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Bending bamboo: Restructuring rural electrification in Sarawak, Malaysia

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ABSTRACT

This article examines the strategy of electrification for Sarawak which centers on large-scale hydroelectric projects. Drawing from extensive in-field interviews of stakeholders in Sarawak who are affected by the soon-to-be-completed 2400 megawatt (MW) Bakun Hydroelectric Project, this article presents documentary evidence that these "hard path" mega energy projects are economically, socially and ecologically sub-optimal. The study suggests that more rigorous development of "soft path" small-scale, decentralized renewable energy systems more effectively support development and electrification aspirations for the region. The paper concludes with an analysis which invalidates the rationale for supporting mega projects yet recognizes that powerful advocates pose significant threats to a transition from hard to soft energy paths. It puts forth a concluding recommendation that pressure to scale down these mega projects and bolster decentralized, small-scale initiatives represents the most feasible approach to optimizing rural electrification in Sarawak. Overall, this case study provides both a detailed analysis of the inadequacies of mega energy projects in supporting economic development in less affluent regions and insight into how to strategically facilitate ideological change from hard (mega projects) to soft (decentralized energy systems) energy paths.

Introduction

The "middle path"—Buddhists view this as the road to enlightenment. It reflects the time-tested logic that tempered behavior, actions, and thoughts represent the most sustainable road to individual well-being. Middle path logic has applications that extend well beyond the realm of spiritual enlightenment. The social sciences are richly influenced by logic of tempered reasoning. The philosopher Georg Wilhelm Friedrich Hegel, for example, viewed the middle path as a state of synthesis wherein the dialectic between a thesis and its contradictory antithesis could somehow be harmonized (Ritzer and Goodman, 2003). In politics, the concept of centrism heralds the promotion of moderate policies to appeal to a broader electoral base. In social and interpersonal interactions, the middle path notions of "compromise" and "collaboration" have long been recognized as the two most viable effective approaches for managing conflict (Whetten and Cameron, 2010).

In energy policy though, the wisdom of middle path thinking has been disregarded in favor of large-scale energy projects which are acclaimed as being a necessary poultice in curing the sluggish development of a given community or region (Lovins, 1979a). Large-scale energy projects create jobs and provide consumers the cheapest possible form of energy through economies of scale—or so the proponents of such projects argue. Conversely, smaller, decentralized energy systems are frequently denigrated as being economically inefficient, troublesome to integrate and inadequate for satisfying the blossoming energy demands of developing regions. Consequently, when energy planners in developing nations turn to the task of mapping out energy infrastructure strategies, there is still a marked tendency to support the development of highly contentious mega projects, as exemplified by the Narmada Valley Dam Projects in India, the Yacyretá Dam between Argentina and Paraguay, the Nam Then controversy in the Mekong Delta, the Baku-Tbilisi-Ceyhan (BTC) Pipeline, the Trans-ASEAN Pipeline, the Chad–Cameroon pipeline, and the project described in this paper, the Bakun Hydroelectric dam. All too often, responsibility for decentralized projects is ceded to the leaders of remote communities or regional energy planners well outside of the mainstream.

This paper critically examines the "appropriateness" of electrification through large-scale hydroelectric dams in impoverished regions by documenting the impact that the Bakun Hydroelectric Project (BHP) has had on community stakeholders in Sarawak. The paper then incorporates E.F. Schumacher's notion of "appropriate technology" and the concept of "hard and soft energy paths" proposed by Amory Lovins, in addition to observations from fieldwork in Sarawak, to advance a case for more robust decentralized energy system. The paper concludes with an analysis which invalidates the rationale for supporting mega projects yet recognizes that powerful megaproject advocates pose significant threats to a transition from hard to soft energy paths. Therefore, it puts forth a recommendation

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that rather than simply attack the current "hard path" strategy as being flawed, the most feasible approach to optimizing rural electrification in Sarawak (and elsewhere) is to apply pressure to scale down these mega projects and bolster decentralized, small-scale initiatives.

The layout of the paper is as follows. The second section details the research methodology through which the Bakun Hydroelectric Project was evaluated. The third section distinguishes between "hard" and "soft" energy paths and defines "appropriate technology". The fourth section describes the Bakun Hydroelectric Project and documents the insights uncovered in the course of interviewing 85 stakeholders in Sarawak. The fifth section discusses the conceptual foundations supporting the argument for smaller, decentralized energy systems in developing countries. The sixth section critically evaluates the rational for supporting mega energy projects over smaller, decentralized initiatives and demonstrates how many of these justifications are invalid in regard to energy planning in Sarawak. Finally, the last section provides concluding thoughts on how the current rural electrification strategy in Sarawak can be restructured despite evidence of powerful political support for mega project development.

Research methods

Case study methodology was adopted in order to gain the richest possible level of insight into the impact that the Bakun Hydroelectric Project has had on residents living within the region. As Yin (2008) points out, case study methodologies allow researchers to delve deeper into a given phenomenon and develop a richer, more descriptive understanding of the subject under study. After conducting a literature review of documents related to this project to provide requisite background knowledge, plans were made to conduct field interviews in the region of Sarawak affected by the Bakun Hydroelectric Project with the assistance of a Malaysian colleague, L.C. Bulan.

In structuring the interview questions, the authors elected to employ an inductive approach to inquiry in order to minimize interpretative bias caused by researchers trying to force responses into preset cognitive frameworks (Blaikie, 2000; Cook and Campbell, 1979; Rochlin and Meier, 1994). This inductive approach was operationalized by fixing four initial questions for each interview and then allowing interview subjects to respond in as much detail as they wanted. The four questions were: i) "What are the primary drivers behind hydroelectric projects in Sarawak?;" ii) "Who will be the key beneficiaries of big and small hydro-projects?;" iii) "What are some of the challenges facing such projects?;" and iv) "What general lessons for public policy and energy policy can be learned?". The authors supplemented these four questions with "probing response techniques" when clarification or elaboration was sought and "reflecting response techniques" in order to elicit deeper reflection when warranted (Whetten and Cameron, 2010). In response to these interviewing strategies, participants often introduced new topics into the conversation not anticipated by the authors. Interviews lasted between 30 and 90 min.

In total, 85 participants from 37 institutions involved with hydroelectricity in Sarawak were interviewed over the course of March 2010 to July 2010. Those interviewed were selected to represent the broadest possible array of stakeholders associated with the hydroelectricity in Malaysia, and included members of:

- Engineering and construction firms such as Alstom Hydro, Sarawak Hidro, and Snowy Mountains Engineering Corporation;
- Government ministries at the federal level, including the National Economic Advisory Council, Economic Planning Unit in the Prime Minister's Department, the Public Private Partnership Unit of the Prime Minister's Department, the Ministry of Energy, Green Technology and Water, and the Ministry of Natural Resources and the Environment;
- Regulatory agencies at the state level, including the State Planning Unit of the Sarawak State Government, Sarawak Rivers Board, Natural Resources and Environment Board Sarawak, and the Regional Corridor Development Authority;
- Energy companies and electric utilities, including Petronas, Sime Darby, Tenaga Nasional Berhad, Sarawak Energy Berhad, and Syarikat Sesco Berhad (formerly the Sarawak Electricity Supply Corporation);
- Human rights organizations including the Bar Council of Malaysia, Human Rights Commission of Malaysia (SUHAKAM), and Suara Rakyat Malaysia (SUARAM);
- Research institutes and civil society organizations, including the Centre for Environment, Technology, and Development Malaysia, Friends of the Earth, International Rivers Network, Universiti Malaysia Sarawak, and World Wildlife Fund International.

Participants were guaranteed anonymity to encourage candor, respect confidentiality, and adhere to institutional review board guidelines at the authors' universities; however, Appendix 1 lists all institutions visited.

To help understand the perspective of those involved with building and operating dams in Sarawak, one of the authors conducted a site visit and a tour of Bakun Hydroelectric Project (BHP) and in the process held face-to-face meetings with the Chief Resident Engineer and project managers of Sarawak Hidro (the firm in charge of BHP), managers of the Malaysia–China Hydro JV consortium (its primary civil builder), and managers of the Sarawak Energy Berhad (the company expected to operate the dam and sell its electricity). The author also visited two other large dams in Sarawak—the operational 108 MW Batang Ai facility in Sri Aman and the 944 MW Murum facility under construction.

Keeping in mind the potential for "soft systems" (smaller, decentralized sources of electricity supply), two micro-hydro sites were also visited, a 10 kilowatt (kW) unit in operation in Long Lawen, and a 25 kW unit under construction at Mudung Abun. The author visited these sites to gain deeper understanding of the feasibility and impact of micro-hydro options in the region. To gather perspectives from households and end users, the authors also spoke with community leaders, village elders and ordinary members of the community in longhouses and villages of Asap, Bakun, Danang, Murum, Long Lawen, Long Wat, Nepi Pasir, Rumah Kelap, Ulu Plirau, and Uma Daro. These visits ensured that a representative mix of different ethnic groups was consulted, including members of the Bukitan, Iban, Kayan, Kenyah, and Penan tribes. We employed full-time, simultaneous translators in order to communicate effectively with interview subjects who spoke a variety of local tribal languages and dialects, as well as the national Malaysian language, *Bahasa Melayu*. When appropriate, interview subjects were also asked to provide sources to confirm factual claims and these sources served as the basis for substantiating claims.

"Hard" and "soft" energy paths

Writing during the energy crises of the 1970s, Amory Lovins (Lovins, 1976, 1978; Lovins, 1979a,b) argued that one could distinguish between "hard" and "soft" paths for energy production and use. Lovins defined a "hard path" as one which depended on non-renewable resources—such as uranium, coal, oil and natural gas—and was poorly matched in scale and quality to energy end-uses. The hard path featured large-scale energy systems that were technologically complex and required teams of engineers in order to maintain functionality. Delays in constructing such large projects or breakdowns during the operation of these large energy plants place enormous strain on the entire energy network. The hard path was also incapable of adapting to sudden changes in demand for energy. Therefore, hard path technologies are preferable for large-scale energy needs in circumstances where environmental degradation can be controlled. Unfortunately, the BHP exemplifies this hard path approach in a developmental setting that is ill-suited to it given the local environmental and social characteristics of economies and communities in Sarawak.

In contrast, Lovins defined a “soft path” as utilizing energy technologies that are of a smaller scale which capitalize on indigenously available, renewable energy sources. Reduced scale delivers three significant advantages. First, the electricity grid becomes more resilient because the failure of one generation unit has far less impact on the overall supply of electricity (Sovacool, 2008). When the BHP becomes operational, for instance, any major breakdowns will leave its industrial consumers stranded without electricity. Second, soft path systems are more responsive to growth in electricity demand. Generation capacity can be added in a modular fashion as demand escalates (Boyle, 2004). This is in stark contrast to the BHP which has been 15 years in the making and still has yet to produce any electricity. Third, employing smaller systems also reduces environmental impact. Rather than erecting enormous dams that cause all of the environmental problems outlined in the BHP case, a soft path may instead advocate micro-hydro systems that have far less environmental problems.

The soft path also advocates technologies that are relatively easy to understand and maintain. This enables members of an indigenous community, for example, to maintain systems themselves and thereby delivers the bifurcate benefits of reduced downtime and enhanced employment.

This soft path of energy system development conflates well with economic development theory for developing nations. In his widely acclaimed *Small is Beautiful: Economics as if People Mattered*, economist E. F. Schumacher (1973) argued that large, expensive technological projects either fail or bring about unintended or undesirable consequences because they are being implemented on the wrong scale. Schumacher developed the term “intermediate technology”—later called “appropriate technology”—to denote technologies that: (a) support local economic growth within a given community; (b) create independence from outside sources of knowledge and capital; (c) use local materials that minimize harm to the social and natural environment; and (d) employ the simplest production methods available.

Soft path energy systems deliver such benefits to communities in developing countries whereas hard path systems such as the BHP tend to ignore and sacrifice local needs to benefit external stakeholders. As outlined below, the BHP has failed to support local economic growth and instead seems destined to benefit heavy industry. It was designed, constructed and will be maintained by foreign firms, thereby failing to provide indigenous communities with independence from outside sources of knowledge. Moreover, the excavation of gravel, deforestation and pollution generated in the construction process has resulted in widespread environmental damage. The BHP is also a very complex project that technologically locks out local businesses from significant levels of involvement.

This dichotomy of hard and soft energy paths gives rise to an important question that is as important for other developing countries as it is for energy planners in Malaysia. Is a hard path strategy appropriate for supporting sustainable energy development of impoverished regions?

In order to begin to answer this question, we first turn to an assessment of the impact that the BHP has had on community members in Sarawak. As we detail in subsequent sections, the BHP represents a prime example of technology that is ill-suited to the needs of developing regions. As our interview subjects recount, the project does not provide energy for local communities, is dependent on foreign labor and technology for both construction and operation, is exceedingly complex, poses significant risks to the environment and adversely impacts the well-being of local communities, including the forced relocation of about 10,000 indigenous peoples, primarily of the Kayan, Kenyah, Kajang, Ukit and Penan ethnic groups.

The hard path: The Bakun Hydroelectric Project

To contextualize why Malaysian planners have embarked upon the hard path, it is useful to first explore the general energy landscape of Malaysia and Sarawak. Malaysia`s total primary energy supply in 2008 consisted of 35.2% oil, 46.8% natural gas, 0.9% hydropower, 13% coal and peat and 4.1% combined renewable and waste to energy sources.[2] However, energy use and access is far from uniform across the country. Table 1 illustrates that Malaysia has connected 98 percent of its rural population to electricity and achieved one of the highest rates of electrification in all of Southeast Asia; however, in some rural parts of Malaysia longhouses and communities are privileged to get 24 h of electricity only when someone dies or during holidays such as Christmas or Chinese New Year. All other times, rural households in communities that are affluent enough to even afford fuel are fortunate to receive 3 to 4 h of electricity per day, usually at night from a diesel generator.

Table 1
Electrification rates for Southeast Asian countries.

	2008 Electrification rate (%)			Population without electricity (millions)
	Total	Urban	Rural	
Brunei	99.7	100.0	98.6	0.0
Cambodia	24.0	66.0	12.5	11.2
Indonesia	64.5	94.0	32.0	81.1
Laos	55.0	84.0	42.0	2.7
Malaysia	99.4	100.0	98.0	0.2
Myanmar	13.0	19.0	10.0	42.8
Philippines	86.0	97.0	65.0	12.5
Singapore	100.0	100.0	100.0	0.0
Thailand	99.3	100.0	99.0	0.4
Vietnam	89.0	99.6	85.0	9.5
ASEAN Region	*71.9*	*91.3*	*54.9*	*160.3*

Malaysian policymakers are fully aware of the key role that electricity plays in advancing economic development and have been struggling to bring energy services to rural populations for decades now, with electrification efforts commencing in the late 1970s (Baginda, 2002). To this end, energy policy presented in the Seventh Malaysia Plan (1996–2000) and the Eighth Malaysia Plan (2001 to 2005) re-emphasized the need to ensure adequacy of generating capacity and the development importance of expanding and upgrading transmission infrastructure (Government of Malaysia, 2006).

The challenges of enhancing electrification for Sarawak stem largely from geographic and demographic factors. Geographically, Sarawak is Malaysia's largest state, covering 124,450 km^2. However, state population is only 2.4 million with approximately 53% living in the four cities of Kuching, Miri, Sibu and Bintulu (Government of Malaysia, 2011). Consequently, nearly half of Sarawak's resident population is dispersed over a wide spatial area, inhabiting small villages not well connected by roads. In short, distribution of electricity in Sarawak trumps supply challenges in terms of improving access to electricity. The Malaysian government set forth objectives in the Seventh Malaysia Plan to improve economic development in Sarawak. Part of the strategy aimed to enhance rural electrification coverage in Sarawak from 67% in 1995 to 80% by 2000 and to 90% by 2005. A key component to meeting such lofty targets for improvement was the construction of the BHP which was initiated in 1995. Unfortunately, construction of the BHP was halted for three years on the heels of the Asian financial crisis in the late 1990s. As a result, by 2000, rural electrification coverage in Sarawak was still only 67%. This has set back the government's electrification coverage targets for Sarawak back by five years. Only by 2005 did electrification coverage in Sarawak exceed 80%. Consequently the goal of facilitating 90% electrification coverage was pushed back to 2010 (Government of Malaysia, 2006).

The reason this one project has had such an impact on electricity planning in Sarawak comes down to size. The BHP is a 204 m high concrete-faced, rock-filled dam located in the Upper Rajang Basin in the

[2] Source: International Energy Agency, Statistics on the Web: Statistics on the Web. Accessed 5 January 2011 at: http://www.iea.org/statist/index.htm.

rainforests of Sarawak which when completed will boast an installed capacity of 2400 MW and 1800 MW of "firm" or "operational" capacity (Fig. 1). The BHP sits on the Balui River, 37 km upstream from Belaga in Sarawak, which is part of the Rajang River system, the largest in Malaysia. When the dam becomes operational, it will be the tallest concrete-faced rock-filled dam in the world. Project leaders began filling the reservoir in October 2010 and when it is full in approximately eight months it will form the Bakun Lake which will be the largest and most voluminous lake in Malaysia. The impoundment area, at 720 km^2, is larger than neighboring Singapore. Fifty-one percent of the land of the reservoir area is Native Customary Land (meaning it is legally owned by indigenous communities), and 230 km^2 of the reservoir area was originally virgin rainforest.

The BHP forms the centerpiece of a Malaysian government initiative known as the Sarawak Corridor of Renewable Energy (SCORE), which was announced in 2008. SCORE is an ambitious plan to develop dozens of dams to attract energy-intensive industries, create jobs and fuel economic growth in the state. Sarawak has 155 potential dam sites and the potential to develop 80,000 MW of hydroelectric capacity with an annual output of 340,000 GWh per year. The SCORE Master Plan calls for developing 20,000 MW of generation capacity at up to 51 of these sites that will produce 87,000 GWh of electricity per year, with the first 12 of those dams representing mega projects that will produce 7000 MW of generation capacity (HRCM, 2009). Although the BHP will likely be operational by 2012, the only other dam currently under construction is the 944 MW project at Murum. If the BHP construction timeline is any indicator of development time for the other 10 mega sites currently in the planning stage, it may be at least a decade before these sites are actually generating electricity.

Meanwhile, the government is also promoting small-scale efforts to electrify the rural population in keeping with the Ninth Malaysia Plan energy policy objectives of diversifying energy sources through "greater utilization of renewable energy" and improving rural electricity coverage "especially in Sabah and Sarawak" (Government of Malaysia, 2006). Under the National Key Result Areas scheme, the federal government allocated RM2 billion (approx. US$ 650 million) for the State of Sarawak to plan and design 2000 projects for rural electrification intended to provide 80,000 households with electricity from 2010 to 2013. The Sarawak state government announced plans to use a portion of the money to fund 10 solar photovoltaic hybrid systems in remote villages and 7 micro-hydro pilot projects. However, it is unclear whether any of this budget allocation will be channeled into the financially troubled BHP project, which is estimated to have run up debt of RM6.1 billion (approx. US$2 billion) (Lee, 2010).

To summarize, energy planners in Sarawak appear to be pursuing a bifurcate strategy of developing mega projects to support industrial development and energy needs in large population centers while encouraging decentralized, smaller projects to support enhancement of rural electrification coverage. Although the BHP was initially conceived to provide electricity to the rural population of Sarawak in addition to industrial users, the current plan (at least as of late 2010) calls for about 90 to 100% of its electricity be consumed by just two aluminum smelters. Cahaya Mata Sarawak and Rio Tinto have already announced intentions to purchase about half of the electricity for a US $ 2 billion aluminum smelter in Bintulu with a capacity of 1.5 million tons per year, and have commented that production will begin as soon as the BHP comes online. Plans for a second aluminum smelter are also under discussion with China's Aluminum Corporation and Malaysia's GIIG Holdings for a $1 billion facility which will produce 330,000 tons per year. Although this implies that there could be some small excess capacity for enhancing rural electrification over the short term, the strategic trend appears to be that mega projects will support mega industry initiatives and smaller projects will support enhanced rural electrification.

Limited local benefit

One community leader aptly summarized the general perspective of the BHP on community well-being:

> *Not a single kWh of electricity from Bakun will actually go to benefit the local people. It is all promised to industrial uses. Not even communities along the transmission network from Bakun to Bintulu will get electricity. These communities do not benefit at all from the project. They've had their land taken away from them, most don't even get to work at the dam site, and in return they will enjoy being exposed to more air pollutants from the smelters and contaminated water from the dam.*

Another lamented that the "rationale behind Bakun is defunct, for it will not benefit the local people at all, it only supports rich companies and government officials who already have enough to live comfortably. It offers no real jobs or skills or training to any of the local communities".

Fig. 1. An aerial view of the 2400 MW Bakun Hydroelectric Dam, under construction in 2010.

Others highlighted the lack of employment opportunities at the dam. One village leader explained:

The average monthly wage someone from Bakun would demand for construction work would be about RM 1,200 (US$390) or as low as RM 1,000 (US320) for general workers. But developers found it less attractive to hire locals because they had to guarantee good conditions and accident insurance. So instead the construction companies and consultants brought in Indonesian and Chinese workers who were willing to work for less, as little as RM500 (US $160) per month, without the need for insurance.

Limited capacity building

The BHP is dependent on outside sources of capital, knowledge, and labor. About five to seven thousand workers, many of them from China, Bangladesh, Philippines, and Indonesia, were involved in the construction phase. One respondent quipped that "the Malaysians do not have the technical capacity to build [large] dams, we had to depend on the Chinese. The local Malaysians would be only good for driving tractors or serving food." Yet another remarked that a "quantum leap in skills and manpower training" was needed to make Bakun a reality.

The daunting technical challenges of building one of the world's largest and most complex dams necessitated reliance on international firms. One respondent summarized the coordination challenge in the following manner:

[To get BHP done], we had to partner with many big players. Electrical and mechanical contracts ended up eventually going to Alstom from France and IMPSA from Argentina. Civil works went to MCH-JV, a joint venture between Sino Hydro and Sime Darby. Diversion works went to Dong Ah from South Korea. Construction of the auxiliary coffer dam was awarded to Global Upline, a Malaysian company. The transmission lines were laid by SESCO. The owners and coordinators are still another group of actors, Sarawak Hidro, a government-owned company, and the Ministry of Finance. Add on top of that hundreds of subcontractors and bureaus, and you have a coordination nightmare.

Fig. 2 shows Filipino and Chinese welders finishing a 300 MW Francis turbine being installed by an Argentinean contractor. The figure illustrates how much of the construction, intellectual property, and contracting related to the BHP must involve foreign partners.

Complex and costly infrastructure

The BHP was capital intensive and required mammoth investments in affiliated infrastructure. Respondents estimated costs of the project from a low of US$1.7 billion to a high of US$7.9 billion, while the official government estimate is US$2.5 billion (Lee, 2010). Respondents also noted that the facility necessitated more than 16.7 million cubic meters of concrete, a gross reservoir storage volume of 48.3 billion cubic meters of water, and a large power intake structure consisting of 8 bays and tunnels, 16 roller gates, and a spillway larger than an aircraft carrier (depicted in Fig. 3). Moreover, one participant lamented that "basically nothing is there in Bakun, we're not talking about incremental development for infrastructure, but development from scratch. We needed to bring in everything from the dam material and generators to roads, water supply, food, ports, airports, and transmission infrastructure." Another added that "Bakun is a big dam and building in a developing country with no roads and no infrastructure meant we had to find a way in, we had to bring 4,000 people and all the things they would need, accommodation, clinics, food, and that's all before construction could commence." Even getting the turbine and transformer components to the dam site proved difficult, with a respondent remarking that "we had to build bridges and dredge parts of the rivers to move heavy equipment to Bakun, the items were way too heavy for a helicopter and some wouldn't even fit on the single logging road leading to the area. The biggest component, the transformer, weighed a hefty 240 tons, and each of the eight turbines weighed another 80 tons".

Managing logistics added to the excavation and construction difficulties confronted. One participant summarized:

For a project like Bakun we are talking about heaps of construction. We had to erect a coffer dam as well as the dam's concrete face. We had to clear the reservoir area, and also build the powerhouse, a quarry, offices for headquarters and subcontractors. We constructed a canteen, two restaurants, a hotel, and a clinic as well as a switchyard, transformer, concrete factory, spillway, tunnels, roads, and housing for workers.

Another put the challenge into perspective by noting "we're building a dam higher than Three Gorges Dam in China, the second highest in the world after Shibuya Dam, but with a greater volume of material, 17 million cubic meters. So we had to build a dam taller than the biggest dam in the world, and with more material than the tallest dam in the world." The BHP also required the installation of a high voltage direct current transmission system comprised of at least 1,000 kilometers of overhead lines cutting through thick forest and steep terrains (Choy, 2005a).

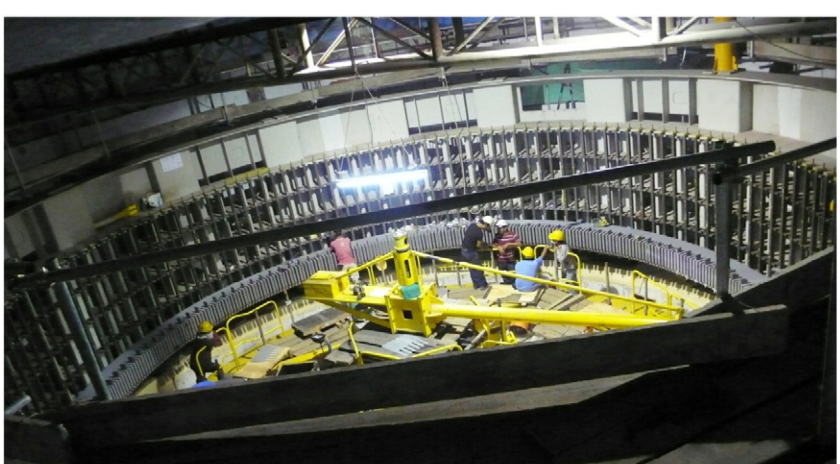

Fig. 2. Foreign welders at the BHP finish one of its turbines, July 2010.

Fig. 3. The spillway of the Bakun Hydroelectric Project.

Social irresponsibility

Lastly, the BHP sired severe social and environmental problems related to forced relocation and resettlement of indigenous people, amplified greenhouse gas emissions, deforestation and pollution. About 10,000 people from the 70,000 hectare reservoir catchment area had to be resettled, against their will, to a 4000 hectare sponsored resettlement site at Sungai Asap. This resettlement process resulted in "entire communities losing their homes, schools, villages, crops, fruit trees, communal forests, and ancestral burial grounds." The communities we spoke with were almost uniformly critical in recounting their experiences with the relocation and resettlement process. The geographical conditions in the Asap settlement are vastly different from that of the Balui Valley, where lifestyles and settlement patterns were largely influenced by their proximity to the rivers. As one resettled villager noted:

> *Before we had to resettle here in Asap, our main source of protein used to be wild boar and fresh fish. Here there is no fish. The Asap river is too small and the Koyan river is too far. Wild boar is extinct in these parts as there is no more forest. It was cool there, but it is hot here. There we could sleep without fans; here we need a fan or air conditioning. We had land for farming there; here we have to travel one hour walking to get to our farmland. There we could use the river for transport; here we have to walk or take a car. There we did not need fertilizer or pesticides; here the land is so harsh that we do. There we used to eat hornbill and what the forest provided; here we have to buy vegetables at the market, we are no longer subsistent. We don't even have the title to this land, meaning if the government wishes to move us again, we have no choice but to go.*

To highlight the reliance on environmental endowments exhibited by residents in rural Sarawak, even two of the guides we hired near Bakun would interrupt our transport between villages to hunt for birds, lizards, and deer to eat because they "had little money for food." Fig. 4 shows one of them cooking wild deermouse for lunch, which one of the authors sampled for the first time.

Other studies have confirmed our somewhat anecdotal findings about resettlement. The Human Rights Commission of Malaysia (HRCM, 2009) found that 80% of the land in the Asap community was unsuitable for cultivation, and the 20% that was cultivatable was rocky and located in remote areas. It also noted that in comparison to minimum subsistence income levels estimated to be RM16000 (US $5200) per year for the region, the average family income in Asap was about RM 5000 per year (US$1600), earned mostly from selling food and vegetables. Rousseau (1994) observed that the resettlement area in Asap is too small for communities to continue to practice swidden agriculture and that, worse, they do not technically own the land, making them more akin to laborers on a plantation. Thomson and Hui (2001) noted that despite promises of compensation, one resettled family was forced to incur a RM 13,700 loan (US$4500) for their house and most of the farmers have become dependent on fertilizers to cultivate crops. Choy further noted that "the Sungai Asap resettlement area is environmentally unsuited to sustaining the social value and cultural identity of the indigenous communities affected by the Bakun Dam project" (Choy, 2004). Jehom (2008), who spent seven months in Sungai Asap and interviewed 1559 people from October 2004 to May 2005 and visited all 15 villages resettled, described the resettlement process as "social disarticulation" for it has "dismantled patterns of social organization, interpersonal ties, and kinship groups." He concluded that:

> *Potential settlers are faced with the critical decision of abandoning their homes and livelihoods, causing emotional distress. Secondly, after moving to the new settlement, settlers are often confronted with inadequate compensation for their loss of natural resources, social heritage and land, adding misery to their already distressed situation. Thirdly, resettling people into an area without any supportive resources, i.e. resources whose purpose is to improve the lives of the settlers compared to their previous situation, fails to accomplish the very purpose of such resettlement.*

Fig. 4. Local Kenyah guides hunt and forage for food near Bakun.

In terms of environmental impact, construction of the BHP has caused widespread deforestation and has adversely affected both hydrological patterns and water quality. It has also altered the course of rivers which harms downstream settlements and jeopardizes the habitats of many endangered species. Choy (2005b) estimated that the BHP will eventually destroy 50 million cubic meters of biomass which currently supports more than 1600 protected plants, 6 rare and endangered fish species, 32 protected bird species, and 6 protected mammals. Endangered species include herons, eagles, woodpeckers, silvered leaf monkeys, Bornean gibbons, langurs, and flying squirrels.

In terms of greenhouse gas emissions, one respondent went so far as to claim that “BHP has massive climate impacts for it essentially took a huge sink of carbon dioxide (a primary forest) and converted it to a source of methane and other greenhouse gases, emissions so large that they are likely equivalent to all of the emissions from Malaysia's coal-fired power plants”.

Respondents also expressed concern that the BHP will alter downstream habitats because the project will change sedimentation patterns, diminish fish stocks and alter the quality of water. In tropical environments, still water bodies are prone to the proliferation of algae. If left unattended, the algae begin to leach oxygen from the water potentially catalyzing a state of hypoxia (oxygen depletion). This threat is amplified in the case of the BHP reservoir because the bottom of the reservoir contains massive quantities of vegetation.

Lastly, participants remarked that the downstream aluminum smelting operation would have its own set of adverse environmental impacts. Aluminum smelting utilizes chemicals such as hydrogen fluoride and silicon tetrafluoride which are hazardous to both human and animal health. The process also emits particulate matter which can be detrimental to human health. As one participant commented, “smelting is highly pollutive and it consumes a lot of electricity, making it a poor choice from an environmental standpoint.” Yet another argued that “when taken together, the methane emissions from the reservoir and HFC-23 and CO_2 emissions from aluminum smelting could double the carbon footprint of if Sarawak had just done coal plants to begin with.” Others expressed concern that the Rio Tinto smelter would operate too closely to the Similajau National Park, home to five species of dolphin including the endangered Irrawaddy dolphin.

The overall impression from field investigations is that the BHP has significantly underperformed in terms of delivering benefits to residents of Sarawak. Rather, there was virtual consensus that the project is to the detriment of the region and to the benefit of pollutive, heavy industry which would extract benefits in the form of subsidized energy and liberal access to raw resources but give little back in terms of enhanced employment or economic value-added.

The soft path: small-scale micro-hydro, biomass, and solar

Meanwhile, as mentioned previously, the Sarawak state government is set to employ RM2 billion (approx. US$650 million) of federal funding to plan and design 2,000 projects for rural electrification intended to provide 80,000 households with electricity from 2010 to 2013, with investment already committed to supporting 10 solar photovoltaic hybrid systems in remote villages and 7 micro-hydro pilot projects. The promise of this “soft path” of energy development utilizing smaller decentralized systems has been effectively summarized above in Section “Hard” and “Soft” Energy Paths.

The remainder of this section extracts observations from our field research to argue that Malaysian planners need not commit themselves to capital intensive, complex, dependent, and inappropriate technology for rural electrification. It argues that three separate small-scale technologies—micro-hydro, biomass, and solar photovoltaics—can in aggregate accomplish what the BHP does while adding value to local communities, generating profits for local businesses, and mitigating impairment of the environment endowments that indigenous rural residents depend upon for sustenance.

Enhancing local benefit

Smaller decentralized forms of electricity supply such as micro–hydro plants or solar panels have the capacity to be owned and operated by indigenous entrepreneurs; therefore, the local economy directly benefits from the provision of such energy services. At Long Lawen, a functional 10 kW micro-hydro system at a remote village near Belaga, seven hours by road from Bakun dam, supplies electricity to more than 70 households. Owned by the *Kenyah Badang* community, the micro-hydro unit (shown in Fig. 5) has been integrated with a rice mill in the turbine house to provide mechanical energy for husking and grinding. It also provides electricity to a communal saw mill and an icehouse. The facility displaced 56 diesel and gasoline powered generators which consumed about 15,000 l of diesel per year. Local community members told us they save RM 110,000 (US$35,700) a year from not having to buy diesel at a nearby timber camp. This savings, which amounts to US$500 per household, is significant when one considers that the average annual income in this region is likely less than US$2000 per year.

Solar photovoltaic panels and solar home systems exhibit similar potential. Compared to the hard path characterized by the BHP which necessitates a dependence on imported Chinese, Korean, and Argentinean technology, a robust solar power deployment strategy could improve local knowledge and produce a number of benefits. As Choy (2005a) surmised:

> *Being an early entrant and a prime mover of inventive activity, Sarawak would be able to enjoy such competitive advantages as increasing returns with adoption, entry barriers and protection from competition, learning effects, and return to scale. Furthermore, the choice of PV technology is also socially and environmentally sustainable when compared with Bakun's technology because it is knowledge based and not resource or pollution intensive.*

Although it should be recognized that some regions may not possess the attributes necessary to allow for affordable soft path energy systems to be developed, this does not pose a problem in Sarawak thanks to an abundance of rivers and access to significant quantities of biomass. Choy (2005b) estimated that at least 155 small and medium hydro project sites near Bakun are more than sufficient to meet the *total* demand for electricity from local households.

Enhanced capacity building

Unlike megaprojects like the BHP, micro-hydro, biomass, and solar technologies integrate with local economies through the use of local materials and/or local labor. Micro-hydro units, for example, utilize rivers in a non-disruptive manner and can be constructed in a fairly low tech manner incorporating more managable low-voltage distribution systems, rudimentary de-sanding basins, and simple masonry lined canals, forebays, and penstocks. Powerhouses need only be as large as a small car, even when they include electronic load controllers and require tailraces. Turbines at these facilities, ranging in size from 1 kW to 100 kW, often weigh less than 50 kilograms and their portability means they can be transported to workshops for repairs. The 25 kW unit at Mudung Abun, depicted in Fig. 6, was made and manufactured almost entirely in Sarawak using local wood and concrete for the canals, the penstock, and the actual dam. The only imported component was the turbine. Biomass generators are similar in that the feedstock can be procured entirely within the community and the system components (with the exception of perhaps the turbine) can be largely cobbled together using local materials. Regarding solar systems, a degree of sophistication is needed in order to manufacture the solar PV panels;

Fig. 5. The 10 kW micro-hydro unit at Long Lawen, Belaga, Sarawak.

however, they are simple to maintain, requiring only "a screwdriver" and "local technician" to install.

Even medium-scale bioelectric plants can incorporate fuels, materials, and labor found easily within Sarawak. Already, the palm oil, wood, and agricultural industries in Sarawak produce RM23 million (US$7.5 million) worth of energy value each year from oil palm waste, waste wood and empty fruit bunches. Choy (2005b) has further estimated that an additional 30 million tons of these byproducts are simply discarded each year. These could, at relatively low cost, be converted into 1530 million kWh of electricity, displacing millions of liters of diesel. Choy (2005b) also calculated that the 42.7 million tons of palm oil mill effluent, also currently discarded, could be put to productive use through anaerobic digestion to produce 2214 million kWh of electricity per year. Even assuming a conservatively low cost of generating electricity of US5¢ per kWh, this implies that nearly US$190 million worth of energy fuels stocks are being squandered each year.

Simplicity

Community-scale renewable energy technologies are also easier to operate and repair because of their smaller size. The simplest, by far, are solar photovoltaic panels, which one respondent noted "are easier to operate than my toaster." Sarawak's equatorial location and abundance of sunshine, gives rise to high solar potential, ranging from 6.0 kWh/day/m^2 to 6.5 kWh/day/m.[2] To put these figures in perspective, that's more than *double* the potential found in the United States and Germany. Choy (2005a) has gone as far as to argue that if the economic benefits associated with reduced pollution, minimized cost overruns, and reliability were internalized, solar PV would already be cost competitive with the BHP. Indeed, Choy argued that if Malaysia had invested $50 million in solar technology from 2005 to 2008, a meager sum compared to the billions needed for the BHP, such volumes would have forced down the unit cost of producing *Malaysian* solar cells and modules even further. Solar panels are also simpler than big dams, Choy concludes, because they avoid the need for constructing massive grids and transmission systems. It merits mention that this was Choy`s contention five years ago. Since then, technological improvements in solar PV technology have improved efficiency and reduced cost.

Micro-hydro units are also "simple to fix and repair," our respondents noted. One mentioned that "fixing our micro-hydro unit is not complicated. There are many of us in the community that can do it." For example, the components of the 25 kW unit under construction at Mudung Abun, shown in Fig. 7, could be carried individually to the project site without heavy machinery or excavators. Fig. 8 depicts one of the village elders who remarked that although he didn't enjoy the manual labor, he was able to construct the powerhouse foundation "with just a few friends and some shovels".

Respondents told us that the simplicity of micro-hydro units often translates into more reliability, especially when compared to the grid

Fig. 6. The 25 kW micro-hydro unit at Mudung Abun.

Fig. 7. Turbine components for the 25 kW Mudung Abun micro-hydro site (under construction).

or diesel generators. The electricity grid in Sarawak is "notorious for being unreliable, with outages almost every day." Stand-alone distributed generation units, mostly diesel or fuel oil, are "expensive to operate" and "a frustration to work with." As one disgruntled villager told us:

> *Our diesel genset is costly to operate. One week it will use more than 20 liters of fuel, and that's only for providing electricity to one house from 6 pm to 11 pm every day used only for lighting and television. There's also the cost of oil to keep the machine lubricated, and the extra costs of either collecting the fuel or paying to have it transported here. I do not think that diesel power can be our future. If the electricity was to be used just for me and my wife, I'd say forget it. I'd rather not have it, but it's my children that need it to read at night.*

Another remarked that:

> *Small generators cost only a few thousand ringgit, but that's excluding maintenance and repairs. My generator breaks down at least once a year, and it costs a few hundred ringgit to fix it every time. I don't know why but my generator is very naughty and evil. It always needs major repairs; it's temperamental in the hot weather and humidity.*

This respondent also mentioned that they "like micro-hydro much, much better—it puts the humidity and the weather to productive use, rather than being degraded by them."

Social responsibility

Small-scale renewable energy technologies exhibit low carbon footprints. Since micro-hydro systems are run-of-river and need no reservoir, the carbon footprint is close to nonexistent. Regarding solar PV, Choy (2005a) estimated that a one square meter solar panel operating in Malaysia saves 40 kg of carbon dioxide emissions per year when it displaces grid electricity. Furthermore, when used as a substitute for the inefficient and all too common diesel genset (depicted in Fig. 9), renewable energy technologies also enhance user safety and improve aesthetics. As one respondent noted "you don't have to have combustible, volatile fuels on hand that can cause fires or leak, and you don't have to worry about the noise, either".

Environmentally, the "soft path" of energy provision represents a strategy for preserving the integrity of a forest ecosystem that produces valuable natural capital. Choy (2005a) has documented that the forests of Sarawak are home to the fourth largest amount of biodiversity in the world after China, India, and Indonesia and provides "a diverse source of invaluable pharmaceutical plants, most of which are unexplored and untapped." Malaysia itself is home to more than 10% of the world's plant species of "high medical value." No less than 287 known species of herbal plants of substantial medicinal value flourished in the reservoir area of the BHP. A list of some of the more prevalent plants is provided in Table 2. Choy estimated that the value of these readily exportable plants and herbs was in excess of US $5 billion, nearly twice the value of the BHP according to government figures.

Explaining support for the hard path: sober lessons for other developing countries

When contrasting the cost overruns and adverse social and environmental problems attributed to the BHP with the economic, social and environmental benefits attributed to smaller, decentralized systems, one might be tempted to conclude that the soft path development strategy should be the only one endorsed by the Malaysian government. This is especially true if Choy (2005b) assertion is correct that a well-focused, decentralized renewable energy development program could meet all of the electricity needs of the region. In an attempt to temper such conclusions, this section will examine five popular justifications for supporting hard path energy projects. However, as will be seen, four justifications are of dubious verity in respect to energy development strategy in Sarawak and the fifth justification is of marginal import that falls well short of justifying the levels of social and environmental damage caused by the BHP project.

Lower generation costs

A widely held tenet of energy planning is that mega energy projects are the most economically efficient. Indeed, one of the interview subjects involved in the BHP echoed such a sentiment:

> *Bakun, like many large projects, enjoys economies of scale and therefore is able to achieve a much favorable power-to-dollar density* [than a collection of smaller hydro-projects]. *Small-scale hydro-power may require less capital but the density would be lower resulting in a lower capacity in total.*

Unfortunately, there are at least four significant reasons why this tenet is rarely true in developing nations. First, all of the external costs associated with the development of mega energy projects—environmental degradation, adverse health impacts due to pollution, costs associated with the displacement of communities—are rarely factored into the cost of projects. While this is true of mega energy projects anywhere in the world, it is particularly an issue in developing nations that typically set lower regulatory standards for such projects and often possess fewer resources for stringent project oversight (Rajagopalan, 2005). Second, the opportunity costs associated with degraded or denuded land are rarely internalized

Fig. 8. The Mudung Abun powerhouse being dug by hand.

into the overall costs of such megaprojects. In the case of the BHP, the value of the land to be submerged – estimated to be at least US$5 billion (Choy, 2005a) — has never been factored into the project cost. Third, corruption which is rampant in the construction industry of many developing countries leads to inflated costs which frequently only become apparent near the latter half of such projects, locking developers into projects that seldom meet cost projections. The BHP, for example, was identified by Transparency International as a "monument to corruption" in its Global Corruption Report of 2005 (Transparency International, 2005). Fourth, downtime is rarely factored into energy cost estimates. Although downtime associated with hydroelectric projects is less than downtime attributed to other conventional generation sources (i.e. coal-fired power and nuclear power), when a major problem does occur with hydroelectric projects, is typically a very costly, time-consuming event. Unfortunately, in developing countries, maintenance is typically of a lower standard and as a result the propensity for major equipment failure is inflated.

Even if all of these potential threats to cost minimization can be averted, the manner in which financial benefits associated with mega energy projects are distributed tends to undermine claims of superior cost-effectiveness in developing countries. Due to the heavy investment requirements of mega energy projects, multinational engineering firms tend to dominate. As outlined earlier, this is indeed the case with the BHP. In such circumstances, the profits associated with these projects rarely wind up re-circulating back into the local economy, meaning the multiplier effect which typically drives economic growth (Frank and Bernanke, 2007) never has a chance to materialize.

In short, the belief that mega energy projects are more economically efficient than smaller, decentralized energy projects is of dubious verity when all costs associated with these projects are internalized, and is very likely a spurious belief in developing nations where amplified levels of pollution, project downtime and corruption exacerbate economic efficiency.

Ease of management

Another common justification for supporting hard path over soft path energy initiatives stems from the perception that on a kWh basis,

Fig. 9. A 15 kW diesel generator and discarded fuel cartons near Long Wat, Murum, Malaysia.

Table 2
Known medical plant species in the Bakun Reservoir Region and potential uses. Source: (Choy, 2005a).

Plant	Number of species	Medical uses
Acanthaceae	10	Fever, hypertension, inflammation, diabetes, stomach ache, sprains, headaches
Annonaceae	22	Diarrhea, fever, asthma, insect repellant, skin disease, eye infection, stomach ache
Apocynaceae	8	Hypertension, diabetes, fever, yellow fever, swollen joints
Araceae	5	Cough, insect bites, skin disease, fever
Compositae	15	Headaches, fever, rheumatism, anti-malaria, gastric ulcer, boils, swelling, chest pains, mumps
Convolvulaceae	5	Cuts, wounds, diarrhea, poisonous animal bites, headache
Cyperaceae	4	Diarrhea, fever, antidote, tonic
Dilleneniaceae	4	Diarrhea, bleeding, cough
Euphorabiaceae	23	Toothache, sore eyes, dysentery, ulcers, muscular pain, fever
Graminae	6	Asthma, fever, cough
Labiatae	9	Fever, skin disease, dysmenorrheal, amenorrhea, hypertension
Lauraceae	5	Rheumatism, lumbago, tonic
Leguminosae	19	Gonorrhea, cough, ringworm, asthma, chicken pox, nose bleeding, inflammation, burns on skin
Melastomataceae	9	Headache, fever, dysentery, diarrhea, rheumatism
Menispermaceae	6	Poisonous animal bites, conjunctivitis, gastric ulcer, hypertension, diabetes
Moraceae	5	Diarrhea, boils, abscesses
Myrsinaceae	4	Fever, tonic, chicken pox, skin diseases
Myrtaceae	5	Post-parturition aids, diarrhea, hypertension, yellow fever
Piperraceae	4	Rheumatism, heart pain, sprains
Rubiaceae	13	Fever, vomiting, chills, conjunctivitis, eye infections, dysentery
Schizaeceae	4	Eye infections, animal bites, fever, rheumatism
Solanaceae	4	Skin diseases, hypertension, sore throat, cough, fever
Verbemaceae	7	Diarrhea, fever, headache, inflammation, post-parturition aids
Zingiberaceae	10	Tonic, skin disease, fractures, fever, cough, swelling
Others	81	Chest pain, anti-malaria, dysmenorrheal, poisonous insect bites, fever, cough, cholera, burns, abortifacient, tuberculosis, scabies, ringworm, sore throat

megaprojects are easier to manage because the management challenge is centralized at one site. As one interview subject surmised:

> *There are technical and geographical barriers in building bundles of small hydropower to accumulate such a huge capacity, so much so that it is also technically and economically not viable to transmit power from scattered mini-hydro sites to meet [Sarawak's] overall demand.*

There is a great deal of research support in management literature that supports the contention that centralized operations are easier to manage than decentralized operations (Bartlett et al., 2003; Meredith and Mantel(Jr), 2006). However, there is one substantial reason why this might not be true when comparing the challenges of managing one mega energy project to the challenges associated with managing a number of soft path energy projects which add up to the same aggregate generation capacity total—technological disparity. Ensuring engineering precision is paramount to the success of mega energy projects such as the BHP. Accordingly, management challenges confronting such projects include complex, quality control issues in addition to the human resources and logistics management challenges typically associated with any construction project. On the other hand, although the decentralized nature of soft path initiatives may complicate the management of human resources and logistics, the relative technological simplicity associated with these projects reduces the need for precision quality control that typically eats up a great deal of project management time in mega projects.

Control over corruption

Another justification for supporting development of mega energy projects over a number of smaller, decentralized energy projects stems from the belief that it is easier to control corruption associated with one large project than to control corruption associated with a number of smaller projects because financial control can be consolidated to fewer responsible parties who can then be monitored more closely because of the central site. Essentially then, this premise is the same as the premise that centralized operations are easier to manage. Therefore, the management literature which supports the benefits of centralized management also applies to control over corruption.

However, there are two elements that cast doubt on this premise when applied to energy planning. First, mega energy projects are multi-billion-dollar initiatives. Therefore, the level of corruption associated with such projects is frequently of a similar epic scale. It is for this reason that the BHP was dubbed a "monument to corruption" by Transparency International. On the other hand, soft path initiatives involve technologies that are modularized and as result, are characterized by fairly uniform cost profiles within each technology. This makes it difficult for project developers to get away with artificially inflating costs. Furthermore, soft path initiatives are typically started by entrepreneurs who act as both the investor and the developer, so there is reduced incentive to inflate costs. Second, as supposed to mega energy projects which serve a massive customer base, smaller decentralized projects are typically community initiatives which benefit from a high degree of local community oversight. The micro-hydro / rice milling unit operated by the *Kenyah Badang* community, which was described earlier, exemplifies such a project (ref. Fig. 5).

Political strategy

Large-scale energy projects tend to attract NIMBY (not in my backyard) opposition. Accordingly, siting of such installations can be politically contentious. Therefore, ceteris paribus, project developers tend to favor installation sites which exhibit the lowest potential for opposition. This means that regions which are either sparsely populated or weakly (or corruptly) governed tend to be seen as attractive locations for such developments.

Sarawak certainly fits the bill of being a sparsely populated region and its wealth of hydropower potential makes it an attractive target for exploitative federal projects. However, that does not seem to be the case with the BHP. Financially, the Sarawak State Government stands to gain significantly from the development of the federally funded BHP. When operational, the Sarawak State Government will receive an initial one-off payment of RM320.9 million (US$104 million) which consists of RM162.3 million as a special payments to recoup the state for costs incurred during the development of the project, RM155 million in water royalties and RM3.6 million in licensing fees. In addition to the one-off payment, the state government will also receive RM320 million (US $100 million) in annual royalties. Additionally, once an undersea cable to the Malaysian peninsula is completed (slated for 2017), the state government will receive additional royalties based on the amount of electricity throughput to the mainland (Then, 2010). In short, the BHP appears to be a sincere albeit ineffective attempt on the part of the federal government to stimulate economic development in Sarawak.

Megaprojects as statements of national honor

Energy megaprojects tend to exhibit high symbolic value. Construction of the Hoover dam between 1931 and 1935 served as a symbolic point of optimism of the ability of the United States to emerge from the Great Depression (Stevens, 1990). Similarly construction of the Obninsk nuclear power plant, which came online in 1954, becoming the world's first civilian nuclear power facility, served to highlight emerging technological prowess of the Soviet Union (Josephson, 2005). Similarly, nuclear power programs in India and South Korea were in part driven by aspirations to produce economies characterized by technological sophistication (Sovacool and Valentine, 2010; Valentine and Sovacool, 2010).

In the case of Malaysia, there is clear evidence that the Malaysian government embraces such symbolic statements. One needs merely to visit the Petronas Towers in Kuala Lumpur or tour a Proton automobile showroom to understand the importance with which the Malaysian government perceives statements of technological competence. Accordingly, of the five justifications for prioritizing hard path energy projects over soft path projects, the symbolic value of the BHP is perhaps the rationale that is most valid. As the website for the BHP decries, the project represents “Malaysia's Future in Clean Energy”.[3]

In summary, on the surface, only one of the five justifications typically put forth for supporting the development of mega energy projects appears to be valid justification for the BHP. The social and environmental damage caused by this project exacts a very heavy price if only to make a symbolic statement. However, we surmise from comments made by those involved in the construction of the BHP that the four other justifications that were invalidated in this section were actually *deemed* to be valid justifications by project planners and in public policy perspective can sometimes trump truth.

Conclusion: the art of bending bamboo

It should be clear to readers by now that a soft path of energy system development represents the most beneficial path for residents of Sarawak. This path involving micro-hydro, solar, and biomass energy provides business opportunities to local entrepreneurs. It enhances local capacity by better integrating local materials and local labor into such projects. The technologies used in the soft path are easy to operate and repair which implies less downtime and more community involvement (employment) in the maintenance of such systems. Lastly, soft path energy projects integrate with—rather than degrade—environmental endowments.

However, it should also be clear from our analysis (and the existence of the BHP) that there is a great deal of support at government planning levels for mega energy projects of this type and indeed at least 10 more large-scale projects are planned for the Sarawak region. Although we contend that support for these megaprojects is based on false perceptions of advantages, it is important when putting forth development recommendations to understand that these misperceptions can derail proposals for soft path energy diffusion strategies, regardless of their merits. This does not mean that hard path projects have no place in Malaysia or other developing countries, only that they may be well suited for industrialization rather than rural electrification or poverty alleviation. Put another way, the hard path may be beneficial in some contexts, just not for Sarawak and Borneo.

Energy planning is characterized by a high level of “stickiness” (Boettke et al., 2008). This is because energy planners tend to prioritize support for technologies that they are most comfortable with because energy planners like other policy planners tend to exhibit high degrees of risk aversion (Valentine, 2010). A sense of comfort arises from elevated understanding of the technologies under consideration and from having previous experience in implementing those very technologies. In contrast to the adage that *familiarity breeds contempt*; in energy planning, familiarity breeds contentment. Even when there are emerging indications that new technologies offer superior results, one can expect substantial resistance from risk-averse energy planners.

The “stickiness” of conventional energy technology has played a role in prompting some soft path proponents to conclude that soft and hard paths are incompatible. When concluding his thoughts about soft and hard paths in the 1970s, Lovins argued that the two approaches were “culturally incompatible” since “each path entails a certain evolution of social values and perceptions that makes the other kind of world harder to imagine” (Lovins, 1979b). Herman Daly (1979) surmised that the choice between the hard and soft paths relied on different orders of thinking—much like the difference between chess and checkers. The soft path recognized sustainability and ecological integration as guiding principles. The hard path prioritized resource extraction and profit making. Daly mused that a good move in the checkers of the hard path was not usually a wise one in the chess of the soft path.

To the contrary, this paper has demonstrated that soft and hard paths are not incompatible in regard to energy infrastructure planning in Sarawak. While construction of the BHP has pressed ahead, the Sarawak government has announced plans for micro-hydro and solar photovoltaic hybrid system pilot projects in remote villages as part of a US$ 650 million initiative put forth under the NKRA scheme for 2000 small-scale energy projects throughout the state. Clearly a degree of ideological co-existence is present in Sarawak.

For the authors, the dichotomous electrification development strategy on display in Sarawak in conjunction with widespread signs of community dissonance related to the hard path approach signifies that energy planning in Malaysia may indeed be in the early stages of a paradigm shift wherein the advantages of the soft path are becoming more evident to broader groups of influential stakeholders and the disadvantages of the hard path are increasingly criticized. Thomas Kuhn, in his seminal work defining “paradigm shift”, points out that the early stages of a paradigm shift are signified by an increase in anomalous events which challenge the verity of the existing paradigm and which fuel escalating criticism (Kuhn, 1967/1996). In Sarawak, this could be at the nascent stages of occurring.

From the perspective of the authors, the two most relevant threats to the diffusion of soft path energy systems in Sarawak stem from implementation failures associated with soft path projects and continued government support for megaprojects as statements of national honor. In regard to ensuring the efficacy of implementing the projects funded under the NKRA scheme, the admonition of Lovins that soft path projects require a different level of social engagement is highly relevant. Tendering systems need to be adapted to entice participation by local communities. Different approaches to oversight are required in order to minimize the potential for corruption associated with managing higher volumes of public participants in energy supply. Training systems need to be established in order to allow members of the local community to take ownership over the design and maintenance of such projects. New approaches to managing the electricity grid will be required to help integrate numerous decentralized systems. Templates for environmental impact assessments need to be developed for each technology to ensure that adequate knowledge exists to allow these systems to integrate effectively with the natural environment. New permitting processes will need to be developed and managed. In short, providing the support for implementation effectiveness of soft path energy systems is a labor intensive process that differs substantially from the tasks necessary to develop and oversee hard path projects. Failure of the Malaysian government to train its energy planners to manage the roll out of these initiatives will likely result in widespread implementation inefficiencies. This in turn will fuel defense of the status quo and prolong the dominance of hard path energy planning ideology.

Moreover, there is little that can be done if Malaysia's federal government continues to drive mega projects at the expense of soft

[3] The BHP website is: http://www.bakundam.com/home.html.

path development. Under the Sarawak Corridor of Renewable Energy (SCORE) initiative discussed earlier, a number of additional large-scale dam projects are being planned for Sarawak. Despite massive problems associated with the BHP, there appears to be no indication that these additional projects are being shelved. Rather, it appears that fiscal constraints caused by the recent global economic slowdown have simply delayed the construction of future dams.

It may very well be that in a Malaysian political context, where "losing face" is a valid political concern, a complete reversal of plans to develop more large-scale dam projects in Sarawak may be infeasible. This is where cultural understanding of the Asian interpersonal strategy of allowing a decision maker to "save face" becomes critical in devising strategies to encourage the adoption of more optimal electrification strategies. Allowing a person to "save face" is facilitated by either an accommodating strategy that simply allows an indiscretion to go unchallenged or a collaborating strategy wherein an attempt is made to acknowledge the plausibility of the logic leading to a given indiscretion and then encourage slight alterations to improve the outcome. For example, in regard to the plan for financing the construction of more large-scale dams under the SCORE initiative, it may be possible for those seeking to facilitate such change by first acknowledge that the BHP has sent a strong pro-development message to the people of Sarawak and then putting forth an alternate plan of scaling down the size of projects—introducing local labor employment stipulations, mandating more stringent environmental impact assessments and reducing the environmental footprint of future projects—as a way of improving upon the "unanticipated" negative consequences associated with the BHP.

In conclusion, this study has demonstrated that the soft path is the preferred one for electrification in Sarawak, but it is not necessary a path that will be supported. Advocating a soft path strategy in the presence of clear evidence that the strategy faces insurmountable obstacles at present is what the Malaysians would describe as *"anjing menyalak di ekor gajah"* (a dog barking at an elephant's tail). The political realities suggest that soft pressure will encourage more rapid change. As another Malay adage advises *"melentur buluh biarlah dari rebungnya"* — to bend bamboo, start from its shoot.

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Appendix 1. List of Institutions Interviewed

Alstom Hydro
Bar Council of Malaysia
Borneo Resources Institute Malaysia
Centre for Environment, Technology, and Development Malaysia
Centre for Orang Asli Concerns Malaysia
Economic Planning Unit, Prime Minister's Department
Friends of the Earth
Global Environment Facility
Human Rights Commission of Malaysia (SUHAKAM)
Institute of Strategic & International Studies Malaysia
International Rivers Network
Ministry of Energy, Green Technology and Water
Ministry of Natural Resources and the Environment
Ministry of Tourism
National Economic Advisory Council, Malaysia
Natural Resources and Environment Board Sarawak
OSK Research
Partners of Community Organizations
Petronas
Public Private Partnership Unit, Prime Minister's Department
Regional Corridor Development Authority (RECODA)
Sarawak Energy Berhad
Sarawak Hidro Sdn Bhd
Sarawak Iban Dayak Association
Sarawak Rivers Board
Sarawak State Government
Sime Darby
Snowy Mountains Engineering Corporation
State Planning Unit, Sarawak State Government
Suara Rakyat Malaysia (SUARAM)
Syarikat Sesco Berhad (Sarawak Electricity Supply Corporation)
Tenaga Nasional Berhad
The Borneo Project
Third World Network
United Nations Development Program Malaysia
Universiti Malaysia Sarawak
World Wildlife Fund International

References

Baginda AR. Malaysia in transition: politics, economics & society. Malaysia: ASEAN Academic Press; 2002.
Bartlett C, Ghoshal S, Birkinshaw J. Transnational management. 4th edition. USA: McGraw-Hill / Irwin; 2003.
Blaikie N. Designing social research. UK: Polity Press; 2000.
Boettke PJ, Coyne CJ, Leeson PT. Institutional stickiness and the new development economics. Am J Econ Sociol 2008;67:331–58.
Boyle G. Renewable energy: a power for a sustainable future. 2 ed. UK: Oxford University Press; 2004.
Choy YK. Sustainable development and the social and cultural impact of a dam-induced development strategy—the Bakun experience. Pac Aff 2004;77:50–68.
Choy YK. Dam-induced development and environmental and social sustainability: the Bakun industrialization strategy revisited. J Econ Issues 2005a;39:123–50.
Choy YK. Energy demand, economic growth, and energy efficiency—the Bakun dam-induced sustainable energy policy revisited. Energy Policy 2005b;33:679–89.
Cook TD, Campbell DT. Quasi-experimentation: design & analysis issues for field settings. Boston, USA: Houghton Mifflin Company; 1979.
Daly HE. On thinking about future energy requirements. In: Unseld CT, Morrison DE, Sills DL, Wolf CP, editors. Sociopolitical effects of energy use and policy. Washington, DC: National Academy of Sciences; 1979. p. 232–40.
Frank RH, Bernanke BS. Principles of macro-economics. 3 ed. USA: McGraw-Hill / Irwin; 2007.
Government of Malaysia. Ninth Malaysia Plan: 2006–2010. In: The Economic Planning Unit of the Prime Minister`s Office (EPU/PMO), editor. Putrajaya, Malaysia: Government of Malaysia; 2006.
Government of Malaysia. In: Statistics Do, editor. Preliminary Count Report 2010. Kuala Lumpur: Government of Malaysia; 2011.
HRCM. Report on the murum hydroelectric project and its impact towards the economic, social and cultural rights of the affected indigenous peoples in Sarawak. Kuala Lumpur, Malaysia: Human Rights Commission of Malaysia (HRCM; 2009.
Jehom WJ. Development and displacement: Kenyah-Badeng in Bakun Resettlement Malaysia. Bonn, Germany: Universität zu Bonn; 2008.
Josephson P. Red atom: Russia's nuclear power program from Stalin to today. Pittsburgh, USA: University of Pittsburgh Press; 2005.
Kuhn T. The structure of scientific revolutions. 3 ed. Chicago, USA: University of Chicago Press; 1967/1996.
Lee KS. Due diligence on cost of Bakun dam project. Kuala Lumpur: Malaysia Star. online ed; 2010.
Lovins A. Energy strategy—the road not taken? Foreign Aff 1976;55.
Lovins AB. Soft energy technologies. Annu Rev Energy 1978;3:477–517.
Lovins AB. Soft energy paths: towards a durable peace. New York, USA: Harper Collins; 1979a.
Lovins AB. A target critics can't seem to get in their sights. In: Nash H, editor. The energy controversy: soft path questions and answers. San Francisco, USA: Friends of the Earth; 1979b. p. 15–34.
Meredith JR, Mantel(Jr) SJ. Project management: a managerial approach. 6 ed. USA: John Wiley & Sons; 2006.
Rajagopalan R. Environmental studies: from crisis to cure. Oxford, UK: Oxford University Press; 2005.

Ritzer G, Goodman DJ. Sociological theory. 6 ed. Singapore: McGraw-Hill Asia; 2003.
Rochlin GI, Meier AV. Nuclear power operations: a cross-cultural perspective. Annu Rev Energy Environ 1994;19:153–87.
Rousseau, Jérôme. 1994. *The Bakun Project: Review of Socio-Economic Studies and Preliminary Recommendations for the Resettlement of the Kayan and Lahanan of the Upper Balui* (Kuching: Report Submitted to the State Planning Unit, Jabatan Ketua Menteri, Sarawak, September 27).
Schumacher EF. Small is beautiful: economics as if people mattered. New York, USA: Harper & Row; 1973.
Sovacool BK. The dirty energy dilemma: what's blocking clean power in the United States. USA: Praeger Publishers; 2008.
Sovacool BK, Valentine SV. The socio-political economy of nuclear energy in China and India. Energy 2010;35(9):3803–13. [September].
Stevens JE. Hoover dam: an American adventure. Oklahoma, USA: University of Oklahoma Press; 1990.
Then S. Bakun dam set to become a cash cow. Kuala Lumpur: Malaysia Star. Online ed; 2010.
Transparency International. Global Corruption Report 2005. Berlin, Germany: Transparency International; 2005.
Valentine SV. Disarming the population bomb. Int J Sustainable Dev World Ecol 2010;17:120–32.
Valentine SV, Sovacool BK. The socio-political economy of nuclear power development in Japan and South Korea. Energy Policy 2010;38:7971–9.
Whetten DA, Cameron KS. Developing management skills. 8 ed. Upper Saddle River, NJ, USA: Prentice Hall Publishing; 2010.
Yin RK. Case study research: design and methods. 4 ed. Newbury Park, USA: Sage Publishing; 2008.