DECT 2020 NR: Sustainability and Scale for the IoT

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INTRODUCTION

DECT-2020 New Radio (NR) is the first non-cellular 5G technology designed for the Internet of Things (IoT) standardized by ETSI. ETSI published the first version of the standard in June 2020. The International Telecommunication Union Radiocommunication Sector (ITU-R) has included it as part of the 5G NR standards within IMT-2020 technology recommendation ITU-R M.2150-1. The value of DECT 2020 NR comes from its potential as a massive IoT technology, able to connect thousands of devices on a single access point. In addition, it offers a streamlined messaging protocol enabling low-latency, highly-reliable connections. Finally, as a 5G standard, it will benefit from a huge and growing 5G ecosystem.

The combination of these benefits present the IoT market with a single technology that can be applied to multiple use cases. In fact, DECT 2020 NR has potential as a fixed line replacement technology. This presents enterprises with multiple benefits that extend from solution simplification to ease of solution management. But DECT 2020 NR, as a result of its capabilities, provides the market with a solution that can drive more sustainable solutions and operations.

This whitepaper will first provide an overview of the key capabilities and features of the DECT 2020 NR standard. It will then review the deployment opportunities that DECT 2020 NR can offer and how it can massively expand the number of IoT uses available to solution providers. This will be followed by its benefits for underserved customer markets, as well as its sustainability benefits. It will conclude with emerging use cases being trialed in the market.

Key Capabilities and Benefits: DECT 2020 NR offers the following features for the IoT market, translating to benefits not available from other connectivity technologies.

Flexible Mesh Network Architecture: In mesh networks, radio nodes can communicate directly with devices, but also act as routers that tunnel traffic between nodes and to the Internet. As a result, a mesh network architecture enables creating coverage and connection quality specific to the needs of the IoT applications using the network. DECT-2020 NR mesh networking supports both very high device densities (more than 1 million portable radio devices per Square Kilometer (km2)) and very low densities (as low as 115 devices per km2), as demonstrated in the performance study from the VTT Technical Research Centre of Finland (https://cris.vtt.fi/ws/portalfiles/portal/45087959/VTT_R_00367_21.pdf). Multi-application IoT scenarios, such as factories and distribution centers, can benefit from mesh networks where network configuration can be designed for the devices and traffic needs that can vary across different operational environments.

Unlicensed and Global Shared Spectrum: DECT 2020 NR operates in the unlicensed spectrum band below 6 Gigahertz (GHz) with primary operation on the 1.9 GHz band. Using unlicensed spectrum avoids the costs of operating on mobile operator networks. As a mesh technology, issues of spectrum noise are limited, as devices have multiple nodes to use for network connectivity. Lowering the cost of connectivity by using unlicensed spectrum expands IoT technologies to more price-sensitive markets, such as Small and Medium Enterprises (SMES) and developing regions.

Low Latency and Dense Massive Network: In factory environments where multiple devices, such as mobile robots, tugs, forklifts, tools, and people, are moving and operating in the same vicinity, network latency is important for controlling machine operations and location. As a mesh technology, DECT 2020 NR latency can be improved by densifying the radio nodes. In evaluation by ETSI (TR103.810) DECT-2020 is proven to achieve single hop latencies as low as 1 millisecond (ms).

Automatic Configuration and Self-Healing Topology: In mesh networks, intelligence is built into the radio nodes for device communications and traffic routing. These features enable self-install networks that will automatically configure and choose the most optimum traffic routing. The benefit is less time configuring and managing networks for companies and firms without Information Technology (IT) know-how and personnel.

Data Throughput and Range: Data throughput in unlicensed spectrum will vary by region based on the maximum operating bandwidth set by regulators. For DECT 2020 NR, a throughput of more than 80Mbps in a 13.8 Mega Hertz (MHz) channel without MIMO is possible. Range is as far as 2 km outdoors in line-of-sight configurations to hundreds of meters indoors. This kind of capacity combined with node densification options, as well as range, allows serving many different vertical markets from outdoor environments, such as utilities (grid and meter monitoring), to indoor/yard environments, such as warehouses and factories (robotics, machine monitoring, asset tracking).

Low Power Consumption: Early studies of DECT 2020 by Tampere University in Finland showed that it was 60% more power efficient than cellular Low-Power Wide Area (LPWA) technologies. Recent analysis performed by Wirepas when DECT 2020 NR software is applied to Bluetooth silicon shows it to be 24X more efficient than Narrowband Internet of Things (NB-IoT). In the same analysis, when DECT 2020 software is flashed onto cellular chips, DECT 2020 demonstrated a 2.4X improvement in power efficiency over NB-IoT devices.

Security: Advanced Encryption Standard (AES) 128-bit, with Cipher-based Message Authentication Code (CMAC) link level security for data integrity protection, is built into the DECT 2020 NR standard. It can also support other application layer security protocols depending on regulations. As a technology for private networks, additional security comes from on-site data storage requirements in markets such as industrial and government.

OPPORTUNITIES—SHORT-RANGE WIRELESS REPLACEMENT TECHNOLOGY

Bluetooth has made great advances from its early days as primarily a pairing technology for smartphones to one that is serving the IoT market. Its primary role in the IoT is still as a pairing technology for connected machines to laptops and tablets typically carried by maintenance workers. However, with the release of BT5, the technology was advanced to add both range and Quality of Service (QoS). This has made it a candidate for multiple other IoT use cases, particularly in the industrial domain for connecting Bluetooth (BT)-enabled machines and BT-enabled sensors to gateways. Another benefit for the IoT ecosystem is there is a large base of semiconductor suppliers that can serve this market, enabling development of a diverse device range and with the scale to maintain BT's traditional low cost.

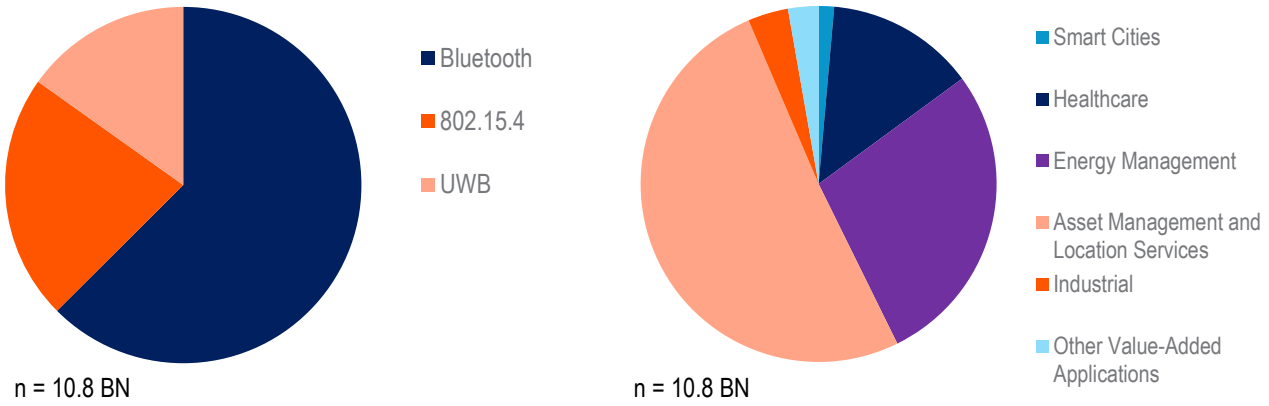
Wirepas has taken advantage of this large and embedded base of BT devices by flashing a product variant of DECT 2020 NR firmware onto BT silicon. The benefit of using BT silicon is it consumes less power and is less expensive than cellular and has a well-established silicon ecosystem.

Over a period from 2022 to 2030, ABI Research estimates the total BT, 802.15.4, and Ultra-Wideband (UWB) device shipments in the Industrial IoT (IIoT) domain to exceed 10.8 billion units. Bluetooth will constitute the bulk of the shipments. All segments mostly represent the use of tags

to track and monitor both equipment and people operating in these domains. By far the largest segment will be asset management and location services applied to track a long tail of goods and equipment found across a variety of venues ranging from airports to manufacturing facilities. These are segments where there will be massive connections on tagged goods and embedded within business and enterprise systems.

Chart 1 ***Industrial Sector Device Shipments: Bluetooth, 802.15.4, Ultra-Wideband Technologies***

(Source: ABI Research)



OPPORTUNITIES—MASSIVE USE CASE EXPANSION

With DECT 2020 NR adding significant benefits as a tag technology, massive use case expansion will come from its deployment in private networks. Two types of private networks are already finding a foothold in the enterprise domain. DECT 2020 NR capabilities are poised to make these network types even more capable and valuable.

Asset Visibility—Neighborhood and City Private Networks: An exciting development is the potential of neighborhood and even city-wide networks enabled through devices and gateways deployed for home and business security/automation systems. Amazon is in the early stages of building such a network (called Amazon Sidewalk) based on the LoRa protocol, adding LoRa connectivity to doorbells and security cameras. Helium has launched the People's Network, also based on the LoRa physical layer allowing people's home/business router and Internet connection to also power a LPWA network.

For delivery companies like Amazon, these networks will allow tracking and monitoring of goods as they enter neighborhood private network zones. For consumers, these networks will enable them to track and monitor all types of items, including sporting goods, lawn/pool equipment, bikes, pets, kids, and even phones and eyeglasses.

LoRa is the protocol with the most traction in these networks and inexpensive LoRa chips allow creating low-cost tags. Utilizing DECT-2020 NR radio protocols (MAC and routing) on BT silicon offers another low-cost tag option, but it also has other advantages relative to LoRa.

Spectrum: LoRa spectrum efficiency is low, which increases the possibility of interference and low service quality. DECT 2020 NR radio protocols' spectrum efficiency is very high, enabling higher node density for the same service quality.

Throughput: LoRa throughput varies from 0.330 to 27 Kilobits per Second (Kbps); DECT 2020 NR throughput is 3.4 Mbps@1.728 MHz in a global 1.9 GHz band. Higher network capacity provides options for the types of devices and use cases enabled on a network.

Node Density: DECT 2020 NR radio protocol has more flexibility for handling communications from a high density of nodes due to its mesh network architecture, higher spectrum efficiency, and higher throughput capabilities. LoRa's centralized network architecture is prone to losses in coverage and throughput as node density increases on every single cell.

Standardized: DECT 2020 NR is an open ETSI standard allowing any chip maker to offer DECT 2020 NR chips. In contrast, LoRa chips are proprietary, silicon Intellectual Property (IP) only offered by Semtech.

Overall, DECT 2020 NR offers a more reliable network and higher density of tag connections, limiting loss in service reliability compared to LoRa. DECT 2020 also expands the use cases with throughput into the Mbps range.

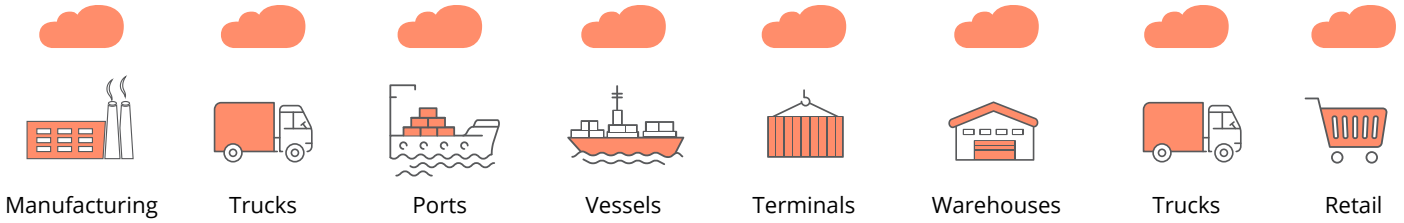
Asset Visibility—Enterprise Private Networks Total Addressable Market (TAM) Expansion: The combination of massive connectivity, longer range, plus the ability to leverage inexpensive silicon greatly expands the TAM for asset visibility, assets owned by a business that either are expensive (tools), carry product (pallets/Unit Load Formations (ULFs)), are high volume and prone to theft (packages) or a combination of the above (pharmaceuticals, electronics).

Private networks will play a key role in tracking and monitoring assets, particularly for assets that are indoors where Wide-Area Networks (WANs), such as cellular, do not offer the same level of building penetration and connection reliability. Private cellular networks can offer indoor coverage, but will struggle to lower tag costs to the same level as Bluetooth tags. This disadvantage limits the number of assets that cellular can monitor and track for a truly massive IoT operation, thus lowering its effectiveness for some enterprise operations.

Private networks will also be critical for tracking assets and goods that move around world. As shown in Figure 1, assets like pallets or crates, or products like produce or raw materials will start their journey moving across various centers of activity typically involving a transformation event (manufacturing) and an aggregation/de-aggregation event (ports/terminals, warehouses, distribution centers) until they reach their final point of sale (retail) or delivery destination (home/business).

Figure 1 B2B Operations Activity Centers

(Source: ABI Research)



Barcode and Radio Frequency Identification (RFID) technologies are the traditional technologies for tagging products that can be scanned at different activity centers as part of the logistics process for tracking, ownership, and payment transactions. While these technologies are inexpensive as a tag technology, both technologies cannot be deployed in networks either individually or together to provide the most comprehensive set of capabilities regardless of use case. Barcode technology is not a network technology, so it cannot be deployed to detect things without human intervention using handheld barcode readers. Only active RFID offers some comparable features for coverage between indoors and outdoors, and for indoor positioning. However, the mesh capabilities of DECT 2020 NR provides far more range to cover outdoor applications, as well as more flexibility with network access points for location and positioning services.

With the advancements provided by DECT 2020, the TAM can greatly increase. In fact, the TAM for assets traversing through the supply chain is in the hundreds of billions of units. Table 1 provides the categories of assets that are actively searching for communications technologies for delivering information on their location and status.

Postal Packages and Cargo

TAM: 100 billion shipped annually

Challenges and Opportunities:

- **Theft Reduction:** Theft of packages is in the billions every year. Connected tag packages can alert customer the moment packages arrives; stolen packages can be retrieved.
- **Packaging Optimization:** More and more cold chain pharmaceuticals are delivered to the home requiring oversized coolers, which limits delivery capacity. Smart connected packaging designed for the route improves load capacity and can alert stakeholders when conditions are in a critical range.
- **Customer Satisfaction and Engagement:** Via text and email, customers can be alerted to package arrival and given special offers.

Intermodal Freight Transport—Intermodal Containers, Rail Cars, Trailers

TAM: 200 million installed base

Challenges and Opportunities:

- **Asset Visibility:** These transportation devices move assets across regions and oceans. They are expensive and, by nature of their size, carry large amounts of cargo measured in revenue. Both device owners and customers need to have visibility of their assets, given the high risk of loss due to journey length.

- **Asset Utilization:** Freight firms need an accurate inventory of transport assets to book customer orders and improve asset utilization.
- **Operations Management/Customer Satisfaction:** Customers of products carried by freight containers plan their operations ranging from manufacturing to retail sale around product arrival within these containers.

ULF Equipment—Pallets, Crates, Roll Containers, Tanks/Drums, Kegs

TAM: 15 billion installed base

Challenges and Opportunities:

- **Prevent Theft and Loss:** These assets move products around and within facilities, via truck and delivery to homes and businesses. Loss of these assets costs enterprises money, not only for the ULF itself, but also for the product carried by the ULF.
- **Asset Utilization:** Throughput capacity is optimized through greater location visibility.
- **Revenue Recognition:** ULF rental business models require traversal of assets back to a designated destination, typically a location where they will be cleaned. Routing away from those designated locations decreases total rental revenue.
- **Sustainability:** National, market, and self-imposed sustainability requirements are driving more reuse of ULFs, increasing the need to track a higher percentage of these assets.

Yard/Campus Transport Equipment—Forklifts, Tugs, Carts, Trailers

TAM: 350 million installed base

Challenges and Opportunities:

- **Building and Campus Operation Efficiencies:** Forklifts, tugs, carts, and trailers are critical for moving products and assets in distribution centers, ports, airports, and other locations where there is a transport and ownership handover, such as from airplane to truck, or long-haul truck to local delivery. Knowledge of location is critical to optimize these high-traffic locations for overall delivery efficiency.

Fixed Line Replacement: Cable, Digital Subscriber Line (DSL), power line, and industrial Ethernet are all important fixed-line connection technologies for powering and connecting IoT applications. Fixed line provided the earliest form of connectivity for the IoT when wireless communications was in its infancy. Its grandfather status has positioned it for use in connecting equipment and things that are stationary. It also has been architected for very deterministic communications, something that, in the past, was easier to do over wireline links, rather than over wireless links. However, fixed-line technologies inherently lack flexibility for connecting things that are mobile or portable. Fixed line also adds weight to systems, such as automobiles or airplanes.

DECT 2020 NR offers an option for replacing some fixed-line connections with wireless because it has WAN capabilities, low latency, and deterministic features. Listed below are four markets and associated use cases where DECT 2020 NR could add value by replacing fixed-line connections.

Commercial Building Automation: Table 1 provides the forecast shipments of devices communicating over fixed lines for monitoring and controlling different systems within commercial buildings. Fixed-line use for commercial building automation is a well-established, legacy technology because the top suppliers in the Building Management Systems (BMS) market, including Siemens, Johnson Controls, Honeywell, and Schneider Electric, have promoted it for its reliability compared to wireless.

Wireless communications is growing in use in the building automation market, as buildings become more automated, such as with door locks, lighting, and smoke/fire alarms. Self-install wireless building automation systems are also finding traction in smaller building markets, such as the retail and hotel/accommodation industry. However, DECT 2020 has the potential to supplant retrofits in existing buildings and replace fixed-line systems in new commercial buildings due to its reliability and ease of network deployment.

Table 1 ***Building Automation System Wired Field Equipment Shipments by Application World Markets: 2020 to 2026***

(Source: ABI Research)

Application	Shipments	2020	2021	2022	2023	2024	2025	2026	CAGR 20-26
HVAC	(Millions)	58.9	58.9	60.3	61.6	61.9	62.8	63.6	1%
Lighting	(Millions)	26.8	26.9	27.6	28.4	28.6	29.1	29.7	2%
Access	(Millions)	8.9	8.9	9.0	9.2	9.2	9.3	9.4	1%
Fire/Life Safety	(Millions)	19.5	19.3	19.6	19.9	19.9	20.1	20.3	1%
Other	(Millions)	4.8	4.6	4.6	4.5	4.3	4.1	4.0	-3%
Total	**(Millions)**	**118.9**	**118.6**	**121.2**	**123.6**	**123.8**	**125.4**	**126.9**	**1%**

Smart Metering: Table 2 provides forecasts for Power Line Communications (PLC)-enabled smart meters. PLC is a well-established protocol that uses electrical power lines to communicate meter usage data to the utility head end. Regions with over 50% of meters connected over PLC include Asia-Pacific, Europe, and the Middle East & Africa. DECT 2020 NR would not drive replacement of existing PLC connected meters, but it could be used to quickly and inexpensively expand smart meter connections to new neighborhood developments and new Multi-Dwelling Units (MDUs). Electrical grid sensorization is another area where wireless communications is a better option than wired. DECT 2020 NR can enable wireless grid monitoring at critical electricity grid control points, such as substations and transformers. Grid monitoring data can be communicated back to utilities via a DECT 2020 NR mesh network or via gateways communicating over the power line network.

Table 2 ***Total Smart Electricity Meter Installed Base by Communication Technology Type World Markets: 2020 to 2026***

(Source: ABI Research)

Region	Installed Base	2020	2021	2022	2023	2024	2025	2026	CAGR 20-26
Power Line	(Millions)	407.8	450.6	487.4	500.8	514.2	529.1	540.0	13.1%

Factory Network Monitoring: Fixed-line connections in factories have historically centered on control loop functions that have automated the control of the various machines that both move products and alter products in a very deterministic way to maximize output and ensure product consistency and quality. Factories are now adding overlay networks to do two things. The first is to monitor the condition of existing equipment to maximize machine utilization by improving maintenance operations and extending equipment life. The second type of overlay network is for automation of product movement through different transformation centers via Automated Guided Vehicles (AGVs) and Autonomous Mobile Robots (AMRs).

Wireless technologies are a better option for adding an overlay network to provide condition monitoring information and communicate with automated delivery vehicles in factory operations. However, the complexity of factory operations, which can vary by the types of machines, factory floor layout, total floor space, and the number of machines used in the transformation process, requires a highly-capable wireless technology. DECT 2020 NR offers features and capabilities to support both types of overlay network types:

- **Latency/Communications Reliability:** 1 ms to 5 ms latency is more than sufficient for communicating with AGVs in most factory operations.
- **Network Coverage and Blind Spots:** In indoor environments, coverage is hundreds of meters, but blind spots can be filled by adding network nodes.
- **Location Precision:** DECT 2020 NR location precision can provide 2 meter to 3 meter accuracy in hospitals, factories, and commercial buildings deployments.
- **Network Deployment Flexibility:** As a mesh technology, DECT 2020 networks can be designed to provide network coverage as appropriate. Indoor environments require higher node density, but outdoor environments around factories can be served with fewer nodes.

Subsystems Connectivity: Subsystems communications are the links between different devices and control units that make up a larger machine. A key benefit of wireless replacing wireline in subsystem communications is the reduction of weight in the system. The market with a distinct interest is in this benefit is automobiles and aircraft. For instance, automobiles use 3 miles to 4 miles of wire to power and send communications between various subsystems.

Texas Instruments (TI) has already created a protocol that could replace the wiring harnesses in battery management systems used for communications between electrical systems and batteries in Electric Vehicles (EVs). Other auto Original Equipment Manufacturers (OEMs) are investigating the use of wireless for communicating with convenience features, such as lights, mirrors, windows, and entertainment.

DECT 2020 NR is an option for facilitating in-vehicle communications. Node density can be designed to address subsystem communications requirements for latency and bandwidth.

MARKET DEMOCRATIZATION—LOWERING BARRIERS TO EXPAND CUSTOMER BASE

Operator Neutral: Operators play an important role in driving IoT adoption. They offer access to cellular WANs that are available worldwide and support both personal devices, such as smartphones, and a large range of IoT devices. These networks also offer scale, which allows millions of devices to connect reliably. This scale also supports enterprises deploying IoT solutions worldwide due to operators using standards-based technologies and the ubiquity of roaming agreements. Finally, mobile operators are large companies by nature of the large networks they have built and support. These large organizations allow supporting a broad swath of IoT device types and are a single point of support for an IoT deployment.

DECT 2020 NR offers these same benefits in telco-grade reliability and wide area coverage. But as an operator-neutral technology, it overcomes some of the challenges of using operator networks for device connectivity.

- **Spectrum Access:** An operator's main source of revenue is subscription access to its network spectrum for which it has paid billions of dollars. DECT 2020 does not need to pay for spectrum access, as it uses the license-exempt, globally-available 1.9 GHz spectrum band.

- **Operator-Approved Devices:** Operators need to control the use of the spectrum they bought to ensure that nearly all devices connecting to their networks are using its resources efficiently. However, operator approval of a cellular device can be an extremely onerous process depending on the region and the operator. This is especially the case for IoT devices, which are given lower priority over smartphones—the devices that drive the majority of operator revenue.

SME Business Accessibility: SMEs with 500 employees or fewer are only about 15% of the IoT WAN connections worldwide in 2021, yet they represent over 90% of firms and over 50% of employment. The lower SME share of the IoT is partly due to not owning the majority of assets that make up the IoT market found in the larger vertical markets of automotive and utilities. It also is due to less money being available to spend on technologies, and fewer IT personnel for deployment and systems integration.

However, SMEs are in verticals where DECT 2020 NR could unlock significant productivity and competitive advantage for them. Table 3 provides a list of vertical markets with a large share of firms and employment from SMEs. Statistics from two regions are shown. U.S. data include statistics for companies with fewer than 500 employees; Europe's statistics are for firms with fewer than 250 employees. As shown, each market has a number of monitoring and tracking use cases of importance to its operations. All would benefit from the affordability and ease of deploying DECT 2020 NR networks.

Table 3 United States and Europe Firm and Employment Share by Vertical Market

(Sources: www.census.gov; Eurostat)

Vertical	United States		Europe		Use Cases
	Share of Firms	Share of Employment	Share of Firms	Share of Employment	
Construction	99.8%	82%	87%	95.0%	Tool tracking, heavy equipment tracking and monitoring, worker tracking and health monitoring, building materials inventory management
Manufacturing	98.4%	43%	50%	99.0%	Inventory management, crate and pallet tracking, building automation, production equipment monitoring, tool tracking
Retail and Wholesale Trade	98.9%	40%	69%	99.9%	Inventory management, crate and pallet tracking, building automation, parcel tracking
Transportation and Warehousing	98.8%	34%	52%	99.8%	Inventory management, crate and pallet tracking, building automation monitoring, forklift/tug tracking and monitoring
Accommodation and Food Services	99.5%	61%	86%	99.9%	Minibar monitoring, food waste monitoring, kitchen equipment control and calibration, crate and delivery package tracking, building automation

Developing Region Benefits: Wireless communications technologies, particularly cellular, have provided developing regions with tremendous opportunities to both transform their economies and participate in global economic growth. Internet access, combined with smartphones, changed how developing regions receive news and information, enabled interactions with customers and employees, provided access to healthcare and health information, and prepared entities to respond to catastrophes.

DECT 2020 NR can add another wireless technology option for helping developing regions benefit from technology and its associated software and services. DECT 2020 NR benefits for developing regions include:

- **Affordability:** The average GDP of developing regions outside of North America, Western Europe, China, Japan, South Korea, and Australia is 1/4 of the rest of world on a per capita basis. As a result, technologies such as DECT 2020 NR that offer similar capabilities as cellular, but are less expensive to deploy and manage, are very attractive. In fact, DECT 2020 NR is already planned in India for smart metering. For the same coverage and service, DECT 2020 NR is 1/10 of CAPEX and OPEX relative to cellular.

- **Self-Deployment:** DECT 2020 NR requires far less skill for deployment and management, which fills a gap in developing regions without the same IT skills and talent availability. As a self-configurable technology, DECT 2020 NR networks offer a less manpower-intensive approach to offering WANs.

- **Made in Region:** Similar to many countries in the developed world, governments in developing world countries are also pursuing "made in XXX country" to help drive their economic growth and keep talent within the country. DECT 2020 NR fulfills this requirement, as the software can be licensed, enabling manufacturing of the devices and network nodes in the country of use.

- **Agriculture:** Agriculture can be as high as 60% of total GDP in developing regions. In some of the larger developing countries, such as India, Pakistan, and Nigeria, agriculture is greater than 15% of GDP and represents 40% of these countries' employment. Major exports include coffee, rice, wheat, millet, and oils (palm, olive, etc.). As climate change makes environmental conditions more erratic and less predictable, sensor monitoring can be deployed to detect how much and when crops are under stress and to determine the proper treatment approaches to maintain yields. DECT 2020 NR not only provides a means to deploy an affordable WAN for field and crop monitoring, but also can provide operational efficiencies for planting and harvesting operations through tracking of machines, personnel, and ULFs.

- **Environmental Protection:** Developing regions, such as Africa, South America, and Southeast Asia, are home to vast areas of forests that need preservation or managed extraction, and wildlife that is endangered. DECT 2020 NR offers an affordable, self-deployable, and low-energy technology for creating networks to detect illegal activities and environmental conditions affecting developing region resources that are becoming more sensitive due to climate change.

Overall, DECT 2020 NR's benefits gives developing regions access to a communications technology that can fill the gap for addressing its needs and participate in the global economy. Accessibility is a key pillar for expanding deployment of IoT solutions into developing world regions. DECT 2020 NR provides both benefits through low cost

SUSTAINABILITY BENEFITS

IoT solutions will play an incredibly important role in making business operations more efficient. This efficiency will lower overall Carbon Dioxide (CO_2) emissions for each unit of output that traverses through the supply chain. ABI Research estimates that over the period from 2022 to 2030, IoT technologies and services will reduce overall CO_2 emissions by more than 2 billion metric tons.

DECT 2020 NR, as a vital connectivity technology for IoT solutions, will contribute to the IoT's sustainability benefits. As noted earlier, in a comparison study performed by Tampere University in Finland, DECT 2020 NR showed up to 60% lower energy use relative to Cat M and NB-IoT technologies. This equates to an increase of 2 to 5 years in device battery life using four, AA batteries or 2.4X more messages for the same energy consumption. While DECT 2020 NR will be very complementary to existing cellular technologies, mainly providing neighborhood and enterprise facilities (factories, warehouses, etc.) with an industrial-grade network solution, DECT 2020 NR may also replace some future cellular networks, with one benefit being to lower an IoT application's carbon footprint.

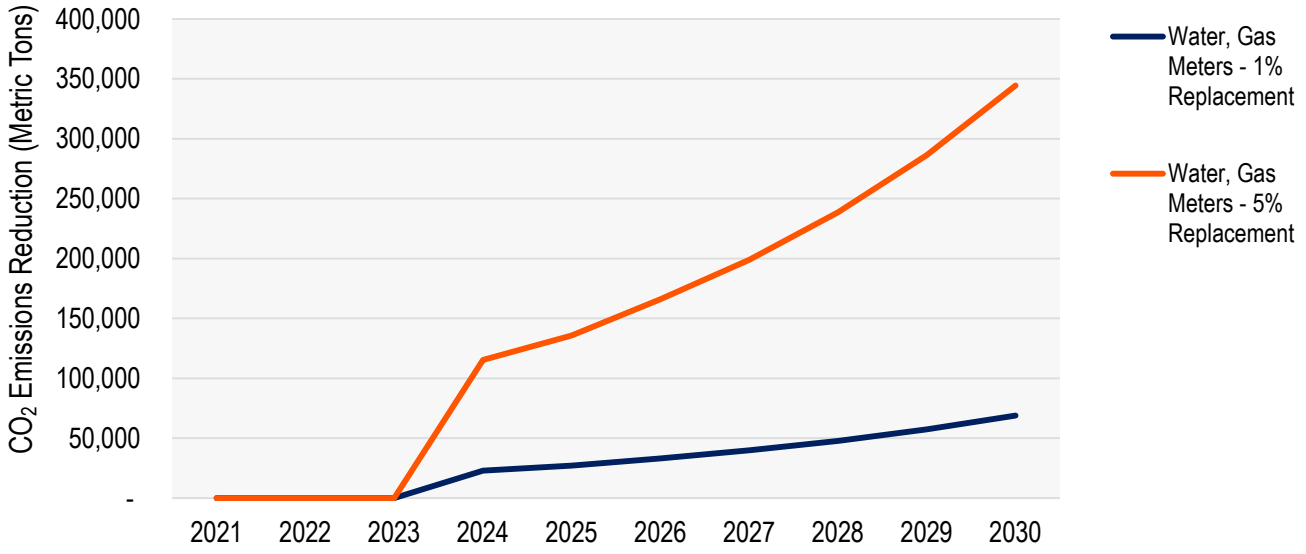
A more substantial sustainability benefit of DECT 2020 is how its power efficiency over cellular will avoid truck rolls for replacing batteries in battery-powered devices. The best example of this is gas and water meters. Cat M and NB-IoT technologies are driving the deployment growth of these devices. However, poor network connectivity, such as when devices are on the edge of the cellular coverage area or inside buildings or underground, can accelerate battery drain.

Chart 2 shows the carbon footprint reduction from fewer truck rolls to replace batteries in gas and water meters. The analysis assumes adoption of DECT 2020 in both developed and developing regions with higher adoption in developing markets due to fewer Cat M and NB-IoT networks and far less coverage relative to developed regions. Developed regions consist of North America, Western Europe, China, Japan, South Korea, and Australia. In this modeling exercise, DECT 2020 will grow in adoption to replace 25% of cellular connections in gas and water meters by 2030. This replacement figure is a conservative representation of technology replacement, as cellular metering markets transition to Cat M and NB-IoT technologies.

The analysis shows both a 1% and 5% replacement rate. Gasoline usage assumes trucks with 10 Miles per Gallon (mpg) engines and a round-trip distance of 10 miles. Based on this analysis, the sustainability benefit is substantial. In a 1% reduction scenario, CO_2 emissions over the 8-year period from 2022 to 2030 are reduced by nearly 300,000 metric tons, the equivalent of 34 million gallons of gasoline consumed. In a 5% reduction scenario, cumulative CO_2 reduction over the period reaches nearly 170 million gallons of consumed gasoline.

Chart 2 ***Carbon Foot Reduction from Fewer Truck Rolls to Replace Batteries in Gas and Water Meters, World Markets: 2021 to 2030***

(Source: ABI Research)



However, the more compelling benefit of DECT 2020 NR is how it will enable more deployments of IoT applications with the inherent benefits, among many, of reducing energy use. In this analysis, the chosen application segments were smart metering, smart street lighting, and commercial building automation, three markets where DECT 2020 is finding traction. Similarly, modeling made

different assumptions based on the differences between developed and developing regions.

For smart metering, households without smart meters were the TAM for DECT 2020 deployments. Deployment penetration of DECT 2020 in developing regions mirrored current smart metering adoption of Cat 1, Cat M, and NB-IoT technologies extrapolated out so that, in 2030, the DECT 2020 penetration rate was 20%. For developed regions, DECT 2020 adoption was assumed to be one-quarter that of developing region adoption, simply due to already high penetration rates of smart metering in developed regions.

For smart street lighting, the TAM for DECT 2020 was forecast for unconnected streetlights without Light-Emitting Diodes (LEDs). Similar to smart metering, the penetration of DECT 2020 used Cat 1, Cat M, and NB-IoT adoption penetration rates calculated from smart street lighting deployment forecasts in these regions. Cellular LPWA adoption is much higher in smart street lighting, but for this modeling exercise, DECT 2020 adoption was pegged at 26% of the TAM in 2030 for developing regions; for developed regions, the model used one-quarter that of the developing region penetration.

Education, lodging, and office were the only building segments used in modeling commercial building automation. These are segments that, regardless of world region, need smart features to limit energy use given their configuration of multiple partitions and rooms, and use profiles that include high and low occupancies depending on location and time of day.

The DECT 2020 TAM for commercial building automation was the forecast base of buildings without smart lighting and smart Heating, Ventilation, and Air Conditioning (HVAC) systems in developing or developed regions. Given the range of connectivity technologies that are used in commercial building automation systems, the penetration rate of smart connected buildings relative to all buildings by region was used to calculate penetration rates for DECT 2020. Unlike smart metering and lighting, developed regions are expected to see higher growth and, hence, higher building penetration rates than developing regions. As a result, the DECT 2020 penetration rate in this model was pegged to grow to 11% for developed regions, and 5% for developing regions in 2030.

The energy use profile for households, streetlights, and commercial buildings can vary by region. The energy savings from implementations of each IoT application can also vary by region for each market. Energy use profiles were obtained from publicly available information, including government sources.

For households, energy consumption was over twice as much in developed regions as in developing regions. This difference would be even higher; however, China's household energy consumption is a large share of developed region energy use per household. Publicly available data on household energy savings by using smart meters ranged from 2% to 10%. For this exercise, 2% was used in the model.

For smart street lighting, the model is based on the installed base of unconnected streetlights transitioning to connected LEDs, so the energy savings should include both replacing high-pressure sodium lamps with LED lamps and the use of connectivity. Reported energy savings for LED re-

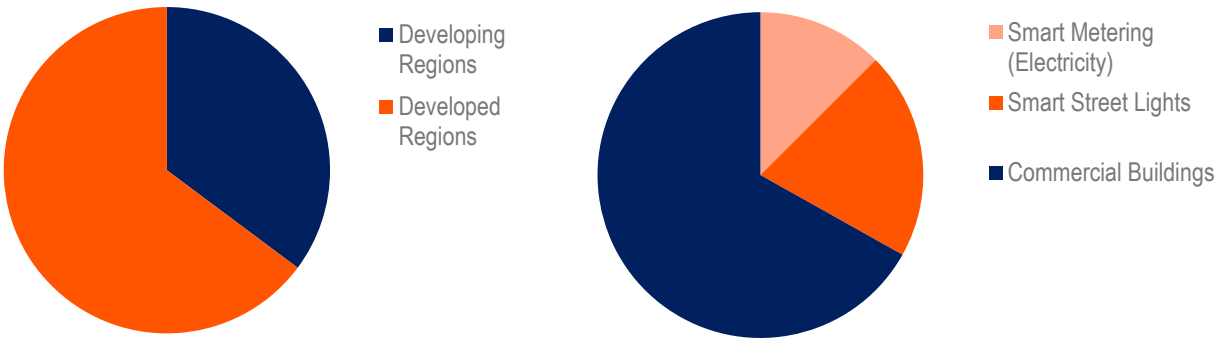
placement is minimally 50%. Adding connectivity can drive up energy savings another 30%. However, to provide a view of only the value of adding connectivity to streetlights, this model assumed the replacement of unconnected LEDs with DECT 2020-connected LEDs, so energy savings was pegged at 30%.

Only HVAC and smart lighting applications were considered in the calculations for DECT 2020 adoption. The reason is that each system can benefit from easily deployable temperature and occupancy sensors communicating with HVAC and lighting control units. HVAC and lighting make up around 60% of energy costs. The energy use profiles in education, lodging, and office collected from Commercial Building Energy Consumption Survey (CBECS) data provided a developed country view. Based on secondary research, developing region commercial building energy profiles were about half of developed region electricity profiles. Smart controls on HVAC and lighting systems have documented energy savings ranging from 15% to 50%. For this exercise, 15% energy saving was applied.

Applying all of these factors, DECT 2020 provides significant sustainability benefits by increasing IoT services adoption due to its low cost, high reliability, and deployment flexibility. Chart 3 shows that developed regions will benefit more mainly due to greater adoption within the commercial building sector, a segment with a much higher energy profile relative to streetlights and households. The net result from this modeling exercise shows that accelerated IoT adoption in the smart metering, smart street lighting and commercial building automation sectors driven by DECT 2020 removes nearly 90 million metric tons of CO_2 from the air. This is equivalent to removing nearly 2 million gasoline-powered vehicles from the road each year between 2022 and 2030.

Chart 3 ***CO_2 Savings by Developing and Developed Region and by Application World Markets: 2020 to 2030***

(Source: ABI Research)



Not surprisingly, DECT 2020 networks are also more power efficient than cellular networks. In a final analysis of DECT 2020 NR's sustainability benefits, estimates of DECT 2020 NR adoption are applied to ABI Research's 4G and 5G forecasts for small cell adoption used in cellular private networks.

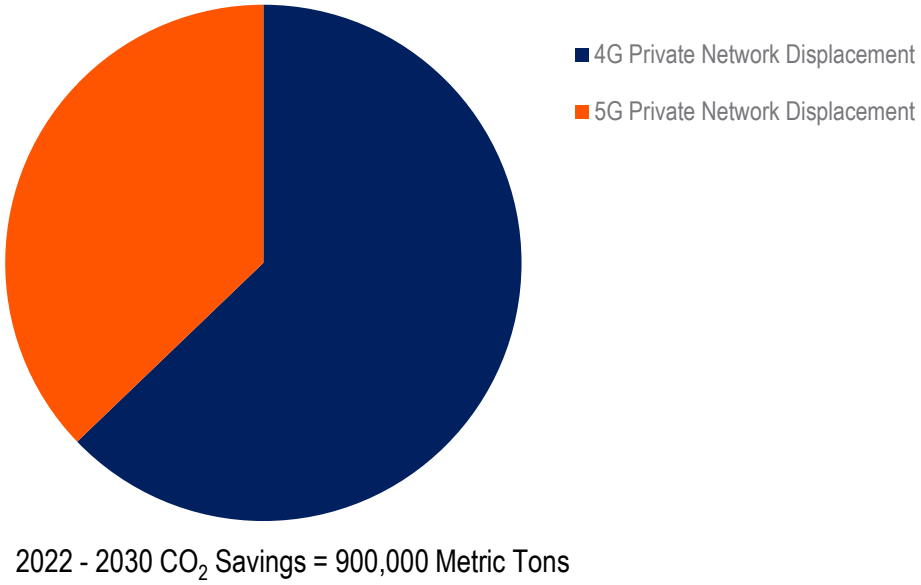
In this exercise, the DECT 2020 NR replacement of cellular is estimated for small cells used in agriculture, energy, healthcare, logistics, manufacturing, retail, and transportation. All of these markets

have operations where private networks will provide tremendous value for tracking and monitoring services in locations like distribution centers, factories, malls, hospitals, and farms. DECT 2020 NR is already deployed in private networks in utilities (energy), logistics, and manufacturing markets, so replacing cellular is higher, reaching 20% in 2030. Reduced replacement estimates are applied in the other markets, where there would be an equal or greater use of smartphones and tablets on private networks.

Chart 4 shows the CO_2 emissions savings when 4G and 5G private networks are replaced by DECT 2020 NR networks. The data traffic of a 4G or 5G small cell used in a typical outdoor cellular network provided a baseline data traffic profile for 4G and 5G small cell networks. As this profile is dominated by smartphone data traffic, the data traffic was reduced to reflect data traffic in an IoT network. Energy profile studies performed by Wirepas, a DECT 2020 NR network for equivalent coverage across a 4G or 5G network uses at most 1% of the energy used in the cellular small cell network. Therefore, the combined CO_2 savings by using DECT 2020 over 4G and 5G small cells from 2022 to 2030 is equivalent to removing the emissions of nearly 200,000 cars.

Chart 4 ***CO_2 Emissions Savings When Replacing 4G and 5G Private Networks with DECT 2020 NR Networks, World Markets: 2022 to 2030***

(Source: ABI Research)



USE CASE EXAMPLES

Wirepas has been leading the charge both in software development and network deployments of the DECT 2020 NR technology. Two use case examples are presented demonstrating DECT 2020 NR value.

Logistics: Prologis is a commercial building leasing provider. It owns more than 4,600 buildings comprising nearly 1 BN square feet of floor space. Customer satisfaction is key to its business philosophy and, as a result, Prologis is investing in smart building technologies. Within the IoT domain, these technologies are designed to address customer's physical operation needs, so they include climate monitoring (air quality, temperature, humidity), mechanicals monitoring (HVAC, lighting), emergency systems monitoring (fire, etc.), and flow monitoring to understand product flows through warehouses and at loading locations.

Wireless was the preferred technology to deliver these applications and Prologis determined that mesh technology provided the most reliable and scalable solution. Also critical in its assessment was a highly energy-efficient technology to ensure that sensor device battery replacement was at least 5+ years.

Prologis chose Wirepas to deploy across its 3,000 and growing warehouse footprint, as it not only meets many of the network requirements, but also can enable asset tracking services. As the DECT 2020 NR device ecosystem grows, Prologis is also selectively deploying LoRa networks in its buildings based on customer requirements for specific sensor needs.

Metering: Elvia is an electric utility company in Norway that serves more than 2 million homes and businesses. It is an aggressive user of technology focused on modernizing its grid to become more resilient using wireless smart sensors deployed in substations and transformers.

Part of its investments in new technology has been the deployment of Wirepas-connected smart meters to nearly 1 million locations. Wirepas was chosen for its flexibility in creating 100% network coverage over a wide area in the tree-dense Norway towns and villages without the need for repeaters. It also was more energy efficient and provided greater connection reliability relative to cellular technology.

SUMMARY

DECT 2020 NR offers the IoT market one of the best connectivity technologies for enabling massive IoT on multiple levels. Its mesh foundation allows building scalable and highly-reliable networks. Its efficient protocol expands its use case breadth to application segments requiring low-latency communications, such as real-time asset tracking and industrial monitoring. The technology can serve both high throughput and high device density application needs. Finally, the silicon ecosystem for building devices is already well established, as the protocol can be flashed onto BT silicon.

The timing could not be better. Trade wars, COVID-19< and operations modernization needs are driving technology investment to enable greater asset visibility. Other technology options, such as cellular and LoRa have not provided as comprehensive a suite of connectivity capabilities in a single technology to cover the full breadth of IoT needs, regardless of use case and vertical market. And where enterprises are finding the most need is in the critical control points of distribution centers, factories, farms, and hospitals. Massive IoT can serve a worldwide supply chain that delivers more than 100 billion assets every year!

The planet is also in need of a technology with a small CO2 footprint. Considering the breadth of DECT 2020 NR capabilities, it is one of the most sustainable network technologies in the market. In fact, as an IoT technology, it will contribute to the estimated billions of CO2 emissions reductions created when business processes are supplemented by smart connected devices.

Low power, low emissions, and highly scalable—these DECT 2020 NR capabilities are helping enterprises meet their digitalization objectives today. But its potential is even greater for not only unlocking new demand, but also expanding the IoT's value to new and underserved markets regardless of business size and world region.

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