



Sustainable Energy & Water Access through M2M Connectivity

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Scene from the Koar village, next to Tambacounda, East Senegal, November 2012.

At the end of the afternoon, women and children gathered to fetch water at a centrally located well. A solar powered telecom tower in the background provides mobile connectivity to the village. The electricity grid does not reach Koar. Even though inhabitants have increased access to solar solutions thanks to a local solar entrepreneur located in Tambacounda, the vast majority still rely on kerosene and candles for lighting, wood for cooking and pay a small fee to charge their mobile phone.

Overview

From urban to rural areas, mobile networks have become the predominant infrastructure in emerging markets and more people are now covered by mobile networks than have access to energy and water. Increased GSM coverage and growing mobile handset ownership in developing countries have become tools of inclusion for the underserved population often lacking access to basic yet critical infrastructure. Beyond voice and SMS, the maturity and cost decrease of Machine to Machine (M2M) solutions coupled to the development of mobile micro-payments are opening new pathways to innovative thinking where mobile connectivity can be leveraged to provide affordable energy and improved water access. At the same time, the prospect of millions of active M2M-enabled devices communicating through cellular networks could represent a compelling commercial opportunity for Mobile Network Operators and the broader mobile ecosystem.

This paper aims to shed light on the opportunities created by M2M solutions to reach and empower underserved populations in the developing world. The emergence of new business models leveraging GSM connectivity for remote operation and monitoring is already helping tens of thousands of people gain access to more affordable and sustainable basic life services. The development of “Pay As You Go” solutions combining the use of M2M technology to mobile money services, provides a microfinance element where the credit on a user’s account can be checked remotely, enabling low income consumers access what would have been normally prohibitively expensive goods/services.

Beyond pilots and nascent commercial deployments, some challenges remain for entrepreneurs providing M2M-based services to better reach the full population lacking access to energy and water. As an important element to achieve scale in resource constrained economies, a section of this report is focusing on the opportunity to design a new GSM M2M module: a simpler module design integrating lighter functionality would stimulate the integration of M2M modules in a wider range of products. Related to this point, M-KOPA, currently providing Pay As You Go solutions for energy access in Kenya, presents at the end of this report, an in-depth testimony about the challenges they envision in increasing the impact and scale of M2M services for the Bottom of the Pyramid (BoP) – see attached article “Unlocking a New Market: Ultra Low Cost M2M”.

This first white paper is part of a wider piece of GSMA research on how mobile “Enhanced Utility Solutions” in the developing world are helping the population covered by GSM networks to have access to basic community services. The term “*Enhanced Utility Solutions*” refers to the use of mobile technologies, either through Machine to Machine (M2M) usage, and/or mobile services, i.e. SMS/USSD and mobile payments, to improve access to energy and water for the population without a formal utility connection. A second report on the use of mobile phones and mobile applications for enhanced decentralized utility services is expected to be published by the end of the first quarter of 2013.

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Context for Inclusion through Mobile Data Connectivity

The Poverty Penalty

In 2008, 22% of the population in developing countries was living in extreme poverty¹ (on less than USD1.25 per day). In Sub-Saharan Africa, this proportion reached 47%². The situation for communities living in rural areas is made worse as these markets are very poorly served, dominated by the informal economy and, as such, relatively inefficient and uncompetitive. This phenomenon of “*poverty penalty*” often applies to low income population and refers to the fact that people in these underserved markets have to spend more than wealthier ones for the same product or service.

A study performed by MicroEnergy International showed that 1 kWh costs USD2.30 in rural Bangladesh, compared to about USD0.30 in Western Europe³. Next to food and housing, energy is the biggest expense for low income households⁴, with an average of 9% at the Bottom of the Pyramid⁵ (BoP) level. For the poorest tier of income, this proportion can be even higher, as households in the BOP500 income group⁶ spend an average of USD148 a year on energy (~30% of their income). As poor households spend increasingly greater shares of their income on energy, they reach a point where they begin to cut back on their energy use to minimum levels and are being deprived of other basic goods and services needed to sustain life.

The Poverty Penalty also applies to water access. For example, in the slums of Jakarta, people spend up to USD7.5/m³ for the water sold by the local water vendors that serve their neighbourhoods, while the official utility tariff⁷ is USD0.12/m³. In rural areas, many households still meet their needs by collecting water from free sources like wells and surface water. However the growing problems of polluted water sources due to industrialization, agricultural practices or poor sanitation drives up the need for purified water services.

Ubiquity of GSM networks and Mobile Devices

The number of mobile connections in the developing world has risen from 2.14 Billion in 2007 (38.2% of market penetration) to 4.96 Billion in 2012 (83.4% market penetration). Today, 3 of every 4 new connections is occurring in the developing world⁸. Sub-Saharan Africa is the fastest-growing mobile market, with an average annual growth rate of 44% since 2000⁹, reaching 64% mobile market penetration in 2012¹⁰. As mobile networks have become increasingly ubiquitous in emerging markets, more people now have access to mobile networks than they have access to energy, water or sanitation (see Figure 1).

¹ World Bank 2012 - <http://iresearch.worldbank.org/PovcalNet/index.htm>

² World Bank 2012

³ Energize the BoP report – Endevo 2011

⁴ The Next 4 Billion report – World Resources Institute 2007

⁵ The Bottom of the Pyramid constitutes the market made up by the world's poorest people, including those with incomes below USD3,000 (in local purchasing power)

⁶ BOP500: BoP group with income per year up to USD500

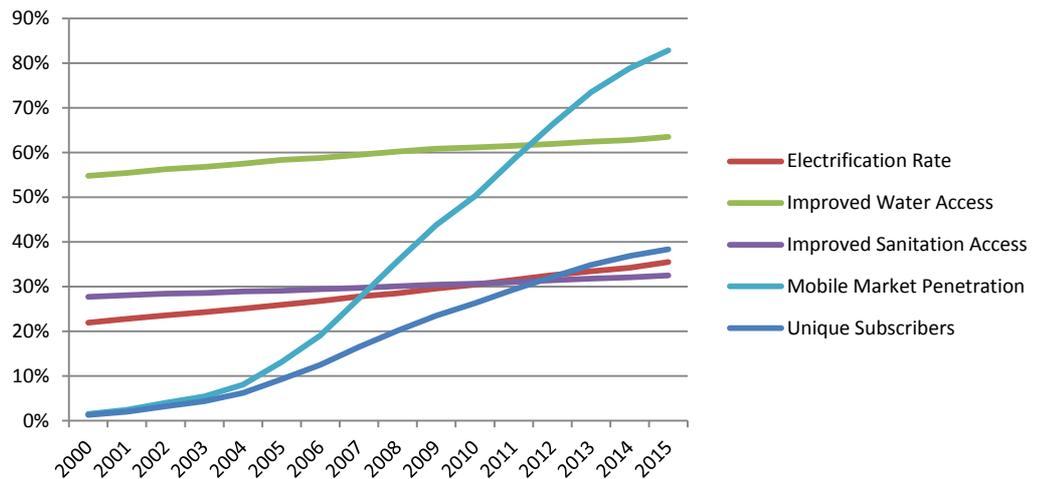
⁷ Access to Safe Water for the Base of the Pyramid report – Hystra, Ashoka, 2011

⁸ Wireless Intelligence 2012

⁹ Sub-Saharan Africa Mobile Observatory report - Deloitte/GSMA 2012

¹⁰ Wireless Intelligence 2012

Figure 1: Mobile Phone Penetration versus Energy, Water, Sanitation Access in Sub Saharan Africa



Source: GSMA, World Bank, IEA 2012

The extension of mobile coverage to rural areas has helped to catalyse the growth of the mobile market (see Table 1). While regions such as Latin America, Middle East & North Africa, and East Asia & Pacific, have more than 80% of their population covered by mobile networks¹¹, GSM population coverage in South Asia and Sub-Saharan Africa is still lagging behind, with respective coverage of 70% and 62% in 2009. The on-going extension of mobile networks to rural and remote areas remains crucial to the growth of the mobile market and to the inclusion of a wider population to the “connected world”.

Reliability of networks is also key to the development of innovative solutions based on the use of M2M solutions for remote monitoring and mobile payment applications. For these systems where communication uptime is critical to service delivery, reliability and latency challenges in GSM networks could hinder the growth of these solutions¹².

Table 1: Developing World Focus - Mobile Penetration and % Population with GSM Coverage

	2006	2009	2012	2015
Total Connections (Billion)	1.51	3.15	4.96	6.30
Market Penetration (%)	27.3	55	83.4	102.2
Connections				
Market Penetration (%)	17.8	28.5	37.7	44.2
Unique Subscribers				
GSM Population Coverage (%)	48	66	>70	-

Source: Wireless Intelligence & GSMA Mobile for Development

The Impact of Mobile Money Services

With more than 2.5 billion adults around the world lacking access to a formal bank account, mobile money services offer a potential solution for financial inclusion¹³. Bill payments, social welfare payments, salary payments or micro-insurance products are examples of much-needed financial services that might be delivered more effectively via mobile.

The story of M-PESA, Safaricom’s mobile money service in Kenya, reflects a transformational innovation in the use of mobile phones. M-PESA allowed people living without access to formal banking services and/or permanent addresses to use a virtual mobile wallet to transfer funds, make payments and now build up savings thanks to their mobile phone subscription. M-PESA has extended basic financial services to the most unlikely of customers, utilizing the mobile network in a way that is good for the population

11 GSMA based on mobile operators coverage maps

12 There are also some systems where data upload can be “buffered” until the network is available i.e. the data is still being collected locally

13 Mobile Money for the Unbanked Annual Report – GSMA 2012 - <http://www.gsma.com/mobilefordevelopment/mmu-2012-annual-report/>

and is commercially viable.

Since launching in 2007, the number of M-PESA users has risen to more than 15 million¹⁴ with over 50% of the adult population now using the system and over KES.1.4 Trillion (~USD12.3 Billion¹⁵) in transactions on the platform. The number of M-PESA agents has also reached over 37,000 countrywide, providing a new category of employment and income to many people in the retail sector¹⁶.

Figure 2: A Safaricom Agent shop in Kitale, Rift Valley Province in Western Kenya



Source: GSMA

In early 2012, Safaricom lowered the size of M-PESA tariffs on the smallest transaction tiers - KES10-49 (USD0.1-0.5) – to KES3 (USD0.03) on each transaction. By lowering these transaction fees, Safaricom is enabling mobile micro-payments to reach an even wider population who manage their day-to-day budgets carefully.

If the story of M-PESA in Kenya has been a staggering success, replication of this model to other countries is challenging¹⁷. Even though 140 mobile money services have been deployed to date¹⁸, the full potential of mobile money is still to be unleashed, partly because regulators are still determining how to allow these schemes to grow without compromising consumer protection, and for mobile network operators as well as banks, to realise the full benefits of using the mobile channel and put in place the appropriate operational structures.

14 Safaricom Digital Sustainability report 2012 - <http://www.safaricom.co.ke/sustainabilityreport/>

15 Currency Rate as of December 2012

16 Safaricom Digital Sustainability report 2012

17 GSMA Mobile Money for the Unbanked Annual Report - 2012 - <http://www.gsma.com/mobilefordevelopment/mmu-2012-annual-report/>

18 GSMA Mobile Money for the Unbanked data as of October 2012 - <http://www.mobileworldlive.com/mobile-money-tracker>

Empowerment through M2M connectivity

Developed versus Developing M2M Markets

M2M has been touted for years as a game changer in developed economies, allowing machines to be connected through a seamless network, empowering customers, increasing efficiency of existing services and creating new opportunities for business applications. After years of slow growth challenged by platform complexity, solution fragmentation, high costs and the lack of partnerships between key players, the M2M market is now experiencing steady growth, with connections predicted to reach 50 billion by 2020, representing a USD1.3 trillion opportunity for mobile operators¹⁹.

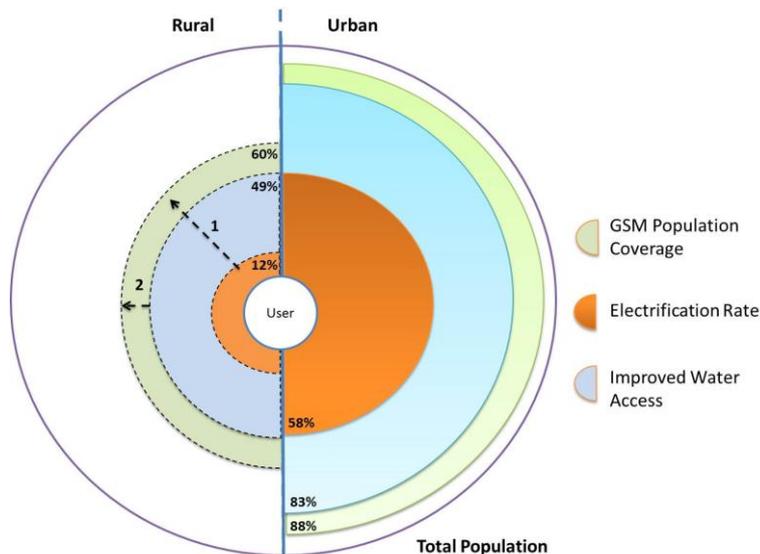
The number of M2M applications in the developing world however only accounts for a very small portion of the overall usage (approximately 1.5%²⁰). South Africa is the most prominent country on the African continent in terms of M2M connectivity, having registered more than 1 Million connections in 2012²¹, for applications such as smart grid and fleet monitoring. Under Business As Usual, where developed world applications are applied to developing markets, the potential of M2M looks dim and distant, tied up to the current access to global infrastructure (i.e. energy grid & water networks).

The same way mobile phones have been successful in emerging markets because of the lack of infrastructure, M2M has the potential to increase the resilience of decentralized utility systems, unlock wider opportunities for the mobile industry and impact the lives of millions of underserved people.

M2M Usage Scenarios in Developing Markets

Worldwide, 1.4 billion people lack access to electricity with 85% of them living in rural areas²² and 783 Million people still have no access to an improved source of water. In Sub Saharan Africa, the situation remains critical as, despite rapid growth of the mobile infrastructure, an important part of the population lacks direct access to energy and water (See Figure 3). Out of the total population covered by GSM mobile networks in the developing world, the GSMA estimates that up to 411 Million people²³ are without access to energy (1) and that up to 165 Million people²⁴ live without improved water access (2).

Figure 3: Access to Energy, Water & GSM Population Coverage in Sub Saharan Africa (Rural & Urban Centres)



Source: GSMA, IEA, World Bank

19 GSMA Connected Life Position Paper – GSMA/Machina Research 2012 - Connected Life Programme <http://connectedlife.gsma.com/connected-life-position-paper/>

20 M2M Market Data for GSMA - ABI Research 2011

21 Global Wireless M2M Market 2012 – Berg Insight

22 International Energy Agency 2010

23 The total addressable market is an estimate of the number of people, on a country basis, who live within the range of GSM mobile networks and have no access to electricity & water, but could hence be impacted by the deployment of GSM based M2M connectivity

24 Ibid

Access to Affordable & Reliable Energy

Off Grid rural families usually gain access to energy services by purchasing batteries or kerosene for lighting, gathering wood for cooking and paying for phone charging services²⁵. In recent years, a new type of Energy Service Company (ESCOs) has emerged providing decentralized clean energy systems integrating GSM connectivity to overcome some of the main barriers to micro-utility sustainability, affordability and maintenance²⁶.

Remote Monitoring

The active monitoring of units (i.e. Solar Home Systems) allows ESCOs to have real time information about on-going operations. At regular intervals (hourly or more frequently), an embedded microcontroller sends information to a central server about user's consumption, photovoltaic energy production, battery voltage and any operational problems that could result in the unit failure. This data is stored in a central database and can be retrieved later²⁷. The central server can communicate with customer cell phones and the local meters using Hypertext Transfer Protocol (HTTP) and SMS messaging over the GSM network. For communication to occur between the customer (through SMS), the server and/or the meter, a communication gateway is needed between the GSM network and the internet²⁸; this communication gateway is provided by the mobile operator or by employing custom software in conjunction with a modem.

Facilitating consumer financing through M2M Connectivity

The microfinance element of the Pay As You Go (PAYG) solutions allows customers to pay a fraction of the price when purchasing an Energy System, and then repay for the full unit price by small instalments. As revenue collection is a challenge for off-grid business sustainability, the integration of mobile money services, such as M-PESA in Kenya, to the energy service, represents a clear disruption in the way low income people have access and pay for affordable energy. In the case of a home solar solution, this business model means eliminating the prohibitively high upfront costs needed to acquire a solar panel, while enabling the customer to pay for the product as they use it. Payments are made through phone applications: either using the Bill Payments mobile money service or by purchasing scratch cards validated using SMS. The flexibility of mobile money services also allows family members living in urban centres to send money wirelessly to the account of their relatives and friends with lower income using the M2M-enabled solar home system.

Several ventures (M-KOPA²⁹, Mobisol and Shared Solar) have now launched commercial services in Africa³⁰ (See Table 2). In their model, connectivity is generally provided bundled-in with the product. This approach is especially appropriate in situations where the potential cost of data required by the device is relatively small compared to the device purchase price.

25 Previous GSMA reports estimate off grid mobile users can pay up to USD3 per month on charging their phone - <http://www.gsma.com/mobilefordevelopment/off-grid-charging-choices-2011>

26 For more information: Harnessing the Full Potential of Mobile for Off grid Energy – GSMA 2011 <http://www.gsma.com/mobilefordevelopment/wp-content/uploads/2012/04/cpwhitepaper161211interactive2.pdf>

27 A Prepaid Architecture for Solar Electricity Delivery in Rural Areas, D. Soto, M. Basinger, S. Rodriguez-Sanchez, E. Adkins, R. Menon, N. Owzarez, I. Willig, V. Modi, Earth Institute at Columbia University, Advancing Energy, ICTD ACM 2012

28 Ibid

29 See M-KOPA complementary article "Unlocking a New Market: Ultra Low Cost M2M"

30 Several other companies offer Pay As You Go solutions today also based on embedded hardware (non GSM) and the use of scratch-cards to allow mobile payments through SMS messaging

Table 2: List of ESCOs leveraging M2M connectivity

Organisation	Location	Solution	Payment Method
SharedSolar	Segou (Mali), Ruhira (Uganda) and Port-a-Piment (Haiti)	Deploys micro-grids connecting up to 20 families. Core technology is smart metering, enabling real time consumption monitoring and prepaid use. SharedSolar gateway is capable of communicating via SMS as well as 2G and can also be tied-in with 3 rd party mobile banking services. In 2012, there were 245 households connected to the SharedSolar platform.	Payments are made through scratch-cards for now (and looking to integrate M-PESA). Customer buys a scratch-card from a local vendor for as low as USD0.50.
M-KOPA	Kenya	Provides solar home systems from D-Light Design to rural Kenyans on a pay-as-you-go basis. M-KOPA solar is currently available in 300 shops across Kenya through Safaricom distribution network.	An initial deposit of KES2500 applies, then customer pays daily instalments of KES40 via M-PESA for a period of one year
Mobisol	Arusha (Tanzania) and Kenya	Distributes 4 types of solar home systems integrated with a pay-as-you-go system which is realised using SMS, GPRS and a mobile app which connects via 2G or 3G.	Users pay a deposit (depending on solar home system model) then monthly instalments, from KES1.100 to 4.400 through M-PESA.

Table 3: Challenges of Energy Access and Impact of M2M solutions

	Challenges	Impact
ESCOs (Energy Service Companies)	<ul style="list-style-type: none"> - Loss of revenues and reliability of services as people tap the grid illegally - Poor Payment Collection, consumers sometimes delay payments increasing project risk - Operational Challenges in maintaining micro-grids 	<ul style="list-style-type: none"> - Real time information on operations - Improved payment processing and increase efficiency (no payment collector needed) - Customer data on energy usage increases knowledge on customer consumption patterns
Community	<ul style="list-style-type: none"> - Low income people are unable to pay for grid connection (can be up to USD2000³¹) or purchase home solar systems - High expenditures on energy (kerosene) and phone charging services - Long time spent on traveling to nearest village to access energy for the most rural parts 	<ul style="list-style-type: none"> - Save Time (local access to clean energy) - Save Money (on travels and phone charging expenditures) - Flexibility of payments (in small increments) and prepaid energy affordability
MNOs	<ul style="list-style-type: none"> - Lower ARPU: Subscribers use their phone less because the phone battery is depleted - High phone charging expenditures (Up to USD3 per month³²) reducing airtime expenditure 	<ul style="list-style-type: none"> - Increased ARPU (10-14%) tied with charged mobile phones - Attract/Retain Subscribers - Drives Transaction & Traffic Volumes (using mobile money platforms & SMS/USSD)

31 L Parshall, D Pillai, S Mohan, and A Sanoh. National electricity planning in settings with low pre-existing grid coverage: Development of a spatial model and case study of Kenya. Energy Policy, Jan 2009

32 GSMA Charging Choices 2011 report - <http://www.gsma.com/mobilefordevelopment/off-grid-charging-choices-2011>

Figure 4: Home Solar Systems (PAYG) on rooftops in Rural Tanzania

Source: Mobisol

Improved Reliability of Rural Water Projects

Millions of women and children spend several hours a day collecting water from distant sources of varying quality. In addition, dysfunctional water supply systems have led to a huge loss of investment (USD1.2 billion for Africa³³), caused by poor maintenance, limited financing and an overall failure to address sustainability challenges in the field³⁴. A recent evaluation of rural water schemes in Africa showed that 30-40% of these were non-functional³⁵ and it can take up to a month or more before pumps are fixed, leaving communities without easy access to clean water. In India, the largest groundwater user in the world, it is estimated that 85% of drinking water is groundwater dependent³⁶.

Mobile technologies, i.e. low cost GSM enabled water meters, could enhance water pump monitoring and improve understanding of user's behaviour. Beyond drinking water services, there could also be a high demand for solutions in sanitation and irrigation services. As stated by Robert Hope of Oxford University leading research on mobile water payments and smart hand pumps: "Technology innovation is occurring both incrementally in the domain of existing water meters becoming smart and also transformationally with innovative applications of mobile technology in the water sector"³⁷.

Remote Monitoring

Researchers from Oxford University³⁸ have started piloting projects in rural areas of Kenya where they installed low-cost data transmitters on hand pumps. These smart hand pumps automatically send SMS messages to the district and national water managers. The data sent by SMS also provide hourly water output estimates for the first time. The information is driving institutional change and new business models to improve maintenance responses to handpump failures at scale. Other country deployments will be shortly launched. The WellDone³⁹ organization will also start piloting their prototype of GSM enabled remote monitoring units for water pumps in the first quarter of 2013.

33 Evan Thomas, Zdenek Zuzr, Christina Barstow, Karl Linden, "Proving Sustainability: The International Development Monitoring Initiative," ghtc, pp.164-170, 2011 IEEE Global Humanitarian Technology Conference, 2011

34 The Sweetlab - http://www.sweetlab.org/wp-content/uploads/2011/05/SWEETSenseOverview_IEEE_GHTC_8.31.11.pdf

35 World Water Development Report – UN 2009

36 World Bank 2010

37 Hope, R.A., Foster, T., Money, A. and Rouse, M. (2012, in press) Harnessing Mobile Communication Innovations for Water Security. Global Policy

38 Mobile Water for Development Research Group: <http://www.oxwater.co.uk>

39 WellDone Organization - <http://www.welldone.org/about-us/>

Figure 5: Hand Pumps in rural Kenya equipped with GSM transceivers



Source: OxWater

The use of real time information and hard data on projects success and failure can also increase accountability of donor projects (See SweetLab⁴⁰ (The Sustainable Water, Energy and Environmental Technologies Laboratory at Portland State University) in Table 4). Data comparability can be a big challenge, and there is a “need for a wider and integrated approach to link to the national monitoring systems”⁴¹.

The recent USD5 Million grant received by Charity Water from Google⁴² to create and install low cost remote sensors on 4,000 wells across Africa by 2015, is also a sign that philanthropists are increasingly willing to support technology enhanced projects having a social impact.

Commercial Solutions

[Grundfos Lifelink](#) (East Africa) and [Sarvajal](#) (India) are the two main ventures which have developed business models based on the use of M2M connectivity for their clean water services.

Sarvajal uses a combination of GSM enabled remote monitoring systems through its Soochak controller and water ATM to provide clean water services in India. The Soochak Controller is a programmable Logical Controller (PLC) that enables remote monitoring and control of filtration operations. Sensors placed throughout the machine captured operational data, which is sent to a virtual number using a GSM modem. Water ATMs are also managed via GSM and enable the use of stored-value smart cards for water purchase. Their franchise business model ensures water production and distribution are run locally and managed centrally. As of November 2012, Sarvajal had 155 franchisees, impacting the life of more than 85.000 persons.

⁴⁰ Sweetlab project - <http://www.sweetlab.org/>

⁴¹ The Solutions Journal - Volume 3, Issue 4, Aug 2012 - <http://www.thesolutionsjournal.com/node/1138>

⁴² <http://www.charitywater.org/blog/google-impact-award/>

Table 4: List of WSPs leveraging M2M connectivity

Organisation	Location	Solution	Payment Method
Oxford University, Mobile Water for development Reserach Group	Several countries in Africa	Research projects on GSM enabled rural hand pumps, mobile water payments & micro-insurance against rural water risk research	-
SweetLab	Global	Sweetlab has developed a data platform using mobile technologies to remotely relay data on performance and use of various development programs, including water treatment, water pumps, water testing, cookstoves, indoor air pollution, sanitation systems,.. They have deployed 200 sensor platforms to date in 10 countries for about 10 different applications.	-
Welldone	Kenya	GSM enabled water pumps to monitor water infrastructure in poor rural areas targeting local utility empowerment (identify dysfunctional well and information water planning). Welldone will start piloting their solution in Q1 2013.	Looking to integrate a mobile payment system into their product so that repair teams can redeem their payment by mobile when they fix a device
Grundfos Lifelink	East Africa	Provides renewable powered water systems to low income markets, combining existing water service technologies, embedded GPRS solution and mobile banking for payment. Grundfos Lifelink has deployed close to 38 sites to date.	Users have to pay usually KES250 (~USD1.7) for a RFID key fob, that could be recharged using M-PESA. Users swipe the card against the water unit and pay as low as KES3 (~USD0.02) per 20L of water.
Sarvajal	India	Builds water systems and recruits local entrepreneurs to sell water to their communities using a combination of embedded solutions and mobile payments.	Users are paying 30 Paise (~USD0.003) per litre and use a RFID card at "water ATM" to get purified water

Table 5: Challenges of Water Access and Impact of M2M solutions

	Challenges	Impact
WSPs (Water Service Providers)	<ul style="list-style-type: none"> - Payment efficiency is low (sometimes <80% in urban water networks) - High water wastage due to unmetered connections - Unreliability of water connections and hand-pumps 	<ul style="list-style-type: none"> - Improved payment processing & higher collection rate - Leak and theft detection - Improved Monitoring and increased water pump resilience - Higher payment transparency through the mobile money platforms
Consumers	<ul style="list-style-type: none"> - People often need to travel to fetch water or reports water usage - Problems of disconnection when payment is not properly taken into account (for metered customers) - High Cost of water in underserved areas (especially urban poor environments) - Quality of water is unknown 	<ul style="list-style-type: none"> - Save Time thanks to local water access & payment - Save Money either on water purchases, reduce trips to pay for water - More reliable access to water infrastructure - Increased water security - Stimulate entrepreneurial activities (ex. growing gardens for families)
MNOs	-	<ul style="list-style-type: none"> - Drives Transaction Volumes (through mobile money use) - Attract/Retain subscribers - Brand Recognition

Source: GSMA

Connecting Rural Health Centres

Even though not directly related to access to energy and water, the following project is a good example of how M2M connectivity is bridging the gap for critical information access between urban and rural settlements.

With 50% of the world's population living outside urban and peri-urban areas⁴³, the rural population often lack access to healthcare facilities; the lack of access to electricity and modern medical equipment represents a challenge to providing efficient and timely care to patients.

Figure 6: Sequoia Technology SMS Printer solution used in Mozambique rural health centres



Source: Sequoia Technology

In the case of HIV blood tests, the results of blood samples taken in rural villages and sent to labs for analysis in urban centres can take weeks or months to make it back to a rural clinic. As a result, HIV patients can fail to get timely treatment, particularly for preventing Mother to Child transfer of HIV at birth. Funded by the Clinton Foundation, Sequoia Technology⁴⁴ has developed a HIV diagnosis communications system using M2M GPRS printers and a dedicated a GSM gateway. The solution allows for test results from far away laboratories to reach the clinics much faster, savings lives in the process. As of September 2012, there were 400 such printers deployed across Mozambique, 300 in Zimbabwe and a few hundred more in Kenya.

43 World Bank 2012

44 Sequoia Technology <http://www.sequoia.com> – The SMS printer project was funded by the Clinton Foundation in 2011

New M2M Module Design Could Unlock High Volume Growth

Among the main barriers to M2M deployments in emerging markets, the GSMA identifies:

Table 6: Challenges of M2M deployments

	Challenges	Suggestions
Module Cost	Cost of M2M connectivity, which includes hardware and all supporting processes (design, integration, certification and provisioning)	New Design integrating lighter functionality Pre Certified solutions to reduce total cost
Compatibility of platforms	Need for more standards based M2M solutions to increase compatibility (i.e. openness) of platforms	Accelerate standards discussion within M2M Encourage MNOs to actively participate in the work of standardisation bodies
Business Models	Lack of innovative & compelling business models	Support emerging ESCOs and WSPs leveraging M2M to reach underserved population

Openness and Standardization

Openness and cost of connectivity are strongly intertwined. Movement in the direction of openness, standardization and interoperability of M2M could help to dramatically simplify the application development, eliminate M2M infrastructure barriers, shorten time to market, and reduce operations and support costs of M2M applications. To achieve market growth, the current vertical M2M approach needs to be replaced by a horizontal one with a common system architecture which shares M2M system elements. Initiatives from the Eclipse M2M IWG⁴⁵ and ETSI, through their Release 1 standard⁴⁶, will help stimulate increased openness in the M2M ecosystem and integrate different M2M technology choices into one managed platform.

As this standardized effort is currently happening in the mobile industry, we chose to focus this section mainly on the opportunity to design a new industrial grade M2M GSM module targeting applications in emerging markets.

Cost and New Design of M2M GSM Modules

The cost of M2M connectivity refers to more than just the hardware module element; it also includes design, integration and approvals over platforms connecting to mobile networks⁴⁷ (for more information on the Total Cost of Ownership of M2M solutions, see Appendix 1). Regarding the aforementioned products and services targeting energy and water access for low income population, we are raising the point in this section of the opportunity to develop a simpler design for low end M2M modules.

GSM module cost has constantly decreased over the past years (See Figure 7), at a rate of 10-15% per year⁴⁸. As of 2012, the cost of a M2M GSM module is in the range of USD13 to USD17 per unit based on current production volumes⁴⁹, while a 3G module costs between USD35 and USD47⁵⁰.

45 The Eclipse M2M Industry Working Group Since was inceptioned in November 2011 - http://www.eclipse.org/org/industry-workgroups/m2miwg_charter.php

46 ETSI M2M Release 1 Information

47 The GSMA Connected Living team has developed an extensive discussion on the costs associated with different hardware and processes -

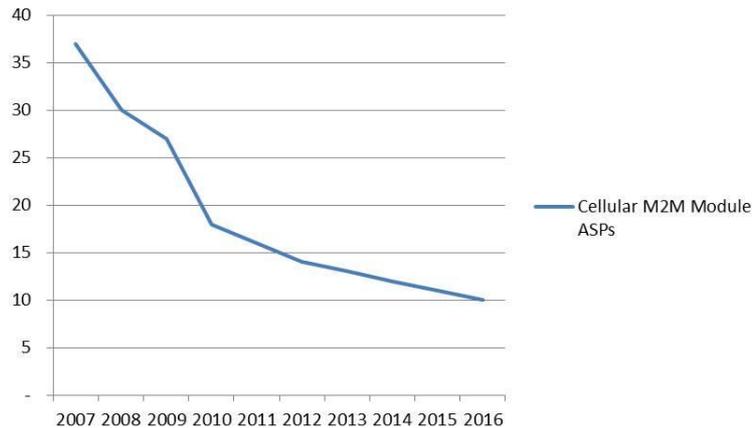
<http://www.gsma.com/connectedliving/sample-page/embedded-mobile-guidelines>

48 GSMA 2012

49 Beecham Research – Cellular Module Pricing Trends 2012 & Analysis Mason – M2M TCO Analysis for GSMA

50 Ibid

Figure 7: GSM/GPRS Module Average Selling Price (ASP) Evolution



Source: Beecham Research, GSMA

In a mobile handset, the cost of the GSM communication module can be below USD3, due mainly to the very high production volumes and yields of chipset providers, releasing tens of millions of GSM chipsets per year. For the type of applications using M2M connectivity, communication modules have a different design, need specific requirements such as ruggedization in order to operate in harsh environments. However low production volumes are hampering cost reduction. If volumes were to increase and the cost of one-time engineering design and licensing fees was spread across a large number of devices, the cost per unit could be reduced below USD10.

For entrepreneurs developing solutions for resource constrained economies, requiring energy efficient, low data bandwidth and no voice usage, a simpler design, achieving a lower cost per unit, could extend the reach of enhanced utility solutions. For example, using a basic stack, e.g. SMS and/or USSD as a data bearer could eliminate the need for GPRS data stack. Community Service Providers (ESCOs and WSPs), such as M-KOPA, are eager to engage with M2M module providers⁵¹ to develop use cases and requirements for new module specifications. These specifications would include:

- Dual Band EGSM 900/1800 MHz
- Reduced Number of Interfaces
- Low Data Rate: 9.6 kbps
- Limited ruggedization according to emerging market environment operations

For more information on module design, see M-KOPA Complementary Article “Unlocking a New Market: Ultra Low Cost M2M” at the end of this report.

Alternative WWAN Technologies

While M2M services generally don't require high-speed capability, the fact that millions of new nodes may use GSM networks would require more spectrum. In direct competition to cellular technologies for Wireless Wide Area Network communications, alternative technologies leveraging white spaces spectrum may emerge to provide more capacity for M2M communication. Although they are more focused on developed markets, emerging wireless wide area network solutions provided by companies such as Neul and SigFox⁵² could offer lower cost M2M modules in time. In terms of Total Cost of Ownership, such solutions would require higher costs of operation and maintenance (and the need to deploy new infrastructure), but the advent of lower cost chipsets is appealing to a large community of entrepreneurs willing to leverage mobile technology in their business model.

Neul, based in Cambridge, uses license-free TV white space spectrum within the existing global TV bands. The costs of spectrum, network infrastructure, back haul, maintenance and deployment are minimized, allowing customers to build and operate their own white space networks. The open network standard (Weightless¹) has recently gained traction

⁵¹ There has been an important consolidation in the cellular M2M module market over the past years. Sierra Wireless, Telit Wireless and Cinterion are the main providers. Other suppliers include Huawei, Novatel Wireless, Quectel, Sagemcom, u-blox, and ZTE.

⁵² Sigfox <http://www.sigfox.com/en/> is based in Paris and has developed a UNB wireless communication technology for cellular data transfer network optimised for low bandwidth M2M/ Internet of Things applications

with the creation of a Special Interest Group that will gather Neul, ARM, CSR and Cable & Wireless, in order to define royalty free specifications⁵³. The group will deliver a common set of specifications, which it claims will support the key requirements for M2M communications, including a chipset cost under USD2, a range of up to 10 kilometres and a battery life of 10 years.

Decentralized M2M-enabled Utility Services to benefit MNOs

In an increasingly competitive mobile market, M2M-enabled services help mobile operators differentiate their offer and also bring the potential to extract more value out of their existing infrastructure. In emerging markets, where 2G networks will remain the main radio access technology for voice and data connectivity in rural environments, this means increasing revenues without additional infrastructure investments.

There is an increasing opportunity for mobile operators to play an important role partnering with entrepreneurs providing services based on M2M communication, either through revenue sharing, distribution or marketing. Beyond the service delivery itself, partnerships allow to build deeper relationships with end-users who have been left out of the access to modern services and products.

The presence of mobile networks in rural areas and the operator's extensive distribution networks reaching remote populations are clear enablers to the success of M2M based solutions. More than pure M2M data delivery, the value is also shifting to building data intelligence on customer usage and payment frequency⁵⁴. In the case of PAYG, getting information on an unbanked customer's payment frequency could be used to provide an objective credit rating to financial institutions for loan allocation.

At this early stage of maturity, added to the marketing and distribution partnerships, the GSMA believes the following actions initiated by MNOs would support the growth of enhanced utility solutions:

- **Data and Mobile Money Channels** - Inexpensive data rates and access to mobile money networks would help mitigate costs and are important enablers to the scalability of nascent business using M2M.
- **Influence on M2M TCO** - Design and provisioning, including approvals and certification processes, represent an important part of the TCO for low-traffic M2M devices⁵⁵. Network operators have a level of approval over back end systems/platforms connecting to their network - movements towards standardized would help reduce cost of solutions TCOs.
- **Operational Commitment** - In the case of Safaricom, the operator has established a new department called *Digital Inclusion*, which supports other departments in enhancing access to Safaricom services more so to the base of the pyramid. Some of the programs the department is championing include m-health, m-agriculture, m-learning and off-grid energy⁵⁶.
- **Fostering Innovation in Emerging Markets** - Given their influence in the developing world, mobile operators could play an important role fostering innovation at the service level and support the development of compelling business models. The rise of tech hubs across emerging markets including the [Silicon Savannah](#)⁵⁷ in East Africa provides good conditions for more local M2M innovation. Hub networks such as the AfriLabs⁵⁸ across Africa would be an excellent channel through which MNOs as well as chipset suppliers could reach young, innovative entrepreneurs and technology companies looking to experiment with M2M and eventually integrate it within their solutions⁵⁹.

53 The Weightless group will define the full release of the standard, which is scheduled for completion in early 2013

54 M2M Communication – Turn Potential into Profit – Informa Telecom 2012

55 The total cost of ownership for embedded mobile devices – Analysis Mason & GSMA 2010

56 Safaricom 2012

57 The Economist article on the Silicon Savannah – April 2012 - <http://www.economist.com/node/21560912>

58 AfriLabs is a network of startup incubators, training spaces, co-working environments and tech communities throughout Africa. Currently there are more than 50 tech hubs, labs, incubators and accelerators in Africa, covering more than 20 countries and include names such as the iHub alongside NaiLab in Kenya, Hive Colab in Uganda and BantaLabs in Senegal.

59 In the developed world, several mobile operators have been increasingly interacting with technology developer's community and providing tools to increase adoption. Taking the example of AT&T's approach in the United States, AT&T partnered in 2009 with Jasper Wireless, launching the AT&T Control Center to enable rapid & large-

GSMA Future Actions

The development of M2M-enabled services based on GSM connectivity could be applied to provide intelligent decentralized infrastructure to the population which lack access to centralized infrastructure and services. Pay As You Go solutions for Energy Access are the most mature systems to date, leveraging GSM embedded technology for remote monitoring and the use of mobile money services for flexible and affordable payment schemes. Beyond energy and water access, M2M connectivity could be applied to a wider range of services and products, providing solutions to the lack of infrastructure in developing markets (health, sanitation, irrigation, etc.).

At this nascent stage, more proof of concepts of M2M connectivity based on cellular technology are needed to streamline business models, increase operations efficiency and foster partnerships. GSM module cost reduction could also be an important factor to increase scale and integration of M2M components in decentralized systems. In the coming year, the GSMA will engage with M2M Chipset Providers to foster the development of a new design targeting low end M2M modules - removing unnecessary specifications and cost to develop a stripped down GSM M2M solution targeting low cost low bandwidth applications.

As part of our newest programme, **Mobile Enabled Community Services (MECS)**, funded by the UK Government, the GSMA will continue to investigate the potential of M2M-enabled solutions for socio-economic empowerment, in order to:

- Catalyse the development of partnerships between key players: entrepreneurs, technology suppliers & mobile operators
- Outline opportunities and addressable markets in the developing world for M2M based solutions for energy access, water access and beyond
- Support Entrepreneurship through market intelligence and innovation funding

Appendix 1 - Drivers to M2M Module Cost Reduction

Solution designers can make a number of choices in specifying the configuration and feature set for a given module type⁶⁰. These choices need to be considered from two perspectives: module-specific costs and total-solution costs⁶¹.

Module specific costs	<p>Module hardware costs – costs for the physical components in a module</p> <p>NRE (non-recurring engineering) costs – one-time engineering design and licensing Fees</p> <p>Time to market – costs for additional manpower and an increase in the time to launch a product due to additional approvals activities</p>
Total Solution costs	<p>Production and sales volumes - One time engineering design costs can be high and need to be amortized over as large a units to drive down cost.</p> <p>Re-use of existing designs - The use of existing designs can provide significant benefits through economies of scale derived from "sunk" costs related to activities such as development and approvals testing</p> <p>Design strategy - Device vendors should evaluate the benefits of a "design-in" strategy as distinct from an "add-on" strategy which might be more costly over the service life of an embedded device</p> <p>Pre-certification -Selection of pre-certified stand-alone modules can reduce TCO for the Embedded Device developer, such as eliminating certification redundancy, simplifying and accelerating new product introduction process, ...</p>

Source: GSMA

From a module cost perspective, device hardware costs constitute only a minor part of total costs of ownership. While the cost breakdown will vary depending on a use case, the following ranges, calculated based on several specific cases, provide an indication of the cost drivers (as a % percentage of the total cost of ownership (TCO))⁶²:

TOTAL COST OF OWNERSHIP	% of TCO
Module Hardware	Up to 15%
Certification – device level versus platform approach	Up to 5%
Device Hardware and Non-recurring Engineering Costs (NRE, e.g. device development and integration)	20%-40%
Support – provisioning, activation, on-going support and upgrades	9-25%
Connectivity and Value-Added Service costs– based on average revenue per user (ARPU) vs connections -oriented business models	30%-57%

Source: GSMA

60 Embedded Mobile Guidelines on Connected Living website: <http://www.gsma.com/connectedliving/sample-page/embedded-mobile-guidelines>

61 GSMA Embedded Mobile Guidelines – Version 3 – March 2012 – Section 3.2.2

http://www.gsma.com/connectedliving/wp-content/uploads/2012/03/GSMA-Whitepaper-Embedded-Mobile-Guidelines-Release_31.pdf

62 TCO excludes the cost of the host device

About the GSMA

The GSMA represents the interests of mobile operators worldwide. Spanning more than 220 countries, the GSMA unites nearly 800 of the world's mobile operators with more than 230 companies in the broader mobile ecosystem, including handset makers, software companies, equipment providers and Internet companies, as well as organisations in industry sectors such as financial services, healthcare, media, transport and utilities. The GSMA also produces industry-leading events such as the Mobile World Congress and Mobile Asia Expo.

About Mobile for Development

Serving the underserved through mobile

GSMA Mobile for Development brings together our mobile operator members, the wider mobile industry and the development community to drive commercial mobile services for underserved people in emerging markets. We identify opportunities for social, economic impact and stimulate the development of scalable, life-enhancing mobile services.

For more information on the GSMA's Mobile Enabled Community Services programme, please email: mecs@gsma.com



Mobile for
Development



Unlocking a New Market: Ultra-Low-Cost M2M Opportunities and Barriers to a New Mobile Frontier

Nick Hughes, M-KOPA



This is Edith Chelangat, a Kenyan mother who for the first time is getting clean, affordable energy and light, thanks to her mobile phone. This lighting system is solar powered and includes embedded GSM technology for monitoring and metering usage. Edith makes micro-payments with her phone to top up her lighting system's 'credit' whenever she wants. It is a pay-as-you-go service with the advantage of no large initial cash outlay. Importantly, it is cheaper and healthier than the alternative, kerosene.

The service that Edith is using is provided by M-KOPA, a company established in 2011 to offer innovative services around machine-to-machine technology (M2M) coupled with micro-payments. The idea is simple; help customers save money by enabling micro-asset financing and allowing them access to previously unaffordable energy products.

Edith represents a vast pool of potential customers in sub Saharan Africa who are off the power grid but have a mobile phone. Her profile is quite typical; she runs a small farm with relatively low income (about USD800 per year), with access to cash being variable, depending on how well her crops have sold. Before M-KOPA, Edith would spend around 50 Kenyan Shillings (KES) (or about USD0.4) on kerosene each day and would spend KES20 three times a week to charge her phone at a local hardware store. With M-KOPA, she pays KES40 per day for all her lighting and charging needs. So, Edith immediately saves money. She can buy units of credit for her lighting system at any time, 24/7 using M-PESA, a mobile payment service operated by Safaricom. As soon as payment is received, a new credit message is pushed to her lighting system. Her payments are flexible allowing Edith to adapt payments to income, and after she has paid down the balance, she owns the system outright.

M-KOPA believes that M2M services for customers like Edith represent a new frontier. There are challenges but there are no impregnable barriers. Principal amongst the challenges is the need to simplify the core M2M technology and reduce its costs to allow it to be used in a wide range of applications. Changing the cost/volume dynamics for appropriately specified M2M units is not easily done, but history teaches us that technology costs will always fall.

The question is: **“Will the M2M incumbents anticipate this and lead the way - or will new entrants steal the show?”**. This case study explores this issue and presents some ideas for consideration by the M2M industry.

The Opportunity

Twenty years ago, few people believed that GSM mobile telephony would become affordable for low-income consumers in developing countries. Today, Africa has a population of nearly 1 billion people. In sub Saharan Africa, nearly 50% of people live off less than USD1.25/day, only one in five have access to formal financial services and yet there are over 688 million mobile subscriptions. Lower cost handsets and pre-pay pricing plans opened up the market to make the mobile phone a ‘must have’ to most families.

The potential scale of embedded M2M services in emerging markets is equally huge. The same technology and business model that is used to sell Edith a solar system is extendable beyond lighting. If a device has an ‘on/off’ function, then an embedded M2M system can be built to allow remote management and micro-asset financing. M-KOPA has been exploring new applications for M2M with the help of grant funding from the UK Government’s DFID, the Shell Foundation and the Lundin Foundation. Working with M2M specialists Eseye Ltd, we see opportunities in a range of verticals across energy, agriculture, health and information-management services. The list is long, for example, water pumps for irrigation or potable supply, chaff cutters for preparing animal feed, egg incubators to drive up productivity, grain driers that can improve storage and retention, water heaters and treatment systems, even smaller items like electric livestock fences. There will be opportunities in cold storage for both domestic and commercial applications, as well as more aspirational products like TVs for family use. The business case firms up if the M2M-enabled device can save customers money or offer them some other benefit, such as improved productivity.

The Barriers

M2M technology is the core enabler for these types of services but it needs to be available at a cost point that allows for scale. Recent research by the GSMA (2012) into the pricing and availability of M2M technology show 3G modules in the price range close to \$45 and even the simplest 2G models range between \$13 and \$15. That is almost as much as a basic phone. This price point of the simplest M2M modules prohibits their potential application in many smaller electronic items. So the key question is how can we drive down costs in a way that provides more business opportunity for all players in the value chain? We present the following ideas:

(1) An “Ultra Low-Cost” M2M specification (*call to action for hardware vendors)

As with GSM mobile communications generally, the basic cost of M2M hardware is the first and perhaps foremost barrier to market change. And like the emergence of low cost mobile phones, we have to begin by asking what are the minimum requirements needed by the end-user in a low income market?

Today, most M2M technology suppliers are focused on ‘high value’ wrappers for their hardware. For example, M2M units in a car can be used for fleet management, logistics tracking, and security. This is a big market with an estimated 7 million such units already in use throughout Europe. Medical services and remote health monitoring is another exciting area, where M2M connectivity is embedded into a sophisticated piece of medical equipment with the accompanying high levels of reliability and performance. These are great applications of M2M and unit prices in excess of USD45 can be justified where long life / high quality specifications must apply.

However, this is not the specification that applies to Edith’s product. The requirements for a M2M-enabled solar system are very simple: 2G data only (no voice required), capable of processing small amounts of data, reliably and at low cost. The relative costs of the M2M module within the total kit price are also likely to be much higher (perhaps 15% of the bill of materials). The amount of data required to be sent over time is also low, typically a few kilobytes at periodic intervals. But despite these lower specification requirements, most 2G modules on the market today are still around USD13 each. M-KOPA believes that this could preclude the adoption of new consumer facing services where the total unit price is sub USD150.

The expense barrier is more difficult to justify when one considers that 2G technology is quite mature. Of course, suppliers will need to protect their investments in intellectual property and the units must work well on the licensed spectrum. But 2G is 20 years old and, in the absence of patent protection (most expire after 20 years), somebody somewhere will build to a low specification without infringing IP, mark it up fairly, and sell it at volume. History has lots of examples of failed attempts to protect high margins on old technology, famously portrayed as the core plot of the “Innovators Dilemma”.

The insert box presents the specification of an M2M unit that would suit the consumer applications that M-KOPA is working on:

M2M Module Specification - Outline



Overview
Simple, robust, low power M2M module required for emerging market consumer electrical devices. High volume, cost sensitive applications.

Features:

GSM:	Dual Band, EGSM 900/1800 MHz
AT Commands:	3GPP TS 27.005, 27.007
SIM Toolkit:	3GPP TS 51.014
GPRS:	Class 8, PBCCH support, USSD, Mobile station class B, coding scheme 1-4
Power:	Off <5uA, idle power saving 1.5mA at DRX=9, dedicated mode 230mA (max) GPRS (Class 8) 360mA (max)
Sensitivity:	108 dBm at 900 MHz and 107 dBm at 1800 MHz
Interfaces:	ITU-T V.24 serial link through CMOS UART, baud rate of 9600 bps
Environment:	-5 to 50 degrees C
Approvals:	CE

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(2) An “Ultra Low-Cost” M2M service proposition (*call to action for M2M service providers)

If modules can become cheaper, then the next challenge comes to service providers, including the likes of M-KOPA and mobile telecoms operators. As with pre-paid airtime, the challenge is to develop service models that suit the price points and needs of low-income consumers. Service providers need to factor a total cost of operation that includes designing the M2M unit into the end-user device, connecting it (with a network operator SIM) and paying for data traffic. Given the highly variable factors in each potential use case, no single fee model exists. In traditional M2M services, when data communication charges are built into the lifetime costs, then USD45 for the M2M hardware pales to a minority cost. Indeed, some M2M applications can have total lifetime costs in excess of USD300. Again, these are not the ‘economics’ that apply to Edith. The repayment model and total cost of operation must have a shorter life span than more traditional M2M applications (certainly shorter than an auto tracking service or remote meter). Balance sheet risk to the service provider gets prohibitively higher where this ‘credit period’ extends beyond, say, two years.

Service providers must focus on building relevant price plans, recovering payment for relevant products in a way that suits the customers’ ability to pay. Research in the financial inclusion sector now tells us that absolute income is only part of the challenge for these types of customers; it is often as much to do with cash flow and dealing with volatile income. Flexibility is therefore key and mobile payment platforms offer us a way to provide for this – moving small amounts of e-money around at low cost. Attention from service providers can turn to the innovative models for the so-called last mile. M-KOPA has focused on doing just that, building responsive, scalable back-office systems to allow for good service provision (tracking devices for usage and performance, monitoring payments, trouble shooting and providing customer care).

(3) An “Ultra Low-Cost” M2M spectrum (*call to action for GSMA and communications regulators)

Finally, there are opportunities for the industry as a whole, including government and regulators, to examine spectrum and spectrum costs (including taxation, licensing and pricing) and open up lower-cost channels for connectivity. At a macro level, we, in the GSM industry, should also look hard at the spectrum requirements for M2M. Is there going to be under capacity in the older networks as 3G and LTE become more prevalent? Challengers will certainly come with different models, perhaps using parts of the spectrum that are under-utilized but already paid for (the broadcasting channels). The so-called ‘white space’ solutions could undercut any attempt to cram more devices into the licensed spectrum. It may be uncomfortable to think this way – but the reality is a gravitational pull to lower cost solutions and whilst incumbents will fight this, new entrants could thrive on a slow reaction by the GSM industry.

It must be possible to carve out space for low specification devices without compromising the higher technology solutions of LTE but this will entail thinking creatively when it comes to issues such as module design (e.g. standardizing board footprints), identification of devices (e.g. using device@domain-name models), and certification requirements. For sure, there is an argument that a cheap unit might preclude successful network integration or hinder post-sales support but that didn’t stop the proliferation of cheap handsets. The telecoms industry is full of ingenuity when it comes to adaption of technology; we see a case here to repurpose some basic technology for new value-creating services.

Conclusion and Recommendations

At the risk of over-simplifying (it's a big debate in a small case study), a hungry enterprise will see this market and move quickly to scale. In such a scenario, there will be longer term implications for the position taken across the M2M value chain (technology, data, consumer services). For the purposes of debate, M-KOPA would encourage the following objectives to be taken up by the industry to unlock the potential of emerging market, consumer based M2M services:

Short term:

- (1) Supply a M2M unit with specification appropriate to needs and reduce the Bill Of Materials cost; for example, targeting a USD5 wholesale price for Multiple Order Quantities of 100,000 by 2015?
- (2) MNOs and service providers should take comfort from the handset proliferation amongst low income customers and build out innovative service models using mobile payments and M2M

Medium term:

- Develop simplified standards and reduce the barriers to efficient, cost effective scaling of high volumes of connected devices, such as common physical footprint, taking platform model approaches, requiring low or zero certifications, and thinking beyond the MSISDN & IMSI identifier models.