A NEW ERA OF SUSTAINABLE NETWORK HUBS?

The Subsea Cable - Data Center - Renewable Energy Connection

BY IAGO BOJCZUK, NICK SILCOX, NICOLE STAROSIELSKI AND HUNTER VAUGHAN

A sea change is underway in global network geography. In the past, subsea cable routes were designed to link major population centers. Following the rise of cloud computing, cables increasingly interconnect data centers, which may or may not be located near the populations they serve. Content providers will account for a majority of CAPEX spending from 2022-2024 across Atlantic, Pacific, and U.S.-Latin America cable routes, observes analyst Tim Stronge of TeleGeography. An important consideration for these companies, he points out, is how to connect their data centers. As just one example, the cable landing point at Virginia Beach in the United States was "the safest spot to land with the shortest distance to 'Data Center Alley'" in Ashburn, Virginia (Glose 2018).

Around the world, data centers are also being established near cable landing sites. Many cables today even land in data centers and network exchanges. As Nigel Bayliff, CEO of Aqua Comms, tells us: "cable landing stations and data centers go hand-in-hand to create the foundation layer of the internet in any country, and as such they are symbiotic--they both lead and lag each other. Data centers get built near landings—landings are built to serve data center locations."

Now, with the increasing pressure of global climate change, a third kind of infrastructure has entered the mix: the electrical network. Data centers demand huge amounts of power, and for reasons both economic and environmental, operators are looking to both cheap and renewable energy sources. A cluster of data centers at The Dalles, Oregon, in the United States, was located there in part because of the inexpensive and abundant hydropower. Google's Chilean data center sources power from a massive solar farm in the Atacama region. Locations such as Iceland and Norway have attracted data center investment in part by leveraging their cool climates and renewable resources.

Subsea cable landing stations themselves require relatively little power to operate, but the cable - data center - energy connection means that network design and decisions about terminal locations are increasingly power-sensitive. This month's Sustainable Subsea column, brought to you by the SubOptic Foundation's Sustainable Subsea Networks research project, asks: how have certain locations emerged as cable hubs, and how did these cable connections become intertwined with the data center landscape? Given that companies are increasingly pursuing net-zero goals, how can networks of the future be connected to renewable energy developments?

As case studies, we hone in on two important nodes in the global

cable network: Ireland and Fortaleza, Brazil. We chose these for several reasons. First, these locations have historically been critical gateways for telecommunications rather than end-destinations in themselves. Their story reveals how existing on-the-way hubs may adapt to a new ecosystem. Second, each has a substantial number of cable connections as well as a relatively green grid. While they do not offer the level of green energy available in Iceland and Norway, they have more cable systems than many Nordic countries and provide a strong foundation of connectivity. Third, although they are not hubs of data center development such as Singapore, they have nonetheless attracted data centers (unlike, for example, the cable hubs of Djibouti). Below, we describe how each location became a telecommunications hub and speculate about how renewable energy might affect its future potential.

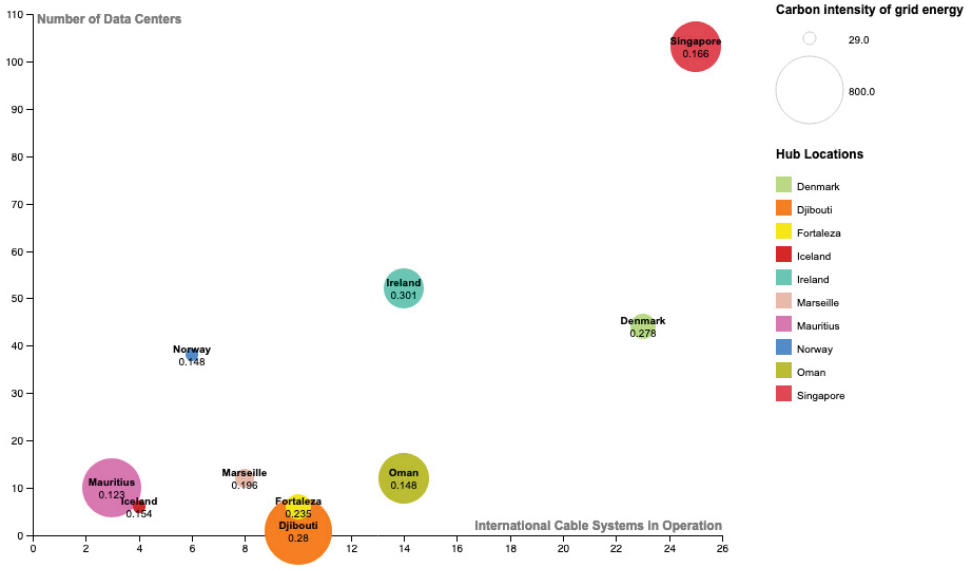

Figure 1: Locations according to the number of data centers and operating international cable systems. The size of each circle refers to the carbon intensity of grid energy. The number at each location refers to the cost of electricity to businesses (USD per kWh).

In an earlier article of the Sustainable Subsea column, "More Cables = Less Carbon?", we suggested that, because cables have a low carbon footprint, a sustainable future might involve laying many more cables to renewable network hubs. Ireland and Fortaleza are two locations that hold possibility as sustainable network hubs: they have cables, data centers, and vast renewable energy potential. The industry has yet to fully embrace this possibility.

This and other green topics will be under discussion at the upcoming Pacific Telecommunications Conference in Hawaii. We invite you to join us at Sunday's submarine cable panels, several of which will be focused around the theme of sustainability.

IRELAND: AN ESTABLISHED "DATA GATEWAY" INTO EUROPE

Our first case study, Ireland, has a rich and unique history of subsea connections, which had little to do with either data center development or the country's energy matrix. The laying of the first transatlantic subsea telegraph cables in the 1850s brought Ireland to the center of the connected world, and for decades the telegraph had enormous social and economic effects on Valentia Island and Galway.

Following the telegraph, however, Ireland was often overlooked in terms of technological advancement and economic investment, leading to a lull in the country's role in global telecommunications. British colonial rule meant Ireland was not able to self-determine its economy and resources were extracted and redirected to British economic concerns. Despite playing an early role in the subsea industry, Ireland was mostly ignored until its independence from Britain in the 1920s. Following attempts at internal economic development, Ireland finally began to emphasize exports as a key economic driver in the mid-twentieth century, which in turn promoted the importance of international connectivity. Cable connectivity, however, was primarily routed through Britain until the PTAT cable was established in 1989.

Today Ireland plays a unique role as a connection point for the global subsea network, claiming fourteen cable connections as of 2020—in comparison to 4 in New Zealand, a nation of similar population size. Ireland's convenient location as a "gateway to Europe" and comparatively low tax rates made the country a destination for businesses seeking to export their operations. Data

centers have become a key feature of the Irish economy, as the country has over 50 operational data centers and dozens of others either under construction or with permission to be built. Business-friendly policies are one of the primary reasons for the development of data center infrastructure in Ireland, alongside the country's cool climate. Lower temperatures are strategic for data center operations as they keep energy costs down. Despite this, Ireland was famously passed over by Microsoft in 1999 as a potential site for a data center because of the perceived lack of connectivity on the island.

This changed soon after as Ireland expanded connection via fiber optic subsea cables. Since 2014, seven new trans-Atlantic cables have entered service, with a total of 72 fiber pairs. Three of these connect to Ireland, and account for 20 new fiber pairs. Nigel Bayliff, CEO of Aqua Comms, states that the original and subsequent choice of Ireland as a landing location was the concentration of usage—they are driven by the market and the concentration of data centers. "With no cables," he tells us, "there is little lifespan in data centers on an island."

In addition to increased connectivity, a key element in the rapid growth of data centers in Ireland was the economic fallout of the global economic crash in 2007 and 2008. Ireland's low tax rates became a primary attraction for companies seeking to expand connectivity during the global economic downturn (Brodie & Bresnihan, 2021). This expansion was met with enthusiasm for those concerned with economic prosperity but has also received significant pushback from environmentalists because of data centers' massive energy demands.

The public pressure from environmentalists, along with technical and logistical concerns about the Irish energy grid, culminated in 2022 with a moratorium on data center expansion. Ireland's state-owned national grid, EirGrid, decided to halt all data center expansion and consider proposals on a case-by-case basis. This followed a decision by the Commission for Regulation of Utilities to limit the energy and environmental impacts of data centers in Ireland. The city of Dublin's local government has moved to codify a data center moratorium but has received pushback from national leaders, including the Office of the Minister of State at the Department of Housing and Development, though the EirGrid moratorium is ongoing. The issue of data center expansion is fraught within Irish politics and the Irish national discourse at large.

Currently, the expectation is that no new data centers will be added until near the end of this decade. The implications of this are wide-ranging for the Irish economy and to connectivity across the Atlantic to Europe. However, most significantly, the moratorium suggests that Ireland could become a case study for the development of telecommunications infrastructure that is not simply efficient, but environmentally sustainable and energy-conscious. Ireland will remain an important subsea landing spot and data center location for all the reasons already described; however, the continued expansion of Ireland as a telecommunications hub will likely need to happen alongside a serious commitment to reduce carbon emissions and energy demands.

FORTALEZA: A CABLE HUB AT THE "CORNER OF THE WORLD"

In addition to increased connectivity, a key element in the rapid growth of data centers in Ireland was the economic fallout of the global economic crash in 2007 and 2008.

Fortaleza, located in the Brazilian northeast state of Ceará, is one of the most connected subsea landings in Latin America and the Caribbean. As of 2022, Fortaleza is home to 16 in-operation cable systems, with at least 10 of them being systems of international capacity. Industry and government stakeholders go as far as to refer to Fortaleza as an "intercontinental hub," "a corner of the world," or a "nodal point of global connectivity." The city and its surroundings do not generate the same buzz in comparison to other hot locations for hyperscale data center developments—such as the Mexican state of Querétaro or the commune of Quilicura, in Chile. Despite this, Fortaleza has still become a critical node in the

global network of data trafficking.

The deployment of submarine cables to support internet-related data transmission started in the second half of the 1990s in Brazil. While the vast majority of ICT and telecommunication infrastructure could be found in the major southeast metropolis of São Paulo and Rio de Janeiro, virtually all the subsea cable systems that leave for other continents stop in Fortaleza. As Erick Contag, Vice-President of SubOptic and Trustee of the SubOptic Foundation observes, "Fortaleza's geographic location represented an ideal point for optical signal regeneration. The subsea and optical technology from this era balanced distance versus capacity per fiber pair, and Fortaleza was perfect for it."

However, in the early 2000s, Fortaleza was far from being a cable hub as we know it today. Although the city attracted tourists for its large dunes and beaches, the existing infrastructures were mostly for oil and gas. In fact, workers would often commute to nearby cities as economic opportunities were scarce. It took about ten years for Fortaleza to lay the groundwork to interlink cable and data center development. Operators established partnerships with local IT firms for win-win economic competition and benefited from government incentives. Since 2014, Brazil as a whole has been witnessing a new wave of subsea cable system developments, with the industry planning and deploying systems with an increased data transfer capacity of up to 138 Tbps. As of 2022, the subsea cable systems arriving in Brazil give the country access to a network of nearly 180,000 km—with connections to Colombia, Venezuela, Bermuda, United States, Cameroon, Portugal, Spain, Senegal, Cape Verde, Argentina, French Guiana, among others (OCDE, 2020). As Tim Stronge points out, there is a long tradition here: "Fortaleza was a major landing site well before the content providers emerged as large consumers of demand and investors in new systems." Today, geography remains a major draw. Clara Casanova of EllaLink says Fortaleza's geographic location as "decisive" for the choice of their recent cable landing.

While the vast majority of ICT and telecommunication infrastructure could be found in the major southeast metropolis of São Paulo and Rio de Janeiro, virtually all the subsea cable systems that leave for other continents stop in Fortaleza.

It is in part because of its long-standing role as a stopover for cables that Fortaleza is today attracting new data center investments from some of the major operators and tech companies in the world. Other factors have also facilitated its emergence as a digital hub, including the attraction of an Internet Exchange to GlobeNet's cable landing station and the establishment of the infrastructural capacity built in the Brazilian state of Ceará. Fortaleza's development as a data center hub has also been strengthened by state policy. As is true for Ireland, the Government of Ceará has been keen on catalyzing investments in the areas of digital, port infrastructure, and the air travel industries (Anuário do Ceará, 2022). The Municipality of Fortaleza also sought to create a favorable environment for these businesses and their sustainable portfolios with tax benefits.

Brazil is a center for data center investment—it concentrates nearly 50% of all the data center investments in the Latin American and Caribbean region (Research and Markets, 2022). And within the country, Fortaleza's capacity is expanding. In the state of Ceará alone, the number of data centers quadrupled since the start of the COVID-19 pandemic, with the majority being in the metropolitan area of Fortaleza. Angola Cables, Century Link, Ascenty, Hostweb, GlobeNet, Amazon, and Google are just some of the private stakeholders expanding their investments in Fortaleza through cables or data centers.

LEVERAGING RENEWABLE ENERGY POTENTIAL

Ireland and Fortaleza each became data center hubs based on similar drivers: tax benefits, local infrastructural capacity, and—decisively—cable connections. Not all cable hubs become data center hubs. Oman and Djibouti, for example, are essential cable hubs but have relatively little data center development. However, cable connectivity is essential for data center development. In turn, more cables are being laid to each of these

locations to connect growing data center infrastructure. Energy is also beginning to play a role in these decisions. There are a host of power-related factors at play in the establishment of cable--data center hubs, Tim Stronge elaborates, including wholesale electricity rates, cooling costs, availability of power from the local grid, local and national taxes on power, and now "the location of these data centers are (in part) determined by the availability of green energy." The case of Singapore is instructive: as a cable—data center hub, it has nonetheless been limited by the availability of (green) energy.

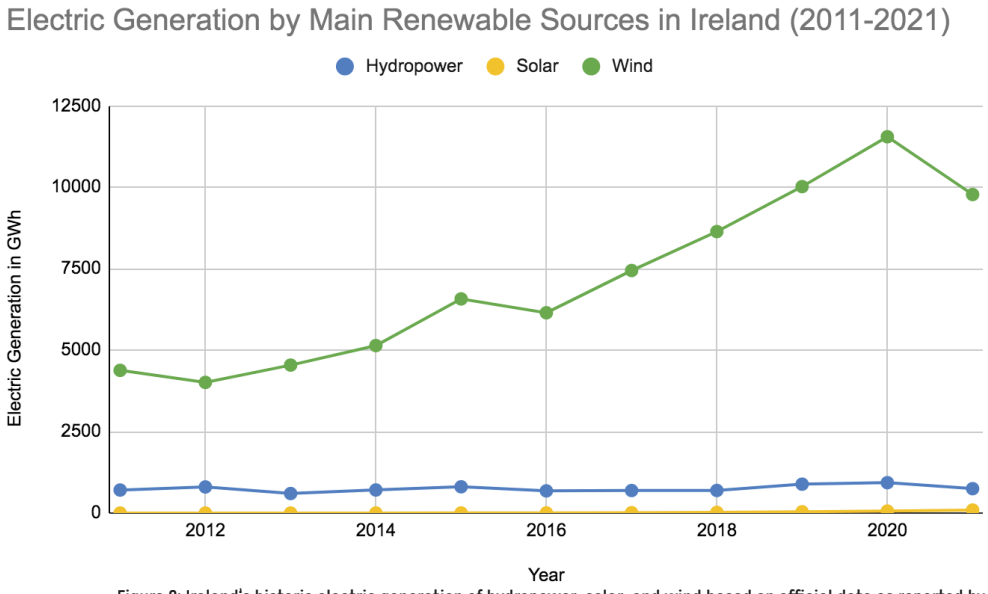

Figure 2: Ireland's historic electric generation of hydropower, solar, and wind based on official data as reported by the Sustainable Energy Authority of Ireland.

While Singapore struggles to import green energy from its neighbors (and even from a massive solar farm in Australia), the future of green energy in Ireland and Brazil is much more promising, especially as new regulations pressure the private sector to adopt it, which in turn accelerates research and development to promote more sustainable solutions. According to Andrea Reschini, Energy Efficiency and Sustainability Program Manager at R&G Telecomm Group, renewables are swiftly evolving and the efficiency to deploy them will increase in the years ahead. "The change in the sector will produce more cost-effective solutions, maybe with systems that do not need huge constructions that are hard to deploy or that have negative environmental effects," she says.

In locations like Ireland and Fortaleza, the possibilities deserve special attention. In both of these sites, there are a dramatically increasing number of investments in renewables and ambitious policy frameworks to promote a more environmentally-friendly future. Alongside the rise in data centers, Ireland also expanded its commitment to and investment in renewable energy, particularly in the development of wind energy technologies. Historically, its main energy source had been natural gas. Fueled in part by the EU's Renewable Energy Directives in 2001 and 2009, Ireland expanded its energy production by renewable sources from three percent in the early 2000s to over 13 percent by 2020, most significantly in wind energy. Today, Ireland is one of eight countries in the world that generates more than 30 percent of its electric-

While Singapore struggles to import green energy from its neighbors (and even from a massive solar farm in Australia), the future of green energy in Ireland and Brazil is much more promising, especially as new regulations pressure the private sector to adopt it, which in turn accelerates research and development to promote more sustainable solutions.

ity from wind and solar (EMBER, 2022).

In light of the economic impacts of the pandemic and the Russia-Ukraine conflict, including inflation and rising energy prices, and the heatwaves of the past several years, energy infrastructure has been stretched thin in Ireland and, as a result, there is some concern about the long-term viability of data center development. The data center moratorium has brought these concerns onto the national and international stages, wedding the future of data centers in Ireland to the country's climate goal and politics.

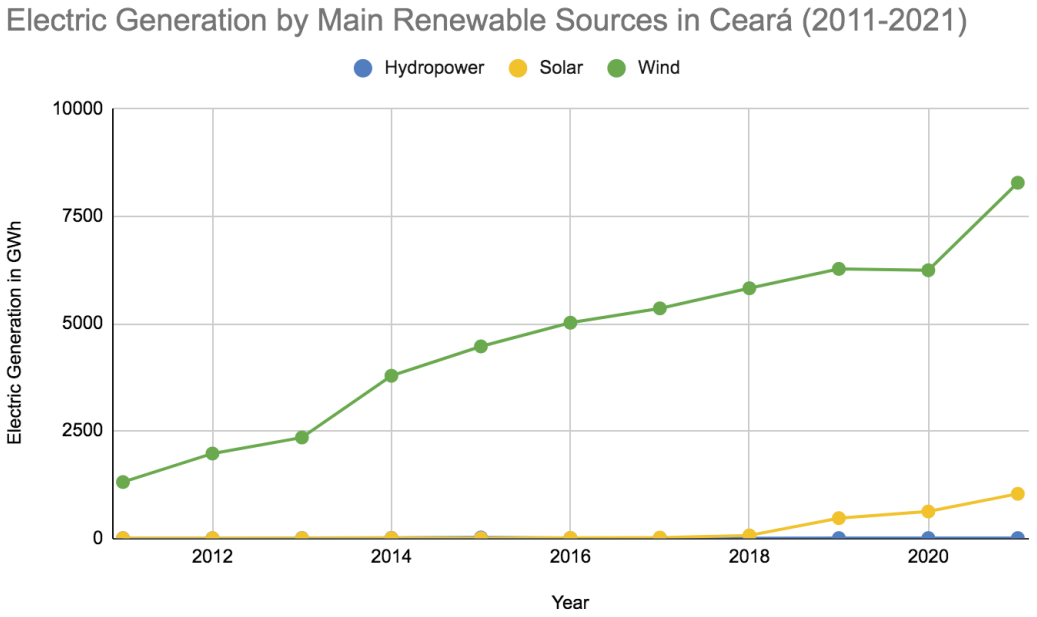

Figure 3: Ceará's historic electric generation of hydropower, solar, and wind of Ceará based on official data as reported by Brazil's Empresa de Pesquisa Energética.

As a result, while Ireland's investment in renewable energy infrastructure was not a motivating reason for the data center development initially, the two have since become intertwined. Amazon has entered into contracts with wind farms to power several of their data centers in Ireland, and Microsoft has agreed to share the capacity of their lithium batteries in their data centers to support the development of renewable energy elsewhere in Ireland. Given the future outlook of energy and climate change, any development in the industry will likely need to be tied to renewable energy to promote long-term economic and ecological sustainability. Without this push for renewable energy, Ireland's energy infrastructure and public pressure would continue to be obstacles to the development of data centers, and therefore subsea cables as well.

While Ireland is a site where concerns about data centers' energy impacts are quite advanced, such concerns have just begun to emerge in Fortaleza. Luckily, the state's renewable infrastructure is also relatively advanced—making it, like Ireland, an ideal site for the development of a sustainable cable--data center hub. Since early 2020, half of Ceará's energy matrix has been made up of renewable energies. Across the state, wind energy is a huge source of electricity generation—it is home to 20% of Brazil's wind farms. Additionally, not only does Ceará take a big chunk of the share of wind farms, but the state also produces far more than the global average–60% higher, due to its geographic characteristics (BRIC Group, 2022).

Yet the state only emerged as a renewable energy hub in recent years—and its development shows just how quickly energy transition can occur. Until 2007, Ceará was totally dependent on energy suppliers from other states. At the time, the state "imported" 100% of the energy it needed and had only a couple of thermoelectric plants that worked on an emergency basis (Carta Capital, 2012). Until about three years ago, thermal plants still dominated the matrix. Although the state's wind power potential was investigated in the late 1990s, Ceará has since become the home of the first commercial wind parks in the country as well as the first commercial solar power plant in Brazil. The development of wind options in Ceará was so swift that it catapulted Brazil onto the world stage: in 2012, Brazil was in 15th place in the world ranking of installed wind energy capacity. Currently, Brazil is in 6th place (Global Wind Energy Council, 2022).

Nowadays hydroelectric power is pervasive in Brazil, yet Fortaleza continues to have many petroleum refineries that pose challenges for the climate, as well as cable and data center operators who will increasingly demand greener energy-efficient facilities. Solar options are present, but largely behind wind capacity. Until the beginning of 2022, there were more than 88 photovoltaic solar power plants, registering about 498 MW of power, totaling nearly 10% share of the energy produced locally. The Municipality of Fortaleza alone has an area with a solar potential of 229.5 km², with estimates of a capacity of 458.9 MW alone, which is yet to be fully explored (Silva, 2021).

Just as geography and tax incentives combined to make Fortaleza a cable—data center hub, so too have Fortaleza and the municipalities across Ceará offered consolidated tax incentives and clear legislation that provides legal certainty to investors of new energy systems. The state is at the forefront of streamlining the environmental licensing process, which is one of the most modern in Brazil (SEMACE, 2012). The State is innovative in making the advocacy and awareness of renewables as clear and open as possible. In fact, Ceará was the first public agency in Brazil to launch an Atlas for renewable energy to better inform and drive more sustainable practices amongst private sector stakeholders. Its most current version is multilingual, available for smartphones, and it covers the potential of wind and solar energy across its territory.

With government support and legislation, new developments began to grow in the state, indicating possible directions for the use of renewables by ICT companies. These examples include the Ceará 2050 Program–Energy and Business, which aims to turn the state into Brazil's hub for renewable energy by modernizing infrastructure, increasing energy efficiency across sectors, and attracting renewable investments. In parallel, in July 2021, a law was passed at the state level that introduces the Program for Attracting and Supporting the Generation of Renewable Energy in Ceará (Law No. 17,553). Complementing these public-funded initiatives, the government of Ceará also instituted the State Energy Transition Plan in 2022, with technical and financial support from the World Bank. Named Ceará Verde (Green Ceará), one of the objectives of the project is to support scientific and technological development associated with the production, processing, and use of renewable energies.

Nowadays hydroelectric power is pervasive in Brazil, yet Fortaleza continues to have many petroleum refineries that pose challenges for the climate, as well as cable and data center operators who will increasingly demand greener energy-efficient facilities.

TOWARD MORE SUSTAINABLE CABLE NETWORK HUBS

Concerns about data centers' energy draw can produce community resistance and spur governmental moratoriums, which in turn preempt network development. As an alternative, looking to the future—**and linking cables and data centers to renewable energy in advance of any opposition** would not only be good for the planet, but good for future data center and cable development.

How can these links be made? First of all, companies might deploy renewable energy at the cable landing station. Renewable technologies have yet to be fully considered in the subsea industry. This is not simply because of the low power draw, but because of the industry's small scale. According to Winston Qiu, Senior Vice President at Pacific Light Data Communication Co., Limited, the problem of adapting renewable energy is in part a structural one: technical teams usually focus on cable system stability, leaving energy cost considerations to top management. As a result, options for energy generation via renewable means remain largely unexplored. "While the industry may lack the economic scale for massive production of applications and facilities for renewable energy, the subsea cable industry provides new possibilities to explore sustainable alternatives and applications," says Qiu.

Another option involves purchasing renewable power already available via the grid itself. It is here that state investments in renewable power will become useful—there are more and more opportunities to connect to

wind and solar energy being created on the grid. Tapping into renewables underscores company commitments to the environment. In places like Ireland, where development is already contentious, and in Fortaleza, where it could become a site of conflict, such commitments are essential to the network's continued development.

To take a step further, both of these locations have the potential to develop as sustainable network hubs. They each face challenges, of course. Ireland is dependent on its advantageous tax policy, which could be affected by UK or EU taxation initiatives. Likewise, Fortaleza remains distant from the major metropolitan ICT hubs in Brazil and Argentina, and it may be preferable to simply skip directly to the south in the future. To become sustainable network hubs, the cable--data center constellation should be linked—via technical means, but also in the public imagination—to available renewable energy infrastructure and the aforementioned government policies for green energy development. In our research we have found that private equity, investors, and content providers are increasingly considering green factors, and such sustainable network hubs will be even more valuable in the future. By intentionally and explicitly finding ways to link to renewable power, cable owners and operators have a chance to participate in a larger movement.

This document is an output from the Sustainable Subsea Networks research initiative, funded by the Internet Society Foundation. STF

Ireland is dependent on its advantageous tax policy, which could be affected by UK or EU taxation initiatives. Likewise, Fortaleza remains distant from the major metropolitan ICT hubs in Brazil and Argentina, and it may be preferable to simply skip directly to the south in the future.

NICOLE STAROSIELSKI *is Associate Professor of Media, Culture, and Communication at NYU. Dr. Starosielski's research focuses on the history of the cable industry and the social aspects of submarine cable construction and maintenance. She is author of The Undersea Network (2015), which examines the cultural and environmental dimensions of transoceanic cable systems, beginning with the telegraph cables that formed the first global communications network and extending to the fiber-optic infrastructure. Starosielski has published over forty essays and is author or editor of five books on media, communications technology, and the environment. She is co-convener of SubOptic's Global Citizen Working Group and a principal investigator on the SubOptic Foundation's Sustainable Subsea Networks research initiative.*

IAGO BOJCZUK *is a PhD student in the Department of Sociology at the University of Cambridge, where his work investigates the material, cultural, economic, and political dimensions of Big Tech infrastructures in the Global South.*

NICK SILCOX *is a Ph.D. candidate in the department of English at New York University where he is working on a dissertation on sensing and sensor technologies and environmentality. Nick is also a research assistant on the Sustainable Subsea Networks project.*

REFERENCES

Anuário do Ceára. 2022. "Agenda de infrastrutura." www.anuariodoceara.com.br/infraestrutura/

Bresnihan, P. and Brodie, P., 2021. "New extractive frontiers in Ireland and the Moebius strip of wind/data." Environment and Planning E: Nature and Space, 4(4), pp.1645-1664. https://doi.org/10.1177/2514848620970121

Brodie, P. & Bresnihan, P. 2021. "Energy vacuums: data Centres, renewable energy, and rural politics." Rupture, Eco-Socialist Quarterly. https://rupture.ie/articles/severed-the-metabolic-rift-between-humans-and-nature-b5x6w

BRIC Group. 2022. "Ceará stands out for renewable energies in Brazil." https://bric-group.com/article/ceara-stands-out-for-renewable-energies-in-brazil

Carta Capital. 2012. "Ceará será autosuficiente apenas com energia eólica, diz governador." www.cartacapital.com.br/tecnologia/ceara-sera-autosuficiente-apenas-com-energia-eolica-diz-governador

EMBER. 2022. "Global electricity review." https://ember-climate.org/insights/research/global-electricity-review-2022/#supporting-material-downloads

Global Wind Energy Council. 2022. "Global wind report." https://gwec.net/global-wind-report-2022/

Glose, B. 2018. "Transatlantic Cables Anchored in Virginia Beach Make the Area a Digital Port." The Business Magazine of Coastal Virginia. https://covabizmag.com/transatlantic-cables-anchored-in-virginia-beach-make-the-area-a-digital-port/

OECD. 2020." Avaliação da OCDE sobre telecomunicações e radiodifusão no Brasil." OECD Publishing, Paris. https://doi.org/10.1787/0a4936dd-pt

Research and Markets. 2022. "Latin America modular data center market - industry outlook and forecast 2022-2027." https://bit.ly/3Tt4gY6

SEMACE., 2022. "Legislações para empreendimentos de geração de energia elétrica por Fonte Solar e Eólica." www.semace.ce.gov.br/resolucoes-estaduais-energias-renovaveis/

Silva, D. 2021. "Estudo de viabilidade de utiliazção de energia solar em duas unidades públicas do município de Fortaleza-CE." Centro Universitário Christus. https://repositorio.unichristus.edu.br/jspui/bitstream/123456789/1130/1/David%20Oliveira%20da%20Silva.pdf