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CASE STUDY

# Energy planning and development in Malaysian Borneo: Assessing the benefits of distributed technologies versus large scale energy mega-projects

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ABSTRACT

**A contentious debate is taking place over plans for a series of mega-dams under development in Malaysian Borneo. There is little quantitative analysis of the energy options or cost and benefit trade-offs in the public discussion or the literature. To fill this gap we developed a model of the proposed energy system and alternative scenarios using the commercial energy market software PLEXOS. We prepared a 15 year long-term capacity energy expansion model for the state of Sarawak which includes existing generation, resource and operability constraints, direct and indirect costs. We explore a range of demand growth and policy assumptions and model the resulting generation mixes and economic trade-offs. Our central finding is that a diversified generation mix including solar and biomass waste resources can meet future demand at lower cost than additional dam construction.**



## 1. Introduction: megaprojects and long term energy planning

Energy megaprojects have become a defining feature of the modern energy transition. Whether driven by growing demand stemming from urbanization and industrialization — or by energy security concerns over foreign dependence and price volatility — large, centralized, national and transnational energy projects are now common centerpieces of energy strategy in many developing countries [1]. Development of large infrastructure is generally characterized by the involvement of a wide spectrum of actors. These projects can be conceptualized as socio-technological systems — embedded in the surrounding socio-economic environment and co-evolving with socio-political institutions. There is, understandably, inherent inertia against departing from the established, centralized patterns of control [2]. This can be a barrier to addressing the multi-dimensional nature of energy access needs.

A critical aspect of energy infrastructure is scale. Because of considerations such as population density, connectivity, rurality or the delocalized nature of industry, scale becomes a key element in determining how to plan and manage infrastructure. Likewise, though the mantra of energy security is often used to justify large-scale energy projects, electricity demand is often overstated and the projects themselves often serve to exacerbate existing social tensions and conflicts, intensifying various manifestations of insecurity [3]. Balancing the need for large infrastructure with locally appropriate solutions thus presents a very real governance challenge.

While there is widespread agreement on the need for a combined approach, most national energy or electrification strategies contain very few details on the integration of decentralized systems and little information on the potential for distributed solutions is available for public discourse [4]. We see this story playing out across Asia, Latin America and Africa where the mega-dam has become a resurgent solution for energy service. A renaissance of World Bank funding for large hydropower projects after a decade long lending hiatus during the 1990s along with infusions of new capital from middle-income countries is driving investment in these large-scale national energy projects. The Three Gorges Dam of China was completed in 2006 [5,6], while the Nam Theun Dam (completed in 2010) and the Xayaburi Dam (under construction) in Laos are the first of a series of dams being built in the transboundary Lower Mekong Basin [7,8]. Construction on the Grand Inga Dam in the Democratic Republic of Congo begins this year [9],

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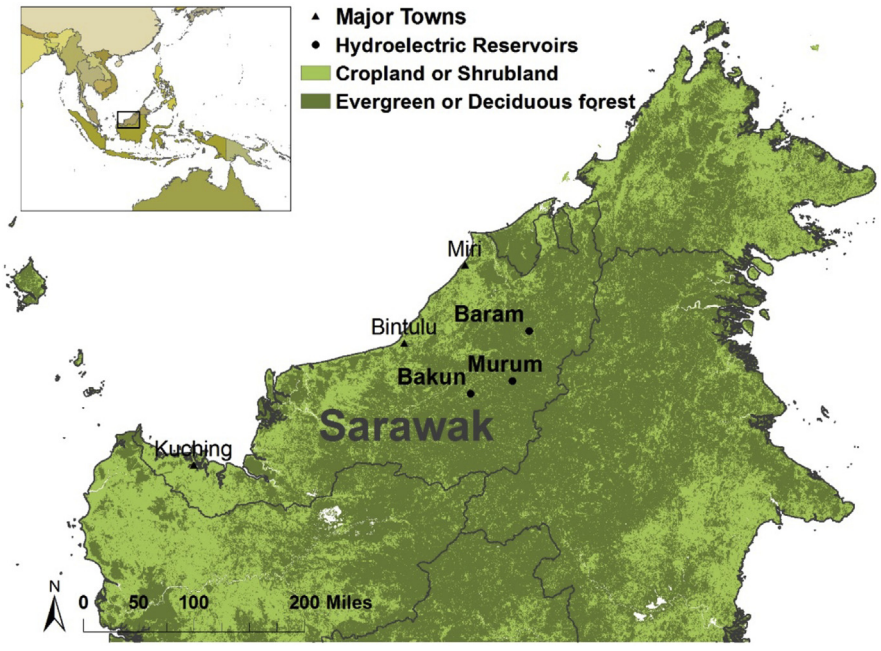


**Fig. 1.** Location of Sarawak, its major towns and the three SCORE dams completed or under construction.

while the Belo Monte Dam in northern Brazil is expected to be completed by 2019 [10]. Tension is growing between civil communities and policy makers as decisions affecting land rights, resource use, industry, and social and ecological health are being made with little discussion of necessity, risk and alternatives.

Our research aims to address this gap and contribute to the literature on management of energy transitions. We present an adaptation of a long term energy planning and analysis tool and demonstrate its use in comparing transition pathways using contemporary mega-dam development in Borneo, East Malaysia as a case study [11].

The island of Borneo has abundant natural resources, immense global ecological importance, a largely rural population and an agrarian economy on the cusp of major industrial transformation. It is a relevant case study to explore the role of decentralized energy systems as well as the direct and indirect costs of supplying energy service. We create a capacity expansion model, which incorporates existing energy infrastructure stocks, resource constraints and system operability constraints to determine technically feasible options for clean electricity supply that satisfy future demand. We use this model to explore the economic, technical and land-use trade-offs of various future energy system configurations under different assumptions of demand growth and different policy scenarios. Our findings are applicable to other developing countries where assessment of large-scale energy infrastructure is critical to public policy discourse.

The remainder of this paper is organized as follows: Section 2 presents our case study. Section 3 describes the methodology, software simulation tool used, demand growth forecasting, data collection and policy scenario development. Section 4 summarizes the results and our model limitations. Section 5 presents our conclusions and a discussion of the implication for other developing countries.

## 2. Background: the Sarawak corridor of renewable energy

In 2006, the Federal Government of Malaysia embarked on a number of initiatives to promote balanced regional development and accelerate growth in designated geographic areas through the Ninth Malaysia Plan [12]. The Plan describes a philosophy of development focused on decentralizing economic growth away from the federal capital through the establishment of *economic corridors* in different states.[1] The Sarawak Corridor of Renewable Energy (SCORE) is a corridor in central Sarawak, an East Malaysian state on the island of Borneo. SCORE differs fundamentally from the other Malaysian economic corridor projects in its predominant emphasis on hydropower [13].

Sarawak, located along the northern coast of the island of Borneo (Fig. 1), is the poorest and most rural state in Malaysia. An increased focus on cheap electricity to attract manufacturing and industry is the state's approach to achieving high income economy status. The current peak annual energy demand in Sarawak is 1250 MW [29], met by a mix of diesel, coal and natural gas generation either operated or purchased by the state utility company. Over the long term SCORE involves building out 20 GW of hydroelectric capacity in Sarawak through a series of 50 dams.

At least 12 large hydroelectric dams and two coal power plants, together constituting 9380 MW of capacity, are scheduled to be built before 2030 [11,14]. Six dams are scheduled to be completed by 2020 with three major dams already under different stages of development (see Fig. 1) [21]. In 2012 the 2400 MW Bakun dam became operational [15]. At 205 m high it is Asia's largest dam outside China. The dam's reservoir submerged 700 $km^2$ of land and displaced about 10,000 people [18]. In 2013 the 944 MW Murum dam was completed and its reservoir is currently being filled. Access roads for the 1200 MW Baram dam have been cleared but preparatory construction work has been stalled since 2013 due to road blockades by local community protesters [16].

With this hydropower backbone the SCORE plan involves attracting investment to promote a number of priority industries in hubs across the state. These priority industries include heavy industry such as glass, steel and aluminum as well as resource based industry such as livestock, aquaculture, tourism and palm oil. The SCORE plan will also involve doubling land area under palm oil plantation concession (to 2 million hectares) by 2020 [11]. The state anticipates these projects will

[1] The five prescribed corridors are: Iskandar Malaysia in Johor; The Northern Corridor Economic Region (NCER) covering the states of Kedah, Pulau Pinang, Peris and Perak's four northern districts; The East Coast Economic Region (ECER) covering the states of Kelantan, Pahang, Terengganu and Johor's Mersing district; The Sarawak Corridor for Renewable Energy (SCORE) and The Sabah Development Corridor (SDC).