Letters from the

MEKONG

TOWARD A SUSTAINABLE WATER-ENERGY-FOOD FUTURE IN CAMBODIA

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On the cover: Sunrise on Tonle Sap Lake

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Satellite image of Cambodia's Portion of the Mekong Basin

EXECUTIVE SUMMARY

This issue brief, the fifth in Stimson's *Letters from the Mekong* series, looks at Cambodia's Tonle Sap Lake as the heart of the Mekong's robust provision of natural resources and introduces alternative pathways for development which can optimize trade-offs to the water-energy-food nexus. These alternative approaches include basin-wide water-energy planning and a deeper incorporation of non-hydropower renewable energy sources into Cambodia's future power mix. If utilized, these alternative pathways can avoid upstream fragmentation of Tonle Sap and Mekong Basin connectivity and preserve the annual monsoon pulse, which underpins the unique conditions that make the Tonle Sap the world's largest freshwater fishery.

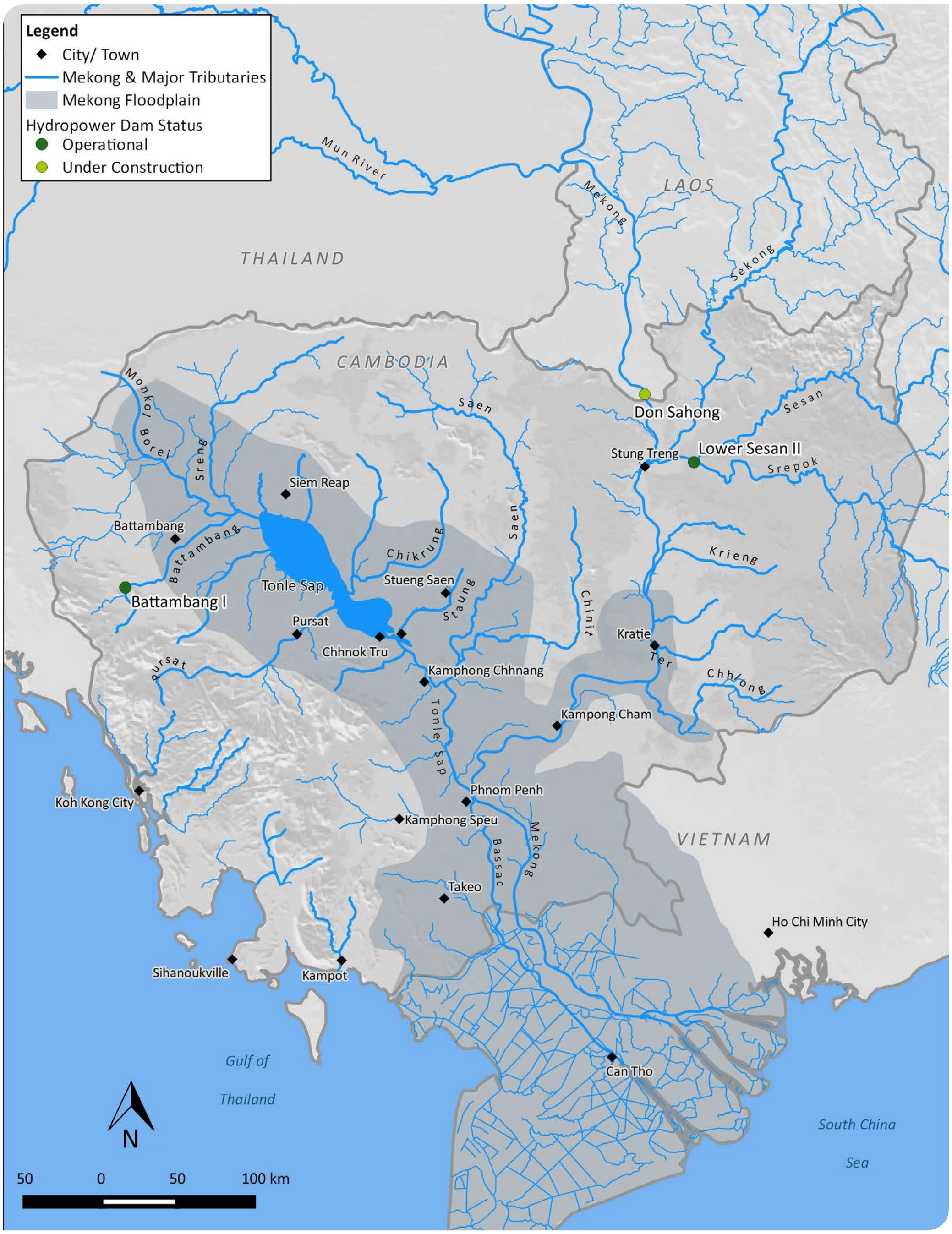
Each year, the entire Mekong Basin produces a 2.6 million tons freshwater fish catch that supports the diets and livelihoods of more than 60 million people living in the basin. To put this into perspective, the total catch from wild fisheries in all of North America's lakes and rivers is only 450,000 tons. The Tonle Sap Lake alone provides an annual freshwater fish catch of around 500,000 tons, which provides Cambodians with 75% of their protein intake. Hundreds of species of fish spend a portion of their lives in the Tonle Sap and then migrate to other parts of the Mekong River system in Laos, Thailand, and Vietnam where some are caught and contribute to the Mekong's overall fish catch.

The annual flooding and draining of the Tonle Sap Lake acts as the natural engine or heartbeat that pumps life throughout the Mekong Basin. This heartbeat is threatened by the ongoing construction of and future plans for hydropower and irrigation dams upstream of the Tonle Sap in Cambodia, Laos, Vietnam, and China. Dams and other built structures block or reduce flows in the Mekong, which reduces the amount of water, fish, and nutrients going into the Tonle Sap each year and also constricts the ability of fish to find upstream habitats. In Cambodia alone, the connectivity of the country's 11,000 kilometers of the Mekong/Tonle Sap river system has already been reduced by 31% by the construction of two hydropower dams and six irrigation reservoirs. The improper siting of dams on Cambodia's tributaries would reduce connectivity by more than 60%, and mainstream dams at Sambor and Stung Treng would cut the Tonle Sap's connection to most of the Mekong River system.

Cambodia needs to develop energy projects to meet rising electricity demand and drive economic growth. Hydropower will and should play an important role in Cambodia's future energy mix, but system-scale planning methods can be used to site and operate Cambodia's future dams in ways that have minimal to no impacts on Tonle Sap connectivity. Hydropower dams can also be sited and operated in ways to pair with intermittent sources of renewable energy such as solar, wind, and biomass that would lead to a more diverse and resilient energy system.

This report introduces system-scale planning methods, provides policy recommendations, and identifies research opportunities which policymakers and other stakeholders in Cambodia can use to develop a more sustainable water-energy-food future for the Tonle Sap Lake and the Mekong basin at large. This report also identifies specific ways in which development partners and investors can engage with stakeholders in Cambodia to develop water and energy resources in ways that more sustainably meet Cambodia's economic development goals.

CAMBODIA'S TONLE SAP: THE BEATING HEART OF THE MEKONG BASIN



The Mekong River flows for more than 4000 kilometers through portions of (or along the border with) China, Myanmar, Laos, Thailand, Cambodia and Vietnam. Many stakeholders who follow Mekong development issues know that the Mekong's waters originate in China's Qinghai-Tibetan Plateau. However, the Tonle Sap Lake, Southeast Asia's largest, is also an important point of origin for the Mekong system. Each year from the lake comes forth a wellspring of life, mostly in the form of a massive fish population that migrates from the lake to the far reaches of the Mekong system both upstream and downstream. Approximately 1.2 million people living around the lake draw resources directly from it, and the annual migration of fish provides tens of millions of households throughout the Mekong Basin with a reliable form of protein and nutrition.

Like the rest of the Mekong Basin, the Tonle Sap receives seasonal flood from the monsoon rains. Unique among all rivers in the world, the Tonle Sap swells each monsoon season when massive rains reverse the directional flow of the Tonle Sap River, sending water, fish, and fish eggs from the Mekong River system flooding into the lake. This makes the Tonle Sap the beating heart of the Mekong Basin. The complex seasonal shifts transform this lake into the forms the basis of world's largest freshwater fish catch upon which Cambodians rely for more than 75% of their protein intake. Each year more than 500,000 tons of fish are caught in or around the Tonle Sap Lake. Comparatively, all of the freshwater lakes and rivers in North America combined produce about 450,000 tons of fish annually. Cambodia's annual fish harvest is currently valued at up to $600 million per year.[1] The dynamic natural processes that happen within Tonle Sap Lake underpin the economic and environmental security of not only Cambodia, but for the region as a whole. But these processes are threatened by plans for upstream dams, climate change, and unregulated human activity around the lake.

During the dry season, the Tonle Sap River drains water out of the Tonle Sap Lake and feeds into the mainstream of the Mekong River at the Chaktomuk confluence at Phnom Penh. Then when the monsoon rains come from the Himalaya and the South China Sea in the summer months, a swelling pulse of water begins to build in China's Yunnan province and accumulates through the Golden Triangle area. Mostly all of the monsoon rains in Laos and all of northeast Thailand contribute to that pulse. When the Mekong enters Cambodia, waters from the Srepok, Sesan, and Sekong Rivers (known collectively as the 3S Rivers) flow into the mainstream. As the monsoons peak, these floodwaters begin to spill out of the Mekong and toward the Tonle Sap Lake as far as 150 kilometers above Phnom Penh.

Into the summer months, farther downstream, the level of the Mekong mainstream at the Chaktomuk confluence rises higher than the Tonle Sap River, and gravity causes the flow of the Tonle Sap River to reverse, sending water flowing back into the Tonle Sap Lake system. This yearly reversal causes the Tonle Sap to expand more than five times its dry season area. At the peak of the monsoon season, the lake will expand to approximately 60 times the volume of water held during the dry season, and its depth fluctuates by as much as 8 meters. A massive mix of nutrient-rich sediment, rotting organic material, grown fish, fish eggs, and larvae flush into the lake, forming the base of a food web that produces an explosion of aquatic life. As the lake expands, fish migrate deep into the Tonle Sap's flood plain to feed on rotting organic material and microorganisms that thrive in this habitat. More than 150 species of fish are found in the lake, making it one of the most biodiverse bodies of freshwater on the planet.

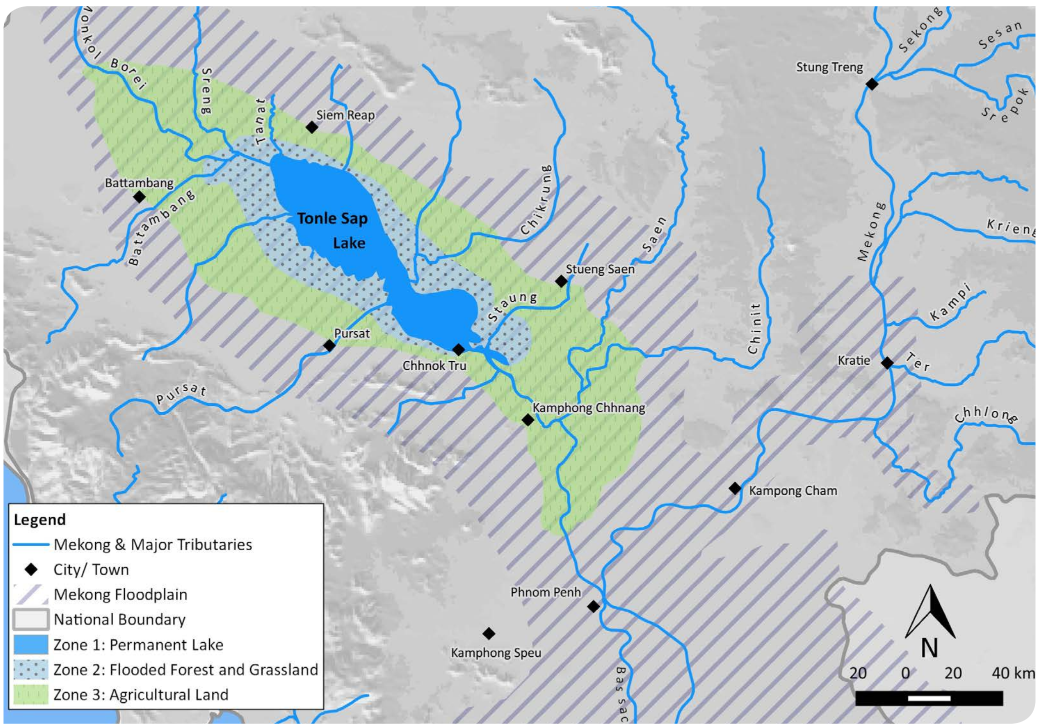
1 Marko Keskinen, et al., "Tonle Sap Now and in the Future?" *Water and Development Publications*, 2013, 13.

When the monsoons wane in November and the dry season approaches, those flooded areas recede, and gravity slowly drains the contents of the lake back into the Mekong mainstream. Most of the sediment that entered the lake is flushed downstream, where it contributes to agricultural production on the Mekong Delta floodplain in Cambodia and Vietnam. The distribution of sediment to the delta also contributes to the expansion of land out into the ocean and supports the delta's overall geological integrity. One of the planet's largest fish migration leaves the Tonle Sap, returning to traditional spawning grounds to lay eggs and wait for the annual cycle to begin again. Some fish migrate upstream to make their way above the Khone Falls at Cambodia's border with Laos, which is more than 500 kilometers from the lake. Others travel up the 3S Rivers or move downstream to Vietnam's Mekong Delta. Some fish also migrate deep into the tributaries that encircle the Tonle Sap.

The annual migratory cycle caused by the lake's expansion and contraction is a necessary rhythm for the fish population of the Tonle Sap Lake and Mekong Basin on the whole. And it has been shown that the power of annual monsoon flooding is directly related to the size of the fish population. In 2004, J. Sarkkula et al. found a direct, positive correlation between flood level and annual fish catches in the Tonle Sap. In other words, the higher the flood level, the higher the annual fish catch.[2] Thus maintaining the nature-driven monsoon pulse and subsequent floods are critical for the preservation of the Tonle Sap's annual fish catch.

2 Juha Sarkkula, et al., "Tonle Sap Pulsing System and Fisheries Productivity" (paper presented at the 29th *International Congress of Limnology*, Lahti, Finland, August 8-14, 2004), 12.

To gain a better understanding of the how Tonle Sap's complex ecology works, the lake can be divided into 3 zones of concentric circles. The innermost zone is the permanent lake, always filled with water. Next is a zone of flooded forest and grasslands which is inundated for about 5 to 8 months of the year during the monsoon season and populated with trees and bushes. This flooded forest area measures more than 7,000 square kilometers and is the most important zone contributing to the Tonle Sap's productive fisheries. Eggs and fish larvae flushed into the lake by the monsoon pulse find habitat in the flooded forest and thrive on the explosion of nutrients from rotting organic material in the flooded forest. Finally, an agricultural zone rich in sediment deposited by the highest floods forms a peripheral area around the lake. The diagram below demonstrates the relationship and size of these zones.



The Tonle Sap's flooded forests are threatened by unregulated timber collection for cooking fuel, home building, and commercial use. Because the flooded forests are rich with deposited sediments, local farmers often clear forests for planting cash crops in the dry season. This behavior robs the next season's fish migration of habitat and food sources. Many of the Tonle Sap's 800 species of fish, birds, reptiles, mammals, and amphibians live in the flooded forest zone. Seventeen globally-threatened or near-threatened species of birds live around or migrate annually to the lake, and most of them find habitats in the flooded forest area. Removing forest cover in this zone threatens their survival. The intense planting of cash crops in the flooded forest zone also introduces toxic chemicals from fertilizers and pesticides into the lake during the monsoon season.

The scale of human activity on clearing the Tonle Sap's flooded forests is widely unknown and deserves greater study. Such human activity can be managed in a sustainable manner by strengthening land and forestry regulation as well as incorporating community-based forest protections measures through establishing community-based conservation zones or incorporating eco-tourism modalities which limit the human footprint on this critical environment. Already efforts sponsored by relevant agencies within the Cambodian government, development partners such as the European Union, local NGOs such as the Fisheries Action Coalition Team, and international NGOs like the International Union for Conservation of Nature (IUCN) have achieved some effectiveness at protecting some portions of the Tonle Sap's flooded forest. These efforts should be expanded and strengthened.

RIVER CONNECTIVITY AND THE TONLE SAP LAKE

The Tonle Sap's annual influx of water, sediment, and biomass is the most critical contributing factor to supporting the lake's fish population, the prosperity of fishing communities around the lake, and by extension the food security of Cambodia as whole. This annual influx is the result of the Tonle Sap's connectivity with the rest of the Mekong River system.

River connectivity can be defined through several dimensions. A first dimension promotes connectivity from the river's headwaters to its mouth and ensures that the distribution of a river's sediment load from upland areas reaches low lying areas downstream where it contributes to food webs and agricultural production. This dimension of connectivity also ensures that migrating fish can access critical spawning grounds and seasonal habitats. This connectivity is impacted by any structures built across a river that block these critical environmental flows. Fish ladders and sediment flushing mechanisms built into dams and weirs can improve the connectivity impacts of these structures to a degree, but their mitigating results could be very limited. In order to be effective, mitigation infrastructure in the Mekong would need to support the movement of as much as thirty tons of fish per hour and be designed for the passage of hundreds of different species of fish of various sizes and swimming techniques. No effective mitigation infrastructure on this scale yet exists.

Above: Floating village on Tonle Sap Lake.

Promoting connectivity across flood plains is a second dimension of connectivity relevant to the Tonle Sap's ecosystem and the Mekong Basin at large. Natural floods distribute sediment across wide swaths of flat land, replenishing the soil with nutrients to support intensified agricultural production. When a river spills over into a floodplain, the heaviest sediments deposit first, creating fertile, natural levees geologically strong enough to support intensified human activity alongside rivers. To illustrate, Cambodia's cities and towns along the Mekong such as Phnom Penh (pop. 2 million) Stung Treng (pop. 111,000), and Kratie (pop. 38,000) are examples of this. Most of Vietnam's Mekong Delta population downstream from Cambodia also lives on these naturally raised levee areas such as Chau Doc (pop. 157,000), Long Xuyen (pop. 386,000), Can Tho (pop. 1.52 million, Soc Trang (pop. 173,000), among others. When sent farther across a flood-plain and toward a river's mouth, sediment distribution naturally fertilizes land and also maintains the dynamic land building processes that contributes to the resilience of landscapes.

The floodplain connectivity around the Tonle Sap Lake created conditions for the rise of the Khmer Empire more than one thousand years ago. Ancient city-states harnessed the agricultural productivity of the Tonle Sap floodplain and the lake's fisheries around its capital at Angkor to become one of the world's most powerful empires at its time. This connectivity continues to contribute to thriving agricultural production and fisheries in modern day Cambodia and the Mekong Delta downstream.

Cambodia produces about 10 million tons of paddy rice per year. This has historically been for domestic consumption, but in recent years Cambodia has transitioned to a net rice exporter, primarily to Vietnam where Cambodian rice is viewed as higher quality than rice from Vietnam's Mekong Delta.[3] Like Cambodia's fisheries, most of Cambodia's rice production comes from the Tonle Sap floodplain and the Mekong floodplain downstream from Phnom Penh. While floods certainly do cause damage to human settlements and agricultural activity each year in both Cambodia and Vietnam, their contributions to agricultural productivity far outweigh the costs. In 2017, the Mekong River Commission calculated the value of damage related to flooding in the Mekong floodplain and delta to be between $60–70 million dollars but calculated that the benefits reach $8–10 billion.[4]

Levees, dykes, roads, irrigation ditches, and other built structures prevent the rising river from reaching the floodplains and inhibit these benefits. For instance, in Vietnam's Mekong Delta, nearly two centuries of over-investment in dykes, sluice gates, and canals have cut off much of the delta's natural floodplain, so much so that achieving high agricultural yields requires increasing amounts of artificial fertilizers and pesticides. Chea et al have demonstrated how the increase of artificial inputs and loss of floodplain connectivity in the Mekong Delta has negatively impacted water quality.[5] In An Giang and Dong Thap provinces, located just across the border from Cambodia, dykes now encircle thousands of hectares of land with the purpose of achieving three yields of rice

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3 "Cambodia," Ricepedia, accessed October 12, 2018, http://ricepedia.org/cambodia/.

4 "Flood and Drought," Mekong River Commission, accessed August 1, 2017, http://www.mrcmekong.org/topics/flood-and-drought/.

5 Ratha Chea, Gael Grenouillet, and Sovan Lek, "Evidence of Water Quality Degradation in Lower Mekong Basin Revealed by Self-Organizing Map," *PLoS One* 11, no. 1 (Jan 2016): e0145527, accessed November 15, 2018, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4701190/.

per year. These encircled areas are now entirely isolated from the Mekong's seasonal floods. This isolation calls for increasing artificial inputs to achieve desired results. A high demand and low supply of these inputs is causing the cost of these inputs to rise year on year. Many farmers in the Mekong Delta are abandoning agricultural practices due to decreasing returns, or they choose to take on high levels of debt to maintain a livelihood. In 2016, 300,000 people left the Delta, many looking for jobs in urbanizing Ho Chi Minh City. [6]

Dams not only impact connectivity from headwaters to a river's mouth but also reduce floodplain connectivity by regulating the level of a river. The reduction of floods during high-precipitation monsoon seasons and release of more water downstream when precipitation and water availability is naturally low alters the flood cycle. These regulatory effects will undoubtedly change the dynamics of water flow in and out of the Tonle Sap. China operates ten mega-dams with a storage capacity of 47 billion cubic meters of water in its portion of the Mekong Basin. This volume accounts for about 10% of the Mekong's annual flow volume overall, but during the dry season an average of 40% of water in the entire Mekong system comes from glacial snowmelt and runoff in China's portion of the Mekong.

Above: 4200 MW Xiaowan Dam on the Mekong in China's Yunnan province

6 Mekong Delta scholar Nguyen Huu Thien in an interview with the authors, Can Tho University, May 26, 2018.

Proponents of China's upstream dams claim that these dams assist with natural disaster relief downstream by regulating and reducing floods during the monsoons and provide drought relief during the dry season. But continued regulation of the river, which is compounded by adding more dams to the basin in Laos and Cambodia downstream, will have a profound effect on the Tonle Sap's annual flood cycle. Upstream dams that release water in the dry season from December to May will raise the river's water level and thus prevent less water from draining out of the Tonle Sap. This will increase the amount of water held permanently in the lake. In turn, a portion of the lake's flooded forest will be permanently inundated. Then in the monsoon season, upstream dams will hold back more water in the monsoon season, lowering the river's average water level between May and December. This will decrease the size of the flood zone and move the boundaries of the flooded forest and flooded grassland closer to the permanent lake.

IS OVERFISHING A PROBLEM ON THE TONLE SAP?

- The Tonle Sap Lake has always been Cambodia's most targeted fishery. The 2012 ban on commercial fishing lots relieved some pressure on the lake's fish population, but lax regulations and increased human migration to the lake threaten the productivity of fisheries.
- The lake is not a selective fishery. Fishers harvest fish indiscriminately using large, often illegal, nets regardless of the size or species of fish. This kind of fishing removes the largest and scarcest fish from the lake first and reduces overall biodiversity levels. As a result, the lake's ecology and the human populations dependent on fish catches become more vulnerable to climate change and upstream dams induced shocks.
- NGOs and international organizations like IUCN have worked with Cambodia's government to achieve success in a few locally managed fish conservation zones which protect a few of deep pools and known breeding areas.
- More work needs to be done to protect the lake's critical habitats and teach fishers to protect and conserve critical species such as the Mekong Giant Catfish and the Giant Barb.

Ultimately, altering the seasonal flooding pattern will not only reduce the size of the flooded forest as habitat for fish but will also impact the overall availability of vegetation that grows in the flooded forests as a food resource. Moreover, with lower floodwaters rushing through the entirety of the Mekong system, fewer trees and bushes will be ripped away from the upstream portions of the river and sent into the Tonle Sap. Researchers Chouly Ou and Kirk O. Winemiller demonstrate in a 2016 study that decomposing vegetation transported into the lake from upstream via floods is the most important contribution to the nutritional base of the lake's food web. Sediment in the lake bed, 70% of which is delivered into the lake system from the Mekong mainstream by annual floods, also supports vegetation in the lake which in turn contributes to the lake's food web. Decreasing the influx of these various components will result in a major net reduction of nutrients available to support the lake's fish population.[7]

MODELLING CONNECTIVITY IMPACTS

In 2013, on behalf of the Cambodian government, Marko Keskinen, a senior water specialist from Aalto University in Finland, led a study to determine how upstream dams and future climate change impacts will change the Tonle Sap's flood cycle. The study found that if the effects of upstream damming and climate change—which is predicted to deliver shorter, more intense monsoon seasons—are considered cumulatively, the dry season water level in the Tonle Sap will rise between 0.5 and 0.9 meters.

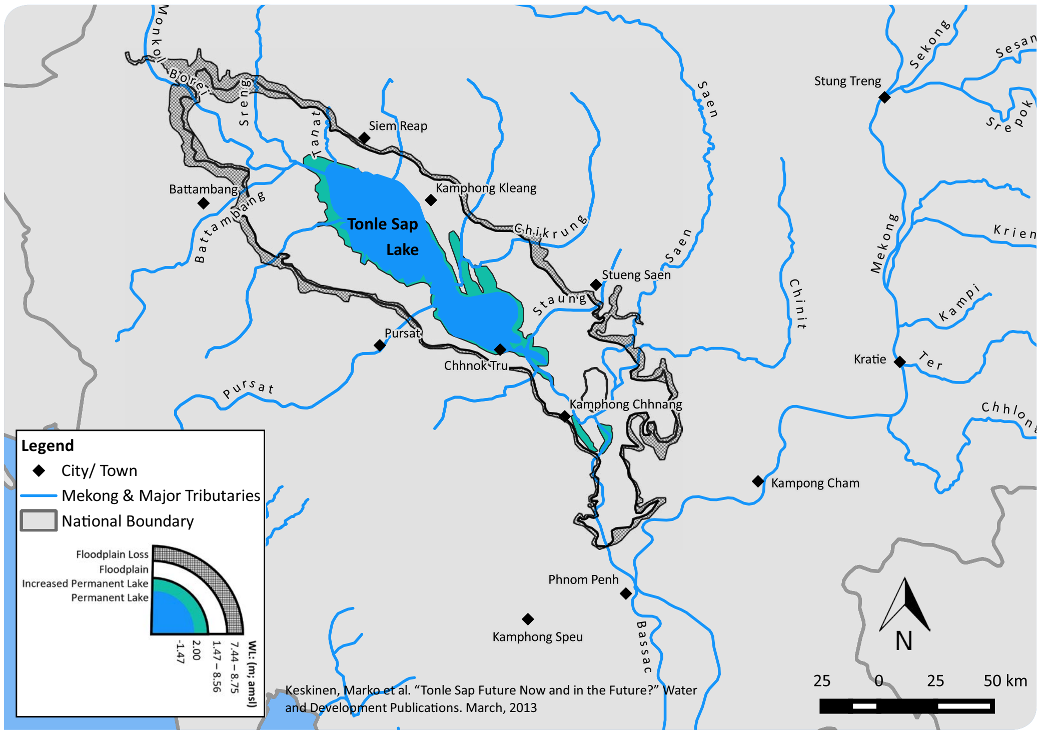
Keskinen's model considers the impacts of 126 dams built in the Lower Mekong through 2042 and 19 upstream dams in China. These dams could double or almost triple the amount of water in the lake during the dry season, increasing the lake's permanent area by 18–31 percent and killing all trees and terrestrial vegetation in this now permanently flooded area.. During the monsoon season, the reduction of flood waters into the Tonle Sap would reduce the current floodplain to 75 percent of its current area. Keskinen's modeling found that because of elevation differences, these impacts will affect different areas differently. The northwestern floodplain would experience the greatest reduction while the impacts to the more elevated areas around the lake's bottleneck would be fewer in comparison.[8]

The study found that while climate change will shorten the monsoon season, it will not have a significant impact on the size of the lake. However, more intense rains and frequent storms brought on by climate change will have a significant impact on fishing communities. The flooded forests act as buffers to protect inland areas from storms and rough water on the lake. With the increase of severe weather events brought on by climate change and a reduction of flooded forest buffer, floating communities and inland

7 Chouly Ou and Kirk O. Winemiller, "Seasonal hydrology shifts production sources supporting fishes in rivers of the Lower Mekong Basin," *Canadian Journal of Fisheries and Aquatic Sciences* 73, no. 9 (March 2016): 1344, accessed November 15, 2018, https://doi.org/10.1139/cjfas-2015-0214.

8 Keskinen, et al., "Tonle Sap Now and in the Future?" 27.

zones used for the planting of crops will become more vulnerable.[9] Household surveys conducted in 2011 among communities around the lake and inside the flooded forest zone also confirmed the increased perception of weather variability.[10]



A 2012 study by Stuart Orr, Jamie Pittock, David Dumaresq, and Ashok Chapagain examined how dams built upstream from the Tonle Sap would reduce the lake's fish population and subsequently impact the protein intake of Cambodians. Their findings suggest under a scenario of 11 mainstream dams (9 in Laos and 2 in Cambodia) built through 2030, damage to fisheries could cause Cambodians to lose up to 60 percent of total protein intake. When considering a second development scenario of eleven mainstream dams plus seventy-seven tributary dams marked for development through 2030, the study determined that Cambodia's protein losses could reach 100%.

To replace the fisheries loss delivered by upstream dam impacts with aquaculture, livestock and other protein sources, the study then measured the necessary increases to land and water availability. Under the first scenario of 11 mainstream dams, the study found Cambodia to require a 29-64% increase in available water and an 13-27% increase of available land. Under the second scenario of eleven mainstream and seventy-seven tributary dams, Cambodia would require an increase of 43-100% in water availability and 42-100% increase in land to replace protein lost by impacts to fisheries. Impacts to water and land needs in the second scenario actually call for replacement rates higher than 100%, suggesting Cambodia would need to turn into a net protein importer in the

9 Eric Baran, Petter Starr, and Yumiko Kura, “Influence of Built Structures on Tonle Sap Fisheries,” Cambodia National Mekong Committee and the WorldFish Center, 2007, 23, accessed November 15, 2018, https://www.worldfishcenter.org/content/influence-built-structures-tonle-sap-fisheries-synthesis-report-0.

10 Keskinen, et al., “Tonle Sap Now and in the Future?” 35.

medium term. These seemingly insurmountable costs will be borne against the loss of a productive fishery that currently produces robust annual fish catches at a comparatively low cost of equipment and time for fishers and ongoing conservation efforts.[11]

Hydropower Impacts to Cambodia's Protein Intake		
	Scenario 1 (11 mainstream dams)	Scenario 2 (11 mainstream dams plus 77 tributary dams)
Cambodia Protein Loss	60%	100%
Water expansion to replace protein loss	29-64%	43-100%
Land expansion to replace protein loss	13-27%	42-100%

Source: Orr et al. (2012). "Dams on the Mekong River: Lost Fish Protein and the Implications for Land and Water Resources." Journal of Global Environmental Change.

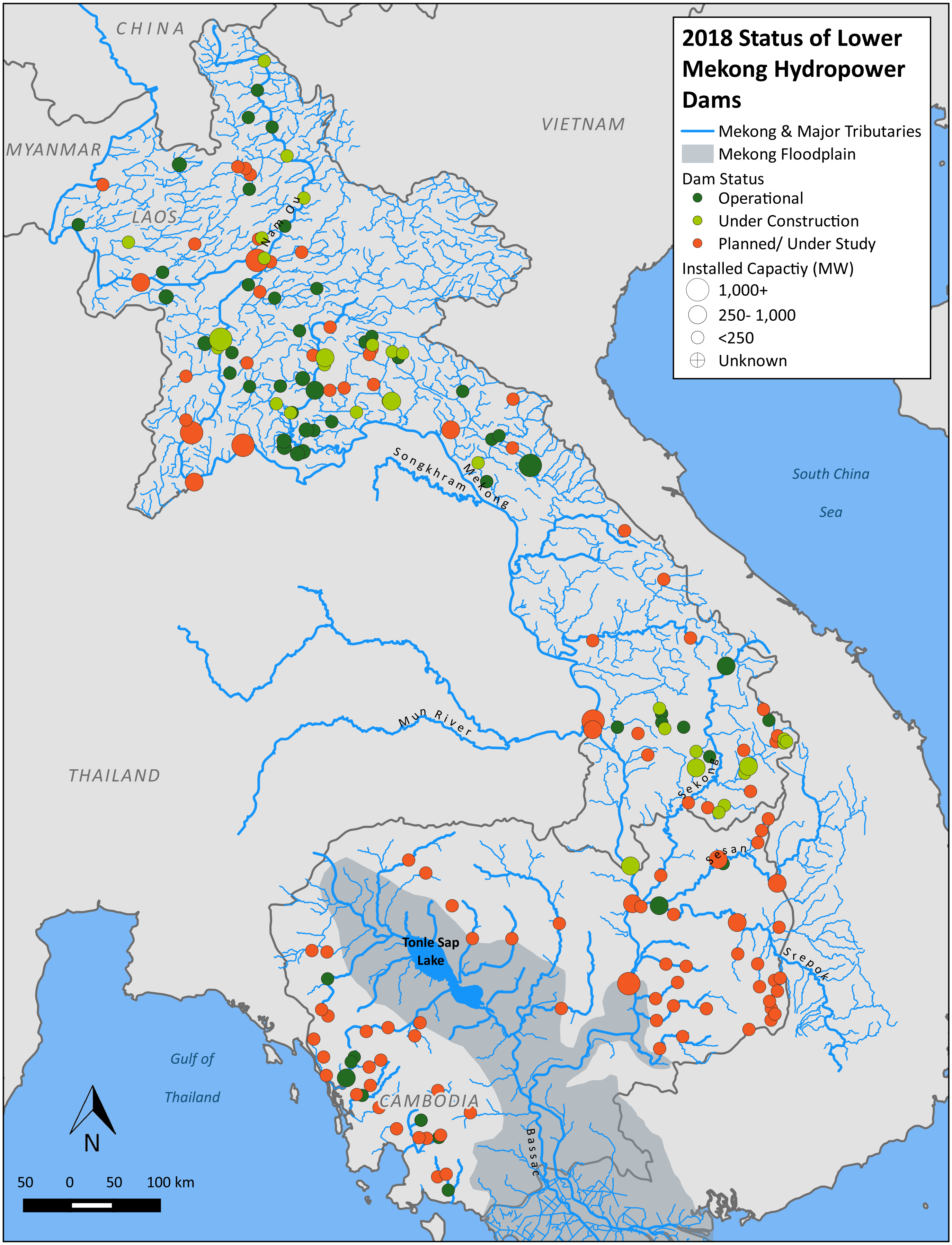
PROMOTING TONLE SAP AND MEKONG CONNECTIVITY IN CAMBODIA

Avoiding risks to the robust Tonle Sap ecosystem today through the exploration of alternatives development options will greatly reduce the future economic costs of mitigating any impacts related to Tonle Sap resource management or the replacement of those resources, should they be wiped out. If stakeholders in Cambodia move forward with a mandate to conserve the Tonle Sap's resources and promote livelihoods of those who live around the Tonle Sap, they will need to find a constructive strategy to engage with neighbors to change the manner in which future dams upstream in Laos are built out. Cambodian stakeholders will also need to dialogue with neighbors on how core environmental flows such as fish and sediment are managed through dams on tributaries and the mainstream once they are built and operating. Equally imperative is the need to avoid further reductions to connectivity between the Mekong and the Tonle Sap inside of Cambodia and maintaining the status of existing free flowing rivers.

Neither of these approaches is anti-dam, but both would require carefully siting and operating dams in locations where impacts are minimized and promoting alternative energy generation sources such as solar, wind, and biomass to meet energy generation requirements inside Cambodia and in neighboring countries. Given the severity of impacts that poorly designed hydropower development can deliver to fisheries and livelihoods in Cambodia, even scenarios which include a limited expansion of some fossil fuel generation such as natural gas or coal may be worth considering.

The following sections outline ways in which Cambodian stakeholders can engage with neighbors in the Mekong Basin and broadly with other stakeholders to achieve a sustainable future for the Tonle Sap.

11 Stuart Orr, Jamie Pittock, Ashok Chapagain, and David Dumaresq, "Dams on the Mekong River: Lost fish protein and the implications for land and water resources," *Global Environmental Change* 22, no. 4 (October 2012): 925-932.


2018 Status of Lower Mekong Hydropower Dams
Mekong & Major Tributaries
Mekong Floodplain
Dam Status
Operational
Under Construction
Planned/ Under Study
Installed Capactiy (MW)
1,000+
250- 1,000
<250
Unknown
CHINA
MYANMAR
LAOS
VIETNAM
THAILAND
CAMBODIA
South China
Sea
Gulf of
Thailand
Nam Ou
Songkhram
Mekong
Mun River
Sekong
Sesan
Srepok
Tonle Sap
Lake
Bassac
N
50
0
50
100 km

ENGAGING WITH NEIGHBORS

Laos has already completed sixty-three dams in its portion of the Mekong Basin with a total generation capacity of about 4900 MW. Another fifty dams are currently under construction with a combined generation capacity of about 5200 MW. Roughly 70 more dams with a combined generation capacity of more than 15,000 MW are planned or under feasibility study, and these include some of the largest dams on Laos's portion of the Mekong mainstream. It is important to note that as of 2018, only two of Laos's mainstream dams, the Xayaburi Dam (1285 MW) and Don Sahong Dam (270 MW), have started construction.

Most dams in Laos are built by foreign developers from countries such as Thailand and China under Build-Own-Operate-Transfer (BOOT) agreements. BOOT agreements usually consist of a foreign developer who builds the project, draws income and earns profit on the sale of hydropower from a project over a period of twenty to thirty years, and then turns the asset over to the Lao PDR Government at the end of the contractual period. This approach to hydropower development means that dams are built out on a "project-by-project" basis without an overall programmatic vision that weighs the tradeoffs of hydropower generation versus other benefits currently provided by nature-driven processes such as fisheries catches or sediment flow. The project-by-project approach to hydropower development in Laos creates a situation where the basin-wide impacts of Laos's hydropower development are unable to be quantified or properly mitigated. The Stimson Center highlighted the challenges and pitfalls of the project-by-project approach in its 2016 publication "A Call for Strategic Basin-wide Energy Planning in Laos".

Upstream hydropower development in Laos is determined by increasing demand for electricity in neighboring countries such as Thailand, Vietnam, and Cambodia. To promote upstream connectivity and reduce impacts to the Tonle Sap, Cambodia can work on a bilateral basis with Vietnam and Thailand to alter the path of future hydropower development in Laos.

It is in interest of Cambodian stakeholders to work with counterparts in Thailand to deliver demand side reductions to Thailand's power consumption and usher in the use of local power generation sources to convince Thai stakeholders to reduce Thailand's footprint on building Mekong dams in Laos. Thailand currently has the capability to meet its domestic electricity production entirely through domestic renewable energy generation. Key stakeholders in Thai government agencies have expressed anxiety over the high-price tag and risks associated with supporting dams across borders in Laos and Myanmar. At the center of this anxiety is an abnormally high electricity reserve margin which requires access to electrical generation capacity 40% higher than peak demand to ostensibly fend off intermittent power shortages in Bangkok and support power demand needs in Thailand's peripheral provinces.

Thailand's 2018 temporary suspension of the 912 MW Pak Beng Dam in northern Laos is a manifestation of domestic anxiety in Thailand about the future of dams in Laos. The fate of this project will be determined when Thailand releases the final results of its power development plan revision scheduled for late 2018. The final decision on whether or not the Pak Beng Dam will move forward will signal to the Lao government whether Thailand will continue to be a major off-taker of hydropower projects into the future. Importantly, a 2018 IEA study provided a clear pathway for restructuring of

Thailand's power sector that demonstrated how a deepened incorporation of solar, wind, and biomass produced electricity into Thailand's power mix can significantly shave down Thailand's power reserve margin, peak capacity needs, and hydropower capacity expansion in Myanmar and Laos.[12]

Given the uncertainty about the future of Thailand's demand and future electricity mix, dialoguing with Vietnam as an off-taker for hydroelectricity from Laos is equally important and also provides more opportunity for in-depth diplomatic engagement and future coordination with Laos. Cambodia and Vietnam share many commonalities in their vision for optimal water and energy outcomes in the Lower Mekong Basin. Both are downstream countries, both share portions of the Mekong Delta and are impacted by river connectivity impacts upstream, and both have rising energy demand needs.

In 2018, Vietnam increased its power purchasing MOUs with Laos to include 1000 MW by 2020 with the potential of up to 5000 MW by 2030.[13] Much of this power will be transmitted to Vietnam through a 500-1000kv transmission line crossing from southern Laos through Vietnam's Central Highlands and distributed to markets in and around Ho Chi Minh City where power demand needs are currently unmet.

Cambodia also has agreed to purchase power from the Don Sahong Dam built in Laos near the border with Cambodia.[14] The transmission line from Don Sahong can also be connected to Laos's broader transmission network in the future. Cambodia's dialogue with Vietnam could utilize an approach of joint Cambodia-Vietnam engagement with Laos to determine the siting, operation, and management of remaining dams to be built on Laos's portion of the Mekong.

Both Cambodia and Vietnam can impact the way remaining hydropower dams are built out in Laos's portion of the Mekong Basin by expressing greater interest in purchasing power from Laos. This can be achieved by demonstrating political will for a basin-wide power development plan in Laos that considers where future dams are sited. Importantly, a robust incorporation of non-hydropower renewables into Laos's power generation mix can replace some of the most negatively impactful dams. Such an approach would keep the Lao government on its expressed pathway of becoming the "Battery of Southeast Asia" by meeting power export expectations but in a more sustainable manner with fewer large dams. This would deliver economic and environmental dividends downstream in Cambodia and Vietnam.

To illustrate the feasibility of a power mix which incorporates a more robust mix of non-hydropower renewable energy generation into Laos's future power capacity expansion, a team of researchers from University California, Berkeley's Energy Resources Group

12 International Energy Agency, "Partner Country Series - Thailand Renewable Grid Integration Assessment," 2018, 5, accessed November 15, 2018, https://webstore.iea.org/partner-country-series-thailand-renewable-grid-integration-assessment.

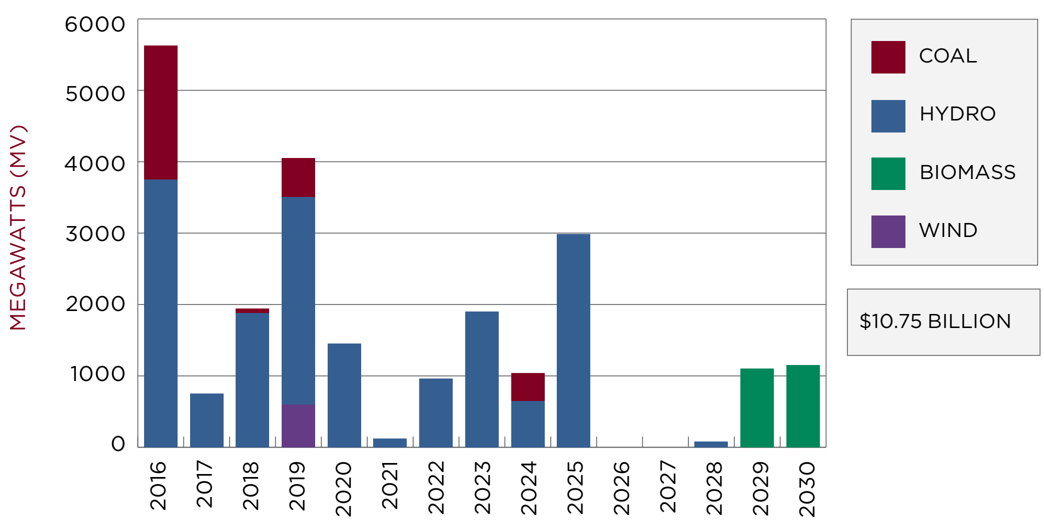
13 News Desk, "Vietnam to expedite electricity purchases from Laos," *Asian News Network*, July 18, 2018, accessed November 15, 2018, http://annx.asianews.network/content/vietnam-expedite-electricity-purchases-laos-77090.

14 Van Roeun, "Hun Sen Visits Laos Dam Site, Again Promises Cheap Power," *Cambodia Daily*, January 11, 2017, accessed November 15, 2018, https://www.cambodiadaily.com/news/hun-sen-visits-laos-dam-site-again-promises-cheap-power-123248/.

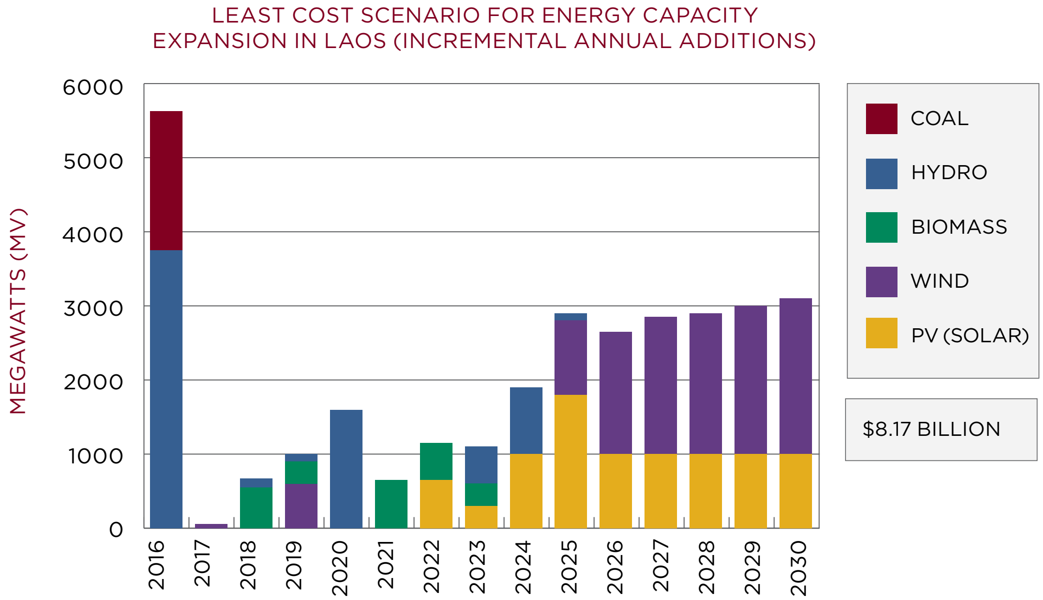
studied various energy mix scenarios.[15] The study concluded in 2017 that the least-cost scenario for Laos would actually incorporate significant levels biomass, solar, and wind generation options to meet its future electricity export needs through 2030. Investment for this least-cost scenario would come in USD $2 billion below the investment needs for the current, business as usual trajectory of hydropower dam development. The least-cost scenario is determined by using the conservative future projections for the market price of renewable energy generation options as manifested in the Mekong region.

In the diagrams below, the results of the UC Berkeley study are demonstrated in a side by side fashion. The first shows the business as usual (BAU) scenario with each year representing an incremental addition to the power capacity in Laos. Most power added is through hydropower development which is represented by the blue bars. This BAU scenario includes a build out of 17450 hydropower and 4828 coal (the Hongsa thermal lignite plant) in Laos. The second, least-cost scenario identifies future energy mix options based on price and availability. This least-cost scenario incorporates projects already under construction such as the Xayaburi Dam, Don Sahong Dam, the 600 MW Monsoon Wind Farm, and tributary dams, but allows the model to select additional types of energy based on price. In filling these gaps, the model starts to select low cost biomass projects in 2019 and then robustly adds solar and wind into the mix as these generation options become most cost competitive after 2022. This second scenario includes a build-out of 8750 solar, 11100 wind, 2360 biomass, and 7070 hydropower in addition to the existing baseload supply of hydropower and coal.

BUSINESS AS USUAL SCENARIO FOR ENERGY CAPACITY EXPANSION IN LAOS (INCREMENTAL ANNUAL ADDITIONS)



15 Dan Kammen, et al., “Power expansion alternatives for economic diversity and resilience in Lao PDR,” (forthcoming).



When considering how to hold productive dialogue with the Lao government on power purchase agreements and bilateral or regional power distribution, stakeholders in Cambodia should prioritize keeping the mainstream of the Sekong River and many of its tributaries free flowing. The Sekong River flows more than 500 kilometers from its headwaters in Vietnam's Central Highlands through southern Laos before it empties into the Mekong mainstream in Cambodia near Stung Treng. It is the longest remaining free-flowing tributary of the entire Mekong Basin and also is the last free-flowing tributary of the 3S River system formed of the Sekong, Srepok, and Sesan Rivers. Importantly, the 3S Rivers contribute more than 20% of the water in the Mekong Basin and are critically located close to the Tonle Sap Lake and Mekong Delta. By extension, it can be assumed that altering connectivity in the 3S Rivers will have a greater relative impact to the Tonle Sap and the Mekong Delta than alterations farther upstream. However, more studies need to be done to verify this assumption.

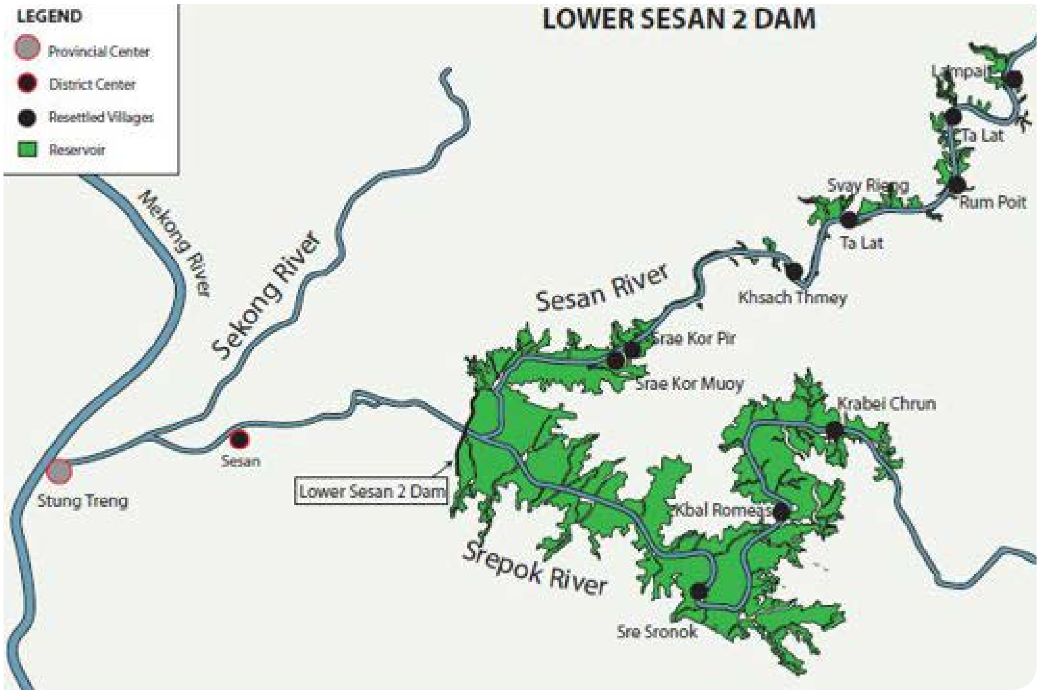
More than 3300 kilometers of river connectivity from the Sesan and Srepok mainstreams and tributaries were lost to the Mekong river system when the 400 MW Lower Sesan 2 was commissioned in early 2018. The 3S system represents a key migratory pathway for upstream spawning for fish in the Tonle Sap. Historically, during peak migration periods as many as 30 tons of fish move through the Mekong mainstream and major tributaries. The Lower Sesan 2 Dam is located below the confluence of the Srepok with the Sesan, and despite efforts by the dam designer to incorporate fish ladders and sediment flushing gates, it is unlikely that the fish ladders at the Lower Sesan 2 will be able to accommodate such a large mass of fish. Further, even if some fish do make it past the dam's fish ladders to spawn upstream, the eggs and fish larvae washed back downstream towards the Tonle Sap by the annual Mekong flood pulse will likely sink and perish behind the dam's wall as the speed of the river slows when approaching the Lower Sesan 2.

The Sekong River is known to be a major pathway for migratory fish, and it is possible that fish which migrate through the 3S system that cannot make it past the Lower Sesan 2 dam could find a way up the Sekong. This potential makes maintaining the Sekong's free-flowing status even more important. However, investor interest in damming the

Sekong mainstream is mounting. Dam developers from Laos, Vietnam, Thailand, China, Korea, and France have MOUs to build more than sixty dams in the Sekong Basin.

On the Sekong's tributaries in Laos, eleven are currently under construction and one is complete. Up to six dams could be constructed on the Sekong mainstream, including one in Cambodia. Physical risks to damming the Sekong basin were made apparent the recent calamitous breach at the Xepian-Xenamnoy Dam, where design flaws resulted in the breach of a support dam on July 23, 2018. This tragedy caused the displacement of 6700 villagers downstream of the dam in Laos, an undetermined death count likely in the hundreds, the evacuation of tens of thousands downstream in Cambodia, and unexpected flooding in Vietnam causing unknown levels of significant damage.[16] The Xepian-Xenamnoy disaster was the second dam breach in Laos in less than a year. Thus, it is not extraordinary to think such disasters will continue into the future particularly given low levels of oversight and management capacity spread across scores of dams in Laos. The physical integrity of these dams will also continuously be tested by increasing frequency of intense weather events as the impacts of climate change take hold into the twenty first century.

16 "Mekong Delta farmers struggle with floods," *Viet Nam News*, August 2, 2018, accessed November 15, 2018, https://vietnamnews.vn/environment/463012/mekong-delta-farmers-struggle-with-floods.html#t6Yxm6P3sb7e0sII.97.



However, there are ways to move energy development forward today in a way that meets electricity needs at a reduced risk toward loss of life and loss of connectivity in the Sekong Basin, Tonle Sap, and Mekong Delta. An existing methodology called Hydropower By Design can be utilized to plan out remaining dams in the Sekong basin, optimize connectivity and environmental flows, and meet cross-border electricity demand needs in Vietnam, Cambodia, and Laos.

Cambodia can work at a bilateral level with countries in the Mekong to utilize the smart planning solutions mentioned above to work toward a sustainable solution for Tonle Sap connectivity. At the same time, stakeholders in Cambodia can also work through mechanisms such as the Mekong River Commission, the Ayeyawaddy-Chao Phraya-Mekong Economic Cooperation Strategy (ACMECS), the Lancang-Mekong Cooperation Mechanism, and the US-led Lower Mekong Initiative to achieve these ends. By reaching across its borders, Cambodia has an opportunity to promote system-scale planning, the coordinated operation of upstream dams that manages sediment flow and fish passage, and the incorporation of non-hydropower renewable energy and other energy sources into domestic power generation mixes throughout the Mekong Basin. The following section introduces ways in which the conceptual framework of Hydropower by Design can be implemented in Cambodia to promote connectivity of Cambodia's rivers.

THE NATURE CONSERVANCY'S HYDROPOWER BY DESIGN APPROACH TO SYSTEM-SCALE ENERGY PLANNING

The Nature Conservancy's Hydropower by Design (HbD) approach to system-scale energy planning is one method that could be a valuable resource for decision makers in Laos. It looks at an entire system, e.g. a river basin, and the impacts that individual projects will have both upstream and downstream on a variety of vectors, including fisheries, agriculture, energy production, etc. HbD has already been applied to basin development in Myanmar, Brazil, Columbia, and Mexico. HbD works to:

- Identify and avoid the most damaging hydropower dam sites and direct development toward sites that will have lower impacts through upstream system-scale planning;
- minimize impacts and restore key river functions through better design and operation of individual dams;
- and offset those impacts that cannot be avoided, minimized, or restored by investing in compensation such as protection and management of nearby rivers that provide similar benefits.

Read more at HTTP://WWW.NATURE.ORG/MEDIA/FRESHWATER/POWER-OF-RIVERS-REPORT.PDF

DOMESTIC APPROACH TO PROMOTING CONNECTIVITY

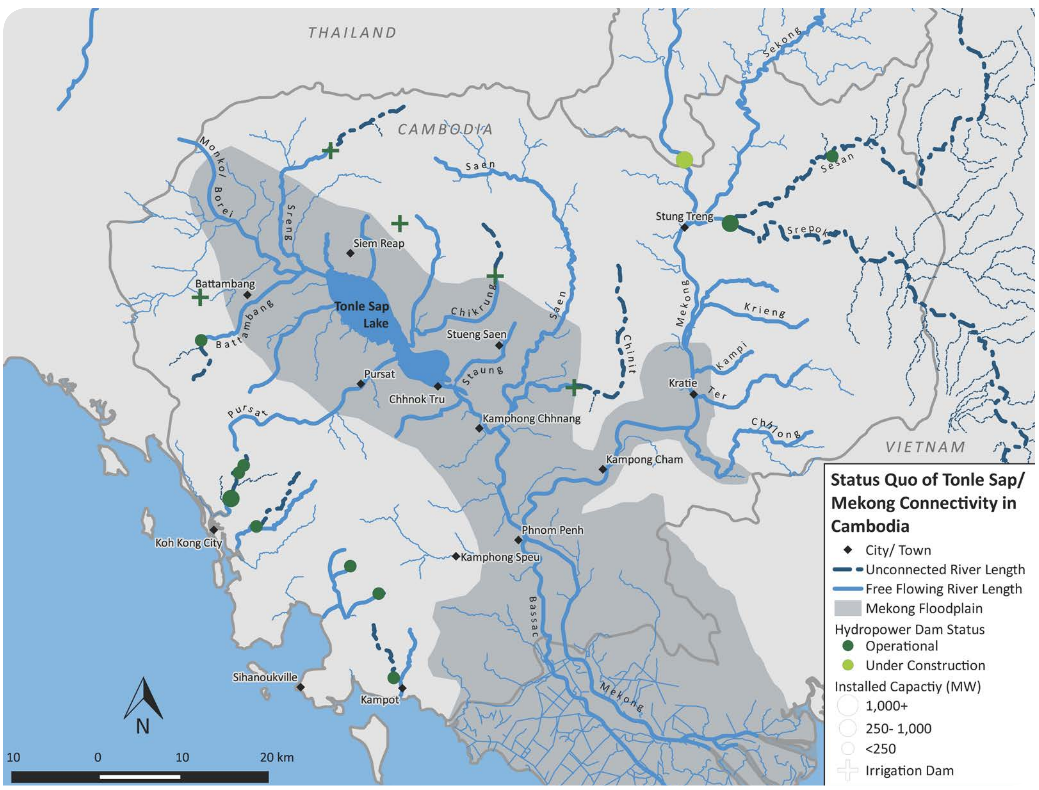
Hydropower by Design's system-scale planning approach can also be utilized in Cambodia to meet domestic energy generation needs and promote connectivity between Cambodia's portions of the Mekong Basin and the Tonle Sap Lake. More than 11,000 kilometers of river systems in Cambodia contribute water and environmental flows to the Mekong Basin. Most of this is from tributaries that flow into the Mekong mainstream above the Tonle Sap confluence at Phnom Penh (5805 kilometers, including the lengths of the 3S Rivers) and the 24 tributaries which surround and flow directly into the Tonle Sap Lake (4512 kilometers).[17] The resource contributions of these Tonle Sap tributaries are often overlooked in the discussion of Tonle Sap resource conservation. The Mekong mainstream, the Tonle Sap River, and the Bassac River combined make up less than 8% of total river length (820 km) in Cambodia's portion of the Mekong Basin, but they serve as critical arteries for the unimpeded delivery of water, sediment, fish, and organic material to the Tonle Sap and the Mekong Delta.

As discussed above, siting the Lower Sesan 2 dam below the confluence of the Sesan and Srepok rivers resulted in a loss of more than 3300 kilometers of river system connectivity. A 2012 study published by Guy Ziv and a team of researchers examined the effects of tributary dams on the Mekong ecosystem and determined the Lower Sesan 2 would

17 These river lengths are conservative estimates counted with measuring tools on Google Earth.

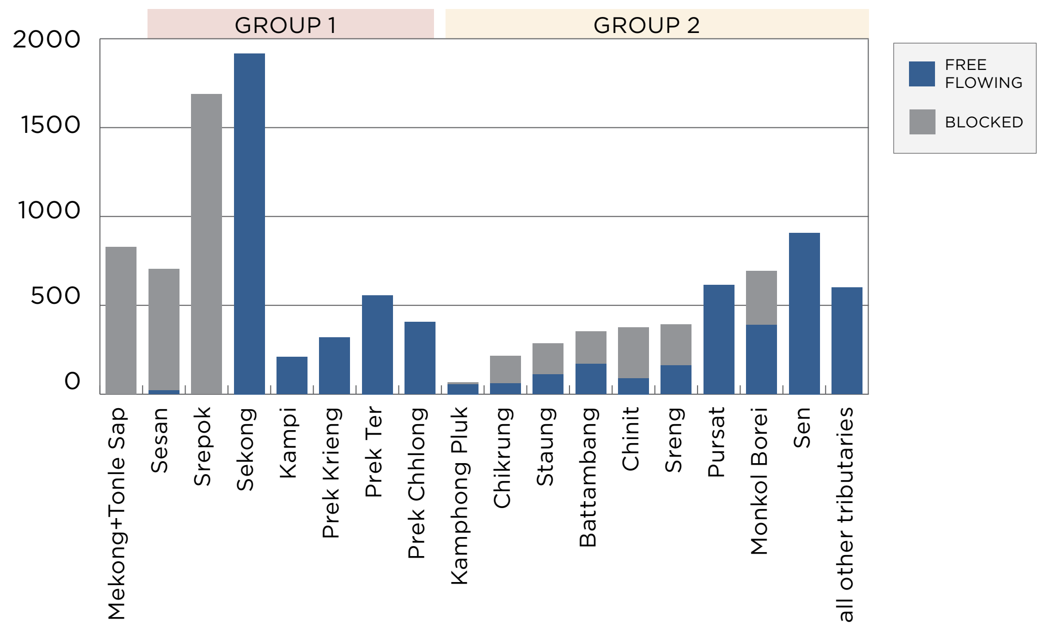
reduce the migratory fish population of the Mekong system by 9.1%.[18] Now that the dam is completed and operational, studies are needed to determine the project's specific impact to Mekong fish population and the Tonle Sap lake.

Examining impacts through the lens of a tradeoff analysis is a particularly useful exercise when making decisions to build structures which impact river connectivity. The quantitative value of a potential loss of 9.1% of fish population versus a 400 MW gain in power generation capacity can and should be squarely considered. Further, expanding the scope of such a tradeoff analysis to consider the impact of six irrigation reservoirs currently built around the Tonle Sap is also of immediate importance. Many of these reservoirs, which are marked on the map below, were built without national level approval and without consideration of downstream and upstream impacts to Tonle Sap connectivity. Like any built structure on a river these reservoirs impact sediment flow and fish migration, and the human activity supported by reservoirs can introduce toxic substances such as pesticides and fertilizers into the downstream and lake system which will have further impact on the fish population and fish production.



18 Guy Ziv, et al., "Trading-off Fish Biodiversity, Food Security and Hydropower in the Mekong River Basin." *Proceedings of the National Academy of Sciences* 109, no. 1 (January 2012): 2.

MEKONG BASIN CONNECTIVITY IMPACTS IN CAMBODIA:
STATUS QUO
(LOWER SESAN 2 + BATTAMBANG 1 + SIX IRRIGATION DAMS)



The chart above shows the current state of connectivity of rivers in Cambodia's portion of the Mekong Basin. The height of each bar corresponds to the length of each respective river and its total tributary system. The blue color represents free flowing, downstream portions of each river. Here free-flowing is defined as free flowing between the Tonle Sap Lake and upstream reaches as to promote connectivity and the "beating heart" effect of the Tonle Sap system. Grey portions represent connectivity losses and the intersection of the blue and grey represent a hydropower or irrigation dam on the respective river.

Added together these lengths total 11,154 kilometers of river that contribute directly to the Tonle Sap Lake. Note that Cambodia currently has only 8 free flowing rivers at lengths longer than 200 kilometers. Currently the combined impact of domestic hydropower and irrigation dams has delivered a connectivity loss of 3718 kilometers and a net reduction of Cambodia's total Mekong connectivity by 33.3%.

These rivers can be divided into two sets. The first set contributes environmental flows and water to the Tonle Sap Lake during the monsoon season and is composed of the Mekong mainstream/Tonle Sap river/Bassac, the 3S Rivers[19] (Sesan, Srepok, and Sekong), and four rivers below the 3S confluence and above Phnom Penh (Prek Kampi, Prek Ter, Prek Krieng, Prek Chhlong). Connectivity of this first set is impacted

19 The 3S river lengths also represents lengths of river outside of Cambodia's border in Laos and Vietnam.

by upstream Mekong dams in Laos and the Lower Sesan 2 dam.[20] While the Mekong mainstream in Cambodia is currently intact within Cambodia, the siting of the 400 MW Lower Sesan 2 dam reduced connectivity by 2373 kilometers, or a net reduction of 21.9%.

The second set of rivers represents twenty-two river systems that encircle and drain directly into the Tonle Sap Lake. A few of these individual rivers have lengths over 500 kilometers (the Pursat at 614km; Mongkol Borei at 693km; and Sen at 908km). Combined, the nine named rivers above and 12 other minor rivers on the lake's south shore contribute 4512 kilometers (40.5%) of river system to Cambodia's 11,154 kilometers of rivers in the Mekong Basin. Currently only two of the nine rivers named in the second set, the Pursat (614km) and the Sen (908km), remain free-flowing all the way to their headwaters. Connectivity in the Battambang River is now blocked by the operational 13 MW Battambang 1 Multipurpose dam completed in 2017, and the connectivity of the six other rivers named in the diagram is impacted by six dams built for irrigation. These irrigation dams are not fit with pathways for fish migration and have been widely documented for their poor performance. [21]

As stated above, the qualitative and quantitative impacts of connectivity of these irrigation dams is mostly ignored in studies of the Tonle Sap and Mekong system and demand further study. 12 minor rivers along the lake's south shore remain free flowing. Combined, hydropower and irrigation dams built on rivers in this second set of rivers which encircle the Tonle Sap reduce free-flowing connectivity by 1345km and a net

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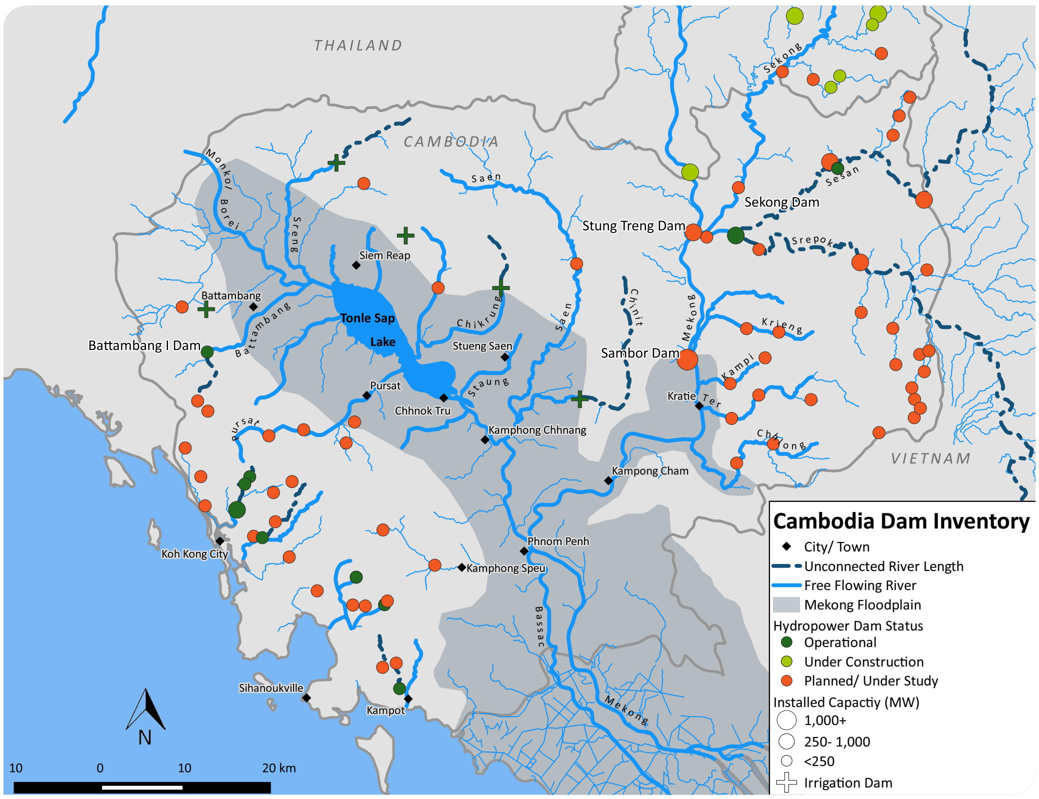
20 We assume connectivity of environmental flows through the Mekong mainstream currently is relatively intact between the river's mouth, the Tonle Sap, and to the Xayaburi Dam in Laos. We assume connectivity of environmental flows through the Don Sahong Dam at the Cambodia/Laos border are minimized due to the widening and deepening of natural channels to permit fish passage around the dam site which is located on one of many channels within the Mekong mainstream. This assumption is based on evidence provided by the Don Sahong Dam company's fisheries management team that fish are migrating through the altered channels. However more studies need to be done by outside researchers to verify this claim and determine the success rate of fish passage through these channels. Also, when the dam is completed in 2020, studies must continue past the dam's completion to determine the success rate of fish passage around the dam. We acknowledge connectivity of tributary rivers in Laos's portion of the Mekong is severely impacted by dozens of hydropower projects, many of them built without mitigation for environmental flows.

21 These irrigation dams and others which arebuilt in an ad-hoc manner not tracked by national authorities encourage local farmers to plant cash crops thus providing an incentive to cut down remaining flooded forests around the lake. David Blake, "Encountering Cambodia's biggest irrigation project, but where's the irrigation?" Mekong Eye, October 11, 2018, accessed November 15, 2018, https://www.mekongeye.com/2018/10/11/encountering-cambodias-biggest-irrigation-project-but-wheres-the-irrigation/; IWMI-ACIAR, "Investing in Water Management to Improve Productivity of Rice-Based Farming Systems in Cambodia Project," 2013, accessed November 15, 2018, http://www.iwmi.cgiar.org/Publications/issue_briefs/cambodia/issue_brief_01-awm_planning_in_cambodia.pdf.

reduction of Cambodia's total Mekong Basin connectivity by 12.07%.[22]

Currently, as a 2018 status quo, Cambodia's portion of the Mekong/Tonle Sap system has already lost 33.3% of its connectivity in exchange for 431 MW of national power generation capacity and some irrigation benefits around the Tonle Sap Lake. Moving forward, additional tradeoffs should be more deeply considered and decision-making must be informed by studies which accurately quantify the economic and social costs and benefits of these tradeoffs. A system-scale planning approach such as Hydropower By Design makes it possible to optimize these tradeoffs.



If connectivity between the Tonle Sap and Mekong upstream is to be preserved, alternatives for Cambodia's planned two mainstream dams at Stung Treng (900 MW) and Sambor (2600 MW) must be found. The Stung Treng Dam is to be sited just above the confluence of the 3S river system with the Mekong and would obstruct all connectivity between the Tonle Sap Lake and the upper reaches of the Mekong River. The Sambor

22 Rivers not included in this list are those few rivers that flow into the Bassac River and the Mekong mainstream below Phnom Penh. These rivers likely serve as habitats for some migratory fish that live for a portion of the year in the Tonle Sap Lake, but these rivers do not contribute water or sediment into the Tonle Sap system and thus are not included in the analysis of Tonle Sap connectivity impacts. While there are also rivers that originate in the Cardamom mountains that are important for biodiversity, these flow directly into the ocean and are not part of the Mekong Basin analysis. It is important to note that six dams are currently built on these rivers and their impacts to connectivity between coastal and upstream areas are unknown. In coastal areas upstream sediment contributes to downstream agricultural productivity, the geological integrity of coastal deltas, and the formation of food webs in estuarial zones and coral ecosystems offshore.

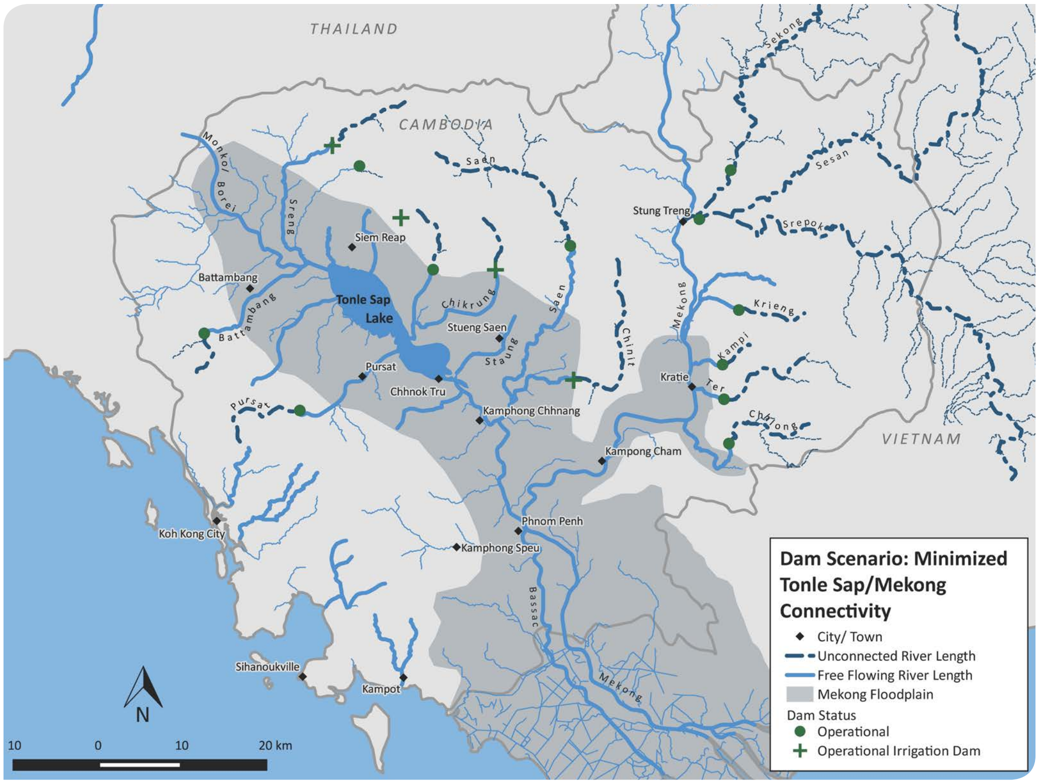
Dam is to be located downstream from the 3S confluence and would obstruct all connectivity from the Mekong mainstream and the 3S system. To generate 2600 MW of electricity the Sambor dam will require a wall 18 kilometers wide and produce a reservoir 82 kilometers long. The project's cost is valued over $3.2 billion making it one of the costliest and riskiest hydropower projects in the world.

A 2018 study undertaken by the Natural Heritage Institute commissioned by the current sponsors of the Sambor Dam found the dam would devastate Tonle Sap fisheries, cause the extinction of the Mekong's freshwater dolphin population, and severely neuter sediment distribution to the Mekong Delta. The study also demonstrated an alternative design models which only dams a portion of the river, allowing connectivity to continue, albeit at a lessened rate. The study showed how the capacity loss from these design options can be replaced with floating solar (PV) installations on the reservoir created by the Lower Sesan 2 dam.[23]

Pressure for power generation is also causing stakeholders in Cambodia's government and infrastructure investors to search for other hydropower and irrigation dam sites around the lake. Currently more than forty MOUs or feasibility studies for tributary dams in Cambodia's portion of the Mekong have been considered as part Cambodia's future energy mix. A failure to consider the system-scale impacts of building out these dams could also result in connectivity losses equal to or greater than the impacts of the Sambor Dam.

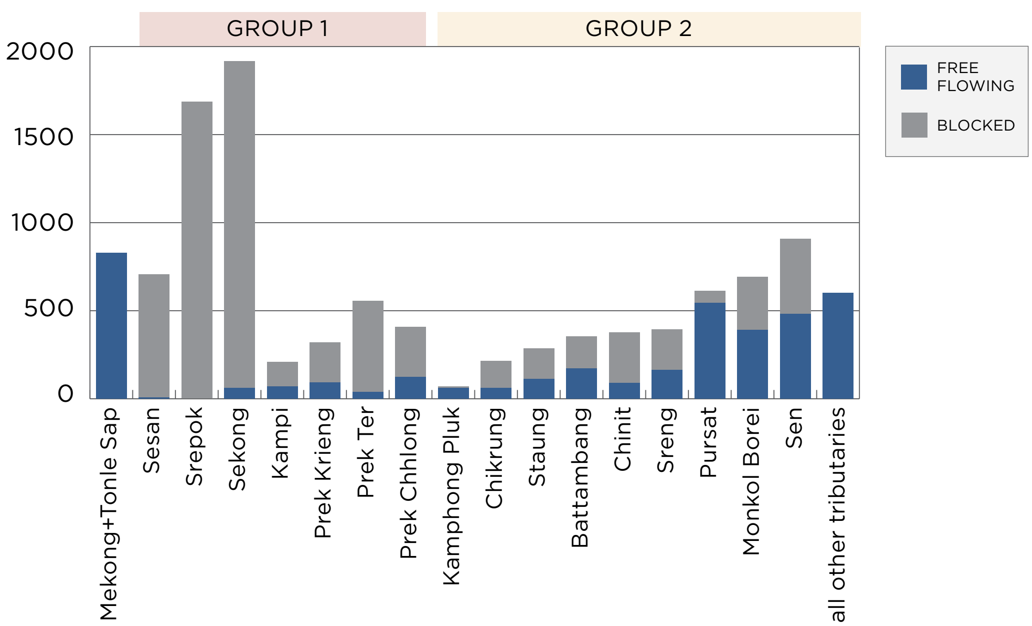
One way to envision preserving the status quo of connectivity in Cambodia's portion of the Mekong is to keep the blue portions of the bars in the diagram below blue. A converse, worst-case scenario for connectivity impacts would develop the dams in Cambodia's inventory that are located closest to mouths of tributaries. These dams are the closest to the Tonle Sap and would thus constrict or tighten the "heartbeat effect" that the Tonle Sap delivers to the rest of the Mekong system. A weakened heartbeat would severely affect the annual inflow and outflow of water to the Tonle Sap system and send much less sediment, fish, and organic mass in and out of the system as well. Headwater areas for spawning would be completely cut off for migrating fish. This worst case scenario, which does not include the Mekong mainstream dams at Sambor and Stung Treng is represented in the map on the next page.

23 Natural Heritage Institute, "Key Findings of NHI's Sambor Hydropower Dam Alternatives Assessment," 2018, accessed November 15, 2018, https://n-h-i.org/wp-content/uploads/2018/03/Cambodia_Key-Findings-of-Sambor-Assessment_updated-11-Mar-2018.pdf.



MEKONG BASIN CONNECTIVITY IMPACTS IN CAMBODIA: MINIMIZED CONNECTIVITY SCENARIO

(STATUS QUO + BUILD MOST DOWNSTREAM DAM ON EACH RIVER)



The diagram above translates the worst case tributary damming scenario into connectivity impacts. In this scenario, Cambodia incrementally loses a total of 3019 kilometers of connectivity by damming all of its free-flowing major tributaries at sites close to the Mekong mainstream. This would result in another loss of 31.7% river connectivity on top of the current status quo, totaling a connectivity loss of 65.17% to Cambodia's portion of the Mekong Basin. The seven newly built tributary dams would produce an incremental increase of only 237 MW of power in exchange for those connectivity losses.

Most of this connectivity loss is represented by losses from building the Sekong Dam which nets a power generation capacity of 148 MW but results in a net loss of 1856 kilometers, or about 16% of Cambodia's total Mekong connectivity. The siting of this dam is particularly problematic for connectivity impacts as it is planned for location only 61 kilometers from where the Sekong River meets the Mekong mainstream.

The exercise above is merely suggestive and should be used to demonstrate the risks to energy planning that does not keep in mind the tradeoffs to river connectivity in Cambodia. However, one programmatic development scenario that could deliver fewer effects to overall connectivity and reap major increases in power generation capacity would develop dams only above the Lower Sesan 2 dam in the upstream reaches of the Sesan and Srepok Rivers. The waters above the Lower Sesan 2 Dam are effectively cut off from the Tonle Sap, so development upstream of the Lower Sesan 2 will potentially deliver a zero net change to the status quo in terms of free-flowing rivers and result in a potential development of 1775 MW of capacity across 23 dams. However, if pursued, this kind of development scenario must take the needs of local communities in terms of resettlement and compensation to mind. Scoping activities for the Lower Sesan 3 dam have already been contested by local opposition. Thus a more prudent plan for upstream development could site dams in locales where resettlement needs are minimal to zero. Further, it could be very costly to build an effective transmission system through the the rugged terrain of Mondulkiri Province and Ratanakiri Province where much of this development would occur. However, electricity generated in this portion of Cambodia could serve both domestic consumption needs and be exported to neighboring Vietnam where the demand for electricity is high.

Some of most risky dam projects in eastern Cambodia above the Lower Sesan 2 dam could be replaced with non-hydropower renewable energy generation sources. The Sesan and Srepok basins are also rich with potential solar and wind endowments. Herein lies the opportunity for developing this portion of Cambodia as a clean energy zone, a fitting project for a multilateral development bank or a regional initiative focused on sustainable economic development to promote. At the same time, other portions of Cambodia are also well-fit for robust solar development.

The next section explores opportunities for Cambodia to diversify its power mix toward the incorporation of more non-hydropower renewable energy sources such as solar and wind. Such an expansion would reduce pressure on building hydropower dams on Cambodia's portion of the Mekong Basin and redefine the role of hydropower to support the intermittency of solar, wind, and biomass.

BEYOND HYDROPOWER: DIVERSIFYING CAMBODIA'S POWER MIX

A driving factor behind hydropower development in Cambodia is the country's rapid electricity demand growth, which has averaged 20% since 2010.[24] In 2011, Cambodia's installed capacity stood at just under 800 MW and was entirely supplied by hydropower.[25] All additional demand was met by imports from Vietnam and Thailand and off-grid diesel generation which is found in ubiquity throughout Cambodia's urban and rural areas.

Power demand is projected to continue to grow, with government estimates indicating that the annual electricity demand growth will average 9.4% through 2020.[26] Outside experts from the International Renewable Energy Agency (IRENA) estimate higher power demand growth totaling between 150-200% cumulatively through 2025.[27] These power projections are not set in stone. The adoption of energy efficiency standards for industry, the commercial sector, and demand-side management practices could help to shave peak demand in future projections. It is worth noting that Cambodia's more developed neighbors Thailand and Vietnam are both in a process of cutting future projections. That said, demand in the near-term will continue to be high. Thus far, this demand growth has resulted in a rapid expansion of Cambodia's electricity mix.

At the end of 2017, Cambodia had more than doubled its installed capacity to approximately 2100 MW.[28] The majority of this—1329 MW—comes from nine hydropower projects. Six of these are located in the Koh Kong region and send electricity through the national grid to Phnom Penh, while three—the 400 MW Lower Sesan 2 Dam, the 130 MW Stung Battambang 1 Dam, and the 1 MW O Chum Dam—are located in the Mekong Basin. 485 MW of the total comes from coal, primarily two plants located in Sihanoukville, which supply power to the city and the port as well as industrial installations. The remaining contributions to the power supply are a combination of imported fuel oil (mostly diesel) and imported electricity from Vietnam and Thailand.

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24 World Wide Fund, "Power Sector Vision: Towards 100% Renewable Electricity by 2050 Cambodia Report," 2016, 5, accessed November 15, 2018, http://greatermekong.panda.org/our_solutions/2050powersectorvision/.

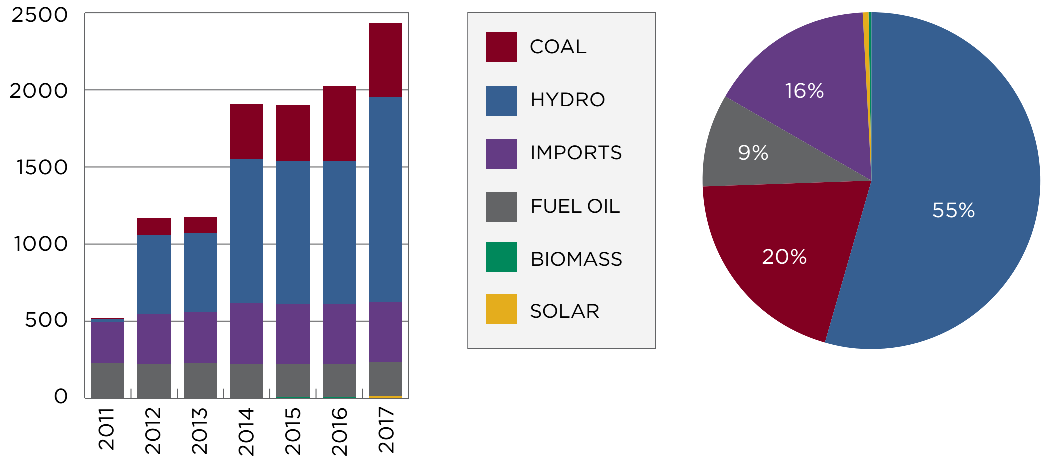
25 Choumnit Gnhoung, "Workshop in Strategic Water and Energy Planning in Cambodia-Laos-Vietnam," Stimson Center, (presentation at the Diplomatic Academy of Vietnam, Hanoi, Vietnam, December 7, 2017).

26 Watson Farley & Williams, "Cambodian Solar Industry: A New Dawn?, 2018, 1, accessed November 15, 2018, http://www.wfw.com/wp-content/uploads/2018/03/WFWBriefing-Cambodian-Solar-Industry.pdf.

27 IRENA, "Renewable Energy Market Analysis: Southeast Asia," 2018, 48.

28 Choumnit Gnhoung, "Workshop in Strategic Water and Energy Planning in Cambodia-Laos-Vietnam," 2017.

CAMBODIA ELECTRICITY GENERATION 2017



Three key challenges need consideration when analyzing the electricity sector in Cambodia: rural electrification, tariff rates, and the strong impetus to diversify the electricity supply.

Most installed capacity links into the grid to supply Phnom Penh and other urban centers, which has led to a high penetration of electricity access in urban areas (97%) but has not yet efficiently addressed needs in rural areas. The national average electrification rate drops to approximately 60% when including rural areas.[29] The government's 2014 – 2018 National Development Plan included a commitment to hasten electrification efforts so that all villages in Cambodia have access to electricity by 2020.[30] This would require stepping up the rates of infrastructure buildout elucidated in previous guidelines, such as the Ministry of Industry, Mines, and Energy (MIME)'s 2007 plan to electrify rural areas using renewable electricity or the 2011 Strategy and Plan for Development of Rural Electrification.

Notably, despite the central push for construction and buildout of a national grid, MIME has long recognized that the remote nature of some villages will lead to the proliferation of local mini-grids in some areas until the national grid is built out. Electricite du Cambodge (EDC) is responsible for either allocating private licenses to supply electricity to these remote villages or—in areas where no private firm bids on the license—to mobilize funds to build mini-grids and stand-alone electricity systems itself.[31]

At the same time that MIME and EDC are investing in the electricity transmission infrastructure to improve access, the Royal Government of Cambodia has a published aim of

29 International Energy Agency, "World Energy Outlook 2017," 2017, 104, accessed November 15, 2018, https://www.iea.org/publications/freepublications/publication/WEO2017SpecialReport_SoutheastAsiaEnergyOutlook.pdf.

30 Royal Government of Cambodia, "National Strategic Development Plan 2014–2018", 2014, 156, accessed November 15, 2018, http://www.ilo.org/wcmsp5/groups/public/---asia/---ro-bangkok/---sro-bangkok/documents/genericdocument/wcms_364549.pdf.

31 UNESCAP, "Session 1: Implementing SDG 7 and Achieving Target 7.1" (seminar at the Transboundary Power Trade and Interconnection 2016 Policy Dialogue on Energy for Sustainable Development, Bangkok, Thailand, June 21-23, 2016).

reducing the electricity tariff to an appropriate level.[32] Cambodia has among the highest electricity rates for consumers in all of ASEAN. Historically prices in urban areas have been as high as 25 c/kWh, whereas rural residents often paid more than 80 c/kWh.[33] In early 2017 the government began implementing tiered usage rates and dropped the overall cost. For households using less than 10 kWh per month, the price dropped from approximately 20 US c/kWh to 12 c/kWh, whereas those using between 10-50 kWh per month would see fees reduced to 15 c/kWh.[34] Even with reductions, industrial consumers also pay higher rates of approximately 14 c/kWh,[35] which is still double average prices between 6-7 c/kWh in neighboring countries. Looking to the future, the government of Cambodia aims to reduce tariffs below 10 c/kWh by the mid-2020s.[36]

One aspect of this tariff reduction ties into the need to diversify the electricity supply. The Royal Government of Cambodia also has a stated priority to shift away from overdependence on imported electricity, which stood at just over 400 MW in 2016 and came primarily from Vietnam and Thailand.[37] Officials in Vietnam have indicated that domestic constraints may make it difficult to continue exporting electricity to Cambodia in the future, prompting policy makers in Cambodia to prioritize domestic replacements in the near-term.

CAMBODIA'S ENERGY PLANS

Looking to the future, Cambodia's most recent Master Energy Plan was finished in 2016 with technical capacity-building assistance from the Japan International Cooperation Agency. Master Energy Plans have been done in the past—a 2006 version was funded by the World Bank and Korea—but they have not been regularly updated and provided to the public for guidance and review in the way that Thailand and Vietnam publish national plans. Cambodia's Master Energy Plans have also not yet included alternative scenarios that take into account varying energy demand growth rates or different energy mixes that would meet the projected demand.

32 Royal Government of Cambodia, "National Strategic Development Plan 2014–2018", 157.

33 Poch, Kongchheng and Savong Tuy,"Cambodia's Electricity Sector in the Context of Regional Electricity Market Integration," in Energy Market Integration in East Asia: Theories, Electricity Sector and Subsidies, ed. Wu, Y., X. Shi, and F. Kimura (Jakarta: ERIA, 2012), 141.

34 *Original figures were given in Cambodian riel, at an initial cost of 800 riel dropping to 480 riel for users of less than 10 kWh/month and 610 riel for users of 10-50 kWh/month;* Yesenia Amaro and Kouth Sophak Chakrya, "Electricity usage-based plan to lower power rates," P*hnom Penh Post*, February 8, 2018, accessed November 15, 2018, https://www.phnompenhpost.com/national/electricity-usage-based-plan-lower-power-rates.

35 Sum Manet, "Electricity prices to be cut for big industry," *Khmer Times*, July 6, 2017, accessed November 15, 2018, https://www.khmertimeskh.com/news/40034/electricity-prices-to-be-cut-for-big-industry/.

36 Authors' interview with MIME energy planner, February 27, 2017, Phnom Penh, Cambodia.

37 Sor, Chandara,"Put more energy into power supply, firms told," *Phnom Penh Post*, January 19, 2016, accessed November 15, 2018, http://www.phnompenhpost.com/business/put-more-energy-power-supply-firms-told.

The full MEP 2016 was also not released for public view, but planners have shared a list including 2,793 MW of planned power generation projects to help meet rapidly rising electricity demand through 2020.[38] Notably, all of this will be from hydropower and coal plants. Although the full MEP includes some natural gas and a few small modern biomass projects, there is no solar or wind included in the national plan. The following section provides an overview of Cambodia's existing energy plans and potential energy sources.

Hydropower

Technically feasible hydropower is widely recognized to be around 10,000 MW, and so it is no surprise that the vast majority of Cambodia's current and future plans for electricity production are centered around hydropower. Almost a third of the technically feasible hydropower would be produced by two dams on the mainstream of the Mekong River: the 900 MW Stung Treng Dam and the Sambor Dam, which could produce 2600 MW if built at full-scale or 450 MW if dam developers pursue an alternative, less environmentally and socially impactful design which would span half the river. The remainder of the power would come from approximately 40 proposed projects that would be built on tributaries to the Mekong and in the smaller rivers that drain southwest into the Gulf of Thailand.

Despite the prominent role of hydropower in Cambodia's energy sector, Cambodia is not a geologically ideal landscape for large reservoir dams like those planned in China and Laos. The first section of this report explored the ways in which hydropower development reduces connectivity and natural resource availability in Cambodia's portion of the Mekong Basin. Unlike other regions of the Mekong Basin in Laos and China, the river does not flow through ravines that would provide a natural boundary and produce the desired hydraulic head for dams with significant hydropower generation capacity. By the time the Mekong River reaches the plains of Cambodia, the majority of the elevation drop has already taken place and the river is primarily flowing through floodplains.

Seasonal variability in water flow makes hydropower development in Cambodia technically challenging as well. During the monsoon season, hydropower dams can run at full efficiency and is able to produce more electricity than Cambodia can utilize domestically, but during the dry season when electricity demand is highest due to air conditioning and cooling needs in urban areas, the efficiency of power generation drops as low as 25%.[39] As a result, while hydropower is able to supply a portion of Cambodia's baseload generation, the future energy mix must be more diverse in order to ensure reliability in spite of seasonal variation.

Of the proposed 2800 MW of new projects included in the Master Energy Plan through 2020, 1858 MW come from four hydropower projects: Lower Sesan, Stung Cheay Areng,

38 IRENA, "Current Status of Renewable Energy in Cambodia," (renewable energy statistics training, Bangkok, Thailand, December 12-14, 2016), accessed November 15, 2018, https://www.irena.org/eventdocs/Cambodia%20presentation.pdf.

39 Royal Government of Cambodia, "National Strategic Development Plan 2014–2018", 47.

Sambor, and Stung Treng. Of these, the Lower Sesan 2 dam began producing power in 2018. Interestingly the Battambang 1 Dam was not included in the Master Energy Plan but became operational in 2017. The Stung Cheay Areng Dam was suspended in 2015, and the Sambor and Stung Treng projects are deeply controversial and despite years of investor interest, have never graduated from feasibility study phases. Given the scale of these projects, it is impossible for these projects to come online as planned in the timeline.

Coal

Cambodia ranks 19th globally for the amount of coal power capacity currently under active development, which is estimated at 3,325 MW.[40] These figures include all potential coal projects that have been listed as well as projects which have been announced for consideration but which no additional progress has been listed. Currently, there are two plants that are actively under construction: a new 150 MW plant in Sihanoukville, which should be completed in 2019,[41] and the expansion of the existing 270 MW Sihanoukville 2 plant to 700 MW. Additional projects could include a 1,800 MW coal plant and a second 700 MW plant in Sihanoukville.[42]

Two notable factors should be considered when analyzing Cambodia's coal expansion. First, Cambodia's emphasis on coal bucks global trends for energy sector investment. In 2017, the world installed more new solar capacity than coal, nuclear, and natural gas plants combined.[43] Much of this new capacity was built in developing countries. While Cambodia shares its continued emphasis on coal with many of its ASEAN neighbors—Vietnam, Indonesia, Philippines, and Thailand are also among the top 20 countries investing in new coal capacity globally— this is a notable departure from other developing countries around the world.

The second notable factor is that Cambodia has limited domestic coal supplies. The existing coal plants in Sihanoukville already rely on imports of coal from Indonesia, as does small-scale industrial capacity that supports cement production. While the government is exploring opportunities for domestic coal production, limited domestically available deposits mean that if additional coal plants are constructed Cambodia will need to significantly increase its imports from the global market. Given the government's stated aim of avoiding over-reliance on imports, it is surprising that energy planners prioritize imported coal over domestically available renewable energy sources.

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40 Christine Shearer, et. al., "Boom and Bust 2018 Tracking the Global Coal Plant Pipeline," CoalSwarm, Greenpeace USA, and Sierra Club, 2018, 12, accessed November 15, 2018, https://endcoal.org/wp-content/uploads/2018/03/BoomAndBust_2018_r6.pdf.

41 Kali Kotoski, "Third coal-fired plant on order," *Phnom Penh Post*, February 28, 2017, accessed November 15, 2018, https://www.phnompenhpost.com/business/third-coal-fired-plant-order.

42 "Coal," Open Development Cambodia, November 4, 2015, accessed November 15, 2018, https://opendevelopmentcambodia.net/topics/coal/.

43 Frankfurt School-UNEP Centre/BNEF, "Global Trends in Renewable Energy Investment," 2018, 6, accessed November 15, 2018, http://www.iberglobal.com/files/2018/renewable_trends.pdf.

Non-hydropower Renewable Energy

The greatest opportunity for diversification of Cambodia's energy mix lies in the promotion and development of non-hydropower renewable energy. While renewable energy plays an important role in national plans for rural electrification, Cambodia stands out as the only ASEAN country which has not yet announced national-level targets for non-hydropower renewable energy as of 2018.[44] Cambodia's non-hydropower renewable energy potential is significant, particularly when compared to its relatively low starting point for installed capacity. Solar irradiation is relatively high: 65% of Cambodia's land area has solar irradiation above 1800 kWh per meter squared and is potentially economically suitable for solar production based on 2016 electricity prices and solar costs. [45] In terms of installed capacity, this is estimated to be a minimum of 8,000 MW of solar potential. [46]

In the case of wind, there have been fewer definitive studies and the estimated technical potential varies greatly but is lower than solar potential. In December 2017, Cambodia's Ministry of Industry, Mines, and Energy (MIME) contracted an updated study on wind potential in the country.[47] The best previous study is from the Asian Development Bank, which estimates that while Cambodia's theoretical wind potential could be as high as 6,500 MW, the low level of grid connection and limited high-quality wind potential limits economically feasible deployment to only 72 MW.[48] Most of this is near the southern portion of the Tonle Sap and along the coast. Given the significant price shifts that have taken place globally since the ADB study was done in 2015—and some technical breakthroughs now allow for economic wind production at lower wind speeds than in previous years[49]—the amount of economically feasible solar and wind projects are likely to have increased from these estimates.

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44 USAID, "Designing Renewable Energy Incentives and Auctions: Lessons for ASEAN," 2017, 22, accessed November 15, 2018, http://usaidcleanpowerasia.aseanenergy.org/resource/designing-renewable-energy-incentives-and-auctions-lessons-for-asean/.

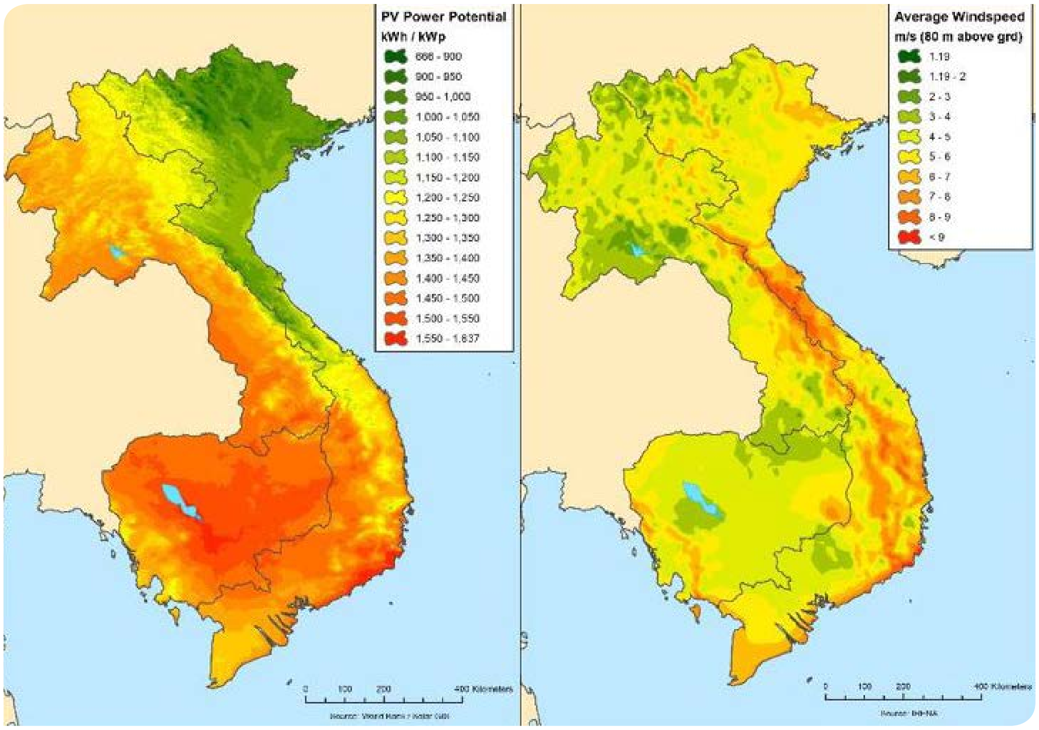
45 Asian Development Bank, "Renewable Energy Develops in the Greater Mekong Subregion," 2015, 15, accessed November 15, 2018, https://www.adb.org/sites/default/files/publication/161898/renewable-energy-developments-gms.pdf.

46 Richard De Ferranti, David Fullbrook, John McGinley, and Stephen Higgins, "Switching On: Cambodia's Path to Sustainable Energy Security," Mekong Strategic Partners, 2016, 16, accessed, November 15, 2018, http://www.mekongstrategic.com/switching-on--cambodia-s-path-to-sustainable-energy-security.html.; For a higher estimate, see Intelligent Energy Systems, Alternatives for Power Generation in the Greater Mekong Subregion: Volume 2, Power Sector Vision for the Kingdom of Cambodia, WWF, March 2016, p. 30.

47 Chea Vannak, "Testing the winds in Cambodia's energy sector," *Khmer Times*, December 4, 2017, accessed November 15, 2018, https://www.khmertimeskh.com/5093692/testing-winds-cambodias-energy-sector/

48 Asian Development Bank."Renewable Energy Developments in the GMS," 19.

49 De Ferranti, Fullbrook, McGinley, and Higgins, "Switching On: Cambodia's Path to Sustainable Energy Security," 17.



One reason that planners have not included significant renewable energy in the Master Energy Plan is that until 2017, there was no commercial-scale solar or wind power in Cambodia to provide familiarity with the technologies and prove their economic and operational feasibility. Historically, the only alternative renewable technology that planners have piloted domestically has been small-scale biomass: a few projects run on wood, sugarcane, and rice husk, with one 10 MW plant run by a factory and a handful of other projects that are less than 2 MW each.[50] One small-scale 250 kW wind project in Sihanoukville supplements diesel generators in supplying the city's port, but it has not yet led to scalable build-up and mechanical problems have prevented it from operating at full capacity.[51]

Things began to change in 2017, when the Asian Development Bank announced that it was supporting the first 10 MW commercial-scale solar PV plant in Cambodia.[52] Following this, the ADB also announced that it was partnering with Electricite du

50 Authors' interview with JICA consultant, Phnom Penh, Cambodia, August 20, 2015..

51 Kongchheng Poch, "Renewable Energy Development in Cambodia: Status, Prospects and Policies," in Energy Market Integration in East Asia: Renewable Energy and its Deployment into the Power System, eds. Kimura, S., H. Phoumin and B. Jacobs, (Jakarta: ERIA, 2013), 252, accessed November 15, 2018, http://www.eria.org/RPR_FY2012_No.26_chapter_7.pdf.; De Ferranti, Fullbrook, McGinley, and Higgins, "Switching On: Cambodia's Path to Sustainable Energy Security," 6.

52 News from Country Office, "ADB Backs Sunseap to Build Cambodia's First Large-Scale Solar Farm," Asian Development Bank, April 25, 2017, accessed November 15, 2018, https://www.adb.org/news/adb-backs-sunseap-build-cambodias-first-large-scale-solar-farm.

Cambodge to open a 100 MW solar park for tender in June 2018.[53] The solar park will provide local evidence as to the affordability and scalability of solar and consist of two tenders: an initial 30 – 50 MW project and then a 50 - 70 MW project following on the heels of the first project.[54] Numerous private companies have indicated interest in solar moving forward, based on the ADB's initial success with the 10 MW Bavet Solar Farm.

Other Energy Generation Options

Inside Cambodia, the discussions on investment in nuclear and natural gas projects for power generation is also ongoing. Policy makers expressed interest in nuclear energy as early as 2012, but initial reports that the government was exploring nuclear plant in Koh Kong province proved unfounded.[55] However, policy-makers have considered the steps necessary to build capacity for long-term pursuit of nuclear power, and in 2017 Cambodia signed agreements with both Russia and China to cooperate towards the acquisition of nuclear energy technologies. Russia and Cambodia aim to build a Nuclear Energy Information Center,[56] and China has an MOU to provide human capacity development for use of nuclear technologies in the power sector as well as other industrial uses.[57] However, the low starting point means that it will be decades before Cambodia has the safeguards in place to pursue nuclear energy.

Oil and gas have also been of perennial interest to policy-makers, particularly after Chevron announced in 2005 that it had discovered oil and gas reserves inside Cambodia's exclusive economic zone in the Gulf of Thailand. However, disagreements over revenue sharing and then the slump in oil prices has prevented development of these offshore fields, and the first agreement for resource exploitation was only signed in 2017.[58] Outputs are not expected until late 2019 or early 2020 if all goes as planned, and the long mean that natural gas is not included in the MEP until 2026 and ultimately plays a minimal role.[59]

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53 Tom Kenning, "Cambodian utility and ADB eye first stage solar park tender in June 2018-SORSEA," *PV-TECH*, November 24, 2017, accessed November 15, 2018, https://www.pv-tech.org/news/cambodian-utility-and-adb-eye-first-stage-solar-park-tender-in-june-2018-so.

54 News from Country Office, "ADB to Partner with Cambodia to Launch National Solar Park Program," Asian Development Bank, June 27, 2017, accessed November 15, 2018, https://www.adb.org/news/adb-partner-cambodia-launch-national-solar-park-program.

55 "Cambodia has no plan to build nuclear power plant for now," *Global Times*, October 29, 2012, accessed November 15, 2018, http://www.globaltimes.cn/content/741035.shtml.

56 Yesenia Amaro, "Russia and Cambodia in nuclear talks," *Phnom Penh Post*, March 2, 2018, accessed November 15, 2018, https://www.phnompenhpost.com/national/russia-and-cambodia-nuclear-talks.

57 "China, Cambodia agree to nuclear energy cooperation," *World Nuclear News*, September 13, 2017, accessed November 15, 2018, http://www.world-nuclear-news.org/NP-China-and-Cambodia-agree-to-nuclear-energy-cooperation-1309174.html.

58 "Cambodia signs deal to develop first offshore oil field," *DW*, August 23, 2017, accessed November 15, 2018, https://www.dw.com/en/cambodia-signs-deal-to-develop-first-offshore-oil-field/a-40203848.

59 Authors' interview with JICA consultant, Phnom Penh, Cambodia, March 1, 2017.

The Master Energy Plan is in many ways a living document. By mid-2017, some hydropower projects included on MEP 2016's list had been suspended, while solar projects that weren't included in the list were already operating. Moving forward, energy planners at MIME aim to review and revise the Master Energy Plan on an annual basis in order to ensure that it remains accurate to updated demand projections and reflects real-world market shifts.[60] Many government officials have emphasized that they support renewable energy sources in principle, but that concerns over cost have prevented early adoption.

The revision of the MEP provides officials with an opportunity to account for the recent solar projects that are now on the books as well as consider adjusting the targeted energy mix through 2030 to take advantage of increasingly affordable solar technologies. As alternative technologies become increasingly economically affordable these revisions will increasingly be necessary. This is particularly true with the advent in the next five to ten years of affordable battery storage, which will address key concerns that many policymakers have about variable renewable energy sources.

60 Authors' interview with JICA consultant, Phnom Penh, Cambodia, July 6, 2017; Authors' interview with MIME energy planner, Phnom Penh, Cambodia, July 6, 2017.

BAVET SOLAR FARM

The 10 MW plant in Bavet City is the first large-scale, commercial solar PV plant in Cambodia. The government of Cambodia selected Bavet as the location for the pilot project given its role as a special economic zone near the border of Vietnam and because the project will meet almost a quarter of Bavet city's local energy demand, half of which used to be met through power imports from Vietnam.[61] The government opened the project for bidding in February 2016. In August 2016, the government awarded the power purchase agreement to Sunseap, which is based in Singapore and one of the largest sustainable energy providers in Southeast Asia.[62] The auction process was notable as Cambodia's first competitive auction for an independent power producer renewable energy project. Sunseap locked in a 20-year solar power purchase agreement with Electricite Du Cambodge with a negotiated price of US$.091/kWh.

The bid came in almost four cents lower than the next most competitive bids, which put them above the government's ideal tariff for new projects of US$0.10/kWh. The low bid was made possible largely because the Asian Development Bank (ADB) is providing $9.2 million of concessional loans, and the overall funding package also included co-financing from the private sector and the Canadian Climate Fund for the Private Sector in Asia.[63] The project was connected to the grid and began operation in August 2017.

61 News from Country Offices, "ADB Backs Sunseap to Build Cambodia's First Large-Scale Solar Farm," Asian Development Bank, April 25, 2017, accessed May 4, 2018, https://www.adb.org/news/adbbacks-sunseap-build-cambodias-first-large-scale-solar-farm.

62 Shuji Hashizume, "Cambodia's First Utility-scale Solar Plant," Asian Development Bank, 2017, slide 17, accessed November 15, 2018, https://www.climateinvestmentfunds.org/sites/cif_enc/files/knowledge-documents/srep_meeting_phnom_penh_01feb17_shuji_hashizume.pdf.

63 Sum Manet, "Solar power set to shine in Bavet," *Khmer Times*, August 22, 2017, accessed May 4, 2018, https://www.khmertimeskh.com/5079197/solar-power-set-shine-bavet/.

EXPANDING SOLAR DEPLOYMENT

To date, Cambodia's renewable energy policy has largely focused on support for off-grid village electrification, rather than commercial-scale deployment. Traditional biomass—the burning of wood and animal dung for fuel and cooking—is actually the largest source of primary energy in Cambodia, providing 51% of the total energy use in 2016 and mainly used by rural residents.[64] There are pressures to shift towards modern biomass production such as biogas given associated health impacts, but even with a shift towards electrification the vast majority of biomass currently utilized is for charcoal production.

Off-grid electricity production has traditionally been diesel-oriented, but now efforts are mounting in Cambodia to shift towards renewable sources. The Power to the Poor program—which is partially funded by outside donors—has provided interest-free loans that helped more than 10,000 households install off-grid solar installations in 2016 alone.[65] As of 2017, approximately 28 MW of off-grid solar were generated from solar home systems.[66] This success has led to a newly announced Ministry of Industry, Mines, and Energy (MIME) project to deploy additional solar and wind projects in the provinces of Pursat, Kandal, and Mondulkiri to electrify remote households.[67] For families which have no other access to power, these programs have substantially improved locals' living standards by providing access to lights and other household appliances. However, the cost of these small systems still comes in around 23 c/kWh, which is usually cheaper than diesel but also more expensive than the on-grid electricity available to consumers in urban areas or larger towns.

Commercial-scale investment was very limited until 2017, largely due to the lack of policy clarity on issues including a clear government target for non-hydropower renewables, net metering policy, whether or not the country will adopt a feed-in tariff to support non-hydropower renewables, the regulatory requirements to sell into the grid, and taxes on imported solar technology.[68] In the case of net-metering, despite some comments indicating support for solar technologies, there have been signs that EDC

64 "Cambodia National Energy Statistics 2016," ERIA, 2016, 33, accessed November 15, 2018, http://www.eria.org/RPR_FY2015_08.pdf.

65 International Energy Agency, "Southeast Asia Energy Outlook," 2017, 107 accessed November 15, 2018, https://www.iea.org/publications/freepublications/publication/WEO2017SpecialReport_SoutheastAsiaEnergyOutlook.pdf..

66 Chea Vannak, "New solar and wind power project unveiled," *Khmer Times*, December 26, 2017, accessed November 15, 2018, https://www.khmertimeskh.com/5098012/new-solar-wind-power-project-unveiled/.

67 Ibid.

68 De Ferranti, Fullbrook, McGinley, and Higgins, "Switching On: Cambodia's Path to Sustainable Energy Security," 27-30.

and EAC are resistant to allowing on-grid solar.[69] Officially, the longstanding policy has been that if a household installs rooftop solar, they cannot also maintain a connection to the grid.[70] While a few large companies have been permitted to install rooftop solar on factories to defray operational costs—Coca Cola meets approximately 30% of their demand through solar power—they are still not permitted to supply excess electricity into the grid.[71] In some cases, residential owners have been threatened with disconnection from the grid if they operate a solar system that sends excess power into the grid.

While EDC has articulated valid concerns about grid stability in relation to incremental additions of intermittent generation sources like solar and wind, the lack of proactive policy making has led to the law lagging significantly behind market trends. By 2017, the price of solar had dropped so significantly on the global scale that foreign investor interest and donor pressure led to the Asian Development Bank's coordination with the Cambodian government on the country's first 10 MW pilot solar PV project (Bavet Solar Farm profiled above) in the country. Even before construction on the Bavet Solar Farm finished, the ADB had already started discussions with the Cambodian government on a second 100 MW solar park. These developments are economically competitive even without the integration of battery storage, which addresses variability issues and is dropping in price rapidly.

In addition to the ADB public-private partnership projects, private investors have entered the playing field – namely Omni Navitas, GPP, Engie/Devenco, the Inter Far-East Public Corporation, and a few unnamed consortiums have all expressed interest in commercial-scale solar investments.[72] In addition to commercial-scale investors, a few individual companies, factories, and owners of other large buildings such as the US Embassy in Phnom Penh have negotiated with EDC to install solar capacity on building rooftops in order to alleviate high costs of electricity from the grid. As of late 2018, more than 60 companies are active in Cambodia's solar sector—while the quality of service varies and most are doing solar home systems, it is clear that there is investor interest.[73]

69 Hang Sokunthea, "Market for Solar Power Heats Up, but Policy Lagging Behind," *Cambodia Daily*, June 29, 2017, accessed November 15, 2018, https://www.cambodiadaily.com/business/market-solar-power-heats-policy-lagging-behind-131927/; Authors' interview with diplomat, Phnom Penh, Cambodia, February 27, 2017.

70 Adolfo Perez-Gascon, "Opportunities And Barriers In Cambodia's Solar Market," *B2B Cambodia*, June 2, 2017, accessed November 15, 2018, https://www.b2b-cambodia.com/articles/opportunities-and-barriers-in-cambodias-solar-market/.

71 Authors' interview with Ministry of Environment Official, Phnom Penh, Cambodia, February 28, 2017

72 Chea Vannak, "A new solar power partnership set to shine," *Khmer Times*, October 12, 2017, accessed November 15, 2018, https://www.khmertimeskh.com/5085846/new-solar-power-partnership-set-shine/; Ayanna Runcie,"Thai solar energy company aims for 20-megawatt plant," *Phnom Penh Post*, May 20, 2016, accessed November 15, 2018, https://www.phnompenhpost.com/business/thai-solar-energy-company-aims-20-megawatt-plant; "US firm pitches massive solar project in Cambodia," Bangkok Post, February 1, 2018, accessed November 15, 208, https://www.bangkokpost.com/news/asean/1405790/us-firm-pitches-massive-solar-project-in-cambodia.

73 Authors' interview with Engineers Without Borders representative, Phnom Penh, Cambodia, November 26, 2017.

KAMPONG SPEU SOLAR PROJECT

In September 2017, Global Purify Power (GPP)—a joint venture including Cambodian, Thai and Lao investors—started constructing a 15 MW solar plant in Kampong Speu province to supply energy to the local industrial zone. This $10 million plant is the start of the company's plan to invest $400 million in 225 MW of solar projects in Kampong Speu, Takeo, and Kampong Chhnang provinces.74 The GPP project actually predates the Bavet Solar Farm pilot project that the ADB successfully constructed in 2017: the GPP consortium first received government permission for commercial-scale solar in December 2015, but it took almost two years to move ahead because GPP is directly responsible for identifying power purchasers. MEM has previously indicated that EDC did not need the electricity in that area, as it is already committed to purchasing from coal and hydropower projects.75 Given the May 2018 announcement of a separate 60 MW solar plant in Kampong Speu,76 it appears that this rationale may be changing.

Above: Solar power project in Thailand, courtesy of the Asian Development Bank

74 May Kunmakara, "$400m solar project launched," *Khmer Times*, September 11, 2017, accessed May 4, 2018, https://www.khmertimeskh.com/5082184/400m-solar-project-launched/.

75 Ibid; "First solar power investment granted to GPP," *Phnom Penh Post*, January 23, 2016, accessed November 15, 2018, https://www.phnompenhpost.com/post-weekend/first-solar-power-investment-granted-gpp.

76 Sorn Sarath, "Two power plants get ministers council OK," *Phnom Penh Post*, May 28, 2018, accessed November 15, 2018, https://www.phnompenhpost.com/business/two-power-plants-get-ministers-council-ok.

As investor interest has manifested and global prices has dropped, government interest in alternative energy has grown significantly in recent years and officials have worked internally to address the significant regulatory questions surrounding solar. In early 2018, the Electricity Authority of Cambodia (EAC) circulated a draft prakas (ministerial proclamation) on tariffs and grid connections for solar power to stakeholders for review.

The final regulation issued in January 2018 does provide key legal clarity. The new regulation confirms that large-scale consumers—for instance, large apartment buildings, factories, or other large compounds—can simultaneously utilize solar projects while also maintaining a grid connection.[77] The EAC confirms that EDC can buy solar power from producers and lays out a tariff structure that will be applied to these sales. However, the new regulation limits power trade to projects that are either already included in the national Master Energy Plan or undergo review by both Ministry of Mines and Energy as well as EDC before connecting. There is also no mention of low-voltage consumers like individual households, which leaves the future of rooftop solar in question.[78]

While the new regulation is a key step towards providing legal clarity for large-scale producers and consumers looking to invest in solar, it did not lay the groundwork of more supportive policies that supporters of renewable energy would like to see. However, many of these advancements are currently included in the draft Environmental Code championed by the Ministry of Environment. While it is still in draft form, the Code requires specific targets for sustainable energy.[79] Specifically in support of solar power, the Code requires the EAC to adopt a net-metering policy and establish a pilot feed-in tariff pilot within one year of the Code's passing.[80] The draft Code also provides broad support for household solar systems and tax breaks for companies that utilize solar (as well as other technologies) to produce their own electricity.[81]

While the timeline for the adoption of the Environmental Code is not yet clear, if these articles remain then this will be a significant game-changer for the adoption of solar power in Cambodia. Widespread adoption of rooftop solar would help significantly cut Cambodia's peak demand, which—like many other countries in Southeast Asia—falls during the daytime when air conditioning use spikes.

The other major challenge to the development of solar power apart from regulatory confusion is that—like hydropower projects—solar farms require land. One MW of solar power re-

77 "Regulations clarifying the use of solar PV in Cambodia," *PV Magazine*, March 15, 2018, accessed November 15, 2018, https://www.pv-magazine.com/2018/03/15/regulations-clarifying-the-use-of-solar-pv-in-cambodia/.

78 Tom Kenning, "Cambodian C&I solar opportunities still strong despite low voltage ban," *PV Tech*, April 11, 2018, accessed November 15, 2018, https://www.pv-tech.org/news/cambodian-ci-solar-opportunities-still-strong-despite-low-voltageban.

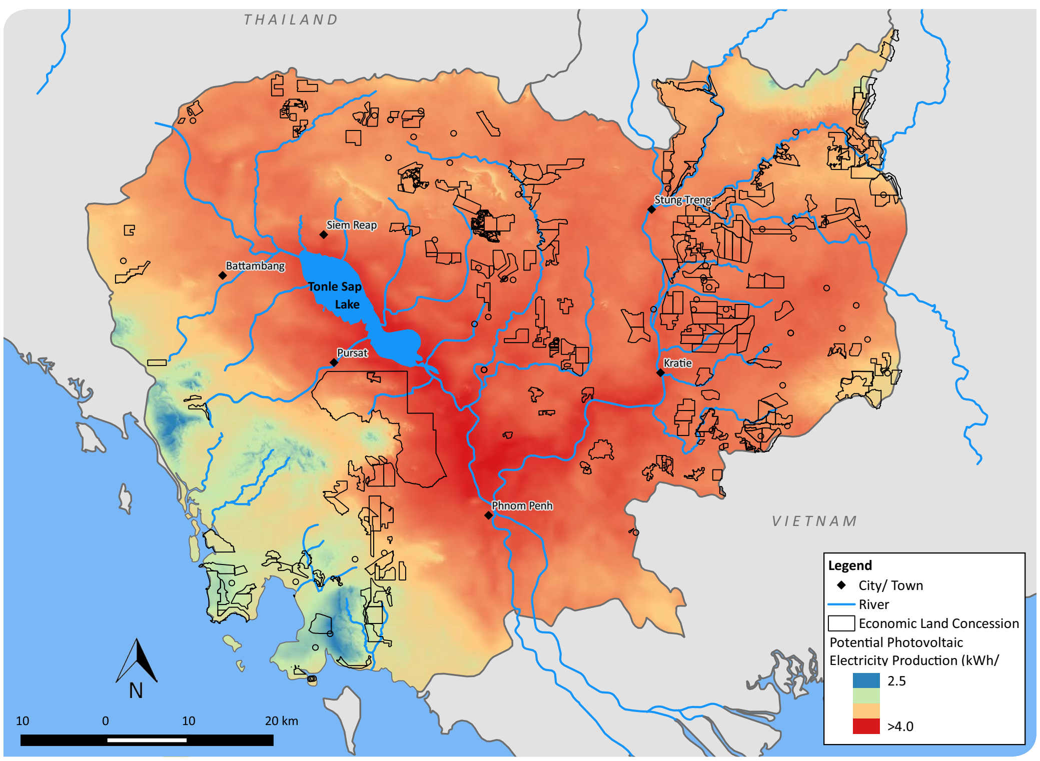
79 "Environment and Natural Resources Code of Cambodia, Tenth Draft--Article 287," 2018, 73.

80 Ibid, pages 78-79.

81 Jay Cohen, Sophea Sin, and David Mol, "A Break in the Clouds: Regulating Cambodian Solar Energy," Lexology, May 25, 2018, accessed November 15, 2018, https://www.lexology.com/library/detail.aspx?g=3e897311-42b4-4531-84eb-cc4b3159c2c0&utm.

quires on average 2 hectares of land in Cambodia.[82] While it is possible to reduce this somewhat using more efficient technology and economy of scale, land is already a contentious issue in Cambodia given a history of land grabs. There have been more than four-hundred thousand people displaced by economic land concessions (ELCs), which are large parcels of land that the government has leased to business investors for agri-business and other investment purposes. ELCs are extremely controversial given the role that they have played in supporting land grabs, often from subsistence farmers. While new concessions ceased in 2012, approximately 2 million hectares, which is twelve percent of the country's land and estimated as almost three quarters of arable land in the country, had been granted as ELCs.[83]

Any consideration of additional ELCs for solar power would be deeply unpopular if not politically impossible given their likelihood of contributing to further illicit land grabbing—however, it may be possible instead to rezone ELCs that are not currently being used. In 2013, the Ministry of Agriculture, Forestry, and Fisheries estimated that approximately one quarter of land leased to foreign investors was used in line with the contract.[84] While some of these ELCs have been revoked in the years since due to lack of development and the government's redistribution processes, others still lie fallow given the low commodity prices in recent years. The map below shows that most ELCs are within the preferred zones for solar PV deployment that receive high solar radiation.



82 Authors' interview with Enrich Institute expert, Phnom Penh, Cambodia, February 28, 2017.

83 "Land," Open Development Cambodia, August 3, 2015, accessed November 15, 2018, https://opendevelopmentcambodia.net/topics/land/.

84 Daniel Pye, "New owners, old story," *Phnom Penh Post*, March 6, 2014, accessed November 15, 2018, https://www.phnompenhpost.com/national/new-owners-old-story.

If Cambodia's government adopts supportive policies towards solar energy, including the rezoning of unused ELCs to support sustainable power generation, Cambodia is perfectly placed to develop a solar belt. This rationale would have suffered from price comparison in past years, but global improvements in solar technology and price drops mean that it is increasingly affordable and competitive with traditional generation technologies on the global scale.

RECOMMENDATIONS FOR STAKEHOLDERS IN CAMBODIA

1. **Adopt basin-wide, system-scale planning to quantify tradeoffs and develop scenarios and apply it to the development of the Sekong Basin and all of Cambodia.**
    a. Maximize river connectivity by avoiding the Sambor and Stung Treng dams on the Mekong mainstream and the Sekong Dam on Cambodia's portion of the Sekong mainstream. Avoiding these dams will promote the flow of water, sediment, fish, and organic material to the Tonle Sap and the Mekong floodplain. Capacity loss from avoiding these projects can be offset by developing floating solar projects on Cambodia's existing reservoirs and broadly increasing investment in non-hydropower renewables.
    b. In Cambodia's portion of the Mekong Basin, only site and build dams above the Lower Sesan 2 Dam. According to Cambodia's current dam inventory, this could result in an additional 1700 MW of capacity added into Cambodia's energy mix while potentially having a net zero effect on Tonle Sap connectivity. Studies should be conducted to explore this opportunity to verify the total amount of economically feasible power above Lower Sesan 2 and confirm that impacts would be limited and identify how to mitigate them.
    c. Acknowledge a new, critical role for hydropower as a supplement and complement to the intermittency of non-hydropower renewables. Position new hydropower assets within Cambodia's power mix to promote this orientation rather than as an independent asset intended to meet baseload demand needs.

2. **Engage with Thailand, Laos, and Vietnam bilateral or via regional mechanisms such as ACMECS and the MRC to promote system-scale hydropower planning and the development of non-hydropower renewables in all Mekong countries, particularly Laos.** Engagement with Laos could be in the form of increased power purchases from Lao energy generation assets conditional on the smart siting of future hydropower project and multi-purpose operation of dams in Laos and a broadened expansion of non-hydropower renewables into Laos's future energy mix. System-scale planning in countries upstream of Cambodia will reduce pressure on the Tonle Sap's natural resources, improve connectivity outcomes, and secure the country's food supply.

3. **Facilitate policy and physical infrastructure for non-hydro RE investment**. One of the most effective way to facilitate the adoption of renewables would be to pass the Environmental Code. While the Code appears to have stalled in the review process, individual policy recommendations and guidance included in draft versions of the Environmental Code could be discussed separately with energy planners. The items below in particular would help put Cambodia on a more sustainable path that would be more diverse and flexible in responding to growing demand pressures and climate change impacts.

    a. **Establish a clear government target for the inclusion of non-hydropower renewable energy in Cambodia's future energy mix.** Government targets are a clear statement of support for alternative energy sources, and would spark additional investor interest in solar, wind, and biomass/biogas plants. Despite slow but steady progress on establishing a regulatory framework for solar projects, the Ministry of Industry, Mines, and Energy currently does not yet have a national target in place. ASEAN has a shared and ambitious renewable energy target of 23% of the energy mix by 2025. While some countries count hydropower as renewable, Cambodia could best align itself with this shared vision by establishing a set of long-term targets for non-hydropower renewable energy.

       Cambodia's energy mix through 2020 is projected to be approximately 3,000 MW. Commercial scale solar plants are easily deployable within a year or so, making it more than feasible for the government to set a goal of at least 5% of Cambodia's national energy mix—or 150 MW—coming from renewable energy by 2020. With an existing baseload of hydropower and coal, this target could easily be scaled up throughout the 2020s. If the Asian Development Bank's 100 MW solar park project gets off the ground within this timeframe and paves the way on regulatory issues for new solar investments, it is very possible to scale this up rapidly to more than 20 or 30%.

    b. **Prioritize the planned rollout of the ADB-supported 100 MW Solar Park and use lessons-learned to standardize an auction framework for future energy investments in Cambodia.** The ADB is finalizing the feasibility study for the 100 MW solar park in November 2018, and bidding is expected to begin immediately after the study concludes. A Bloomberg New Energy Finance study revealed that auction systems can result in an additional price drop of up to 40% for renewable energy projects. India is a perfect example of a country which benefited rapidly from the rollout of an auction system: in 2017, the price of commercial-scale solar dropped 26% in only three months due to competitive bidding.

For Cambodia, where the price of solar is between 9-11 c/kWh, a similarly rapid price drop could lead to prices as low as 6.8 – 8.25 c/kWh. This would quickly put solar projects on competitive footing with new thermal coal and hydropower plants. Utilizing the lessons-learned from the ADB to standardize the auction system—and also the other related regulatory frameworks such as permitting, power purchase agreements, etc.—would allow the government to capitalize on the rapid price drop to meet rapid electricity demand through non-controversial, domestically produced, and renewable electricity in coming years.

c. **Work with foreign leaseholders in economic land concessions sitting fallow to consider utilizing the space for solar production**. The Ministry of Agriculture, Forestry, and Fisheries estimated in 2014 that only one quarter of Cambodia's ELCs were being used for their intended purpose. Many of these unused ELCs lie fallow given the low commodity prices in recent years. Solar energy plants can be installed quickly and could put this land—much of which has already been cleared for agricultural purposes—to use in the short-term. ELCs within close proximity to high energy demand areas such as Phnom Penh, Siem Reap, and Battambang or close to existing hydropower projects with existing grid extensions should be prioritized.

   Cross-ministry coordination between the Ministry of Mines, Industry, and Energy and MAFF would allow the government to identify the ELCs with the best solar irradiation, which are located near existing transmission lines and other key infrastructure, and target these for rezoning. Foreign investors who are just sitting on investments might welcome the opportunity to put the land to use making money within a couple of years, in which case the government could work with the leaseholders to directly develop these ELCs as solar farms. In cases where investors are not interested in alternative uses for the land, the government could negotiate to buy back the rights or work with the leaseholder to sell them to a third owner who would develop a solar park.

d. **Establish a net-metering policy that would allow consumers to earn credits for excess production sold into the grid**. The electricity price in Cambodia is high enough that it makes business sense for many enterprises—and even some homeowners—to install rooftop solar panels and utilize this electricity directly. However, unlike many of Cambodia's neighbors, EDC does not allow the sale of excess electricity into the grid. While utility operators correctly recognize that a large influx of power from small producers would require a shift in management style, the amount of solar electricity that would flow into Cambodia's grid is unlikely to cause serious issues in the near-term and can easily be managed by operational changes in the medium-to-long term. Global energy trends are moving towards increasing decentralized production and adoption of renewables, meaning that this question will continue to arise in the future. It would be in Cambodia's interests to start trialing a net-metering policy in Phnom Penh now, so that the management changes and challenges can be identified and worked out while the amount of solar that would flow into Cambodia's grid is still small.

e. **Classify solar energy technologies, wind technologies, and batteries as exempt from import duties**. Solar panel costs have dropped nearly 85% since 2009, and solar installations have reached record prices under six cents a kilowatt in many other developing countries such as India. One key factor keeping prices high in Southeast Asian countries is that there is not yet a local manufacturing base, and the equipment is taxed upon entry. Suspending or decreasing the import duties on solar panels, wind turbines, batteries, and other equipment in an effort to encourage local adoption of these alternative technologies would help kickstart the application of solar technologies in Cambodia and support technology transfer.

4. **Utilize Cambodia's National Council for Sustainable Development (NCSD) to develop a coordinated national plan for basin-wide water and energy development that promotes non-hydropower renewable energy.** Cambodia is the only country in the region with an inter-agency mechanism for coordinating sustainable development policy at the national level across various ministries. The NCSD can convene various stakeholders in an iterative and participatory manner that identifies needs of relevant stakeholders and act as a constructive decision-making platform that can guide the national government toward a plan for basin-wide water and energy development. The NCSD can also coordinate with funding and capacity building efforts of development partners who can assist in this process. Effective usage of the NCSD can reduce delays, costs, and environmental and social risks associated with of water and energy investments in Cambodia and move the countries development forward in a timely fashion.

5. **Facilitate robust democratic processes to gain sustainable development dividends**. Over the last two decades, processes related to Cambodia's democratization have played a critical role in identifying the risks posed to Cambodia's natural resource endowment and the communities who draw livelihoods from these resources. These processes have consistently developed constructive pathways which can drive sustainable development forward in Cambodia.

RECOMMENDATIONS FOR DEVELOPMENT PARTNERS

1. **Utilize Cambodia's water and energy sector development as a case study for system-scale planning**. Cambodia presents an opportunity for joint planning and investment from emerging US-EU-Australia-Japan infrastructure development partnerships and/or stakeholders involved with China's Belt and Road Initiative. Each of these countries has ongoing initiatives at the policy, think-tank, and academic levels which can promote and contribute to system-scale planning in Cambodia. Chinese stakeholders have a significant opportunity to move such a plan forward given that Chinese developers hold most MOUs for hydropower dams and Chinese stakeholders hold leases for a majority of Cambodia's Economic Land Concessions. The Ayerwaddy-Chao Phraya-Mekong Economic Cooperation Strategy (ACMECS), the Lower Mekong Initiative, the ADB GMS Economic Corridors Program, and/or the Lancang-Mekong Cooperation Mechanism could provide the convening power to move the system-scale planning process forward.
2. **Provide capacity-building support for the power sector transition**. There is significant technical capacity inside multinational institutions such as the Asian Development Bank, International Energy Agency, and International Renewable Energy Agency (IRENA) that can be transferred to utility operators and energy planners in developing countries like Cambodia. Development partners should prioritize financial support for technical training, exchanges, and other capacity-building activities to bring this technical expertise to Electricity du Cambodge and the Ministry of Industry, Mines, and Energy.
3. **Business councils should work with the government of Cambodia and other development partners to identify opportunities for solar, wind, and biomass investment and identify policy obstacles that make these projects bad investments.** Business Councils such as the US – ASEAN Business Council, Australian Chamber of Commerce, Chinese Chamber of Commerce, and other business organizations include many large companies which would benefit—either through direct investment in power plants or through the deployment of commercial-scale rooftop solar on offices, factories, or warehouses—from addressing these policy obstacles discussed above. By speaking as a collective and offering a business-perspective on which policies and regulations would need adjustment, they may provide constructive momentum to the energy transition.

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ABOUT STIMSON

The Stimson Center is a nonpartisan policy research center working to protect people, preserve the planet, and promote security & prosperity. Stimson's award-winning research serves as a roadmap to address borderless threats through concerted action. Our formula is simple: we gather the brightest people to think beyond soundbites, create solutions, and make those solutions reality. We follow the credo of one of history's leading statesmen, Henry L. Stimson, in taking "pragmatic steps toward ideal objectives." We are practical in our approach and independent in our analysis. Our innovative ideas change the world. The Southeast Asia program takes a pragmatic view of energy and water development in the region, recognizing both the negative impacts and positive benefits of hydropower development while also acknowledging the realities of regional development. Our team seeks to identify feasible alternatives that would lead to more sustainable outcomes than the current development trajectory.

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LETTERS FROM THE MEKONG

This is the fifth in the *Letters from the Mekong* series of issue briefs from Stimson's Mekong Policy Project, a long-term initiative at the Stimson Center that focuses on alternative solutions to transboundary environmental and food security and regional stability impacts arising from proposed hydropower dams on the mainstream and major tributaries of the Lower Mekong River. The Mekong Policy Project seeks to promote further awareness about these impacts and the need for a more coordinated development strategy among regional actors, policy-makers in riparian countries, donor governments to the MRC, and civil society actors. Letters from the Mekong will integrate information from research trips that the Southeast Asia team makes to the region and will examine changing trends for hydropower development, sustainable development, and changing perceptions among regional actors.

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