TFE Energy

Digital Operations

Part of the report: **Energy Access, Data and Digital Solutions**

DISCLAIMER

This report is supported by the German Federal Ministry of Economic Affairs and Energy on the basis of a decision of the German Bundestag.

February 2020, Munich, Germany.

Authors from TFE Energy

Tobias Engelmeier
William Duren (lead researcher)
André Troost
Sam Duby
Philippe Raisin

Supported by:

Federal Ministry for Economic Affairs and Energy

On the basis of a decision of the German Bundestag

CONTENTS

THIS DOCUMENT IS PART OF THE REPORT "ENERGY ACCESS, DATA AND DIGITAL SOLUTIONS".

The report shows that the large-scale and often realtime collection, analysis and use of all kinds of datasets, enabled by the rapid, global technology shift called "digitalization," is in the process of transforming the energy access industry. Companies across the energy access spectrum use digital solutions to enable their businesses and as the industry matures, there is a growing number of specialized digital solution providers.

The full report can be downloaded here (link).

DIGITAL OPERATIONS

KEY POINTS

- Remote monitoring gives the energy access industry the data to transform their businesses from the provision of energy services to offering a broader set of customer solutions.
- The combination of digital payments with digital operations, particularly remote lockout technology, has led to the success of PAYGO.
- Without digitalizing operations, it will be very difficult to scale mini-grids beyond 10-20 sites.

Image provided by senivpetro

There are very few industries in the world today that do not use digital tools to streamline their operations in some way. Examples range from widely used accounting, inventory and CRM tools, to more specialized ones, such as call center and sales force management apps, and to highly sophisticated analysis of user data to accurately target advertising, products and services. While the energy access industry has benefited from many of these, there are operational challenges unique to this industry that required the development of specialized digital solutions. These challenges fall loosely into two categories: the operation and optimization of technology in remote areas and the management of a widely dispersed, often poor customer base.

The first challenge has been met using remote monitoring tools. These allow companies to monitor the state and usage of their assets and enable remote control of these assets. The second challenge, dealing with remote and often unbanked customers, has been met with the development of GSM- and internet-enabled smart meters (in the case of mini-grids) and PAYGO switches (in the case of OGS). Both of these tools unlock two fundamental functionalities: the ability for customers to incrementally pay for services remotely using mobile money and the ability for a company to remotely lock an asset or disconnect a customer when appropriate.

1 THE DEVELOPMENT OF DIGITAL OPERATIONS

The development of digital operations tools has evolved through three phases. Starting in 2010, first movers into the rural electrification market, such as Bboxx, EarthSpark International, access:energy and Devergy, were forced to develop their own proprietary digital operations solutions because there simply was nothing available on the market to meet their specific requirements. As the industry grew, companies began to specialize and offer these digital tools to others. This first took place in the mini-grid sector with access:energy and EarthSpark International evolving out of smart meter specialists SteamaCo and SparkMeter, respectively. More recently, digital operations specialists, such as AMMP Technologies and FernTech entered the market. The value-add of these companies is their ability to aggregate multiple data sources across vendors of both smart meters and energy generation technology. With these solutions, customers can see valuable operational and customer insights from a large portfolio of projects. This enabled significant cost and efficiency gains and provided the mechanism for their operations to scale.

» AMMP is a crucial tool in operating our power systems across West Africa. It allows us to monitor all critical aspects in real time, enabling us to intervene immediately.«

JASPER GRAF VON HARDENBERG, Daystar Power Group[107]

Photo by Christopher Gower on Unsplash

In the OGS sector, leading companies like Bboxx and Mobisol continue to use their own end-to-end digital operations and customer management tools. This is now changing. A number of companies offer generic PAYGO tools to the sector.

—

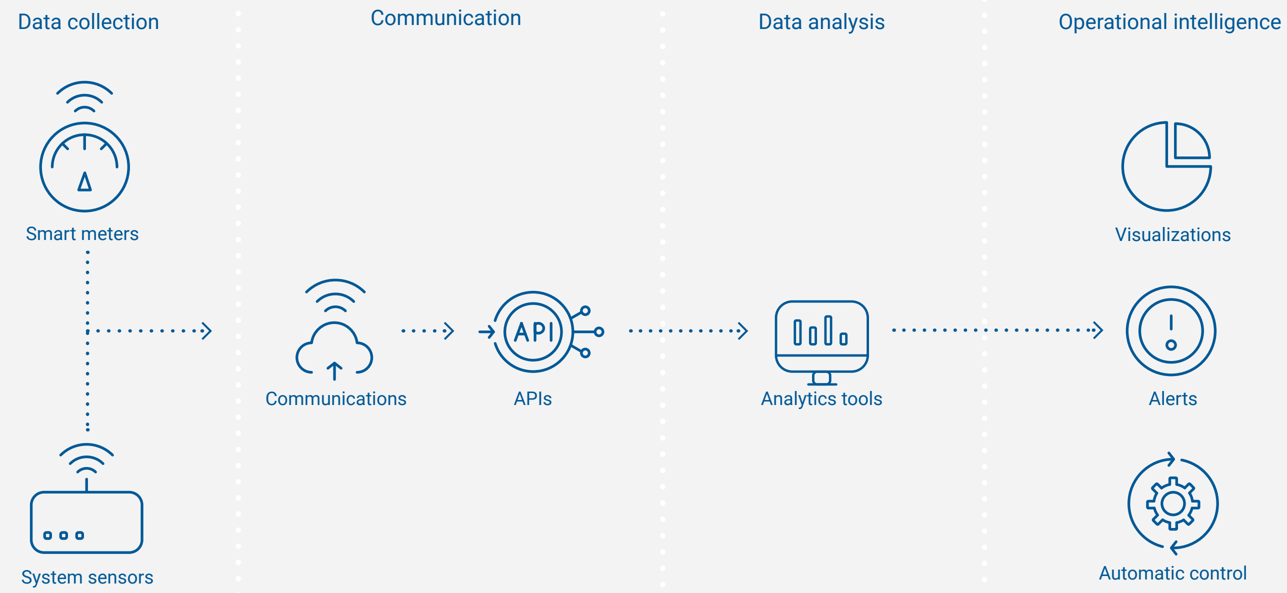
CHRISTOPHER BAKER-BRIAN, Bbox[108]

» Our IoT monitoring gives us the ability to see how our 200,000 solar home systems (SHS) around the world are performing, switch them on or off, and anticipate any issues before they arise. Moreover, it gives us access to data on how the customer is using our product, which can then be used to perform credit checks and identify customers with a high potential to upgrade or to move on to new systems.«

107 – Customer testimonial provided by AMMP Technologies
108 – TFE Energy, Case study interviews, Christopher Baker-Brian, Bboxx

Figure 18 – Illustrative setup of remote monitoring

Remote monitoring consists of four key steps: Data collection, communication, data analysis and operational intelligence.



1.1 DATA COLLECTION

The data collection process to enable remote operations begins with hardware located in the field.[109] OGS products and mini-grids, whilst different in scale, both use sensors to collect data on, for example, customer energy use, battery state of charge, power quality and numerous other technical indicators. The data then needs to be transferred to a centralized platform, often hosted on cloud services, such as Amazon Web Services. This can be done using USSD, SMS or internet protocol over the mobile phone networks, and even by satellite communications, if GSM or other types of phone coverage is not available.

The mobile phone revolution reduced the cost of GSM modem modules (for SIM cards) to approximately $6-$8. Also, competition in the telecoms sector has substantially cut the cost of data packets. Yet, when aggregated across tens or hundreds of thousands of units, these costs become significant. As such, there is considerable pressure on remote asset operators to make any small savings they can. The most accessible point of leverage is optimizing and streamlining the way data is transferred. This can take multiple forms: either cleverly encoding each message to pack as much information in as few bytes as possible or being flexible with how often messages need to be sent. For example, a product can be set to send a bare minimum of summarized messages when operating

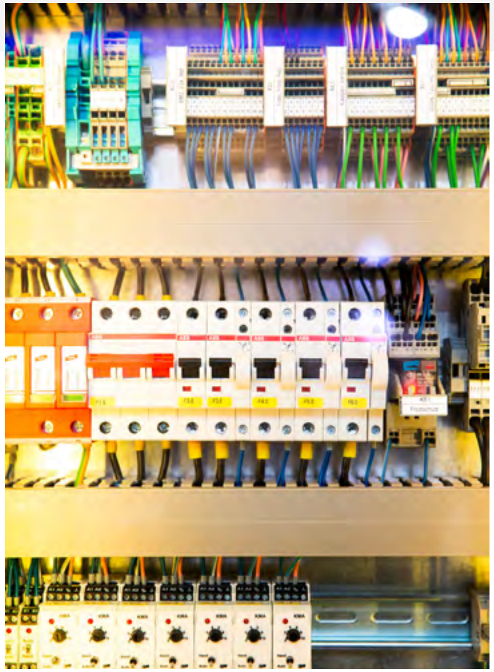


Photo by Markus Spiske on Unsplash

109 – Hardware here refers to components with the ability to collect and transmit data.

normally, but to boost the amount of data sent, if there is a problem that might benefit from remote diagnostics.

Another way to optimize communication is to leverage edge processing. This concept relies on the increasing processing power of cheap processor chips to enable “smart” remote devices to make more decisions, autonomously reducing the need for remote diagnostics via a central service. OGS products and mini-grid smart meters can equally benefit from these developments in global microprocessor technology (see Appendix for details).

» It depends on the operator’s system layouts and portfolio but really as they move past 10 to 15 mini-grids, the operator will start to feel some pain points around being able to operate their assets in a sustainable manner.«

SVET BAJLEKOV, AMMP Technologies[111]

Unlike OGS products, mini-grid data collection can benefit from having large numbers of smart meters operating in relative proximity (in the houses or businesses of all connected mini-grid users in a village). This allows smart metering providers to use low-power, low-bandwidth local communication technology, which allow many devices to communicate (over a distance of a few kilometers depending on technology used) with a central unit (often located in the power hub). This central unit can then aggregate and summarize the data from the numerous smart meters into a single communication with the cloud platform, reducing the communications burden of remote smart meter operations. Smart metering companies have various approaches to local communications, from using RF mesh technology developed specifically for the sector to adopting off-the-shelf technology pioneered in the IoT industry such as LoRa.[110]

» At 10 grids you do not need [system] data to operate, but as soon as you want to go bigger, you need data.«

NIKHIL JAISINGHANI, Co-founder and former executive director of Mera Gao Power[112]

There are two main categories of useful data that mini-grid operators gather. The first is operational data on how well the system is performing, usually from a smart inverter. The second is commercial data on energy sales, originating from smart meters. The usual communication channel for this data is an internet connection through the mobile phone cellular networks.

The share of global inverter sales that go into rural mini-grids is low. Thus, traditional manufacturers had little reason to customize their technologies for these bandwidth-challenged sites, which often have poor cellular signal. Smart meter companies like SteamaCo and SparkMeter, on the other hand, almost exclusively operate in these markets. Their products are usually built with back-up communication channels, switching to lower bandwidth SMS channels, a different SIM from a different cellular service provider or high reliability, high cost satellite-based channels, if the need arises.

The data costs for mini-grid operation can be high. To minimize these costs, many smart meter systems can also read the data being generated by an inverter and combine this with their own data into a single, data-optimized outgoing data stream.

As the energy access market matures, and companies increasingly source data-enabled hardware from a number of different manufacturers, synchronized data collection becomes more complex. This can already be seen with some of the larger mini-grid developers who use, for example, meters from both SparkMeter and Stea-

110 – LoRa, NB-IOT (Narrowband IOT) and Sigfox are all long-range, radio frequency wide-area network (LPWAN) technologies increasingly used in IoT applications worldwide. LinkLabs estimate that the number of interconnected devices using these technologies will reach 125 billion by 2030 (link).
111 – TFE Energy, Case study interview, Svet Bajlekov, AMMP Technologies
112 – TFE Energy, Market expert interview, Nikhil Jaisinghani, Co-founder and former executive director of Mera Gao Power

maCo, and inverters from both Victron and SMA. All four manufacturers provide independent data platforms. A data aggregator, like AMMP Technologies, can monitor and integrate data from different sources.

1.2 DATA ANALYSIS AND OPERATIONAL INTELLIGENCE

Data analysis can be as simple as checking to see if values (such as battery voltage readings) are within a normal operating range, basic queries such as searching large data bases for anomalies or complex algorithms to uncover deeper patterns in the data.

Operational intelligence is the creation of actionable insights from data analysis. Figure 19 shows a snapshot of the AMMP Technologies platform with graphs and live information. As the number of customers in a portfolio grows, operators often do not have the bandwidth to actively and consistently monitor multiple data streams. Feedback from mini-grid operators shows that a particularly useful section is the box in the bottom right, labeled “Alerts history”. It shows pressing issues that require immediate attention, allowing operators to focus on anomalies in the data or specific issues that require human input. As automated analysis techniques become ever more sophisticated, a single operator is able to monitor an ever-larger number of sites and customers.

Data analysis can be used to guide a variety of interventions. For example, if there are consumers on a mini-grid with significant inductive loads (such as an electric motor driving a grain mill) and their power factor shifts from an ideal 1, the mini-grid operator will have to provide more actual energy to that connection than they are being paid for. This can put a burden on equipment and weakens the business case. An analysis of the power factors of large consumers can guide the development of compensating mechanisms such as the installation of power factor compensators near the specific loads or the design of special tariffs for customers of this kind.

More advanced monitoring platforms enable automated load limiting to balance systems or dynamic tariffs to reactively influence user behavior and “nudge” them towards consumption patterns better matched with environmental conditions such as poorer than average sunshine.

Figure 19 – Example of a remote monitoring user interface by AMMP[113]

The type and manner in which data is displayed, depends on the platform. Interfaces are often accessible via web apps, which can be viewed on a computer with internet access or a mobile phone.

113 – Image provided by AMMP Technologies

Some platforms, such as those developed by Mobisol and Bboxx, can automatically detect and characterize technical issues with products, generate repair tickets and then dispatch a technician to address the issue. Mobisol's system has similarities with Uber: Through the mobile app, a local, licensed technician can accept or deny a maintenance or repair task. Using geolocation technology, the app shows the location of a faulty product. Then, when the technician sets off, the physical route is tracked via GPS so that she can be reimbursed for travel costs. Once the technician has arrived, she takes an image of the system, repairs it and scans any replaced parts. Finally, she takes another image of the system once the repair is complete. This level of tracking increases quality of the work performed, and images can be used to manage warranty claims.

—

» Mobisol leverages machine learning to predict, before the customer even realizes it, which batteries are about to fail or have already failed. This way we can sell them a refurbished or new battery for their system.«

STEFAN ZELAZNY,
Mobisol [116]

» Features such as time of use load-limiting and designing our own tariff system within the SteamaCo platform have been an invaluable asset.«

JESSE PIELKE,
Africa GreenTec [115]

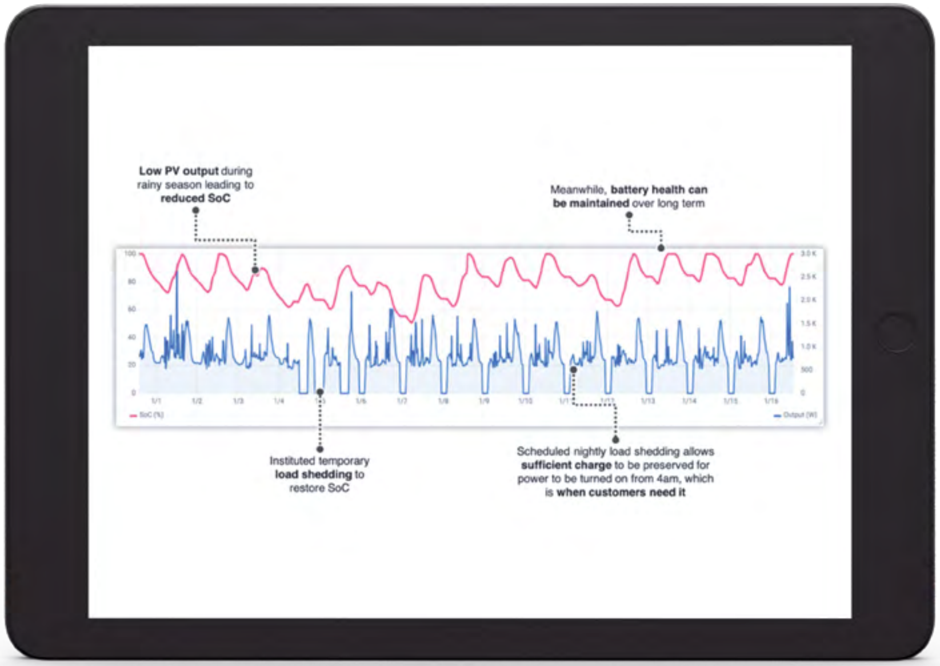


Figure 20 – Example of a system monitoring interface by AMMP[114]

Tracking data on battery state of charge (SOC) is crucial to understanding operational behavior and identifying measures to improve battery performance.

114 – Image provided by AMMP Technologies
115 – Customer testimonial for SteamaCo (link)
116 – TFE Energy, Case study interview, Stefan Zelazny, Engie Mobisol

2 HOW DIGITAL OPERATIONS ADDRESS THE MAIN CHALLENGES OF ENERGY ACCESS

In the energy access market, the harsh operating conditions, remoteness and wide dispersion of assets, poor infrastructure and low-income customer base, make digital operations particularly relevant and provide a good driver for innovation that can spread into the wider energy industry. A number of digital operations specialist solution providers are exploring services for on-grid and developed country markets.

2.1 IMPACT ON SCALE

The need for coordinated, digital operations grows with portfolio sizes and geographic dispersion of electrification companies. This is especially true for mini-grid operators. Remote monitoring allows operators to manage large numbers of assets and PAYGO services provide a scalable mechanism for monetizing them. As the volume of available data increases, data analysis will become ever more useful to tease out patterns and make predictions on what potential new mini-grid sites or new OGS markets and customers are viable.

2.2 IMPACT ON COST

Digital operations can reduce operating costs of mini-grids, which account for approximately 13% of the LCOE,[119] by an estimated 15% with basic monitoring, and up to 30% with advanced monitoring.[120] At the component level, solution providers have driven down the cost of smart meters, which in turn reduces the overall CAPEX of a mini-grid. Five years ago, a smart meter would cost hundreds of US dollars. Today SparkMeter offers it for approximately $50. The OGS market has so far not published data on the impact of digital operations on their bottom line.

» It is valuable to be able to diagnose remotely and have a local technician solve the issue without someone from the team having to go there.«

JOHN KIKENDA, PowerGen[118]

Digital operations also reduce the cost of energy services for customers. For example, data gathered by ZOLA Electric indicated that the 100W solar panel on their unit was larger than it needed to be. By using a smaller panel, the company reduced overall system cost, without affecting user experience.[121] Mobisol, ZOLA Electric and Bboxx all take advantage of their ability to update their firmware remotely, which enables them to remotely improve the performance of their systems, in some cases significantly. Mobisol was able to increase the lifespan of batteries from 3 to 8-10 years with a remote battery management software update.

» When we started in 2011, we had an average battery life of three years, which was not the best, and a lot of batteries broke before the end of their warranty. Right now, we expect a lifetime of eight to ten years for a battery of the same size, technology and price. We have made huge improvements just by working with the data, improving our algorithms and having access to feedback from the broken batteries.«

STEFAN ZELAZNY, Engie Mobisol[122]

118 - TFE Energy, Case study interview, John Kikenda, PowerGen
119 – Rocky Mountain Institute, Minigrids in the money, 2018, (link)
120 – AMMP Technologies, Reducing the cost of operations and maintenance for remote off-grid energy systems, 2018 (link)
121 – TFE Energy, Case study interview, Alessandro Pietrobon, ZOLA Electric
122 – TFE Energy, Case study inteview, Stefan Zelazny, Engie Mobisol

2.3 IMPACT ON RISK

Digital operations reduce investment risk by creating operational transparency, tracking key financial and technical metrics, and by building a basis of operational data for future investment or sales decisions. Bboxx, for example, found that operational data helped them secure follow-up funding for expansion within a geographic area – but not really beyond it.[123]

Operational data is also used to develop trust between operators and investors. For example, Mobisol and Bboxx have created investor portals on their platforms to provide a real-time view into the performance of portfolios of systems an investor has invested in. Such portals only make sense beyond a threshold investment value and the OGS market has seen several deals larger than $10 million. From this size, investors have the incentive to actively monitor portfolios, track performance and flag issues before they become a problem. The mini-grid market currently has less stringent reporting requirements, but as deal sizes grow, so too will the need for transparent reporting.

Digital operations data also help make impact and customer service quality measurable. This is important for impact investors. Furthermore, companies that leverage predicative maintenance can identify and mitigate operational risks earlier. Finally, remote lockout technology is a key component of the PAYGO business model and is a key mechanism to reduce investor perceptions of default risk. Recent research by CGAP shows, however, that while creditors are reassured by the use of lockout technology, it may not actually prevent defaults.[125]

CHRISTOPHER BAKER-BRIAN, Bboxx[126]

» In Togo and other markets, we have secured follow on finance through the use of customer data. By illustrating customers' repayment and usage profiles, this data gives local banks confidence to help fuel our expansion. It is more difficult to raise funding in markets that lack historic data.«

» Once you move beyond a certain level of investment, really beyond venture capital or impact driven money, you have to be transparent because people are extremely careful when investing in these markets. The only way you can build trust is through transparency and the best way to provide transparency is by opening up a technical channel, which gives a real-time view into the performance of their investment. «

STEFAN ZELAZNY, Engie Mobisol[124]

Screenshot provided by Odyssey Energy Solutions

123 – TFE Energy, Case study interview, Christopher Baker-Brian, Bboxx
124 – TFE Energy, Case study interview, Stefan Zelazny, Engie Mobisol
125 – CGAP, Remote Locations: The Dark Side of Pay-as-You-Go Solar, 2018 (link)
126 – TFE Energy, Case study interview, Christopher Baker-Brian, Bboxx

3 CHALLENGES TO DEPLOYMENT

The limited size of the energy access market today is a barrier for all digital solutions, but particularly so for digital operations. The pain of not having digital operations is often only felt once companies start to scale beyond their initial pilot systems and since few companies have reached this point, it is difficult for digital specialists to prove both the value of their solution and their business model. In addition, the few electrification companies that have reached scale, will not try out every single digital operations solution on the market, but rather select one or two to pilot, and then pick one and stick with it. Changing the solution later might be costly and add overall complexity. This creates a path dependency and a significant barrier to entry for new digital operations solutions.

4 LOOKING AHEAD

Digital operations solutions are firmly embedded in the business processes of leading mini-grid and OGS companies. In the future, they need to become more accessible to smaller, newer market players. Also, there is a strong case for aggregating operational data and insights for the benefit of the industry as a whole.

4.1 STANDARDIZATION AND DATA POOLING

Efforts are underway, for example by the Africa Mini-Grid Developers Association (AMDA) and the African Development Bank (AfDB),[127] to develop a mechanism through which electrification companies can report aggregated, anonymized data on costs, revenues and operational performance of their projects to demonstrate the efficacy and value of mini-grids and OGS as an energy access route. This should improve investor confidence in the sector. It should also be an incentive for governments to place more trust in off-grid electrification and develop supportive legislation.

Comparing data on, for example, mini-grid service level between operators or across geographies can only be done if standard methodologies to measure, record and report this data are implemented. Initiatives, such as NREL's Quality Assurance Framework (QAF)[128] work towards this. They borrow heavily from quality assurance protocols developed for the traditional grid, but obviously need to be adapted for the rural mini-grid context.

4.2 THE CASE FOR BIG DATA ANALYSIS

The large amounts of operational data gathered by OGS and mini-grid companies can be still much better lever-

127 – TFE Energy's work with these organizations shows the need for a tailored quality assurance framework.
128 – With support from Sustainable Energy Fund for Africa (SEFA) the NREL QAF (link) has been adapted by TFE Energy into a QAF for the rural green mini-grid (GMG) context. This has resulted in the GMG QAF (link).

aged to improve their business case, customer service and investment readiness. The growth of the larger digital ecosystem (from processing power to machine learning algorithms, as described in the Appendix) will offer more and more tools to do so. Some of them can be deployed by the companies themselves, some will be offered by specialists. Some will be open source and standardized, others will be customized to the industry or individual companies. To unlock the potential of operational data analysis, there could be more cooperation between digital specialists, energy access companies and researchers.

KIERAN CAMPBELL, PowerGen[129]

» There is not much recognition or acknowledgement of the backend processes that enable mini-grids. People often only consider the hardware or systems themselves and do not have visibility into the software infrastructure that is required for it to function.«

» Currently, we use machine learning for anomaly detection. However, as with any tool, you have to figure out the best way to apply it. We do not want machine learning to be one of those solutions where we have a hammer, and everything looks like a nail.«

SVET BAJLEKOV, AMMP Technologies[130]

Today, many companies are still able to gain significant insight through aggregating data and implementing simple rules, which trigger alarms or automated control outputs. Machine learning may grow to have a larger impact in time, but currently, more basic techniques that are cheaper and quicker to develop seem to be sufficient.

—

FURTHER READING

AMMP Technology's white paper, ***Reducing the cost of operations and maintenance for remote off-grid energy system: The impact of remote monitoring***, 2018, (link), provides a deep look into the impact of remote monitoring on mini-grid operations. The report is unique in that the team tracks current and potential impact through their history with the former mini-grid company, Rafiki Power.

GMSA's report, ***The IoT development journey for utility enterprises in emerging markets***, 2017, (link), discusses the development of individual IoT solutions. GSMA has partnered with a number of energy access companies, such as SteamaCo and Kramworks, to provide anecdotal evidence of the process of developing IoT solutions with a strong focus on GSM enabled IoT.

SparkMeter's presentation, ***Unlocking the Economics for Emerging Market Electric Utilities*** (link), explains the use cases and features of different smart meters available in the market. (SparkMeter itself sells smart meters.)

TFE Energy's article, ***Standardisation in the Microgrid Industry – Together We Are Stronger***, 2019, (link), discusses how quality assurance frameworks can be used to standardize energy access data collection. This work brings together many industry stakeholders including the AfDB, AMDA and Odyssey Energy Solutions.

—

129 – TFE Energy, Market expert interview, Kieran Campbell, PowerGen
130 – TFE Energy, Case study interview, Svet Bajlekov, AMMP Technologies

ABOUT TFE ENERGY

TFE is dedicated to achieving universal energy access and to improving investments into remote infrastructure. Our team consists of data technology experts on the one side and village electrification experts on the other. This breadth allows us to continuously test and validate new data technologies in the field and work towards specific solutions – such as Village Data Analytics – that create tangible value to the electrification ecosystem. We are always looking for passionate, talented people to join our teams in Munich/Germany and Cape Town/South Africa (for open positions see here).

CONTACT US

10 Franz-Joseph Str.
Munich 80801
Germany

contact@tfe.energy
www.tfe.energy

PUBLISHER

TFE Energy GmbH
10 Franz-Joseph Str.
Munich 80801
Germany

DESIGN

Concept & layout:
www.simpelplus.de

Cover design
Alessandro Burato