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System of and Solution for Pay-As-You-Use (PAYU) and Automation of LPG Cylinder Supply Chain through Internet of Things Based Real Time Uses and Inventory Data Analysis

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***Abstract* –** Considering the economics of cooking fuel used by Below Poverty Household in India, the biggest challenge in transition of such household from conventional cooking fuel to clean and modern cooking fuel like LPG is unavailability of price fragmentation and Pay-As-Use features while purchasing LPG. Recent development in the field of Internet of Things has proven stories where assets can be tracked, monitored and controlled remotely. There is huge scope as well as requirement for innovative idea that can bring the principle of mechanical engineering, electrical engineering and data analytics together to achieve the feature of price fragmentation for LPG uses. This paper presents system and solution for tracking real time LPG consumption and inventory data by using Internet of Things (IoT), connecting the different stakeholder of LPG supply chain, analysis and computation of data to automate LPG cylinder booking and delivery practice, make the LPG supply chain transparent at each level and use the data tracking and analysis system to provide "Pay-As-You-Use (PAYU) apparatus to the LPG consumer in general and financially marginal consumers in particular.

Keywords: LPG, Supply-Chain, IoT, Pay As You Use, Price Fragmentation, Clean Cooking

I. INTRODUCTION

Transforming the way India is using energy has become one of the major challenge for Government considering three major goals viz. making available clean and modern energy sources to Indian household, efficient use of energy resulting into better conversion ratio of fuel and responsibility to reduce the carbon footprint resulting from use of energy sources. To ensure achievement of all the goals without compromising on any, India need Public Private Partnership based initiative for bringing automation and optimization in Energy Supply Chain and Distribution network [1]. India has seen multiple schemes and initiative from Government to promote use of clean fuel as source of energy in last one decade. These schemes result into coverage of greater portion of Indian population under availability of clean energy source like electricity and LPG.

Around 40% of the total energy requirement in India is used for cooking, beside energy consideration, cooking style and use of cooking fuel also play vital role in health and empowerment of women in India [2]. As per the recent report published by PPAC [3] on January 2018, 79.2% (25.68 Million) households were connected with the LPG. As per the Energy Source of Indian Households for Cooking and Lighting Report [4] published by National Sample Survey Office (NSSO), in rural area, firewood and chips is the primary source of cooking fuel in most of the households. A total of around 76% households uses firewood and chips as the primary source of cooking fuel followed by LPG (11.50%), Dung Cake (6.30%), Kerosene (0.80%). The conflicting data related to coverage of LPG connection and use of LPG as source of cooking fuel simply reveal that even when LPG is available as source of cooking fuel for majority of household, it is not used as primary cooking fuel in India. Majority of household are still using solid biomass fuel as the primary cooking fuel or use more than one fuel for their cooking energy needs. Traditional cooking fuel like solid biomass still be used as primary cooking fuel in rural area. 90% of the total rural household and more than 30% of urban household use traditional cooking fuel either as primary cooking fuel or alternate fuel

for their primary fuel. According to ***S. D. Pohekar et al.***(2005) the use of clean cooking fuel is still restricted at less than 40% of total fuel used for the purpose of cooking [5]. The use of traditional fuel for cooking purposes has multiple disadvantages. It has been proved in many study that use of solid biomass as cooking fuel has harmful effect on human health as well as climate change. ***MeenaSehgal et al.*** (2014) found that emission of air pollutants such as carbon monoxide (CO), sulfur dioxide (SO2), respirable particulate matter (PM2.5and PM10), poly-cyclic aromatic hydrocarbon (PAH), benzene, and metals like lead and copper from use of solid biomass as cooking fuel has been identified as fourth leading risk factor for disease burden [6].

Government of India assigned CRISIL responsibility to conduct study to find out the cooking fuel pattern and barrier in transitioning from Solid Biomass based cooking to Clean Energy based cooking. CRISIL submitted its report and found that Affordability, Accessibility and Awareness are three major barriers in transitioning of Indian household from Solid Biomass based cooking to Clean Energy based cooking [7]. CRISIL survey identified four major concern of household that are not using LPG as cooking fuel for their shifting to LPG for cooking energy requirement:

1. Cost of LPG connection
2. Cost of LPG refilling
3. Waiting time and unavailability of LPG Refill in rural area
4. Myth regarding used of LPG versus Solid Biomass as cooking fuel

Cost of LPG Connection: In India it costs around 2000.00 to get an LPG connection. Government accepted the challenge related to inability of BPL household to pay the connection process, and come forward to assist such family with grant for purchasing the new connection under Pradhan Mantri Ujjwala Yojna (PMUY). Under the scheme, the Government of India has provisioned for 12500 Crores to provide a subsidy of 1,600 to government-owned oil manufacturing companies for every free LPG gas connection that they install in poor rural households.

Cost of LPG refilling: As per CRISIL report, on an average 35% of cooking fuel requirement of households that does not have LPG connection get fulfilled by fuel alternative that are available for free and spend approximately 350 to 400 on cooking fuel per month. The conventional fuel is available at fragmented rate where the household can buy the conventional cooking fuel on daily basis at amount as little as 10 (INR Ten), however for LPG refill, the household require to spend 736 at the time of refill out of which the subsidy amount of 240 get reimbursed in their bank account under Direct Benefit Transfer (DBT) scheme [8]. In CRISIL study also, 86% household consider high initial cost of LPG connection and 83% household consider high recurring cost of the cylinder as the key barrier in shifting to use of LPG as cooking fuel. Government of India has addressed the first concern of high initial cost of LPG connection through PMUY, however the high recurring cost of the cylinder needs to be addressed.

Waiting time and unavailability of LPG Refill in rural area: The wait time to get delivery of refill cylinder are largely imbalanced between rural and urban area. Rural area particularly hilly and far flung area is witnessing long wait time which may extend up to 20 days for refill cylinder. The wait time force consumer to opt for back-up for such wait period or use LPG for emergency cooking only.

Myth regarding used of LPG versus Solid Biomass as cooking fuel: There is huge perception that LPG is costly fuel than the Solid Biomass. As per CRISIL report, on an average household use approximately 121 kg/month of firewood, 98 kg/month of dung cake, 83 kg/month of crop residue and about 3 liters/month of Kerosene (Kerosene used mainly to light firewood and dung cake). Comparing the cost of Solid Biomass with LPG we find that the Energy Content (MJ per KG) for LPG is 45.5 MJ with a conversion efficiency of 60% making the total useful energy of cooking for LPG at 27.3 MJ per KG. To achieve the requirement of 495.38 MJ of useful energy of cooking for household, one require 18 KG of LPG fuel which cost the household 627.00 for same amount of useful energy (price taken @ 495.63) for which they need to pay 654.00 for the fuel requirement in form of conventional fuel sources. It is evident from the study of current use of cooking fuel, its effect on health and environment, barriers in transition of household from solid biomass based cooking to LPG bases cooking that India require solution which can handle the concern related to cost of refill and availability of refill and supplement the existing Ujjwala Yojna.

The innovation in the field of internet, telecommunication, electronics, data analytics, and mechanical engineering has paved way to smarter machine that can be connected with each other through central unit and perform particular task to solve problems of supply chain and asset management. Internet of Things (IoT) consolidate the functionality of internet, telecommunication, electronics, data analytics, and mechanical engineering to allow a sensor/actuator to send and receive data by connecting through internet using telecommunication and electronic modules. According to ***Rafiullah Khan et al.*** (2012) The IoT tremendously evolved in last two decades to bring solutions related to healthcare, smart homes, smart metering, pharmaceuticals etc. and there is huge potential of using the concept of IoT to develop further capabilities and features in Prediction of natural disasters, Industry applications, Water Scarcity monitoring, Design of smart homes, Medical applications, Agriculture application, Intelligent transport system design, Smart metering and monitoring, and Smart Security [10].

The use of concept of IoT in utility industry Meter like water meter, electricity meter is already in use that makes it possible to get accurate automated meter reading and issuance of invoice to the customers. Such smart metering help to track consumption pattern and enable dynamic pricing by using real time uses data. According to directive it is made compulsory to install smart meter to all utility user and enable the user to receive information on actual energy consumption and costs by 2020 [11]. ***Jessica Stromback et al.*** (2011) concluded from his study that the intention is to lower energy consumption by 20%, lower CO2 emissions by 20% and ensure that 20% of energy is generated using renewable resources. Recent studies have shown that implementation of smart metering enable electricity consumption saving of up to 5-15% [12]. Encouraged by the result of such studies, many organization as well as academician is working on more efficient use of principle of IoT to solve the problem of price dynamics and supply chain management of different utility sector. In last couple of years, few utility services providing companies have introduced pay-as-you-go (PAYG) financing models in their energy businesses to cater need of low income group consumer. PayGo Energy has become leading organization in providing pay-as-you-use facility to its consumer using IoT based platform. In India, also substantial progress has been made in applying IoT based smart device to solve community problem for example, Tata Communication team up with Mahanagar Gas Limited (MGL) to deploy 5,000 smart gas meters in Mumbai [13], Tata Power Delhi Distribution Ltd. is installing 250,000 smart meters in Delhi [14], SmarterHome, a start-up company is working towards saving water consumption in the city of Bengaluru in Karnataka by using IoT based smart meter, however all such initiative is limited in scope and target benefit. IoT based system and solution has much higher potential to manage the asset, efficiently use the assets as per requirement, save wastage, increase consumption by including new consumer base, bringing price dynamics and centralizing the control to eliminate any pilferage.

This paper is examining the proposed systems and solutions for pay-as-you-use (PAYU) and automation of LPG cylinder supply chain through Internet of Things (IoT) based real time uses and inventory data. These real time uses and inventory data can be used to predict the demand accurately which can further be used for making proactive supply chain related decisions.

Rest of the paper is organized as follows, Section I contains the introduction, Section II explains the value chain of proposed solution, Section III contain the design and specifications of the proposed solution, Section IV discuss the results obtained through the mock data generated for LPG uses to understand and plot the uses pattern, Section V explain the advantages of proposed solution and Section VI concludes research work with future directions).

II. SYSTEM AND SOLUTION FOR PAY-AS-YOU-USE (PAYU) AND AUTOMATION OF LPG CYLINDER SUPPLY CHAIN: A SOLUTION

The above referred challenge in India and development in technology and science in related field have inspired the researchers to invent and propose:

(i) Portable, multipurpose and safe apparatus for measuring, tracking, transmitting, monitoring and analyzing the records related to the household LPG consumption,
(ii) Computing methodology of storing and analyzing such tracked data
(iii) Portable and safe apparatus which can control the flow of LPG from LPG cylinder to cooking stove
(iv) Efficient and affordable system of use based payment of LPG refill.

The solution is proposed by combining the proven principle of Mechanical Engineering, Electronics Engineering, Computer Science and Data Analytics together with the blend of Internet of Things (IoT). The overall working principle of the solution can be summarized in Fig. 1 & 2 illustrating the complete flow diagram & Value Chain of solution related to measurement, tracking, transmission, integration, storage, computing, analysis of data, payment system, flow of information from actuator to server and from server to actuator available in present embodiment.

In Operation, Consumer Base Kit is installed by the trained engineer at consumer location and mount the cylinder on the weight measurement trolley. The reading of weight measurement ***trolley*** shall be set remotely by using two level authentications using One Time Password (OTP) made available on customer followed by is set at One Time Password (OTP) made available to the LPG Vendor. The server will automatically check the payment status with each refill of LPG Cylinder. If the balance is available then the valve shall get open and allow the gas flow to the cooking stove. In case balance is not available, the valve will shut down and stop the flow of gas to cooking stove. In situation where the balance is not available and flow of gas is stopped, the customer need to recharge the balance using available payment options. The available payment option may include payment using (i) payment based mobile application (Paytm, Bhim, Mobikwik etc.), (ii) recharge coupon available at stationary shops, (iii) internet recharge using online as well as offline facilities, (iv) recharge by calling IVR system (v) cash at Public Distribution Centre (PDS) or authorized agent at Panchayat Bhavan (Village Administrative Office) or similar body. Once the recharge is initiated, the recharge data shall be transmitted to the central server and being validated by secure IoT gateway Protocol. In case the recharge data is not validated by the protocol, the data get rejected. In case the recharge data is validated by

the protocol, the data get registered against the unique identification number (UIN) of the consumer and recharge metadata is created for the consumer by tagging the recharge ***metadata*** to the UIN. After tagging recharge value is registered and start reflecting in the account of the Consumer. A message is sent back to actuator as per pre-defined business rule reflecting the new balance. The new balance will show during payment status check and open the valve and allow the gas to flow to cooking stove.

In parallel, after mounting of the cylinder on the weight measurement trolley and setting up the reading of trolley, the weight measurement trolley shall measure the LPG cylinder at identified frequency on real time basis. The LED bulb based panel will turn on the yellow light in case the inventory level is lower than the threshold limit against the recharge. This would be the indicator for the consumer that the recharge should be made in order to enjoy uninterrupted service. The Consumer Base Kit shall transmit the real-time weight data measured to IoT Gateway Protocol for validation for integrity which being validated by secure IoT gateway Protocol. In case the weight data is not validated by the protocol, the data get rejected. In case the data is validated by the protocol, the data get registered against the unique identification number (UIN) of the consumer after stamping the time of receipt of data. The weight data thus received by the cloud based central server through IoT gateway protocol shall be arranged as per the pre-defined algorithm and computed for uses pattern and inventory status as per identified logic. The use pattern, inventory status, payment status, LPG cylinder stock at dealer's end and OMC business data shall be compared and computed to take automated business decision. The business decision shall include automated refill booking for consumer, automated delivery note published on daily basis for dealer, refill booking for dealer, fleet booking and delivery note at Bottling Plant etc.

III. DESIGN AND SPECIFICATION OF PROPOSED SOLUTION APPARATUS

With the advancements in sensors and communication technologies, smart monitoring and smart supply chain managements are now booming everywhere. Daniel Newman [15], mentions how IoT offers operational efficiencies. To achieve operational efficiencies, four such components are proposed which would together form the IoT network:

A. Consumer End Kit:

Fig. 3 shows a Platform Trolley for housing the cylinder. The trolley would be built consisting of a load cell that would measure the weight of gas cylinder and send the weight data to the Main Panel. A custom designed smart valve such as a solenoid valve is used in between the LPG cylinder and cooking stove for the controlled flow of LPG based on Pay as you use concept. Fig. 4 shows the shaded perspective view of the apparatus for clarity. This sketch shows Platform on which LPG gas cylinder will be kept. This sketch also discloses the base of the Platform Trolley, the Main Panel, the smart valve and the wheels that supports the Trolley. A main Panel that would host a microcontroller and its peripheral assembly and a Transmitter. Fig. 5 shows the exploded perspective view of the sub-assembly of the main platform. The Housing Component Known as the Platform Trolley houses the LPG Cylinder **(**not shown**)**. The total height of the Consumer Kit is kept under 60mm so that the height is not too large to allow the Platform to properly place beneath the Cylinder.

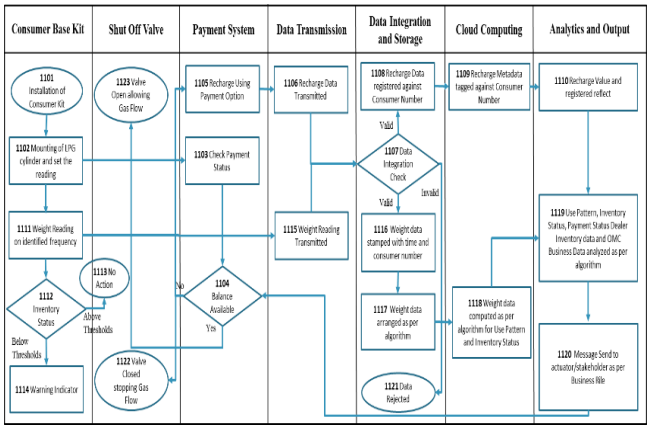


Fig 1: End to End Solution Flow Chart

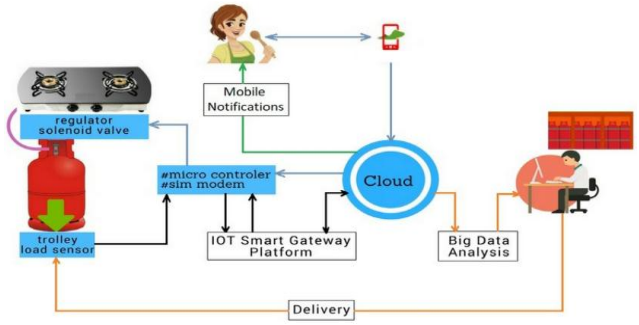


Fig 2: LPG Pay-As-You-Use (PAYU) Solution – A Value Chain

Fig 3: Consumer End Kit with a LPG cylinder to be installed at the consumer's location

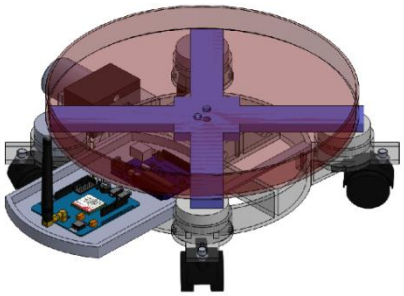


Fig 4: Shaded Perspective view of Consumer End Kit

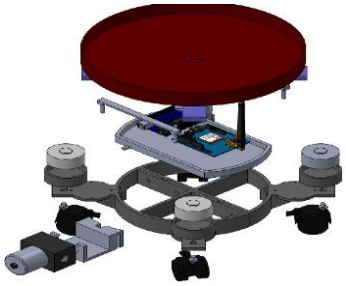


Fig 5: Exploded Perspective view of Consumer End Kit

B. IoT Gateway for Data Transmission:

IoT Gateway would serve as medium for Device connectivity with the help of Field Connector. Fig 6 represents block diagram of high level architecture and gives an idea of the service flow. The gateway would have a dedicated internet connectivity which would allow it to transmit the packets received to a cloud server where the data can be refined and analyzed. Field tests suggest that Lora WAN has good network coverage up to 3 Kms in suburban areas and up to 10-15 Kms in rural areas. Sure enough there is a possibility of collision of packets arriving at the IoT Gateway, but LoRaWAN has its own protocol to resolve such collisions [16].

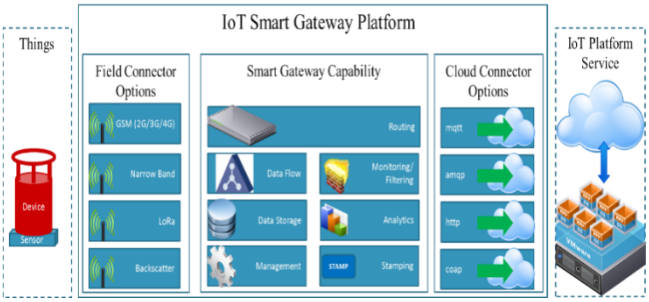


Fig 6: High Level Architecture for Data Transmission

C. Cloud Based Solution and Application

A Cloud based central server shall be established that will collect the weight data transmitted by several consumer end kits via IoT Gateway and analyze the data through Analytical tools to convert the raw data into actionable insight like Gas usage trend, Days to get Gas exhausted, demand forecast, flagging of suspicious activity, automatic demand booking etc. This server will consist of:

i. Cloud storage rack.
ii. Analytical software.
iii. Machine Learning Technique to analyze the data pattern and provide actionable insight.

There are multiple tools that provides Data Storage Infrastructure like Microsoft Azure, HDFS, Kudu, HBase, Kafka. Fig 7 shows the possible technologies available for cloud storage and analysis of data.

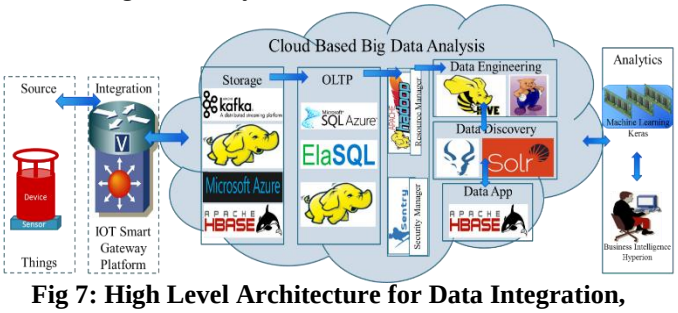


Fig 7: High Level Architecture for Data Integration, Storage, and Analysis

D. Payment System for Use of LPG

The Consumer Base Kit shall have indication lights. The Green Light indicates that sufficient LPG is available. The Yellow Light indicates that balance is available for one day which would be based on the usage pattern of the consumer. The Gas Flow although shall remain "ON" in such situation, until exhaustion of balance in consumer's account. The Consumer is

required to recharge the balance by using one of the different payment options available to ensure uninterrupted service. Also, a Red Light indicates that the balance in consumer's account has been exhausted completely. As the balance is completely exhausted, the Gas Flow has been "Shut Down" automatically and require minimum recharge immediately to resume the Gas Flow.

The present work provides these recharge options:

a. Recharge using Mobile based payment App/Digital Wallet
b. Recharge using Aadhar linked Bank Account.
c. Recharge using Scratch Card using IVR system.
d. Recharge using cash payment.

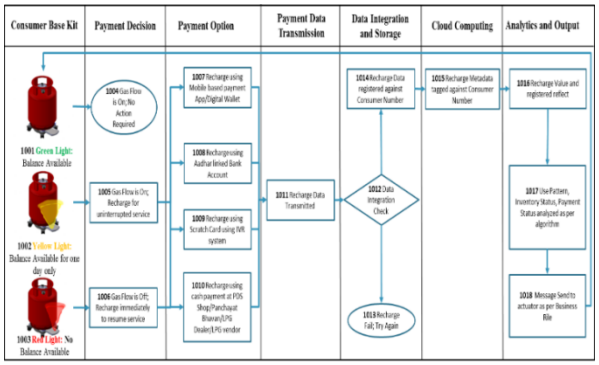


Fig 8: End to End Payment Flow Chart

Once the recharge data is validated by the protocol, the data gets registered against the unique identification number (UIN) of the consumer. After tagging recharge value would reflect in the account of the Consumer. A message shall be sent back to actuator as per pre-defined business rule reflecting the new balance. The new balance will turn the indicator light to Green or Yellow based on the updated parameters. The complete course of actions that would take place in end to end payment flow is summarized in Fig 8.

E. User Interface Website/Application

A user interface website as well as a mobile based application shall be designed that would host the graphical and textual presentation of actionable insight to the user. The website will be designed for different users like consumer, retail distributor, refill station and Gas Distribution Company. The Website shall be used to access and study the outcome of data analysis like trend charts, gas uses pattern, red-flagging of suspicious activities, demand forecasting etc. Examples of functionality that will be part of User Mobile Application and Website based User Interface are:

- Role based login and data access
- Ability to access tabular, graphical and text based data based on inventory status, usage pattern, analysis, forecasting and flagging of suspicious activity

IV. RESULTS & DISCUSSION

To get overall view of the kind of data we might expect, mock data set is generated. The dataset is generated keeping in mind all the steps of the proposed solution. A total of 200 customer data for a period of 2 weeks is generated. Following assumptions are made while generating the dataset:

1. Customer is assigned an initial amount of LPG gas. The initial values so assigned are randomly generated and are in range of 1000 to 3500 grams. The range is decided based affordability of a rural household.
2. Data is updated on hourly basis. Also cooking doesn't take place throughout the day. Accordingly, the LPG content tends to be unaffected during idle times of the day.
3. Occasionally customer may want to recharge or may be delay recharge, depending on whether they have money to spare. It was assumed that customers recharge with a probability of 50%. The recharge amount has been fixed to 3500 grams just for the purpose of simplicity.

Graphs are rendered to get a picture of how LPG usage would fluctuate from one household to another. 2 types of graphs are generated, one that depicts daily usage pattern and other with usage pattern over the entire 2 weeks. Daily usage plot would show individual analysis and long-term plot would help in inventory tracking.

To get the daily usage pattern, a day was chosen at random out of the 14 days and the corresponding usage pattern for that day was plotted.

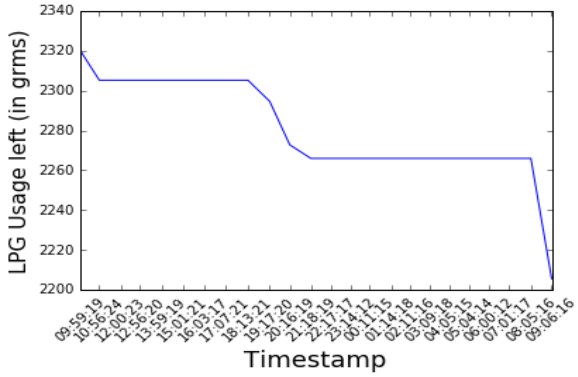
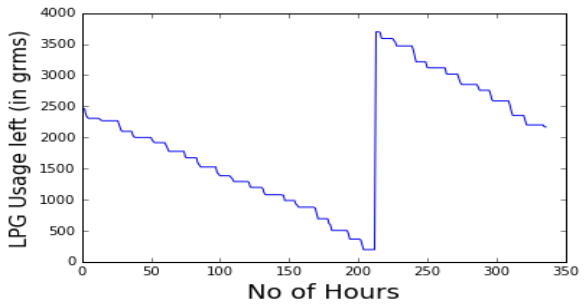


Fig. 9 (a) Daily Usage pattern of Customer 1



(b)

Fig. 9 (b) Long term usage pattern for Customer 1

It can be inferred from Fig. 9 (a) that customer 1 starts with an initial LPG fuel of 2320 grams, which then decreases with hourly usage. Further it can be noticed that there is no usage during the time intervals 10 AM to 5PM and during 8:15 PM to morning 7 AM. It can also be pointed out that the peak usage occurred during morning 7 AM to 8AM, which can be inferred from the peak slope of usage pattern during the interval. Fig 9 (b) shows long term usage of customer 1, in which It can be noticed a recharge was done at around 212nd hour which would be 9th day of use. It can be seen as a spike in the figure. Further it can be noticed that new LPG fuel value rose to slightly more than 3500 grams.

It can be inferred from Fig. 10 (a) that customer 2 starts with an initial LPG fuel of a little more than 2800 grams, which then decreases with hourly usage. It can be noticed that there is no usage during the time intervals 3:30 AM to 6:30 AM and during 10:30 AM to evening5:30 PM. The peak usage occurred during morning 6:30PM to 7:30 PM, which can be inferred from the peak slope of usage pattern during the interval. Fig 10 (b) shows long term usage of customer 2, in which It can be noticed a recharge was done at around 230th hour which would be 10th day of use. It can be seen as a spike in the figure. Further it can be noticed that new LPG fuel value rose to slightly more than 3500 grams.

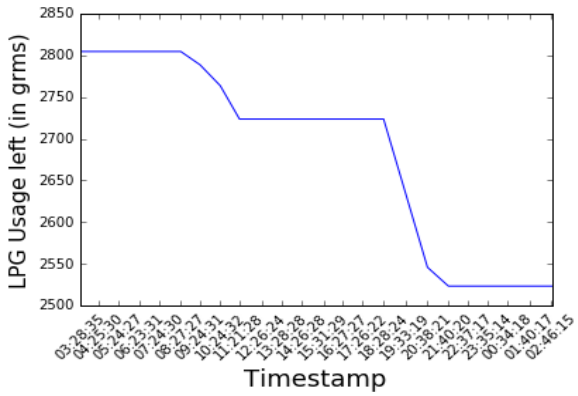


Fig. 10 (a) Daily Usage pattern of Customer 2

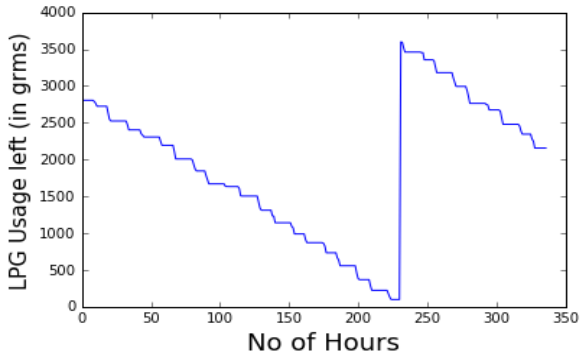


Fig. 10 (b) Long term usage pattern for Customer 2

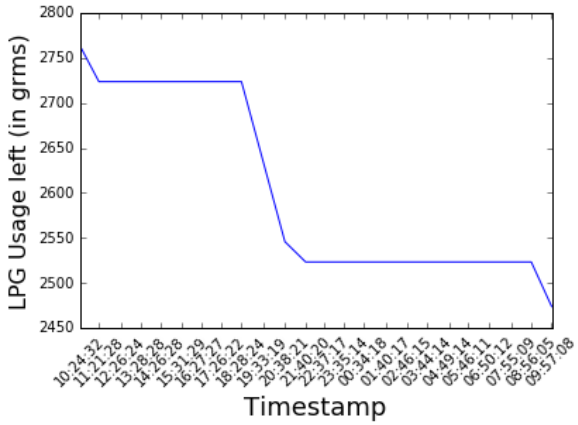


Fig. 11 (a) Daily Usage pattern of Customer 3

It can be inferred from Fig. 11 (a) that customer 3 starts with an initial LPG fuel of a little more than 2750 grams, which then decreases with hourly usage. It can be noticed that there is no usage during the time intervals 10:30 AM to 5:30 PM and during 8:30 PM to morning 8 AM. The peak usage occurred during evening 5:30 PM to 7:30 PM, which can be inferred from the peak slope of usage pattern during the interval. Fig 11 (b) shows long term usage of customer 3, in which It can be noticed a recharge was done at around 230nd hour which would be 10th day of use. It can be seen as a spike in the figure. Further it can be noticed that new LPG fuel value rose to slightly more than 3500 grams.

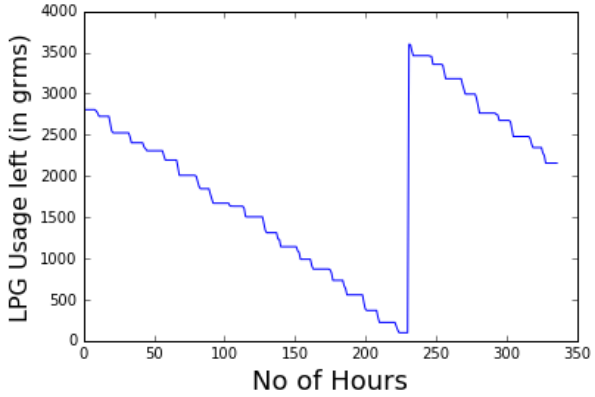


Fig. 11 (b) Long term usage pattern for Customer 3

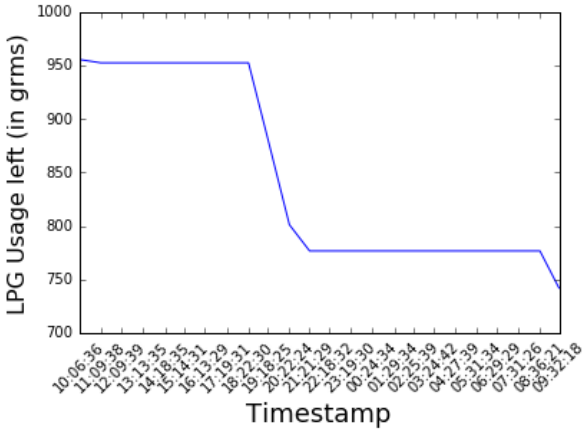


Fig. 12 (a) Daily Usage pattern of Customer 4

It can be inferred from Fig. 12 (a) that customer 4 starts with an initial LPG fuel of a little more than 950 grams, which then decreases with hourly usage. Further it can be noticed that there is no usage during the time intervals 10 AM to 5 PM and during 8:30 PM to morning 7:30 AM. It can also be pointed out that the peak usage occurred during evening 5:30 PM to 7:30 PM, which can be inferred from the peak slope of usage pattern during the interval. Fig 12 (b) shows long term usage of customer 4, in which It can be noticed two recharges was done, one at around 60th hour which would be 3rd day of use and the other at around 330th hour which would be 14th day of use. These recharge instances can be seen as spikes in the figure. Further it can be noticed that new LPG fuel value rose to slightly more than 3500 grams in both cases.

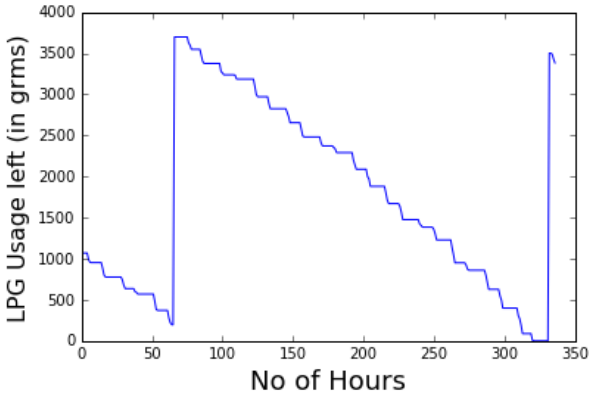


Fig. 12 (b) Long term usage pattern for Customer 4

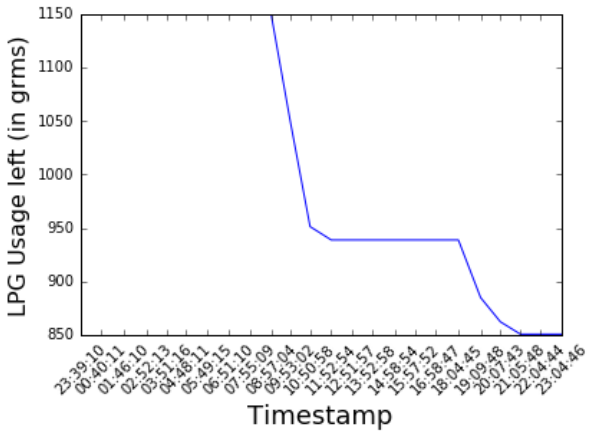


Fig. 13 (a) Daily Usage pattern of Customer 5

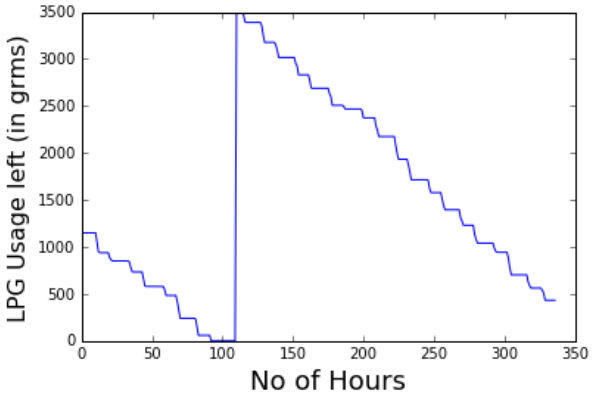


Fig. 13(b) Long term usage pattern for Customer 5

It can be inferred from Fig. 13 (a) that customer 5 starts with an initial LPG fuel of 1150 grams, which then decreases with hourly usage. It can be noticed that there is no usage during the time intervals 11:39 PM to morning 8:00AM and during 10:50 AM to evening5 PM. It can also be pointed out that the peak usage occurred during evening 8AM to 9AM, which can be inferred from the peak slope of usage pattern during the interval. Fig 13 (b) shows long term usage of customer 5, in which It can be noticed a recharge was done at around 110thhour which would be 5th day of use. It can be seen as a spike in the figure. Further it can be noticed that new LPG fuel value rose to 3500grams.

V. ADVANTAGES OF PROPOSED SOLUTION

The proposed solution shall be able to provide the provide price fragmentation facility which can be as low as 10. This would make way for people belonging even to the lowest strata of income band to be able to get included in the access to clean energy source. The solution to affordability and accessibly of LPG can replace the solid biomass based fuel that the people need to buy from market and cost more or equal to LPG. The total share of such fuel used for cooking is 65% of the total cooking done using solid

biomass or 39% of total cooking fuel used. This may lead to increase of LPG uses by 30%-40% resulting in huge business opportunity for Oil Manufacturing Companies.

The ability to track, monitor, analyze the real-time data for LPG inventory can enable the Oil Marketing Companies and Government to co-relate the supply and demand with more accuracy and reliability. This analysis of real time LPG inventory data and uses pattern can be used to strengthen the supply chain

management and distribution of LPG cylinder efficiently. The co-relation of uses pattern, LPG inventory and seasonal fluctuation pattern can be combined together on the concept of Big Data Analysis to predict the demand at the accuracy that can go to more than 99%. Such prediction can be used make demand booking automatically and deliver refill cylinder without any wait time. This will not only have potential to improve consumer satisfaction but also can be used to eliminate the capital cost required to procuring and maintaining double bottled cylinder (DBC). As of now more than 110 Million LPG consumers in India who are registered for DBC. The cost of one LPG cylinder is 1400.00 which means the total capital cost involved in DBC is 154 Billion. We may have demand of same number of LPG cylinder in future as we have another more than 110 Million consumers who are not registered for DBC currently but might require DBC eventually.

VI. CONCLUSION

Transition to clean energy is responsibility of every person and every government. More than half of the world's population is till forced to use conventional source for their energy requirement. Countries irrespective of their economic condition are encouraging innovative method that can help this transition or make the already transitioned process more efficient.

- It is observed that IoT based solution discussed here has provided ability to track the data at asset level with the help of sophisticated sensors and actuators.
- The discussed communication analytical tools in can make it possible to analyze millions and billions of data in almost no time to gain actionable insight.
- In this paper, an attempt is made such that the daily LPG usage pattern of several days for a particular customer can be studied and analyzed to predict the usage pattern over the long run and predict when a recharge is required.
- Based on daily usage pattern for the customers under observation, it can be seen that average LPG burn rate is different for each consumer and can be seen in the form of different slopes in the respective graphs. Monitoring LPG burn rate for each house hold would allow predicting when a cylinder gets exhausted and its subsequent replacement.
- These accurate and reliable predictions can enable the LPG distributor to manage the demand and supply resulting into efficient supply chain management.
- Comparing the long term usage pattern of the consumers, we can see that consumer 4 has made more recharges than others. It suggests that consumer 4 tends to consume more LPG fuel than others and is like to make more such recharges soon. This could be of interest to the distributer.
- The data thus tracked combined with smart mechanical kit can be used to solve price fragmentation problem to include the marginal people also into the clean energy drive.
- The price can be fragmented up to Rs. 10 so that Below Poverty Line (BPL) people can enjoy the maximum benefit of using the cleaner energy.
- The proposed researched solution has ability to eliminate double bottle cylinder reducing the capital cost up to 154 Billion.

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REFERENCES

[1]. P. Balachandra, "Modern energy access to all in rural India: An integrated implementation strategy", Energy Policy,Vol. 39, Issue. 12,pp. 7803-7814, 2011.
[2]. N.H. Ravindranath, J. Ramakrishna, "Energy options for cooking in India", Energy Policy Vol. 25, Issue. 1,pp. 63-75, 1997.
[3]. PPAC, 2018. LPG Profile — Data on LPG; "Marketing" Petroleum Planning and Analysis Cell, 2018
[4]. NSS Report 542 (66th Round, 2009-10)
[5]. S.D. Pohekar, D. Kumar,M. Ramachandran, "Dissemination of cooking energy alternatives in India—a review", Renewable and Sustainable Energy Reviews, Vol. 9, Issue. 4,pp. 379–393, 2005
[6]. M. Sehgal, S.A. Rizwan, A. Krishnan,"Disease burden due to biomass cooking-fuel-related household air pollution among women in India",Global Health Action, Vol. 7, Issue. 1, 2014. Available at DOI: 10.3402/gha.v7.25326, 2014
[7]. PPAC, 2016. Petroleum Planning and Analysis Cell, "Assessment Report — Primary survey on household cooking fuel usage and willingness to convert to LPG"
[8]. PPAC, 2018. Price Build-up of Domestic LPG (Subsidized) at Delhi.
[9]. J.K. Parikh, A.Sharma, C. Singh, S.Neelakantan, "Providing CleanCooking Fuel in India: Challenges and solutions",Report published in International Institute for Sustainable Development 2016

[10]. R. Khan, S.U. Khan, R. Zaheer, S. Khan, "Future Internet: The Internet of Things Architecture, Possible Applications and Key Challenges", In the Proceedings of the 10th International Conference on Frontiers of Information Technology (FIT) 2012, Available at DOI: 10.1109/FIT.2012.53 (ResearchGate)
[11]. EU Directive 2006/32/EC
[12]. S. Jessica, D. Christophe, H.Y.Mazin, H.Y., "Empower Demand — The potential of smart meter enabled programs to increase energy and systems efficiency: a mass pilot comparison",VaasaETT – Global Energy Think Tank, 2011
[13]. The Economic Times, "Tata Communications and Mahanagar gas Ltd to deploy 5,000 smart gas meters in Mumbai", 03 April 2018
[14]. The Economic Times, "Smart Meters to rationalize electricity consumption in India", 18 March 2018.
[15]. D. Newman, "How IoT Will Impact The Supply Chain", Forbes, 9 January 2018
[16]. J. de Carvalho Silva, J. J. P. C. Rodrigues, A. M. Alberti, P. Solic and A. L. L. Aquino, "LoRaWAN — A low power WAN protocol for Internet of Things: A review and opportunities," In the Proceeding of the 2nd International Multidisciplinary Conference on Computer and Energy Science (SpliTech), pp. 1-6, 2017.

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