Renewable & Appropriate Energy Laboratory
RAEL

http://rael.berkeley.edu

Science and Policy Tools & Challenges for Mini-Grids

Daniel Kammen

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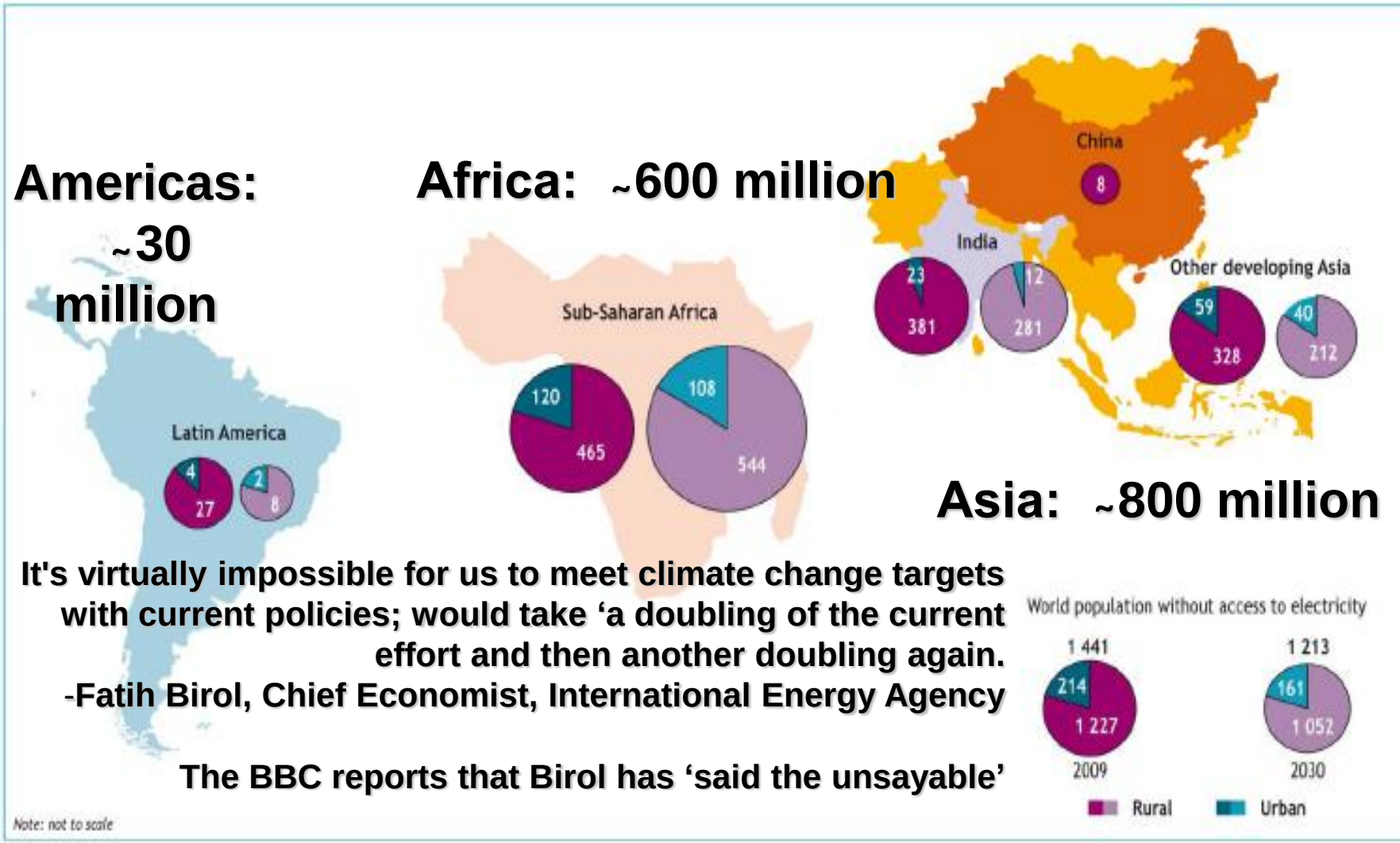
Director, Renewable and Appropriate Energy Laboratory
University of California, Berkeley

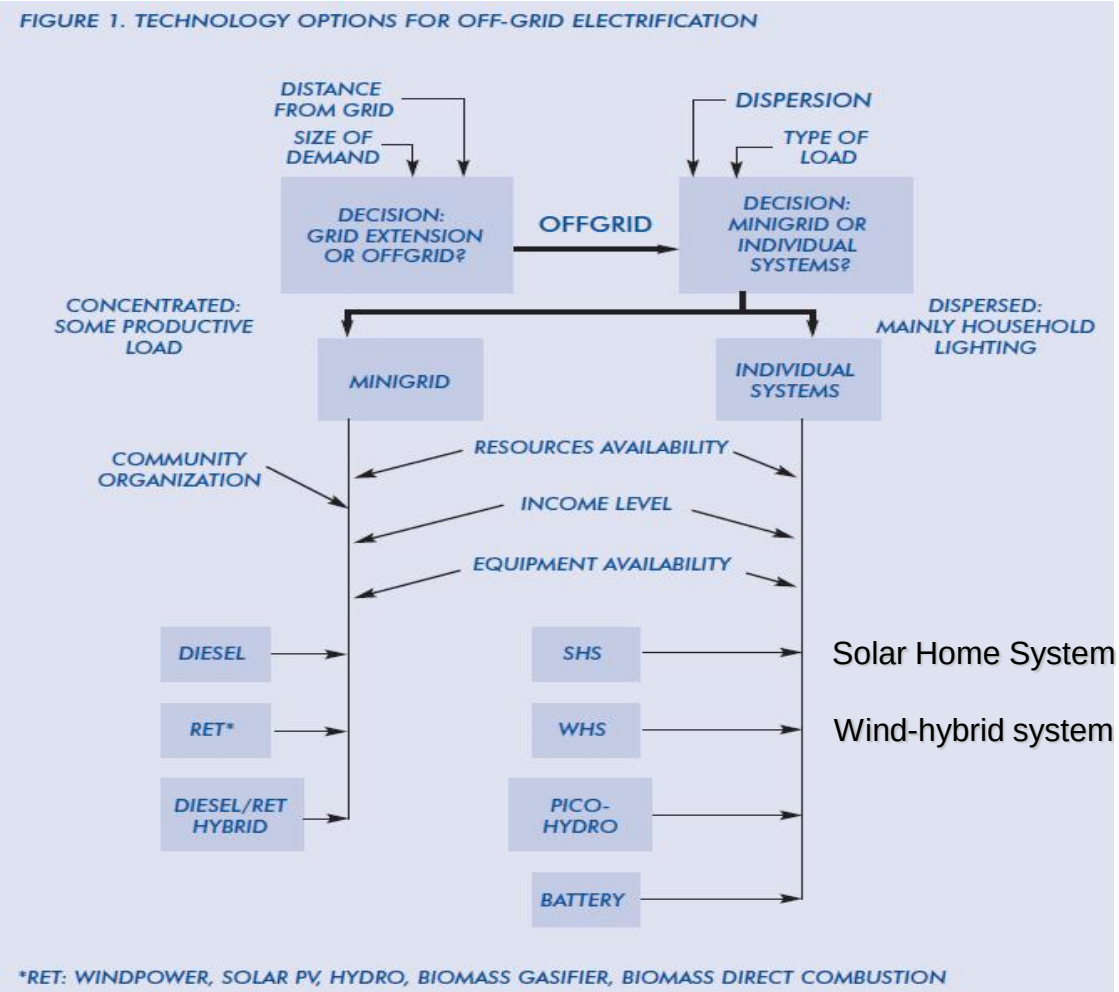
Mini-grids as New Market Opportunities
GIZ Microenergy Minigrid Workshop, February 26, 2013

The Number of Unelectrified People (and fuel based lighting users) in Asia is Even Higher than in Africa



Source: IEA, 2010 World Energy Outlook

Technology ‘Decision Tree’

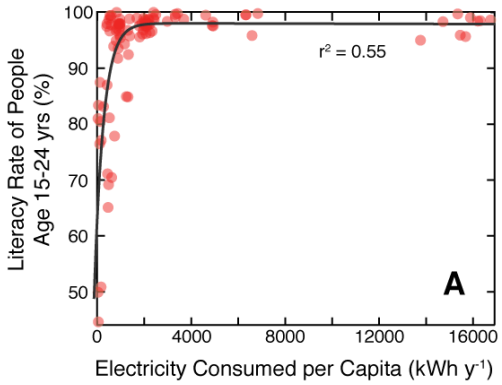


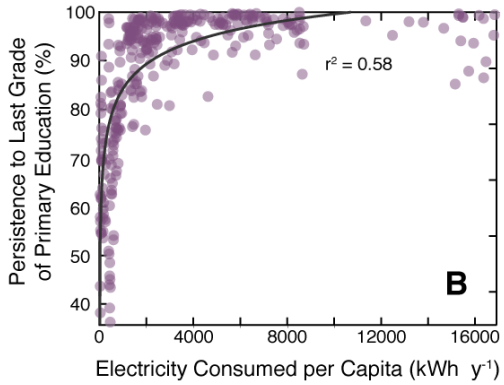
Source: World Bank

Far too simplistic: social issues at least *as important …*

Quantitative Assessments: Energy and Human Development

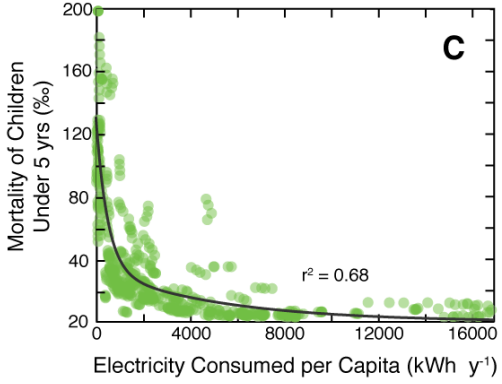
Literacy

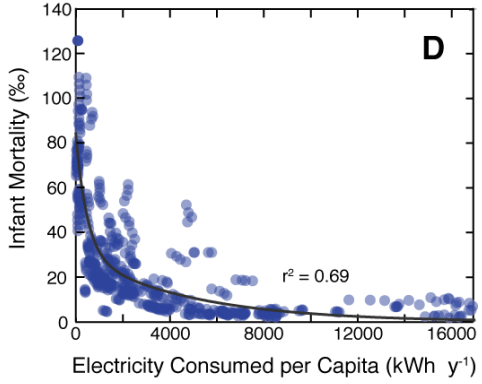




Education

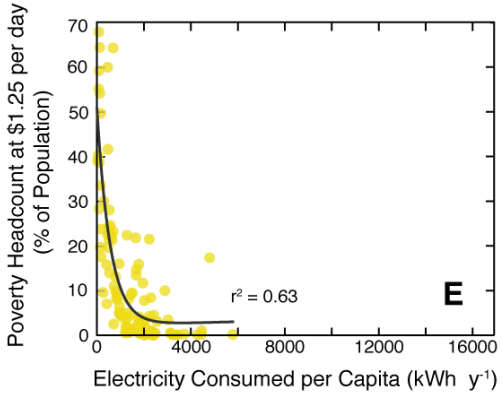
Mortality (Children)

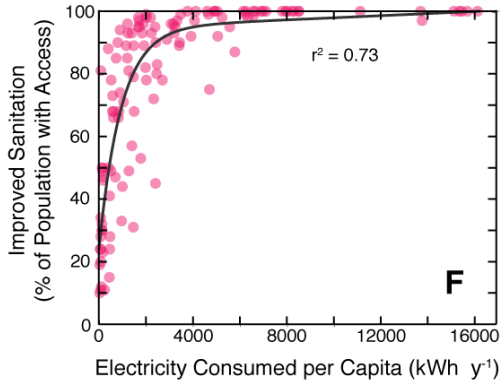




Mortality (Infants)

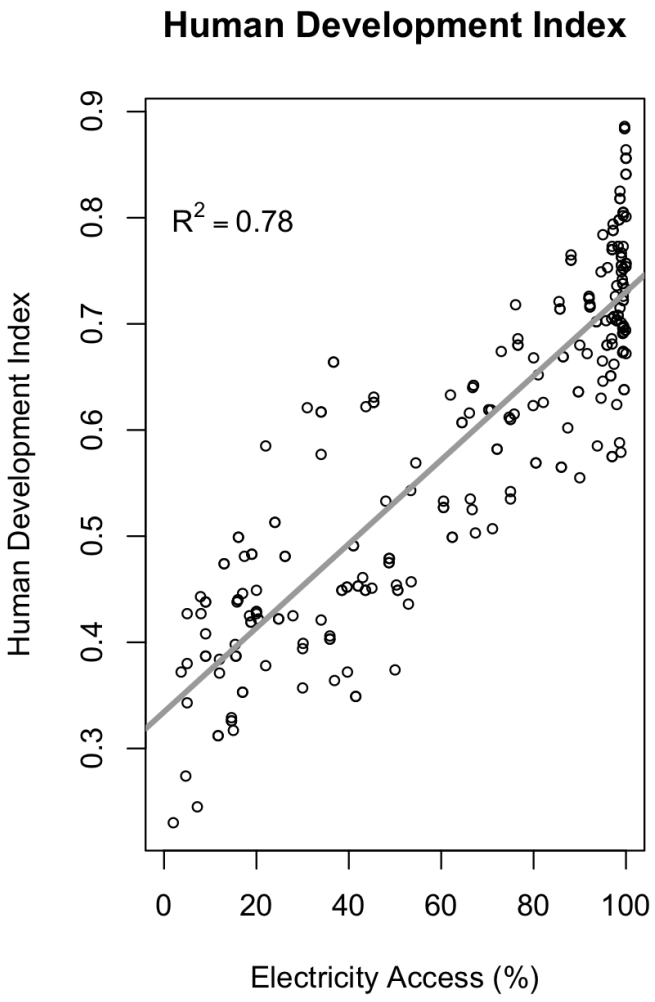
Poverty

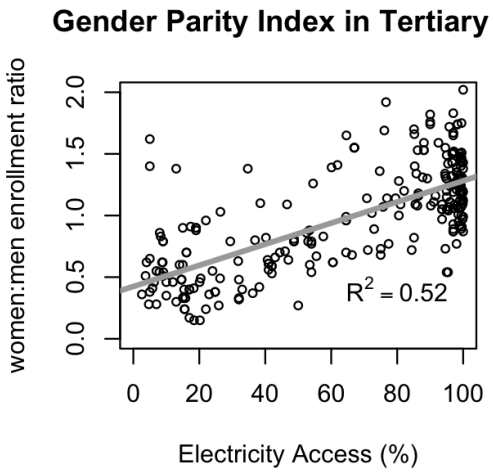


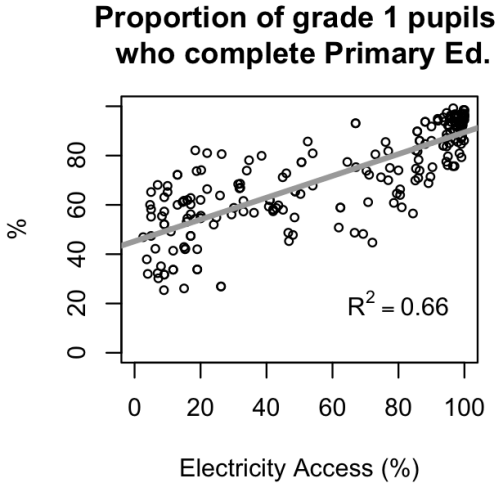


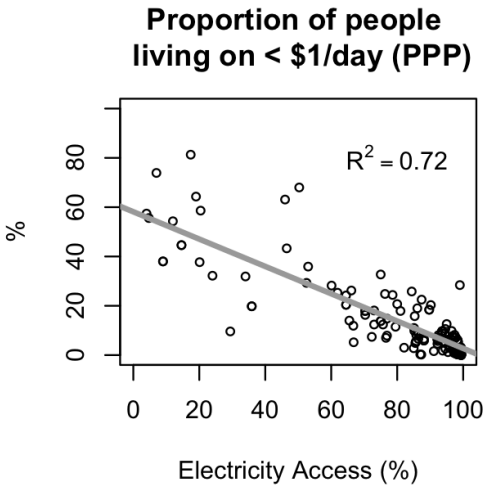
Sanitation

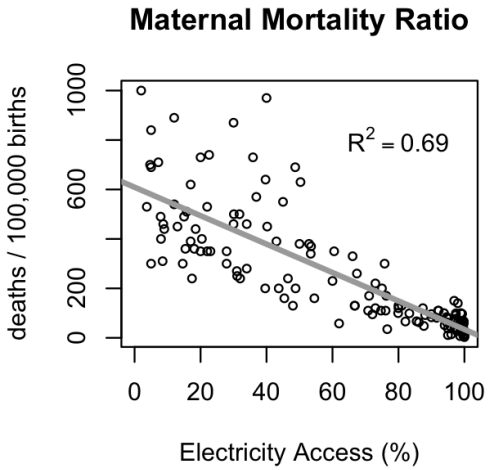
Electricity Access and the Millennium Development Goals











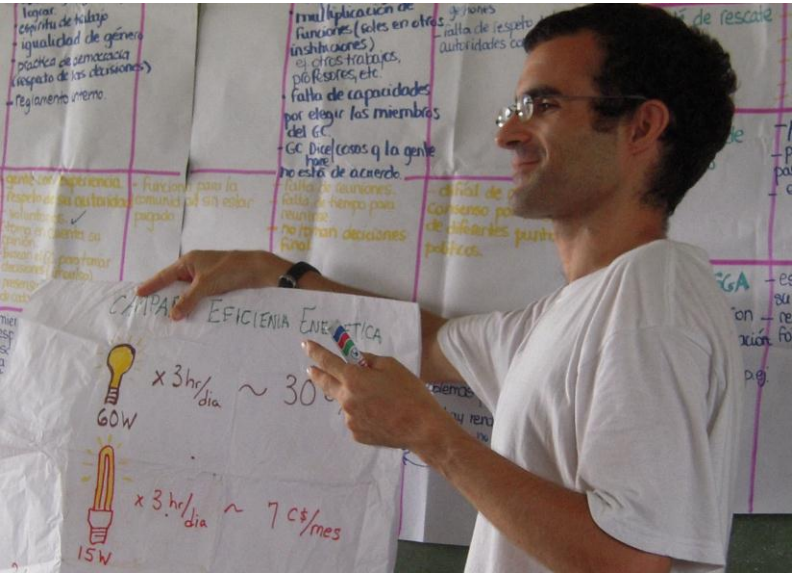
Gershenson, Alstone, Kammen, *et al,* in progress

Diverse Energy Opportunities

- RAEL is engaged in energy systems science across scales
- Off-grid, mini-grid, low-carbon large scale energy systems
- RAEL Mini-grid projects in:
  - French Polynesia, Kenya, Nicaragua, Malaysian Borneo, South Sudan, First Peoples Nations (N. America)
- Tools for low-carbon system design and assessment
- National Geographic Great Energy Challenge

http://environment.nationalgeographic.com

Community Energy Mini-grid Systems:
Atlantic coast of Nicaragua



Community energy education

Energy options: wind and biodiesel

Market woman, “must freeze fish”

Households with mini grid and satellite

Casillas and Kammen (2010) “The energy-poverty-climate nexus,” *Science*, 330, 1182-4

Technology to Make Mini-grids Social

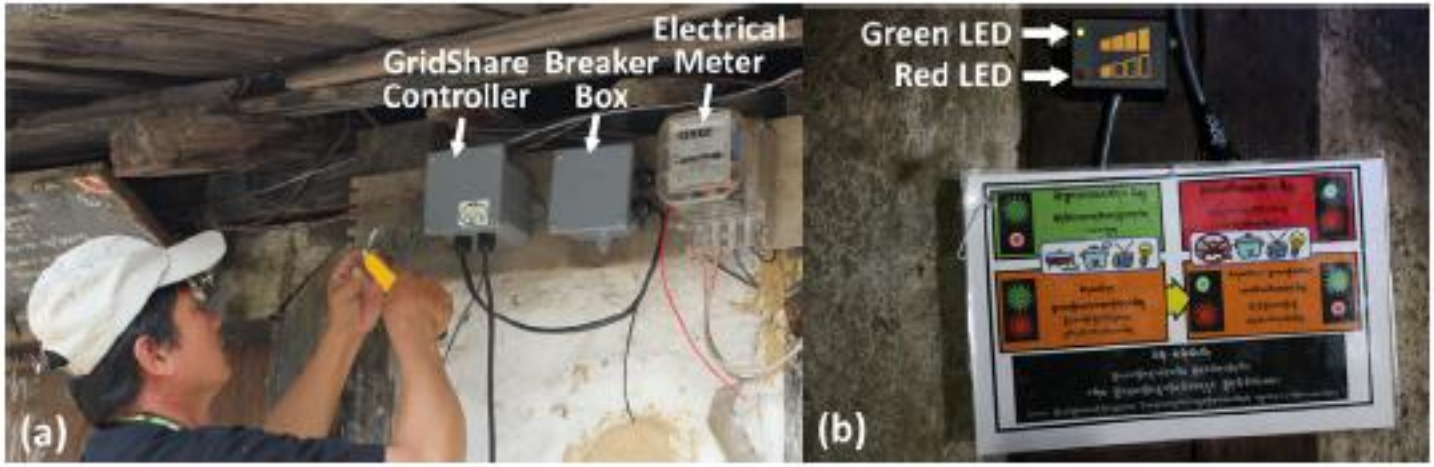


Figure 1. BPC electrician installs a GridShare and breaker box near the electrical meter (a). LED indicator lights with an instructional sign are installed near the rice cooker (b). Borrowing from familiar power-indicating graphics on cell phones, the yellow bars next to the green LED remind users that when the green light is lit, the grid is at 'full power' and any appliances may be used, while the empty bars next to the red LED suggest that the red light means the grid electricity is limited and only low power appliances can be used.

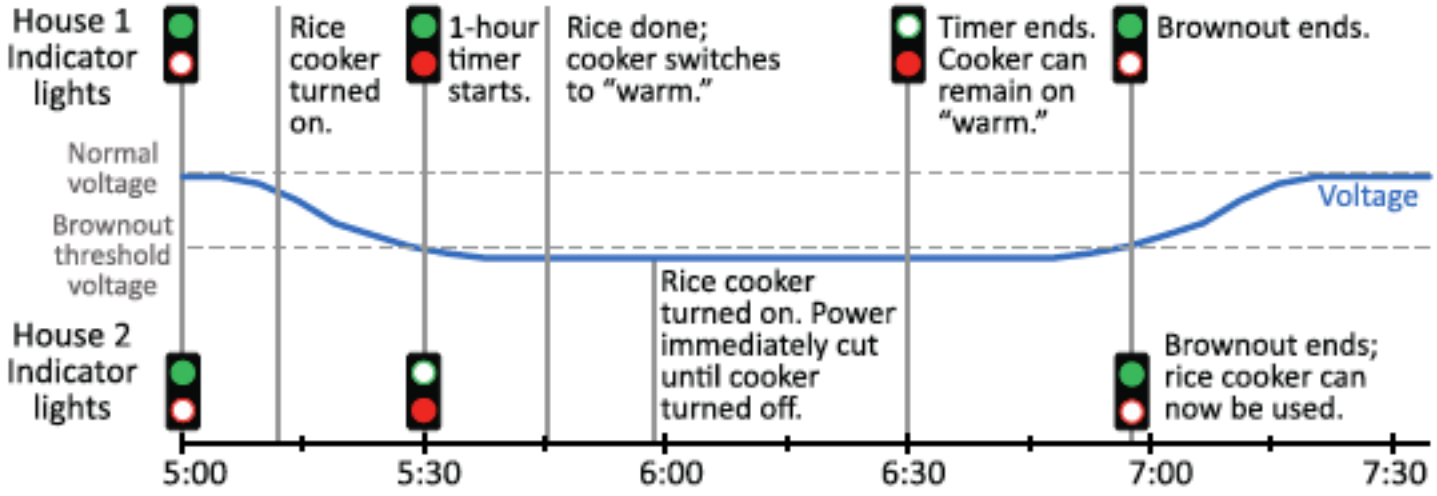


Figure 3. A hypothetical timeline of two homes in a brownout to clarify the indication and enforcement aspects of the GridShare. A rice cooker is a 'large appliance' unless on warming mode, which for a typical 600 W rice cooker requires approximately 40 W.

Sabah, Malaysia
(former British North Borneo)

Community Mini-grid, Crocker Highlands
Sabah, Malaysian Borneo

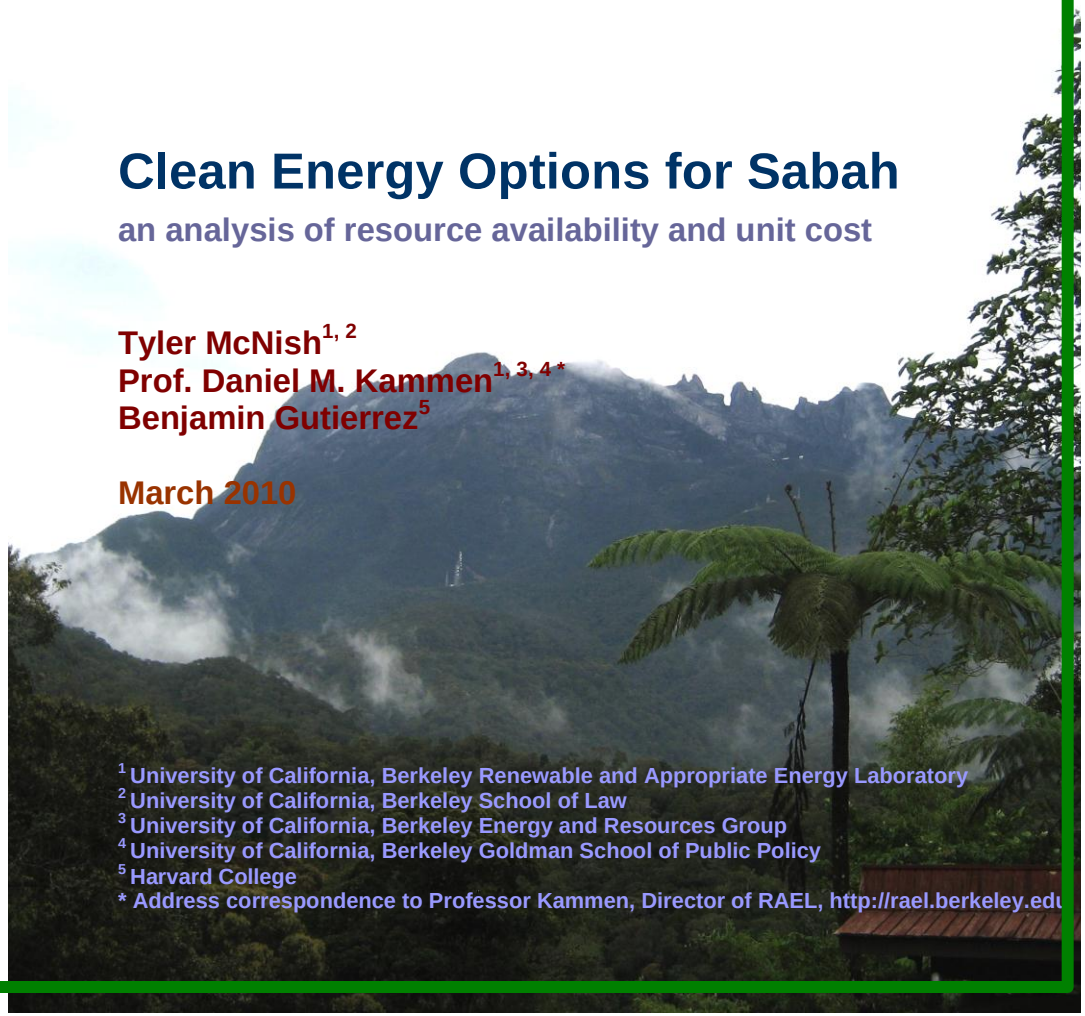
Renewable & Appropriate Energy Laboratory
Energy & Resources Group
University of California, Berkeley

Clean Energy Options for Sabah

an analysis of resource availability and unit cost

Tyler McNish[1, 2]
Prof. Daniel M. Kammen[1, 3, 4 *]
Benjamin Gutierrez[5]

March 2010



[1] University of California, Berkeley Renewable and Appropriate Energy Laboratory
[2] University of California, Berkeley School of Law
[3] University of California, Berkeley Energy and Resources Group
[4] University of California, Berkeley Goldman School of Public Policy
[5] Harvard College
* Address correspondence to Professor Kammen, Director of RAEL, http://rael.berkeley.edu

Biomass can replace coal – Professor

By Sandra Sokial

KOTA KINABALU: Palm oil mill waste, or commonly known as biomass, can feasibly be used to replace coal as a source of energy in Sabah.

Dr Daniel M Kammen, a professor of energy at the University of California, Berkeley, disclosed this in his talk during a forum on Energy Options for Sabah here yesterday.

He said biomass presented an attractive electricity supply option and should continue to receive support from the government and utilities.

Kammen, who carried out a study on clean energy options for Sabah, said that biomass waste projects were cost competitive compared with coal, adding that it also solved two environmental problems at once.

"One is the problem of disposing of potentially hazardous mill waste in open ponds and landfills and the problem of supplying Sabah's energy demand," he said.

Adrian Lasimbang

Dr Daniel M Kammen

Several oil palm mills in Sabah have already adopted the project and a number of national incentives are aimed to stimulate further investments.

Kammen said based on the 2008 palm oil industry production statistics and conservative growth estimates, they calculated that 700MW of theoretical baseload capacity was economically feasible and logistically achievable via a four-project per-year ramp-up programme. "We recommend that Sabah support this project," he said.

During the study, Kammen, Tyler McNish and Benjamin Gutierrez also carried out a research on other energy options such as hydropower, solar, wind, geothermal and demand-side energy efficiency.

He also recommended phasing out fossil-fuel subsidies that distort energy markets and the 10MW limit on investment under the small renewable energy power programme be repealed.

"There should be continued research and outreach efforts targeted at increasing the quantity of grid-connected electricity available from palm oil mills besides recognising renewable energy status as a premium product.

"It is also important to continue studying the feasibility of renewable investments at known geothermal, wind and environmentally-sound micro hydro sites," he said.

In addition to this, Kammen said the continuation and extension of Malaysia's existing solar promotion programmes should be continued, and supplement these efforts by launching a state-level solar energy commission.

Another speaker, Adrian Lasimbang of the Pacos Trust, believes that Sabah should be a role model and spearhead the development of renewable energy (RE) in Malaysia.

The public participating in the question-and-answer session with the experts during the forum yesterday.

Also touching on biomass as another option to electricity supply, he said there were over 110 oil palm mills in Sabah, and were mainly located in the east coast of the state.

"With such numbers, there is abundance of biomass waste which could be used for power supply thus reducing the electricity shortage faced by the people in the east coast of Sabah.

"We have initiated several projects in several villages to utilise agro-based waste as alternative to power supply. It helps to generate jobs for the villagers and other support services, such as transportation," he said.

About 400 people attended the forum which was organised by Green Surf.

Opportunities and trade-offs

Integrating these systems tools with civil society-industry dialog

TIME

Science

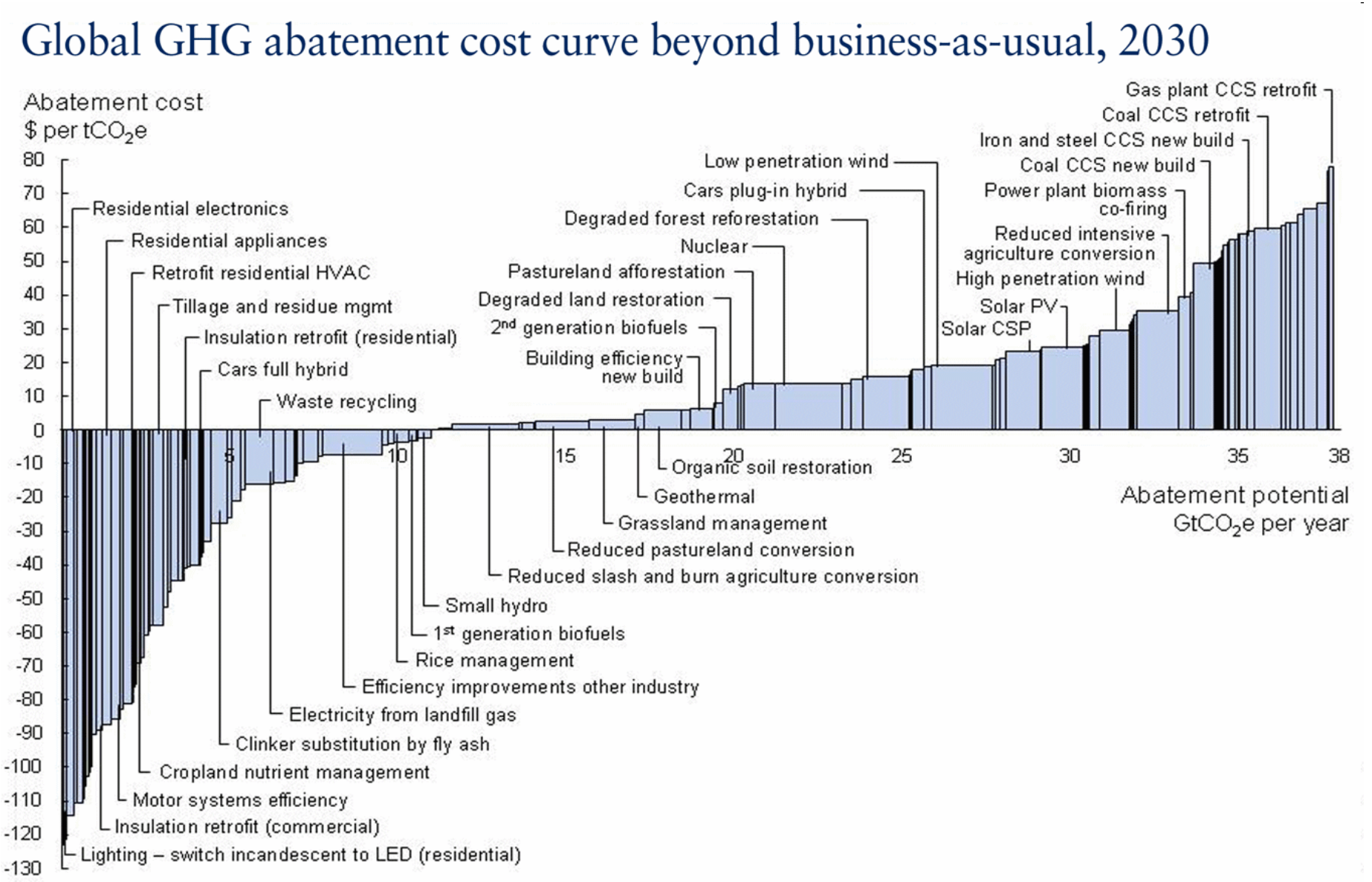
Borneo Says No to Dirty Energy

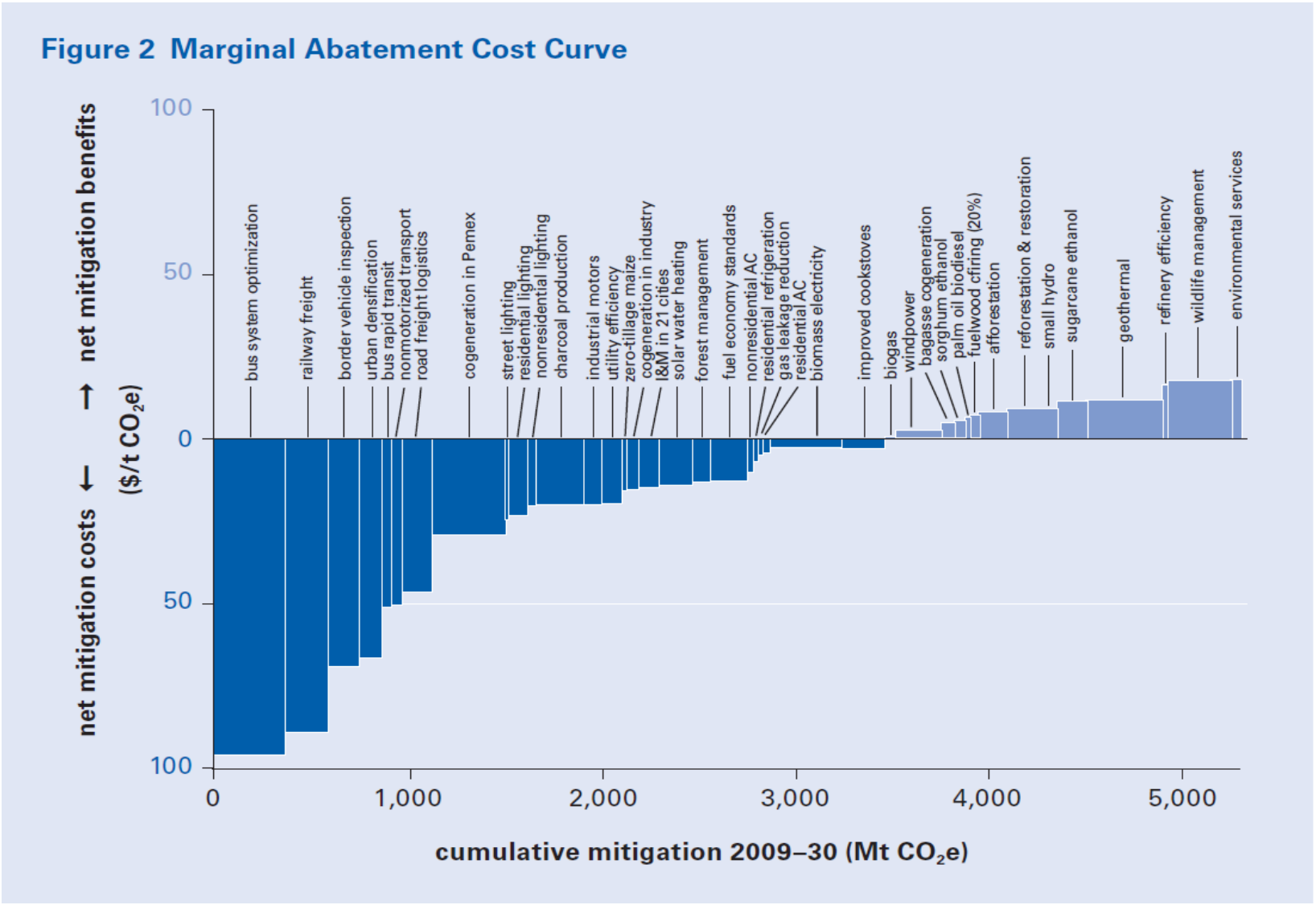
By Jennifer Pinkowski Tuesday, Feb. 22, 2011

Daniel Kammen of the University of California, Berkeley, who directed an energy and environmental-impact study commissioned by a coalition of green groups, which was used widely in the discussions of Sabah's energy options. "It is a turning point that should bring deserved praise and partnerships to Malaysia at the upcoming climate conference in Durban, South Africa,"

http://www.time.com/time/health/article/0,8599,2052627,00.html#ixzz1lvOeiiyz

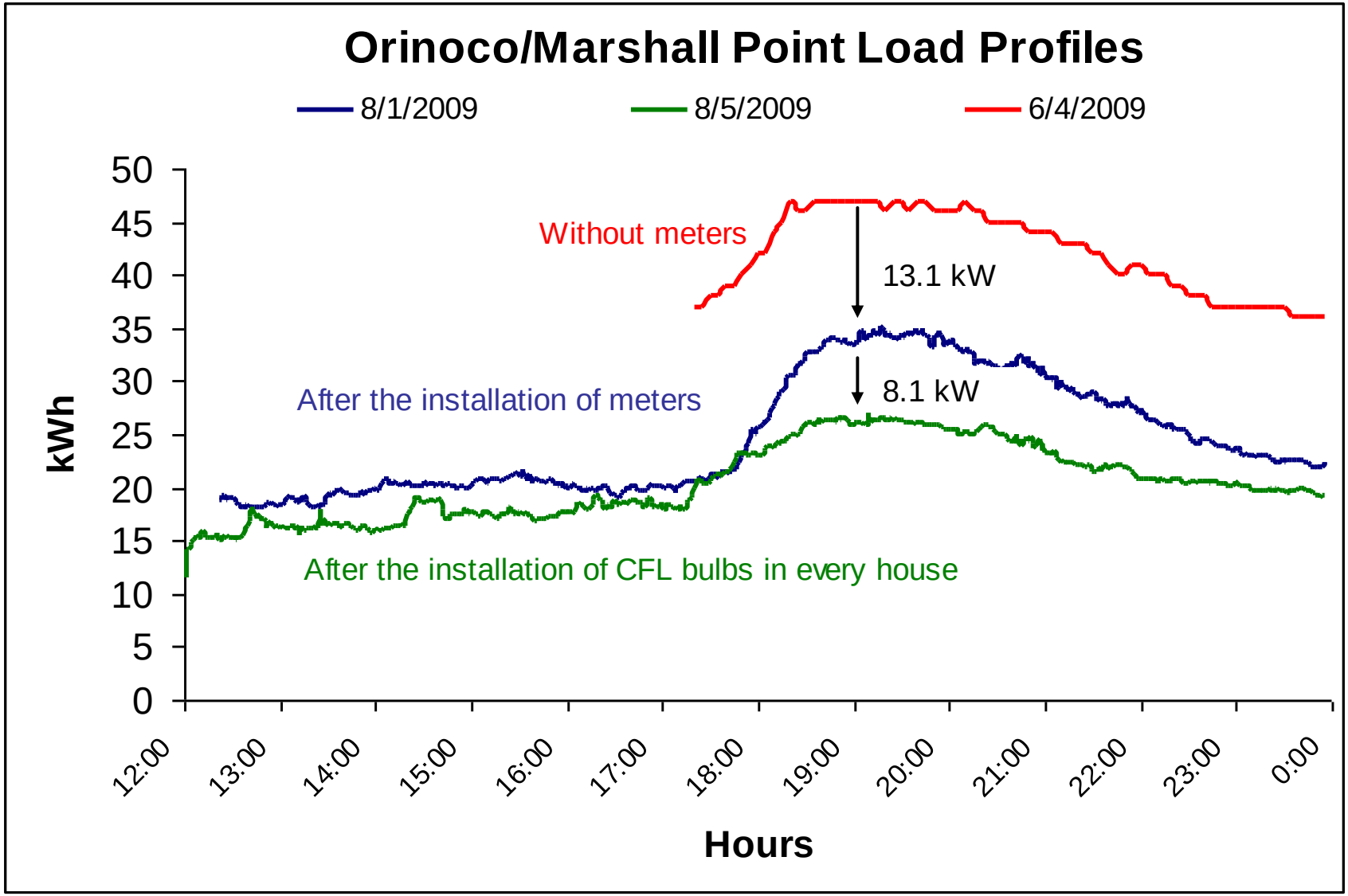
Evaluating Costs and Magnitudes:



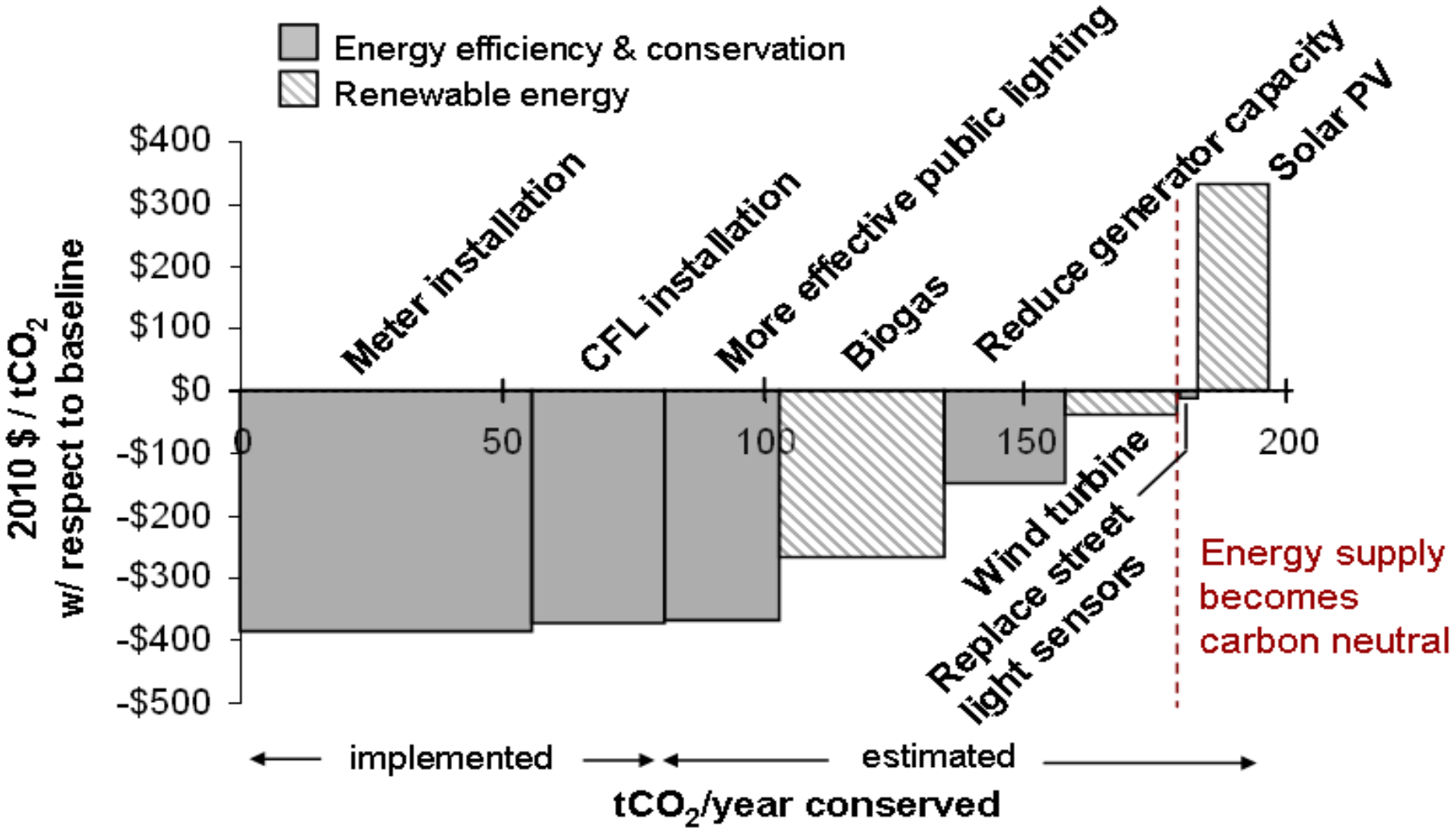


Johnson, et al., *Low-carbon study for Mexico (2010)*: The World Bank

Observed Reductions



Community Marginal Abatement Curve…



Casillas and Kammen (2010) "The energy-poverty-climate nexus," *Science*, **330**, 1182 - 1184

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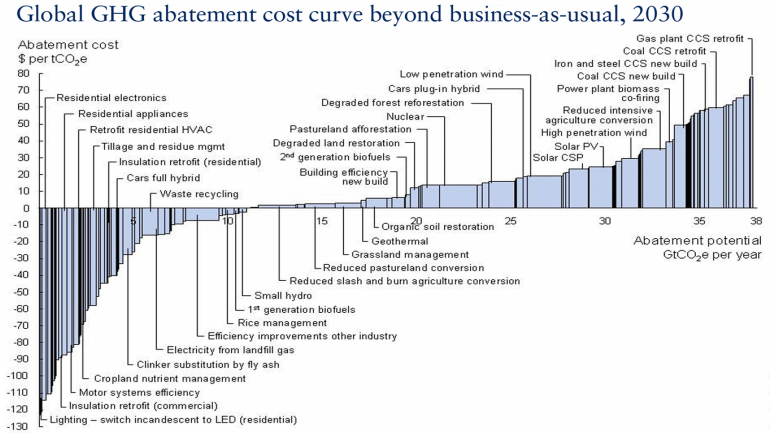
SCALES OF ANALYSIS:

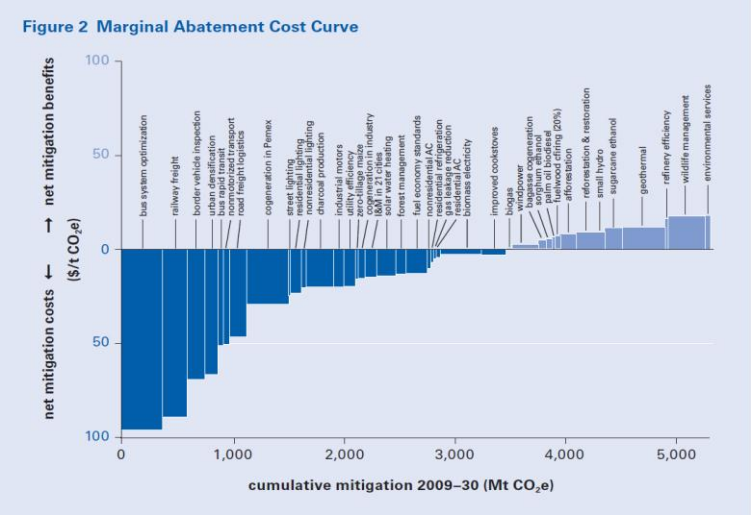
PLANNING AND DECISION MAKING FROM LOCAL TO GLOBAL

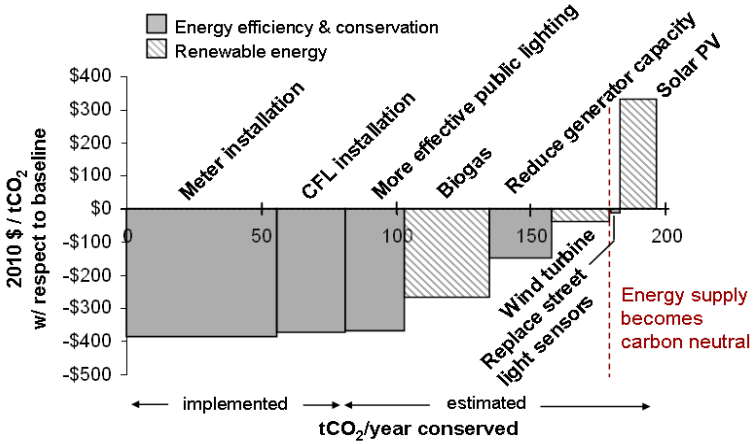
GLOBAL

NATIONAL: Mexico

LOCAL Atlantic Coast, Nicaragua



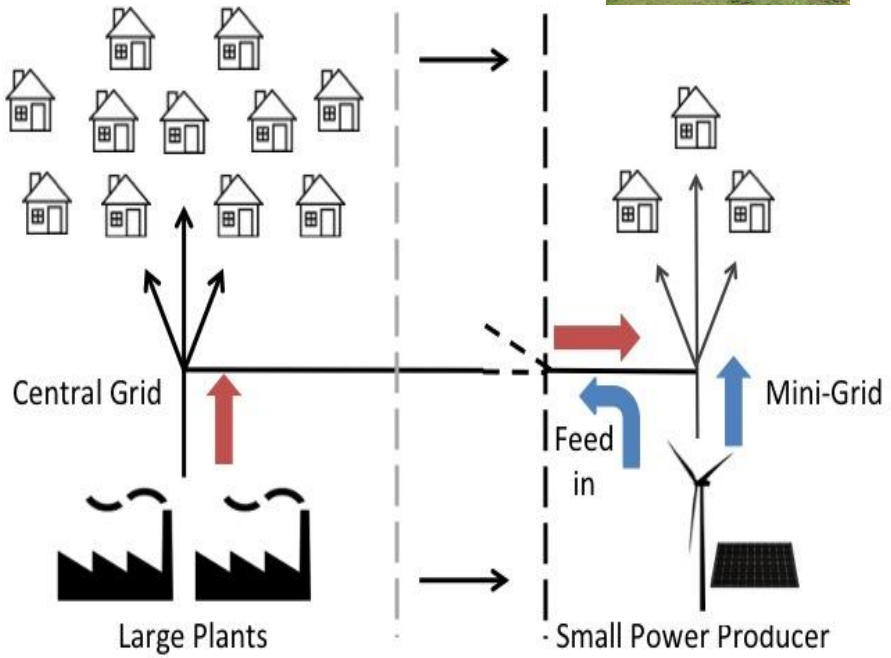




Mini-grid Service and Sustainability

Multiple challenges exist, including:

- System flexibility as demand evolves (victim or beneficiary of success?)
- Local technical and financial management
- Evolution when mini-grids interact with central grids



2012 INTERNATIONAL YEAR OF SUSTAINABLE ENERGY FOR ALL

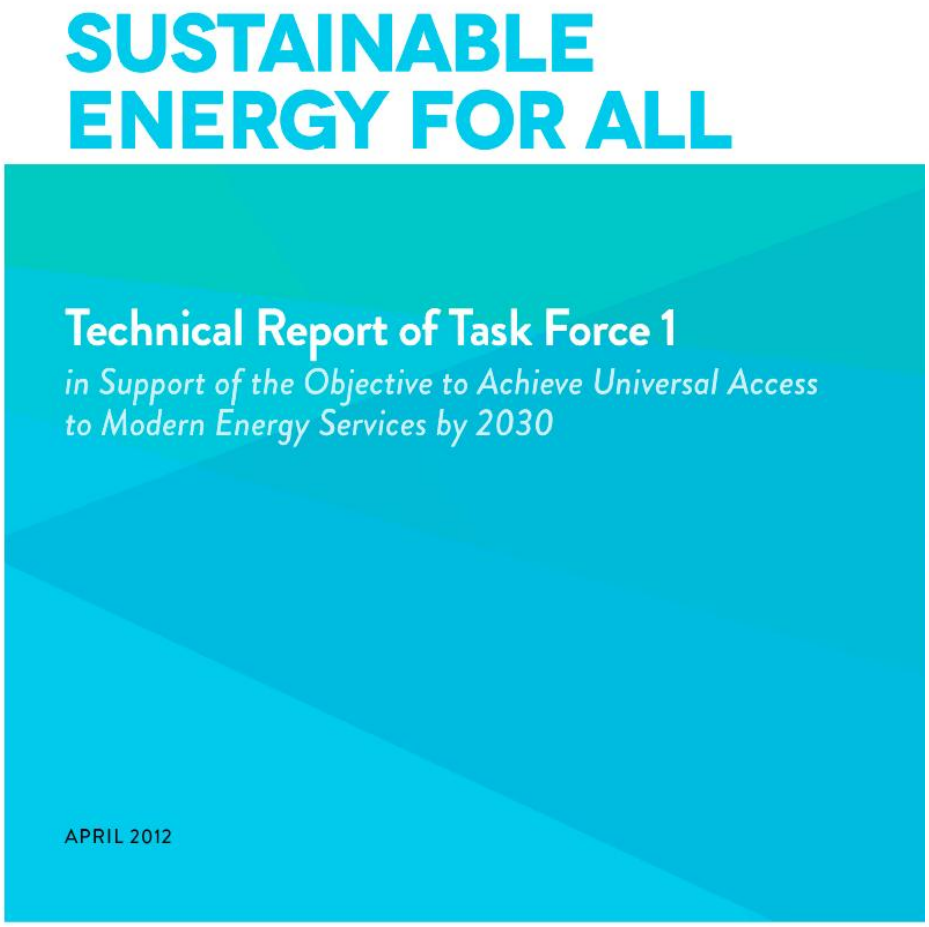
United Nations Secretary General's High Level Commission on Sustainable Energy for All

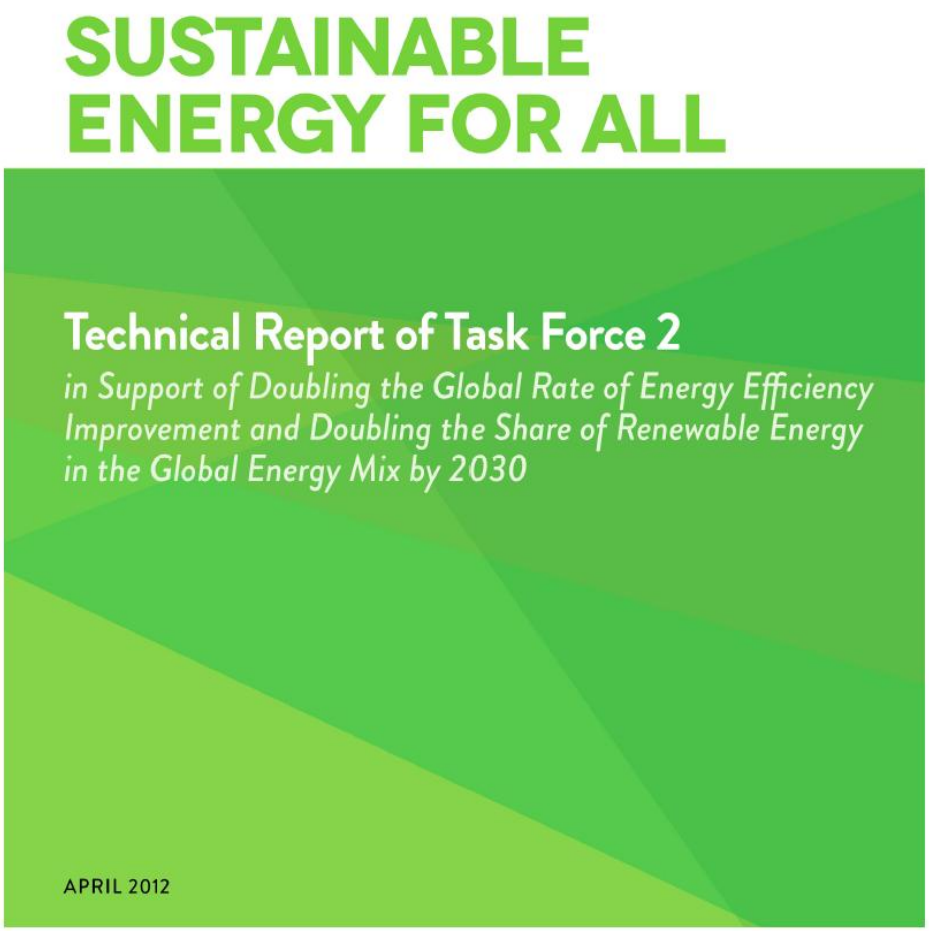
(SE4All, http://www.sustainableenergyforall.org/)

- Universal Access to Modern Energy Services
- Doubling the Rate of Improvement in Energy Efficiency
- Doubling the Share of Renewable Energy in Global Energy Mix

UN Assembly, September 24, 2012

Sustainable Energy For All:





SUSTAINABLE ENERGY FOR ALL

SUSTAINABLE ENERGY FOR ALL

Energy and Climate Partnership of the Americas

ECPA

Daniel Kammen, ECPA Ambassador for the U. S. State Department, 2010 -

Chief Technical Specialist for Renewable Energy and Energy Efficiency, The World Bank, 2010 - 2011

Renewable & Appropriate Energy Laboratory
Energy & Resources Group
University of California, Berkeley

** Version 1 **

Sustainable Energy Options for Kosovo

An analysis of resource availability and cost

Daniel M. Kammen, Maryam Mozafari and Daniel Prull

January 15, 2012

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http://rael.berkeley.edu/kosovoenergy