The Subir & Malini Chowdhury Center for Bangladesh Studies

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Bangladesh Research Notes

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CLEAN ENERGY IN BANGLADESH

INNOVATING FOR A CLEAN ENERGY ECONOMY IN BANGLADESH

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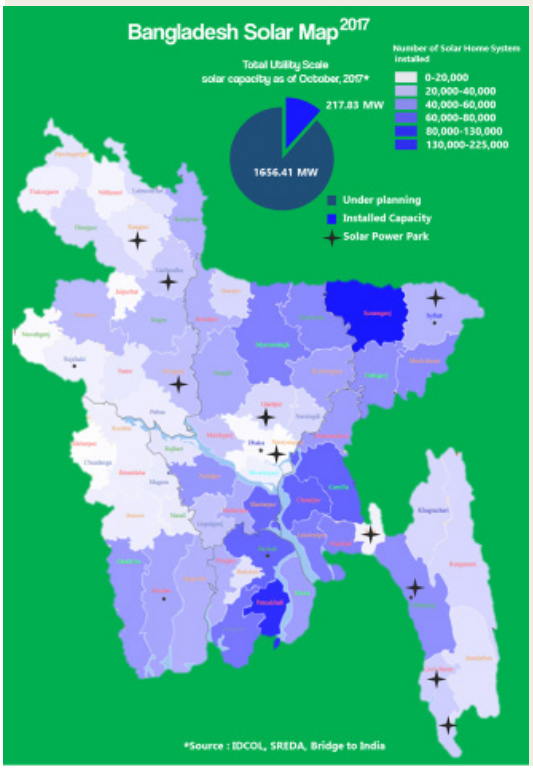
Bangladesh is an important emerging economy widely acknowledged to be making strides in human development and economy. With an economic growth rate of over 7%, Bangladesh's economy was the third fastest economy of 2017 with population of 50 million and more (World Bank 2018). However, inadequate infrastructure and unreliable power supply constrain growth and ac- cess to affordable, reliable social services. Not only does poor power supply create commercial losses that dampen national revenue earnings, but more than a third of the population remains without electricity access. In 2016, Bangladesh joined the Climate Vulnerable Forum in striving to meet 100% domestic renewable energy needs as rapidly as possible (Climate Vulnerable Forum 2016).



In sharp contrast to its remarkable success in domestic off-grid Solar Home System (SHS) program with about 4.5 million SHS installations generating over 200 MW of electricity (SREDA 2017), Bangladesh's development and operation of utility-scale renewable energy is very limited. Instead, the Bangladeshi government through the Bangladesh Power Development Board (BPDB) plans to add substantial coal-fired and natural gas fired power plant capacity to the current gener- ation mix to catch up with rapidly growing electricity demand, resulting in increased reliance on foreign resources. The Rampal Power Plant for instance – a 1.3 GW coal power plant scheduled to begin operations by 2021 – is a partnership between the Bangladesh Power Development Board and the Indian state-owned National Thermal Power Corporation. The plant is facing fierce local and international opposition, with calls from UN experts to halt development.

Inadequate geospatial and economic information on clean energy resources is often a significant barrier to policy makers considering socially equitable, environmentally friendly and cost-effective energy development. In addition to the assessment of theoretical or technical potential of renewable resources, other criteria to assess viability of energy projects such as the appropriate economic valuation of high quality

SUMMARY

Energy poverty, is arguably the most pervasive and crippling threat society faces today.

Lack of access impacts several billion people, with immediate health, educational, economic, and social damages.

Furthermore, how this problem is addressed will result in the largest accelerant of global pollution, or the largest opportunity to pivot away from fossil-fuels onto the needed clean energy path.

While debate exists on the optimal path or paths to wean our economy from fossil fuels, there is no question that technically we have today a sufficient knowledge and technological foundation to launch and to even complete the decarbonisation

DAN KAMMEN is the Class of 1935 Distinguished Professor of Energy at the University of California, Berkeley, with parallel appointments in the Energy and Resources Group, the Goldman School of Public Policy, and the department of Nuclear Engineering. He was appointed the first Environment and Climate Partnership for the Americas (ECPA) Fellow by Secretary of State Hilary R. Clinton in April 2010.

Kammen is the founding director of the Renewable and Appropriate Energy Laboratory (RAEL), Co-Director of the Berkeley Institute of the Environment, and Director of the Transportation Sustainability Research Center. He has founded or is on the board of over 10 companies, and has served the State of California and US federal government in expert and advisory capacities.

In 2016, he was selected as a U.S. Science Envoy by the United States State Department. He resigned from this position in 2017, citing what he believed to be President Trump's failure to denounce white supremacists and neo-nazis. His August 23, 2017, resignation letter went viral, as netizens noticed that the first letter of each paragraph spelled out I-M-P-E-A-C-H.

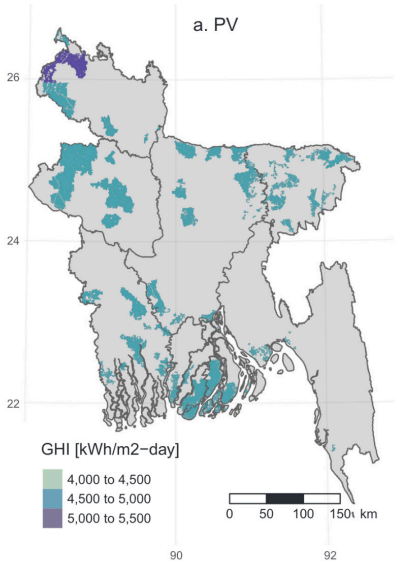
Dr. Kammen was educated in physics at Cornell and Harvard, and held postdoctoral positions at the California Institute of Technology and Harvard. He was Assistant Professor and Chair of the

renewable resources, grid operability, transmission and road infrastructure costs are important. Also critical but less commonly included in decision frameworks, are land use conflicts, such as proximity to or overlap with environmentally sensitive areas, population density and competition for land for food production. Such information is often lacking, as is the case in Bangladesh, presenting a major challenge to balanced decisions on large-scale grid-connected energy development.

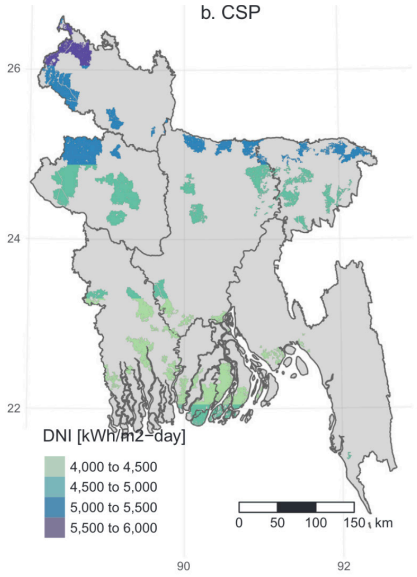
Findings: RESOURCE QUALITY AND GENERATION POTENTIAL IN PROJECT OPPORTUNITY AREAS (POAS)

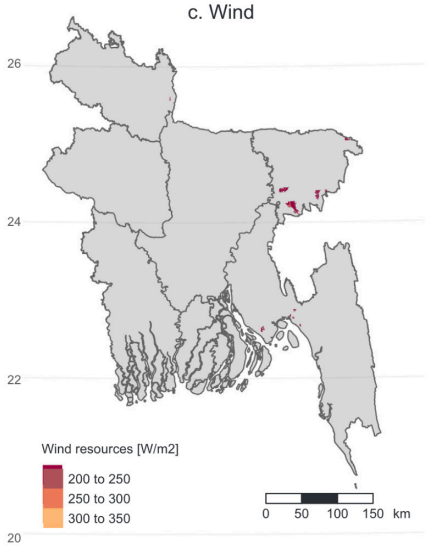
Here we present on results of our analysis. Project opportunity areas (POAs) are identified and summarized in Figures a, b, and c. On the other hand, as shown in Figure c, wind resource is available only in Sylhet and Chittagong. Our analysis finds that more than 99% of the resource area of solar PV and CSP and 100% of wind resource area are located in areas that are primarily cropland according to MODIS classification (NASA). This suggests that for large scale clean energy integration in Bangladesh, carefully targeting of non-cropland area within POAs that are primarily cropland will be critical.

Annual generation potential and capacity of solar PV, CSP, and wind are summarized in Table 1. The annual generation potential in project opportunity areas for solar PV, CSP with and without 6-hour storage, and wind are approximately 8.4-84 TWh/year, 9.8-98 TWh/year, 17.3- 173 TWh/year, and 1.7 TWh/year, while the current national demand in FY 2015-2016 was 52.2 TWh/year. Likewise, the generation capacity in project opportunity areas for solar PV, CSP with and without 6-hour storage, and wind are approximately 5.3-53GW, 3.0-30GW, 5.3-53GW, and 0.57GW, while the current generation capacity was 12.3 GW in 2016. These estimates are dependent on the land use discount factor of cropland, as explained below. Because the project opportunity areas of solar PV and CSP completely overlap, the potential generation and capacity of solar PV and CSP are mutually exclusive - only one can be developed in each POA.

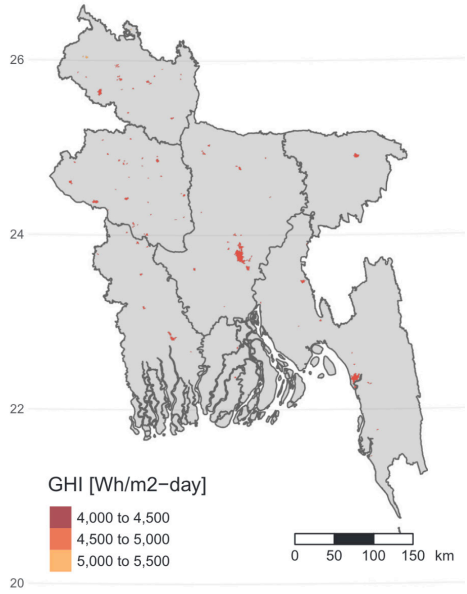


As a comparison to the utility-scale renewable energy





potential, rooftop solar PV potential in urban and built-up areas was roughly estimated. Although urban and built-up areas are excluded in identifying project opportunity areas for utility-scale projects, rooftop solar PV can be deployed in those areas. Figure 3 shows solar PV resources in urban and built-up areas in Bangladesh. Urban and built-up areas are defined as lands covered by buildings and other man-made structures in MODIS. Assuming 1-10 % of urban area is used for rooftop solar PV, its potential is 0.32-3.2 TWh and 0.20-2.0 GW. With the same level of capital costs of rooftop PV in India, which is 1.56 USD/Wp in 2016 (WRI 2016), weighted average generation LCOE is calculated as 130 USD/MWh. While rooftop PV could play a critical role in swift electrification of distant, rural areas, Table 1 shows that the size of generation potential by rooftop PV is relatively small and more costly than utility-scale solar PV. However, rooftop solar PV could serve a different purpose than utility-scale PV; it can be a point of use energy source, as in the Solar Home System in Bangladesh. Rooftop solar PV can be quickly installed (in less than one week); can flexibly meet the required demand of the end user due to its modular design; and with batteries and a backup generator can be used to implement a 'micro-grid' for multiple consumers. For rural areas with no current electrical infrastructure, the costs of developing and maintaining a distribution grid needs to be take into account when comparing the costs of the rooftop solar PV and utility-scale solar or other energy options. For accurate estimation of rooftop solar PV potential, image recognition techniques are necessary, which was beyond the scope of this study.



Samira Siddique, Dan Kammen, with Director Saleemul Huq at the International Center for Climate Change and Development (http://www.icccad.net) headquarters, Dhaka, February, 2018

Table 1
Clean energy potential estimates and their weighted-average LCOE in Bangladesh compared with installed/projected electricity capacity in 2016/2030.

	Land-use discount factor in POAs that are primarily cropland	Percentage of area in urban and built-up area used for rooftop PV	Generation [TWh/yr]	Capacity [GW]	Necessary cropland area [km^2; relative to national land in parenthesis]	Weighted average LCOE [USD/MWh]
Solar PV	1% 5% 10%	–	9.4 42 84	5.3 26 53	169 (0.1%) 864 (0.6%) 1,690 (1.2%)	91
CSP without storage	1% 5% 10%	–	17.3 86.7 173	5.3 26.4 53	169 (0.1%) 864 (0.6%) 1,690 (1.2%)	143
CSP with 6-h storage	1% 5% 10%	–	9.8 49 98	3.0 14.3 30	169 (0.1%) 864 (0.6%) 1,690 (1.2%)	267
Wind	–	–	1.65	0.57	–	106
Rooftop solar PV	–	1% 5% 10%	0.32 1.6 13	0.20 1.0 2.0		244 (generation)
Peak demand & capacity installed in 2016	–	–	61.7	9.0 (demand) 12.3 (capacity)	–	Total: 68 Hydro: 14 Gas: 28 Coal: 110 HFO: 237 Diesel: 472
Projected demand & planned capacity in 2016	–	–	–	34 (demand) 39 (capacity)		

Bio contd.

Science, Technology and Environmental Policy Program at the Woodrow Wilson School at Princeton University before moving to the University of California, Berkeley. Dr. Kammen has served as a contributing or coordinating lead author on various reports of the Intergovernmental Panel on Climate Change since 1999. The IPCC shared the 2007 Nobel Peace Prize. He serves on the Advisory Committee for Energy & Environment for the X-Prize Foundation.

During 2010-2011 Kammen served as the World Bank Group's Chief Technical Specialist for Renewable Energy and Energy Efficiency. He was appointed to this newly-created position in October 2010, in which he provided strategic leadership on policy, technical, and operational fronts. The aim is to enhance the operational impact of the Bank's renewable energy and energy efficiency activities while expanding the institution's role as an enabler of global dialogue on moving energy development to a cleaner and more sustainable pathway.

He has authored or co-authored 12 books, written more than 300 peer-reviewed journal publications, testified more than 40 times to U.S. state and federal congressional briefings, and has provided various governments with more than 50 technical reports. Dr. Kammen also served for many years on the Technical Review Board of the Global Environment Facility. He is a frequent contributor to or commentator in international news media, including Newsweek, Time, The New York Times, The Guardian, and The Financial Times. Kammen has appeared on 60 Minutes (twice), Nova, Frontline, and hosted the six-part Discovery Channel series Ecopolis. Dr. Kammen is a Permanent Fellow of the African Academy of Sciences, a fellow of the American Physical Society. In the US, he serves on two National Academy of Sciences boards and panels.

The Subir & Malini Chowdhury Center for Bangladesh Studies, at the Institute for South Asia Studies (ISAS) at UC Berkeley champions the study of Bangladesh's cultures, peoples and history. The first of its kind in the US, the Center's mission is to create an innovative model combining research, scholarships, the promotion of art and culture, and the building of ties between institutions in Bangladesh and the University of California.

Bangladesh Research Notes is published by the Chowdhury Center to promote dialogue and exchange between scholars who work in inter-disciplinary fields related to Bangladesh, as well as to convey to the wider public the variety of exciting projects going on at Berkeley. Bangladesh Research Notes are available at chowdhury-center.berkeley.edu/research.

COAL DOESN'T BENEFIT THE POOR

"There's been a series of academic reports analysing, on a cost-benefit basis, how different coal projects around the world, from Kosovo, to Pakistan, to Mongolia, might or might not be cheaper, better, than the renewable energy alternatives. In each case that I've studied, the renewables came out better…

"The lessons of these different coal assessments…was a very, very resounding message that the coal projects were essentially always out of date, in terms of how much more or less they would cost. In almost every case we find the coal projects are just more expensive, flat out. And then you get to environmental impacts, you get to social impacts, and the fact that coal doesn't even deliver the thing for which it's really been touted for, and that is, bringing people out of poverty because somehow it's this least-cost fossil fuel source.

"In fact, what we see is that…coal, if anything, has kept people in poverty, because big coal projects in poor countries tend to be projects that favour a few big industry customers. They don't really actually affect and benefit the poor."

—DAN KAMMEN ON ENERGY ACCESS AND POVERTY

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