Data-driven investment into mini-grids

ODYSSEY

Learning Report

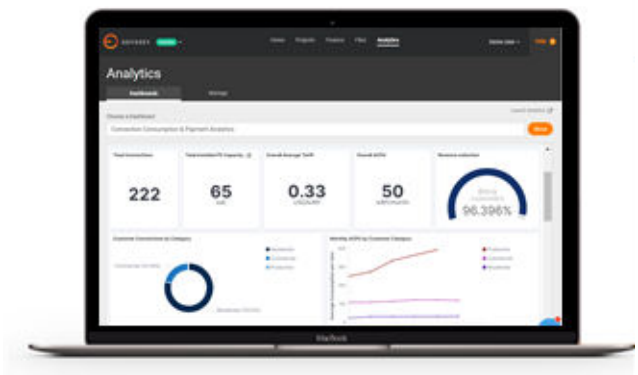
Mini-grids are essential to the United Nations Sustainable Development Goal 7 (SDG 7), which aims to provide universal access to affordable, reliable, sustainable and modern energy by 2030. In order to achieve this goal, 238 million households will need to gain access to electricity.

It is estimated that mini-grids can serve nearly half of these households, and are often the lowest-cost form of electrification for off-grid populations. This would require USD 128 billion in mini-grid investments over the next ten years.

In early 2019, Odyssey embarked on a partnership with Crossboundary Energy Access (CBEA), the first mini-grid project finance vehicle in Africa, to develop the technology platform required to accelerate mini-grid finance. The project was funded by the Shell Foundation and the UK Foreign, Commonwealth & Development Office (FCDO) and the Opec Fund.

The purpose of this report is to share some of the key learnings the team has gained in the course of developing the sector's first mini-grid investment platform.

Odyssey wishes to thank its partners, including Crossboundary Energy Access, the Shell Foundation, FCDO and the Opec Fund for their support.



A sample data dashboard for CBEA representative data only

A new frontier in distributed energy

To date, mini-grid development has been primarily financed by corporate-level ("on balance sheet") investments; unlocking project finance is essential to enabling scale for the sector.

However, project finance vehicles for the mini-grid sector face unique challenges, particularly with respect to effectively managing investment portfolios.

A mini-grid portfolio is comprised of many small assets, each with unique financial and technical attributes that must be measured and aggregated in order to track portfolio performance.

At the heart of the financing challenge is data: mini-grid portfolios generate high volumes of complex data that must be processed and managed in order to draw real-time insights on portfolio performance, operational agreements, and other key fund activities.

Odyssey and CBEA partnered to address this challenge, developing the technology solution that CBEA – as Africa's first mini-grid project finance vehicle – needed in order to effectively operate its facility.

The lessons learned regarding the data technologies required for effective portfolio management in the mini-grid sector provide some key industry-wide insights that are becoming increasingly important as investors look to scale their portfolios.

Key learnings

A. To build bankable mini-grid portfolios, investors need advanced data technologies that pull reliable insights from challenging data sets

Mini-grid investing presents unique challenges when it comes to calculating metrics essential for measuring the financial performance of an asset portfolio; even fundamental investment decisions depend on collecting and processing complex big data. As Gabriel Davies, Head of Mini-Grids at Crossboundary explains:

> **"Lack of reliable data means no bankable project structures, which means no financing for mini-grids… If we didn't have a data platform, our operating contracts would not be bankable as we wouldn't be able to monitor the critical KPIs to the level of accuracy and granularity required. The number of data points that Odyssey manages for CBEA is currently at 643 million. KPIs based on large sections of these data points… would be nearly impossible to measure without a data platform."**

The data challenges faced by CBEA – and mini-grid asset owners in general – can be categorized into three key issues.

1. Data volumes

Managing a mini-grid investment requires aggregation of many small projects into a coherent portfolio that can be analyzed at varying levels of granularity, from individual customers to portfolio-wide analytics.

The sheer volume of data contributing to this analysis – which comes from frequent smart meter readings across the full customer base, system power electronics, customer relationship management systems, and other systems used for mini-grid operations – cannot be underestimated. Without big data technologies that can automate analytics, the cost of portfolio management would quickly become prohibitive.

Millions – or even billions – of data points compromise a single monthly metric, such as Average Consumption per User, for a portfolio, because the raw data contributing to the calculation is generated at high-frequency intervals (e.g. 15 minutes) across all smart meters deployed.

17 minigrids + 5 data sources = ~ 700m data points analyzed / year

2. Lack of standardization

The mini-grid sector is still nascent and as a result the technologies deployed for mini-grid management are still in flux. Many mini-grid developers are developing proprietary systems for asset monitoring, payment collections, or smart metering. Some of the more common third party vendors are continuing to develop their technologies, with significant implications for how data can be accessed and analyzed from these evolving systems.

These dynamics result in a lack of data standardization in the sector. The metric Average Revenue per User provides an illustrative example. Calculating this critical metric so that it can be compared across different mini-grids requires identifying each provider's distinct characterization of transactions, and automatically processing each type of transaction according to this characterization.One provider might handle transaction types such as "bonuses" or "payment reversals"differently from another; another might tag sales accounts separately from customer accounts.

Often, even the definition of a "user" – the key denominator of ARPU – varies across technologies. In order to accurately generate ARPU, each reading from providers must be recognized and processed in a manner that will results in consistent results across providers.

3. Data quality

Not surprisingly, given the volumes of data being processed – coupled with the deployment of technologies to rural areas that often have low connectivity – data quality is also a challenge. Generating accurate KPIs requires identification of data outages, anomalous readings, and other data quality issues that may impact analytics. Such data cleaning procedures at high volumes require new machine learning methodologies to detect and address data quality issues before generating analytics.

B. Solidifying KPIs was key to developing data technologies tailored to mini-grid investments

For CBEA, two essential fund Key Performance Indicators (KPIs) were **Average Revenue per User and Power Reliability**. These two metrics enabled the fund to understand how the assets' revenues were tracking against forecasted project returns, and to ensure that their operating agreements were being met. Even these two KPIs, however, required new data technologies to generate reliable metrics.

The complexities and heterogeneity of the data, as described above, necessitated two essential decisions: which KPIs were most critical to calculate, and how could the platform's underlying data model be standardized to generate all these KPIs across all scenarios? Odyssey and CBEA established a core set of KPIs to be tracked by the fund, all of which answer essential questions about the portfolio's financial and technical performance, and are calculated via integration of diverse live data feeds from systems deployed by the mini-grid operators. A representative set of these KPIs are listed in the "CBEA KPIs" table.

CBEA KPIs
Sample List Only

1. Average Revenue per User
2. Average Consumption per User
3. Customers by Type
4. Total Revenues
5. Average Tariff
6. Revenue Collection
7. Uptime
8. SAIFI/SAIDI
9. Energy to Load by Sources
10. Renewables Fraction
11. Customer Churn
12. Solar Generation vs. Expected
13. Avg. Distribution Line Losses

The first step Odyssey took to ensure that these KPIs could be compared across all systems and operators was to develop standard "indices" for the data model. When data is ingested into the CBEA investment platform – via diverse data sources, and at different time intervals – each data point is re-directed to a standard "index," or a data grouping that best defines the key questions the data answers. These indices also correspond with the standardized KPIs defined by CBEA, although some KPIs require analyses across several data sets.

Index Name	Data Descriptions	Examples of investment information
Consumption	Customer power use, often pulled from smart meter readings	How are customers using power
Customers	Characteristics of customers	Who is being powered? How can customers be segmented?
Payments	All aspects of payments made for power	What do payment patterns look like? What are revenues?
Utility	Operations and performance of the generation system	Is the system providing reliable power?
Survey	Surveys conducted with customers, communities, and others	How do customer surveys compare to results?
Projects	Characteristics of a site or system, such as total installed capacity or population of community. Often includes pre-development data	What was the capex of the project? What type of batteries are being used?
Ingestion	Logs tracking live API integrations	Are my integrations providing all available data?

Unlike static data sets, performing operations on live, big data is a significant challenge, as the size and rate of change makes these data sets unwieldy to work with.

To address this, as the second component of the data model, Odyssey built a separate "transformation" application that would operate on live data to render the data into a more workable format for analytics. Two key transformations are consistently running on new data ingested into the platform:

1. Aggregations

Odyssey performs aggregations, or roll-ups, that bring data to a more usable level and size for generating analytics. Based on the time stamp of the data ingested into the platform, Odyssey creates "daily" and "monthly" summary indices, which serve as the basis of generating insights into the data.

Returning to the ARPU metric, for example, data is aggregated first into a monthly index before it is averaged across different customer segments. This aggregation significantly improves the processing time by reducing the data set size to the granularity required for the metric (in the ARPU case, monthly).

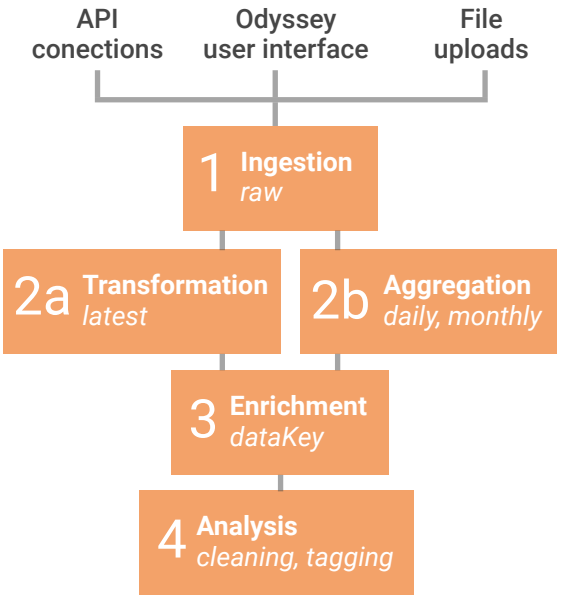
2. "Latest"

Many metrics depend on understanding the most recent state of an entity, such as a customer, smart meter, generation system, etc. Granular time series data, therefore, is extraneous to the analysis.

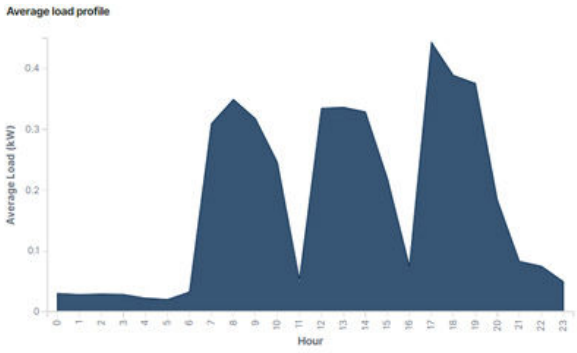
Therefore, the second transformation the platform conducts is to generate data sets that describe only the most recent state of an entity. Each time Odyssey's data pipeline runs the ingestion process, it will check whether there is new information on any given entity, and if so, it will update the entity's "latest" record accordingly.

Before data is ready for analysis, it is "enriched." This process joins data from different indices together, enabling cross-index analytics. For example, joining information about customer characteristics with meter data enables analysis of how different customer segments consume power.

Visualization of Odyssey's data ingestion and transformation process



Using this data model, the platform is able to quickly move between granular data – such as specific consumption readings for a single user at one mini-grid site – to portfolio-wide analytics across across the entire portfolio of sites that CBEA is managing.



As an example of the type of analytics enabled by the data model, the above graph depicts the typical daily load profile for a fisherman in Tanzania, averaged across the past year. To generate this graph, information from the "Customer" index was joined with data from the "Consumption" index in order to provide insights on how a specific type of customer consumes power. The load profile illuminates the fisherman's daily activity: charging batches of batteries for the community's fisherman.

C. To make financial transactions viable for the mini-grid sector, new document management technologies are essential

Many of the technologies powering CBEA's investment platform were built to manage quantitative data. However, mini-grid portfolios also generate high volumes of another data type: documents and files. As with any financial transaction, investing in mini-grid assets requires collection and organization of numerous documents, including customer contracts, technical drawings, technology sheets, and more.

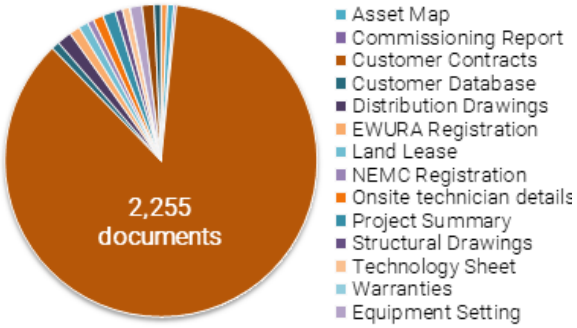
For off-grid assets, however, this challenge is compounded by the fact that every transaction involves many assets, each with its own set of transaction documents such as customer contracts, technical drawings, technology sheets, community agreements, and more. Furthermore, each mini-grid has many off-takers, requiring significant documentation of customer agreements.

CBEA found that standard data room technologies were not sufficient for managing transaction documents. Not only did CBEA need to organize and view documents, the team needed to **conduct analytics on the data room itself** in order to confirm that all required documents had been provided across many thousands of files. As Gabriel Davies explained,

> **"Our investments require new technologies for managing the hundreds and thousands of contracts, warranties, land leases, and permits that come with a mini-grid portfolio."**

The team designed a "smart" data room technology, with options to tag each file uploaded according to standard nomenclature. Scripts can be run on the data room, generating analytics on the quantity and type of files uploaded. These scripts enable CBEA to rapidly determine if an operator has provided all of the required documents.

Example of data analytics run on CBEA's transactions data room for one transaction



Conclusion

Driving the level of investment required to scale the mini-grid sector will require many innovations in the sector, including but not limited to data management.

As summarized herein, the journey of building CBEA's platform has tested and confirmed many assumptions about data needed to accurately predict and manage financial and operational performance of mini-grid portfolios and also given rise to new ideas and understanding. New asset classes require new investment technologies and this technology will likewise continue to improve.

Odyssey and CBEA will continue to drive development of an industry platform for mini-grid investment and hope that sharing this journey can also be useful to other investors and operators in the sector.