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A world away and close to home: The multi-scalar 'making of' Indonesia's energy landscape☆

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ABSTRACT

Indonesia is the world's largest producer of palm oil, a feedstock for agrofuels and an important source of direct, nutritional energy for human consumption. The country is also an important global supplier of coal, petroleum and natural gas while per capita fossil energy consumption is relatively low. For biomass- and fossil fuel-based energy, Indonesia has been transforming its energy landscape in order to provide for foreign demand. The landscape - both in literal and in the figurative sense - simultaneously forms and is formed by the material resource flows required for society's biophysical reproduction, i.e. the social metabolism; in the context of the ongoing energy transition, both are subject to change. In our analysis of Indonesia's palm oil production, we find that the drivers shaping the country's resource use as well as its energy landscape are located at a spatial, temporal, and functional distance from where they take effect. The energy landscape and resource use patterns are formed across levels of scale, from the subnational to the global. Energy policy confined to the framework of the sovereign nation-state cannot effectively address the complex drivers of increasingly detrimental environmental change associated with energy transitions nor can it trigger a sustainability transition.

1. Introduction

From oil platforms in Indonesia's territorial waters, ever-nodding oil pumps, and open-pit coal mines to deforested plantation land surrounding palm oil mills, the extraction and production of energy is visibly written into wide stretches of Indonesia's landscape. This materiality of the landscape is an expression of economic production and its political organization and is simultaneously a prerequisite for the development trajectory currently pursued by the Indonesian government. In this development trajectory, Indonesia acts as a global supplier of energy in two ways: 1) through inputs of energy into the production of goods for export and 2) through the direct export of energy (carriers), both fossil and biogenic. Export-orientation is manifested in Indonesia's membership in the Organization of the Petroleum Exporting Countries (OPEC) from 1962 to 2009 and again as of January 2016: Even though the country depends on monetary net-imports to meet its petroleum needs (EIA, 2015; UNSD, 2016), it is a biophysical net-exporter of fossil energy carriers and plays an important role as a supplier to the global economy (Brad et al., 2015). With regard to biomass-based alternatives to fossil fuels, Indonesia is the dominant global supplier of palm oil, both for direct, nutritional energy and as a feedstock for biodiesel.

Indonesia is a global energy supplier and fits into a widely observed pattern. Much of the energy needs of the global North and emerging economies are met by countries of the global South: directly, via the export of energy carriers, as well as indirectly through the export of energy-intensive goods (Giljum and Eisenmenger, 2004; Haberl et al., 2011; Wiedmann, 2009). The South is seen as a predestined supplier of biofuels (or their feedstock) to the North (Mathews, 2007). Through the international provisioning of energy, the global North may be held responsible for a higher amount of carbon dioxide emissions than those occurring on the territory of its countries (Hertwich and Peters, 2009; Peters et al., 2011). As a supplier of energy, Indonesia's energy landscape – that "constellation of activities and socio-technical linkages associated with energy capture, conversion, distribution and consumption" (Bridge et al., 2013, p. 335) is shaped not only by domestic factors but also by foreign demand, politics and political and economic decisions.

We propose that the landscape – both in the figurative sense that Bridge et al. (2013) evoke as well as in its literal, biophysical sense – in which Indonesia's expanding palm oil production is embedded is configured and shaped domestically and internationally. Accordingly,

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we must extend our analysis across levels of scale from the global to the sub-national in order to understand trends of (un)sustainability at the national level. As we will demonstrate, the Indonesian energy landscape consists not only of oil palm plantations, oil mills, and refineries but also of the trajectory of Chinese, Indian, and Southeast-Asian as well as European energy demand, of trade relations, and of the challenge of maintaining political power in a country as dispersed and diverse as Indonesia.

The Indonesian energy landscape simultaneously forms and is formed by the material resource flows required for society's biophysical reproduction, i.e. the social metabolism (Fischer-Kowalski and Haberl, 2015). By considering societies as hybrid, i.e., as subject to both a biophysical and a socio-cultural sphere of causation, we can analytically define the flows into and out of the biophysical compartment of society. We consider that compartment to encompass humans, their livestock, and their artefacts (which include infrastructure, buildings, and durable goods). Economy-wide material and energy flow accounting (EW-MEFA) is the tool with which we track inflows into Indonesia's socio-economic system – domestic extraction from agriculture, forestry, and mining, and imports – and outputs to the environment or to other socio-economic systems through the discharge of waste and emissions or through exports. These flows are linked to the landscape literally because a prerequisite for the extraction of most types of materials is a *colonization* effort, i.e., a continuous and directed intervention into the environment intended to transform that environment in such a way that it is more useful for extractive activities (Fischer-Kowalski and Erb, 2016; Fischer-Kowalski and Haberl, 1998). Examples for colonization include deforestation, tilling, weeding, etc. for agricultural production. If the colonizing activities were to cease, the landscape would relatively soon be covered in (secondary) forest again (Gingrich et al., 2016). Colonization represents severe intervention into natural habitats and ecosystems, usually with severe environmental impacts, including contribution to anthropogenic climate change and biodiversity loss.

The material flows observed through the lens of social metabolism are also linked to the energy landscape in a figurative sense: decision-making power over colonization activities and control over material flows depend upon and simultaneously lead to the gain or drain of political power as our case study of the expansion of oil palm plantations in Indonesia demonstrates.

The links between the energy landscape and social metabolism are dynamic. Changes in landscape and social metabolism over time are mutually dependent and are shaped by and shape political, social, and economic development. We have studied the transition of the links between Indonesia's energy landscape and metabolism in the expansion of oil palm plantations. In Section 2, we provide our conceptualization of the energy transition as seen from the perspective of landscape and metabolism. Based on the method and data presented in Sections 3 and 4, we explore the Indonesian energy transition empirically, focusing on palm oil production, in Section 5. Understanding the mutual dependence between energy landscape and social metabolism is a prerequisite to developing more sustainable and viable energy policies, applicable not just in the context of our Indonesian case study.

2. Background: Energy transition as the changing relationship between landscape and metabolism

In interdisciplinary fields of study of society-nature relations, energy transitions, although gradual as they occur, are conceptually marked by coinciding (and co-dependent) shifts in societal organization and in the composition and quantity of energy use (Leach, 1992; Sieferle, 2003; Smil, 2010). The shift from a biomass- to a fossil fuel-based form of societal energy use is a key example for such a meta-trend, as is the potential for a future transition to a renewable energy system. The environmental historian Rolf-Peter Sieferle (2003, 2001, 1997) has described energy transitions in terms of the changes in metabolic flows and in societal organization, leading to the identification of socio-metabolic modes: two biomass-based – hunting and gathering and agriculture – and one fossil fuel-based industrial mode (Krausmann et al., 2016; Sieferle, 2003). While societies subsisting mainly on hunting and gathering passively make use of solar energy, the agrarian system actively harnesses this energy source by intervening into the environment to actively control which crops are grown and when. Under the industrial mode, biomass (and hence current solar energy) is no longer the principal source of energy. Instead, solar energy of the past is used through the combustion of fossil fuels (product of historical photosynthesis, i.e., of solar energy of the past). The average energy requirements under different forms of subsistence differ strongly. While a human being on average requires 3 billion Joules (Gigajoules GJ) of energy per year (GJ/cap/a) in order to survive (including some use of fire for the preparation of food), the hunting and gathering mode requires almost 4 times as much: 11 GJ/cap/a. Under the agrarian mode, an average of 50 GJ/cap/a are used (more than 15 times the basic rate), and under the industrial mode, the range of energy use per capita is widest with an average of 200 GJ/cap/a, two orders of magnitude above the basic metabolic rate (Fischer-Kowalski et al., 2014a; Fischer-Kowalski and Haberl, 2007). Each of these basic modes of societal energy use simultaneously enables and requires very specific forms of societal organization. The transitions from one energetic mode to another are associated with fundamental and possibly revolutionary (Fischer-Kowalski et al., 2014b) transformation (Mitchell, 2013; Moss et al., 2016; Shove and Walker, 2014). These changes, paired with the new societal 'reach' that fossil fueled transportation and communication enables (Fischer-Kowalski and Schaffartzik, 2015), also dramatically change both the temporal and the spatial scale at which any given society may exert its influence.

Indonesia is undergoing an energy transition: Although biomass continues to be an important source of cooking fuel, especially in rural areas (e.g., Lee et al., 2015; Parikesit et al., 2001), the major share of the country's energy use already stems from fossil energy carriers. In 2013, fossil energy carriers contributed approximately two thirds of Indonesia's total primary energy supply (TPES) while combustion of biomass accounted for less than one quarter (IEA, 2016). The use of fossil energy carriers is linked to household electrification, commonly enabled by coal-fired power plants, and to petrol-fueled mobility; petroleum is the country's dominant source of energy (IEA, 2016).

In Indonesia, it was around the turn of the century that fossil fuels surpassed biomass in terms of their contribution to total final energy consumption (Fig. 1A). At the global average, this point was already reached prior to the oil price shocks of the early 1970s (Fischer-Kowalski and Schaffartzik, 2015). Especially those countries in Europe, North America, and Asia which industrialized early by international comparison, saw this shift in dominant energy source even earlier. In 1970, TPES in Indonesia corresponded to a little less than 12 GJ/cap (Fig. 1B), approximately the average identified for societies subsisting on hunting and gathering. It is important to consider here that TPES is higher than final energy consumption because of energy losses during transformation. In Indonesia, this comparatively low level of per capita consumption is the result of high disparities at the subnational level with much higher levels of consumption in industrial centers than in rural areas (Rehman et al., 2012). Averaged across a very large population, this results in a comparatively low level of per capita TPES. By 2010, Indonesian TPES amounted to approximately 36 GJ/cap (Fig. 1B) and was still lower than the average identified for agrarian societies.

The transition from a mainly biomass- to a fossil fuel-based energy system is associated not only with a significant shift in the composition and magnitude of material flows but also with far-reaching changes to the energy landscape. These changes are driven by energy use patterns in Indonesia and by the ongoing industrialization in other countries of the Asian region to which Indonesia supplied and supplies energy