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PATHWAYS TO A SUSTAINABLE AND JUST TRANSFORMATION OF THE MEKONG REGION'S ELECTRICITY SECTOR

EDITED BY:

Carl Middleton
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Center for Social Development Studies

The Center for Social Development Studies (CSDS) within the Faculty of Political Science of Chulalongkorn University produces critical interdisciplinary research on social development in Southeast Asia, engages in policy-making through building partnerships, supports young and mid-career researchers and public intellectuals through hosting fellowships, internships and our affiliated graduate studies in international development studies program, and provides a public forum for debating critical issues. Since 2018, CSDS has hosted the Chulalongkorn University Center of Excellence on Resource Politics for Social Development (www.csds-chula.org).

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Table of Contents

Acronyms

ACE	ASEAN Center for Energy
ADB	Asian Development Bank
ASEAN	Association of Southeast Asian Nations
BDS	Basin Development Strategy (of the Mekong River Commission)
BRI	Belt and Road Initiative (of People's Republic of China)
CBAM	Carbon Border Adjustment Mechanism
CO2	Carbon Dioxide
CSO	Civil Society Organization
DFIs	Development Finance Institutions
DRE	Decentralized Renewable Energy
EdC	Electricity du Cambodge
EDL	Électricité du Laos
EER	Energy Efficiency Rating
EGAT	Electricity Generating Authority of Thailand
ESB	Enhanced Single Buyer
ESCOs	Energy Service Companies
EU	European Union
EVN	Vietnam Electricity
EVs	Electric Vehicles
FiTs	Feed-in-Tariffs
GDP	Gross Domestic Product
GHG	Greenhouse Gas Emissions
GMS	Greater Mekong Subregion
GW	Gigawatt
GWh	Gigawatt-hour
HVDC	High Voltage Direct Current
IEA	International Energy Agency
IPPs	Independent Power Producers
IRENA	International Renewable Energy Agency
KWh	Kilowatt-hour
LCOE	Levelized Cost of Energy
MOFCOM	Ministry of Commerce People's Republic of China
MoU	Memorandum of Understanding
MRC	Mekong River Commission
MTE	Marginal Trapping Efficiency
Mt	Million tonnes
Mtons	Million tons
MW	Megawatt
MWh	Megawatt-hour
NDCs	Nationally Determined Contributions
NEP	National Energy Plan
NEPC	National Energy Policy Council
NGO	Non-Governmental Organization

Acronyms

NGV	Natural Gas Vehicle
PDP	Power Development Plan
PPA	Power Purchase Agreement
PSH	Pumped Storage Hydro
PV	Photovoltaic
RE	Renewable Energy
ROIC	Return on Invested Capital
SDG	Sustainable Development Goals
SPPs	Small Power Producers
SOEs	State-Owned Enterprises
TWh	Terawatt-hour
UHV	Ultra-High-Voltage
UNDP	United Nations Development Programme
VSPPs	Very Small Power Producers
WB	World Bank

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PATHWAYS TO A SUSTAINABLE AND JUST TRANSFORMATION OF THE MEKONG REGION'S ELECTRICITY SECTOR

Carl Middleton and Tarek Ketelsen

Introduction

As electricity demand continues to rise across the Mekong Region, the current approach to meeting this demand has been predominantly new supply generated by large-scale coal-fired and gas-fired power stations, or large hydropower dams. There are a growing number of reasons to suggest that the current technologies and practices of the electricity sector in the region could be on the cusp of transformation. There are various initiatives, for example, towards decentralized and large-scale renewable electricity (RE), energy efficiency (EE) and demand side management (DSM) that in general result in less risk of environmental and social harm, and that are gaining momentum even as their full potential has not been realized (Foran et al, 2010). 'Disruptive' technological changes, such as electric vehicles and battery storage, also hold the potential to shift the electricity systems in the near future. More broadly, emerging actions on climate change including the implementation of the Paris Agreement and more specific initiatives such as the European Union's plans for border tariffs on embedded carbon, could significantly change the wider landscape within which electricity decision-making takes place. While this context is certainly dynamic, the electricity sector's future form is by no means determined. Despite all the indicators that are suggestive of a significant transformation being imminent, the 'business as usual' practices, technologies, and policies of electricity generation and supply are also well embedded economically, socially, and politically, and various actors who currently benefit from them may have reason to question and hinder the changes proposed.

How electricity is generated, and how it is accessed, is of central importance to sustainable development in the Mekong Region, including in terms of environmental impacts, social wellbeing, and economic growth. On the one hand, electricity brings a range of social and environmental benefits, for example powering various household services such as lighting and electrical appliances such as refrigerators. It also powers public services such as street lighting or mass transport systems, the latter of which can improve urban environmental quality. On the other hand, depending on the choices of electricity generation, a range of social and environmental harms and risks are generated, including forced displacement, pollution, and ecological degradation. The Sustainable Development Goals (SDGs), which all of the region's governments have committed to, also address affordable and clean energy (SDG7), and how electricity is generated and used is of consequence to many if not all the other goals. Recently there have been several important studies produced by civil society groups and think tanks that have drawn attention to the significant potential for RE in the region (e.g. AVI and KAS, 2021; Phoumin et al, 2020; WWF, 2016). These opportunities are also regularly reported on in the media and the subject of opinion pieces, as well as electricity plans and policies more broadly and on flashpoint controversial projects (e.g. Opperman and Kammen, 2020; Guild, 2021). A growing number of academic studies have also pointed towards the significant potential for a renewable energy transition in the region (e.g. Huang et al, 2019; Siala et al, 2021). Renewable energy industry-connected organizations are also seeking to promote and accelerate the electricity transformation process through research and policy advocacy (e.g. IRENA, 2018; Tagub and Lister, 2021; REN21, 2021).

Until recently, electricity planning was largely perceived to be the domain of technical experts, although some projects proposed would attract controversy, public protest and debate. However, this debate is typically on the periphery of the technical decision-making process. There is now, however, growing recognition that electricity policy and planning – and the principles and processes by which it is conducted – is an important dimension of attaining sustainable development (Smits, 2015). More broadly, it is increasingly recognized that electricity demand itself can be understood as the product of societal decisions associated with modernization and the expansion of mass consumerism, for example encouraging the purchase of various electrical appliances that reflect lifestyle choices (Shove, 2015). This itself is significant, as technical studies tend to assume that expanding electricity demand is a given to be then addressed by supply side (generation) or demand side (energy efficiency / demand side management), rather than viewing electricity demand as more fundamentally socially produced.

Given the complexity and range of environmental and societal issues, the provision of safe, reliable and affordable electricity is clearly more than a technical planning challenge – although it can certainly be this. Even the introduction of RE technologies entails a wider range of societal changes, for example in terms of consequences for employment, education and shifts in environmental resource use such as land and water. The growing number of studies outlined above highlight the diversity of perspectives and interests towards shaping electricity policy and planning, although tend to emphasize the technical and economic potential for RE, rather than the underpinning socio-political implications of engaging in these discussions on transforming electricity systems. In addition to debating the technical strategies and options for electricity planning, public deliberation is also required on the underlying assumptions of electricity options, policy and planning, including its narratives, justifications, and values, how it relates to the choices of technology deployed, the knowledge created, and the policies adopted, and the visions and goals that it is working towards.

It is this overarching perspective on the importance of public debate on the wide-ranging social, ecological and economic implications of electricity planning that motivated the compilation of think pieces in this publication. The Center for Social Development Studies (CSDS) in the Faculty of Political Science, Chulalongkorn University and the Australia – Mekong Partnership for Environmental Resources and Energy Systems (AMPERES) invited researchers active on electricity issues in Southeast Asia from a variety of backgrounds to join a discussion to explore the opportunities and challenges to sustainable and just electricity transformation in the Mekong Region. The process entailed: a half-day inception workshop (May 2021); preparation of draft think pieces that were deliberated at a one-day deep dive (July 2021); and then revision and peer review of the draft think pieces for publication.

The aspiration of this publication is not to assemble a consensus report, but rather to gather diverse viewpoints on the opportunities and challenges in attaining ‘sustainable and just electricity transformation’ in the Mekong Region. To this end, the report aims to set out some new terrains for the electricity debate at scales that range from the local to the regional. However, all contributing authors share a belief that public deliberation on this topic is of importance. Therefore, the think pieces presented in this publication reflect the ongoing original research of the authors in an accessible format for the purpose of informing and stimulating public deliberation.

A sustainable and just electricity transformation

There is nowadays a rising public expectation that electricity systems transform to address urgent sustainability objectives. The process of transformation, however, has implications for different groups in society, who may support or resist transformation based on who gains, who loses out, and whether distribution and process is perceived as fair. In this context, the concept of 'energy justice' have been proposed and deliberated by some academics, policy makers and practitioners. Sovacool and Dworkin (2015:437), with reference to existing scholarship on environmental (in)justice, identify three key elements of energy justice:

- Costs, or how the hazards and externalities of the energy system are imposed on communities unequally, often to the detriment of the poor and already marginalized.
- Benefits, or how access to modern energy systems and services are highly uneven.
- Procedures, or how many energy projects proceed with exclusionary forms of decision-making that lack due process and representation.

Another dimension of 'just transition' has emphasized the impact on labor of decarbonization. It raises questions of how to support those who work in parts of the energy industry that are to be phased out and replaced, as well as its implications for local and national economies. More broadly, there is an emerging literature on 'green transformation' that emphasizes that a sustainable and just transformation is not merely the substitution of one technology for another (i.e. fossil fuel and large hydropower for renewable energy), but entails more fundamental shifts in power relations between actors including state, private sector, civil society and community, more inclusive participation, changing market structures including entirely new approaches such as 'prosumers', and better practices of planning including regarding transparency and accountability (Scoones, Leach and Newell, 2015).

More focus on to social and environmental dimensions of electricity systems implies a conceptual shift from viewing electricity planning as being primarily about technology selection, to viewing technology (and its innovation) as emerging from, embedded within, and also shaping society. Accordingly, the generation, distribution and use of electricity can be understood as a sociotechnical system (Geels, 2014) or an 'energyscape' (Kaisti and Käkönen 2012) that includes technical, financial, economic, and institutional dimensions among others. The emergence of sociotechnical systems and how they change – or resist change – over time can be analyzed using a 'pathways' analysis. Leach et al (2010: xiv) define a pathway as "the particular directions in which interacting social, technological and environmental systems co-evolve over time". Pathways are often contested between policy coalitions in various configurations of state, private and civil society actors who produce 'narratives' to represent and legitimize the pathway that they support, whilst downplaying or seeking to discredit others. Analysis of electricity sociotechnical system pathways entail analyzing how different actors' visions are being formulated and acted upon, the legitimizing narratives produced, the knowledge created, the decision-making processes involved, the power-relations in place, and the material consequences such as selection of technologies and construction of infrastructure networks.

Unpacking the sociotechnical pathways approach to analyze how innovation and change may occur, Geels (2002, 2011) proposed the multi-disciplinary 'sustainability transition' framework. Within this framework, the Multilevel Perspective (MLP) conceptualizes processes of sociotechnological change as occurring at and between three levels: niche, regime and landscape (Geels 2002).

- 'Niches' are spaces where sociotechnical innovation can occur and that are protected from regime selection criteria, for example by subsidized research and pilot projects, or by culturally held values.
- 'Regime' refers to the existing dominant and dynamically stable sociotechnical system with its associated scientific knowledge, policy, industrial networks, markets and user practices, technology, infrastructure, and cultural meaning.
- 'Landscape' refers to the external environment in which the 'regime' evolves and 'niches' exist; it includes broad geographical factors, and political, economic and societal trends.

The transition from one sociotechnical regime to another is a dynamic and non-linear process that entails a substantial change in the configuration of technologies, infrastructures, institutions, governance and actors. Existing sociotechnical regimes may become unsettled when: broad landscape-level changes create pressure (macro-economic environment, society values, and so on); there are growing processes towards and within the regime itself that destabilizes it; and niche-level pilots offer alternatives and gain momentum (Geels 2002; 2014). 'Business as usual' may be resistant to rapid change for a range of economic, institutional, cultural, and technical reasons, including due to how some actors benefit from it. Hence, the regime can be analyzed in terms of its lock-in, path dependence, and inertia. More recent application of this framework has emphasized how sustainability transitions are inherently a political process, emphasizing various forms of power, agency and resistance (Geels, 2014).

The electricity system of each country in the Mekong Region has emerged in different political, social and economic systems, and with varying resource endowments, while there is also some trends towards cross-border power trade and accompanying investments. Therefore, it is important to pay attention to the specificities of the electricity sectors within and between countries of the region. There is an emerging body of work in the Mekong Region that view electricity through a sociotechnical lens (Kaisti and Käkönen 2012; Sawdon 2014; Smits 2015; Middleton 2016; Foran et al. 2017; Delina 2018). Along these lines, the think pieces in this report, which we summarize in the next section, also widen the scope of the debate on electricity to draw attention to some of the ecological and social dimensions.

Overview of the think pieces

Twenty-six researchers contributed to developing the thirteen think pieces in this publication covering a wide range of topics. While each piece was written separately, from the Multi-Level Perspective they are tied together by two narratives seemingly in tension: one narrative on the potential for renewable energy as a niche innovation to transform the dominant regime, and the other narrative on this regime's resistance to change. On the one hand there is great interest and celebration of the potential and rapid, recent expansion of non-hydropower renewables. Thang et al, for example, review the potential for solar, onshore wind, offshore wind and pumped storage hydro and conclude that their techno-economic potential is at least two orders of magnitude greater than the current installed capacity of the region. They show that wind and solar exhibit complementary generation profiles and that there are some advantages to countering the variability of renewables if these technologies are developed in tandem, especially if a regional approach is taken. Weatherby, and Intrawalan and Wood analyze the case study of Vietnam, which has installed more than 16.5GW of solar by 2020 reaching their 2037 target 17 years ahead of schedule. The experience of Vietnam demonstrates that effective industrial policy can harness the growing appetite of the private sector to deploy renewables at scale, from scratch.

On the other hand, there is a narrative that reflects the persistent fossil fuel dependency in the Mekong Region. Weatherby notes that globally, new capacity in renewables has started to outpace fossil fuels since 2010, and over the past four years solar PV alone has received more than double the investment of coal and natural gas combined. But in ASEAN the majority of investment is planned to continue to focus on coal in the near term, and natural gas in the medium term, especially in the Mekong Region.

Thus, the immense potential and notable signs of progress on RE exist while the region continues a structural dependency on fossil fuel. These tensions are characteristic of sociotechnical regime change as niche innovations in technology (i.e. the technology transfer to non-hydropower renewables) challenge the established regime to transform business as usual. Whether the sociotechnical regime will shift or niche innovation be marginalized remains an open multi-dimensional question and fertile ground for the think pieces in this volume. Broadly the perspectives of the think pieces focus on five main dimensions of this open question, some salient points of which we draw out in the following sections: technology change; the role of markets and state; regionalization; rethinking hydropower; and rethinking scale.

Technology change

Several think pieces reflect on the process of technology transformation, drawing on experience from within the region, and globally, to understand the technocratic features of shifting generation technology to non-hydropower renewables. Weatherby, and Kittner take stock of the barriers and challenges preventing the adoption at scale of renewable energy (RE). They point to issues of grid reliability, RE variability, cost competitiveness, solar PV waste management, investor interest, financing availability and stranded fossil fuel and large hydro assets. Importantly, both authors identify signs for optimism demonstrating that in recent years some of these issues are already solved and as RE continues to scale globally, the signs are promising that specific countries will also find solutions. Intralawan and Wood and Weatherby draw lessons from reviews of the national experience of Mekong countries and outline areas for shared learning between them, while Kittner goes further to point out that bilateral trade between Mekong countries (in this case Thailand and Laos) could be made more resilient and more sustainable by integration of non-hydro renewables backed by energy storage.

The role of markets and state

For Sirasoontorn, and Nuntavorakarn the technology change implied in the energy transition is complicated by shifts in the role of markets and states. They note that energy transition is more than a question of disruptive technology; it is also a question about the role of government, industrial policy and the nature of market reform. Reflecting on the experience in Thailand, where renewables were adopted earliest in the region, these authors open discussion on the political economy dynamics of transition and identify structural elements of the incumbent sociotechnical regime that work to resist change. Nuntavorakam points, for example, to economic weaknesses of the existing power development planning processes, the limitations of Power Purchase Agreements (PPAs), and the influence of large companies with vested interest.

Sirasoontorn concurs that Thailand's targets on RE lack ambition and effective policy support but also points out that the market reforms needed to guarantee a level playing field for new businesses harnessing disruptive technology have not been achieved. Within Thailand this has strengthened the market hold of large conglomerates as new small and medium enterprises struggle to compete; regionally ineffective market reform and competitiveness has seen Thai companies look to regional neighbors exporting their expertise to develop renewables in Vietnam, Cambodia and Laos. These issues have profound influence on niche technology innovation and are a significant reason why RE deployment has slowed in Thailand over recent years. Both authors frame these issues of market reform with reference to the impact on Thai consumers and point to recent promising signs for peer-to-peer electricity trading that encourages people to be "prosumers" of electricity, and decentralized energy systems as offering another type of technology disruption.

Regionalization

The political economy issues associated with a technology shift to renewables also has a regional dimension. Shen, Delina and others note the commonality of this issue across the region, especially in relation to state-owned and private sector interests of the incumbent industry. For these authors, the role of RE in the Mekong Region is therefore fraught with challenges and barriers which they contend are best solved through an agenda for electricity regionalization.

Regionalization of electricity trade has loomed as an unfulfilled promise of the Mekong Region since the 1950s. Yang et al note that the interest in electricity trade stems from the potential for economies of scale to reduce the cost of electricity, which Thang et al report could reduce overall energy costs by one-fifth. More recently there is also a growing interest that regionalization of electricity could also play a role in accelerating the transition to RE by connecting a wide base of variable renewable resources and reducing the variability in supply through the interconnection of different geographical and climate regions.

Some of the think pieces frame energy regionalization through the lens of a four-stage roadmap first promoted by the Asian Development Bank in 2002. The first stage focuses on bilateral, predominately one way trade between neighboring countries facilitated by project-level PPAs. The second stage matures to a system level allowing trade of surplus system capacity across national borders, while the third stage allows third party utilization of a country's transmission facilities and participation in trading under a multi-lateral model. The final stage of regionalization would unify and harmonize national electricity grids into a fully competitive regional market.

However, as many of the think pieces show, although regionalization of electricity trade has been discussed for more than two decades, the ambition of the regionalization project is matched only by the modesty of progress achieved. Thang et al highlights that only 2% of electricity generation in the Mekong Region is traded, with the relative percentage of imports/exports for electricity an order of magnitude below that for Total Energy or Total Goods and Services. In comparison to some other regions such as Europe, the Mekong has a far lower level of regional electricity trade, but also when compared to other regions like South America that have comparable levels of transmission infrastructure to the Mekong Region.

Several think pieces reflect on why regional power trade has not emerged as anticipated. They cite technocratic barriers of inadequate infrastructure, inflexible PPAs, regulatory barriers to third party access, uncoordinated planning, weak regional institutions, technical capacity, unstandardized transmission and distribution protocols, and slow progress on market liberalization. As the authors acknowledge, these barriers are well understood and widely discussed; but they are also narrowly focused on the structural features of the sociotechnical regime. What is much less frequently or adequately discussed are the political economy issues within the Mekong landscape which underpin the oft-cited technocratic issues and ultimately govern regime resistance to regionalization.

Yang et al attempt to unpack the evolution of the political economy landscape in the Mekong to broaden the policy debate on the topic and open space for new approaches and solutions. They chart the overly political origins of regional cooperation in the 1950s/60s (avoiding war, stemming the spread of communism), through to the emergence of the neo-liberal agenda in the 1970s of integrating markets in the region, and hence integrating also the infrastructure (transport, energy etc) required to service market integration. They show the impact of rapid national economic growth in the 1980s and 1990s, when governments struggled to match the escalating investment needed in energy infrastructure to keep up with rising electricity demand. This was a factor in government decisions to entice private sector investment first into generation and later also transmission assets. Last, they point to the contemporary phase of the ASEAN 'soft approach' which emerged in the 2000s as a characteristically Southeast Asian solution to regional intergovernmental cooperation, which the authors define as the pursuit of sovereign interests within non-legalistic regional process and agreements – primarily through the pursuit of discrete project-based initiatives.

The political economy arc of the Mekong Region deepens our understanding as to why regional cooperation has remained at the project-level, with one-way, bilateral trade, predominately between Laos and Thailand (Stage 1) to date, although more recently Laos has exported more electricity to Vietnam. The think pieces dive into these issues of national security concerns, political trust amongst neighbors, regional leadership in a contested regional power dynamic, the challenges of legitimacy for regional institutions, and the growing awareness of the far-reaching environmental and social impacts that the large energy infrastructure underpinning regional trade entails.

Looming large in the discussion of electricity regionalization is the role of China. China's role in the Mekong is complex, contested and sometimes polarizing as reflected in several think pieces. According to Shen from the Chinese perspective it is also an issue with both a domestic and international lens. Domestically, the Mekong Region is a source of hydropower for China; even with the extensive hydropower development already on the Lancang River, the region remains an area of significantly untapped hydropower potential which has long featured in national development plans but has stalled due to declining demand and cost competitiveness of hydropower against other generation sources located closer to demand centers on China's Eastern seaboard. However, the Chinese government's recent pledge to achieve net zero by 2060 could regalvanize an interest in hydroelectricity production both within southwestern China and within the territories of its neighbours, in particular Laos and Myanmar. Whether China's domestic decarbonization agenda has adverse consequences for sustainability in downstream states is another open question of critical importance.

Internationally, the Mekong Region also features large on China's agenda. Shen, and Delina catalogue some of the grand schemes that are under development, like the Belt and Road Initiative (BRI), and most expansive of all is the Global Energy Interconnections (GEI) through which China seeks to lead a planetary energy transition based on Ultra High Voltage transmission lines to connect most of the regional grids spanning Asia, Southern Africa, Europe, the Baltics, Canada and South America. As the neighbor to the south, the Mekong Region is at the forefront of these initiatives. While these grand schemes have a focus on economic growth and decarbonization, as Shen notes the commercial interests of State-Owned Enterprises who are financing, building and operating overseas energy infrastructure projects have grown into the biggest driver for China's engagement in the Mekong energy sector, while Delina also notes the pressure within China to find new markets for its purported excess renewable energy as a driver. With China increasingly disinterested to finance fossil fuel generation overseas, there is potential that China's engagement in the Mekong Region could switch to RE, or it could return to hydropower. As with the ramifications of China's domestic policy, the direction and implications of China's engagement with the Mekong Region remains an open question.

Rethinking hydropower

Both on the Lancang River and on the Mekong River downstream, the role of hydropower emerges in a number of think pieces as a contested space in the energy transition. Within the incumbent sociotechnical regime, hydropower has occupied a dominant role in generation, helping to meet existing electricity demand and comprising the majority of economic trade of electricity. However, Chanthavong, and Ketelsen et al note there is growing evidence of the adverse social and environmental impacts of hydropower, making hydropower one of the most important challenges to sustainability in the Mekong Region. Focusing on resettled communities in Laos, Chanthavong outlines the process for resettlement and concludes that for the case study project, resettled people have found few opportunities but faced many difficulties, especially in relation to access to suitable agricultural land. Ketelsen et al focus on sediments as a proxy for ecological integrity of the river basin and document what has been a rapid and devastating collapse in the Mekong's sediment transport. As concluded by the Mekong River Commission, sediment transport in the Mekong could all but disappear by 2040, and the consequences for fisheries, delta stability, riverbank erosion, and floodplain fertility are dire. It is in this context that hydropower has emerged as one of the most important environmental justice issues of the existing Mekong region's sociotechnical regime. As Ketelsen et al argue; historically the multitude of resource and livelihood benefits of the free-flowing Mekong River were dispersed to tens of millions of people throughout the basin, while today reservoirs on the river have concentrated benefits into one sector and a smaller stakeholder base who possess closer proximity to political power. This is a classic example of enclosure of the commons, but it is also a justice issue and hence an important element for any discussion for a sustainable and just energy transition.

Some of the think pieces take up this question. Chanthavong adopts a remedial approach and suggests practical steps which could improve the resettlement process, which if adopted could reduce the adverse social impacts on affected communities. Kittner also proposes important suggestions to improve the sustainability of hydropower but does so by squarely positioning the issues within the push and pull factors of an energy transition. He argues that energy storage can be used to improve planning processes and efficiency of bilateral electricity trade from hydropower sources. Battery storage and non-hydro renewables could get more out of existing hydropower and avoid the need for new hydropower on the Mekong mainstream which would further damage an already degraded system. Thang et al draw on recent techno-economic analysis to show an immense potential for pumped storage hydro which could allow the harnessing of the region's immense water resources without blocking and fragmenting the water course. This represents an avenue where a renewable energy transition could have direct and positive impact on the pervading sustainability crisis facing the Mekong River, its tributaries, and other rivers across the region. Kittner warns that a lack of foresight to integrate these technological advances could render some large hydropower projects in Laos uncompetitive against domestic solar or wind in Thailand, leaving those assets stranded. Ketelsen et al also take up this point to argue that the significant and growing environmental and social costs of large hydropower, already manifest in the basin, coupled with the rapid rise of non-hydro renewables first globally and now in the Mekong, offers the potential for a change in direction for energy infrastructure development and restoration of the degraded Mekong system. They outline a case for rewilding the Mekong River and identify 52 dams in the lower Mekong basin which, if removed, could increase the annual sediment load from 49 to 87 Mt/y reconnecting the floodplains of Cambodia and the Mekong delta with a vital annual supply of sediment.

Rethinking scale

Ham picks up the issue of sustainability and justice in the energy sector but takes an altogether different line of argument. He argues that the value of renewable energy technology also encompasses its ability to decentralize and distribute sites of generation, allowing generation to be located closer to settlements of consumption. By doing so the energy transition has the potential to restructure the electricity services into decentralized microgrids, reducing the need for large, centralized generation like polluting fossil fuel plants and environmentally damaging large hydropower. Through several case studies from Cambodia, Ham demonstrates that the value proposition of renewables is also about innovation to governance models, allowing communities to own and manage their own mini-grid services. With communities having a seat at the decision-making table,

Rooftop solar in Vietnam
by Tarek Ketelsen

decisions on who benefits and what kinds of benefits could recalibrate towards a more equitable course. Ha and Nguyen review a community energy project in Vietnam and confirm these findings. They undertook a cost effectiveness analysis between community microgrids, grid extension and home-battery systems to demonstrate not only the governance merits of the community microgrid, but also the economic benefits with the community system substantially cheaper than both the grid extension and household battery options. Ha and Nguyen use these findings to build a case for distributed renewable energy systems in national electrification agendas, arguing that for many rural and remote communities throughout the Mekong, reliable, universal electricity access could be achieved quicker, cheaper and with a wider range of community benefits by using community-owned distributed renewable energy systems.

Conclusion

The thinkpieces compiled in this publication attest to the multi-dimensional character of electricity in relation to sustainable and just development in the Mekong Region. They reveal how decision-making processes are much more than exercises in technical planning but in fact reflect underpinning societal practices, values and power relations. In this introductory article, therefore, we have presented electricity as a more complex sociotechnical system that is structured by a range of factors including knowledge production, policy, industry structure, forms of markets, user practices, technology, infrastructure, and cultural meaning, and that is animated by the various aligned and competing interests between the state, private, civil society and community actors involved. Each think piece contributes a layer of evidence and insight to understanding the dynamics of electricity in practice in the Mekong Region, which has ranged from analysis on the regional scaled plans for electricity trade, to examination of the national level processes on power development planning and its outcomes, to local level opportunities and challenges for decentralized off-grid electricity solutions.

Across the think pieces, there has been attention to the political economy of electricity, the positive and negative social and environmental outcomes, the inclusiveness of public participation, and the underpinning societal values and cultural practices that are emphasized or marginalized in the processes of decision-making. It is very clear from the think piece analysis that issues of energy justice lie at the heart of electricity planning and practices in the region, which is a crucial reason why electricity can only ever be in part considered a technical issue. Within the existing electricity regime, a number of examples have been detailed in which the environmental and social costs of electricity generation, especially in larger scale projects, have been imposed onto nearby communities including in terms of forced displacement and environmental degradation that has consequences for livelihoods and quality of life. While electricity can broadly bring social and environmental benefits for those who can access it, it is also apparent that access to electricity in terms of quantity and quality is still uneven across the region, between rural and urban areas as well as within them, and also between the countries of the region. Meanwhile in terms of decision-making procedures, there remains only limited opportunity for public involvement in the preparation of power development plans, with some countries being slightly more open than others, and where there is an opportunity for participation the process itself could be improved. At the project level environmental and social impact assessments have too often been instrumentalized to support projects to proceed without seriously taking account the concerns of nearby communities who would be impacted. Each of these dimensions of energy justice require attention if a sustainable and just electricity transformation is to occur in the region. The think pieces are also suggestive of how a more sustainable and just system could be in the making. Looking forward at the 'landscape' level, climate change commitments on net-zero emissions that are beginning to emerge from governments across the region could begin to shape electricity policy and practices. There is also growing public awareness of the environmental and social consequences of electricity generation and consumption. This connects, for example, to specific types of projects like large hydropower dams where there have been vigorous debates on rethinking the value of rivers in the region in the ways that they sustain diverse ecosystems and connect to livelihoods that depend upon them.

Much analysis has also been presented on the various 'niche' innovations emerging in the region, with the clear example being renewable technologies. Crucially, the focus is not only on the technical and economic viability of the technology themselves, but on the various social and political conditions under which they are emerging. This includes on redefining the relationship between the consumers of electricity and its provision, including the emergence of peer-to-peer practices in Thailand and the case studies of decentralized electricity generation in Cambodia and Vietnam that require a 'prosumer' mindset. They have also been enabled due to policy innovations that reflects shifting governance practices, although here much more could be done including on improved accountability in planning decisions.

Many of the think pieces have paid attention to the existing electricity regime and its political economy that helps us understand why large-scale fossil fuel and hydropower technologies have remained relatively consistent, including in recent years. Narratives that rationalize these projects as more efficient and needed for national and regional electricity security and economic growth continue to prevail, even as RE begins to gain ground. Within the existing regime, however, across the region there has

Nam Ou Dam 2, north of Luang Prabang, Lao PDR
by Suphakit Nuntavorakarn

been some significant shifts in structure, including an expanded role for private sector actors. To date, however, these have been dominated by a limited number of large businesses, including corporatized state-owned enterprises, that are more associated with the large-scale fossil fuel and hydropower projects that have prevailed to date. Yet, as observed in some of the think pieces, even these businesses have begun to identify opportunity in a shifting regime towards RE. Moreover, there have been some remarkable shifts, in particular in Vietnam with the unanticipated rapid RE expansion responding to government policy that are suggestive of the potency of transformative change that can occur. It also suggests the potential of how new forms of employment in RE industry can be created in the process.

A sustainable and just transformation cannot be understood only as the replacement of one technology with another within the existing regime. Rather, in order to address the energy justice dimension on distribution of harms and benefits among groups in society and between countries, a wider range of shifts are required including on ensuring inclusive and meaningful participation and valuing diverse forms of knowledge, opening the electricity industry to new actors including RE private sector, encouraging new user practices such as 'prosumer' practices, and strengthening transparency and accountability of decision-making processes. We hope that the compilation of evidence and analysis in the think pieces in this publication contribute towards this important public debate and further builds momentum towards a sustainable and just transformation of electricity in the Mekong Region.

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RENEWABLE ENERGY IN THE MEKONG: POSITIVE MOVEMENT BUT SIGNIFICANT UNMET POTENTIAL

Courtney Weatherby

Introduction

Based on national policy plans from the ten countries of the Association of Southeast Asian Nations (ASEAN), the International Energy Agency projects that Southeast Asia's cumulative energy demand will rise 60% between 2019 and 2040 (2019, p. 10). A significant portion of this is due to regional progress towards universal electrification, ongoing industrialization, and rapidly rising electricity consumption from urbanization and rising living standards. ASEAN's projected electricity demand growth averages 4% annually through 2040, nearly double that of the rest of the world (IEA, 2019, p. 15). While the Mekong countries account for only a portion of this growth, their national electricity demand growth rates are significantly higher than the ASEAN average.

Although the region's renewable energy capacity is projected to grow exponentially to help meet this demand growth, most ASEAN countries are also planning a parallel rise of additional coal capacity. This is in contradiction to global trends, as most other regions are anticipating a long-term decrease in coal capacity. All five Mekong countries anticipate expanding coal-fired electricity generation in coming decades to varying degrees. The Mekong Infrastructure Tracker shows that Cambodia has 2 coal plants with 965 MW of capacity currently under construction and plans for another 2,700 MW in coming decades (2021). Laos has signed agreements to export 2,400 MW of electricity from new coal plants to Cambodia (Vireak 2019). Myanmar's most recent Nationally Developed Contributions under the Paris Agreement indicate plans for 2,120 MW of coal by 2030, which is a reduction from a business-as-usual scenario but still a significant expansion from current levels (National Unity Government, 2021, p. 7). Thailand has two proposed coal projects with 2,800 MW of installed capacity, although the government may replace the coal projects with a natural gas plant due to public concerns over social and environmental impacts from coal plants (Praiwan, 2021). Although Vietnam has significantly reduced the amount of planned coal through 2030 between its revised 2016 Power Development Plan 7 and the February 2021 draft of the Power Development Plan 8, it still anticipates bringing approximately 14,000 MW of new coal plants online through 2030 (Mekong Infrastructure Tracker and MOIT, 2021, p.19).

Global investment in renewable energy first surpassed investment into fossil fuel plants in 2010. In the early 2010s these investment amounts did not directly correlate to a shift in capacity additions due to relatively high costs of solar and wind, but starting in 2015 new renewable energy capacity began consistently and rapidly outpacing non-renewable capacity additions (IRENA, 2021, p.42). The IEA reports that global investment in just solar photovoltaic (PV) alone has been more than double the global investment in both coal and natural gas over the last four years (IEA, 2020). In contrast, a September 2019 report by Wood Mackenzie indicates that most annual investment in ASEAN will go to coal in the short-term and natural gas in the medium term and that renewable solar and wind investments are only anticipated to make up 23% of Southeast Asia's power sector investments through 2040 and won't outpace fossil fuels until 2034. This is a significant lag compared with many other regions of the world, including both industrialized areas such as Europe and the United States as well as industrializing countries in Africa and Latin America. This raises questions about why countries in the Mekong Region are not being more ambitious towards the renewable energy transition. This think piece utilizes data from the Stimson Center's Mekong Infrastructure Tracker to provide a data-driven overview of how various types of renewable energy have grown in each of the five lower Mekong countries of Southeast Asia since 2010. Following an overview of renewable energy deployment to date, the think piece explores the changing narratives about the obstacles, challenges, and opportunities of adopting renewable energy in each country. The challenges discussed (and in some cases questioned) include concerns over costs and economic competitiveness, reliability, challenges of grid integration and management, structural features of existing planning and regulatory regimes, and the more recently raised concerns over managing waste materials from old solar plants. Finally, the think piece closes with analysis on the differences in responses between countries to the obstacles and narratives discussed previously.

Renewable Energy Developments in the Mekong Region

Under the ASEAN Plan of Action for Energy Cooperation Phase 2, ASEAN members have a shared target to supply 35% of the region's installed power capacity from renewable energy by 2025 (ASEAN 2020, p.2). This target is not enforceable, and some member states such as Indonesia and Singapore are not currently on track to meet that target. There are also differences of interpretation among countries about what counts as renewable energy: some countries such as Vietnam do not consider large-scale hydropower as renewable in national planning processes given the significant environmental impacts, while other members like Laos and Thailand count all hydropower as renewable. There is an ongoing debate over whether hydropower counts as renewable energy or not; for the sake of clarity between established and new technologies, this think piece distinguishes between hydropower and non-hydropower renewable energy alternatives. The five Mekong countries have significantly

Solar power project in Thailand
by Asian Development Bank via Flickr

expanded non-hydropower renewable energy between 2010 and 2020: the Mekong Infrastructure Tracker shows that in 2010, the five Mekong countries only had 261 MW of operational solar, wind, and biomass capacity, but as of 2020 this has risen to 19,289 MW of installed capacity, a 73-fold increase. Although biomass and wind had initial leads, most of the capacity as of 2020 —15,635 MW—is from solar power.

Thailand was the earliest adopter of non-hydro renewable energy in the region, driven in part by recognition of the need to reduce carbon emissions and in part by the desire to reduce energy imports. Installed capacity for solar, wind, and biomass in Thailand outstripped the combined installed capacity of the other four countries for the better part of the decade. However, starting in 2016 Vietnam provided a feed in tariff with the aim of substantially increasing deployment of wind and solar power. Thailand's grid-connected renewable energy projects stagnated in 2018. In 2019, rapiddevelopments of solar projects due to private sector investment led Vietnam's installed solar capacity to outstrip that of Thailand. By the end of 2020 Vietnam's installed renewable energy capacity had skyrocketed due to private companies trying to bring projects online under the attractive feed-in-tariff rates, comprising more than 86% of all installed renewable energy capacity in the five lower Mekong countries.

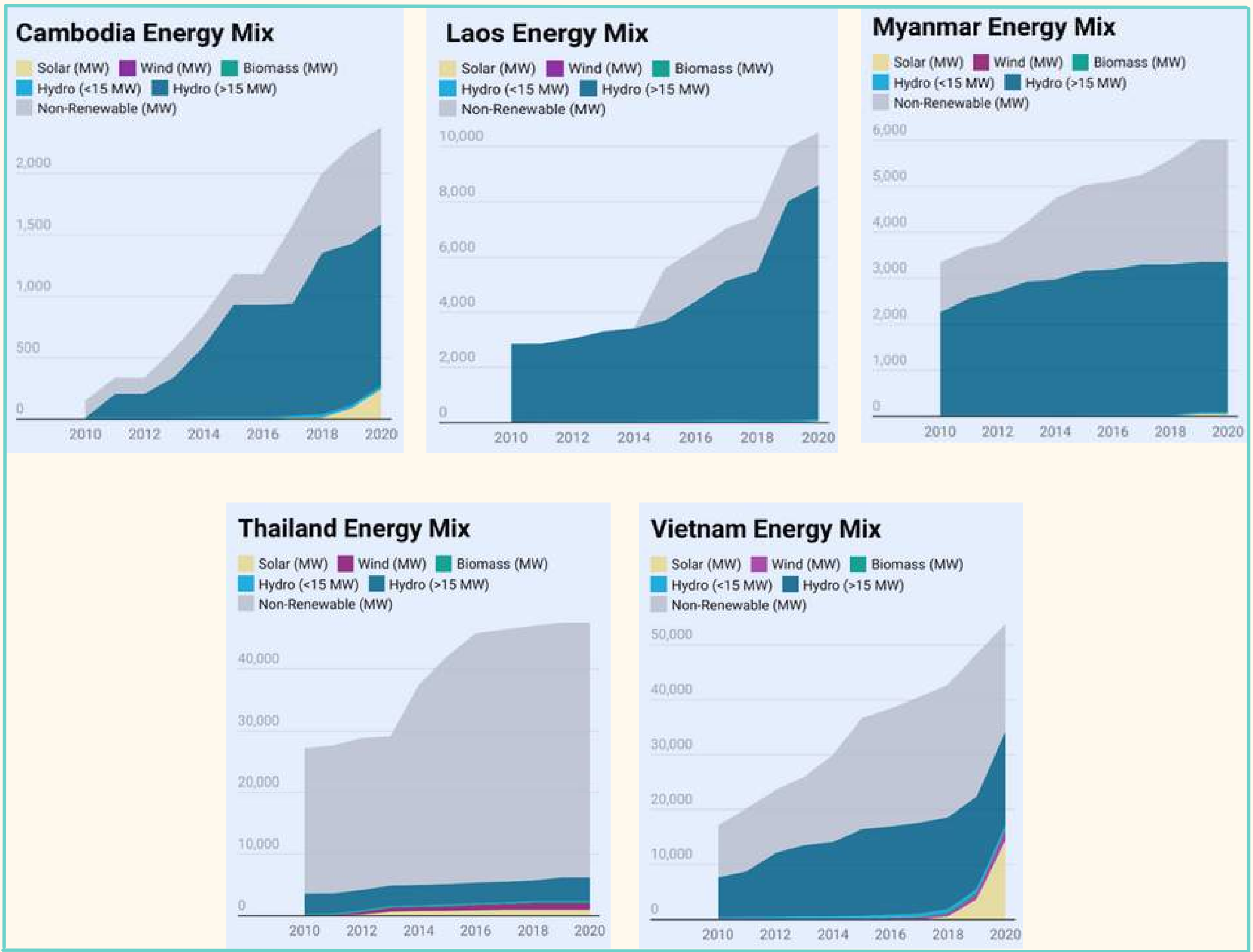

Figure 1: Energy mixes in the five lower Mekong countries, 2010-2020. The charts were created in DataWrapper and used data on installed power generation capacity from the Stimson Mekong Infrastructure Tracker.

Country	Cambodia	Laos	Myanmar	Thailand	Vietnam
Initial renewable Energy Targets (2005-2012)	N/A	2025 Target: RE 30% of total energy supply	N/A	2022 Target: 20% percent of final energy consumption from RE	N/A
Recent renewable energy targets (2013-2017)	N/A	2025 Target: RE 30% of total energy supply	2020 Installed Capacity Target: 15% - 20% RE 2030 Installed Capacity Target: 57% hydro, 5% solar/ wind	2036 Installed Capacity Target: 2% imported hydro, 15% domestic hydro, 18% mix of solar, wind, biomass	2020 Installed Capacity Target: 7% RE 2030 Installed Capacity Target: 10% RE
Current renewable energy targets (2018-2021)	2023 Target: 20% of electricity from solar/wind	2025 Target: 30% RE in total energy supply	2021 Installed Capacity Target 8% mixed RE 2025 Installed Capacity Target: 12% mixed RE	2021 Target: 25% of final energy consumption is RE 2036: 30% of final energy consumption is RE 2037: 36% of total installed capacity; 20% of electricity production from RE	2025 Installed Capacity Target: 12% wind, 17% solar 2030 Installed Capacity Target: 13% wind, 14% solar, 2% energy storage (battery and pumped hydropower)
Installed renewable capacity in 2021 (MW)	Biomass: 37.5 Hydro: 1,341.6 Solar: 245 Wind: N/A **Total: 1,625**	Biomass: N/A Hydro: 8,594.7 Solar: 42.3 Wind: N/A **Total: 8,637**	Biomass: N/A Hydro: 3,305.2 Solar: 51.2 Wind: N/A **Total: 3,357**	Biomass: 498.3 Hydro: 4,015.2 Solar:15,46.7 Wind: 1,105.7 **Total: 7,171**	Biomass: 391.7 Hydro: 18,263.2 Solar: 14,414.7 Wind: 1,093 **Total: 34,163**
Past electricity demand growth (2010–2018) (%)	18.3%	10.5%	13.9%	3.8%	10.5%
Projected electricity demand growth (%)	8.80% to 2030	N/A	7% to 2040	3.8%	9.1% to 2025, 7.9% to 2030

Table 1: Key energy targets and statistics by country.

Initial Renewable Energy Targets *references Lao PDR, 2011, p. 13.* ***Recent Renewable Energy*** *Targets references Lao PDR 2011, p.13; IEA 2017; Sirasoontorn and Koomsup 2017; Koushan, 2020.* ***Current Renewable Energy*** *Targets references Bunthoeurn 2019; Lao PDR Ministry of Energy and Mines, 2020, p.5; ITA, 2019; PDP 2018; and MOIT 2021, p.19.* ***Installed Renewable Energy Capacity in 2021*** *references the Mekong Infrastructure Tracker.* ***Past Electricity Demand Growth*** *rates are drawn from ERIA national energy outlooks and national power development plans.* ***Projected Electricity Demand Growth*** *are drawn from ADB 2018, ERIA 2019, Thailand MOE 2020, and MOIT 2021.*

Country summaries

Cambodia was initially entirely dependent on oil for energy consumption—but this began changing in 2011 after the 193 MW Kamchay Dam came online, followed by six other large-scale dams. As of June 2021, hydroelectricity had expanded to 1341 MW. Cambodia's energy supply was thus relatively clean in terms of carbon emissions for most of the 2010s, though oil continued to contribute and coal production began to rise in 2017. New renewable energy technologies like solar and wind did not attract policy support or attention until 2017, when the first pilot solar project went up for tender with support from the Asian Development Bank. A drop in hydroelectricity production during the 2019 drought—and the following blackouts in Phnom Penh—prompted officials to diversify the power supply away from hydropower. Since the first pilot solar project came online in 2017, Cambodia has built five additional solar farms with a total capacity of 245 MW and has an additional five plants under construction which will add 435 MW of capacity to the national power supply (Mekong Infrastructure Tracker, 2021). Government officials from the national utility company Electricite du Cambodge have stated that they expect solar will meet 20% or more of the national power supply by the mid-2020s (Bunthoeun, 2019). There are a series of small biomass pilot projects, and investors have shown interest in pilot wind projects, but neither has yet been scaled up.

Laos has a long-term plan to gain national revenues through the export of electricity to neighboring markets under the "Battery of Southeast Asia" development plan. Hydroelectricity has consistently provided the majority of Laos' electricity production and currently provides 81% of Laos' total installed capacity and the majority of electricity for export. Laos began selling hydroelectricity to Thailand as early as 1971 when the first large-scale dam, the Nam Ngum 1, came online. The non-hydroelectricity is primarily produced from the Hongsa Coal Power Plant, although Laos has a small number of pilot solar and biomass projects contributing to the domestic electricity supply. Few large-scale renewable energy projects have moved ahead since the first solar pilot came online in 2016. However, this is changing: in 2021 a Thai company signed a power purchase agreement to sell electricity from the 600 MW Monsoon Wind Farm in southern Laos to Vietnam (Setboonsarng, 2021) and the government has expressed support for large-scale floating solar projects which could add up to 1,440 MW on the Nam Ngum 1 and Nam Theun 2 reservoirs (ANN 2021, Yap 2020).

Myanmar's electricity demand growth is among the highest in ASEAN and demand has consistently outpaced supply, resulting in frequent brownouts and blackouts. Expansion of power generation have historically faced constraints due to international sanctions against the junta until 2011, an export-oriented development of natural gas, and public concerns over the impact of large-scale hydropower projects in a complex domestic political environment. Myanmar's first large-scale power generation project was the Baluchauang-2 Dam in 1954. The Mekong Infrastructure Tracker shows that although natural gas supplied the majority of electricity from 1980 to 2009, hydropower capacity has expanded to 55% of Myanmar's installed capacity with the addition of 18 dams and 2,527 MW of hydropower capacity since 2009. Non-hydropower renewable energy has been slow to develop at the commercial scale: two pilot solar projects of less than 1 MW came online in 2017, and one 50 MW solar plant began operations in 2019. There are no operational wind projects. The government has recently changed its approach and began holding solar auctions: in 2020 the NLD-led government held an auction for 1,060 MW of solar capacity at over thirty sites around the country (Lynn and Kean, 2020), and in 2021 the military regime opened up 12 projects for international bidding (The Irrawaddy, 2021). Myanmar has recently reached 68% electrification, but renewable energy plays an important role in addressing this. In 2015 the government of Myanmar indicated its intent in the Myanmar Master Energy Plan to utilize distributed and off-grid renewable energy installations in remote rural areas with no grid access to achieve full electrification. Myanmar's energy future is currently uncertain due to the military coup in early 2021. It is likely that the military regime will prioritize different projects than the NLD government or the National Unity Government, and the likelihood of funding challenges is high in the near-to-medium term due to the reissuance of sanctions and high risk for outside investors given ongoing conflict.

Thailand's energy system is largely dominated by fossil fuels, as the majority of installed capacity is natural gas and coal. Domestic hydropower was first developed in the late 1950s and currently makes up approximately 6.6% of Thailand's installed capacity. Thailand's domestic hydropower development slowed in the 1990s in part due to opposition over social and environmental impacts of large-scale hydropower, and as a result no new dams came online in Thailand between 2004 and 2018. Thailand does however import hydroelectricity: as of June 2021, Thailand imported approximately 5,720 MW (EGAT 2021). Most of this is Lao hydroelectricity, although 1,473 MW is coal power from the Hongsa Power Plant (Hongsa Power, 2021).

A recently as 2016, Thailand was the only Mekong country with significant solar, wind, and biomass generation capacity, due in part to an early starting point. The Mekong Infrastructure Tracker shows that initial pilot projects came online as early as 1987 for biomass,1988 for solar, and 1996 for wind. Despite being an early adopter for pilot projects, large-scale development did not really pick up significantly until 2006 when the Thai government provided a feeder tariff for biomass, solar, and micro-hydro through the Very Small Power Producer program (ERIA, 2019, p.2). Starting in 2013, the Thai government utilized a feed-in-tariff policy (Tonsopit et al, 2014, p.9). This led to a boom: Thailand's Alternative Energy Development Plan 2015 included a target of 6,000 of solar MW by 2030, but IRENA reported that by 2017 Thailand was already approximately half-way to its target (p.26). As a result, in the Power Development Plan 2018 (rev.1) Thailand raised the total solar target to 11,465 MW by 2037. Thailand is likely to revise this target upwards again in the next Power Development Plan 2022, as the Electricity Generating Authority of Thailand indicated that it plans to nearly double floating solar capacity from a target of 2,725 MW to 5,000 MW and may consider further increases in future (Praiwan, 2021).

Vietnam has utilized hydropower since the first dam came online in 1945. Vietnam's electricity demand has risen rapidly over the last two decades as electrification rose from only 14% in 1993 to near universal electricity access in 2014 (Dione, 2018), and hydropower capacity expanded significantly between 1994 and 2015. Most of the 18,271 MW of installed hydropower is outside of the Mekong basin, although approximately 2,800 MW are constructed in the upper reaches of the Srepok and Sesan basins. The Srepok and Sesan basins are themselves transboundary tributary rivers to the Mekong.

Starting in 2017 the government of Vietnam announced a series of policy changes to support renewable energy, including an attractive feed-in-tariff for solar projects. Vietnam's installed capacity rose from almost nothing in 2017 to more than 5,000 MW by the end of 2019 (Wood Mackenzie, November 2019). Vietnam's feed-in-tariff policy has been adjusted a few times, but inclusion of rooftop solar brought in an additional 9,500 MW of solar capacity in 2020 and early 2021 (EVN Solar 2021).

The feed-in-tariff for wind has not attracted as much investment as solar has, but the Mekong Infrastructure Tracker shows that Vietnam currently has two operational wind projects which came online in 2019 contributing 486 MW with an additional 472 MW under construction and 1,146 MW at an earlier stage of project development. Vietnam is currently in the midst of finalizing the next Power Development Plan 8 (2021 – 2030), but the draft version anticipates that wind, solar, biomass, and other renewable energy will make up 29% of the total energy mix by 2030 and 44% by 2045 (MOIT 2021).

It is clear that individual countries have adopted different policies towards renewable energy over the previous decade, which had varying effects on the investment environment: Thailand experienced an early solar boom which stagnated for a few years in the late 2010s; Vietnam and Cambodia have both experienced exponential growth after providing regulatory clarity starting in 2017; and Laos and Myanmar have both seen more limited deployment of renewable energy which has just started to pick up in 2020. This next section will explore some of the concerns and obstacles to renewable energy deployment and consider the extent to which these constraints are evolving in individual countries.

Obstacles to Renewable Energy Development

There are a series of key concerns which policymakers around the world have raised about renewable energy, and many of these are echoed by government officials in the Mekong. Interviews and public statements by government policymakers around the Mekong countries have at various points over the last decade referenced concerns over cost competitiveness; concerns about reliability or intermittency; challenges of grid integration; and management of waste materials. Non-government observers both from within the region and without have also. pointed to regulatory issues surrounding power purchase agreements and structural features of power planning systems that preference traditional and familiar power sources as an obstacle to project bankability.

Concerns Over Cost and Competitiveness

One recurring concern raised throughout the early and mid-2010s about renewable energy prospects was cost competitiveness. This concern was accurate at the time that initial power plans came out in the late 2000s and early 2010s when solar and wind technologies were largely uncompetitive. In 2009, the levelized cost of energy (LCOE) for unsubsidized solar was more than three times the average LCOE for coal or combined-cycle natural gas. However, over the course of the decade the LCOE dropped to only \$31 - \$40/MWh, a 90% decrease since 2009 (Lazard, 2020, p.9). Using global averages, the cost of solar PV began to become competitive with coal around 2013 and with natural gas in 2015 (Lazard, 2020, p.8). There are many reasons for the price drop, including economy of scale due to high production in China, efficiency improvements, and improved bankability due to rising trust in the technology by financial institutions.

These global price drops took time to reach the Mekong Region, in part because national regulatory regimes often didn't have existing policies surrounding non-firm power generation from variable renewable energy sources like solar or wind. Interviews with government officials in Cambodia in February 2017 revealed that they felt price was a major obstacle and that they didn't anticipate adopting utility-scale solar for the better part of a decade. Interviews with officials in Laos (2017) and Vietnam (2016) revealed similar concerns and dismissal of short-term adoption of solar due to cost. However, successful pilot projects and investor interest swiftly led to policy changes: in early 2017, the Asian Development Bank announced movement on a 10 MW pilot solar project in Cambodia after a competitive auction. As this project moved ahead and the results of the bid became public, an interview five months later with the same official who had previously suggested commercial solar was a decade away revealed that the Cambodian planning department was starting to seriously consider additional scale-solar projects (July 2017).

The issue of cost—previously the first item raised in discussions about challenges of renewable energy—has been little deliberated since 2019. In fact, the rapid drop in solar price is widely acknowledged in Thailand, which as an early adopter was utilizing a tariff system to attract investment and had to adjust policy as a result of faster-than-anticipated price drops. As the price of solar dove throughout the 2010s, Thai utilities were committed to paying prices above the new market rate. This prompted a series of policy adjustments, leading by 2017 to a competitive bidding scheme with a feed-in-tariff set as a ceiling rather than a floor in order to minimize government exposure (IRENA 2017, p.22). Interviews with Thai officials in 2018, 2019, and 2020 explored a number of obstacles to the deployment of renewable energy, but affordability was rarely brought up.

Variability and Grid Integration

Following cost, a commonly raised concern is how to handle the variability of wind and solar in a way that will not destabilize the grid or impact reliability of the overall power system. Ensuring that the electricity supply can be rapidly scaled up to meet peak demand and ensure that the system remains balanced is necessary to avoid blackouts that affect consumers and could harm industrial growth. Unlike traditional fossil fuels and hydropower, solar and wind are not dispatchable—meaning that they cannot be turned on or off on demand—because they rely on sunshine and wind and are consequently outside human control. Such concerns have come up in numerous personal interviews with government officials in 2016, 2017, and 2018 in Cambodia, Laos and Vietnam. In some cases concerns were linked directly to the lack of dispatchability and the challenges this posed to providing reliable baseload power to consumers. In other cases, the concerns were over how operations of variable power would impact the electricity grid's reliability as the amount of renewable energy grew and a resulted in hesitancy to expand solar production too quickly.

Variability is a concern at high levels of grid penetration, particularly for countries which have under-invested in grid infrastructure—however, low levels of penetration by variable renewable energy can largely be managed through operational changes in dispatch of electricity and utilization of detailed daily weather and load forecasting. Numerous studies have indicated that variable energy can constitute 30% of the energy supply without causing stability problems for a modern grid, and case studies from the United States indicate that ramping up to 40% or even higher is feasible through management innovations (Weiss and Tsuchida, p. 4-5).

At the time of writing in July 2021, the Mekong Infrastructure Tracker indicates that the only two countries in the Mekong with high penetration of variable renewable energy are Cambodia and Vietnam, with 10% and 24% of installed capacity respectively. In Cambodia a set of ADB-supported studies identified a roadmap to integrating 350 MW of solar without necessitating any further investment in transmission system upgrades and additional steps to integrate more than 1,000 MW through 2030 (ADB 2018, p.7). In late 2020 statements from EDC's Director General indicate a goal of maximizing solar production within the grid limitations (Chan and Boken, 2020). Vietnam, however, has faced grid curtailment challenges where local solar production has outpaced the transmission grid's capacity to integrate the power. This has resulted in projects with available capacity being unable to connect or sell to the grid. In early 2021, the National Power Dispatching Center of Vietnam indicated that the government would need to curtail 500 million kWh of solar generation due to over-capacity during peak hours (Seetao News, 2021). This is a particular problem in Ninh Thuan and Binh Thuan provinces, where investment in solar generation has outpaced investment in transmission infrastructure (Sticher, 2020).

Grid curtailment is not a problem without a solution: the government has allowed private investment in transmission lines and is currently considering amending the Electricity Law to address grid capacity issues (Do and Burke, 2021). Government officials in other Mekong countries of Laos, Myanmar, and Thailand should consider these challenges in planning, but have significant time and buildout left before reaching a threshold where variable penetration is sufficient to cause grid instability. There are also significant opportunities to reduce grid instability through the use of storage, which can be used to save excess solar or wind electricity to provide to the grid when it is needed at other times, and can also help to smooth the sudden spikes or drops in electricity production when a cloud passes in front of the sun or the wind stops blowing.

Managing Solar PV Waste

Some materials used in solar PV panels are toxic and require special handling after the lifespan of the solar panels is over. While this PV is still a young technology in the Mekong Region, it is a question which has attracted significant attention. This issue was raised in personal conversations with officials in Laos in 2019, one of whom suggested that it was necessary to identify a solution to deal with the solar PV waste before providing further support for solar investments. Government attendees at a June 2019 workshop in Cambodia also raised questions about the relative environmental impacts of solar pane waste and how this affected long term competitiveness of solar vis-à-vis other energy sources. The topic has entered the public discourse in Vietnam, with National Assembly member Ksor Phuoc Ha asking the government to provide clarity on responsibility for managing solar waste and noting local concern (Do, 2021).

Studies indicate that up to 99% of the materials used in solar panels are recyclable (Vietnam Economic News, 2021). The amount of solar waste in the Mekong is not currently significant enough to support a widespread commercial recycling industry—but there is little to suggest that one will not develop as the amount of solar waste grows and there is commercial benefit to be found through recycling the materials. Concerns over solar waste should not be dismissed, particularly as waste management and recycling have become international political issues. But this should likely be treated as an opportunity rather than an obstacle for further deployment of renewables as the solar recycling industry will have significant opportunity for commercial growth given global demand for solar PV.

Conclusion

There are positive signs that the Mekong countries are collectively moving to incorporate renewable energy into national power plans—but there is still significant opportunity for the region to raise its ambitions in terms of higher targets and faster timelines. Many of the perceived obstacles which have prevented prioritization of renewable energy in previous power development planning processes—particularly price and competitiveness—are no longer an issue.

While national policies are not the only determining factor—investor interest, financing availability, and overall economic trajectory all influence the power sector—there are clear lessons learned about what has worked in Vietnam and Thailand for power generation. Both have regularized revision of national power planning processes and are currently in the midst of finalizing near-term targets and plans for further deployment of renewables in the power sector. Both have useful lessons for neighboring countries in terms of providing policy and regulatory clarity in order to unlock private sector interest in non-hydropower renewable energy. Vietnam's experience with rapidly deploying over 15 GW of solar power over the past four years is a particularly clear example of how quickly the renewable energy transition can transform the power sector when the government adopts proactive and supportive national policies. While not wholly successful, these experiences identify useful lessons for Cambodia, Laos, and Myanmar in terms of identifying ways to unlock investment.

Addressing barriers related to grid integration and financing availability will likely require similar overhauls to help de-risk and motivate investment in modern transmission, distribution, and storage systems and promote early dialogue on and exploration of recycling models. Some of these additional policy revisions may be complicated due to the vertical integration and centralization of the power system in many Mekong countries. But while these remaining obstacles and concerns are not insignificant, they are surmountable and must be surmounted to ensure that the Mekong region's electricity supply remains resilient and sustainable.

Big C puts solar on its rooftop in Thailand
by USAID via Flickr

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CHINA'S ROLE IN MEKONG REGION'S ENERGY TRANSITION: THE ELEPHANT IN AND OUTSIDE THE ROOM

Wei Shen

Introduction

China has tremendous impacts on the energy transition pathway in the Mekong Region mainly from two aspects. On the one hand, in the past two decades China has been relentlessly exploiting the hydropower potential on the upper half of Mekong River (also known as the Lancang River) in China. The Lancang River has long been listed as one of the 'Chinese hydropower bases' that have significant untapped hydropower potential (around 30% of total exploitable capacity within China) despite eleven existing large dams being constructed in the past two decades. The environmental and social impacts of these dams to the lower Mekong countries have attracted tremendous academic, policy and public attention in recent years (Räsänen et al, 2020), even if China has exhibited increasing wiliness to adopt a coordinated approach in mitigating these impacts (Han, 2017; Xie et al, 2018).

On the other hand, under the banner of China's 'going out' strategy and the more recent Belt and Road Initiatives (BRI), Chinese companies have become increasingly active in engaging with lower Mekong countries' fast expanding energy sectors by developing, constructing and financing various energy infrastructure projects. According to Boston University's China Global Energy Finance database, leading Chinese development finance institutions (DFIs) such as China Eximbank and China Development Bank, offered 21.80 billion USD to finance energy projects in Laos, Myanmar, Cambodia, and Vietnam between 2000 and 2020 (CGEF, 2020). These activities mainly concentrate on conventional energy sources such as hydropower and coal-fired thermal power plants. Chinese technologies, finance, and construction capacity are therefore transformative in the region's energy landscape and development pathways. Yet, again, the real contribution and social/ecological footprint of these Chinese projects to the recipient countries and local communities has often attracted intense debate (Siciliano et al, 2016; Soukhaphon, 2021).

As a result, China's impacts on both upper and lower Mekong regions need to be understood comprehensively from the viewpoint of its domestic energy governance and overseas engagement strategy. It is noted that these two policy areas are closely linked and highly dynamic, with frequent and substantial institutional changes throughout the last two decades. This think piece particularly focuses on recent policy developments, such as the Green BRI policy, the 14th Five Year Plan (at central and provincial level), and – more recently – the 2060 carbon neutral pledge, exploring their impacts on attitudes and practices among key Chinese actors related to the energy activities in both upper and lower Mekong regions. I will apply a political economy analysis to the changing interests and beliefs of Chinese central government, local government (in Yunnan and Tibet specifically), state-owned enterprises (SOEs), and DFIs. The think piece will then discuss how these changes may (not) shape energy transition pathways within China and other lower Mekong countries. I argue that China's existing approach in developing large conventional energy infrastructure projects both within upper and lower Mekong regions is increasingly challenged at international, national and local levels, both within and outside China, which may spark off notable institutional changes in the coming years.

China's domestic vision for the Lancang river: All eyes on eastern Tibet now

Hydropower is one of the few sectors that failed to meet the development targets set in the 13th Five Year Plan (2015-2020). The total installed generation capacity from hydropower reached 365GW by 2020, which is slightly short of the 380GW goal set by the central government (Chinese Electricity Council, 2021; National Energy Administration, 2015). The increasing construction cost of large dams on major Chinese rivers is the major reason for the missed target, mainly due to the running out of less challenging project sites, 'low hanging fruits'. Therefore, the 14th Five Year Plan (2020-2025) is the first time that the central government set no specific targets for new hydropower capacity, as it is difficult to estimate the actual pace and difficulty in un-tapped potential. However, lacking specific central government targets did not thwart local governments' ambition in this sector, particularly among the western provinces, where a large amount of hydropower potential is not yet fully exploited. Sichuan, Yunnan, Tibet, and Guizhou all made highly ambitious plans for dam building.

As the hydropower potential on mid and lower Lancang River that runs through Yunnan province has been largely exploited, the focus has been now shifted to the upper Lancang river within the Tibet autonomous region. Currently, there are eight cascade power plants planned on upper Lancang with total instalment capacity of 9.62GW: Cege (129MW), Yuelong (129MW), Kagong (240MW), Banda (1500MW), Rumei (2600MW), Bangduo (720MW), Guxue (2100MW), and Gushui (2200MW). Among these eight power stations, Gushui, which is located on the border of Yunnan and Tibet, will probably be the first to be constructed during the 14th Five Year Plan, plan, but it is expected that all eight plants will be completed by 2030 (HLR, 2021). Accordingly, the Tibet government raised its hydropower target to 15GW in its provincial 14th Five Year Plan. Meanwhile, a large solar energy development plan (10GW) was also announced to complement the hydropower development (Tibet Government, 2021).

The main developer of these planned power plants is Huaneng Lancang River Hydropower Inc. (HLR), which is a public listed subsidiary of Huaneng Group, one of the top five Chinese SOEs in the power generation sector. HLR was first established in 2001 and is currently jointly owned by Huaneng Group and the Yunnan government. The company's sole mission is to exploit power generation potential along the Lancang River. HRL recently announced that it will spend around 6 billion RMB yuan (0.93 billion USD) for the preliminary preparation works on the eight dams in Tibet, with a total of 218.54 billion RMB yuan (33.73 billion USD) to be invested (HLR, 2021). It is increasingly clear that the intention of exploiting remaining hydropower potential on the upper Lancang river in Tibet fits closely with local government's political ambition and the leading SOEs' commercial interests, despite the notable technical challenges and possible social or environmental impacts.

Yet there is one remaining question from the demand end for this additional power generation. The newly added hydropower capacity from the Lancang River is an essential part of the national strategy of the West East Power Transmission Programme (西电东送) starting from the 1990s, in which power generated in northwest, central west, and southwest provinces can be transmitted and consumed in the most developed coastal areas, particularly around Beijing, Shanghai, and Guangdong. As one of the major destinations of power consumption, Guangdong has been relying heavily on electricity imported from Yunnan and Guizhou between 2000 and 2015.

A bi-provincial framework agreement between Yunnan and Guangdong governments was reached as early as in 1991 and revised several times later on. However in recent years China's overall energy consumption is gradually peaking due to rising energy efficiency, and slowing down of economic growth. Guangdong's actual electricity demand from western provinces is also decreasing rapidly. As a result, the negotiation for power purchase agreements has become increasingly difficult between the two provinces due to the over - capacity of power generation from both ends. Once the power plants in eastern Tibet are completed, the oversupply from the western provinces may be exacerbated, bearing the risk of severe curtailment as observed in Yunnan in the previous decade (Liu et al, 2018).

On top of the declining energy demand, tariff inversion is another issue. Currently, the electricity transmitted from Yunnan is likely to be more expensive than locally generated power due to the cost of long distance transmission, which further discourages Guangdong from purchasing power from the western provinces. China is currently reforming its electricity market; distribution of electricity will be increasingly based on market price schemes rather than a guiding tariff set by the central government (Guo et al, 2020). In the foreseeable future, power produced at higher cost may be further squeezed in the electricity market. Considering that the construction and transmission cost of hydro powerplants in eastern Tibet may be even higher, and local electricity demand in Tibet would be much smaller compared to relatively more developed and industrialised Yunnan and Guizhou, the commercial prospect for upper Lancang dams is highly uncertain. Another concern is the potential competition between Tibet and Yunan regarding the export of electricity to Guangdong, particularly taking into consideration that HRL is partially owned by the Yunan government. On nearly every front, Tibet is less competitive in an increasingly marketized electricity regime across China.

Despite these uncertainties, it seems that the acceleration of dam building on the upper Lancang River is increasingly conceivable, particularly after Chinese government's announcement of reaching carbon neutrality by 2060. Although the specific pathway and road map to fulfil the pledge has yet to be announced, it is almost certain that China needs to urgently transform its fossil fuel based energy system. Large hydropower has been portrayed as the crucial component of the low-carbon transformation, and such narratives have been increasingly endorsed by the top Chinese leaders. For example, when the giant Baihetan hydropower plant (16GW) on the upstream branch of Yangtze river was launched to generate electricity in June, 2021, Chinese president Xi Jinping sent a congratulation letter, in which Xi called for a bigger team contribution to reach the carbon peaking and neutrality goal, and to promote comprehensive social/economic green transformation' (Guangming Daily, 2021).

Apart from the claimed climate benefits, notable technological progress is also driving China's confidence in constructing large dams in the most challenging environments. The growing capacities in developing GW level turbines and higher dams, which were previously unattainable tasks, are now viewed as the symbol of China's world leading manufacturing strength, often referred to as "crucial technologies for a leading nation (大国重器)" in mainstream Chinese media . Together with other leading technologies such as the high speed train, China's hydropower sector is increasingly being framed as another manifestation of China's rising industrial power, and has consequently became a source of national pride. Such strong nationalist beliefs are now conveniently aligned with the interests and preferences of local governments and related SOEs – as explained previously – to further consolidate the drive for continuing exploitation of the Lancang river in the years to come.

It is still unclear whether these planned projects on upper Lancang are all run-off hydropower stations with relatively less environmental or social impact, or they involve any large dam building. Given the highly challenging geological conditions in Tibet, the design and safety of these ongoing projects would inevitably affect all downstream areas (including Yunnan province). Therefore, to what extent HLR will eventually publicise its feasibility studies in the coming years is crucial. It is also expected that, before construction, some assurance efforts would be made by the Chinese government to the downstream countries or communities, which are increasingly suspicious regarding the impact of upstream projects on their livelihoods.

Chinese engagement with lower Mekong countries' energy transition

Similar drivers of ideology and interest can be also noted when explicating China's strong involvement in hydropower activities across lower Mekong countries, particularly in Laos and Cambodia. According to Boston University's China Energy Finance database, there were 16 new Chinese financed hydropower plants in Laos between 2000 and 2020, amounting to 6 billion USD, while in Cambodia four Chinese projects were recorded with a total amount of 1.2 billion USD. China's engagement with Vietnam in the past two decades has been focusing on thermal power stations, with thirteen coal fired power stations being constructed amounting to 8.8 billion USD. Most of these projects are contracted using the traditional Engineering, Procurement and Construction (EPC) + Finance model with leading Chinese power construction SOEs, such as China International Water & Electric Corporation (CWD), Gezhouba, and Sinohydro, as main contractors for these turn-key projects, backed by the Chinese DFIs. Another unique active player in the region is the China Southern Power Grid (CSG), which is one of the two monopoly utilities in China with specific responsibility for investing, constructing and operating transmission and distribution systems in the southern provinces of Yunnan, Guizhou, Guangdong, Guangxi and Hainan. CSG has also been appointed by the Chinese State Council as the corresponding unit to develop cooperation with ASEAN countries in the power sector, and since then has become active in both power generation and transmission activities in the region.

It has become increasingly clear from previous studies that the commercial interests of SOEs are the biggest driver for Chinese engagement in the local energy sector, rather than the political motivations of central and local government (Breslin, 2013). This is particularly pertinent as most of the SOE groups in power generation sectors are focusing on both domestic and overseas markets. In the long run, China's peaking energy demand means inevitable slowing down of construction of power infrastructure, and consequently growing pressure to explore overseas opportunities, just like most energy companies from the developed countries in the past few decades. However, questions regarding where, how, and what to invest in actually depend on several factors, to be explored next.

To start with, most Chinese energy infrastructure projects are essentially demand driven; most Chinese SOEs are rather reactive to host government's long-term energy development plans and short term policy targets. For example, due to the obvious over-capacity in hydropower generation after a decade of dam building, the focus of current cooperation has been gradually shifted to both upstream and downstream activities in the energy supply chain. In Yunnan Province's 14th Five Year

Plan, the cooperation with Laos in the electricity sector is still highlighted (Yunnan Government, 2021), but the major area for cooperation is now in improving Laos' transmission system. As a result, CSG has just established a joint venture with Électricité du Laos (EDL) to invest, construct and operate Lao's 230KV grid and cross-border transmission systems. Total investment from this new company, known as EDL-T, is estimated at 2 billion USD in the coming years (Chinese Embassy in Laos, 2021). Meanwhile, a Yunnan based company has been co-investing with EDL in one of the 'electricity industrial parks' that aims to localise the manufacture of power equipment. Chinese engagement in the region has become increasingly diversified along the energy production chains, to meet fast changing demand of local government and markets. Such diversifying strategy is used to avoid an imminent debt crisis due to overinvestment in the power sector (Barney & Souksakoun, 2021), yet it would require CSG to get involved in energy sector governance, which is likely to further complicate the political struggles particularly around power sectoral reforms and electricity exports.

Second, recent Chinese government policies may also contribute to the changing practices of Chinese SOEs in the coming years. Since 2017 Beijing has called for a 'Green BRI' on various occasions and expressed willingness to align the UN's Sustainable Development Goals to the BRI projects (MEE, 2017). Yet how such vision is to be implemented on the ground by the SOEs and DFIs still remains to be seen, as the definition and implementation pathways of Green BRI remains abstract and unclear. Among different Chinese government agencies, opinions appear to be divergent and incoherent on some carbon polluting activities such as coal fired power plants. For example, in a recent report from the BRI International Green Development Coalition (BRIGC) initiated by the Ministry of Ecology and Environment MEE, coal fired power plants are categorised as a high environmental risk that should be strictly controlled (BRIGC, 2021).

Yet a senior officer from MEE expressed the exact opposite opinion later on by stating that Chinese investment in coal-fired power plants is in line with the actual demand and energy endowment of these low income countries, and therefore should not be completely halted (China News, 2021). President Xi Jinping's pledge to stop financing new coal plants abroad at the United Nations summit seems to have closed the debate among Chinese officers abruptly, but to implement that pledge requires tremendous efforts in re-negotiating around the existing deals.

It is obvious that among Chinese regulators there are competing beliefs regarding overseas fossil fuel investment. Our field investigation also indicates divided beliefs also exist among ordinary employees of Chinese SOEs and DFIs. Many believe such investment is producing unnecessary damage both to the environment and China's global reputation, while others believe that for many developing countries this is the 'inevitable pathway' of development as alternative options are not yet available. The new visionary policies around Green BRI hence have at least generated some implicit policy debate, but no fundamental changes of attitude and practices among most core SOEs and DFIs have been noted at the current stage. Since China is a country that has embraced a developmentalist approach over several decades, the ideological shift towards a more ecological oriented approach would take time among various actors.

Therefore, the real potential factor to destabilise the status quo would rather be interest-driven than ideological, particularly from the rising opportunities around non-hydro renewables such as wind and solar in recent years. For example, in Myanmar's 1GW solar energy procurement programme, Chinese companies won 29 out of total 30 bidding contracts. Among the winners are familiar names of traditional SOEs such as China Machinery Engineering Corporation (CMEC), State Power Investment Corporation (SPIC), and Gezhouba group. But there are new names too, such as Chinese private companies GCL, New Energy and Universal Energy. In Vietnam's fast growing wind energy market, Chinese companies are also playing an active role, which again includes both traditional players like Power China, Energy China, and Dongfang Electric Corporation (DEC), and relatively new players in the regional market like Envision and Goldwind. These emergent opportunities are transforming existing SOEs, as many of them have now established dedicated units or even subsidiaries for overseas wind and solar energy projects. Meanwhile, as Chinese wind and solar technology have become mature enough for exploring overseas markets, leading Chinese technology suppliers are also keen to explore new opportunities in the lower Mekong Region. These new units, subsidiaries, and companies are likely to form an emergent coalition within China to press for more favourable policy support from DFIs and local government, which may eventually challenge the existing rules or norms in supporting conventional energy projects.

Chinese wind and solar companies also have some unique advantages in the lower Mekong Region: for example, their rich experiences with floating solar power systems, which have been widely experimented with on the large scale fishponds in China's eastern provinces, or their technological capacities in developing wind farms within lower wind speed zones. Although the current institutional arrangements dominated by SOEs and DFIs are not well equipped to support distributed renewable energy systems, many Chinese solar companies have managed to invest in new production lines of solar panels and modules in Vietnam and Thailand that can further support the fast growing renewable energy sectors in the region. All these activities will aggregately tip the balance between conventional and new infrastructure, which favours cleaner energy sources and novel finance/business models in the long run.

The political economy of China's role in the Mekong region's energy transition pathways

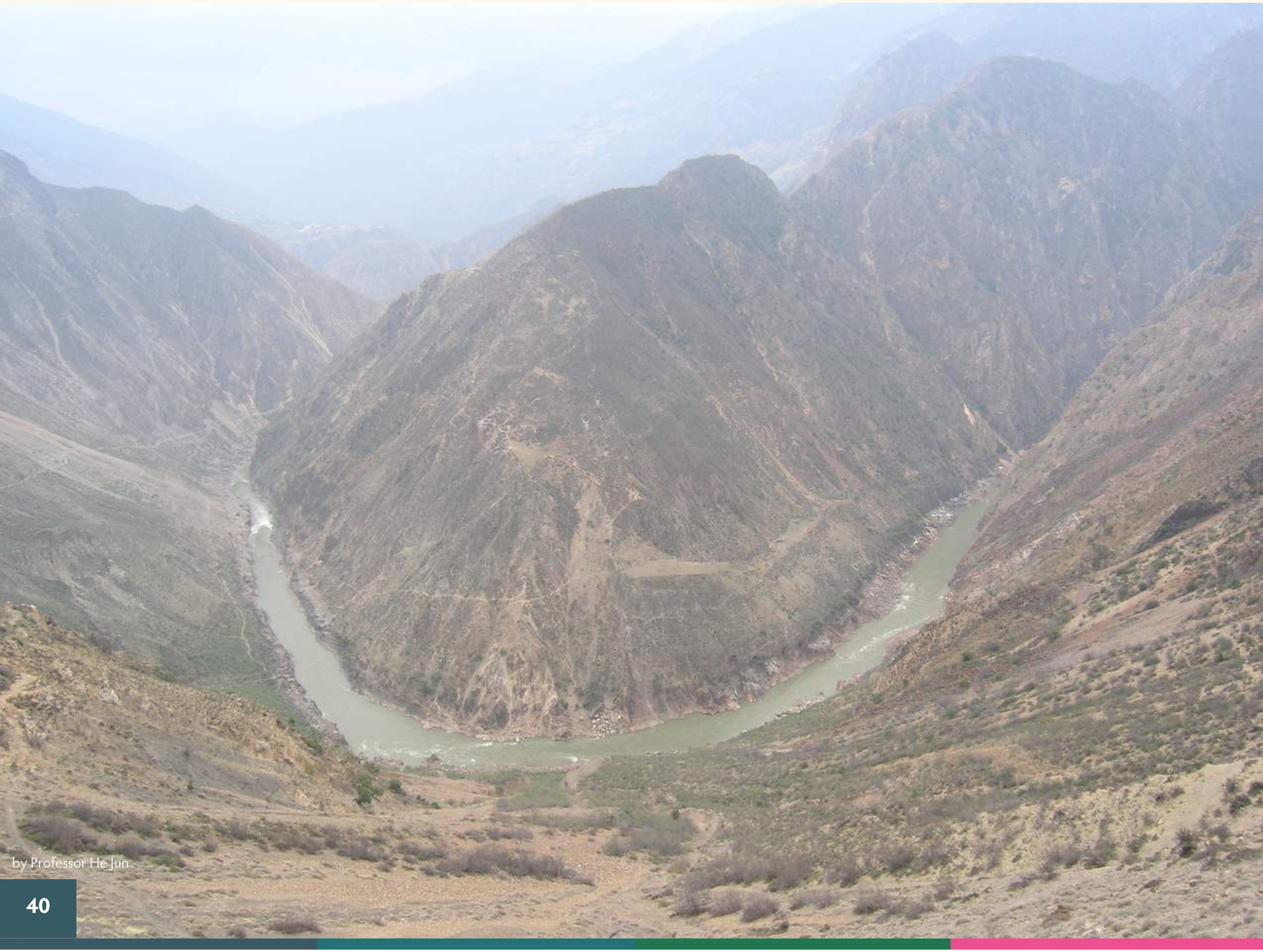
In the preceding sections, I have identified the ideological, institutional and interest-based explanations of Chinese policies and activities in both upper (Lancang) and lower Mekong regions. In many previous studies these activities are often analysed separately as domestic and international issues. From the political economy perspective, however, I argue that the linkages and comparability between the two domains is evident. Chinese activities on the Lancang river are largely driven by an increasingly consolidated policy advocacy group led by SOEs and local governments for the continuous exploitation of the Lancang river. And their focus in the coming years will be the upper Lancang river in eastern Tibet. The coalition seeks to capture the pro-hydro narratives endorsed currently by the central government and the top leaders, despite potential frictions with the local communities, major off-taking provinces in eastern China (particularly Guangdong), and presumably some lower Mekong countries who are worried about the environmental and social impacts. Although developing large hydropower projects in such a challenging environment would exhibit China's world-leading engineering and technological capacity, the actual and long-term economic, social and environmental benefits of these dams need to be demonstrated with much stronger evidence, plus a more transparent project screening and implementation procedures to materialise.

Similar conclusions can be drawn from China's engagement with lower Mekong countries' power sector development, which has created comparable problems of over-capacity in the power generation sector in some countries, again driven by synergized government and corporate enthusiasm for large dams, and other conventional energy generation infrastructure. Another comparable insight would be the similar economic imbalances between major power suppliers and off-takers both in the upper and lower Mekong Region. Eastern Tibet as an additional hydropower supplier is economically underdeveloped compared to Guangdong, and so is Laos compared to Vietnam and Thailand. Over-reliance on a single off-taker would make the suppliers increasingly vulnerable particularly in the context of notable saturation from the demand side. China's shifting focus recently on transmission and distribution systems and local manufacturing capacities in Laos seems to indicate that Chinese actors are now at least aware of the issue of generation over-capacity and tend to mitigate its impact by investing in upstream and downstream activities. Although a smarter and more reliable grid system and enhanced local manufacturing capacity (if both achieved) can help reducing the power generation and transmission cost, a fully integrated and free market for both electricity and power equipment may face tremendous political struggles. In this regard, both China's own West East Power Transmission Programme (on Lancang) and the regional Power Trade and Interconnection (as envisioned within the Greater Mekong Subregion Program of the ADB on lower Mekong) are based the strong beliefs of technological or engineering fixes but tend to overlook the political challenges associated. Yet if even China's strong central government cannot effectively coordinate inter-provincial power trade within its borders, the prospect for the lower Mekong Region to coordinate cross-country deals under current regional governance regimes could be even more dismal, particularly when considering that the major trading participants in most countries are essentially state-owned entities rather than commercial organisations.

In addition, China's recent pledge of carbon neutrality by 2060 may produce mixed impacts Chinese investment in the region. In the short run, it may create enticements for carbon leakage due to the increasingly stringent climate policies at home to push Chinese high carbon industries, such as the coal power sector, to seek overseas opportunities for their survival. In the medium and long run, however, changing beliefs and values in low carbon transformation may encourage SOEs and DFIs to revise their attitudes and reduce their appetites for fossil fuel investment. Recently, Chinese led AIIB promised to stop coal-related financing, followed by the refusal of China's leading commercial bank, ICBC, to support Zimbabwe's coal power stations. It seems that gradual change is already taking place. Acceleration of such changes, however, depends on the emergent opportunities around non-hydro renewable energy projects for the Chinese companies and the formation of new coalitions as a result. After all, incumbent pathways can only be destabilised during a period when new pathways are becoming promising (Leach et al, 2010). Therefore, the market prospects and policy framework in supporting wind and solar sectors from the lower Mekong countries are still the most determining factors.

Currently, the majority of Chinese activities in the lower Mekong Region focus on the utility scale projects, with little direct engagement with distributed renewable energy systems. This is largely because China's foreign aid sector has lagged far behind its highly efficient export credit and development finance systems (Brautigan, 2011). The newly established China International Development and Cooperation Agency (CIDCA) seems reluctant to take over the leading position of MOFCOM in governing the foreign aid system. Currently, this highly centralised governance system lacks willingness – and probably capacity too – in coordinating various civic groups, consultancies and private companies in the way often required in delivering decentralised energy systems particularly in the rural areas. As a result, China's contribution to the rural electrification and mini-grid systems seems likely to remain limited, apart from supplying specified solar equipment, either through export or local Chinese manufacturers.

To conclude, China's previous engagement with power sector development in both upper and lower Mekong regions can be largely characterised as a commercially-driven, technologically-inspired, and state-supported model. This distinctive approach therefore has favoured large scale infrastructure for conventional energy sources and long-distance transmission systems which has shaped the energy transition pathway with its embedded beliefs and institutions. However, such a development approach is faced with increasingly complex power dynamics and political struggles at both international, national and local levels both within and outside China, particularly at the juncture of combating climate change, peaking energy consumption, and emergent new technological options. As new actors (MEE, CIDCA, wind and solar companies), institutions (the 14th five year plan, the Green BRI, and net zero targets), and ideas (rising environmentalism and nationalism) have all come into this arena in the past few years, they put new options on the table, ranging from pumped storage hydro (PSH) plants to floating solar PV (IEA, 2021). All these new developments among actors, institutions, and technological choices suggest possibilities to depart from the existing energy transition pathways, with China still playing a crucial but notably different role.



by Professor He Jun

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THE POTENTIAL AND CHALLENGES OF REGIONAL ENERGY TRANSITION THROUGH THE CHINA-MEKONG MULTILATERAL GRID INTERCONNECTIONS

Laurence L Delina

Indroduction

China, which seeks to achieve carbon neutrality by 2060, offers the world the Global Energy Interconnections (GEI) project to bring about a planetary energy transition. A China-led vision of a globally interconnected energy system future, the GEI envisages synchronizing eighteen regional energy grids connecting most of the world's energy systems into a planetary grid spanning most of Asia, Southern Africa, Europe, the Baltics, Canada, and South America (GEIDCO, 2016). The GEI comprises the webbing of smart grids, using long-distance ultra-high-voltage (UHV) transmission backbones to address supply reliability, especially as demand rises, through renewable energy exports. The GEI, thus, seeks to fulfil a global sustainable energy transition to wean the world from the need to burn fossil fuels for energy (GEIDCO, 2016), hence also projecting China's climate action leadership. The GEI, alongside China's export of solar and wind energy technologies, is poised to become a crucial part of China's 'Going Out' policy in the energy sector. An unnamed senior Chinese government official quoted in The Financial Times (2018) mentioned that Xi Jinping considers the GEI "a personal priority." The GEI, thus, complements China's leadership in the energy sector, which already includes financing large hydropower projects (Chen and Lerner, 2018) and solar panel and wind turbine manufacturing and export (Fialka, 2016). This think piece argues that in the Mekong Region the GEI holds the potential to contribute to a renewable energy transition while addressing supply reliability issues; but, there are significant political economy and sociotechnical challenges to overcome.

The geographically proximate world region to China is to its south, the Mekong Region comprising the southeast Asian countries of Myanmar, Thailand, Vietnam, Cambodia, and Laos. After UHV deployment in its territory, the next geography for the GEI, thus, is the Mekong. Although a formal agreement to interconnect China's southern grid with any country in the Mekong is currently non-existent, there have been plans, at least on paper, to interconnect China's UHV lines in Yunnan to its southern neighbors (United Nations, 2018). This vision is technically possible given that a UHV transmission line already exists connecting Yunnan's hydro-rich generators with demand centres in Guangdong. In a report jointly authored by the ASEAN Centre for Energy (ACE) – the ASEAN think-tank on energy matters – and the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) – a United Nations regional body, the GEI ambition is advanced in the Mekong and the rest of the ASEAN (United Nations, 2018). The ACE-ESCAP report contains provisions on measures to expand the deployment of renewable energy in Southeast Asia and provides "a firm foundation for achieving regional energy interconnection, which also promotes sustainable transboundary power trade" (United Nations, 2018). The report seamlessly linked the ASEAN vision of more robust regional integration with China's GEI project.

The China-Mekong GEI, if realized, could deliver at least three significant impacts. First is the deepening of the economic and institutional integration process among Mekong countries, especially as energy demand rises. The second is addressing supply reliability gaps. The third is the acceleration of renewable energy transition in the Mekong Region, which has substantial

by uk_mal

implications for climate commitments in these countries. Yet, for the China-Mekong GEI to be a reality, several infrastructural and policy challenges have to be hurdled by China, the individual Mekong countries, and the sub-region's existing institutional arrangements as a whole.

Understanding both potentials and challenges is crucial. Most significantly, knowing how the proposed China-Mekong GEI could affect the technical aspects of energy systems and their social dimensions is essential so that strategies to address the barriers and mitigate future challenges can be designed in advance of their actual deployments. Since the GEI depends on cooperation, understanding the barriers for advancing partnerships bilaterally – between China and the individual Mekong countries – and multilaterally – across all parties – also matters. This thinkpiece discusses these potentials and challenges. The next section describes the GEI's potential to address supply reliability issues and accelerate energy transition. After that, the critical barriers for the China-Mekong GEI are scoped, taking into consideration the political, economic, social, and resource diversity of the Mekong Region in terms of energy regimes, trust levels with China, the actual conditions of their grids, issues of sovereignty and national security, and their heterogeneous markets and regulations. Overall, this think piece argues that the GEI can become a new tool for increasing supply reliability and accelerating energy transition in the Mekong countries. Still, the technical and non-technical challenges need addressing for this vision to be realized.

The promise of energy transition in the Mekong through China's GEI

The high capital costs of large-scale renewable energy technologies are among the main issues facing energy transition in Mekong countries. China's GEI, which brings about new funding and infrastructures to interconnect disparate national grids to its renewable-rich regions, thus, offers an opportunity for the Mekong Region. Thailand, which has some local production of renewable energy technological components (Asian Development Bank, 2015), already had 11.8 Gigawatts of renewables in its energy mix in 2019, supplying about 16.5% of its energy demand (Department of Alternative Energy Development and Efficiency, 2020). Vietnam's renewable energy deployment has also accelerated faster than the rest of the Mekong countries since 2020. The commitment from the Vietnamese government to boost renewable energy with policy support led to Vietnam becoming the Mekong country with the highest installed solar energy generating 16.5 GW of new solar power by the end of 2020 (Vu, 2021). Nevertheless, accelerating the transition in the Mekong remains paramount – and any support these countries can get would be needed.

All Mekong countries are parties to the Paris Agreement, which requires them to contribute to climate mitigation via renewable energy transition. They all have renewable energy targets, although these range widely from 6% to 20% of the total energy supply (Asian Development Bank, 2015). These targets, however, are understated, especially when compared to country potential (Asian Development Bank, 2015). The abundance of solar, biomass, biogas, wind, and hydropower in the Mekong Region means that an energy transition can contribute to climate mitigation and, at the same time, address supply reliability issues. A China-Mekong GEI offers a regional vision to meet these ambitions via Chinese exports of its surplus energy and new technology deployment, especially a UHV distribution system and smart grids.

China has long been a bilateral energy development partner of all Mekong countries (see Appendix 1 of Delina, 2021 for a partial list of these China-supported energy projects). Among them, the Cambodian energy sector has received the most support from Chinese financing. China, for instance, has provided US$ 2.6 billion in funding for six large hydro projects in Cambodia that are now operational (Delina, 2021). While a majority of Chinese energy financing in Cambodia is for large hydro development, it also has exposure to coal-fired power plants, including the 700-MW plant in Preah Sihanouk, at a cost of US$ 1.2 billion (Bloomberg, 2010). In Vietnam, China's energy sector funding is towards coal-fired powerplants with capacities ranging from the 740-MW Uong Bi power station (Chengda, 2012) to the proposed 5,600-MW Vinh Tan powerplant (Vietnam Net, 2020). In Laos, China funded the Nam Ou hydropower scheme at a cost of US$ 2.73 billion (Power China, 2016). In Myanmar, the proposed 135-MW natural gas-fired powerplant in the Rakhine state will be jointly funded by the Kyaukphyu Electric Power Company and Chinese state-owned Power China Enterprise (The Myanmar Times, 2020). Although China's energy funding in the Mekong is mostly fossil fuel-based and contentious hydro, some projects support an energy transition, albeit smaller in capacity and lower in cost. In Thailand, for example, China has funded a 45-MW hydro-floating solar hybrid project in Ubon Ratchathani (Solar Business Hub, 2020) and a 90-MW solar farm in Changwat Khon Kaen (Tsanova, 2020).

Exporting China's renewables to the Mekong?

China's national energy profile faces overcapacity, a situation where its energy-generating companies could not sell as much electricity as they can produce; in simple words, supply exceeds demand. As a result, overcapacity has become an intense issue between Chinese utilities and China's central and local governments, whose interests have not often aligned. State Grid, one of the country's most valuable state-owned enterprises covering 88% of China, is the most interested UHV actor. State Grid envisages bringing most of China's renewable energy resources located in the interior (in the west) to demand centers concentrated primarily on urban and industrial centres in the east. State Grid's UHV vision is shown in a plan to construct 19 UHV lines by 2013 and 37 UHV lines by 2020 around China (Yi-chong, 2017). However, UHV deployments have slowed down as China experiences electricity generation overcapacity. This situation derailed State Grid plans. In addition, China's State Grid ambitions appeared not to have chimed with policymakers in provincial governments. Provincial planners had registered their worries that UHV interconnections could lead to China-wide blackouts (Delina, 2021). Provincial governments, thus, tended to support provincial-scale electric generation and distribution. This capacity is mostly fossil fuel-based (Delina, 2021).

As China's electricity demand slowed down in recent years, UHV deployments also ebbed. From a national average of 11.7% in 2003 to 2012, China saw electricity demand growth dwindling to 4.5% from 2012 to 2017. In 2015, demand growth was at its lowest: only 0.5% (Downie, 2020). As the Chinese economy continues slowing down, Chinese energy demand likewise tends to slide. As a result, there is now more energy supply in China than China needs, hence the exigency to export this surplus and, in effect, the introduction of the GEI as a global project of electricity surplus export (Delina, 2021). Although the GEI is anchored on energy transition with renewable energy at its core, there is no guarantee that these energy exports will come from renewable energy sources. It is also important to note the critiques surrounding large hydro, especially in terms of being branded as renewable energy (International Rivers Network, 2003) and its impacts on biodiversity, livelihoods, and economies downstream (Campbell and Barlow, 2020).

The China-Mekong GEI would be more hydro-oriented: China exporting its excess hydropower to downstream Mekong countries via a UHV Yunnan-Mekong system. Mekong countries are geographically positioned to connect their grids with hydro-rich Yunnan province. This prospect also appears appealing given the extant bilateral and multilateral cooperation mechanisms between China and the countries in the Mekong. China is a key investor in the Laos grid (Voice of America, 2021). Vietnam has been importing electricity from China (Danganan, 2019). Regionally, the Greater Mekong Subregion (GMS) program provides an institutional arrangement to which the China-Mekong GEI can be attached since energy trade is among the GMS' key economic programs (Asian Development Bank, 2015). This sub-regional economic cooperation program seeks to enhance economic relations among Mekong countries sharing a natural economic area in the Lancang-Mekong River systems. It was created under the auspices of the Asian Development Bank in 1992 and has long since been planning for enhanced economic cooperation in the subregion, including energy cooperation (Asian Development Bank, 2015).

by Zhudifeng

The barriers for China-Mekong grid interconnections

Grid interconnection does not occur in a technology vacuum; it also requires social, economic, and political shifts. Most likely, the barriers would exist in complex social lines rather than grid engineering. To facilitate the China-Mekong GEI, China and Mekong countries have to harmonize their grids and the regulations governing them. This section discusses some of the hurdles for realizing the China-Mekong GEI vision in terms of (1) extant grid conditions, (2) the Mekong countries' relatively high renewable energy potential, (3) China's and Mekong countries' heterogeneous energy regimes, (4) Mekong countries' trust levels with China, and (5) sovereignty and national security contexts.

Extant grid conditions

A critical characteristic of China's UHV lines is that its application is limited only to interconnection projects that convey vast volumes of electricity over relatively long distances (Hu and Yao, 2017). A key challenge in the China-Mekong GEI, thus, is that the Mekong Region may have lower capacity demand and needs than the volumes that China's UHV lines are seeking. Mekong countries have different demand profiles, from relatively heavy energy demand in Thailand and Vietnam to low energy demand in Cambodia, Laos, or Myanmar. Another issue concerns UHV line malfunctions, which can mean that a disruption in one line could affect other lines. This could be an issue since the China-Mekong GEI will serve multiple countries. Malfunctions, however, can be addressed by introducing flexibility in the grids of Mekong countries to ensure reliability and stability. With flexibility built onto the China-Mekong GEI, electricity demand and supply could be balanced at every second.

Grid flexibility, however, also means that the operational behaviours of Mekong country grids have to align with China's UHV requirements (Huang et al., 2019; IEA, 2016; IEA et al., 2015). As higher percentages of China's renewable energy travel into the Mekong regional grid, smart grids – which are core GEI technology – can assist in supply-demand management. The next critical question, thus, is how ready the grids in Mekong countries are in transitioning them into smart grids. Flexibility is crucial before the China-Mekong GEI can be deployed since, according to a study (Huang et al., 2019), no Mekong countries perform exceptionally well in this area. The same study suggests Thailand's local renewable energy can contribute to regional grid flexibility (Huang et al., 2019), while the relatively limited investments in Laos, Cambodia, Myanmar, and Vietnam suggests that these countries could easily and immediately accommodate China's renewable energy and develop their grid infrastructure in alignment with the UHV system (cf. Huang et al., 2019).

The high renewable energy potential of Mekong countries

While the China-Mekong GEI will be conveying renewable energy in the region – most likely Yunnan's excess hydropower – thereby increasing the share of renewables in the energy mixes of these countries, it is critical to note that the Mekong countries also possess their own vast renewable energy potential. A pertinent question along this line, thus, is: if Mekong countries can produce their own renewable energy, why is it then necessary to import China's renewable energy? If it will be Yunnan's hydropower, the question further extends to the contentions surrounding the construction and operations of large hydro. A 2016 report has even suggested that 100 percent of the Mekong's power supply can be generated by renewable wind, solar, biogas, geothermal, and biomass by 2050 – without contribution from large hydro (WWF, 2016). This vision of 100 percent renewable energy is among the growing corpus on the technical and economic plausibility of fully transitioning to renewable electricity to meet 2050 demand. A Stanford study, for instance, details how the Mekong countries can achieve this objective using their local renewable resources (Jacobson et al., 2018). In this vision, Thailand's 2050 energy requirements can be provided from 56 GW of solar photovoltaic systems in existing residential, commercial, government, and industrial rooftops, 20 GW from concentrated solar thermal plants, and 23 GW from offshore wind (Delucchi et al., 2016). Renewable energy can also fully met Myanmar's energy requirements by that year: 10 GW from rooftop solar, 2 GW from concentrated solar, 3 GW from onshore wind, and 2.5 GW from offshore wind (Delucchi et al., 2016).

Renewable energy can also fully met Myanmar's energy requirements by that year: 10 GW from rooftop solar, 2 GW from concentrated solar, 3 GW from onshore wind, and 2.5 GW from offshore wind (Delucchi et al., 2016). In Vietnam, a fully renewable energy transition by mid-century is also possible with contributions from 29 GW rooftop solar, 8 GW concentrated solar, and 12 GW offshore wind (Delucchi et al., 2016). A Cambodian 100% renewable energy transition can be met in 2050 by 3 GW rooftop solar, 2 GW concentrated solar, and 3 GW onshore wind (Delucchi et al., 2016). The Stanford study does not have projections for Laos. All these projections require only the deployment of market-ready solar and wind energy technologies and the ramping up of the efficiency of existing hydropower, with zero new installations.

As climate action becomes a stringent requirement, alongside the rapid drop of renewable energy technologies and the availability of capital financing for their deployments, Mekong countries could generate their renewable electricity using their vast potential. Already, Vietnam has shown in 2020 that it can ramp up solar power deployments when it installs solar capacity equivalent to six coal-fired power plants (Vu, 2021). The challenge with the China-Mekong GEI, thus, is whether an increasing renewable energy generation in the Mekong countries could also contribute to the region's overcapacity. In that regard, conflicts as to whose renewable energy should be given priority of entry to the regional grid can surface. If China insists that its supply should be prioritized, then that could hinder local innovation in Mekong countries and, instead, foster energy dependence from China.

Mekong countries' heterogeneous energy regimes

The energy regimes of China and Mekong countries are also relatively distinct. For example, electricity tariffs and rules vary across countries. However, they also share some commonalities in terms, for instance, of the role of state-owned enterprises in either energy generation or distribution or both, albeit there are also privatized and independent players (IEA, 2015). In addition, there are also bilateral energy trade deals between some countries in the Mekong based on individual take-or-pay contracts, such as the Thailand-Laos agreement on hydropower trade. This heterogeneous mix of utility structures and institutional arrangements could create complexities for China-Mekong electricity trade agreements and regional efforts in the electricity sector. This heterogeneity, thus, makes the prospect of a China-Mekong regional energy interconnection more complicated than, for example, a relatively homogenous European regional electricity market. Therefore, for the China-Mekong GEI to be realized, new ways of doing business have to be introduced into cross-border energy trade. This institutional innovation requires the transformation of distinct national energy regimes.

One of the advantages of regional energy cooperation is that resources – not only energy but also financial capital and skills – can be pooled regionally. In the longer term, pooled energy resources could address supply reliability issues since a larger supply can balance country deficits. Managing pooled resources, however, requires a multilateral energy regime to manage its complexities. This regional institutional arrangement is needed to oversee a regional energy market and harmonize country-specific tariffs and rules into a coherent, if not single, regime. For example, grid codes need to be introduced, or, if they already exist, reformed to allow China's UHV connection to flow south of its Yunnan border, for smart grids to be incorporated in national grids, and for renewable energy supply to flow across the region undisrupted. Grid codes require new regulations regarding how grids should behave and could be coordinated multilaterally (Cochran et al., 2014). Already, the GMS has been working on the GMS regional grid code to advance regional electricity trade (Greater Mekong Subregion, 2021). A harmonized grid code means that China's grid should be responsive to Myanmar's to Thailand's to Cambodia's, and so on. Energy resource allocation is another area that requires correspondence across countries (Cochran et al., 2014), necessitating the development and deployment of forecasting systems and, again, harmonized regulations to govern the allocation (Cochran et al., 2014). A regional institution tasked to lead these efforts and innovations, thus, is critical for a working China-Mekong GEI.

As long as a regional energy interconnection institution vested with specific, appropriate, and adequate powers is absent, the prospect of China-Mekong GEI could remain but a vision. However, this may not be far into the future, given the modest experiences with bilateral energy cooperation between China and Mekong countries and the advances in planning for regional electricity cooperation under the GMS program.

Trust levels with China

The sponsorship of the GEI by the Chinese Government does not free the China-Mekong GEI from political and economic suspicions over China's industrial expansionist agenda. China's militarization in Southeast Asia, particularly since 2012 in the South China Sea, has already increased regional volatility and has shaken the region's confidence in multilateral and norms-based cooperation (Thu, 2018). Vietnam, a Mekong country, strongly opposes China's incursion in the disputed territories, leading to a relatively low level of trust towards the latter. Diminishing trust towards China in Vietnam occured when the latter already had received a significant volume of energy-related bilateral deals with the former, as discussed earlier.

China also suffers from a deficit of trust among the Cambodian public despite Cambodia receiving the bulk of Chinese funding in the region (Kung, 2014). Winning the trust of all Mekong countries would be a necessary precondition for the China-Mekong GEI to be successful and requires strategic geopolitics and diplomacy that go beyond energy issues.

Sovereignty and national security contexts

It is also crucial to recognize that Mekong countries put a premium on the role of their electricity sector in national development, economy, security, and politics. The distinct political economy of energy regimes across the Mekong Region, thus, presents an essential challenge for the China-Mekong GEI. Governments in the region still consider electricity a vital political good, meaning they will not easily forego control of it. A challenge, thus, can arise in terms of whether these governments would consider the GEI solely for its purpose of strengthening a regional energy system and advancing the energy transition, and not as an avenue that can be perceived as a threat to their respective sovereignties and security. Therefore, it would not be abnormal if governments hesitated to entrust their grids and, consequently, their energy systems to the control of other, albeit neighbouring, states, including China. National security issues relative to grid control by another sovereign state have already arisen in Laos as China Power Grid Company became part owner of their grid (Voice of America, 2021). A related challenge could transpire in Thailand since a Thai law limits the degree to which the country's electricity system can depend on imports, even from those generated by Thai companies in neighbouring countries (Energy Policy and Planning Office, 2007). Another issue that can be envisaged pertains to the capacity and willingness of host state actors and, in many cases, of their domestic oligarchs. to participate in a regional energy market, and at what point (cf. Camba, 2020). Addressing these political economy challenges requires building strong support for integration across multi-interested actors. In the case of the Mekong countries, this means negotiating with state-owned and private utilities, energy generators, state agencies, business people, and local communities affected by the siting of the new UHV lines.

Conclusion

As China seeks new markets for its purported excess renewable energy, the GEI is effectively proposed as a new tool for addressing long-standing energy challenges in the Mekong. The China-Mekong GEI offers an opportunity to address the Mekong region's supply reliability issues and accelerate a regional energy transition at the same time. Despite this promise, this envisaged regional energy interconnection underscores ongoing challenges that need hurdling if this vision of energy cooperation has to materialize. This think piece tackled some of these critical challenges, ranging from the technical (i.e., extant grid conditions and the Mekong countries' renewable energy potential) to the non-technical (i.e., heterogeneous energy regimes, trust levels with China, and security and sovereignty issues). The GEI is as ambitious as the prominent Belt-and-Road Initiative, China's primary 'Going Out' strategy. As both initiatives seek to export China's overcapacity (i.e., energy in the case of the GEI) while increasing its power position globally, they are also subjected to intense hurdles that are not necessarily global but rather nationally specific. These barriers are not only technological and economic but also social and political. Addressing the latter inarguably requires more than infrastructural and financial outlays from China. It remains, therefore, to see how the Chinese vision of interconnecting the world's energy systems into a planetary grid can start in its southern neighbors in the years to come.

by Scott Hortop

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POWER CONNECTIVITY IN THE GREATER MEKONG SUBREGION: THE NEED FOR A WIDER DISCOURSE

Muyi Yang, Deepak Sharma, Xunpeng Shi, and Kristy Mamaril

Introduction

Regional power connectivity – in the context of this think piece – refers to fully interconnected national electricity systems that enable the trading of electricity across countries (regions), facilitated by harmonised regulatory arrangements that ensure coordination in the operation (for example, generation scheduling and dispatch, and congestion management) and planning (such as long-term supply adequacy) of a regional electricity system (IEA, 2019). The purported rationale for regional power connectivity is lower electricity supply costs, achieved through the exploitation of scale and scope economies in electricity generation and supply. This, in turn, would incentivise much-needed private investment in large-scale power projects that would otherwise not be viable at national levels, especially for smaller, resource-rich, countries with relatively small electricity demand. This, it is also argued, would result in increased access to electricity and provide economy-wide benefits (UNESCAP, 2019). More recently, regional power connectivity has also been cited for its contribution to emissions reduction by enabling higher penetration of renewables in the electricity systems. The basic argument is that power connectivity could allow the sharing of complementary renewable resources (especially, wind, and solar) that are often distributed unevenly across the region (IRENA, 2021).

For these reasons, various regions around the world have over the years pursued power connectivity. A deeper review of the global experiences however suggests considerable variations in the actual progress of power connectivity across these regions. In Europe, for example, power connectivity has progressed with relative ease, where the gradual integration of the day-ahead markets has been achieved for over 85% of the European electricity system (Algarvio et al., 2019). In Central America and some parts of Africa (e.g. Southern Africa), power connectivity has also progressed significantly although not yet at the level of connectivity evident in Europe (SAPP, 2021). In most other regions, despite considerable efforts to promote power connectivity, the actual progress has been relatively insignificant. The Greater Mekong Subregion (GMS) – the region of focus of this study – is one such region.

The GMS is a trans-national region of the Mekong River basin, which comprises five Southeast Asian countries (Cambodia, Laos, Myanmar, Thailand, and Vietnam) and two provinces of China (Yunnan and Guangxi). Despite nearly 30 years of efforts, power connectivity in the region remains rather low, limited to a few uncoordinated bilateral cross-border exchanges of electricity. Overall, the current volume of electricity trade across the region stands at 2% of total regional electricity consumption (ADB, 2020).

There is significant commentary on the possible reasons for the slow progress of power connectivity in the GMS. These reasons range from insufficient infrastructure, to lack of human resources, to uncoordinated regulatory processes (see, for example, Shi et al., 2019). However, considering that some other regions, such as Central America, and Southern Africa, although beset by similar difficulties as the GMS, have managed to appreciably progress power connectivity and achieve significant levels of multilateral electricity trade, one starts to question if the existing thinking on


by mrganso

the matter, in GMS, is sufficient.

Against this backdrop, the primary objective of this think piece is to review the existing thinking on the reasons for the slow progress of power connectivity in the GMS, with specific emphasis on identifying the 'limits' of such thinking, and hence ways to rectify the situation.

Existing thinking on GMS's slow progress toward power connectivity

Power connectivity in the GMS is planned to progress in four stages, characterised as follows: 1) one-way power sales under a power purchase agreement (PPA) from an IPP in one country to a power utility of another country using dedicated interconnection facilities; 2) system-to-system trading between two countries, initially using spare capacity in the dedicated interconnection facilities, and eventually transitioning to using a third country's transmission facilities; 3) all countries become interconnected, and the planning and system operation functions are regionally coordinated; and 4) all countries complete the transition to regulatory frameworks that enable the establishment of a regional competitive market for electricity.

GMS countries were committed to developing the first two stages of cross-border electricity trading by the signing of the Inter-governmental Agreement on Regional Power Trade in 2002. After almost twenty years, the region is still in the process of transitioning from Stage 1 to Stage 2. Notwithstanding that the countries of the region have negotiated a large number of bilateral project-specific PPAs, there has been very limited progress towards multilateral electricity trading, except the recent 'pathfinder' trial (i.e. LTMS-PIP) on electricity export from Laos to Malaysia (and later Singapore) via Thailand.

Key factors responsible for this slow progress of transitioning from Stage 1 to Stage 2 in the GMS, as identified by the existing literature, are as follows.

Inadequate infrastructure

The national grids in some GMS countries (Cambodia, Laos, and Myanmar, in particular) are weakly-integrated and mainly built on low and medium voltage backbone lines that are unsuitable for long-distance transfer of electricity. For example, in Cambodia, the national grid is made up of 24 weakly integrated provincial systems, mainly built on 115 kV and 230 kV lines, despite the fact that 500 kV lines are more efficient in long-distance transfer of electricity (ADB, 2018). Similar observations can also be made for Laos and Myanmar. In Laos, the national grid is made up of three weakly integrated systems (namely central, northern, and southern) dominated by 115 kV and 230 kV lines (ADB, 2019b). Myanmar's national grid has been developed primarily to serve the southern urban area (particularly, the Yangon area) where the modern economy is concentrated. The grid is made up of 132 kV and 230 kV lines with one 500 kV line linking Meiktila with Hlaingthaya currently under construction (ADB, 2016). In contrast, China, Thailand and Vietnam have well-developed grid systems with high-voltage integrated backbone lines. This variability in terms of grid quality has posed a significant technical barrier for deeper power connectivity across the region.

Inflexible power purchase agreements

Cross-border power trading in the GMS has largely been conducted bilaterally, through PPAs between independent power producers (IPPs) and electric utilities of the importing countries. In some cases, electric utilities in the importing countries are given exclusive rights for using the interconnection facilities with no access granted to other entities (even the host country's utilities). The lack of third-party access to the interconnection facilities has affected the transition to deeper connectivity with system-to-system trading, especially if one notes the long-term nature of most PPAs (25 years, in most cases) (Antikainen et al., 2011).

No third-party access to the grid

Third-party access is a key pre-requisite for deep power connectivity, whereby generators can use the interconnection assets, for a certain wheeling fee, to trade electricity with power utilities or large consumers connected to the network of importing countries. The basic requirements for the third-party access are: 1) all countries should permit third-party access under non-discriminatory, transparent rules; 2) there must be a published list of use-of-system charges; and 3) there should be clear procedures for handling congestion and disputes. However, these basic requirements are not met in the GMS at present (ADB, 2020).

Uncoordinated planning and operation processes

The planning of power sector development has not been coordinated nor optimised in the GMS to minimise long-term investment. Progress was made in developing an integrated regional modelling database, and initial training was provided to regional power utilities in the use of various planning tools (e.g., OptGen). However, these modelling tools have not been widely adopted, and there has been little progress on a coordinated effort by regional power utilities or regulatory bodies to redress this issue. As a result, GMS countries have continued to develop unilateral plans for electricity system expansion (ADB, 2020). Similarly, while some progress has been made in developing a common grid code for governing the operation, maintenance and planning of the electricity systems across the GMS, the grid code has not yet been implemented with representatives from some GMS countries indicating, during the meeting of the Working Group for Planning and Operation in 2019, that the implementation of the grid code in their respective jurisdictions is likely to be delayed (ADB, 2019a). The lack of coordination in the planning and operation processes makes the transition to deeper power connectivity difficult in the GMS.

Lack of technical competence

Most electric utilities and regulators in the GMS lack necessary technical skills and knowledge for conducting regional electricity trading and planning. As identified by the Asian Development Bank (ADB), there are three priority areas for capacity building. Firstly, training should be provided to staff from electric utilities in the region to improve their ability to evaluate the benefits and costs of cross-border power trading and negotiate PPAs. Secondly, training should be provided to staff from planning institutions in the region on integrated resource planning techniques. Thirdly, experience of power connectivity in other regions (for example, Nord Pool) could provide valuable learning opportunities for the GMS, and should be shared with decision-makers and planners in the region (ADB, 2020).

No regional body for promoting regulatory coordination

To deepen power connectivity, the GMS governments signed in 2012 a memorandum of understanding (MoU) to develop a Regional Power Coordination Centre (RPCC). The RPCC would act as a coordinating body for promoting regional electricity trading and planning and would play a facilitating role in enabling trading and planning to take place effectively (ADB, 2020). So far, limited progress has been made in developing the RPCC, due mainly to the disagreement among GMS countries on the host (location) of the RPCC (Shi et al., 2019).

Limits of the existing thinking

Clearly, the existing literature overwhelmingly tends to attribute the slow progress of power connectivity in the GMS to industry-centric factors, that is, factors that are proximate to the electricity industry (e.g. insufficient infrastructure, lack of technical competence, and uncoordinated regulation). Such industry-centric thinking, on the reasons for the slow progress of power connectivity, we contend, is narrow and acontextual. It is largely unappreciative of the influence of wider contextual factors in shaping the socio-political acceptance for power connectivity. It is therefore unlikely to provide, on its own, meaningful insights into the ultimate reasons for the slow progress of power connectivity, and hence, the bases for designing measures to promote a greater level of connectivity. This contention is substantiated by a historical review of power connectivity in the GMS.

The post-war period (1950s to 1970s) witnessed some early efforts to promote economic cooperation in the GMS. One key effort was the creation of the Mekong Committee, as an intergovernmental organisation of four riparian states (Cambodia, Laos, Thailand, and the Republic of Vietnam), to promote regional cooperation in exploiting the potential of the Mekong River for hydropower, irrigation and flood control (MC, 1957).

The stimulus for economic cooperation during these years came from an array of external contradictions, such as Cold War contentions and the Sino-Soviet schism, which perpetuated internal instabilities and conflicts (e.g. communist insurgency), widespread poverty, and an ever-widening rural-urban divide in countries of the Mekong Region, and exacerbated a series of territory and border disputes and outright wars across the region (Makim, 2002). In such circumstances, national security became a palpable concern for countries of the region, and the pursuit of economic cooperation in select areas (for example, hydroelectric projects) was viewed as a means of rectifying the situation, as it could 'inhibit violence in the region, and evoke, among the riparian countries, a sense of what is possible if they cultivate the habit of working together' (Black, 1970).

This view was also supported by the United States and its allies, which considered economic cooperation as an alternative strategy to contain growing communism in the region without the necessity of large-scale military involvement. Guided by this consideration, the United States and the US-led international development organisations (such as the World Bank) provided significant technical and financial support for economic cooperation programs and projects in the Mekong Region (Cosslett & Cosslett, 2014).

As part of these programs, the Mekong Committee initiated several large hydroelectric projects in the 1960s and 70s. However, most of these projects were impaired by the continuing regional war and turmoil that characterised the post-World War history of the Mekong Region.

One example is the Prek Thnot dam in Cambodia's Kompong Speu province, where the work began in the late 1960s, but was suspended in the mid-1970s because of wars (Weatherbee, 1997). A complex array of diplomatic and socio-political issues, arising from the Indochina Wars and Vietnam's reunification, also created substantial uncertainty for countries of the region to commit themselves to regional power projects (Makim, 2002). Aside from several hydroelectric projects jointly developed by Laos and Thailand, the initial outcome of efforts to promote power connectivity in the region was minimal largely limited to maintaining a dialogue between various countries of the region (Weatherbee, 1997). The 1970s saw a radical shift in developmental ideology, toward market-oriented neoliberalism. This ideological shift led to the implementation of wider economic reforms that emphasised market opening, de-regulation, and privatisation. This trend was initially observed in the Western countries and later extended to the developing countries, including countries of the Mekong Region. Consequently, the national economies of the region began to be re-integrated into the globalised world market. This process was further expedited by the end of the Cold War (Makim, 2002).

It is in such context that economic cooperation gained momentum in the GMS, mainly serving as a strategy for attracting foreign investments and redressing the challenges posed by economic globalisation (Weatherbee, 1997). This momentum led to the implementation of several initiatives for promoting 'physical' connectivity across the Mekong Region, through better coordinated infrastructure planning and development, and large power projects were considered key elements of these initiatives. Additional impetus for these projects came from the power crises of the mid-to-late 1980s and early 1990s. These years witnessed increasing inability of the electricity industries in several countries of the region (such as Thailand) to meet their fast-growing electricity needs, and of the governments to finance electricity development, and growing complexity involved in the development of local hydro projects. As a result, many of the efforts to promote power connectivity in these years tended to focus on facilitating private participation in large-scale hydro projects and associated exporting facilities. The outcomes of these efforts were however uninspiring, typified by a general lack of interest from the private sector, especially after the 1997 Asian Financial Crisis. Another issue that affected the progress of power connectivity at the time was the reluctance of some major GMS economies (e.g. Vietnam) to participate in cross-border electricity trade due to energy security considerations.

The Asian Financial Crisis had far-reaching impacts on the Mekong countries, and it exposed their inability to deal effectively with the risks of contagion originating from global market forces. This further reinforced the political appeal of economic cooperation among neighbouring countries, which resumed its momentum in the early 2000s as the economic situation gradually stabilised across the region. This momentum, as observed by Amitav Acharya and many other scholars, has manifested in the pursuit of a 'soft' approach to economic regionalism (Acharya, 2001; Katzenstein, 2000). This approach, in stark contrast with European-style formal bureaucratic structures and legalistic decision-making procedures, emphasises informal and less legalistic styles of decision-making for promoting regional economic cooperation. Its attractiveness mainly comes from its ability to accommodate the desire to protect and enhance national sovereignty and autonomy in the regionalisation process.

The implementation of this approach has resulted in economic cooperation through a dense network of working groups and advisory committees (notably the Regional Power Trade Coordination Committee, in the context of power connectivity), where a diverse range of state actors interact with each other in pursuit of their own interests in the regionalisation process. More recent years also witnessed the growing influence of non-state actors (civil society, NGOs, etc.) in shaping the regionalisation process, enabled by various consultative and deliberative practices. In such settings, regional economic cooperation has become activity-based, mainly involving the implementation of regional projects in specific areas (such as energy, telecommunications, transportation, and tourism), based on mutual understanding, accommodations and tacit agreements.

The evolution of power connectivity in the GMS appears to provide some additional support for the above-noted observation, i.e. the pursuit of a 'soft', project-based, approach to regional economic cooperation. Power connectivity is arguably one of the key areas for economic cooperation in the region, as cheap and reliable electricity supply is widely considered as a catalyst for the development much needed to reduce poverty and the rural-urban divide in most Mekong countries, especially Cambodia, Laos and Myanmar. One of the most comprehensive programs for promoting power connectivity is the 10-year strategic framework, endorsed by regional policy makers in 2002, to strengthen physical infrastructure linkages in order to facilitate cross-border trade, investment, tourism, and other forms of economic cooperation (ADB, 2007). Specific objectives, as set out in this framework for achieving deeper power connectivity, included: facilitating the development of grid interconnection infrastructure; increasing private participation in power projects; and promoting the development of regional electricity trading (ADB, 2007).

Later in 2011, the second 10-year strategic framework was endorsed, which attached higher priority to strengthening the institutions (e.g. regionally coordinated regulations and associated enforcement agency) that support the physical infrastructure, in order to maximise the impact of past and future infrastructure investments (ADB, 2012). In relation to power connectivity, the strategic framework calls for the establishment of a GMS Regional Power Coordination Centre (RPCC), responsible for overseeing power trade development, harmonising regional power plans and investments, coordinating regulatory and trading regimes, and internalising environmental and social impacts in the preparation of the GMS power expansion plans (ADB, 2011).

Progress toward the establishment of the RPCC has, however, been quite slow, due mainly to the disagreement among GMS countries on the host of the RPCC (Shi et al., 2019). In the absence of a regional body responsible for promoting greater harmonisation and coordination in electricity regulation, power connectivity has progressed in the GMS essentially as a project-based initiative, focusing on the development of large hydroelectric and interconnection projects. As a result, cross-border electricity trading has been limited to a series of uncoordinated bilateral exchanges of electricity between IPPs and electric utilities of the importing countries. There is little scope for system-to-system trading (ADB, 2020).

Conclusion

Much of the policy debate on the slow progress toward power connectivity in the GMS has been industry-centric in nature, attributing it to factors internal to the electricity industry, namely: insufficient infrastructure, lack of technical competence, and uncoordinated regulation. Through an analysis of the historical evolution of power connectivity in the GMS, this think piece demonstrates that this debate (on industry-centric factors) is inadequate for providing a fuller appreciation for the reasons for the slow progress towards power connectivity and hence potential remedies to expedite the pace of connectivity. Such appreciation can instead be gained, this think piece contends, by developing a wider discourse on the geopolitical and socio-economic issues, especially those that are central to creating a backdrop which is essential for converting GMS's growing physical electricity connectivity into a region-wide coordinated electricity market.

One key issue of this kind is about Myanmar. Myanmar is part of the Mekong community, and a truly region-wide electricity market cannot emerge without it. Yet, its recent military coup and ongoing anti-coup movements have created substantial uncertainty for other Mekong countries to engage with it. Another issue is how to address concerns arising from the impact of power connectivity on national sovereignty and autonomy. Deeper power connectivity in the GMS entails the creation of regional institutions – coordinated planning processes and operational practice, and their implementing agencies – for governing increasing cross-border electricity transactions. This implies that the governance of some electricity issues (e.g. electricity pricing, congestion management, and supply sufficiency) is taken out of the scope of national policymaking, which may be at odds with GMS countries' fundamental norms of protecting and enhancing national sovereignty, as evidenced by the long tradition of non-interference in the internal affairs of other nations across the region.

Other important issues include how to secure sufficient regional leadership in driving the regionalisation process (regional power connectivity, in our instance) on the back of growing geo-political competition in the GMS between several major powers, as evidenced by the presence of multiple and sometimes overlapping regional cooperation programs initiated by them, as well as how to build a shared regional identity and define what regional power connectivity can bring to this identity across the GMS.

GMS's electricity landscape is currently in the throes of change. While the scope and pace of the change has differed across GMS countries, its shape and direction has essentially been the same, namely, a rapid uptake of wind, solar and other renewable energies to replace coal and other fossil fuels in the generation-mix. This change has been prompted by a wide array of considerations including, for example: enormity of the climate change challenge and argument about the role of renewable energies in mitigating the rate of growth of CO_2 emissions; technological innovations and cost reduction in renewable technologies; growing concerns about the social and environmental impact of large hydro projects; and the cogency of the economic growth-electricity nexus narrative.

Deeper power connectivity across the region is considered an attractive option for facilitating such a change. It can enable better access to low-cost supply options in neighbouring countries where renewable energies are abundant. It can also help improve the flexibility of the national grids to cope with the variability and uncertainty in renewable generation. Yet the question remains as to how to progress power connectivity to a higher level in the GMS. An initial first step of our quest for the answer to this question is to broaden the policy debate on the topic to include issues embedded in the geo-political and socio-economic contexts, some of which have been selectively discussed above.


by Kynny

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RETHINKING ELECTRICITY TRADE IN THE GREATER MEKONG SUBREGION

Thang Nam Do, Paul J. Burke and Bin Lu

Introduction

Boosting cross-border electricity trade offers an important way for the Greater Mekong Sub-region (GMS) countries to improve their ability to meet the region's increasing electricity demand in an economically advantageous, environmentally sustainable, and socially just manner. Regional interconnectivity could also result in more stable and efficient grid systems due to geographical diversification of electricity generation. GMS power interconnectivity has been estimated to be able to reduce the present value of overall energy costs by around one-fifth in an integrated scenario versus a business-as-usual scenario (Asian Development Bank, 2009).

Other than relatively large-scale purchases by Thailand from Lao PDR, electricity trade between most countries in the GMS has been limited. This think piece reviews barriers to cross-border electricity trade in the region in the contemporary context in which low-emission electricity sector outcomes are highly desirable. It recommends solar and wind power together with off-river pumped-hydro energy storage and boosted cross-border electricity trade as a promising way forward. Other recommended enabling strategies include: 1) focusing on bilateral interconnection development with regional planning and coordination over the short term (2021–2025); 2) improving information sharing on the operation of existing hydro dams; 3) enhancing political and social support; and 4) developing a super high voltage direct current grid.


by Marcus Millo

Status of GMS cross-border electricity trade

The Greater Mekong Subregion (GMS) includes Cambodia, China (Yunnan and Guangxi Provinces), Lao PDR, Myanmar, Thailand, and Vietnam. It had a population of 345 million people in 2017 and an average annual growth rate in real gross domestic product (GDP) of 5.9% over 1993–2017 (GMS Secretariat, 2021). Annual electricity generation in the GMS increased by about 430% between 1995 and 2016, reaching 775 TWh (GMS Secretariat, 2021). With its growing population – and as a result of income growth, urbanisation, and industrialisation – electricity demand growth is likely to continue into the future despite the short-term interruption of the COVID-19 pandemic.

GMS economies have sizeable solar and wind resources, resources that vary geographically (Lee et al., 2020). If traded electricity were to come from these renewables instead of fossil fuels, cross-border electricity trade could increasingly become part of the solution to the challenge of substantially reducing greenhouse gas emissions from the energy sector. This could help GMS countries to contribute to the achievement of the Association of Southeast Asian Nations (ASEAN) goal of 23% of the energy mix (excluding traditional biomass) coming from renewables by 2025.

Theoretically, there are three broad models for cross-border electricity trade: the bilateral model, multilateral model, and unified model (International Energy Agency, 2019b). Under a bilateral approach, trade occurs between two jurisdictions. Multilateral trade involves several jurisdictions and can entail either multidirectional trade among differentiated markets via multilateral power purchase agreements (PPAs) or trade among harmonised markets. Under the unified model, all generation clears in a unified wholesale market. Regional institutions are responsible for managing the power system across multiple jurisdictions (International Energy Agency, 2019b).

Regional electricity trade has remained high on the GMS cooperation agenda since the 1st GMS Summit of Leaders in 2002 (GMS Secretariat, 2021). Supported by the Asian Development Bank-hosted GMS Secretariat, a Regional Power Trade Coordination Committee comprising representatives from six national energy ministries has been coordinating regional electricity trade in the GMS since 2002 (International Energy Agency, 2019a). Multilateral development banks such as the Asian Development Bank and the World Bank have provided technical and financial assistance (Asian Development Bank, 2012, 2020; World Bank, 1999).

GMS regional electricity trade has been guided by a roadmap that specifies four stages (International Energy Agency, 2019a). In Stage 1, bilateral trade occurs between neighbouring countries based on power purchase agreements without synchronisation. Stage 2 involves trade in surplus output between any pair of GMS countries via third-party access arrangements. In Stage 3, third parties other than utilities can participate in trading under the multilateral model. Ultimately, a fully competitive regional market or the unified trade would be established in Stage 4.

Cross-border electricity trade in the GMS has been rather more limited than envisioned in initial plans, mostly remaining in Stage 1. Only about 2% of the electricity generated in the region is traded across borders. The openness index for electricity is much lower than those for total energy and for the total value of goods (Figure 1).

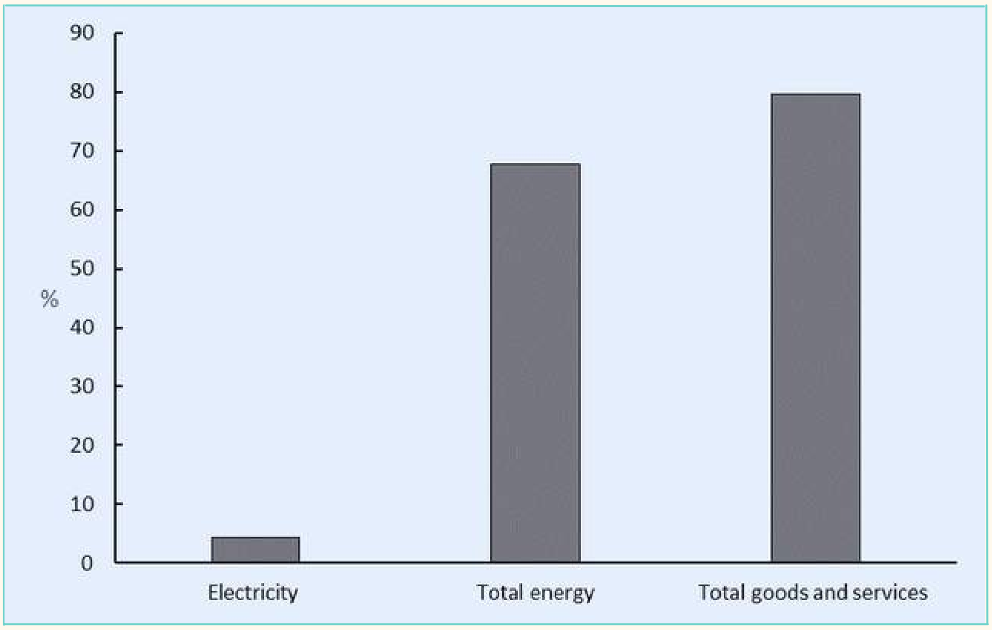

Figure 1: GMS Openness Index values for electricity, total energy, and total goods and services, in 2016.

Source: GMS Secretariat (2021). The openness index measures total imports plus exports as a percentage of domestic production, using national borders. The calculations for electricity and total energy are based on physical measures. Those for total goods and services is based on value data in US$.

One notable exception is the highly-developed electricity trade partnership between Lao PDR and Thailand. As shown in Table 1, Lao PDR is by far the largest exporter (27 TWh in 2018) and Thailand by far the largest importer (27 TWh) of electricity in the GMS. Indeed, in 2018 Laos was the world's 7th-largest exporter of electricity and Thailand the 8th-largest importer. Other exporters include Myanmar (2.4 TWh) and Yunnan, China (1.9 TWh). Vietnam and Cambodia imported 1.7 TWh and 1.6 TWh respectively in 2018 (USEIA, 2020).

	Generation	Import	Export
Cambodia	7.9	1.6	0.0
Guangxi, China	127.5	0.0	0.0
Yunnan, China	268.6	1.4	1.9
Lao PDR	33.0	0.3	27.0
Myanmar	24.0	0.0	2.4
Thailand	173.0	27.0	1.0
Vietnam	231.0	1.7	0.7
Total	865	32	32.3

Table 1: GMS cross-border electricity trade (TWh)

Source: GMS Secretariat (2021), USEIA (2021). Data for Guangxi and Yunnan are for 2016 and only for trade across China's national border. Data for other countries are for 2018.

Cross-border electricity trade with countries outside the GMS has been even more limited. The only sizeable project with non-GMS trading partners is the Lao PDR-Thailand-Malaysia-Singapore project. This is also the only project that has entered Stage 2 of the regional roadmap. Under this project, Lao PDR exports electricity to Malaysia and ultimately to Singapore via Thailand. The project started at 100 MW in 2018 and was expanded to reach 300 MW in 2021 (International Energy Agency, 2019a). Myanmar also has a tiny amount of trade with India through 3 MW of interconnection (USAID, 2018).

GMS countries have shown interest in further expanding cross-border electricity trade. Vietnam has indicated an increase in its interconnections with Lao PDR from 572 MW in 2020 to almost 5,000 MW by 2030 (Vietnam Institute of Energy, 2021). Thailand has announced plans to increase interconnections with Lao PDR by over 10,000 MW (Bangkok Post, 2021). China, Myanmar, and Thailand have also prepared plans for hydropower dams to promote regional economic integration through electricity trade (Suhardiman and Middleton, 2020).

Key barriers to GMS electricity trade

Among numerous barriers to electricity trade, security concerns, environmental and social costs, and institutional and technical constraints are arguably the most important for the GMS.

Security concerns

Security concerns have impeded cross-border electricity trade in many parts of the world (Asian Development Bank, 2020; Halawa et al., 2018; Li & Kimura, 2016; Shi et al., 2019). Given the increasing importance of electricity to economic systems, concerns about system security risks are prominent (International Energy Agency, 2019a). Political trust among GMS countries has generally yet to become strong enough to facilitate high cross-border reliance. There is also an absence of well-developed mechanisms to reduce the risks of having stranded transmission line assets in the case that countries cease electricity trade.

GMS countries are also concerned about potential imbalances between scheduled cross-border electricity trade and actual traded electricity (Asian Development Bank, 2020). Electricity systems require supply and demand to be instantaneously equated to avoid system disruptions. A lack of energy storage and of a coordinating institution would make electricity systems more prone to disruption risks. While cross-border electricity trade could be managed with the use of suitable institutions, GMS countries have tended to give more emphasis to national self-sufficiency (del Barrio-Alvarez & Horii, 2017).

Environmental and social costs

Traded electricity in the GMS has been mainly in the form of hydroelectricity, with hydro dams imposing large environmental and social costs that also cross borders (Wu, 2016). Large-scale hydropower dams in the Mekong basin have resulted in biodiversity loss, fishery and sediment losses, droughts, and salt intrusion in the Mekong delta (Grafton et al. 2019; McCartney & Brunner, 2020; Soukhaphon et al., 2021). Hydropower development has also posed risks to the livelihoods of millions of people in the Mekong River basin (Soukhaphon et al., 2021). In 2018, the external costs of the development of 11 planned large-scale hydropower dams in the LowerMekong Basin were estimated to be about US$18 billion in present value terms (Intralawan et al., 2018). The construction of transmission lines also results in environmental costs and social costs for local communities.

Cross-border environmental and social implications can slow progress towards regional electricity trade. For example, civil society and local communities in Cambodia and Vietnam are unlikely to support the development of new electricity export dams being built upstream. The large number of affected people living across various locations makes it hard to take coordinated actions for addressing external cost issues. Agreement on cross-border externality pricing is highly challenging. Regional electricity trade may carry adverse distributional effects if environmental and social concerns are not properly addressed.

Technical and institutional issues

Diverse power systems in terms of standards, specifications, and protocols for electricity transmission and distribution have also hindered regional power trade (International Energy Agency, 2019a). Sensitivity due to national security and other concerns causes GMS countries to tend to be reluctant in data sharing. Various regulations on cross-border licensing, non-discriminatory access to networks, custom tariffs, and administrative procedures have also posed obstacles (Shi et al., 2019). Institutional capacities of many participating utilities have yet to reach an adequate level for moving beyond Stage 1.

Electricity market structures in the GMS have been another barrier. Domestic vertically-integrated market structures and traditional state-owned utilities are prominent in the GMS despite some progress in domestic wholesale market reforms that have enabled the participation of private independent power producers (Owen et al., 2019). State-owned utilities are often reluctant to see a change to their business models that might reduce their economic position or create new challenges. Some high-cost electricity generators would become uncompetitive if wholesale prices were to converge under a strong form of market integration, so are naturally against this (International Energy Agency, 2019b). Electricity utilities often favour the status quo and lobby against regional integration (Oseni and Pollitt, 2016).

Solar, wind and pumped hydro energy storage as potential replacement of new large-scale hydropower to boost cross-border electricity trade

Solar and wind power are becoming competitive with new hydropower in the GMS, even without considering their lower external environmental and social costs. In 2020, the globally weighted levelized costs of electricity (LCOE)[1] for solar PV and onshore wind were US$57/MWh and US$39/MWh respectively, while for hydropower this was US$44/MWh (International Renewable Energy Agency, 2021). Importantly, the globally-weighted solar and wind LCOEs have been falling fast: by 85% and 56% respectively over 2010–2020. In contrast, the LCOE for hydropower increased by 18% over this time. While GMS has substantial potential for additional hydropower, new hydropower plants face a risk of becoming stranded assets.

The GMS has high potential to pursue new solar and wind power projects instead of new large-scale hydropower dams. The potential installed capacities for solar PV and onshore wind power at onshore sites with an LCOE of less than US$150/MWh as of 2018 in the Mekong countries have been estimated to be 25,578 GW and 1,114 GW respectively (Lee et al., 2020). This far exceeds the current installed generation capacity in the GMS (about 140 GW as of 2017) (ASEAN Centre for Energy, 2020; Statistica, 2018). This potential would be augmented if sizable offshore wind potential in Vietnam and Guangxi, China is included (Technical University of Denmark, 2021; World Bank, 2019). The GMS would benefit from developing solar and wind power concurrently, as wind resources are complementary to solar resources. Due to the winter monsoon, wind and solar energy are also complementary on a seasonal basis in many parts of the GMS.

[1] The LCOE is the present value of the cost of electricity from a new project per unit of electricity generated. It includes both up-front and ongoing costs.

GMS countries have relatively high potential capacity factors of solar PV, ranging between 16% and 18% for many parts of the region (Solargis, 2021). Seasonal variation in solar resource is relatively low.[2] This means that while diurnal energy storage would be needed to stabilise solar energy systems, there would not be a substantial need for long-term, seasonal energy storage provided that domestic and regional electricity transmission interconnectivity is well developed. GMS countries such as Vietnam have a sizeable need to upgrade domestic transmission grids to facilitate the uptake of solar and wind power (Do et al., 2020; 2021).

Off-river pumped hydro could be an ideal solution for these short-term energy storage needs. Pumped hydro is by far the most economical option for large-scale energy storage on timescales ranging from hours to a few days (Schmidt et al., 2019). Unlike conventional on-river hydropower, off-river pumped hydro can be located away from rivers and has relatively low environmental impacts. The GMS has about 27,300 potential sites with a combined storage capacity of over 896,000 GWh (Stocks et al., 2021). These figures are two orders of magnitude larger than what would be required to support 100% renewable energy systems in the region.

Off-river pumped hydro has the potential to replace the dispatchability services that are currently provided by hydropower (Waldman et al., 2019). Off-river pumped hydro could also provide ancillary services such as frequency control, which would be able to shore up energy security in energy systems dominated by variable wind and solar energy. Technologies such as smart grids would increase the effectiveness of this solution (Schmitt et al., 2019).

Adoption of solar and wind power plus off-river pumped hydro energy storage in the GMS could bring substantial benefits. Modelling for Myanmar's case shows that this solution would result in significantly reduced impacts on rivers in terms of sediment losses and habitat fragmentation. It would also involve lower system (including infrastructure) costs – $8.4 billion compared to $11.7 billion under business-as-usual over 2021–2030 (Schmitt et al., 2021). At the regional scale, these technologies could be adopted with a highly competitive LCOE of US$55–115/MWh (Lu et al., 2021). The approach would also reduce the risks of insufficient water availability for dam operations in the dry season.

By replacing new large-scale hydro and thermal power projects, solar and wind power plus off-river pumped hydro energy storage would mitigate negative social and environmental impacts to local communities. This approach could help to enable regional energy sector decarbonisation and electricity trade in an environmentally sustainable and socially just manner.

Near-term strategies

Focusing on bilateral interconnection development during 2021–2025

Over the short term, GMS cross-border electricity trade would benefit from continuing progress on bilateral interconnections and regional planning and coordination efforts. The gradual approach of developing bilateral interconnections has proved to work satisfactorily to date (del Barrio-Alvarez & Horii, 2017). The bilateral model requires less technical and institutional harmonisation and fewer structural challenges than a more integrated approach (International Energy Agency, 2019b). Bilateral negotiations also offer more flexibility in addressing environmental and social issues regarding the water-energy nexus (Ibrahim, 2019). Bilateral negotiations can be faster, easier, and more likely to gain political trust than multilateral negotiations.

[2] The maximum:minimum ratio for the monthly average solar energy resource is less than 2 on average.

The bilateral model fits well with the current electricity market structures of the GMS, and in particular the low grid flexibility across the system (Huang et al., 2019). Bilateral interconnections would facilitate gradual development of technical and institutional capacities to prepare for eventual integration (Wu, 2016). This would save resources and avoid the potential failure of prematurely moving to deepening integration. GMS countries could also prioritise upgrades to their domestic transmission grids. Therefore, focusing on developing bilateral interconnections in the near term would be more practical than striving towards a deeper level of integration for cross-border electricity trade.

Enhancing hydrological information sharing

Enhancing information sharing on hydro dam operations could help to improve the management of the environmental and social costs of hydropower. Having more information on hydro dam operations, for example the timing and quantity of water releases, enables riparian countries to make better informed decisions on impact mitigation and adaptation activities. It could also make the impacts of cross-border traded electricity more transparent and hence facilitate negotiations on internalising the environmental and social costs. As a result, more confidence could be created in cross-border electricity trade (Biba, 2018; Thu & When, 2016).

Information on hydro dam operations needs to be improved in terms of both coverage and quality. Specifically, member countries' domestic regulations could be revised to enable information sharing and the Mekong River Commission database could be upgraded to improve compliance with the Commission's Procedures for Information and Data Exchange and Sharing (Thu & Wehn, 2016). China's recent agreement to share some of its year-round hydrological data on the Lancang-Mekong River could expand to cover not only data from monitoring stations at the border gates but also from domestic monitoring stations (Lancang-Mekong Water Resources Cooperation, 2021). Regional data sharing would also benefit from furthering public online platforms such as the Mekong Dam Monitor (Stimson Centre, 2021) to provide real time data on operations of hydro dams in the whole Mekong River Basin. Strong political support would be needed for the countries to share the information.

Long-term strategies

Strengthening political and social support

Political support is crucial for regional electricity trade (Brinkerink et al., 2019; Puka & Szulecki, 2014), and was a key enabler for establishing cross-border electricity trade in GMS in the early 1990s, especially in bringing Lao PDR and Thailand together (del Barrio-Alvarez & Horii, 2017). GMS cross-border electricity trade is unlikely to progress without further political commitments (International Energy Agency, 2019a).

One possibility is assigning the Ministries of Foreign Affairs with the leading role in cross-border electricity trade negotiations. The strategy of omitting representatives from Ministries of Foreign Affairs from regional electricity trade negotiations so as to avoid political disputes seemed to work well in the early days (del Barrio-Alvarez & Horii, 2017). However, their marginalisation seem to no longer suit the current situation. These ministries are currently overseeing overall cooperation frameworks for the GMS and other key regional initiatives such as the Lancang-Mekong Cooperation, ASEAN, ASEAN+3, and Regional Comprehensive Economic Partnership. They could play vital roles in heightening cross-border electricity trade in the political leaders' regional cooperation agenda.

Arguments for political support for regional electricity trade could focus on addressing security concerns. One approach would be for countries to establish regional agreements on reliable and sustainable electricity supply, with specific sanctions for violations. For example, a country could be penalised in other ways if it violates an electricity trade agreement. The agreements also need to consider environmental and social costs, with affected parties being adequately compensated for their losses. The duration of political risk insurance provided by the Multilateral Investment Guarantee Agency could be extended beyond 20 years to match the life of cross-border transmission assets (World Bank, 2020). Specifications of risk insurance for cross-border electricity trade under this scheme would strengthen investor confidence.

The needed political support could be enhanced by support from the community. Indeed, strong support from civil society has been a key factor in the Nordic Electricity Market's success (Andrews-Speed, 2016). Increasing public participation in decision-making on developing power plants for trade could enhance social support. Strategic environmental assessments of power trade proposals would broaden the scope of the environmental impacts assessments of hydro dams that typically have been limited to only a short distance from the dam site (Hirsch, 2020).

International organisations could assist in overcoming financial and technical barriers. Multilateral development banks have played important roles in assisting the development of the Southern African Power Pool and the Central American Electrical Interconnection System (International Energy Agency, 2019a). Ongoing assistance from the Asian Development Bank and the World Bank may well be important. The Asia Infrastructure Investment Bank is another potential source (Feng et al. 2020).

Regional high-voltage direct-current super grid development

Modern high-voltage direct-current (HVDC) technology has the potential to facilitate cross-border electricity trade. HVDC enables long-distance, bulk electricity transmission over thousands of kilometres with relatively low energy loss (3% per 1,000 kilometres). For example, the Changji-Guquan HVDC link in China can transfer 12 gigawatts of electric power over 3,000 kilometres at ±1,100 kilovolts (Hitachi ABB Power Group, 2021). Because of the direct-/alternating-current conversion, the interconnected electricity systems are actually "decoupled". This largely avoids the failure of one system being rapidly transmitted to other energy systems (Lu et al., 2021).

In the GMS, an HVDC super grid could be built to interconnect the member countries and other external partners. Specifically, the Lao PDR-Thailand-Malaysia-Singapore electricity trading initiative could be extended towards forming an ASEAN Power Grid (International Energy Agency, 2019a). The interconnection could then even include countries further afield such as Australia, a potential solar and wind power exporter (Halawa et al., 2018; Lu et al., 2021). Electricity trade could also be expanded to reach other provinces in China, as well as India and Bangladesh (Feng et al., 2020; USAID, 2018). Interconnecting with East Asian economies such as Japan, Korea, and Chinese Taipei could also be beneficial to access their sizable offshore wind resources and demand centres. Figure 2 summarizes key barriers and recommended strategies.

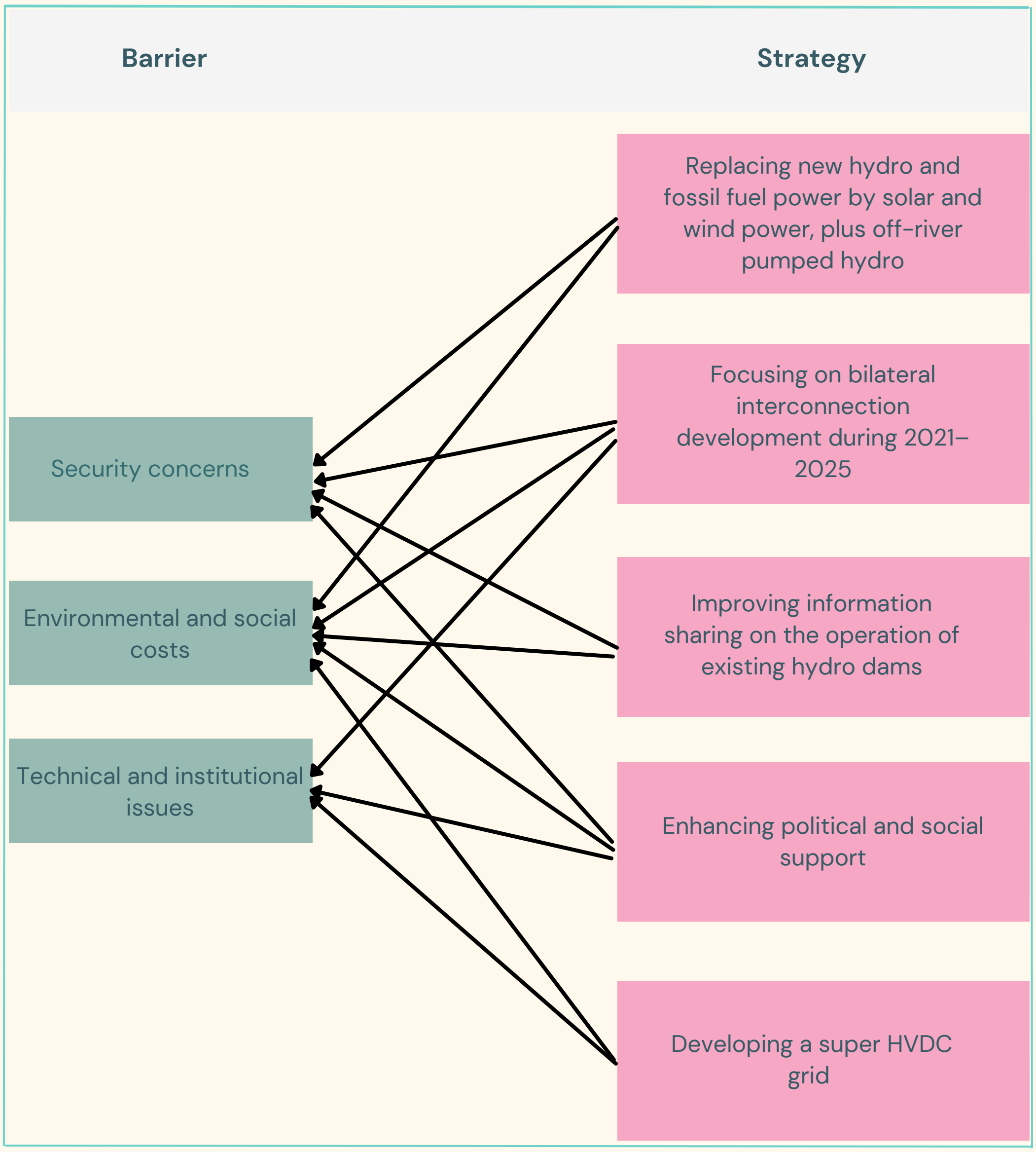

Figure 2: Summary of key barriers and recommended strategies

Conclusion

The GMS has the potential to increase cross-border electricity trade to help meet increasing energy demand in an economic, environmentally sustainable, and socially just manner. Solar and wind power combined with off-river pumped hydro has emerged as a promising alternative to new large-scale hydro or thermal power in an era in which low-emission, sustainable options are highly prioritised. This approach would help to address concerns about negative environmental and social impacts, hence boosting confidence in electricity trade. While the transition will take time, short-term actions such as stopping the building of new hydropower and fossil power plants while ramping up investment in solar and wind and needed transmission connections – both domestic and cross-border – are important. Environmental safeguards will be needed for all solar, wind, storage, and transmission projects.

Other strategies are also needed. Immediate and relatively less resource-intensive strategies include improving information sharing on the operation of existing hydro dams and focusing on bilateral interconnection development with regional planning and coordination during 2021–2025. The former could help to manage concerns about their environmental and social impacts while the latter would build the necessary infrastructure and institutions for a regional electricity market. GMS cross-border electricity trade would also benefit from long-term measures such as developing a super HVDC grid and cultivating stronger political and social support.

by Mikel Martinez de Osaba

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ACCESS TO AGRICULTURAL LAND FOR PEOPLE RESETTLED FROM THE NAM NGIEP 1 DAM IN LAO PDR

Sypha Chanthavong

Introduction

This think piece analyzes the process of how people who are resettled from a hydropower project get access to agricultural land, from both a legal and empirical perspective. The Nam Ngiep 1 (NNP1) dam in Bolikhamxay Province, central Lao PDR is the focus of this study. The key informants of the research are resettled people who decided to resettle themselves and who received a resettlement package from the project.

The think piece highlights the fact that the people resettled from the NNP1 have found few opportunities and faced many difficuties in their efforts to access to satisfactory amounts of agricultural land.

There were two ways, which will be examined, for resettled people to gain access to agricultural land. First, people moving to a resettlement site prepared by the dam developer could receive 1.5 hectares of paddy field, and 1 hectare of grassland for cows, buffaloes, goat raising or orchard plantation. Second, people who had agricultural land in the former village before resettlement and received a higher rate of cash compensation for it, could then buy new land. In contrast, the compensation rate for people who did not own agricultural land in the former village was insufficient for them to buy land in a new self-resettled village.

Irrigation system provided by the Nam Ngiep 1 Hydropower plant to resettled people by Sypha Chanthavong

Rationale and Background

According to the Government of Laos, hydropower development is one of the key drivers of industrialization and modernization to enhance the well-being of the people and the prosperity of the country, which aims to be ranked as an upper-middle-income country by 2030 (Ministry of Investment and Planning, 2021, p.21). The government intends to use the revenues from the production of electricity to contribute towards the development of the country, and for poverty reduction. The industrial sector, in particular electricity generation, is the main pillar of economic growth in Lao PDR (aside from service and tax sectors), Between 2015-2020 electricity generation increased by 19% per year and the installed capacity reached 4.502MW due to the completion of 56 power plants (Prime Minister's Office, 2021, p.24).

The government receives revenues from dams though shareholding, taxes, service fees and royalties (ADB, 2019). However, hydropower development is controversial regarding its rewards and impacts, which are mainly environmental and social (Shoemaker & Robichaud, 2018). Compensation for the agricultural land is very debatable from the earliest to the most recent dams: for example, from the Nam Ngum 1 dam (Phommachanh et al, 2013) to the NNP1 (Chanthavong, 2019). At the same time, downstream countries raise multiple questions about impact on fish population and river flow patterns, where links to dam development in Laos are generally discovered (Baird, 2011; Baird & Barney, 2017; Middleton, 2012).

This think piece aims to clarify the access to agricultural land of people under dam resettlement, by comparing their agricultural land rights in law with what empirically happened to them. It is based on empirical fieldwork conducted in 2021. Ten key informants were questioned regarding access to agricultural land. Four of the ten had received the resettlement package and were living in a resettlement site prepared by the dam developer. The other six key informants were self-resettled, of whom three could access agricultural land and the remaining three could not.

Access to agricultural land of hydropower-affected people, based on the laws of the Lao PDR

In Lao PDR, natural resources including land are the property of the national community, or State, as provided for in the Constitution which is the fundamental document of the Lao PDR legal system. The Constitution of Lao PDR, amended in 2015, contains several provisions relevant to the ownership of natural resources and the rights that individuals or entities can hold in relation to such resources. Article 17 Paragraph 2 provides that: "land, earth, water, air, forest, non-timber forest products, aquatic animals, wildlife and other natural resources are the property of the national community which are managed by the State on its behalf". It further states: "Natural resources are managed by the State with the aim to achieve sustainable goals, when organisations and citizens must pursue the protection of the natural resources" (National Assembly of Lao PDR, 2015). However, the Constitution and Civil Code 2019 also acknowledge property rights over land (rights of possession, rights of use, rights of usufruct, rights of disposition) and inheritance rights to individuals, legal entities, and organisations in accordance with the laws.

Article 3 of the Land Law, 2019, reaffirmed in Article 17 of the Constitution of Lao PDR, provides that "the land of the Lao People's Democratic Republic is the ownership of the national community where the State represents the ownership holder and manages lands in a centralized and uniform manner across the country with land allocation plans land use planning and land development". Land in Lao PDR is classified in eight categories including agricultural land. Article 32 of the Land Law 2019 states that "Agricultural land is land which is determined to be used for cultivation, animal husbandry, fishery, irrigation and agricultural research and experiment".

From the above provisions of the Constitution of Lao PDR and Land Law 2019, the State acknowledges the rights of use of agricultural land for Lao citizens by issuing land titles as evidence about land use rights to all Lao citizens. In terms of access to agricultural land for dam-affected people, this is also guaranteed by laws and regulations, mainly the Law on Resettlement and Vacation 2018 and the Decree on Compensation and Resettlement Management in Development Projects 2016.

The Law on Resettlement and Vacation 2018, Article 22, provides for six types of compensation for people who lost land to development projects including hydropower. First, affected persons having lawful documents for land use rights, and who have lost the whole or part of their land where the remaining area is not usable, shall receive full compensation through the allocation of a replacement piece of land at a pre-set substitute value as determined periodically by the resettlement management committee of the project. This would give them the land use rights documents for that piece of land, subject to being responsible for all expenses related to the obtaining of such documents. Second, in the case that the value of the land and house of an affected person is lower than the pre-set value of the allocated lands and house, the resettlement management committee shall consider an appropriate solution. Third, an affected person having lawful documents for the land use rights and who have lost the whole or part of their land where the remaining area is still usable, shall receive compensation only for the lost part, to a pre-set substitute value. A deed of land use rights shall then be issued for the remaining area of land. Fourth, an affected person having customary land use rights, but having lost such rights as certified by the local administration and relevant authority, shall receive the same compensation as described in the first and second conditions. Fifth, an affected person without documents for the land use rights as required in the first, second and third conditions, will not receive compensation for the loss of their land, but for the loss of their buildings, trees and produce according to the pre-set substitute value. Sixth, in the case that the land or buildings temporarily cannot be used, the affected person who is the owner of such land or buildings shall receive compensation on a case-by-case basis and shall ensure that the land or buildings are returned to the affected person in original condition. The intention of these six types of compensation to people for land lost to dam development is to ensure that their living conditions and livelihoods will be the same or better than before resettlement, and to enable them to graduate from poverty.

The Decree on Compensation and Resettlement Management in Development Projects No. 84, dated 5 April 2016, provides that "the compensation shall be in the form of land, material or money for the land, agricultural products, livestock and incomes that are affected by development projects based on the compensation value". Concerning compensation for land, the decree has the same meaning as the Law on Resettlement and Vacation 2018, which provides for six types of compensation for land. Moreover, the Decree stipulates the implementation of a livelihood rehabilitation plan which requires the project owner to provide agricultural land in appropriate ways, including the creation of new livelihood options and stable income generation activities, and promotion of local wisdom, in addition to protecting agricultural production activities for the affected people (Prime Minister's Office, 2016).

Compensation for agricultural land is extremely controversial for dam-affected people nationwide in the Lao PDR, although this land compensation is acknowledged to be very important to the livelihoods of resettled people (Souksavath & Maekawa, 2013). Beyond Lao PDR, the access to natural resources of resettled people is an issue which also has a broader global context (World Commission on Dams, 2001). In the Greater Mekong Subregion and neighboring countries of the Lao PDR, compensation for dam-affected people is questionable. For example, in the case of China the right to refuse relocation may not be offered (Daojiong, 2015). In the case of Vietnam, compensation for productive land and alternative livelihoods for communities resettled from hydropower development has been documented as insufficient (Ty et al. 2013). Meanwhile, in the case of Thailand, people affected by the Pak Mun dam (completed in 1994) were still, many years later, protesting and appealing to the dam developer for just compensation for lost land and livelihoods (Blake, 2013). In Cambodia, compensation packages in cash and land were not sufficient to improve the livelihoods of people affected by the Lower Sesan 2 dam (NGO Forum on Cambodia, 2015). In the case of Myanmar, Kyaw Thu Han (2018) highlighted the potential impacts to downstream communities of the Hatgyi Dam on both men and women, in which women would suffer more if the project were built, because their daily lives depended on the river.

In Laos, Syladeth and Guoqing (2016) found that aproximately 101 villages (5,699 households comprising 31,579 people) have been relocated due to hydropower projects in Laos. Baird at al (2015), found that riverbank gardens along the Xe Bang Fai River and the Nam Theun River were affected by the Nam Theun 2 (NT2) dam, which have declined in terms of number and size because gardens had to be located further away from the river. Kanokwan et al. (2017) analyzes the relationship between the NT2 and its impact on the livelihood of the Brou ethnic group.

The above findings will inform our examination in the next sections of what is happening to the resettled people from the NNP1 dam, particularly regarding impacts on minority groups.

The negotiation process for access to agricultural land of the people displaced by the Nam Ngiep 1 dam

The NNP1 affected all residential and agricultural land in four villages in Hom District, Xaysomboun Province. 384 households, (2,735 people) were required to resettle (NNP1, 2014). These villages are located in the upstream area which the NNP1 project identified for the reservoir of the dam; this means that all the residential and agricultural land will be flooded or at risk of flooding.

How the people of the four villagers negotiated with the dam developers – including the NNP1 project, the Government of Laos, and the local authorities – is very significant. The negotiation is narrated to show how the NNP1-affected people were able to use their kinship networks, historical background and identity to come to terms with powerful actors regarding dam development in Lao PDR.

Negotiation was meaningful for the NNP1-affected people in their effort to get fair compensation. A major tactic that affected Hmong people used is kinship. This is because during the time of negotiation, there were national-level leaders who are Hmong, such as the President of the National Assembly of the Lao PDR who is also a member of the politburo of the Lao People's Revolutionary Party (LPRP), and the Minister of Justice and the Governor of Xaysomboun who are members of the Central Committee of the LPRP. These powerful actors were linked automatically to the negotiating table at which interests of the NNP1 dam-affected were discussed. Without doubt, any government negotiator had to take this ethnic kinship into account; there might also have been more specific clan affiliations with those powerful actors which could have been mobilized.

Another of the main tactics draws on shared historical background. Some Hmong senior people who had served the Pathet Lao Movement could exert influence over negotiators. This is because, during the secret war in Laos, many Hmong served the Movement. At least one senior Hmong among those affected by the NNP1 was identified as a national hero who held influence in the negotiations including for other affected people (see Chanthavong, 2019).

Some Hmong referred to the spirits of ancient people, asking for additional compensation for graves. They explained that if they are moved to another area, the spirits of ancestors might give them less protection; hence they ask for a meaningful ceremony to make the spirits satisfied to move with them. Otherwise, they said, they would not be happy to resettle, for the spirits would not protect them and would make them unhealthy (see Chanthavong, 2017). As a result, negotiations to determine the compensation unit price have taken place more than twenty times, and it seems that the negotiations with the NNP1 dam developers may be identified as relatively successful for the affected people. For example, the Xaysomboun governor as chairman of the resettlement committee of the NNP1, issued an agreement on the unit of compensation price for assets which was higher than in the case of the Lao-China high-speed train project (see Chanthavong, 2019).

The Nam Ngiep 1 and its resettlement program for agricultural land

The NNP1 construction was completed at the end of 2019. The NNP1 is projected to bring in US$ 4.8 billion through a 27-year concession period via royalties, taxes, and revenues. The NNP1 has an installed capacity of 290 MW. The NNP1 is divided into two dams. The main dam has a height of 167 meters, a length of 530 meters and a rated output of 272 MWh, or 1,546 GWh per year. Its electricity will transmit from the power house to the Nabong station in the national capital, Vientiane, via a 230 kilovolt transmission line, and then travel across the Mekong River to Thailand. Meanwhile, the sub-dam or re-regulation dam has an output of 18 MWh for domestic consumption. The Hatsaykham community, four villages of Hom district, and some households in three villages in Thathom district, have been resettled in the designated Houaysoup resettlement site, located on the bank of the Ngiep River in Bolikhan District in Bolikhamxay Province (Nam Ngiep 1 Hydropower Company, 2014).

The NNP1 affects currently more than 3,000 people who are required to resettle. Over 90% of these affected people are Hmong who live in Bolikhan District of Bolikhamxay Province and in Hom and Thathom Districts of Xaysomboun Province. Almost all of the villagers of Hatsaykham village, which is the location of the construction site and who thus are required to resettle, are Hmong (Nam Ngiep 1 Hydropower Company, 2016).

Regarding the compensation for people affected by NNP1, the Xaysomboun Governor, as the chairman of the Resettlement and Livelihood Restoration Committee of the NNP1 appointed by the

Prime Minister in 2014 (Prime Minister's Office, 2014), issued an agreement (henceforth here termed "The Agreement") on unit price for compensation of people affected by the NNP1 in 2014. Two types of compensation for the NNP1 were offered. First, the affected people could choose to live in the designated resettlement site and receive partial compensation for their lost assets (referred to as in-plan). Second, affected people could receive complete compensation for their lost assets and decide to self-resettle (referred to as out-plan). The majority of the NNP1 affected people (more than 340 households) chose the out-plan because they would receive more and have freedom in resettlement. Approximately 80 households chose the in-plan resettlement.

This thinkpiece focuses on agricultural land compensation for both in-plan and out-plan resettlements. The Agreement defines agricultural land as land designated for planting, animal raising, and other agricultural activities. The Agreement divides agricultural land into six types, namely: paddy field land (din na in Lao), shifting cultivation land (din hai), garden land (din suan), land adjacent to the paddy filed (din kheme na), grazing land (din lieng sad) and fishpond (din nong pa). Each type of land is divided into sub-types, which could be factors in the details of the implementation.

Definition of each type of agricultural land is based on rights to use, or allocation for family land use, but the total area of land should not be above the amount set by the Land Law 2003, Article 17, which provides that: the State authorises individuals and families to use agricultural land in accordance with the allocation plan and objectives, for the long term and in an effective manner, according to areas determined as follows:

- For those using land for cultivating rice and raising animals, the maximum area is one hectare per labour force in the family;
- For those using land for industrial plantation and growing crops, the maximum area is three hectares per labour force in the family;
- For those using land for fruit tree plantation, the maximum area is three hectares per labour force in the family;
- For those who use unstocked land or grassland and thereafter transform such land by planting crops or grass [suitable for grazing] livestock, the maximum area is fifteen hectares per labour force in the family.

From the provisions of law and the NNP1 Agreement, each type of land receives different compensation as shown in Table 1. Compensation amounts for fruit trees, and short- and long- cycle plants are shown in Table 2.

Asset type	Compensation level (LAK/m2)
Construction land (land for house or other building purposes)	2400
Paddy rice field used annually	14,000
Paddy rice field left unused for more than three years	4,000
Land under stable plowing shifting cultivation	3,500
Land under rotation of shifting cultivation for 1-3 years in the Houy Soup area	1,200
Land under rotation for 1-3 years of shifting cultivation in other affected areas	500
Garden land	4,000
Land planted with commercial trees	3,000
Land adjacent to paddy rice field	400
Grassland for raising large animals, with mature planted grass or natural grass and with fence	2,000
Mature natural grassland with fence	600
Fishpond land with digging and blocked stream	22,800

Table 1: Compensation amounts for land under the NPP1 Agreement

Asset type	Compensation level (LAK)
Jack fruit tree more than 6 years from planting date	461,000
Rubber tree aged 1-6 years, per year of maturity	30,000
Rubber tree older than 7 years	300,000
Small chili	25,000 /kg
Big chili	22,000/kg
Watermelon	5,000 /kg
Casava	2,500/hole
Banana	80,000 /hole
Sugarcane tree	7,000 /hole

Table 2: Compensation amounts for trees and plants under the NPP1 Agreement

It seems that those people who have agricultural land affected by the NNP1 and who have planted many valued kinds of tree and other plants, then receive a large amount of compensation for both land and plants. However, people who have no agricultural land will not be compensated, and those who have small plots of land, get little compensation. Their condition after resettlement from their former residences to other sites will be the main focus of the next section.

Access to agricultural land for people resettled from the Nam Ngiep 1 dam

Two types of resettled people from the NNP1 regarding agricultural land were examined: firstly, affected people who moved to the resettlement site which had been prepared by the NNP1 in Houaysoup or Phouhomxay resettlement village; and secondly, people who had agricultural land in the former village before resettlement, and received a higher rate of compensation for it, so that they could then buy new land and assets. In general, this last group of people were quite satisfied with the compensation rate.

The first group of people that could access agricultural land could do so because they selected in-plan relocation to Phouhomxay Village in Bolikhan District of Bolikhamxay Province. This village received 83 households that moved from the sites affected by the dam. They were mainly Hmong (71 households), the remainder being Lao Loum. These people moved to the resettlement village in 2017, and each household received 8,000m2 of garden land, 4,000m2 of paddy rice field, 10,000m2 of grazing land, and 1,200m2 of construction land, irrespective of household size. At the same time, their paddy rice field had access to an irrigation system which enabled them to cultivate in all seasons. These resettled Hmong people believed that their paddy rice field could produce rice for year-round consumption because they produced common white rice (Khao Chao), believing that this was a better option as it produces more volume when cooked per unit weight of rice than sticky rice (glutinous rice, the more popular staple in Laos), taking into account the quantity consumed in each meal. 4,000m2 of paddy rice field can produce about 2,000kg of rice each season or approximately 4,000kg per year.

Figure 1: Rainy season rice field in Phouhomxay Village
Source: Author on 17 Sep 2021.

Their grassland is prepared for large animals such as buffaloes, cows, and goats.

Controversy around the NNP1 is unavoidable even though the NNP1 compensates at a higher rate of cash for affected people compared with the Laos-China high speed train project. The NNP1 compensated stable shifting cultivation land at a rate of LAK 35 million/hectare (USD 3,500/hectare), while the Laos-China high speed train only compensated those who lost land at LAK 5 million/hectare (USD 500/hectare) (Luangprabang Governor's Office, 2018). However, the affected people still required higher compensation than the NNP1 gave them, in terms of land. During 2014, the Governor of Xaysomboun Province had issued a different Agreement on the Unit Price for Compensation on Land, Building, and Yield Affected by Development Projects within Xaysomboun Province (Agreement 261), which promised compensation at a higher price than the NNP1. For example, the NNP1 compensation price of construction land is set at LAK 24,000/m2 and garden land at LAK 3,000/m2, while under Agreement 261, the price is set at LAK 30,000/m2 and LAK 4,000/m2 respectively. However, Agreement 261 is used for the land that is located near the main and submain roads in the urban areas of Xaysomboun Province (Chanthavong, 2019).

The majority of the people in this resettlement village have planted valuable trees in their own grassland, such as *Pahudia cochinchinensis* and *Dalbergia ochinchinensi*. This is because animals and valuable trees are identified as assets that people in rural areas must have for making money and using in case of emergency. As well as obtaining agricultural land, people in the village can access basic public services such as hospital, road, school, and education.

The NNP1 made provision for households of three sizes. First, a household that has less than 5 people will receive a small-sized house of 50 m2. Second, a household with 6-8 people will receive a medium-sized house of 75 m2. Third, a household with 9-13 people will receive a large-sized house of 100 m2. For the first five years, the NNP1 provides rice rations to the resettling population: 0.7 kg/day/adult and 0.5 kg/day/child under 15 years old. Key informants in this village said that they are lucky because they can access agricultural land prepared by the NNP1. However, when they first moved to Phouhomxay resettlement village, they were not familiar with the surrounding environment, and adaptation to a new style of livelihood was not easy for ageing people. Moreover, a key informant also explained that if all the people affected by the NNP1 decided to come to this village, the agricultural land would not be enough and difficulties of livelihood without sufficient rice to consume over the year would surely occur.

The second group examined is the group of those who had agricultural land in the former village before resettlement, and hence received a high rate of compensation for land, trees, and crops. This group of people preferred the out-plan under which they received full compensation for affected assets and people could manage their lives without conditions or control by the NNP1. Some moved to villages in Bolikhan and Thathom Districts. Key informants who had resettled in Bolikhan District explained that before moving out of their previous residences they got compensation for all assets according to the Agreement. Some may have gained more than they had before, but some got less. Moreover, people who were able to access to agricultural land in one village of Bolikhan district said that, because of receiving high compensation for agricultural land which had trees and crops, they could buy a new plot of paddy field with an area of 6,000 m2 at the price of LAK 80 million in 2017. One of key informants said:

"Before moving here, our family discussed in-plan or out-plan resettlement, but the majority of my family members voted for out-plan. After that, myself and the cousins who preferred the out-plan went around the nearby and far-away villages, searching for a place where we could buy new agricultural land for paddy rice field, animal-raising and crop-planting for normal consumption. Luckily, myself and my cousins with – a total of five families – can buy agricultural land in this village. In my case our family received compensation for agricultural land with trees and crops amounting to approximately LAK 200 million, with which we managed to buy paddy rice fields, grassland and construction land. At the same time, the NNP1 allowed us to move the materials of our wooden house to build a new one here, which saved some money and allowed us to move the materials of our wooden house to build a new one here, which saved some money and allowed us to meet other expenses."

It seems that the outcomes for the resettled people who were able to buy agricultural land in this village – whether they could secure their livelihoods and whether their livelihoods will be happy or not – are dependent on what they decided and how they were able to negotiate with the NNP1 developers.

In the same village of Bolikhan District, there is a group of affected people who could not access agricultural land. This is the group who owned a house in the village that was made to move, but who did not own any agricultural land. Therefore, when they were resettled, they received compensation for their houses, but not for agricultural land. However, this group of people decide to select the out-plan because, when the rumored news of negative impacts of dam development on affected people nationwide were widely discussed among society in rural and urban areas of Lao PDR, some people did not trust that the in-plan would be delivered as promised. Moreover, the compensation received was enough to buy construction land and to build new houses, but they could not afford paddy rice land in the village, because paddy rice land in this village is very expensive: it costs approximately LAK 13,333/m2.

As a result, people moving to this village can obtain only a small plot of grassland which they can buy with the remainder of their money from the NNP1 compensation. However, alternative means to secure enough rice to consume over the year are available. First, they can rent paddy rice field from villagers, under the condition of dividing the rice production into 30% for the owner and 70% for themselves, or 40% and 60%. However, rental paddy rice fields are not easy to find. Second, some people work for a daily wage. Notably, teenagers are moving to Vientiane or another city to find jobs and send remittances to their parents. Overall the people in the group without paddy rice fields explained that their livelihoods would be difficult if there is no one to rent paddy fields to them and they cannot receive remittances.

Conclusions and recommendations

Law and regulations in the Lao PDR contain clear provisions on access to agricultural land for dam-affected people, to try to ensure that the livelihood of affected people will not be lower than or equal to their situation before resettlement. Agricultural land is very significant for people in the rural area of the country. This kind of land connects to food security and poverty reduction.

In the case of affected people from the NNP1, people moving to the project's resettlement site can access agricultural land because the majority of affected people select the out-plan resettlement program. People who selected out-plan have been receiving high compensation for agricultural land and have good livelihood prospects after resettlement. People who have received less compensation or who have mismanaged their compensation money are in a hard situation. The group of people who did not get access to agricutural land is facing unstable livelihood conditions.

The NNP1 is not concerned with out-plan resettlement; it seems that problems are being shifted from the NNP1 to affected people and local authorities. The difficulties encountered by some of the out-plan resettlement people require the NNP1 to pay attention to this option. In other words, for this group of people, there must be responsibility and consideration on how the risk can be reduced, and the process be fair in that sense. However, the fact that the NNP1 has offered both in-plan and out-plan compensation represents a good practice, in which dam-affected people can decide on their own in terms whether to move to the project's resettlement site or to self-resettle.

Solar panels in rural Laos
by fototrav

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EMERGING ENERGY STORAGE TECHNOLOGIES AND ELECTRICITY SYSTEM TRANSFORMATION IMPACTS ON THAI-LAO POWER TRADE

Noah Kittner

Introduction

A transition to net-zero electricity systems to deal with increasing effects of climate change and address global energy challenges will require adoption of emerging energy storage technologies. These innovative batteries and storage supply options will have unique effects in Thailand and Laos when implementing new power system projects. Technologies such as flow batteries, hydrogen, and thermal energy storage have the potential to disrupt current power system planning processes that are dominated by large-scale hydropower and thermal generation. In particular, storage could shave the peak demand for electricity at periods experiencing the most consequential environmental impacts. This think piece seeks to identify opportunities for Thailand and Laos to benefit from a social and environmental perspective, and perceived challenges where emerging storage technologies could exacerbate current issues related to cross-border power trade and non-competitive utility structures. Storage technologies can both match electricity generation at demand centers and encourage distributed generation, marking a shift from centralized power generation and transmission. Specific applications of storage could leave countries with stranded large-scale hydropower and thermal power plants; yet integration with systems-level planning could enable more efficient power system operations and dramatically reduce the need for new generation projects that threaten livelihoods of the poor. Storage also can improve reliability and power quality to enhance human development across the region. By reviewing existing technologies, this sheds light on ways for new electricity storage to disrupt an era of unchecked power generation expansion.

Thailand is undergoing a transformational stage in energy policy making. As part of Thailand's Energy 4.0 strategy to promote technological innovation and emerging technologies, the Ministry of Energy is developing an integrated framework to improve efficiency, cost, and service in the energy sector (Energy Policy and Planning Office, 2019). This type of planning will require the adoption and integration of energy storage into electricity generation, transmission, and distribution – in addition to managing a transition to low-carbon energy. This think piece explores the role of storage in the transition to renewables using cross-border trade agreements between Thailand and Laos, and explores how emerging storage technologies could improve environmental and social outcomes from the power sector.

The Thailand Energy 4.0 strategy seeks to prioritize four key areas in the electricity sector : a) increase energy efficiency, 2) improve firm renewable energy capacity through supply-demand electricity balances, 3) develop a central wholesale electricity market, and 4) move toward distributed generation. Cross-border power trade, including the increased purchase of electricity from neighboring countries, is central to the strategy of balancing electricity supply and demand and firming variable renewable electricity capacity. The creation of an ASEAN Electricity Hub and central wholesale electricity market also promotes cross-border imports and power trade selling and reselling electricity at competitive rates to neighboring countries. At the same time, domestically within Thailand an emphasis on distributed microgrid generation is being placed to reduce investment in new transmission lines, under which future transmission lines would be built to allow for increased import and export of power across ASEAN. Simultaneously, the electricity strategy is developed in a cross-sector manner, with emphasis on electrification in transportation and more competitive markets for gaseous heating fuels.

A significant aspect of Thailand's electricity strategy involves innovative improvements to address challenges in balancing intermittent renewable electricity and reduce costs on the grid by moving toward a market-based electricity trading hub that dispatches electricity on merit order (Energy Policy and Planning Office, 2021). A doubling of renewable electricity consumption is targeted by 2036, while also reducing dependence on natural gas by 50%. These targets are in absence of any major national climate change strategy, and offer a view into the security lens through which renewable electricity, energy storage, and cross-border power trade may play as Thailand seeks more authority within ASEAN.

Current issues that Thailand faces in the electricity sector include very low energy efficiency standards for existing power plants, a lack of firm capacity to support variable renewable electricity, and inefficient electricity markets that operate without cost considerations. This increases electricity costs for consumers and across EGAT; electricity dispatch and bidding is not yet a competitive process. Hybrid and firm renewable electricity capacity supported by either energy storage systems or supplemented by cross-border power trade would bring Thailand closer toward achieving the Thailand Energy 4.0 Strategy.

Energy storage unlocks new technological opportunities to realize this electricity trading strategy because increased investment in energy storage would 1) reduce variability and intermittency of renewable electricity, 2) improve grid operations by introducing merit order dispatch[1] and price arbitrage, and 3) allow for less costly remote distributed generation in rural communities.

With energy storage technologies varying by power and energy capacity and other key metrics such as discharge duration, this think piece seeks to identify emerging technology trends and develop ways in which energy storage technologies could augment environmental and social outcomes in the region as a part of a way to ameliorate past challenges. Hydropower has impacted millions who live in the Mekong River Basin (Soukhaphon et al., 2021). Both Thailand and Laos have faced increased concerns over air pollution due to reliance on coal and natural gas in the power sector and diesel and petroleum in the transportation sector. Energy storage technologies have the opportunity to displace thermal power generation for electricity and also reduce transportation emissions.

In particular, pumped storage hydropower has served as the largest energy storage technology in Southeast Asia for the past decade in terms of installed nameplate capacity. Pumped storage hydropower typically is a closed-loop system that does not obstruct river flow and maintains water in an upper and lower reservoir, while pumping water into the upper reservoir to store as a form of gravitational potential energy. Pumped storage hydropower therefore does not suffer from the same fragmentation and livelihood displacement issues as large Mekong-based hydropower generation. Sometimes existing dams can be retrofitted to operate as pumped storage hydropower in Europe, but there have been few examples in Southeast Asia. Despite pumped storage hydropower's advantages over hydropower generation, concerns over water management rights, drought, and the siting of hydropower plants have affected livelihoods of hundreds of thousands who

[1] Merit order dispatch refers to economic prioritization of electricity dispatch based on the short-run marginal cost of electricity. For instance, power plants would be called upon in a competitive market to bid prices, and the lowest marginal cost providers would fulfill orders first.

live in the Mekong Region and depend on the watershed for agriculture (MRC, 2020).

Therefore, finding pathways to improve technological innovation in the energy sector while diversifying the storage resource could benefit the operational efficiency of Thailand and Lao power trade. As part of Thailand's 4.0 Energy Strategy, an MOU has been signed to import an additional 9,000 MW of unspecified power capacity from Laos. Simultaneously, emerging energy storage technologies have the potential to rapidly achieve UN Nationally Determined Contributions (NDCs) resulting from the Paris Climate Agreement and make the electricity sector more resilient to climate extremes and weather shocks.

The dramatic cost decline of solar, wind, and energy storage technologies is reshaping the energy sector in Thailand and Laos. With plans for increased cross-border power trade, storage takes on a new role as a balancing technology and complement to increasing penetrations of variable and intermittent wind and solar electricity.

Business-as-usual in Thailand and Laos

At present, Thailand has a distinct advantage as a buyer of electricity from Laos. The electric grid in Laos is currently divided into four main zones across the North, Central 1, Central 2, and South regions. The net transfer capacity of electricity between regions is limited. For example, the poor transmission infrastructure in Laos does not efficiently move electricity from Northern and Central Grids to the Southern Grid which up until recently (2016) was disconnected from the rest of the country's grid system. The lack of transmission interconnectivity in Laos undermines the strategy of becoming the Battery of ASEAN. Laos currently generates a surplus of electricity with the intent to export neighboring countries. Storage could assist Laos' power grid operations by reducing the variability of hydropower, wind, and solar facilities that are slated for power export and exchange. The storage can allow for more dispatchable electricity which can allow for firmer – and hence a higher volume of – power purchase agreements in the long-term. In the short-term, storage can also reduce the need for transmission by increasing resource adequacy. Typically utilities meet resource adequacy needs by constructing new electric generators. Current power purchase agreements between Thailand and Laos favor Thailand as the latter is able to purchase electricity at between 1-2 Thai baht/kWh (~$0.03-0.06/kWh). Laos adds to its debt burden by purchasing power back from Thailand at $0.11/kWh. This is a major problem for Laos as it exacerbates inequities felt by communities who are impacted by hydropower dams that export power abroad, yet face increasing electricity costs to serve their own communities.

Energy storage offers a wide range of value propositions within the power sector. In Germany and Australia, for instance, most longer-duration energy storage technologies have entered the market first through ancillary service provision, by providing frequency regulation and voltage maintenance for power system stability (Gitis et al., 2015). Even though the technologies may be able to store electricity for long periods or discharge electricity for more than four hours, they have been used for other applications. Then as costs decline and business models emerge, other applications more appropriate for the technology, such as peak shaving and load shifting became more feasible. In the Mekong, there are a variety of beneficial applications and use-cases for energy storage that would alter electricity sector dynamics. One major benefit could be through peak demand management in Thailand. As temperatures rise, there may be increased electricity demand in the middle of the afternoon for air conditioning. Figure 1 shows the Thai power system's average daily load profile, demonstrating the early global price volatility. While building new high-voltage transmission lines could be considered environmentally challenging from a land-use perspective, the increased adoption of both storage and transmission make solar and wind investments much more financially attractive, and from a technical perspective could displace more coal and natural gas electricity. That would reduce overall greenhouse gas emissions, improve air quality significantly, and reduce water supply needs for power plant cooling. There are other environmental benefits, including the afternoon peak and ramp that coincides with air conditioning demand (Huang et al. 2019). Electricity storage that reduces peak demand combined with solar electricity would offer a range of environmental and societal benefits to reduce reliance on large-scale hydropower plants. Other potential applications include load shifting, ramp rate reduction, and power quality management. Load shifting and peak demand management will particularly affect the transmission and distribution operations of the grid in Thailand and Laos. This could be positive if applied to reduce reliance on coal and natural gas in the grid during peak demand hours.

Thailand's plan for cross-border power trade is emerging as the prevailing energy strategy in the region. However, as the cost declines for energy storage options, competing technologies could cost less in the long term than large-scale transmission lines, reaching below $100/kWh (Kittner et al., 2017; 2020). They may act in a complementary way – storage could reduce the amount of transmission necessary for a functioning grid – while also providing both Thailand and Laos a "bank" of electricity to arbitrage price spikes and improve system operations. Without a competitive market, drought and supply chain issues can cause price spikes in electricity tariffs. In particular drought has affected hydropower generation, and supply chain issues have caused imported natural gas (of which Thailand is a net importer) to become more expensive and subjected to potential to avoid construction of new large-scale power plants that threaten river scale power plants that threaten river ecosystems and would affect global efforts to limit global warming to two degrees centigrade.

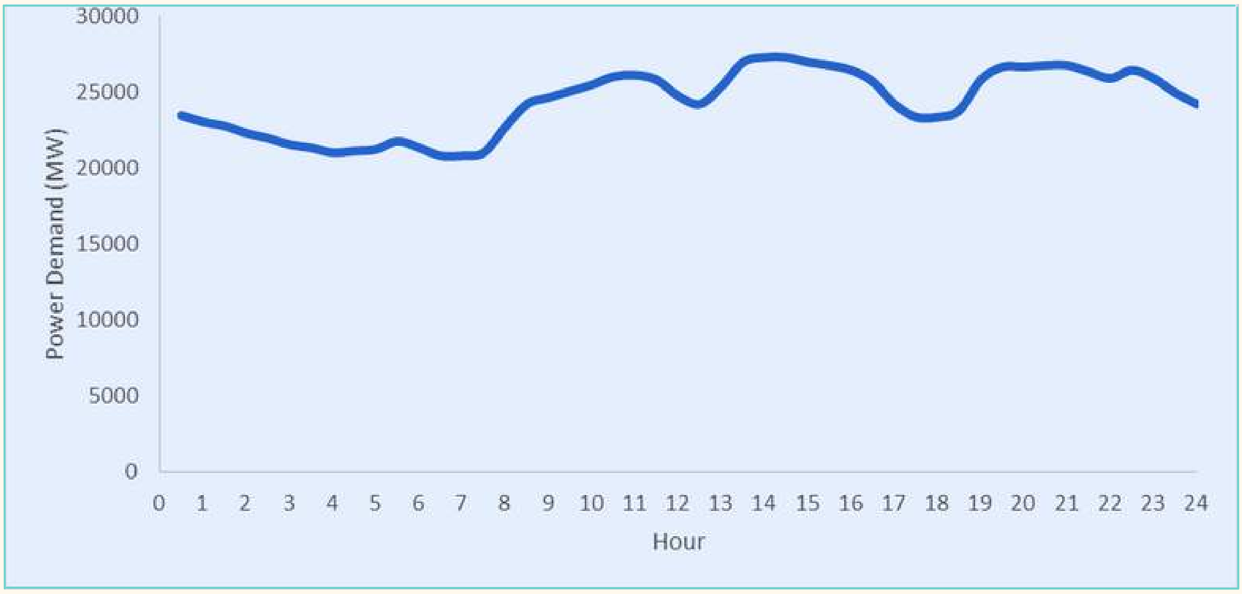

Figure 1. Aggregated system average daily load profile for Thailand. Data adapted from Huang et al. 2019.

Currently the monopolistic structure of Thailand's electricity market deters independent players from competing there, and exacerbates reliance on inefficient electric thermal power plants. By allowing more competition in the electricity market to improve distributed generation and allow for new independent power producers (including storage developers), there are more opportunities to reduce unequal electricity tariffs across customer groups, improve the environmental performance of the grid by reducing reliance on heavily polluting coal and natural gas combustion turbines, and reduce dependence on foreign hydropower such as in those projects in Laos that may displace thousands from their homes in the next decade.

Why peak demand management for the Mekong?

Peak demand management in Thailand will be one particularly important strategy to utilize energy storage as a way to improve environmental and social outcomes. Thailand often imports electricity during peak times to manage strain on the grid, or operates less efficient natural gas combustion turbine plants to meet peak demand. Approximately 25% of the natural gas is imported. Thailand's strategy to reduce reliance on natural gas in the past decades has included the increased operation of coal-fired power plants, which have even higher greenhouse gas emissions and negative effects on the surrounding communities.

Why energy storage?

Energy storage is one opportunity that cuts across multiple aspects of Thailand's Energy 4.0 strategy to improve overall energy efficiency by reducing the utilization of inefficient thermal power generation, improving the ability to arbitrage and shift peak loads, and move toward future distributed generation and less reliance on centralized electric grid systems. The value is three-fold: 1) environmental, reducing pollution and power sector emissions, 2) social, enabling business models for new independent project developers and power producers outside the monopolistic grid business structure, and 3) indirectly redirecting resources away from transmission lines that can harm communities because they are often built alongside hydropower dams.

Review of storage technologies

Traditional energy storage technologies such as pumped storage hydropower and lithium-ion batteries will likely play a role as Thailand and Laos integrate higher shares of variable renewable energy into the grid (IRENA, 2017). In addition, the cost of the incumbent storage technologies have decreased to the point where solar+storage projects are emerging in the form of utility-scale solar and batteries, and Thailand now leads the world in floating utility-scale solar installations that can be coupled with pumped storage hydropower on existing reservoirs. For example, the 45 MW floating solar array on the Sirindhorn Dam in Ubon Ratchathani province is the world's largest as of 2021.

Part of the impetus for utilizing more energy storage is to manage peak demand challenges in Thailand. Currently, peak demand is met by demand is met by utilizing natural gas combustion turbines which import the majority of natural gas resources from other countries. This also exacerbates pollution. Different storage options exist to flatten the shape of Thailand's load profile and reduce variable increases in natural gas generation to accommodate fluctuations in demand and integrate higher shares of renewable electricity. Because much of the planned renewable electricity can be met through solar and biomass energy, there is a concern that with increased penetration of variable solar electricity Thailand will either need to invest more heavily in storage to cope with afternoon ramping of demand or in extra cross-border transmission capacity to accommodate the variability.

Emerging storage technologies include new designs of pumped storage hydropower, flow batteries, hydrogen, and thermal energy storage. The reason that these technologies may contribute to environmental benefits in Thailand is due to the opportunities for solar and low-carbon electricity to displace natural gas in the electricity generation sector. Each technology has its own benefits and costs that may alter electricity trade dynamics between Thailand and Laos. The primary reason for this is that storage could compete both on a short-duration, intra-day scale by balancing intermittent resources and on a long-duration, cross-day scale that could also impact seasonal supply shortages of electricity faced by reliance on hydropower dams in Laos.

A primer on the technologies and their characteristics is presented in the following sections.

Pumped storage hydropower

Pumped storage hydropower (PSH) is the most mature electricity storage technology. The predominant design features two reservoirs with an elevation difference, storing energy in the gravity differential between the two areas. These PSH systems already exist to some extent in both Thailand and Laos, for example in the 1,000 MW Lamtakong PSH facility in Nakhon Ratchasima. Closed-loop pumped storage hydropower systems can reduce their environmental footprints on the river and provide a significant source of long-duration storage and seasonal energy and water storage services.

Emerging pumped storage hydropower retrofits would take existing and operational run-of-river or reservoir-based hydropower facilities and convert them into water and energy storage facilities. Some of these dams can also integrate utility-scale floating solar as an alternative. Pumped storage hydropower may be favorably viewed in the region due to its ability to retrofit existing power plants. Secondly, it may provide a buffer against extreme climate and weather events that include drought, variable water flows that impact hydropower dam operations, and seasonal availability of electricity for cooling. The potential benefits of pumped storage hydropower range from bulk power management applications such as seasonal load shifting and peak shaving to fast-responding back-up and possible black start capabilities if water is available in the upper reservoir.

Flow batteries

Flow batteries are an exciting technology due to the technological design in which electrolytic tanks are separated by a membrane, allowing for unique combinations of high power and longer-duration energy applications. They can be utilized in micro-grids or off-grid distributed applications with longer durations than lithium-ion batteries. There are already flow battery manufacturers located in Thailand such as BCPG, a leader in vanadium-redox flow technology. However, deployment across flow battery technology in Thailand is limited to several hundred kWh, mostly for remote village-based microgrids.

One major advantage of flow batteries over other larger-scale storage technologies is their flexibility to operate either in a distributed setting in the distribution grid or at utility-scale in a grid-connected mode. Therefore flow batteries may be critical technologies to increase adoption of mini-grids that already serve mountainous regions such as Mae Hong Son province.

The utilization of flow batteries could facilitate a shift from more centralized electricity grids to decentralized solutions that better meet the needs of remote populations and community-shared solar+storage projects. The flexibility offered by flow batteries offers solutions at different scales, from off-grid, to micro-, mini-, and full grid connections.

Hydrogen

Hydrogen is an energy carrier than can serve as short-term, cross-day, or seasonal energy storage. The flexibility in hydrogen is that excess power from the grid can be converted using water electrolysis to hydrogen gas, which can be liquified to use as a fuel or used in gas form to power a fuel cell that provides building back-up power or grid-scale storage. Unlike other storage devices mentioned in this primer, hydrogen is an energy carrier, really a gas- or liquid-based fuel that can be used for electricity generation or storage and in the transportation or industrial sector for heat or combustion. There are many opportunities for hydrogen production in Thailand and Laos and use as energy storage or an energy carrier. For instance, as Thailand utilizes natural gas for electricity and in the transportation sector, there are opportunities to produce renewable hydrogen using water electrolysis and implement low-carbon fuels into the existing infrastructure. Hydrogen can serve many industrial purposes in instances where electricity is not an option such as the production of heat and steam for manufacturing.

Decarbonized, or "green" hydrogen remains costly, but the European Union, US, and Japan have made significant investment in the technology. Green hydrogen has a longer path toward becoming commercially viable, but, with Thailand's current reliance on natural gas, there could be an attractive element of domestic hydrogen production via solar electricity and utilization of existing pipeline infrastructure. It will be important for Thailand and Laos moving forward, as hydrogen provides a potential seasonal energy storage option with minimal idle losses over a period of multiple months. If solar, wind, and hydropower electricity generation all increase in Thailand, the use of liquid or gas-phase hydrogen could serve as a way to maintain resource adequacy during droughts or periods of shortfall in the dry season. In Germany, hydrogen production as an ancillary service provision to the grid is becoming cost-competitive (Scolaro and Kittner, 2022). In the US, the role of hydrogen remains uncertain, yet a hydrogen pathway could present multiple synergies with transportation and industrial decarbonization (Kittner et al, 2021). There may be additional cross-sector opportunities that can be applied for the case of Thailand and Laos in terms of replacing natural gas infrastructure and mobilizing hydrogen production for domestic energy security.

Thermal energy storage

Thermal energy storage is comprised of multiple technologies – there is traditional thermal particle storage typically used in conjunction with concentrating solar power, and there is also thermal heat or cooling storage in media such as silica sand, rocks, water, or air. Additionally, there are emerging companies trying to make AC-to-AC electricity storage systems. The range of thermal storage technologies are attractive in Thailand at different scales. At the commercial/building scale, thermal ice storage could provide an alternative cooling method to traditional air conditioning, that drives much of the electricity demand during the peak times in the afternoon. Additionally, for industrial purposes, industrial heat can be used as process energy and thermal storage plants could capture heat during times when the price is low or electricity is sustainable and use it at later times. This could improve system operational efficiency and allow for reduced use of coal or natural gas thermal energy.

As a decarbonization strategy, thermal energy storage would enable many industrial processes in the economy to continue, while coal is more rapidly phased-out. This could be a critical strategy for Thailand as an energy hub as, if it decarbonized part of its energy sector, it would be crucial to establish renewable energy certification schemes. The certification schemes would then allow for power exports to countries with higher environmental standards, such as Singapore.

Another exciting application of thermal storage unique to Thailand and Laos is thermal ice storage in buildings for improved solar or electric cooling systems. Air conditioning demand is driving peak afternoon electricity usage and, because of the hot tropical climate, ice storage for buildings could allow for better energy demand management and efficiency. The efficiency of ice storage is notably less than efficiency of thermal storage in rocks or particles such as silica sand or molten salt.

Other types of thermal storage technologies such as a "pumped heat energy storage" system promoted by Malta Inc., and particle thermal storage, could serve as industrial replacements for retired thermal power plants while also providing industrial grade steam and heat services that can be used for manufacturing and for process heat. The use of thermal storage coupled with electricity from solar or wind investments would allow for decarbonization of manufacturing products and allow for broader exports to key markets in Europe or Singapore that have implemented embodied carbon border taxes for imported goods.

Lithium-ion battery storage

Lithium-ion battery storage is the most efficient form of electricity storage to date, based on roundtrip efficiency, and its use is widespread globally. Lithium-ion battery storage has grown tremendously in the United States, Europe and China. Lithium-ion battery storage can be used on the electric grid and in the transportation sector. The advantages of lithium-ion battery storage include its larger energy capacity than previous batteries used with solar electricity such as lead-acid batteries. The decreasing cost of lithium-ion battery storage is attractive for investors. There are some limitations to lithium-ion storage, notably that most batteries discharge power for a maximum of four hours. Therefore it might not provide full discharge capabilities through the night. It can provide significant load shifting and peak demand reduction applications. Lithium-ion battery storage also competes with thermal generation as it can dispatch electricity and respond to frequency changes on the grid within seconds. In tropical locations, lithium-ion batteries often need cooling centers such as air-conditioned space to keep the power high; although lithium-ion maintains a higher overall roundtrip efficiency than other storage options mentioned here, the cooling could be a challenge for Southeast Asian countries, which underscores the importance of also developing innovative alternative storage technologies that could excel in Thailand and Laos as well as on the global market.

The Opportunity of Electricity Storage

Grid-scale storage would impact the current electric grid and transmission networks in the following ways. First, it could alleviate Laos' debt problem by enabling the purchase of imported electricity at a high markup during the dry season. Second, it could allow Thailand to export more of its own solar and wind electricity. (This electricity can be certified for sale in countries such as Singapore that would not accept thermal power generation from Laos due to high carbon emissions.) Overall, it would increase the amount of cleaner renewable electricity used across the region, especially if Thailand and Laos were the primary investors in storage technologies.

Laos needs to diversify its power sector through investments in non-hydro renewable electricity such as solar and wind and it must address a seasonal electricity supply shortfall in the dry season due to over-reliance on hydropower. The seasonal shortage can lead to increases in Laos' debt burden and major problems when imports of electricity increase. Investment in emerging energy storage technology can alleviate some of this key challenge and debt curse by allowing Laos to generate more electricity than it needs and perhaps develop seasonal storage that could allow for electricity generation during the dry season.

In Thailand, storage would also be beneficial, as Thailand seeks to serve as the cross-border electricity trading hub for ASEAN – therefore, storage can help arbitrage prices between low-cost power purchase agreements from Laos and off-takers such as Malaysia, Myanmar, and Singapore that may require the certification of cleaner renewable electricity. Thailand could use storage technology as a way to import electricity at a low cost and then dispatch cleaner solar and wind electricity generated in Thailand to other neighboring countries. This flexibility is a major system boon. The IEA developed an extensive grid flexibility study for Thailand in 2021 that expands on the system-wide benefits of large-scale storage.

Peak Demand Management

Electricity demand in Thailand peaks in the early evening or late afternoon. However, with increased planned installation of solar electricity, the peak demand time could shift. Furthermore, with air conditioning demand peaking in the heat of the afternoon, there are opportunities to manage the efficiency and cost of the electric grid by using storage technologies. Currently the transmission system may be used to balance intermittency and peak demand changes due to renewable electricity, but storage could play an increasing role as more renewable energy is utilized across ASEAN (Huang et al. 2019).

Seasonal changes in hydropower availability and drought may create load balancing challenges for imported electricity to Thailand in the coming years. With increased expected electricity demand for air conditioning in buildings, energy storage could provide a buffer between the variability of hydropower generation in Laos and other options.

Peak demand management is one of the best strategies for increasing energy storage application in Thailand because of the potential to improve air quality during peak electricity demand events and the opportunity to use storage as a price arbitrage. A price arbitrage allows storage devices to charge electricity when prices are low and operators can use stored electricity on-site when electricity becomes expensive. At a system scale, this arbitrage strategy can reduce overall volatility in electricity prices due to changes in demand. New storage technologies could reduce peak demand and improve the sustainability of the power grid by reducing imports of natural gas and utilizing higher shares of solar and wind electricity. Storage diversifies the power sector and provides much-needed flexibility for generation and transmission systems.

Social and Environmental Impacts Resulting from the Transition

Reduced reliance on hydropower could lead to a deferral of investment in – and construction of – tributary dams and mainstem hydropower dams that are slated for supplying electricity to Thailand: dams that would dramatically alter people's livelihoods and rivers. There have been many analyses documenting the environmental harms related to sediment starvation, river fragmentation, and land subsidence resulting from increased investment in hydropower resources (Schmitt et al. 2019; Schmitt et al., 2021).

In Thailand, the transition to renewable energy has been resisted for many years by dominant industry actors, including utilities such as EGAT (Middleton, 2016). The majority of renewable energy projects have emerged outside of EGAT, through independent power producers and small power producers, which comprise less than half of the domestic electricity generation within Thailand. The power and structure behind PTT (Petroleum Authority of Thailand) also has significantly exerted influence and strategic decision-making for the Energy Policy and Planning Office. Storage could either hinder or augment power structures already in place depending on siting, location, and interaction with independent power producers. There is already a trend for independent power producers (IPPs) to increase their share of total electricity generation in Thailand to rival that of EGAT, as EGAT reduces its generation investment strategy due to its economically uncompetitive fleet of power plants. A shift to use of storage would reduce plans for new generation investment that threatens ecosystems and livelihoods. Simultaneously, it could make solar and investments more attractive, as coupling solar and wind with storage projects would enable better direct competition to natural gas and thermal coal facilities for power generation.

Future Outlook

Storage technologies need support from the government and utilities in Thailand and Laos to benefit society and the electric grid system by providing both reliability and resilience support. The seasonal variation of electricity supplies in the Mekong Region is dominated by the wet and dry seasons. Because hydropower has traditionally played a role in the variability of the energy sector, and climate change is expected to alter river flows, energy storage has an opportunity to reduce seasonal supply shortages in the long-term and, in the short-term, improve the flexibility of the grid to accommodate higher shares of solar, wind, and variable renewable electricity.

Battery storage, such as lithium-ion batteries and flow batteries has the opportunity to change the shape of the power grid through its distribution and transmission systems. More communities can share resources and pool together solar and biomass-based fuels in mini-grids. Decentralized storage could improve operations on the distribution side of the power grid. These technologies may also affect transmission-scale investments as part of a centralized strategy for storage. Increased investment in distributed and centralized storage could defer new generation projects and facilitate the bankability of new solar and wind investments. There may be a suite of policies for Thai and Lao communities to benefit from energy storage. One would be a comprehensive and integrated energy storage strategy that fits within and alongside each country's energy and climate plans. This could include deployment targets to achieve certain outcomes such as peak demand reduction, seasonal supply security, short-term reliability, and improved resilience to climate events. Diversification of generation and storage has been raised as a critical strategy to improve the flexibility and security of Thailand and Laos' energy systems (Tongsopitet al., 2016; IEA, 2021).

Another advantageous policy could be targeted subsidies for storage, similar to a dynamic feed-in tariff. For instance, this could be applied exclusively to solar+storage projects or it could be applied to stand-alone energy storage investments. Stimulating the investment market for storage would be very beneficial and Thailand's success with Very Small Power Producer and Small Power Producer programs demonstrates a viable pathway to support private companies investing in innovative storage deployment.

In terms of social acceptance, for storage to benefit more people there needs to be a focus on the air pollution and health benefits of storage options in addition to the water savings benefits from those affected by hydropower dams. Civil society organizations have effectively advocated


Floating solar system on Sirindhorn Dam, Ubon Ratchathani, Thailand
by Pat Hemjan

against mainstem hydropower dams and are challenging leadership decisions and forcing the government to reconsider several mainstem dams due to impacts on river-connected resources and agricultural lands. There have also been recent protests in Bangkok due to urban air pollution, and, recently, successful opposition movements to prevent a new coal plant from being constructed in Krabi province. Therefore quantifying the air pollution and health benefits of implementing energy storage in Thailand's and Laos' electricity networks will be very important as a way to integrate higher shares of solar and wind.

There is already a significant investment in generation and transmission assets to accommodate cross-border trade agreements between Thailand and Laos. A storage agreement would be helpful to reduce reliance on large-scale coal and hydropower and enable a transition to reliance on more sustainable renewable electricity such as solar. Recent announcements related to floating solar PV installations on top of pumped storage hydropower reservoirs are a first step. Newer storage technologies such as industrial thermal storage, or hydrogen, which could act as a liquid transportation fuel or substitute in gas networks for natural gas, would also greatly benefit integration of variable renewable energy and promote a more aggressive decarbonization target that also provides resilience buffers against seasonal weather and electricity demand changes.Ice storage for air conditioning is also a potential solution for buildings that utilize electricity in Thailand and Laos and have increased cooling requirements due to rising temperature extremes.

Conclusion

The energy storage landscape is changing globally with gigawatt-scale installations happening in many countries, but Thailand and Laos present very unique cases for energy storage where storage could be the missing component to transition past centralized thermal coal and mainstem hydropower generation to increase utilization of solar and wind in the power sector. It would also greatly complement the already existing solar investment in Thailand and Laos, which are competing with Vietnam directly in terms of total new solar installations. Integration of renewable technology into the grid is the best pathway to maximize the benefits of solar electricity investments and build new economies that are less resource dependent on water and coal.

Storage offers unique applications in Thailand and Laos to increase efficiency in power grid operations, reduce inequities in cross-border power trade agreements, and improve environmental performance of the grid by reducing greenhouse gas emissions and other harmful air pollutants. With heightened awareness of the controversy surrounding large-scale investments in thermal power generation and hydropower projects, storage offers an alternative energy technology path that could reduce the need for large projects. In the long term, storage could facilitate higher shares of solar and wind adoption on the grid, lead to peak demand management, and improve human development throughout the region primarily through improved air quality, reduced human displacement from energy projects, and a more diversified ownership structure of energy system assets.

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APPLYING GLOBAL ENERGY TECHNOLOGY TO REDUCE CARBON DIOXIDE EMISSIONS FROM THAILAND'S ELECTRICITY SECTOR

Apisom Intralawan and David Wood

Introduction

Electricity consumption in Thailand has more than doubled in the past twenty years as a result of the country's rapid economic growth and higher living standards. This has resulted in a similar increase in carbon dioxide (CO2) emissions from electricity generation which reached about 90 million tons (Mtons) in 2020; power generation is the largest sector in terms of Thailand's carbon dioxide emission and accounts for more than one third of total CO2 emissions (Energy Policy and Planning Office, 2021a).

In line with the global effort to address this challenge, Thailand's government plans to decarbonise all sectors including the energy sector. However, according to the current power development plan, CO2 emissions from the electricity sector are projected to increase during the next ten years. The CO2 emissions from additional electricity generation from coal and natural gas outweigh the partial replacement of fossil fuels with solar and wind. Furthermore, dependency on fossil fuels for electricity generation (73% from coal, lignite and natural gas in 2020 and 54% forecast for 2030) is still high compared to many countries. The Electricity Generation Authority of Thailand (EGAT) plans to replace some old coal power plants with natural gas and renewable energy but, as discussed below, a more ambitious plan to phase out coal completely would have a much larger impact on Thailand's CO2 emissions.

Net zero carbon is a global strategy to combat adverse climate change impacts. Many countries have pledged timelines to achieve this target, including the USA by 2050 and China by 2060. They are developing action plans focused on increasing energy intensity and replacing fossil fuels with renewable energy which has experienced a large cost decline during the past decade. Like other countries, Thailand is currently formulating a Long-term Low Greenhouse Gas Emission Development Strategy (LT-LEDS), and recently announced a net zero target date of 2065-2070 (Office of Natural Resources and Environmental Policy and Planning, 2020a)

Literature reviews indicate that Thailand's plan to decarbonize the electricity sector is not very ambitious. This plan is hampered by inflexibility of the country's power system both in technical and contractual terms. Thailand has a very high generation reserve margin which means there is no urgency to add generation capacity using renewable energy. Also, the government decarbonisation policy involves several ministries with different mandates and they have been slow to react to the rapid technology and cost changes in power generation from renewables.

This think piece responds to the above problems and develops policy options which would significantly reduce CO2 emissions related to Thailand's electricity sector. We suggest that the potential for CO2 emission reductions could be considerable; the estimated CO2 emission reduction is about 50 Mtons/year by 2030 and 130 Mtons/year by 2040. These options will help Thailand to accelerate decarbonisation of the energy sector and meet climate change commitments.

by Acilo

Carbon Dioxide Emissions from Thailand's Electricity Sector

Thailand signed the 2015 Paris Agreement on climate change mitigation and intends to reduce its greenhouse gas emissions by 20% from the projected 2030 level of 555 Mtons CO2 equivalent/year according to its "business-as-usual" scenario (Office of Natural Resources and Environmental Policy and Planning, 2020b). This would mean a greenhouse gas emission target of 444 Mtons CO2 equivalent/per year by 2030 which is comprised of several contributions. The major contribution is about 300 Mtons CO2/year from fossil fuel combustion and industry processes (Asia-Pacific Economic Cooperation, 2019). Other contributions are CO2 emissions from agriculture, forestry and land use plus CO2 equivalent contributions from other greenhouse gases such as methane, nitrous oxide and chloro/fluorohydrocarbons. From the global perspective, Thailand has a CO2 emission of 4 tons per capita per year which is modest but has considerable potential for reduction especially in the electricity and transport sectors (Energy Policy and Planning Office, 2021b). According to the national plan, Thailand generally aims at decarbonization by reducing fossil fuel dependency, higher energy efficiency and increasing the use of renewable energy for electricity generation.

For this think piece, electricity sector CO2 emission data were collected from government reports and analyzed for the past two years, as 2020 may not be a representative year because of Covid-19 impacts; Thailand's electricity consumption in 2020 was 3% lower than 2019 due to impacts from Covid-19. An analysis of government plans for electricity generation and consumption showed many areas with high CO2 emissions and potential for emission reductions. EGAT has already identified several measures to decrease carbon dioxide emissions and achieved a total of 4 Mtons CO2/year in 2020 which is only 1.5% of total country CO2 emissions.

These measures do not seem ambitious compared with other country action plans (EGAT, 2018).

A screening study was carried out to identify areas which met three criteria: technical feasibility, cost effectiveness, and potential to reduce CO_2 emissions by at least 10 Mtons/year. This resulted in the following list:

(i) Phase out existing coal power stations and replace with solar and wind
(ii) Improve efficiency of space cooling for buildings
(iii) Increase use of electric vehicles
(iv) Improve transmission/distribution system including smart meters

More thorough estimates of forecast CO_2 emissions were then made for the above areas and these estimates were compared with Thailand's plans for CO_2 reduction forecasts.

This study also considered the implications of introducing a carbon tax in Thailand. Although desirable from an environmental viewpoint, the Thai government is taking a cautious approach on carbon tax. Thailand may follow global trends and introduce a carbon tax in the next few years to comply with export requirements. However, it will probably not have a major impact on CO_2 emissions by 2030.

Thailand's CO_2 emissions were approximately 250 Mtons in 2020 with the largest contribution (91 Mtons) from electricity generation; the industrial and transport sectors each emitted approximately 70 Mtons (Energy Policy and Planning Office, 2021c). This 2020 emission is already 83% of Thailand's 2030 Nationally Determined Contribution to the CO_2 emission target (approximately 300 Mtons CO_2/year from fossil fuel combustion and industrial processes) which highlights the need to curb increases during the next ten years (Pichalai, 2015).

Table 1 presents available generation capacity, actual electricity generation and CO_2 emissions in 2020 for different fuel sources (Energy Policy and Planning Office, 2021c); To be consistent with EPPO data, this study uses the same assumption which is zero CO_2 emissions from hydropower, solar, wind, biomass/biogas and imports.

	Generation Capacity (GW)	Electricity Generation (TWh)	CO_2 Emissions (Mtons/year)
Coal/Lignite	7	37	35.5
Natural Gas	24	114	55.4
Fuel Oil	0	1	0.1
Hydropower	5	5	0
Solar	3	5	0
Wind	2	3	0
Biomass/Biogas	4	12	0
Imports	5	30	0
Total	**50**	**207**	**91**

Table 1: Electricity sector carbon dioxide emissions in 2020

As shown in Table 1, most of Thailand's electricity (73%) is currently generated from fossil fuels and only 4% from variable renewable energy (VRE). The generation from fossil fuels has a significant impact on CO2 emissions contribution. The peak demand in 2020 was 29 GW, which corresponds to a reserve margin of 42% (Energy Policy and Planning Office, 2021c). This results in high electricity generation costs due to operations and maintenance of power stations which are only used for short periods during the year. It has been reported that three power stations were completely idle in 2020. Thailand's reserve margin is much higher than global norms of 15-20%; the Thai government plans to reduce the reserve margin during the next ten years.

Global Energy Technology Trends

Some global energy technology trends provide useful lessons for Thailand. In this paper, the authors selected Germany and Vietnam as case studies due to their recent successes in moving the renewable energy transition policy agenda forward. Furthermore, these countries share many things in commons with Thailand, especially the dominant role of coal and natural gas for the country energy portfolio mix.

Germany Clean Energy Transition

In light of the climate change crisis, Germany plans to gradually phase out all electricity generated by coal fired power plants from the current capacity of about 30 GW. This amount is roughly five times Thailand's current coal capacity. In this regard, existing coal companies will receive financial compensation in return for decommissioning their plants: the bulk of the plants by 2030 and the remainder by 2038 (Oei, Brauers, & Herpich, 2020). The plan also bans the construction of new coal fired power plants. By creating a broad consensus, this has led to a just transition for workers and communities and institutional and to structural change (Gürtler, Beer, & Herberg, 2021). Germany's Commission on Growth, Structural Change, and Employment has been developed to gain legitimacy on phasing out coal strategies. The government plans to spend €40 billion on the coal region to develop new businesses and compensate workers who lose their jobs (Oei, Hermann, et al., 2020).

Vietnam's Rooftop Solar Expansion

During second half of 2020, Vietnam added 9.3 GW rooftop solar (Do et al., 2021). At the end of 2020, total solar capacity was 16.5 GW which exceeded its 2037 power development target (Riva Sanseverino et al., 2020). Vietnam provides a good example to ASEAN countries of very responsive renewable energy market adaptation and renewable transition, by providing generous feed-in tariffs and other supporting policies including income-tax and land-lease payment exemptions for utility-scale investors. The main incentive was the feed-in tariff of $0.084/kWh for rooftop solar and grid access for owners to sell surplus electricity to the national distributor at a price similar to the 2020 retail electricity price for households and businesses (ibid). The key drivers for policy change include government commitment, public demand for environmental protection, and government efforts to develop new economic sectors in response to climate change, as well as international community advocacy (Baulch, Do, & Le, 2018). Barriers to solar penetration include limited transmission capacity, complex procedures, regulation mismatch, policy uncertainty, an entrenched fossil fuel industry, and low foreign investment attractiveness. By contrast, high upfront cost and lack of communication and technical assistance were ranked top among rooftop solar respondents (ibid). In addition, restructuring the energy market by introducing net metering to increase financial rate of return and cutting payback period by half was seen as a key leverage point toward successful rooftop solar penetration in Vietnam (Lan et al., 2020).

Both the German and Vietnamese case studies point to the benefit of regulatory interventions to accelerate decarbonization. Thailand has also experimented with rooftop solar feed-in tariff schemes but has not been as successful as Vietnam (Sharifuddin & Zainudin, 2021). Thailand started a two-year rooftop solar feed-in tariff scheme in 2013 but this was limited to 100 MW for commercial/industrial rooftops and another 100 MW for residential rooftops. Another scheme was introduced in 2019 with an annual target of 100 MW of residential rooftop solar, but implementation has been very slow due to restrictions on capacity (maximum 10 kW per system) and the low feed-in tariff (initially Baht 1.68/kWh and later increased to Baht 2.2 which is much lower than the Thailand retail electricity price). More rigorous policy interventions such as higher FIT together with permission for peer-to-peer energy trading would help to expedite the renewable transition process in Thailand (Junlakarn & Kokchang, 2020).

Potential Ways to Reduce Carbon Dioxide Emissions

Gradually replacing all existing coal power stations with solar and wind

A key proposition in this think piece is to phase out all existing coal power stations by 2030 and not to build any new coal power stations. Phasing of the shut-downs will allow time to build more VRE in areas currently relying on electricity supply from coal power stations (e.g., Mae Moh in northern Thailand) and to improve the Energy Storage System (ESS) and grid supply from other regions. A major benefit of shutting down the coal power stations based on our own estimation is the reduction of 35.5 Mtons CO2 emissions/year. Another important benefit is the decreased air pollution from coal power stations which is expected to reduce premature deaths by thousands per year and to save millions of dollars worth of health care costs, based on studies in other

	Generation Capacity (GW)	Electricity Generation (TWh)	CO2 Emissions (Mtons/year)
Coal/Lignite	0	0	0
Natural Gas	29	138	67
Fuel Oil	0	0	0
Hydropower	5	5	0
Solar	19	33	0
Wind	6	13	0
Biomass/Biogas	6	20	0
Imports	12	30	0
Total	**77**	**269**	**67**

Table 2: Estimated electricity sector carbon dioxide emissions in 2030 with 15% VRE

countries (Greenpeace, 2015; Koplitz, Jacob, Sulprizio, Myllyvirta, & Reid, 2017; Vohra et al., 2021).

A recent study of Thailand's electricity system also noted the benefits of reducing the high reserve margin (40%) and decreasing dependency on fossil fuels (International Energy Agency, 2021). The IEA highlighted the potential for roof-top solar and strongly supported EGAT plans to further increase use of VRE to 15% of generation capacity by 2030. This plan involves 19 GW solar plus 6 GW wind, which is technically feasible within the existing distribution system. This scenario (15% VRE) was combined with data from Thailand's AEDP 2018 (Ministry of Energy, 2020) and used as a basis to forecast CO2 emissions for 2030 as shown in Table 2 below. Huang, Kittner & Kammen (2019) concluded that integration of 25% VRE into total generation capacity will be feasible by 2040, based on improved grid flexibility combined with energy storage developments (pumped storage hydro and battery storage). Increasing the share of VRE from 15% to 25% by 2040 would result in 35 TWh more electricity supplied by VRE and an additional reduction of 17 Mtons of CO2 emissions/year. It would also reduce natural gas consumption which is an important security issue for Thailand, as the domestic gas reserve is forecast to be depleted by 2030. The peak load is forecast to be 40 GW in 2030 and the generation reserve margin is estimated to be 16% without any contribution from VRE. This should be more than adequate for supply security.

Improve efficiency of space cooling for buildings

Space cooling for offices, commercial buildings, factories and houses currently accounts for about 20% of global electricity consumption (International Energy Agency, 2018). This demand is expected to increase significantly. Sales growth of air conditioners is forecast to outstrip gains in energy efficiency. For Thailand, EGAT estimates that 46% of electricity used in the residential sectors is consumed by air conditioning (NAMA Facility, 2021). Based on EGAT information for residential air-con plus rough estimates for the commercial and industrial sectors, it is estimated that air conditioning in Thailand used about 60-90 TWh in 2020.

Literature has shown that improved air-conditioning efficiency is the most readily achievable area to curb electricity demand growth, which would reduce required generation capacity and distribution capacity, and hence the total amount of investment needed for peak generation capacity, and ultimately impact CO2 emissions (IEA, 2018).

Higher air-con efficiency

Much of Thailand's air conditioning is provided by "fixed-speed split units" which are cheaper than "variable-speed (inverter) types" but have 30% lower efficiency. Global air-con efficiency is increasing considerably, and there are forecasts of 50% higher efficiency by 2030 and 80% higher efficiency by 2050 compared to 2016. There is a wide range of Energy Efficiency Rating (EER) in air-con units available for sale in different countries. Thailand air-con units have an EER range from 2.5 - 4.5 watt/watt with a market average of 2.8 – which is near the bottom of the range – while the best available air-con units in other countries have an EER of 6 - 7 (ibid). There is considerable potential to increase domestic air-con EER and reduce electricity consumption by improved building design. Improved regulations for efficiency standards could reduce Thailand's air-con electricity consumption by a factor of three.

Improved building design

Thailand's Energy Efficiency Plan targets a 9% reduction in building energy consumption by improved design, LED lighting and efficient household appliances. Another study reported that building energy consumption is 250-350 kWh/m2/year and estimated that this could be reduced to 100-150 kWh/m2/year by improved air-con and stricter building code regulations (Fungtammasan et al, 2017).

Potential electricity and CO2 emissions reduction

Assuming the same energy efficiency of air-con units and buildings as in 2020, the estimated electricity consumption for air-con would be about 100 TWh in 2030 and 130 TWh in 2040, which is about 30% of total electricity consumption in Thailand. These forecasts for air-con electricity consumption could be significantly reduced by government regulations for a stricter Minimum Energy Performance Standard (MEPS). Stricter building codes for new commercial buildings should be easy to implement, but changing existing buildings may not be technically or economically feasible. Taking these factors into account, we conservatively assumed 20% higher domestic air-con energy efficiency (10% for business and industrial air-con) and a 5% reduction in electricity consumption from improved building design by 2030 which would save 17 TWh/year. Assuming 30% higher domestic air-con energy efficiency (20% for business and industrial air-con and 10% reduction from building design) by 2040, it may be possible to save 39 TWh/year. Based on these electricity savings, the potential CO2 emissions reductions are 8 Mtons/year by 2030 and 20 Mtons/year by 2040 assuming electricity generated from natural gas.

Increased use of electric vehicles

Thailand's transport sector is the largest energy consumer (39% of total energy) and is expected to undergo a major change over the next twenty to thirty years due to the introduction of electric vehicles (EVs) driven by cheaper battery technology and the government's decarbonization policy. This will decrease carbon dioxide emissions (even if the electricity comes from coal or gas) as EVs have a higher energy efficiency (80%) compared to petrol and diesel engines (20-25%). The reduction in carbon dioxide emissions with EVs is even greater if electricity is supplied by solar or wind. Also, EVs will improve air quality (less NOX and particulates) especially in urban areas where old diesel buses used in public transport will be replaced with modern electric buses. A recent study in India estimated a large reduction in premature deaths/year and considerable public healthcare savings by switching to EVs by 2050 (Sahay, 2019).

Currently there are about 19 million vehicles (10 million cars, 8 million pick-ups, 1 million trucks and 200,000 public transport vehicles) in Thailand but less than 200,000 plug-in hybrid cars and only 2,000 battery EVs. The Thailand government announced an EV Roadmap with target production capacity of 750,000 EVs per year by 2030, and production of only EVs (no more cars with internal combustion engines) after 2035. This target was updated by a Ministry of Energy working group which forecast 6.4 million EV cars by 2035. With strong government policies and government investment in charging infrastructure, Thailand could have about one million EVs in Thailand by 2030 and about ten million EVs (cars plus pick-ups) and 0.5 million EV trucks by 2040. We estimate that EVs would use less than 1% of Thailand's electricity consumption in 2030 and about 6% in 2040. The impact on CO2 emissions from EVs will only be small (3 Mtons/year) by 2030, but transport sector CO2 emissions could be reduced by 23 Mtons/year by 2040 assuming electricity supplied from natural gas, and 42 million tons/year assuming electricity from solar or wind. The estimated CO2 emission reduction in 2050 is much higher (over 100 Mtons/year) as the transition from internal combustion engines to EVs will be nearly complete and most heavy-duty trucks plus public transport buses will probably be EVs or hydrogen powered.

Improve transmission/ distribution system including smart meters

An improved grid management system would allow EGAT to maximize the use of least cost electricity, maintain grid stability and reduce the need to increase generation capacity for peak loads. Maximizing the use of VRE, which has nearly zero operating cost and nearly zero CO_2 emissions, would reduce the total electricity supply cost and allow EGAT to lower the retail price for consumers. Installation of consumer smart meters (with information on electricity use, electricity price and hourly price forecast) in houses and buildings will increase consumer awareness of electricity cost and lead to more efficient daily electricity use and provide an incentive to purchase more efficient household appliances. Experience in Scandinavian countries (over 50% households have smart meters) showed a decrease in domestic electricity consumption and a shift in peak load to non-peak (IRENA, 2019).

Increasing VRE capacity above 15% generation capacity will require improvements to the grid management system, such as demand forecast and demand response tools, high voltage transmission cables and cross border transmission links. Also, more pumped storage hydro and battery energy storage are needed for better peak load management. During the past ten years, battery performance has improved considerably (longer range, faster charging) and prices have decreased by 90% (current price is \$120/kWh which is forecast to drop to \$50-80/kWh by 2030) (Bullard, 2020).

Carbon Pricing

Many researchers have tried to estimate the environmental and social cost of CO_2 emissions and have reported values ranging from \$30 to \$100/ton (Department for Business, 2018; EDF Environmental Defense Fund; Interagency Working Group on Social Cost of Greenhouse Gases, 2016). Some economists think that this cost should be used as a basis for a direct carbon tax which would be the most effective and equitable way to achieve a reduction in CO_2 emissions. The World Bank estimated that a tax of \$40-80/ton CO_2 by 2030 and \$50-100/ton CO_2 by 2040 is required to curb CO_2 emissions in line with the Paris Agreement goals (Carbon Pricing Leadership Coalition, 2019). However, attempts in several countries to introduce a direct carbon tax have not been successful due to general opposition to increased taxation and the lack of political will. The IMF recently reported that the average carbon tax in countries which have implemented such tax is less than \$10/ton CO_2 (Ian Parry, 2019). In Europe, a cap-and-trade system has been operating for about ten years (with CO_2 emissions valued at \$5 to \$15/ton for most of this period but recently increased to about \$30/ton) and this has resulted in a reduction in CO_2 emissions from utilities companies. China, which is the largest CO_2 emitter in the world, introduced a cap-and-trade system only in 2020, so it is too early to assess its effectiveness. Vietnam has approved a carbon trading scheme which will start in 2022.

The EU plans to introduce a Carbon Border Adjustment Mechanism (CBAM) which aims to prevent imports of goods produced in countries with lax environmental standards. This means that Thailand and other Southeast Asian countries will have to implement stricter CO_2 regulations which meet EU carbon pricing rules, in order to export to the EU market.

The Thai government has considered implementation of a carbon tax for many years but has still not decided whether to introduce such a tax and faces a difficult dilemma. If a carbon tax is introduced, then new coal power stations in the Power Development Plan will not be economically viable and existing coal power stations will become obsolete (a carbon tax of $30/ton would increase the LCOE of coal from $0.09/kWh to $0.12/kWh compared to solar at $0.04/kWh). This would adversely impact EGAT's profits and decrease forecast government income from EGAT.

Although desirable from an environmental viewpoint, the Thai government is taking a cautious approach on carbon tax. Even though a carbon tax may be introduced in the next few years, it is likely to start at a low level and would not have major impact on CO_2 emissions in 2030; therefore it was not included in the CO_2 emission forecast.

Government energy conservation plan

Thailand's Alternative Energy Development Plan 2015-2036 (AEDP) has well-defined energy conservation action plans aimed at a 600 TWh/year reduction of energy consumption by 2036, made up of 90 TWh/year of lower electricity consumption and 510 TWh/year of thermal energy (Asia-Pacific Economic Cooperation, 2017). The largest saving (58%) is expected from the transport sector by increased fuel efficiency and more use of gasohol (mix of petrol plus ethanol) and biodiesel. However, recent technology developments (solar and EVs) have made these targets out-of-date. EGAT reported that several energy-saving measures had reduced CO_2 emissions by 4 Mton/year by 2019 but this is only 1.5% of total emissions.

Conclusion

Implementation of the above four strategies will require strong government intervention, and recommended policy and regulation changes are discussed below.

Considerable capital investment has been made in Thailand's coal power stations and the supply of coal to these coal power stations, which typically involves long-term supply contracts. Shutting down coal power stations before the end of their useful life will clearly result in major economic penalties. These include financial compensation by the Thai government to owners and staff as well as coal suppliers whose agreements and employment are terminated. There will also be considerable costs for disposal of power station equipment and site clean-up. However, lessons learned from the German case showed that the costs of these impacts are likely to be accepted by a society aware of the health benefits (improved air quality) of coal plant closures and the benefits of market efficiency and reduced CO2 emissions to mitigate climate change impacts. However, this strategy may not be well accepted as increased VRE with distributed rooftop solar may change the current market structure, ownership, and regulations, and erode EGAT's monopoly supply position. This exit strategy will require considerable investment (VRE capacity, battery storage and improved grid) to ensure adequate electricity supply to areas currently supplied by coal power stations. The main barrier to switching from coal to VRE is financial rather than technical. However, the experience of other countries (e.g., Germany and Vietnam) switching from coal to VRE may be useful for Thailand.

The IEA study on Thailand's electricity system concluded that the main barrier to maximizing benefits from VRE in Thailand is current inflexibility of power purchasing agreements with independent power producers, due to the high minimum off-take requirement which sometimes exceeds demand (International Energy Agency, 2021).

The IEA concluded that technical measures (retrofitting existing power stations) to improve current grid flexibility would not be cost effective and they recommended that some Power Purchase Agreements (which start to expire after 2034) should be renegotiated to reduce high minimum offtake obligations.

Increasing air-con efficiency will require new regulations for stricter standards which may meet resistance from manufacturers and consumers. A requirement for 100% inverter types (no more fixed speed types) would improve efficiency but some Thailand manufacturers would need to acquire this technology, which may be difficult for them. Also, more efficient air-con units will increase the price and may cause consumer resistance as an important consideration of Thailand consumers is price rather than efficiency. However, consumer payback for more efficient air-con units is estimated to be only 1-3 years depending on air-con capacity (CLASP, 2019).

A switch from internal combustion engines to EVs can only be achieved with strong government policies and regulations on car manufacturing, battery manufacturing and EV charging infrastructure. This means phasing out production of vehicles with internal combustion engines, combined with investment incentives for car manufacturers to build EV and battery factories in Thailand, and subsidies for consumers to purchase EVs. These new factories, plus associated battery service and recycling centers, will provide more jobs in Thailand. It will also require an improved electricity distribution management system to deal with the expected increase in peak electricity demand caused by many people charging their EVs in early evening when electricity generation from solar is low. Currently, the price of EVs is higher than comparable cars with internal combustion engines, although the price difference is expected to decrease.

Another concern to be addressed is the availability of EV charging stations; Thailand's EV Roadmap has a target of 7,000 stations by 2036 whereas France plans seven million charging points (private and public) by 2030.

At the moment, Thailand's grid is not fully flexible. The ability of the grid management system to respond to changing demands/supply and intermittent VRE is still lacking (Huang et al., 2019). Technologies for transmission/distribution improvements including bi-directional meters for cross border electricity flow with VRE and grid supply from rooftop solar, and consumer smart meters have already been developed and implemented in other countries. Also, accounting systems are available so there should not be any financial barriers, especially in view of the large economic benefits which should lower electricity costs for EGAT and consumers. The main barriers to achieving fully flexible two-way PPAs are political and energy security concerns, for example which country has priority when there are electricity shortages. The potential carbon dioxide emission reductions in 2030 and 2040 are summarized in Table 3.

The potential CO2 emission reductions (approximately 50 Mtons/year by 2030 and 130 Mtons/year by 2040) are much higher than the government's projected CO2 emission reduction.

	Key assumptions	CO2 reduction by 2030 (Mtons/year)	CO2 reduction by 2040 (Mtons/year)
Replace coal with VRE	Phase out coal by 2030 and increase VRE to 15% by 2030 and 25% by 2040	35	50
Increase EVs	1 million EVs by 2030 10 million EVs by 2040	3	40
Space cooling	Increase efficiency 20% by 2030 and 30% by 2040	8	20
Transmission system plus smart meters	5% demand reduction by 2030 and 10% by 2040	7	20
Total		53	130

Table 3: Potential carbon dioxide emission reductions in 2030 and 2040

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ROLE OF MARKET, COMPETITION AND REGULATION IN ENERGY TRANSITION IN THAILAND

Puree Sirasoontorn

Introduction

Under the enhanced single buyer (ESB) model of the electricity supply industry (ESI) in Thailand, the Electricity Generating Authority of Thailand (EGAT) is the largest state-owned, vertically integrated utility. It plays the key role in electricity generation and transmission in the Thai power sector. In the electricity generation business, EGAT is the largest power producer, followed by independent power producers (IPPs), small power producers (SPPs) and very small power producers (VSPPs). Thailand imports electricity supply from neighboring countries. Electricity generation in Thailand relies largely on natural gas power plants, followed by coal power plants and renewable energy including solar, wind, biomass and hydro-power.

EGAT owns 100 percent of transmission assets nationwide and performs a role of a system operator. IPPs and SPPs produce and sell electricity to the high-voltage transmission system solely owned by the single buyer, EGAT, via power purchase agreements (PPAs). It is obvious that without structural and organizational unbundling of EGAT and ring-fencing guidelines from the regulator, there is potential for private power producers to be treated in a discriminatory way (Sirasoontorn and Koomsup, 2017).

EGAT sells power to the two distribution companies, Metropolitan Electricity Authority (MEA) and Provincial Electricity Authority (PEA). EGAT also undertakes limited direct sales to certain large retail customers. VSPPs can sell power directly to MEA and PEA whereas SPPs can sell directly to their own customers. However, the share of electricity direct sale in Thailand is negligible. MEA and PEA are electricity distribution and retailing state-owned enterprises (SOEs), each operating in different areas as monopolists. Since the establishment of the Energy Regulatory Commission (ERC) in 2007, both SOEs and private operators in ESI need licenses for their energy operations and network system. The ERC inspects and regulates the energy industry operation of the licensees to ensure energy security, efficiency, transparency and reliability of the power system.

In the past, Thailand's key energy policies objectives were energy security to cope with the increasing power demand and to take account of fuel diversification and economy to maintain an appropriate cost of power generation. The objectives of environment, ecology and carbon emission reduction were not prioritized. Together with the long-term load forecast which was related to the forecast of long-term economic growth, Thailand has overestimated its load forecast. As a result, in recent years, Thailand has experienced the excess reserve margin at 50 percent of total capacity, much higher than the international standard of 15-20 percent. The more power reserve, the higher tariff is charged to the consumers.

Although the Power Development Plan (PDP2018Rev1) aims to diversify the fuel mix of power generation from natural gas to renewable energy (Energy Policy and Planning Office, 2020), electricity generated by natural gas still gained the largest share of total electricity generation. According to the Alternative Energy Development Plan (AEDP) 2015, the target of electricity generated from domestic renewable energy, at 20 percent, was not ambitious enough to contribute to greenhouse gas emission reduction in the energy sector (Department of Alternative Energy Development and Efficiency, 2020).

Disruptive technology in both energy and non-energy sectors – particularly transport and information and communication technology sectors – has influenced the level of electricity consumption and the consumption behavior of residential, commercial and industrial users in different ways. New technology has created an opportunity to reduce the cost of electricity supply from renewable energy and attracted new but small electricity producers and prosumers to enter into the electricity market. In addition, the COVID-19 pandemic has influenced considerably the electricity sector in various aspects, particularly on the demand side. Electricity users have to reconfigure their habits of living, working, travelling and spending, in ways that are likely to change their electricity consumption in the post-pandemic period. In addition, public demand for clean air and environmentally friendly sources of electricity, and the government's commitment to international climate change treaties, are key drivers for policy changes.

As a result, in 2020 the government drew up a new National Energy Plan (NEP) together with revising the PDP2018Rev1 and AEDP2018, aiming for a low carbon economy and carbon neutrality in 2065-2070. The objectives of the NEP are to increase electricity from renewable energy to 50 percent of total power generation, to increase electric vehicles on the road and develop charging infrastructure, and to increase energy efficiency by using new technology to reduce electricity consumption by 30 percent. Plans for decarbonization, decentralization, digitization, de-regulation and electrification have been drawn up for energy transformation. That will create more investment and jobs in the energy and energy-related industries and ultimately economic recovery and growth after COVID-19.

Since the COVID-19 pandemic has triggered the opportunity to accelerate sustainable transformation in the electricity sector in Thailand, there is still no apparent competition within the electricity market. In order to realize the benefits of energy transformation, the actors and interaction between various players and business models should be clearly identified. The electricity market in Thailand needs to be restructured to incorporate and deploy new technology more efficiently, particularly electric vehicles, smart grid and smart meters, energy storage and demand response mechanisms, and for the consumers to have more flexibility and control over their electricity usage and costs. A restructured electricity market together with clear regulation on competition are needed in order to reap more social benefits from disruptive technology and to promote a green post-pandemic recovery.


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Progress on electricity market restructuring in Thailand

There is no emphasis in the NEP on an electricity market restructuring plan. However, the generation business has gradually opened up for new private entrants since 1992, through a private sector participation policy. Since then the numbers of private operators, namely IPPs, SPPs and VSPPs, has substantially increased. Most of the principals are large and dominant companies, with their subsidiaries holding several power purchase agreements with SPPs and VSPPs on hand.

SPPs can either sell electricity through the national transmission and distribution network operated by either EGAT, MEA or PEA, or directly sell to their direct customers, whereas VSPPs are allowed to sell electricity through the MEA and PEA networks. VSPPs are key operators to promote renewable energy in electricity generation and to implement a decentralization policy but they are facing regulatory barriers to enter into the market and to trade competitively in the market due to the technical barriers on the grid.

The government has partially liberalized electricity generation activities through decarbonization and decentralization by implementing various policies, particularly renewable energy promotion in PDP2018Rev1, and the community-based power plant and solar PV promotion policy.

Moreover, the government has supported digitization by allowing new technology for trading electricity in the ERC sandbox program. Although this peer-to-peer (P2P) power trading is not yet officially operating, the sandbox has given opportunities to experiment with new digital technology in electricity trading. Solar rooftop generation, likewise, is now operating, though without clear licensing rules. However, in Thailand it has been regarded as an initiative mainly for prosumers.

In addition, there has been a growing number of independent power supply (IPS), operating independently of the national grid, based on private PPAs and self-consumption. The key players include SPPs that sell electricity to industrial users (IU-SPP) and operators of solar rooftops installed over factories and department stores. IPS is subject to higher business risk because private PPAs lack a fuel cost pass-through mechanism (Ft). IPS is subject to higher business risk.

Thailand has a relatively diverse installed renewables base, not relying on a single primary generation source, but including hydropower, solar, biomass and wind power. This diversified base offers a valuable opportunity to take advantage of the costs and benefits across a range of renewable technologies and geography.

In 2019, under the VSPP program the government initiated an Energy for All renewable power scheme, known as the community-based power plant policy, to encourage businesses and communities to jointly invest in biomass and biogas-based power generation projects, but it has faced several delays including the pandemic and a need to redesign the scheme in order to create employment, income and energy self-reliance in the community. The selection process included technical and price-bidding competition.

Entry into the community-based power plant program is “competition for the market” not “competition in the market”. The high technical requirements are the key barrier to entry for the community. They do not open the door for true, local and new power plants to be directly operated by the community. Moreover, the plant ownership between private investors and communities was not clearly stipulated. Since ownership matters to gain more economic benefits in term of revenue sharing and green jobs, the local community is likely to gain fewer economic benefits throughout the value chain if they were not the key shareholders of the plant.

As a result, the participants passing the technical rounds are the energy conglomerates with strategies of expansion, penetration and diversification of their portfolio into renewable energy. The communities are reaping indirect and minor benefits through the firms' employment and purchase of local agricultural products as fuel for electricity generation. Questions arise whether and to what extent the community can directly gain economic and social benefits from the community-based power plant.

The process to select participants based on bidding was overseen by the ERC. After competitive price bidding in September 2021, the average winning feed-in tariffs (FiTs) of biomass and biogas were 2.7972 and 3.5717 baht per kWh, respectively. These FiTs are much higher than the cost of electricity from biomass around the globe, at 0.076 USD per kWh (approximately 2.53 baht per kWh) (International Renewable Energy Agency , 2021). The winning firms will receive direct income together with transferable PPAs.

The FiT bidders in the community-based power plant program offered the rate of discount on an average electricity tariff. The winning bidders are those who offered the highest discount. Therefore, the bidding price did not reflect the true cost of electricity generated from biomass and biogas. The puzzle remains whether the winners are efficient renewable energy power producers or not.

Decarbonization and decentralization policy relying on a renewable energy promotion scheme, particularly feed-in-tariff measures, has resulted in financial burdens on energy users. The government has implemented a full-cost passthrough and uniform electricity tariff policy. The uniform electricity consists of base tariff and fuel adjustment mechanism (Ft). FiT is one of the components in Ft that renewable power producers receive at the rate stipulated in PPAs.

Challenges for the structural design of the electricity market in Thailand

For consumers and society to realize benefits from energy transition and disruptive technology, apart from well-designed government energy policies, Thailand faces several challenges as follows.

Firstly, energy mix and capacity are allocated among SOEs and private operators and stipulated in the 20-year national PDP. Gas-fired power plants still take the largest proportion of capacity. Since there is no wholesale electricity market, the PDP itself acts as the barrier to entry for the potential power producers. A large amount of capacity is allocated to a few SOEs and big private power producers with long-term PPAs, despite there being large numbers of SPPs and VSPPs competing for PPAs in the business of generation from renewable energy. While they are competing for PPAs, they are not competing in the wholesale electricity market, of which the market size is larger than the capacity of renewable energy electricity generation allowed in the PDP.

Secondly, with a small share of capacity in renewable energy, a number of SPPs and VSPPs are subsidiaries of dominant and incumbent power producers. Some of these are power conglomerates which have expanded and established new power companies as subsidiaries. They are dominant operators in each type of renewable energy. For example, hydropower is dominated by EGAT and is also protected by strict laws and regulations. Wind Energy Holdings is the dominant wind power producer, also seeking renewable investment opportunities in other countries such as Australia. The most competitive renewable power producers have chosen to invest in other countries where they can compete freely in the wholesale market.

In addition, the large oil-and-gas and energy companies have shifted to invest in renewable energy nationwide and worldwide and have diversified to alternative fuel sources or created new business models in order to increase their renewable energy in their portfolios. These companies include subsidiaries of PTT (Global Power Synergy Plc (GPSC) and Global Renewable Synergy Plc (GRSC)), subsidiaries of BANPU (Banpu NEXT and Banpu Infinergy), EGCO, and RATCH. Mergers and acquisitions are key strategies to expand their business quickly. The entry of large conglomerates has narrowed down the opportunity for new small and medium enterprises or communities to enter into the electricity generation business. However due to the excess supply of electricity in Thailand, Thai investors have sought opportunities to invest in the electricity industry in neighboring countries rather than investing and creating more green jobs in Thailand.

The next challenge is market liberalization. Liberalization of Thailand's power system could play an important role in this transition, helping the country achieve the planned fifty-percent total production capacity increase highlighted in PDP2018Rev1.

The government must reform electricity trading, allowing power producers to directly compete with each other and with EGAT, to offer the cheaper electricity prices to final users and to solve the problem of oversupply in the national power system. Unbundling the transmission network to a separate entity is a necessary condition to liberalize the wholesale electricity market. Following the electricity market reform, the electricity tariff should be redesigned to match with stakeholders and their business models. Currently Thailand lags behind other countries which have already reformed electricity rates to promote competition and prepare for the prosumer model.

One of the key challenges is whether the long term PPAs are contrary to competition law or not. Competition law aims to establish a level playing-field in the market. The operators who already have PPAs with longer and superior terms and conditions can earn more excess profits than their counterparts. Although the long-term power PPAs are crucial to securing prices in the long run and to gaining energy security, they are key obstacles to the transition and development of the wholesale electricity market.

Next, Thailand faces significant regulatory uncertainty. The revised rules and regulatory procedures together with postponement of selection of the community-based power plants and delay of the announcement of qualified investors are good examples. The rationale and selection criteria and process have been changed up to the point that an advantage for the local community cannot be realized.

Community-based power plants have monetary and non-monetary benefits in their localities. The challenge is how the community realizes these benefits. It depends on the degree of community engagement. The regulation so far allows only limited community human capacity and a limited degree of community-based ownership. It does not enhance linkages within a value chain of local resources and power plants, and integration of micro-grid expansion at community level. Resilient communities and strong local organizations are necessary conditions to have successful community-based power plants that prioritize the benefits to their own communities.

Potential pathways for the electricity market in Thailand

The potential pathways that can enable a low carbon electricity supply to achieve the objectives of the NEP are as follows.

Firstly, there is an urgent need for market analysis of ESI in Thailand to identify the roles and business models of stakeholders. The flows of electricity, money and data among stakeholders should be clearly identified during the transition to reap benefits from new technology. The generic value network includes the following core business roles: power production, power transmission, power distribution, wholesale market operation, power retailers, balance services, aggregators, energy efficiency and management services, power consumption, and energy storage (Leal-Arcas et.al., 2021). The actors may undertake a single business role or multiple roles. Therefore, the end-user is a consumer and can become provider of electricity. This actor is considered as a prosumer. This generic value network can be adapted to integrate smart grid, electric vehicles, demand response, virtual power plant and energy storage.

Secondly, managing and balancing demand and supply of electricity to ensure energy security, meet the domestic demand and lead to a low carbon economy should rely on a market-based mechanism, particularly at the wholesale level. The establishment of an electricity wholesale market with grid flexibility will allow competition within the market and reduce the regulatory cost of a selection process for power producers, particularly those with cost-competitive renewable energy.

Due to an increase in the electrification of transport across vehicle types and higher industrial demand for power, the load forecast and electricity consumption is expected to increase. The impacts to energy security will be limited since Thailand still has an excessive reserve margin. There is a potential for Thailand to meet the future demand by price-competitive renewable energy.

To utilize excessive reserve margins, Thailand can export electricity to neighboring countries. Hence, power interconnection networks in the region should be cooperatively regulated among the energy regulators in ASEAN.

Thirdly, gradual liberalization efforts that introduce enabling regulations and unbundle utilities, further supported by a competitive wholesale and retail market, could be an important trigger for much-needed investment that allows the country to adopt renewable energy technologies more rapidly and comprehensively. The government should revise the PDP and remove the limit of renewable energy capacity.

Next, Thailand should adopt a pro-competitive liberalization policy in the energy sector in order to encourage new and efficient entry not only into generation but also retailing businesses. In addition, to promote community participation in the community-based power plant program, entry assistance measures should be carefully and selectively implemented.

Location based competition or zonal competition should be considered, particularly when the community can produce power for its own use and sale. Competition in the community area together with requiring community engagement should be criteria for bidding to allow community self-reliance.

Investments are needed to modernize and upgrade the electric grid. That would increase network efficiency and strengthen cross-border interconnections. A smart grid with technical flexibility will accelerate and facilitate the adoption of electric vehicles and energy storage and the utilization of digital technology in both the supply and demand of electricity. Rules and regulations of grid integration for renewable energy should be established comprehensively. To ensure the operational capacity of the grid, the regulator should accelerate the legal procedures to upgrade and renew the transmission and distribution grid and to increase the private sector's involvement in


by Pexels--2286921

grid development and community micro-grids.

Lastly, the transition to a sustainable, low carbon economy requires consumer awareness. The regulators should provide technical guidance for households to create better understanding and cooperation.

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THAILAND'S POWER DEVELOPMENT PLANNING AND A JUST ENERGY TRANSFORMATION

Suphakit Nuntavorakarn

Introduction

The Power Development Plan (PDP) is the master plan of power sector development in Thailand, including both power generation and power grid expansion. This think piece provides an overview of the context of the Thai power sector, and identifies the over-capacity of generation in Thailand for many years as a key challenge. Despite this, many large power plant projects are in the pipeline for future construction. Each large power plant will 'lock' the power sector for 20 years or more. The over-capacity of generation results from the over-forecasted future demand of electricity, which is the first step of the PDP planning.

The influence of large private sector companies and the accountability mechanisms in the PDP process, including the roles and challenges of the Energy Regulatory Commission, are analyzed. I argue that an unduly favorable power purchase agreement guarantees the benefits of project owners, while the costs and risks can be passed through to electricity consumers.

This think piece also examines the development of renewable energy and energy efficiency in the power planning process, including the Alternative Energy Development Planning (AEDP) and Energy Efficiency Development Planning (EEDP). Several alternative PDPs that focus on energy efficiency and decentralized renewable energy have been proposed by civil society groups. In general, they can provide higher benefits to the people and society than the formal PDP, including socio-economic and environmental advantages. But, to date, the main direction of the PDP has still not changed much.

In the latter part of this think piece, key technical and institutional barriers that prevent a transformation to a more desirable power sector relying mainly on renewable energy are analyzed, and recommendations are made towards a just energy transformation in Thailand, drawing out the implications for the existing PDP process.

by Jaroslaw Kilian

The key context of the Thai power sector

The structure of the power sector in Thailand is still vertically-integrated, under the responsibility of three government-owned enterprises. The Electricity Generating Authority of Thailand (EGAT) is responsible for its own generation, for buying from other power producers, for transmission, and for system operations. The other two bodies are responsible for distribution and retail service in different areas. The Metropolitan Electricity Authority (MEA) is responsible for the Greater Bangkok area, while The Provincial Electricity Authority (PEA) is responsible for all other 74 provinces.

The electrification rate has been high for decades, as almost 97 percent of villages in Thailand are connected to the power grid since 2006 (Department of Alternative Energy Development and Efficiency, 2006). The government and electricity authorities still put effort and investment into providing electricity to all households. The percentage of households that have access to electricity increased from 98.8 percent in 2009 to 99.9 percent in 2015 (Digital Government Development Agency, 2021).

The private sector can generate electrical power and sell to the authorities through four channels.

1. As Independent Power Producers (IPPs), who are domestic centralized fossil fuel power plants.
2. As Small Power Producers (SPPs), who are power producers selling electricity to the grid, up to 90 MW. SPPs have to use a co-generation system or renewable energy. SPPs with constant generation, mainly gas and some coal, can make a firm contract for favorable conditions, while SPPs who cannot guarantee constant generation – mainly those using biomass and other forms of renewable energy – have non-firm contracts. Consequently, the majority of SPPs use fossil gas under the co-generation system, while the other SPPs use renewables, mainly biomass. But new biomass SPPs with better technology are increasingly able to make firm contracts.
3. As Very Small Power Producers (VSPPs), who are power producers selling not more than 10 MW to the grid and who have contracts directly with the distribution authorities, MEA or PEA. Almost all VSPPs use renewables.
4. Imports from neighboring countries are treated separately from IPPs in Thailand's Power Development Planning. They are based on a bilateral Memorandum of Understanding (MoU) on Energy Cooperation between Thailand and the country. According to the present PDP2018, three MoUs are mentioned as 'formally enforced' (Ministry of Energy, 2019).
   - MoU with Laos PDR: 9,000 MW and no end date
   - MoU with Myanmar: no specific capacity and 31st December 2020 as the end date
   - MoU with Cambodia: no specific capacity and no end date.

The Thai private sector has participated in these power plant projects in neighboring countries, mainly large hydropower, and a lignite-fired power station in Lao PDR. Regarding regional power trading, Thailand has tried to promote itself as a regional hub for energy trading, starting with Laos selling 100 MW of electricity to Malaysia via the Thailand grid since early 2018: a sale which was planned to increase to 300 MW in January 2020. Thailand wanted Myanmar, Cambodia, and Singapore to join the arrangement in the future (Phaicharoen, 2019).

In a different approach, small-scale and peer-to-peer electricity trading was introduced as a pilot project by the private sector in the 'T77' property project in Bangkok in 2018 (Techsauce Team, 2018; Bangchak Corporation, 2019). The participating buildings had different installations of solar rooftop capacity, some not installing solar panels at all. They also had different electricity-consumption patterns. The experiment went well. The main purpose was to explore solutions and recommendations to existing barriers, including the legal ban on electricity transactions between people (ibid.).

The PDP and its key challenges

The Power Development Plan (PDP) indicates how many power plants will be built, which type of fuel will be used, as well as the expansion of the power grid. The PDP covers a 20-year timeframe but it was revised or making a new plan almost every year during the last 10 – 15 years. The Ministry of Energy determines when to revise the PDP or make a new PDP, without any clear public criteria for doing this.

The first step in PDP planning is to make a forecast of future demand: a task which is the responsibility of a working group comprising independent experts, electricity authorities, the National Economic and Social Development Council, and the Energy Policy and Planning Office (EPPO). Then, a draft PDP with data and analysis on energy efficiency as well as supply options (including fossil gas, coal, imports, renewable energy) will be prepared by EPPO together with EGAT and presented for the comments of the PDP sub-committee, which is comprised of several agencies under the Ministry of Energy, and some members from academia and the private sector.

The Energy Policy Administrative Committee, formed from representatives of related ministries and chaired by energy minister, will approve and submit the proposed PDP to the National Energy Policy Council (NEPC), which is the most important step as it is chaired by Prime Minister and comprises related ministers and directors of some government agencies. If approved by the NEPC, the final step is the decision by the Ministerial Cabinet. Normally, EPPO will arrange one public hearing on the draft PDP in Bangkok before submitting it to the NEPC. But sometimes, EPPO also arranges public hearings in the main cities of the four regions of the country and may also arrange a technical hearing in Bangkok.

Over-investment and the burdens on consumers and society

The key problems of the PDP relate to over-investment for many years, which has created burdens for consumers and society. The peak demand forecast has been mainly linked to future economic growth and the results are usually over-forecasted as shown in Table 1.

Year	Forecast in PDP (MW)	Actual peak demand (MW)	Differences between the forecast and actual demand (MW)
2004	19,600	19,326	274
2005	21,143	20,538	605
2006	22,738	21,064	1,674
2007	24,344	22,586	1,758
2008	23,957	22,568	1,389
2009	22,886	22,045	841
2010	23,249	24,010	-761
2011	24,568	23,900	668
2012	26,355	26,121	234
2013	27,443	26,598	845
2014	28,790	26,942	1,848
2015	29,051	28,082	969
2016	30,218	30,973	-755
2017	31,385	30,304	1,081
2018	32,429	29,969	2,460
2019	31,377	32,273	-896
2020	32,732	30,342	2,390

Table 1: The demand forecast in PDPs and the actual demand 2004 – 2020.
Source: Compiled by the author from various PDPs

This has led to too many power plant projects being planned and built. Furthermore, the Ministry of Energy set the reserve margin at least 15 percent above peak demand for electricity supply security. For example, if the peak demand is forecasted to be 40,000 MW, the generation capacity will be developed to be at least 46,000 MW for the year.

Each large power plant project has to spend a large budget for preparation – such as for site selection, land acquisition, environmental impact assessment report – and also has to enter into a number of agreements, for example: fuel supply agreement, power purchase agreement, and financial agreement. In addition, the authorities also invest in power grid expansion to take electricity from these projects. Therefore, these projects have their own momentum even though the actual demand is less than anticipated.

More important is that when a new PDP is planned, the new power demand forecast tends to be less than the previous one because the actual demand was lower and the assumed economic growth was also lower. Yet, an over-forecast appears in each new PDP, and too many power plant projects have been built year after year. As shown in Table 2, the actual reserve margin has been significantly and continuously greater than the 15 percent standard for more than 15 years. EGAT and the Ministry of Energy have tried many ways to justify the widening reserve margin, including energy security for future economic growth, preventing power outage, and the rather low electricity tariff, compared to other ASEAN countries.

Year	Peak demand (MW)	Total installed power generation capacity (MW)	Generation capacity above peak (MW)	Reserve margin (%)	Excess capacity above the 15% standard (MW)
2006	21,064	27,107	6,043	28.7	2,884
2007	22,586	28,530	5,944	26.3	2,556
2008	22,568	29,841	7,273	32.2	3,887
2009	22,045	29,212	7,167	32.5	3,860
2010	24,010	30,920	6,910	28.8	3,309
2011	23,900	31,447	7,547	31.6	3,961
2012	26,121	32,600	6,479	24.8	2,561
2013	26,598	33,681	7,083	26.6	3,093
2014	26,942	34,688	7,746	28.8	3,705
2015	28,082	38,815	10,733	38.2	6,521
2016	30,973	41,096	10,123	32.7	5,477
2017	30,304	42,433	12,129	40.0	7,584
2018	29,969	41,627	11,658	38.9	7,163
2019	32,273	42,504	10,231	31.7	5,390
2020	30,342	42,813	12,471	41.1	7,919

Table 2: The reserve margin of the Thai power sector 2006 – 2020
Source: Compiled by the author from various PDPs

Thailand's electricity tariff is based on a 'cost-plus' principle so almost all of the costs can be passed on to consumers. The profits of all electricity authorities are based on a fixed rate of return on invested capital (ROIC), so the profits are guaranteed. The profits of all large power plants have been guaranteed by favorable power purchase agreements for 20 years or more, and many risks are also passed on to consumers. Small power producers with firm contracts enjoy the favorable conditions for investors as well. In addition, fuel supply agreements also guarantee minimum take-or-pay obligations, particularly on fossil gas, and so guarantee minimum profits for fuel supply businesses as well (International Energy Agency, 2021a).

From Table 2, as a rough calculation, if we assume an investment of one million USD per MW, the over-investment that is ultimately borne by consumers is in the range of 2.5 to 7.9 billion USD or around 83 to 261 billion Thai Baht over the period 2006 – 2020 depending on the excess capacity in that year. These investments eventually contribute towards meeting rising electricity demand in Thailand, but these power plants are not needed when they are built and operated.

Each power plant does not only add more to the electricity tariff, but it also causes environmental and social impacts, ranging from (in the case of large hydropower) loss of natural forest, impact on river ecology, and displacement of local communities, to (in the case of coal or gas power plants) air and water pollution, waste, and carbon emissions. Furthermore, society is exposed to many risks from these power plants, including emergency water release, dam collapse, gas pipeline explosion, accidents in coal mines and coal transportation. These risks and negative impacts of the 'excess' power plants should not have been imposed.

The influence of the large companies, and benefits to them

It is rather clear that the parties who receive the benefits from the over-investment are the power plant owners. This benefit is not to EGAT itself, as it has been allowed mainly to build new power plants to replace retired ones. In other words, EGAT's total generating capacity has remained almost the same for 15 years. Rather, as shown in Table 3, the main capacity expansion has been by the private sector including companies that have some state shareholdings.

Producers	2006		2013		2020	
	Capacity (MW)	Percent	Capacity (MW)	Percent	Capacity (MW)	Percent
1. EGAT	15,795	57.7	15,010	41.7	16,035	32.4
2. IPPs	8,610	31.4	12,742	35.4	14,249	28.8
3. SPPs	2,338	8.5	4,376	12.2	9,474	19.1
4. VSPPs	11	0.04	1,451	4.0	4,022	8.1
5. Imports	640	2.3	2,405	6.7	5,721	11.6
Sum	27,394	100	35,984	100	49,501	100

Table 3: Installed capacity by type of producer in 2006, 2013 and 2020

Source:
1. Electricity Generating Authority of Thailand, 2021a
2. Energy Regulatory Commission, 2021
3. Energy Policy and Planning Office, 2021
4. Energy Regulatory Commission and Office of the Energy Regulatory Commission, 2014
5. Energy Policy and Planning Office, 2007

Even though there are many companies taking part in power generation, it is the companies that own large power stations and/or fossil fuel capacity that receive the most benefits. The four major companies are as follows:

- EGCO is an associated company of EGAT, and RATCH is a subsidiary of EGAT, and both of them are listed in the stock market. Both companies have grown with a lot of generating capacity, including IPPs, SPPs, VSPPs, and imports.
- PTT is the corporatized Petroleum Authority of Thailand and was listed on the stock market in 2001. The Ministry of Finance owns about 51 percent of PTT's shares and the rest are traded on the stock market. PTT also controls the fossil gas industry and owns the gas pipeline network. The PTT group owns a large amount of generating capacity through all four channels for private participation.
- Gulf is a large private company that first started as an IPP in 1994, and now owns a significant amount of generating capacity in the form of IPPs, SPPs, and VSPPs. The company is also considering investing in large hydropower dams on Mekong mainstream in Lao PDR.

These companies have developed many joint projects and joint companies together and also have developed many joint projects and joint companies with other companies, both domestically and internationally.

Board members of these companies include some present and many past ministers and high-level staffers from the Ministry of Energy, Ministry of Interior, Ministry of Finance, Office of the Auditor General, National Economic and Social Development Council, Royal Thai Army, Ministry of Commerce, Ministry of Foreign Affairs, Ministry of Natural Resources and the Environment, Energy Regulatory Commission, and National Security Council (Electricity

Generating Authority of Thailand, 2021b; EGCO, 2021; Ratch Group, 2021; PTT, 2021; GULF plc, 2021). Each board member in each company receives an annual income covering a meeting allowance and may also include fixed salary or other costs. Some companies also allocate an annual bonus to their Board, which raises the risk of a conflict of interest in the case that Board members are also employed as government staff.

The accountability mechanisms of the PDP

There are several issues and mechanisms about the accountability of the PDP planning and decision-making process. Firstly, as mentioned earlier, the Ministry of Energy normally arranges one public hearing or more on the draft PDP in Bangkok and may arrange some in other main cities as well, before submitting it to the National Energy Policy Council. However, the announcement of the PDP public hearing is usually less than a week beforehand, and the slide presentation of the draft PDP is disseminated shortly before the hearing – maybe one day before or sometime on the day of the hearing – so participants do not have enough time to understand, analyze, and develop the recommendations. During the hearing, the questions from participants may be answered or not and the Ministry usually does not open the channel for comments after the hearing. Most importantly, it is not clear how the comments and recommendations received from the public hearings influence or improve the draft PDP.

The overforecast in many PDPs has also been a problem for a long time but no one is held accountable or disciplined in any way. The sub-committee on demand forecast and the experts remain largely the same. Also, despite the fact that the over-investment above the standard reserve margin is an excess costs that has been passed through to the tariff, and is thus a burden to consumers in Thailand of several billion USD, no governmental staffers have been held accountable, particularly within the Ministry of Energy and the National Energy Policy Council.

Even though there has been over-investment and a high reserve margin in the power sector for many years, new PDPs still continue to add more large power plant projects. Some new criteria have been introduced in PDP planning, which have led to new projects being approved even under the existing situation of over-investment. Some examples of these criteria include a capacity deduction for each power plant project to calculate their 'Dependable Capacity' and then another deduction to give a 'Reliable Capacity' that is then the number for matching with the peak demand forecast. Also, the current PDP2018 separated its analysis for each region of the country and also set new criteria for each region to have enough capacity if the largest power plant in the region has an accident, even though the power grids of all regions are linked together already (Ministry of Energy, 2019). Consequently, new large power plant projects are added to some regions, even though the overall situation is of over-capacity for many years to come already.

In 2008, the semi-independent Energy Regulatory Commission (ERC) was established by the Energy Industry Act 2007. One duty of the Commission is to provide opinions on the PDP and the investment plan of the electricity industry to the Minister of Energy. However, the Commission is only semi-independent, because the Minister of Energy can influence the Commission through the Screening Committee for the nomination of the Commission's members, the criteria to be retired from the ERC, and the approval of the annual budget. Consequently, it is hard for the ERC to solve the PDP problems if the Minister does not agree.

Alternative pathways to the PDPs

Within the context of an increasing role of the private sector in electricity generation and the dominant role of EGAT decreasing, renewable energy and energy efficiency have been proposed and pushed forward by NGOs, communities, academics, and other stakeholders as the more sustainable options for electricity generation.

Alternative PDPs by civil society

In 1999, at a time when there were conflicts over new IPP coal projects, an analysis on "the sustainable energy options in the case of 1,400 MW coal-fired power plant project in Prachuab Khiri Khan Province" was prepared by academics and NGOs and launched with a press meeting. The report showed that developing biomass, small hydropower, and demand-side management to replace the coal project would lead to a higher GDP contribution, reduce import burdens, create more jobs, and reduce GHG emissions (Lund, Hvelplund, and Sukkumnoed, 1999).

Moving beyond the project level, the first alternative PDP was proposed by National Economic and Social Advisory Council in 2004 with the main aim of reducing the investment requirement and thus, releasing the pressure for EGAT privatization (Sukkumnoed, 2007). Subsequently, a number of alternative PDP studies were developed by academics and NGOs, and presented to stakeholders and the public. Some studies addressed directly the existing and the new PDP by the government. Some tried to propose a better PDP (Sangarasri Greacen and Greacen, 2012). Some started from options for reducing GHG emission in the power generation sector (Nuntavorakarn et. al., 2011). These studies are different in their analyses and other details, particularly in different supply options such as repowering, cogeneration, or solid waste incinerators. Yet, the main focus of these alternative PDPs were developing various sources of renewable energy, together with energy efficiency and demand-side management, instead of large power plants, particularly fossil fuel. They all argued that these could lead to higher benefits to society than the formal PDP, for example by creating more jobs and supporting economic growth around the country, reducing dependency on imports, adding more value to agricultural residuals, and reducing GHG emissions and other pollution.

Other studies at the province and regional levels

Apart from several analyses and studies at the national level, there are also analyses and studies on alternative power development at regional and provincial level. In 2015, Fraunhofer ISE, a German public research institute, working together with a Thai university in cooperation with Thai Ministry of Energy, analyzed a renewable energy scenario that incorporated energy efficiency for three Thai provinces in different regions, namely Phuket Province, Rayong Province, and Nan Province. It found that within 20 years, Phuket (which relies mainly on tourism) and Rayong (which relies mainly on industries) could achieve 40 percent renewable energy or more, while Nan (which relies mainly on agriculture) can achieve 100 percent renewable energy (Stryi-Hipp, Steingrube and Narmsara, 2015).

In another major study, WWF with an IES consultant and their network reported in 2016 that five countries in the Lower Mekong Region – Cambodia, Lao PDR, Myanmar, Thailand and Vietnam – could achieve 100 percent renewable energy by 2050 (WWF and Intelligent Energy Systems, 2016). Also, in 2018, during a time of controversy over a coal power plant project in Krabi province in the Southern region, Greenpeace, together with academics, NGOs and civil society in Krabi province, published a report saying that Krabi could achieve 100 percent renewable energy by 2026 and – further – could develop toward providing electricity from renewable energy to other provinces (Charoenlarbnoppanun et. al., 2018). In the following year, the Healthy Public Policy Foundation did a study on energy strategy for 14 provinces of the southern region, including Krabi province, and found that they could achieve 100 percent renewable energy by 2031 in the base case and 2033 in the case of high electricity demand growth. After that, the Southern region can develop more renewable energy and send the electricity to other regions, particularly to the Bangkok area (Nuntavorakarn, Yaikratok, and Kwangkaew, 2019).

Alternative Energy Development Plan and the PDP

Within the Ministry of Energy, the Department of Alternative Energy Development and Efficiency (DEDE) develops the Alternative Energy Development Plan (AEDP), which is the master plan of renewable energy development that includes power generation, heat, and biofuels. The first AEDP was AEDP2008 (2008 – 2022), which set out the vision, objectives, and targets, as well as various implementation measures, the budget, and benefits to the economy, society, and the environment. Natural Gas for Vehicles (NGV) were included in the AEDP2008 but not in any other AEDPs later on. The target for power generation from renewable sources was set at 5,608 MW in 2022, including seven different sources of renewable energy and excluding large hydropower (Department of Alternative Energy Development and Efficiency, 2008).

But the PDP2007 Revision 2, which was approved by the government in March 2009, did not set a clear target for renewable energy, even though it included renewable energy in several parts of the plan, to be implemented by several actors e.g. EGAT, SPPs, and VSPPs (Electricity Generating Authority of Thailand, 2009). It was only in the next PDP2010 that the renewable energy target was clearly specified, at 4,803 MW in 2022 and 6,101 MW in 2030 (Electricity Generating Authority of Thailand, 2010).

In December 2011, DEDE developed a new AEDP – AEDP 2012–2021 – which set a target of 9,201 MW in 2021 for power generation from eight renewable energy sources (Department of Alternative Energy Development and Efficiency, 2012). The following PDP, which was PDP2010 Revision 3 (2012 – 2030), set a target increased to 9,377 MW in 2021 and another 5,203 MW for 2022 – 2030 (Energy Policy and Planning Office, 2012). The next AEDP was AEDP2015 (2015 – 2036) with the target of 19,684 MW in 2036, including large hydropower (Department of Alternative Energy Development and Efficiency, 2015a), and PDP2015 (2015 – 2036) accordingly set its target at 19,634 MW in 2036 (Energy Policy and Planning Office, 2015). (The difference of 50 MW was due to the exclusion of industrial waste in the PDP.)

But the next PDP in 2018 was different because the Minister of Energy chose to focus mainly on the PDP, so it was developed and approved in April 2019 before the planning and approval of AEDP2018. The PDP2018 (2018 – 2037) set the increase of renewable energy from 6,473 MW in 2018 to 25,086 MW in 2037. Regarding large hydropower, it would only increase through imports of 4,783 MW (Ministry of Energy, 2019). Consequently, AEDP2018, which was approved in October 2020, took the targets from PDP2018 and added the existing and committed projects in order to set a target of 26,491 MW in 2037, while domestic large hydropower was to be the same at 2,920 MW (Department of Alternative Energy Development and Efficiency, 2020a).

In summary, the AEDPs have helped renewable energy planning to be more clear and systematic with a long-term target which is normally included in the following PDPs. But it depends on the Minister of

Energy whether he or she wants to do the planning in other ways, as was the case in 2018. Moreover, the details of short and medium term targets can be different between the AEDP and PDP.

Energy Efficiency Development Plan and the PDP

Apart from the AEDP, the Energy Policy and Planning Office also developed the Energy Efficiency Development Plan (EEDP), which is the master plan for increasing the energy efficiency in the electricity, industrial, and transportation sectors. Clear targets were set out both in the short term (five years) and the long term (20 years). The EEDP also includes various implementation measures, analysis on the benefits of energy-saving and avoiding CO2 emissions, as well as the budget for the first 5 years.

The first EEDP was EEDP2011 (2011 – 2030), which was approved in 2011 with a target of 96,653 GWh in 2030 for the electricity sector (Ministry of Energy, 2011). The following PDP – PDP2010 Revision 3 – set the Energy Efficiency target at only 20 percent of the target in EEDP2011 with a short explanation about the economic stimulus policy of the government. Hence, the Energy Efficiency target in the PDP decreased the peak demand forecast by only 3,494 MW in 2030 (Energy Policy and Planning Office, 2012). If the Energy Efficiency target in the PDP had been set to be the same as in the EEDP, about 16,000 MW of power plant projects would have been avoided. In 2013, the EEDP Action Plan 2011 – 2030 was also developed.

The next EEDP – EEDP2015 (2015 – 2036) – came out about the same time as the PDP2015 and it set a target of 89,672 GWh by 2036, which was lower than EEDP2011 due to lower future electricity demand forecast (Department of Alternative Energy Development and Efficiency, 2015b). PDP2015 set the same target for energy efficiency, but part of the target (22,456 GWh) to be achieved by 2036 was through current measures, and these were already reflected in the future demand forecast model. Therefore, only the other part of the target (67,216 GWh) can be considered as an additional target; it resulted in a 9,645 MW peak reduction in the PDP by 2036 (Energy Policy and Planning Office, 2015). In 2016, the 5-Year EEDP Action Plan 2017 – 2022 was developed as well.

Concerning PDP2018, as mentioned earlier under AEDP2018, the Minister of Energy chose to develop only the PDP2018, and it was approved before the planning and approval of EEDP2018. The energy efficiency target in PDP2018 was set at only 4,000 MW in 2037 with a short explanation that it included only the energy efficiency measures that were proven and for which the cost was lower than grid parity (Ministry of Energy, 2019). Then, the EEDP2018 was developed and approved in October 2020. The target for the electricity sector was set at 180,489 GWh in 2037, while the peak reduction had already been specified in the PDP as 4,000 MW (Department of Alternative Energy Development and Efficiency, 2020b). Yet, if comparing to the target of 89,672 GWh and the peak reduction of 9,645 MW in EEDP2015, the target of 180,489 GWh in EEDP2018 should lead to about 19,000 MW of peak reduction in 2037. Consequently, with the reserve margin of 15 percent, about 22,000 MW of new power plant projects can be avoided. In summary, since energy efficiency generally has a minimal cost in comparison to electricity generation options, and also has very low environmental impacts, the EEDP could be the most important strategic plan for Thailand's power sector development. But the proposed targets of the EEDPs are only included in the PDPs to a limited extent. As discussed above, sometimes only 20 percent of the EEDP's target is included in the PDP, while on one occasion the PDP itself set a low target that the following EEDP had to follow. Therefore, Thailand's PDP still emphasizes investment in the supply side and has only made limited steps on the integrated energy planning that the Thai Ministry of Energy has claimed to be working towards.

Opportunities and challenges for a just transformation of Thailand's power sector

Even though renewable energy has been included in many PDPs, and the targets have been increased regularly, the main focus of the PDPs is still on fossil gas, coal, as well as large hydropower in neighboring countries. Renewable energy is still a 'supplement' to these centralized power plants. Energy efficiency faces more obstacles than renewable energy in its integration into the PDP. Despite the continuous increase in the targets in the Energy Efficiency Development Plans, the peak reduction target in a PDP may include only a part of the Energy Efficiency target, while another PDP may unilaterally set a comparatively low target.

In practice, renewable energy has been mainly developed by companies, particularly the case of solar PV. The majority of solar PV capacity is ground-mounted solar farms because related policies and measures were in favor of solar farms rather than solar rooftop. Hence, a very small amount of solar rooftop has been developed, selling the excess electricity to the grid. Other stakeholders, notably including those who have potential such as universities, hospitals, shopping malls, local governments, and community savings groups have not yet begun developing solar rooftop or other renewable energy and supplying electricity to the grid.

In August 2021, the National Energy Policy Council approved the framework of a new National Energy Plan – including PDP, AEDP, EEDP, oil and gas plans – toward Carbon Neutrality by 2065 – 2070, taking into consideration technological changes and financial support factors. The key measures are renewable energy (which will account for more than half of new generating capacity, but taking into consideration the long-term cost of energy storage) and increasing energy efficiency by more than 30 percent in terms of energy intensity compared to the 2010 level. The other measures include increasing the production of electric vehicles to 30 percent of the annual production by 2030, and power sector restructuring for the energy transition (National Energy Policy Council, 2021). At the time of writing, the Ministry of Energy was planning to arrange a hearing on these plans. The framework of new National Energy Plan sets a good direction but the remoteness of the target years (2065–2070) is among the key concerns. Construction of all the fossil projects in the present PDP2018 can continue up to 2045 as they will end their lifetime by 2065–2070. So, the changes from the government side are not enough for ensuring a just energy transformation. In order to improve or reform the PDP, the key barriers need to be addressed and solved.

The main arguments against renewable energy made by the authorities in public discussions were higher costs and the intermittency of generation. Since the costs of renewable energy have been declining, particularly solar PV, the argument on higher costs is gone. Thus, the only key argument left is the unreliable supply of renewable energy. But it is clear from the technical point of view that the Thai power sector is rather well developed and, at least in the short term, more renewable energy can be added without any further measures (International Energy Agency, 2021a). For the medium- to long-term, increasing the flexibilities of the power sector is the key for adding more renewable energy to be the majority or 100 percent of the supply. Many policies and measures are available for increasing the power sector flexibilities. These are, for example: more flexibilities of large power plants and renewable energy, especially fossil gas, biogas, and small hydropower; increasing the demand responses and demand-side management;

various options for energy storage; and management of the increasingly-numerous electric vehicles for electricity load shifting (Greenpeace Thailand, 2020).

Another barrier, beyond the technical arguments against renewable energy, are the institutional issues that lock-in profitable returns on investments on large projects and fossil fuel. As discussed earlier, many existing power purchase agreements as well as many fuel supply agreements have favourable conditions that guarantee the benefits of project owners. Thus, these projects are locked into the power sector for the contract period (normally 25 years), reducing the flexibility of the power sector to add more renewable energy. These agreements make the technical solutions for adding more renewable energy economically unfeasible or at least less feasible (International Energy Agency, 2021a). Also, the incentive structure of return on invested capital (ROIC) makes Thailand's electricity authorities focus more on investment in order to increase or maintain the profits. This is particularly so in the case of EGAT, which has tried to developing large power plant projects including large renewable energy like floating solar.

The frameworks of power purchase agreements, and fuel supply agreements, as well as the incentive structure of the electricity authorities should be reoriented toward power that is based on renewable energy. Some solutions and recommendations have been proposed by academics and civil society, but the linkages between large energy companies with present and past high-level governmental staffers are also influential on energy policies and planning, as discussed above, and might resist such desirable changes.

The structure and the decision process of the National Energy Policy Council (NEPC), which is the most important decision-making body, also needs to be carefully examined. The decisions by the NEPC can lead to huge benefits for some businesses or strong impacts on other business, but there has been no clear accountability mechanism. Some examples of these decisions are the approval of PDP2015 and PDP2018 that add many large power plant projects, while the reserve margin has been high for many years. The fossil gas, large hydropower, and coal businesses were beneficiaries of the approval. Another example was the NEPC decision in December 2014 to immediately stop accepting new renewable energy projects via a resolution to change the 'Feed-in Tariff with Competitive Bidding' within three months (National Energy Policy Council, 2014). The change took a much longer time to finish and NEPC resolutions approved these postponements (National Energy Policy Council, 2015). This had a strong impact on many renewable energy businesses, as the opportunity to develop new projects was practically closed for more than two years and they had no opportunity to participate in the decision process.

Regarding energy efficiency, there have been no clear arguments against the higher target in the PDP, but the PDP planning has been biased toward investment in supply options rather than investment in reducing demand. This may be related to the way that the Energy Conservation Fund operates, which was established since 1995 to collect some amounts from all gasoline and diesel sales in the country and to allocate that budget of about several billion Thai Baht (several hundred million US dollars) annually for energy efficiency and also renewable energy. The fund has provided support for numerous projects but not for changes or reform at the policy or institutional levels. Since projects will receive the budget from the Energy Conservation Fund, they do not need to be included in the PDP. But the power plant projects, either by EGAT, the private sector, or suppliers of imports, need to be included in the PDP in order to be implemented.

Recommendations toward a just energy transformation

The push for desirable changes in the PDP could be stronger if electricity consumers – especially the general Thai public – were more aware of the excess burdens in the bill that they pay every month due to having too many power plants, and that more power plant projects are still being built. These issues are particularly salient now that many in Thailand face economic hardship due to the COVID 19 pandemic. Academics, civil society, and media should take the lead for better consumer awareness. Furthermore, the increasing GHG emission into the future, according to the present PDP (PDP2018 Rev.1), and the slow pace of targeted progress to carbon neutrality in 2065–2070, announced by the government in August 2021 (National Energy Policy Council, 2021), should alert the groups, organizations, and networks who are concerned to take more action on climate issues, and push for fewer GHG emissions and a more urgent real-zero target in the new PDP. With strong and persistent efforts from many parts in the society, the accountability for over-investment should be better, which would be fairer for consumers.

Moreover, the development of energy efficiency and renewable energy, especially in a decentralized manner, can create new socio-economic opportunities for people around the country as many jobs and Small and Medium Enterprises can be created, mainly solar rooftop, but also biomass, biogas, mini hydropower, small wind, and energy efficiency businesses. This is much needed for economic recovery now and after COVID 19. Therefore, the PDP should

A small solar panel in a temple in Bangkok by Suphakit Nuntavorakan increase both targets of energy efficiency and renewable energy and this should be developed in line with limiting climate change to 1.5 degrees. Carbon emissions from the power sector should be decreased every year from now and reach 50 percent reduction by 2030. Then, the Thai power sector should set the target to achieve carbon neutrality by 2040 (International Energy Agency, 2021b). After that, energy efficiency and renewable energy can still be developed to supply renewable electricity to other countries if they need it.

The energy transformation just described would lead to the reduction and phase-out of centralized power plants and fossil fuel. In terms of ensuring a just transformation, the PDP planning would need to start considering its impact on employment, which at present it does not, given that workers in the fossil gas, coal, and large hydropower industry would lose employment. There is, however, much more potential for job creation through renewable energy and energy efficiency. For some workers the shift may be rather easy, but for others support will be needed for re-skilling or up-skilling, and compensation may even be necessary in some cases.

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A COMMUNITY-OWNED MODEL AS A KEY TOWARD JUST TRANSFORMATION IN CAMBODIA'S RENEWABLE ENERGY PRACTICE

Oudom Ham

Indroduction

In spite of the fact that Cambodia's rural areas are still relying on expensive and polluting energy sources (including fossil fuel), a number of renewable energy (RE) opportunities in the country, especially small-scale community-owned projects (such as solar battery charging, solar home systems, biomass gasifier/digester and micro-hydropower) continue to be overlooked by the state's rural electrification mission. Several remote villages (through shared ownership modalities) have been experiencing cheap and clean energy usage from these small/off-grid distribution projects, but these are often scrapped after the arrival of the state's centralized grid. Despite the fact that they have a great untapped potential to share the load of ensuring clean and affordable electricity access, they are not given a long-term assurance that would enable them to grow to their fullest potential. This thinkpiece argues that the community-owned model is a key toward fulfilling the missing gap of a just energy transformation in Cambodia. Although community-owned renewables have long been proposed as part of the transition strategy within the government's energy master plan, together with private sector acceleration (MIME, 2009), they continue to lack formal recognition at policy level. This is very discouraging for long-term investment in the sector. The technical and financial support so far made available to rural communities has mostly been under the auspices of development partners and non-governmental organizations (NGOs). This think piece highlights the key successes of a community-owned RE model, along with the barriers that are preventing it from being optimized. It finally proposes a strategic direction on how this success story can be scalable.

A solar battery charging project in Rattanakiri, Province by project operator via Oudom

Cambodia's energy transformation and the counter-argument

While enjoying a fast-growing economy, overall Cambodia continues to face an energy shortfall and heavy reliance on polluting or non-environmentally-friendly and high-cost electricity sources. The country has a total domestic electricity generation of 2,916MW or 8,513GWh, of which 1,330MW (46%) comes from large-scale hydroelectricity, 675MW (23%) comes from coal-fired power plants and 643MW (22%) comes from fuel oil, whereas renewable sources comprise only about 9%, made up of 237MW (8%) solar and 31MW (1%) biomass power (EAC, 2020). The Cambodian government's electrification goal is to have 100% of villages in Cambodia with access to electricity by 2020, and at least 70% of all households in Cambodia with access to grid-quality electricity by 2030 (JICA, 2006). Currently, over 97% of the approximately 14,200 villages in Cambodia have been electrified. But out of the three million or so households that are connected to electricity grid, only about 40% are connected through the national grid, whereas about 60% of consumers are connected via sub-transmission lines to rural hubs operated by private electricity suppliers. The electricity quality is low while the price is high, particularly in rural areas, as the private electricity supplier needs to purchase high power generation from the state's utility, Electricity Du Cambodge (EDC), and to bear high system losses due to transmitting electricity long distances to low-density areas and using Medium and Low Voltage (MV & LV) transmission lines. The recorded system losses are up to 23% of total purchased power compared to a loss rate of only about 8% in High Voltage (HV) transmission lines which are only available for EDC (EAC, 2021). Many areas next to the border are still dependent on imported electricity from neighboring countries; this made up 25% of the total country's electricity supply in 2020. And mini-grid diesel generators are still actively involved in many hard-to-reach communities such as the island and highland areas (EAC, 2020).

In a country where power generation is highly dominated by dirty fossil fuels and environmentally-destructive energy sources such as coal-fired generation and large dams, it is reasonable to be concerned about the energy trajectory, especially if there is no shift away from the current business-as-usual of the power development plan, which projects even more large dams and coal power plants. (Chugoku Electric. Power Co., Inc. 2020). This is continuing to hold back Cambodia's energy progress toward a just energy transformation. In this case it is very important to be critical about the relation of the state's centralized model of electrification and the community-driven model of rural electrification, to discern whether it is complementary or inconsistent.

Cambodia is ranked as one of the world's most vulnerable countries to the consequences of climate change – including floods, droughts, windstorms, and seawater intrusion – which mostly affect agriculture, infrastructure, forestry, human health sectors, and costal zones (NCSD, 2015). The country has recognized and expressed a commitment to jointly combat the climate change problem and accelerate the transformation to a climate-resilient and low-carbon sustainable model of development through a nationally determined contribution (NDC). Energy sector generation contributes 22.2% of Cambodia's greenhouse gas emissions, at 34.4 MtCO2e (Million Tons of Carbon Dioxide Equivalence) (NCSD, 2020). The Ministry of Mines and Energy (MME) has also developed a climate change action plan (2021-2023) in an attempt to address the potential climate implications associated with the energy sector. Maximizing RE is part of the action plan; however, the state has made very slow progress in practice, which is reflected in the fact that there is as yet no clear guidance for the transformation in the NDC framework. The MME argues specifically that the amount of greenhouse gases that the Cambodian energy sector is urged to reduce in order to catch up with the NDC, is not clearly consistent with the power development plan of the government (MME, 2020). As a result, no matter how high the potential of the RE sources (solar, wind and biomass) is (IES & MKE, 2016, pp.77-87), the national target for RE utilization is not clear and the incentive policies such as the feed-in-tariff (FIT), net-metering and RE portfolio are not even in place. This makes it hard to scale up the RE development in the country (ERIA, 2019, pp.56-64).

Even without proper recognition at the political level, some forms of off-grid renewable innovation have taken place. Stand-alone or decentralized RE systems, especially solar home systems, are a suitable option for rural households who bear high electricity costs or are hard to reach by the grid system, as even without government's subsidy, in the last five years the Levelized Cost of Electricity (LCOE) of off-grid electricity (such as diesel generators) was already about 50% cheaper than the existence electricity price in rural areas. Solar home systems enabled rural residents to reduce spending on electricity while increasing their deposable incomes and social wellbeing in rural communities (Han, 2015). Overall, the decentralized model of energy delivery is the most appropriate way of tackling energy poverty in remote areas (Hogarth and Granoff, 2015). By generating more electricity from small distributed systems, it can help decrease the need for long-distance transmission and distribution from coal and hydropower (de Ferranti et al 2016). It can involve supply-side projects, such as RE installations and storage, and demand-side projects, such as community education, energy efficiency and demand management. Community energy can even include community-based approaches to selling or distributing energy (C4CE, 2015). The cost sharing, community ownership model gives energy users the privilege of collectively owning and managing the community's energy assets including energy generation systems, energy storage systems and energy efficiency systems. The contribution to community RE development and scale-up is well-incorporated as well under this community-owned model (IRENA, 2020).

The potential of community-owned renewables: A case study of LOCAB

The solar battery charging system was among other solar technologies/services that Local Capacity Builder (LOCAB), a local non-profit organization, introduced to Cambodia in 2008. The first demonstration took place in the form of a twelve-month project in four off-grid communities in Kampong Chhnang Province. It was later replicated in other rural off-grid areas in the country. I will now discuss the narrative of technological innovation of the project, its socio-economic and environmental benefits. This narrative is derived mainly from available secondary sources as well as the author's recent interviews with the founder of LOCAB.

LOCAB introduced a hybrid solar battery charging system in order to provide immediate electricity access for climate change solutions and socio-economic benefits to rural communities in Cambodia where local people were using car batteries for lighting, powering TV and radio, cooling, charging phones and pumping water for family agricultural activities.

The battery charging system was mostly run by solar power and used a diesel generator for back-up when there was not enough energy from PV, or during peak load. With funding support from UNDP's GEF Small Grants Programme, starting from 2008, LOCAB began its pilot on the RE system by building four solar battery charging stations, two in Kampong Tralach and two in Kampong Laeng district, Kampong Chhnang province. Each station had one 56 kWp PV system and a 28 VDC diesel backup generator. The PV modules were installed on a metal substructure, which was movable and connected with a pole that elevated the modules up to three meters in height. Four ropes were placed on the edges of the panels below the modules, which allowed an operator to move their biaxial tracker manually, offering an increase in solar energy yield of about 30%. To reduce cost, hand-made diodes (invented by LOCAB) were used as charge controllers, instead of imported ones. The charge controller helped prevent batteries from overcharging so the battery's life lasted longer than by charging through the diesel generator. Charged through a solar PV, battery power lasted seven to eight days, as compared with approximately five days when charged through diesel generator.

Success story

The existing local operators of diesel generator battery-charging services had been approached by LOCAB with the hybrid model of combines photovoltaic and diesel generation. The diesel generator operators were persuaded to shift from operating their battery-charging services entirely by diesel generator, to using the generator temporarily while mostly generating energy from solar PV. Once the local operators agreed on joining the project, they were offered the solar system free of charge, although they were bound by some particular conditions. Their existing diesel generator was required to become an in-kind contribution to the project and was used temporarily as backup power when PV could not provide enough power. The solar PV was then installed on the existing battery charging station that was once powered by diesel generator, although this time they needed to collaborate with a community group called the Green Power Committee (GPC), whose members were trained by LOCAB, on how to operate the solar charging station and deal with income management. This was to ensure the transparency and accountability of the operation. Based on the agreement which was designed to be sufficiently attractive for the diesel generator, the operator received 50% of the generated income from the charging service, while the GPC received 20% and the rest of the income went for maintenance and the community's development. Local government officials up to district administration level were very supportive, as electrifying the rural off-grid areas is part of their remit.

The local operator related that they previously earned US$ 2.5 per day without taking into account the maintenance cost, whereas they subsequently earned US$ 5 per day (including maintenance cost) by using PV battery charging. At the same time, local villagers expressed satisfaction with charging their batteries through the solar PV as it was cheaper than the diesel generator: their battery's life was longer as well, and the process took place without smoke and noise pollution. About 420 households from the two mentioned districts in Kampong Chhnang Province directly benefited from this system, especially through the cheaper battery charging fee[1] and the shorter travel distance to charge the battery, which was especially helpful for women and children who previously needed to carry a heavy battery for a long distance.

By not relying completely on diesel generator, the solar battery-charging not only helps villagers cut unnecessary expense (by about US$ 10 per year per family), it also helps reduce a significant amount carbon dioxide (CO2) emissions.

[1]Prices implemented by LOCAB in Kampong Chhnang Province in 2008 for charging a 12-volt battery were equivalent to $0.20 for 50Ah, $0.25 for 70Ah and $0.30 for 100Ah (source: Antje KlauB-Vorreiter, Vice-president, International Solar Energy Society/German Section, 2009).

For instance, based on the calculation of the mentioned 420 targeted households, the system could help reducing 4,380 litres or 11.2 tons of CO_2 per year.[2]

Challenges

Unfortunately, the PV system could not attract customers after they were connected to the grid. None of the four studied installations is still operational nowadays. In some cases, they relocated the PV system to other off-grid areas or sold it at a cheap price to those who needed it. In the case in Kampong Tralach, the solar system has been transformed into a water pumping station as it is still cheaper than the electricity grid system. The other challenge is that there are ongoing PV battery charging projects, but people, especially in Tonle Sap Great Lake area, are using the batteries to shock and catch fish which is both a destructive way of fishing and an illegal act under the law. This is one of the reasons that even the founder of the LOCAB no longer recommends solar PV battery charging. Rather, he encourages PV systems to be used for water pumping as there is also a lot of demand for water for agricultural activities and clean water for communities' wellbeing. In the meantime, he is choosing the mini-grid system as it can be well integrated with the national grid system when it arrives, whereas the solar PV battery charging station had not prepared for synchronization with the grid system. People have become more demanding; they use more electrical appliances, and therefore, they no longer want to use 12-volt batteries to power their modernized life style. LOCAB itself no longer exists; the founder has transformed it into an enterprise called International Multi-Business Cambodia which is still working on providing RE services. The founder explained that operating as an NGO, he can only run small-scale community projects. In order to be able to execute larger scale energy projects and to cover larger areas, it has to become a private company.

[2] Formula from www.icbe.com/carbondatabase/volumeconverter.asp

Replication of the community model: A case study of the ethnic minority groups in Veal Kambor community

A number of solar battery charging projects have been replicated to other off-grid communities by various local CSOs following LOCAB's model, especially in the Tonle Sap area and mountainous areas in Northeast Cambodia. Unfortunately, the actual number of the replicated projects has not been identified. The hybrid system (solar plus diesel generator) is not always adopted, as some areas such as the Veal Kambor community (described below) have installed solar PV charging without any back-up diesel generator.

In mid-2021, the author had an opportunity to carry out field work into one of the indigenous communities in the Northeast, known as Veal Kambor community protected area, where the solar battery charging system had been installed by adapting LOCAB's model to benefit approximately 536 families (over two thousand people), mostly of Lao ethnicity but also including Tampuan, Brao and Kraol indigenous groups. However, they did not use the hybrid system as, at the time of installation, diesel generators were not used in this area.

Success story

The ethnic minorities in Veal Kambor protected area in Lumphat District, Rattanakiri Province, who play an important role in forest and wildlife conservation, were still relying on long-distance battery charging by diesel generator before the arrival of the solar battery charging station in 2016. The solar battery charging was introduced to the community by the Democratic Resource Center for National Development (DND) through an exposure visit to LOCAB's solar battery charging project in Kampong Chhnang province in

2016, in order to interact with the experienced community and to get a real sense of the solar battery charging system. Thirteen community representatives joined the exposure visit, one of which later became the local operator of the system, as he expressed high commitment and was willing to let the solar station be installed on his land without seeking any rental fee. Five other people have formed a committee to jointly manage the community project, as they also expressed genuine interest in understanding and operating the system. In the meantime, it was notable that the community representatives were usually trusted by the local community members to address the community's needs, even though they were not government officials.

The solar committee members take turns in attending and assisting the local operator in charging the batteries through the solar system. They make note of the number of batteries that get charged each day, and report to the rest of the local villagers and involved local authorities. The number of members of the solar committee varies in different areas. The whole committee gets 15% of the total income from the charging station in exchange for their labor in assisting the solar battery charging regularly. The local operator/land owner gets 30%, and the remaining 50% is for the community's development purposes. The community's development revenue is split into forest patrolling, maintenance of the solar system, and community development activities. This is unique for the case of Veal Kambor: other projects may use the share for community development differently according to their situation. This has to be agreed beforehand, alongside the solar battery charging fee for the local villagers. The price can be varied based on different areas and different times as well. (See the Veal Kambor 2021 charging prices in Table 1).

Electrical capacity	Voltage	Charging prices via solar system
20 Ah-40 Ah	12	KHR 2,000 / USD 0.48
50 Ah-70 Ah	12	KHR 2,500 / USD 0.61

Table 1: Prices of Battery Charging in Veal Kambor community, Rattanakiri Province in 2021.
Source: Mr. Sami, local solar battery charging operator in Phum Thmey, Lumphat district, Rattanakiri province, Cambodia

Since this was instituted, the solar system has become an innovative shared platform for the local community to join in making decisions. The locally elected committees discuss with village and commune authorities on behalf of the rest of the community members, for instance, on how they use the saved funds from the solar battery charging for the community's development. Resulting from that, a collective decision was made to establish a community meeting hall, fix the road and school, and contribute to some important community ceremonies as well.

Before handing over to the local committee to own the system, the solar battery charging operator and committee (as in the original LOCAB projects) were trained on how to manage and operate the solar battery charging system: training that included financial management and maintenance skills. After the project cycle, which was one year, the NGO-funded PV system was transferred to the local operator for free. He then needed to ensure the electricity access through the operation of the system while also continuing to provide benefit for the local community via the cheap price of solar charging.

Continuity and difficulty in the Veal Kambor project

Although the PV charging station is still operating at present, it is facing some challenges. First of all, there is no clear legal obligation binding each of the actors involved, although the community has a bylaw (recognized by the subnational government authority) which specifies the purposes, roles and shared benefits to the community and individuals in the community. But there is no legal recourse for any misconduct during the operation, for example, if the operator is not transparent and accountable to manage the generated income from the PV charging station. Secondly, there are locally elected representatives (the community energy committee) but they operate under a limited consultation process with the majority of people in the community. Thirdly, the committee acts as if it were the electricity producer/owner and entitled to earn income from the project, while the rest of the villagers consider themselves as typical consumers/customers whose stereotype is to expect a cheap product at high quality. Fourthly, regardless of the cheap battery charging fee and the budget contributions to the community's development from the solar station, many villagers went back to the diesel generator (which charges a higher price), when they could not get their battery charged fast enough by solar. At the present time, there are two diesel generator battery-charging units in the community. Consequently the number of batteries at the solar PV station has declined, which means there is not enough incentive to support all the committee's labour. Nowadays the system operator performs the task alone, as income keeps declining. Finally, there are local villagers who believe that electricity is a symbol of development and prosperity. One of the solar battery-charging committee members said: 'Everyone believes that more electricity, whether on the supply or consumption side, can create more development opportunities. When they can get better electricity access, they will find a way to afford it. Our battery charging facility will then be replaced. No one will want to use a battery any more as they do not want to bother with carrying the battery to be charged'. Currently, there is an electricity company which has secured the license to cover the electricity supply in the whole of Lumphat District – including the Veal Kambor community – although they are waiting until they see enough electricity demand.

Lessons learned from LOCAB and Veal Kambor case studies

The hybrid model of combined solar PV and diesel generator that LOCAB implemented in Kampong Chhnang presents a win-win strategy between the development assistance of the local NGO and the local informal private enterprises that run diesel generators for electricity supply. Some carbon emissions are still produced, although a significant amount is reduced compared to when the villagers were entirely dependent on diesel generator. And once the local diesel generator owner is transformed into the operator of the community's solar PV battery charging, the benefits have been shared more widely among the local community, especially through the cheaper battery charging and the shared income going to community development, from which everyone is gradually benefiting. However, the chance to further accelerate the community-owned model has melted in front of the community due to their lack of participation in co-managing the system. A more inclusive space for wider community participation does not seem to be prioritized in the project's agreement or bylaws, even though it does make sure that the community benefits from the scheme.

Willingness to give up land as an in-kind contribution for locating the solar battery-charging system, and offering labor for installing and operating the system, which is provided by the local operator and the project's committee, have become essential to sustain the operation, although only a few of the community people have contributed.

Solar battery charging could work well in certain geographical areas, such as the floating communities on the Tonle Sap lake and in forested areas such as the Veal Kambor community, especially before the arrival of the grid system. However, without having a back-up strategy to technically and socially integrate into the grid system, it runs out of space to operate when the grid system arrives. Both case studies revealed that the local communities' mind-sets are influenced by the ideological myth of centralized energy development, which does not seem to be questionable for them even if it is vague. If there are more electricity services, they will have effects on local productivity, health, education, safe water and communication etc. However, it does not necessarily mean that electricity will be affordable, environmental-friendly and equally shared across a population with various geographical, socioeconomic and cultural backgrounds. And it takes time to come.

When the electricity grid system arrived (at short notice), at the sites of LOCAB's off-grid projects, the actors involved found immediate solutions in the new situation: they transformed the PV battery-charging systems into water-pumping systems and/or sold them off at a low price. Even the pioneer of the RE project has transformed his service into a more advantageous position based on an assumption that an entrepreneur can cover larger areas with RE. It is also easier to be moving in the direction of the government's recommendation, which is a centralized grid system via a mini-grid system.

Good intentions in reducing carbon emissions through using RE could unexpectedly be turned into tools to destroy natural ecosystems, as in the case of Kampong Chhnang where people used the battery charged through the solar system to shock and catch fish from the river. Meanwhile, the carbon reduction narrative can be secondary to people's prioritization of time-saving, as with the community people in Veal Kambor who are making a U-turn toward polluting diesel generators over PV battery charging systems even though they once acknowledged that PV operation is cheaper and does not yield noisy and smoky electricity.

Conclusion

Experiences from the two community-owned solar PV battery charging projects have pointed out some key successes in filling the missing gaps of just energy transformation, in particular, those hard-to-reach island and mountainous populations whose electricity access is still out of reach and whose local model is ignored by the state's centralized electrification approach. It also has identified barriers preventing this model from being further developed.

There has been effective collaboration among civil society organizations, development partners and grassroots communities in co-creating a decentralized community-owned model which could help satisfy urgent energy demand in rural off-grid communities, offering affordable prices and reducing the carbon footprint at the community level. Additionally, the intention to sustain the community RE system through seeking in-kind contributions, labor and responsibility from the local operator and committees did work out at some level, although it requires a wider contributions and shared responsibility from the majority of the community. This is very crucial not only for keeping the system running but also to make it more suited and adaptable to the community's needs. For instance, if local villagers no longer want to carry batteries back and forth for charging, they can consult among themselves and experts on what the existing solar PV can do to improve their way of life, since it can be used in multiple ways. Some of the PVs in Kampong Chhnang have already been repurposed to pump water after being used for battery-charging for some time. At the same time, a more meaningful participation from the majority of the community members, especially in paying close attention to the battery charging and discharging process, would then be able to help ensure that the original purpose of the community-owned RE is not diverted according to individual misbehavior, such as the act of using the PV charged battery to destructively catch fish and ruin the river's ecosystem in Tonle Sap area in Kampong Chhnang Province.

Finally, it takes time, resources and energy to build up the community-owned RE model, which involves a number of actors including development partners, CSOs/NGOs, academic and rural communities. Therefore, to save time, resources and the climate, it should be a model to be built on, not completely replaced by electricity infrastructure brought by the state or a private actor. A more integrated and transparent energy planning process is required, especially regarding the relationship between the national grid and off-grid system, so as to reduce electrification cost, save time, safeguard the environment and encourage wider community participation: ultimately to help ensure an equitable, just and sustainable energy transformation.

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ENABLING UNIVERSAL ELECTRICITY AND WATER ACCESS TO REMOTE VILLAGES: A DECENTRALIZED RENEWABLE ENERGY-WATER APPROACH

Ha Thi Hong Hai and Nguyen Quoc Khanh

Introduction

Vietnam has achieved remarkable milestones toward Sustainable Development Goal (SDG) 7: ensure access to affordable, reliable, sustainable and modern energy for all (UN, 2015). By the end of 2020, 99.28% of households had accessed to electricity (EVN, 2021). In order to achieve this figure, the Government of Vietnam (GoV) has focused on grid-expansion investment and centralized solutions through the leading role of Vietnam Electricity (EVN). The GoV has also made a significant effort to reach SDG 6: ensuring availability and sustainable management of water and sanitation of all (UN, 2015). By 2019 it achieved about 88.5% of the total rural population accessing reliable water sources, through building centralized water systems and providing household-sized water pumps from the state budget and public loans (NCERWASS, 2020). These achievements are the results of political will and efforts in recent decades, in the National Targeted Program (NTP) of Rural Electrification, and the NTP of Water and Sanitation for Rural Development.

However, about 200,000 households were living without both electricity and treated water access at the end of 2020. These households are in very remote places where expanding the grid is too costly – and sometimes impossible – due to low household density, long distance, and difficult terrain. Indeed, the remaining un-electrified communities are located in mountainous and remote areas, especially in the Central Highlands (GIZ, 2020). Clean water access in these remote mountainous areas (where a high proportion of the people belong to ethnic minorities) was enjoyed by less than 50% of the population as of 2019 (Mai et al., 2020). The minority groups are relying on surface water for drinking and and cooking, even though they acknowledge its being increasingly contaminated and causing infectious diseases especially for children (UNICEF, 2020). Investigating six South Asian countries, (Abbas et al., 2021) shows a statistically significant relationship between poor power connections and access to sources of drinkable and clean water. Consequently, local households are facing risks from mosquito bites and other public health issues. This also means the same households which are lacking electricity are limited in terms of safe drinking water services as well, and are suffering adverse consequences in their daily lives.

Against this background, this thinkpiece explores a dual electricity-water model for remote electricity and clean water supply by examining the system in Earot Village (in Cu Pui Commune, Dak Lak Province) as a typical example. This study examines the technical and financial viability of a solar mini grid implemented from 2017 to 2021, for electricity supply and running a reverse osmosis (RO) water purification system for a mountainous community. Technically, the operation principle of this system is that redundant power during the day is used – after being fully stored in battery banks – to power a RO water purification system to produce clean water. Financially, the initial cost has been co-funded by external sources and commune budget while the revenue for operation and maintenance (O&M) comes from the sale of electricity and water. This pilot model, if proven financially, will pave the way for replication not only in Vietnam but also other countries in the Mekong, for the purposes of both rural electrification and safe drinking water supply.

The rest of the thinkpiece is organized as follows. The next section presents a review of the literature on decentralized renewable energy (DRE) initiatives globally for electricity-water supply, and discusses gaps in the current approach in Vietnam. Then we look more closely at the pilot system in terms of local circumstances, system design, financing and operation, and management mechanisms. Before we sum up the success of the studied case, and discuss implications for larger-scale deployment, another section identifies more generally the potential advantages and strengths of a decentralized renewable electricity-water approach compared to alternatives.

Unpacking the decentralized renewable energy-water approach

Recently, DRE systems have drawn more attention to dual electricity and water supply strategies in remote rural areas around the world, for reaching SDG6 and 7. DRE infrastructures are recognized as playing a crucial role in tackling water stress and scarcity in countries with limited water sources (Sanders et al., 2013). Bertheau (2020) found that an off-grid renewable energy (RE) intervention showed significant advantages in the improvement of water supply on Cobrador island in the Philippines. For water production in combination with RO purification, RE technologies can provide cheaper energy than conventional energy sources (Eltawil et al., 2009). The integration of RE and water treatment technologies has been strongly recommended for isolated rural areas in Sudan (Omer, 2001) and Ghana (Adaramola et al., 2017).

In Vietnam, the importance of DRE solutions in rural electrification has been recognized and highlighted frequently in recent years. Several donors and international organizations – including the World Bank (WB), the Asian Development Bank, the European Union delegation and GIZ – have provided technical and financial support for such projects. Typical DRE systems include stand-alone systems for households, whether pure solar home systems or hybrid systems featuring a combination of RE technologies such as photovoltaic cells, wind turbines and/or hydropower together with combustion generator or battery storage (GIZ, 2020). These initiatives have been undertaken by the GoV or the local authorities to provide electricity only.

However, there is still an absence of models for dual rural electricity and water supply with RE technology. Up to now, rural water supply and rural electrification to remote areas have been approached independently through a top-down approach. Administratively, the rural electrification is led by the Ministry of Industry and Trade (MOIT) whereas the rural clean water supply is in the charge of the Ministry of Agriculture and Rural Development (MARD). The National Centre for Rural Water Supply and Sanitation of Vietnam (NCERWASS) (2020) makes very limited reference to decentralized water systems powered by RE sources. Even though MARD shows interest in integrating RE technology adoption in water treatment solutions, further guidelines and policies to promote DRE for the water-energy nexus require more efforts, capacities, and cooperation.

A decentralized renewable energy-water system in Earot community

Snapshot of electricity and water consumption in Earot village

Earot village is a remote village in Cu Pui Commune, Krong Bong District, Dak Lak Province. Its location is 12.58N and 108.58E and it is about 20km from the commune centre, with very poor road access (Figure 1). The village has 168 households in several clusters, each cluster having about 30 households. All of the people are of H'mong ethnicity. Agriculture activities are conducted to meet the families need, with a limited amount of surplus production sold locally due to limited access to further away markets because of the poor transportation. Before October 2017, most of the households had no access to a reliable and stable power source. Villagers used rechargeable batteries for lighting in the evening and phone charging. The batteries were usually charged every 3-5 days at the commune centre, 20 km from the village. Children hadn't enough light for their evening study.

The H'mong population collected and consumed water from local springs because of their ancestors' long tradition and beliefs in its cleanness and convenience. Women and children took care of collecting for family's usage and stored it in an open tank.

In fact, the quality of open water sources such as spring water raises a concern about contamination. Examining the water source in Cu Jut District, Dak Nong Province, Anh et al. (2010) showed that the household drinking water bore risks of faecal contamination even after boiling and/or filtering in the home. The faecal contamination became more serious in untreated water sources such as in household tanks and other outdoor water collection. Cu Jut and Cu Pui are about 70km from each other and share similar social-economic, geographic and climatic conditions. The majority of inhabitants in both districts are farmers who are using surface-water sources from the local springs and rivers.

Technical design of the decentralized solar electricity-water system

The Earot villagers' load profile was ascertained based on a survey of electricity consumption conducted in the neighbouring village with that had been connected to the grid for between 5 and 7 years. Local families consume electricity for lighting, entertainment (television), phone charging and cooling (fans), and 85% of total demand is in the night-time (Figures 2 and 3). The maximum electricity need for the group of 18 households is 14.44 kWh per day. The power requirement for the RO system was measured based on two 1.5HP water pumps. The typical load profile for the dry and rainy seasons are as in Figures 2 and 3. Earot village receives a high solar radiation at 4.94 kW/m2/day (Table 1).

To meet that demand, a 6.24-kWp solar hybrid – a combination of solar photovoltaics (PV) and battery storage – was selected to provide electricity and operate the RO water purification system. The detailed technical information is presented in Figure 4. The technical design made allowance for a future expected demand increase and grid integration of the system if applicable.

Figure 1: Location of Earot village

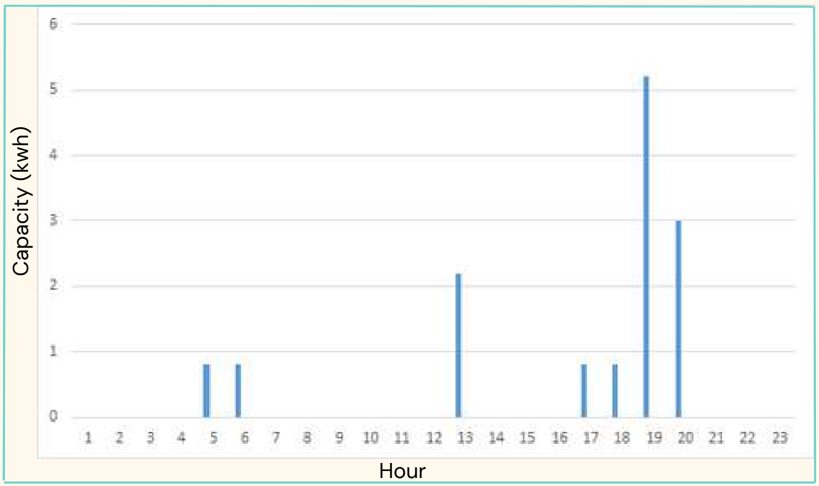

Figure 2: Load profile in dry season

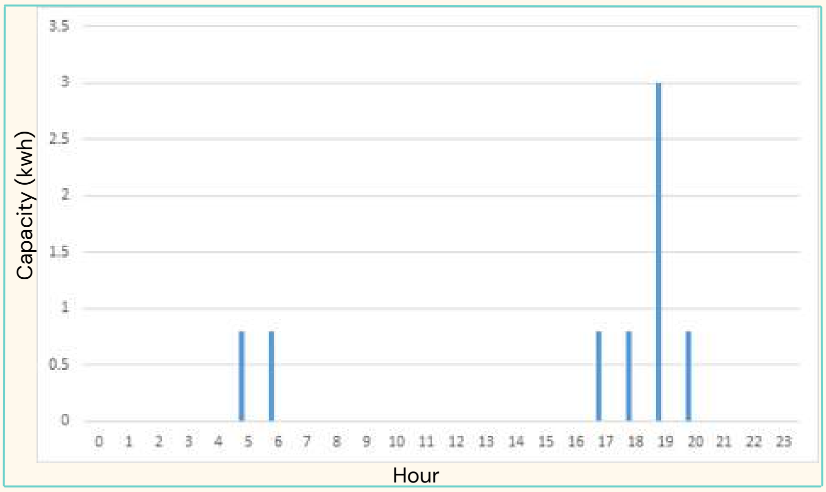

Figure 3: Load profile in rainy season

Month	1	2	3	4	5	6	7	8	9	10	11	12	Average
Solar irradiation (kW/m2/day)	4.96	5.8	6.16	6.06	5.36	4.83	4.74	4.46	4.55	4.30	4.00	4.06	**4. 94**

Table 1: Average monthly irradiation in Cu Pui Commune (Source: WB database)

With an average solar irradiation of about 4.94 kWh/m2/day, the expected average of electricity generation was 21 kWh/day. During the daytime, local villagers go to the field, so the major electricity consumption is in the evening. Having the sunlight during the day, the battery system is charged fully for night use and for reserve, and the remaining solar electricity is spent on running the two pumps of the purification system, and storing water in two tanks, one for underground water and one for purified water. The water treatment system consumes 2.2 kWh/day directly from the system, producing 300 litres of drinking water per hour. The RO water system enables not only a clean source of drinking water but also additional energy storage. By the end of the day, all power generated is consumed or stored in different ways.

The system was completed in July 2017 using a turnkey contract. By April 2020, the system had provided electricity for 23 households and one church, while 168 households had accessed clean water from the purification system. The power was distributed to a small number of households that are close to each other, but not to households that were scattered far from the system, whose supply would have caused high losses in transmission and distribution and thus been economically inefficient.

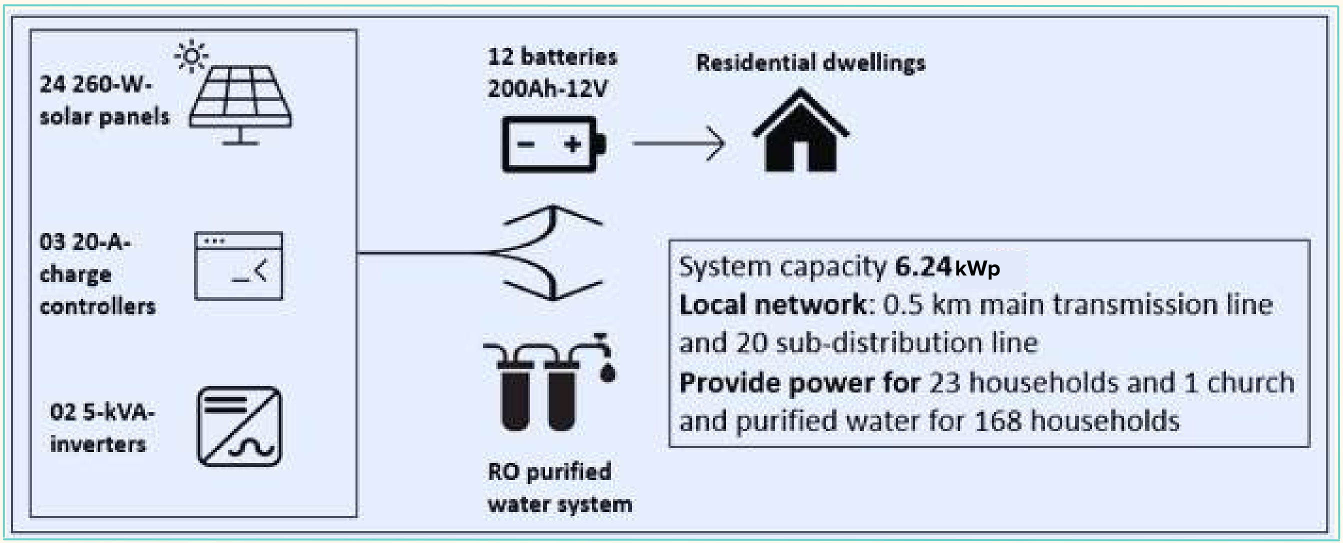

Figure 4: Overview diagram of power and water supply system in Earot village

Advantages of the dual electricity and water supply model

The technology selection process went through two stages. Firstly, a technical and financial analysis was done by a consultant service provided and jointly sponsored by an international donor and a local non-profit organisation, namely the Green Innovation and Development Centre (GreenID). Then, a transparent community consultancy round took place to collect local villagers' opinions. The consultant team presented their analysis of the DRE option to the local people. For comparison, two other options using grid extension and home batteries (suitable for household use) were also analysed to inform their choice. To facilitate comparison, all options were measured in two components producing an equivalent level of both electricity service and cleaning water service. The local community chose the DRE system for water-energy supply for its cost, technical and social benefits, as summed up in the following paragraphs.

Technical and economic advantages of solar hybrid system for Earot community

Compared to the DRE solution, the option of expanding the grid to Earot was clearly an unviable option technically and economically. Earot village is located 20km from the closest electricity station and the population density is lower than 40 households per km of 0.4kV distribution line required. With this long distance, the grid-based option requires a huge amount of investment cost, roughly 3 billion VND in total, which would place a pressing burden on the local budget. Also, it would take time to mobilise this kind of resource such that the grid expansion to Earot community would not be available within at least five years. Even though the grid could be expanded using national subsidies, concerns about electricity service quality – such as low voltage and poor reliability – were raised by the Earot community. A long distribution line through mountainous areas causes high losses and serious challenges in operation and maintenance of the network (GIZ, 2020).

In addition, the decentralized renewable energy-water approach offered quicker delivery of a power and clean water service within only four months. If a centralised solution had been taken, it could have taken three times as long to complete due to the complex administrative procurement process and huge construction workload. Besides, if the grid were eventually expanded to the village in the future, the design of the solar mini-grid system allows it to be integrated into the national network without additional investment. As long as the solar mini-grid connects to grid, the replacement cost of a battery system would not be needed anymore. Moreover, Earot community could expect to have more revenue from selling the electricity to grid to cover other parts of O&M of the system. Hence, the local commune leader and residents decided to build the DRE system to meet the existing local power demand.

Making a comparison with the total life-cycle cost of using a battery at home, which is the current local solution, the amount of investment capital for the proposed DRE system cost is five-sixths as much. With a solar hybrid system, local villagers can use AC electric appliances while a battery only allows use of DC appliances. Installing a DRE system, the children have enough light for doing their homework in the evening. Time and cost for charging the battery are saved, especially as the road condition is much worse in the rainy season. All community members can use the same number of electric appliances, such as lighting, television and fans, which could reduce the income inequality between families in local village. Before 2017, only wealthier families in the village could afford to buy a high capacity battery system to power their television and fans, while poorer households only bought small batteries suitable for lighting only.

Under the grid expansion and home batteries options, if the community members want to use clean water for drinking and cooking, they must still travel 20km to the centre of the commune and buy drinking water on the market at a price of 10 000 VND per 19-litre bottle. Local households are currently collecting water from the domestic spring with high risk of water contamination. By installing a solar hybrid system, the Earot community now have a clean source of water for drinking and cooking. The price that was set (by the community) for a 19-litre bottle of water produced by the system is 1.5-times cheaper than the market price and no longer requires travel o the commune center. The women in the community can spend time on relaxing, entertaining, caring for their children and learning new things instead of water collection.

Table 2 summarizes the DRE system's advantages compared with other options.

Criteria	DRE system	Grid expansion	Battery
Operations and maintenance	By trained local technician, highly responsive and low cost	High cost of technical service from local electricity utilities	Families doing this by themselves. Very poor practices influencing service quality and lifetime of the equipment
Water supply	Integrated and locally available	Not integrated; to be transported from commune centre	Not integrated; to be transported from commune centre
Water collection	At the village	At the centre of the commune, 20 km from home	At the centre of the commune, 20 km from home
Price of 19-litre water bottle	7,000 VND	10,000 VND (market price)	10,000 VND (market price)
Community involvement	Active local participatory and having community ownership	Not at all: the system is owned by local power companies	Only single family

Table 2: Benefits of the DRE system compared with grid expansion and battery usage

Local contribution and their reflection on dual electricity and water supply system

Both residents and the head of the village supported the proposal to speed up the DRE construction. As for financial mobilisation, the funding was contributed by international donors, private donations and community contributions based on the principle of inspiring self-investment, with subsidies less than 50% of the total investment cost. The local financial contribution included land donation, construction labor and responsibility for the O&M.

The community members and village leaders were involved in identifying local demand, selecting technology, selecting land requirement and land availability, and doing construction and O&M jobs. Also, the Earot community took responsibility for setting up their own technical and financial monitoring plan on an ongoing basis including bill collection and financial arrangements for maintenance. All decisions were made based on transparent discussion and public consent among villagers.

After operating the system, Earot families believe that life is improved day by day as they have the necessary services of water and power supply. They share their story of change happily and excitedly within the community and with others as well. The children have light for study while the parents enjoy their favourite entertainment programs on television and radio. They still talk about the construction work as a collective activity where they worked together to build a community site and learnt about green energy as well. From a management perspective, the commune leader affirms that the system contributes to reducing the pressure on resource mobilization and that it attracts study tours from various groups in the region.

[1]Four fifths of the initial costs covered by international donors, GreenID, and private contributions. The community contribution includes one-fifths of the investment cost from the commune budget and other costs, such as allocation of land availability and labor contribution.

Community role in operation and maintenance of the system

After construction was completed, the DRE system was formally handed to the local community, affirming community ownership of this system. Since then, a representative of the Earot community has taken the responsibility for operating and monitoring the system regularly. He has been trained to do O&M. The local technician still gets the support of installers and experts via a mobile supervision program which helps to solve arising problems quickly. The local O&M service and a remote monitoring system application in the Earot system address one of the significant concerns about poor O&M in other models. The Earot water-energy system is run and managed by the local people so that the labour cost for O&M drops dramatically.

Additionally, the local representative is in charge of doing accounting tasks and financial management. As the initial investment cost had been partially subsidized,[1] the local people and commune leaders agreed that the electricity and water price should be set at only 2,000 VND/1kWh and 7,000 VND/bottle, respectively. If no subsidy had been provided, the electricity price would have been 15,000 VND/1kWh and the price of one 19-litre water bottle would have been 10,000 VND to reflect the market price. The revenue from selling water and electricity is enough to cover the costs of the operation and equipment maintenance needed (Table 3).[2] All the money from selling electricity and water has been kept in one bank account and will be spent on operation and maintenance cost. In the case that the revenue from system operation is not enough, the commune will have a meeting to determine an appropriate funding mechanism.

[2]The cost of replacing the solar PV itself is not included, which has a lifetime of 20 years. Components that require replacing several times during this period are included, such as the battery and some water system components (Section A of table 3)

	Items	Value (VND)
A	**O&M cost requirement of Earot system**	
i	Solar PV system	
	Cost for inverter replacement (in 10th year)	5,000,000
	Cost for battery replacement (every 3 years)	108,350,000
ii	RO water treatment system	
	RO water treatment system	4,500,000
iii	Labour cost for O&M such as replacing equipment, etc.	3,600,000
	Average discounted annual cost required for O&M over the life span of system (discount rate at 10%) (1)	**13,811,237**
B	**Average annual revenue (actual record from 7/2017-4/2020)**	
i	From selling electricity *(1,491 kWh/year x 2,000 VND/kWh)*	2,982,000
ii	From selling water *(2,545 bottles/year x 7,000 VND/bottle)*	17,815,000
	Average discounted annual revenue (measured based on actual record) (discount rate at 10%) (2)	**18,963,656**
	(2) – (1)	**+5,152,415**

Table 3: Summary of average annual cost and revenue of Earot system

The successes of the dual electricity and water system

Enable electricity and clean water access in remote areas

The analysis for Earot case study presented above confirms the cost-competitive and technically viable benefits of a decentralized renewable energy-water approach to meet both household power and clean water requirements in remote and mountainous areas. This has been seen in similar circumstances in other developing countries. For example, in Sub-Saharan Africa, DRE systems have shown potential in some locations as a cost-effective solution for removing microbiological and chemical contaminants reliably and simultaneously from local water sources for rural drinking water supply (Schäfer et al., 2014). In Sudan, solar-water pumping systems have been strongly recommended for nationwide promotion as a technical and economic way to improve the power and water accessibility conditions in isolated rural areas (Omer, 2001). A DRE system contributes to providing information related to health, nutrition and other services, through enabling the reception of television programs and clean water services that are extremely valuable for community's life quality, especially for ethnic minorities (Kabir et al., 2017, Mala et al., 2009).

The sustainability of the project

In many locations where DRE projects have been previously installed (both in Vietnam and in other countries), although the projects were seemingly initially successful, later technical issues and maintenance problems led to the decline of power production. In Vietnam, failure of previous DRE systems for rural electrification has been recorded because of weak local participation and poor business models (GIZ, 2020). Due to a top-down approach, there was a lack of local community involvement in deciding suitable sources and technologies to meet their own demand. More specifically, with a centralised approach, local people were not involved in O&M duties while O&M was rarely taken care of by local power and water companies, due to large distances from urban centres, and poor road access. This is identified as one of key causes of DRE system failure for both rural electrification (GIZ, 2020) and clean water supply (NCERWASS, 2020) in Vietnam. In contrast, all these challenges are addressed by the community-centered approach applied in developing the Earot system. By having a voice and being the owners of the intervention, they became more active and committed through all steps of the project.

The success of the community-centered approach in the Earot system is paralleled by DRE initiatives in other case studies. For example, using the Gandhian system, development workers trained villagers in Barapita village (Odisha, India) as solar engineers, which enabled them to do O&M tasks and keep the solar system operational for the whole of its designed life time (Mishra, 2021). In Kenya, community-managed solutions have succeeded in running decentralized systems for electricity and water access in remote areas (Marks and Davis, 2012). Shi et al. (2016) affirmed that local engagement is ranked one of the top five effective facilitating instruments for efficient investment in off-grid RE systems in developing countries. Clearly, the engagement of local communities in O&M is a valuable approach to promote DRE dissemination widely (Yaqoot et al., 2016, Schäfer et al., 2014).

The local active participation and ownership characteristic is the key success factor in the adoption of DRE initiatives. Oakley (1991) wrote that local participation in determining the objectives and priorities of a project and then making plans and decisions could contribute most to the efficiency, effectiveness, and sustainability of a project. Similarly, Bauknecht et al. (2020) contend that participation – in the tripartite forms of procedures (engagement in decision-making), democratic representation and financial contribution – will play an important role in the uptake of future decentralized interventions. Endorsing this argument, Piterou and Coles (2021) agreed that community ownership and local engagement often contribute more the sustainability of DRE in remote areas.

Last but not least, the spread of DRE systems in remote areas is accompanied by various social impacts that need to be measured well and responded to. Indeed, the practical electricity and water consumption of Earot villagers was about a half of the original capacity design, recorded by April 2020. The reason is that the local people partly continued to use their own batteries and collect spring water for daily activities. It's true as Lindgren (2020) argues that households often supplement instead of abandon completely their older technologies. This finding fits with the previous argument that replicating DRE for dual electricity and water purposes in a given site requires a more active form of local acceptance than only technical transfer (Piterou and Coles, 2021, Sanders et al., 2013, Mankad and Tapsuwan, 2011).

Conclusions and recommendations: Implications for decentralized renewable energy-water uptake

More recently, the GoV has launched the national target of universal electricity by 2025 (MOIT, 2021) and universal clean water by 2045 (NCERWASS, 2020). Along with the centralised system, the GoV affirms the importance of renewable energy and decentralized technologies to achieve this national goal of electrification and clean water supply. This thinkpiece now discusses the implications for properly supporting policies and mechanisms to foster dual electricity and water supply model to address SDG 6 and SDG 7 for Vietnam.

Issuing government supporting policies and guideline should assign clear roles for multi-stakeholders in management and cooperation

Firstly, government policies and guidelines are a vital factor to enable space for dual water-electricity models' application in remote communities. With a long history of centralized approaches for remote areas, Vietnam lacks policy frameworks and detailed guidelines for management and operation of decentralized systems. Also, there are multiple stakeholders who need to be involved in order to produce a robust performance on SDGs 6 and 7 in Vietnam, including funders, communities, non-government organizations, installers, and government agencies at many levels. Each player has their own aims and expectations for the sustainability of proposed solutions. It is necessary to design a regulatory framework to guide the adoption and management of DRE system installation. To reach "the last mile consumer" requires substantial collaboration and cooperation between different ministries, development organisations and local partners.

The adoption of RE technologies, especially DRE systems, also plays an important role in reducing greenhouse gas emissions and achieving the national target of net zero carbon by 2050. This is because DRE systems take advantage of local resources, contribute to reducing the dependence on imported energy, and cut the amount of carbon emission relative to conventional technologies in Vietnam. Hence, the contribution and efforts from not only the government but also other stakeholders – and not any single sector but also cross cutting industries – would be necessary for reaching a national commitment and optimising resources as well.

Providing the incentives and financial mechanisms for dual water-electricity model uptake

Not only Vietnam but also other countries in the Mekong Region are facing challenges in the form of limited funding sources for remote electrification and water supply programs. In the Earot model, the average life-cycle cost is roughly VND 44.3 million per household excluding community contribution. For the remaining unelectrified households, the GoV needs at least VND 8.860 trillion, equivalent to USD 386 million, to achieve SDG7 by 2025. If the funding for a centralised water supply system is separate, the burden on the national financial plan will be double or even more.

Meanwhile, several external supporters have committed their technical and financial assistance for electrification and rural water supply in Vietnam in the coming period. In particular, the European Union is going to provide about USD 140 million for lighting up remote areas and islands during the period 2021-2025 (MOIT, 2021). In terms of technology, WB supports DRE technology installation for lighting and improving water usage conditions in rural areas (WB, 2016), and is providing a national loan of approximately USD 200 million by 2023 to scale up good practices in rural water supply and sanitation programs nationwide (WB, 2021). Thus, a suitable financial mobilization mechanism can encourage public-private investment, joining with state and local authorities' efforts in reaching the universal water and electricity goals.

A diversified and flexible financing mechanism should be encouraged, consisting of partial subsidies, public-private partnerships and a social entrepreneurship model. For example, the GoV should provide state subsidies for initial investment cost reduction. Having no expectation of repayment for assets contributes to reducing budget pressure on local villagers and triggering local responsibility for the system operation as well. Moreover, the dual electricity and water supply system is in the early stage of deployment so that providing subsidies also means promoting the market for this technology. A typical success story is seen in the California Solar Initiative (CSI) which provided upfront cost support for solar energy systems. By 2015, CSI recorded a 13-fold increase in solar PV capacity in this state since its enactment (Hallock and Kinman, 2015).

Creating space for emerging business models to mobilize resources for DRE installation and ensuring their sustainability

Among non-state-owned systems, some typical business models include energy service companies (ESCOs) as commercial actors in project management, energy cooperatives and municipal energy agencies. All of these models highlight the active involvement of end-users in design, development, and delivery of energy services from DRE projects. The idea of ESCOs is to involve the private sector in providing and operating micro-generators for remote communities while energy cooperatives and municipal energy agencies call all resources in a geographical area together, including both consumers and institutions (Piterou and Coles, 2021). Under a cooperative energy structure, a DRE system in Brixton (London) is partially by end-users who have rights of control over the system but also help ensure the supply-demand balance (IRENA, 2019).

Integrating advanced technologies in O&M of DRE in remote areas

Applying advanced technologies could address the current challenges in human resource costs and timing factors in O&M of systems for powering and supplying water in remote communities. For instance, pay-as-you-go (PAYG), a combination of internet and RE solution, proved its success with more than four million customers in East Africa, in tracking the amount of consumption as well as paying bills remotely (IRENA, 2020). Another success story is a network of 50,000 solar home systems connected to an aggregator in South Australian to lower about 30% of participants' electricity bills (IRENA, 2019).

Strengthening local engagement in DRE deployment to strengthen community resilience and make a responsible contribution to the national effort of achieving SDGs 6 and 7

Local communities should be involved in all stages of project development including planning, designing, financing, managing, and operating. As O&M poses challenges of cost and timeliness in remote areas, local responsibility for O&M services provided by communities is a great solution. The GoV should provide a capacity needs assessment to identify the needs and benefits for remote communities of adopting DRE systems. Based on this, technical assistance programs and resource mobilisation would be provided for reliable support to local capacity development. The capacity training program should give priority for off-grid groups and could integrate with the current vocational training framework for rural areas.

Additionally, there should be a government-led awareness-raising campaign to enhance public diffusion of new technologies while regular monitoring and evaluation programmes provide knowledge on what motivates long-term behavioural change. The social-cultural context and local norms will shape the proper provision in each situation. Making the community a fundamental part of DRE interventions is a vital way of keeping the model functional and truly adapted to meeting local needs. This concept is also supported by Oakley (1991), which suggests that the DRE system with active participation can become a true local asset and build local confidence, self-reliance and independent pride in the community's future.

In brief, the above success story of the Earot community proves that a DRE system utilizing local resources can provide the villagers' power and water consumption needs as well as make more robust the Vietnam's progress toward completing SDGs 6 and 7. The solar mini-grid for electricity supply and running the RO water purification system shows not only technical and economic efficiency but also other benefits such as timing-pressure reduction in water collection and local well-being improvement. The system's sustainability is shaped by strengthening local participation through empowering local inhabitants, increasing in ownership, and establishing a hybrid financing mechanism.

This thinkpiece therefore highlights the importance of governance regulation and supporting policies, suitable business models and local participation to enable rapid, decentralized, renewable energy-water technology dissemination in remote areas nationwide. Both technical-economic monitoring and social science evaluations should be carried out in developing the project to ensure the long-term success of dual water and electrification supply deployment. Moreover, pre-feasibility studies in specific circumstances would be highly recommended to expand this intervention in Vietnam and the Greater Mekong Region for achieving SDG 6 and 7.

by GreenID

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REWILDING THE MEKONG: CAN THE MEKONG BE RESTORED?

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Introduction

Hydropower dams act as barriers that fragment, regulate and degrade the hydro-ecological processes which underpin the productivity and diversity of river systems. For more than two decades researchers analysing the Mekong system have warned about the implications of the rapid and uncoordinated development of large hydropower projects on the river. They have warned of bank erosion (Brunier et al, 2015; Li et al, 2017); reduced floodplain fertility (Bussi et al, 2021); sediment starvation, a shrinking and sinking delta (MRC, 2019; Kondolf et al, 2018, Schmitt et al, 2021); increased saline intrusion and drought (Binh et al, 2020; Eslami et al; 2019); the demise of wetland productivity (Arias et al, 2014); the collapse of the Tonle Sap flow reversal (MRC, 2021); fisheries collapse and food insecurity (Orr et al, 2012; Ziv et al, 2012; Ngor et al 2018; Golden et al, 2019), increased economic inequity and rural insecurity (Intralawan et al, 2018; Green et al, 2020); growing regional tensions (Hensengerth, 2015); the risk of dam collapse, community displacement and loss of livelihoods (Latrubesse et al, 2020; Kura et al, 2017).

Today with 124 projects constructed, operating or planned in the Lower Mekong Basin and a further 18 projects on the Lancang River (Upper Mekong), these changes have begun to manifest and fundamentally alter the integrity and functioning of the Mekong system, with profound societal implications for the Mekong countries.

Indeed, in 2021 the Mekong River Commission (MRC) released a new Basin Development Strategy (BDS) for the Lower Mekong Basin, which explicitly recognised the significant degradation of the Mekong system due to hydropower development and the centrality of these changes as challenges for management, singling out the decline in sediment loads, *"Given the importance of sediments to nutrient transport, erosion and deposition processes, delta stability, and fisheries and agricultural productivity, this decline is alarming. The loss of sediments in the river is only likely to increase with further construction of dams and sand mining. One worst case scenario suggests the sediment load by the time the flow reaches Kratie could almost disappear by 2040"* (MRC 2021).

The BDS laments the damage to the Mekong system and the ecological crisis that is unfolding, but concludes, that development of water control infrastructure is necessary and that Mekong countries should focus on efforts to partially mitigate the full scale of adverse impacts and to continue exploiting the economic benefits of water resources development. That is to say, the BDS treats the degradation of the Mekong as a fait accompli, and a consequence of the necessary environmental trade-offs implied by an economic development strategy built on large hydropower.

We fundamentally disagree. The significant and growing cost of large hydropower and the rapid rise of alternatives (non-hydro renewables) offers the potential for restorative change in direction for energy infrastructure development, and a chance to bring back sustainability to the Mekong system. In this paper we explore the possibility of the removal of large hydropower in the Mekong and its implications for the ecological health of the basin and the livelihoods which depend upon it. We introduce the concept of river rewilding to promote the recovery of connectivity between river ecosystems through removal of human influence for a wider, shared socio-ecological benefit (Rideout et al, 2021). In particular, we argue that the case for rewilding the Mekong, is strengthened by the decreasing costs of non-hydro renewable energy and an increasing understanding of the cost externalities of large dams.

Hydropower development in the Mekong basin

Since at least the end of the last glaciation the Mekong basin has been in a state of dynamic equilibrium with the climate and landscape which has resulted in a variable but predictable annual hydrograph (Adamson et al, 2009). While there is a long history of continuous human settlement in the Mekong basin, there is little evidence of any significant basin-scale influence of human activities on the hydro ecological process of the Mekong prior to the 1970s. There is some evidence that in the 1970s and 1980s the impact of agricultural intensification in the Lancang catchment altered the sediment load arriving to the Lower Mekong basin (Walling, 2009), but it was not until the 1990s that anthropogenic influences began to reach a sufficient scale that impacts were visible basin-wide. The expansion of human activity in the basin has been a consequence of rapid growth and structural change in regional economies. The development of extractive and natural resource-based industries (agriculture, forestry, mining and energy) and modern infrastructure systems that support these activities in particular has been important in driving change in the basin. For both the scale and the pace of infrastructure development, hydropower has been the predominant driver of anthropogenic influence.

During the 1950s and 60s large hydropower began to be promoted as an economic development strategy for the Mekong Region, based on replicating the perceived success of the Tennessee Valley Authority (TVA) in the United States to alleviate poverty during the 1930s – 40s (Biggs 2006). The strategy of economic prosperity through hydropower in the lower Mekong Basin was heavily promoted by the newly established Mekong Committee,[1] however wars and political upheaval in the basin meant that during the 1950s – 1980s, progress was slow with only one project in Lao (Nam Ngum 1, 1971) and several projects in Thailand being developed. By the late-1990s development of hydropower in Thailand had stalled due to escalating concerns over the adverse impacts of large hydropower on both the environment and local communities. This culminated with the temporary opening and effective decommissioning of the Pak Mun dam in the early 2000s, and adoption of a policy of no new hydropower within Thai territory which remains the case to the present day.

In the remainder of the lower Mekong basin, hydropower deployment began to accelerate at the end of the 1990s. In the 2000s Vietnam developed cascades of hydropower on its parts of the Sesan and Srepok Rivers, while Lao began to develop projects in the Nam Ngum, and Nam Theun-Kading basins.

In the Lancang River, the introduction of large hydropower started with the construction of the Manwan Dam, the first hydropower dam on the Mekong mainstem, which was commissioned in 1995. An additional seven mainstem projects have since been constructed, including the two largest projects in the basin – Xiaowan (commissioned in 2008 with a total storage capacity of 14.9 km^3) and Nouzhadu (commissioned in 2012 with a total storage capacity of 23.7 km^3) (Liu et al, 2020). The combined Lancang cascade of 8 hydropower dams has a total storage capacity of 41.9 km^3 and a total installed capacity of 15,720 MW (Liu et al, 2020).

[1] The Committee for the Coordination of Investigations of the Lower Mekong Basin (the Mekong Committee) was an intergovernmental organisation comprising Cambodia, Laos, Thailand and the republic of Vietnam and set up under the auspices of the United Nations with international funding (Cosslet, et al, 2013).

By the mid-2000s the large size of reservoirs on the Lancang cascade were exerting an observable effect on the hydrology of the Lower Mekong basin (see for example Adamson, 2008). This regulation of the Mekong hydrograph also rekindled interest in lower Mekong mainstream dams as the regulation of the river's flood pulse, and higher dry season flows made lower mainstream dams more economically attractive (ICEM, 2010). In total 11 lower Mekong mainstream dams have been under consideration. Of these, Xayaburi was the first project completed in 2019, Don Sahong commissioned in 2020.

As of 2019, of 124 identified major dam sites, 32 were operating, 24 were under construction, and 68 potential sites remained undeveloped (Schmitt et al., 2019). These projects have a capacity to generate 146,585 GWhr of electricity each year; approximately 68% is generated on the Lancang, 11% on the lower Mekong mainstream and 21% by the lower Mekong tributaries.

As noted in the introduction there is a growing and persuasive body of evidence cataloguing the impact of these hydropower projects on the hydrology, sediment, fisheries, ecological, and social systems of the Mekong. If this development pathway continues the outcome is a degraded Mekong with a collapse in sediment and ecological connectivity and further instability in the Mekong floodplains and floodpulse. The scale and rapidity of these impacts, we argue, represent one of the most important challenges for sustainable development of the Mekong River basin and its communities.

Introducing the concept of re-wilding

Rideout et al (2021) define rewilding as *"…an ecological restoration concept that promotes the natural recovery of ecosystems, through (initial) active or passive removal of human influence."* The term rewilding was coined in the 1990s, but the approach it entails emerged earlier in North America in the 1970s as a response to a growing understanding of the adverse impacts of human interventions on the ecosystems of the southwest of the USA (Foote, 1990). Historically rewilding has been used successfully in managing terrestrial biodiversity through the reintroduction of species – especially apex predators (for example the reintroduction of wolves into parts of North America). In the context of river management, rewilding is typically associated with local-scale river restoration including the physical restoration of specific fluvial habitats through in-channel structures and flow management (Rideout, 2021). Kondolf et al (2007) reviewed two decades of river restoration efforts in California (1980 – 2007) identifying more than 4,000 projects requiring more than USD 2 billion in expenditure during that period. Of these projects, the majority were focussed on water quality management, riparian zone management and bank stabilisation. Similar restoration efforts have been successfully applied in other parts of the world, for example restoration of environmental flows in the Barmah – Millewa wetlands of the Murray-Darling Basin of Australia (Ward, 2015), and the Danube and Oder deltas in south-eastern and northern Europe respectively.

Rideout et al (2021) note that most efforts at river rewilding that adopt a local, restoration approach rarely attempt to recover ecosystem functions at a larger scale, often focussing on incremental, small-scale interventionist strategies such as habitat restoration. These localised efforts of habitat restoration can have important benefits at the site of restoration, but they are often focussed on addressing the symptoms of the problem not the underlying causes. For example they may be effective in addressing accelerated riverbank erosion, but not the underlying changes in sediment load or fluvial hydrodynamics which may be causing the increased rates of erosion. In their framework for rewilding Rideout et al (2021) emphasise the need to restore rivers through a basin-wide focus on hydrological function, and in particular the restoration of natural flow and sediment regimes, as a foundation upon which other ecological functions depend.

Example of the Elwha River dam removal[2]

The position of Rideout et al (2021) in stressing the importance of restoring natural flow and sediment regimes is supported by the illustrative example of the rewilding experience on the Elwha River, and in particular the dramatic and rapid positive impacts on deltaic environments (Figure 1). Two hydropower dams were built on the Elwha River, Washington State USA between 1912 and 1927. The dams were 32 and 64 m high with a combined storage capacity of 60 MCM. At the time of removal approximately 30Mt of sediment had deposited behind the dam. As a consequence of the dams inhibiting sediment transport, the Elwha experienced ~160m of shoreline retreat between 1939 – 2006, which managers attempted to mitigate through a series of local infrastructure interventions (sea walls, and boulder rip rap). Dam removal took three years of incremental lowering which resulted in releasing two thirds of the stored sediment to the downstream littoral zone and the rapid restoration of deltaic accretion (Figure 1). Within a few years of completing the dam removal, the shoreline experienced progradation of hundreds of meters near the river mouth and tens of meters for distal beaches (Warrick et al, 2019). On this basis, Warrick et al (2019) conclude that restoring sediment processes in dammed rivers can significantly change the evolution and fate of a river's littoral zone.

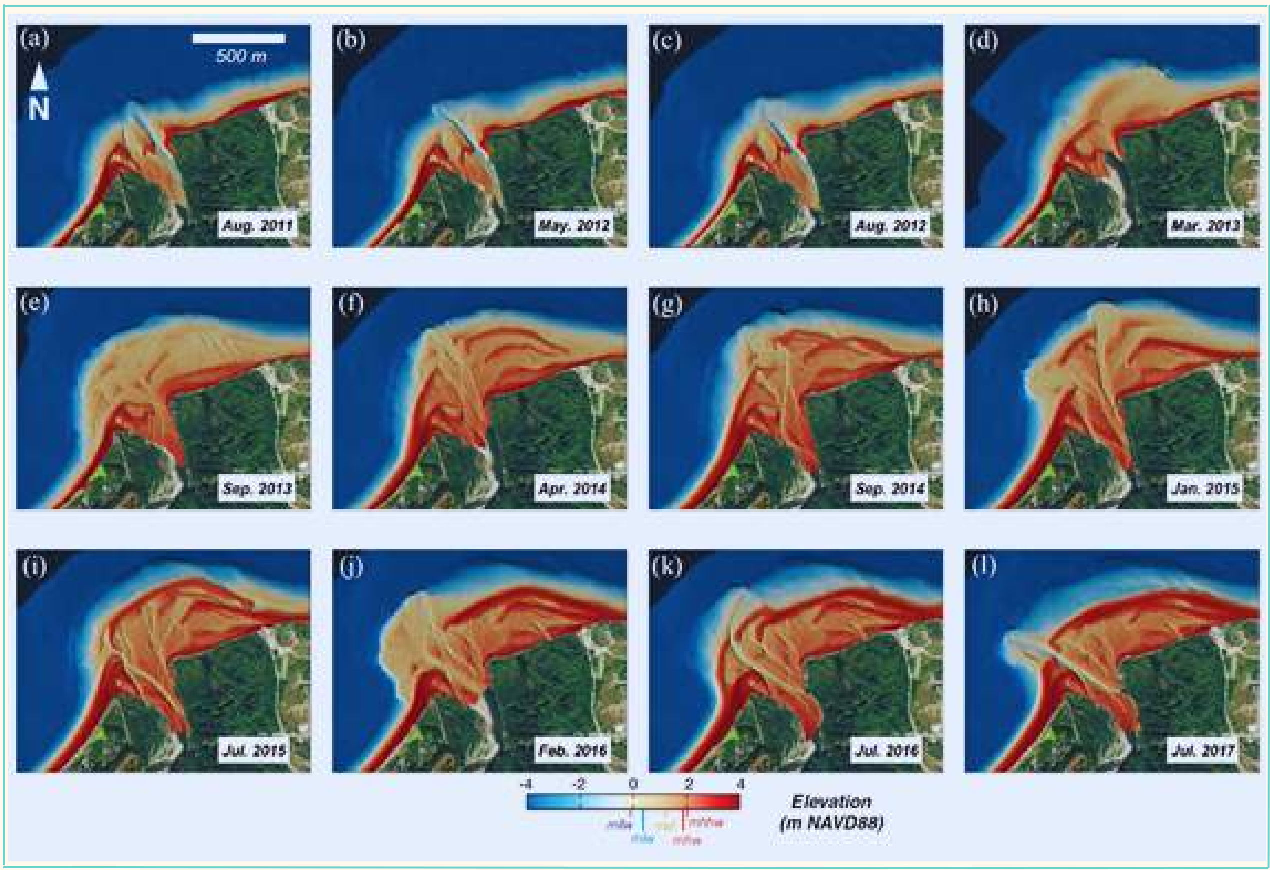


Figure 1: Impact of rewilding on the Elwha River delta

Source Warrick et al, 2019

[2] The description of the Elwha River case study is summarised from Warrick et al, 2019

Sediment in the Mekong Basin

The Mekong fluvial estate comprises the land area, wetlands and waterways of the Mekong that are characterised by the ecological features of individual habitats and by the ecological processes and functions that connect habitats into an integrated assemblage of fluvial ecosystems. Collectively the fluvial estate provides for human and animal communities who live in the basin, including the socio-ecological services provided by rivers and wetlands such as agrarian land, fisheries, water resources for hydropower, and sites for human settlement.

A defining feature of the Mekong fluvial estate are the river ecosystem functions that underpin system productivity. Rideout et al (2021) identify approximately a dozen ecosystem functions that are common to all river systems, these include functional components (metabolism, decomposition, primary production, secondary production), structural components (groundwater recharge, flood/flow pulse, water purification, flood attenuation, nutrient recycling, habitat provisioning), and biotic components (food web complexity, functional redundancy). Only the human drivers of changes to the flow and sediment regimes of river systems and climate change are capable of directly influencing all ecosystem functions of the fluvial estate.

Mekong sediments originate from erosion processes in the headwater catchments. Sediments are transported downstream before reaching Kratie and debouching into a large, low-lying floodplain including, the Tonle Sap Lake and extensive flood plains southeast of Phnom Penh (Cambodia), and the 40,500 Km2 Mekong Delta (Vietnam). There is general consensus that the pre-dam sediment load of the Mekong is c.a. 160Mt/yr (Kummu et al, 2007; Walling, 2009; Kondolf et al, 2014; Schmitt et al., 2017, Schmitt et al, 2019,). According to Ta et al (2002), this sediment load has remained stable during the last three thousand years and has been a driving process for progradation and formation of the delta.

The source of sediment varies significantly across the Mekong basin reflecting the diverse tectonics, climate, lithology and land use. Kondolf et al (2014) delineated nine geomorphic regions for the Mekong basin based on geological history and geomorphic characteristics. Of these two of the zones are sediment sinks (Tonle Sap and Delta) and seven zones of provenance (Figure 1). Sediment yields for the productive geomorphic provinces ranges from 40 – 450 t/km2/yr., while the average annual sediment yield for productive zones of the Mekong Basin (i.e., upstream of Kratie) is 213 t/km2/yr. The Lancang River has a yield more than double the basin average, and with a substantial basin area represents the largest input of natural sediments into the Mekong system. In the Lower Mekong Basin, the southern Annamites (headwaters of the Sre Pok, Se Kong and Se San basins) and the catchments of northern Lao (e.g., Nam Ou, Nam Tha, Nam Beng) are also zones of high sediment production, while river basins in central Lao and Thailand's Chi – Mun basin have lower sediment contributions. The geographical provenance of sediment also varies with hydrology; during wet years the LMB tributaries contribute a greater proportion of the annual load, while in dry years the dominance of the Lancang component is increased (Sarkkula et al, 2010).

Other characteristics of the Mekong sediment regime are also important from the perspective of basin wide processes. First, sediment loads exhibit a wide range of interannual variability in response to the region's complex climate. The analysis of sedimentary deposits by Ta et al (2002) indicated an annual variation of +/- 25% from the long-term average.

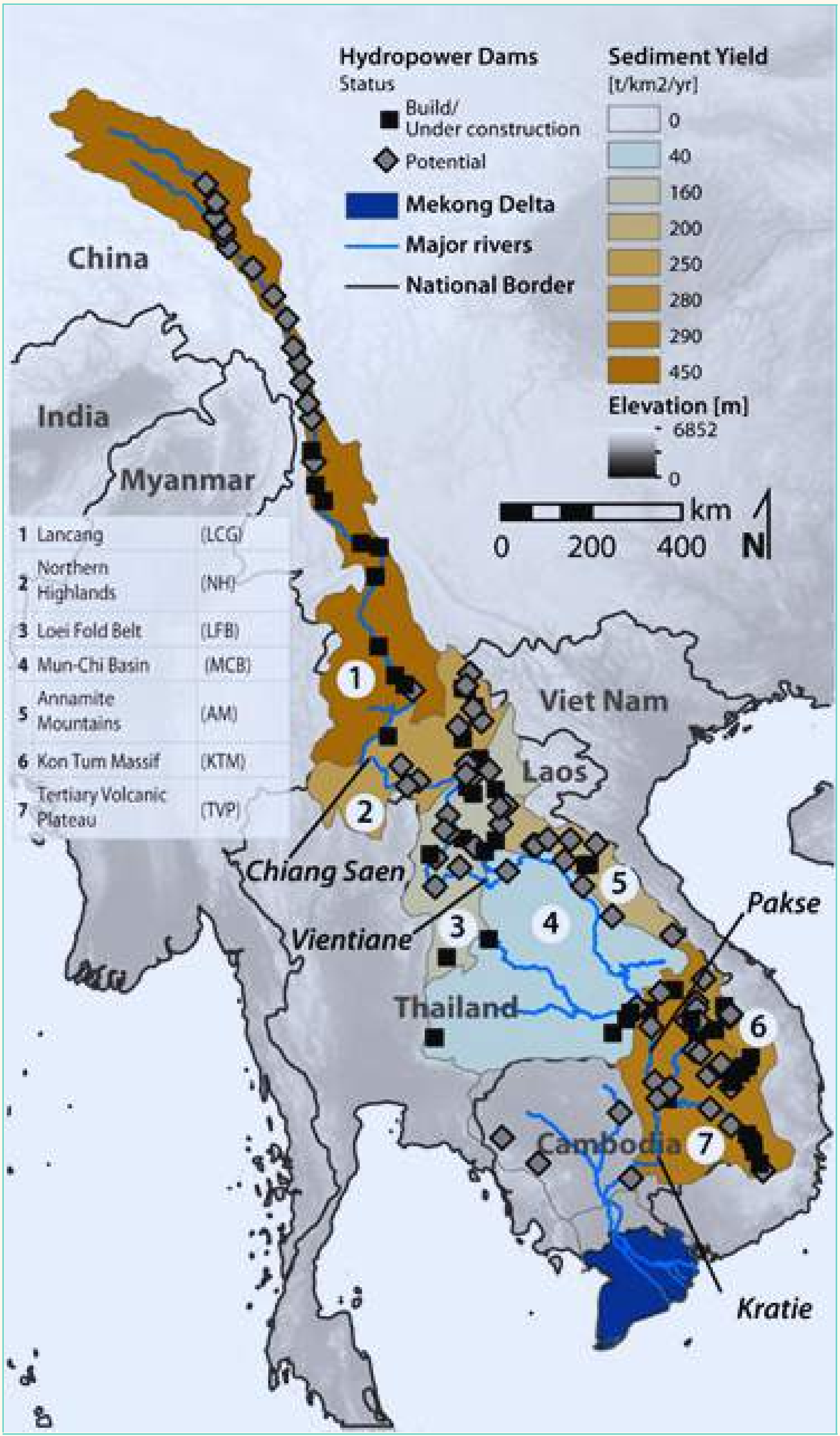


Figure 2: A geomorphological perspective of the Mekong River basin[3]

[3] The labelled towns and cities (Chiang Saen, Vientiane, Pakse, and Kratie) mark the boundaries for five Hydro ecological zones (HEZs) which were first developed by the unpublished MRC Integrated Basin Flow Management Program and later used in the MRC Strategic Environmental Assessment of the Mekong mainstream hydropower (ICEM, 2010).

Second, sediment transport is not uniform throughout the year and responds to the changing flood-pulse hydrology. Analysing sediment data from 2009 – 2013, Koehnkhen (2016) concluded that 80% of the annual sediment transport occurs during the four months of the flood season, with 60% of that transport occurring within the two-month period coinciding with the major flood pulse.

Third, the size of sediment also varies considerably, with the Mekong system carrying a wide range of bedload (gravel, cobbles), sands, silts and clay. The differing sizes of sediment and governing hydrodynamic processes means that some smaller sediments can be transported along the river within a single flood season, whilst other larger fractions are mobilised for shorter durations and over shorter distances, taking years to progress downstream.

Fourth, sediment deposition creates, maintains and fertilises the vast floodplain complex of the Mekong. As the river enters these environments there is a significant reduction in topographical gradient reducing stream power and allowing sediments to deposit. Transported sediments are deposited into the Tonle Sap Lake (~5%), Cambodian floodplain (15%), Mekong Delta (16%), the estuarine river-mouth environment of the two main distributary channels – the Bassac and Mekong (3%) and the near-shore marine environment 61% (ICEM, 2010). Seasonal differences in water levels, the size of the flood peak, the timing of flood flows and its interaction with tidal effects can shape and alter the pattern of deposition year on year.

The impact of hydropower on Mekong sediments

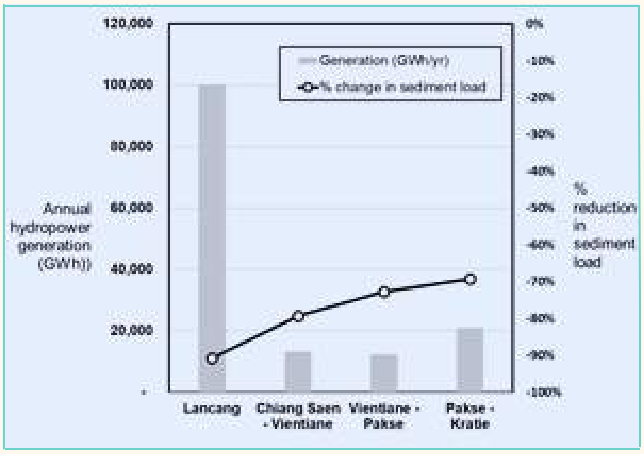
Large hydropower reservoirs act as barriers which disrupt the longitudinal connectivity of sediment transport and induce sediment deposition within reservoirs. This accumulation of sediment reduces the operating life of reservoirs, but as noted above, the main system-scale impact of reservoir sedimentation is the disruption to sediment transport processes and the adverse impact of reduced sediment load on downstream environments. There is already observational evidence that by 2013 the sediment load of the Mekong had been substantially reduced in the Lancang River from 85Mt/yr to 11Mt/yr (MRC, 2021), and on the Mekong from 160Mt/yr to 90Mt/yr (Koehnken, 2016) – representing an 87% and 44% reduction in Mekong sediment transport respectively. The larger reduction in the Lancang is due to both the earlier deployment of hydropower on the Lancang and the immense size of the storages that the Lancang cascade entails.

Since 2013, the deployment of large hydropower has continued unabated, including the introduction of mainstream projects on the lower Mekong mainstream, however observed sediment data is not publicly available. We use results from a basin-wide sediment routing model coupled with a multi-objective evolutionary algorithm developed by Schmitt et al (2019) to extend the record to include all existing, under-construction and planned large hydropower in the basin as of 2020. The modelling incorporated two scenarios to assess the implications for sediment transport, sediment volume trapped and changes in hydropower production. First a 2020 scenario considers all existing hydropower dams as reported in published literature, second a 2050 scenario includes all existing and all known planned dams. Identification of dams used in the scenarios comes from Schmitt et al. (2019) based on compiling and crosschecking data from the MRC, CGIAR's Mekong WLE initiative and Räsänen et al (2017). Results for both scenarios are shown in Table 1.

The cumulative effect of all existing hydropower dams in the Mekong is a 70% reduction reduction in the sediment load from 160 Mt/yr to 49 Mt/yr at Kratie, resulting in more than 1,600 Mt of sediment trapped by reservoirs over the next 30 years. If all currently proposed projects are built then the sediment load would reduce by 95% from the pre-dam average to 9.3 Mt/yr at Kratie, with a sediment resource of more than 6,000 Mt sequestered in reservoirs by 2050.

River zone	Sediment load (Mt/yr)			Sediment stored in reservoirs (Mt)	
	Pre-dam (1965)	**2020** (Existing dams)	**2050** (existing + all proposed dams)	**2020** (Existing dams)	**2050** (existing + all proposed dams)
Lancang (Upstream of Chiang Saen)	75.9	7.0	3.9	1,362	3,496
Chiang Saen – Vientiane	113.1	23.4	2.9	55	1,179
Vientiane – Pakse	129.3	35.3	8.1	165	478
Pakse – Kratie	160.0	49.3	9.3	111	874

Table 1: Impact of existing (2020) and proposed (2050) dams on Mekong Sediment transport



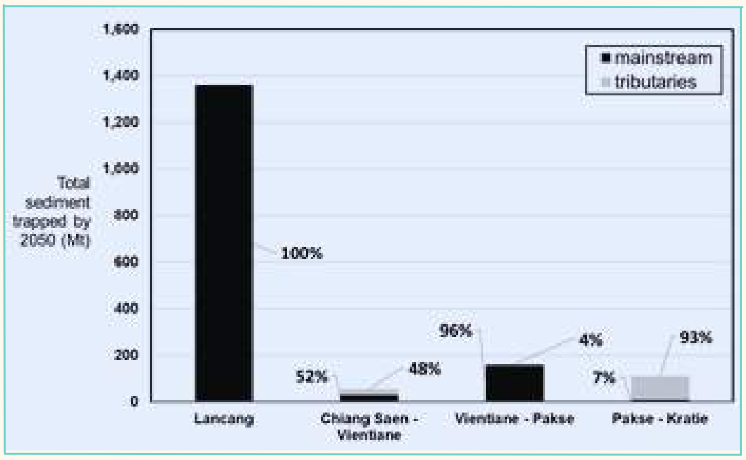


Figure 3: Existing Mekong hydropower:
(Left) hydropower generation & reduction in sediment load,
(Right) influence of tributary and mainstream dams on reductions on sediment load.

Outlining an agenda for re-wilding the Mekong

The defining sustainability issue for the Mekong basin is the trade-off between electricity production through hydropower development and maintaining the biodiverse and productive fluvial ecosystems of the basin, which we define as the Mekong fluvial estate.

Between the mid-90s and today, the five countries of the Mekong basin have implicitly made a decision that 146,585 GWh of annual electricity production from large hydropower is worth the loss of 110.7Mt of annual sediment transported from source to sink. Under current likely development scenarios by 2050 approximately 267,891 GWh/yr will be produced for the loss of 151Mt/yr of sediment transport, equivalent to 1.77 MWh for every ton of sediment lost each year. The question is, is this trade-off worth it?

To understand whether the benefits to the countries of electricity generation are worth the losses experienced through a degraded and disconnected Mekong, requires an ability to estimate the full societal value on each side of the trade-off. Electricity and sediments are both associated with the generation of a wide range of social and economic values. In the case of electricity production, hydropower plants generate relatively cheap, relatively clean electricity, generate employment in related sectors in their construction and operations, they bolster energy security, provide additional government revenues and return profits to investors (discussed further below). Sediments, on the other hand are linked to wide range of ecological functions including fisheries production, floodplain fertility, subsistence farming, rural and urban nutrition, agricultural exports, navigation and food security. One of the challenges facing decision makers is understanding the value of these benefits which are realised by different groups, in different countries over different timescales, and provide a range of qualitatively (private, public and common goods) and quantitatively different benefits. The implicit trade-off is also complicated by efficacy of the planning processes used to make decisions. Schmitt et al (2018, 2019), amongst others, note that the development of hydropower reservoirs in the Mekong basin has largely proceeded on a project-by-project basis without benefit of a binding, integrated basin-wide plan which provides equal emphasis on protection, resilience as well as economic development. The consequence of this unplanned approach is an exacerbated level of adverse environmental and social impacts. The same quantum of electricity as is being generated by hydropower today could have been achieved with a more sustainable portfolio of hydropower with less than half the impact on basin sediment flows had a regional portfolio planning approach been adopted (Schmitt et al, 2018). In addition, non-hydro renewables now offer a viable option for large scale power generation, reducing the relative economic benefit of hydropower development.

Following Rideout et a (2021) we focus upon sediment transport throughout the basin as a foundational condition for the ecological health of the system and propose an agenda for rewilding the Mekong to enable a recalibration of this trade-off and allow for better economic, social and environmental outcomes. Our proposal for rewilding is based on three main management objectives which relate to three main categories of basins (Figure 3). The potential basin wide implications of rewilding are significant, it could shift the development trajectory of the Mekong from its current course of degradation and instability towards a restoration of sediment and nutrient transport, rejuvenation of floodplain and delta fertility and restoration of delta and alluvial channel stability. We identify three distinct management objectives for rewilding which respond to the different development states of Mekong basins.

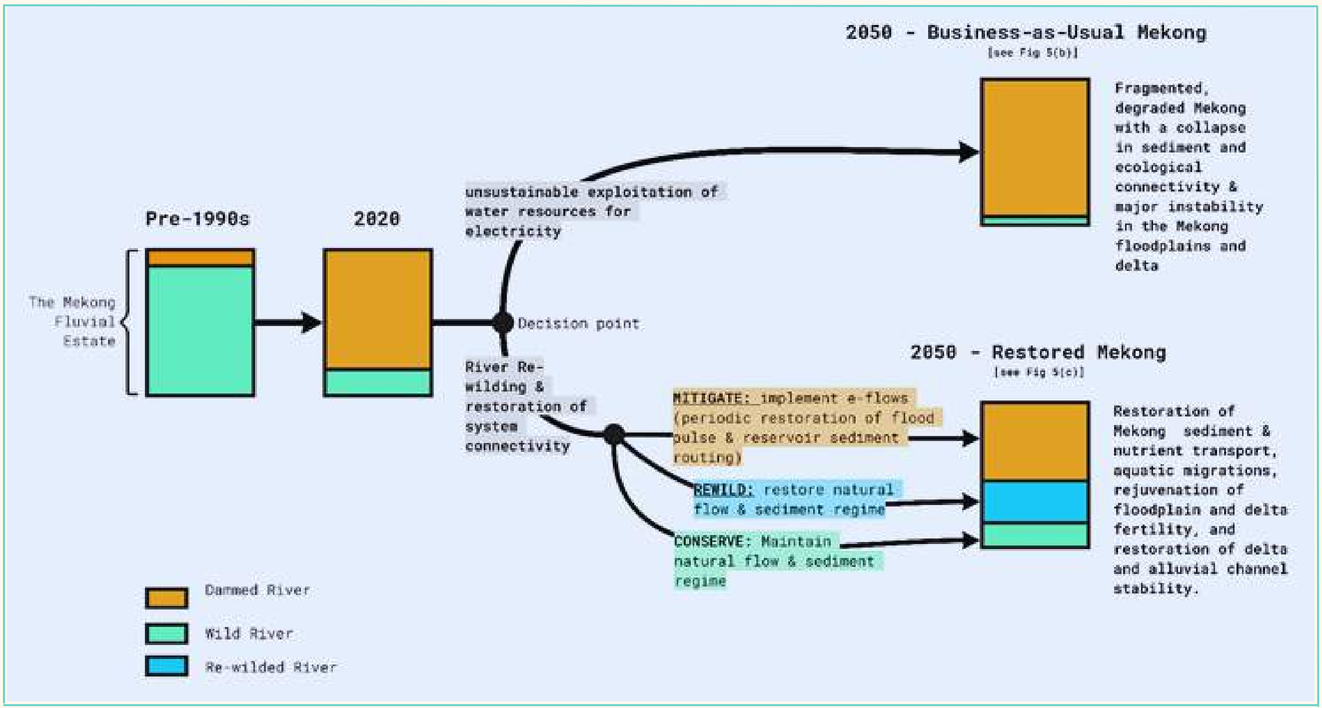


Figure 4: An agenda for rewilding the Mekong fluvial estate

Rewilding in free-flowing tributaries

The extent of hydropower development means that only 9% of the Mekong tributary and headwater areas flow freely into the lower Mekong mainstream. By 2050 as little as 3% of the tributary catchment area could remain free flowing. These remnant wild catchments include a number of small catchments draining into the Mekong upstream of Vientiane, as well as a number of larger tributary catchments in central Laos draining the Annamite mountains. They possess an elevated level of importance in maintaining the remnant sediment dynamics for the whole basin given the degradation experienced in dammed rivers. For the 9% of river reaches and tributaries that have never been regulated by a large hydropower project the re-wilding management objective should emphasise preservation of hydro-ecological processes to maintain the efficacy of sediment transport dynamics. An Intact Rivers or free-flowing rivers policy provides a managerial instrument capable of implementing the rewilding objective for free-flowing rivers, and has been utilised in other basins globally; as well as currently being considered by Government of Laos in the development of their new national water resources strategy.

Rewilding in dammed tributaries

In the vast majority of the Mekong basin a hydropower dam, or a cascade of dams' act as barriers regulating flow and fully, or partially, blocking sediment transport from the headwaters of tributaries to the Mekong mainstream. For each of these tributary rivers and their catchments society must weigh the adverse ecological and social impacts of hydropower against its energy and economic benefits. For tributaries in which impacts outweigh benefits (e.g., where notable sediment sources and/or spawning grounds for migratory fish are cut off by dams), management objectives should arguably focus on dam removal and restoring the system's connectivity to restore the supply of sediment to the Mekong mainstream. For this dam removal agenda to be effective, we must also consider basin wide connectivity, ensuring that any sediment transport restored in a tributary catchment can be transported unimpeded to the floodplains and delta downstream of Kratie. Hence, while rewilding must be implemented at a tributary scale, it is also essential that a basin-wide approach, which takes into account the full system level understanding of sediment transport dynamics, is employed to ensure that sustainability gains at the tributary scale accrue their benefit at the basin scale.

For some dammed tributaries where the benefits of hydropower generation far outweigh the adverse social and environmental costs, dam removal would not typically be justified. In these tributary basins a secondary rewilding objective is to improve the effectiveness of sediment transport by implementing an environmental flow regime which restores the flood pulse and coordinates sediment passage through reservoirs.

Sediment routing for large reservoirs and cascades of reservoirs is not a new phenomenon and there are several stakeholders who have proposed this for the Mekong. However, proposals for sediment routing should be cognizant of the limitations facing this management measure. First, the flood pulse hydrology of the Mekong means that 60% of sediment is transported during the 1-2 months of the flood peak, which means that passing sediment through the reservoirs would require near-complete restoration of the flood pulse if the natural grain sizes and volumes are to be effectively resuspended and mobilised. Second, in most dammed rivers where the sustainability calculus favours retaining reservoirs (rather than dam removal), there are likely several hydropower projects in cascades producing a large quantum of electricity. In these cascade conditions there are physical limits to the efficacy of sediment routing; for example, if each reservoir in a cascade of ten projects has a 90% efficiency to route sediments through its structure, only 30% of the sediments would make it through the whole cascade. From a system-wide connectivity point of view sediment routing is a second-best option compared to dam removal.

A preliminary assessment of rewilding priorities

In order to make decisions on which rivers to dam, which to rewild and which to preserve as wild, this study utilises a river reach analysis based on the marginal trapping efficiency (MTE) of each reach. The MTE incorporates the two important metrics of the hydropower-sediment trade-off – annual electricity production and annual sediment load – and compares the quantum of energy production foregone for each tonne of sediment restored (Mt/GWh). Comparison of river basins reveal that the MTE varies significantly across the basin from 58 tonnes of sediment trapped annually for each GWh produced in the Nam Theun – Kading basin to 2,033 t/GWh annually on Mekong mainstream Chiang Saen to Vientiane (Figure 4). River reaches with higher MTE would yield greater benefits to sediment continuity from rewilding than those with lower MTE values.

Based on maximising the total sediment load restored with the smallest reduction in power generation, we estimate that at Kratie a total of 37.5 Mt/yr can be added to the current situation (49.2 Mt/yr) increasing the load to 87Mt/yr. This amounts to 54% of the pre-dam load. In addition, an estimated 284Mt of sediment trapped in the reservoirs will be released as a pulse. Achieving this restoration of sediment load will require foregoing generation of 26,854 GWh each year.

A strategic rewilding program would focuses on the lower Mekong mainstream zones from Chiang Saen to Kratie. These zones contribute the majority of the restored sediment load (21.3Mt/yr), as well as serving as the main conduit for all restored sediment to reach the delta and floodplain. In addition, seven tributary rivers are also good candidates for rewilding: the Sre Pok and Xe Done; and the Nam Ou, Nam Tha, Nam Ma, Nam Khan and the Nam Pouy (Table 2). This restored load reconnects 90% of the fragmented Lower Mekong load to the downstream floodplain and represents the upper limit of rewilding the Mekong without rewilding the Lancang.

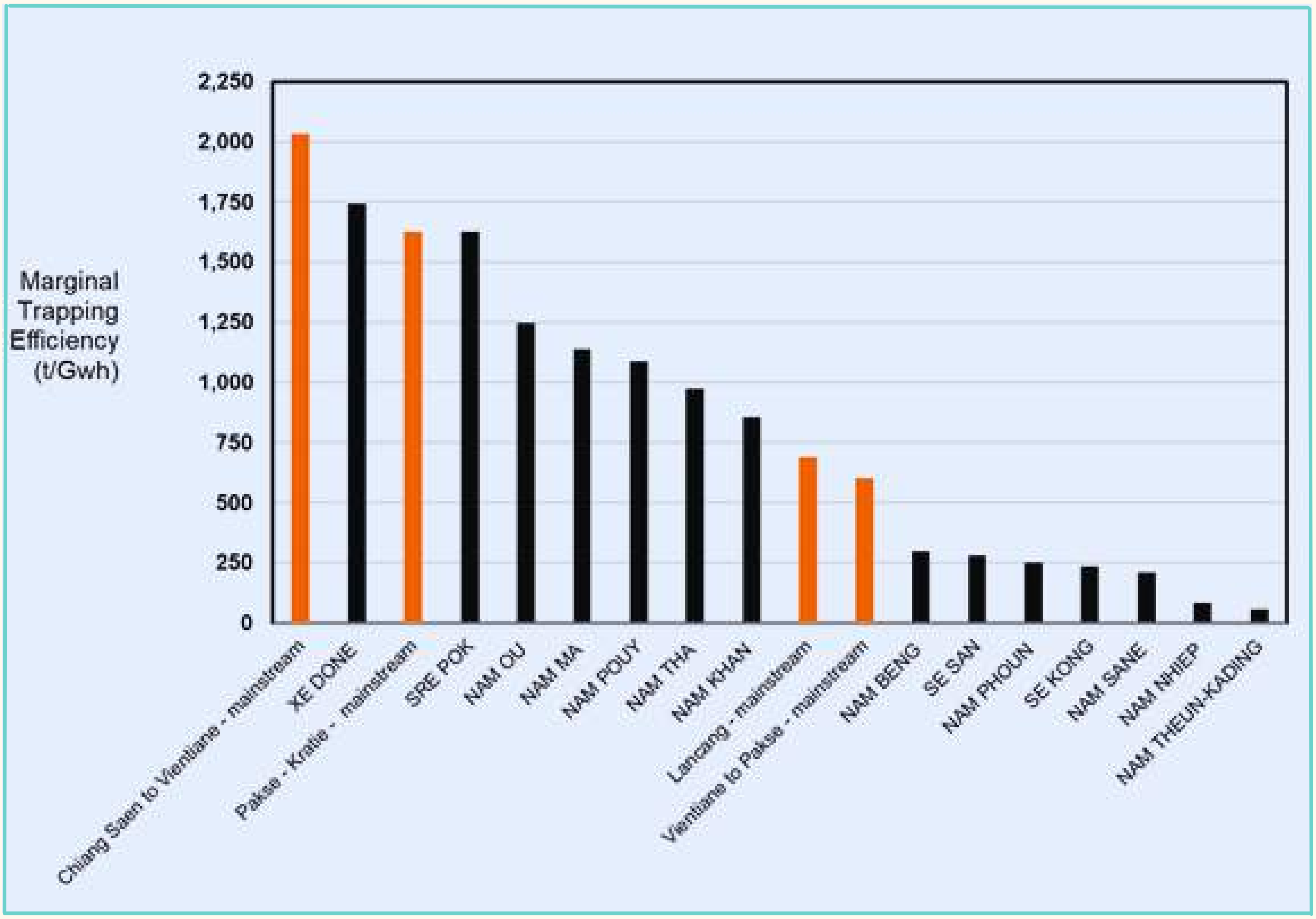


Figure 5: Marginal Trapping Efficiency of Mekong river reaches with existing projects (Mekong mainstream reaches in ORANGE)

Mekong River Reach	Area	Hydropower projects		Sediment characteristics		Marginal Trapping Efficiency
	(km2)	*Foregone productio n (GWh/yr)*	*Existing 2020 load (Mt/yr)*	*Additional sediment load (Mt/yr)*[4]	*Released sediment pulse (Mt/yr)*	*t/GWh*
Mekong mainstream (Chiang Saen – Vientiane)	89,327	6,750	23.4	13.7	28.7	2,033
Mekong mainstream (Vientiane to Pakse)	192,528	5,920	35.3	0.7	158	599
Mekong mainstream (Pakse to Kratie)	33,443	2,375	49.3	3.9	7.8	1,626
Xe Done	7,860	497	0.8	0.9	28.7	1,746
Sre Pok	32,618	5,340	7.9	8.7	55.9	1,626
Nam Ou	29,473	3,663	1.3	4.6	16.9	1,248
Nam Ma	3,235	577	0.02	0.7	3.3	1,138
Nam Pouy	2,017	172	0.08	0.2	0.2	1,089
Nam Tha	10,228	759	1.4	0.7	1.5	974
	8,340	801	0.4	0.7	4.1	854
	409,071	**26,854**	**49.3 @ Kratie**	**38**	**284**	

Table 2: Summary of rewilding priorities

[4] Note that this additional sediment refers to the additional sediment trapped within that reach and restored. For the Mekong mainstream, these reaches also serve as conduits passing released sediment that arrives from upstream and passes through the reach.

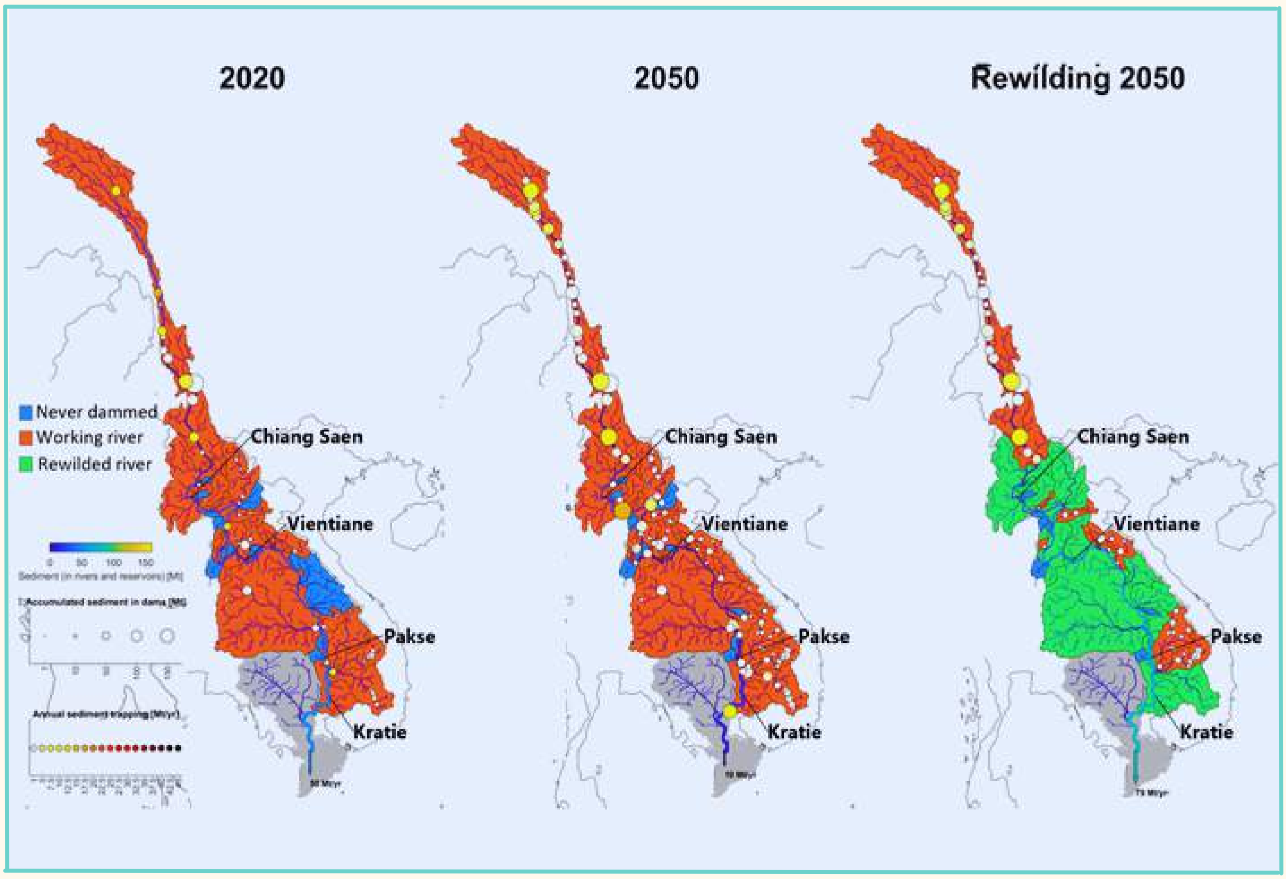


Figure 6: Scope for rewilding the Mekong: (a) 2020 - the current fragmentation of the Mekong basin; (b) 2050 – tthe business-as-usual case for the Mekong if all planned hydropower projects proceed, and (c) Rewilding 2050 – an initial scope for rewilding the Mekong

Strategic implications of rewilding the Mekong

Despite the importance of strategic trade-offs we have referred to in the literature, the reality of the situation is that considerations of the putative economic benefits of hydropower when considered against the costs are moot. Not only do these considerations, constructed as they are in terms of a narrow cost-benefit analysis, leave aside broader strategic concerns, such as the macro-economic impacts of Lao PDR's infrastructure boom, including the increased unsustainability of national debt (Barney, et al, 2021); a good portion of the sustainable development benefits attributable to the development of hydropower are contingent upon effective management of revenues, something which in the weak institutional environments of the basin are far from guaranteed.[5]

Rents generated from hydropower dams on the Mekong are not evenly distributed between countries or groups within countries. The main beneficiaries are electricity users in China, Lao PDR, Thailand and Vietnam and importing countries (mainly Thailand), financiers and project developers, EPC contractors and suppliers and the governments which host the projects, most notably that of China, Lao PDR and Vietnam. Within these broad categories there is likely to be a range of both legal and illicit interests. The benefits of cheaper, more reliable or cleaner power are

[5] To cite the World Bank's NT2 website: "If the around US$2 billion in revenues are spent efficiently, and transparently—in accordance with project agreements—NT2 will provide significant support to Lao PDR's poverty reduction and environmental management efforts. (italics added)". The same could be said of similar hydropower projects in the region. That the World Bank chose to caveat the potential of this revenue to contribute to sustainable development as being contingent upon appropriate use of resources by the government is significant. And points to the fact that it is unlikely that adequate safeguards are fully in place. This issue is likely to be even more acute for projects with no IFI involvement.

widely distributed. However, other benefits such as those associated with project development, financing and ownership are likely to be much more concentrated – with political and economic elites.[6] These beneficiaries in particular are likely to resist any move to decommission hydropower projects - as this will potentially threaten the current and future rent streams these groups are able to appropriate.

In this context, it is clear that any decision to decommission or remove dams will not be a technical one,[7] but one determined primarily by the political economy context. Development of the hydropower sector has been a central plank of government policy in all Mekong countries with the exception of Thailand. There are powerful and entrenched lobbies in favour of hydropower,[8] therefore significant political resistance needs to be anticipated and addressed (See for example; Germaine et al,2017; Coleen et al, 2016; Brewitt, 2014). While a detailed examination of the political economy context and the detailed impact of removal of hydropower dams is beyond the scope of this paper, here we identify some key institutional and political economy considerations related to dam removal and suggest some strategies for overcoming them.

Firstly, there is an important distinction between economic rents obtained as a consequence of formal institutional and legal processes (e.g., PPAs, loan agreements, contracts for the supply of goods and services etc.), and economic rents obtained through 'informal' processes (e.g., kick-backs, bribes, embezzlement) typically enabled by patronage networks. It is important to note that informal rents while orders of magnitude smaller than formal streams of rent generated by these projects, concentrate benefits in the hands of a few elites and therefore have a disproportionate influence on decisions that are made (Stuart-fox, 2006). We should also note that informal rent generation practices are common in the countries of the basin, with many Mekong countries ranking low on Transparency International's corruption perceptions index (Transparency International, 2021). And the World Bank's recent Public Expenditure and Financial Accountability Assessment also found "weak and inefficient public sector management", in many southeast Asian nations, particularly in terms of accountability, government effectiveness, regulatory quality, rule of law, and corruption (World Bank 2019)."

In these regards, there are clear possibilities for compensating the legal beneficiaries of decommissioned dam projects. What may be more difficult, is recognising the real politick of the context, and the real possibility of, explicitly or implicitly, compensating *informal* interests. If not explicit, there likely needs to be a tacit recognition of these rent seeking practices and a means of compensating their loss through the provision of other legal opportunities.

Considering losses associated with national level power production, these could potentially be compensated for by a concentration on renewables technologies such as wind and solar (Waldman et al, 2019). This may address domestic electricity consumption needs as well as the need to generate export revenues. Already the Monsoon Wind farm project is under development in southern Laos and will export 600 MW of electricity to Vietnam. Similarly, remaining hydropower plants could be augmented and enhanced by the provision of floating solar PV (ADB, 2019); or through retrofitting some reservoirs for pumped hydro storage operations. According to recent research the potential for each of solar PV, onshore wind, and pumped hydro storage in the Greater Mekong Subregion (GMS) is at least two orders of magnitude larger than current installed capacity of the region (Stocks et al, 2021).

[6] For a description of Lao PDR as a rentier state see Barma, (2014)
[7] Whether that considers economic, social or environmental factors.
[8] See for example, Matthews (2012) or Hancock et al (2018).

One of the significant advantages of the new renewables energy boom in the region is that the switch in technology (hydro to solar or hydro to wind) may still allow project development to adopt conventional, established political economy dynamics of infrastructure development in the Mekong – in doing preserve the accrual of both formal and informal rent. While this may not improve the economic efficiency of infrastructure development it would make the technological change from hydro to renewables more palatable for formal and informal stakeholders.

There is also the potential for the more extensive development of smaller scale distributed generation, which may be more effective in realising livelihood improvement goals by better enabling supply to more remote areas given low population densities in these areas of the country and prove to be more resilient than the centralised model currently being pursued.

Secondly, it will also be necessary to compensate investors in these projects. Simple expropriation of the projects, if feasible at all from a geo-political perspective, would mean massive financial losses for investors and would likely seriously damage prospects for future FDI investment in countries that attempted such a course of action. Compensation schemes could be based upon the ADB proposal for the early retirement of coal plants in Southeast Asia. The plan is to use a facility with a mixture of debt, equity and concessional finance to purchase coal plants (i.e, "blended finance"). The lower cost of capital available to the proposed facility than that available to commercial plants would allow them to make a larger profit, for a shorter time, generating similar returns but with earlier decommissioning than would have been the case with private financing (Reuters, 2021). If this model is adopted and shown to be workable, a similar approach may also be an appropriate means to enable the early decommissioning of dams on the Mekong.

Thirdly, decommissioning may be met with resistance from the hydropower sector, both private and within government as this would set a precedent and likely have a negative impact on investment in the sector. In the longer term this could be mitigated by better social and environmental due diligence, if proper consideration of social and environmental impacts were made before development of hydropower plants there would be little risk that they would need to be decommissioned at a later date. Although it should also be acknowledged that stricter due diligence may also be resisted as it would be likely to affect investment in the sector would slow down the development.

Finally, as noted above, the likely illicit benefits captured in the process of plant development and operations by various elites will likely pose a significant barrier. The elites able to appropriate these resources will resist decommissioning as it is likely to stymie the development of future projects and generation of further rents. Ethically, the best approach is to clean up and better ensure good governance in the permitting, procurement and operations of projects thus removing this incentive. Realistically, if other rent generation opportunities are available – such as in renewables, or other profitable sectors, elites may be convinced to support them. At present, the generation of illicit economic rents is likely closely tied to the hydropower sector.

Conclusions

Trade-offs – the pursuit of superior performance in one objective gained by lowering the performance of another objective (Nunes et al, 2020) – is inherent to sustainable river basin planning as managers seek to balance a diverse and complex portfolio of interconnected social, economic and environmental outcomes. In the context of the Mekong, the predominant trade-off has emerged between hydropower as a strategy for electricity generation and economic growth, and preservation of the unique hydro-ecology of the Mekong which is the basis for diversity and productivity of both ecosystems and human communities. As demonstrated in this paper, the former concentrates benefits into one sector and a smaller stakeholder base who possess a closer proximity to political power, while the latter sees benefits accrue through a wide range of sectors dispersed to tens of millions of people across both rural and urban areas of the basin.

In recent years the evidence is clear that the balance in this trade-off has swung heavily in favour of unregulated and often uncoordinated deployment of hydropower. The Mekong fluvial estate – an assemblage of globally important habitats, biodiversity and natural resource dependent communities is fragmented, degraded and under increasing threat. The annual sediment load of the Mekong has already been reduced by 70% to 49Mt and could be reduced by 95% to 9.3Mt if all planned hydropower projects are commissioned.

At the heart of this trade off is 146,585GWh of annual electricity production which results in the loss of 110 Mt of sediment transport each year. This trade-off has been accepted as a necessary fait accompli by the MRC and its member countries.

In this paper we show that unsustainable decisions can be reversed, and that river rewilding offers a pathway for restoration that could have profound implications. If the lower Mekong countries of Cambodia, Laos, Thailand and Vietnam commit to rewilding the Mekong, then dam removal could restore 37.5Mt of sediment transport, increasing the load to 87Mt/yr (54% of the natural load). This rewilding agenda would require a removal of all Lower Mekong mainstream dams, as well as large dams in six tributaries of Lao PDR (Xe Done, Nam Ou, Nam Tha, Nam Ma, Nam Khan and the Nam Pouy) and the Sre Pok in Vietnam and Cambodia.

A program of rewilding must also address the significant costs of dam removal. First the restoration of 37.5Mt/yr of sediment transport would induce a reduction in electricity production of 26,854 GWh/yr. The rise of non-hydro renewables offers an opportunity to replace the lost quantum of electricity generation, cheaply and, potentially with strong technical compatibility with remaining hydro (e.g., through floating solar PV on reservoirs). Importantly, the switch in technology (hydro to solar or hydro to wind and through retrofitting some existing reservoirs for pumped energy storage) may still allow project development to adopt conventional, established political economy dynamics of infrastructure development in the Mekong – in doing preserve the accrual of both formal and informal rent, which could increase sectoral and political appetite for rewilding.

Second, and more challenging, all hydropower in the Mekong basin were built with a long-term contract for the sale of electricity. The early removal of a dam prior to its contractual operating life will result in massive financial losses for investors, and seriously damage investment confidence for foreign and domestic investors in Mekong countries. Compensation will be required and could be adapted from compensation schemes for early coal-plant closure which industry and government are trialling in Southeast Asia and other coal-dependent regions of the world.

Third, rewilding of dammed rivers is a remedial measure designed to correct unsustainable decisions. At the same time there remains an urgent need in the Mekong to improve social and environmental due diligence and the quality of integrated planning. These efforts would allow managers to properly account for social and environmental impacts before hydropower projects are built which would reduce the risk of early decommissioning at a later date. A binding, evidence based intact rivers policy for the remnant wild rivers of the Mekong, coupled with a binding integrated river basin plan for the whole Mekong, and robust environmental and social safeguards that accurately internalise environmental externalities are therefore essential for any agenda to rewild the Mekong. Progress must be made on these fronts as well.

Finally, the case for rewilding is made through a simplified conceptualisation of the trade-off between electricity production and reduced sediment transport. In reality, the Mekong is much more complex there are a wider suite of dimensions to this trade off, fish migrations, navigation and water infrastructure for irrigation to name a few. Further steps are needed to expand the discussion of rewilding in these directions.

The agenda for rewilding sketched above introduces a novel idea and an ambitious reorientation of the sustainable development agenda for the Mekong. The intention is to open a discussion with stakeholders in the region on a topic which has little exposure to date but is gaining traction globally as a viable, effective approach to restoring degraded river basins. The proposed shift in planning is profound and will need substantial discussion on its merits among experts, riparian communities and the wider public in order to turn an interesting idea into an understood, effective and palatable part of the solution for the dire problems facing the Mekong Region.

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