SUMMARY REPORT

CUTTING-EDGE WORKSHOP

HOW INFORMATION AND COMMUNICATIONS TECHNOLOGY (ICT) IS POISED TO TRANSFORM THE DELIVERY OF ENERGY SERVICES

AUGUST 30 AND 31, 2017 - HILTON HOTEL, WASHINGTON D.C.

AUTHORS

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ACKNOWLEDGEMENTS

This workshop was organized by IBD's Energy Division (ENE) in collaboration with Columbia University, and the IDB's Knowledge and Learning Division (KNL). Special thanks to Vijay Modi and team (Columbia University), the participating speakers, and Roberto G. Aiello (Team Leader, ENE) and Carolina Aclan (KNL) for their work on this event.

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INTRODUCTION

The goal of this workshop was to introduce new and innovative possibilities for the future grid to staff working in the energy sector within the IDB Group. Given recent developments in alternative energy sources and growth in the use of sensors, this workshop aimed to showcase the role which information and communication technology (ICT) could play in improving energy provision and services. The key themes presented in this workshop included the problems in developing grids, projections on how the grid will look in the future, and solutions to current problems to bring the grid into a favorable future.

The utility business was historically hardware driven, where utilities generated power and hoped it reached the customer. They meter the consumption at the home, and replace resources when failure is reported by the customer. Over the last decade a lot has changed, how measurements are made, what types of generation are widespread, and the price of monitoring equipment. Through digitization it is now possible to repair equipment before it breaks, utilize more renewable sources, and maintain large grid networks with fewer people.

EXECUTIVE SUMMARY

A. CURRENT INSIGHTS ON THE STATE OF THE GRID.

1. In many low and middle income settings the challenges of electricity provision are not technical alone, but also include ensuring reliable bottom up revenue flow from customers whose monthly payments are low.

2. Increasing electricity access for the last few percent of population can become rapidly more expensive. Such customers are amenable to “grid-like” mini-grid systems which in spite of their somewhat higher cost are able to provide reliable and robust 24-7 pay as you go service, that is both more affordable and permits seamless growth of consumption. Digitization is a natural starting point for such systems.

3. Growth of renewables has become an imperative both to meet INDC (Intended Nationally Determined Contribution) goals and increasingly for economic reasons. Renewables such as solar and wind are essentially upfront cost propositions and hence financing is critical. To de-risk financial flows, one needs to prove through data the electricity generation. Given the decentralized nature of such systems it becomes increasingly important that developers have the means to monitor generation, detect anomalies and use analytics to automate such functions.

4. Heating/cooling systems for thermal comfort become adopted with economic growth and can be directed to aid grid stabilization. While countries are at early stage of adoption it is important to ensure that their role in flexibility is tied to early programs that can ensure that these systems are compatible with common communication protocols.

B. PROJECTIONS FOR THE FUTURE OF THE GRID.

1. Increasingly, utilities should be able to benefit from management of demand response and grid-interactive services, carried out internally or though contractors and subsidiaries. There are several critical aspects of utility operation that will be impacted by the new technologies: demand projection, network planning, network expansion, equipment upgrade, fault detection and response, meeting remote area or last-mile access and/or CSR (Corporate Social Responsibility), commercial side operations such as meter reading, billing, and collection. The future utility needs to prepare for

cost-effective and efficient operation of all above functions.

2. The electric grid will be an enabler for reducing emissions. It is changing from being a "one-way" provider of electricity to one that is more transactional and accommodating of prosumers and other measures of flexibility. A more interconnected grid that encourages distributed local generation through renewables will thereby lower emissions.

3. Digitization is leading to the democratization of the grid and its resources, where private sector players can increasingly provide generation and other services beneficial to the grid and get paid for it. Thereby creating viable investment and/or business opportunities that can support both the grid and the customer.

4. Digitization of the utility will benefit almost all aspects of utility operation: meeting voluntary INDC (Intended Nationally Determined Contribution) targets of individual countries, e.g. renewable integration, efficiency, and energy access, as well as maintaining the financial health of the utility.

5. Countries where infrastructure growth is still occurring can be key beneficiaries of standardized ID protocols. They ensure that appliances can be tagged to customer meters, customer meters to distribution lines and transformers, transformers to feeders, feeders to substations (MV to LV), and sub-stations to transmission lines. Additional geo-tagging tools have reduced in cost dramatically as well. This alone can pay off in conjunction with transformer level metering and feeder lever metering in ensuring both customer level and meter reader level loss detection and accounting.

6. Deeper integration of renewables will be enabled through ensuring flexibility in the grid. Such measures will be derived through a combination of hardware and software: operational rules, interaction agents, demand response, load shifting, and peak reduction measures. Increasing flexibility will be an earlier win compared to deep deployment of battery storage.

C. PRACTICAL SOLUTIONS: POSSIBLE WAYS FORWARD FOR THE GRID.

1. Low-cost smart or prepaid metering can create a virtuous cycle of financial accountability, allowing visibility into where the non-technical losses are and hence a means to stem them. This can lead to improved financial health of the utility, a challenge in many low and middle income settings.

2. To most efficiently modernize or expand utility operations, you must know the state of installed resources. What is the current level of digitization in metering and what is the current level of variable renewables penetration. From these two factors you can determine what to prioritize first.

3. Various enabling environments can support digitization of the traditional grid, e.g. geospatial tools, legislature, software, data analysis platforms, cloud computing, cyber security, supercomputers, and a smarter world.

4. Hydropower can be rethought as a grid resource to enable higher utilization of renewables, as the future primary energy supply might come from renewables. This is especially important where hydropower is common in Central and South America. For example, adjustable speed turbines are more likely to adapt to rapid up/down ramping requirements.

5. Developing appliance standards and standardization of protocols for interaction of the grid with appliances/aggregators will allow easier deployment. Such deployment when carried out in conjunction with scheduling algorithms or demand response measures can expand flexibility beyond industrial and commercial customers to residential loads as well. Through development finance and other financing sources there is an opportunity for ensuring inter-operable systems and achieve cost reductions through scale.

6. Electric vehicles offer particular opportunities in scheduled charging cycles that could ensure higher grid utilization without higher investment becoming a win-win for the consumer and the utility. Latin American countries, perhaps led by Chile (with high Copper and Lithium reserves) can play an important role in becoming leaders in flexibility through electric vehicle charging.

7. Scheduling pumping loads could be another low-cost source of flexibility. In several middle-income countries irrigation pumps and other water infrastructure continue to be a significant portion of the load.

8. In many low-income settings, the poor do not have credit history or any record of regular payments. Through ICT and communication one can ensure financial inclusion for the poorest. Data from the field shows that the poor are actually creditworthy while frequently it is the service provider that is not. Hence data can enable financial inclusion for the poor as well as allow the utility to remove weak links in the accountability chain, thus proving its own credit.

PRESENTERS' TAKE-AWAY MESSAGES

PRERIT AGARWAL: REAL-TIME RENEWABLE MONITORING INFRASTRUCTURE

● Real-time System Monitoring is valuable as it provides means to verify the value of one's investment in renewables, and provides confidence in its proper operations.
● Performance of solar panels should be evaluated by comparing the expected energy with generated energy. The expected energy, is obtained using sensors, pyranometer or reference solar cell, to estimate the amount of energy given the actual irradiation hitting the panel.

SHAZIM CHAPRA: SMALL/MEDIUM SCALE SYSTEMS: ENTREPRENEUR PERSPECTIVE

● Monitoring allows for real picture of site without being at the site itself, thus providing a clear picture of what is happening.
● Centralized solar in Pakistan has not taken off because of infrastructure problems. If the grid is unstable then it is a huge knock on possible financial generation of the country.
● It is difficult for the consumer to tell what is a quality solar product. IADB could help countries develop standardizations to show quality devices.

ARIEL NUNEZ: GEOSPATIAL DATA - BEST PRACTICES & DATA INFRASTRUCTURE

● Spatial data infrastructures or geospatial information must persist after a project is completed.
● Prioritize open source software and foster an ecosystem of local talent. Open by default, if you want to close access to something then a reason should be provided.

BALKI IYER: DIGITIZATION OF THE UTILITY: SUPPORTING INTEGRATING RENEWABLES INTO THE GRID AND DEMAND SIDE MANAGEMENT.

- The top priorities for the utility are electric vehicles, constant transmission, distribution efficiency, renewables, and storage. None of these strategies can be fully implemented without a digital framework.
- With depleting fossil resources and the expected increase of atmospheric CO2 over the next 20 years (400-440 ppm) decarbonization is imperative.
- Utilities need to embrace the cloud. Their security for non-cloud storage is less than that currently implemented on cloud systems.
- Digitization is going to be economically beneficial. Companies which will succeed have already embraced digitization while those that do not embrace it now, will be penalized later. Ignore exponential trends at your own peril.

YASHRAJ KHAITAN: METERING, BILLING & COMMERCIAL SYSTEMS OF THE UTILITY TO SUPPORT DIAGNOSTICS, AUDIT & REVENUE COLLECTION.

- India's power sector loses 17 Billion USD on an annual basis. This is enough to provide power to Bangladesh for 5 years.
- Non-payment of bills causes a vicious cycle of bad debt and lack of trust in the utility. A very easy payment process is necessary to ensure good payment. There needs to be a timely way to generate the bill so customers get regular account status updates.
- Digitization and proper bill management can be very effective in increasing utility revenue and decreasing losses.

DR. MATTHIAS PREINDL: THE FUTURE OF ELECTRIC VEHICLES & THE GRID

- In addition to decentralized energy generation gaining traction, the numbers of Electric Vehicles (EVs), are also growing. Predictions tend to be around 50-60% of market being electric in the next 10 years, higher if an investment in charging infrastructure is made. By 2030, 24% of the vehicle market will be EVs and 5% of global energy consumption will be from EVs.
- With all these new EVs there is a potential to provide energy back to the grid. They could serve as an additional distributed resource for the grid. EVs can be used as backup batteries to stabilize the grid. With home charging controllers, EVs can provide energy to the home when the prices are high and charge when the prices are low. This could benefit the consumer's wallet as well as the utilities' if both embrace the technology.

DR. FRED JIANG: THE FUTURE OF SENSORS & COMMUNICATIONS

● Smaller granularity in sensor data increases the possibilities for analysis and data aggregation. If data is visualized it can help stem excess consumption.

● Mapping your energy footprint in real time can provide informative feedback that then impacts everyday interactions.

JACK BOTT & JIA JI: MINIGRID EXPERIENCES FOR REMOTE REGIONS - IOT WITHOUT THE INTERNET

● The last mile customer can be exponentially expensive to connect to the grid. For these customers grid-like power from off grid systems can be more appropriate.

● Share generation to get higher utilization and payback from initial expenditure. Lower maintenance on central generation as well. For properly managed systems, digital management and minimizing the human from the loop can make the system work.

● Systems need to be sustainable, train locals, continually generate revenue or your system will fail.

MAIN POINTS

I. DEMOCRATIZE THE GRID

Distributed resources should be embraced not shunned. More and more private individuals are investing in renewables and electric home appliances; heat pumps, solar hot water heaters, electric cars, and backup batteries. Through digitization these resources can be a boon for the grid instead of a hindrance. No longer will the grid be exclusively a “one way” provider of electricity. A more modern grid is more transactional and accommodating of prosumers.

If the traditional grid ignores the trend towards decentralized resources then consumers will find other means to profit from them without the grid benefiting. Con Ed customers in Brooklyn got together when the utility did not want to pay a feed-in tariff for solar generation into the grid. They used blockchain technology to create a network of generation and usage among themselves.[1] These multiple generation points could then also provide stability, during natural disasters or otherwise, making it much more difficult for everyone to lose power at once.

Islands like American Samoa are an example of how renewables can be managed properly to provide nearly 100% of power demand.[2] Solar provides 99% of the consumed energy on American Samoa. Wind power on other islands amounts for 30-40% of generation. With more digitization and sensor deployment everywhere else could follow suit. Improvements in weather forecasting and the presence of a digital utility can also enable demand side management.

In addition to decentralized energy generation gaining traction, the numbers of Electric Vehicles (EVs), are also growing. Predictions tend to be around 50-60% of market being electric in next 10 years, higher if an investment in charging infrastructure is made. By 2030, 24% of the vehicle market will be EVs and 5% of global energy consumption will be from EVs. With all these new EVs there is a potential to provide energy back to the grid. They could serve as an additional distributed resource for the grid. EVs can be used as backup batteries to stabilize the grid. With home charging controllers, EVs can provide energy to the home when the prices are high and charge when the prices are low. This could benefit the consumer’s wallet as well as the utilities’ if both embrace the technology.

With all these new developments in technology, utilities are shifting roles from traditional energy providers to managers of microgrids. Digitization is leading to the democratization of the grid and its resources. Private sector players can provide generation and other services beneficial to the grid and get paid for it, creating viable business models that can support both the grid and its customers.

II. SMART METERING

The utility business was historically hardware driven, where utilities generated power and hoped it reached the customer. In such traditional systems, inexpensive meters are used to measure the consumption at the home. However, many drawbacks are associated with these types of meters. In the case of India, where the power sector loses $17 billion in revenue annually, traditional metering only contributes to electricity loss and by convention revenue loss. The lack of consistent and usable data from the existing meters results in inefficiencies in bill collection, little to no maintenance, and poor procurement of electricity infrastructure.

India operates on an L1 procurement strategy where the lowest bid gets chosen. Ten to twenty percent of all its existing meters are purchased on a yearly basis and of these procurements only 25-30% are for new connections, most are to replace faulty meters. Faults on static meters which are the majority of those installed, are undetectable unless seen in person; if the customer complains or a technician is present at the site. In addition, these meters are not geo-tagged, thus upwards of 40% of the customers in some regions of India are “ghost consumers” or non-paying consumers. Due to poor organization, customers may not get a bill for 6 months and when they do it is too high for them to pay. This leads to default in payments and mistrust between the utility and consumers. As a result, power theft becomes prominent, as potential customers are not willing to pay the utility for services given the lack of reliability in the metering and bill generation process. The situation is made worse by voltage spikes and dips, from 60 VAC to 1000 VAC in places where it should be a constant 240 VAC. Consequently, customers are being asked to pay for power that burns their appliances. This creates a vicious cycle between customers and their utility. This story is not unique to India, in fact many utilities in developing countries face the similar challenges when it comes to metering and monitoring their network.

Low-cost smart or prepaid metering can increase financial accountability, allowing visibility into where the non-technical and technical losses occur and hence a means to stem them. This can lead to improved financial health of the utility, a challenge in many low and middle income settings. Connected smart meters and sensors can find the loses on the grid. It then becomes more of an issue to deal with the person stealing power rather than detecting theft.

One company benefiting from digitized resources is Greenewable Solar, partnered with Locus Energy. Their business model is to lease rooftop solar systems. Their digital monitoring allows them to remotely track production at the site. As an example, they have had many issues with cleanliness of solar panels, an issue for any solar operator. The Locus monitoring tools allow them to know when panels are dirty. They found one customer needs to clean their panels 3 times a week because of fumes coming from their building. Without monitoring enabled by smart metering, the panels would have been maintained with conventional wisdom and would not have produced as expected.

The goal of smart metering is to reduce operation and maintenance expenses, to analyze sites for outlier performance and to reduce response times by sending the right teams to fix issues when they occur. Even in developed nations there must be a larger push for collecting and utilizing smart metering data from the grid.

Today there are 50 billion IOT sensors in the world. They are getting cheaper and can be put on anything. The cloud storage market is expected to grow from $18 billion to $112 billion in less than 3 years. Utilities need to embrace such technologies to collect and store data. The most progressive utilities use less than 10% of the data they collect. Utilities can’t even tell customers if there is going to be an outage or that there is an outage, customers have to let the utility know. This needs to change as we move through the 21st century.

III. CHALLENGES OF ACCESS & RELIABILITY

Universal electricity access is a mandate that all countries strive to achieve. Electricity access typically begins in urban centers - as the demand for such services are usually by wealthier high consuming customers, and then spreads to the more remote areas.

Electricity access in remote areas is a challenge because grid connection becomes more expensive as customers become more remote. With more access comes a divergence between the increasing cost of connecting new customers and the low consumption of newly added customers. The consumption of new customers no longer covers the cost of providing the service.

Knowing where the customers are, their possible consumption, and the cost to connect them is relevant when planning for access in remote areas; how much wire is necessary, do they currently have an alternative source of power, and do they have a revenue stream that would allow them to pay for electricity. Knowledge of where customers are located enables service providers to plan how best to connect them. The per customer cost of connection wires is minimal when the customer is less than 200 meters from the grid. Beyond this threshold the cost of connection increases with wire distance. Finally, understanding the demand (kW) and the consumption (kWh) will influence the choice of technology suitable for the customers. For low consuming customers, grid-like services from distributed generation sources (e.g. solar systems, minigrids) might be more suitable in matching their consumption needs at a lower cost.

Distributed generation sources such as solar home systems have gained traction in recent years due to new service models like Pay As You Go (PAYG). This model has shown more potential for systems which cost between $300 - $400. Anything lower, the transaction cost is too high. In poor remote regions, solar home systems can provide about 3 kWh/month. Typical grid systems in remote areas can provide 50 - 70 kwh/month, while the monthly consumption ranges from 15 - 30 kWh. The consumption is higher than what a solar home system can provide but too low for the grid to be properly utilized. Thus there are opportunities for distributed systems, with and without batteries, within this range which could provide grid-like services. The price reduction in battery cells makes it of more interest for grid or stationary based applications.

Distributed systems with grid-like services should be designed such that they can be upgradeable should the demand grow. Systems requiring low capital should be implemented in demand clusters where growth in consumption can occur. The system should be inclusive to allow users with different resources and levels of education to access the technology. Digitization of distributed systems for metering, bill generation, payment and monitoring can reduce operation costs and increase system transparency. Considerations for data collection and security should be put in place prior to deploying such systems.

In urban areas, grid infrastructure is primarily plagued by a lack of reliability, in the form of electricity theft, outages etc. A proposed solution to improving reliability might be to increase generation by adding power plants to meet the load. If the grid infrastructure is very poor, then improving the data streams along the electricity network can be more effective in reducing losses and thereby improving reliability. Good data collection on the electricity network allow operators to know and detect problems, thereby allowing the operators to fix the problems.

IV. A MORE EFFECTIVE GRID PLAN | HOW TO DIGITIZE?

Nearly all goals of the utility and individual countries (e.g. renewable integration, efficiency, energy access and financial health of the utility) would benefit from digitization. It allows the utility to incorporate lower cost systems, energy accounting, demand side management and renewables. Various advancements and enabling systems (e.g. geospatial tools, legislature, software, data analysis platforms, cloud computing, and cyber security) can support digitization of the traditional grid in a cost effective manner.

GEOSPATIAL TOOLS

Geospatial tools allow the utility to know how its assets are spatially distributed. This includes knowing locations of transformers, poles, lines and customers relative to generation plants. However, maintaining geospatial data tends to be more important than creating the data. When considering appropriate geospatial tools, open source software and data sharing should be prioritized. Involving local teams and government will support sustainable data collection and management. Finally, user communities should be encouraged to develop and maintain usable tools which meet the needs of diverse users.

SOFTWARE PLATFORMS

Utilities are used to procuring hardware; wire, poles, generation plants, but when adding software there are many new challenges. Software platforms should support multiple manufacturers and should expose the data including metadata to the necessary party. They should also allow infrastructure to be managed remotely from a central location especially in cases where it is hard to access electricity assets.

STANDARDS & PROTOCOLS

As utilities develop a digital strategy, it is equally important to develop software protocols and equipment standards that will allow for a more cohesive grid. The goal of these protocols and standard should be to facilitate procurement of equipment and enable easy repairs of infrastructure. The standards can help minimize equipment turnover from year to year.

NEW BUSINESS MODELS

In India, utilities incur $4-5 in transaction costs (software, administration etc.) to serve the consumer, after paying for power. Average revenue per user is $22 and 70% of that goes to purchasing power. In well run utility, transaction costs for the utility should be no more than 10% of the revenue. To reduce its per customer transaction cost, utilities could outsource digitization and system management to a company through a meter, billing, and collection (MBC) business model. This is similar to telecom companies who have employed long term technologies such as IBM/Ericsson. A meter, billing, and collection (MBC) Agency model can allow the utility to serve customers at $1- $2 per customer.

Business models which save costs, improve revenue collection efficiency, and decrease electricity losses should be adopted by the utility. The utility also benefits from having one service provider for all its digital needs where it can set clear performance metrics to ensure accountability. However, clear contract terms should be outlined for both the MBC Agency and the enrolled utility.

PERFORMANCE METRICS

Relevant performance metrics are needed to ensure that the right digitization strategy is in place. In the case of monitoring outputs from renewables, comparing actual energy output to the expected or forecasted output, is one approach to ensuring that a solar system or project is performing as desired. Expected energy can be estimated from a reference cell given irradiation hitting the cell. Other metrics such as amount of loss reduced in the network or bill collection efficiency are more relevant when evaluating the value of deployed meters on the network. Proper determination of appropriate metrics should be done to ensure that the right digitization strategy is chosen and that its performance is sustained.

AGENDA

HOW ICT IS POISED TO TRANSFORM DELIVERY OF ENERGY SERVICES

DAY 1

8:45		BREAKFAST	SESSION 1
9:15	IADB	WELCOME	
9:20	IADB	INTRODUCTIONS	
9:30	VIJAY MODI	FUTURE OF THE ELECTRIC UTILITY: DIGITIZATION RENEWABLE INTEGRATION, ACCESS & LAST MILE	
10:30		COFFEE BREAK	
11:00	PRERIT AGARWAL & SHAZIM CHAPRA	REAL-TIME RENEWABLE MONITORING INFRASTRUCTURE SMALL/MEDIUM SCALE SYSTEMS: ENTREPRENEUR PERSPECTIVE	
12:15	VIJAY MODI	ELECTRICITY ACCESS & CHOICE OF TECHNOLOGIES	
13:00	JACK BOTT & JIA JI	MINIGRID FIELD EXPERIENCES FOR REMOTE REGIONS - INTERNET OF THINGS WITHOUT THE INTERNET	
13:30		LUNCH	SESSION 2
14:30	BALKI IYER	DIGITIZATION OF THE UTILITY: SUPPORTING INTEGRATING RENEWABLES INTO THE GRID AND DEMAND SIDE MANAGEMENT.	
15:45		COFFEE BREAK	
16:15	YASHRAJ KHAITAN	METERING, BILLING & COMMERCIAL SYSTEMS OF THE UTILITY TO SUPPORT DIAGNOSTICS, AUDIT & REVENUE COLLECTION.	
17:30		WRAP-UP	

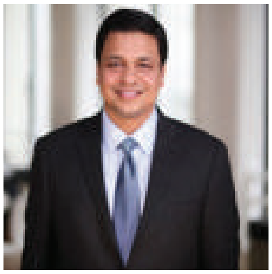
AGENDA

HOW ICT IS POISED TO TRANSFORM DELIVERY OF ENERGY SERVICES

DAY 2

8:45		BREAKFAST
		SESSION 3
9:15	DR. MATTHIAS PREINDL	THE FUTURE OF ELECTRIC VEHICLES & THE GRID
10:30		COFFEE BREAK
11:00	DR. FRED JIANG	THE FUTURE OF SENSORS & COMMUNICATIONS
12:15	ARIEL NUNES	GEOSPATIAL DATA - BEST PRACTICES & DATA INFRASTRUCTURE
13:00	VIJAY MODI	WRAP-UP DISCUSSIONS

SPEAKER LIST



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Prerit heads the solutions and delivery team for commercial, industrial, and utility projects at Locus Energy along with International Business Development. He has over nine years of experience in the solar and renewable industry. He overlooks Locus businessfor International markets with a focus in India, APAC, MENA, and Africa. He also previously worked at Ausnenco, Amonix and United Technologies in automation and controls. Prerit holds a Master's Degree in Computer Science from the University of Southern California, and earned his Bachelor's Degree in Computer Engineering in India."

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ack works as a Mechatronics Engineer at the Quadracci Sustainable Engineering Lab, New York, NY, where he is focused on solar mini-grids for irrigation and household electricity. He is pursuing an MS in Electrical Engineering at Columbia University, has a BS in Mechanical Engineering from Columbia University, and a BA in Physics from Bard College. Jack has field experience deploying control systems across Africa.

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Shazim is a business professional with over 15 years of experience running his family industrial holdings in Pakistan and South Africa. He is currently the CEO of Greenewable Solar, a renewable energy company developing solar PV solutions for the commercial, industrial, agricultural and residential segments in Pakistan. He also is a principal at MI Ventures, a New York based early stage fund that makes investments in seed stage technology companies. He is credited with turning around two businesses during his time in South Africa. He holds a Bachelor's degree in Mechanical Engineering from Columbia University and an MBA from NYU's Stern School of Business.

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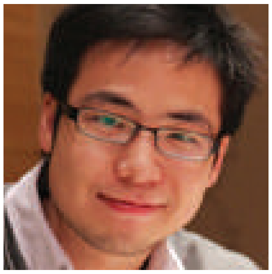
Ji Jia is a candidate in the Computer Engineering Program at Columbia University. Currently he is doing IoT research with Prof. Xiaofan Jiang (EE) in the Columbia Intelligent and Connected Systems Lab. He is also working with Prof. Vijay Modi (ME) on the SharedSolar project as part of QSEL. Mr. Jia graduated from B.Sc.(2011) in Hefei, China. Mr. Jia has broad experience in both research labs and industry, as he has taken part in software systems development, and has led research projects as well as four manufacturing projects in the last few years. His specialty is filling the gap from research to product.



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Xiaofan (Fred) Jiang is an Assistant Professor in the Electrical Engineering Department at Columbia University and a member of the Data Science Institute. Fred received his B.Sc. (2004) and M.Sc. (2007) in Electrical Engineering and Computer Science, and his Ph.D. (2010) in Computer Science, all from UC Berkeley. Before joining SEAS, he was Senior Staff Researcher and Director of Analytics and IoT Research at Intel Labs China. Fred's research interests include cyber physical systems and data analytics, smart and sustainable buildings, mobile and wearable systems, environmental monitoring and control, and connected health & fitness.

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Yashraj Khaitan is the Founder and CEO of Gram Power, which is an energy technology company founded out of UC-Berkeley. Gram Power provides the industry's lowest cost and most integrated smart metering solution and works with Power Utilities as their technology backbone to help them radically reduce distribution losses. Yashraj graduated from UC-Berkeley with an undergraduate degree in Electrical Engineering and Computer Science in 2011 and opted out of his post grad program to launch Gram Power in India. After building the core team and technology, he currently heads business strategy, partnerships and technology vision for the company.

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Vijay Modi is a Professor and past-Chair of Mechanical Engineering in the School of Engineering and Applied Science and a faculty member at the Earth Institute, Columbia University. Between October 2011 and 2012, he was a member of the U.N. Secretary General's high-level task force on "Sustainable Energy for All" and he currently leads the U.N. Sustainable Development Solutions Network working group on Energy Access for All. He received his Ph.D. from Cornell University in 1984 and worked as a post-doc at MIT from 1984 to 1986 before joining the faculty at Columbia University. Prof. Modi's areas of expertise are energy resources and energy conversion technologies. His laboratory, the Quadracci Sustainable Engineering Lab (QSEL), has been responsible for technologies such as "SharedSolar" and widely used tools such as "Network Planner" and a free open-source app called FormHub, used over a million times.

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Ariel Núñez is an Electronic Engineer with Masters studies on Computer Vision and Machine Learning. He worked for the World Bank for more than 6 years advising on Open Data and Open Source Software for Disaster Risk Reduction and Climate Change projects and at the World Food Program on the development of Geospatial Systems for Field Security. He now heads an engineering consulting firm based in Colombia working for Universities, Governments and International Organizations on Geospatial Data and Robotics using Open Source Software.

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Matthias Preindl received the B.Sc. degree in electrical engineering (summa cum laude) from the University of Padua, Padua, Italy, the M.Sc. degree in electrical engineering and information technology from ETH Zurich, Zurich, Switzerland, and the Ph.D. degree in energy engineering from the University of Padua, in 2008, 2010, and 2014, respectively. He was an R\&D Engineer of Power Electronics and Drives at Leitwind AG, Sterzing, Italy (2010-2012), a Post-Doctoral Research Associate with the McMaster Institute for Automotive Research and Technology, McMaster University, Hamilton, ON, Canada (2014-2015), and a Sessional Professor in the Department of Electrical and Computer Engineering, McMaster University (2015). He is currently an Assistant Professor in the Department of Electrical Engineering, Columbia University in the City of New York, NY, USA. He received the Career Award of the Futura Foundation in South Tyrol, Italy and the CAREER Award of the US National Science Foundation (NSF) in 2016 and 2017, respectively.