Mega-dam Renaissance in Borneo Prompts Need For Comparing Alternatives

Executive Summary of three recent studies from the Renewable and Appropriate Energy Laboratory (RAEL) of the University of California, Berkeley conducted in Sarawak.

The Renewable and Appropriate Energy Laboratory (RAEL), an independent energy research facility at the University of California, Berkeley, recently conducted an in-depth analysis exploring the potential of clean energy solutions for the state of Sarawak in Malaysian Borneo. Under the Sarawak Corridor of Renewable Energy (SCORE) 2008 - 2030 Development Plan at least six dams are scheduled to be completed in Sarawak by 2020. One of these dams (Bakun Dam) is now operational while two others (Murum and Baram Dams) are in various stages of development. Local opposition to the state-led development plan, and in particular to the Baram Dam – the dam next in line for construction – has garnered significant regional and international attention. In addition to the displacement of tens of thousands of people, the mega-dams would flood several hundreds of square kilometers of rainforest in a biodiversity hotspot.[1] The Bakun Dam alone has submerged an area of 700 square kilometers of rainforests, an area equivalent to the size of Singapore.

The RAEL research agenda has three main project areas: (a) modeling long-term utility scale electricity generation alternatives in Sarawak to determine trade-offs across different technologies; (b) exploring the potential for rural communities in dam-affected areas to satisfy energy access needs using local resources; (c) demonstrating a rapid assessment method for estimating the impact of mega-projects on biodiversity. The results of the three RAEL studies call into question the necessity of building additional dams, in the light of potential for lower cost, lower impact clean energy alternatives in the state.

A) Long-term Utility Scale Electricity Generation

In spite of the contentious nature of the SCORE development plan there is very little quantitative analysis of the energy options or cost/benefit tradeoffs in the publicly available literature and public discourse. The RAEL study fills this information gap by comparing the costs of different energy technologies through modeling the expansion necessary to meet Sarawak's demand in 2030 under four different energy demand growth scenarios:

(i) The 'Business as Usual (BAU)' Projection, which applies the national annual growth trends and histories based on government statistics and forecasts. This scenario projects an annual growth rate of 4% annual through 2015 followed by a gradual decline to 3.0% by 2020, and a further decline to 1.5% growth by 2030.

[1] Bruno Manser Fonds. "Sold Down River: How Sarawak Dam Plans Compromise the Future of Malaysia's Indigenous Peoples." 2012.

(ii) The ‘Seven Percent Growth’ Projection assumes the energy demand will increase at a 7% growth rate per year every year to 2030. This rate is higher than the average projected for Malaysia, and is already an ambitious goal.

(iii) The ‘Ten Percent Growth’ Projection assumes the energy demand will increase at a 10% growth rate per year through 2030. This is an even more ambitious goal than the previous scenario, and has never been sustained by any country for the time frame in question. For example, China’s energy demand growth rates were 10% or higher during a period of three years in the 2000s, but rates have steadily declined since.[2]

(iv) The ‘SCORE’ Projection uses a more than 16% annual growth rate every year to 2030 to approximate the SCORE Development Plan intentions of building out over 20 GW of capacity by 2030.

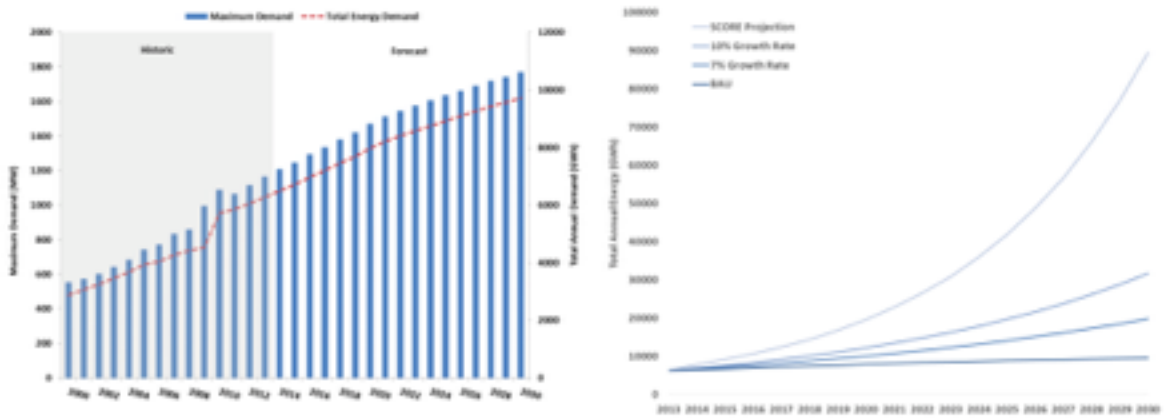

Figure 3 (a) Showing State Growth Forecast (BAU Assumption); (b) Long Term Load Demand under Four Different Growth Assumptions

By glancing at the different scenarios it is already evident that the SCORE development plan is an extreme outlier. Under the extremely aggressive 10% growth scenario, energy demand grows to 30,000 GWh/year in 2030. Under the SCORE scenario energy demand grows to 90,000 GWh/year in 2030 (see Figure 3b).

To generate the model RAEL collected (i) publicly available data on fossil fuel, hydro, solar and wind resources and biomass waste availability; (ii) data on build, operation, and maintenance costs; (iii) local emission factors from generation technologies and (iv) data on local policy incentives such as Feed-in Tariffs (FiT) and Renewable Portfolio Standards (RPS). A Feed-in Tariff is one of many government incentive mechanisms that can promote the growth of renewable energy. In this mechanism, the utility company provides renewable energy power producers a fee (a "**tariff**") above the retail rate of electricity, providing long-term security for renewable energy producers, typically based on the cost of generation of each technology. FiTs have been implemented in states across peninsular Malaysia and in Sabah. Another policy mechanism is a Renewable Portfolio Standard (RPS) which requires a certain quantity of electricity production to be supplied through renewable energy generation units by a prescribed time. RAEL used this data to predict the most optimal (i.e. least cost) generation mixes for meeting demand under various policy scenarios.

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[2] Dai, Yande. “Outlook for Energy Supply and Demand in China.” *Green Low-Carbon Development in China*. Eds. Xue, J., Zhao, Z., Dai, Y., Wang, B. Springer, 2013.

Unsurprisingly, the results shows that SCORE has a greater total cost and levelized cost (i.e. the per kWh cost of building and operating the associated generation units over their lifetimes) than other policy scenarios. While it has a low fuel cost, the annual build cost and associated fixed costs are high because the system is exceedingly overbuilt. The models show that there are a number of alternative choices to SCORE that meet future demand at the 7% rate and the 10% rate at lower cost. The Bakun Dam alone satisfies a third of demand by 2030 under the 10% growth assumption, and half of the demand under a 7% growth assumption. Two existing dams (Batang Ai and Bakun) and recently installed combined gas and coal-fired generators are sufficient to meet demand at a very aggressive 10% growth rate if properly managed. Where the Bakun Dam, Murum Dam, and Baram Dam are all built and committed, there is a large excess of undispatched energy (note Capacity Reserve Margin). At current technology costs, solar and biomass waste technologies become cost effective under government incentive schemes such as an RPS or a FiT. These findings are consistent with other national studies that find solar and biomass waste to be effective under incentivization programs given the large resource potential.

B) Sustainable, Local Energy Access

To explore how rural communities in dam-affected areas can satisfy energy needs using local resources, RAEL conducted a case study in the Baram Basin, the next basin to be flooded for a SCORE dam reservoir. In East Malaysia most rural villages are not grid connected and rely heavily on high-cost diesel fuel for electricity and transportation. While 60-70% of village families in Baram own diesel generators, these generators are typically operated at very low efficiencies. Village households often pay twice as much as urban households on monthly electricity, even with diesel subsidies. A large number of the families that own generators cannot afford a consistent monthly fuel supply. The SCORE mega-dams proposal has dramatically raised the profile of these rural communities and the stakes in local energy services versus a larger development agenda.

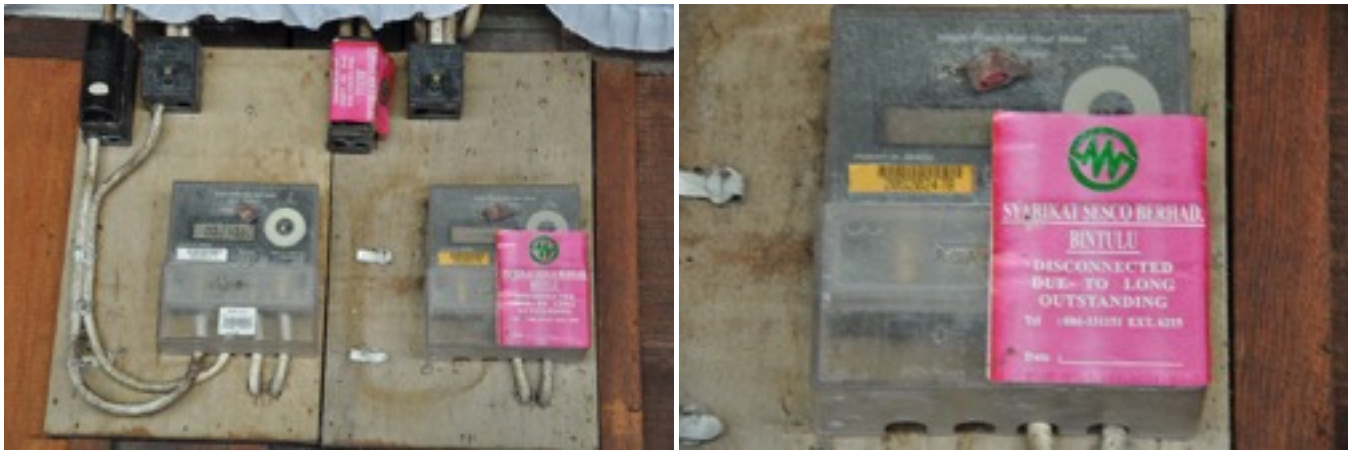
In preparing this study the RAEL team conducted site visits to 12 villages along the Baram River. They collected information on energy use and energy resource availability in the villages, visited local biogasification projects, and interviewed 20 government agencies and NGO groups on small scale energy incentives, opportunities and limitations. The study finds that the least cost options for energy services can come from a mixture of locally managed small-scale renewable energy systems and accompanying batteries where necessary. Specifically:

- Micro-hydro turbines are often the least cost generator, given the abundant river resources in close proximity to village communities.
- Small scale biogasification is also technically feasible for rice-farming villages where rice husk waste is readily available, though maintenance can be costly.
- The main drawback of renewable systems is reliability, especially during the dry season. To ensure zero energy shortage, batteries often become necessary.
- Diesel, even at the subsidized government retail rate, is the most expensive form of electric production for Baram villages given the recurrent fuel costs.

The study highlights the potential of villages in rural Sarawak to satisfy their own energy access needs with local and sustainable resources at affordable costs. In contrast, the SCORE

mega-dams are likely to incur enormous costs and are unlikely to benefit the communities that they forcefully displace. In a recently published Oxford study[3] researchers analyzed a sample of 245 large dams built between 1934 and 2007 and found that the vast majority of large dams are "too costly in absolute terms and take too long to build to deliver a positive risk-adjusted return". In consistent fashion, Bakun Dam was built over the course of two decades at a final official figure that was astronomically higher than projected. The dam was originally meant to cost RM2.5 billion. While the official expenditure figures have risen to RM7.4 billion, researchers from The National University of Singapore calculate the actual cost of the Bakun Dam to be RM15.325 billion.[4] Construction began in 1994 and the dam was meant to be operational in 2003. It was not completed until 2011, but even today, it is not running at full capacity.

The development of large scale dams with high voltage transmission from rural areas rarely translates into electricity access for affected or upland river communities. Villages that were displaced for construction of the Batang Ai and Bakun dams for instance do not have access to this energy; they are powered by diesel generators managed by a subsidiary of Sarawak Energy Berhad (the government-owned energy supply company in charge of dam development), and when they are unable to meet this monthly expense the company removes the fuses from the house (see photos below). The micro-hydro system is an explicit representation of alternative use of the very same river resource. For example, in the village of Long Lawen half of the residents rejected relocation plans during the inundation of the Bakun Dam in 1998 and moved to higher terrain within its ancestral land claim, while the other half were resettled at the Sungai Asap Reservation. Working with Green Empowerment and Tonibung, two NGOs specializing in community-based renewable energy, they commissioned a 8kW hydro-turbine and micro-grid network in 2002. This micro-grid is still functional today. In line with RAEL's findings, the new micro-grid system cost 50% less than the total prior investment in generators present in the community. Sungai Asap is still dependent on diesel generators.



Above: Household energy disconnected when communities displaced by dams are unable to pay electricity fees.

[3] Ansar, Atif, Bent Flyvbjerg, Alexander Budzier, and Daniel Lunn. "Should we build more dams? The actual costs of hydropower megaproject development." Energy Policy, 2014. http://dx.doi.org/10.1016/j.enpol.2013.10.069i .

[4] Benjamin K. Sovacool and L.C. Bulan. "Settling the SCORE: The Implications for the Sarawak Corridor of Renewable Energy (SCORE) in Malaysia." Lew Kuan Yew School of Public Policy, Energy Governance Case Study No. 4, March 2011.

The contrast of pursuing micro-hydro in the face of inundation provides a powerful symbolism of resistance and inspiration to surrounding villages. The RAEL study emphasizes the potential of bottom-up energy solutions in contributing to the energy agenda and their larger role in social movements and paradigm change.

C) Biodiversity Impacts of Three Dams

The third RAEL study measured the impact of three dams, Bakun, Murum, and Baram, on mammal, bird, tree, and arthropod species. Given that the rainforests of Borneo have the highest biodiversity of any terrestrial ecosystem, it comes as no surprise that the three dams would have a tremendous impact on the rich biodiversity of the area.

Using global species range data, GIS tools, and species area scaling relationships, the team predicted three distinct measures of biodiversity impact: the total number of species affected by the dams, the number of individuals affected, and the number of potential species extinctions that could result.

The study found that at least 57% of Bornean birds (331 species) and 69% of Bornean mammals (164 species) would be negatively affected by the dams. The affected species include critically endangered mammals such as the Sunda Pangolin, the Bay Cat, the Otter Civet, the Grey Gibbon, the Hairy Nosed Otter, and the Flat-headed Cat, and critically endangered birds such as the Storm's Stork and the Bornean Pheasant. Additionally, the study found that two-thirds of all tree and anthropod species will be impacted, resulting in 4 tree and 35 anthropod species extinctions. The number of species extinctions does not take into account the potential extinction of subspecies or local populations, both of which may be critical to species' long-term viability.

The study also provided numbers on lost individual organisms -- animals, insects, and trees that would perish because of loss of habitat from clear-cutting and inundation. The results are staggering. The three dams alone are estimated to cause the loss of 3.4 million individual birds and 110 million individual mammals. To put this into perspective, that's more individual birds than were counted in the North American Breeding Bird Survey in 2012, and more individual mammals than the entire inventory of cattle in the United States in 2012. A minimum of 900 million individual trees and 34 billion individual arthropods would also be lost.

This study was based on habitat loss from inundation of just three of the dams, and the authors note that this analysis does not take into consideration the other impacts the dams will have on biodiversity. A full accounting of the impacts on biodiversity would need to consider the impact of roads and other infrastructure relating to the dam, the downstream changes to the river and flooding regime, the indirect costs of displacing communities, and the greenhouse gas emissions from the reservoir.

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