Supplementary Materials

Benjamin K. Sovacool[1]

[1] *Institute for Energy and the Environment, Vermont Law School*

Acknowledgments: The author is appreciative to the Centre on Asia and Globalization and the Lee Kuan Yew School of Public Policy for some of the financial assistance needed to conduct the research interviews, field research, and travel for this project. The author is also extremely grateful to the National University of Singapore for Faculty Start-up Grant 09-273 as well as the MacArthur Foundation for Asia Security Initiative Grant 08-92777-000-GSS**,** which have supported elements of the work reported here. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author and do not necessarily reflect the views of the Centre on Asia and Globalisation, Lee Kuan Yew School of Public Policy, National University of Singapore, or MacArthur Foundation. Finally, the author is immensely grateful to Anthony L. D'Agostino from Columbia University in the United States, Malavika Jain Bambawale from Bosch in Singapore, Olivia Gippner from the Freie Universität Berlin in Germany, Saroj Dhakal and Ira Martina Drupady from the National University of Singapore in Singapore, Martin Stavenhagen from Physikalisch-Technische Bundesanstalt in Germany, and Debajit Palit from The Energy and Resources Institute in India for helping collect some of the primary data for this study.

S1: Case Selection Process

The author started by exploring the academic literature on energy access projects in Asia as well as reports and case studies on energy poverty published by a variety of energy institutions. This initial review produced a possible 1,156 projects and programs related to renewable energy systems published in the last two decades.

Since this was a voluminous amount of data, the author relied on a seven-phase selection process to reduce the number of case studies to a manageable number. First, to be included in the study, a program had to involve the direct provision or supply of energy services through renewable energy to rural or poor communities and areas. This meant, in practice, that programs distributing other end-use devices, such as light bulbs or mobile phones, were ineligible. This reduced the case study pool to 944.

Second, a case study had to be a fully implemented program in operation for at least four years. The intent here was to exclude pilot and demonstration projects, and also projects so short lived it would be difficult to draw general lessons from them. This reduced the pool to 332.

Third, the author excluded case studies that did not promote solar home systems, wind turbines, biogas, microhydro units, and cookstoves. This criterion meant that only small-scale technology, below 10 MW of installed capacity, was included. Excluded were renewable energy projects at the centralized, electric-utility scale. This lowered our pool to 290.

Fourth, the author wanted programs of a moderate size. So the author excluded case studies that had budgets of less than $50,000, which distributed energy services or technologies to less than 750 homes or customers, and/or those that installed less than 100 kW of total capacity. This dropped the number to 117.

Fifth, a case study had to be recent, either currently in operation or completed in the past ten years. This meant the author excluded all projects ending before the calendar year 2000, lowering the pool to 55.

Sixth, sufficient data had to exist on the case study in question. This was admittedly subjective, but generally it meant the exclusion of cases with less than five published sources of credible information. This did create a bias in favor of cases from the World Bank, the Global Environment Facility, and the United Nations, as they are extensively documented. This reduced the pool to 24.

Seventh and lastly, the case in question had to either be a clear-cut example of success or failure. By success, it accomplished its goals, at or below cost, and before or on schedule. By failure, it did not accomplish its goals, was above cost, and/or completely behind schedule. The literature on case study selection calls these "extreme" cases, for they study those at the outermost end of success or failure. This left the 10 case studies summarized in S2.

S2: Ten Selected Case Studies of Renewable Energy Access in Asia

Table 1: Overview of Ten Renewable Energy Access Case Studies

Type	Country	Case Study	Primary Partners	Primary Beneficiaries	Technology	Dates	Cost ($)	Accomplishments
Success	Bangladesh	Grameen Shakti	Grameen Shakti, Grameen Technology Centers, World Bank, Infrastructure Development Corporation Limited, and Government of Bangladesh	Rural communities and women	Solar home systems, biogas, and improved cookstoves	1996 to present	$100 million (annual)	Installation of 500,000 solar home systems, 132,000 cookstoves, and 13,300 biogas plants among 3.1 million beneficiaries.
Success	China	Renewable Energy Development Program	World Bank, GEF, National Development and	Manufacturers and nomadic herders	Solar home systems	2002 to 2007	$316 million	Distributed more than 400,000 units in 5 years

			Reform Commission, and local solar manufacturers					
Success	Laos	Rural Electrification Project	Electricité du Laos, Ministry of Energy and Mines, World Bank, GEF, and PESCOs	Rural communities and PESCOs	Small hydro and solar home systems	2006 to 2009	$13.75 million	Electrified 65,000 previously off-grid homes and disbursed more than 17,000 solar home systems
Success	Mongolia	Rural Energy Access Project	World Bank, National Renewable Energy Center, Ministry of Fuel and Energy, Ministry of Finance, and Ministry of Environment and Resources	Nomadic herders, *soum* centers, and local solar companies	Solar home systems and wind turbines	2007 to 2011	$23 million	Distributed 41,800 solar home systems, hundreds of wind turbines, facilitated the rehabilitation of 15 mini grids in soum centers, installed 11 renewable-diesel hybrid systems
Success	Nepal	Rural Energy Development Program	World Bank, Government of Nepal, UNDP, Nepal Alternative Energy Promotion Center, District Development Communities, Village Development Communities, and Microhydro Functional Groups	Rural communities	Microhydro	2004 to 2011	$5.5 million (original proposal)	Distributed 250 units benefitting 50,000 households in less than 10 years
Succe	Sri	Energy	World	Rural	Solar	1997	$55.3	Installed

ss	Lanka	Services Delivery Project	Bank, GEF, Ceylon Electricity Board, and national banks	communities, national banks, and local companies	home systems and microhydro	to 2002	million	21,000 solar home systems and 350 kilowatts of installed village hydro capacity in rural Sri Lanka, in addition to 31 megawatts of grid-connected mini-hydro capacity
Failure	India	Village Energy Security Project	Ministry of New and Renewable Energy, World Bank, and Village Energy Committees	Rural communities	Biomass gasifiers, biogas systems, and improved cook stoves	2004 to 2011	$8.6 million	Aimed to install 61 biogas projects, only 21 of 50 projects still functioning by 2009
Failure	Indonesia	Solar Home System project	World Bank, GEF, Ministry of Energy and Mineral Resources, Perusahaan Listrik Negara, and local banks	Rural communities	Solar home systems	1997 to 2003	$118.1 million	Aimed to install 200,000 SHS across one million users; only 8,054 SHS units ever installed reaching 35,000 villagers
Failure	Malaysia	Small Renewable Energy Power Program	Ministry of Energy, Green Technology, and Water, Tenaga Nasional Berhad, and Sabah Electricity Sendirian Berhad	Rural communities, manufacturers, and IPPs	Solar home systems, microhydro, biogas, and waste incineration	2001 to 2010	$220 million (unconfirmed)	Tried to install 500 MW of small-scale renewable energy technology by 2005, but ended up achieving only 12 MW. Target altered to 350 MW by 2010, but only 61.7 MW were built by project close.
Failure	Papua New Guinea	Teachers Solar Lighting Project	World Bank, GEF, Departmen	Rural school teachers	Solar home systems	2003 to 2010	$2.9 million	Attempted to install 2,500 solar home systems and

	t of Education, Papua New Guinea Sustainable Energy Limited, and Teacher's Savings & Loan	jumpstart a local market, ended up installing only 1 single unit.

S3: Data Collection Process

The author and his research team relied on what academics call an inductive, narrative case study approach based on data collected from research interviews and field research. In aggregate, the team conducted 441 of these research interviews and meetings with 200 institutions over the course of four years, research trips summarized in Table S1. In each case we had simultaneous real-time translation into local languages and dialects. We relied on a purposive sampling strategy, meaning experts with extensive knowledge of each case were chosen to participate, and also a critical stakeholder analysis framework that required us to include respondents from government, civil society, business, academia, and local communities, as well as people in favor, and opposed to, each project. We made sure to include participants from:

- *Government agencies* such as the Nepal Ministry of Energy, Indonesian Ministry of Finance, Indian Ministry of New and Renewable Energy, Chinese Ministry of Science and Technology, or Sri Lanka Sustainable Energy Authority;
- *Intergovernmental organizations* such as the South Asian Association for Regional Cooperation, the Global Environment Facility, and the United Nations Development Programme;
- *International civil society organizations* or *think tanks,* including Conservation International, Friends of the Earth, Transparency International, and the Stockholm Environmental Institute;
- *Local civil society organizations* or *think tanks,* including Grameen Shakti, Yayasan Pelangi Indonesia, and Pragati Pratishthan;
- *Electricity suppliers* including the Nepal Electricity Authority, Tenaga Nasional Berhad in Malaysia, Ceylon Electricity Board in Sri Lanka, and Papua New Guinea Power Limited;
- *Manufacturers, industry groups,* and *commercial retailers* such as Alstrom Hydro, Barefoot Power Systems, Sime Darby, Siemens, and Sunlabob;
- *Financiers* and *bilateral development donors* including Deutsche Gesellschaft für Technische Zusammenarbeit, United States Agency for International Development, the Asian Development Bank, and the World Bank Group; and
- *Universities* and *research institutes* including the International Center for Integrated Mountain Development, University of Dhaka, University of Papua New Guinea, and the Chinese Academy of Sciences.

For each case study, we asked participants to (a) Identify the benefits of the program at hand, (b) summarize some of the key barriers to implementation it had to confront, and (c) discuss general lessons that the case study offers energy policy and development practitioners. Due to Institutional Review Board guidelines, as well as the request of some participants, we present such data as anonymous, though information from the interviews was often recorded and always carefully coded.

Table S1: Overview of Research Interviews

Country	Case Study	Number of Interviews	Number of Institutions	Dates Visited
Bangladesh	Grameen Shakti	48	19	June 2009 to October 2010
China	Renewable Energy Development Program	30	17	May 2010 to June 2010
Laos	Rural Electrification Project	16	11	March 2010
Mongolia	Rural Energy Access Project	22	10	June 2010
Nepal	Rural Energy Development Program	57	24	August 2010 to November 2010
Sri Lanka	Energy Services Delivery Project	56	28	February 2011
India	Village Energy Security Project	51	17	September 2008 to June 2009
Indonesia	Solar Home System project	36	22	June 2011
Malaysia	Small Renewable Energy Power Program	89	38	March 2010 to February 2011
Papua New Guinea	Teachers Solar Lighting Project	36	14	February 2010 to April 2010
Total		**441**	**200**	**September 2008 to June 2011**

To ensure a degree of triangulation and reliability, and to better understand our case studies, we augmented our research interviews with direct observation and site visits to 90 renewable energy facilities in our ten countries over the course of March 2009 to June 2011 (see Table S2). These included a variety of different sources, systems, sizes, and capacities, including some grid-connected facilities to gain a comparative perspective, as well as laboratories, testing centers, factories, and assembly lines. The site visits enabled us to discuss our cases with actual renewable energy operators, managers, and manufacturers. They also served as a useful vehicle to arrange additional research interviews.

Table S2: Summary of Renewable Energy Site Visits

Name	Type of Facility	Capacity	Owner/Operator	Location	Date Visited
Various (fifty separate community systems)	Biogas, SHS	-	Various communities	The states of Assam, Chhattisgarh, Gujarat, Madhya Pradesh, Maharashtra, Orissa, and West Bengal	March, 2009 to November, 2009
Nam Theun 2	Hydroelectric	1,070 MW	Nam Theun 2 Power Corporation	Khammouane, Laos	March, 2010
Westlink Solar Enterprises	SHS distribution	-	Westlink Solar	Port Moresby, Papua New Guinea	March, 2010
Sikikoge Primary School	SHS	160 Wp	Sikikoge Primary School	Goroka, Papua New Guinea	March, 2010
Madang Elementary School	SHS	220 Wp	Madang Elementary School	Madang, Papua New Guinea	March, 2010
Monmat Solar Energy	SHS distribution	-	Monmat Solar Energy Ltd	Ulaanbaatar, Mongolia	June, 2010
HK Mart Solar	SHS distribution	-	HK Mart	Ulaanbaatar, Mongolia	June, 2010
Green Eco-Energy Park Project	SHS, mini-hydroelectric, and wind	110 kW	Daesung Group	Nalayh, Mongolia	June, 2010
Photovoltaic and Wind Power Systems Quality Test Center	SHS and wind turbines	-	Chinese Academy of Sciences	Beijing, China	June 2010
Beijing Jike New Energy Technology Development Company	SHS manufacturing and assembly	-	Beijing Jike	Beijing, China	June 2010
Gesang Solar Energy Company	SHS manufacturing and assembly	-	Gesang Solar	Xining, China	June 2010
Qinghai Tianpu Solar Energy Company	SHS manufacturing and assembly	-	Tianpu Solar	Xining, China	June 2010
Xining Moonlight Solar Science and Technology Co.	SHS manufacturing and assembly	-	Xining Moonlight Solar	Xining, China	June 2010
Xining New Energy Development Co. (NIDA)	SHS manufacturing and assembly	-	NIDA	Xining, China	June 2010

Nanhui Wind Farm	Wind	21 MW	Shanghai Electric	Shanghai, China	June 2010
Batang Ai Hydroelectric Station	Hydroelectric	108 MW	Sarawak Energy Bhd.	Batang Ai, Sarawak, Malaysia	July 2010
Bakun Hydroelectric Project	Hydroelectric	2,400 MW	Ministry of Finance/Sarawak Hydro Bhd.	Bakun, Sarawak, Malaysia	July 2010
Murum Hydroelectric Project	Hydroelectric	944 MW	Sarawak Energy Bhd.	Murum, Sarawak, Malaysia	July 2010
Kg. Mudung Abun Microhydro Plant	Microhydro	25 kW	Mudung Abun Community	Denang, Sarawak, Malaysia	July 2010
Long Lawen Microhydro Plant	Microhydro	10 kW	Long Lawen Community	Long Lawen, Sarawak, Malaysia	July 2010
Lubok Antu Palm Oil Mill	Palm Oil	1 MW	Salcra Sdn. Bhd.	Sri Aman, Sarawak, Malaysia	July 2010
Grameen Technology Center - Singair	Improved cookstoves (manufacturing)	-	Grameen Shakti	Singair, Bangladesh	October, 2010
Grameen Technology Center - Mawna	Biogas (manufacturing and installation)	-	Grameen Shakti	Mawna, Bangladesh	October 2010
Malekhola Microhydro Village Electrification Project	Microhydro	26 kW	Malekhola Village Development Committee	Malekhola, Nepal	November 2010
Daunne Khola Microhydro Village Electrification Project	Microhydro	12 kW	Daunne Khola Village Development Committee	Daunne Khola, Nepal	November 2010
Bom Khola Microhydro Village Electrification Project	Microhydro	100 kW	Bom Khola Village Development Committee	Bom Khola, Nepal	November 2010
Sungai Kerling Minihydro Plant	Minihydro	2 MW	Renewable Power Sdn Bhd.	Kerling, Selangor, Malaysia	January 2011
Langkawi Cable Car Solar-Diesel Hybrid	Solar photovoltaics/Diesel	109.5 kW	Langkawi Development Authority and Tenaga Nasional Bhd.	Pulau Langkawi, Kedah, Malaysia	January 2011
Hybrid Integrated Renewable Energy System	Solar/Wind/Diesel	400 kW	State Government of Terengganu and Tenaga Nasional Bhd.	Pulau Perhentian, Terengganu, Malaysia	January 2011
TDM Palm Oil	Palm oil	1.0 MW	TDM Plantation	Dungun,	January

Estate			Sdn. Bhd.	Terengganu, Malaysia	2011
Kajang Waste-to-Energy Plant	Waste incineration	8.9 MW	Core Competences Sdn. Bhd., Recycle Energy Sdn. Bhd.	Semenyih, Selangor, Malaysia	January 2011
Bukit Tagar Sanitary Landfill	Landfill gas capture	1 MW	Kub-Berjaya Enviro Sdn. Bhd.	Bukit Tagar, Selangor, Malaysia	January 2011
Bell Palm Oil Mill	Palm Oil Mill Effluent, methane capture and Empty Fruit Bunch incineration	1.7 MW Gas Capture, 10 MW Combustion (under construction)	Bell Eco Power Sdn. Bhd. and Bell Palm Industries Sdn. Bhd.	Batu Pahat, Johor, Malaysia	February 2011
Meddawatte Village Hydro System	Microhydro	12 kW	Meddawatte Village Electricity Board	Sabaragmuwa Province, Sri Lanka	February 2011
Watawala Hydroelectric Power Plant	Hydroelectric	2.7 MW	Mark Marine Services (Pvt) Limited	Central Province, Sri Lanka	February 2011
Carolina Estate Minihydro Project	Hydroelectric	2.5 MW	Caroline Tea Estate	Central Province, Sri Lanka	February 2011
LOLC Solar Power Plant	Solar (recycled SHS)	48 kW	**Lanka** Orix Leasing Company Ltd	Colombo, Sri Lanka	February 2011
Hambantota Wind Farm	Wind	3 MW	Ceylon Electricity Board	Hambantota, Sri Lanka	February 2011
Trimba Solar Demonstration Facility	SHS (solar modules, street lamps, batteries)	-	PT. Trimbasolar	Jakarta, Indonesia	June 2011

To receive input from energy-users, the research team conducted targeted focus groups and spoke with almost 800 community members, village leaders, and households in aggregate including local political representatives, interactions summarized in Table S3.

Table S3: Summary of Community Discussions and Focus Groups

Case Study	Name/Location	Technology	# of Discussions (Approximate)	Date Visited
India	Assam	Biogas and SHS	14	March, 2009
India	Chhattisgarh	Biogas	6	April, 2009
India	Gujarat	Biogas	2	May, 2009
India	Madhya Pradesh	Biogas and SHS	10	June, 2009
India	Maharashtra	Biogas	5	July, 2009
India	Orissa	Biogas	9	September, 2009
India	West Bengal	Biogas and SHS	4	November, 2009
Laos	Mai Village, Keo Oudom District	SHS	100	March, 2010

Laos	Nongsa, Nazay Thong District	Microhydro	30	March, 2010
Papua New Guinea	Akameku	SHS	10	March, 2010
Papua New Guinea	Asaroka	SHS and wind	15	March, 2010
Papua New Guinea	Lufa	SHS	25	March, 2010
Papua New Guinea	Kundiawa	SHS	25	March, 2010
Papua New Guinea	Okifa	SHS	20	March, 2010
Papua New Guinea	Simbu	SHS	15	March, 2010
Papua New Guinea	Talidig	SHS	20	March, 2010
China	Qinghai Province	SHS	40	June 2010
Mongolia	Terelj	SHS	10	June 2010
Mongolia	Nalaikh	SHS	15	June, 2010
Mongolia	Tsonjinboldog	SHS and wind	5	June, 2010
Malaysia	Selangor	SHS	5	July 2010
Malaysia	Asap	SHS	40	July 2010
Malaysia	Bakun	SHS	15	July 2010
Malaysia	Upper Bakun	SHS, ICS	25	July 2010
Malaysia	Danang	Microhydro	5	July 2010
Malaysia	Murum	SHS	50	July 2010
Malaysia	Lubok Antu	Microhydro	5	July 2010
Bangladesh	Singair	ICS and biogas	20	October 2010
Bangladesh	Manikguni	ICS and SHS	15	October 2010
Bangladesh	Mawna	Biogas and SHS	15	October 2010
Nepal	Changdol	Microhydro	10	November 2010
Nepal	Chongba	Microhydro	15	November 2010
Nepal	Kavre	Microhydro	10	November 2010
Nepal	Lukla	Microhydro	12	November 2010
Nepal	Dhading	Microhydro	14	November 2010
Nepal	Puchetar	Microhydro	18	November 2010
Sri Lanka	Meddawatte Village	Microhydro	10	February 2011
Sri Lanka	Indigolla Village	SHS	20	February 2011
Sri Lanka	Dagama Village	SHS	15	February 2011
Sri Lanka	Ponnilawa Village	SHS	25	February 2011
Indonesia	Jangari Village, West Java	SHS	10	June 2011
Indonesia	Lake Cirata, West Java	SHS	25	June 2011
Indonesia	Serdang Village, Lampung	SHS	30	June 2011
Total	43 Communities		789 participants	

We lastly supplemented our interviews, site visits, and community consultations with a review of reports and peer-reviewed articles relating to energy policy in each country.