Integrated Energy Planning and Clean Energy Alternatives in Borneo, East Malaysia

Rebekah Shirley, Post Doctoral Fellow
Energy and Resources Group, University of California, Berkeley
Sustainable Energy for Sarawak & Sabah

Media coverage of our June 28, 2015 press conference in Kuching, Sarawak: The Borneo Post, August 11, 2015 - Adenan wants SEB to light up the rural areas. The Malaysian Insider, July 31, 2015 - Adenan puts Baram dam on hold, agrees to listen to natives. grousers Radio Free Sarawak, July 15, 2015 - "Solve it should be out", say Sarawakians [...] 

Topics: 
E and SE Asia  energy modelling  national and multinational energy policy

Project Members: 
Kammen, Daniel
Shirley, Rebekah

http://www.rael.berkeley.edu
http://erg.berkeley.edu/
http://erg.berkeley.edu/people/shirley-rebekah/
http://rael.berkeley.edu/project/sustainable-energy-for-sarawak-sabah/
RENEWABLE AND APPROPRIATE ENERGY LABORATORY
A blend of capabilities to support energy decision-making by government and private agencies in low carbon energy planning

**Repeatable methodology** to model electric grids using both direct and proxy data

**Grid Mapping Capabilities**

**Energy Systems Modeling**

**Policy Analysis Tools**

Integrates policy, physical energy systems, and finance into a *single consistent model*

Integrated team of energy and finance experts provide *robust and credible analysis* to inform policy and project planning decisions

---

**Track Record**

- Evaluated impacts of proposed hydro-dam project in Chile
- Evaluated system costs of different GHG reduction targets
- Our analysis informed a policy decision that is expected to lead to **$2 billion** in annual savings after 2030
- Built green job and carbon tools for EDIN Program
RENEWABLE AND APPROPRIATE ENERGY LABORATORY

Research teams working in many countries across the world

Current Low-Carbon Modeling Efforts

New profiles can be built to analyze region-specific challenges
Analysis of Clean Energy Options for Sabah prepared by Berkeley in 2010

Biomass waste projects at large palm oil mills are cost-competitive with coal

Alternate Palm Oil Waste OR Geothermal/Micro Hydro Systems could meet future demand at equal cost while dramatically reducing emissions

Policy recommendations on phase out of coal subsidy, support of PV incentive schemes and regulation of Palm Oil Ind.
MEDIA RESPONSE TO SABAH ENERGY CONVERSATION
“Sabah is a global leader in Sustainable Development”

Biomass can replace coal – Professor

By Sandra Sekilad

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 held 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.

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 state-level solar energy commission.

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

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 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.
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,"
RESEARCH MOTIVATION
Supporting the integration of bottom-up solutions into local energy development planning for Borneo

What are feasible alternative energy mixes for Borneo that meet future energy demand for the local population given priorities of cost, human and environmental impact?

• What is the potential for sustainable resources to satisfy (a) rural energy needs and (b) commercial (utility scale) needs?
• What are the implications of different energy market scenarios on optimal generation technologies?
• How can ecological impacts of energy alternatives be measured/estimated in a data constrained context?
• How can this information filter into the assessment and socio-political discussion of energy alternatives?


Rebekah Shirley and Daniel Kammen, Kampung Capacity: Assessing the Potential for Distributed Energy Resources to Satisfy Local Demand in East Malaysia, *RAEL Report* 2014
1. The current grid system is **overbuilt**. How are we projecting energy **demand**?

**Tool**: Power System Simulation and Optimization Program

**Data**: Spatial Primary Energy Resource Measurements, Biomass Data, Hydrometric Data, Generation Technology and Fuel Costs,
2. Even under high-growth assumptions, Solar PV and Biomass Waste in addition to existing generation meet future energy demand. How can we overcome barriers to integration?
3. **Two-thirds** of Bornean Bird, Mammal, Tree and Insect Species may lose habitat **forever** due to hydroelectric reservoirs. How do we **value** this impact?

### Table 1. Showing Number of Species Affected and Estimated Number of Individuals Lost for SCORE Dams

<table>
<thead>
<tr>
<th>Hydroelectric Dam</th>
<th>Status</th>
<th>Reservoir Area (km²)</th>
<th>Number of Species Affected</th>
<th>Total Number Individuals Lost (Millions)</th>
<th>Number of Species Affected</th>
<th>Total Number Individuals Lost (Millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bakun</td>
<td>Operational since 2011</td>
<td>701</td>
<td>302</td>
<td>1.75</td>
<td>142</td>
<td>55.09</td>
</tr>
<tr>
<td>Murum</td>
<td>Being inundated</td>
<td>242</td>
<td>312</td>
<td>0.61</td>
<td>147</td>
<td>19.55</td>
</tr>
<tr>
<td>Baram</td>
<td>Under Construction</td>
<td>414</td>
<td>318</td>
<td>1.04</td>
<td>162</td>
<td>35.52</td>
</tr>
</tbody>
</table>

**RESULTS:** Mammal and Bird Species Counts for Borneo based on IUCN Data; Specific Hydroelectric Reservoir Biodiversity Impacts
4. Rural energy solutions can **support** rural **autonomy and economy**. Village households pay three times as much as Urban households for the same kWh of electricity. **Micro-grid** technologies are more sustainable and more affordable than diesel. How do we increase **rural energy access**?
5. **Sustainable energy futures** that meet multiple stakeholder objectives are **possible** for Borneo. How will science support **inclusive** planning?

**RESULTS:**

Suitability Analysis of Decentralized Energy Solutions in Sarawak

- **Palm Oil Mills**
- **Existing Thermal Power Stations**
- **Existing 132 kV Line**
- **Existing 275 kV Line**
- **Roads**
- **Existing Dam Reservoirs**
- **Possible Biomass Waste**
- **Possible Solar Resource (kWh/m²/day)**
  - 4.60 - 4.75
  - 4.76 - 4.85
  - 4.86 - 4.95
  - 4.96 - 5.05
  - 5.06 - 5.25
Borneo Says No to Dirty Energy
By Jennifer Pinkowski

On Wednesday, Borneo, another tourism-driven region, regularly influx of people and the need for sustainable energy has led to the announcement that Sarawak may see the end of mega dams.

Sarawak may see end of mega dams
June 29, 2015, Monday ▲ Jonathan Chia, reporters@theborneopost.com

Kammen (second right) addressing members of the media. With him (from left) are Kallong, Gabriel and See. — Photo by Muhammad Rais Sanusi

The university's Professor in the Energy and Resources Group, Daniel M. Kammen, said that Datuk Seri Musa Aman’s recent remarks that Sabah had the potential to become a notable producing energy from biomass, mini hydro, geothermal and even micro-algae and tidal technology.

Kammen said the report titled "Clean Energy Options for Sabah: An Analysis of Resource and alternative energies for the State in the context of a seven percent growth in energy demand" would build a 300-Megawatt coal-fired power plant, which has since been shelved.

Environmentalists and locals win fight against coal plant in Borneo
Jeremy Hancox
February 16, 2011

Environmentalists, scientists, and locals have won the battle against a controversial coal plant in the Malaysian state of Sabah in northern Borneo. The State and Federal government announced today that they would "pursue other alternative sources of energy, namely gas, to meet Sabah's power supply needs." Proposed for an undeveloped beach on the north-eastern coast of Borneo, the coal plant, according to critics, would have threatened the Coral Triangle, one of the world's most biodiverse marine ecosystems, and Tabin Wildlife Reserve, home to Critically Endangered Sumatran rhinos and Bornean orangutans. Local fishermen feared that discharges from the plant would have imperiled their livelihoods.
Figure 1. Landsat images showing successional changes (in pink) built between 1990 and 2009 in an area of the ‘Heart of Borneo’, Sarawak, Malaysia.
Thank You!

Thanks to our collaborators:

The Borneo Project
Bruno Manser Fonds
Rainforest Foundation Norway
Tonibung and Green Empowerment
PACOS and JOAS
Land, Empowerment, Animals and People (LEAP)
International Rivers Network

Find our reports at
https://rael.berkeley.edu/sustainableislands
- Oxford researchers analyze a sample of 245 large dams built between 1934 and 2007.
- Three out of every four large dams suffered a cost overrun in constant local currency terms.
- Actual costs were on average 96% higher than estimated costs.
- For nearly half of dams costs exceed expected benefits (considered stranded) – i.e. its upfront sunk costs are unlikely to be recovered.
- Forecasts of costs of large dams today are likely to be as wrong as they were between 1934 and 2007.
Use the Carnegie Landsat Analysis System (30m res)
Rates and patterns of change poorly measured by conventional satellite approaches
~364,000 km of roads constructed through the forests of East Malaysia
Nearly 80% of the land surface of Sabah and Sarawak impacted by previously undocumented, high-impact logging or clearing operations from 1990 to 2009
• Analyzes six micro-grid developers with over 12 individual sites:
  – Chhattisgarh Renewable Energy Development Agency (India, PV)
  – DESI Power (Biomass)
  – Electricité d’Haiti (Haiti, Diesel)
  – Green Empowerment/Tonibung (Malaysia, Micro-hydro)
  – Husk Power Systems (India, Biomass)
  – Orissa Renewable Energy Development Agency (India, PV)
  – West Bengal Renewable Energy Development Agency (India, PV)

• Best Practice for business model, financing, funding, system maintenance

• GE Success: Micro-hydro as a means of social movements and community empowerment
• Estimates the area of forest land that would be directly affected by land clearing for technology development.
• We then incorporate the cost of direct forest land loss using land value estimates taken from the 2012 WWF Heart of Borneo (HoB) Study.
• The estimated value of forest land is US$900 ha\(^{-1}\) year\(^{-1}\) over the past decade and project that it double by 2030. This is based on estimates of the weighted average potential profit from land uses.
• Combined with land intensity estimates for each technology.
Defining the Energy ‘Problem’ and its ‘Solutions’: What are Utility Scale Energy Supply Options for Sarawak?


c. Historical and Predicted Peak and Average Electricity Demand – Federal and Local Utility Companies

Historical and Predicted Demand

Demand Growth Scenarios

Solar and Wind Resource Quality Data

Wilmar Plantations 2013
RESULTS: Generation Profile, Cost Components and Generation Characteristics of Scenarios under 7% Demand Growth
Using Global Species Range Data for Borneo

- Top-down Approaches: large-scale maps of species occurrence, expert assessment or distribution models
- Bottom-up Approaches: high quality small-scale data upscaled using scaling relationships (e.g. SAR)
- Our Study - Combined Approach: Able to estimate three distinct measures of biodiversity impact for each dam and all three dams together: (i) the number of affected species, (ii) number of local extinctions and (iii) number of lost individual organisms
- Completed for four taxonomic groups: mammals, birds, trees, and arthropods
SCORE Dams will affect two thirds of Terrestrial Bornean species

Table 1. Showing Number of Species Affected and Estimated Number of Individuals Lost for SCORE Dams

<table>
<thead>
<tr>
<th>Hydroelectric Dam</th>
<th>Status</th>
<th>Reservoir Area (km²)</th>
<th>Number of Species Affected</th>
<th>Total Number Individuals Lost (Millions)</th>
<th>Number of Species Affected</th>
<th>Total Number Individuals Lost (Millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bakun</td>
<td>Operational since 2011</td>
<td>701</td>
<td>302</td>
<td>1.75</td>
<td>142</td>
<td>55.09</td>
</tr>
<tr>
<td>Murum</td>
<td>Being inundated</td>
<td>242</td>
<td>312</td>
<td>0.61</td>
<td>147</td>
<td>19.55</td>
</tr>
<tr>
<td>Baram</td>
<td>Under Construction</td>
<td>414</td>
<td>318</td>
<td>1.04</td>
<td>162</td>
<td>35.52</td>
</tr>
</tbody>
</table>

Table 2. Showing Red List Category Break Down for SCORE Dams (Bakun, Murum, Baram)

<table>
<thead>
<tr>
<th>Code</th>
<th>Definition</th>
<th>Birds</th>
<th>Mammals</th>
</tr>
</thead>
<tbody>
<tr>
<td>EX</td>
<td>Extinct (EX)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>EW</td>
<td>Extinct in the Wild (EW)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>CR</td>
<td>Critically Endangered (CR)</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>EN</td>
<td>Endangered (EN)</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>VU</td>
<td>Vulnerable (VU)</td>
<td>14</td>
<td>24</td>
</tr>
<tr>
<td>NT</td>
<td>Near Threatened (NT)</td>
<td>75</td>
<td>14</td>
</tr>
<tr>
<td>LC</td>
<td>Least Concern (LC)</td>
<td>240</td>
<td>103</td>
</tr>
<tr>
<td>DD</td>
<td>Data Deficient (DD)</td>
<td>0</td>
<td>16</td>
</tr>
</tbody>
</table>

Table 3. Impact Summary Statistics (Bakun, Baram, Murum)

<table>
<thead>
<tr>
<th></th>
<th>Birds</th>
<th>Mammals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Number of Species Globally</td>
<td>10424</td>
<td>5513</td>
</tr>
<tr>
<td>Total Number of Species in Borneo</td>
<td>580</td>
<td>239</td>
</tr>
<tr>
<td>Number of Species Affected</td>
<td>331</td>
<td>164</td>
</tr>
<tr>
<td>Percentage Global Species Affected</td>
<td>3.2%</td>
<td>3.0%</td>
</tr>
<tr>
<td>Percentage Bornean Species Affected</td>
<td>57.1%</td>
<td>68.6%</td>
</tr>
<tr>
<td>Maximum Percentage Global Range Affected</td>
<td>4.7%</td>
<td>1.8%</td>
</tr>
<tr>
<td>Corresponding Species</td>
<td>Petaurillus emiliae</td>
<td>Oriolus hosii</td>
</tr>
<tr>
<td>Common Name</td>
<td>Lesser Pygmy Flying Squirrel</td>
<td>Black Oriole</td>
</tr>
</tbody>
</table>

http://brighterfuturechallenge.com/gray-gibbon-hylobates-moloch/
http://www.vulkaner.no/n/africa/pangolin.html
http://evoluahomosapiens.blogspot.com/2013/02/gato-vermelho-de-borneu-catopuma-badia.html
http://www.gbwf.org/pheasants/borneo03.html
RESULTS: Feasible Small Scale Solutions

Optimal System Configuration for Tanjung Tepalit

Fixed

Biomass Scaled Average (tonne/day) = 0.03
Diesel fuel price ($/L) = 0.55
Domestic (Night) Load Scaled Average (kWh/d) = 50.00

[PV: Capital Cost Multiplier (*), PV: Replacement Cost Multiplier (**) = (1.00, 1.00)]

Fixed

Biomass Scaled Average (tonne/day) = 0.03
Diesel fuel price ($/L) = 1.50
Domestic (Night) Load Scaled Average (kWh/d) = 90.00

[PV: Capital Cost Multiplier (*), PV: Replacement Cost Multiplier (**) = (1.00, 1.00)]
<table>
<thead>
<tr>
<th>Village</th>
<th>Category</th>
<th>System Specification</th>
<th>Initial Cost (US$)</th>
<th>Annual Operating Cost (US$)</th>
<th>Total NPC (US$)</th>
<th>LCOE (US$/kWh)</th>
<th>Average Fuel per Day (L/day)</th>
<th>Capacity Shortage (%)</th>
<th>Annual Operating Cost Ratio</th>
<th>NPC Ratio</th>
<th>LCOE Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tanjung Tepalit</td>
<td>Least Total Cost</td>
<td>9 KW Hydro + 60kWh Battery</td>
<td>29,170</td>
<td>2,166</td>
<td>54,408</td>
<td>0.150</td>
<td>0.00</td>
<td>5.3</td>
<td>0.16</td>
<td>0.33</td>
<td>0.35</td>
</tr>
<tr>
<td></td>
<td>Diesel Base Case</td>
<td>20kW Diesel</td>
<td>8,800</td>
<td>13,470</td>
<td>165,771</td>
<td>0.433</td>
<td>27.60</td>
<td>0.0</td>
<td>0.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Long Anap</td>
<td>Least Total Cost</td>
<td>7kW Hydro + 20kW Diesel + 120kWh Battery</td>
<td>62,870</td>
<td>18,018</td>
<td>272,847</td>
<td>0.354</td>
<td>35.29</td>
<td>4.6</td>
<td>0.66</td>
<td>0.81</td>
<td>0.85</td>
</tr>
<tr>
<td></td>
<td>Diesel Base Case</td>
<td>40kW Diesel</td>
<td>17,600</td>
<td>27,334</td>
<td>336,145</td>
<td>0.416</td>
<td>57.17</td>
<td>0.0</td>
<td>0.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Long San</td>
<td>Least Total Cost</td>
<td>11kW Hydro + 40kW Diesel</td>
<td>18,900</td>
<td>27,444</td>
<td>338,723</td>
<td>0.306</td>
<td>57.74</td>
<td>5.8</td>
<td>0.68</td>
<td>0.68</td>
<td>0.72</td>
</tr>
<tr>
<td></td>
<td>Diesel Base Case</td>
<td>60kW Diesel</td>
<td>26,400</td>
<td>40,650</td>
<td>500,115</td>
<td>0.426</td>
<td>84.00</td>
<td>0.0</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>