



# THE INTERNET OF THINGS (IoT)

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Opportunities for the LPG industry

May 2019



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## ACKNOWLEDGEMENTS AND PARTICIPANTS OF THE WORKING GROUP

The World LPG Association (WLPGA) would like to thank everyone involved in the production of this report.

David Tyler produced the initial draft with valuable assistance from Andre Pimentel of ISA Sensing.

The following members of the working group agreed the terms of reference, provided initial feedback to a questionnaire and helped with the final drafting. This feedback, together with comments on subsequent drafts, formed the basis of the final report.

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The WLPGA would also like to thank everybody else who participated during the drafting. Especially those who attended the IoT powerplay session, held during the World LPG Forum in Houston, USA, in October 2018 and those that joined the two WLPGA IoT webinars held during November 2018.

The full minutes of the powerplay and a link to the webinar recording are included in Appendix Three of this report. Some of the feedback from these events is also included in the main body of this report.

# EXECUTIVE SUMMARY



**The Internet of Things, or IoT, refers to the growing range of internet-connected devices that capture, or generate, an enormous amount of information every day. It has been described as a development of the Internet in which everyday objects have network connectivity, allowing them to send and receive data.**

**“TELEMETRY IS AN AUTOMATED COMMUNICATIONS PROCESS BY WHICH MEASUREMENTS AND OTHER DATA ARE COLLECTED AT REMOTE/INACCESSIBLE POINTS AND TRANSMITTED TO RECEIVING EQUIPMENT FOR MONITORING”**

Telemetry has been used in the LPG industry for many years, mainly for monitoring stocks in the bulk LPG sector where the cost was more easily justified. Initially direct phone lines were used to transmit measurements and data before the cellular networks were introduced. Now the power of the internet cloud is being harnessed which is opening new opportunities across the whole business.

The report addresses two main issues:

- What are the main developments happening in the IoT space?
- How can they be applied to the LPG industry from production, through primary and secondary storage to the distribution channel and onto the end user?



**KEY OBSERVATIONS THAT ARE MADE IN THIS REPORT ARE:**

- ▶ IOT IS ONE OF THE MOST GAME-CHANGING EVENTS FACING THE LPG INDUSTRY
- ▶ DEVELOPMENTS IN IOT ARE CHANGING FAST AND NEED TO BE CONSTANTLY MONITORED
- ▶ IOT WAS NOT PART OF THE WLPGA STRATEGIC PLAN THREE YEARS AGO
- ▶ THERE ARE MANY COMPANIES, INCLUDING START-UPS, DEVELOPING EXCITING TECHNOLOGY
- ▶ THE LPG INDUSTRY IS LAGGING OTHER INDUSTRIES IN THE APPLICATION OF IOT, ESPECIALLY IN OPERATIONS
- ▶ CASE STUDIES OF LPG IOT APPLICATIONS ARE LIMITED - COMPANIES ARE UNWILLING TO SHARE SUCCESS
- ▶ ...BUT EXAMPLES FROM OTHER INDUSTRIES MAY BE APPLICABLE
- ▶ THE CAPITAL INTENSITY OF THE LPG INDUSTRY PROVIDES OPPORTUNITIES FOR IOT
- ▶ 'START SMALL AND EMBRACE CHANGE'
- ▶ BRING IOT 'OUT OF THE GARDEN INTO THE HOUSE'
- ▶ KEEP INVESTING IN IOT OR THE INDUSTRY WILL BE LEFT BEHIND
- ▶ OPPORTUNITIES EXIST FOR ORGANISATIONS TO JOIN FORCES TO EXPLOIT IOT
- ▶ IOT APPLICATION NEEDS CONTINUOUS COMMITMENT FROM TOP MANAGEMENT



The significant improvements with the evolution of communications over the last fifteen years has enabled the internet cloud to store data rather than retain it on the ground, reducing cost.

An example is the way transponders, or tags, have now become just the links to cloud data allowing them to be much simpler and cheaper devices, and opening opportunities to monitor low cost assets such as small cylinders.

The IoT has created an opportunity to now manage these LPG assets, and also, to improve the way the LPG industry operates.

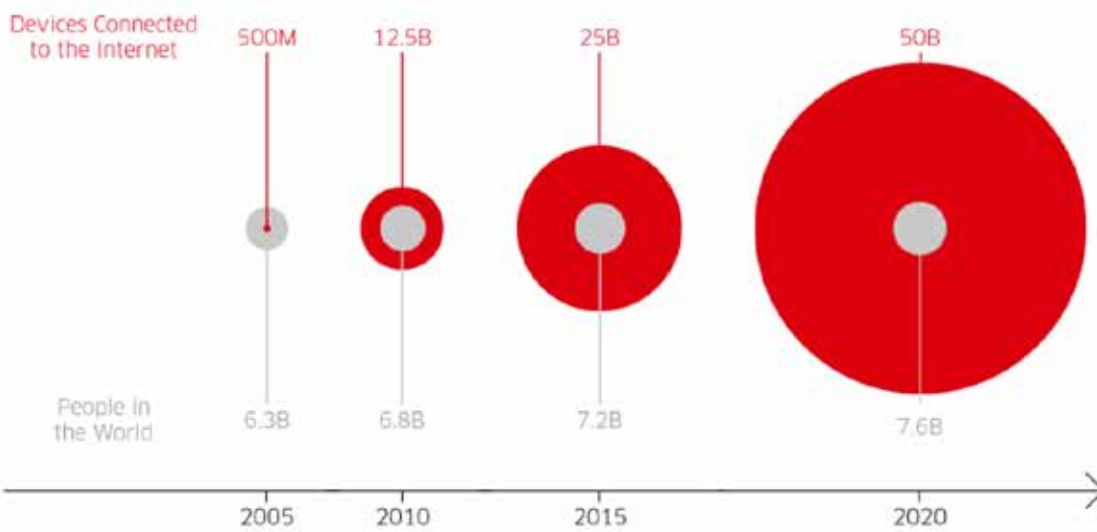
The LPG industry is very capital intensive. For every cylinder delivered to a household, there are two or three more cylinders at the filling plant or in the distribution chain, in support.

Bulk customers require on-site storage tanks, supplied from road tankers serviced from depots with their own bulk storage facilities and loading gantries.

These assets require inspection, servicing and maintenance to ensure they are continually safe and fit for purpose. They also need to be fully utilised.

The IoT generates massive amounts of data. Cloud computing provides a pathway for that data to travel to its destination.

It is estimated by Cisco IBSG that by 2020 there will be 50 billion devices connected to the internet, a one-hundred-fold increase compared to 2005.



Cisco IBSG estimate that by 2020 there will be 50bn devices connected to the internet



The world's population will have increased by just 20% in the same period.

So IoT is here, and growing very fast, but there are concerns about its adoption.

According to Morgan Stanley, their World Industrial Automation Survey concluded that 46% of respondents put security as the most serious challenge to IoT adoption.

Other challenges identified included a lack of standardisation (35%), up-front investment (30%), return on investment (ROI) (27%), and data integrity (23%).

Some of these concerns were mirrored in the feedback received during the development of this report.

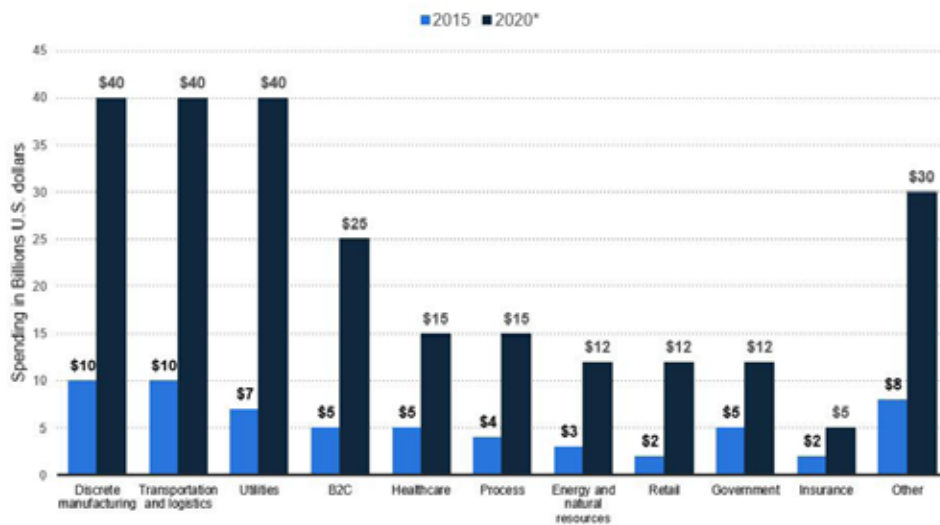
The LPG industry has been described as '...at least ten years behind the telecommunications industry when it comes to the adoption of new technologies...!'

And, according to Forbes, the worldwide spending by the energy and natural resources sector on IoT is relatively low compared to other industries.



*Lego man with a 18mm tag*

### Spending on Internet of Things Worldwide by Vertical in 2015 and 2020\* (in billions of U.S. dollars)



Internet spending by sector according to Forbes - 2018

If the LPG industry is so far behind, then the adoption of IoT could present some real opportunities.

This opportunity for adoption extends right through the business, from the natural gas well head and refinery, through the entire LPG supply and distribution chain to the end user. It is against this background that this report was conceived.

A key objective of this report is to showcase IoT, and how it might be applied in the LPG industry - with some real examples (described in chapter 7.0) - to encourage its uptake, and make the industry safer, smarter, more efficient and more accessible; More accessible, because three billion people have no access to modern energy.

The up-front cost of an LPG cylinder, regulator, hose and appliance makes the use of LPG a financial challenge for many people reliant on traditional fuels for their primary energy.

But now LPG can provide an immediate solution to that.



## ...IOT IS ONE OF THE MOST GAME-CHANGING EVENTS FACING THE LPG INDUSTRY ...

This report demonstrates some exciting new technology that can provide a solution to this challenge by using cylinder smart meter technology which measures and regulates the flow of gas remotely via an electronic signal (see 7.6). Other examples show how assets as small as 3kg cylinders can be tracked; how efficiencies of bulk deliveries can be improved by monitoring contents; and how road vehicles can be tracked to improve safety.

Identifying where and how IoT can be applied in the business can also be a challenge.

The Brazilian company, Ultragas, overcame this by inviting 100 start-up companies to brainstorm their business to find ways to improve. The result was the identification of new areas of the business where IoT could make a difference.

There should be a long-term plan to continually track and monitor developments in IoT in the LPG industry. This could include webinars and perhaps a pilot programme to provide a detailed demonstration of some key opportunities within the industry.



# OBJECTIVES



Technology developments with IoT have increased at a pace in recent years, and present real opportunities for the global LPG business to work safer, smarter, more efficiently, and facilitating deeper market penetration in countries where low household incomes present a barrier to using LPG.

The improvements in communications have supported these developments, and with reduction in costs, have opened opportunities which previously were uneconomic to apply, especially on low cost assets.

“The objective is to fully understand and document the current IoT environment and to set out opportunities where the LPG industry can fully exploit these technologies throughout the value chain to improve the business.”

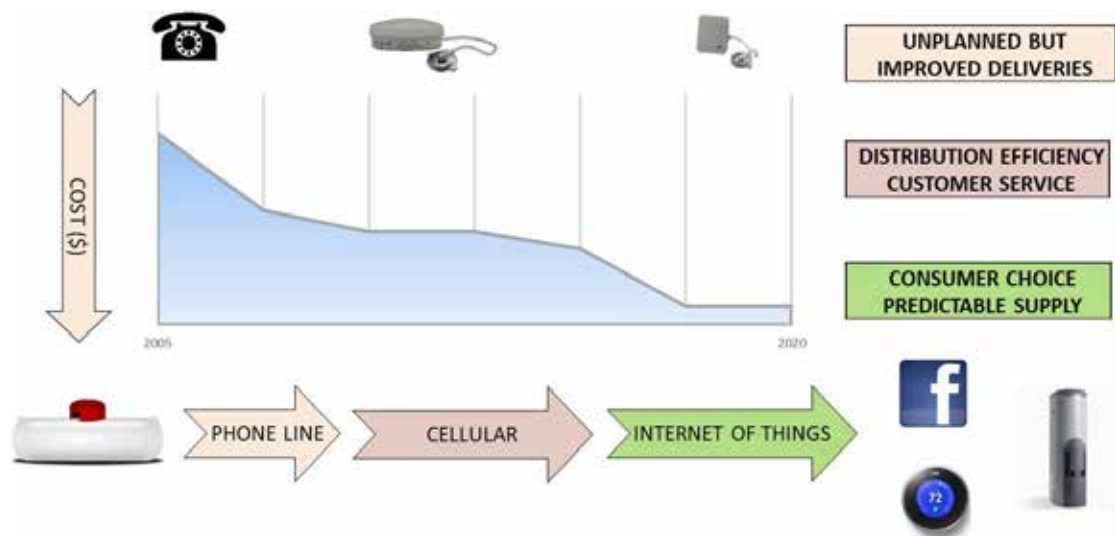


This project seeks to understand what these developments are, and how they can be applied to the LPG industry from production, through primary and secondary storage, to the distribution channel and onto the end user (see chart below of the LPG distribution chain - courtesy of Argus Media).

The objective is to fully understand and document the current IoT environment and to set out opportunities where the LPG industry can fully exploit these technologies throughout the value chain to improve the business, using some examples where this is already happening (see chapter 7.0).

This desk-top project specifically addresses technology relevant to LPG (but could also be applied to natural gas).

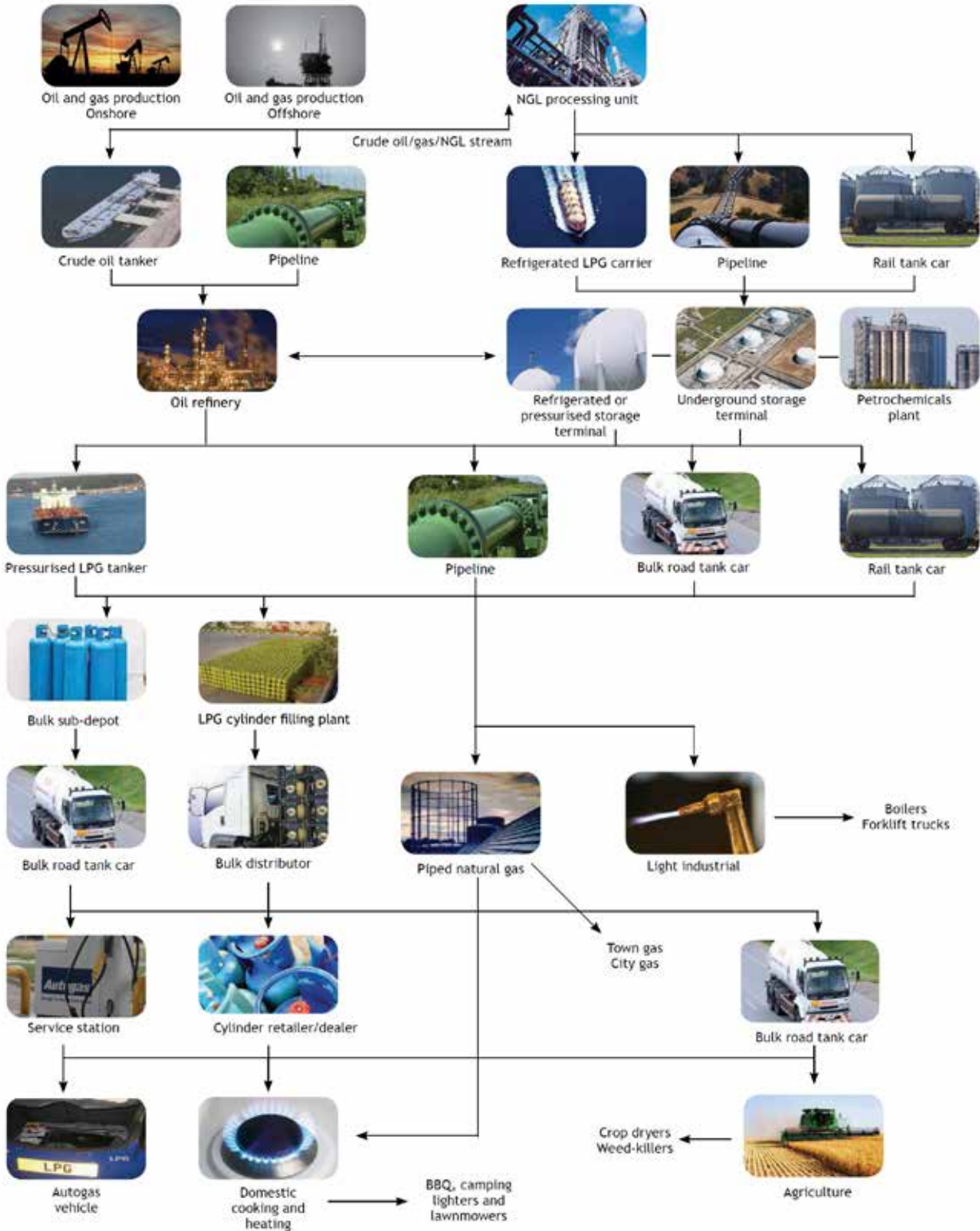
These opportunities lie throughout the supply and distribution chain, from the well head to the consumer.



Impact of telecommunication evolution - Silicon Controls

The following chart of a typical LPG supply and distribution chain is taken from the WLPGA 2018 Global Statistical Review published by Argus Media.

### LPG DISTRIBUTION CHAIN



Typical LPG distribution channel - Argus Media



# METHODOLOGY AND STRUCTURE



**The WLPGA Industry Council directs the WLPGA by identifying issues, developing strategies, and formulating projects. The Council comprises leading companies from the LPG industry worldwide.**

The WLPGA included this project as part of the 2018 Action Plan following discussions with the WLPGA Industry Council in Marrakech (2017) and Santa Barbara (2018).

A working group was established with members who have an interest in the subject of IoT and a draft scope and terms of reference was agreed.

A questionnaire was circulated to each member of the working group and the feedback, and the subsequent comments on the drafts, form part of the input and main conclusions to this report.

Mr Andre Pimentel, of ISA, made a significant contribution to the drafting of this report and worked closely with Mr David Tyler in its development.

During the 31<sup>st</sup> World LPG Forum, the subject of IoT was included during the WLPGA Matrix Day discussions and in a one-hour open IoT powerplay session which was held to debate and receive further input. The input from both the Matrix Day the IoT powerplay is reflected in this report. The full minutes of the IoT powerplay are included in Appendix One.

In November 2018 two webinars were held to discuss IoT in the LPG industry which attracted over 70 participants. The recording of one of the webcasts can be found here: <https://youtu.be/VfVN9xQDHpA>. This link, and copies of the presentations made during the webinars, are also included in Appendix Two.





**The structure of this report follows the questionnaire that was agreed by the working group. The following questions were circulated both within the group and to other interested parties:**

- ▶ WHAT INFORMATION ARE COMPANIES LACKING TO MAKE INFRASTRUCTURE INVESTMENTS?
- ▶ HOW COULD IOT PROVIDE MORE INFORMATION AND CONTROL OVER LPG ASSETS?
- ▶ WHO ARE THE KEY IOT PLAYERS GLOBALLY?
- ▶ HOW COULD THEY HELP THE LPG INDUSTRY?
- ▶ WHAT IOT DEPLOYMENTS HAVE TRANSFORMED OTHER INDUSTRIES?
- ▶ WHAT LESSONS CAN WE LEARN FROM THOSE DEPLOYMENTS?
- ▶ WHAT ARE SHORT, MEDIUM AND LONG-TERM TECHNOLOGIES THAT COULD BE ROLLED OUT ACROSS THE INDUSTRY?
- ▶ CAN WE DEVELOP NEW COMMON STANDARDS FOR THE USE OF IOT ACROSS THE INDUSTRY?

**This report addresses two main issues from the above questions, and which were also the focus of discussion during the powerplay and webinars:**

- ▶ A GLOBAL OVERVIEW OF IOT, WHAT IS GOING ON IN THE IOT SPACE?
- ▶ HOW IOT MIGHT BE APPLIED TO THE LPG INDUSTRY

# GLOBAL OVERVIEW



**IoT is a global phenomenon and one of the fastest growing technologies in the world today. The massive growth in the number of internet devices, and the power they contain, is staggering.**

**But for many IoT is a black box. And investment decisions in black boxes are not easy to make. But the opportunities for applying IoT to make businesses smarter will increase and for those industries that decide not to invest will be left behind.**


## **1. DEFINITION OF IOT**

According to Gaurav Dixit from Oil and Natural Gas Corp, IoT is the practice of capturing, analysing, and acting on data generated by networked objects and/or machines.

IoT has evolved from the convergence of wireless technologies, micro-electromechanical systems (MEMS), microservices and the internet. The convergence has helped tear down the silo walls between operational technology (OT) and information technology (IT),

allowing unstructured machine-generated data to be analysed for insights that will drive improvements.

The Internet, which was introduced to connect people, is now connecting objects to people and is constantly collecting, analysing, and communicating data.



## ...THE KEY DRIVERS IN THE ADAPTATION OF IOT ARE SENSORS, NETWORKS, STORAGE, AND BIG DATA/ANALYTICS ...

### ► **SENSOR**

The Institute of Electrical and Electronics Engineers provides a formal definition for sensors: "An electronic device that produces electrical, optical, or digital data derived from a physical condition or event. Data produced from sensors is then electronically transformed, by another device, into information (output) that is useful in decision making done by 'intelligent' devices or individuals."

### ► **NETWORK**

The information that sensors collect must be communicated and collected at some location. This involves transmission of data via networks. The first step in the process of transferring data from one machine to another via a network is to uniquely identify each of the machines. Network protocols are a set of rules that define how computers identify each other. Open protocols such as Internet Protocol allows for interpretability and scalability in the system

### ► **STORAGE**

Sensors generate huge amounts of data every second that are communicated through networks and stored. In IoT, data are handled in two ways: real-time frontend data, which interacts directly with IoT-connected devices, and offline backend data which are stored for in-depth analysis. These storage methods are mostly completed on the cloud or in big storage facilities. Due to progress in technology, the price for data storage has fallen dramatically in the past ten years. However, the protection of the collected data is a significant challenge and has become a major expense

### ► **ANALYTICS**

The collected data must be analysed to give some insight into the working of "things." Unfortunately, in the oil and gas industry many companies are still using Microsoft Excel as a main analysis tool.

- Descriptive analysis, which describes what has happened
- Predictive analysis, which answers what could happen
- Prescriptive analysis, which answers what should happen

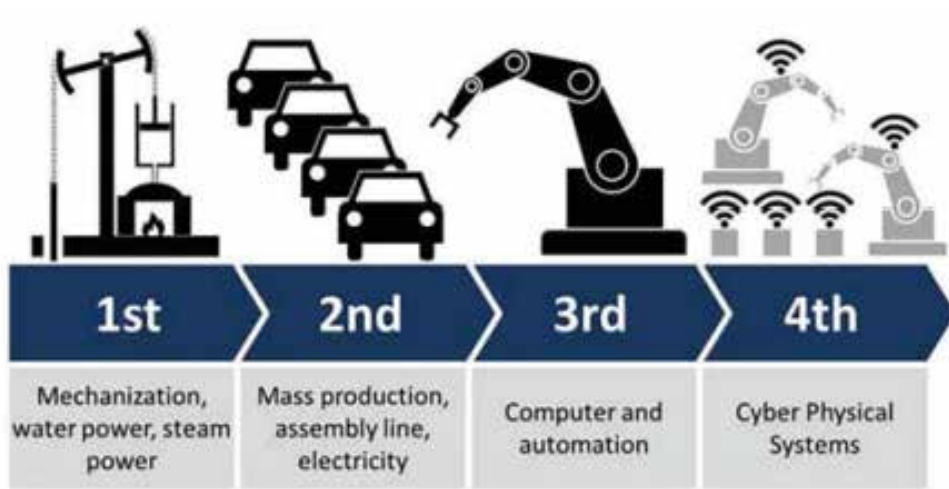
Where the IoT focuses on connectivity to give convenience to consumers, the Industrial IoT (IIoT) connects devices to provide greater data visibility, improve performance or enable automation in industrial settings.

Both the IoT and the IIoT are part of Industry 4.0, also known as the Fourth Industrial Revolution. Industry 4.0 refers to the current trend of automation and data exchange in manufacturing technology. It was preceded over the past 200 years by a progression of technological advancements:

To help manage the automation and data that the IIoT yields, software and services are often run on the Internet, rather than being stored locally on a computer.

This process of Cloud Computing allows information to be accessed on any device with an internet connection.

The promise of the IIoT encompasses many areas, ranging from time saving to energy use and customer service.



Evolution of industrial development

## 2. DESCRIPTION OF THE CURRENT AND EVOLVING LANDSCAPE OF KEY IOT TECHNOLOGIES AND COMMUNICATION NETWORKS

The Institute of Electrical and Electronics Engineer (IEEE) working group 802.11ah enhanced communication development to support M2M (Machine to Machine) applications. Among these are Bluetooth Low Energy 4.0, ZigBee, and Wi-Fi/IEEE802.11 to support short-range communication for MTC.

LPWA technologies including Ingenu Random Phase Multiple Access (RPMA), SigFox and LoRa, are promising technologies operating

in the unlicensed Industrial, Scientific, and Medical (ISM) spectrum band for providing low-power and long-range communications as proprietary solutions.

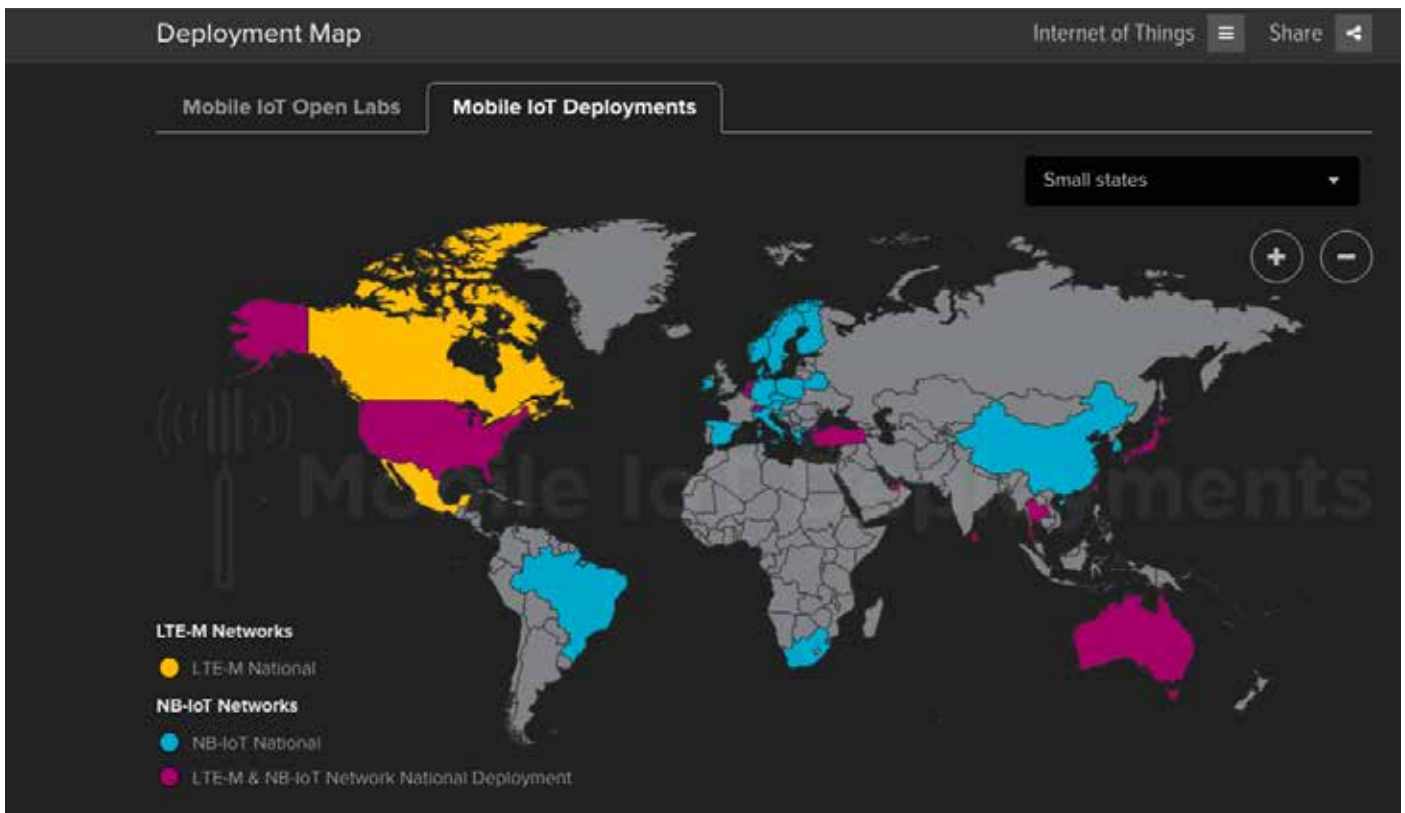
At the same time, to ensure that M2M applications are efficiently supported in 2G, 3G, and LTE Cat-1 and higher networks, the 3rd Generation Partnership Project (3GPP) proposed enhancements in its future release for MTC including Enhanced Machine-Type Communications (eMTC), Extended Coverage-Global System for Mobile Communications for the Internet of Things (EC-GSM-IoT) and Narrowband-Internet of Things (NB-IoT) as cellular-based LPWA technologies for the IoT.

Enabling modern IoT connectivity in the licensed approved spectrum bands will be key for IoT use since it offers diverse applications with different service opportunities within a single network. The challenge however, is how the fifth generation (5G) mobile network will meet the diverse requirements of the IoT.

It is hoped that basic requirements such as high throughput, low latency in terms of data delivery, high scalability to enable massive number of devices, efficient energy consumption technique and the provision of ubiquitous connectivity solution for end-users will be efficiently supported using the 5G mobile network for the IoT.

An assessment has been made below of several countries to demonstrate the varying levels of development in communications technology. This is constantly evolving but has been included in Appendix Three.

The GSMA represents the interests of mobile operators worldwide, uniting more than 750 operators with over 350 companies in the broader mobile ecosystem, including handset and device makers, software companies, equipment providers and internet companies, as well as organisations in adjacent industry sectors. The GSMA also produces the industry-leading MWC events held annually.



IoT deployment map - GSMA

The LoRa Alliance is the fastest growing technology alliance. A non-profit association of more than 500 member companies, committed to enabling large scale deployment

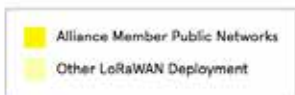
of Low Power Wide Area Networks (LPWAN) IoT through the development and promotion of the LoRaWAN open standard.

**100**  
Network Operators

**68**  
Alliance Member Operators

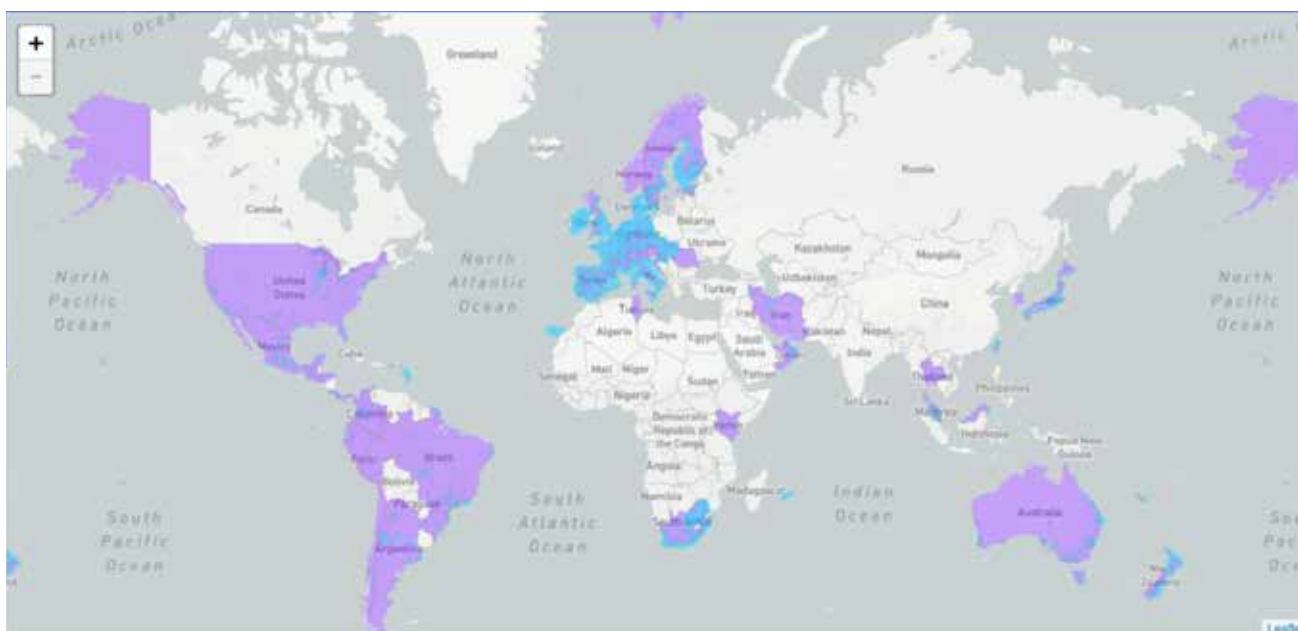
**51**  
Countries operating in

**100**  
Countries with LoRaWAN Deployments



LoRa Alliance coverage map

● Live coverage ● Country under roll-out



Sigfox coverage

### 3. THE KEY IOT PLAYERS

Examples of blocks from the “IoT Landscape 2018” by Firstmark:

#### Applications (Verticals)



## Applications (Verticals)

SOFTWARE		SECURITY
<p><b>FULL STACK</b></p> <p>Cisco Kinetic   Predix   ptc</p> <p>relayr.   SAP   Leonardo</p> <p>neurala   afero   NOVUMIND</p> <p>kontakt.io   Litbit</p> <p>CLEARBLADE®   ALTIZON</p> <p>Telit   TEMSOO®   EUROTECH</p>	<p><b>MIDDLEWARE</b></p> <p>opentext   Numerex   CRYSTAL</p> <p>greenWAVE systems®   Orbital Insight   ZEBRA</p> <p>Ayla Networks   arrayent   prodea</p> <p>PubNub   Descartes Labs   FOG HORN</p> <p>MAANA   KONUX   Audio Analytic</p> <p>BSQUARE   seebo   meshify</p> <p>peoplepower   dawa networks</p> <p>MOTIVE®   FTIT   thingsquare</p> <p>wisilica</p>	<p>Symantec.   gemalto®   THALES</p> <p>SentinelOne   MOCANA   Log</p> <p>DRAGOS   FORTINET.   Log</p> <p>sparkcognition®   FORGEROCK   TEM</p> <p>CLAROTY   ZingBox   Indegy</p> <p>BRYSHORE   Bastille   CyberX</p> <p>IONIC   escrypt   SECUR</p> <p>CyberFlow   SHODAN   OWASP</p>

## Building blocks

HARDWARE	
<p><b>PROCESSORS / CHIPS</b></p> <p>intel   QUALCOMM   TOSHIBA   TEXAS INSTRUMENTS   BROADCOM   Atmel   arm   NVIDIA   LG</p> <p>CYPRESS   GEO Semiconductor   CROSSBAR   menlomicro   zGlue   NXP   HEDA SYSTEMS   SILICON</p> <p>MYTHIC</p>	
<p><b>SENSORS</b></p> <p>NXP   Atmel   TEXAS INSTRUMENTS   NATIONAL INSTRUMENTS   libelium   vesper   psikick   Qualtré   VALEN</p> <p>MEMSIC   XERAFY®   JADAK   mCube   MONNIT.   ST   dialog   SENSYS networks</p> <p>Motionloft   SST.   SAFECAST</p>	
<p><b>PARTS / KITS</b></p> <p>ARDUINO   Raspberry Pi   Octopart   adafruit   XILINX.   XETHRU   TTech</p>	
<p><b>CHARGING</b></p> <p>uBeam   Pi   WiTricity   humavox   AMPY   OSSIQ</p>	



	CONNECTIVITY	ANALYTICS
ForeScout Rhythm inside secure PERED SWANIE NexDefense THINGS VIRGIL SECURITY	machineQ ALIEN sigfox Jasper helium Silver Spring Networks SIERRA WIRELESS Activity iGENU senet cubic telecom FILAMENT SENSORO Hologram VENIAM ARKESSA KAAZING M2M SPECTRUM NETWORKS MMB Networks SILVAIR haystack KORE Cirrent neul intamac aeris	UPTAKE IoT OSIsoft AWS IoT Analytics cloudera MAPR splunk sumologic Preferred Networks STRATOSCALE iguazio stroom UNDERSTORY EAGLEVIEW influxdata logtrust machineshop TIMBER glassbeam Flutura TIMESCALE

	INFRASTRUCTURE
SIEMENS LABS swift ELL TE OWISIO	<p><b>CLOUD</b></p> Google Cloud Platform amazon web services™ Microsoft Azure CISCO ARTIK™ IBM Watson IoT Platform salesforce IoT cloud SAP Cloud Platform
	<p><b>EDGE COMPUTING</b></p> Azure IoT Edge SAP Leonardo AWS Greengrass EDGE X FOUNDRY™ HPE Edgeline IoT Systems
	<p><b>MOBILE OS</b></p> iOS android Essential Ambient OS Brillo BlackBerry HomeKit

#### 4. WHAT IOT DEPLOYMENTS HAVE TRANSFORMED OTHER INDUSTRIES? IDENTIFY KEY ADVANCEMENTS MADE IN OTHER INDUSTRIES

The working group was asked this question of IoT deployment to provide a list of examples that might create awareness and stimulate interest in areas of the LPG business that could benefit from IoT. Their responses are included below.

Applications of IoT in the oil and gas sector are endless.

For the manufacturing sector, four of the main benefits could be in quality control, predictive maintenance, boosting production efficiency and seeking gains in profitability.



Source: Accenture Industrial Internet of Things Infographic 2015

The upstream business, where LPG is produced and shipped from the production centres – natural gas fields and refineries – to the global markets have many examples (see 7.1).

Large amounts of reservoir data can be integrated with real-time field data to plan well placement and flow rates.

The LPG industry is very asset intensive, and the protection and utilisation of these assets is critical.

The industry is reported as losing millions of dollars every year due to nonproductive time (NPT). IoT could be used to help reduce NPT events by using real-time data to predict

breakdowns and schedule preventative maintenance.

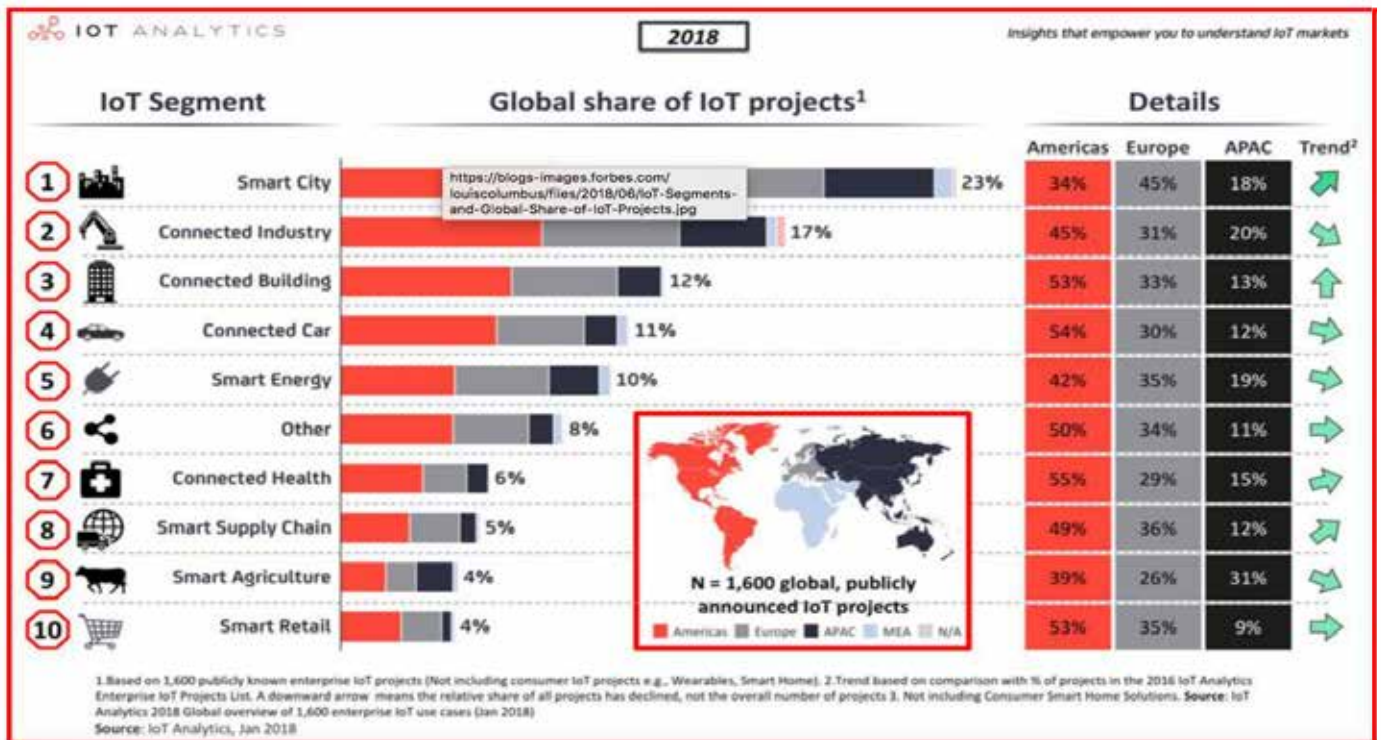
Accidents can be prevented, and processes can be optimised. The downstream LPG industry has the challenging task of transporting variable volumes and grades of products from multiple locations to new end-users and markets.

Connecting pipeline, ships, railroad, road tanker networks, sensors, leak detection, alarms, and emergency shutdowns to interact seamlessly and to be available for analysis and interpretation in real time would significantly reduce some of the major risks that this sector of the industry deals with.

The downstream LPG, and natural gas, industry is commercially one of the most challenging branches of the business. Refinery shutdowns, handling various grades of crude oil and natural gas streams, and changing environmental regulations, create financial challenges.

IoT is the next step in the evolution of the gas industry. Data will have to flow in real time and seamlessly from production sources to boardrooms. This will enable better decision making, better optimisation of processes, and a safer working environment.

With the use of IoT, refineries and natural gas fields can plan shutdowns and schedules, minimise downtime, and improve safety.



SOURCE: IOT ANALYTICS, THE TOP 10 IOT SEGMENTS IN 2018 – BASED ON 1,600 REAL IOT PROJECTS.

In an industry that spends millions of dollars every year on exploration, development, distribution, marketing and maintenance of assets, even a single-digit percentage improvement through IoT will have a significant financial impact.

Several industries have been transformed, in the last few years, due to an extensive set of applications of IoT devices.

...IT IS EARLY  
DAYS FOR IOT...  
THE SIGNIFICANT  
CHANGES ARE IN  
THE FUTURE ...

**The following are some examples of industries and some examples of IoT applications:**

**Consumer applications**

- ▶ A growing portion of IoT devices are created for consumer use, including connected vehicles, home automation/smart home, wearable technology, connected health, and appliances with remote monitoring capabilities
- ▶ Vehicle sharing; reporting vehicle whereabouts - in case of theft or loss
- ▶ Wearable computers
- ▶ Traditional home appliances such as refrigerators (automatic sensors to re-order groceries), washing machines (sensors defecting faults such as leaks), gas stoves (sensors defecting leaks)

**Energy management**

- ▶ Significant numbers of energy-consuming devices (e.g. switches, power outlets, bulbs, televisions, etc.) already integrate internet connectivity, which can allow them to communicate with utilities to balance power generation and energy usage and optimise energy consumption as a whole
- ▶ These devices allow for remote control by users, or central management via a cloud-based interface, and enable functions like scheduling (e.g., remotely powering on or off heating systems, controlling ovens, changing lighting conditions etc.)
- ▶ The smart grid is a utility-side IoT application; systems gather and act on energy and power-related information to improve the efficiency of the production and distribution of electricity
- ▶ Using advanced metering infrastructure (AMI) internet-connected devices, electric utilities not only collect data from end-users, but also manage distribution automation devices like transformers

- ▶ IoT has helped bring electricity to millions of homes in Asia, Africa and Latin America, using Pay-As-You-Go technology

**Smart grids of appliances**

**Medical and healthcare**

- ▶ IoT devices can be used to enable remote health monitoring and emergency notification systems. These health monitoring devices can range from blood pressure and heart rate monitors to advanced devices capable of monitoring specialised implants, such as pacemakers, Fitbit electronic wristbands, or advanced hearing aids. Some hospitals have begun implementing “smart beds” that can detect when they are occupied and when a patient is attempting to get up. It can also adjust itself to ensure appropriate pressure and support is applied to the patient without the manual interaction of nurses
- ▶ One key application of smart home is to provide assistance for disabled and elderly individuals. These home systems utilise assistive technology to accommodate an owner’s specific disabilities
- ▶ Voice control can assist users with sight and mobility limitations while alert systems can be connected directly to Cochlear implants worn by hearing impaired users. They can also be equipped with additional safety features. These features can include sensors that monitor for medical emergencies such as falls or seizures. Smart home technology applied in this way can provide users with more freedom and a higher quality of life

## Manufacturing

- ▶ Network control and management of manufacturing equipment, asset and situation management, or manufacturing process control bring the IoT within the realm of industrial applications and smart manufacturing as well

## Infrastructure applications

- ▶ Monitoring and controlling operations of sustainable urban infrastructure. Urban and rural infrastructures like bridges, railway tracks, on- and offshore- wind-farms is a key application of the IoT
- ▶ The IoT infrastructure can be used for monitoring any events or changes in structural conditions that can compromise safety and increase risk
- ▶ IoT can benefit the construction industry by cost saving, time reduction, better quality workday, paperless workflow and increase in productivity
- ▶ It can help in taking faster decisions and save money with real-time data analytics
- ▶ It can also be used for scheduling repair and maintenance activities in an efficient manner, by coordinating tasks between different service providers and users of these facilities
- ▶ IoT devices can also be used to control critical infrastructure like bridges to provide access to ships
- ▶ Usage of IoT devices for monitoring and operating infrastructure is likely to improve incident management and emergency response coordination, and quality of service, up-times and reduce costs of operation in all infrastructure related areas
- ▶ Areas such as waste management can benefit from automation and optimisation that could be brought in by the IoT

## Logistics

- ▶ Automated warehouses (e.g. Amazon: currently underway)
- ▶ Shipping and logistics have been transformed with this use of live data tracking, route optimisation etc.

## Agriculture

- ▶ There are numerous IoT applications in farming, such as collecting data on temperature, rainfall, humidity, wind speed, pest infestation, soil content
- ▶ This data can be used to automate farming techniques, take informed decisions to improve quality and quantity, minimise risk and waste, and reduce effort required to manage crops
- ▶ For example, farmers can now detect which areas have been fertilised (or mistakenly missed), if the land is too dry and predict future yields
- ▶ This data could be linked to predicting LPG consumption

## Smart Home

- ▶ IoT devices are a part of the larger concept of home automation, which can include lighting, heating and air conditioning, media and security systems. Long term benefits could include energy savings by automatically ensuring lights and electronics are turned off.

## 5. WHAT LESSONS CAN WE LEARN FROM THOSE DEPLOYMENTS?

Throughout all industries, IoT deployments have become more and more efficient, clearly showing that the application of lessons learned from previous deployments and applications is very valuable.

... IOT IS NOT ABOUT GADGETS...IT'S ABOUT SOLUTIONS TO IMPROVE AND BE SMARTER ...

**Gathering the feedback from other applications of IoT, namely in other industries, five lessons learned were highlighted:**

### 1. Define goals and measure outcomes

When deploying an IoT project, or any project at all, it is very important to define the goals to accomplish and measure the outcome regularly. It may seem obvious that goals must be defined and measured but it is a very common mistake on IoT pilot projects and mass roll-out.

In order to properly define goals, past data and analytics generated with IoT deployments can give useful insights. Discussing with companies that have experience rolling out similar project, can be a very effective way to accurately define the project goals and support the decision-making process.

### 2. Manage the change

Launching a project that may significantly impact business systems and procedures will, invariably, create challenges within the company, driven by the required changes.

While project management can have effective methodologies to drive projects, set milestones and deliverables, change management is crucial to drive people within the organisation to see IoT as an opportunity, never as a threat, and to work alongside to make it a success, embracing the change.

### 3. Patience, commitment and perseverance

Depending on the IoT project, results and improvement might be immediate or, most likely, might take some time to show the real benefits that they can bring to the business.

It is important to understand how the project is going, by measuring the outcomes, as mentioned before, and adjusting any variables that need to be adjusted, or even tested.

Iteration through the project life-cycle with the same level of commitment is key to drive a successful implementation of an IoT project roll-out. Naturally, patience and perseverance are also essential ingredients to launch a successful IoT project, or any project at all.

### 4. New business models

Regular outcomes of IoT projects include development of new business models or optimization of existing business models. The effect that IoT had in other industries can influence how business models can be adapted to LPG industry in order to be more efficient.

In the same line of thought, there are new business models from IoT providers that can range from full CAPEX to full OPEX, passing through a profit-sharing partnership. Thus, one should understand all the business models available in the market as well as those practiced in other IoT projects and evaluate what would work best for its own case.

### 5. Financing

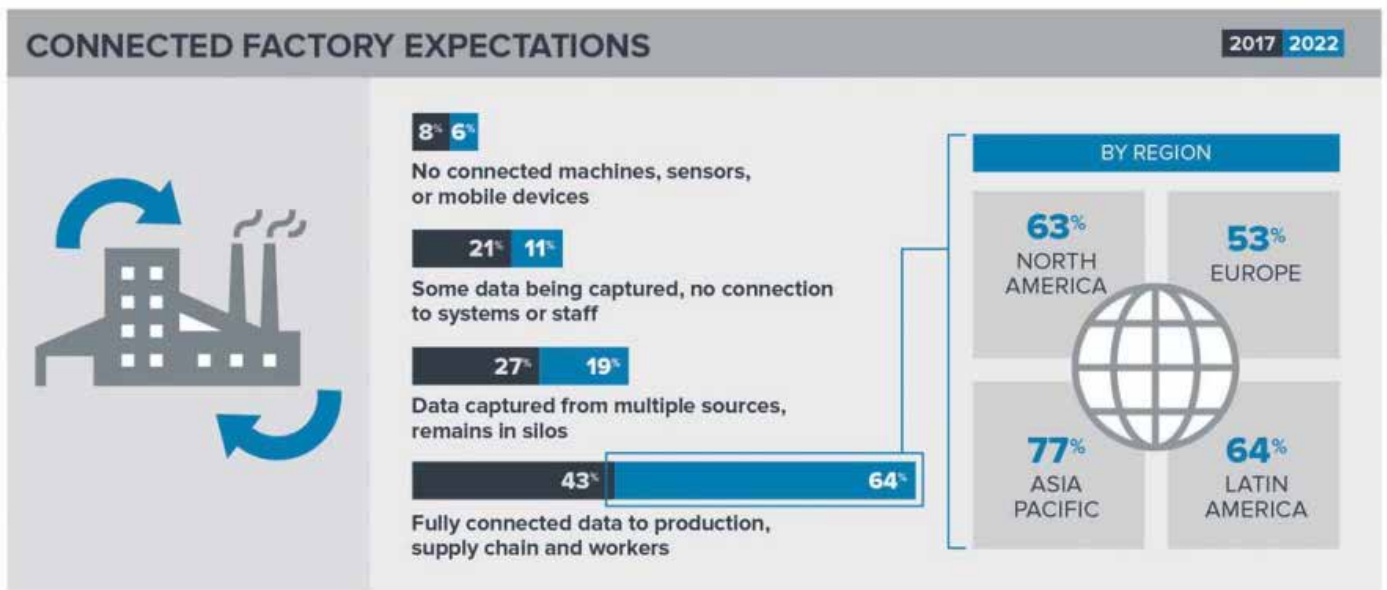
Considered as an adoption barrier, the financing of IoT projects does not need to be a hurdle. Indeed, launching a full IoT project, on day one, for all equipment with all the tricks and tools can be a very expensive project, and most likely, very inefficient.

While evaluating a project's Return on Investment (RoI), companies should take into account savings and efficiencies in labour, time and money by harnessing suitable technologies in innovative ways, while utilising existing structures, or even changing existing structures to make them more efficient.

IoT projects should be launched step-by-step, while measuring evolution and impact on both project goals and RoI. Thus, it is recommendable to start small, within company capabilities, and grow depending on the outcome and financials, making the IoT project as sustainable as possible.

## ... IOT CAN IMPROVE DEMAND FOR LPG ... CONVENIENCE SELLS...

**The key question is '...how can we improve demand for LPG - and LPG-powered products - and make LPG-powered products more popular...'. IoT can help make that happen. Convenience sells.**



Source: Zebra 2017 Manufacturing Vision Study

# IOT IN LPG



## **1. HOW CAN IOT PROVIDE MORE INFORMATION AND CONTROL OVER LPG ASSETS? SCOPE AND IDENTIFY APPLICATIONS ACROSS THE ENTIRE LPG SUPPLY CHAIN? HOW COULD IOT HELP THE LPG INDUSTRY?**

According to a 2015 survey of about 200 automation executives conducted by Morgan Stanley and Automation World magazine, improving operational efficiency and productivity are the most critical business drivers among manufacturers adopting the IoT.

The low hanging fruit for IoT in the LPG industry most likely lies in the distribution channel.

LPG primary & secondary storage and distribution, LPG filling plants, point of sale and customer delivery plus smart residential metering, are some examples.

For cylinder filling plants, the provision of productivity data to identify sources of improvement, and the application of preventive maintenance with vibration sensors.

With an estimated two billion in circulation, the LPG cylinder is one of the most capital-intensive items in the LPG business. Cylinder management is not only a safety critical activity it drives profitability.

Information about the total history of the cylinder – its birth certificate – is traditionally, permanently embossed on its shroud.

This data can now not only be stored on the cloud it can also constantly updated to include date of filling, date issued into the market, maintenance controls, requalification dates etc. It can also be tracked.

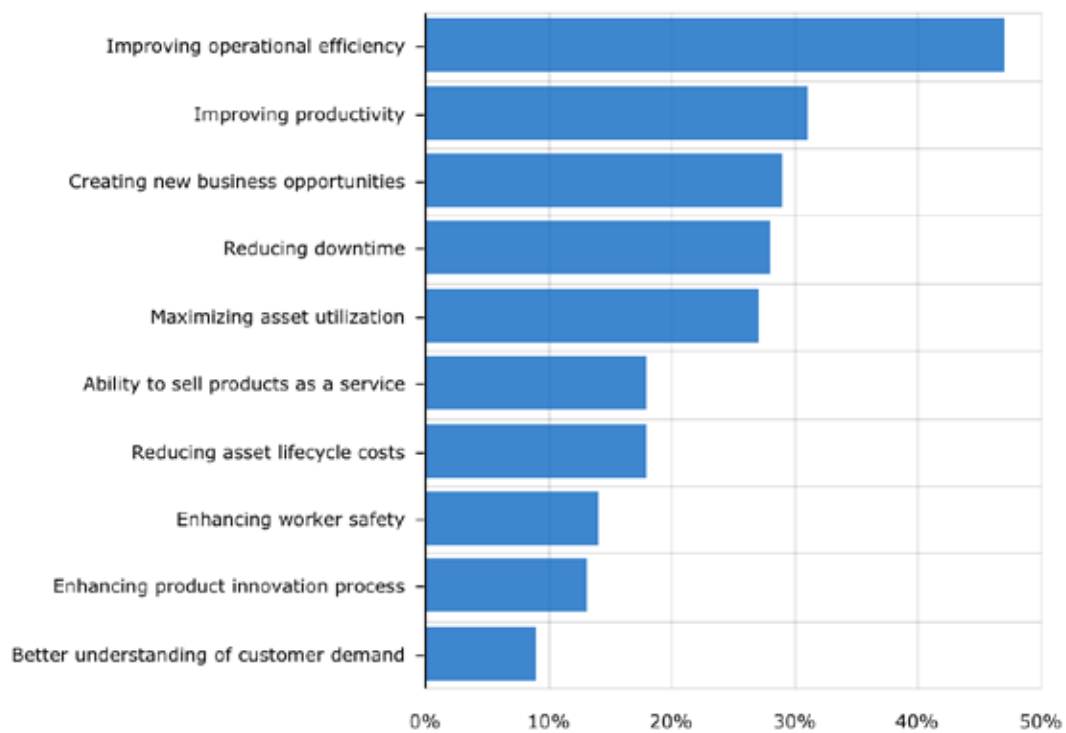
IoT can be applied to manage safety by monitoring information on the fill levels in cylinders, check whether the connections are sound and gas tight between valve and regulator, check if there are leaks between cylinder and appliance, product temperature etc.





## Adoption Drive

**Efficiency & Productivity Drive IIoT Adoption**



Sources: Morgan Stanley-Automation World Industrial Automation Survey, AlphaWise

**The applications for IoT across the LPG supply and distribution channel can be used very effectively at some of the following critical points. Some examples provided by the working group include:**

- ▶ LPG vessels that are shipping product will give real-time positioning information and expected arrival ([www.vesselfinder.com](http://www.vesselfinder.com))
- ▶ Exact time of vessel berthing can be automatically calculated if all ports and vessels interchange data with a common system using IoT
- ▶ An integrated system with sensors on pipeline networks, rail tank wagons and bulk LPG road tankers will give the actual picture of product under movement from source to unloading plant; and through the distribution channel to the consumer
- ▶ An LPG Plant can have IoT connected equipment, which will get precise communication from customers (required product, package, time, etc.) and, based on product and cylinder availability, the production system can be configured
- ▶ LPG cylinder trucks can tracked with GPS monitoring devices to show driving behaviour (speed, location, acceleration, deceleration, direction etc.) and estimated time of delivery to distributors/retailers/ consumers (see 7.7)
- ▶ LPG cylinders can have RFID/Bar-code based identification giving detailed information regarding due date of testing, company, weight, etc. and the cylinders can be tracked through to the end consumer (see 7.11)
- ▶ IoT implementation can provide information to end consumers regarding the exact location of product delivery
- ▶ Autogas (LPG in transport) underground storage tanks can be fitted with sensors to communicate with distributors to alert contents to plan optimum delivery loads
- ▶ Connecting end-users to LPG distributors, linking demand with supply. Providing more data to drive operational efficiencies across the entire supply chain, i.e. predicting demand using consumption history
- ▶ Conducting marketing interventions to drive up consumption. Perform better price elasticity analysis. Provide asset control for LPG companies
- ▶ Asset tracking, supply chain optimisation (from filling to delivery), closing the gap with end customer, smart gas metering
- ▶ The 'SmartGas' distribution model tracks cylinders, and the contents, throughout the journey from the filling plant through the distribution channel to the consumer and back ensuring the integrity of the LPG in the cylinders
- ▶ IoT can provide a company with visibility over their entire LPG vehicle fleet. It can provide live data on how much gas is remaining in each cylinder at the customer's premises. This can improve just-in-time LPG delivery, so the customer never runs out of gas, and is not tempted to seek an illegal refill. It also improves delivery efficiency for LPG distributors. It helps distributors improve their asset throughput. (In Kenya a 98%-cylinder retention rate has been demonstrated)
- ▶ New business in facility management
- ▶ Cost optimisation (Capex & Opex)
- ▶ Better understanding of customer behaviour and usage pattern
- ▶ Cross-selling and improved customer service
- ▶ IoT implementation will ensure the complete integration of import, logistics, production and storage in LPG industry
- ▶ Moving to online or mobile payments can help reduce instances of cash losses or incorrect bookkeeping

- ▶ Providing managers with accurate data on assets owned and accurate figures on losses sustained; an understanding what is going on at customer locations and in the supply chain, including distributors, and drivers
- ▶ Increasing safety of users by monitoring safety critical conditions, reducing total costs and optimising infrastructure, increased innovation in the LPG industry and positioning towards other energy sources (natural gas, oil, wood, electricity)

## 2. WHAT INFORMATION ARE COMPANIES LACKING TO MAKE INFRASTRUCTURE INVESTMENTS?

A vision study conducted by Zebra ([http://online.zebra.com/Retail\\_Vision\\_Study\\_US](http://online.zebra.com/Retail_Vision_Study_US)) mentioned several barriers that companies might face when adopting IIoT. These included understanding the complexity of technology available, concerns over the security of the technology, and resources and budgetary requirements.

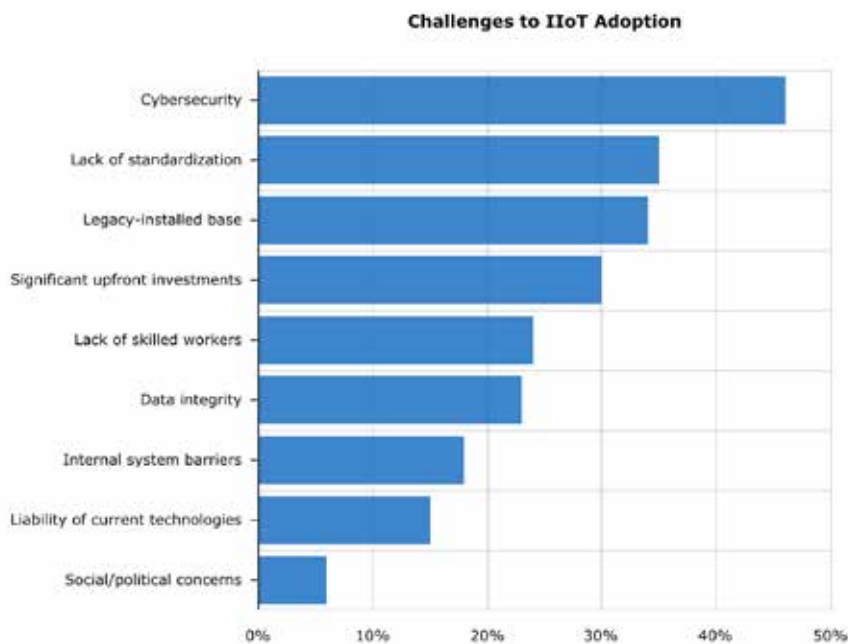
### BARRIERS TO IIOT ADOPTION



Source: Zebra 2017 Manufacturing Vision Study

During the WPGA powerplay session some of these same concerns were raised.

According to the same survey conducted by Morgan Stanley, the main challenges and barriers for the adoption of IoT were not dissimilar. This is something the LPG industry is also likely to face.



Sources: Morgan Stanley-Automation World Industrial Automation Survey, AlphaWise

### 3. SHORT, MEDIUM AND LONG-TERM TECHNOLOGIES THAT COULD BE ROLLED OUT ACROSS THE INDUSTRY

Some of the current activities that are being monitored through IoT include:

#### Short Term:

- ▶ Asset tracking system for LPG cylinders, with interoperability. Some companies already have their own cylinder management systems, so this may not be new to them. Digital financial ledger systems ('...let's get rid of pen and paper, Excel, etc.)
- ▶ Leveraging existing IoT devices, for example, if every LPG distributor had a good internet listing then they could easily be found via voice search. Similarly, tank dispensers and fueling stations could be more readily findable.
- ▶ Bulk and storage tank monitoring
- ▶ Cylinder cage monitoring
- ▶ Auto-changeover valve monitoring
- ▶ Automated meter reading
- ▶ GPS for tracking and locating assets; RFID, barcode or OCR for identifying assets; Sensor technology for detecting and reporting on status of assets. This will help companies:
  - Count inventory
  - Invoice for lost assets
  - Comply with maintenance requirements
  - Automate customer invoicing
  - Track vehicles and driver performance (implementing rewards programmes)
  - Eliminate pilferage of cylinders and gas

- Optimise processes in plant, in the field and in accounting processes
- Create an improved and more personalised customer experience

- ▶ Sensors on tanks that allow homeowners to know when they need to refill, especially if it is linked to weather forecasts.

#### Medium Term:

- ▶ Asset monitoring devices (answers the question of how much gas is left in the cylinder - when to schedule a replacement)

#### Long Term:

- ▶ Predictive analytics and big data (getting better at forecasting demand and de-risking investments in LPG infrastructure)
- ▶ Ways to streamline and optimise LPG-logistics on a wider scale

The technology rollout will depend on:

- ▶ The level of development and application of LPG among countries
- ▶ Study of LPG users and LPG industry needs
- ▶ Deployment of an IoT communication network
- ▶ Elaborate ROI scenarios and business planning
- ▶ Mandatory regulation



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# CASE STUDIES OF IOT IN LPG



There can be both a fear of new technology, and a risk of having a blinkered approach to new ideas.

...TO MEASURE IS TO KNOW, IF YOU  
CANNOT MEASURE YOU CANNOT IMPROVE  
LORD KELVIN  
(WILLIAM THOMPSON 1824-1907) ...

The following examples illustrate some applications where IoT is being used successfully in the LPG industry today. They include an initiative used to create an open mind to IOT by using resources outside the industry.

## **1. THE BLUE ROOM - ULTRAGAZ ([WWW.ULTRAGAZ.COM.BR](http://WWW.ULTRAGAZ.COM.BR))**

An example of how one company broke through this barrier to identify opportunities for IoT in their LPG business is Ultragaz, Brazil.

Their key objective was to test new business models in order to develop different alternatives to improve efficiency across their entire business

needs. Ultragaz did not want to be restrained with blinkered thinking so they created their UltraOne project.

UltraOne was based on recruiting 100 start-ups to test concepts as they searched for opportunities to find improvements in their total business. There was commitment from the Ultragaz management and board, the allocation of a 'Blue Room' to stimulate free thought, and - using a hackathon approach to brainstorm ideas - the group interrogated challenges and came up with possible solutions.

The next step for Ultragaz is to develop partnerships to exploit the new projects identified within the business areas.



## 2. DIGITALLY CONNECTED OILFIELDS – INGENU (WWW.INGENU.COM)

A less obvious example from the upstream business, where LPG originates from, is in Africa. The Niger Delta produces approximately two million barrels of crude oil a day, making Nigeria one of West Africa's biggest producers of petroleum. As a key operator in the region, Shell Nigeria needed to automate several manual processes to create a work environment that is safer and more secure for its employees as well as the production facility.

After investigating several IoT technologies, the company knew creating a digitally connected oilfield could help its processes become more efficient and its operations more productive. However, because of the location and rugged terrain, bringing connectivity to the oilfield was challenging and expensive. Details of how this was overcome are in the following case study: <https://www.ingenu.com/solutions/industries/digital-oilfield/>

To monitor its oilfield operations across a large and remote area in the Niger Delta, Shell Nigeria relied on a series of manual processes for wellhead monitoring and pipeline surveillance.

The company is involved in all segments of oil operations, including exploration and production, upstream and midstream.

Its IoT solution needed to scale for future expansion as well as be able to deliver different information over different communication protocols. The IoT solution requirements were:

- ▶ Real-time monitoring of different processes throughout the oilfield
- ▶ Two-way communication that improved the company's ability to monitor remotely and perform remote intervention for scheduled maintenance as well as unscheduled incidents
- ▶ Support for the end devices to run solely on battery power only because the remote locations of some equipment made hardwired electrical connections impossible
- ▶ The ability to monitor operations through a local operations centre as well as at the company's headquarters in Europe
- ▶ A system that provided reliability, data integrity and security.

Connectivity was a key factor—how could Shell take advantage of all that IoT had to offer its operations without incurring significant expense in building out infrastructure to support IoT connectivity? The company needed to make not only a strong technology case for the IoT solution, but also a strong financial case.

Shell evaluated several options, including satellite, SMS and General Packet Radio Service (GPRS). Each of these options required significant infrastructure investment in the form of towers, radios, data communications equipment, battery banks, logistics and installation, making them too expensive.

The problem with other solutions Shell considered was that they were designed for use by people, not machines. Shell could benefit most from a technology that was designed specifically for machine connectivity. To meet its needs for reliability, security and longevity, they selected Random Phase Multiple Access (RPMA®) technology from Ingenu™, one of the pioneers in delivering connectivity exclusively to machines, and end devices from Croatia's KONČAR, a producer of industrial electronics and power electronics devices and systems. Upland Consulting Nigeria provided all the necessary support and conducted all field/installation services.

KONČAR has built RPMA modules into its end devices, and Shell Nigeria has installed these

devices in the flow-stations, manifolds, at wellheads and other customers' facilities. The devices provide two-way connections between the oilfield and the office, providing a reliable stream of data from the field such as pipeline pressure, temperature and flow. The devices can also encrypt transmitted data, control power consumption, perform over-the-air (OTA) parameterization and updates, and conduct scheduled and alarm reporting. In addition, KONČAR delivered the multiple connection and data export system with its Modbus Gateway & Management Studio (MGMS), enabling MODBUS TCP/IP and OPC connectivity for Shell. The KONČAR Remote Terminal Units and wireless pressure and temperature transmitters were installed in flow stations, manifolds, and wellheads to provide connection from the field.

### 3. INTEGRATED FILLING PLANTS - INDIAN OIL CORPORATION (WWW.IOCL.COM)

IOC has carried out its first proof of concept (POC) for an IIoT project in LPG plants by hooking-up all LPG cylinder filling plant operating machines such as the carousel, checking equipment, etc. to a centralised server. This created a centralised dashboard for higher management where all details with respect to performance parameters are displayed with built-in analytics. This is expected to result in marked improvement in OEE (overall equipment efficiency) and in turn increased productivity.







Sensor in location

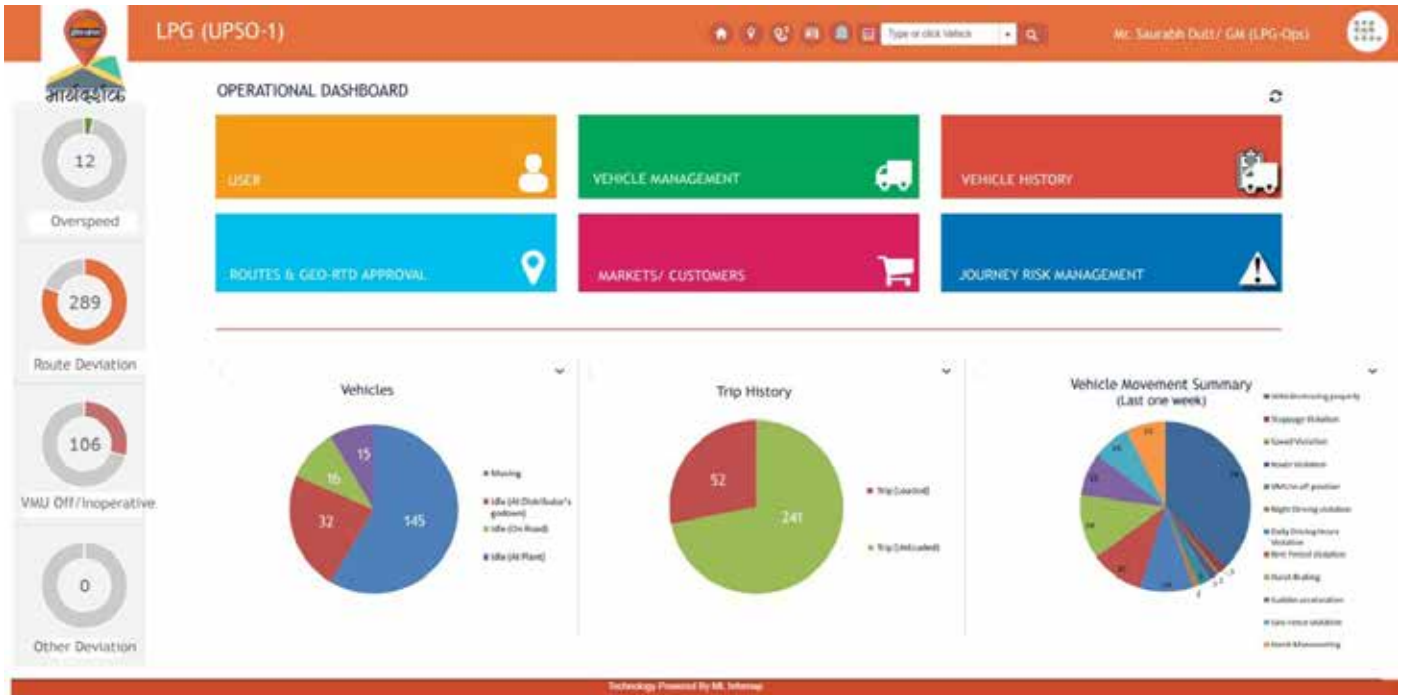


VTS VMU (vehicle mounted unit) mounted on an LPG Truck (IOC)

The diagram above shows a central web-enabled dashboard for Remote monitoring of filling shed equipment.

IOT implementation has been done by logistics service providers by utilising vehicle tracking systems (VTS) on trucks.

The same concept in an integrated manner is being implemented by IOC in India where around 20,000 LPG vehicles will connect with VTS devices for carrying out live tracking of vehicular movement. This results in obvious advantages such as increased safety en-route, lower turn-around times, lower overall logistics cost, and the monitoring of drivers driving behaviour, etc.



Standardised web-enabled VTS dashboard (IOC)

## 4. BULK TANK MONITORING - ISA SENSING (WWW.ISASENSING.COM)

Intelligent Sensing Anywhere has deployed IoT to optimise deliveries of bulk LPG through the deployment of 50 bulk tank monitors at consumer sites. The result is a reduction in ‘bad’ drops and an increase in ‘good drops’ as shown below in the first case.

### Customer Case – Example 1

#### Goal

Optimisation of LPG deliveries with tank monitors

#### Project Description

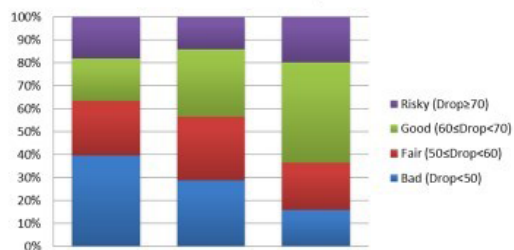
Gathered delivery data from customers

Deployed 50 tank monitors

Worked with operations to deliver LPG based on the forecast & alarms

Analysed data of delivers after three months

Evolution of LPG Drop Amount



#### Outcome

In first three months the ‘bad’ drops decreased around 25%  
While the ‘good’ drops increased 30%

The second example, following the deployment of 30 tank monitors, illustrates an almost 20% reduction in cost over a three-month period.

### Customer Case – Example 2

#### Goal

Optimisation of LPG deliveries with tank monitors

#### Project Description

Gathered delivery data from our customer

Deployed 30 tank monitors

Worked with Operations to deliver LPG based on the forecast & alarms

Analysed data of deliver after three months

Outcome	Total Volume of Deliveries (gallons)	Total Number of Deliveries	% Tank Level Before Delivery (DIP)	% Tank Level Delivered (DROP)	Total Cost (C\$)
Before Tank Monitoring	67 526	337	43%	44%	\$6,403
After Tank Monitoring	100 657	276	30%	59%	\$5,244
% Change	49%	-18%	-30%	34%	-18%



## 5. THE ROAD TO 60% AVERAGE FILL

Silicon Controls (WWW.SILICONCONTROLS.COM) describe how IoT can create a competitive advantage in the LPG distribution channel through the deployment of IoT & its integration with forecasting, ticketing and scheduling systems.

### Customer case study – US Customer 1:

The customer deployed 5,000 cellular IoT devices to 25% of their commercial and domestic tanks over 4 years. Using Silicon’s change management model (fig 1) in conjunction with Gaslog Transform ©, Silicon’s business analytics package, they were able to halve out of gas (OOG) rates, almost triple gallons/drop and reduce their truck fleet by 20%. Future IoT deployments will likely include both cellular and LPWAN IoT monitors (Figure 2).



Figure 2 - LPWAN IoT Device

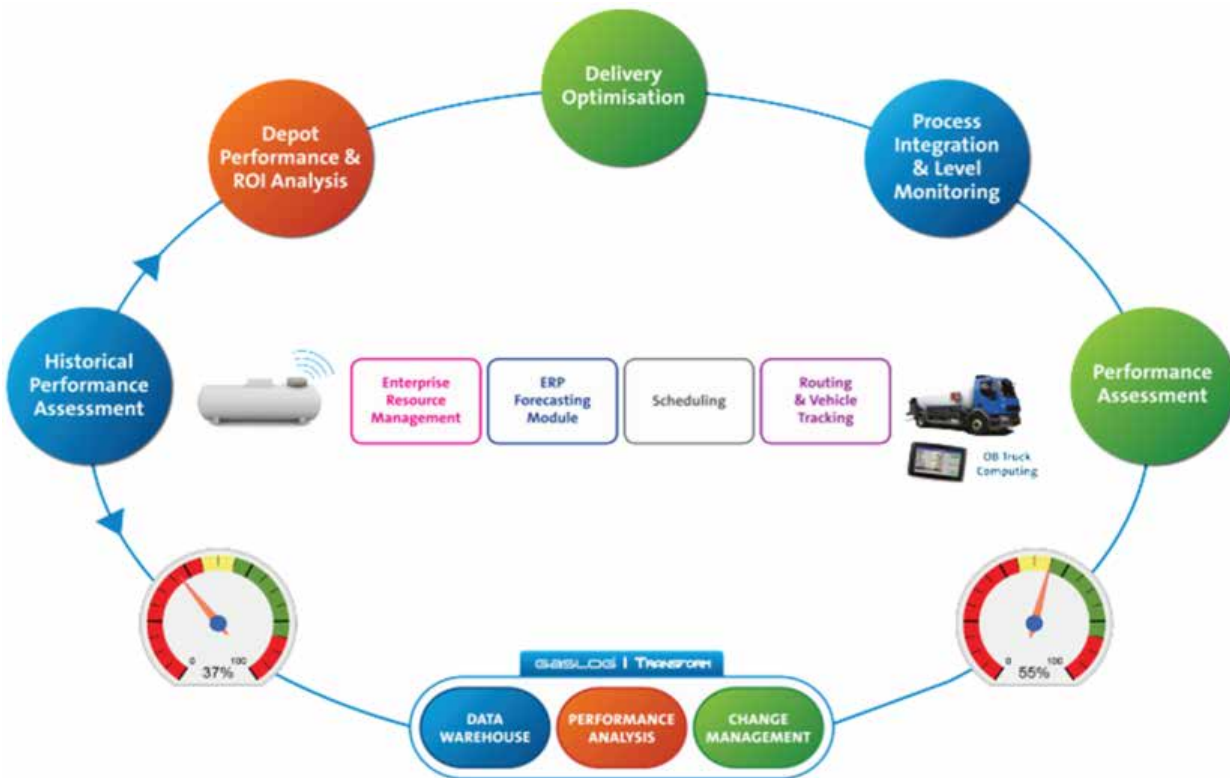


Figure 1 - The Road to 60% Average Fill

### Customer case study – US Customer 2:

Over four years, the customer rolled out 5,500 cellular IoT devices to 8% of customers, targeting tanks with 5+ fills/year, averaging fill rates of <39%. Using Transform to assess the impact of deployed devices, IoT data was used to both refine delivery rates and optimize routes (minimum miles/stop).

#### IoT MONITORED TANKS

- 34% OF DELIVERED GALLONS
- 13% OF STOPS
- 3.6 X UNMONITORED DROP SIZE
- AVERAGE FILL ALREADY 54%

#### UN-MONITORED TANKS

\$2.9M EXCESS COST ON CURRENT STOPS

WINTER 2018	UNMONITORED	MONITORED
Average fill	43%	54%
Fills @ 55% to 65%	30%	59%
Saveable fills @ 55%	80,673	4,389
Number of A/Cs	56,827	5,300
Total Deliveries	163,619	23,747
Total Gallons	22,090,318	11,445,021
Gallons/drop	135	482
Delivery cost/gallon	\$0.28	\$0.08
Excess fill cost	<b>\$2,976,429</b>	<b>\$160,131</b>

Based on these results, roll out will reach 10,000 tanks by mid-2019.

### 6. CYLINDER SMART METERTM - PAYGO ENERGY (WWW.PAYGOENERGY.CO)

'...probably one of the most exciting developments to hit the LPG industry ever...' is how one person described the cylinder smart meter (CSM) technology developed by PayGo Energy.

In emerging markets, products and services are reduced to their lowest level of consumption, a single serve, or sometimes a less costly three-day use, which makes it more affordable for the mass market. This is known as the sachet economy.

Fast Moving Consumer Goods (FMCGs) companies such as Unilever have perfected this business model. In India for example, 95% of shampoo sales are through single use sachets.

Fuels for heating, lighting and cooking are no different. Three billion people globally still cook with wood, charcoal and/or kerosene, because it is not possible to purchase a single serve of LPG.

Fuel	Single Serve Cost (\$ USD)	
 <p data-bbox="639 349 730 376">Charcoal</p>	<p data-bbox="967 349 1182 376">\$0.50 - Lasts one day.</p>	
 <p data-bbox="635 584 730 611">Kerosene</p>	<p data-bbox="967 584 1177 611">\$0.50 - Lasts one day</p>	
 <p data-bbox="687 853 730 880">LPG</p>	<p data-bbox="887 853 1257 880">\$24.00 per 13kg refill - Lasts 90 days.</p>	

Making the LPG cylinder smaller has been tried before and is too costly. Smart metering works in piped natural gas systems. PayGo Energy has successfully piloted an LPG cylinder smart metering system since 2015. It is important to note that this too, is not a new concept.

The coin-in-the-slot meter that was common in kitchens in the 1950's – dispensing small amounts of gas through a meter following the insertion of a coin – PayGo Energy has developed a modern-day equivalent that uses mobile money and can be fitted to LPG cylinders enabling households with restricted incomes to access gas instead of traditional fuels such as wood and charcoal.



With the use of its LPG cylinder smart meter, PayGo Energy can sell customers a single serve worth of fuel. This system helps unlock the three billion people currently priced out of LPG.

The Cylinder Smart Meter (CSM) serves two purposes. For the end consumer, it is a new way to purchase a single serve worth of gas. For the LPG marketers, the CSM allows them to see where their cylinder assets are, and how much gas is left in each cylinder in real time.

Distributors can better optimise and orchestrate cylinder exchanges, to be much more efficient and serve the same customer base with fewer cylinders.

As the cylinder is in the household on consignment the consumer does not have the responsibility of refilling it. This mitigates the risk of illegal filling because the LPG supplier

has that responsibility and replaces the nearly empty cylinder with a full one before it runs out.

With the data that is collected, as the consumer buys small quantities of gas, the supplier can predict when the gas is being used, the rate at which it is being used, and use that information to plan logistics efficiently.

The real benefit of this technology though is to reduce the barrier to LPG when transitioning from traditional fuels. Potentially the cylinder smart meter technology can provide the opportunity to present modern energy to a population that thought it was financially beyond their reach. Their financial outlay with the cylinder smart meter is no more than when buying a bag of charcoal or a bundle of firewood. Even the deposit for the equipment can be organised with micro finance.

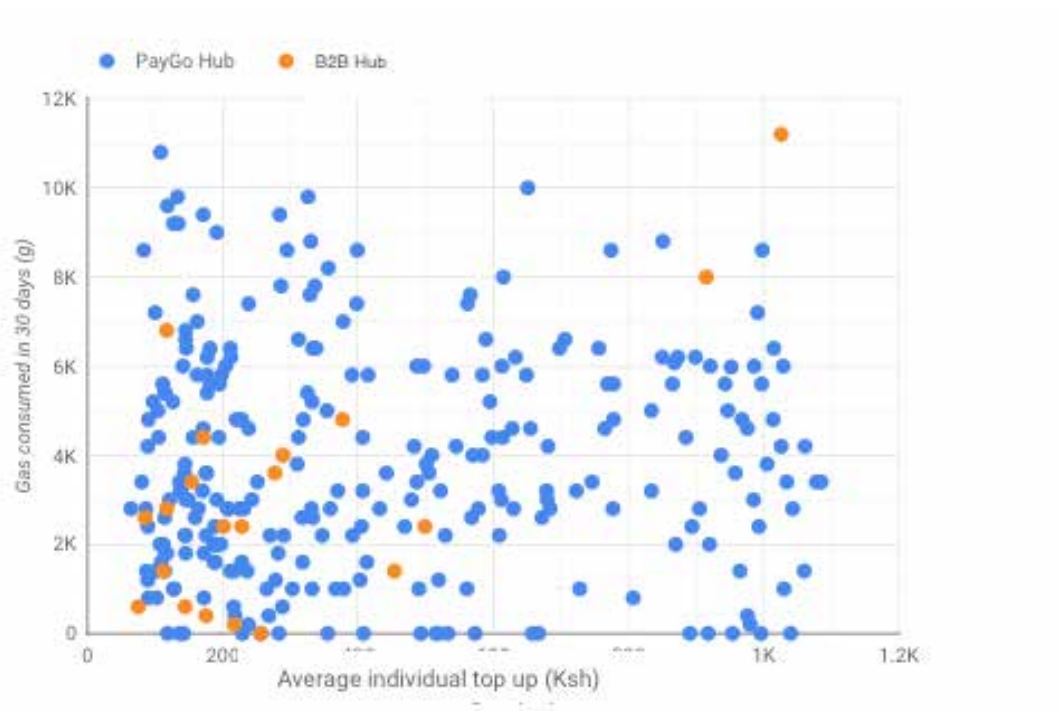


## Results from Field Trial in Nairobi Kenya

The scatter plot below shows the comparison of customer top up sizes versus the average consumption of that household per month. The graph has both PayGo customers from their own retail operations (blue) and their B2B pilot customers (orange) which is currently ongoing with a multinational OMC. What this shows is that there are emerging clusters of purchasing behavior that demonstrate clearly that the meter is critical in enabling both customers in the left quadrants to continue to purchase gas in small amounts and in the right quadrants you have customers that did not use gas before, but are

now ready to move off of the meter because they are making larger and larger top up amounts. In this way, the meter is catalytic in that it can move to multiple households to drive gas consumption from customers that prefer to make small purchases as well as customers that change their behavior over time and eventually purchase a full cylinder.

Another key data point from the operations, is that in nearly two years of operation they have lost just 2% of their cylinders. That is because they have a unique value proposition at the household and control the cylinder as it flows through the supply chain using the PayGo platform.



### Key Results

- ▶ Pilot operations began in **October 2015** and are currently ongoing
- ▶ **98% cylinder** retention
- ▶ **90% customer** retention
- ▶ **86% of customers** are first time LPG users
- ▶ Average **consumption is 12kg** per capita per year
- ▶ Over **10,000 digital payments** made using mobile money

## 7. DRIVER EFFICIENCIES – CEFA (WWW.CEFA.COM.AU)

An Australian company was contracted by BG in 2006 to transport 400MT/day of propane by road from Sfax to Gabes in Tunisia while a pipeline was being installed to take the product from the natural gas plant to the port for exporting to the Mediterranean, a 120km journey. The challenge was to ensure the whole operation, which could potentially last some years while the land leases were being negotiated for the pipeline, was carried out with zero incidents.

While the operation could be carried out with state-of-the-art loading and unloading equipment and 'best in school' prime movers and road tankers, the main challenge evolved around the quality of drivers and their adherence to procedures, both while on the road and at the loading/unloading bays.

Recruitment and training of the drivers was conducted in the knowledge that the prime movers and road tankers were to be fitted with GPS tracking that was able to monitor not just the location of the prime mover (and road tanker in case they were separated) but also speed, acceleration rate, deceleration rate etc.).

The ability to monitor the vehicle and drivers to this extent allowed the operation to be tracked in detail to demonstrate compliance to traffic rules. Drivers were able to report back on weather, traffic and road conditions enabling scheduling to be adjusted if necessary.

Engagement with the drivers at the beginning of the programme was critical to the success of the operation. Their acceptance of their driving behaviour being analysed to such a degree had to be understood as a positive measure to avoid them believing they were being 'watched'. To achieve this the monitoring programme was linked to a safety campaign where drivers were selected each month for an award based on their driving behaviour.

The result was an incident free operation which lasted three years.

This Tunisian project was over ten years ago and since then technology has advanced to the extent that facial recognition technology is now available to be used to facial-recognition technology is not just about identifying people, it can also be useful aid to stop people falling asleep at the wheel.

According to the UK government's 'Think! campaign' (<https://www.think.gov.uk/>), almost 20% of accidents on major roads are sleep related and about 40% of those accidents involve commercial vehicles. Drowsiness-detection facial recognition systems work by monitoring head and eye movement, alerting the driver to stop before they fall asleep.





## **8. METER TRACKING - DREAMTEC (WWW.DREAMTECHSYSTEMS.COM)**

has a two-part system - Meter Tracking and Mobile Fleet Management (<http://dreamtechsystems.com/how-it-works/>).

The Meter Tracking system is a stand-alone system that can be installed easily into an existing fleet of delivery vehicles. It gives business a running total of deliveries in the field, independent to any ERP system, along with the exact/accurate mapping of where the delivery occurred. The system works seamlessly in the background, gathering data on the deliveries as they occur but also tracking the vehicles' location. Office staff can quickly search for metered tickets and the system will pull the relevant ticket printed by the meter in PDF format. The real benefits for the office staff are not having to chase down bits of paper from drivers. The electronic ticket is available to office staff once it has been printed.

If businesses are suspicious of any fraudulent activity then it is quickly discovered by Meter Tracking, the system has some exception events that are built in. Geofencing is used for certain deliveries, any deliveries that occur outside that fence are then reported. There are also smartphone apps available that give real-time snapshots of the delivery fleet. Dreamtec also do some business benchmarking on where companies fit into their customer base in order to compare against certain statistics e.g. key performance indicators (KPI's) such as the number of deliveries per day per driver, the average distance travelled between deliveries etc.

Dreamtec have published a case study based on Northern Energy, a family-owned, fourth-generation oil and LPG distributor based on the edge of the Yorkshire Dales in the UK. <http://dreamtechsystems.com/case-study/northern-energy/>.

Northern Energy had reached a point in its development where growth management was rising to the top of the agenda. To maintain and improve current levels of performance and customer service, management began to look for a system that would enable real-time visibility over the entire fleet.

Northern Energy wanted a solution that would not only allow fleet tracking but also stock monitoring. This type of insight into delivery activities and trends would give them the tools they needed to make informed decisions, to grow in an agile, sustainable and controlled way and to enhance their customer service offering.

Northern Energy trialed two systems for three months including the DreamTec Command's meter tracking which was selected and installed across their fleet. It integrated with the LC TE550 and MechTronic flow meters.

Following the success of meter tracking, Northern Energy progressed to mobile fleet management. As a due diligence measure, Northern Energy trialed DreamTec Command's mobile fleet management against another system on the market, both of which were capable of integrating with its ERP, Codas. After two months, DreamTec Command was selected and the system was rolled out across the entire fleet.

By choosing a system that monitors both fleet and stock in real time, Northern Energy has been empowered to elevate its standards of customer service and productivity. The live data presented by DreamTec Command gives the team a complete picture of vehicle and stock movements throughout the day and allows for instant redeployment of resources based on location and onboard stock levels.

Same-day orders can be sent to drivers electronically without disturbing their workflow. Troubleshooting is simplified, and the team can proactively manage customer accounts in an organised manner.

Knowing where each vehicle is, and how much fuel it has on board at any time throughout the day, enables quick decision-making and a speedy resolution of customer queries. Independent meter stamping and electronic processing of transactions have also improved billing accuracy and allow for faster invoicing of completed deliveries.

DreamTec also have LPG customers using their technology in Cyprus and Jersey.

## 9. SMART TANK TECHNOLOGY - SUPERIOR PROPANE, CANADA (WWW.SUPERIORPROPANE.COM)

Superior Propane have a simple approach to describing what digital transformation means to them.

Superior Propane's digital assets are highly integrated with logistics, operations, call centre, and back office.

Their three key objectives are:

- ▶ Customer experience: Convenient and paperless, web or mobile, reliable and seamless
- ▶ Operational excellence: Improved efficiencies, improved asset utilisation, lower overheads
- ▶ Organic growth: Unique value proposition, differentiated offer, improved acquisition and retention

This is triggered through smart tank technology that first sends a reordering alert via the network leading to the following transaction flow.

The plan is to roll out the MySUPERIOR concept across Canada under project LOGISTICS 2020. This will result in tens of thousands of smart tanks using big data optimise routing autonomously, improving service levels, efficiencies and human intervention.



# '...IOT ADOPTION WILL CONTINUE TO ACCELERATE WITH SMALLER ORGANISATIONS BEING ABLE TO HARNESS THE ADVANTAGES OF IOT TECHNOLOGY TO DRIVE GREATER EFFICIENCY AND VALUE FOR THEIR CUSTOMERS...'

PHIL SKIPPER - HEAD OF BUSINESS DEVELOPMENT IOT - VODAFONE GLOBAL ENTERPRISE

40% of Superior's customers access their websites and portals through mobile devices. By 2020 it is estimated that 75% of US households will use Smart Speakers.

Superior are exploring opportunities to integrate with Google Home and Amazon Alexa. The company believe the future is mobile and connected in-home with consumers able to say: "Hey Google, what's the level of my tank?"

They believe digital improves the customer experience, loyalty, operational efficiencies, and lowers costs. Digital allows them to differentiate and '...help them win...'

Key future initiatives include and AI-enhanced LOGISTICS 2020, and a new service platform. They state they will continue to innovate in mobility, Internet of Things (IoT) and smart home devices.

## 10. THE CHALLENGE - VODAFONE (WWW.THENEXTWEB.COM)

Vodafone UK launched the Vodafone Challenge in 2018 (<https://thenextweb.com/vodafone-tnw-iot-challenge/>) where several companies, including LPG company SHV Energy, joined as one of the partners.

The IoT Challenge is a unique collaboration between Vodafone and TNW (<https://thenextweb.com/>) aimed to help IoT companies grow and reach new customers.

At the same time, boosting large organisations to stay competitive.

Vodafone promote the Challenge with: '...The Internet of Things (IoT) is transforming lives and business around the world, and it's not hard to see why. IoT solutions can help you unlock new revenue streams, improve efficiency and increase customer engagement and loyalty. Why risk being left behind? We can help you make the most of this powerful technology, delivering immediate benefits and setting you up for future success...'

One of the companies partnering in the Challenge is SHV Energy who are '...looking for smart technologies to provide insights in the location and fill levels of gas cylinders in order to facilitate new services such as the analysis of usage patterns in order to prevent running out of stock. Solutions may be attached directly to the cylinders, or to the pallets that they are transported on. Solutions for any type of cylinder are welcome. SHV Energy is a leading dedicated global LPG distributor. In that capacity, it continuously aims to break new ground in developing existing and new markets for LPG around the world through effective innovation, education and promotion strategies. SHV Energy operates in more than 20 countries, where it provides decentralised energy sources LPG, LNG and biomass to tens of millions of customers...'

The Vodafone Challenge is an example, like Ultragas, where companies are not afraid 'to look outside the box' for solutions to business challenges using IoT.

## 11. RFID – TROVAN (WWW.TROVAN.COM)

Trovan develop radio frequency identification (RFID) technology for LPG Asset Management and Cylinder Tracking. They estimate that between 10% - 40% of LPG cylinders go missing every year.

Customers do not return cylinders, mandatory safety inspections are missed, operators have no means to track vendor performance (cylinders, valves, 'o' rings and other components), and pilferage and diversion of LPG prevails.

Trovan have been developing RFID technology since the 1980's and have been tracking LPG cylinders for over 20 years.

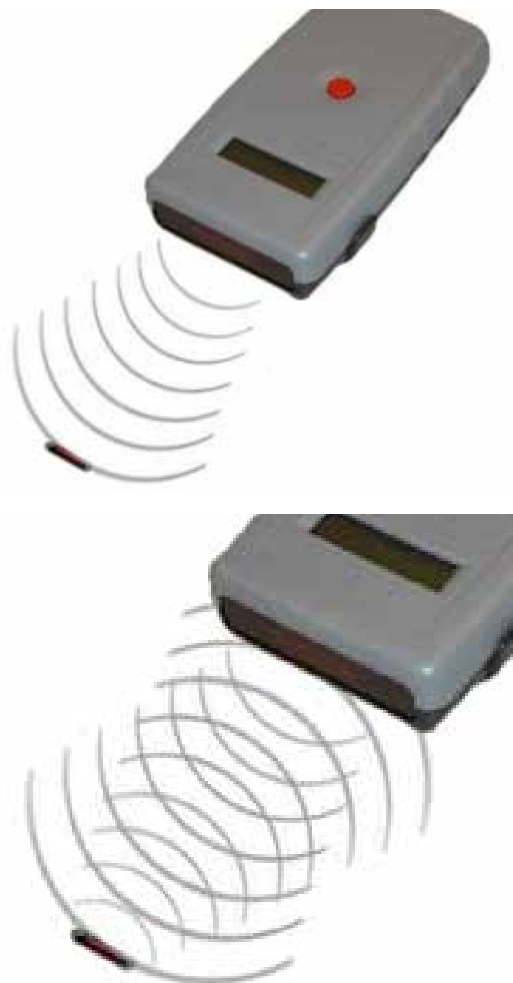
The reader emits a magnetic field and when a tag passes through the field its antenna coil is energised. The tag sends its ID code back to the reader where the reader's coils senses the tags signal. The tags code is displayed on the readers LCD.

RFID cylinder tracking technology enables asset control, improves supply chain management, determines proof of ownership, reduces cylinder inventory and the amount of money tied up in non-performing assets as well as maximising cylinder circulation rates.

An example of how this technology has been applied is in Portugal with Digal/Oz Energia. They introduced RFID on their cylinders in 2013.

The tracking system monitors the cylinders in the supply chain to the end user. The Siraga filling carousel conveyor can be run at standard speeds (no slowdown, stops) and no spacing is required between cylinders or any special tag orientation.

The RFID tags will work on cylinders in poor condition. Cylinders are automatically ejected if they are due/overdue for requalification or any other criteria. The palletisers and depalletisers are equipped with ATEX-certified readers to read pallets and the system associates cylinders with the pallets.



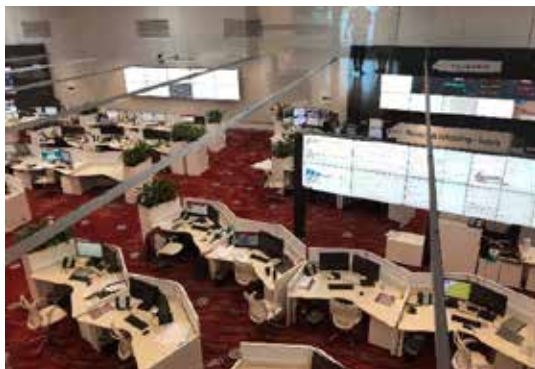
Dispensed fuel, and residual LPG in each cylinder, can be tracked. Digal/Oz Energia has been able to accomplish the following:

- ▶ Positively identify each cylinder for life: from manufacturer to scrapping
- ▶ Achieve supply chain transparency
- ▶ Track each cylinder from filling plant all the way to the consumer
- ▶ Prove ownership of cylinders
- ▶ Assure cylinder safety
- ▶ Automate billing and generation of reports
- ▶ Pro-active sales forecasting, production planning, capacity planning
- ▶ Accelerate inventory circulation and eliminate dead inventory
- ▶ Access important cylinder information automatically and quickly (date of purchase, tare weight, inspection date, maintenance records, history of cylinders).

## 12. DRIVERLESS OPERATIONS – ROY HILL ([WWW.ROYHILL.COM.AU](http://WWW.ROYHILL.COM.AU))

Roy Hill is a recently developed 55 million tonne per annum (MT/year) iron ore mining, rail and port operation in West Australia’s Pilbara region.

Its entire on-site operations are undertaken without drivers or operators.



The operations are conducted from Perth, 344km away, at the Roy Hill Remote Operations Centre (ROC).

Situated approximately 340 kilometres south east of Port Hedland in West Australia, Roy Hill is a low phosphorus, Marra Mamba iron ore deposit located in the Pilbara – close to Asia and in one of the world’s premier iron ore provinces. Roy Hill is an independent iron ore operation with West Australian majority ownership.

Operations consists of a:

- ▶ Conventional open pit, bulk mining operation from multiple production benches
- ▶ 55MT/year wet processing plant
- ▶ 344 km single line, heavy haul railway
- ▶ Purpose built, dedicated two berth iron ore port facility in West Australia, capable of receiving, stockpiling, screening and exporting 55MT/year (wet) of direct shipped iron ore as lump and fines

Roy Hill has a defined mineralisation of more than 2.2bt of +50% Fe iron ore of which 1.2bt is +55% Fe, enough to sustain a mine life of more than 17 years. With integrated mine, rail and port facilities, which has the capacity to deliver 55Mtpa – Roy Hill is one of the world’s major resource-based operations, which will deliver enormous benefits to the broader community for years to come. Roy Hill loaded its first shipment of ore for export on 10 December 2015 and has since loaded multiple shipments to its key markets in Japan, Korea, China and Taiwan.

# STANDARDS AND REGULATIONS



## 1. ASSESS THE REGULATORY LANDSCAPE

IoT technologies and standards are still far from its maturity ages, therefore new developments see the sunlight every day. There are some IoT standards being used for a variety of use cases, some for very specific industries, however, some emerging standards within IoT are fighting for dominance in the market to become a “de facto” standard, while some other are looking for the stamp and approval of a specific association.

According to Gartner, in “Hype Cycle for IoT Standards and Protocols, 2018” by Billy Ray, which standards around connectivity, security and messaging systems for the Internet of Things, one can clearly see that there many standard and protocols rising and falling:

### ► On the Rise

- Backscatter Communications
- Micro OS
- Li-Fi
- 5G mMTC
- 802.11ax
- Ultrasound
- OMA SpecWorks LightweightM2M
- Hardware Security

### ► At the Peak

- RISC-V
- Constrained Application Protocol
- 802.11ai
- Bluetooth 5
- FIDO Authentication Protocols
- Secure Processing Unit
- Advanced Development Boards
- e-SIM
- LoRa
- NB-IoT

### ► Sliding Into the Trough

- Arduino
- Data Distribution Service
- LPWA
- Sigfox
- Thread
- oneM2M
- 802.11ad
- DotDot
- MicroPython
- Bluetooth Beacons
- Wi-SUN
- 802.11ah
- 802.11p
- Trusted Environments
- LTE-M



► **Climbing the Slope**

- Message Queue Telemetry Transport
- IPv6
- AMQP
- 6LoWPAN

On top of all these standards and protocols, some others industry-related, such as DLMS-COSEM for smart metering, are also being developed and customized to serve better its purposes.

The security around IoT is another topic that is generating a lot of attention as more and more equipment is deployed. As an example of what is being done, in September 2018, California's Governor Jerry Brown signed a cybersecurity law (bill SB-327) making California the first state with an IoT security law. Essentially, this law states that any device that connects to the internet must have some specific security features implemented and activated to minimize chances of cyberattacks.

There is still a long way to go until there is some clarity on the standards adoption for IoT, however, it is clear that the discussion is on-going and that it should benefit all of those that are looking into IoT.

**2. CAN WE DEVELOP NEW COMMON STANDARDS FOR THE USE OF IOT ACROSS THE INDUSTRY?**

With IoT being in the early stages of development there is a need to develop new common standards for its use across the industry.

Following the work of Paygo Energy the Kenyan Bureau of Standards is now developing the world's first standard for LPG cylinder smart meters in collaboration with, and support from, the WLPGA.

The WLPGA may have an important role in facilitating the creation of a common minimum safety standards playbook, which will ensure the safety of products for end consumers.

# APPENDIX 1:

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## POWERPLAY

WLPGA Houston Forum  
Wednesday 3rd October 2018 – 2.15pm to  
3.15pm  
Summary of notes from the meeting

Mr Tyler introduced the powerplay workshop by explaining that the feedback from the one-hour powerplay would be incorporated into a report that was part of the WLPGA action plan to understand ‘...what is out there in this IoT space...?’ and ‘...how can it be applied to the LPG business...?’

He asked the group to think back to 2008 and ‘...remember where you were ten years ago...’ and introduce yourselves to each other on the four tables. He then pointed out that in 2008 the smart phone was not even on the market, demonstrating how far technology has progressed in ten years. Mr Tyler then asked the group to make a list of all the things you can do with a smart phone or tablet e.g. camera, compass, recorder etc.

Feedback from the group suggested there were at least fifty different applications demonstrating the power that these devices have and an illustration of what power we have in our pocket. Mr Tyler then introduced Andre Pimentel of ISA Sensing who invited the group to consider how this technology could be harnessed to improve the LPG business by addressing four questions which are in the report:

- ▶ What are some of the short, medium and long-term technologies that could be rolled out across the LPG industry?
- ▶ Describe at least three examples where IoT has made a major impact on the LPG industry?

- ▶ Identify new common standards (and subjects) that should be developed for IoT in LPG?

- ▶ What information are companies lacking to make infrastructure investments?

Each table considered the questions and reported back to the group.

Table 2 (& observers) reported back on the question ‘Describe at least three examples where IoT has made a major impact on the LPG industry?’

- Remote tank monitoring (the logistics involved with that has been a big gamechanger)
- GPS monitoring of truck assets
- Apps have been created to buy LPG at the push of a button (Supergas button)
- Predictive maintenance at LPG plants using sensors to decrease the down time of machinery

Table 3 reported back on ‘identifying new common standards (and subjects) that should be developed for IoT in LPG?’

- Safety
- Standards for encryption allowing for privacy
- Security
- Benchmarking and collection of data
- Scalability - as business grows the capacity of system grows
- Interoperability – subsidisation and optimisation



Table 4 reported back on the question 'what information are companies lacking to make infrastructure (IoT) investments?', or as Mr Pimentel said '...what can help the adoption of IoT...?' Table 4 said they had a lot of good discussions summarising into:

- The need for information and accurate information, especially for government and other stakeholders. Today there is no way of knowing how much gas is in the cylinder and where the cylinders are.
- Numbers just not adding up; because you can read different sources and having one single source it important and IoT can help with that
- Repsol are using RFID to track where cylinders are, and where they end up
- New security uses to know how many cylinders somebody buys to prevent potential terrorism incidents
- Issues in Mexico cylinders go missing and get filled illegally by competitors and GPS or something less expensive to track where they end up could be used to stop that
- The table also mentioned the 'button to order gas'. How do we look at IoT to help the consumer and make it easier for them
- Telemetry was a big thing... knowing when to come to replenish stocks and making it easy for the customer to stay and buy your gas
- Keep investing in IoT or the industry will be left behind

Table 1 reported back on the question 'What are some of the short, medium and long-term (end point vision) technologies that could be rolled out across the LPG industry?'

- The table concluded that the short-term steps will take you to the mid-term and the mid-term evolution will take you to the long-term vision so there is a connection
- Short term IoT devices provide RFID capability, so appliances, cylinders, tank tracking - which has not traditionally been part of monitoring type technologies can be included
- The cost of ownership of IoT which starts to bring us down into \$/month/tank or \$/month/appliance means you can do fully pervasive deployments of

IoT across all tanks and bring down significantly the number of trucks deployed and reduce the cost of delivery beyond what traditional solutions can provide today

- IoT will move out of the garden (on the tank) into the house. So the appliances that use LPG are going to be smart and transmit their own requirements and their own usage profiles so that independent third parties can provide a better service
- In the not too distant future, the truck will be able to talk to the tank. There will be a relationship between what the tank needs precisely and what the truck has in it controlling the truck pump and meter
- Ultimately we will move more to the utility model - smart meters with IoT with bulk delivery will become the norm
- Where that will take us in the medium term the concept where an LPG distributor is really a lifestyle provider to their customers. If you're collecting data from smart devices from appliances from the tank, you control the cost of the energy. If I'm a customer using my smart phone I should be able to say '...I want to spend \$xx/month...' and '...I want this quality of life in terms of the temperature of my house...' and your job is to deliver energy at that cost and give me that lifestyle and never let me run out of gas. Software is a service taking advantage of a multitude of devices providing the data
- A disruptive opportunity, which is quite scary if you're an LPG distributor, technology has created provided Ecommerce markets. If a community owns their own tanks with IoT on it. They can easily create a website and allow LPG distributors to bid for their business. Rather than having a tight, three generation relationship with your customer you potentially create an opportunity where a bank or finance institution can build an LPG business by leveraging data from the communities needs. That might be something we want to avoid.
- End-point vision – emerging markets have an opportunity to take advantage of technology – if you have poor roads you could delivery cylinders by droids (drones) becomes a real opportunity. Taking the truck talking to the tank leading to driverless vehicles. Autonomous vehicles driving around with a delivery system that allows them to deliver without any driver involvement
- All of this might be done from the next generation of smart phone or whatever new device we might have

In general discussions the group raised the issue of the threat of technology disrupting the business by, for example, introducing new competitors. If we own the customer, we will be able to change whatever form of energy we are providing. IoT can have a very important role in knowing or owning the customer.

The group considered the dangers of the IoT system getting hacked. One delegate said '... Train your staff to watch for rouge emails, monitor your emails, its non-stop vigilance...', '...Pick up the phone and call the suppliers or customer to double check before taking action...'; '...there are companies out there to help you monitor...'

One delegate reported an experience where they had an attack on their system. '...The hacker told us we had to pay up to release the data. They wanted a lot of money and would have continued to hit us. What we did was to increase the redundancy of our system so now we go off-line. We have a grandfathering system where everything is backed up on the cloud, and the server and go completely off line...' He said if we had paid up they would have continued to hit us. He also said they now had geographically different locations to make it very difficult for it to happen again.

Another delegate said '...Be careful, a lot of viruses come on memory sticks...'

One delegate said privacy is a big issue, ensuring customers' privacy and data privacy. He said his company now masks customers' personal data on their on-line file, you see the first three letters and then its blank because if they let themselves get hacked it's still a privacy issue. It's a big deal.

Another said the risk depends on the information. '...If the US govt can be hacked, then anyone can be hacked...' After a few fact-finding trips his company found out that in the residential sector end users are pretty local and they tend to stay with the same supplier so if its only the information about the rate of uptake and rate of utilisation then we're not that concerned because its reasonably well known information.

Mr Tyler pointed out that one company have learnt so much from their Nairobi residential trials that they not only know when the family is cooking, but what they are cooking, from the time and gas utilisation data. He said it's a scary thought and we need to be a little bit careful how we handle this consumer information.

A company involved in the IoT business added to that security thought by saying he's noticed a tremendous increase as a tank monitoring company in the demand for security. The LPG industry has been somewhat lapse in sharing passwords and we're now being required to increase the amount of data we collect during transport. It's the first time we've seen that requirement being stipulated to that level.

Mr Tyler summed up by thanking everyone and asking for feedback from this first powerplay session and requested feedback from everyone on its usefulness. Especially the length of time of the powerplay, the scope of subjects being discussed.

25th October 2018

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Andre Pimentel [APimentel@isasensing.com](mailto:APimentel@isasensing.com)

# APPENDIX 2:

## WEBINARS

Two webinars were held on 22nd November 2018 which attracted over 70 participants. The link to a recording of one of them is here:

<https://youtu.be/VfVN9xQDHpA>

The two presentations shown during the webinar are here:

WLPGA webinar introduction.pdf (presented by David Tyler, WLPGA)

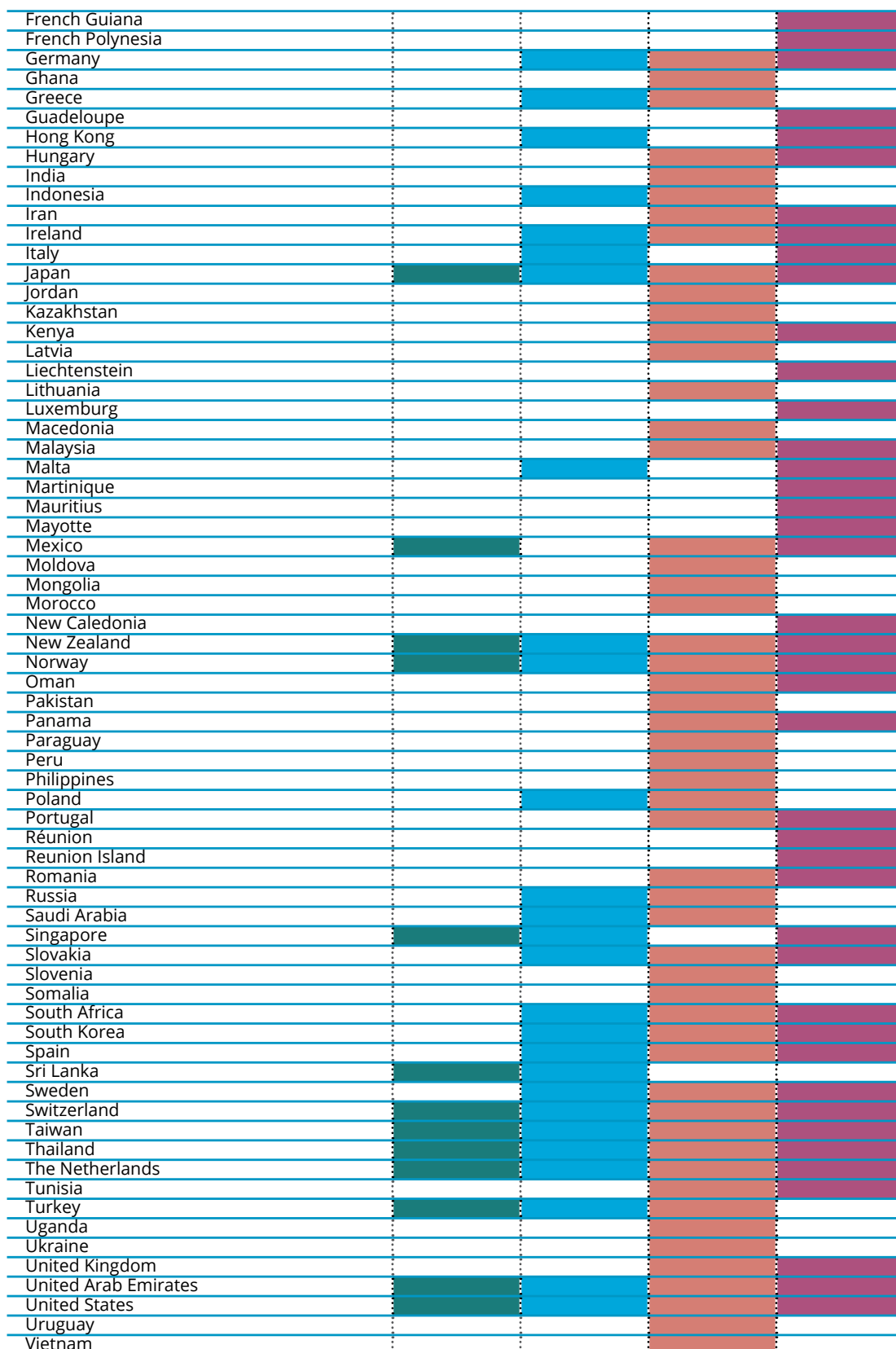
Webinar IoT Presentation.pdf (presented by Andre Pimentel, ISA Sensing)

# APPENDIX 3:

## COMMUNICATIONS TECHNOLOGY BY COUNTRY

	LTE-M	NB-IoT	LoRa	Sigfox
Argentina				
Australia				
Austria				
Bangladesh				
Belarus				
Belgium				
Benin				
Brazil				
Bulgaria				
Burkina Faso				
Canada				
Chile				
China				
Colombia				
Costa Rica				
Croatia				
Czech Republic				
Denmark				
Ecuador				
Egypt				
El Salvador				
Estonia				
Finland				
France				





# APPENDIX 4:

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## REFERENCES & LINKS

Safety

GDPR

ePrivacy regulation

Gaps in current regulations around cybersecurity and privacy:

<https://www.cioapplicationseurope.com/cxinsights/iot-a-moving-regulatory--nid-132.html>

Data security & integrity

In the LPG industry, the most relevant regulations affecting IoT are ATEX Certifications and related national compliance requirements which are necessary for all hardware/electronics in filling plants

ISO and OMIL

Widespread panic over the opportunity for damage from hacking.

There is a vast number of emerging IoT standards. The latest Gartner Hype Cycle for IoT Standards and Protocols profiles 30 standards, 15 of which have been marked to deliver "high business benefit." Six of those are expected to become mainstream in the next five years, including:

6LoWPAN: IPv6 over Low-Power Wireless Personal Area Networks is an IETF standard to deliver IPv6 connectivity over non-IP networking technologies such as NFC and LoRa over extreme low power, such that compliant devices can potentially run for years on battery power.

Contiki: an open source OS for low-cost, low-power IoT microcontrollers.

LiteOS: a Unix-like OS for wireless sensor networks.

OneM2M: a machine-to-machine service layer that can be embedded in hardware and software to connect devices.

Random Phase Multiple Access (RPMA): a proprietary standard for connecting IoT objects.

Sigfox: a proprietary low-power, low-throughput technology for IoT and M2M communications.

<https://www.hpe.com/us/en/insights/articles/iot-standards-a-starting-point-but-not-the-finishing-line-1802.html>

<https://www.hpe.com/us/en/insights/articles/iot-standards-a-starting-point-but-not-the-finishing-line-1802.html>

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<https://www.manufacturingtomorrow.com/article/2017/02/what-is-smart-manufacturing--thesmart-factory/9166>

<http://www.information-age.com/advantages-industrial-iot-secure-123470377/>

<http://www.saviantconsulting.com/blog/iot-implementation-challenges-enterprises.aspx>

<https://www.iotforall.com/prepare-your-company-for-iot-boom/>



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Aerial night view of Earth from space, showing the curvature of the planet and the glowing network overlay of white lines and nodes. The network is composed of numerous small white dots connected by thin white lines, creating a complex web that spans the entire width of the image. The Earth's surface is illuminated by city lights, and the atmosphere is visible as a thin blue layer.