Harnessing the Power of Data

Sustainable Energy Transitions Initiative Conference

May 15–17, 2018, Durham, North Carolina

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Duke NICHOLAS INSTITUTE FOR ENVIRONMENTAL POLICY SOLUTIONS

SETI SUSTAINABLE ENERGY TRANSITIONS INITIATIVE

Duke | ENERGY ACCESS PROJECT

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Summary

On May 15–17, 2018, more than 100 academic researchers and energy access practitioners gathered at Duke University to discuss critical issues related to energy access as part of the third annual conference for the Sustainable Energy Transitions Initiative (SETI).

Presentations by Kyle Bradbury of Duke University, Johannes Urpelainen of Johns Hopkins University, Nathan Williams of Carnegie Mellon University, and Jay Taneja of the University of Massachusetts–Amherst highlighted remarkable advances in energy data analytics, described applications for developing world energy challenges, and outlined remaining data-related hurdles impeding progress on energy access.

Energy developers, utilities, planners, and policy makers are often not equipped with the necessary tools to understand the changing landscape of energy delivery options and customer preferences. Researchers and grid operators are often restricted by outdated, unavailable, or biased data in the field. Through innovative methods and analytical tools, such as remote sensing, satellite imagery, and machine learning, data analytics are improving our understanding of energy demand in rural areas, customer needs and expectations, the local availability of energy resources, and the realities of providing electricity to underserved communities.

These proceedings present key conference takeaways related to the core theme of energy data analytics.

INTRODUCTION

On May 15–17, 2018, more than 100 academic researchers and energy access practitioners gathered at Duke University to share research findings and discuss paths forward on critical issues related to energy access as part of the third annual conference for the Sustainable Energy Transitions Initiative (SETI). The full program can be found on the Energy Access Project website. Key takeaways related to the core theme of energy data analytics are presented here.

NOT ALL "ELECTRIFIED" VILLAGES ARE CREATED EQUAL

On April 28, India's Prime Minister Narendra Modi declared that every village in India has access to electricity. This declaration was widely criticized due to the Indian government's definition of access: that 10% of a village have electricity (Mohammad and Srivas 2018). With recent breakthroughs in machine learning capabilities, researchers have identified a novel paradigm for understanding what "electrified" actually means. "With refinements of that paradigm, Duke University's Kyle Bradbury led a team that created high-resolution predictions of electrification in 36,000 villages in Bihar state in India (Wong et al 2018). Application of the approach to predict electrification in the neighboring state of Uttar Pradesh (Figure 1) appears to suggest that household access is far from universal; results are currently being validated. A key challenge will be repeating these analyses in new areas with a potentially different set of characteristics (such as different housing densities, agricultural practices, local environments, or topographies), because the correlations among variables considered in the prediction algorithm may vary across space and time. As machine learning methods are fine tuned to address energy access questions, verifying realities on the ground will be critical to maintain and improve the methods' accuracy (Bradbury 2018). That task also raises interesting questions about how coordinating development of these promising methods with existing or new and targeted data collection efforts can be optimized.

Figure 1. Prediction of village electrification in Bihar and Uttar Pradesh, India
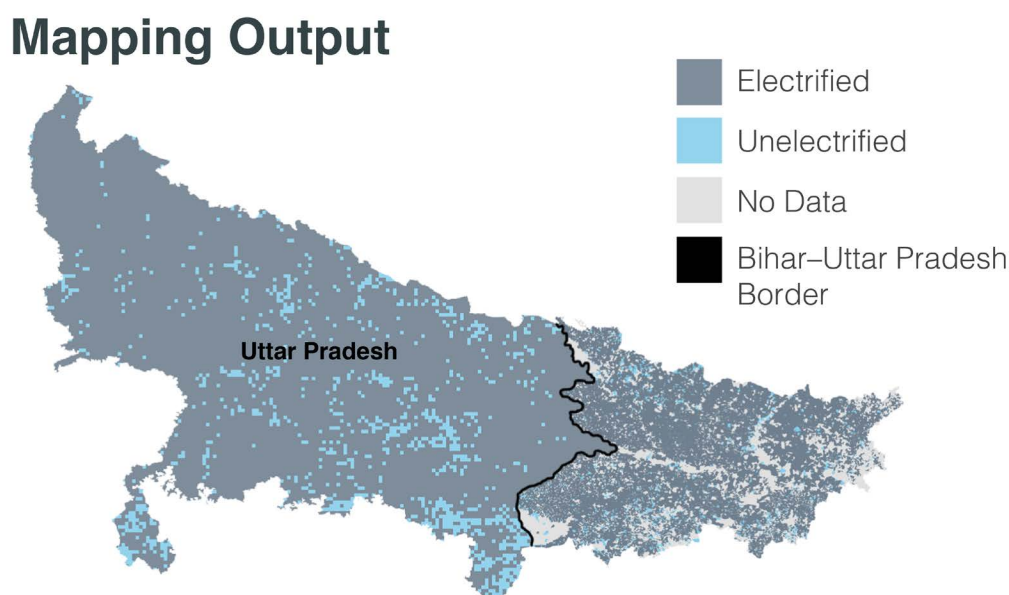
Source: Bradbury, K. 2018. "Estimating Electricity Access from Remote Sensing Data." Presentation at the 2018 Sustainable Energy Transition Initiative Conference, Durham, North Carolina, May 17, 2018.

PREDICTIONS CAN COUNTER UNRELIABLE DATA, BUT THEY MUST BE GROUND TRUTHED

From measuring income inequality (Biswas 2018) to understanding the behavior of authoritarian regimes (Ingram 2018), we are witnessing powerful potential applications of data, particularly satellite nightlight data, which could connect luminosity with economic activity and growth (Figure 2). However, Johns Hopkins University's Johannes Urpelainan called for caution when relating nightlights, census data, and economic indicators in different Indian states (Dugoua, Kennedy, and Urpelainen 2018). Although his team has found a strong association between communities predicted to have electricity access and government-provided electrification measurements, it did not find a correlation with energy access and economic well-being in rural areas. Nightlights data can perhaps be used for large-scale income and wealth comparisons, but they are

not necessarily a good proxy for economic activity on a small scale in rural settings. To make better policy choices, decision makers need to understand the conditions under which electricity access actually improves well-being. The use of satellite imagery brings newfound transparency, timeliness, and relevance to a domain in which existing alternatives for data are potentially outdated (due to infrequent data collection), unavailable (due to proprietary ownership by utilities), highly aggregated (as in administrative data), or biased (due to political incentives to misstate electrification or related statistics). It is essential, however, to evaluate the accuracy of these new data processing methods using ground truthed data and to complement these methods with understanding of what access really means for people in the communities observed.

**Figure 2. Satellite image of India at night**

Source: NASA Earth Observatory images by Joshua Stevens, using Suomi NPP VIIRS data from Miguel Román, NASA's Goddard Space Flight Center, 2016, https://www.nasa.gov/feature/goddard/2017/new-night-lights-maps-open-up-possible-real-time-applications.

OLDIES REALLY ARE GOODIES

Rural customers newly connected to the grid in Kenya are using less electricity than those connected in previous years, according to Jay Taneja of the University of Massachusetts, Amherst (Taneja 2018). Even after an initial period of consumption growth, rural customers connected in 2014 and 2015 demand roughly 40% less energy on average than customers connected just a few years earlier. As utilities expand coverage, they typically enroll more rural and low-income customers who consume less energy—a likely explanation for the significant consumption gap showing in Figure 3.

Figure 3. New rural customers consume relatively less electricity
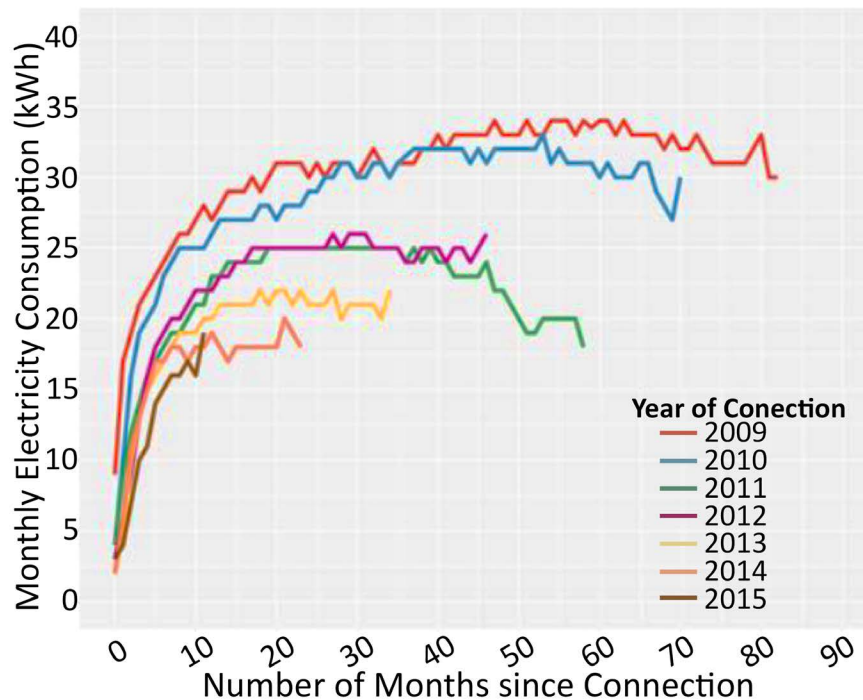
Source: Taneja, J. "Growth in Electricity Consumption in Kenya and the Implications for Energy System Planning." Presentation at the 2018 Sustainable Energy Transition Initiative Conference, Durham, North Carolina, May 17, 2018.

Data can improve the ability of planners and policy makers to forecast demand and choose more appropriate electrification solutions as they work to connect more first-time electricity users. In turn, they can better predict whether and how the costs of infrastructure investments can be covered.

KNOW YOUR CUSTOMER! USING HOUSEHOLD AND USAGE DATA TO RIGHT-SIZE MICROGRIDS

Microgrids hold great promise for helping address the energy access challenge, but for a host of reasons, they are not yet commercial or attracting scaled investment (Phillips 2018). More precise projections of system-wide demand, and ultimately revenue, would help to right-size system design, improve the financial sustainability of microgrids, and reduce investment risks—all essential to attracting private capital to the sector (Figure 4). High-resolution data can help facilitate these improved predictions.

**Figure 4. Better demand forecasts are crucial to engineering and finance**

- *Current forecast methods inaccurate*
- *Forecasts are crucial to system design and financial modeling*
- *Improper sizing leads to unutilized capacity or poor service quality*
- *Revenue uncertainty is a major investment risk*
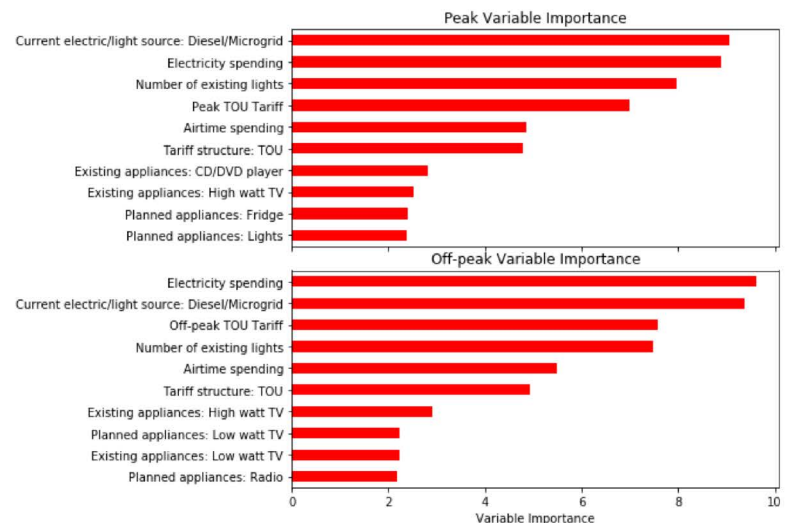
Nathan Williams of Carnegie Mellon University works with microgrid developers in East Africa to analyze the data collected through smart meters used in new systems (Figure 5) (Williams 2018). Operating on a smaller scale than traditional utilities, microgrid developers tend to have deeper relationships with their customers and often collect detailed socio-economic data before connecting households and businesses to their systems. Analyzing smart meter consumption data in combination with household-level characteristics data can improve future demand prediction and electricity planning.

Figure 5. Daily electricity consumption data collected from smart meters from East African microgrid customers
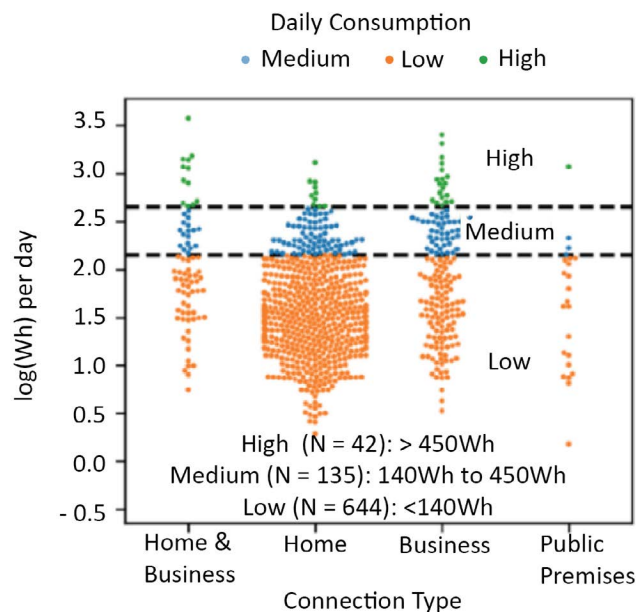
In research using customer-level data, Williams highlights the need to update traditional methods for predicting energy consumption for new energy consumers. Williams' work with smart grid data improves on the methods currently used to forecast demand in the microgrid sector. With the help of researchers, these data can be used to make more robust predictions of future energy demand and better meet consumer needs.

LOOKING AHEAD

The challenge of providing reliable energy access to billions of people around the world is monumental—especially when energy provides a critical link to other development indicators such as health and education. The SETI conference highlighted remarkable advances in data analysis and applications, and it outlined remaining data-related hurdles impeding progress on energy access. The tools used by energy planners rely on data and methods that do not always reflect the rapidly changing landscape of options and customer preferences. Existing data are often outdated, unavailable, highly aggregated, or biased, underscoring the need for continued improvement of data collection and analysis.

Research supporting the goals of energy access practitioners is critical to enhancing ongoing efforts to combat energy poverty. Analyses using satellite imagery can provide a snapshot of information on energy resources and infrastructure without expensive, time-consuming, and potentially unreliable data collection. Researchers are looking ahead to accelerate predictions of how new customers are likely to use electricity before they are even connected. New analytical tools will be critical to improving planning and evaluation of current energy interventions and policies. Better data will inform more appropriate project sizing and design, improve forecasting, enhance customer service, and help align investor expectations in new technologies (e.g., renewable energy microgrids) with the realities of providing electricity to unserved communities (Attia and Guay 2018).

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Nicholas Institute for Environmental Policy Solutions

The Nicholas Institute for Environmental Policy Solutions at Duke University is a nonpartisan institute founded in 2005 to help decision makers in government, the private sector, and the nonprofit community address critical environmental challenges. The Nicholas Institute responds to the demand for high-quality and timely data and acts as an "honest broker" in policy debates by convening and fostering open, ongoing dialogue between stakeholders on all sides of the issues and providing policy-relevant analysis based on academic research. The Nicholas Institute's leadership and staff leverage the broad expertise of Duke University as well as public and private partners worldwide. Since its inception, the Nicholas Institute has earned a distinguished reputation for its innovative approach to developing multilateral, nonpartisan, and economically viable solutions to pressing environmental challenges.

Sustainable Energy Transitions Initiative

The Sustainable Energy Transitions Initiative (SETI) is an interdisciplinary global collaborative that aims to foster research on energy access and energy transitions in low- and middle-income countries and to better understand their impacts on health, social outcomes, economic growth, climate change, and natural resources. This "center without walls" is coordinated by Duke University faculty Subhrendu Pattanayak and Marc Jeuland and is sponsored by the Swedish International Development Cooperation Agency through the Environment for Development Network.

Duke University Energy Access Project

The Energy Access Project at Duke University is a new research and policy effort that aims to address the challenges around increasing access to modern energy solutions to underserved populations around the world. It takes an interdisciplinary approach to developing sustainable, modern energy for all. The Energy Access Project is working to provide policy makers, project developers, investors, civil society and impacted communities with the tools and analysis to help drive this transformation. Key Duke collaborators in this effort include the Nicholas Institute for Environmental Policy Solutions, the Duke University Energy Initiative, the Sanford School of Public Policy, Bass Connections, and the Nicholas School of the Environment.

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