Institution: De Montfort University		
Unit of Assessment: 13		
Title of case study: Transforming Rural Lives Through Mini-Grids in India		
Period when the underpinning research was undertaken: October 2009 through July 2016		
Details of staff conducting the underpinning research from the submitting unit		
Name(s): Prof. Subhes Bhattacharyya	**Role(s) (e.g. job title):** PI, Professor	**Period(s) employed by submitting HEI:** 31 August 2012 to present
Period when the claimed impact occurred: January 2014 – December 2020		
Is this case study continued from a case study submitted in 2014? N		

1. Summary of the impact

Research led by Prof. Bhattacharyya has firmly established solar-powered mini/micro-grids in rural India as a basic electricity supply option. Consequently, 5,000 non-electrified households gained electricity access, which has increased income generation, created new livelihood opportunities and reduced fossil fuel use and carbon emissions (kerosene use reduced by 20% per year, saving 375t of CO_2 per year). The work helped project delivery partners Mera Gao Power, Mlinda Foundation and Onergy Solar during their initial growth phase to realise their business targets. Prof. Bhattacharyya's team's advice underpinned the basis for the Department for International Development (DFID) India's Decentralised Renewable Energy Access Markets (DREAM) project and the Government of India's guidelines for solar power integration in rural distribution.

2. Underpinning research

Globally, approximately 770,000,000 people still lacked electricity access in 2019 and most of them were concentrated in South Asia and sub-Saharan Africa. The underpinning research was carried out through an EPSRC/DFID funded project (EP/G063826/1 and EP/G063826/2) – OASYS South Asia between October 2009 and April 2015 and subsequent research work in 2016 for DFID India Through Practical Action (ITC15055/1516/xx/EP/SDM) and involved investigation of decentralised electricity solutions for rural areas without electricity. Led by Prof. Subhes Bhattacharyya of De Montfort University (DMU), the OASYS project was delivered by a consortium of five research institutes. In addition to DMU these were University of Manchester, Edinburgh Napier University, The Energy and Resources Institute (TERI, India) and TERI University (India).

Our research highlighted the role of local mini/micro-grids for decentralised electrification of rural areas [R1, R2] and demonstrated alternative business models through action research. Solar PV-based micro-grid pilot projects were implemented for electrification of four locations in India between 2012 and 2015 [R1, R2, R3].

(1) Community-managed electrification of a cluster of five remote villages in Dhenkanal district of Odisha (15kWp PV system for 140 households);
(2) Shared solar AC pico-grid in the Sundarbans, West Bengal delivered by Mlinda Foundation, serving 500 households and 200 shops;
(3) Private-sector driven solar DC micro-grids in Uttar Pradesh delivered in association with Mera Gao Power serving 2,200 households initially, with a promise to electrify another 1,200, reinvesting the profit;

(4) Community-managed mini-grid with the support of Kandhamal district administration, Odisha, serving 250 households and a school with 700 students (18kWp AC mini-grid).

All these projects provided access to basic lighting and mobile-phone charging facilities and supported electricity use for productive, educational and social purposes (street lighting, community halls etc.). The project team carried out the action research at sites 1 and 4 while the delivery partners, Mlinda Foundation and Mera Gao Power, chosen through competitive bidding, implemented the activities at two other sites. DMU, as the lead team, was responsible for the overall project delivery.

Our research confirmed the technical feasibility of electricity supply through mini/micro-grids [R5] but as one size does not fit all, appropriate solutions have to be found [R1, R2, R4]. Moreover, a utility-like approach, offering a flexible, efficient and locally grounded service is required for successful commercial delivery of small-scale off-grid projects and suitable enabling conditions are required in terms of tariff, joint liability sharing, and flexible payment options [R2]. The potential for integration of cleaner livelihood opportunities through decentralised electrification interventions was also demonstrated [R3].

Subsequently, considering the thrust on grid extension in India, Bhattacharyya et al. [R6] have suggested the potential for embedding MW-scale solar PV generators at the distribution grid level to create a cost effective, reliable, rural supply option.

3. References to the research

[R1] Bhattacharyya, S.C. and Palit, D. (2016) ‘Mini-grid based off-grid electrification to enhance electricity access in developing countries: What policies may be required?’ *Energy Policy*, 94: 166–178; DOI: http://dx.doi.org/10.1016/j.enpol.2016.04.010

[R2] Bhattacharyya, S.C. and Palit, D. (eds) (2016) *Mini-Grids for Rural Electrification of Developing Countries: Analysis and Case Studies from South Asia*, Cham: Springer; ISBN 9783319048154

[R3] Narula, S. and Bhattacharyya, S.C. (2017) ‘Off-grid electricity interventions for cleaner livelihoods: A case study of value chain development in Dhenkanal district of Odisha’, *Journal of Cleaner Production*, 142(1): 191–202; DOI: http://dx.doi.org/10.1016/j.jclepro.2016.07.176

[R4] Chmiel, Z. and Bhattacharyya, S.C. (2015) ‘Analysis of off-grid electricity system at Isle of Eigg (Scotland): Lessons for developing countries’, *Renewable Energy*, 81: 578–588; DOI: https://doi.org/10.1016/j.renene.2015.03.061

[R5] Sen, R. and Bhattacharyya, S.C. (2014) ‘Off-grid electricity generation with renewable energy technologies in India: An application of HOMER’, *Renewable Energy*, 62: 388–398; DOI: https://doi.org/10.1016/j.renene.2013.07.028

[R6] Bhattacharyya, S.C., Palit, D., Sarangi, G.K., Srivastava, V. and Sharma, P. (2019) ‘Solar PV mini-grids versus large-scale embedded generation: A case study of Uttar Pradesh (India)’, *Energy Policy*, 128: 36–44; DOI: https://doi.org/10.1016/j.enpol.2018.12.040

The funding for the research was received through a rigorous competitive process organised by EPSRC and DFID. The research outputs were published in peer-reviewed academic journals of high standing and in books published by the leading academic publishers.

4. Details of the impact

The research on mini-grids at DMU has generated significant socio-economic and environmental impacts at three levels (local, national and international) as highlighted below.

(1) LOCAL LEVEL IMPACTS

Action research undertaken through OASYS South Asia project has produced wide-ranging impacts beyond academic knowledge creation. A brief summary of social, environmental and economic impacts follows.

Social impact

The project has impacted 5,000 rural households directly and reduced their dependence on kerosene. For example, in Dhenkanal site, kerosene consumption was reduced by half – from 7l per household per month to 3.50l [C1]. Similarly, pico-grid users of Mlinda have reported a reduction of kerosene use from 3l to 1.50l per month, resulting in a saving of 75% in kerosene expenditure [C2]. Women are a direct beneficiary here – lights in the kitchen make cooking easier [C2].

Access to light has improved the quality of life of the communities. In the Mlinda intervention area, electricity has reached schools and shops as well as households. Shops are using electricity for 3 to 6 hours per day, allowing for business after dark. Light in the evening has allowed pupils to read 2 to 3 hours at night [C1, C2] and helped womenfolk to continue with their handicraft work. Streetlights in the site have instilled a better sense of security in the villages.

Reduced kerosene use has mitigated health hazards and safety risks. Improved roads have made it easier to take patients to hospitals and the local community health staff have started to visit the villages at the Dhenkanal site [C1].

Electrification of a school in the Dhenkanal site and another in the Kandhamal site has contributed to better education, and pupils in electrified villages are taking more interest in their studies. A teacher in Baguli village in Dhenkanal revealed that 'Children come prepared to class now, they study at home under light.' Earlier that wasn't the case and they 'used to never do their homework' [C1].

Environmental impact

Four demonstration projects have saved kerosene consumption between 90,000l and 150,000l per year. This resulted in a carbon saving between 225t and 375t of CO_2 per year [C3]. In addition, the availability of clean electricity has reduced local pollution in terms of smoke, fumes and particulate matter.

Economic impacts

The availability of electricity is supporting income generation prospects in the villages. Some 60% of the shops electrified through pico-grids in the Mlinda intervention area reported an increase in income and 67% of those reporting an increase in profit attributed this to electricity access [C2]. The social enterprises Mlinda Foundation and Mera Gao Power received support from the project, which has allowed them to grow their business activities and reach their targets [C4]. Similarly, the complex project has given experience to the EPC (Engineering, Procurement and Construction) contractor, Onergy Solar, to become a mature player in the sector [C5], although the economic benefit is difficult to estimate in monetary terms.

(2) MACRO-LEVEL IMPACTS

The research led to a follow-up advisory project with DFID India led by Prof. Bhattacharyya, which resulted in the development of the DFID investment programme, DREAM (2016–2020) [C6]. In addition, the Government of India has prepared a Guideline for Development of Decentralised Solar Power Plants [C7] based on the project report and the subsequent publication by Bhattacharyya et al. [R6].

(3) INTERNATIONAL IMPACTS

The research and debates on mini-grids have been shaped and influenced by the work reported here. Chapters of two books from the OASYS South Asia project have been downloaded many times: 25,000 downloads for 'Mini-Grids for Rural Electrification of Developing Countries' and 17,000 downloads for 'Rural Electrification Through Decentralised Off-grid Systems in Developing Countries'. The paper by Sen and Bhattacharyya [R6] has been cited more than 305 times according to the Scopus database. Professor Bhattacharyya has been appointed as the adviser for the Springer Sustainable Development Goals Series (for subseries SDG 7: Affordable and Clean Energy).

The OASYS South Asia project has also received two awards: the Green Gown Award 2015 for Community Innovation at the national level and at the international level. The judges highlight that: 'This is an innovative project that aims to empower and improve the lives of off-grid rural communities with real scope for expansion' [C8]. The project was one of the three shortlisted projects for the Energy Institute Award for 2020 in the Energy Access category.

The work has featured in the media: *BBC Futures* has carried a story based on off-grid systems where Bhattacharyya has been cited [C9] while the *New Scientist* has also carried a story and interview [C10].

5. Sources to corroborate the impact

[C1] Palit, D., Rakesh, S. and Pradhan, J.D. (2015) *Impact Assessment of Implementation of Solar PV Mini-Grids in Five Off-Grid Villages of Dhenkanal District. Odisha*, OASYS South Asia Research Project, Working Paper 21, http://www.academia.edu/22682281/WP21_Impact_assessment_report_OASYS_Dhenkanal

[C2] Murali, R., Malhotra, S., Palit, D. and Sasmal, K. (2015) 'Socio-technical assessment of solar photovoltaic systems implemented for rural electrification in selected villages of Sundarbans region of West Bengal', *AIMS Energy*, 3(4): 612–634; https://www.aimspress.com/article/10.3934/energy.2015.4.612

[C3] Bhattacharyya, S.C. and Palit, D. (2016) 'Mini-grid based off-grid electrification to enhance electricity access in developing countries: What policies may be required?' *Energy Policy*, 94: 166–178. DOI: http://dx.doi.org/10.1016/j.enpol.2016.04.010

[C4] Testimonial from Mlinda Foundation.

[C5] Testimonial from Onergy Solar.

[C6] Business Case and Summary 204884 (DREAM project, 2017), https://devtracker.dfid.gov.uk/projects/GB-1-204884/documents

[C7] Guidelines for Development of Decentralised Solar Power Plants, Ministry of New and Renewable Energy, Government of India, https://mnre.gov.in/img/documents/uploads/file_f-1580894745068.pdf

[C8] Extract from 2015 Green Gown Award Winners Award brochure, https://www.eauc.org.uk/2015_green_gown_award_winners1

[C9] Gardiner, K. (2017) 'BBC Future Story: The small Scottish isle leading the world in electricity', *BBC.com*, 30 March; http://www.bbc.com/future/story/20170329-the-extraordinary-electricity-of-the-scottish-island-of-eigg

[C10] Grossman, L. (2014) 'Race to electrify rural Africa could help the West too', *New Scientist*, 20 August (article features an interview with Prof. Bhattacharyya), https://www.newscientist.com/article/mg22329832-900-race-to-electrify-rural-africa-could-help-the-west-too/