eSIM AND SMART METERS: WHY eSIM AND WHY NOW?

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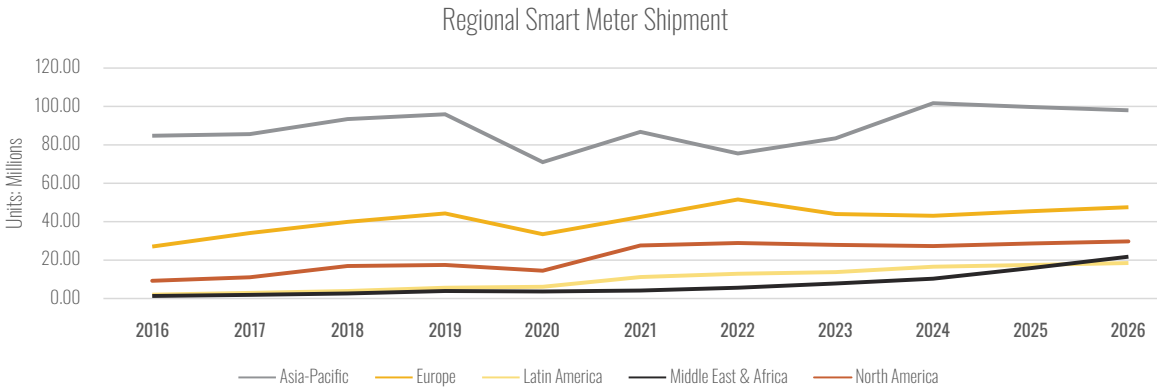
The utility industry is embracing digital technologies, not simply to survive, but to thrive amid these challenging times. Digitalization is considered an essential cornerstone from which utilities can realize new levels of efficiencies, not only related to meter-to-cash applications, but also for setting in motion the foundations to achieve long-term sustainability goals. Backed by government initiatives and mandates, utilities are becoming increasingly more reliant on cellular and the accompanying technologies, such as Embedded Subscriber Identity Module (eSIM) in order to meet their obligations and mandates, while also looking to leverage digitization as a means to ultimately reinvent the way in which they do business in the future.

Upgrades to utility distribution infrastructure can be characterized by regional regulatory policies and business investments. Globally, upgrades are at various stages of implementation, with energy and water distribution networks using Internet of Things (IoT)-enabled digital tools. One of the key aspects of the utility progress toward a digital distribution grid is the replacement of electromechanical meters with smart meters with bi-directional communication networks. The new-generation smart meters deployed by utilities can capture several parameters from the customer premises metering point, offering granular insights and control of energy consumption, quality, and asset management.

OVERVIEW OF REGIONAL SMART METER SHIPMENTS

Globally, deployments in key regions are driven by government initiatives either mandating smart meter implementation or driving adoption through financial incentives. The global market for smart meters has witnessed robust growth since the beginning of 2007, starting with several large utilities in Europe and North America upgrading their energy (electricity and gas) and water distribution infrastructure by implementing smart meters. In 2019, smart meters for electricity had more than 700 million meters installations, accounting for nearly 77% of the global smart meter installed base.

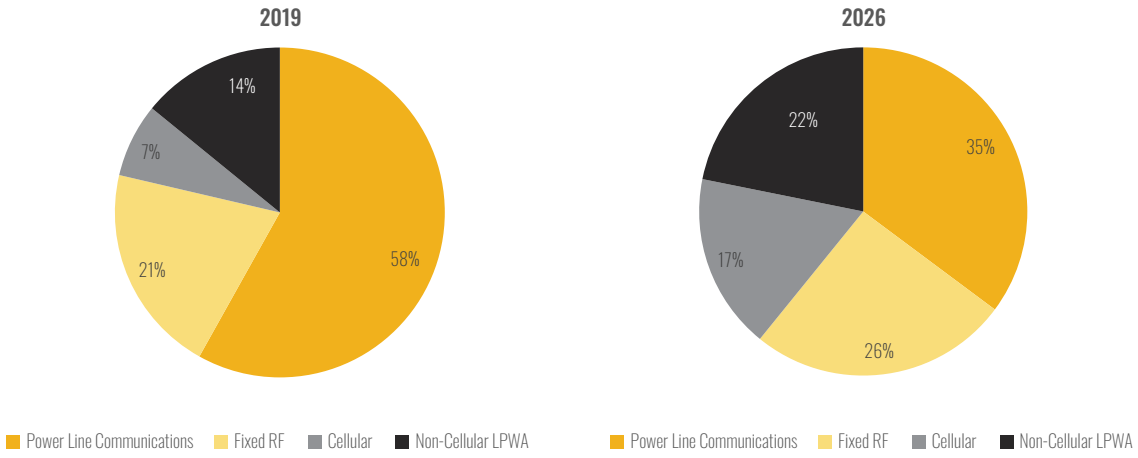
As energy utilities ramped up their smart meter deployments, taking advantage of the decreasing cost of smart meters, Low-Power Wide-Area (LPWA) network connectivity infrastructure, and the overall maturity of the solution ecosystem, water utilities started exploring opportunities in deploying smart meters to upgrade their aging distribution infrastructures. By the end of 2026, ABI research estimates that battery-operated smart meters used for water and gas metering will have an installed base of more than 640 million meters globally.



GLOBAL SHARE OF CELLULAR CONNECTIVITY IN GLOBAL SMART METER IMPLEMENTATIONS

The smart metering connectivity market share can vary based on the region, regulatory policies, availability and coverage of networks, Total Cost of Ownership (TCO), security, and several other factors that influence a utility's choice of connectivity in smart meter implementations. Adoption of cellular air standards in smart metering has largely been limited to ad-hoc use to connect dispersed or rural metering points. Recurring subscription costs, a lack of deep indoor coverage, and higher costs of cellular connectivity hardware's impact on the overall price of smart meters are some of the key issues that have held back wider adoption of cellular connectivity in large-scale smart meter deployments.

Today, with decreasing cellular connectivity and hardware costs and with the commercial availability of cellular LPWA networks, utilities are keen to leverage private and public cellular networks for their digital grid infrastructure. In 2019, cellular connectivity accounted for more than 7% of the connectivity market share in smart metering, but its market share will expand to 17% by the end of 2026, driven by cellular LPWA networks.



FUTURE GROWTH PROSPECTS OF CELLULAR LPWA IN THE UTILITIES SEGMENT: DRIVERS AND BARRIERS TO LARGE-SCALE DEPLOYMENTS

A telco's value proposition to utilities is cellular connectivity's ubiquitous population coverage offered as a secure and professionally managed communication network infrastructure as a service. Smart electric meters have seen the adoption of cellular communication technologies as a direct Wide-Area Network (WAN) solution; however, large-scale rollouts have been mostly limited to a few implementations, such as in the United Kingdom and Netherlands. In 2019, 2G had a dominant share among cellular air standards, connecting more than 54% of the cellular smart meters, followed by 3G or Wideband Code Division Multiple Access (WCDMA) technology.

Cellular network connectivity uptake in smart gas and water meters witnessed little traction, as traditional cellular air standards, such as 2G/3G/4G, were too power hungry to connect battery-powered smart meters. However, cellular LPWA networks specifically built for battery operated sensor networks are gaining momentum as a viable connectivity option to connect smart meters. In 2019, Narrowband-IoT (NB-IoT) and Long Term Evolution for Machines (LTE-M) networks' share among cellular air standards was less than one-fifth of all cellular connections. However, by the end of 2026, NB-IoT and LTE-M will connect more than 335 million smart meters, accounting for 85% of all cellular connections.

CELLULAR TECHNOLOGY ADOPTION DRIVERS

- **Global Cellular LPWA Network Footprint**: More than 154 cellular LPWA networks are commercially available in 59 countries. There are more than 109 NB-IoT networks at various stages of nationwide commercial deployments, followed by 45 LTE-M networks.
- **Reliable Network Coverage**: Cellular LPWA network technologies are built from the ground up for IoT applications, optimized for long signal reach and deep indoor penetration, which are critical requirements for smart meters.
- **Shift from Proprietary to Standards-Based Network Solutions**: Utilities implementing smart grid communications networks have traditionally relied on using proprietary private networks to implement specific grid applications. However, as the technology market evolves, new smart grid concepts are changing the way implementations take place within vertical silos, driving the market toward more standards-based technologies that enable interoperability across grid applications.

- **Sunsetting of 2G and 3G Networks**: As carriers around the world switch off their legacy 2G and 3G networks in favor of 4G and 5G technologies, companies are beginning to transition their IoT devices to lower cost LTE-M and NB-IoT.
- **Security**: There are several national and international efforts aimed at driving security for critical infrastructures, such as power and water grids, with the International Electrotechnical Commission (IEC) publishing several Information, Communication, and Technology (ICT) security standards for power and water utilities.
- **Demand for Low-Cost Smart Meters**: There is increasing demand from energy and water utilities to reduce the TCO of implementing and maintaining smart meters. Today, most of the costs involved in rolling out smart meters are attributed to the smart meters themselves, and the corresponding deployment services that can vary by region. In the last 18 months, the cost of NB-IoT and LTE-M modules have decreased by 50% to reach an Average Selling Price (ASP) of US$5 and US$9, respectively. Low-cost cellular LPWA modules will help significantly reduce the Bill of Materials (BOM) to manufacture low-cost devices and make cellular-based smart meters more competitive in an increasingly price-sensitive market.

CELLULAR TECHNOLOGY ADOPTION INHIBITORS

- **Cellular LPWA Network Coverage**: Lack of homogeneity in cellular LPWA network deployments and network roaming agreements among operators have, in many regions, resulted in the availability of either LTE-M or NB-IoT networks. Furthermore, the lack of carrier roaming agreements for cellular LPWA networks has resulted in a lack of sufficient coverage required for smart meter deployments. However, it is worth noting that, eventually, most telcos are expected to support both LTE-M and NB-IoT, and roaming agreements among major telcos in Europe, Asia, and North America are starting to gain momentum in 2020.
- **High Cost of Cellular-Based Smart Meters**: The use of multi-mode cellular LPWAN modules with 2G/3G/4G fallback used to mitigate the coverage challenges can be a cost-prohibitive solution and negate the power efficiency gains from LPWA networks. Furthermore, the Average Selling Price (ASP) of cellular LPWA-based smart meters is still 30% to 120% more expensive when compared to alternatives, such as wireless M-Bus, Zigbee, non-cellular LPWA, and Powerline Communications.
- **Communication Service Provider (CSP) Vendor Lock-in**: The increasing complexity of communication network requirements from various grid applications is driving utilities to rethink and consider managed cellular network services offered by CSPs. However, as utilities' smart meter implementations have a product life of over 10 to 15 years, there are severe reservations in the industry about using public cellular networks due to the fear of potential vendor lock-in and additional costs involved in changing CSPs, especially the additional cost of truck rolls required to replace SIMs.
- **Risk of Cellular Technology Obsolescence**: Utilities have been key proponents of using private networks for grid applications for several reasons, including control and longer returns on their capital investments. The sunsetting of 2G and 3G networks can potentially disrupt utility operations and result in a complex and potentially expensive transition to new networks.
- **4G *versus* 5G**: The market hype about the future availability and capabilities of 5G technology adds further complexity, as utilities decide to invest in a future-proof network technology that can support a broad spectrum of grid applications for several decades.
- **Coverage, Connectivity, and SIM Management**: Ensuring coverage and managing multiple operator SIMs drives up deployment and maintenance costs, in addition to the various management costs that invariably stack up on the meter vendor side.

However, the rapidly increasing commercial availability of CAT-NB and LTE-M networks with the corresponding decrease in connectivity cost, as well as the evolution of these network technologies into the 5G era, has rendered the first five points above less critical in the last 18 months.

Moreover, evolution in SIM technology, when adapted to smart metering, has simplified connectivity and SIM management, while ensuring real promise that the coverage issues of the past are no longer a problem.

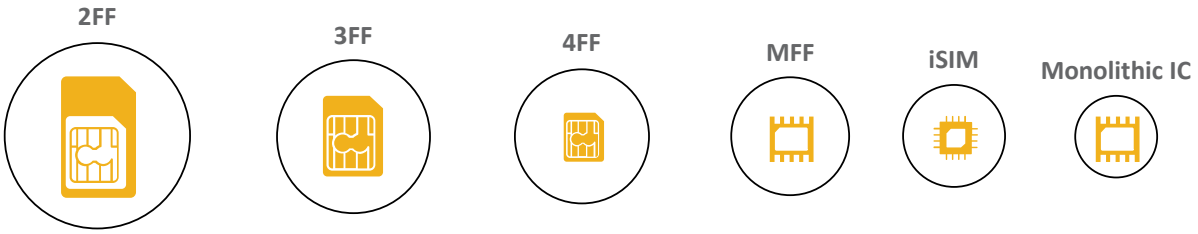
DEMYSTIFYING THE eSIM

THE eSIM IS DEFINED BY ITS FUNCTIONALITY, NOT BY ITS FORM FACTOR

An eSIM is defined by the software, Operating System (OS), and additional functionality, which enables Remote SIM Management (RSM) or Remote SIM Provisioning (RSP) capabilities. It is a common misconception that an eSIM has to be physically embedded/soldered onto a Printed Circuit Board (PCB) in either a MFF1 or MFF2 form factor.

Although it is true to say that the majority of the eSIMs in circulation today are indeed physically soldered and embedded variants, the fact remains that an eSIM can come in a variety of different form factors, including removable SIMs, in 2FF, 3FF, or 4FF sizes. An eSIM can also be physically embedded in soldered versions or even integrated at the processer level, such as an Integrated SIM (iSIM) or a monolithic chipset. A monolithic approach combines different functionalities onto one singular chipset, most notably products that combine eSIM and Secure Element (SE) functionality to enable secure connectivity and management, as well as the ability to encrypt or tokenize other critical data.

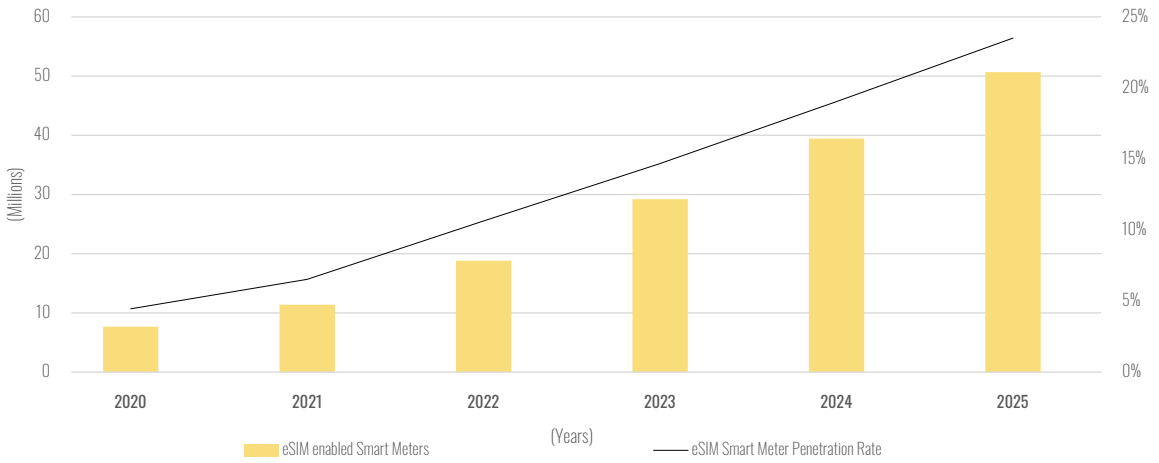
VARIETY OF eSIM/ EMBEDDED UNIVERSAL INTEGRATED CIRCUIT CARD (EUICC) FORM FACTOR



When thinking of an eSIM, focus needs to be placed on the functionality aspects, rather than its physical form. Embedded by name does not mean embedded by nature and the variety of different eSIM form factors lends eSIM well to an extremely diverse Machine-to-Machine (M2M)/IoT devices market capable of providing a form factor that best suits an Original Equipment Manufacturer (OEM).

ADOPTION AND MATURITY OF eSIMS

From an energy management perspective, significant movement in cellular enablement is already evident, with smart metering initiatives already well established, including projects in India, Sweden, Belgium, and the Netherlands, to name but a few, all of which are at various stages of completion. Although not all of these projects are using an eSIM form factor today, eSIM is considered a natural evolutionary step to ensure future-proof flexibility and guaranteed connectivity, even in rural areas, all without the need to physically replace the SIM.



Tenders for eSIM smart meters are already in the mix and ABI Research expects that these tenders will translate into significant volumes over the next 5 years, moving the market from shipments of 7.7 million devices in 2020 to exceeding 50 million shipments by 2025, accounting for just over 24% of all smart meter device shipments. The market momentum is increasing and utilities are looking toward eSIM functionality to address market-specific pain points. Utilities are also looking to use the eSIM as a means to realize and execute automation and digitization strategies, as well as strategies related to green initiatives via real time meter readings.

WHAT WILL THE eSIM DO FOR YOU?

Being defined by functionality, rather than form factor, and driven by enhanced software and OSs, the eSIM brings myriad additional benefits when compared to a standard SIM approach.

The pain points that eSIM can address vary depending on the end market in question, but at a very high level, eSIM can bring new levels of service digitization, automation, Over-the-Air (OTA) management, and digital security. However, specific to the smart metering market are four distinct market pain points that eSIM can address:

Automation: In the wake of the global COVID-19 pandemic, there is an increased need and desire to future proof business models, service access, and, in this instance, billing. eSIM is a key technology and service that can "pandemic proof" operations via automation. With social distancing rules looking set to remain for the foreseeable future, traditional meter readers and the physical requirement to enter a property will become unviable. Therefore, automating the readers will help utility companies adhere to government rules and regulations related to social distancing.

Furthermore, utility companies are being mandated to reduce their carbon footprint, make use of greener energy sources and, ultimately, bringing energy usage to the forefront of the consumer's mind to help reduce unnecessary consumption. The smart meter is used to not only allow the digital gathering of meter readings for the utilities, but also as a physical and screened device to directly communicate with consumers their energy consumption and cost in real time. Utilities can also make use of near-real-time meter readers to better understand usage patterns and map out times and days when usage exceeds the average. A real-time meter reading every 15 minutes to an hour will enable the use of data, combined with analytics, to help utilities reach their "green" goals and mandates.

Stock Keeping Unit (SKU) Management: SKU management can be a costly and time-consuming exercise as it relates to ascertaining Mobile Network Operator (MNO) partnerships and SKU certification. This results in an "SKU explosion," with each MNO partnered requiring a different SKU, and is an extremely cost- and time-intensive exercise for any smart meter OEM with international expansion ambitions. The requirement for multiple SKUs increases costs and increases the complexities of smart meter installation. In many instances, several SKUs will be required for a country to ensure country-wide reliable connectivity. eSIMs can negate this complex issue via RSM/RSP functionality, enabling out-of-the-box borderless connectivity, device wake-up, and the ability to download a local MNO profile on site, shifting SKU management responsibility toward the RSM/RSP service provider.

Network Coverage: Even in countries where cellular infrastructure is widespread, reliable, and with near 100% coverage, blackspots will still exist. In a traditional smart metering approach, this would involve a trial and error scenario at the point of installation by physically inserting a SIM (locked to a specific MNO) to gauge cellular coverage and quality. In some instances, a field engineer may need to try several different MNO-specific SIM cards before ascertaining which network provides the best and most reliable coverage. Some eSIM management solutions negate this issue. Those that can connect out of the box and are based on a set of pre-defined attributes can auto download the most appropriate MNO profile to guarantee a consistent and reliable connection. This saves significant time in the field and significantly simplifies the process, from installation to connection.

Longevity: Many IoT devices are required to be out in the field for 10 to 20 years and smart meters are no different. In the instance of smart meters, devices are designed with a field life of between 10 and 15 years, making resilience a prerequisite. This is new territory for the cellular market, with the majority of devices currently connected having a life of 3 to 4 years. The requirement for longevity raises a number of questions:

1. What happens if the MNO I've partnered with goes out of business?
2. What happens if an MNO I've partnered with is acquired?
3. What happens if a new MNO emerges with more competitive price points?

With the traditional SIM approach, the SIM cards provided will be locked into a particular MNO, which significantly increases the risk of operator lock-in. In order to change operator, a field engineer would need to physically replace the SIM, increasing costs. The eSIM turns this possible scenario on its head, thanks to RSP/RSM functionality and the ability to remotely download MNO profiles. This eradicates the need to physically replace the SIM should an MNO go out of business or a new connectivity deal is struck with

a new MNO, and this also helps avoid operator lock-in. eSIMs give additional MNO partnerships flexibility for the initial connection, while also offering in-field operator flexibility to ensure the highest possible level of service as it relates to coverage, speed, and connectivity.

WHY NOW?

ALL THE MARKET SIGNS ARE THERE

The eSIM market has been moving at a rapid pace over the past 3 years, with the market tipping point fast approaching within the consumer market. This is due to eSIM's integration in popular consumer devices, such as Apple's iPhone range of smartphones and cellular-enabled smartwatches, Samsung's S20 and Note device ranges, and Huawei's inclusion in its latest P40 and P40 Pro smartphones. Significant strides made by major consumer OEM brands have directly resulted in increased MNO Subscription Manager Data Preparation (SM DP+) infrastructure investment in order to support the entire life cycle of the eSIM.

Utility companies have been taking note of the eSIM and, although not all smart meters are making use of the eSIM specification today, RSM and RSP functionality is considered the next evolutionary step in smart metering cellular enablement, building on what has already proven successful and layering on additional functionality. Digitized billing and operational resilience via resilient connectivity and security, given the mission-critical nature of infrastructure, are all functions that utility companies desire.

However, although growth in M2M connections has been on a significant upward trajectory over the past 10 years, adoption of the M2M eSIM specification has been slightly slower. The M2M specification was originally designed with the automotive market in mind, but heavy infrastructure investments, SKU development, and certification requirements continue to be considered too heavy for many M2M end markets, such as smart meters.

THE ECOSYSTEM HAS BEEN LISTENING: CONVERGING M2M AND CONSUMER SPECIFICATIONS

The good news for the smart metering industry is that the ecosystem has been listening. It has been developing products and solutions to help ease these pain points, looking to bring to market a scalable and simplified solution that combines the best of the M2M and consumer eSIM specifications.

This will be enabled by combining the manufacture of cellular modules with the consumer specification, for initial device waking, with a hosted cloud-based platform to automatically define the long-term connection.

The boot strap profile will allow out-of-the-box, borderless activations or device wake-up and this will be combined with pre-defined MNO agreements between the utilities and MNOs. A hosted cloud-based platform will house a set of provisioning rules, based on a set of pre-defined parameters, with the connection being defined by a number of pre-conceived factors, including signal strength, country, and region. All factors and rules will have been pre-defined by utilities or grid managers, according to their specific needs.

One of the most significant benefits of the specification convergence is the fact that smart metering manufacturers or utilities do not need to invest in Subscription Manager (SM)-Secure Routing (SR) infrastructure, or any infrastructure for that matter. In this instance, leveraging already existing MNO

Subscription Manager Data Preperation (SM-DP+) infrastructure is possible, not only reducing set-up costs, but also creating a seamless and scalable solution.

Today, the majority of MNOs already have the required SM-DP+ servers, although originally invested in for the consumer market, that can be reused for M2M applications. As already highlighted, the use of the consumer eSIM specification will eliminate enterprise or utility investment in SM-DP+ infrastructure and the ongoing associated maintenance and management costs, which is a considerable market barrier today.

Merging the two defined specifications will help further drive uptake of eSIMs within the smart meter market, offering the ability to push messages to smart meters without the need for permission, while using MNO infrastructure already in place.

Combining the best bits of the consumer specification and pairing with intelligence at the cloud level will bring new levels of deployment flexibility and simplicity, providing an out-of-the-box experience, easing time to market, improving scalability while significantly reducing back-end investment requirements and installation times.

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