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Are green jobs just jobs? Cadmium narratives in the life cycle of Photovoltaics

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ABSTRACT

This paper explores a tension between environmental justice and green jobs. Photovoltaic (PV) manufacturing processes involve hazardous chemicals similar to those found in the electronics industry, where impacts such as groundwater contamination, worker exposures to chemicals, and other air and water emissions overlap with environmental inequality. In the US, cadmium-based thin-film PV was financed with support from the American Recovery and Reinvestment Act producing new political ecological configurations of energy procurement and generation, linking Malaysian thin film PV fabs to public lands in the US desert southwest. By integrating traditions in global commodity chains, political ecology, and science and technology studies, this research shows how life cycle assessment was used to shape the debate about cadmium pollution from thin-film PV. As metrics have the power to obscure environmental injustice, the findings call for humility when interpreting life cycle assessment.

1. Green jobs, environmental justice, life cycle analysis

The past decade has seen renewed efforts to promote solar energy mobilized under the banners of climate change and economic recovery with an emphasis on green jobs—manual jobs in enterprises whose products and services improve environmental quality (Pinderhughes, 2006).[1] The moniker "green jobs" came into the vanguard starting around 2005 and by 2008 was a mainstream storyline of US Presidential hopefuls Barack Obama, John McCain, and Hilary Clinton. Soon after the election, the US Bureau of Labor Statistics codified the green job (US Bureau of Labor Statistics, 2011) as an official statistical measure formally linking the discourse of the Presidential campaign to tens of billions of dollars invested in clean energy innovations through the American Recovery and Reinvestment Act (ARRA) of 2009. ARRA investments in green jobs were seen as a contemporary manifestation of green statism (Barry and Eckersley, 2005), leading some observers to term this the "Green New Deal" (Friedman, 2007; Luke, 2009).

While these investments may hasten clean energy and create green jobs, there is an emerging tension between innovation and environmental justice as efforts to drive down the cost of solar energy introduce new environmental, health, and safety risks (Fthenakis and Moskowitz, 2000; Mulvaney, 2013). From 2009 to 2011, billions of dollars in ARRA investments targeted emerging thin-film photovoltaic (PV) technologies that directly convert photons from the sun into electricity (Table 1). Thin-film PV such as CdTe[2] and CIGS[3] can be cheaper to manufacture than the incumbent technology based on crystalline silicon, but rely on semiconductor alloys based on the metal cadmium, widely known to be a carcinogen, mutagen, and genotoxin (CDC, 2013).

On the one hand, green jobs in thin-film PV manufacturing portend increased employment across urban and rustbelt communities, in Silicon Valley, or even in the hi-tech corridors of East Asia. On the other hand, these vocations may reproduce environmental inequalities similar to those found in the electronics industries, which burdened communities in Silicon Valley with groundwater contamination (Szasz and Meuser, 2000) and caused significant occupational hazards among mostly female minority workers (Pellow and Park, 2002). PV manufacturing involves a number of environmental, health, and safety impacts related to electronics industries (Table 2), despite it being common parlance to refer to both industries as "clean-tech."

As production networks globalize, impacts are increasingly offshored to distant supply chains and contract manufacturers

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[1] "Green collar jobs" is also widely used in the literature (Pinderhughes, 2006; Jones, 2008). Sometimes it is described as green white collar jobs.

[2] The industry norm for cadmium telluride is to write CdTe and say "cad-tel" so the reading of this paper is improved if you say cad-tel when you read CdTe. CdTe is one semiconductor alloy layer with the second layer commonly cadmium sulfide (CdS).

[3] CIGS is a PV semiconductor with one layer an alloy of copper, indium, gallium, and selenium, and a second layer typically, but not limited to, cadmium sulfide (or, more recently, zinc sulfide).

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Table 1
ARRA investments in cadmium-based PV technologies.

Project	Developer	Costs
200 MW PV manufacturing	Solyndra	$535 million
180 MW PV manufacturing	Abound	$400 million
150 MW PV manufacturing	SoloPower	$197 million
Agua Caliente PV farm	First Solar	$967 million
Antelope Valley PV farm	First Solar	$646 million
Desert Sunlight PV farm	First Solar	$1460 million
Total		$4205 million

Table 2
Selected PV semiconductors and environmental, health, and safety hazards.[a]

PV type	Chemical hazards & emissions
Crystalline silicon (c-Si)	Silicon tetrachloride waste, lead solder and metallization pastes, strong acids (HCl, HF), caustics, solvents, pyrophoric gases
Amorphous silicon (a-Si)	Pyrophoric gases, solvents, indium tin oxide (ITO)
Cadmium Telluride (CdTe)	Cadmium (Cd), ITO
Copper indium gallium selenide (CIGS)	Cd compounds, ITO, selenium
Gallium arsenide (GaAs) crystalline	As compounds, phosphine gas, trichloroethylene solvents
Polymer/organic	Carbon nanotubes, Cd nanospears, ITO
Dye-sensitized	Nanoparticles, ruthenium, ITO

[a] Selected list compiled by the author from various sources mainly compiled by the National Photovoltaic Environmental Research Center (NPERC, 2013).

(Raj-Reichert, 2013) linking dissimilar micro-political ecologies across spaces that touch down from China to California through the life cycle of global commodity flows. A green job installing PV in California may linked to less-than-green jobs elsewhere along the PV commodity chain. Luke (2009, p. 15) asks, "…is a Green New Deal possible? Is this highly sought after 'greenness' only a superficial coating brushed across truer grey, brown or black qualities in urban industrial society that inescapably remain the same underneath the rhetoric?" Some argued for public investments to stimulate job growth in rustbelt and urban areas (Nordhaus and Shellenberger, 2007). EJ leaders such as Green For All's Van Jones (2008) were calling for green jobs explicitly in a justice frame—to ensure the approaching green wave lifts all boats. Few asked if the emerging thin-film PV innovations might be accompanied by unequal distributions of environmental impacts.

One tool for anticipating environmental impacts is risk assessment where a hazard and its likelihood are assessed. While helpful for some kinds of problems, the risk assessment framework makes it difficult to ask probing questions about the roots of environmental problems. This and other critiques of risk assessment (Sexton, 2000) led to calls for ways to assess the full resource and energy impacts of production (Hunt et al., 1996). O'Brien (2000) argued for a paradigm shift away from risk assessment to precaution, one that flipped the burden of proof from avoiding false positives to avoiding false negatives. This would be particularly true in cases where the implications are more than epistemological, but ethical—with something highly valued at stake (Schrader-Frechette, 1996). However, integrating the precautionary principle into the redesign of production systems requires a more comprehensive analytical approach, preferably with commensurable and quantified results.

Starting with Coca-Cola in 1969, and now increasingly popular among Fortune 500 firms, life cycle assessment (LCA) has become the preferred comprehensive framework to anticipate and measure environmental impacts. LCA is a form of environmental accounting (Hopwood, 2009) used to characterize the material and energy flows from raw materials extraction to disposal (EPA, 2013). LCA inventories environmental impacts according to accepted principles and norms (ISO, 1995) and it is increasingly used in public policies related to environmental performance (Hyatt and Spicer, 2012). The output of the analysis is a representation of environmental performance in the form of a quantified impact normalized by a value called its functional unit, which becomes a basis for comparison. Some examples of outputs include greenhouse gas (GHG) emissions per product produced, energy output per unit area, and heavy metals emissions per unit energy.

What kinds of environmental and health claims about cadmium-based PV are produced from LCA and do they differ from the kinds of claims produced through a political ecology approach to global commodity chains? Pellow (2000) argued that LCA could be an important tool to explore the roots of environmental inequality. This paper shows how LCA metrics became part of the cadmium PV assemblage by framing the issue of cadmium in a particular way—a quantified result that minimized concerns about cadmium pollution.

Recent work at the intersection of geographical thought and the sociology of science has brought attention to the social processes involved in the construction of metrics. Whether it is for market exchange or measuring environmental performance, constructing metrics requires the social activities of abstraction, commensuration, and reification (Espeland and Stevens, 1998; MacKenzie, 2009; Maurer, 2006). From this perspective, tools such as LCA are understood as calculative devices (Callon and Muniesa, 2005), with a politics predicated on their construction (Lohmann, 2005; 2009) and the propensity to displace social agency (Preda, 2006).

The sometimes conflicting epistemologies between the abstraction of environmental problems through LCA and the tools of political ecology are explored through a case study of claims made about cadmium pollution along PV commodity chains. The opening pages describe the approach to understanding commodity chains as global assemblages comprised of socio-ecological relationships (Odgen et al., 2013). "*Global* implies broadly encompassing, seamless, and mobile; *assemblage* implies heterogeneous, contingent, unstable, partial, and situated" (Ong and Collier, 2008, p. 12). By reassembling these relationships, explanations for environmental controversies can be rooted in multiple logics spanning nature, culture, governance, and capital, which are often in tension. After describing the methodology, the case of PV, LCA, and cadmium pollution is detailed. The paper concludes by explaining how different ways of discovering facts about the world might shape global PV assemblages and ultimately whether green jobs are just jobs.

2. An environmental justice analytic for global commodities

2.1. Global commodities

Commodity production touches down in local communities and has differential impacts on human bodies, communities, and ecosystems. This is often at the core of important questions raised by environmental justice (EJ) scholars and political ecologists (Guha and Martinez-Alier, 1997; Agyeman et al., 2003). But it may be that the local EJ lens can miss this more global understanding of production. A green job in one part of the world could be complicit with the reproduction of environmental inequality elsewhere. If there are environmental burdens with green jobs, who bears them? How does the spatial composition of production mask these disparities?

One important analytical concept used to answer these questions is the global commodity chain, an approach developed to