. One of their benefits is that they provide a standard that allows these documents to be traded.[37] Only the person or entity that "cancels" or "retires" the certificate can claim the usage of that specific MWh, and this system applies to EACs worldwide. Investments in EACs boost the renewable energy market by demonstrating an increasing demand for these resources.[38] Their biggest benefit is that companies of any size can purchase certificates in locations where renewable targets are most significant for business, particularly where on-site renewables or PPAs are not practical.

While there are many benefits to EACs, there are also some setbacks. EACs come in two forms: bundled and unbundled. Bundled EACs are sold together with the energy associated with them, whereas unbundled EACs are separated from the physical electricity they represent.[39] Corporations can buy unbundled EACs in one area of the country and apply it to their own energy usage in a different area of the country, which makes the environmental impact difficult to assess. Although unbundled EACs will count towards emissions reductions, they are not a strong driver of decarbonization. Some regional markets with high rates of renewable deployment (like wind power in Texas) are oversaturated with EACs, which trade for low prices far beyond the region. Access to these cheap EACs may result in companies continuing to use high-carbon electricity in other regions, reducing industry pressure for a transition to lower-carbon energy, while claiming to be powered by 100% renewables on paper.

EAC
Energy Attribute Certificate

> **Electricity providers are beginning to offer additional ways for customers to purchase renewable energy and receive EACs in return.**

Bundled EACs, conversely, can help accelerate the clean energy transition. Advanced contracts for EACs are often used by renewable energy companies as a means of financing new projects in the same region as purchasers. The 'additionality' (whether or not a purchase can be said to make a meaningful change to the overall trajectory of the energy sector) of bundled EACs is therefore far more secure. For more sustainable and long-term environmental investments, companies can also consider combining bundled EACs with power purchase agreements (PPAs), described in the next section.

EACs are sometimes confused with carbon offsets, which are discussed later in this report. Broadly speaking, these energy certificates are used to address scope 2 emissions, or those indirect emissions associated with purchased electricity. Offsets, on the other hand, are measured in metric tonnes of CO_2 or CO_2 equivalents and are sourced from projects that avoid or reduce GHG emissions. They can be used to reduce any scope of emissions from an organization's calculations, as a net adjustment. The basic difference is that EACs don't require additionality test requirements, and offsets do require them, as each project is tested for this factor to ensure it is beyond standard operations. This heightens the impact of purchasing bundled EACs.

There are several companies that have invested in EACs. Ciena purchased RECs (a type of EAC) to compensate for approximately 50% of its 2021 site energy usage.[40] Although the vast majority of its renewable energy comes from bundled EACs, Equinix purchases unbundled EACs when the former are not an option. Fujitsu's Finland offices have been using 100% renewable energy from hydroelectric power since 2014 through EACs.[41] KDDI is switching to renewable energy sources for electricity using EACs.[42] Microsoft uses RECs to achieve 100% renewable energy for its data centers.[43]

Power Purchase Agreement (PPA)

Purchase Power Agreements (PPAs) are one of the most common ways for a company to acquire EACs and claim use of renewable energy. A PPA is a contract for the purchase of power and associated EACs from a specific renewable energy generator. The PPA encompasses the amount of electricity to be supplied, negotiated prices, accounting, and penalties for non-compliance. This agreement may be appealing for producers and customers who are looking to finance or stabilize long-term power delivery.[44] There are many advantages to physical PPAs including potential electricity cost savings with no upfront costs, long-term electricity cost stability and predictability, and purchasing large volumes of electricity in a single transaction. In addition, the customer can engage directly with a specific energy project and negotiate the specific terms of the contract. However, PPAs are largely restricted to customers in competitive electricity markets, require a long-term contract, and limited to customers with large electricity loads and investment-grade credit. PPAs can be concluded by a consuming company through corporate PPAs or with an electricity trader who purchases the electricity produced through merchant PPAs. Corporations have also begun investing in PPAs to hedge against volatile electricity prices, locking in steady rates. Corporate PPAs come in four forms: off-site, synthetic/financial, sleeved, and on-site.

Off-site PPAs are an alternative to a direct or on-site PPA. The major difference between the two is that the renewable energy project does not need to be in the same region as the customer. There is still a contract reached between a power supplier and a customer, but there is no physical delivery of the power generated. Off-site Power Purchase Agreements can come in two forms: synthetic/financial or sleeved/green tariff.[45] Synthetic PPAs separate the physical flow of electricity from its financial flow, which allows for greater flexibility in contracts. Corning has signed virtual PPAs for solar projects in the US and Taiwan, adding 126 MW defined conditions of capacity to their renewable energy portfolio.[46] Nexans has also begun executing a pan-European virtual PPA that will not only help finance and realize new renewable energy assets but also cover the electricity consumption for all its premises in Europe.[47]

Electricity providers are beginning to offer additional ways for customers to purchase renewable energy and receive EACs in return. These often come in the form of sleeved PPAs or green tariffs. Large companies can negotiate a long-term contract with utility companies for green power. In these agreements, utility companies establish a PPA with a renewable energy project and provide the EACs to their customers. When cable landing station campus New Jersey Fiber Exchange (NJFX) realized that its electricity provider offered a carbon neutral option, the company opted to go-green, and sign up for a multi-year contract. Small companies can inquire with the utility providers to see if there are green sources of electricity available. Meta also works with utility companies to set up green tariffs that support over 4,000 MW of new wind and solar capacity projects.[48]

Many companies in the telecommunications and digital infrastructure sector industries have off-site PPAs as their source of EACs. Many of Ciena's offices in the U.S., UK, and Australia receive utility-sourced renewable energy, and they buy RECs to reach their 100% renewable energy goal.[49] Digital Realty uses 100% renewable energy from wind, solar, and hydro sources for their colocation business and European portfolio, 910 MW of which comes from contracted solar and wind power.[50]

Equinix has seen a 160% increase in PPAs under long-term contract since 2021, which has helped the company reach 96% of renewable energy coverage for overhead infrastructure and customer IT load.[51] Currently, 223 sites are 100% covered by RE, as the company uses different types of EACs from around the world.[52] Five new solar projects in FY23Q1, in addition to the company's most recent PPA project in FY23Q2, will bring Equinix's contracted PPA capacity to 715 MW globally.[53]

Over the past few years, Cisco has made significant strides to execute numerous, longer-term renewable energy contracts like PPAs and utility green power contracts that have stronger additionality claims than unbundled RECs.[54] These contracts now deliver more than 300,000 MWh per year of renewable energy for Cisco.

To source renewable energy from wind, Fujitsu Australia has signed a PPA that will provide around 40% of its NSW data center load, or 30% of its annual Australian consumption.[55] Google has signed PPAs since 2010, first for 114 MW of power from a wind project in Iowa.[56] Since early 2023, Google has acquired over 9000 MW of renewable energy through PPAs. Microsoft has signed PPAs that will contribute to bringing more than 10,000 megawatts of new renewable energy capacity online.[57] Orange has also invested in PPAs for years, particularly for solar energy projects. In 2021, the Group signed for a total capacity of 500,000 MWh/year, 10% of Orange's annual electricity consumption in France, 9% in Poland and 50% in Spain. As of 2022, 100% of energy used by Orange in Spain now comes from renewable sources thanks to PPAs.[58] Telstra has signed PPAs for one of the largest onshore wind farms in the world, which will provide 350,000 MWh per annum of energy.[59]

Figure 4. Fugro Singapore facility, newly equipped with solar panels in 2023. Photo by Fugro.

On-site Renewable Installations

A third option for the adoption of renewable energy is the direct construction of on-site or off-site solar (or less frequently, wind), although it is important to mention that manufacture and installation of renewable energy still carries a critical carbon cost. Many companies have invested in on-site power for their offices. Ciena's offices and labs in Gurugram, India are powered in part by solar PV panels.[60] Corning has also invested significantly in on-site solar power.[61] Its location based in Pune, India, was the first to use solar in 2014, and the Vineland, NJ site has 11,300 panels totaling about 2.8 MW. Panels in Gqeberha, South Africa are used to heat water around the company's plant. Beyond purchasing energy, Equinix has on-site solar projects, fuel cells, and other low-carbon technology.[62] In late 2022, Equinix deployed its largest solar project to date in Australia with a capacity of 1 MW. Overall, Equinix's existing on-site solar capacity has grown to 4.4 MW globally in 2022.

Fujitsu also uses on-site solar and batteries.[63] Their UK and Ireland offices have PV systems installed on the roofs of their buildings, and they developed technology to optimize battery usage to effectively use solar power. At their Consulting India Private Limited facilities in India, solar panels were also installed with a capacity of 0.35 MW from 2019. Cisco has 1.2 MW of onsite solar systems in Texas, North Carolina, and India that produce about 1.4 million kWh of electricity and avoid approximately 750 metric tonnes CO_2e a year.[64]

NTT Group has developed a policy for promoting solar energy. Many of NTT Group's facilities have solar panels, whose specifications can be found on the company's website.[65] Many Nexans facilities have deployed renewable energy: solar panels in Cortaillod, Switzerland, solar heating in Suzhou, China, wind power in Buizingen, Belgium, and photovoltaic panels in Lebanon.[66] Orange produces its own energy through solar panels[67] and is also opening its first solar farm.[68]

On-site renewable installations can also involve PPAs. In such agreements, there is a direct physical supply of electricity to a facility, which requires the physical proximity of a power plant and the customer. The power generation plant is located behind the metering point of the consumer, often being at the same location.

Our discussion of EACs, PPAs, and on-site installations are broadly relevant across corporate operations. Later in the report we describe specific renewably-powered subsea cable infrastructure, covering the key contributions of the following companies:

Manufacturing Facilities:

- Alcatel Submarine Networks
- Corning
- Hexatronic
- NEC

Cable Landing Station and Dry Plant:

- Alcatel Submarine Networks
- Aqua Comms
- BT
- Bulk Infrastructure
- Equinix
- HMB-IX
- NJFX
- Telecom Egypt

Carbon Offsets

Offset or Remove Emissions

Carbon Offsets

One option to meet CO_2 targets has been to offset emissions. Carbon offsets describe reductions in GHG emissions used to compensate for emissions that occur elsewhere. Offsets are used to address both direct and indirect GHG emissions through additional, external projects that are then verified for global emissions reduction. Offsets are used to subtract from a company's emissions to calculate net organizational emissions. This approach to achieving net zero offers financial benefits when compared to other strategies. For example, companies can purchase a carbon offset from a region that is more affordable when investing in sustainable technologies that are expensive. After a project is completed, these offsets can be sold.

> **Offsets are used to address both direct and indirect GHG emissions through additional, external projects that are then verified for global emissions reduction.**

Ciena has committed to being carbon neutral by 2024 across certain scope 1, 2, and 3 operational emissions that include contract manufacturing, upstream transportation and distribution, waste, business travel, and employee commuting. Ciena has invested in renewable energy and as of 2021, is no longer purchasing carbon offsets for scope 2 emissions. In 2021, emissions within the boundaries of Ciena's carbon neutrality goal were 51,040 metric tonnes CO_2e. Of those emissions, 41,107 metric tonnes of CO_2e were offset from scope 1 and 3 relating to natural gas, rental cars, commuting, and certain manufacturing and logistics emissions.

To achieve carbon neutrality, Google has invested in a range of offset projects since 2007.[69] Google only partners with what they call "high quality offsets," as determined by an internal review process. According to Google's standards, a high quality offset is one that provides additionality, or a project that wouldn't reduce emissions without Google's investment, prevents leakage or shifting emissions to another location or activity, and are verifiable and contribute to ongoing, permanent emissions reductions. To date, Google has invested in landfill gas capture from decomposing waste, agricultural methane capture from farms, and forestry projects around the world.

Tata Communications also offsets their emissions through afforestation projects. To ensure that its investments have a substantial impact, the company has kept their offsets local. Beyond planting over 125,000 fruit saplings, Tata Communications has also distributed efficient cookstoves in rural areas like Jharkhand, Orissa, Meghalaya, and Maharashtra in order to consume less wood and reduce smoke. According to their 2022 sustainability report, these cookstoves will offset 9,945 tonnes of CO_2 every year, starting from 2023. Both of these projects together will have the potential to offset around 41,000 tonnes of CO_2 in FY 2029-30.[70]

> **Because offset projects are difficult to verify for durability and reliability, it is important that companies use accredited carbon offsets when choosing this option or set high standards for offset reductions.**

A number of companies buy offsets strategically to target specific company activities or emissions targets. Southern Cross Cable Network has made it company policy to offset all emissions produced by company travel through carbon offset credits. Telstra has purchased over two million carbon offset credits from a variety of global offset projects, including projects that support biodiversity and forest fire management projects. Like Google, Telstra's evaluation of carbon offset programs follows guidelines, in this case set by the Australian government's Climate Active plan.

Red Penguin Marine, a subsea cable consultant, committed to offsetting its CO_2 emissions beginning in 2023. The company has begun to undertake extensive research on potential organizations with whom to partner, including a local oyster restoration project, Project Seagrass.

We have begun to see the introduction of offsets into some regulation. For example, the California Air Resources Board requires developments at the state level to do air quality analysis and to calculate GHG emissions. It requires offsets of emissions for some developments. HMB-IX, a cable landing station in California, goes above the required level of offsetting.

Carbon offsetting is an intermediary step, and not always an effective long-term solution, for several reasons.[71] First, the amount of CO_2 that is being offset is not always calculated accurately. Because carbon offsets require detailed accounting, the environmental benefits are not always as effective as initially calculated.[72] Many times, offsets can overcompensate for emissions reductions, and afforestation projects can go awry.[73] This approach may also prevent companies from making long-term investments and significant changes internally. Finally, the difference in emissions may not have the same impact across regions. For example, investing in reforestation in one country may not have the same impact as reduction efforts have in another.

To address these problems with offsetting, many companies have high standards and guidelines for their investments. Teléfonica, for example, will only use carbon offsets if the projects reduce emissions in ways that would not be possible through other means, have a long term impact, and are certified according to national and international standards. Most importantly, Teléfonica prioritizes investments in regions where the company is present.[74] Because offset projects are difficult to verify for durability and reliability, it is important that companies use accredited carbon offsets when choosing this option or set high standards for offset reductions.

Carbon Removal

Beyond purchasing offsets, companies can take a step further and invest in carbon removal projects. Carbon removal only accounts for the physical subtraction of existing CO_2 in the atmosphere by storing it or by implementing carbon capture technologies.[75] Carbon offsetting projects and carbon removal projects can involve the same practices, including planting new forests, increasing the amount of carbon stored in soil, and building machines that can suck carbon dioxide out of the atmosphere.[76] However, carbon removal projects account for durability and reliability. For example, using a carbon storage practice one year and then plowing fields regularly the next does not achieve long-term change. Furthermore, afforestation projects do not sequester carbon forever, as mature forests reach an equilibrium state after some time. In other words, carbon removals guarantee investors a time-based solution, which more accurately accounts for its mitigation effects.

Meta has invested in a number of carbon removal projects and reports that it has applied 90,000 tonnes of carbon removal credits to its overall carbon accounting.[77] Meta's carbon removal projects have supported forests and soil health to improve natural carbon sequestration in places like Kenya, Mexico, and India. Keppel Corporation has made it a priority to invest in carbon capture and sequestration technologies and techniques as part of its plan to halve its carbon emissions by the end of this decade.[78]

Microsoft is spearheading one of the largest carbon removal projects through its endeavor to be carbon negative by 2030.[79] It plans to deploy $1 billion of its capital in a Climate Innovation Fund for carbon reduction and removal technology.[80] In 2022, Microsoft announced a partnership with CarbonCapture, a company developing Direct Air Capture (DAC) machinery, to support "Project Bison," a new DAC project in Wyoming aimed at permanently removing and storing five million metric tonnes of CO_2 from the atmosphere per year.[81] In addition, Microsoft invests in more standard removal projects[82] focused on restoring ecological carbon sequestration and claims to have acquired "1.4 million tonnes of carbon removal" from various sources.[83]

Companies don't need to be as large as Microsoft or Meta to participate in carbon removal projects. Shopify's Sustainability Fund offers suggestions for carbon removal projects that are simpler and less-time consuming.[84] Its carbon removal buyer guide is a useful resource for learning how to get buy-in from internal stakeholders, construct a portfolio, and retire the credits that have been received.[85] Broadly speaking, Shopify's Sustainability Fund recommends companies diversify purchases to mitigate the risks that come with these investments. In addition, carbon removal projects should find the appropriate combination of local impact and carbon credibility in order to maximize reliability. Shopify offers a spreadsheet as a model for monitoring progress.[86]

We have not found carbon offsetting or carbon removal to be widespread practices across the subsea cable industry. We recommend that companies make the distinction between offset and removal projects when making mitigation investments and to verify projects prior to investment.

> Standards offer frameworks for companies to internally assess and improve their sustainability initiatives.

Meet Standards and Obtain Certifications

Meeting standards and obtaining certifications add credibility to a company's products or services and demonstrates that it meets certain levels of environmental management and sustainable practice. Standards also offer frameworks for companies to internally assess and improve their sustainability initiatives.

Below we discuss some major standards relevant to the subsea cable industry, the most widespread and significant of which are run by the International Organization for Standardization (ISO) and augment the United Nations Sustainable Development Goals.

Some standards and certifications relevant to the subsea cable industry

ISO 14001: Environmental Management

The ISO 14000 is a series of standards that offer guidelines for systematizing and improving environmental management efforts. The standards specify requirements to establish an environmental management policy, determine environmental impacts of products or services, plan environmental objectives, implement programs to meet objectives, and conduct corrective action and management review. The ISO 14001 is the most popular of the ISO 14000 group, which also include sustainable standards for water, material circulation, environmental reports, and Life Cycle Assessments.[87]

Last reviewed and confirmed in 2021, the primary aim of the ISO 14001 standard is to make the environment and sustainability a fundamental pillar of a company's objectives.[88] Specifically, it helps organizations manage, monitor, and control their environmental dimensions holistically. This means that a company must consider all environmental issues relevant to its operations, such as air pollution, water and sewage issues, waste management, soil contamination, climate change mitigation and adaptation, and resource use and efficiency. According to the ISO's Introduction to the ISO 14001:2015, the most recent revision pushes for an increased prominence of environmental management within an organization's strategic planning processes, greater input from leadership, and a stronger commitment to proactive initiatives that boost environmental performance.[89] Any organization can adopt this standard, regardless of size, type, and nature. Companies may apply the standard to any particular part of their operations, but in order to comply with ISO 14001, all of the above requirements must be incorporated into the company's strategy. The ISO also offers a practical guide for SMEs to implement ISO 14001 successfully.[90]

ISO 14001 is the most popular environmental standard in the subsea cable industry. Its adopters include the consultants Red Penguin Marine and WFN Strategies; marine operators such as E-marine, EGS Survey, Global Marine, and Orange Marine; cable owners and landing station operators such as BT Group and Globe Telecom; equipment manufacturers such as Ciena; and recovery and recycling companies such as Mertech Marine and Subsea Environmental Services. Hexatronic is not only certified, but requires its suppliers to be ISO 14001 certified as well in order to secure the consistency of its products and service quality. Other companies with this certification are: A-2-Sea, Cisco, Corning, Fujitsu, GlobeNet, Indigo TG, Infinera, Keppel Corporation, KDDI, Microsoft, Nexans, Telstra, Tata Communications, and Vodafone.

In explaining its decision to pursue this certification, Alcatel Submarine Networks (ASN) states that the company is "committed in environmental matters to offer for the next generation a greener world. To support us in this approach, the ISO 14001 standard for Environmental Management Systems allows us to develop a robust environmental management system we are continuously improving." ASN credits the system with achieving strategic business aims and providing a competitive advantage through improved efficiencies and reduced costs. Marine operator Fugro has likewise cited that ISO 14001 has provided "objectives and practical tools to manage the company's environmental responsibilities."

Operators of cable landing stations have also pursued certification for their facilities. Telxius has implemented an Environmental Management System certified under the ISO 14001 standard which covers all the company's processes globally. In addition to this, it has several cable landing stations certified under ISO 14001: Rio de Janeiro and Fortaleza (Brazil); Virginia Beach, Boca Raton, and Jacksonville (USA); and the Derio Communications Hub, Bilbao (Spain). Equinix has also implemented ISO 14001 at some of its data centers where subsea cables terminate as well as being certified in all EMEA sites and is in the process of global ISO certification. These include Equinix PE2 (Shenton Park, WA, Australia); SY4 (Alexandria, Sydney, AU); LS 1 (Prior Velho, Lisbon, PT); MC1 (Murayjat, Oman); LD4 (Slough, GB, UK); and MI3 (Boca Raton, FL, USA). Bulk Infrastructure has also sought out ISO 14001 certification, and has obtained certification for its data centers operations in Oslo and Kristiansand in Norway, and Esbjerg in Denmark.

ISO 50001: Energy Management

The ISO 50001 standard provides a framework for organizations to achieve efficient energy use, fix targets and objectives to meet the policy, use data to better understand and make decisions about energy use, measure results, and review how well the policy works.[91] Based on a model of continual improvement, this standard makes it easier for organizations to integrate energy concerns into their overall efforts in quality and environmental management.[92] It offers a guide for organizations to adopt the standard.[93] The ISO 50001 certification has been used to improve the energy management of many companies, including BT Group, Equinix, Fugro, Fujitsu, Globe Telecom, Google, Keppel Data Centers, Meta, and Microsoft.

> **"The ISO 14001 standard for Environmental Management Systems allows us to develop a robust environmental management system we are continuously improving."**
>
> –Alcatel Submarine Networks

ISO 9001

ISO 9001: Quality Management

The ISO 9001 standard specifies requirements for a quality management system (QMS).[94] Organizations that take up the standard must demonstrate the ability to consistently provide products and services that meet customer and regulatory requirements. The focus of this standard is to reinforce quality management principles such as a strong customer focus, motivation of top management, as well as process approaches and continual development. Companies that use the ISO 9001 standard are required to document planning and process interactions. They must manage all resources, including human resources and the work environment. Corrective and preventive action activities such as internal audits are encouraged.

> **ISO 9001 recognizes the importance of leadership in creating high quality products, which can incentivize organizations to demonstrate a commitment to sustainability and communicate this priority as part of the company culture.**

Although ISO 9001 is a quality management system rather than an environmental management system, establishing this standard can further sustainable efforts that are aligned with ISO 14001. The 9001 standard focuses on disciplined problem solving, continual development, and enhancing customer satisfaction.[95] Because the focus of ISO 9001 is on customer needs and customers increasingly want to engage with environmentally conscious organizations, having this certification pushes companies to create, repair, reuse, and recycle better quality and longer lasting products.[96] When the standard went under revision in 2015, the 9001 introduced a new clause, "context of the organization," which requires companies to consider internal and external issues, like environment and sustainability, that can impact objects and quality. Most importantly, ISO 9001 recognizes the importance of leadership in creating high quality products, which can incentivize organizations to demonstrate a commitment to sustainability and communicate this priority as part of the company culture.

This standard is one of the most popular in the sector, and has been taken up by the following companies: A-2-Sea, Alcatel Submarine Networks Norway, BT Group, Bulk Infrastructure, Ciena, Cisco, Corning, EllaLink, E-marine, Equinix, Fugro, Fujitsu, Google, Global Marine, Globe Telecom, Indigo TG, Infinera, Keppel Data Centers, Makai Ocean Engineering, Microsoft, Mertech Marine, NEC, Orange Marine, Pioneer Consulting, Red Penguin Marine, Subsea Environmental Services, Tata Communications, Telstra, Vodafone, WFN Strategies, and Xtera. To ensure that their product and service quality are consistent, Hexatronic requires its suppliers to be ISO 9001 certified as it is.

TL 9000: Telecom Quality Management System

TL 9000 defines the telecommunications quality system requirements for the design, development, production, delivery, installation, and maintenance of products and services.[97] The TL 9000 helps to protect the integrity and use of information and communications technology (ICT) hardware, software and services, as well as define effective cost and performance-based measurements to guide progress and evaluate the results of quality management system implementation. Established in 1998 by the QuEST Forum, one of the benefits of the TL 9000 is that it is based on the ISO 9001 standard, but it is specifically tailored to the ICT industry.

The TL 9000 is a two-part quality system that accounts for both management and measurement. All companies that seek to be TL 9000 certified must meet the requirements of the ISO 9001. The TL 9000 supplements the ISO standard by ensuring that 1) performance measurements are based on reliability of product, 2) software development and life-cycle management are taken into consideration, 3) specialized service functions such as installation and engineering are required, 4) communications between customers and suppliers are thorough, and 5) companies report quality measurement data to a central repository. TL 9000 certified organizations must comply with ICT-specific requirements.

Certified under TL 9000 are the Alcatel Submarine Networks offices in Paris-Saclay, Calais, and Greenwich, Ciena, Cisco, Corning, Fujitsu, Infinera, NEC, NTT, and Tata Communications. A full list of TL 9000 certified organizations is available on their website.[98]

Notably, the TIA QuEST Forum has a Sustainability Working Group composed of companies that prioritize sustainability and corporate social responsibility, which clarifies "various [standards] requirements with regards to sustainability."[99] For participants who manage a supply chain, the group helps to identify and share best practices in corporate and supply chain performance related to sustainability. The most recent TL 9000 handbook,[100] revised in October 2021, contains input from the Sustainability Working Group to clarify requirements with regards to this effort.[101] One of its significant changes was in operational planning and control, where it requires life cycle models to take into consideration "improved energy performance and resource consumption, ecologically responsible disposal, and proper end-of-life treatment." Furthermore, it recommends that sustainability be considered when selecting external providers and results from sustainability assessments should be considered during management review.

The TIA QuEST Forum has also developed a Sustainability Assessment Model.[102] This tool allows companies to self-assess and benchmark their sustainability and corporate social responsibility programs with industry best practices. Through this model, companies can receive feedback along with a prioritized set of recommendations for improvement.

TL 9000

EcoCable

EcoCable

While not developed specifically for the subsea cable industry, the Prysmian Group's EcoCable certification, "the first green label in the cable industry," is an interesting example of certification of an individual cable product.[103] Overall, this certification uses a set of criteria to measure and assess how much the Prysmian Group's cables contribute to climate change. In order to qualify for the label, cables must pass an assessment based on the following criteria: carbon footprint, substances of very high concern, recyclability and circularity, recycling input rate, environmental benefits, and cable transmission efficiency. Notably, the carbon footprint must be calculated according to a "cradle-to-gate" approach for a holistic accounting of emissions. The EcoCable label, however, remains an internal standard for cable systems managed by the Prysmian Group.

Leadership in Energy and Environmental Design (LEED)

Established by the United States Building Council, the Leadership in Energy and Environmental Design is the most widely used green building rating system in the world. Its framework for sustainable buildings focuses on health, efficiency, carbon, and cost-saving and is in line with the UN's Sustainable Development Goals.[104] Building projects that seek LEED certification do so by a point-based system which measures how a company addresses carbon, energy, water, waste, transportation, materials, health, and indoor environmental quality. The projects are verified and evaluated by Green Business Certification, Inc., an independent organization that supports credentialing.[105] Once the points are calculated, a project receives a level of certification: Certified (40-49 points), Silver (50-59 points), Gold (60-79 points) and Platinum (80+ points).

LEED is available for all types of projects including new construction, interior fit outs, operations and maintenance, and core and shell.[106] In the latest update to its standards, LEED v4.1, the organization strives to ensure that sustainability is addressed at all scales. For example, it now ensures that all building stakeholders benefit from sustainable design, construction, operations, and performance.[107] LEED also offers economic benefits by providing companies with a higher resale value and lower operational costs for its facilities, along with the achievement of ESG and decarbonization goals. According to a study on quantifying the comprehensive greenhouse gas co-benefits of green buildings, LEED standardized buildings contribute to 50% fewer GHGs than conventionally constructed buildings due to water consumption, 48% fewer GHGs due to solid waste and 5% fewer GHGs due to transportation.[108]

Cables land in several LEED-certified Equinix data centers. In the United States, this includes Equinix's LA4 in California (landing point for the Curie and PLCN cables). In Asia-Pacific, this includes SY4, located in Sydney, Australia (landing point for Hawaiki and Japan Guam Australia South). Beyond cable landing sites, companies including Keppel Networks, Meta, Microsoft, and NTT have data centers and office buildings that meet LEED criteria. Fugro's TechCentre facility has received a LEED rating, and Cisco's and Google's commercial buildings have been evaluated by the organization. Ciena complies with LEED standards for their facilities, where possible. Other companies including Nokia, Corning, Orange, and Tata Communications own LEED-certified facilities. A full list of certified projects can be found on the LEED website.[109]

Energy Star Certification

Some standards are specifically designed for a given country or geographic region. Energy Star is the United States government-supported symbol for energy efficiency. Administered by the U.S. Environmental Protection Agency (EPA) since 1992, the program has saved 5 trillion kilowatt-hours of electricity, avoided more than $500 billion in energy costs, and achieved 4 billion metric tons of greenhouse gas reductions.[110] While household appliances are typically what receive the Energy Star label, commercial buildings, industrial plants, and organizations are also eligible to apply.

In order to receive the label, a building must meet performance standards set by the EPA.[111] Like the LEED certification, this standard is awarded according to a point-based system, where a score of 75 or higher on a 100 point scale indicates that it performs better than 75% of buildings worldwide. Points are determined according to actual, measured energy use of a building and calculated by the EPA's Energy Star Portfolio Manager tool.[112] The score accounts for operating conditions, regional weather data, and other important considerations.[113] Buildings must be recertified every year to ensure that they maintain their performance. Industrial plants are given the label through a similar point-based process.[114] Energy Star certified buildings emit, on average, 35% fewer greenhouse gasses than those without certification.[115] Starting in 2024, existing commercial buildings that are both energy efficient and low carbon can apply for the Energy Star NextGen Certification.[116]

Energy Star is not a widely used certification in the subsea cable industry, although Equinix's LA4 facility in California (landing point for the Curie and PLCN cables) is certified. Corning Incorporated has been named an Energy Star Partner of the Year by the EPA for the 10th consecutive year, an award that highlights the effectiveness of the company's energy management programs. The following companies also have Energy Star certified facilities, though these are largely data centers and office buildings: Digital Realty, Google, Meta, Microsoft, and NTT. A full list of certified buildings and plants can be found on the Energy Star website.[117]

> **In order to receive the label, a building must meet performance standards set by the EPA.**

Green Data Center

SS 564: Green Data Center

While applicable to data centers rather than cable landing stations, the SS564 standard provides an interesting model for the subsea cable industry. Since 2013, Singapore has offered this label, modeled on the ISO 50001 standard, to green data centers. Developed by the IT Standards Committee (ITSC), Infocomm Development Authority of Singapore (IDA), and SPRING Singapore, it focuses on energy and environmental management systems.[118] Through the framework, companies can mitigate the risk of energy waste and optimize energy efficiency. Although it is only focused on data centers, the standard also helps with the implementation of best practices for IT equipment, design, and mechanical and electrical systems. Having a common benchmark allows the data center industry to track performance and improvements, ultimately reducing the cost of operations and demonstrating sustainability investments to their customers. Equinix, Digital Realty, and Keppel Data Centers are the three companies that have complied with SS564 for their data centers.

BCA-IMDA Green Mark for Data Centres Scheme

Another instructive Singapore-specific standard for data centers is the BCA-IMDA Green Mark for Data Centres. Established by the government's Infocomm Media Development Authority,[119] the agency responsible for the city-state's digital transformation efforts, and the Building and Construction Authority, the scheme provides recognition to data center operators that have employed sustainable practices.[120] The Green Mark is a rating system that helps data centers measure their "degree of greenness" relative to their competitors.[121] By providing data centers with categories such as Platinum, Gold, and GoldPLUS, the government incentivizes companies to improve their performance, reduce operating costs, and improve corporate branding. Green Mark data centers are evaluated based on energy efficiency, water efficiency, sustainable construction and management, indoor environmental quality, and other sustainability features. The criteria differ for new data centers and existing data centers.[122] Certified data centers include Equinix SG2 (existing, Platinum awarded 2017); Keppel T-27 (new; Platinum awarded 2013); and Equinix SG1 (existing, Certified awarded 2013).[123]

> **The Green Mark is a rating system that helps data centers measure their "degree of greenness".**

> **Green Marine is an initiative founded in 2007 to foster the improvement of environmental performance for the maritime transportation industry.**

Green Marine Europe

Green Marine is an initiative founded in 2007 to foster the improvement of environmental performance for the maritime transportation industry.[124] Green Marine's certification program was first targeted for Canadian and U.S. companies, but with heightened interest, it expanded its program to include Europe. In 2019, the organization partnered with Surfrider Foundation Europe to establish a French environmental program that eventually became Green Marine Europe.[125] Both the North American and European certification use the same proven model: a collaborative approach that emphasizes team and structure.

Green Marine offers a framework for maritime companies to benchmark and reduce their environmental footprint. It has eight performance indicators, ranging from waste management to underwater noise.[126] Of most relevance for the subsea cable industry's sustainability efforts is the greenhouse gas emissions performance indicator.[127] The criteria in Green Marine's assessment include: monitoring of regulations (Level 1); implementing basic policies and strategies to minimize emissions (Level 2); inventorying GHG emissions and developing a decarbonization plan (Level 3); and achieving an annual average reduction in GHG emissions (Levels 4 & 5).

Companies must self-evaluate every year and consult an external verification every two years. The results of these verifications are publicly shared at Green Marine's annual conference and published on Green Marine's website under its participants profile and its results page.[128] In order to encourage increased sustainability, participants must demonstrate continual improvement for at least one indicator until all indicators have basic policies and strategies in place.

In 2020, Orange Marine obtained certification based on the seven indicators of performance, going above and beyond the environmental regulations in place. As of 2021, Orange Marine has achieved Level 2 in the Greenhouse Gas Emissions indicator and Level 3 in the Pollutant Air Emissions indicators (concerning NOx, SOx and PM). In 2023, Louis Dreyfus Armateurs, the company that manages Alcatel Submarine Networks' fleet, will be certified under the Green Marine program.

Sustainable Design and Manufacturing

Cable design, manufacturing, and supply is a difficult area to assess specific sustainability data and information. The exact composition of cable materials is generally confidential since it can be used to calculate the cost of a cable. Although cable manufacturing is limited to only a few companies, these suppliers generally modify cable design to meet the specific needs of individual subsea cable systems, including the amount of strength and armoring. From the supplier's perspective, if customers were to ask for different cable compositions—including less carbon-intensive designs—they would be interested in meeting this demand.

While sustainable cable design—aside from energy efficiency—is not yet in high demand from subsea cable customers, suppliers have been doing many things to improve the sustainability of their own operations as well as the systems they are building. This includes connecting their facilities to carbon neutral and renewable energy; developing energy efficiency strategies at their facilities; and advancing eco-design.

Connect Facilities to Carbon Neutral and Renewable Energy

There are several cable manufacturing facilities around the world that are powered by carbon-neutral or renewable power. Alcatel Submarine Networks' site in Calais is equipped with a surface of 1781 m^2 of solar panels, inaugurated in October 2022. It has also begun roof studies for an installation on its Greenwich site. Cable supplier NEC has solar installations across its network of facilities, including its head office building, data centers, and factories. It has installed a 0.5-MW solar power plant at the Ōtsuki Repeater/Branching Unit Factory and also has renewable energy at its OCC Cable Factory in Kita Kyushu. Both ASN and NEC have committed to purchasing green electricity in addition to these installations. The Hudiksvall plant of cable manufacturer Hexatronic is powered by 100% renewable energy from hydropower.

Corning, a supplier of optical fiber, has conducted life cycle assessments (LCA) for major products. Corning's LCA study for optical fiber confirmed that the electricity required in manufacturing is the main source of impact, contributing 70-80% to the overall carbon footprint. As a result, the value of continued energy efficiency efforts and a greener electricity mix is clear and being pursued by Corning. Since 2006, the company has reduced the energy intensity of its global fiber and cable manufacturing facilities by over 50%, including the facilities used to manufacture optical fibers for subsea cables. Corning is also on a path to 100% renewable electricity in the next four to six years in the United States and Europe, where most of its optical fiber is manufactured. This transition to renewable electricity can decrease the carbon footprint by up to 70%, as demonstrated by their LCA.

Make Facilities Energy Efficient

Some suppliers have made extensive energy efficiency upgrades at their facilities. NEC has undertaken LED light replacements, renewed its air-conditioning systems, and made upgrades in the electrical substation at their OCC cable factory. In its Ōtsuki Repeater/Branching Unit Factory, the company has installed energy efficiency equipment (chiller, LED, compressor, heat insulating material) and shifted CFCs in cooling equipment to substitutes.

ASN has installed a heat recovery system and uses thermal emissions from its operations to heat its facilities. Hexatronic has similarly installed a district heating system, powered by bio-based sources. In addition, the factory and other premises are partially heated with the excess heat generated by machines.

Eco-Design

There are several critical materials used in cable composition: copper, steel, aluminum, HDPE and LDPE. Currently, these materials are all drawn from virgin stocks, given the quality requirements for subsea cables. There is a possibility in the future that recycled materials could be used for some components.

In the meantime, fiber and cable manufacturers and suppliers have begun to think about sustainability in cable design. In 2022, Corning piloted a Design for Sustainability program and is now developing sustainable design guidelines and tools for product developers. ASN has been intentionally working to develop slimmer cables, which helps to reduce materials and therefore both cost and carbon footprint. A slimmer cable design also helps to optimize length in the vessels, which in turn could reduce the number of trips a vessel takes. Depending on the type of project and the kilometers of cables, the fuel consumption of the ships might also be reduced in the process. Most importantly, with slimmer cables, the quantity of raw material is reduced. ASN has been replacing copper with aluminum for several reasons, including improved energy consumption.

> **A slimmer cable design also helps to optimize length in the vessels, which in turn could reduce the number of trips a vessel takes.**

Hexatronic has also been working to develop slimmer cables. The company has recently adopted a slimmer design using a fibrin metallic tube or loose tube design, using a thin stainless steel tube with slimmer fibers with a core diameter of only 190 µm instead of traditionally 250 µm, and thus further reducing their carbon footprint.

Multiple companies are also designing repeaters—the technologies that amplify cable signals on the way across the ocean—in ways that will minimize energy and environmental impact. NEC has developed an energy efficient repeater with lower power consumption. Xtera designed smaller and lighter repeaters for their NO-UK cable. They also included novel hybrid Raman/EDFA modules that provide lower noise optical amplification, and thus their cable required less repeaters. Xtera utilized intelligent powering modules that optimized the power demand based on the individual repeater requirements, minimizing system power-feed.

For ASN the development of energy efficient products and technologies is a part of the company's "Green Charter." One of the charter's stated goals is to optimize electrical consumption by increasing the number of fiber pairs per cable and thus reducing power consumption per Tb/s. Corning is also working toward the goal of increasing the capacity of optical fibers, which will in turn increase efficiency of subsea cable networks.

Reduce Emissions from Armor

The steel armor used in shallow water to protect the cable is one of the most significant contributors to its carbon footprint. In a steel double-armored cable, more than 80% of the carbon footprint of the cable is generated by the raw materials of the steel wire for the armor and the manufacturing process to produce this wire. Steel, which typically uses coal in both the coking process of the metal and in the furnaces used to produce it, often ends up with a carbon footprint almost twice as heavy as the steel itself: to produce 1 tonne of steel typically involves 1.27–1.85 tonnes of carbon emissions. This remains a challenge for companies to address, as armor is a key component of cable protection (see below for a discussion of cable protection).

One potential solution for this is zero-carbon steel, currently under development in a range of green industrial research and development initiatives. By using renewable energy to power electric arc furnaces and carbon capture and sequestration technologies for remaining production emissions, the climate impacts of steel manufacturing can be reduced significantly. Hexatronic follows the development of zero-carbon steel with great interest. When steel without carbon emissions is made commercially available, Hexatronic expects that the carbon footprint of the cable can be reduced substantially without changing the design.

Another direction for sustainability in the industry, one that is already underway, includes armor considerations in the route planning stage of a cable project. Efforts to reduce the need for extensive segments of heavy armoring (and/or the overall length of the cable) will significantly lower the overall climate impacts of the project. Currently, armor is assigned to a cable based on physical conditions and external threats as early as a feasibility study, which helps to determine the cost of a system upfront. Reducing cable footprint, and armoring requirements, to the extent possible, both reduces cost and helps with sustainability. At the same time, since armor is a primary method of cable protection, it facilitates the reduction of cable maintenance. It is critical to recognize this important and dynamic relationship between cable material, protection, cost, and sustainability.

> **It is critical to recognize the important and dynamic relationship between cable material, protection, cost, and sustainability.**

Sustainable Marine Operations

Marine operators face some difficult sustainability challenges. We found that companies generally want to adopt sustainable practices, but face economic constraints. Bruce Neilson-Watts, CEO of Global Marine, tells us that "it's really difficult for our industry to change...we are hamstrung because we sunk a lot of CAPEX into equipment and technology which is decades old." For the last fifteen years, since the dot-com and infrastructure bust and industry collapse, it has been a customer's market with very low pricing. The "price point investment has not moved far enough" to be able to build new $90 million ships, he observes.

> **Companies generally want to adopt sustainable practices, but face economic constraints.**

Along these lines, BT also stated that it would like to adopt additional measures for sustainability on cable ships, but this is difficult since the technology is still far from where it needs to be in order to be feasible. This is especially true because much sustainable technology has not been developed specifically for cable ships, with their size and specialized equipment.

In this climate, it is particularly notable that Orange Marine decided to build a new cable ship, the Sophie Germain, which reduces CO_2 emissions by 20% and NOx (nitrogen oxide) emissions by 80% from its predecessor, the Raymond Croze. It achieves these reductions through the use of new technologies. The vessel will be a hybrid, combining generators and batteries in order to limit the use of generators on cable operations. The energy and propulsion systems are at "the cutting edge of technology": POD type propulsion engines (azimuthal with a submerged electric motor) and thin management of the efficiency of the generators (multi-stage power, semi-fast diesel). NOx emissions are reduced by installing a system comparable to a catalytic converter on the exhaust of the diesel engines. During its standby, the ship will be electrically connected via shore power to the land network. The ship will be certified with CLEANSHIP.

The construction of new ships can take advantage of new computational systems for designing new hull forms, and in turn, more energy efficient vessels. Orange Marine's Sophie Germain has an optimized hull design, with lines designed for energy efficiency, for repair cable loading, and a transit speed of 12.5 knots. Global Marine is looking at hull design as well.

Another example of investment in new forms of eco-friendly technology is the cable ship Maram, launched in 2016 as part of E-Marine's fleet. It was certified a "Green Plus" cable ship, a class notation that evaluates the degree of environmental friendliness of both seagoing and fixed location operated ships.[129]

In Nokia's 2021 environmental report, it outlines that—in line with its marine strategy—Alcatel Submarine Networks has been rejuvenating its fleet over the past three years. ASN has sold three older vessels and bought three new vessels with lower tonnage and lower fuel consumption.

Despite the obstacles to building new ships, we found many creative initiatives to increase efficiency and decrease emissions. These fall into three main categories: cable ship and marine operations efficiency strategies; connecting to shore power; and fuel conversion.[130]

> Careful management on board the ship is a key part of sustainability.

Make Vessels and Marine Operations Efficient

Marine operators are engaging in many strategies to make their operations as efficient as possible. IT International Telecom is actively replacing low-efficiency light fixtures with marine LED fixtures. Fugro has long-term fuel efficiency initiatives that include upgrading to LED lighting and less heat absorbent deck paints. NTT undertook a partial upgrade of LED energy-saving lighting for its two cable ships, Kizuna and Subaru, in 2018–2019.

Other tactics for reducing emissions include looking at the kind of paint used on ships. Global Marine has switched paint in order to reduce friction with the water—a process that also increases fuel efficiency. Alcatel Submarine Networks is also specifically evaluating ways to improve energy efficiency on its marine fleet.

Careful management on board the ship is a key part of sustainability. There are new technological developments that enable on-board continuous monitoring of ships. Just as networks have network operations centers, the vessel itself is now connected back to a central operations center. From registering the set of inputs via monitoring, Global Marine is able to build a footprint for the vessel and take a proactive approach to maintaining it. This equates to a sort of "just-in-time maintenance." Bruce Neilson-Watts remarks: this "saves you money in spare parts; saves downtime; saves flights."

Efficient management of ships in installation and maintenance also increases sustainability. BT is doing multiple installs at the same time, which saves fuel. It observes that running a tight program enables economic efficiency alongside positive environmental impacts. When asked about where he saw areas for improvement, Salvador Jimenez-Sanchez of Red Penguin Marine pointed out that vessel usage was very important. The least amount of time that the vessel is out, the better for the environment and the less expensive for the company. This is why effective planning—and having a day-to-day plan in place—is so important. Fugro has been using route optimization tools and economic speed models, and Alcatel Submarine Networks has been optimizing transit routes using ADRENA SHIP. The company also mobilizes regional-based chartered vessels to reduce transit. NTT also optimizes route selection in relation to ship speed, ocean currents, and weather conditions, based on a Ship Energy Efficiency Management Plan.

One key parameter that companies have debated is transit speed. Vessels burn less fuel when they run at an optimal speed for energy efficiency, often slower than maximum speed. Global Marine specifically asks its customers if they would like the vessels to go at a more efficient speed. A slower transit time leads to less fuel burned, but in turn the company has to pay more for the crew on the ship. Obviously, this is a less viable option when time is an issue, such as transiting to repair a broken cable or install a new one, but might be a consideration for the return voyage when time is less pressing. Takahiro Kashima of NEC cautioned, however, that "speed optimization does not always lead to carbon reduction." If the marine installation is not completed during the workable season due to the adoption of speed optimization, additional vessel mobilization could be required, which would result in additional CO_2 emissions.

At the Pacific Telecommunications Council conference in 2023, Andrew Robinson of Xtera asked: "Would more sharing of these high impact resources (factories, ships) more effectively across the industry in general lead to improved sustainability?" Is there "spare" industry capacity that can be redistributed for both cost and sustainability benefit?

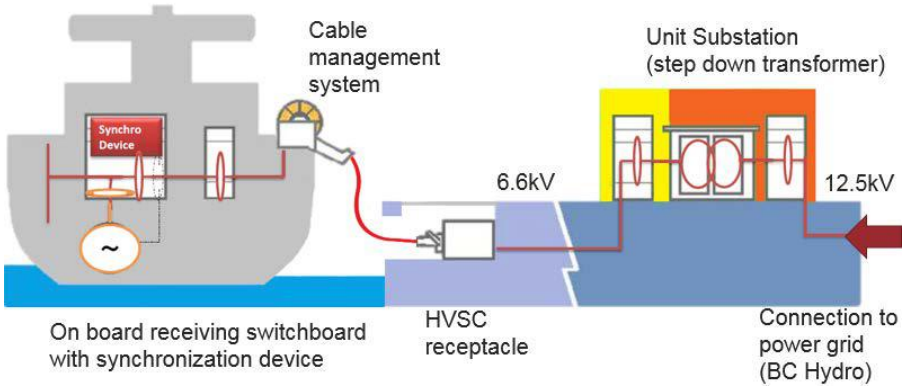

Figure 5. Schematic representation of a vessel utilizing shore power. Graphic by Cavotec.

Plug into Shore Power

One key sustainable technology for marine vessels is shore power. Also known as Onshore Power Supply (OPS) or Alternative Maritime Power (AMP), shore power enables ships to connect to the electrical grid while docked, reducing emissions and air pollution. The on-shore infrastructure of shore power can be set up in different ways, depending on where the power converter is placed and the existing vessel infrastructure (Figure 5), but its advancement requires investments from ship owners as well as from ports. Retrofitting existing vessels with shore power is more cost-effective than building and buying new ships. Notable organizations such as the U.S Environmental Protection Agency, the United States Navy, and the Commission of European Communities have acknowledged the potential of shore power and advocated for its implementation, economic incentives, and the exchange of best practices. Over 60 ports worldwide have implemented shore power.[131]

On-shore power adoption benefits local air quality by replacing emissions at the berth with emissions from electricity generation, which are generally lower and farther from population centers. How much CO_2 is actually reduced through shore power depends on two key factors: the emission factor of marine diesel used by the ship and the emission factors of the power plants feeding the grid.[132]

Although shore power can offer significant emissions benefits, it is not always available for cable ships. "The truth is most major ports do offer shore power, but it's usually reserved for cruise liners, ferries, large cargo ships, and the like," said Steve Arsenault, Director of Global Submarine Solutions at IT International Telecom. "Cable ships are typically given berths away from those main areas, without shore power access." IT International Telecom is committed to using shore power to minimize emissions, connecting to the terrestrial grid whenever possible and compatible with their ships' electrical requirements. It currently relies on shore power in Halifax, NS; North Carolina (Detyens Shipyard); and Port Alberni, BC, with additional locations also available.

Global Marine's fleet is also shore power compatible, and connects to the land-side grid when docking at ports including Port Washington, U.S. and Portland, UK, which possess the necessary infrastructure. ASN recognizes shore power as a key area in its marine sustainability strategy and EGS Survey uses shore power when available. Orange Marine is also prioritizing shore power—it currently connects 75% of its fleet to the terrestrial grid, and even has solar panels installed at port. In 2020 Orange Marine installed 850 m2 of solar panels in its marine base in La Seyne-sur-Mer (Southern France), providing part of the energy consumed by the ship connected on the shore power.

Transition Fuel Source

Transition Fuel Source

The sustainability of the maritime sector will eventually necessitate the transition from fossil-fuels to clean energy-based fuels. The maritime sector, however, poses unique challenges to implementing some of the more common renewable sources of power, such as wind or solar, since shipping is time-bound and requires the ability to effectively store energy in fuel both at port and on the ship itself. Alternative fuel sources most amenable to marine transport are methanol-based (which has been available for some time), hydrogen (increasingly common), and ammonia (still expanding). Hydrogen and ammonia fuel sources are not yet operating at scale, though this does seem to be changing, especially as the price of hydrogen is becoming more affordable. Fugro plans to have the first methanol conversion for its survey vessel Fugro Pioneer to be completed in 2024. The company offers its clients biofuel as a short-term solution.

Each of these alternatives lowers the carbon intensity of transportation, but their processing can often remain carbon-intensive and reliant on fossil fuels. In order for these fuels to be maximally sustainable, they would need to be sourced from processors that use renewable energy sources. An additional limitation is the lack of infrastructure, including updated technologies in ports and on ships. This intensive undertaking will require a coordinated, sector-wide approach that leverages both technology and the supply chain. According to the United Nations Conference on Trade and Development (UNCTAD), achieving the goal of reducing greenhouse gas emissions from shipping by at least 50% by 2025, as outlined by the International Maritime Organization (IMO), will require comprehensive strategies with many stakeholders.[133]

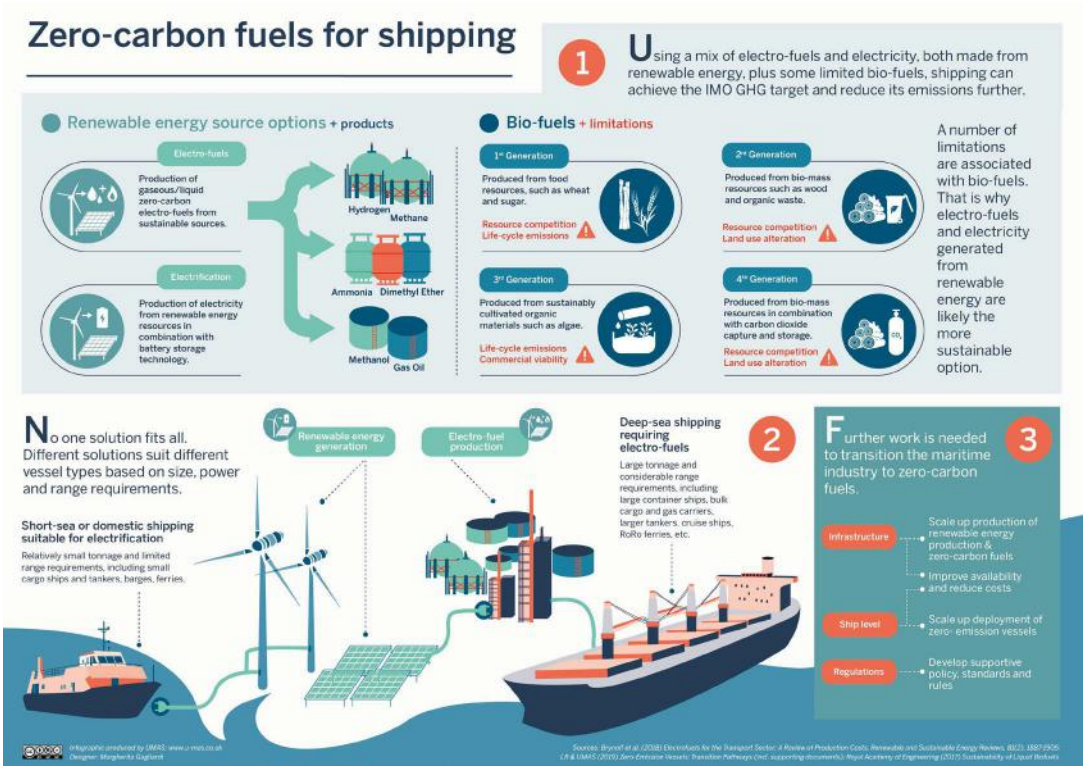

Figure 6. Zero-carbon fuels for shipping. Graphic by: UMAS, Shipping Team, University College London [154]

Fuel transition can only be driven by cooperation across the maritime sector and by joint investments in cleaner fuel sources. As Bruce Neilson-Watts of Global Marine observes, this connection is necessary. He reflects: "The investment in new port facilities and greener vessels is expensive for both port operators and vessel owners but eventually it is something that will have to be done. The key to success though is ensuring all stakeholders communicate their needs/wants, and port owners communicate their future green energy roadmap as this assists ship owners to make more informed decisions on newer propulsion technology. Where possible we want to avoid port owners investing in fuelling infrastructure that is not aligned with shipowners' future vessel investment plans."[135]

In the meantime, however, marine operators have begun to transition away from the intensive Marine Diesel Oil (MDO) or Heavy Fuel Oil (HFO). MDO and HFO have been traditionally used in shipping until recent IMO regulations attempted to curb emissions and encourage low-sulfur alternatives. MDO/HFO, while cheap, generate significant amounts of sulfur, nitrogen, and carbon. IT International Telecom has adopted Ultra Low Sulphur Marine Gas Oil (MGO).[136] ASN has stopped using heavy fuel oil as well. To further reduce emissions, Orange Marine uses 100% biodegradable hydraulic oil derived from biomass and low sulfur diesel oil (0.1%) in its cable fleet.

Another option for more efficient shipping is to use ships that have hybrid diesel-electric propulsion engines, or engines that combine diesel combustion with an electric battery. EGS Survey has switched to diesel-electric engines. Fugro has also invested in hybrid propulsion technology. For NTT, its cable-laying vessels utilize an electric propulsion system which optimizes how many engines are in operation, taking into account the load and weather. They are thus able to minimize the amount of fuel used and reduce CO_2 emissions.

Having multiple generators on board means that electric power rather than individual engines can be used for auxiliary equipment as well as for propulsion. On the vessels of IT International Telecom nearly all auxiliary machinery onboard—cable equipment and subsea equipment—are driven by electric power, and not direct-engine driven.

Connect to Offshore Renewables

Several companies in the industry have taken on new business in offshore renewables. While this does not currently directly increase the sustainability of subsea telecommunications cables, it does leverage the industry's investments in cable surveying, installation, and maintenance to support the renewable energy future.

Cable installation and maintenance companies are at the forefront of this transition. For instance, the Global Marine Group's CWind has focused on the implementation of wind energy since 2007.[137] It has constructed a smaller vessel specifically for its offshore renewable business. Orange Marine has completed power cable projects to support both wind and wave energy developments. Marine surveyors including Fugro and EGS Survey offer services for renewable energy installations.[138] Makai Ocean Engineering also offers tools and services to offshore wind including power cable routing, anchoring and platform technologies, as well as installation support.[139]

> **Where possible we want to avoid port owners investing in fuelling infrastructure that is not aligned with shipowners' future vessel investment plans.**
>
> -Bruce Neilson-Watts of Global Marine

> The adoption of USVs in the industry could potentially reduce emissions of the survey process.

Deploy Autonomous Vessels

Traditional marine survey methods have long relied on large vessels and a crew. These vessels use diesel fuel, which increases the CO_2 emissions as well as operating costs. The daily fuel usage for securing vessel operations at sea ranges from 1,000 to 5,000 gallons on average.[140] This has implications not only for the environment, but for the economic cost of a system: the normal daily rate for a marine survey vessel typically ranges from $35,000 to $45,000 each day, with a portion of that cost attributed to fuel.

One new development, which poses opportunities for sustainable marine operations, increased efficiency, and reduced costs and risks, is the development of Uncrewed Surface Vehicle (USV) technologies for mapping routes for subsea telecommunications cable systems. The ongoing operation of USVs generate a low or non-existent carbon footprint and very minimal environmental impact. The adoption of USVs in the industry could potentially reduce reliance on traditional vessels, while significantly reducing the emissions of the survey process. Machine learning capabilities integrated into USVs optimize their operations, further reducing energy consumption and environmental impact. USVs can also operate over long distances and durations, up to 365 days without returning to port, providing persistent and continuous monitoring of subsea cables. This persistence, combined with real-time data access, can enable expedited decision-making and efficient maintenance or repair operations.

Marine surveying companies, such as Fugro, are investing in USVs, investigating new methods for mapping the seafloor, and working to use these technologies to provide accurate data that will assist technical teams in delivering cable systems (Figure 7). Fugro has expanded its USV fleet with the development of the Blue Prism™ and the Blue Shadow®. Both vessels are designed for safe and efficient hydrographic and geophysical survey operations in coastal and offshore environments. Fugro has already used unmanned vessels to supplement mapping near coastlines and the company is planning to do a survey in the deep sea using an unmanned vessel, which would eliminate the need for a crew of 9-10 people. In early 2023, Fugro's Blue Essence® received approval from the UK Maritime and Coastguard Agency (MCA) to operate as the first USV with an electrical remotely operated vehicle (eROV) in UK waters, marking a significant milestone for Fugro's remote and autonomous solutions in the maritime industry.[141]

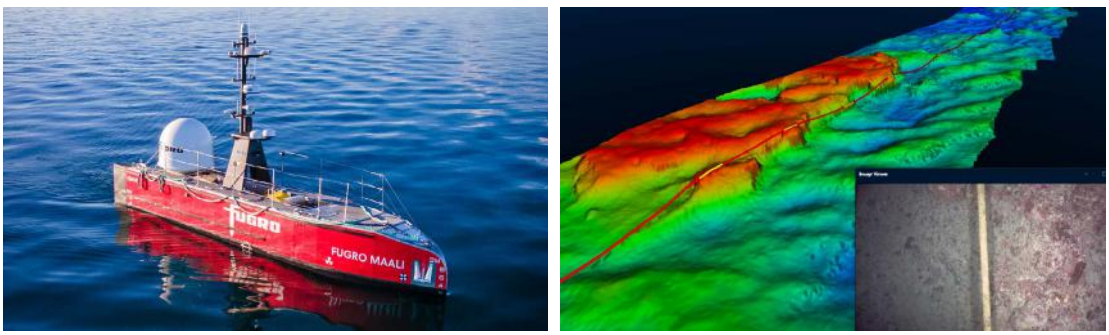

Figure 7. Uncrewed surface vessel (USV), Blue Essence® with a near real-time visual display of cable asset. Photos by Fugro.

LOW RES

Figure 8. Photo of a Saildrone Surveyor, alongside with the technical specifications of its acoustic payloads as presented in March 2023 at SubOptic Conference in Bangkok, Thailand. Photo and graphic by Saildrone.

USVs
Uncrewed Surface Vehicles

Saildrone, a company with several USVs, has grown significantly over the past ten years, expanding from ocean data collection to maritime domain awareness and ocean surveying. The company developed the Saildrone Surveyor, a 65-foot vehicle equipped with advanced systems, as well as wind and solar energy, and which is capable of operating "over-the-horizon" i.e. without a mothership, in challenging conditions while collecting highly accurate data for high-resolution seafloor mapping (Figure 8).[142] Saildrone's USV Surveyor, equipped with a multibeam acoustic payload, can survey depths up to 11,000 meters.

USVs can operate in diverse environments, from the Arctic to the tropics, and can function in harsh conditions where it would be hazardous to send crewed ships, ensuring the safety of personnel. The adoption of USVs has the potential to enhance operational safety alongside reducing costs and advancing sustainable practices. By augmenting and reducing the reliance on crewed support vessels, USVs can decrease operational expenses, complexity, and risks. Although still in the early stages of widespread adoption, USVs have thus far demonstrated reliability and resilience.

Another benefit of USVs compared to traditional crewed vessels is improved availability and scalability. It is not uncommon for subsea cable projects to be delayed over a year awaiting the availability of a survey vessel. By the nature of their reduced cost and scalable production lines, USVs can be built to support accelerating project timelines, which can have a direct impact on the production of the actual subsea cable.

USVs are not without their limitations. USVs have lower resolution imaging across a narrower survey corridor than standard surveyor ships (they nonetheless meet the industry standard for imaging) and lack many of the extensive capabilities demanded for shore surveys, and they will likely never fully replace traditional surveys. However, as pointed out by Kitch Kennedy, Director of Business Development for Ocean Mapping for Saildrone, the goal is not to replace the fleet of existing survey vessels, rather "to use autonomous vehicles for the more routine tasks which can be accomplished with automation and uncrewed technology, freeing up crewed vessels for more complex operations."[143]

Protect Cables

Protect Cables

One of the most important things that can be done to reduce emissions in wet plant design and maintenance is to minimize repairs. An adequately-protected cable requires fewer repairs, lower levels of utilization of ships, and the emission of significantly less CO_2.

Different protection strategies generate different levels of carbon emissions. Steel armor remains an essential component of cable protection, even as it contributes to a cable's carbon footprint. Ploughing and cable burial is also a crucial protection strategy that is linked to armoring. A buried cable must be armored to protect it during the passage through the plough itself. Michael Clare, Principal Researcher at the UK's National Oceanography Centre, points out in his recent study that cable burial temporarily disturbs seafloor sediments and may have disturbed 3-11 MT of seafloor carbon to date. Placing this in a wider context, the study shows that the total volume of disturbed carbon by cable burial over several decades is still orders of magnitude less than that disturbed by bottom fishing in a single year.

There is not yet research conducted on the sustainability benefits of armor and/or cable burial, as they are reflected in decreased levels of repair.

One protection strategy that generates little to no carbon emissions is an effective cable protection regime supported by law. This might include, in some specific instances, establishment of cable protection zones. By limiting fishing activity around a cable and potentially avoiding the need for cable burial, these zones could offer sustainability benefits while also reducing repairs. These zones, however, may not be the most effective means of protection in many parts of the world. We suggest referencing the International Cable Protection Committee's (ICPC) Government Best Practices document which outlines many of the mechanisms that governments can take to protect cables.

Several further points are crucial to mention in this context. Given the regional variance in cable fault rates, with east and southeast Asia being the location of the most cable faults, the resulting CO_2 emissions generated by activities associated with subsea cable repairs also vary according to geography. Cable owners undertake extensive measures and invest resources to protect cables in locations where fault rates are highest, yet poor regulation and the low prioritization of the protection of critical infrastructure by governments means that there is little consequence to causing a cable fault.

Overall, however, evidence shows that the subsea cable industry is generally getting better at protecting cables. The fault rate/km has decreased significantly, particularly since around 2018, and this shows that better route planning, marine installation and other risk mitigations are effective and do reduce the number of repairs, which has major sustainability advantages. According to ICPC data provided by the marine maintenance agreements worldwide, the number of faults in the High Seas beyond national jurisdiction remains very low. This is important because those repairs are the ones that require the longest transits, and hence, have the biggest CO_2 emissions impacts.

Extensive peer-reviewed research has demonstrated that subsea cables generally have minor, short-lived impacts on the marine environment. Additional research could be used to substantiate the long-term carbon emissions impacts of improved cable protection as well as the sustainability benefits of different approaches to cable protection.

> Cable stations should work quite well for sustainability because they are a long-term investment and they can be used for other purposes.

Sustainable Cable Landing Station (CLS) and the Dry Plant

The cable landing station (CLS) is an important site for sustainable development. As one interviewee observed: "Cable stations should work quite well for sustainability because they are a long-term investment and they can be used for other purposes." We found three primary approaches to CO_2 emissions reductions at the CLS: the purchase or installation of carbon neutral or renewable energy; the development of technologies or techniques of energy efficiency; and the upgrading of SLTE equipment and the extension of cable lifetimes.

Power Cables with Carbon Neutral and Renewable Energy

There are several examples of carbon neutral energy and renewable power at cable landing stations in the North Atlantic region. BT Group is powered by 100% renewable sources, and this includes all of the company's subsea cable landing stations.[144] Aqua Comms, a company that operates subsea infrastructure across the Atlantic and beyond, reviewed its energy providers to consider the transition to renewable energy, and has since taken steps to power many of its cable landing stations with green energy. As of 2022, it connected to seven stations that were powered by 100% renewable energy, including Eastpoint, Killala, and Old Head (Ireland); Parc y Cybi (Wales); Blackpool and Newcastle (England).[145] One of the stations that their cables land in, the New Jersey Fiber Exchange (NJFX), has been powered by carbon neutral energy since 2020. Bulk Infrastructure is powered by nearly 100% renewable power, with cable landing stations either fully or partially on hydropower including Kristiansand, Norway (for Havsil, Havfrue and Leif Erikson), Happy Valley Goose Bay, Canada (for the Leif Erikson cable) and Hanstholm, Denmark (for the Havsil cable).[146]

Equinix has numerous data centers around the world where subsea cables land, and several of these—and thus the networks that connect them—are covered by purchased renewable energy. In the United States, Equinix's LA4 in California and MI3 facility in Florida are both covered by 100% renewable wind energy from RECs (from U.S. wind VPPAs and Green-e wind RECs) for the Curie, Monet, and PLCN cables. In Singapore, Equinix SG3 (landing point for AAE-1) is covered by 100% renewable from small hydro/wind/solar I-RECs from Vietnam. In Muscat, Oman, the Equinix MC1 facility is the landing point for the Oman Australia Cable, and is covered 100% by renewables from I-RECs from UAE wind/solar. The Japan-Guam-Australia North cable terminates in Equinix's TY2 facility, which is covered by 100% renewable energy (Japanese non-fossil certificates from wind/solar (20%) and I-RECs from Chinese small hydro/wind/solar (80%)). The CrossChannel Fibre cable is a renewably-powered system from London to Paris, terminating in PA7 (bundled GoOs from local hydro) and LD4 (GoOs and REGOs).

The presence of renewable energy is playing a small, but increasingly important role in the determination of data center locations, which in turn affect cable landing sites. EllaLink observed that the presence of renewable energy was among the many reasons that Sines, Portugal, one of its landing points, was developing as a technology hub.

Solar Power

Solar Power at the Cable Landing Station

While CLSs around the world are powered by purchased wind, solar, and hydropower, solar power is the most common renewable technology for on-site installation. Telecom Egypt's solar investments date back to 2010, when a solar array was installed to power part of the in-line terrestrial segment between two subsea cable landing points. When the company developed an expansion of this in-line terrestrial network in 2020, a set of eight additional solar arrays were implemented. These are hybrid systems, as solar cells cannot provide power 24/7—a diesel generator assists with provision of power 4-5 hours per day. Initially, Telecom Egypt's installations were constructed out of necessity, since there was no commercial power available at the amplifier sites. However, the company is considering green energy moving forward.

On the 2Africa cable, several cable landing stations have been equipped with solar power by Alcatel Submarine Networks, including in Berbera, Somalia and Muanda, Democratic Republic of the Congo. ASN reports that since the average electricity consumption is 380 kWh/day for one CLS, there is an estimated 41 to 59 tonnes CO_2 per year reduction. By installing photovoltaic panels on three cable landing stations, up to 178 tonnes CO_2 emissions per year could be saved. Other notable solar developments include the cable landing station HMB-IX's engagement in a partnership with the city of Hermosa Beach, California in the United States to support the installation of rooftop panels on a nearby city building.

Solar development at the CLS may be facilitated by the possibility of selling energy back to the power company where grid tie-in is available. Yet it also faces several challenges. One of the limitations is that the CLS may be a shared facility. A cable owner therefore does not necessarily have a say in how the cable landing station is powered. A second limitation is that air-conditioning units are sometimes located on the rooftop, occupying valuable real-estate that might otherwise be dedicated to solar panels. A third constraining factor is land. It takes a significant amount of land to install a solar array and there can be technical challenges in designing the array for particular landscapes. Telecom Egypt's solar installations, for instance, largely exist on land that they own, although a few exist on leased property. The company states that the acquisition of land is one of the main issues that they encounter in building out solar capacity. Overall, on-site renewable energy sources can be beneficial, but they often necessitate more space, money, and sometimes maintenance.

> **Solar development at the CLS may be facilitated by the possibility of selling energy back to the power company where grid tie-in is available.**

Success Story for Renewable Development: Tokelau

The island of Tokelau, and thus its cable landing station, is powered by solar installations. This is a unique case that illuminates possibilities for small islands. In 2012, via the Tokelau Renewable Energy Project (TREP), Tokelau became the first territory in the world to supply virtually all of its electrical demands with solar power. TREP was established in response to climate change, the high costs and environmental effects of delivering diesel fuel, and the need to maintain a dependable and sustainable energy source.[147] Previously, Tokelau had been fully dependent on diesel, utilizing around 160,000 liters of imported fuel.[148] The installation of 4,032 photovoltaic panels, 392 inverters, and 1,344 batteries over the three atolls was made possible by a US$ 7 million initiative sponsored by the New Zealand government and carried out by PowerSmart and IT Power Australia.[149] This move—combining efforts by the public and private sectors—offered more stable power infrastructure for local inhabitants.[150] In 2020, Tokelau announced a jointly financed update of an additional 210 kilowatt solar arrays and two megawatt hour lithium-ion battery storage systems.[151] The following year, when the Southern Cross Cable Network landed its Southern Cross NEXT system in Tokelau, it became home to one of the first renewably-powered Pacific Island cable landing stations.

Inspired by Tokelau, other Pacific islands have expressed interest in going solar, with Tuvalu and the Cook Islands following suit.[152] This achievement is an inspiration for other Small Island Developing States to adopt renewable energy.

Success Story for Renewable Development: Curaçao

The Caribbean and its thirty-one island markets are challenged by high electricity costs, which present considerable financial risks to data center operators in the region. Despite having access to subsea cable systems, these companies face energy expenses that are double the U.S. average, at US$ 0.25 per kilowatt-hour (kWh). Imported fuels are heavily relied upon, with nine of the eleven Caribbean nations studied dependent on them to generate more than 80% of their electricity.[153] Notably, Curaçao, a Dutch Caribbean Island, opened its first data center in 2014, establishing itself as a connection between Latin American and European markets. According to the U.S. Department of Energy, commercial and residential power tariffs in Curaçao reached the $0.35 per kWh in 2022.[154]

However, unlike other island governments in the region that lacked the necessary balance of economic and political commitment, Curaçao has a lengthy history of energy diversification attempts dating back to the 1970s. This explains why the island has been a pioneer in prototyping services and energy via renewables, particularly through wind turbines. In the early 2000s, the island made a huge commitment to renewable energy when they implemented a solar energy feed-in tariff, which has allowed for even more investment in the island's renewable energy sector.[155]

“In the early 2000s, the island made a huge commitment to renewable energy when they implemented a solar energy feed-in tariff, which has allowed for even more investment in the island's renewable energy sector.”

Today, Curaçao is home to seven operational submarine cables and two data centers—Tier III E-commerce Park Curacao and Tier IV CTEX, along with the Blue NAP Datacenter. In a notable stride towards sustainability, one data center operator purchased land adjacent to their center to build a solar energy generator unit.[156] The solar energy generating unit by this data center operator was not only efficient but also extremely productive. It produced so much solar energy that the excess was sold to the local power company, further enhancing the benefits of renewable energy integration. Given the Caribbean region's substantial solar radiation, Curaçao is an example of how returns on renewable energy investments can be expedited.

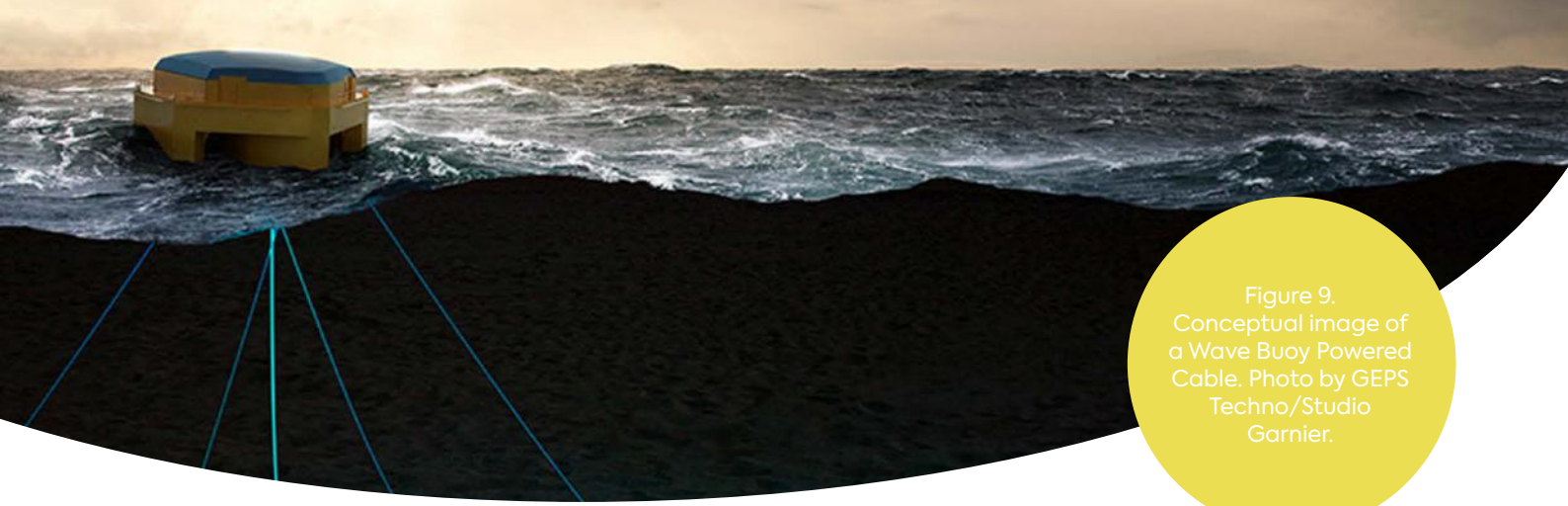

Figure 9. Conceptual image of a Wave Buoy Powered Cable. Photo by GEPS Techno/Studio Garnier.

Wave-Powered Cables

One new technology currently under consideration is the powering of subsea cables by ocean waves (Figure 9). In this model, wave buoys would be located on the surface of the ocean along the cable route and connected to the cable below. The motion of waves would be converted into electricity, as buoys rise and fall and move back-and-forth. Buoys could also be outfitted with solar panels to supplement the wave power. This would be a sustainable, renewable alternative to powering cables solely from their termination points at cable landing stations. In 2022, GEPS Techno announced it was partnering with Meta to investigate remote powering of high-capacity subsea cables.[157] While this is far from the implementation stage, it is one example of how companies are beginning to innovate towards sustainability.

Hydrogen Fuel Cells

Hydrogen fuel cells are not widely used to support subsea cable infrastructure. They are, however, being pioneered in its data center sector and some of our interviewees speculated that they would be an interesting technology for usage at the cable landing station.

Equinix is actively evaluating the use of fuel cells in their data centers.[158] To date, the company has installed 43.5 MW of fuel cells in its U.S.-based facilities, avoiding approximately 175,000 megatons of CO_2e. Equinix's SV11 in San Jose, California, is powered by hydrogen-capable fuel cells, only consuming energy from the grid in emergency situations. Equinix's plan is for this source of energy to be proven at scale and demonstrate that fuel cells can power facilities in scenarios where the local grid cannot support the demand. All of the company's currently deployed fuel cell technologies are designed to accept up to a 50% hydrogen blend "as is," positioning Equinix well to take advantage of the future hydrogen market as it evolves.

The challenges of using hydrogen fuel cells include the cost of building out this infrastructure and the uncertain availability of renewably-sourced hydrogen in certain locations. Hydrogen power, the fuel cells, and hydrogen extraction require significant investment and have yet to be scaled to be globally applicable. This does appear to be changing as the price of hydrogen fuel cells and hydrogen energy has continued to decline, suggesting that this might be an affordable option in the future. In addition, hydrogen power is not always renewably-sourced and, when it is, can be logistically difficult to access. With the uncertainties around hydrogen power, we have not seen investments in this area from subsea cable companies.

Hybrid Generators

Alternatives for Diesel Generators

A significant source of emissions are the diesel generators used for backup power at the cable landing station and data centers, which are required to keep communications up and running when grid power goes out. These are rarely used, but when they are, the generators are quite carbon intensive. Their emissions can range from 0.2–10 tonnes CO_2e/year per cable landing station. It is not realistic to eliminate backup power, but there are companies that are beginning to look at sustainable fuel sources. Some companies, including Vodafone, have initiatives to investigate hybrid generators. Equinix, among other companies, is currently piloting the use of alternative fuels for diesel such as Hydrotreated Vegetable Oils (HVOs) across a handful of sites globally.

Renewable Energy Feasibility Study

Before installing new energy technologies at the cable landing station, it would benefit owners to consult with local stakeholders, utilities, and regulators. We have developed a Renewable Energy Feasibility Study (REFS) model to facilitate this process. REFS was initially implemented in the summer of 2022 in partnership with a cable owner and operator. The primary outputs of the first iteration of REFS included:

- **Technical and financial viability assessment of on-site renewable energy:** Contributes to carbon emission reduction, resilience enhancement, and accommodation of growing energy needs;
- **Exploration of suitable renewable energy systems given local geographic conditions:** Identification of optimal solutions for renewable backup power and site expansion crucial to the efficiency and reliability of subsea cable operation;
- **Understanding global and local energy policy:** Knowledge of the latest renewable energy trends and local regulatory environment can guide strategic decisions;
- **Integration of sociocultural perceptions:** Ensuring local stakeholder acceptance is vital for the successful implementation of renewable energy projects;
- **Practical recommendations for a renewable future:** Clear, actionable advice based on comprehensive analysis.

REFS can be useful for companies striving to optimize their investments while reducing energy consumption. This model, which encompasses research on existing and new renewable technologies, alignment with local/regional policies, connections with local communities, and projection of long-term economic benefits, provides an assessment matrix to guide companies towards carbon neutrality at the subsea cable landing station.

Make the Cable Landing Station Energy Efficient

Maximizing energy efficiency at the cable landing station is a critical path to sustainability. This shift is well-underway, especially in the design of new cable landing stations. From a technical perspective, the advancement of optical technology and the introduction of subsea systems with higher fiber pair counts have led engineers to reconsider the design of the CLS. The trend is now shifting away from large-scale infrastructures towards modular designs. These designs are more adaptable to the demands of new technology, offering a more efficient allocation of space and power. Cables are also terminating in data centers, where energy efficiency has been a concern for many years.

As one example, in 2016, a new cable landing station was built at the NJFX campus in New Jersey in the United States. It was developed by a building designer who had worked for Equinix and in the data center industry for many years, and came to the project with several ideas about energy efficiency. Similar to the ASN and Hexatronic facilities described previously, NJFX also uses heat recovery technologies to use energy from customer equipment to heat the facility in the winter. Gil Santaliz, CEO of NJFX, observes that many of these developments were possible largely because NJFX was building a new station. Today, he observes, "energy efficiency is always at the forefront when considering design in power intensive critical infrastructure."

> **Energy efficiency is always at the forefront when considering design in power intensive critical infrastructure.**
>
> -Gil Santaliz of NJFX

Retrofitting the Cable Landing Station

Retrofitting and improving existing facilities is often more difficult. At the time of many earlier CLS constructions, the notion of efficient airflow management was absent, and energy was regarded as an inexhaustible resource. Much infrastructure was designed for telecom equipment, specifically 48VDC optical transmission equipment, and was not prepared for the demands of modern, densely-populated servers. Instead of being data halls, these facilities served as mere equipment rooms. Rather than employing a hot/cool aisle system, some CLSs still rely on perimetral air conditioners and standard ductwork, aiming to maintain a uniformly cool temperature throughout.

The Spanish telecommunications infrastructure company Telxius has taken a lead in developing energy efficiency projects at their facilities around the world, often upgrading facilities from earlier eras of CLS development. They have completed projects at cable landing stations in Virginia Beach (USA); San Juan (Puerto Rico); Santos, Rio de Janeiro, El Salvador, and Fortaleza (Brazil); Valparaiso and Arica (Chile); Derio Communications Hub, Bilbao (Spain); Las Toninas (Argentina); Salinas (Ecuador); Puerto San Jose (Guatemala); and Lurin (Peru).

Another notable pioneer in this space includes BT Group. Environmental improvements have been made at BT's landing stations, which serve both cost-reduction and environmental purposes. These include efficiency improvements, including increasing temperature, as well as the shift from refrigerant cooling to free-air cooling. BT expects that cold water cooling will be a potential option for cable landing stations in the future. Telstra has also undertaken initiatives around efficiency, including LED lights and powering off devices when not in use. Telstra has also adjusted the cooling plant set points and the airflow management for their data centers, and in the newly fitted areas, installed raised flooring with hot/cold aisle arrangement.

In recent years, consulting companies have also emerged to facilitate the uptake of energy efficiency measures. One of these, oriented primarily toward serving the subsea sector, is R&G Telecom. Andrea Reschini, responsible for overseeing R&G's Sustainability and Energy Efficiency Programs, sees potential for substantial energy savings at the CLS and identifies cooling, equipment upgrades, and hardware repurposing as crucial considerations for all CLS facilities.

R&G recently completed a project at a Caribbean CLS that was established in the early 2000s. Although the station was state-of-the-art when built, energy optimization was not a guiding principle during construction. Among other enhancements, R&G installed a drop ceiling, hot air return plenums, dampers, and high-performance raised floor panels. These modifications were complemented with HVAC settings adjustments and diligent energy usage tracking.[159] The company also improved the separation of cold and hot air flows, transitioning the station from a room-cooling to equipment-cooling concept. After putting in place these air management strategies, they added "optimization" procedures such as monitoring, upgrading and adding intelligence to old HVAC systems to regulate their functioning according to the new thermal scenario.

Power Usage Effectiveness (PUE)

One metric of efficiency in wide use in the data center sector and relevant to cable landing stations, with several caveats, is PUE, Power Usage Effectiveness. PUE is measured by dividing a facility's overall power use by the power used by its IT equipment. The efficiency of the facility increases as the PUE value gets closer to 1.0, which means that less energy is consumed for lighting, cooling, and other non-computational operations. Among other things, optimizing airflow to lower cooling requirements, updating to energy-efficient gear, and putting energy-saving procedures into place are all ways to improve the PUE of the CLS. It is rare for CLSs to publicize their PUE. Telstra uses PUE as an internal metric for its cable landing stations, and this is recorded and reviewed on a monthly basis. Equinix has been improving its PUE incrementally YoY and recently published a global annualized PUE of 1.46. It is important to note, however, that PUE is not an appropriate metric to use in all circumstances. Several white papers and peer-reviewed publications have highlighted the limits of PUE, how PUE statistics may potentially generate misleading conclusions, and how this metric should be supplemented with a variety of others.

Upgrade Submarine Line Terminal Equipment (SLTE) and Extend Lifetime

Upgrading the Submarine Line Terminal Equipment (SLTE) at the cable landing station typically has a twofold contribution to sustainability: new equipment is more energy efficient, and since the capacity increases, the energy per bit is dramatically reduced. At the 2023 SubOptic Congress on Sustainability, Brian Lavallée, Senior Director, Verticals & Solutions Marketing at Ciena, promoted emissions per bit transported as a measurable metric. "Operating cables at lowest power per bit transmission is the best way to keep systems operating at lowest emissions,"[160] he stated (see Figure 10). There is typically an economic benefit to the transition as well.

> **Operating cables at lowest power per bit transmission is the best way to keep systems operating at lowest emissions.**
>
> –Brian Lavallée of Ciena

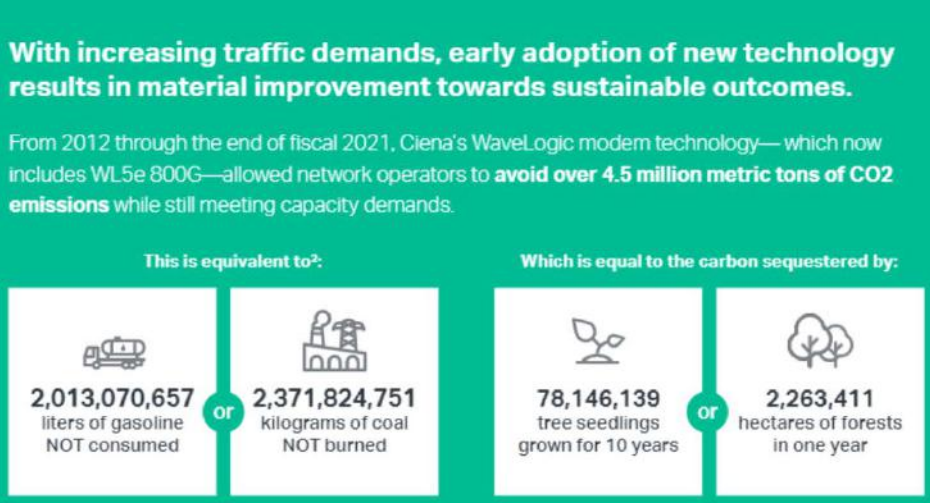

Figure 10.
Graphic by Ciena

A further benefit to sustainability of SLTE upgrades is that the increased capacity of the system has the potential to extend the lifetime of the cable. Andy Palmer-Felgate, Submarine Cable Engineer at Meta, also pointed out at the SubOptic Congress that an under-discussed aspect of cable sustainability is their longevity. He explains, "most systems are traditionally designed to last 25 years, but their actual life is when they become economically obsolete, which is usually when the operations and maintenance start to become expensive."[161] However, systems that are in operation longer are often more sustainable, since the emissions generated in construction are averaged over a longer number of years.

It is important to note that generating efficiency improvements through equipment upgrades is also a leading edge of data center sustainability research. Preliminary testing has shown that the replacement of 20-year-old equipment with the latest, high-speed routers can result in a 70% decrease in power consumption.[162] Furthermore, while the architecture of data centers has improved over the past years, many recognize that there is still huge energy efficiency potential in the IT equipment itself that remains largely untapped, including more frequent hardware upgrades and server optimization for active idle efficiency.[163] Older data center technology uses disproportionate amounts of energy while only offering a limited amount of computational power. It is critical, however, to also take into account the carbon emissions generated with every aspect of a new procurement.

Energy-efficient solutions are a necessary part of the move toward sustainable infrastructure, and this is one strategy that is already underway. SLTE upgrades are currently a normal part of operating a cable, with owners capitalizing on more efficient SLTE and SLTE manufacturers developing smaller footprint, lower power equipment.

Sustainable Business Operations

Many companies in the subsea cable industry, especially consultants, do not produce a substantial amount of CO_2 as they are primarily limited to office activities and employee travel. We found two primary ways in which these companies, and business operations across the sector more generally, could be made more sustainable: development of more efficient in-office operations and the transition to remote office work, with some caveats mentioned below.

Operate Environmentally

Operating offices both efficiently and with sustainability in mind can create both environmental and economic benefits. Many companies have developed internal mechanisms for enhancing these measures. Global Marine, for example, is not only undertaking energy efficiency efforts in the marine side of the business, but has developed initiatives shoreside as well.

Often the transition to sustainability takes the upfront investment of employee time. Red Penguin Marine, as a consultant, does not have a substantial carbon footprint. Nonetheless, the company dedicated the time of a new employee to develop an extensive CO2 tracker for the Red Penguin Marine's day-to-day business. This tracker included a recycling/waste log, in which bags of general waste, recycling waste, printer ink/toner, and reams of paper used were all counted, alongside the more typical factors of electricity and water usage. As the company moved into a new building, it also considered carbon impact as they selected furniture and appliances, choosing furniture with recycled fabrics.

These mechanisms, in larger companies, can be quite extensive. For example, Hexatronic developed an internal system of tying management bonuses to meeting the company's sustainability targets. The company has an internal sustainability award and has created sustainability action teams across groups for internal communication. The company has also worked to reduce the emissions generated by the transportation of goods by optimizing pack sizes, coordinating deliveries, enhancing forecasting, and establishing local production sources.[164] The company has changed from shipping goods via air to ground transportation and has made strides towards a zero-emissions vehicle fleet.

Another approach to reducing emissions is internal carbon pricing. At the SubOptic 2023 conference in Bangkok, Nancy Cai of Telstra presented on the benefits of implementing internal carbon pricing within the broader subsea ecosystem, and how applications may vary depending on an organization's profile and sustainability goals. This mechanism involves putting a price on carbon emissions generated by different activities within an organization in order to drive sustainable behavior.[165] For example, since 2012 Microsoft has had an internal carbon fee that is being expanded to include emissions from its supply and value chains.

Another trend we have found across several subsea cable companies is an investment in electric vehicles and infrastructure. All vehicles in the business area of Bulk Fiber Networks are electric. Fugro is encouraging its employees not to commute by car in Singapore. The Southern Cross Cable Network has a company policy to use carbon neutral ground transportation for travel, when possible. And at NJFX, several electric car charging stations were installed, even though employees live on average seven miles from the campus and some bicycle to the facilities.

Work Remotely

The subsea cable industry relies heavily on global air travel. This constitutes a small but not insignificant part of its overall carbon footprint. Our analysis showed that, prior to the COVID-19 pandemic, a large-scale consortium cable project could result in the emission of 1,235 metric tonnes CO_2e, which is equivalent to 619,796 kg of coal burned.

During COVID-19, the subsea cable industry began to rethink how networks were developed, deployed, and maintained. In a short period of time, the industry transitioned relatively smoothly to remote operations. Projects including Dunant, Jupiter, JGA, EllaLink, and regional cables were completed amidst the pandemic, largely relying on remote work. As pointed out by Cynthia Perret, Senior Infrastructure Program Manager at Meta, "the pandemic created the perception that everything could be managed remotely."[166]

The transition to remote work not only offers sustainable opportunities for companies to reduce their carbon footprint, but financial opportunities for companies to reduce travel-related budgets, and has remained important for subsea cables even after travel restrictions were lifted. As Pernilla Eriksson and Lynsey Thomas challenge the industry: "An easy change that we can all make is to increase the number of travel-free meetings."[167]

> **I think you can do a lot on Zoom... if people know each other. If there's not too many time zones involved and if there's not... forceful parties... If you're trying to develop a kind of a policy or strategy from nothing...then I don't know if that's really effective. think that's quite hard to do because knowing people is very, very important in this industry.**
>
> -John Tibbles, Advisor to the SubOptic Foundation

Figure 11. Smart Glasses. Graphic by Alcatel Submarine Networks.

Since the pandemic, we have since seen more complex forms of remote work emerge in the industry. Ciena, for example, provides the capabilities of remote provisioning and diagnostics of SLTE, which helps with emission reduction by avoiding travel to remote and often distant cable landing stations. Additionally, companies such HMN Technologies and Alcatel Submarine Networks are exploring innovative ways to promote remote work, such as expanding real-time monitoring, establishing global control centers, and developing new tools for remote work such as high bandwidth audio and video streaming helmets. ASN has publicized its successful use of "smart glasses" for remote repairs and Factory Acceptance Tests (Figure 11).

> **Non-verbal cues are missed over the phone, and partially over video-based platforms.**
>
> Paul Gabla of Alcatel Submarine Networks

There are some limits to remote work that are specific to the subsea cable industry. Building and maintaining relationships within the subsea cable industry has been crucial to its growth, and these interpersonal relationships are hard to replicate in remote settings. For example, as one industry member noted, "lobbying within the consortium often requires bilateral meetings," which can be difficult to achieve through video-conferencing. Additionally, in commercial purpose, the social aspect of the industry can be deeply affective, as "non-verbal cues are missed over the phone, and partially over video-based platforms," according to Paul Gabla, VP Sales & Marketing of Alcatel Submarine Networks. Introducing new business practices requires overcoming not only technical and operational challenges but also navigating social dynamics and relationships.

Challenges such as cultural differences, time zones, and strategic priorities of companies have been observed by staff across all teams—from operations to sales. One industry expert speculated that the chance of success is inversely related to the number of cultural, ethnic, and linguistic differences between parties. In sum, we found that global travel is likely to paradoxically remain part of the social fabric that binds the network together. The need for in-person meetings will never go away entirely.

It also is critical to recognize that, as recent studies have suggested, realizing remote work's environmental benefits requires coordination of sustainable practices across lifestyle, home, and office.[168] While emissions may be reduced in some remote work, it is possible for remote workers to emit more due to other types of travel or increased energy use at home. Moreover, reductions of technical "in person" work may have consequential emissions increases down the pipeline.

A qualitative survey of the industry conducted by the SSN team suggests that the effectiveness of remote work depends largely on factors such as project stage and the social fabric in place.[169] On-site visits are crucial in early stages while video-conferencing may work for shared corporate cultures. Management practices vary by age group, with younger generations favoring video calls. Rajesh Kheny, Lead in Global Program Management – Submarine Cable at Meta, suggests that companies should consider planning with the question: "if we managed somewhat successfully remotely, can we continue to manage that way since it helps those who don't like traveling and those who like a decent work-life balance to manage effectively and indirectly result in cost savings as a benefit?" The solution is to prioritize meaningful travel that is sensitive to the project stage and social relationships in place.

In light of these findings, we developed the first Remote Work Carbon Footprint Reduction Calculator for Subsea Cable Systems for the industry to measure carbon emission savings in transitioning to remote work (Figure 12).[170] Based on indicators from companies across the industry, the tool estimates the emissions savings of a shift to video conferencing in the development of a single consortium system, as summarized in the table below. Our analysis showed that a hypothetical large-scale consortium project going partially remote results in avoiding emissions equivalent to around 154 gasoline-powered passenger vehicles driven for one year.

Remote Work Carbon Footprint Reduction Calculator for Subsea Cable Systems~

Main Travel-related Indicators	Planning & Development	Joint-Business Agreement & Procurement	Construction	Total
Period (months)	18	18	36	72
Meeting Frequency (months between meetings)	1.5	1.5	1.5	4.5
Number of Meetings	12	12	24	48
Average Number of Participants Traveling/Meeting	12	18	15	45
Average Number Participants Traveling/Project	144	216	360	720
Percentage of Meetings Possible via Zoom	80%	90%	30%	
Number of Individual Trips Saved with Zoom	115.2	194.4	108	417.6
Average Distance Traveled per Individual Trip (km)*	4000	4000	4000	
Total Air Travel Distance Avoided (km)	460800	777600	432000	1670400
Carbon Savings per Project (kg CO2e) Δ	197600	333450	185250	716301

Notes

~ Sample estimations assume a large-scale consortium system.

Δ Conversion factors are taken from the 2021 UK Government's GHG Conversion factors, inclusive of radiative forcing and presuming business class travel.

* Average air travel distance is assumed to be a mid-length international flight. Obs.: 4,000km was selected as a fair estimate—roughly the distance between Los Angeles and Honolulu.

Figure 12. Remote Work Carbon Footprint Reduction Calculator for Subsea Cable Systems
Online calculator available at https://www.sustainablesubseanetworks.com

The industry can use this tool for an initial assessment of the emissions impacts of remote work. As described above, it should be used alongside incentives and policies to ensure the realization of environmental benefits at both the office and at home.

> **Where and as practical, we should take advantage of the multiple opportunities presented by recovering and recycling out-of-service submarine cables; congested, proven routes can be cleared and re-used, and the cables themselves are an excellent source of high-quality, recyclable materials.**
>
> – John Theodoracopulos of Subsea Environmental Services

Sustainability at End-of-Life

Recover and Recycle Cables

One carbon-intensive process in the subsea industry is the manufacturing of cables, which relies on the mining and processing of virgin raw materials, especially aluminum, copper, and steel. One of the most direct ways to mitigate this impact is through cable recovery, recycling, and the re-introduction of materials into the circular economy. Ninety-nine (99.9) percent of cable materials can be recycled, with the exception of any tape on the outside of the cable. Recovering and recycling cable, as well as dry plant Submarine Line Terminal Equipment, provides cable owners the opportunity to incorporate sustainable practices into their ordinary business operations, improve environmental outcomes, and to better reflect on the sustainability of the subsea telecommunication cable industry as a whole.

While cable recovery does require the deployment of additional ships, initial studies by the Sustainable Subsea Networks research team, alongside the carbon footprint self-analyses of cable recovery and recycling firms Mertech Marine and Subsea Environmental Services (SES), have found that emissions saved by recycling cable materials exceeds the emissions produced by recovery ships. Recycling cables is significantly less carbon-intensive than the production of raw materials. Depending on the size of the vessel, the marine component of recovering cable can maximize the fuel efficiency involved. In the future, new ships with updated, more efficient technology will be able to make broader use of alternative fuels, an improvement that will make recovery efforts even less carbon intensive. In short, recovery and recycling are a net carbon negative operation that could improve the carbon footprint of the industry.

Recycling is also an opportunity for cable owners to bring in additional revenue, as these retired systems hold value in their material composition. Recovering cable is also beneficial for the industry at large as a sustainability intervention, and it reduces the build-up of cables on the ocean floor. This makes repairs, maintenance, and new cable deployment easier, more efficient, and cost effective in the future. This in turn allows operators to make use of a more proven route where a corridor has been opened through the recovery of sections. Cable congestion over time can slow or disrupt these processes, requiring more time and resources.

The benefits of this process are not in question, yet there remain uncertainties about how to develop an effective metric for recycling efforts. Some of our interviewees thought that there should be a defined minimum percentage of the cable that should be recovered and recycled. Others pointed out that in some places it might make sense to leave shore ends in place, given how at times this can interfere with sensitive environmental habitats and potentially face increased regulatory challenges in removal. Moreover, not all cables can be recovered, such as in places where they are excessively buried or where they lie under or close to other cables.

On a commercial scale, recovery and recycling efforts are not easy processes. There are many logistical hurdles in dealing with permitting, equipment, and facilities. The business case for recovery and recycling companies is not yet assured. As a result, these variables concerning how and when to recycle are still up for debate. We found that currently recovery and recycling should be assessed on a cable-by-cable basis, since some cables are more easily recovered than others. A holistic view of "sustainability" is necessary, with various environmental impacts being considered. In addition, the circular economy for subsea cables is not a fully closed loop. Materials recycled will often not be sufficiently high grade for re-use, with cables finding their re-use in other industries.

The companies that are leading the recovery and recycling landscape of the subsea cable industry include both Mertech Marine and Subsea Environmental Services, among others who are exploring entering the market. They work directly with cable owners to recover and recycle their out-of-service cables.

Mertech Marine (established 1998) has been involved in the recovery and recycling of subsea cables since 2004, and it has recovered and recycled more than 105,000 km of cable from the ocean. The company currently owns and operates two vessels and will be adding another vessel to the fleet. Mertech Marine operates a low environmental impact recycling facility in Gqeberha (Port Elizabeth), South Africa, where the materials from recovered cables are processed using environmentally-friendly methods. Mertech Marine's cable recycling process enables the recovery of valuable materials such as copper, steel, aluminum, and polyethylene, which can be reused in various applications. By recovering subsea cables, the company actively contributes to reducing the need for energy-intensive production of virgin materials.

The decision to recover and recycle a cable system should be made considering multiple factors and stakeholders, including environmental, sustainability, safety of crew and other live cables and infrastructure from other seabed users, commercial, route congestion, etc.. A one-size-fits-all approach should not be adopted. Ultimately, it makes good sense to recover as much cable as can be removed safely and responsibly.

-Alwyn du Plessis of Mertech Marine

Individual companies, such as BT and Telstra, have also prioritized recovering and recycling retired cables. For BT's TAT-14 cable system, 95% of the cable was recovered and recycled. Telstra was majority owner in a consortium that has recently contracted a recovery company to recover its 1984 ANZCAN telephone cable. Telstra also had ownership in the HAW 4, TPC2, and TPC3 submarine cables, which have now been sold for the purpose of recovery and recycling. Telstra is currently conducting an internal evaluation of their business strategy with regards to COMPAC, SEACOM and AIS, along with several other Pacific cables they have an ownership stake in, with a view to sell them to be recovered and recycled.[171]

Subsea Environmental Services (SES), which purchased its first cable in 2012 and commenced marine operations in 2014, has to date recovered approximately 45,000 kilometers of submarine cable representing over 70,000 metric tonnes of material recycled and re-introduced into the circular economy. Subsea (SES) currently owns and operates a single, modified 5000 DTW ship and has signed an LOI for two additional ultra-eco newbuilds further aligning operations with the highest climate policies of the IMO and EU. Both Subsea (SES) and Mertech Marine's operations are ISO:14001 and ISO:9001 certified.

Subsea cable recovery is complicated, resource intensive, and requires expertise in executing complex offshore marine operations. Mertech Marine and Subsea (SES) have highly specialized crews that are experts at recovery, however, the process is nonetheless demanding and intricate. These companies have limited crews because of the specialized nature of the work. The licensing process for cable recovery can be a disincentive, depending on the agreed upon end-of-life service plan and the willingness for companies and local governments to include and prioritize recovery and recycling as a viable end-of-service goal. Cable recycling and redeployment requires collaboration between cable companies and operators, regional governments, and other significant actors in the management and regulation of subsea cables. This is a significant challenge and an important opportunity for the industry.

Subsea cable recovery is complicated, resource intensive, and requires expertise in executing complex offshore marine operations.

In addition to recovery of cables themselves, recycling and reuse can also happen in the dry plant. Ciena is currently working to recycle and recirculate electronics from cable landing stations. The company offers product take back and refurbishment services to assist with this endeavor. Other companies, such as PICS Telecom, specialize in deinstalling surplus assets from subsea networks, refurbishing these assets, finding new homes for the equipment, and ensuring responsible waste management.

Figure 13. Mertech Marine Processing Facility. Photo by Mertech Marine.

Figure 14.
Dedicated yard space for storage of systems before they are recycled.
Photo by Mertech Marine.

Figure 15.
Cable offloaded at the port for coiling and trans-shipped to the Mertech Marine facility in Gqeberha, South Africa.
Photo by Mertech Marine.

Figure 16.
High grade steel coils are separated during processing of a cable system. Photo by: Mertech Marine.

Figure 17.
The granulation of copper chips into a raw material product. Photo by Mertech Marine.

Figure 18.
The facility can extrude and process the recovered polyethylene from each cable system. Photo by Mertech Marine.

Figure 19.
The production of polyethylene pellets. Photo by Mertech Marine.

Redeploy Subsea Telecommunication Cables

Once recovered, some cables can be redeployed to new locations, giving the systems a second life of service. Repurposed cables, including early fiber optic cables that are now reaching the end of their current run of service, can be deployed to underrepresented areas of the global network, especially where maximum capacity is not as significant an issue. Small Island Developing States (SIDS), especially, could purchase recovered cables at a lower cost and establish a connection more quickly than developing a new system. For these reasons, redeployment might be a boon to smaller cable operators and regional telecommunications companies.

Recently, 800 km of recovered cable previously operating in the North Atlantic was redeployed in the Caribbean. The cable was recovered, re-laid, and operating in the new location all within a year, for a significantly lower cost compared to manufacturing and installing a new system for the region. In 2017, Telstra decided to pull up a cable, along with fourteen repeaters, along the coast of Taiwan to reuse as spares on other cables.[172]

Although older cables may operate with less capacity than the latest systems, they still provide reliable telecommunications. This lower barrier of entry could make a difference for communities that would otherwise have limited access to global connectivity.

Cable Sensing through Dual-Use Technologies

Subsea fiber optic cables have been utilized for purposes other than commercial communications infrastructure for decades, though to a much smaller global extent. Such uses of cables have typically included the incorporation of sensor nodes into a cable system or use of the fiber itself specifically for military sensing applications or university or government funded ocean observatory systems. The technology to collect information utilizing sensor nodes integrated into a cable system, or use of the fiber itself, has more recently been developed and/or implemented into the design of modern commercial subsea communications infrastructure as a secondary (or dual) use of the cable or for the purpose of monitoring cable integrity.

A primary goal of subsea cable owners is to protect their asset from damage in order to maintain reliable data and communications transmission along a fiber optic cable. Sensing technologies which primarily use the fiber as a sensing mechanism have been able to provide cable owners with an asset management and protection tool that assists in the overall protection of a cable, resulting in fewer repairs. Technologies such as distributed acoustic sensing (DAS), state of polarization (SoP), and interferometry provide a remote sensing capability using the fiber in a submarine cable and associated land-based equipment, to detect vibrations along a cable that could be associated with a human or natural activity or events that may damage a cable. Inadvertent (not malicious) damage of submarine cables from bottom contact fishing and vessel anchorages poses the largest risk to cables and is the source of almost all cable faults globally each year. Detection of fishing or an anchor being dragged near to a cable provides a warning mechanism to operators who can then better manage and maintain their infrastructure.

> **Sensing technologies have been able to provide cable owners with an asset management and protection tool.**

Separate from asset management or cable protection applications, fiber-based sensing technologies as well as sensor node technologies can also collect marine environmental data which has spurred much interest over the last decade including the development of the United Nations Joint Task Force (JTF) on SMART (Science Monitoring and Reliable Telecommunications) cables. Traditionally sensor nodes have not been incorporated into a commercial telecommunications cable because the commercial interest to collect scientific or ocean monitoring data does not exist outside of the fundamental and crucially important role cables play in global communications. Often the purpose of collecting scientific data has been served by university or government funded ocean observatory systems developed specific to that single purpose. These systems have also been used to detect earthquakes and act as early tsunami warning systems in places such as Japan. The opportunity to use sensor nodes in a commercial subsea cable is compelling, but not without its challenges as the intersection between commercial companies and scientific bodies such as universities still needs to be established, particularly in light of the high capital costs associated with constructing, installing and maintaining a subsea telecommunications cable.

These technologies, however, could offer a path towards improved sustainable development of digital infrastructure. Cable protection methods using sensing technologies help reduce damage to cables, and therefore lessen the need for vessel-based repair activities (and their associated carbon footprint). Collection of environmental data, aside from the potential contributions to the scientific research community, could also offer a path towards protection of marine biodiversity – by monitoring the marine environment in real time, it can be better protected from impacts of other human activities where restrictions may be in place such as activities taking place in Marine Protected Areas.

However, these types of dual uses present significant challenges and require careful consideration with collaboration between industry and governments. While the application of sensing technologies using subsea fiber optic cables presents great potential opportunities, the intersection between technology and government regulation is one that needs to be defined in a collaborative manner in order to consider dual uses as a viable opportunity and to see any sustainable benefit in the future. What is clear, however, is that this is a fast-developing area where technological developments, and industry and government interest will grow quickly.

“Cable protection methods using sensing technologies help reduce damage to cables, and therefore lessen the need for vessel-based repair activities (and their associated carbon footprint).”

SUSTAINABLE SUBSEA NETWORKS

THE FUTURE OF SUSTAIN-ABLE SUBSEA NETWORKS

> **For the subsea community to fully embrace change we need to ensure that sustainability becomes a fully integrated part of every business: they should be a natural and integrated part of decision-, steering-, monitoring-, acquisition-, and planning processes. Company cultures need to change, management teams must 'walk the talk'. Involvement and collaboration of employees, customers, suppliers and stakeholders is crucial.**
>
> -Pernilla Eriksson of Hexatronic and Lynsey Thomas of Subsea Networks Ltd.

The Future of Sustainable Subsea Networks

Motivating Forces for Change

Why are subsea cable companies going green? What can be done to amplify this trend? When asked about the primary motivating factors for sustainability, one interviewee observed that in the early 2020s, conversations kept popping up about sustainability at conferences and meetings. Being green was "in the air," not just at subsea cable events but in the data center industry and in the broader ICT sector. A growing awareness of climate change's severe effects was "in the air" as well.

Our research and industry partnerships provide insight into the primary factors motivating the shift to sustainability, which can be grouped in five categories: customer demand and economic benefit; regulation changes; the emergence of "green finance" or investors who are interested in sustainability; parent companies' climate values; and the commitment of individual people within companies. Our description of these motivations below provides a clearer picture of how changes within the industry can be sparked and leveraged.

The Bottom Line and Customer Demand

Investments in sustainability not only benefit the planet, but in many cases offer both short and long-term economic gains. As one of our interviewees told us, upgrading to energy efficient equipment "is just common sense." Another interviewee informed us that their efforts to reduce the carbon footprint of subsea cables was initiated by cost considerations, but their company also recognizes the sustainability benefits. Beyond energy efficiency projects, additional economic benefits can be derived from upgrading capacity and installing renewable energy.

We heard from many interviewees that although customers were not yet factoring green aspects into purchasing, they anticipated green purchasing will become a trend in the future. Many companies are beginning to set science-based targets and look at scope 3 emissions. Companies anticipate that customers will begin to look for contractors and subcontractors that are environmentally conscious. Some also anticipate that they will seek more local suppliers to minimize transportation carbon costs. Numerous companies that we spoke to across the subsea industry expressed a desire to fulfill this future customer demand for sustainability.

Across the sector, companies believe that moving toward sustainability is not only better for the environment, but better for their economic viability as carbon emissions impacts become increasingly important. These companies aim to be leaders in the field and to develop a sustainable reputation that will make their products and services more viable in the future.

In turn, accounting for scope 3 emissions is increasingly leading companies to consider sustainability in the selection of vendors and suppliers. In 2022, Fugro conducted a full analysis of its scope 3 emissions, estimating its 2022 scope 3 at 236 kilotonnes CO_2—the majority of these emissions were related to purchased goods and services, which could in turn be assessed in relation to sustainability. Leading companies are putting pressure on their own suppliers. For example, when Red Penguin Marine interviewed and chose their travel supplier, a decisive factor was the vendor's provision of a CO_2 report for all of the flights taken each year.

> **Across the sector, companies believe that moving toward sustainability is not only better for the environment, but better for their economic viability**

NEC is also working to reduce its scope 3 emissions, not only by creating more energy efficient products, but by encouraging its suppliers to reduce their CO_2 emissions. The company does so in part by setting up a supplier award system, offering seminars and workshops, and introducing suppliers to services for reducing CO_2 emissions. ASN favors the use of local subcontractors and suppliers, asks them to provide eco-friendly products compliant with environmental regulations, and encourages the adoption of standards and certifications. In 2022, Corning designed a strategy to engage suppliers on the reduction of their emissions. The focus is working with suppliers to develop emission reduction plans and key performance indicators.

Bulk Infrastructure requires that all of its suppliers run their operations sustainably. In addition, the company has acknowledged that its business case is based on renewable energy availability in Norway and Denmark, which the company imagines will make the region "attractive to new customers due to an increasing demand for both scope 3 emission reduction actions and low renewable energy costs."

Hexatronic has also begun pushing for sustainability among its suppliers, though the company noted that its customers have not yet really started asking the hard sustainability questions. As an exception, they noted a recent bid in which sustainability was factored into the evaluation process and affected its capacity to secure a contract. The company anticipates that this will become more frequent in the future.

Green Regulation

Governments and regulatory agencies are also driving sustainable initiatives in the ICT sector. Policies dictating standards in energy efficiency, carbon emissions, and sustainable practices or disclosures are becoming more common. In addition, businesses are becoming more proactive in adopting sustainability initiatives as they anticipate regulation at some point in the future.

Across our interviews, we routinely heard that one of the strongest motivators for change is regulation, either regulation that has become law or the likelihood of regulation at some point in the near future. "Companies in the UK have a lot of pressure coming down from the government to be more environmentally-conscious," reports Salvador Jimenez-Sanchez of Red Penguin Marine. ASN suggests that one of the advantages of adopting the ISO 14001 standard is to demonstrate compliance not only with current regulation, but with future legal requirements. Echoing these sentiments, Bulk Infrastructure states in its TCFD report: "there are also increasing legislative regulations at both the national and EU levels that have an impact on our operations."

National and international policy is also starting to shape the industry in the marine sector. The International Maritime Organization (IMO)'s policies and frameworks are a major driver towards developing more efficient and sustainable marine transportation. The IMO has developed targets for ships that are relevant to companies involved in survey, installation, maintenance, and recovery. The 2023 IMO Strategy on Reduction of GHG Emissions from Ships provides enhanced targets to tackle harmful emissions. The strategy includes an ambition to reach net-zero GHG emissions from international shipping by or around 2050, a commitment to ensure an uptake of alternative zero and near-zero GHG fuels by 2030, as well as indicative check-points for 2030 and 2040. This will impact most marine vessel operations.

We anticipate that, as environmental regulation focused on the ocean has expanded significantly over the past several decades, this may be another area in which environmental policy could alter the practices of the subsea industry, particularly in relation to surveying, installation, and repair. We anticipate that CO^2 emissions regulation may surface in permitting documents such as environmental impact assessments and license applications. Moreover, a more effective regulatory regime that streamlines national and local laws around permitting not only reduces uncertainty and enhances consistency in cable operations, but could also increase sustainability. An example of this is a well-coordinated permitting regime that would allow a vessel to sail directly to a cable fault location and avoid the need for the vessel calling in at the port, ultimately burning less fuel.

> "A more effective regulatory regime that streamlines national and local laws around permitting not only reduces uncertainty and enhances consistency in cable operations, but could also increase sustainability."

Green Finance

Green finance will be a key driver of sustainability in subsea networks and ICT more broadly. In light of uncertainty due to climate change, green investments in businesses that adopt sustainable approaches are seen as less risky in both the short and long term. This is particularly true for ICT, since digital technologies are understood as a necessary part of a sustainable future. Across international contexts, governments are also incentivizing certain kinds of green development through various forms of institutional investment: tax breaks, grants, and subsidies, among other strategies. In the United States, for example, the 2022 Infrastructure Bill provided incentives around the expansion of green initiatives and capacity across various sectors.

Additionally, certain mechanisms for lending and investment, such as "green bonds," have made it possible for institutions around the world, including banks, corporations, and governments, to invest in sustainable infrastructure projects with low-risk returns. Green bonds are typically used to invest in certain kinds of infrastructural improvements, including renewable energy, increased efficiency, and low-carbon transport, all of which are appealing in the ICT sector. Green bonds make securing investments more accessible and attractive. Although there is not widespread mobilization of green bonds in the subsea industry, this is a promising avenue for the future.

As one example, Bulk Infrastructure discloses in its TCFD report that it believes that the company's efforts to increase their environmental performance will "make cheaper green, sustainable and sustainability-linked financing available" since "Norwegian and Scandinavian banks are expected to offer financing and bonds with better terms in the years to come when a company can prove high or improved environmental performance." The company has already established a competitive edge by issuing a green bond with Medium Green shading by Cicero.

Parent Companies' Climate Values

Another significant motivating force for the adoption of sustainable practices is pressure from a parent company. Parent companies can encourage sustainability reporting and the adoption of certain standards, targets, or initiatives. ASN, as part of Nokia, actively participates in CO2 emission reduction towards Nokia's targets.

As another example, the subsea cable company Aqua Comms was acquired by Triple Point's D9 Infrastructure PLC Group in 2021. Triple Point's D9 Infrastructure has staked out sustainability as a corporate value, going so far as to take its name from the UN sustainable development goal number nine, on industry and infrastructural innovation. D9 cites a "cleaner world," as part of their corporate strategy and specifically identifies renewable energy as a key to sustainable economic and industry growth. Since being acquired by D9, Aqua Comms has reported scope 1 and 2 emissions and invested in renewable energy for its cable landing stations.

The factors that drive larger parent companies to enforce sustainability initiatives and environmental action or to adopt sustainability as a core value or mission are diverse. Companies may contain motivated individuals that are able to influence the organization's values, they might see oncoming regulation as a reason to adjust now, or they may be influenced by investors and the emerging role of green finance.

Individual Commitment

In our research we have also found numerous cases in which individuals have pushed sustainability forward and significant changes are motivated from people within a company. As René d'Avezac de Moran of OMS observes, the change is coming from everywhere within a company and for the new generation, "it's a way of thinking."

As just one small-scale example, Andrew Joel Siru of the Solomon Islands Submarine Cable Company (SISCC) began in 2021 to develop a green agenda for the organization to act responsibly for the environment. This included measures to increase efficiency and reduce energy consumption, which he designed after consulting with people who developed similar programs at other companies. Siru helped to launch company initiatives to turn off lights, air conditioners, and devices in the offices of SISCC when these were not in use. He was able to install nozzles on sinks in the facility to reduce water consumption. In addition to these initiatives, Siru started the process of tracking energy usage for SISCC. Even in situations with limited resources, the motivation of individuals can help to push forward sustainability work one small step at a time.

Next Steps in Sustainability

While many of the best practices outlined above can be undertaken by a single company, we have identified four paths toward a sustainable future that require collective effort: an industry-wide sustainability working group; the development and harmonization of metrics; coordination with regulators and policy-makers; and a rethinking of global network architecture in order to leverage the low-carbon footprint of subsea cables.

Support an Industry-wide Sustainability Working Group

The subsea industry can advance sustainability through the support of an industry-wide committee committed to these issues. One of the key findings of our research is that there are a number of companies who have independently developed sustainability initiatives with no outlet for broader dissemination of the successes of those initiatives. An industry-wide working group could function as that platform. The same group could also lead industry initiatives, discuss sustainability targets and standards, establish connections and share knowledge, and encourage ongoing reflection on environmental issues as the industry is confronted with new challenges and technological advancements. Moreover, a united approach may help to circumvent conflicting regulatory perspectives worldwide.

Such a working group is already in operation in support of Sustainable Subsea Networks. This research project first emerged from the Global Citizen Working Group supported by the SubOptic Association. From 2021-2023, key industry members have participated in the working group and facilitated dialogues on sustainability.

As a step toward a broad and impactful industry-wide committee on sustainability, we planned and executed the Congress on Sustainability at the SubOptic conference in Thailand in 2023. This was the first intentional gathering of members from across sectors and around the world to discuss sustainability in the subsea cable industry. It brought together leaders to share insights from ongoing initiatives and potential strategies for the cable networks of the future. The Congress's conclusion underscored the pressing need for industry collaboration and coordination.

Following the Congress, the Sustainable Subsea Networks research initiative has broadened the Working Group, now composed of over thirty members spanning all phases of the cable life-cycle, from manufacturing to end-of-life. Ongoing support of spaces for collaboration, whether through this working group or others, is necessary to fully embrace sustainability.

Develop and Harmonize Metrics

The establishment of industry-wide metrics could significantly improve companies' capacity to develop and sustain environmentally friendly policies and practices. Metrics will also be essential if sustainability practices, targets, and standards are to be written into contracts—in procurement agreements, vendor contracts, lease agreements, among others. Collaborating to standardize and harmonize metrics and frameworks across the subsea cable industry would be instrumental in ensuring sustainable practices across the supply chain.

Coordinate with Regulators and Policy-makers

One of the most impactful forces for environmental change is the development of regional, national, and international policy frameworks that enshrine certain practices, standards, and regulations. As these frameworks are being created around the world, it would benefit the subsea cable industry to take steps to be ahead of the curve on anticipated regulation. Michael Constable, at the SubOptic Congress on Sustainability, emphasized the importance of regulators worldwide: "We will be forced by the regulators around the world with their own ideas on things, possibly without industry input," he cautioned.

Industry discussion about green policy and pre-emptive engagement with government stakeholders is important. Given the global distribution of the industry and its many sectors, sustainability should be addressed via a multipronged approach, developing strategies for minimizing emissions that are specific and appropriate to individual contexts. Policy effects should be considered in both the short and long term, at the local level and at a global scale, within an individual company and across multiple operations. Following in the footsteps of the data center industry, the subsea cable industry might proactively set a course of action to evaluate, track and lower emissions. In turn, by anticipating regulation and developing internal policies, companies increase the likelihood that their practices would shape regulation.

Coordinated policy frameworks would also ensure long-term certainty and uniformity for companies across the industry, thereby ensuring more confidence in sustainable infrastructure investments.

Rethink Network Design for Sustainability

The fact that the carbon footprint of a subsea network is relatively small opens up a new direction for sustainability: considering network design. By expanding cable capacity to locations where renewable energy is abundant, the Sustainable Subsea Networks team has proposed, it may be possible to reduce the carbon footprint of the internet's infrastructure as a whole.[174]

Regional differences are a key part of this strategy. Each location in the world comes with very specific opportunities and constraints, including ecological conditions predisposed to certain kinds of renewable energy. Networks might be reconfigured to increase traffic to locations that embrace renewable energy sources or limit fossil fuels. In turn, parts of the network that are carbon intensive might be targeted for increased sustainability efforts. This could situate subsea cables as an economic accelerant of regional energy transitions.

This approach to network architecture is not without precedent and some companies are already engaging in this kind of work. Google has recently adopted a similar model with its regional data center compute strategies, dynamically moving computational work to data centers that are situated in lower carbon energy settings, hour by hour. Google calls this "carbon intelligent computing," and it is a key part of its effort to decarbonize by 2030. Bulk Infrastructure, advocating for more cables to the renewable energy-powered Norwegian data centers, states, "Location has been one of the key elements in our sustainability framework from the beginning, of which availability of renewable energy and further plans for development in the area are among the main decision criteria." Bulk advocates that the industry "move away from transferring gigawatts—but instead focus on transferring gigabytes."

These projects make it clear that a regional, comparative approach to carbon impacts and sustainable energy use across the network is both possible and impactful. The subsea cable industry could be a key component and champion of this proposal: it already has a small footprint, which could be mobilized to move data around the world between hubs of clean energy generation.

> **We will be forced by the regulators around the world with their own ideas on things, possibly without industry input.**
>
> -Michael Constable

Figure 20.
The SubOptic Foundation Congress on Sustainability chaired by Nicole Starosielski on March 13th, 2023. From left to right: Merete Caubet (Bulk Infrastructure), Michael Constable, Dean Veverka (Southern Cross Cable Network), Brian Lavallée (Ciena), Takahiro Kashima (NEC), Andy Palmer-Felgate (Meta), Alwyn du Plessis (Mertech Marine), Emmanuel Danjou (Alcatel Submarine Networks), René d'Avezac de Moran (Fugro), Michael Clare (UK's National Oceanography Centre), and Nigel Bayliff (Aqua Comms). Photo by Terrapin Events.

SUSTAINABLE SUBSEA NETWORKS

APPENDICES

Appendices

Author Biographies

Principal Investigators
Anne Pasek is Assistant Professor and Canada Research Chair (Tier II) in Media, Culture, and the Environment at Trent University, cross-appointed between the Department of Cultural Studies and the Trent School of the Environment. Her research explores technical and cultural approaches to climate action with a particular emphasis on the tech sector. Pasek is the Energy and Climate lead of Sustainable Subsea Networks, responsible for the development of The Subsea Cable Carbon Emissions Calculator. Her books include *Digital Energetics* (2023) and *Energy In/Out of Place* (2023).

Nicole Starosielski is Professor of Film and Media at the University of California, Berkeley. Starosielski is author or co-editor of over thirty articles and five books on media, infrastructure, and environments, including *The Undersea Network* (2015), a book about the history and cultures of the subsea cable industry. Starosielski serves as the Industry Research lead of Sustainable Subsea Networks, coordinating with companies across the subsea industry on sustainability. Since 2019, Starosielski has been a co-convenor of the SubOptic Association's Global Citizen Working Group.

Anjali Sugadev is an independent legal consultant and recipient of the 2015 Rhodes Academy Submarine Cables Writing Award. Her works include "Global Regulation of Submarine Cables and Pipelines: Similarities, Differences and Gaps" (2016), "India's Critical Position in the Global Submarine Cable Network: An Analysis of Indian Law and Practice on Cable Repairs" (2017) and "Review of Selected National Legislations Relating to Access and Benefit-Sharing" (2019). As the Law and Policy Lead of Sustainable Subsea Networks, Sugadev examines the legal frameworks, international and national, to understand the role of regulation and policy in shaping a carbon-reduced future.

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Graduate Research Assistants
Iago Bojczuk is a Ph.D. candidate in the Department of Sociology at the University of Cambridge, where his work investigates the material, economic, and political dimensions of data centers and the formation of cloud regions in Latin America. Originally from Brazil, he holds a M.S. in Comparative Media Studies from the Massachusetts Institute of Technology (MIT). His expertise includes the intersection of policy and the broader digital infrastructure sector, especially in the context of Global South countries, as well as the adoption of remote work and feasibility investigation in renewable energy transition.

George N. Ramirez is a Ph.D. candidate in the Department of Media, Culture, and Communication at New York University. Ramirez's expertise includes the adoption of sustainable technologies at marine ports as well as the role of regulation and standardization in carbon emissions and renewable energy targets.

Nicholas R. Silcox is a Ph.D. candidate in the Department of English at New York University and his work focuses on the intersection of media, technology, and the environment. In particular, his research explores the role of emerging media and infrastructure in addressing our relationship to climate change. His areas of contribution include emerging environmental sensing and monitoring technologies, the relationship between the subsea industry and science, and recycling and redeployment.

Index of Contributing Companies

A-2-Sea (ISO 14001, ISO 9001)

Alcatel Submarine Networks/Nokia (Overview of Best Practices, Greenhouse Gas (GHG) Protocol, CDP, Sustainability Indices, Near-term Targets (2030), RE100, ISO 14001, ISO 9001, TL9000, Leadership in Energy and Environmental Design (LEED), Green Marine, Connect Facilities to Carbon Neutral and Renewable Energy, Make Facilities Energy Efficient, Eco-Design, Sustainable Marine Operations and the Wet Plant, Make Vessels and Marine Operations Efficient, Plug into Shore Power, Transition Fuel Source, Solar Power at the Cable Landing Station, Make the Cable Landing Station Energy Efficient, Work Remotely, Cables for Science: SMART Cables and Ocean Observatories, The Bottom Line and Customer Demand, Green Regulation, Parent Companies' Climate Values, Support an Industry-wide Sustainability Working Group)

Aqua Comms (CDP, Commit to Energy Targets, Power Cables with Carbon Neutral and Renewable Energy, Work Remotely, Parent Companies' Climate Values, Support an Industry-wide Sustainability Working Group)

BT Group (Greenhouse Gas (GHG) Protocol, Task Force on Climate Related Financial Disclosures (TCFD), Sustainability Indices, Near-term Targets (2030), RE100, ISO 14001, ISO 50001, ISO 9001, Sustainable Marine Operations and the Wet Plant, Make Vessels and Marine Operations Efficient, Power Cables with Carbon Neutral and Renewable Energy, Retrofitting the Cable Landing Station, Recover and Recycle Cables)

Bulk Infrastructure (Overview of Best Practices, Greenhouse Gas (GHG) Protocol, Task Force on Climate Related Financial Disclosures (TCFD), Other Targets, ISO 14001, ISO 9001, Power Cables with Carbon Neutral and Renewable Energy, Operate Environmentally, The Bottom Line and Customer Demand, Green Regulation, Green Finance, Support an Industry-wide Sustainability Working Group, Rethink Network Design for Sustainability)

Ciena (Greenhouse Gas (GHG) Protocol, CDP, Task Force on Climate Related Financial Disclosures (TCFD), Near-term Targets (2030), Commit to Energy Targets, Energy Attribute Certificate (EAC), Power Purchase Agreement (PPA), On-site Renewable Installations, Carbon Offsets, ISO 14001, TL9000, Leadership in Energy and Environmental Design (LEED), Upgrade Submarine Line Terminal Equipment (SLTE) and Extend Lifetime, Work Remotely, Recover and Recycle Cables)

Cisco (CDP, Task Force on Climate Related Financial Disclosures (TCFD), Sustainability Indices, Long-term Targets (2050), Commit to Energy Targets, Power Purchase Agreement (PPA), On-site Renewable Installations, ISO 14001, ISO 9001, TL9000, Leadership in Energy and Environmental Design (LEED))

Corning (Overview of Best Practices, Near-term Targets (2030), Power Purchase Agreement (PPA), On-site Renewable Installations, ISO 14001, ISO 9001, TL9000, Leadership in Energy and Environmental Design (LEED), Connect Facilities to Carbon Neutral and Renewable Energy, Eco-Design, The Bottom Line and Customer Demand)

Digital Realty (Greenhouse Gas (GHG) Protocol, CDP, Task Force on Climate Related Financial Disclosures (TCFD), Near-term Targets (2030), Power Purchase Agreement (PPA), On-site Renewable Installations, Energy Star Certification, SS564: Green Data Center)

E-marine (ISO 14001, ISO 9001)

EGS Survey (ISO 14001, Plug into Shore Power, Transition Fuel Source, Connect to Offshore Renewables)

EllaLink (ISO 9001, Power Cables with Carbon Neutral and Renewable Energy, Work Remotely)

Equinix (Greenhouse Gas (GHG) Protocol, CDP, Task Force on Climate Related Financial Disclosures (TCFD), Near-term Targets (2030), RE100, Energy Attribute Certificate (EAC), Power Purchase Agreement (PPA), On-site Renewable Installations, ISO 14001, ISO 50001, ISO 9001, Leadership in Energy and Environmental Design (LEED), Energy Star Certification, SS564: Green Data Center, BCA-IMDA Green Mark for Data Centres Scheme, Power Cables with Carbon Neutral and Renewable Energy, Hydrogen Fuel Cells, Make the Cable Landing Station Energy Efficient)

Fugro (Greenhouse Gas (GHG) Protocol, CDP, Task Force on Climate Related Financial Disclosures (TCFD), Sustainability Indices, Near-term Targets (2030), Commit to Energy Targets, On-site Renewable Installations, ISO 14001, ISO 50001, ISO 9001, Leadership in Energy and Environmental Design (LEED), Make Vessels and Marine Operations Efficient, Transition Fuel Source, Connect to Offshore Renewables, Deploy Autonomous Vessels, Operate Environmentally, The Bottom Line and Customer Demand, Support an Industry-wide Sustainability Working Group)

Fujitsu (Greenhouse Gas (GHG) Protocol, CDP, Task Force on Climate Related Financial Disclosures (TCFD), Sustainability Indices, Science Based Target Initiative, RE100, Energy Attribute Certificate (EAC), Power Purchase Agreement (PPA), On-site Renewable Installations, ISO 14001, ISO 50001, ISO 9001, TL9000)

Global Marine (ISO 14001, ISO 50001, Sustainable Marine Operations and the Wet Plant, Make Vessels and Marine Operations Efficient, Plug into Shore Power, Transition Fuel Source, Connect to Offshore Renewables, Operate Environmentally)

Globe Telecom (Greenhouse Gas (GHG) Protocol, Sustainability Indices, Near-term Targets (2030), ISO 14001, ISO 50001, ISO 9001)

GlobeNet (ISO 14001)

Google (Greenhouse Gas (GHG) Protocol, CDP, Task Force on Climate Related Financial Disclosures, Near-term Targets (2030), RE100, Power Purchase Agreement (PPA), Carbon Offsets, ISO 50001, ISO 9001, Leadership in Energy and Environmental Design (LEED), Energy Star Certification, Rethink Network Design for Sustainability)

Hexatronic (Overview of Best Practices, Greenhouse Gas (GHG) Protocol, CDP, On-site Renewable Installations, ISO 14001, ISO 9001, Connect Facilities to Carbon Neutral and Renewable Energy, Make Facilities Energy Efficient, Eco-Design, Reduce Emissions from Armor, Operate Environmentally, The Bottom Line and Customer Demand)

HMB-IX (Carbon Offsets, Solar Power at the Cable Landing Station)

Indigo TG (ISO 14001, ISO 9001)

Infinera (Greenhouse Gas (GHG) Protocol, Task Force on Climate Related Financial Disclosures, Sustainability Indices, ISO 14001, ISO 9001, TL9000)

IT International Telecom (Make Vessels and Marine Operations Efficient, Plug into Shore Power, Transition Fuel Source)

KDDI (CDP, Task Force on Climate Related Financial Disclosures (TCFD), Sustainability Indices, Near-term Targets (2030), Energy Attribute Certificate (EAC), ISO 14001)

Keppel Corporation (Greenhouse Gas (GHG) Protocol, Sustainability Indices, Other Targets, Carbon Removal, ISO 14001, ISO 50001, ISO 9001, Leadership in Energy and Environmental Design (LEED), SS564: Green Data Center, BCA-IMDA Green Mark for Data Centres Scheme)

Makai Ocean Engineering (ISO 9001, Connect to Offshore Renewables)

Mertech Marine (ISO 14001, ISO 9001, Recover and Recycle Cables, Support an Industry-wide Sustainability Working Group)

Meta (Greenhouse Gas (GHG) Protocol, Sustainability Indices, Near-term Targets (2030), RE100, Power Purchase Agreement (PPA), Carbon Removal, ISO 50001, Leadership in Energy and Environmental Design (LEED), Energy Star Certification, Wave-Powered Cables, Upgrade Submarine Line Terminal Equipment (SLTE) and Extend Lifetime, Work Remotely, Support an Industry-wide Sustainability Working Group)

Microsoft (Greenhouse Gas (GHG) Protocol, CDP, Task Force on Climate Related Financial Disclosures, Sustainability Indices, Near-term Targets (2030), RE100, Energy Attribute Certificate (EAC), Power Purchase Agreement (PPA), Carbon Offsets, Carbon Removal, ISO 14001, ISO 50001, ISO 9001, Leadership in Energy and Environmental Design (LEED), Energy Star Certification, Operate Environmentally)

NEC (Overview of Best Practices, CDP, Task Force on Climate Related Financial Disclosures (TCFD), Sustainability Indices, Near-term Targets (2030), RE100, On-site Renewable Installations, ISO 9001, TL9000, Connect Facilities to Carbon Neutral and Renewable Energy, Make Facilities Energy Efficient, Eco-Design, Make Vessels and Marine Operations Efficient, The Bottom Line and Customer Demand, Support an Industry-wide Sustainability Working Group)

Nexans (Greenhouse Gas (GHG) Protocol, Task Force on Climate Related Financial Disclosures, Sustainability Indices, Near-term Targets (2030), RE100, Power Purchase Agreement (PPA), On-site Renewable Installations, ISO 14001)

NJFX (Power Purchase Agreement (PPA), Power Cables with Carbon Neutral and Renewable Energy, Make the Cable Landing Station Energy Efficient, Operate Environmentally)

NTT Group (Task Force on Climate Related Financial Disclosures (TCFD), Sustainability Indices, Near-term Targets (2030), On-site Renewable Installations, TL9000, Leadership in Energy and Environmental Design (LEED), Energy Star Certification, Make Vessels and Marine Operations Efficient, Transition Fuel Source)

Orange (Greenhouse Gas (GHG) Protocol, CDP, Sustainability Indices, Near-term Targets (2030), Commit to Energy Targets, Power Purchase Agreement (PPA), On-site Renewable Installations, ISO 14001, ISO 9001, Leadership in Energy and Environmental Design (LEED))

Orange Marine (ISO 14001, Green Marine, Sustainable Marine Operations and the Wet Plant, Plug into Shore Power, Transition Fuel Source, Connect to Offshore Renewables)

R&G Telecom (Retrofitting the Cable Landing Station)

Red Penguin Marine (Overview of Best Practices, Carbon Offsets, ISO 14001, ISO 9001, Make Vessels and Marine Operations Efficient, Operate Environmentally, The Bottom Line and Customer Demand, Green Regulation)

Saildrone (Deploy Autonomous Vessels)

Solomon Islands Submarine Cable Company (Individual Commitment)

Southern Cross Cable Network (Greenhouse Gas (GHG) Protocol, RE100, Carbon Offsets, Solar Power at the Cable Landing Station, Operate Environmentally, Support an Industry-wide Sustainability Working Group)

Subsea Data Systems (Cables for Science: SMART Cables and Ocean Observatories)

Subsea Environmental Services (ISO 14001, ISO 9001, Recover and Recycle Cables)

Tata Communications (Greenhouse Gas (GHG) Protocol, Near-term Targets (2030), Other Targets, Commit to Energy Targets, Carbon Offsets, ISO 14001, ISO 9001, TL9000, Leadership in Energy and Environmental Design (LEED))

Telecom Egypt (On-site Renewable Installations, Solar Power at the Cable Landing Station)

Telstra (Greenhouse Gas (GHG) Protocol, CDP, Task Force on Climate Related Financial Disclosures, Near-term Targets (2030), Commit to Energy Targets, Power Purchase Agreement (PPA), Carbon Offsets, ISO 14001, ISO 9001, Retrofitting the Cable Landing Station, Power Usage Effectiveness, Operate Environmentally, Recover and Recycle Cables, Redeploy Cables)

Telxius/Telefónica (Overview of Best Practices, Greenhouse Gas (GHG) Protocol, CDP, Sustainability Indices, Near-term Targets (2030), RE100, Carbon Offsets, ISO 14001, Retrofitting the Cable Landing Station)

Vodafone (CDP, Task Force on Climate Related Financial Disclosures, Sustainability Indices, Near-term Targets (2030), RE100, ISO 14001, ISO 9001, Alternatives for Diesel Generators)

WFN Strategies (Overview of Best Practices, Greenhouse Gas (GHG) Protocol, Climate Pledge and SME Climate Commitment, ISO 14001, ISO 9001)

Xtera (Task Force on Climate Related Financial Disclosures, ISO 9001, Eco-Design, Make Vessels and Marine Operations Efficient)

SUSTAINABLE SUBSEA NETWORKS

ENDNOTES

7. Endnotes

[1] The plan extended from 2022-2026. More information can be found at https://www.nec.com/en/global/csr/eco/target.html.

[2] Developed in 2021, the pillars of this agenda include certification and legal compliance, keeping assets in compliance with environmental standards, reducing energy consumption and environmental impact of new products, and greening ways of working for both employees and contractors. See Ocean Titans, (2023). "Connecting the World Responsibly." https://www.youtube.com/watch?app=desktop&v=RZRZQ1hW4TU

[3] In 2022, Ciena also launched a Sustainability Leadership Committee to oversee its sustainability strategy, programs, and progress, as well as approve all associated goals and targets. The committee is comprised of senior-level executives from across the business who have functional accountability for programs and topics that are aligned to the company's sustainability focus areas.

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[7] The CDP's disclosure platform provides the mechanism for reporting in line with the TCFD recommendations. The CDP's questionnaires were developed by translating the TCFD's recommendations into a standardized annual format. In other words, the CDP brings the TCFD into real-world practice and companies who disclose through the CDP are also in line with TCFD recommendations. CDP's climate change questionnaire contains over 25 TCFD-aligned questions, which can be fully explored through the CDP Technical Note on the TCFD. The CDP also released an initial insights paper that presents a high-level overview of how major indices are aligning with TCFD recommendations.

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[17] In order to be considered net zero, companies must do two things. First, they must reduce all three scopes of GHG emissions to zero. In addition, these organizations must neutralize residual emissions by the net zero target date and maintain it after that. Companies who commit through SBTi must keep a timeline with a baseline that is no earlier than 2015 for both short- and long- term targets. Reduction must happen over the course of five years at minimum and ten years at maximum, starting from the date that the target reaches the organization for validation. The SBTi offers an extensive guide with detailed definitions on setting targets, boundaries, and accounting.

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