A Comparative Analysis of Enabling Technology for PAYG LPG

M-KOPA Labs weighs the cost, feature and remote monitoring benefits of non-locking IoT technologies to underpin a PAYG LPG business model

OVERVIEW

Affordability and accessibility are the primary barriers to adopting liquified petroleum gas (LPG) cooking amongst sub-Sahara African households.

Seeking to serve customers' modern cooking needs, M-KOPA Labs "Labs", a dedicated Research and Development team, undertook technical research to explore the technological requirements to underpin a pay-as-you-go (PAYG) LPG financing model for M-KOPA's existing smartphone customers. As the market PAYG leader with more than 1 million customers, M-KOPA has deep expertise in anchoring a line of flexible credit for products through IoT connectivity that were previously out-of-reach for customers.

With support from MECS, Labs assessed the viability and cost benefits of low-cost securitisation technologies (beyond emerging smart locking valves) to remotely monitor customers' LPG usage and communicate fulfilment and payment crediting via the M-KOPA App. This investigation sought to bypass use of a smart locking valve for a PAYG LPG model while still locating the gas cylinder across the value chain and tracking gas consumption at the household level.

This note summarises the research undertaken by M-KOPA's engineers, entailing testing of:

- QR codes, Bluetooth beacons, radio-frequency identification (RFID) and near-field communication (NFC) tags for location tracking, and
- ultrasonic sensors, thermal gas level strips, and digital scales for gas usage.

RATIONALE

Importantly, in testing non-lockable tracking and monitoring technologies, Labs has in mind 'upgrading' M-KOPA's PAYG smartphone customers onto a PAYG LPG plan. In this scenario, existing PAYG Phones customers with existing credit histories in possession of lockable assets can opt to finance the purchase of LPG by re-collateralising their smartphone.

Several technology companies have developed 'smart locking valves' to dually regulate LPG usage and geolocate the cylinder in real-time to secure a line of credit for customers who finance gas use on a PAYG basis. CircleGas (who acquired KopaGas), PayGo Energy, Envirofit and Fenix are the trailblazers in this growing PAYG LPG market.

While smart locking valves provide many advantages to providers in term of accuracy and remote monitoring, they have yet to show market viability. In practice, providers integrate a smart locking valve onto LPG cylinders to regulate usage, credit mobile money payments to cylinders via GSM, and geolocate cylinders with a GPS tag. The company's fleet management system monitors customer repayment behaviour and cylinder tracking.

It was discovered that the added hardware, telemetry, and other material costs for a locking valve amount to $43, although some industry experts note it is closer to $200. The smart locking valve's high cost relative to that of the LPG cylinder erodes affordability for customers and scalability for providers.

Seeing the need to increase affordability for customers, Labs explored the accuracy and economics of alternative monitoring and tracking technologies.

METHODOLOGY

M-KOPA's engineers evaluated sensors in Woking to validate accurate location tracking and gas usage monitoring. Select high-potential sensors were then shipped to Kenya for localised tests, entailing checking the sensor's accuracy with local cylinders at different gas levels, practicality in the local market context, and IoT capabilities.

KEY LESSONS LEARNT

1. QR codes prove to be the most economical, appropriate means to track cylinders across the distribution chain

Digital payments and marketing are a few of the many QR code applications used across Kenya. ProGas has adopted them by metal-etching them onto cylinders to manage its fleet through its distribution network. Its familiar interface and proven usage in the LPG context informs its superiority compared to other location tracking sensors. High customer awareness of the technology and low cost also reinforce its high score relative to the assessment framework.

Criteria	**QR Code**	**NFC**	**RFID**	**Bluetooth Beacons**
Cost of good	5	4	3	1
Ease of use	3	3	5	2
Fault Tolerance	5	3	3	3
Market Fit	5	3	3	1
Remote Monitoring	2	2	2	1
Total	**20**	**15**	**16**	**8**

Table 1: Scores of the location sensors against the success criteria

Whereas other sensors require extra costs and are prone to market faults, a QR code is free to generate, requiring only the sticker cost – ranging from $0.16 for vinyl labels to $1.13 for stainless steel etchings.

QR codes are not without their limitations though. This technology is characteristically passive, meaning it does not provide just-in-time, 'pull' location updates. Instead, the codes are manually scanned and tagged at distribution points by workers across the value chain (i.e., factory workers and truck drivers) using smartphones to send or 'push' location updates. This information is fed into a cylinder fleet management system that monitors the inbound and outbound logistics of cylinders and tracks for losses in the market. Therefore, LPG cylinder providers are exposed to the diligence of workers pushing updates and GSM connectivity to transmit data, which can be difficult in Kenya's remote areas.

The importance of tracking cylinders cannot be understated. Inability to track a cylinder's movement through the value chain represents a primary pain point for providers wanting to scale LPG operations into hard-to-reach areas (e.g., rural communities). Improving transparency by producing a trustworthy record of a cylinder’s movement history will also give distributors more confidence to retain cylinders in their networks, monitor history, and enact appropriate safety tests, when needed.

Without the ability to track and minimise leakage of cylinders (and value!) into the market, providers are met with disincentives to scale, leaving rural customers with few options beyond traditional cooking fuels.

2. Bottom-mounted ultrasonic sensors are accurate, reliable sensors that fit Kenyan LPG cylinders

Usage sensors were assessed against a five-point framework that prioritised the most influential factors regarding customer experience, safety, and commercial value. A durable sensor must be able to withstand transport along road bumps and mishandling without damage, and accurately monitor usage so custeomrs are not over/under charged. Equally, ease of use ensure customers are not turned away by an over-complicated experience.

Criteria	**Bottom- mounted ultrasonic sensors**	**Side-mounted ultrasonic sensors**	**Gas level strip**	**Digital weighing scale**
Cost of good	3	4	5	4
Durability	4	3	5	3
Accuracy	5	4	1	4
Fit	5	3	1	3
Remote Monitoring	4	4	1	4
Total	**21**	**18**	**13**	**19**

Table 2: Scores of the location sensors against the success criteria

Durability & Fit: The bottom-mounted ultrasonic sensors fit the local Kenyan LPG cylinders well, aptly sitting at the bottom of a cylinder above the ground for protection. Placement in the space between cylinder and ground also means the sensor stays in place and undamaged when stacked in lorries travelling over bumpy roads.

Figure 1: MOPEKA's ultrasonic sensor

In comparison, other technologies attached poorly to the spherical-bottomed cylinder. In particular, the digital weighing scale was not wide enough to fit around the local 6kg cylinders and sat directly underneath the 6kg cylinder, deemed unsafe for cooking.

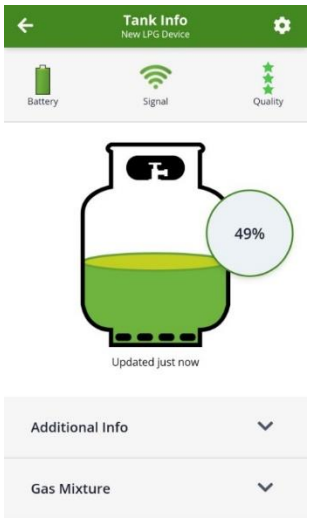

Figure 2: MOPEKA's mobile application

Accuracy: The bottom-mounted sensors were the most accurate and have bespoke mobile applications (*see Figure 2*) which track gas usage. This mobile application indicates that there could be a partnership between M-KOPA and the sensors' manufacturers to build a mobile application for target LPG users. Also, user-specific data can personalise M-KOPA and the customer's relationship, such as a forecasted refilling schedule.

Side-mounted ultrasonic sensors and thermal gas level strip provided inaccurate results. The results were static since it provided information relating to a singular point on the cylinder.

Cost: Bottom-mounted sensors have the most extensive retail price range, between $34 - $170. However, its lowest retail price is cost-competitive with other sensors' retail price ranges, i.e., digital weighing scales ($19 - $30), side-mounted-ultrasonic sensors ($22 - $48), and thermal gas level strips ($3 - $5). Expectedly, the bottom-mounted ultrasonic sensor cost is cheaper than the retail price; however, additional research will define by how much. M-KOPA's engineers will take apart the sensors to improve their knowledge of the sensor's bill of material, which is critical if there is future product development. Given that M-KOPA's tests are a novel use case for

these sensors, M-KOPA engineers will remove high spec parts that increase the cost but do not affect the accuracy or feedback of household gas consumption.

Remote monitoring: M-KOPA's awareness of the customer's behaviour enables a superior customer experience through timely refills and clear customer support. Compared to the thermal gas level strip, the digital scales and ultrasonic sensors automatically 'pulled' mobile application updates without any customer intervention. Gas level updates are critical for servicing and financing, and a daily update would suffice for M-KOPA's concept. Current sensors update the gas level on the mobile application hourly. Regular updates consume a lot of battery power and its high frequency dampens its meaningfulness. To suit the project's needs and conserve cost, M-KOPA's engineers will investigate how to employ a daily gas consumption update to the mobile application rather than hourly updates.

3. Despite higher costs, smart locking valves remain a better acquisition solution

Early tests show that integrating QR codes and ultrasonic sensors on an LPG cylinder provides reliable readings, has fewer features than the smart locking valve, and is cheaper by $9 (*see Table 4*). However, despite the smart locking valve's unproven economics, a combined QR code and ultrasonic sensor cannot compete with a smart locking valve's ability to service customers not in possession of an M-KOPA connected asset to act as collateral.

Success Criteria	M-KOPA's Concept	Smart Locking Valve
Cylinder agnostic	Y	Y
Lock gas flow	N	Y
Real-time gas and location tracking	N	Y
Cylinder fleet management	Y	Y

Table 3: A features list comparison between the smart locking valve and M-KOPA's concept

Cost-comparison: Examining the bill of material for M-KOPA's concept versus smart locking valve costs illustrates the slim cost-competitiveness of Labs' off-the-shelf concept (*see Table 4*). While M-KOPA's concept has a slightly lower midpoint expected cost, M-KOPA's Engineers expect to generate further cost savings through a deeper analysis of potential redundant component parts in the sensor.

Item	M-KOPA's Concept	Smart Locking Valve
QR code	$ 0.16 - $ 1.13	
Ultrasonic sensor	RRP $34 - $170	
Total	**$34.16 - $170.13**	**$43 - $200**

Table 4: A unit economic comparison between the smart locking valve and M-KOPA's concept

Product-market fit: Compared to smart locking valves, a QR code and sensor combination cannot secure the initial line of credit to unbanked customers, making them ill-suited for first-time PAYG customers. As such, M-KOPA's ability to scale this proposition is tied to its capacity to grow its base of PAYG Phone customers, who must have acceptable repayment behaviour and willingness to adopt LPG.

Enabling tech: Importantly, the selected sensors that M-KOPA tested are also characteristically smartphone-centric, requiring both customers and LPG service providers to manually push updates via mobile applications. For example, truck drivers and warehouse workers will use smartphones to register inventory updates, manage delivery routes, and update receipt/shipment histories. Customers will use their smartphones to record the bottom-mounted sensors' gas usage reading through a mobile application. Despite the

growing adoption of smartphones in sub-Saharan Africa, this is a core limitation of M-KOPA's concept that could impact scalability.

NEXT STEPS

In Q1 2021, M-KOPA Labs will collaborate with M-KOPA Uganda to deploy and test the ultrasonic sensors' accuracy with a sample of domestic cooks in Kampala, Uganda.

The pilot will monitor daily usage of the cooks gas usage with bottom-mounted ultrasonic sensors that are validated with handheld weighing scales. Participants will fill out a diary each day, sharing their meals cooked and the gas cooking experience.

The knowledge gathered will deepen Labs' technical understanding of the sensors' accuracy of daily cooking, cooking behaviour and preferences. These lessons are critical to further refinement of M-KOPA valve solution. A solution which indicates price-competitiveness, reliability, and scalability.