Evaluation Of The Efficacy Of Iot Deployment On Petro-Retail Operations

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ABSTRACT : After the Internet revolution, Internet of Things (IoT) is expected to be the next big technological change, connecting equipment as well as everyday objects to help businesses explore new ways of creating and delivering value. In the Oil & Gas industry context, IoT has been deployed extensively in the upstream sector and also to some extent in the mid-stream sector. However, it's implementation in the downstream (retail) sector has been limited. This paper explores the applicability and impact of deploying an IoT solution at a fuel retail outlet. In our experiment, a live outlet was chosen in Kolkata, where a limited IoT solution was deployed, for a period of 3 months. Our research shows that IoT implementation can yield significant operational benefits by reducing the response times, leading to increased operational uptime and hence sales. It can also help improve the root cause analysis process by providing increased data to identify the issue(s).

KEYWORDS: Internet of Things, Indian fuel retail, IOT in Oil & Gas, New Technology adoption, customer experience

ABBREVIATIONS: IOT, Internet of Things; FCC, Forecourt Controller; UPS, Uninterrupted Power Source; HTTP

INTRODUCTION

In the recent times, rapid growth is witnessed in the adaptation of Internet of Things (IOT). Traditionally, IOT aims to foster ubiquitous connectivity amongst individual equipment as well as everyday objects helping business to explore new ways of creating & delivering values (Atzoriet. al., 2010). It is also apparent from the different domain, in this era of technology convergence, there appear to be growing usage of IOT (Atzori.et.al., 2014).

Prior to the evolution of IOT, multiple attempts were made over the years in different contexts to integrate systems or machines through the existing connectivity mechanisms that leveraged specific protocols. In order to overcome the limitation of interconnectivity among the systems due to their proprietary nature, IOT now promulgates, standard – based connectivity that envisages Internet of Things, growing to extent of things, IOT and Internet of Everything (Uckelmannet.al).

The affordances of new sensing , analyzing and responding capabilities promised by IOT technologies have led to widespread anticipation of bumming traditional industry demarcations. This obviously raises various possibilities across functional areas (Atzoriet. al., 2010) including operations, manufacturing, Health Safety & environment, service provisions, product support, sales , marketing , branding etc from the point of view of providers while allowing customers to optimize their utilization and expenses (e.g. smart marketing) and leverage the technology for delivering next levels of human benefit (e.g. ambience assisted living).

From the architecture perspective, IOT is having four broad levels such as devices, connectivity, data analysis and applications, each with unique challenges & opportunities.

In Oil & Gas context, IOT are hugely used in upstream and middle stream while downstream has very less usage of IoTs that is too predominantly at refining side. In fuel retailing area, IOT can be used for enhancing operational excellences, consistence in service and customer satisfaction & better experience & customer loyalty(https://www2.deloitte.com/us/en/pages/consulting/articles/iot-digital-oil-and-gas.html).

According to McKinsey, global gas demand is expected to reach 4,503 billion cubic meters (bcm) in 2035, showing a more than 1% annual growth from 3,736 bcm in 2017. Asia is expected to be the biggest consumer of the resource at 47%, followed by the rest of the world (24%), the Middle East (16%), and the United States

(14%). AI and the internet of things (IoT) have found their way into the oil and gas world. IoT is the technology that allows devices, machinery, and other equipment to communicate with each other. It enables oil and gas companies to manage and store data, create applications, and set security protocols using data science methodologies. IOT along with the usage of Artificial Intelligence (AI) and enabled edge computing shall help in predictive maintenance in plants i.e in upstream, mid-stream and in refineries (*Internet of Things in the Oil and Gas Industry – Current Applications, 2019*).

Some of the major challenges faced by executives in the Oil & Gas value chain include (i) aging equipment and legacy systems, (ii) hazardous environment and (iii) growing competition &increasing regulatory oversight. Today's technology has great potential to not only solve these challenges, but also enhance performance in this field. IoT applicationin the oil and gas sector includes usage of sensors, smart algorithm, predictive & preventive maintenance, etc. While robots, drones and wearable are the approaches getting the most attention and investment,IoT serves as a basic foundation for continuous monitoring and analysis of data. In this regard, the application of IoT technologies in oil and gas monitoring systems makes a significant difference. Given the recent advances in sensor technology as well as increasing connectivity options, the management in the oil and gas industry can monitor anything in real-time, from the changing seabed topography, chemical composition of crude oil to the integrity of a gas pipeline and tanker fleet positioning. The enhanced capabilities of IoT-based monitoring systems can be applied throughout the oil and gas supply chain - upstream, midstream and downstream. Further, the deployment of IoT also enables usage of advanced data analytics and visualization tools. Management can use convenient dashboards to track operations and read the latest measurements on PC or mobile, from the comfort of one's office or home, and respond to changes remotely using actuators and controls in real-time. Remote monitoringhelps workers reduce repeat on-site visits.Performing routine manual checks isn't the only benefit of using IoT for oil and gas production and distribution, which also (i) enables real-time equipment, fleet and environmental conditions monitoring, and provides better transparency and control over processes, (ii) allows for timely on-demand equipment maintenance and optimizes related cost and effort, (iii) ensures better worker safety and transfers risky on-site operations to robots and UAVs, (iv) introduces automation, including automated leakage and breakage control, (v) reduces the negative environmental impact associated with oil and gas production and distribution and (vi) optimize manpower and cut down on non-productive time and downtime(https://www.digiteum.com/category/iot, 2019).

For the Oil &Gas (O&G) industry, the advantages of IoT applications lie in creating value through an integrated deployment strategy. IoT will allow the industry to digitize, optimize, and automate processes that were previously unconnected to save time andresources, and increase safety. IOT can add value in following areas: (i) **Remote Services**: IOT can be used to get real time data, information in upstream industry to predict break down or scheduled maintenance activities , (ii) **Predictive and Preventive Maintenance**: can be used at upstream, middle stream and downstream facilities, especially at storage locations, (iii) **Health and Safety**: accidents can be very costly. By deploying IoT- enabled safety measures, O&G companies will not only keep their employees safe but benefit from a decrease in corporate liability and an increase in profit, (iv) **Asset Tracking and Monitoring**: tracking sensors provide useful information so that Companies can better identify inventories. If an item is missing, an IoT system can be used to track shipments with the exact location of each oil and gas asset, (v) **Data Management** : Data management and analytics from the oilfields, pipelines, refineries, and other energy sites, are crucial to the success of the O&G industry. Data plays a significant role in improvements, such as increasing uptime and recovery rates, making better decisions, and enhancing refining capacity(Lee 2019).

Study has revealed that with connected IOT solutions, companies can (i) lower the cost through increased automation and monitoring of remote processes, (ii) Increase workplace safety and ensure environmental protection through collection of real-time sensor data and conditions, (iii) Increase operational efficiency through more accurate billing, loss prevention and better maintenance strategies including off-shore equipment and (iv) increase reliability and longevity of equipment through remote monitoring and data collection (https://www.sierrawireless.com/applications/energy/oil-and-gas/).

Study has showed that there are 5 ways in which IOT canrejuvenate Oil & Gas industry, and these are (i) Improved Operational Efficiency, (ii) Revenue, (iii) Real Time data,(iv) Decreased safety risk and (v) Environmental foot prints (Chakravarthi 2018).

A study on the implementation of IOT at fuel stations in India showed that this can increase the operational efficiency with respect to accuracy, service quality, cost, security and time consumption(Haridas and Pillai. 2019).

A mobile app-based application was developed and studied towards creating IOT-based smart petrol station in India. The app was developed to track nearby fuel stations using geo-location (Goyal 2016).
IOT-based fuel station alert systemshave also been tried to determinethe probable design for generating alerts in case of theft of fuel and introduction of security matrix for appropriate communications (Kumar et.al, 2017).
The experimental work in setting up intelligent& smart fuel stations helped provide operators easy access for fuel management and monitoring of fuel price trends through web interface(Gupta et.al , 2016).

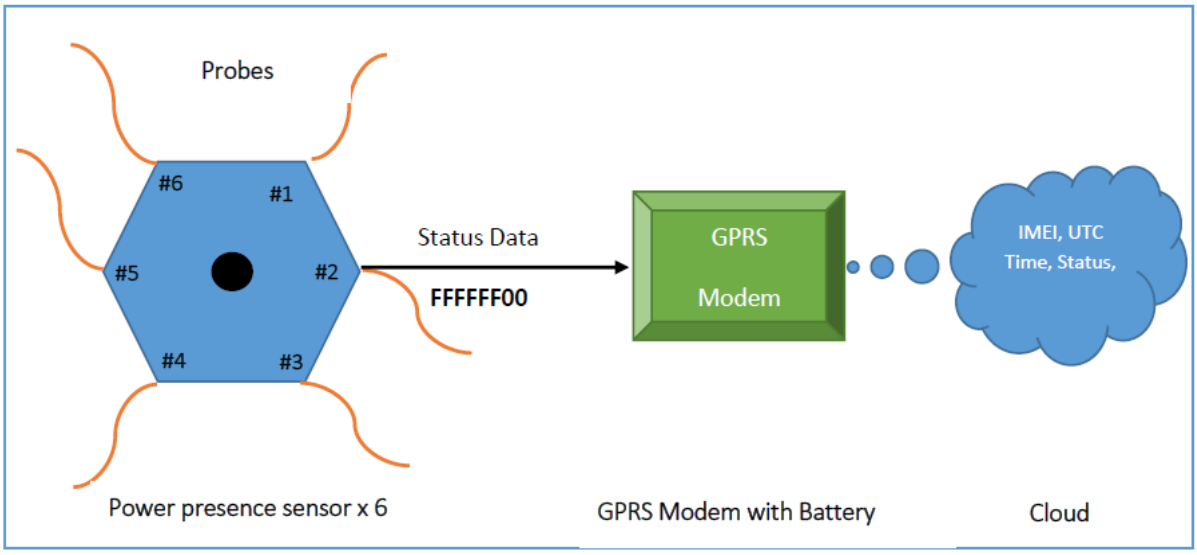
METHODOLOGY:
1.Solution Philosophy

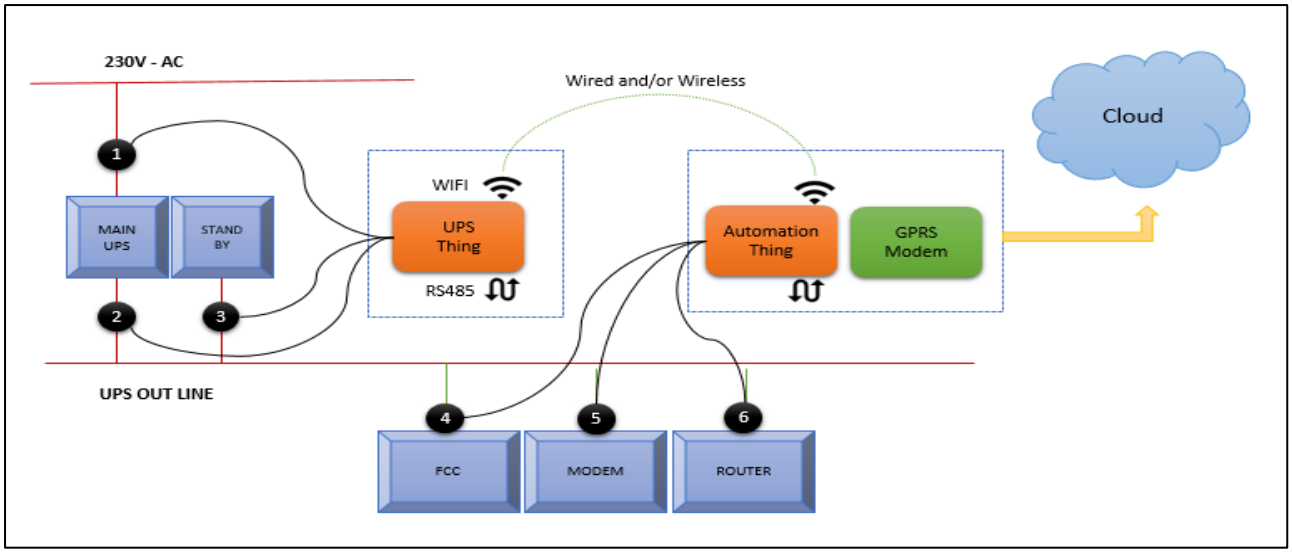
Fuel stations play a veryimportant role since fuel is necessary for mobility via automobiles.Ensuring availability of all devices in working condition is an important requirement, not only for the profitability of the service providers, but also for ensuring availability of desired service deliveries to the customers. Putting in place an IoT based solution at the fuel station can be one of the ways to ensure the desired uptime of the equipment. The IOT based solution monitors power supply to the UPS, Forecourt controller(FCC), network Router and Modem by means of a system comprising sensors and transmitting deviceconnected to back office application withreporting on real time basis. The detection of uptime of the equipment is based on power disruption at any point in time to thesedesignated equipment. Any change in the presence or absence of power to the selected equipment is immediately reported to the application server at the back end. UPS is responsible for supply of uninterrupted power supply to all the devices in the fuel station. FCC gathers all fueling transactions, available product stock level as well as alerts & events generated by the equipment present at the retail outlet. Modem & Router ensure availability of fuel station's connectivity to its back-office server of their respective companies. The sensor system posts its power status at 2 minutes intervals to the central server. In case of power failure, the solution will have its own battery back-up to ensure that the sensor and transmitter arrangement still operates and is able to send notification of such "no power" event to the central server. The solution has been tested for 4 weeks as a pilot. The data transmission occurred over secured HTTS data channel to the back-end server using GPRS. For the purpose of study, six sensor points were finalized in a limited manner:

- Input Power to Working UPS
- Input Power to Standby UPS
- Output power from combined UPS
- Input power to FCC
- Input power to Modem
- Input power to Router

The IOT system also provides device identification, location (Latitude and Longitude), and UTC Timestamp along with data packets transmitted to back end for identification of the data for further analysis and reporting at the backend. The back-end application is capable of sending notification/alerts in the form of SMS/email immediately on receipt of failure signal from the sensors.

1. Solution architecture:





As shown in the above design, Sensors work on direct voltage sensing method. The sensing devices communicate to each other over WIFI Peer to Peer (P2P) communication. RS485 has been provided for back up communication channel. A reporting dashboard provides live status of power, historical data of status by RO, and also the email triggered on malfunction as well as its resolution.

2. Sensor Panel

Sensor panel consists of six non-contact current sensor probes. These probes are attached to power lines of the target equipment. This enables the identification of presence / absence of power in the connected lines. Sensor panel compiles the output from the six sensors and creates a status data packet to be sent by the GPRS modem.In order to monitor the power quality, which is important fromequipment failure point of view (critical for digital equipment), and will enable the service provider to take timely action to safeguard this device before it reaches the threshold limit of burnt out. **View above a Voltage-Ammeter-Frequency Meter (VAF) was installed** to check the voltage and frequency readings on real time basis using the same IoT equipment, with sensors for monitoring power supply.

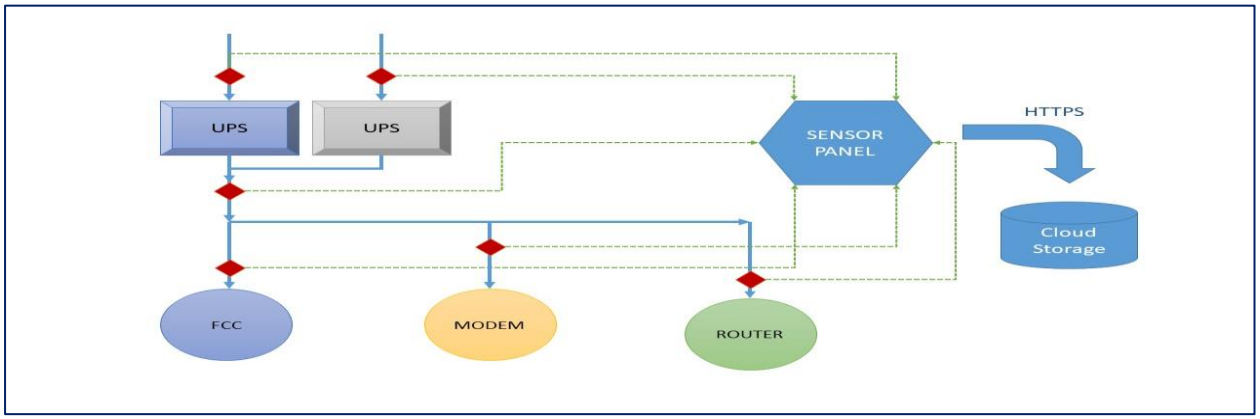
a. GPRS Modem

GPRS modem receives the data from the sensor panel and sends it to the client server on cloud using GPRS connectivity over HTTPS (Hyper Text Transfer Protocol – Secured). Modem also adds information related to time of capture (UTC Time Stamp) and 16-digit unique identification number of the device. GPRS Modem is equipped with L1 band GPS in order to track the location of the equipment as well. Location information of the device is sent once in a day.

b. Cloud Application

Cloud application receives the data. It is comprised of a user interface to create a timeline of the power status by retail outlets. During the installation process, device IMEI numbers are mapped tothe relevant retail outlets along with mapping of sensor probes with respective power lines.

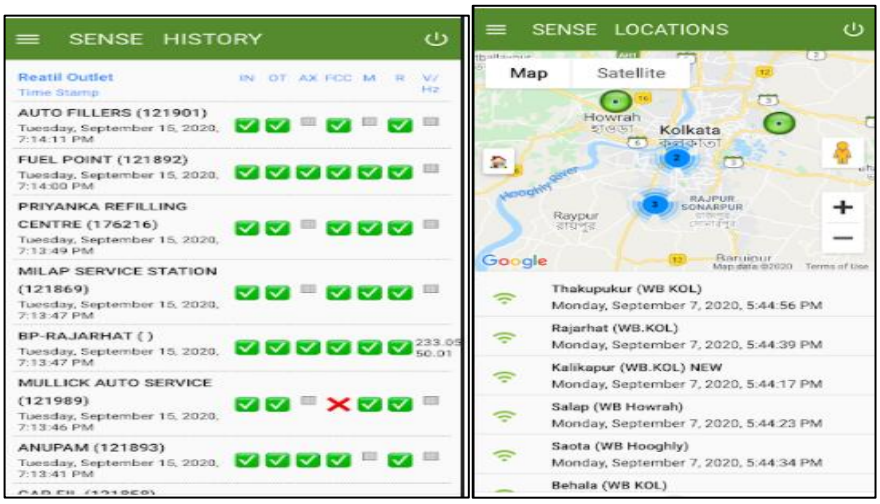
Line Diagram for the solution deployed:

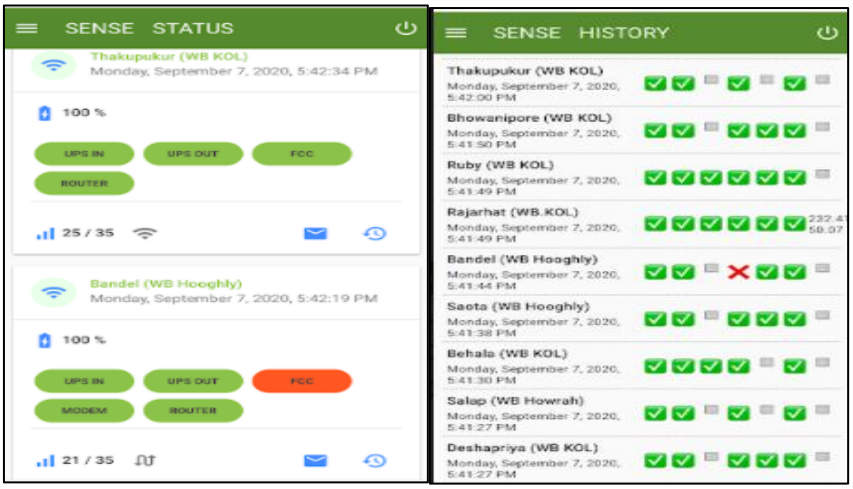


RESULTS & DISCUSSION:

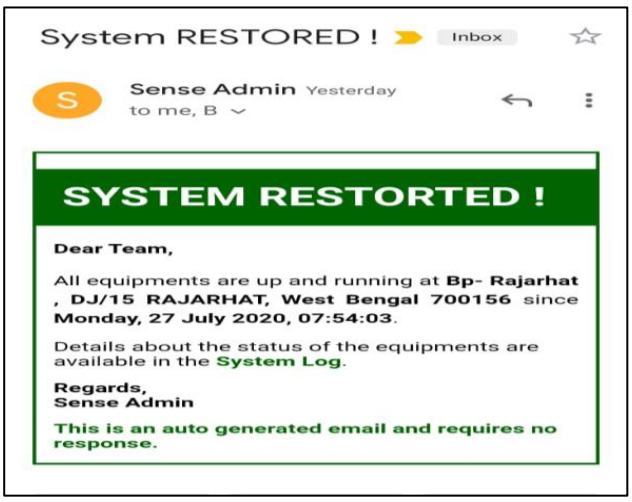
The IoT based solution is envisaged for providing real time status including alert in case of failure of critical equipment for fuel station operation and management. The system is capable for sending information with escalation to predefined people through SMS & emails for downtime after set time intervals, if not resolved. Reporting dashboardsare created to enable users to monitor via a GUI webpage. The dashboards reflect the location-wise equipment-wise status on a real-time basis. It also providesthe location-wise historical status for the equipment. Panels ofa few dashboards created are depicted below:

Retailer ID	Retailer	Latitude	Longitude	Time Stamp	UPS IN	UPS Out	FCC	Modem	Router
RT1010	XYZ Enterprise	22.123456	88.123456	1/27/2020 10:30	✓	✓	✓	✓	✓
RT1010	XYZ Enterprise	22.123456	88.123456	1/27/2020 10:50	✓	✓	✗	✗	✗
RT1010	XYZ Enterprise	22.123456	88.123456	1/27/2020 11:10	✓	✓	!	!	✓
RT1010	XYZ Enterprise	22.123456	88.123456	1/27/2020 11:30	✓	✓	✓	✓	✓
RT1010	XYZ Enterprise	22.123456	88.123456	1/27/2020 11:50	✓	✓	✓	✓	✓
RT1010	XYZ Enterprise	22.123456	88.123456	1/27/2020 12:10	✓	✓	✓	✓	✓
RT1010	XYZ Enterprise	22.123456	88.123456	1/27/2020 12:30	✓	✓	✓	✓	✓
RT1010	XYZ Enterprise	22.123456	88.123456	1/27/2020 12:50	✓	✓	✓	✓	✓
RT1010	XYZ Enterprise	22.123456	88.123456	1/27/2020 13:10	✓	✓	✓	✗	✗
RT1010	XYZ Enterprise	22.123456	88.123456	1/27/2020 13:30	✓	✓	✓	✗	✗
RT1010	XYZ Enterprise	22.123456	88.123456	1/27/2020 13:50	✓	✓	✓	✗	✗
RT1010	XYZ Enterprise	22.123456	88.123456	1/27/2020 14:10	✓	✓	✓	✗	✗
RT1010	XYZ Enterprise	22.123456	88.123456	1/27/2020 14:30	✓	✓	✓	✓	✓
RT1010	XYZ Enterprise	22.123456	88.123456	1/27/2020 14:50	✓	✓	✓	✓	✓
RT1010	XYZ Enterprise	22.123456	88.123456	1/27/2020 15:10	✓	✓	✓	✓	✓
RT1010	XYZ Enterprise	22.123456	88.123456	1/27/2020 15:30	✓	✓	✓	✓	✓
RT1010	XYZ Enterprise	22.123456	88.123456	1/27/2020 15:50	✓	✓	✓	✓	✓
RT1010	XYZ Enterprise	22.123456	88.123456	1/27/2020 16:10	✓	✓	✓	✓	✓
RT1010	XYZ Enterprise	22.123456	88.123456	1/27/2020 16:30	✓	✓	✓	✓	✓
RT1010	XYZ Enterprise	22.123456	88.123456	1/27/2020 16:50	✓	✓	✓	✓	✓
RT1010	XYZ Enterprise	22.123456	88.123456	1/27/2020 17:10	✓	✓	✓	✓	✓
RT1010	XYZ Enterprise	22.123456	88.123456	1/27/2020 17:30	✗	✗	✗	✗	✗





In the event of any malfunction arising from non- availability of power supply to designated equipment, emails are triggered and sent to the fuel station Manager, company officials, vendors providing maintenance support and other designated people.Upon rectification, Restoration email is also sent out. Frequency of email triggers is at every 4 hours for escalation in case of non-resolution.



The IOT based solution providesthe following benefits to the fuel station ecosystem:

- Ensures immediate trigger of an "event' e.g. lackof power supply to the UPS and its downstream equipment e.g. FCC, Modem and Router.
- Helps to initiate corrective action on power supply thereby increasing uninterrupted service to the customer.

Upon studying the performance, it is observed that UPS is the most critical equipment since it provides power to other equipment like modem, router and FCCs . Hence, any improvement in the performance of UPS leads to improvement of the overall performance of the system and for fuel station as a whole. The improvement in UPS downtime and number of customer grievances related to non-availability of fuel due to UPS related issues is analyzed for three months time post implementation of the system and compared the same with three months data for pre- installation period as per below table .

Table -1

	Pre Installation of IOT	**Post Installation of IOT**	**Improvement**
UPS Down time (in Hr)	864	208	76%
Customer grievances (numbers)	102	53	48%

From the above, it is observed that down time of UPS have been reduced by 76% there by reducing the chances of other equipment since UPS is the source of power to other equipment. Further drilling down inanalyzing the performance,it is observed that the customer grievances has also reduced by 48% during this period and one of the major contributor towards the improved performance is the monitoring mechanism which has enabled the ecosystem for improved response time of the service provider due to visibility of down time on real time basis to them.

CONCLUSION

IoT has had significant impact on the processes in upstream and mid-stream oil & gas industry. While some research has been done regarding potential application of IoT in downstream Oil & Gas, conclusive primary research demonstrating the benefits of its application is extremely limited. Our research shows that IoT implementation can yield significant operational benefits, in terms of uptime and thus enhanced sales, even with a limited deployment. The key is to correctly identify prime equipment impacting business drivers and then successfully monitor them via IoT deployment. This can help improve operations equipment uptime performance via:

- Reduced response times
- Identifying frequent breakdowns
- Designing standardized responses as per breakdown categories
- Anticipating/proactively monitoring equipment downtime

A key takeaway from this research is also that IoT deployment could be extended beyond the limited operational deployment for a more holistic management oversight. Similarly, IoT deployment could also be extended to the customer experience touchpoints to capture the user journey for improving the customer experience and satisfaction.

Thus, rapid technological advancements as well as increasing exposure to digitization have led to increasing adoption of digital technologies, including IOT.The IOT-based solutions havea positive impact in the following areas:

- ✓ **Operational excellence & profit maximization**: The solution provides indication to the responsible personnel to take care of equipment health immediately or proactively. It helps ensure uninterrupted operation at fuel station with no sales loss, thereby increasing operational excellence and maximizing revenue.
- ✓ **Enhanced Customer experience:** customer aims to have a smooth fueling experience without any hiccups at the fuel stations**.** AnIOT-based solution shall ensure uninterrupted availability of fuel to customers, enhancing their fueling experience. Similar IOT solution can also be adopted at fuel stations for enhancing customer experiences in the arena of consistency in service delivery and product availability.

FUTURE SCOPE

In this article,we have tried to articulate how IOT based monitoring equipment that can be helpful in fuel retailing business as well from service provider & customer perspective. The device & study conducted on 6 parameters which can be extended for more parameters based on the requirement of the fuel stations. The current study will be helpful for understanding and usage of IoTs for various field of fuel retailing for further enhancement in customer experience, operational efficiency.

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Conflict of Interest: The authors confirm that there are no known conflicts of interest associated with the publication of this paper.

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