

7 in 2017: Top global technology trends in 2017

Fast forward: What lies ahead for tech in a brand-new year

The 7 big themes identified in this paper represent what we at IHS Markit Technology believe will be the most significant and impactful trends in technology during 2017—hence, the “7 in 2017” in our title. From currently the most buzzworthy, such as artificial intelligence and virtual reality, to those less well-known, like low-power wireless, the themes and trends listed here affect, influence or shape virtually every technological sector of import today, as well as all manner of tech devices, gear and apparatus that we hold dear.

Artificial intelligence seems to be suddenly everywhere and on everyone’s lips, definitively liberated from the hallowed realms of science fiction and now incarnated as a helpful—if somewhat impersonal—aide, most familiar to us in the guise of personal assistants such

as Apple’s Siri or Amazon’s Alexa. While AI has been with us for some time, technological innovations—in areas like cloud computing, high-speed connectivity, process nodes and, in particular, machine learning—have finally paved the way for the mass deployment and expansion of AI into commercially useful applications.

The same is true of virtual reality, now gaining extraordinary attention and promising to reshape and alter our current perception of three-dimensional space. After years of unrealized potential, VR is back with a bang and gaining much broader appeal, thanks to more affordable VR headsets, new content categories and big tech investments from major players that include Google and Facebook.

In fact, what the two technologies above share with the rest of the big themes and trends in our predictions is that each of the 7 has arrived at this watershed moment as a result of incremental advances and efficiencies developed over time in parallel branches of knowledge and operation. The cloud and the Internet of Things, two other prominent entities in the technology space and among the 7, could not have come about without the astounding developments in connectivity, made possible in turn by more economically priced device modules and components resulting from improved manufacturing and production. Smart manufacturing, low-power wireless, solar renewable energy—all these other themes in the 7 are also the happy outcome of valuable synergies achieved through the dynamic interplay of diverse technological forces and factors.

1 Artificial intelligence gets serious: weighty implications for the future, humans and society

Artificial intelligence (AI) is a broad and ill-defined ideal, typically used to describe the human perception of machine learning over time, rather than as a clearly defined and absolute capability. It may be that the only way to consider whether we have created AI lies in the end result: if we have truly achieved the emulation of an intelligence; or if we have merely succeeded in laying out the mechanics for achieving such an intelligence.

Perhaps the crucial change in recent machine intelligence is the development of machine learning, and more specifically, deep learning. Machine learning uses large volumes of data to recognize patterns based on similar experiences. This method often utilizes neural networks, where probabilistic outcomes are combined to make assertions about what a particular piece of information represents. It allows for complex behavior to emerge from repetition and trial-and-error, and allows for non-programmable patterns to be recognized, such as faces, animals, objects, language and syntax. The power of machine learning is that it can be applied to any source data, thereby opening up possibilities for the rapid acceleration of machine intelligence.

From here, it will be interesting to speculate on what will happen next. Might there be a new super-trend or über-theme that could emerge if a new configuration of forces came about and caused new alignments? What, for instance, will we encounter at the nexus of AI and, say, low-power wireless; or between VR and solar?

Standing at this juncture, we at IHS Markit are ready for all that is yet to come.

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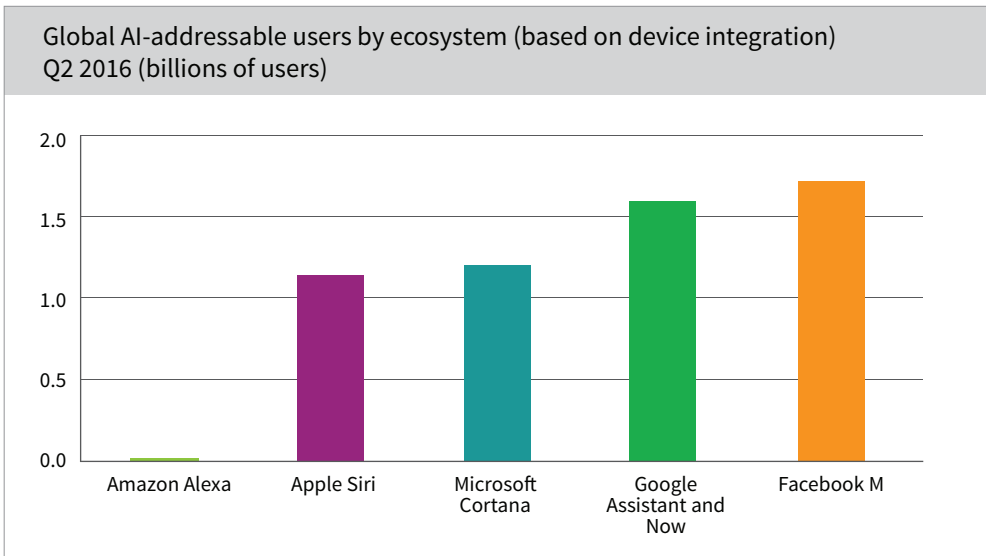
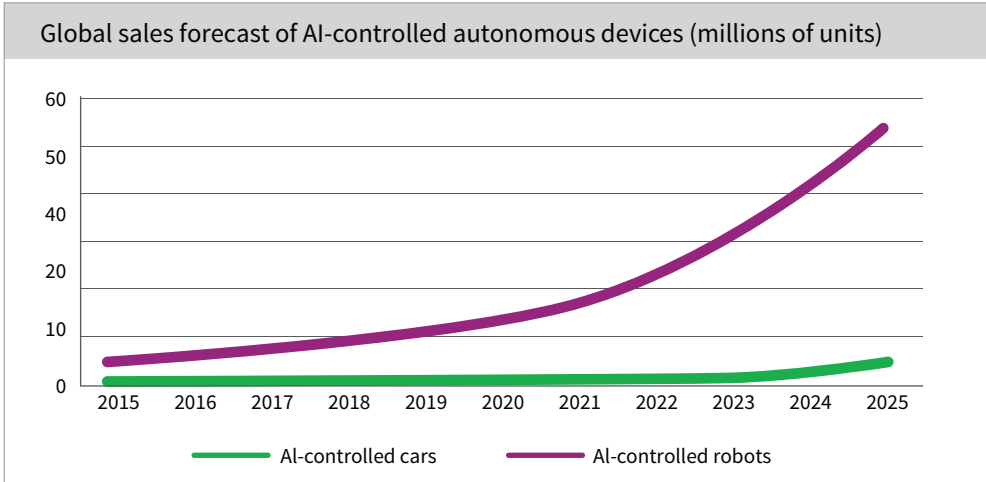
With contributions from the following analysts: *Francis Sideco, Tom Morrod, Josefin Berg, Ian Fogg, Paul Gray, Piers Harding-Rolls, Jenalea Howell, Jack Kent, Daniel Knapp, Bill Morelli and Stephane Teral*

Machine learning has allowed AI to move quickly from formulaic logic processing to contextual language and learning, resulting in behaviors that can sometimes appear to be creative or to demonstrate understanding. As AI exhibits scalable learned behaviors, the resulting effects are then employed in a variety of uses. Given enough data to train with, these same learning processes can be taught, in turn, to recognize cars on a road, sounds in a word, what a dog looks like, the game of Go or an unexpected pattern of risk. The implications of AI can, therefore, be far-reaching. Personified AI assistants from a handful of companies already have access to billions of users, via smartphones and other devices. But the bigger change will come when we cede levels of human control to AI directly, such as in semi- or fully autonomous cars or robots. When we trust our AI to perform tasks that we designate, how long will it take before we allow AI to define its own tasks?

Aside from the technical impact and opportunities of AI, there is a very real human impact. The same AI that can book a hotel for you after a natural conversation can replace a human travel agent. The same AI that can order your shopping by figuring out what is in your fridge can replace a supermarket. The same AI that can drive your car can replace a taxi driver. And the same AI that can construct a house will replace builders.

Navigating the transition to a world where most things can be done better by cloud intelligence or an intelligent machine will be of huge societal importance, as will making accountable the companies that own and operate the most prominent AI systems.

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2 Virtual worlds, once obscured, start to gain greater reality in the physical realm

After several years of hype, the operative reality behind creating virtual, augmented and mixed digital worlds is set to manifest more fully during 2017. And what looks like a cooling of interest now on the surface will, in fact, be the first steps toward true mass adoption of virtual reality (VR) and augmented reality (AR).

While the early development of various headsets was what grabbed news headlines, most VR sales, in reality, have been of smartphone accessories. In 2017 the technology for AR and VR devices will advance significantly as big brands like Facebook, Google and Microsoft consolidate their existing technologies into more exhaustive strategies designed to corner this burgeoning but potentially very lucrative space.

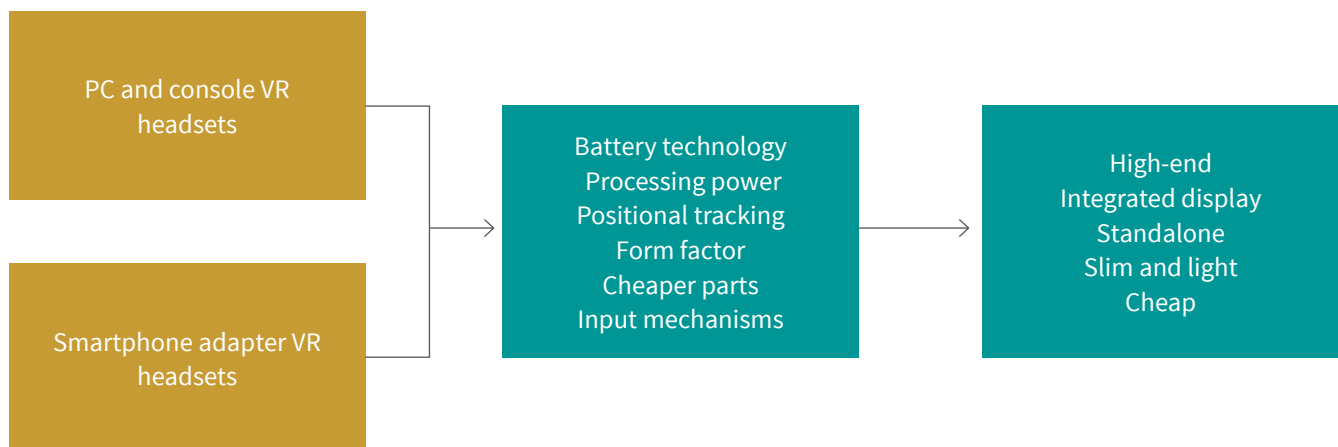
The influx of big names will, in turn, bring many more device manufacturers, including a number of Chinese smartphone brands, into the market for VR and AR hardware. The rollout of new versions of VR-capable games consoles with 4K video upscaling and high dynamic range (HDR) will create the medium for high-quality VR content, even if availability for the next few years will remain limited.

Perhaps of even greater importance will be the way that VR and AR find uses and commercial opportunities in a range of professional, industrial and commercial applications, spanning retail to design, through to medical rehabilitation and experience cinema. The ostensible boundary between augmenting reality and virtualizing reality will blur in many of these real-world applications: for example, shopping may start to employ AR overlays on windows together with mixed augmented reality browsing as well as VR experiences, serving up an entirely fresh and novel way for consumers to apprehend merchandise in a store prior to purchase.

As technology develops further, the experience of virtual worlds will progress from simple viewing to increasingly sophisticated interaction, and finally to full and total immersion. And when the ecosystems for the various uses of VR become completely integrated, the prospect for consumers to move through a highly immersive virtual world will then shift from what was once the provenance of esoteric science fiction into a new order of tangible, expressive reality.

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Prototypes of all-in-one VR headsets sell the future



3 The meta cloud is here: bigger yet more flexible, and with new edge data centers

From private and public clouds to hybrid and infrastructure clouds, cloud services have now mushroomed into something even bigger: the meta cloud—a sort of cloud-of-clouds in which multiple clouds could be accessed from a single web interface. Over the last six months, discussion on this subject has expanded and amplified, and we have seen numerous cloud OS vendors as well as application delivery vendors offering software and services targeting enterprises using multiple cloud service providers (CSPs).

At the same time, there are multi-tenant data-center operators that have been growing their service-provider-neutral data centers (DCs), allowing interconnection among multiple telecommunication carriers or colocation providers. Housing cloud-service-provider data centers in a single location, these network-neutral DCs offer enterprise connectivity with service level agreements (SLAs) that act as a blueprint for the cloud computing services they provide.

In particular, communication service providers plan to provide a single connection with SLAs to the enterprise, acting as a gateway to their CSPs. This innovation is the meta cloud, which IHS Markit believes offers significant opportunity for growth.

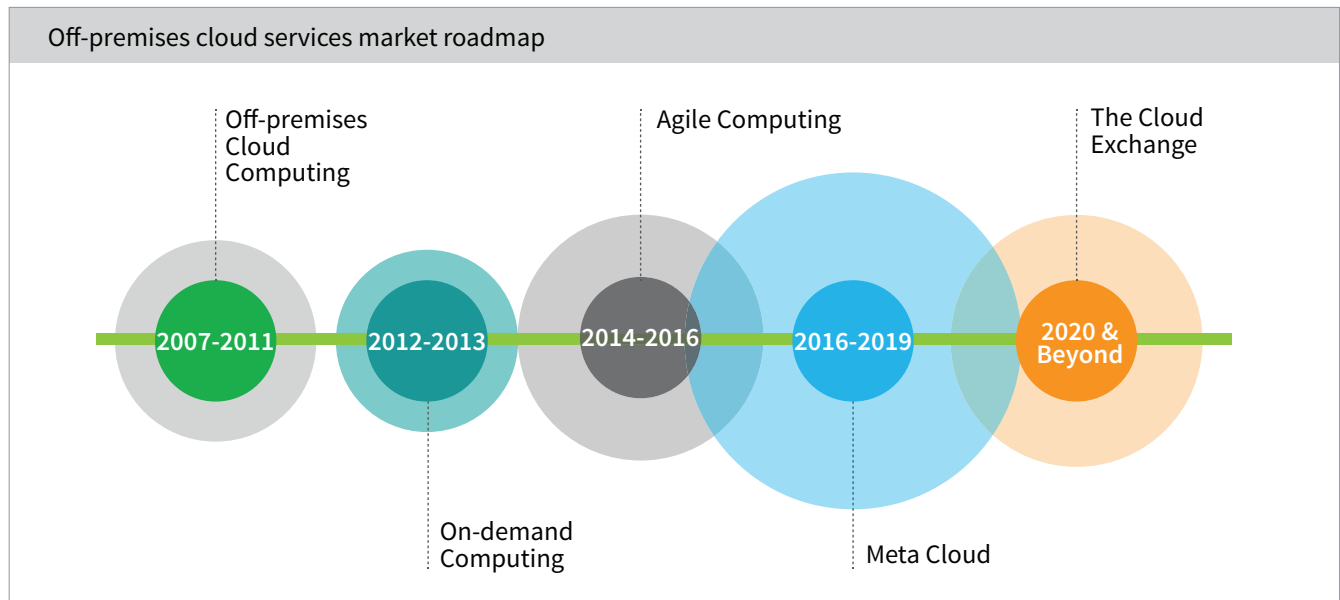
Overall, the drive to leverage machine learning (ML) and artificial intelligence (AI) capabilities, integrated with enterprise and mobile applications, continues to flourish. New services are available from traditional Software-as-a-Service (SaaS) vendors, coupled with the expansion of existing offers from the likes of Google, IBM and Amazon. Most noteworthy is the deployment of specialized silicon for processing ML and AI algorithms by Google, via the Tensor chip. For the next 24 months, IHS Markit believes that we can expect to see more specialized silicon being developed and deployed.

The meta cloud offers significant market opportunity for growth. Expect to see more specialized silicon being developed and deployed.

Also of significance is that the Internet of Things (IoT), bandwidth-intensive content and the greater expectation of speedy access all require that more data centers be placed closer to end users. Here edge DCs, located at the logical ends of a network, can be deployed for various purposes: to cache data-heavy content, aggregate data from local connected devices, or limit the traffic to and from geographically dispersed data centers. The emergence of edge DCs is helping to drive the 20% growth in revenues during 2016 from containerized or modular data centers, supporting the expansion of a new type of specialized colocation supplier.

While edge network requirements spur small DC deployments, an even more impactful force is driving very large data center builds. As more businesses outsource data center operations to cloud or colocation providers, medium DCs are also closing their doors, causing larger, hyperscale cloud and colocation DCs to expand their space. IHS Markit now estimates that cloud and colocation DCs account for 40% of total square footage for data centers worldwide, each with an average footprint of 150,000 square feet, compared to an average of roughly 10,000 square feet for traditional enterprise DCs.

To this end, the consolidation into fewer, larger data centers—along with the building of small edge DCs—is causing a “scoop” out of the midsize data center market while also generating a shift to both small and large DCs.



4 LPWAN to extend reach to IoT devices otherwise inaccessible by traditional wireless means

As the IoT universe continues to expand by leaps and bounds, IoT devices located in remote or inaccessible locations will need to be connected in more efficient ways than those now offered by traditional wireless technologies.

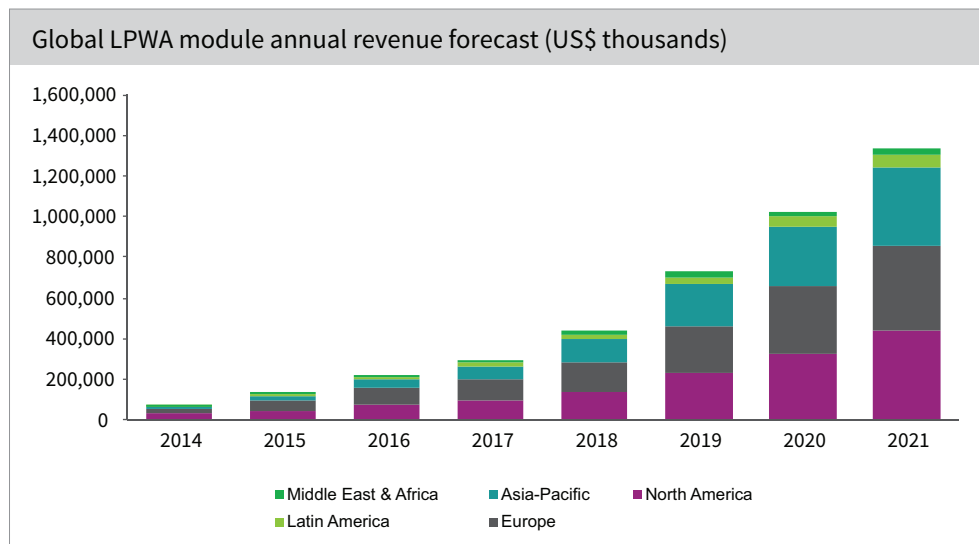
Here is where low-power wide area network (LPWAN) technologies could come into play, dealing with the challenges of limitations in range as well as poor signal strength even when coverage is available. Suitable for use in long-range applications, LPWAN is also capable of robust data transfer, does not require high power that would drain batteries and is economically priced to cut down on installation costs.

In 2017 the first batch of Narrowband IoT (NB-IoT) and LTE Cat-M networks will go live around the world. These LPWAN technologies will open up opportunities for telecom operators to support low-bit-rate applications currently served by short-range wireless

(SRW) standards such as Wi-Fi, Bluetooth, ZigBee and Thread. They will also help operators address the competitive threat posed by LPWAN challengers like LoRa, RPMA and Sigfox. IHS Markit expects global LPWAN shipments to grow from 46.4 million units in 2017 to nearly 383.0 million units in 2021.

The increased availability of low-cost, long-battery-life devices based on NB-IoT, LTE Cat-M and other LPWAN technologies from 2017 will drive connectivity for a variety of applications, including smart metering, smart buildings, precision agriculture and environmental monitoring sensors. In smart metering, for instance, where network coverage is an important issue, meters located in remote rural locations or hard-to-reach places such as cellars can now be connected by NB-IoT. In agriculture, sensors can be deployed to track environmental conditions such as pollution or precipitation.

LPWAN will also open up new vertical markets for the platform and module vendors that support these new technologies.



LPWAN can deal with challenges seen in short-range wireless while also driving connectivity for smart metering and many other applications.

5 New device formats result from the smartphone and mobile revolution

In just five short years from 2010 to 2015, the number of mobile handsets grew by a sizable 40% with smartphones becoming the world’s key mobile handset type, demoting to lesser standing once-dominant feature phones.

The surge in smartphone sales is worth noting, as it has had the salubrious effect of redefining the supply chain for mobile phone components, drastically reducing their price, dramatically increasing their availability and noticeably lowering their power requirements. The affected components span the entire spectrum of the mobile value chain, ranging from processors and memory chips, to sensors and semiconductors for connectivity, to display screens and battery power units.

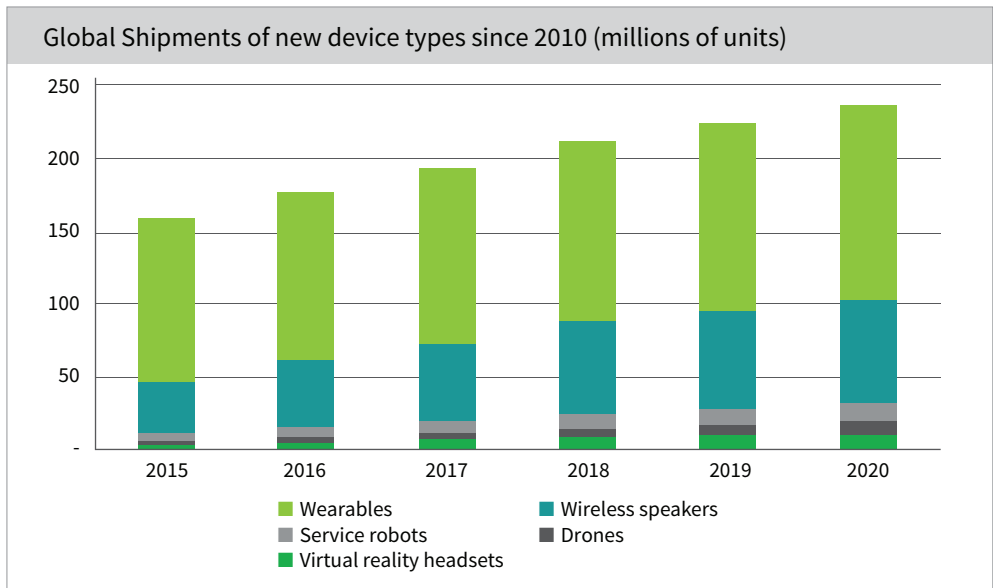
The smartphone revolution has now sparked an equally monumental upheaval in new device formats. Virtual reality headsets, smartglasses, smartwatches, Bluetooth headsets and speakers, drones and consumer robots—all these have all been made possible at

mass-market prices because of the diverse efficiencies developed over time by the mobile supply chain. The sensors for autonomous cars and service robots, for instance, are based on smartphone sensors. The screens for wearable devices are based on smartphone screens. And the nearly ubiquitous connectivity present in the IoT is based on smartphone radios. In short, we are at the beginning of an explosion in device innovation and connectivity made possible by the supply chain for smartphones, accelerating in both velocity and vigor even as growth plateaus in the mature and saturated smartphone space.

Most of the current trends in innovation fall into one of two categories: taking already created devices into the mass market, or connecting everything that already exists. Perhaps the closest example of a product type that was invented during the past few years and then came to fruition as a mass-market item is the drone. Today 3D printers and 3D pens are heading the same way, becoming more commonplace and affordable as technology is democratized all around.

The next set of new devices may well materialize at the boundary of cheap 3D printing and inexpensive smartphone components, in the process creating completely novel device types and uses.

The smartphone revolution has sparked an equally big upheaval in new device formats—thanks to lower prices and innovations in the mobile supply chain.



6 Smart manufacturing to advance further with more real-world projects coming online

Much has been made of the Fourth Industrial Revolution and the central role played by emerging technological breakthroughs. Today companies utilizing IoT and Big Data analytics alongside cyber-physical technologies such as robotics and 3D/additive manufacturing are able to effect transformation on various fronts, including product design, supply chain management and the production process.

For the last two years the topic has produced merely a plethora of press releases and conferences but little of actual substance. However, a number of projects using smart and other new technologies that previously had been in the proof-of-concept (PoC) phase are now complete, and we expect details of many more “real-world” projects announced over the coming 12 months.

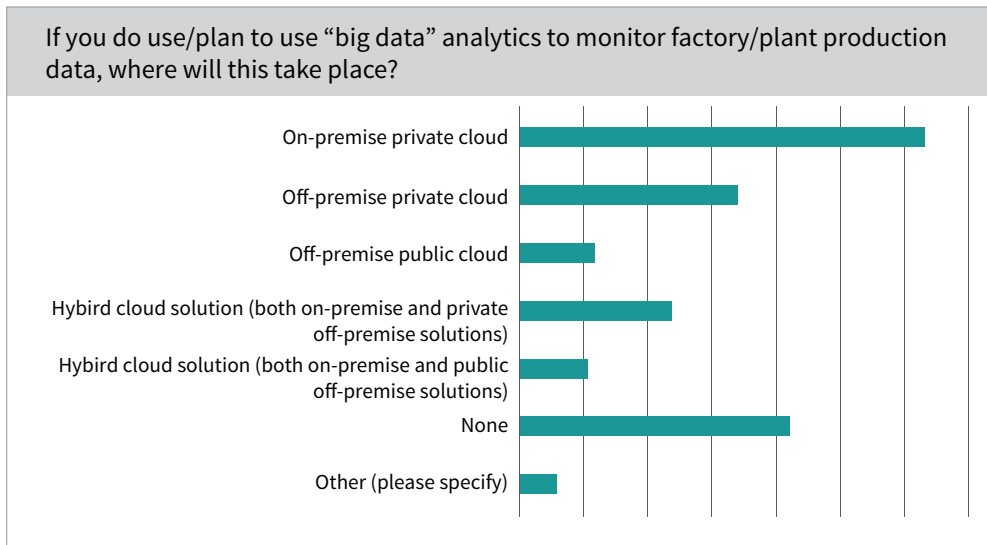
In 2017 news feeds will also be kept buzzing with both acquisitions and partnerships on the technological front.

For instance, look out for automation/operator technology (OT) companies releasing their own

Platforms as a Service (PaaS) in the cloud, as they compete to offer IoT projects to the industrial market. Many of these suppliers still have significant gaps in their portfolio, and we expect other companies to follow suit, set by the likes of Siemens and GE, bidding for software companies that will either provide or augment solutions to enable an IoT and cloud offering.

Also in 2017, local and “edge” computing will gain increasing focus as the technology—central to the early success of some vendors—pushes computing to the outer edges of a network, away from centralized nodes and data cores. Because many end-users remain reluctant to place sensitive manufacturing data onto a remote cloud (whether public or private), the availability of platforms operating on a local cloud will be critical in making smart manufacturing solutions accessible to a broader audience.

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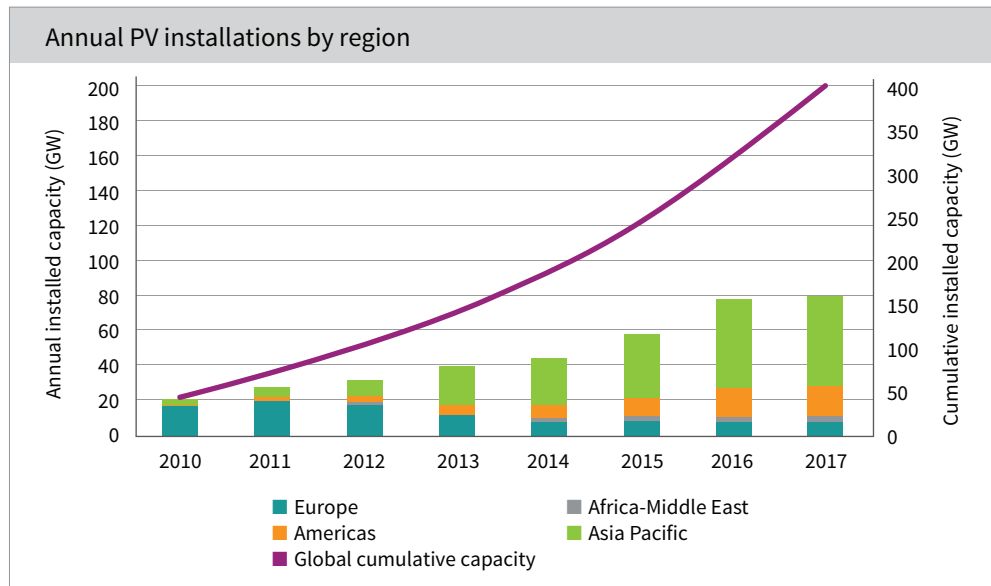
7 Solar technology to preserve leading position in renewable power

With the world continuing to look for fresh sources of renewable energy, solar will retain its place next year as the primary source of new power. For 2017, IHS Markit projects that 79 gigawatts (GW) of photovoltaic (PV) panels will be installed worldwide, up from 77 GW in 2016, bringing total installed PV capacity in the world to 400 GW—more than double at the end of 2014.

Of all new power-generation capacity added in the world in 2016 and 2017, more than a quarter will be in the form of solar panels. The continued growth of PV power generation can be attributed to sharp drops in the costs of PV systems, combined with favorable country policies toward renewable power and the versatility of solar use, with applications ranging from one-panel off-grid systems to vast utility-scale power plants.

IHS Markit also predicts further decreases in PV pricing, which will serve to uphold the pre-eminent position in renewables of solar in the years to come. With PV module pricing now only a quarter of 2010 levels, a 50-megawatt PV power plant today requires a substantially smaller investment of approximately \$50-70 million—a third that of levels six years ago. And as PV demand has grown, at first initiated by generous

Among new global power capacity added in 2016-17, more than a quarter will be in the form of photovoltaic panels, affirming solar as the primary source of renewable energy.



policy support schemes across several countries, PV module production capacity has rocketed over the years, resulting in commoditization. These developments, in turn, have caused PV production costs to plunge, and competition is now fierce among major module manufacturers to further bring down costs in hopes of beating market rivals on price.

The successful deployment of PV technology has, in fact, spawned its own confounding paradox, with many manufacturers now struggling to keep up with ongoing intense competition in order to maintain healthy margins.

We project, therefore, that 2017 will be a decisive year for PV makers in the solar module value chain.





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AMERICAS

T +1 844 301 7334

E AmericasLeads@ihsmarkit.com

EMEA

T +44 1344 328 300

E technology_emea@ihsmarkit.com

APAC

T +604 291 3600

E technology_APAC@ihsmarkit.com

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