A SPECIAL REPORT FROM RCR WIRELESS NEWS AND ENTERPRISE IOT INSIGHTS

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The green credentials of 5G and IoT –

CAN CONNECTED TECHNOLOGIES HELP SAVE THE WORLD?

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Introduction: 'It's not just about helping yourself'

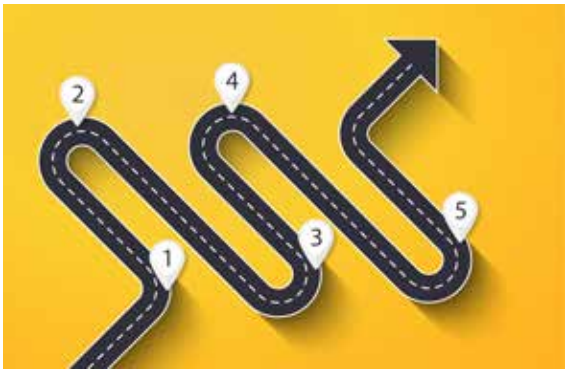
Telecommunications and technology firms the world over are focused on delivering 5G- and internet of things-based solutions—as well as a litany of complementary tech like artificial intelligence, machine learning, edge computing, data analytics engines and more—in service of enterprise digital transformation. These enterprises are investing in technology-enabled business outcomes that create new efficiencies, reduce operational costs and open up new revenue-generating opportunities.

Both the buyers and the sellers in this equation are looking to monetize their investments, whether that's the network, the sensor, the software, the platform, the bundled product, or the end result. While these stakeholders work on implementing and deriving value from execution on technology strategies, they're also pursuing a separate but very much related goal—sustainability. The logic around corporate sustainability initiatives has two primary thrusts: first, with increasing urgency around carbon emissions, power consumption and other macro environmental factors, implementing green practices where possible is the right thing to do; second, a more efficient, sustainable business is very likely a more profitable, more valuable business. When you consider those two thrusts in a larger, longer-term context, a more sustainable world with a more predictable future environmental outlook is inherently more stable. And stability is good for business.

Discussing the relationship between sustainability and business success, Ericsson North America Chief Technology Officer Mike Murphy pointed out that investors and financial firms now consider sustainability a critical factor in determining the long-term value of a business.

Sustainability is "not just about helping yourself," he said. "It's become a business imperative. And so it's a business imperative in general, and our customers are putting demands on us to support them in this regard. And that's showing up in RFPs… The whole ecosystem is moving towards a situation where business success demands a strong sustainability program as well."

In this report we endeavor to examine the green credentials of 5G and IoT, then explore how these systems can individually be architected as more sustainable than preceding technologies, while also driving sustainability through their widespread adoption. As for the role of the communications service provider in all this, Verizon Chief Sustainability Officer Jim Gowen explained, "I'd say we are probably responsible for the biggest enabling role in changing the way the world really lives sustainably with things like 5G and IoT."



Green goals: The corporate roadmap

International bodies, such as the United Nations Framework Convention on Climate Change (UNFCCC), have established sustainability standards and targets to foster a greater sense of climate responsibility amongst corporations and governments. In response, different sectors of the telecom space — operators, vendors and hyperscalers — have all made changes and pledges to better align themselves with these efforts.

Image courtesy of UNFCCC

The Paris Agreement

Negotiated by 196 parties at the 2015 United Nations Climate Change Conference in France, the Paris Agreement — also known as the Paris Climate Accords — is an international treaty designed to curb the effects of climate change. As of November 2021, 193 members of the UNFCCC are parties to the agreement.

Since its inception, the treaty has become a standard for business operation and action as companies around the world seek to align themselves with the Agreement's guidelines.

In fact, in the U.S., the desire to do so was strong enough in 2017 that when former-President Donald Trump was still only considering leaving the Paris Agreement, several top U.S. companies penned a letter urging him not to. Signed by Apple, Microsoft, Google, Intel and others, the letter laid out the benefits of participation in the agreement, saying doing so strengthens competitiveness, supports sound investment, minimizes operation costs and creates jobs, markets and growth.

Across the entire telecommunications ecosystem, companies have committed to climate action by — but not limited to — reducing CO2 emissions and power consumption and by leveraging and investing in renewable and clean energy sources. These commitments have resulted in concrete pledges and roadmaps to arrive at net-zero or carbon-neutral. But these roadmaps are ambitious. What concrete steps are different companies across the telecom ecosystem taking to chip away at the long, winding paths to their climate goals?

Peters Suh, industry lead for North America at Accenture's Communications & Media, told *RCR Wireless News* that even as 5G leads to more network efficiencies and to use cases that will likely offset any increase in power consumption, it is still crucial for telecom operators to get onboard with reducing the carbon footprint of our networks. This is because, according to him, the global communications industry produces twice as large a carbon footprint as the airlines industry.

The good news, though, is that there is a heightened focus on sustainability and climate change among operators, and even more important, the effort appears to be genuine.

"We are starting to see more and more of our customers saying I want to hear that story," said Suh. "It has a dual benefit. One is if operators are more efficient, you have lower operating costs, but there is also that sustainability element as well."

For operators, sustainability and efficiency can be complementary

*A Q&A with **Jim Gowen**, Senior Vice President of Supply Chain Operations and Chief Sustainability Officer, Verizon*

"When it comes to sustainability, we realize that a rising tide lifts all ships."

Verizon is one operator with its ear firmly turned to this story of sustainability. In the Q & A below, Jim Gowen, Verizon's senior vice president of Supply Chain Operations and chief sustainability officer, shares further insight into the carrier's green goals and how it plans to get there.

Q What are Verizon's most notable sustainability goals?

A The blanket statement is that we're committed to reducing our environmental impact and supporting the transition to a greener grid, bottom line. Being

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Image courtesy of Verizon

a network company, our biggest impact is energy, so that's why we are doing so much with energy efficiency and renewable energy.

If I take it up a level, our biggest commitment and loftiest goal is now that we will be net-zero in our operations by 2035. That's scope 1 and Scope 2, which are the fuels and the energy. Then you look at Scope 3, which is our biggest impact on the world because it's our value chain and our supply chain. The Scope 3 piece is focused on reducing our operational emissions by 53% by 2030 and then our value chain scope 3 by 40% by 2035.

Q How is the company achieving these goals?

A We recently announced seven renewable energy purchase agreements, totaling 910 megawatts of additional renewable capacity, which differentiates us from others. Our entire strategy is about additionality. It is not about going out and buying green RECs [Renewable Energy Certificates] that already exist; we want to make sure we are greening the grid and greening it with new, additional activity.

Those additional seven purchase agreements bring us to 20 total renewable energy purchase agreements in three years — more than 2.6 gigawatts of renewable energy that is being built into the system. It equals about 4.8 million metric tons of CO2 reduced annually.

Again, energy is what drives our data centers and our networks, so that's why we've put our focus here. It's all solar and wind because that's the greenest we have. We've looked at natural gas, and we've done some things there. It's good, but I only look at it as being about 45% better than brown energy.

We are also planting 200 million trees and have a commitment of 10 million pounds of e-waste. We are also focused on our people — we've got the largest green team, we think, in the world. We've got more than 50,000 Verizon employees in 54 countries that are part of our voluntary green team.

Q What role do you believe telecom companies play in ensuring a more sustainable future?

A Selfishly, I'd say we are probably responsible for the biggest enabling role in changing the way the world really lives sustainability with things like 5G and IoT and sensors. Disney World, for example, and the way you can find a parking spot now. Silly example, but it's really important when you think about its impact on driving. Or addressing water pipe leaks in New York City. All these things are done through sensors running on a network, and 90% of the time these days, it's a wireless network. Irrigation, remote working. There are so many opportunities for technology companies — more than any other industry out there, I believe — to really change the way the world works.

Q How important are partnerships in achieving sustainability goals?

A We're not doing it alone. There's a lot of competition out there, but I'm sitting with AT&T to my right, Huawei two over from me and the rest of our global competitors and we're talking about how we need to do things better and together to raise us all. It's just an amazing conversation to have. We leave those rooms and we're staunch competitors, but when it comes to sustainability, we realize that a rising tide lifts all ships.

5G MONETIZATION FORUM 2022

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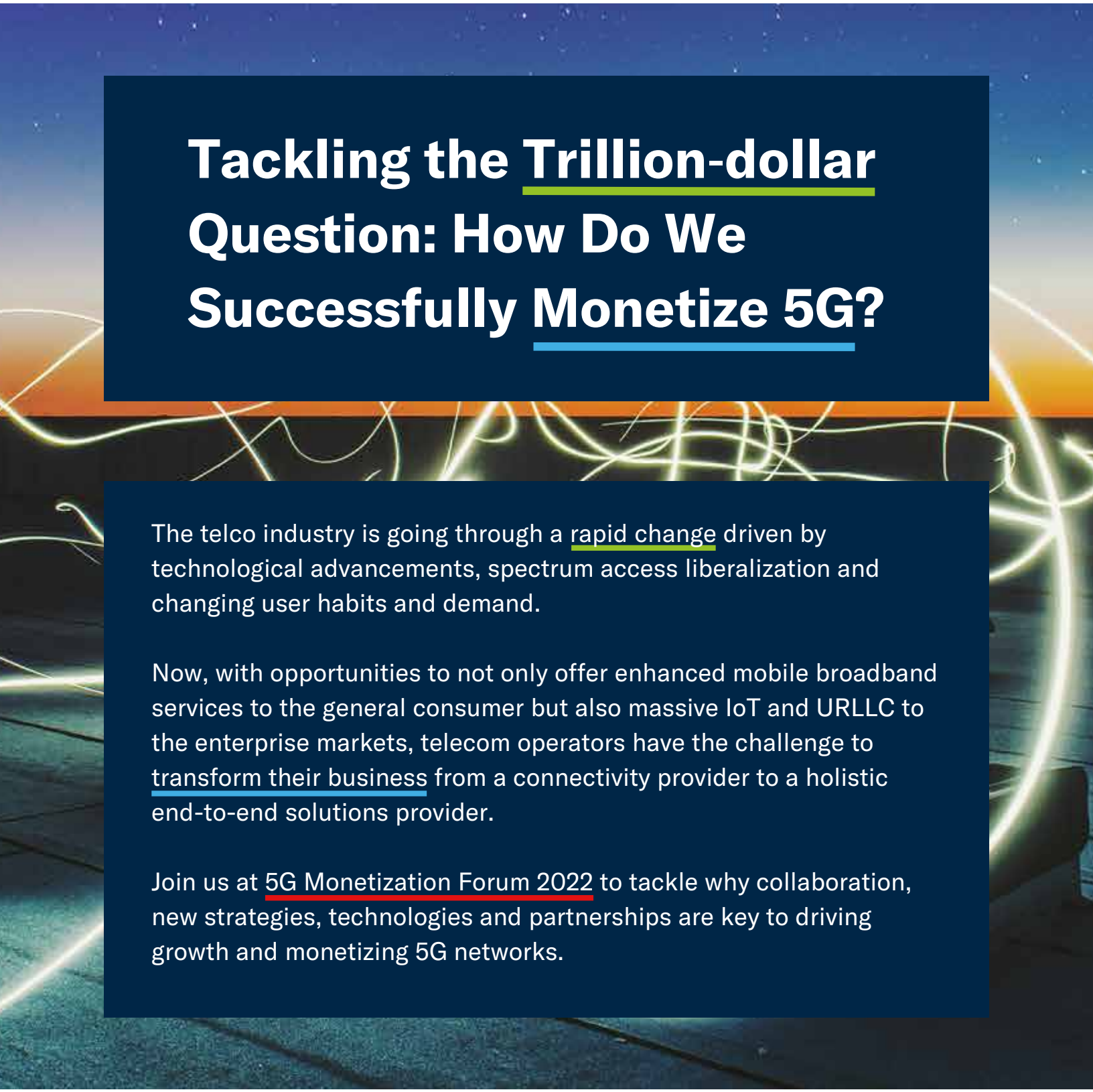

Tackling the Trillion-dollar Question: How Do We Successfully Monetize 5G?

The telco industry is going through a rapid change driven by technological advancements, spectrum access liberalization and changing user habits and demand.

Now, with opportunities to not only offer enhanced mobile broadband services to the general consumer but also massive IoT and URLLC to the enterprise markets, telecom operators have the challenge to transform their business from a connectivity provider to a holistic end-to-end solutions provider.

Join us at 5G Monetization Forum 2022 to tackle why collaboration, new strategies, technologies and partnerships are key to driving growth and monetizing 5G networks.

Virtual Event, February 15th, 2022
Register for free: www.5gmonetizationforum.com

Qualcomm's path to net-zero by 2040—water conservation and renewable energy

"5G technologies and products will be instrumental in driving an environmentally sustainable future."

Cristiano Amon, President and CEO, Qualcomm

Qualcomm has supported the Paris Agreement since 2015. At the time, Nate Tibbits, the company's senior vice president of Government Affairs, called the agreement a "strong step forward toward a low-carbon, sustainable future" in a blog post; he said then that the chipmaker was setting out to reduce its Scope 1 and 2 greenhouse gas (GHG) emissions 30% by 2025.

But, with the 2021 UN COP26 summit as a backdrop, Qualcomm recently updated its sustainability pledge to address the Paris Agreement's call to action more aggressively. Qualcomm is now promising to achieve net-zero emissions by 2040 by first reducing its Scope 1 and 2 greenhouse gas emissions by 50% from base 2020 levels by 2030. Next, the company will reduce its Scope 3 emissions by 25% from where they were in 2020.

Scope 1 emissions refer to direct emissions from owned or controlled sources, Scope 2 covers indirect emissions from the generation of purchased electricity, steam, heating and cooling consumed and Scope 3 includes all other indirect emissions that occur in a company's value chain.

While Scope 1 and 2 are mandatory to report, Scope 3 is not. It is also the hardest to monitor. In Qualcomm's case, for instance, indirect emissions include those generated by fabs TSMC and Samsung, and other partners whose products go into producing its chips. Therefore, a company only has so much control over its Scope 3 emission numbers.

As part of its net-zero mission, Qualcomm is purchasing 100% renewable energy for its San Diego headquarters, as well as transitioning to renewable energy via long-term Power Purchase Agreements (PPAs), decarbonizing its operations and using a minimal amount of Renewable Energy Credits (RECs) and carbon offsets for residual emissions.

In the shorter term, Qualcomm is reducing its carbon footprint by turning to energy-efficient lighting, heating and cooling systems, data centers and IT equipment.

"By sourcing, designing and building with sustainable products, we minimize waste and water usage, improve indoor air quality, and help reduce GHG emissions," the company said, adding that these energy efficiency efforts have realized approximately $7.5 million in avoided costs each year across its building spaces in California and Bangalore, India, where the company owns and operates on-site solar generating systems.

In India alone, Qualcomm reduced its GHG emissions by approximately 22,485 tons of carbon dioxide equivalent (CO_2e) through the purchase of solar energy for its Bangalore offices. These overseas sustainability efforts reflect the "obligations of developed countries to support the efforts of developing country Parties to build clean, climate-resilient futures" outlined in the Paris Agreement.

Additionally, because semiconductor processing is water intensive, the chipmaker is also taking a special interest in water conservation, reportedly prioritizing assessing its water footprint, particularly in California, where water scarcity is a constant threat.

In its facilities, Qualcomm uses reclaimed water instead of potable water for irrigation and for its cooling plant systems "whenever possible," adding that it also works closely with its key suppliers to promote efficient water use by asking them to report their water use via the CDP water disclosure survey or the RBA (Responsible Business Alliance) Environmental Reporting Initiative.

Without efforts across its entire supply chain, Qualcomm will not be able to deliver on its net-zero promise. Qualcomm has also earned considerable recognition for publicly and consistently reporting to a third-party verified GHG emissions inventory for its operations and has been responding to the CDP Climate Change survey annually since 2010.

This level of supply chain transparency and emissions reporting echoes the Paris Agreement's guidelines concerning the

Image courtesy of Qualcomm

need for "reliable, transparent and comprehensive information on GHG emissions, climate actions and support."

"By communicating information on greenhouse gas (GHG) emissions and actions to reduce them, as well as on adaptation and means of implementation such as finance, technology transfer and capacity-building, the transparency and reporting system allows to understand ambition and progress on climate actions and support by Parties, – and informs the COP deliberation and guidance on these matters," states the UNFCCC on its website.

For Cristiano Amon, Qualcomm's president and chief executive officer, one of the most promising answers to our climate woes is 5G and the efficiencies and use cases it will enable.

"5G technologies and products will be instrumental in driving an environmentally sustainable future," he said, adding that the company is working closely with partners and customers to "reduce emissions footprints, conserve resources and harness the sustainability benefits of 5G globally."

Amazon using the cloud for climate action

Ever the over-achiever, Amazon established its own sort of sustainability pledge, calling it The Climate Pledge. The pledge, founded in partnership with Global Optimism, is a commitment to power its operations with 100% renewable energy by 2025, as well as achieve net-zero carbon emissions across its business by 2040, a timeframe that the company has bragged about being 10 years ahead of the Paris Agreement.

Currently, The Climate Pledge has more than 200 signatories that span across 26 industries and 21 countries. The company also invested in a net-zero arena in Seattle, Washington, and named it the Climate Pledge Arena.

Amazon claims to have already made decent progress towards its climate goals, stating that it has reached 65% renewable energy across the business in 2020, up from 42% in 2019, decreased our overall carbon intensity by 16% from 2019 to 2020 and invested $2 billion to support the development of technologies and services that reduce carbon emissions. The company also said it is the world's largest corporate purchaser of renewable energy.

Other sustainability initiatives include the rollout of 100,000 Rivian electric vehicles in Los Angeles in February 2021 and the launch of a sustainability website where the company reports on its commitments and performance, which reflects the Paris Agreement's stance on progress transparency and reporting.

But where Amazon aligns even more directly with the Paris Agreements guideline about developing and investing in technology that supports climate action. The UNFCCC defines "climate technology" as "technologies that help us reduce GHGs." "Developing and transferring technologies to support national action on climate change has been an essential element from the beginning of the UNFCCC process," states the UNFCCC on its website. "Over the years, technology development and transfer with regard to adaptation has received increasing attention. The Paris Agreement speaks of the vision of fully realizing technology development and transfer for both improving resilience to climate change and reducing GHG emissions."

While the UNFCCC primarily considers renewable energies — such as wind energy, solar power and hydropower — to be climate technologies, Amazon AWS has demonstrated that cloud technology might be just as compelling as a climate technology.

The City of Santa Fe, New Mexico uses RUBICONSmartCity, a cloud-based technology suite supported by AWS' cloud

Images courtesy of Amazon

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services for more efficient waste and recycling management operation. The result, wrote the AWS Public Sector Blog Team, is "an Internet of Things (IoT)-enabled waste collection fleet."

"By using the cloud to bring a recycling program directly to residents' doorsteps, Santa Fe dramatically increased the recycling rates of its citizens and enabled the city government to divert more waste away from landfills and reduce the city's greenhouse gas emissions," stated the AWS blog team.

Drivers carry a smartphone equipped with the RUBICONSmartCity technology as they conduct their trash routes, giving them insight into optimized collection routes and live telematics information and data, which is then streamed back to headquarters via the cloud, where it is used to track several route and fleet metrics.

"As seen with Santa Fe, the cloud can do more than modernize programs," said AWS. "It empowers governments to harness technology to streamline operations and work towards long term sustainability goals, while improving customer service and conserving taxpayer dollars. Cloud technologies, like those provided by AWS and AWS Partners, can help state and local governments make a greater and more immediate impact in the fight against climate change."

Las Vegas taps 5G, IoT and digital twins to reduce carbon emissions

Digital twin provider Cityzenith and IoT firm Terbine are jointly developing a technology solution to transition the city of Las Vegas to net-zero carbon emissions.

The Las Vegas Digital Twin project encompasses a seven-square kilometer area of downtown Las Vegas and will leverage advanced 5G networking, plus IoT and urban digital twin technology to improve mobility, air quality, noise pollution, water management, and emissions from major buildings in the city.

Las Vegas CIO Michael Sherwood explained that digital twins are rapidly becoming vital to how cities are run. We have to be able to really start understanding how our city operates, and digital twins will allow us to start predicting the future or see what kind of impacts we can make today and how they might impact a city several years down the road," Sherwood said in a recent webinar.

"We really believe this technology is going to be a game changer. It's going to propel our city and our leadership to make better decisions and to be able to really have an impact on sustainability efforts across the board, not just in some of the areas we're looking at traffic buildings, but the general area throughout so we're very excited about that," Sherwood added.

Cityzenith will provide the digital twin technology as part of its 'Clean Cities - Clean Future' initiative to implement its SmartWorldOS digital twin platform in major cities around the world to drive down urban emissions and significantly improve cost efficiencies for local building owners. Other cities involved in the initiative are New York, Los Angeles and Phoenix.

Project partner Terbine brings together and contextualizes IoT data from local government agencies, building operators, transportation systems and vehicle manufacturers to provide the high volumes of sensor

"The bottom line is that digital twins are going to be the future of how cities are managed and how they're operated"

Michael Sherwood, Chief Information Officer, City of Las Vegas

information needed by the urban digital twin, while Cityzenith's platform manages and reports emissions performance and analytics across assets in real-time to ensure on-going operational metrics and compliance goals are maintained.

Cityzenith highlighted that Las Vegas Digital Twin project is currently developing at a fast pace– the base twin is now completed, and soon, stakeholders from across the city of Las Vegas will be invited to join the project, including real estate owners, government agencies, university researchers, data partners, architects, and casino operators.

"Through the 'Clean Cities - Clean Future' initiative, we have pledged to sponsor the implementation of digital twins in major cities around the world that will help energize the Race to Zero in these cities, specifically focusing and helping building owners and infrastructure operators find cost effective ways to eliminate or significantly

Upcoming Events

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5G MONETIZATION FORUM 2022

February 15th, 9am-4pm EST
Virtual Event

Tackling the trillion-dollar question: how do we successfully monetize 5G?

The telco industry is going through a rapid change driven by technological advancements, spectrum access liberalization and changing user habits and demand. Now, with opportunities to not only offer enhanced mobile broadband services to the general consumer but also massive IoT and URLLC to the enterprise markets, telecom operators have the challenge to transform their business from a connectivity provider to a holistic end-to-end solutions provider. This event seeks to tackle why collaboration, new strategies, technologies and partnerships are key to driving growth and monetizing 5G networks.

www.5GMonetizationForum.com

women IN TELCO

March 8th, 9am-4pm EST
Virtual Event

Pioneering Female Leadership and Representation in Telecoms

It has been widely reported there is a large gender gap in the technology industry, with the gap widening further in the telecoms sector. This event will seek to provide a community for women wanting to enter the sector, develop their careers, and for leaders to attract and retain talent. The event will provide delegates with practical information to enhance their professional growth and promote diversity in the telecoms industry.

Explicitly but not exclusively for women.

www.WomeninTelco.com

TELCO CLOUD FORUM

March 29th, 9am-4pm EST
Virtual Event

Can cloud economics make 5G the engine for digital transformation?

Cloud-native is a new frontier for the telecoms set and a necessary frontier given CAPEX and OPEX constraints, as well as the need to imbue 5G networks with hyperscale and new levels of flexibility. At the same time, the telecoms sector is a burgeoning market for hyperscalers looking to take learnings from more simplistic operational and business models and apply them to what is arguably the connective fabric of global commerce. With our deep expertise in telecoms, RCR Wireless News is positioned to facilitate a meaningful dialogue between major stakeholders who are committed to advancing their independent and collaborative growth strategies.

www.TelcoCloudForum.com

Explore all upcoming events at RCRWireless.com/events

Images courtesy of Cityzenith

reduce carbon emissions," Cityzenith CEO Michael Jansen said in a recent webinar.

"Buildings are the largest polluters in cities around the world. In cities like New York, Las Vegas and others, buildings could represent 75-85% of total emissions. Globally, 30-39% of total emissions come from buildings," Jensen said.

Las Vegas's own 5G network will play a key role in this initiative at it would provide key connectivity for all the tech components involved in the project. In July 2021, California-based private network provider Terranet Communications and Baicells, an equipment manufacturer of 4G LTE and 5G Near Radio End-to-End solutions, deployed a LTE, 5G-ready private municipal network for the City of Las Vegas. Las Vegas' CIO Michael Sherwood noted that the 5G-ready network had been constructed to meet the city's specific requirements.

A four-stage plan is in place to expand the wireless network across the entire city of Las Vegas and potentially neighboring cities, with a goal of improving connectivity for other city services, including law enforcement, telehealth, and general IoT infrastructure.

"Wireless in general is a critical component to cities of the future. The ability to connect and transmit data without wires allows technology to only be limited to the availability of power. This allows sensors and IoT devices in general to have greater flexibility, add in private LTE, CBRS and traditional 5G and now you have vastly improved metrics for a connected city," Sherwood said in a previous interview with *RCR Wireless News*.

The partners explained that the initial twin will be a digital model of buildings, transportation systems and infrastructure in downtown Las Vegas, which will be fed by IoT data transmitted by sensors over a 5G network. The project stipulates that the data will come from a wide range of systems over time, including those owned by Las Vegas but also the county, state and commercial providers.

David Knight, CEO of Terbine, said the initiative is particularly advanced as the digital twin will be "wired into the actual city". "That means that things happening on the streets, in the electrical grid, air quality and many other factors are going to be loaded into the digital twin. Eventually, this will allow control by the city itself," Knight said during the webinar.

Knight also said that they are already working with companies like Cisco on gathering data for this model and using a machine learning-based permissions model, which will allow various users to control infrastructure such as lighting and traffic systems through the digital twin.

Images courtesy of CityZenith

"We're going to have a digital twin that not only has data from buildings. It'll have the infrastructure itself, what's happening on the streets, under the streets, over the streets, what's happening with electricity and with EV charging stations," Knight said.

The rise of the green data center

The past decade has seen a doubling of the global number of internet users but a 15-fold increase in the amount of internet traffic produced, according to the International Energy Agency (IEA). The IEA's 2021 Data Centers and Data Transmission Networks report shows that data centers have maintained efficiency remarkably steadily through that time, according to the report, but they will be tested in the years to come as global demand continues to climb.

While internet traffic has increased 30% year-over-year since 2010, according to the report, 2020 saw a 40% leap. Predictably, that jump is pandemic-related, owing to the changing dynamics of global consumer and business Internet use. The growth of bandwidth-intensive apps like video streaming and conferencing, online gaming, and ever-richer social media experiences push consumers and businesses to demand more from data center operators.

The U.S. Department of Energy says that data center operations account for about 2% of all the electricity consumed in the United States (globally, that number is about 3%). Per square foot, data centers consume 10- to 50-times the energy of a normal office building, said DoE.

It's not hard to understand why: data centers consume vast amounts of power, generate vast amounts of heat in the process, and require vast amounts of cooling to stay operational. Measuring and controlling those resources is top-of-mind when it comes to Data Center Infrastructure Management (DCIM).

Internet traffic compared to data center workload and energy use, worldwide from 2010-2020.

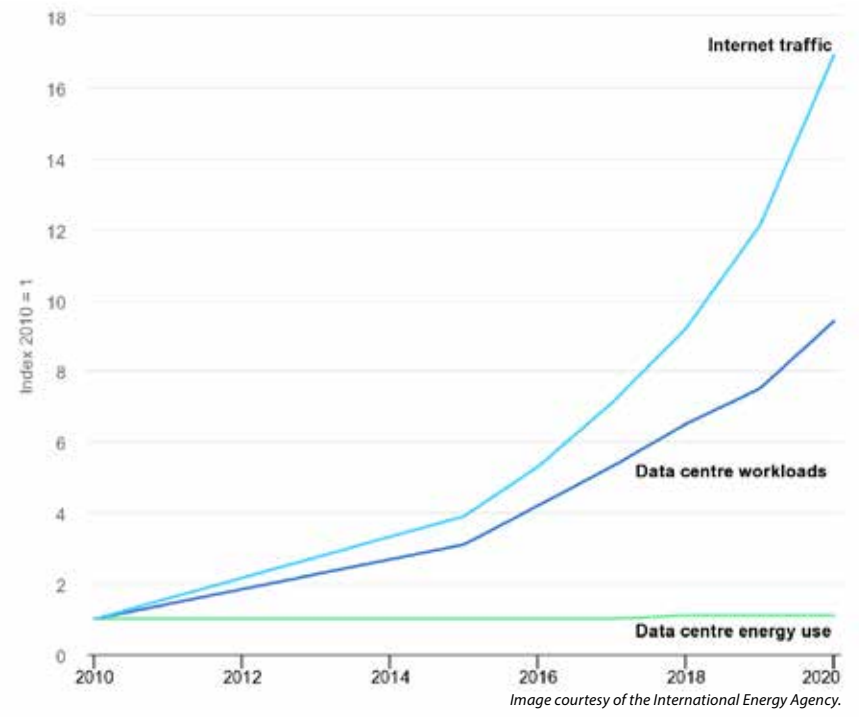


Image courtesy of the International Energy Agency.

Data center KPIs

There are numerous ways data centers track operational and power efficiency. PUE is one of the best-known key performance indicators (KPIs) used to determine data center efficiency. First proposed by a data center trade group The Green Grid, PUE was adopted as an ISO standard in 2016.

PUE divides the total energy used for data center operations by the energy used for operating the computing equipment. So, lights and cooling, environmental controls and IT equipment used to manage facility operations are accounted for separately from the energy used by the energy used for compute tasks. Operators want a value as close to 1.0 as possible.

The reciprocal KPI to PUE is Data Center Infrastructure Efficiency (DCIE). This ratio compares the total power used by IT equipment to total facility power, multiplied by 100%. A data that uses half its total power consumption to power computing equipment would have a 50% DCIE.

The U.S. National Renewable Energy Laboratory (NREL) is the federal government's renewable energy and energy efficiency research and development lab. NREL says that national data center PUE average is around 1.8, while large-scale data centers might achieve PUE values of 1.2 or lower. For its part, Google says its data centers run at an average PUE of 1.10.

The Uptime Institute in a 2020 study calculated essentially flat average data center PUE ratios from 2013 onward to around 1.58 in 2020. The study said that it's often not cost-effective or safe to upgrade older data centers with refits to improve efficiency.

A third data center efficiency KPI is Water Usage Effectiveness (WUE), used to

measure a facility's cooling efficiency. WUE is the ratio between water used at the data center for cooling and electricity delivered to the IT equipment. The U.S. Department of Energy (DoE) estimates that the average data center WUE is 1.8 liters (L) per 1 kilowatt-hour (kWh), or 1.8 L/kWh.

This only scratches the surface. Other relevant KPIs to measure data center efficiency include carbon intensity, which divides total carbon emissions by total data used. By this measure, Verizon has reduced its carbon intensity by 53% in three years.

The move towards larger data centers with better scale of operations and economy is reflective of a larger trend. That trend is away from smaller, siloed corporate data centers and onto the public cloud or a hybrid cloud either on premises, in a colocation facility, or a data center. The shift away from the traditional data center continues as everything moves to the cloud. Gartner says that by 2025, 80% of enterprises will shut down their traditional data centers.

Hyperscalers and other large-scale cloud computing service providers are responding to exploding demand from enterprise and consumers by building larger data centers. Increased scale means better efficiency.

But older data centers remain largely static once they're built, so recent innovations in efficiency have been limited largely to newer constructions. In fact, smaller data centers – those occupying less than 5,000 square feet (ca. 465 m^2) – house half of all servers in the U.S., according to Lawrence Berkeley National Laboratory's United States Data Center Energy Usage Report. The report concluded that smaller data center operators don't have the same economic imperative to improve efficiency.

Resiliency and high availability remain key operational characteristics of data centers around the globe. But more scrutiny than ever is being applied to where data centers get their electricity from.

Rating data centers

Data centers are, principally, rated on their resiliency and high availability – not sustainability or "green" qualities. All data center operators boast high guaranteed availability. But there are common methodologies used to different data centers based on their redundancy and resiliency to failure. One such method is a four-step tier classification system developed by The Uptime Institute:

- Tier I: the basic capacity level with infrastructure to support information technology for an office setting and beyond.
- Tier II: incorporates redundant capacity components for power and cooling that provide better maintenance opportunities and safety against disruptions.
- Tier III: concurrently maintainable with redundant components as a key differentiator, with redundant distribution paths to serve the critical environment.
- Tier IV: with several independent and physically isolated systems that act as redundant capacity components and distribution paths.

The Telecommunications Industry Association (TIA) has its standard for data centers. ANSI/TIA-942 describes a similar four-level rating system:

- Rated-1: Basic site infrastructure
- Rated-2: Redundant capacity component site infrastructure
- Rated-3: Concurrently maintainable site infrastructure
- Rated-4: Fault tolerant site infrastructure

Green data centers, green money

The market is quickly growing for energy-efficient data centers which use renewable sources of energy. That's one conclusion of a recent Mordor Research Green Data Center Market forecast. The study pegged the value of the green data center market at $53.19 billion in 2020. The report anticipates $181.91 billion in global green data center revenue by 2026, with a

Apple's California Flats solar farm. Image courtesy Apple Inc.

compound annual growth rate (CAGR) of 23.0%.

What's driving green data center adoption? Better consumer awareness about energy consumption and generation is one factor. Grave scientific and political concerns about climate change have accelerated general awareness and political action in favor of more sustainable energy policy and use.

In this respect, green data centers provide a carbon-sink for corporate balance sheets that make them an attractive option. Customers with large footprints in manufacturing, transportation, construction, and other carbon-heavy ventures can offset their emissions with green data center operations.

North America is the biggest market share for green data centers, with 5G and cloud computing seen as key market drivers for green energy. Tech giants in North America have staked green claims.

Since 2017, for example, Google has bought enough renewable energy to offset its entire corporate electricity consumption, including Google Cloud operations. Microsoft plans to do the same by 2025, and Amazon said it will follow suit by 2030. Facebook is also relying on 100% renewable energy sources. Apple and other tech giants have also made commitments to green energy and carbon neutrality.

What this means in practical terms, however, varies. Contracting power from renewable sources is one thing. It's another thing entirely to use 100% renewable power in a data center operation that requires better than 99.9% uptime and extreme workload demand and flexibility. So for many businesses, it's a shell-game to offset the actual carbon cost of producing electricity by buying "green" power.

Some tech giants like Apple are making efforts to improve renewable energy storage, made available on demand as needed. But green energy storage technology and construction lags far behind green energy generation technology.

From fossil to fjord to fission

Green data center power has become a key differentiator for the country of Iceland, which markets its green data centers to international customers. The country's surfeit of geothermal and hydroelectric energy provides 100% renewable power for local data centers, its naturally cool environment contributes to low PUE ratings, and its strategic mid-Atlantic location between North America and Europe guarantees reliable backbone communications. Other factors favoring Iceland data centers, especially for European countries, include favorable tax rates, cheap energy, and a large professional workforce.

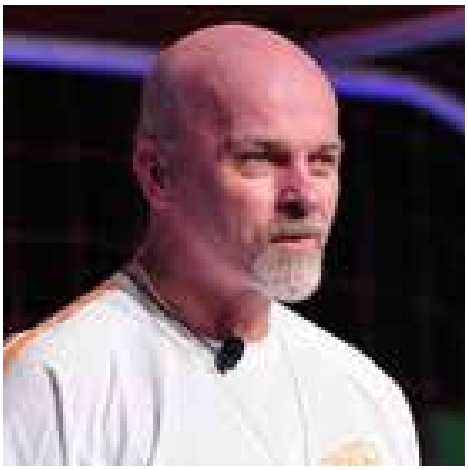
Low-carbon alternatives to fossil fuel-generated electricity don't stop at renewable sources like hydroelectric, solar, and geothermal. There's also a nuclear option. Literally. One-quarter of the power generated in the European Union already comes from nuclear sources, according to the World Nuclear Association. With that in mind, Rolls-Royce is developing a solution for data centers and other power-hungry business that harnesses fission but does so at a smaller scale and lower cost than traditional nuclear power plants.

Rolls-Royce has plans to build small modular reactors (SMRs) with sufficient power to operate large-scale data centers entirely off the electric utility grid. The company is reportedly in talks with hyperscalers and other tech giants who operate their data centers.

The plan is to build most of the reactor parts in factories, then assemble them onsite. This follows similar methods as those used to manufacture and assemble prefabricated homes and office structures. Rolls-Royce's efforts have garnered business partners and funding from the U.K. government, but those efforts are not expected to bear fruit until the 2030s.

Sustainable 5G: Network modernization, energy-smart operations and renewable energy

*A Q&A with **Mike Murphy**, CTO, Ericsson North America*



Q If you look high-level at 5G, you see operators installing more infrastructure and deploying more spectrum in order to move more data. Historically that would equate to a higher level of energy consumption. Can operators achieve their various 5G goals without simultaneously driving up their energy consumption?

A What drives energy consumption, first and foremost, is the availability of new spectrum, thus requiring more equipment to be deployed to use it. And then on top of that, as you alluded to, is data consumption, driving usage of the equipment.

These two things kind of suggest that we're on a significant energy growth trend. And at the same time, our customers have set carbon neutral goals for roughly 10 to 15 years from now. You would think, how is it possible that we're not going to grow energy consumption dramatically in the transition to 5G? And I think the answer is, it really takes a holistic approach.

Practically what that means is network modernization, so upgrade of equipment. Energy-smart operations, meaning how you use it, and looking at different renewable energy sources. But we believe by doing it right, you can actually reduce total energy consumption over time from where we are now.

I'll give you a few good examples; numbers always help. For example, technology we used in one of our newer 5G radios in Vodafone in the U.K…we got about 43% to 55% less energy consumption compared to the previous generation. And that's only on a single radio. And then in Ooredoo in Indonesia, we deployed some solar energy for some of our sites, and we saw about a 50% reduction for those sites. Those are really big numbers.

That's on the hardware side. Now above and beyond that on the software side, there were a lot of good things done in 3GPP to make the spec more supportive, let's say, of energy consumption. And then on top of that, we have our own innovations where we look at how do I actually turn off radio emissions altogether? And that can reduce consumption a further 15% during idle periods.

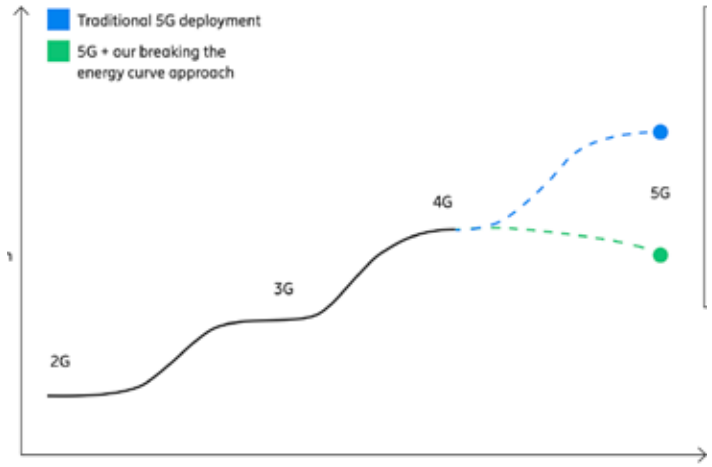
In short, we have a lot of tools and technology available now that we didn't have before. And if you apply it appropriately and holistically like I mentioned, we actually think you can change the demand trend quite significantly.

Q Could give us a look back and some historical perspective on the energy curve as it relates to previous generational upgrades of cellular; what has that trend line looked like?

A If we look over the last 10 years, smartphones grew from about one to six billion users, and traffic increased about 300-fold. But at the same time, energy consumption only went up about 64%, from 90 to 150 terawatts. And that 10 years, by the way, so going back 2011 to 2021, that's pretty much the 3G to 4G transition time. You could say that the transition from 3G to 4G caused a 64% increase in energy consumption. If we didn't do anything, we did everything in the exact same way, then the transition from 4G to 5G, you might expect it to be in a similar kind of ballpark. And in fact, that's what our study shows, that if we don't take action, then we will have growth like that.

But if we apply some of those tools I mentioned earlier, we think you can get

This graph compares energy consumption (y-axis) over time (x-axis).



that 64% to drop down dramatically, even below today's consumption rates. But it does take this holistic type of approach. And I guess we'll see if the industry and our customers are really ready to do that. But they made these carbon neutral commitments, so I think this is actually the only way they can achieve them.

Q Beyond more power efficient network infrastructure, how are you thinking about 5G and internet of things technologies as enablers of applications that can drive sustainability in other commercial sectors?

A COVID has resulted in remote work and it looks like that's more or less going to be on a permanent basis. Maybe not 100%, but at least 50% or so. And that's enabled by fixed and wireless solutions. And the side effect of that is a dramatic decrease in energy consumption, due to travel and basically not using some of our corporate buildings.

The whole idea of 5G is to apply it to digitization and automation of vertical industries. The numbers say something like 1.5% of the global carbon footprint of the world is due to the ICT industry. But the ICT industry can also impact a further 15% by the sectors that it supports.

Ericsson's 5G-enabled factory is an Industry 4.0 "Global Lighthouse"

Ericsson's 5G factory in Lewisville, Texas, is in many ways a manifestation of the company's hopes for a 5G future: Sustainable and smart, sleek and spacious.

In February 2020, the newly built facility began producing Ericsson's Street Macro millimeter-wave 5G product – the same equipment that is deployed within the factory, using 28 GHz spectrum in a private network with on-site core that also utilizes LTE frequencies, additional wireless technologies and advanced data processing to realize the potential of Industry 4.0.

Smart factory use cases in play at the facility include autonomous mobile robots and mixed reality for remote support. Additionally, the factory is certified LEED gold and uses 100% renewable power. Last year Ericsson's Texas factory was designated by the World Economic Forum as a Global Lighthouse, meaning it shows other firms the path towards more sustainable, productive manufacturing through the use of Industry 4.0 technologies.

Murphy called the Lewisville factory one of the company's "pride and joys," and explained that it's part of a larger sustainability plan. Ericsson support the United Nations Sustainable Development Goals and climate action targets.

"You can have all these targets and they sound great," he said. But "What's more important is how you're actually going to track to achieve them. In Ericsson, in 2020, we've reported a 57% reduction in greenhouse gas emissions for company operations versus 2016."

Specific to the smart factory, he said it was designed to be 24% more energy efficient and use 75% less water than similar factories, and use 100% renewable power generated on-site from solar arrays and drawn from a renewables-based grid. In terms of business outcomes, he said the company has seen a 2.2-x improvement in output per employee.

"Aside from doing technology for good," Murphy said, "we see these goals as attracting employees…[and] helping support our customers' goals. And being good for the bottom line at the end of the day."

Images courtesy of Ericsson.

Parsing the 5G power equation: Is 5G actually greener?

When the conversation turns to 5G's potential to be a "greener" technology than previous generations, the subject of power usage is one of the first that comes up. Most often, it is framed in the context of power efficiency: That 5G is more efficient than 4G systems, on a basis of energy consumption per unit of data (watt/bit) and therefore, greener.

There's a bit of a "yes, but …" moment here. Yes, 5G as a system is designed to be more power efficient – but that doesn't mean it will use less power on an absolute basis. Let's look at the picture merely in terms of scale, with China as an example: Chinese operators have already installed more than 1.3 million 5G base stations across the country, according to recent data from the Ministry of Industry and Information Technology (MIIT). The MIIT has plans to more than triple that figure within four years, for a target total of 3.64 million 5G base stations (BTS) by the end of 2025. Huawei figures the total power consumption by telecom networks in China already exceeds 50 billion kWh – and that will double, once 5G networks are fully deployed, to an estimated 100 billion kWh. Huawei estimates that more than 30% of existing tower sites will need to have their power supply systems retrofitted to adjust to 5G.

"Over the course of time, I think it is very possible, maybe even probable, that 5G will take less power because of the flexibility that 5G has. You can power efficiency through flexibility"

Jeff Reed, Founding Director, Wireless at Virginia Tech

5G's energy use matters greatly, not just to carriers' green initiatives but also to their bottom line. Energy costs account for an estimated 5-6% of operating expenses, according to MTN Consulting, which says there will be upward-pressure on that figure with the shift to 5G, due in part to the use of higher frequencies, edge compute facilities and new IoT services that will add to overall network power usage. "The bottom line is that, in an increasingly 5G world, telcos will face significant growth in their energy bills. To address this issue, telcos will need to take actions at the organizational, architectural, and site levels," MTN says.

There are, then, actions that can be taken. Part of the argument that 5G systems are greener is that the New Radio standard allows power-saving features to be used in ways that LTE simply doesn't enable.

For example, Ericsson has indicated that base station resources are generally unused between 75-90% of the time, even in highly loaded networks. "This raises an obvious question: If the base stations are spending so much of their time not transmitting user data, why are they still consuming energy all the time?" Ericsson researchers wrote in 2019. The reason is that most hardware components stay active in order to transmit mandatory LTE idle mode signals (reference signals, synchronization signals and system information).

In comparison, 5G offers a far more efficient overall structure in terms of its physical layer and need for such reference signals, according to Dr. Nishith Tripathi, a wireless researcher and adjunct associate professor of electrical and computer engineering at Virginia Tech (formerly of Samsung Research America). "We have taken care to make this a physical layer operation that is very efficient, so it will consume less power to get the information that we want," he explains. "But it takes time for technology to stabilize, and [move] away from Non-Standalone, so we can reap the benefits of that 5G capability."

Fundamentally, 5G provides "much better support for implementing energy-saving features in network products," according to an Ericsson blog post from October 2021. "The crucial difference is the vastly improved support for energy savings during low-to-medium traffic."

Power-saving mechanisms also offer the possibility that instead of steady-state power consumption, that at times of low usage, radio channels could be shut down, explains Tripathi.

In LTE, the number and timing of synchronization and reference signals provide very little space for time gaps, where "micro-sleep" energy-saving features can operate. 5G can allow gaps in transmission as long as 20 ms in SA and 160 ms in NSA mode, which are 100 to 800 times longer than what is allowed in LTE, along with requiring far less "always-on" signaling, according to Ericsson. "Since more components can be put in sleep mode for longer periods, there is a significant potential to reduce energy consumption of 5G-NR products and eventually the overall network energy consumption," Ericsson's experts write. However, they also point out that the network should be built with precision in order

to take advantage of power-saving features – so that high-capacity products are only put where that capacity is needed.

In current 5G networks, the industry may be seeing a particularly strong strain on power use – but that may change as the tech matures. Early 5G implementations are limited in coverage, which can drain device batteries faster as the device jumps back and forth between LTE and 5G New Radio. In addition, 5G Non-Standalone, the mode in which most 5G networks operate today, still relies on LTE for control-plane communications and adds more processing (and power) demand as a result. As 5G SA becomes a larger part of the network, the numbers (on a watt/bit basis) improve.

France's telecom regulator, Arcep, recently published its analysis of energy assessment of 4G versus 5G, in the context of how each technology would perform under traffic growth assumptions through 2028 in the 3.5 GHz band. What it found was that initially, 5G generated an increase in energy consumption – just how long that period was, depended on the specific 5G rollout scenario being modeled. But generally, the study concluded, "energy efficiency gains achieved from 5G deployment will begin in 2023 and be clear by 2028 in the most densely populated areas."

Compared to 4G-only densification strategy over the same time period, Arcep said, 5G deployment enabled total energy savings of up to ten times 2020 consumption levels by 2028, and was associated with a corresponding decrease of greenhouse gas (GHG) emissions of up to eight times 2020 GHG emissions. However, "In less densely populated areas, however, where traffic density is lower, virtually non-existent gains will not be seen until 2025 at the earliest, and by 2028 at the latest."

So essentially, another "yes, but …" Yes, 5G will consume a great deal of energy—but 4G would consume even more under the same conditions. Progress in energy savings, as in many things, is incremental.

"I believe that as time progresses, we will become more and more green in terms of the 'G,'" said Tripathi. "So 5G, greener than 4G; and 6G will be greener than 5G. … We are working on all those things to make things a little bit greener compared to the previous generations.

"Once the idea is introduced in the standard, it takes some time before they are implemented in real products," he notes. "So things take time. But gradually, we are moving in that direction."

Dr. Jeff Reed is a Virginia Tech professor in the Bradley Department of Electrical and Computer Engineering, and one of the core faculty members for its Wireless @ Virginia Tech program. Among his research is a 2017 paper that examined the role of power amplifiers in cellular systems and presented candidate architectures for more energy-efficient networks.

"Over the source of time, I think it is very possible, maybe even probable, that 5G will take less power because of the flexibility that 5G has. You can gain power efficiency through flexibility," he offered. That includes flexibility not only in how base station components operate, but also in the flexibility of where to place compute within the network—and in software upgradability that can improve function and operations over time. He also expects that an improved ability to harness energy-harvesting from ambient environmental sources, as well as the use of artificial intelligence to more intelligently manage power-saving features, will have a greater impact in the power usage of future 6G systems.

Alongside the continuing evolution of 5G and the ultimate definition and development of 5G, the IoT (arguably the most meaningful high-level 5G use case) is making strides in becoming more sustainable. By driving down unit costs and baking-in green principles from the design phase, IoT follows the same course as 5G in terms of pushing sustainability into the industries that invest in IoT-based projects.

Editor's note: Since publication of this report, Sigfox has gone into receivership. Read more at EnterpriseIoTInsights.com

Long-life IoT for 30 cents?

Sigfox counts the cost – and it is lean, green and (ultra) cheap

Sigfox reckons it can get IoT hardware costs down to just 30 cents ($0.30) per unit, with battery life lasting up to 13 years. It suggests it can, on paper, get to this price using printed biodegradable batteries and other circuitry. The claim extends, by some margin, its work so far to move the needle on tracker pricing closer to the magic dollar mark, plunging the race to the bottom on IoT costs (and to the top, in theory, on IoT volumes) into a new dimension.

The firm's dogged pursuit of dirt-cheap IoT hardware is long-running. A couple of years back, before Covid-19 cancelled the conference circuit, it distributed $1 'button' prototypes, as panic buttons on keychains, to developers at its annual Sigfox Connect event in Singapore. By late 2020, China-based chip firm CMOSTEK Microelectronics had commercialised them for pallet tracking in the supply chain and postal market, where Sigfox has decent contracts.

A second unnamed chip vendor, we were told, was in the wings, promising similarly-specified modules for $1-$1.50. At the time, Sigfox said the units would last three years, to match the shelf-life of pallets and weeks or months in certain ultra-budget cases, with enough power to issue "hundreds of messages". Both single-usage and reusable versions were to be available, it said; a recycling scheme to counter e-waste was also in development.

Between times, lots has changed. Sigfox has introduced a new category for dollar-range IoT devices, dubbed as U²LC (ultra-ultra low-cost). Nominal pricing for these units, meanwhile, has gone through the floor, and provisional longevity has gone through the roof. It has also, it seems, dispensed with the idea of recycling altogether; all its R&D guns are now turned on recyclable parts, optimal system design, and, to a lesser extent, energy harvesting.

"Deploying 'massive IoT' with conventional battery chemistry and conventional [engineering] techniques, without scrutinizing the waste-versus-gain ecological trade-off, would be a catastrophe," says Christophe Fourtet, co-founder and chief technology officer at Sigfox, in email conversation with *Enterprise IoT Insights*. His responses are constructive and detailed, and potentially game-changing in their import. They are transposed in full below.

But we should set the record straight, first of all. These U²LC units are not IoT trackers, in fact; they are 'tracers' in the Sigfox parlance. As with the 2020-vintage dollar-range CMOSTEK units, and as with dumbed-down trackers on LoRaWAN and cellular IoT, they make certain modifications. Invariably, they dispense with secondary receivers, whether GNSS, Wi-Fi, BLE, or otherwise, used variously to capture positioning data in indoor and outdoor trackers.

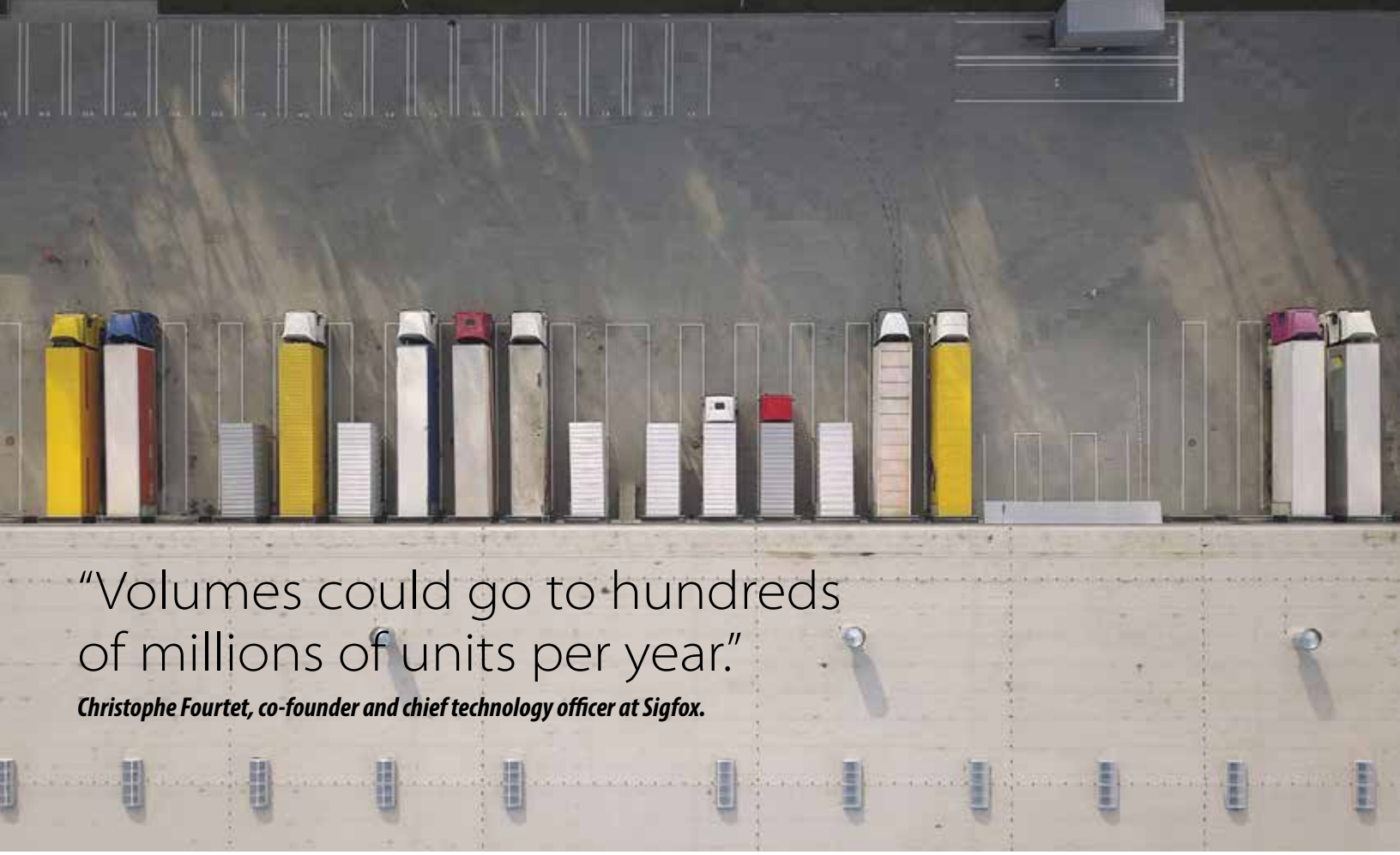
Most dispense with a primary radio receiver, as well, leaving them as transmit-only 'unidirectional' affairs; often, where network coverage is decent, the front-end power amplifier is also jettisoned. "A 'tracer' is a normal [LPWAN] uplink modem that is localized [instead] through trilateration or similar techniques by the network itself. With tracers, the best [result] is rough geo-localization, which can be further improved with additional processing."

Fourtet says a stripped-back Sigfox tracer can deliver positional read-outs with an accuracy of 100 metres (ranging up to 10 kilometres) in a public wide-area network (WAN) environment. He explains: "But many logistics applications are happy with this [and] there is no additional burden. The price – BOM-wise and most importantly energy-wise – increases drastically with trackers. The 'tracer' concept somehow exists in a long-range corner of the RFID world."

All of which we know, of course; the road to massive IoT will be paved with this kind of slimmed-down U²LC hardware, offering a cold-blooded pulse to animate however-many billions of semi-dormant sensors. There are coverage and complexity issues to sort out, but this is how IoT becomes a no-brainer, and rushes head-long into the enterprise mass-market, giving rein to as-yet unknowable use cases that do not require much thought.

Because everything else – all the red-hot wireless circuitry being set down with private 5G, say, and other higher-grade industrial technologies, and even all the hybrid gadgetry being attached to standard cellular and non-cellular LPWA tracker solutions – requires, often, painstaking planning and budgeting. In the latter case, the mega deals, breaching the million-connections mark, are still not coming so easily.

The enterprise market needs a gimme from the IoT sector; ultra-cheap tracer solutions might just be it. If only the green question, about how to stop from littering the planet with cheap disposable tech, can be answered. Fourtet is good on this subject (see below), reasoning that biodegradable parts and optimised systems (and, somewhere down the line, energy harvesting mechanisms) will make massive IoT easily



"Volumes could go to hundreds of millions of units per year."

Christophe Fourtet, co-founder and chief technology officer at Sigfox.

carbon-negative, in effect. He is also forensic about the theory to get IoT hardware to 30 cents and 13 years.

Just lastly here, before giving the floor over completely to Fourtet; what about those volume numbers? Because Sigfox, lest we forget, with somewhere south of 20 million connections on its network currently, has quoted a frankly bonkers target in these pages before — albeit more as a 'moon-shot' to gee-up the troops and stimulate the market — to get to a billion by 2025. So what kind of business does Sigfox expect to deliver, exactly, with ultra-low cost trackers and tracers?

"Volumes could go to hundreds of millions of units per year," responds Fourtet. Not quite so massive, perhaps; but a major advance on its (and anyone's) current run-rate – and a somehow more reasonable-sounding moon-shot from someone talking, without any sense of impossibility, about selling (the hardware components in) intelligent radio network solutions for less than the price of postage stamp – and a second-class one at that. But, here's Fourtet, in full; all the answers below are from him.

What use cases will these ultra low-cost trackers be for / open up?

"In logistics, large containers, and lorries in some cases, can justify 'high-end' trackers from an ROI standpoint; by contrast, pallets and crates — and certainly parcels — require tracers. But even letter logistics, which is currently considered as a dream [concept], is achievable with U^{2}LC tracers.

"In the industrial space, process optimization — for tracing of tools, crates, goods, machines indoors and outdoors across vast work sites — can also be addressed with ultra low-cost tracers. And livestock and wildlife monitoring, which remains limited to scientific experiments today, will become a reality with lower-cost IoT."

How is this cost-price achieved? What is left out, and what is kept in?

"The whole Sigfox approach is geared towards the simplification of end devices; it is about sophisticated network infrastructure at the service of simple IoT devices. But choices have to be made – about the elimination, for example, of the downlink receiver element, which removes the mandatory electromagnetic shielding and antenna burden, and of the auxiliary GNSS or beacon receiver, which is the case anyway with the tracer model.

"Equally, there is a question about using lower power and simpler modulation, in return for different usage and performance – like a lower success rate in public WAN and a need for denser coverage. But [these compromises on performance] also, often, bring lower power and longer life. And many use cases do not require these additional components – and are greener, effectively, without. It is also worth noting that, with Sigfox, there is no need for a downlink receiver to achieve a high quality-of-service (QoS) because the network itself is massively 'cognitive'."

What is their life expectancy, when IoT prices go ultra-low?

"The Sigfox system is unique so far as the lifespan of devices goes, allowing IoT developers to fully predict usage – and therefore power and longevity. This is because the network does not provide QoS through classic network-device protocols, which

are subject to fluctuation in device consumption. Instead, QoS is achieved through cognitive properties and massive signal processing in base stations and the network core, as well as through collaborative space diversity and other infrastructure tricks.

"Sigfox devices never negotiate their data rate or modulation. They initiate the downlink by themselves. The infrastructure adapts dynamically to 'everybody', in real time – like, the infrastructure compensates for a lack of device 'discipline' so the devices are as simple as possible. But as ever in engineering, it requires choices to be made – around data rates (100bps and 600bps), dissymmetry in downlink volumetry, delay in remote control, and so on.

"But the network infrastructure has zero influence on consumption, which is fundamental for low energy IoT devices and long lasting IoT systems. So the lifespan only depends on the usage profile – which is pre-programmed over weeks, months, years – and such things as the battery capacity, and the battery chemistry and packaging reliability in hostile environments.

"To give an idea, a $5 tracker with a 1Ah battery can last:

~8 years at 100bps and ~9.5 years at 600bps for 3 positions per day;

~4 years at 100bps and ~5.5 years at 600bps for 10 positions per day;

~1 year at 100mbps and ~2 years at 600bps for 2 positions per hour.

"By contrast, a $1 tracer with 1Ah battery can last:

~37 years at 100bps and ~83 years at 600bps for 3 positions per day (limited by battery / packaging)

~14 years at 100bps and ~51 years at 600bps for 10 positions per day

~3 years at 100bps and ~16 years at 600bps for 2 positions per hour

~1 year at 100bps and ~6 years at 600bps for 1 position every 10 minutes

"Beyond advantages in the network system, autonomy is still dependent on many parameters. Output power for instance could be a significant parameter if a certain degradation can be accepted. For example, the same tracer devices can work with less-expensive coin cell batteries, or equivalent U^{2}LC power sources, bringing the [hardware] cost even lower, and the lifespan lower with it.

"Using the same matrix, a sub-$ U^{2}LC tracer with a coin cell, or equivalent can last:

~6 years at 100bps and ~13 years at 600bps for 3 positions per day (battery-chemistry permitting)

~2.5 years at 100bps and ~8 years at 600bps for 10 positions per day

~6 months at 100bps and ~2.9 years at 600bps for 2 positions per hour

~70 days at 100mbps and ~1 year at 600bps for 1 position every 10 minutes

"This U^{2}LC model is somewhat opportunistic in a public WAN environment, of course, with many frames potentially being lost. But it would work for enterprises to track 'points of interest' within a few kilometres, with the installation of two or three small gateways – working as a kind of RFID extension for IoT apps, for instance. And this U^{2}LC concept leads to a 'sweet-spot', potentially, with complete devices priced at less than 30 cents ($0.30), with printed biodegradable batteries and full compatibility with existing infrastructure.

"The tradeoff with a printable battery – or some form of energy harvesting (although I am less optimistic for this in the short-term) – is that battery capacity is fixed at 10mAh and the battery power is limited to a peak current of a few-hundred µA (microamperes), and the [transmission] power to 100 µWatt or so. The coverage range, meanwhile, would go from a few hundred metres to a few kilometres.

"But as you see, as we go from one extreme (600 bps, 1 frame per day) to another (100 bps, 1 frame per 10 minutes), the lifespan ranges from more than 11 years (depending on the battery chemistry) to more than 540 days – and you can still operate one frame per minute at 100mbps and 600mbps for 60 days and 300 days respectively."

What is the green impact, potentially? What is the risk?

(continued on page 22)

Disposable IoT – how massive, really?

The narrative here, about the environmental impact of disposable IoT trackers, begs the question, of course; how many, exactly? How massive does 'massive IoT' get? And how big is the risk the planet will be littered with millions (billions?) of dirt-cheap tags and sensors? We should, probably, ask an analyst; and amid the bombast and contradiction that characterizes IoT forecasting, Transforma Insights has a forensic line on the matter.

For context, the UK-based firm says there will be "over" four billion low-power wide-area (LPWA) IoT connections by 2030. Of these, 2.7 billion will be on LTE-M and NB IoT, the twin cellular-based LPWA network offerings; the rest will be with non-cellular alternatives, notably LoRaWAN and Sigfox. Transforma teases-out numbers from the cellular IoT count for certain key applications, as a talking point; the ratios for non-cellular LPWA tech are similar (see below).

Among these, a decent chunk, almost 800 million units (about 30 percent of the 2.7 billion figure in 2030), will be for 'asset tracking and monitoring' of various kinds, to support track-and-trace (notably; about 700,000), plus things like bike and scooter sharing, container tracking, pest control, and agricultural solutions. A bigger chunk (940,000; over a third) will go on metering; white goods, alarms, and environmental monitoring will also see massive-ish volumes.

Of note, and of relevance, Transforma lumps 'disposable devices' into its asset tracking category. These comprise the kinds of ultra (ultra!) cheap one-way IoT sensors ('tracers') being developed by the likes of Sigfox, which promise to

"The tech space is littered with examples of things that might have taken off, but never did."

Jim Morrish, founding partner at Transforma

open-up brand new IoT cases – and which also risk, if not conceived properly, a major environmental waste problem, as they are discarded after single-usage. Transforma says their number will reach 11.3 million in 2030.

Interestingly, Jim Morrish, founding partner at Transforma, suggests licence-exempt LPWA is less well-suited to disposable devices – "since to support tracking of a disposable device it's helpful to have nationwide and multi-country coverage". Sigfox says different, of course, and quotes "hundreds-of-millions" as the near-term prospect for its 'ultra-ultra' low-cost 'tracer' segment. The LoRaWAN brigade, meanwhile, is pursuing the same course, on its own terms.

Morrish says this category is hardest to predict, just because novel R&D efforts may open the flood gates, and may also reveal that the river is dry. "There is clearly significant upside potential [with] disposable devices, as it is a niche that has potential to really 'take off" – although we've seen few signs of it actually happening. The tech space is littered with examples of things that might have taken off, but never did," he says.

At the same time, a trickle is starting to leak through the gates. "These things already exist," he says, pointing to Vodafone's work with German pharma firm Bayer to develop printable NB-IoT tracking labels for a couple of euros each to monitor products through the supply chain, and also to the example of Land Rover, which has sent interactive mail packs featuring Sigfox-connected replicas of vehicle 'start' buttons to get drivers to book a test-drive.

In other words, the ultra low-cost IoT market remains nascent, but its potential to deliver massive IoT is clear, albeit unknowable. What does Morrish make of the environmental risk? Like others in these pages, he suggests the net impact should be positive in terms of business efficiencies and, therefore, their total environmental impact, even deploying disposable trackers.

He comments: "Clearly there is a negative sustainability impact with producing an individual device but, certainly in an enterprise context, new applications tend to be implemented with the aim of increasing efficiency, so the net impact tends to be positive." Between the lines, as with others, the message is to optimize hardware usage, and to innovate in the meantime to develop alternative power supplies, and come up with better answers than batteries (see page 27). ■

Use Case	Application Group	2030
Asset Tracking & Monitoring	Track & Trace	707,392.3
Smart Grid	Electricity Smart Meters	394,035.6
Smart Grid	Water Smart Meters	358,670.7
White Goods	White Goods	224,197.0
Smart Grid	Gas Smart Meters	188,128.0
Security & Fire Alarms	Security & Fire Alarms	151,830.4
Environmental Monitoring	Agriculture	61,260.6
Inventory Management & Monitoring	Inventory Management & Monitoring	57,389.8
Environmental Monitoring	Environment Monitoring	55,154.9
Connected Vehicles	Usage-Based Insurance	43,060.2

Use Case	Application Group	2030
Smart Grid	Electricity Smart Meters	775,482.2
Asset Tracking & Monitoring	Track & Trace	773,400.4
Smart Grid	Water Smart Meters	578,675.1
Smart Grid	Gas Smart Meters	339,088.7
White Goods	White Goods	336,238.0
Security & Fire Alarms	Security & Fire Alarms	177,380.7
Environmental Monitoring	Agriculture	172,995.7
Inventory Management & Monitoring	Inventory Management & Monitoring	98,212.2
Environmental Monitoring	Environment Monitoring	81,389.1
Lighting	Public Space Lighting	69,893.4

"Deploying 'massive IoT' with conventional battery chemistry and conventional [engineering] techniques, without scrutinizing the waste-versus-gain ecological trade-off, would be a catastrophe. We all have in mind today that the pollution from a single car — even from a 'muscle car', even a 2000 horsepower air-show Warbird — is not an issue, on its own.

"The issue is the multiplication, in terms of pollution and resources, when it goes to massive scale. It is obvious, of course, but that multiplication has to be worked into the calculation right at the beginning. Which means the 'green impact' has to be incorporated into the design phase."

Will IoT devices be disposable, ever?

"It is a complex problem. Sigfox has done its homework from a system optimization standpoint. But if these devices are to be disposable, then they must also be biodegradable or reusable, or else have support from the recycling sector. The problem is with the battery, in the end – and the packaging. The electronics are almost a detail if the solution is well-tailored to the optimal mission. The battery is the hardest thing to make green.

"Printable batteries — based on paper, glucose, carbon, oxygen — are under development. They will be biodegradable. But the energy and particularly the currents they will deliver will be very limited. Classical batteries are more powerful. They could be recyclable, even today. But they can't be biodegradable. The question — the age-old question — is about the recovery costs: who is going to pay for the recycling? The industry cannot answer that yet."

Interactive mail – Land Rover has sent mail packs featuring Sigfox-connected 'start' buttons to get drivers to book test drives.

Is Sigfox looking at recyclable/biodegradable parts? Which parts; made from which substances?

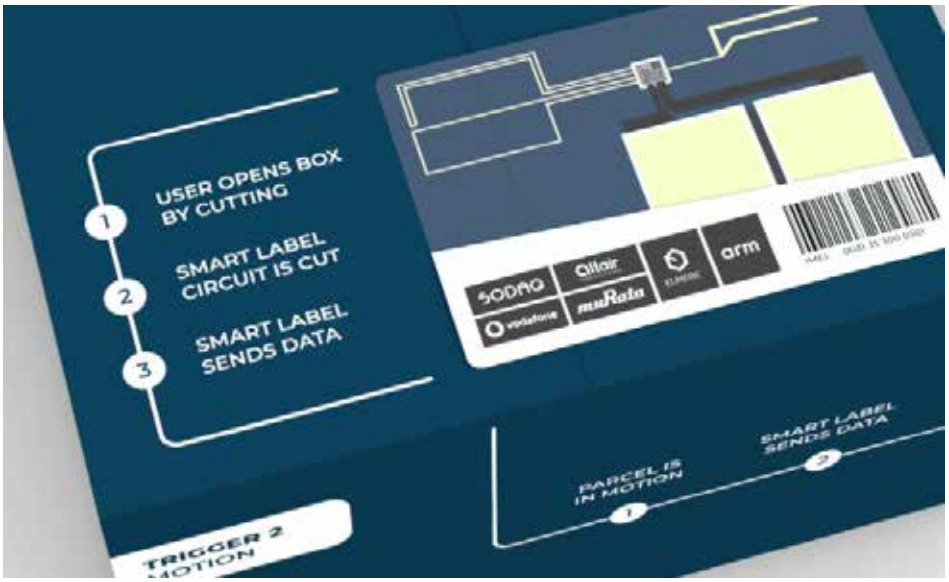
"Yes. But the first point, again, has to be to keep the mission as simple as possible. The benefit/sacrifice ratio must be as high as possible, and a central concern from the beginning. Too much gadgetry is bad; post-production simplification is not an option. Beyond this, the battery is the key part. For batteries, simple – not to say 'natural' – chemistries are preferred, such as oxygen and carbon molecules, along with a minimal amount of metal – and if possible, as with carbon, no metal at all.

"With the printed circuit board (PCB) and antenna, there is no way today to go too far from epoxy – which is a medium pollutant – for radioelectric and cost issues. But there is a smarter way to reduce the [circuitry] footprint by limiting usage and pushing the printed antenna pattern onto a less polluting material like paper. With hardly any performance reduction, and with clever trade-off, the antenna can be printed on paper with carbon materials. Which avoids 'plain metal' antennas – although metal antennas still offer the best performance.

"With regards to the active components, the principle is that smaller components mean fewer pins and less metal – which means a greener outcome. Again, the discipline is to pinpoint the parameters in the use case, and stick to them to keep the silicon content to the bare minimum. The mantra goes: keep RF power as low as possible to avoid GaAs (gallium arsenide), and keep with basic CMOS (complementary metal oxide semiconductor) devices.

"Smaller components mean fewer pins and less metal – which means a greener outcome."

"Progress has been made to limit tantalum or chemical capacitors, to the bare minimum – and to eliminate them completely, in some cases, with exclusive use of ceramic capacitors. Printed components are also coming. The other thing is packaging, and the use of polluting plastics. 'Natural' biodegradable plastics — based on corn, for instance — are now available, [sometimes] with interesting mechanical and industrial characteristics. But they are



Supply chain – roll containers in DHL depots (top) are being tracked; Vodafone and Bayer (bottom) have developed printable trackers

less durable. Increasingly, we are looking at direct integration into the material body of the final product – such as the pallet, crate, trashcan, machine, whatever."

What are the near-term prospects for energy harvesting? How soon?

"We are less confident in the short term. The most compatible wireless tech is ambient RF (radio frequency) energy harvesting, but it remains hugely challenging. The market is unclear. Most other methods – thermo-electric cooling devices, turbines, voltage step-up converters – are too expensive, still, and seem only to be for niches. Ultra-low-cost solar/light harvesters are available, and on some IoT products – as are low-cost aero-wind harvesters.

"They often require a small battery buffer, and an amount of surface space. But when the climate and the space allow, they are one of the best options, delivering energy at a nominal voltage, and minimizing energy conversion electronics to almost nothing. All the other options — like vibration, friction, temperature, RF — are very weak and require costly energy converters/accumulators."

Is the functionality and application of IoT devices limited with energy harvesting? How limited?

"Definitely. There is no chance, probably, that energy harvesting IoT devices will provide the same features as power-supplied IoT devices for the next few decades. Once again, the focus has to be on the minimum hardware for the greatest benefit. There is no room for surplus gadgetry. A system approach is essential."

Is Sigfox confident massive IoT can also be sustainable and environmentally-friendly IoT?

"Yes, but only by taking an 'ecological' approach. And I mean that from an etymological standpoint – to look at the whole system, and consider how it interacts within its environment. It has to be a whole-system approach, where the sacrifice and the benefit is deeply scrutinized. The best engineering is about deciding what to chuck out. Which has been the Sigfox DNA from the start, and has to be the guiding principle for IoT going forward."

Batteries not included:

The only way to make IoT massive, and also green

Amsterdam-based Nowi, a specialist in energy harvesting tech for integrated circuit (IC) microchips, has just (January 2022) announced work with narrowband IoT provider Sigfox to produce IoT modules that extract power from ambient energy sources, instead of from conventional single-use or rechargeable batteries. It has similar arrangements, it says (see below), with producers of LoRaWAN and cellular IoT (NB-IoT and LTE-M) products.

Together, these low-power wide-area (LPWA) technologies — plus a few others, plus local-area low-power equivalents BLE and Zigbee, plus everyday in-between technologies like WI-Fi — will drive the so-called 'massive IoT' market, comprising billions of sensor 'things' connecting millions of monitoring applications. This is the real IoT market, nominally defined as massive machine-type comms (mMTC), which will drive societal change.

So the story goes. By contrast, the brighter IoT pyrotechnics (loosely, ultra-reliable low-latency comms; URLLC) on private (someday-sliced) 5G networks, in Industry 4.0 and other digital-change sectors, are a sideshow – highly-engineered and powerful, but also rather niche. Everything else in the new connectivity game is about flexing (enhanced mobile) broadband (eMBB) for the old internet-of-people.

This is an interpretation of the cellular world-view, anyway; it is simplistic, and probably dogmatic, but useful as a prism through which to regard 'digital transformation' — this grand sales effort to reimagine industrial economies as smart, profitable, and sustainable. The problem with massive IoT — mMTC; just plain enterprise IoT – is that, even if it is good for business, it looks bad for the environment. Billions of throwaway IoT trackers? What a mess!

Because the barrier for massive IoT, until now, has been price and complexity. But these are being put right, progressively, probably belatedly. IoT costs are coming down – to as low as a couple of dollars, and ever-closer to the magic dollar mark, for hardware and to about a dollar-per-year for airtime. There are other fees, too, but these are being hammered out and hammered down in clearer total-cost-of-ownership (TCO) calculations.

"If the IoT industry cannot answer the green question, it cannot move forward."

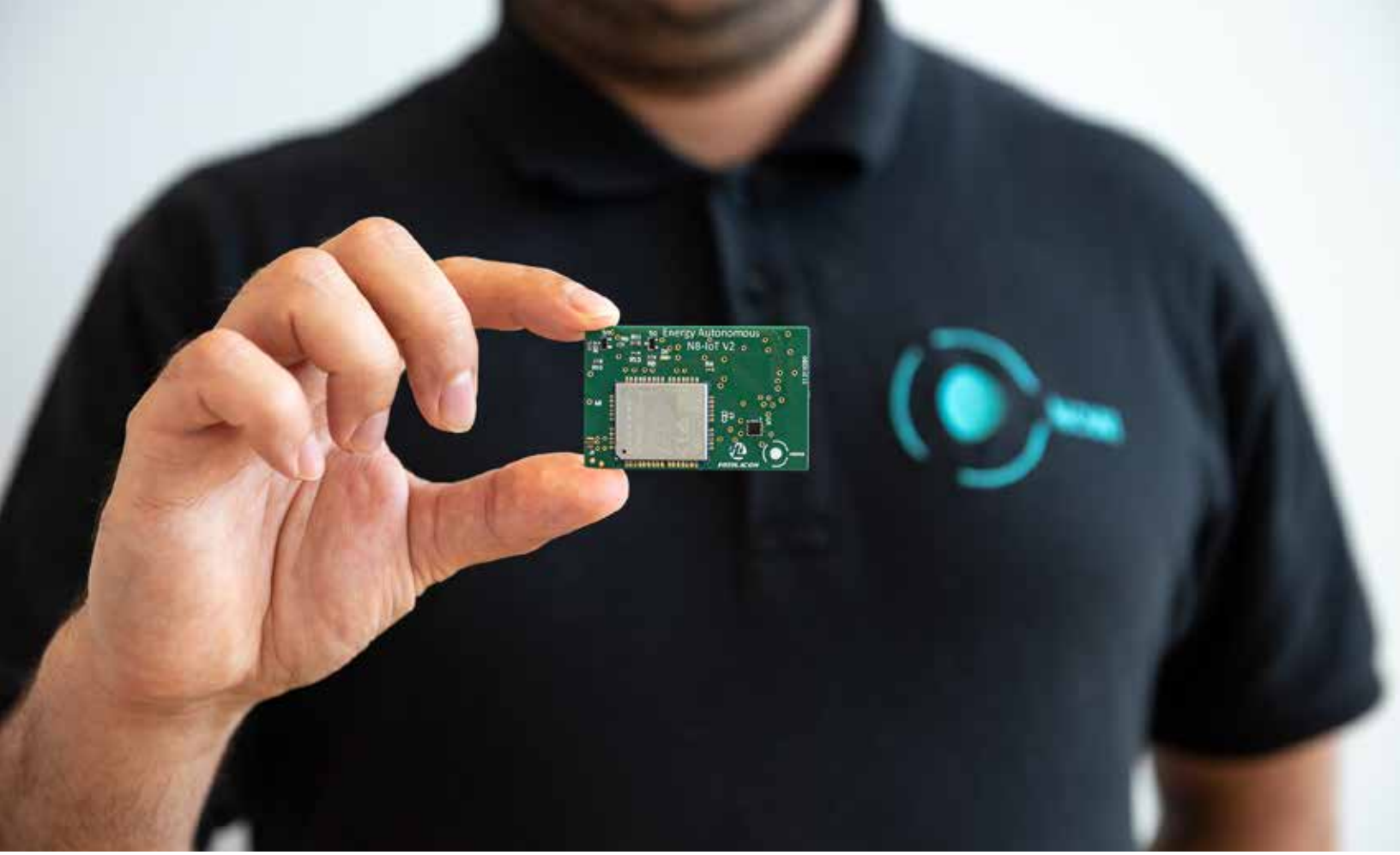
Meanwhile, complexity is being abstracted all the time; the design-once (deploy anywhere) mantra is starting to work for airtime, through flat-rate pricing, international roaming and integrated SIM (iSIM) rollout, and also for software development, as the low-code/no-code movement (and tiny ML trend) makes machine learning (ML) accessible (and portable to the device-edge), and open app interfaces (APIs) untangle the mad web of IoT airtime standards.

But alarm bells are ringing as IoT gets cheaper and easier, and the IoT industry looks to make good on its promise of however-many billion trackers and monitors. Because at a dollar-a-pop, where the initial ROI becomes irrefutable, there is surely no wriggle-room to replace or recharge batteries on huge fleets of IoT sensors, every five or 10 years. So realistically, where will they go, really, if they are not to litter the planet?

There is talk about using alkaline batteries, instead of lithium batteries, which are "dissolvable"; the same for the other printed components, bar the chip, which can be retrieved, the industry thinks. There is also talk about using biodegradable plastics made from fish scales for the substrate (wafer) in the chips. Such innovations are hopeful, but they all tend to look at the problem for massive IoT – and electronics, in general – from the old viewpoint.

Nowi, now we get back to it, looks at it differently; it wants to get rid of the battery altogether. In the end, massive IoT is not being held back by cost and complexity, actually, says Simon van der Jagt, the company's chief executive, but by the existential issue of its environmental impact. If the IoT industry cannot answer the green question, it cannot move forward. And the only way to do that, he says, is by jettisoning the battery to harness natural power sources.

Which is the basis of its work with all



the LPWA brigade, including teams Sigfox, LoRaWAN, and NB-IoT/LTE-M. The company's power-management IC (PMIC) extracts power from ambient energy sources like light and vibration to charge a variety of energy storage elements such as a rechargeable battery (!) or a capacitor. In conversation with *Enterprise IoT Insights*, van der Jagt says there is no other way for IoT than with energy harvesting.

The full transcript is below, and makes for important reading; all the responses are from van der Jagt. A new editorial report by *RCR Wireless News* and *Enterprise Iot Insights* on the green credentials of 5G and IoT, including with input from van der Jagt at Nowi, will be available next month; check back for its release.

Can massive IoT – millions and billions of dirt-cheap, possibly disposable, trackers – also be green IoT?

"I think the question is more the opposite. Can massive IoT exist without being green? Green in this context effectively means a low-cost-of-ownership as it eliminates the need for battery changes. Currently IoT solutions are often either limited in functionality or in operational costs due to their power constraints.

"Vendors can choose to limit functionality — such as the number of transmissions per day — in order to prolong battery life, or [else] try to incorporate the costs of battery changes into their business models. In practice, both [options] are... prohibitive for mass deployments. Many high-volume applications will require energy harvesting in order to be economically viable. As such, it is not a nice-to-have, but a need-to-have."

How can the environmental impact of massive IoT be mitigated by the industry?

"By thinking about the total product life cycle and how batteries play a central role in this. We often think about production cost in relation to sales price when launching a new product. This is important, clearly. But with IoT, the purchase price is often a fraction of the total lifetime cost of operating a sensor.

"Having to change a single battery during the lifetime of a sensor changes the business case entirely – not so much because of the battery cost itself, but mostly because of the labour and logistics involved in doing this maintenance. Discarding large amounts of batteries is harming the environment, but it is also detrimental to the viability of massive IoT business cases."

So, batteries not included? Batteries cannot be either replaceable and recyclable for dirt-cheap dollar trackers?

"The solution to make IoT greener will not be to make batteries slightly-less polluting; it will be to make them redundant altogether. Fundamentally, the problem is how to get energy to a product. As users, we are used to bringing energy to our devices – with a cable or a battery. But with massive IoT this starts to become unfeasible. It is unpleasant as a consumer, and expensive as a business. It often requires someone to drive around and climb a ladder, literally, just to

swap a single battery – and repeat 100,000 times over a large area.

"Few business cases can survive additional operational costs of this magnitude, let alone for IoT trackers that should be inexpensive. The end-user should no longer be made responsible for bringing energy to devices; instead, the responsibility for powering the device should fall to the product engineers – to develop products that are self-powered by design."

What are the near-term prospects for energy harvesting? How soon?

"We have seen demand skyrocket recently as more and more IoT projects have failed to scale after initial pilots. Energy harvesting is no longer an interesting technology for making IoT deployments greener; it is now often required in order to make the business case for a deployment work in the first place.

"Nowi's PMIC (power-management integrated-circuit) design has simplified and lowered the cost of having high-performing energy harvesting in a product. With multiple partner programs and reference designs with LoRa, Sigfox and NB-IoT vendors, [energy harvesting] is made even easier as all the tools are readily available to implement this into a product."

What are the most viable energy harvesting techniques for low-power IoT?

"Each application is unique, however they often share similarities. Because of this reason we have made platforms and reference designs available with IoT connectivity vendors that help users get to around 80 percent of their design. That last 20 percent will be different for each user.

"These platforms have been based on indoor and outdoor light harvesting, as we have seen the largest demand here. Light is reliable, has a high-power density per area, and is low-cost to implement. As such it has become very popular. At the same time there are applications in which movements, vibrations or temperature gradients can be used to power the device."

Is the functionality and application of IoT devices limited with energy harvesting?

"More often than not it is enhanced as energy harvesting enables a larger daily energy budget and thus more daily functionality. This is of course application dependent as some applications might be used in a way that makes energy harvesting difficult to implement. Nowi's application engineering team helps companies in deciding what type of harvesting and implementation will work best in their application."

Massive IoT – the net impact

This discussion is missing something, of course. IoT is not supposed to be written about as an environmental risk. The idea that billions of disposable trackers might litter the planet is an alarmist angle, arguably, on a tech-for-good story. Because, in most cases, the mission to attach sensors across all of public and private society is geared to drive efficiencies, and in many cases those efficiencies are directly or indirectly linked to energy-burning actions.

And as IoT sensors get cheaper, even going to sub-dollar, their numbers will multiply upwards and their applications will multiply outwards – and energy usage will multiply downwards. That is the story we have not told (which actually gets told all the time), which is important to re-tell in the context of the scare-mongering about dirty-cheap IoT. "At lower costs, more sensors will be deployed, providing more data across a wider range of use cases."

This is the line from Derek Wallace, vice president of marketing at the LoRa Alliance, in charge of the non-cellular LoRaWAN standard. "Lower-cost sensors will create new use cases [and] enable massive scaling of many existing ones... Massive IoT has enormous potential to positively impact the environment. The number of green use cases is staggering." He runs through a few, for environmental monitoring, water conservation, food production.

"The list goes on and on," he says, before settling on the role of IoT to reduce carbon footprints in buildings of all kinds – and to make them "smart sustainable buildings", or "blue buildings". He explains: "Sustainability has become a broader concept – about a building's ability to provide a healthy and productive environment over its lifecycle without negatively impacting the natural environment."

So is there a trade-off with the resources it takes to manufacture, distribute, install, and recycle the IoT gadgetry that is being put into service to drive efficiency and productivity? Jim Morrish, founding partner at Transforma, responds: "It's actually very positive, in terms of net impact. Yes, they take resources… but when they're in use many tracking devices can save significant resources."

Lower-cost sensors will create new use cases [and] enable massive scaling of many existing ones... Massive IoT has enormous potential to positively impact the environment. The number of green use cases is staggering."

Derek Wallace, vice president of marketing at the LoRa Alliance

He gives examples of simple IoT-connected mousetraps and tire pressure sensors, saving fuel and labour (and money) on ad hoc manual checks. It is the same for any kind of remotely manageable alert-system, whether for distribution centres, streetlights, or heart monitors. Wallace rejoins, and redirects the conversation back to IoT design principles, echoing Sigfox (see pages 18-22) that the hardware footprint, in the end, should be properly optimised.

The whole point with new(ish) LPWA solutions, of course, is they are geared to last for ages; up to 10 years in the case of LoRaWAN, says Wallace. But he acknowledges as well that IoT solutions must be tailored right. "It is important to plan and actively manage IoT deployments to achieve optimal results with minimal cost and impacts. The industry [must take responsibility] to ensure massive IoT is delivered in a way that is sustainable," he says.

What does the LoRa Alliance see from its vibrant developer ecosystem, to make IoT greener-by-design? He mentions the same R&D pursuits Sigfox is pushing, around recyclable and biodegradable parts ("eco-friendly components – hydrogen by splitting water molecules," he says), including batteries, as well as energy harvesting (see page XX). "New technologies like these will have a profound impact once they're used at massive scale."

He adds: "Innovation is a constant, and ensuring that massive IoT is sustainable is at the forefront of development activities. Our ecosystem is committed to deploying products and solutions that are fit-for-purpose, optimized for long-life, and [which] will continue to evolve to not only support environmental monitoring, but to minimize the impact on the environment in parallel."

What does Morrish, as an analyst, considering the market from every angle from the outside, say about energy harvesting? "Eventually a whole host of techniques will be deployed. The critical factor will be the frequency with which devices need to connect. The more infrequent, the more 'exotic' the energy harvesting technique can be – right through to approaches based on changes in atmospheric pressure and ambient temperature." ■

Principles of Green IoT Design

How should we be thinking about designing IoT systems that live up to their potential as "greener" technologies? After all, says IoT standards organization OneM2M, mobile and IoT technologies have some of the greatest potential for helping organizations meet their sustainability goals, through the combination of remote connectivity, low-power and low-cost devices and the use of IoT data. But the use of mobile or IoT doesn't inherently make a solution greener over its lifetime; effort has to be put in at the planning and design stage of IoT projects and solutions. A white paper from oneM2M, published in late 2021, gives a run-down of the primary considerations.

First, on a macro-level: Think horizontally instead of vertically. There are plenty of IoT solutions available that promise a rapidly deployable, end-to-end solution for a specific problem. But oneM2M warns against approaching IoT applications in isolation: If those solutions end up as one-offs that don't, or can't, integrate with existing or future systems, they may ultimately end up being a waste and needing to be replaced. This is particularly relevant for smart city ecosystems, where assets may be designed to last 50 years or more.

The problem with quick-to-market, single-purpose solutions is that, as OneM2M concludes, "With the passing of time, they demand significant new investment in redesign and system integration efforts to avoid becoming 'orphan' or silo investments." That's a waste of money, effort and resources. So IoT project design and planning needs to not only consider the problem at hand – say, smart parking or dynamic street lighting – but how common platforms, infrastructure and even individual devices could be re-used as applications and use cases expand over time.

The second broad recommendation is to actually implement the available standards features that exist specifically with greener goals in mind. Sleep mode configurations established by 3GPP for IoT are one such option; OneM2M has an API for interworking with 3GPP networks that translates 3GPP data structures to allow IoT developers to define sleep schedules on the basis of application requirements. Network management features also come into play: Can device schedules be coordinated for optimal times to send and receive data, taking efficiency into account? In addition, OneM2M says, remote management and standards-based upgradability improves the longevity of IoT devices, enabling a long service life and the ability to re-purpose devices with backwards-compatible software, rather than abandon "things" that have become obsolete.

Standardization often serves bakes in most of these principles and has a "magnifying" impact on them, the group said.

"If … IoT capabilities are to achieve widespread impact, participants in the IoT ecosystem and neighboring sectors need to focus on long-lasting and scalable

On a more granular level, the IoT standards organization recommends four principles for developers and service providers for sustainable IoT design. These are:

- **Interoperability**, from interchangeable components to cross-silo data exchange capabilities.
- **Scalability**, to leverage economies of scale from a base of multiple suppliers.
- **Modularity** in system and software design, so that new capabilities can be introduced to legacy systems and prolong their useful life.
- **The 're-use' principle**, which aims to create "solutions and sub-systems that other developers can employ to save time and improve their productivity." In other words, a platform approach that provides service functions in common and expands the usability and potential applications that can be served.

deployment," the group said. "This begins with investments in IoT systems that promote reusability and resource-sharing across multiple applications and users. … As the sustainability flywheel gains momentum over the coming years, organizations need to adjust their strategies away from legacy approaches toward sustainable and circular economy approaches."

Nokia, GSMA survey finds that network professionals overwhelmingly support green efforts

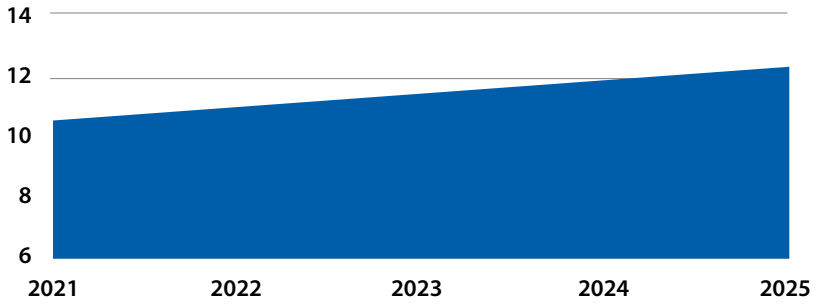
While 5G is 90% more energy efficient than LTE, according to industry experts, this gain is somewhat compromised by the surge in traffic and demand for capacity. The increase of traffic on both LTE and 5G will lead to higher energy demands on networks, and this, combined with consumer and government pressure, is positioning sustainability as an emerging priority in the telecom industry.

In fact, a survey of 130 telecom respondents across 45 markets conducted by Nokia and the GSMA projected that by the end of 2021, the telecoms industry will serve more than 5.3 billion unique mobile subscribers worldwide, which is equivalent to 70% of the population.

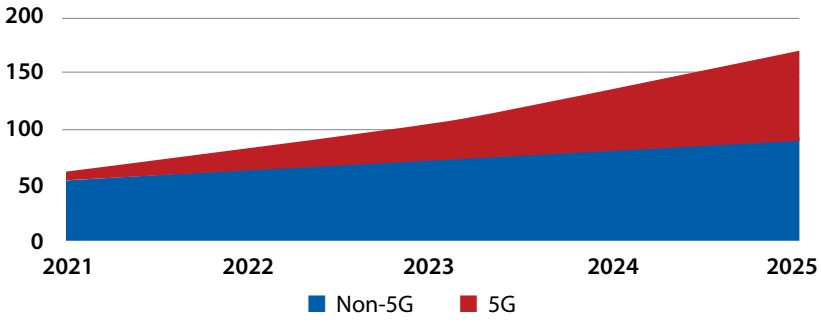
The same survey found that to address the growing concerns around sustainability and energy efficiency, more than 30% of wireless carriers have made public commitments that align with the Paris Agreement's effort to curb further damage to our climate. Additionally, a staggering 83% of network professionals rate energy efficiency as "extremely important" or "very important" in their network transformation strategy.

"The mobile section has worked collaboratively to create an industry-wide climate action roadmap to achieve net-zero

Number of cellular connections, 2021-2025 (Billion)



Mobile Data Traffic, 2021-2025 (EB/month)



Images courtesy of GSMA Intelligence; data courtesy of Ericsson

How important is energy efficiency in your network transformation strategy? (Percentage of respondents)

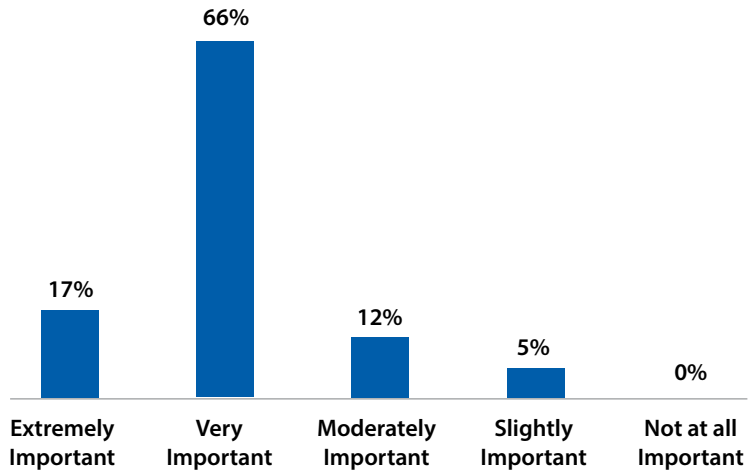


Image courtesy of GSMA Intelligence

greenhouse gas (GHG) emissions by 2050," stated the report.

Customer expectations are going green

Various factors, such as the rising price of energy costs and government requirements, are driving the increased attention that operators are dedicating to reducing their consumption; however, one motivator is leading the pack: customer expectations, as pointed out my Ericsson's Murphy at the beginning of this report.

Customers, both consumers and at the enterprise level, now consider the real-world green capabilities and strategies of an operator when choosing to go into business with them, and operators are starting to feel the pressure. The Nokia/GSMA survey found that 50% of network professionals said fulfilling customer expectations is the primary goals driving their network energy efficiency strategy.

"Sustainability is becoming a business-critical topic and it involves many stockholders and broad involvement in our customer base," said Volker Held, head of marketing for managed services at Nokia. "It is also being used as criteria in the stock market. There is some evidence that companies that are more sustainable, have an advantage in their evaluation at the stock market."

'Low-hanging fruit': AI for improved energy efficiency

An increasingly common stop to make along this road to net-zero GHG emissions is the implementation of Artificial intelligence (AI) and machine learning (ML) to deliver new network capabilities and to support energy efficiency efforts. According to Nokia and the GSMA, such technologies allow network equipment to perceive, reason, intuit and provide new ways for solving technical challenges.

While only 2% of network professionals have already implemented AI-driven network optimization and shutdowns in their network, 78% of network professionals expect AI-driven solutions to be an extremely or very important part of their network transformation strategy and 50% are in the planning and testing phase, suggesting an impending rise in live deployments.

"Using AI-based software and services is an approach that is low-hanging fruit," said Held. "You can save massive amounts of energy and you can do so rather quickly because you don't have to deploy new hardware; it's purely software. And machine learning can further increase the savings over time. From our perspective, that makes it the most attractive approach."

Held said that while there are several different approaches to reducing the power consumption of a network such as modernizing hardware and decommissioning legacy 2G and 3G networks, implementing AI-based energy solutions that optimize network power usage and component shutdowns is emerging as the most promising because it offers the clearest ROI.

He acknowledged that when it comes to the most effective strategy to reduce an operator's carbon footprint, the use of renewable energy on the energy-production side combined with AI-based energy saving software to reduce energy consumption is the best answer.

Image courtesy of Deutsche Telekom.

"When looking at the energy consumption side of things, however, they must utilize this energy in the best possible way," he stated, adding that in the survey, for most respondents, (35%) AI-driven network optimization is the best bet, followed by data center cooling (30%) and RAN cooling and air-conditioning (16%).

Europe is leading the way, and other key trends

Finally, Nokia and the GSMA identified a number of green trends in the telecom space, one of which is that Europe is thus far emerging as the front runner in this space. Several European operators have committed to supporting the European Green Deal's climate change initiatives.

Deutsche Telekom, for example, has amended its climate deadlines to reflect the urgency of the situation, moving its target to achieve neutrality for in-house emissions from 2030 to 2025. Further, the carrier said it will achieve net-zero status across its whole supply chain by 2040 — 10 years earlier than originally planned — and since 2021, has reportedly been purchasing 100% of its electricity from renewable energies.

More broadly, in the spring of 2021, the CEOs of 13 European telecom firms were among the 26 initial signatories of the European Green Digital Coalition. The Coalition is an agreement amongst several ICT companies to take action to support the green and digital transformation of the EU and according to its website, is committed to:

- Investing in the development and deployment of greener digital technologies and services that are more energy- and material- efficient.
- Developing methods and tools to measure the net impact of green digital technologies on the environment and climate by joining forces with NGOs and relevant expert organizations.
- Co-creating, with representatives of other sectors, recommendations and guidelines for the green digital transformation of these sectors that benefit the environment, society and economy.

Held pointed to Europe's stricter sustainability regulations and a more established political ambition around making improvements.

Other trends include the use of AI in energy management, as well as network design to make networks foundationally energy efficient, and lastly in testing, where AI can reduce the size of testing crews, their travel time and the related petrol and electricity costs, all of which results in reduced energy usage and waste.

Held emphasized the central role that operators play in the future of our planet, and gave the example of smart manufacturing, a vision involving both 5G and IoT technologies: "Just look at sectors like manufacturing where with connectivity, you can enhance the productivity of the sector, but also the energy efficiency of that sector because you are making production processes leaner and less wasteful. Operators should be aware that they play a major role in the decarbonization of the whole industry and society."

Ericsson's Murphy concluded: "In deploying 5G, we can do that in a sustainable way. 5G in itself helps subscribers…to also reduce their energy curve. At the same time, on top of all that, by using 5G the way it was really intended, to digitize and automate vertical industries, we can further reduce the energy consumption. You see a connection between multiple points here. It's a happy feedback loop or flywheel."

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