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Assessing the potential of a low-carbon future for Cambodia

Furqan Asif,[1] Melissa Marschke,[1] and Chanrith Ngin[2]
[1]*School of International Development and Global Studies, University of Ottawa, Ottawa, Ontario K1N 6N5, Canada*
[2]*Faculty of Development Studies, Royal University of Phnom Penh, Phnom Penh, Cambodia*

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This paper examines Cambodia's current carbon pathway and considers if Cambodia could move towards a low carbon future. We do so by examining two of Cambodia's largest carbon emitting sectors: energy and transportation. We argue that Cambodia has a unique window of opportunity to pursue a low carbon pathway given that, despite significant economic growth, the country is currently producing less CO_2 per capita compared to most other countries across Asia. Cambodia could benefit greatly (in economic, social, and environmental terms) from adopting a low carbon pathway. Promising harbingers are present, such as recent shifts to hydropower, adoption of urban master plans, and citizen frustration with traffic congestion and poor air quality that may enable public buy-in for innovative low-carbon solutions. Achieving this will require sharpened and harmonized policy, approaching all planning activities from a low-carbon perspective, and support (both institutional and financial) from regional bodies and multilateral organizations. *Published by AIP Publishing*. [http://dx.doi.org/10.1063/1.4978495]

INTRODUCTION

The 2015 Conference of Parties (COP21) Paris Climate Conference marked an important chapter in efforts to address climate change and its associated risks to populations, economies, and security around the world. Of this, the so-called "biggest opportunity of our age," emerged a clear message: Collectively, we must radically reduce carbon emissions and shift the global economy towards a low-carbon future (King, 2016). There is an emerging consensus that the world will need to achieve net zero emissions by 2100 to prevent global mean temperatures from going past the 2 °C target (relative to the preindustrial era) agreed to at COP21. This message was echoed during the 2015 G7 nation meeting (representing the seven largest high-income economies—the United States, Japan, Germany, the United Kingdom, France, Italy, and Canada): There has to be a "decarbonisation of the global economy over the course of this century" (G7 Germany, 2015, p. 15). The global economy must decarbonize if dangerous levels of carbon emissions are to be avoided.

The shift to a low-carbon economy will have significant implications for the global North and global South. Arguably, this new policy paradigm is particularly important for global South countries whose governments and institutions are already tasked with making investments to address poverty and inequality while advancing economic growth. To achieve a low-carbon future, global cooperation and coordination will become paramount, requiring the use of, and support via, regional bodies, unions, and associations. For the Southeast Asian region, this task rests with the Association of South East Asian Nations (ASEAN), which comprises ten countries: Indonesia, Malaysia, Philippines, Singapore, Thailand, Brunei, Myanmar, Vietnam, Laos, and Cambodia—collectively representing approximately 625 million people and a nominal Gross Domestic Product (GDP) of US $2.6 trillion (ASEAN, 2015). As the ASEAN community continues to push for further regionalization, integrating economies, and infrastructure (ASEAN, 2015), in a way that is sustainable and minimizes carbon emissions, will be critical.

Within ASEAN, pathways towards a low-carbon future have been articulated in the ASEAN Economic Community Blueprint 2025 and the ASEAN Plan of Action for Energy Cooperation 2016–2025. These have primarily focused on improving energy efficiency, promoting the use of biofuels for transportation, supporting increased adoption of renewable energy and building capacity for nuclear energy, and including the development of "a framework to support the deployment and utilisation of efficient and low carbon technologies" (ASEAN, 2015, p. 20 and Trajano and Vineles, 2016). Although ASEAN member countries represent a relatively low percentage in terms of global CO_2 emissions, their projected economic growth and consequent energy needs required to achieve this growth give the region an important role to play in the global effort at decarbonizing. Striking a balance among growth, integration, and a low-carbon future will not be without challenges for the ASEAN community (while ASEAN is an important regional governance body, particularly since national governance can be weak in some countries, we also recognize that there is an important role for the private sector and markets to play in transitioning towards a low carbon economy).

In this paper, we focus on one ASEAN member country, Cambodia, which we argue is particularly vulnerable because of its low adaptive capacity (Yusuf and Francisco, 2009) and being seriously affected by climate-related disasters (Kreft *et al.*, 2014). Standard and Poor's—in an assessment of the vulnerability of 116 countries to climate change and economic risk—rated Cambodia as the most vulnerable (Standard and Poor's, 2014). The report also states that the vulnerability rating of a country could also affect the interest rates at which the country can borrow money on international financial markets. This is especially significant for Cambodia—a country that is presently grappling with an ever-increasing debt burden. Cambodia continues to rely on the agriculture sector as a driver of economic growth (26.6% of GDP in 2015; industry: 27.7%; and services: 39.8%) (Ministry of Economy and Finance, 2016), and has more than 10% of the population living at or below 5 m above sea level and a high ranking on the vulnerability index compiled by Notre Dame University via their Global Adaptation Index (ND-GAIN). Seasonal climatic events, as seen with the severe monsoon season in 2013 that resulted in 168 deaths and an economic loss equivalent to 2% of its GDP (UNDP, 2014), are impacting Cambodians on multiple levels. Even as Cambodia "develops," serious governance challenges across multiple sectors remain (Biddulph, 2014 and Work, 2015).

Cambodia has seen remarkable economic growth—from 1993 to 2013, the country had on average an annual growth rate of 7% and GDP per capita increased from US $251.4 to US $1215, respectively (Ministry of Economy and Finance, 2016). As high economic growth is expected to continue with an increasing focus on the manufacturing and industrial sectors (Ministry of Planning, 2014), the consequent energy needs from this growth will have to be met. Hydropower is emerging as an important energy source that could transition Cambodia into a low carbon future, even as high carbon-emitting methods such as coal fired power plants have also been built. Each energy source is not without contestation: This also hints at the competing, sometimes contradictory, visions for energy growth in Cambodia.

This paper attempts to assess Cambodia's current carbon pathway and considers how Cambodia could move towards a low carbon future. Currently, most analysis on decarbonization has been confined to high emissions and/or high income countries with little analysis conducted on low-emission, low and lower middle-income countries (Deep Decarbonization Pathways Project, 2015). This paper contributes to filling this gap by focusing on Cambodia, which is characterized by low emissions, both overall (4496 metric tons in 2011) and per capita (0.31 metric tons in 2011), and has been classified by the World Bank as a lower middle-income country (World Bank, 2014b; 2015). We begin with a brief characterization of Cambodia's carbon emissions, before focusing on the energy production and transportation sectors since these areas are not only some of the largest emitters of greenhouse gases but also offer real potential for a low carbon future. We argue that, even though challenging, Cambodia would benefit greatly (in economic, social, and environmental terms) from adopting a low carbon pathway.

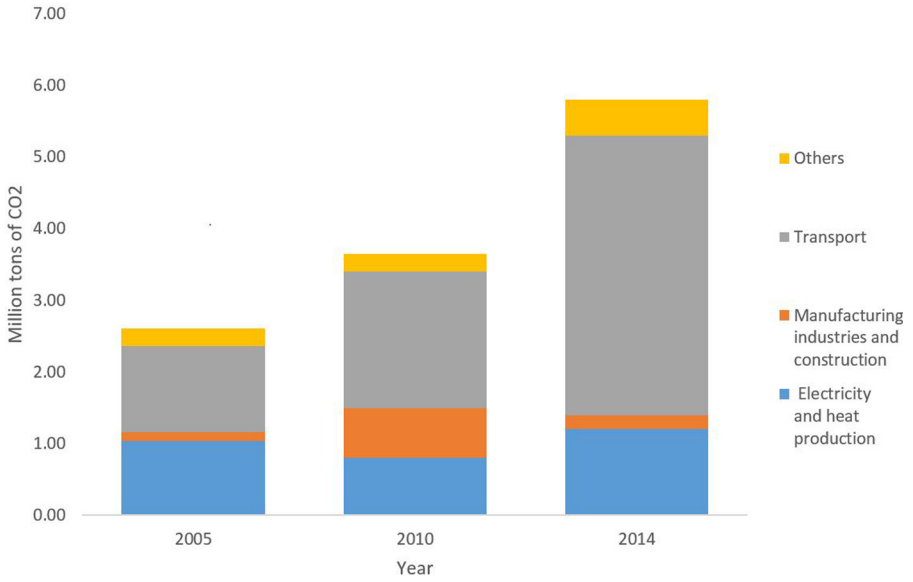

FIG. 1. CO_2 emission by source in Cambodia (million tons of CO_2). Source: IEA (2007; 2012; and 2016). Extracted from International Energy Agency database on Nov. 5, 2016.

METHODS

We based this article on a review of peer review literature, newspaper articles, and grey literature. Data for carbon emissions and GDP growth rates were obtained from the online World Bank Development Indicators Database and the International Energy Agency (IEA) and then further analyzed using Stata (a statistical software package). Emissions of global carbon dioxide are estimated to be accurate within 10%, recognizing that country estimates can have larger error bounds: Trends estimated from a consistent time series trend tend to be more accurate (World Bank, 2016). Our data analyses were drawn from a ten-year interval, starting from around 2000 (depending on the dataset).

Economic growth and greenhouse gas (GHG) emissions

The main drivers of economic growth in Cambodia are tourism, construction, manufacturing (principally textiles), and agriculture (rice paddy cultivation) (Senghor, 2015). These sectors also contribute to greenhouse gas (GHG) emissions (million metric tons of carbon dioxide equivalent), in particular, agriculture (38%), although land-use change (land clearance) and forestry contribute the most (over 46%) (World Resources Institute, 2016). Figure 1 illustrates, however, how the transportation sector as a percent of fuel combustion has contributed a significant amount to CO_2 emissions that has increased since 2000, whereas there is a decrease in emissions from electricity and heat production linked to Cambodia's recent transition to hydropower (which we discuss later). Undoubtedly, the link between the economic growth and carbon emissions will inform potential targets for decarbonization (MIME, 2013). Sustaining economic growth will require increasing energy input, which will contribute to increased carbon emissions; therefore, it will be important to identify priority areas/sectors on which decarbonization efforts have to be focused. Economic growth is also tied to increasing connections the country is making within the Greater Mekong Subregion (GMS)—the GMS is an economic area made up of six countries (Cambodia, China, Laos, Myanmar, Thailand, and Vietnam), all having ties (geographically) to the Mekong River. While increasing trade will contribute to economic growth, this will largely be facilitated by energy (e.g., for transportation and logistics) and thus likely contribute to GHG emissions. Striking a balance between increasing regional trade and a decarbonization agenda will be a challenge.

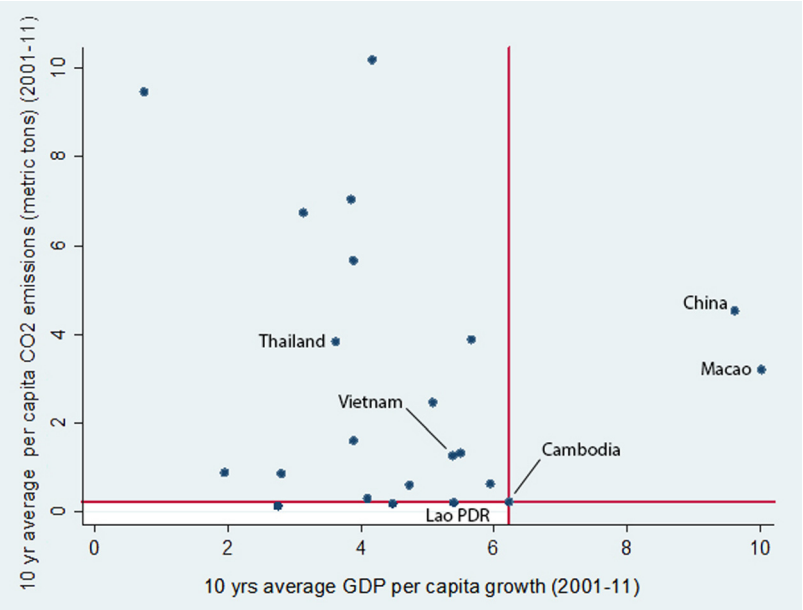

FIG. 2. 10-year per capita GDP compared with CO_2 emissions across Asian countries. Source: World Bank (2016).

When we draw on carbon dioxide (CO_2) emissions to better understand where Cambodia fits in the region in terms of GHG emissions (we acknowledge that other drivers such as methane are also worth considering, but these are not within the scope of this paper), we see that Cambodia is in an opportune position to pursue a low carbon pathway. Figure 2 compares Cambodia's CO_2 emission with other Asian countries (23 countries, in total). The horizontal (x) axis shows the average GDP per capita growth over 10 years (2001–2011), while the vertical (y) axis reports the average CO_2 emission in metric kiloton over 10 years (2001–2011). Among the neighbouring countries, Cambodia, Laos, and Myanmar face similar CO_2 emissions per capita (Figure 2). However, when CO_2 emissions are compared with economic growth, a more nuanced picture emerges. Cambodia had the third highest per capita economic growth in the Asian region (across 22 countries) between 2001 and 2011 although per capita CO_2 emissions were far lower than in China or Macao (Figure 2). Among the 19 Asian countries that achieved lower per capita GDP growth than Cambodia, 16 had higher per capita CO_2 emission than Cambodia, with the remaining three countries (Nepal, Timor Leste, and Laos) producing marginally less CO_2 emissions than Cambodia. In other words, even with significant economic growth, Cambodia is producing less CO_2 per capita at this moment in time than most other Asian countries. This is partly because a large portion of the population is rural, and in many areas, communities are not connected to the national electricity grid. However, as urbanization increases, particularly in secondary urban centers (and concomitant migration of people to them), the current position of Cambodia is expected to change quickly.

An analysis of two emerging sectors

Energy production

As the economic landscape of Cambodia has dramatically changed over the past decade, so has its energy landscape, with both availability and use showing twenty-fold increases (EAC, 2015). It is noteworthy to mention that Cambodia has one of the highest energy rates in the region, ranging from 700 to 1200 riel per kilowatt (0.17–0.29 USD); however, recently there have been reductions in electricity tariffs which have brought down the price of electricity to 780–800 riel (0.19 USD) per kilowatt for average households (Muyhong, 2015b), with further reductions indicated (but not specified) up to 2020 by the Electricity Authority of Cambodia

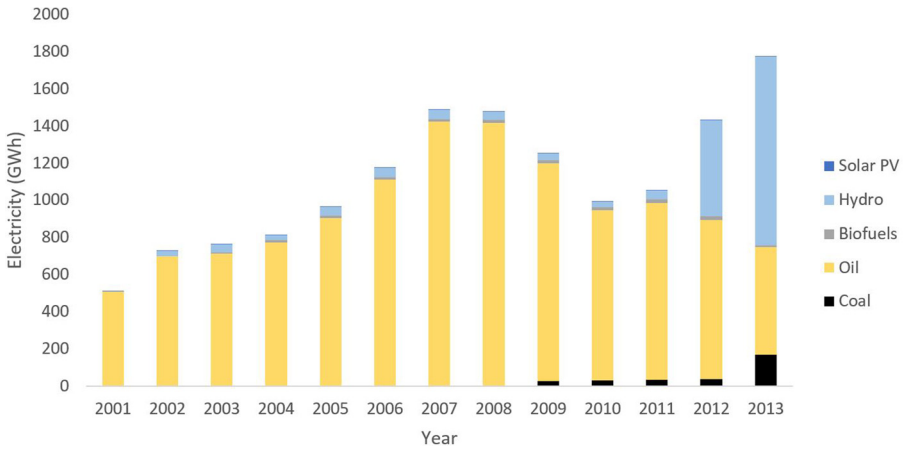

FIG. 3. Energy sources for Cambodia's electricity generation (in GW h). Source: IEA (2007; 2012; and 2016). Extracted from International Enegery Agency database on Nov. 5, 2016.

(EAC, 2015). In contrast, rates for industry and business are, and have become, even lower than residential rates (from 12.9 cents/kWh in 2015 to 12.6 cents/kW h in 2016) (EAC, 2015).

Over a period of twelve years (2000–2012), electric power consumption increased six-fold, from 33 to 207 kW per capita, and will likely continue to do so (World Bank, 2014a). However, the most significant changes, and those that will have an implication for Cambodia's decarbonziation, have occurred since 2013. Energy generation has increased nearly 73% from 2013 to 2014 with energy imports from Thailand and Vietnam decreasing (9.76% and 25.16%, respectively) and energy imports from Laos increasing (28.33%). Overall, from 2013 to 2014, the total energy imports decreased by 20.98% (EAC, 2015). The increase in endogenous energy production has been primarily driven by the addition of major power plants in 2014, both hydropower and coal (Figure 3), with the former taking the largest share of energy mix (60.54% as a proportion of energy sent out in 2014, followed by 28.22% for coal and 10.68% for diesel). The reason hydropower and coal have been pursued as the preferred energy sources lies not only in easy access to funding and technical capacity (via joint Cambodian-Chinese ventures and build-operate-transfer or build-own-operate schemes) but also because the latter serves as a way to curb energy shortages and as a cheap means of backing up hydropower or providing a way to supplement power, especially to industrial zones whose demands for it are increasing (Kotoski and Sokhorng, 2016). In addition, hydropower has been identified by the government as key in providing "stable electricity prices" to Cambodians (Vannarin, 2013). Although nuclear energy is not part of Cambodia's current energy mix, it is worth noting that Cambodia and Russia have recently set up a joint working group on peaceful uses of atomic energy (Yee, 2016).

Electricity predominantly serves urban areas. Phnom Penh itself accounts for approximately 85% of the country's total electricity consumption but has only 10% of the population (Pode *et al.*, 2015), whereas nearly 80% of Cambodia's population is rural (National Institute of Statistics, 2013). Indeed, almost 100% of urban households are electrified, while only 22.62% of rural households have access to grid electricity (this percentage of electrification for rural households has not changed significantly over the past 10 years, despite the consistently high GDP growth rates—although there are ambitious plans for improving rural electrification (EAC, 2015 and Pode *et al.*, 2015)): 10% use batteries, 3% use small diesel generators (500 W–5 kW) with the remaining using kerosene, candles, biomass, or other sources, and 30% of households have no energy access whatsoever (MIME, 2013 and Pode *et al.*, 2015). The Electricity Authority of Cambodia (EAC) is supporting rural electrification through a program that provides interest-free loans to meet costs associated with connecting to the electricity grid and another program that provides access to a fund for licensees to facilitate their investment into expanding electricity supply infrastructure in rural areas (EAC, 2015). However, the model of

passing the cost along to end-users, through loans, is problematic from a long-term perspective, especially since many rural households are already burdened with debt (ADB, 2014). Cambodia's electricity consumption is projected to grow annually at an average rate of 5.2% from 2009 to 2035 with the industrial sector expected to have the highest growth, followed by residential and commercial sectors (MIME, 2013). Given this, we now consider the energy sources that are currently being used, as well as those which have potential to contribute to a low-carbon future.

Fossil fuels

The discovery of untapped oil and gas resources, both on land and offshore, has sparked interest by the Cambodian government as a potentially important source of revenue and has been attracting outside investment (from Vietnamese, Japanese, and American oil companies), with US oil giant Chevron making the most advances in exploratory drilling and production (Senghor, 2015). Thus far, 19 Onshore Blocks have been mapped out; however, most remain undeveloped with only three contracts having been granted. As of 2016, only one of these blocks (located east of Tonle Sap Lake, granted to PetroVietnam) was active with exploratory drilling to be conducted (Baliga, 2016 and Ferrari, 2015). The economic benefits from this could be staggering, with analysis showing that the total contribution from the oil and gas industry to Cambodia's economy, in terms of total annual output, could range from US $46 million to US $10 billion (depending on the actual discovery and recovery rates), with government revenues ranging from US $15 million to US $2 billion (depending on royalty rates and actual recoverable deposits) (Senghor, 2015). However, despite this potential and reports anticipating production as early as 2013 (Gronholt-Pedersen, 2012)—later updated to 2016 (Weinland, 2012)—the recent dramatic fall in oil prices, combined with the government unable to sign agreements with companies, has led not only to the government cancelling concessions (Kunmakara, 2016) but also to the country unlikely to see oil production until oil prices increase significantly. According to one economic analysis, offshore production will not be feasible until the price of oil reaches at least $70 per barrel (Reaksmey, 2015).

A step towards decarbonization could involve shifting investment away from carbon intensive fuels such as coal to less carbon intensive fuels such as natural gas (Ellis *et al.*, 2013). While the currently low price of oil is enticing, along with identification of coal deposits in the northern parts of the country (Japan Development Institute, 2009), focusing on using these two sources for energy production in the long-term is not only short-sighted but will also galvanize carbon "lock-in," i.e., heavy investments made in unsustainable, high carbon infrastructure, making it more difficult (financially) to transition to low carbon infrastructure and an overall low carbon strategy.

Hydropower

One of the most significant changes in Cambodia for the last five years has been the increasing importance of hydropower in fulfilling the country's energy needs. This measure complements national policy (e.g., the National Strategic Development Plan (NSDP), 2014–2018), which emphasizes the central importance the energy plays in achieving sustainable growth and catalyzing poverty reduction. The approval of Cambodia's first major hydropower project (the 193 MW Kamchay Dam in Kampot, which came online in 2011) in 2005 foreshadowed the start of what has become a widespread hydropower program, largely supported financially by the Chinese government and companies such as Sinohydro Corporation (China's largest dam builder) (International Rivers, 2016). Since then, five other dams have been built and are in operation (producing a total of 842 MW) (ODC, 2016b). This trend is expected to continue: 17 sites have been identified for (medium or large scale) hydropower projects, along with another 16 (large or medium scale) under study (i.e., either a Memorandum of Understanding has been signed or a desk study has been conducted)—the amount of energy (in terms of installed capacity) in total from hydropower currently in Cambodia (1049 MW) represents only 15% of the total potential production (6885 MW) (ODC, 2016b). While there is limited

information about the exact projected lifespans of these hydropower plants, based on estimates of other existing dams, they are likely projected to last until the end of the century. For example, the Lower Sesan 2 dam is expected to have an operational lifespan of 100 years (Grimsditch, 2012) and thus is expected to still be operating at the end of the century (i.e., the time horizon of the decarbonization goal). Notwithstanding the projections, there are also other considerations such as hydroplant efficiency and potential, as well as rates of sediment build up, which are outside the scope of this paper (see Bosshard, 2011; Grimsditch, 2012; and Ogonda, 2014).

When hydropower development was started, there was optimism that Cambodia could do it in a sustainable way. One of the early reports alluded to this when it declared that "the country has the capacity to strive to be the best hydropower developer in the world, drawing on lessons learnt elsewhere to nurture an industry that contributes to the social and biophysical well-being of the nation, as well as its economic needs" (McCallum, 2008, p. 4). A recent case study of the Kamchay Dam by Siciliano *et al.* (2015), however, shows that the results are mixed, with some villagers temporarily benefiting from dam construction while others are struggling to pursue their traditional livelihoods. Chiefly this was due to the collectors having to travel farther away to areas inaccessible by bicycles (which they used normally); thus, they had to rent motorbikes, cars, and pay ferries to traverse the reservoir to access the forest (Siciliano *et al.*, 2015). A scanning of newspaper coverage of dam development highlights the challenges the villagers face in and around dam areas (cf. ODC, 2016a for news coverage) although a government committee has been set up to look at appropriate compensation for villagers displaced during dam development (Samean, 2016). Within this backdrop, there is tension between national and local priorities insofar as the costs, both environmental and social, for dam development disproportionately fall on local communities, while the benefits (e.g., energy access and generation capacity) are derived by urban areas (Siciliano *et al.*, 2015).

While in the context of transitioning to a low-carbon future hydropower efforts should be lauded, the general consensus on hydropower development in Cambodia is that there is minimal, often inadequate and passive implementation of regulations regarding environmental and social measures (Hensengerth, 2014; International Rivers, 2016; and NGO Forum Cambodia, 2013). It is also worth mentioning here the growing concern that hydropower development can have significant impacts on climate change (see Hensengerth, 2014; International Rivers, 2016; NGO Forum Cambodia, 2013; Samean, 2016; and Siciliano *et al.*, 2015) via methane and carbon dioxide emissions released as a result of decomposition of organic matter, particularly in tropical reservoirs but also downstream of the dam (Giles, 2006 and Kemenes *et al.*, 2007). Studies conducted thus far on carbon emissions from hydropower do hint that this area has been underestimated (Li and Lu, 2012) and, thus, could potentially compromise hydropower's contribution towards a low-carbon agenda. However, the issue remains inconclusive partly due to limited datasets and studies on emissions from dam reservoirs (Giles, 2006 and Magill, 2014).

Along with macro-level impacts, the socio-economic (e.g., on fisheries and livelihoods—see Ren (2015) and WWF (2016)) and environmental impacts of the medium and large-scale dam development to communities living near future sites will need to be taken into consideration in a more rigorous, proactive, and comprehensive fashion by both dam builders and the Ministry of Industries, Mines and Energy if hydropower is to form a "three-pronged" strategy of facilitating economic growth, contributing to poverty reduction and to a low-carbon Cambodia.

Transportation

While playing an important role in economic growth, the transportation sector is also a major contributor to overall CO_2 emissions in Cambodia: Emissions from the transport sector are anticipated to increase, from 785 Gg CO_2 ($GgCO_2$) equivalent in 2000 to 11 376 $GgCO_2$ by 2050 (MPWT, 2014). On the macroscale, this contributes to global warming, and on the more microscale, people experience both traffic gridlock and poor air quality. Despite Cambodia not

being a very industrialized country, it ranks 146 (out of 180 countries) on the Environmental Performance Index (which uses three indicators for air pollution: average exposure to fine particulate matter, PM 2.5; exceedance of PM 2.5; and indoor air quality) (Hsu, 2016). Could traffic gridlock and air pollution serve as a catalyst to get broad-scale buy in for a low carbon transition?

Even though motorcycles constitute the majority in the registry of vehicles (2.5×10^6 out of 3×10^6) (Chan, 2015), the bulk of the emissions is attributed to cars and trucks (MPWT, 2014). Compared to other Southeast Asian countries, Cambodia stands out with the transportation sector constituting a disproportionate percentage of total fuel combustion even as Cambodia has a relatively low number of registered vehicles for its population (202 per 1000 people versus 454 for Vietnam, 481 for Thailand, and 81 for Myanmar; Registered vehicle data for Vietnam (data for 2013), Thailand (data for 2012), and Myanmar (data for 2014) from World Health Organization's Global Health Observatory data repository (WHO, 2015) and for Cambodia via statement by Secretary of State Mr. Min Meanvy, from the Ministry of Public Works and Transport (Chan, 2015). However, over time, this is expected to change as the Ministry of Public Works and Transport (MPWT) estimates that every month, approximately 4000 cars and trucks, in addition to 300 000 motorcycles, are registered (Chan, 2015).

In addition to the increase in vehicle numbers, three other factors have contributed to increasing GHG emissions in the transportation sector. First, the majority of vehicles on the roads are second hand, inadequately maintained, and have poor efficiency, resulting in high CO_2 emissions. Second, heavy traffic volume in urban areas causes congestion, especially during rush hours, resulting in substantial idling in stand-still traffic (i.e., increased CO_2 emissions), and third, the poor railway infrastructure of the country means that roads serve as the dominant means of transporting both people and goods (MPWT, 2014). While there is GHG policy in place—the Ministry of Public Works and Transport (MPWT) has developed a *Strategic Framework for Greenhouse Gas Mitigation in Transport Sector*—it will take a serious push to develop public transportation or enhance traffic management in cities such as Phnom Penh. One of the roadblocks to achieve such a system has been the lack of effective travel-demand management and transport planning coordination (MPWT, 2013).

There are also gaps between stated regulatory/policy/strategy objectives and capacity. Taking the example of vehicle emissions, Article 6 of MPWT's Motor Vehicle Technical Inspection Procedure (2000) specifies the maximum concentrations of carbon monoxide, hydrocarbon, and related emissions, buttressed by a strategy presented in the Ministry's Climate Change Strategic Plan which aims to improve inspection and maintenance of vehicles. At the same time, this section is prefaced by acknowledging, on the one hand, that the "RGC [Royal Government of Cambodia] does not give high priority to the abatement of vehicle emission control, due to limited national budget," while on the other hand, an admission that "there are very few I/M [inspection-and-maintenance] stations" in the country (MPWT, 2013, p. 24).

Notwithstanding these issues, there are signs that hint at momentum for a low-carbon focus on the transport sector. For example, the recent rehabilitation and opening of part of the railway system linking Phnom Penh to Sihanoukville for passengers in addition to an increase in freight rail service (Crane, 2016 and Kotoski, 2016) are promising. In addition, a railway linking Phnom Penh to Poipet (close to the Thai-Cambodia border) is slated to be completed in 2016, with an even more ambitious 400 km, $9.6 billion railway project connecting the northern province of Preah Vihear to the coastal area of Koh Kong province in the pipeline (Equitable Cambodia, 2013 and Vanntey, 2016). Although the latter project is slated to be completed in 2017 (Equitable Cambodia, 2013), detailed information on the project has thus far been limited, along with delays in construction (Coltrane, 2015 and de Carteret, 2014). Just as Cambodia's land offers potential for contributing to a low-carbon future, so too do its 3000 km of navigable waterways. To that end, feasibility studies are currently being conducted to determine how the country's waterways and ports could be better used for transport, as they are already in neighbouring countries such as Thailand and Vietnam (Muyhong, 2015a). The adoption and mix of these initiatives (partially motivated by commercial interests) will provide an opportunity to add towards creating a multi-modal transportation network for goods but also of people, and

concomitantly, reducing the overreliance on road-based transportation (and thus, fuel). Tourism, contributing (directly and indirectly) nearly one-third to Cambodia's total GDP in 2015 (World Travel and Tourism Council, 2016), is another sector that offers an entry point for low-carbon transportation. Electric vehicles are slated to move tourists around the Angkor Wat complex (Baliga, 2015), and a Cambodian development company has designed Cambodia's first self-modified electric car (Chi, 2014). Solar powered tuk-tuks and buses are also being introduced to the Cambodian market ("Solar Bus - Star8," 2016).

Meanwhile, donors such as The Japan International Cooperation Agency (JICA) have supported and led efforts to develop an urban transport master plan, including conducting preliminary studies and outlining a system of buses, a sky-train, walking paths, and biking trails (Nary, 2015; Odom and Henderson, 2015; and Pheap and Henderson, 2013). More recently, the long-awaited Urban Master Plan of Phnom Penh (supported by the French embassy), adopted by the National Committee for Land Management and Urban Planning, was approved in 2015 by the Council of Ministers. The Master Plan is set to guide urban development in the capital until 2035, with a significant portion of investments dedicated to infrastructures such as roads/bridges and waste water treatment plants (Naren, 2015 and Sokthy, 2016). Meanwhile, this year saw the approval of the Battambang Land Use Master Plan (2030), an urban center which is projected to grow at 2.5% per year, which focuses on green sustainability (e.g., public green space and tree planting) (Kotoski, 2016).

An Urban Master Plan is designed, ostensibly, to guide the development of urban centres in terms of infrastructure and land-use planning. This includes consideration of transportation corridors (e.g., roads) and guiding the use of city spaces. Since transportation constitutes a significant portion of carbon emissions for Cambodia, its connection to planning is important and cannot be overlooked. To contribute to a low-carbon pathway, an Urban Master Plan for major urban centers (not just Phnom Penh) has the potential to positively influence the transportation sector by, for example, including the creation of pedestrian- and bicycle-friendly spaces instead of infrastructure for automobiles and advocating for improved utilization of urban waterways.

Taken altogether, while some efforts are more people-centered (e.g., raising awareness, linking air pollution with traffic congestion), others are technical (e.g., traffic management, transport planning coordination, and improving emissions' regulation and compliance). Both will require significant policy prioritization and financial assistance if the transport sector is to be transformed to align with a low-carbon future.

DISCUSSION AND CONCLUSIONS

Cambodia is at an opportune moment to seriously consider a transition towards a low carbon economy. Relatively speaking, Cambodia's CO_2 emissions are low: Even with significant economic growth, Cambodia is producing less CO_2 per capita at this moment in time than most other Asian countries. Hydropower is a growing sector. While not without its challenges, hydropower is something that Cambodia plans to harness in the years to come. Smart hydro development—which would include a series of smaller dams and a serious consideration of the social-ecological impacts of dam development—could also support the electrification needs of rural households. Solar generation may be something to pursue in rural areas that cannot be served by hydro development. In terms of mobilizing people to get into a carbon transition, along with the everyday challenges of living in Phnom Penh (traffic gridlock greatly impacting movement in the city; poor air quality), the emergence of the middle class presents an opportunity.

The socioeconomic landscape of the population has shifted (e.g., 49% of 20-somethings complete secondary school; internet penetration is at 38%) (Dijkhuizen, 2015) with Cambodians being more connected than ever before (99% of internet-connected Cambodians have a Facebook account). This represents an opportunity to raise social awareness around climate change and a low-carbon future. Consumption patterns of consumers will need to shift (data on consumption behavior of Cambodians are limited): A rising middle class could represent the adoption of values around political activism, the role of science and technology (ADB,

2010), and environmental awareness. Low carbon transitions can connect with people's everyday needs and aspirations for a healthier lifestyle in the city. Such a view is also sound from an economic perspective: By one recent estimate, congestion (along with lax respect of traffic laws) in the capital city is costing the country $6 million a month (from cost of petrol and lost job productivity) (Sotheary and Kunthear, 2015). However, shifting consumer behaviour and generating an interest in low carbon pathways will require local buy in, along with sustained campaigning on behalf of civil society, the development community and policy makers. Cambodia remains a context with weak laws (cf. Work 2015), meaning that consumer demand and shifting consumption patterns will be a key aspect of a low carbon transition.

This said policy will need to be further focused and enforced, since a discordance currently exists with respect to Cambodia transitioning to a low carbon future. For instance, within Cambodia's Climate Change Strategic Plan (CCCSP) (2014–2023), the vision states that the development of Cambodia is "towards a green, low carbon, climate-resilient, equitable, sustainable, and knowledge-based society" (Ministry of Environment, 2013, p. xvi). At the same time, the plan recognizes that "oil, gas, and mineral extraction industries will come to play a significant role in contributing to GDP growth in the near future" (Ministry of Environment, 2013, p. xv). If this is the trajectory that is to be followed, it will be very difficult, if not impossible, to avoid carbon lock-in while also taking away momentum towards decarbonization. Adding to the policy disjointedness (with practice), the CCCSP recognizes that "it is important that integration of renewable energy sources be considered in future energy production" (Ministry of Environment, 2013, p. 9). As Figure 1 shows, over a ten-year period, the relative percentage that renewable energy sources have contributed to energy production has remained largely unchanged. The transformation into a low carbon society will need to be intentional, with leadership being taken to develop innovative, timely policies.

By incorporating a low-carbon mindset at the outset of planning, this opportunity also has the added benefit of supporting a global decarbonization movement and several global Sustainable Development Goals (SDGs). For example, improved urban transport will support SDG 3 ("ensure healthy lives and promote well-being for all ages") by reducing air pollution (especially, particulate matter, PM10 and PM2.5) and resulting in fewer health risks. Further, shifting away from carbon-intensive energy sources to less carbon-intensive along with renewables will support SDG 7 ("ensure access to affordable, reliable, *sustainable*, and modern energy for all," emphasis added). Both these examples would also support more overarching goals such as SDG 9 ("build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation") and SDG 11 ("make cities and human settlements inclusive, safe, resilient, and sustainable"). From an investment perspective, climate and carbon are no longer externalities and are being factored into business decisions (Standard and Poor's, 2014). Therefore, as Cambodia seeks to attract more foreign direct investment and develop its industrial and manufacturing sector, decision makers will eventually have to proactively incorporate climate risk and the price of carbon in their planning.

While there are great challenges—institutionally, fiscally, and societally—for Cambodia to transition to a low-carbon future, there are also promising signs on the horizon including the recent shift towards hydropower, discussions of urban master planning, transport via waterways, and citizens being fed up with traffic gridlock and poor air quality. Policy makers, planners, and citizens, engaged at multiple levels, can push for a shift towards a low carbon economy, in large part because it is an opportunity to enhance everyday life, particularly in the city. With such a vision, Cambodia could be a model for other countries in the region for low-carbon development and also for showing leadership in addressing climate change challenges more broadly. The shift to a low-carbon economy for the world will have to be achieved in a dramatically short timeframe in order to avoid crossing critically important planetary boundaries and to prevent runaway global warming (Leggewie and Messner, 2012). Given this, while Cambodia can, and should, take steps towards more sustainable growth, it cannot be overstated that achieving a low-carbon future will require exceptional global cooperation and support for Cambodia to do so.

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