Energy infrastructure is undergoing a paradigm shift towards a digitally enhanced, multi-dimensional and integrated system. This article investigates the implications of energy digitalization on impact evaluation via access to location- and time-specific data on electricity loads. Such large-scale and timely data will help evaluations reflect values created by new technologies and ultimately promote innovative financing instruments to enable energy market reform.
Yang Liu, Macroeconomics Policy, Forecasting & Research Department, AfDB.

Key Messages

- Energy digitalization is transforming the way electricity is supplied and consumed, blurring the distinction between supply and demand.
- Higher granularity of data can address heterogeneity in impact evaluation.
- Frontier impact evaluation enables market change and guides energy policy.

Introduction

The advent of information and communications technology over the last decade has had profound implications for how different elements of the power sector interact—specifically, two-way communication between utilities and customers, responsive transmission and distribution networks, and software and protocols allowing for interoperability among a multitude of actors and technologies (Liu and Zhong 2018). The implications of these digitalization trends on impact evaluation of energy infrastructure are profound. The greatest transformational potential of energy digitalization is its ability to blur the distinction between supply and demand, and to enable the interaction with consumers to balance demand with supply in real time (Liu et al. 2020).

This article addresses the issue of energy digitalization, and how it is transforming electricity supply and consumption, blurring the distinction between supply and demand. It also highlights how technology (e.g., smart grids, automated meters and block chain) offer tremendous opportunities for impact evaluators to make the most of location- and time-specific data on electricity loads which would otherwise not have been accessible.

More Data and Better Evaluation

The increasing connectivity, stemming from digitalization, generates a great amount of data, providing a robust and cost-effective tool for addressing heterogeneity in impact evaluation. The key success factor of impact evaluation is to conduct a counterfactual analysis, which is meant to disentangle the impact of a policy or program intervention and inherent attributes of individual units. It is well known that heterogeneity is a major issue on the applied grounds of impact evaluation. Considered observations are not identical and cannot be added to form an aggregate.

Household energy consumption behavior varies across different segments of the population. This heterogeneity may relate to household characteristics such as income, age, education and energy-saving awareness. For example, to better understand the impact of a subsidy program for energy-efficient household appliances, there is a need to disentangle the policy-driven and household-specific effects on the changes in energy consumption (Yao et al. 2014).

Today, energy digitalization significantly improves the accessibility of big data on load profiles and prices at specific times and
locations. The average cost of a smart meter has dropped by about one-quarter since 2008, with nearly 800 million smart meters being deployed globally as of 2017. The International Energy Agency (IEA) estimates that by 2040, 1 billion households and 11 billion smart appliances could actively participate in interconnected electricity systems across the world. Combined with the increased use of digital sensors and control equipment, these smart appliances can be connected to a network and controlled remotely (IEA 2019).

Disruptive technologies, such as block chain and machine learning, enable customers to track and identify clean energy sources, and thus conduct peer to peer trading of renewable electricity, which would have large implications on redefining the interaction of consumers with energy suppliers and electricity retailers. Such technologies can also significantly alter how people view and manage their energy services.

A data-enabled energy management system will certainly facilitate data-intensive evaluation of the impact induced by a policy or program intervention, not only in the way end-users can be more easily engaged as part of randomized control trials or field surveys, but more importantly in the sense that we can better control for heterogeneity of a large number of treatment groups through data analytics. Similarly, an automated energy metering system will enable matching large-scale heterogeneous attributes with policy changes in a cost-effective and timely manner; while a block chain-enabled energy monitoring system can greatly enhance transparency of an impact evaluation.

New Market and Frontier Evaluation

More than ever, as the energy market is undergoing a paradigm shift, impact evaluation practitioners today are expected to deepen their understanding of innovative policy design and business models. Specifically, this calls for frontier insights into the effects of policy changes, through which new market players can deliver accessible and affordable energy goods and services to underserved communities.

In many African countries, ageing and overloaded transformers of central grids cannot keep up with peak demand. Consequently, load shedding and power outages are a major impediment to reliability of electricity supply. Meanwhile, Africa is the second largest and the fastest growing mobile market in the world. This disconnect is leading to a rethink of the energy sector. For instance, in Nigeria, Unpela.ng set up an Internet of Things (IoT) mobile platform to provide real time information on the total hours of electricity supply in local communities. The system detects the current state of power supply (On/Off), records the last time power was restored or disrupted, and predicts when next it might be restored or disrupted. Based on this information, households who own back-up power generators can host those who need power at an affordable rate. The business concept is like a kind of Airbnb, but for energy.

By connecting peers with each other, this collaborative economy business model can value the under-utilized and already existing assets. With this model, small energy developers gain a major benefit in terms of the cost structure. They can scale up their business extremely fast if potential customers are willing to join the collaborative network.

To grasp the impact of such systems, evaluation practitioners will need to sharpen their skills to undertake an impact assessment of these new developments. With the support of novel digital tools, it is easier today to integrate dispersed and small end-consumers and suppliers into a large-scale evaluation program. This enhanced representativeness
is particularly critical if impact evaluation is to play a key role in assessing the many benefits of these innovative business models (made possible by digitalization) at the broader societal level.

Currently, the global off-grid solar sector serves 420 million users, and accounts for a USD 1.75 billion annual market (ESMAP 2020). In Africa, Kenya, Tanzania and Ethiopia together account for around half of the 5 million people with access to new solar home systems in 2018 (IEA 2019). This notwithstanding, it is a known fact that to accelerate electrification in Africa, the most expensive to reach often also happen to be the least able to pay and/or consume when connected.

Most of large-scale electrification program interventions will not be economically viable unless markets are able to translate wider social and economic impacts into business values. Obviously, these electrification projects have good potential to expand to other critical social services such as solar water pumps, cold storage, support to community healthcare and schools. However, it is imperative that multiple impacts are explicitly monitored, evaluated and reported. Doing so will help to demonstrate some of the pay-for-success instruments such as social impact bonds and development impact bonds—innovative financing mechanisms that make funding conditional upon the delivery of concrete results, and most importantly, directly reward high impact firms with premium payments for achieving social results.

Conclusion

Energy digitalization is transforming the way the electricity is supplied and consumed, blurring the distinction between supply and demand. Deployment of smart grids, notably automated meters and block chain technologies will offer tremendous opportunities for impact evaluators to make the most of location- and time-specific data on electricity loads which would not have been accessible otherwise. Digital tools will also enable a cost-effective and timely evaluation program by incorporating massively dispersed observations, while the pace of decentralized trends is accelerating for the future energy infrastructure landscape. More importantly, this much needed evaluation work will capture system-wide costs and benefits and thus help unlock the full potential of innovative business models in the energy market.
Dr. Yang Liu is currently principal economist at the African Development Bank. Prior to joining the AfDB, Yang was a Senior Fellow in the Energy Studies Institute of the National University of Singapore, where he led research and consultancy projects in the areas of integration of renewables and energy efficiency, energy market design, and policy evaluation. Yang has more than 15 years’ experience with the energy industry, government bodies and academia in both developing and developed economies, including as an energy specialist at the International Energy Agency, where he co-authored the 2015 and 2016 IEA Global Energy Efficiency Market Reports, and provided technical assistance to emerging economies on the energy market reform.