

# *Human Capital in a Climate-Changed World*

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## *Abstract*

At the center of the crisis of climate change is an amazingly efficient but inert fossil fuel-centered energy industry. What makes the energy industry so inert is its massive stock of capital: the facilities, structures, networks, and other physical assets required to extract, process, distribute, and combust fossil fuels. This capital stock is predicated on fossil fuel exploitation, and does not adapt well to alternative methods of meeting energy needs. Fossil fuel subsidies have bloated capital investments in the energy sector, producing low prices and in turn, economic development. It has thus been widely assumed that this is the most reliable model for economic development.

Two things have become increasingly clear: (i) that fossil fuel subsidies and low energy prices are not a condition precedent to economic development, and (ii) human capital development, primarily through broad provision of education, *is* a condition precedent to economic development. The climate crisis highlights the environmental harms of fossil fuel combustion, but it also shines a spotlight on the faulty economic reasoning behind a fossil fuel-centered model of economic growth. This chapter suggests that as a minimum, two no-regrets policies be linked: the phase-out of fossil fuel subsidies, and the robust financing of broader access to education. The climate crisis introduces a new set of inequalities, those in which some countries have benefited disproportionately from the combustion of fossil fuels, and a mostly different set of countries will suffer disproportionately from the harms of climate change. Effecting a direct transfer of fossil fuel subsidies to educational objectives simultaneously reduces the inert capital in fossil fuel industries, increases more productive capital in the form of human capital, and provides a compensatory mechanism for those disproportionately harmed by climate change. Ultimately, the most beneficial and lasting aid that can be provided for developing countries most vulnerable to climate change is one that increases human capital through broad educational initiatives.

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## 1. Introduction

Having already imposed costs on human societies likely in the hundreds of billions of dollars,<sup>1</sup> and with the worst still ahead,<sup>2</sup> it is clearly not an exaggeration to label climate change as a "crisis." In addition to the threat to humankind generally, much has been made of the fact that certain harms from climate change will accrue unevenly. Moreover, contributions to the buildup of greenhouse gases have been (and continue to be) very uneven.<sup>3</sup> In the light of these climate change-related welfare disparities, several redistributive proposals have been put forth to disgorge those disproportionately responsible, and for those parties to compensate those disproportionately harmed. Broadly speaking, these proposals seem to fall under the label of "climate justice." But in the calls for climate justice, the actual redistributive remedies are unclear. If there is a payment of money, how and to whom will it be disbursed? From whom and how much should a contribution be owing? Since the costs of climate change are expected to increase over time, should compensation be set aside for future generations?

This chapter focuses on one critical, mostly under-analyzed aspect of the global economy, as the key to climate justice: the role and nature of *capital*. Broadly speaking, capital is any asset that generates some future benefit or stream of benefits. Investment in capital is central to economic growth, and the enormous scale of capital in developed economies means that it inevitably plays a central role in determining the direction of economic growth. Massive investment in fossil fuel-centered methods of energy generation, transmission and consumption has meant that developed economies have unsurprisingly evolved around fossil fuels, to the exclusion of a vast array of alternatives.

The climate crisis requires us to reconsider how we think about capital and economic growth, and how government policy should treat capital. Clearly, it is a grave and monumental mistake for the world to have arrived at this ecological precipice; that it has done so in large part due to the accumulation of trillions of dollars of fossil fuel-centered capital is cause for examining the assumptions underlying this capital investment. In so doing, lessons can be learned for both mitigation policy and for adaptation policy, while putting forth the best way of compensating developing countries that have contributed little but will suffer the most. In particular, a focus on capital can help avoid making one crucial mistake all over again: making big bets on large, expensive physical capital that cannot be undone if circumstances or knowledge changes. This was the mistake that was made in building up the world's trillions of dollars of capital used to produce energy using fossil fuels, the very presence of which has delayed, perhaps catastrophically, the advent of climate policy.

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1 See, e.g., Fundación DARA Internacional 2012, *Climate Vulnerability Monitor* (2d ed., 2012) at 17.

2 See, e.g., Simon Dietz, Alex Bowen, Charlie Dixon & Philip Gradwell, *Climate Value at Risk of Global Financial Assets*, NATURE CLIMATE CHANGE, April 4, 2016, online: <http://www.nature.com/nclimate/journal/vaop/ncurrent/pdf/nclimate2972.pdf>.

3 Simon Caney, 'Two Kinds of Climate Justice: Avoiding Harm and Sharing Burdens' (2014) *Journal of Political Philosophy*, 22:125-149.

## 2. The Nature of Capital

Capital and labor are the two stylized inputs to production. Given the abundance of labor in developing countries, it is clear that capital is usually the limiting ingredient of economic growth.<sup>4</sup> Furthermore, more capital is better. Adding capital never decreases output.<sup>5</sup> Capital may be costly and may not be worth the cost, but capital is never modeled as having negative productive value.<sup>6</sup>

Despite the central role that capital plays in economic models,<sup>7</sup> a widely-accepted definition is lacking. Adam Smith defined capital as "[his] stock .... which, he expects, is to afford him his revenue."<sup>8</sup> Robert Solow has defined it in passing as a "stock of produced or natural factors of production that can be expected to yield productive services for some time."<sup>9</sup> Gregory Mankiw defines capital as foregone current consumption to produce more income later.<sup>10</sup> In my earlier work I adopted a broad working definition of capital as an asset that generates a stream of benefits over time.<sup>11</sup> Under this broad definition, a very wide variety of equipment, structures, machines and other assets are capital that serve as an engine for economic trade, growth and prosperity. In energy industries, capital includes power plants, refineries, oil rigs, natural gas processing plants, electricity transmission and pipeline networks, and many other large, structural resources that together form an efficient energy extraction, processing, delivery, combustion, and consumption system.

Although capital can take many forms,<sup>12</sup> it is most easily conceived of as physical capital, such as an industrial facility that is large and expensive but produces some good in mass quantities over an extended period of production. The nature of such large, expensive physical capital – power plants, refineries, oil rigs, steel mills, cement factories, and other brick-and-mortar investments – is that they produce some commodity in large quantities, and only gradually, over relatively long periods of time, pay for themselves. Economies of scale tend to be important to production of these

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4 Solow's fundamental neoclassical growth model posits growth as a general function of labor, capital, and technology, the latter being a multiplier that makes the other two inputs more productive. Robert M. Solow, *A Contribution to the Theory of Economic Growth*, 70 Q.J. ECON. 65 (1956).

5 Idiosyncratic exceptions may exist, but the Cobb-Douglas production function is almost never deployed with capital having an inverse relationship with productivity.

6 The Cobb-Douglas production function, which every economics student learns about in undergraduate economics, posits production as a function of the quantity and productivity of just two types of inputs: labor and capital. Charles W. Cobb, and Paul H. Douglas, *A Theory of Production*, 18 (supplement) AM. ECON. REV. 139 (1928). The now-familiar Cobb-Douglas formulation,  $Y = ALaK\beta$ , with  $Y$  representing output,  $L$  representing labor, and  $K$  representing capital, has become a foundational relation in economic theory.

7 Robert M. Solow, 'A Contribution to the Theory of Economic Growth' (1956) 70 *Quarterly Journal of Economics*, pp. 65-89, at 70.

8 ADAM SMITH, AN INQUIRY INTO THE NATURE AND CAUSES OF THE WEALTH OF NATIONS 351 (1776).

9 Robert M. Solow, 'Notes on Social Capital and Economic Performance' in P. Dasgupta and I. Serageldin (eds.), *Social Capital: A Multifaceted Perspective* (World Bank, 2000), pp. 6-9, at 6.

10 N. Gregory Mankiw, Edmund S. Phelps & Paul M. Romer, 'The Growth of Nations' (1995) 1995 *Brookings Papers on Economic Activity*, 275-326, at 293.

11 Shi-Ling Hsu, 'Capital Rigidities, Latent Externalities' (2014) 51 *Houston Law Review*, 719-779, at 729.

12 Financial capital is not discussed because it does not produce the kind of path-dependency problems identified in this article. Natural capital, ecosystems that produce environmental services, are also excluded because they are generally not owned, and thus are not sought to be protected by rent-preserving activities. Social capital is not discussed in this article because legal rules do not promote their formation or protect existing social capital.

commodities, so that such machinery *must* be large and long-lived. Many of these commodities are traded globally and are sold at fairly thin profit margins, so that competitiveness is often important to the owners of this capital.

The problem with this large-capital, low-cost model of production is that large capital is vulnerable to changes in the legal and economic environment.<sup>13</sup> At any given time, capital may be rendered obsolete by regulatory changes or changes in the economic environment. The value of the typically very high-cost capital in oil extraction and refining have been dramatically reduced by a nearly two-year decline in the global market price of oil.<sup>14</sup> Climate policy, if effective, could also severely reduce the value of this capital. It is one thing to lose value due to market conditions, but it is another to lose it due to regulation; the latter can be resisted. Given the large stakes in perpetuating operation of expensive capital, the owners of this capital become very protective, seeking to ensure that the legal and economic environment in which they operate remain static long enough for them to realize some reasonable return. When threatened with some change in its economic environment, owners of capital will naturally attempt to influence law and policy so as to preserve the value of their capital.<sup>15</sup> What we observe under these circumstances are *rent-preserving activities*, the ex post analog of rent-seeking, and the exercise of protecting existing rents.<sup>16</sup> As opposed to attempts to affirmatively procure legal privilege that is privately advantageous but publicly costly, rent-preserving activities are attempts to preserve existing privilege.<sup>17</sup> Although capital is generally an economic good, the little-appreciated downside is that once it is in place, it creates its own political economy to protect it. Given the vast size of capital stocks, they hold the potential to dramatically change the political economy of regulation, trade, and other changes in the economic and legal environment.

Capital can also be *human capital*, the formal and informal education and on-the-job training that enable people to perform skilled productive tasks.<sup>18</sup> Like physical capital, human capital generates a stream of benefits, and is a powerful ingredient for economic growth. Like physical capital in the fossil fuel-centered industries, it can create its own political economy against reform. However, human capital can be a much more flexible form of capital, so that it might be deployed for a number of different purposes. Human capital is simply useful knowledge, and can thus be narrow, specific knowledge – in which case could give rise to rent-preserving activities – or it can be broad, general knowledge, which might be less vulnerable to changes in the legal and economic environment. Moreover, human capital has been a more reliable stimulant of economic growth than the physical capital embedded in fossil fuel-centered energy industries. Along these lines, this chapter proposes that investment in human capital is likely to be a better economic development strategy than using fossil fuels to ensure low energy prices.

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13 Hsu, 11, at 735-43.

14 'BHP Billiton Takes £5bn Writedown on US Oil Assets as Price Slump Takes Toll' (2016) *The Guardian*, January 14, 2016, available at: <https://www.theguardian.com/business/2016/jan/15/bhp-billiton-takes-5bn-writedown-on-us-oil-assets-as-price-slump-takes-toll>.

15 Mancur Olson, *The Rise and Decline of Nations* (Yale Univ. Press, 1982), at 41-47.

16 Mancur Olson, *The Rise and Decline of Nations* (Yale Univ. Press, 1982), at 41-47.

17 See, e.g., William J. Baumol and Janusz A. Ordover, *Use of Antitrust to Subvert Competition*, 28 J. L. & ECON. 247, 249 (1985).

18 Gary S. Becker, *A Theoretical and Empirical Analysis, with Special Reference to Education* (Univ. Chicago Press, 3d. ed., 1993), at 30-54.

### 3. How Capital Has Stalled Climate Policy

Energy capital has accomplished, on a grand scale, what economists hope for: economic development. Low energy prices produced by fossil fuel exploitation have enabled an enormous amount and range of economic activity, giving rise to tremendous economic growth over the last century. The positive externalities are very large. But the negative externalities have also been very large, and the fossil fuel-centered energy industries have done their best to obscure them.

Fossil fuel-related industries are among the most capital-intensive industries in the world.<sup>19</sup> Changes in environmental and other regulations can severely affect the profitability and therefore the value of fossil fuel-related capital, and are vigorously resisted. It is in this challenging political environment that climate policy has operated: fossil fuel-centered energy industries with capital that is expected to generate benefits for a long period of time, find their capital threatened by climate policies that impose additional, potentially crippling costs on fossil fuel-related operations. Resistance to this policy threat has included an extensive public relations campaign to sow doubt about the existence and seriousness of climate change.<sup>20</sup>

Historically, the compensating benefit of fossil fuel-centered energy industries has been the predictability of revenues, as developed economies have always been highly dependent upon energy as a staple of economic growth. Fossil fuel-centered industries could also, until recently, look forward to the promise of expanding production and sales in developing economies, as economic development was thought to bring demand for fossil fuel-derived energy. The massive scale of production and consumption generates large profits, and is itself a powerful lure for investment. Upsetting this paradigm is thus upsetting a very large apple cart. Publicly-traded energy companies in Canada and the U.S. made profits of \$257 billion in 2014, which is greater than the GDP of Chile.<sup>21</sup> That figure excludes the privately-held Koch Industries, which itself had estimated revenues (not profits) of \$100 billion.<sup>22</sup>

To protect this mode of business, fossil fuel-centered industries have demonstrated their ability and their inclination and ability to engage in rent-preserving activities. A push in the 1990s and early 2000s to deregulate retail electricity markets in the United States has foundered.<sup>23</sup> Initially, deregulation was favored by nearly all stakeholders, from integrated electric utilities to consumer groups to rural electric cooperatives. But when proposals became concrete and winners and losers

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19 See, e.g. Jeffrey Chow, Raymond J. Kopp & Paul R. Portney, 'Energy Resources and Global Development' (2003) 302 *Science* 1528-31, at 1529.

20 See, e.g., NAOMI ORESKES & ERIK M. CONWAY, *MERCHANTS OF DOUBT: HOW A HANDFUL OF SCIENTISTS OBSCURED THE TRUTH ON ISSUES FROM TOBACCO SMOKE TO GLOBAL WARMING* (2011).

21 Shakuntala Makjjani & Lorne Stockman, *Despite Falling Prices North America's Fossil Fuel Sector Makes Healthy Profits*, Oil Change International, May 5 2015; online: <http://priceofoil.org/2015/05/05/despite-falling-prices-north-americas-fossil-fuel-sector-makes-healthy-profits/>.

22 Andrea Murphy, *America's Largest Private Companies*, FORBES, July 20, 2016; online: <http://www.forbes.com/pictures/eggh45ejji/2-koch-industries/#3bba20474ef1>.

23 The U.S. Energy Information Administration considers fifteen states as "active" in deregulation or "restructuring," and seven in a "suspended" mode of deregulation. U.S. Energy Information Administration, Status of Electricity Restructuring by State, [http://www.eia.gov/electricity/policies/restructuring/restructure\\_elect.html](http://www.eia.gov/electricity/policies/restructuring/restructure_elect.html) (September 2010). Other definitions of "deregulation" may yield different results. See, e.g. Severin Borenstein and James Bushnell, 'The U.S. Electricity Industry After 20 Years of Restructuring', (2016) — *Annual Review of Economics*, at [7-8] (forthcoming), available at: [http://papers.ssrn.com/sol3/papers.cfm?abstract\\_id=2640081](http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2640081).

became tangible, opposition hardened.<sup>24</sup> In particular, utilities worried about what would happen to their "stranded assets," their capital that would be rendered uncompetitive by a new, deregulated, and more competitive electricity marketplace.<sup>25</sup> The stranded assets that took center stage in the deregulation debate were mostly in the form of coal-fired power plants. A deregulated electricity generation environment was expected to render many of those coal-fired power plants obsolete.<sup>26</sup> In some unexpected ways, this has come to pass, at least in jurisdictions in which competition for the retail provision of electricity is allowed.<sup>27</sup> This trend has been amplified by the advent of hydraulic fracturing, which has dramatically lowered natural gas prices so as to render coal uncompetitive as a fuel source.<sup>28</sup>

In those jurisdictions that have not taken up electricity deregulation, and remain in a regulated utility legal regime,<sup>29</sup> fossil fuel-centered electric utilities have continued to fend off innovation and evolution of their industry.<sup>30</sup> Non-utility firms now exist to install solar panels on the roofs of private residences, allowing the homeowners to defray the cost of utility-provided electricity,<sup>31</sup> but face resistance. In the U.S. State of Florida, which enjoys strong solar energy resources,<sup>32</sup> utilities have aggressively resisted efforts to liberalize entry. Florida law allows only regulated utilities to sell electricity in the retail market,<sup>33</sup> which is an important prohibition, because if an individual homeowner sought to finance her residential rooftop system, the financier may be considered a "utility" that would have to comply with all of Florida electric utility regulations.<sup>34</sup> Complying with the quagmire of utility regulations is a prohibitive cost to non-utility firms, which lack the resources and legal expertise that regulated utilities possess. The sizable compliance department needed to operate as a regulated utility is generally only feasible for large regulated utilities, which can spread the costs over their captive ratepayers, a luxury start-up companies with creative energy ideas cannot afford. A ballot initiative to liberalize electricity generation by relaxing the scope of regulation and facilitate the installation of rooftop solar photovoltaic panels was met with a strong

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24 Reed W. Cearley & Daniel H. Cole, 'Stranded Benefits Versus Stranded Costs in Utility Deregulation' (2003) in P.Z. Grossman & D.H. Cole (eds.) *The Economics of Legal Relationships: The End of a Natural Monopoly: Deregulation and Competition in the Electric Power Industry* at 169.

25 Timothy J. Brennan and James Boyd, 'Stranded Costs, Takings, and the Law and Economics of Implicit Contracts' (1997) 11 *Journal of Regulatory Economics*, 41-54, at 42.

26 Brennan and Boyd, n. 25 above, at 42.

27 Power plants in states that deregulated electricity generation employed about 6% fewer employees after deregulation and, incidentally, enjoyed a 13% decrease in nonfuel operating expenses. Kira Fabrizio, Nancy L. Rose & Catherine Wolfram, 'Does Competition Reduce Costs? Assessing the Impact of Regulatory Restructuring on U.S. Electric Generation Efficiency' (2007) 97 *American Economic Review*, 1250-1277, at 1266-69 (Tables 4 & 5).

28 See, e.g. Thomas W. Merrill & David M. Schizer, 'The Shale Oil and Gas Revolution, Hydraulic Fracturing and Water Contamination: A Regulatory Strategy' (2013) 98 *Minnesota Law Review* 145-263, at 148.

29 For a review, see Richard J. Gilbert, Edward P. Kahn and David Newbery, 'Introduction: International Comparisons of Electricity Regulation' in Richard J. Gilbert and Edward P. Kahn (eds.) *International Comparisons of Electricity Regulation* (Cambridge Univ. Press, 1996), pp. 1-24, at 2-3.

30 Wesley D. Sine and Robert J. David, 'Environmental Jolts, Institutional Change, and the Creation of Entrepreneurial Opportunity in the US Electric Power Industry, (2003) 32 *Research Policy* 185-207, at 193.

31 Dianne Cardwell, 'SolarCity to Make High-Efficiency Panel' (2015), *New York Times*, October 2, 2015, at B2, available at: <http://tinyurl.com/omvq2q6>.

32 National Renewable Energy Laboratories, Solar Maps (2015), available at: <http://www.nrel.gov/gis/solar.html> (accessed December 14, 2015).

33 Florida Statutes § 366.82(1)(a).

34 *PW Ventures v. Nichols*, 533 So. 2d 281 (1988).

industry-led campaign and a *competing* ballot initiative to prevent potential competitors from making inroads on the customers of regulated utilities.<sup>35</sup>

In this context, it should not be surprising that fossil fuel-centered energy industries should resort to litigation,<sup>36</sup> political influence,<sup>37</sup> and even manipulating public opinion<sup>38</sup> to forcefully contest policies that threaten their capital. But the exact nature of their interest has not been carefully scrutinized. It turns out that their engine of growth and efficiency – their capital – is the source of vulnerability, and the impetus for zealously protecting its own fragile economic and legal environment.

#### 4. Rigid Capital

Capital impedes legal reform because new regulation is costly to the capital owner. This may be the case when the impetus for reform is the identification of negative environmental externalities, and production must add on some pollution-reducing equipment, or shift entirely to a new mode. The problem arises when capital that is deployed for a specific production method cannot be easily re-deployed to a different, less environmentally harmful production method. If capital is specific enough, then any legally-mandated shift in production methods could effectively "strand" that capital and render it worthless.

But capital *could* be less of an obstacle if it were flexible, and susceptible of redeployment. After all, if an asset can be used for a variety of purposes, in a variety of industries, then it will continue to hold value even if the regulatory environment or competitive conditions change. In and of itself, capital is not necessarily an obstacle to reform; it is only the *rigidity* of capital that should raise "what-if" questions about the possibility of future regulation or obsolescence.

Capital in fossil fuel-related industries, unfortunately, does not tend to be flexible.<sup>39</sup> Fossil fuel-centered energy industries have steadily evolved for over a century so that capital embedded in the various stages of energy production are the result of continuing experimentation, development, and very large-scale production, not to mention massive government subsidization.<sup>40</sup> This continuing development has produced countless small operational efficiencies, which have cumulated to create increasingly efficient but task-specific capital, focused as it is on extracting ever more fossil fuels from less favorable conditions, and producing it at ever-decreasing cost. The

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35 Jim Turner, 'Solar Choice Ballot Initiative Targets 2018' (2016) *Sun Sentinel*, March 6, 2016, available at: <http://www.sun-sentinel.com/business/consumer/fl-nsf-solar-choice-2018-ballot-20160111-story.html>.

36 See, e.g., *In re Murray Energy Corp.*, 788 F.3d 330 (D.C. Cir. 2015); *cert. granted*, 136 S. Ct. 999 (2016).

37 Peter Newell & Matthew Paterson, "A Climate for Business: Global Warming, the State and Capital" (1998) 5 *International Review of International and Political Economy* 679-703.

38 See, e.g., Justin Gillis and Clifford Krauss, *ExxonMobil Investigated for Possible Climate Change Lies* by *New York Attorney General*, N.Y. TIMES, November 6, 2015, at A1; online: [http://www.nytimes.com/2015/11/06/science/exxon-mobil-under-investigation-in-new-york-over-climate-statements.html?\\_r=0](http://www.nytimes.com/2015/11/06/science/exxon-mobil-under-investigation-in-new-york-over-climate-statements.html?_r=0); Clifford Krauss, *Exxon Accused of Trying to Mislead Public*, N.Y. TIMES, January 4, 2007, at C7; online: [http://www.nytimes.com/2007/01/04/business/04exxon.html?\\_r=0](http://www.nytimes.com/2007/01/04/business/04exxon.html?_r=0).

39 Paul L. Joskow, 'The Role of Transaction Cost Economics in Antitrust and Public Utility Regulatory Policies' (1991) 7 *Journal of Law, Economics, and Organization* 53-83, at 67.

40 David P. Coady, Ian Parry, Louis Sears & Baoping Shang, 'How Large Are Global Subsidies?' (2015) *International Monetary Fund Working Paper* 15/105, available at: [http://papers.ssrn.com/sol3/papers.cfm?abstract\\_id=2613304](http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2613304).

relentless quest for technical efficiency has created tightly integrated and interdependent systems of extraction, production, transportation and distribution, delivering enormous amounts of energy at low consumer cost. The price of such technical efficiency has been flexibility.

Offshore oil rigs are an example of the extensive development and massive scale of production embodied in fossil-centered energy capital. Typical large modern offshore oil rigs, which can extract crude oil from ever-greater depths, have the capacity to extract up to 200,000 barrels of oil per day<sup>41</sup> over their typically thirty-year lifetimes.<sup>42</sup> A current state-of-art cost rig carries a price tag in the billions of dollars.<sup>43</sup> Profit is highly dependent upon economic conditions (as the recent global plunge in crude oil prices demonstrates), and is highly dependent upon a stable regulatory environment. Most importantly, an offshore oil rig can be used for only one purpose: drilling for oil in oceanic waters.

Coal-fired power plants have also served the cause of economic development, delivering large amounts of electricity at low consumer cost.<sup>44</sup> But these large, multi-billion dollar plants, with their enormous boiler chambers, turbines, and smokestacks and even pollution control equipment are designed to carry out one function in one way: burn large amounts of coal to spin a very large turbine to generate an electrical current. These coal-fired power plants can be converted into natural gas-powered power plants (which emit much less pollution),<sup>45</sup> but the process is expensive.<sup>46</sup> Coal-fired power plants are thus another example of the rigidity of expensive capital in fossil fuel-centered energy industries.

If economic conditions or environmental regulations put a halt to operations, the owner of those oil rigs and power plants will suffer huge losses. In a post-carbon world, there is little or no salvage value for offshore oil rigs, coal-fired power plants, or any number of large expensive, single-purpose facilities predicated on the combustion of fossil fuels. It is as if the fossil fuel-related industries have, like complex and undisturbed ecosystems, created narrow ecological niches for many species of physical and human capital. The disadvantage of such finely-tuned and interdependent systems is that they have evolved into highly specific and interdependent parts, and are vulnerable to disturbance. The response has been predictable: these industries have not permitted their capital to fail. American trade groups such as the American Petroleum Institute and the Edison Electric Institute have exercised enormous power over the U.S. legislative and

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41 See, e.g., *Atlantis Deepwater Oil and Gas Platform Gulf of Mexico, United States of America*, OffshoreTechnology.com (no date), online: <http://www.offshore-technology.com/projects/atlantisplatform/>.

42 Chevron, *Jack/St. Malo* (2001), online: <https://www.chevron.com/projects/jack-stmalo>.

43 *Id.*

44 That is to say, purchasing electricity has been inexpensive, even if the external costs have been large. A recent study of the net economic benefits of a wide variety of industries in the U.S. found that coal-fired electricity production almost certainly subtracts more from GDP in the form of health and environmental harms than it contributes, in the form of electricity provision. Nicholas Z. Muller, Robert Mendelson, and William Nordhaus *Environmental Accounting for Pollution in the United States Economy*, 101 AM. ECON. REV. 1649 (2012).

45 U.S. Energy Information Administration, Frequently Asked Questions, 'How Much Carbon Dioxide is Produced When Different Fuels Are Burned?' available at: <https://www.eia.gov/tools/faqs/faq.cfm?id=73&t=11>.

46 Scott Gossard, 'Coal-to-Gas Plant Conversions in the U.S.' (2015) *Power Engineering*, June 18, 2015, available at: <http://www.power-eng.com/articles/print/volume-119/issue-6/features/coal-to-gas-plant-conversions-in-the-u-s.html>.



administrative processes,<sup>47</sup> as has the Canadian Association of Petroleum Producers over Canadian government.<sup>48</sup> Governments heavily dependent upon oil revenues, such as Saudi Arabia and Venezuela, have stalled climate policy in international negotiations.<sup>49</sup>

## 5. Better Capital: Human Capital

It is indisputably true that low energy costs have spurred economic development. Developing countries have only been left out because of a lack of money needed to acquire energy capital. But apart from the aggressive industrial interventions in policy to stall climate policy, the massive government subsidies for fossil fuel-related industries, under the guise of capital formation for economic development, call into question the intrinsic value of fossil fuels. A recent study by the International Monetary Fund estimated that eliminating energy subsidies would raise government revenue by \$2.9 trillion, reduce global CO<sub>2</sub> emissions by 20%, and halve premature air pollution deaths.<sup>50</sup> Achieving low energy prices, powered by fossil fuels, has long been the dominant paradigm of economic development. As it happens, old paradigms of economic development and capital investment fade slowly, in large part due to the sheer size and ubiquity of embedded capital.

The climate crisis provides the impetus and an opportunity to cast off anachronistic mindsets on capital and economic development. If there is a public purpose of capital, it is to generate economic growth. The problem with industry captains is that they have conflated the two; their capital has become their own *raison d'être*. Large financial exposure due to the high costs of capital have led fossil fuel-centered industries to distort public policy to protect their capital, even if economic growth can be decoupled from fossil fuel-centered energy production. It seems quite likely that titans in fossil fuel-centered industries, faced with mounting evidence of the massive (and growing) environmental harms of their operations, have responded by deluding themselves into believing that low fossil-based energy prices are still the key to economic salvation.<sup>51</sup>

At the same time, international relations continue to play a central role in both domestic and international climate policy, which have implications for capital. Developing countries strongly reject any suggestion that they be deprived of the same economic opportunities already enjoyed by developed countries. But development in this much-larger segment of the world's population clearly cannot be achieved by the formation of the same kind of energy capital as that which fueled economic growth in the twentieth century. Stimulating economic growth in developing countries will require new thinking on capital.

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47 Darren Samuelson & Katherine Ling, 'Fragile Compromise of Power Plant CEOs in Doubt as Senate Debate Approaches' *E&E News*, 5 August 2009.

48 Michael Bolen, 'Peter Mansbridge Was Paid by Oil and Gas Lobby for Speech' *The Huffington Post Canada*, 26 February 2014, available at: [http://www.huffingtonpost.ca/2014/02/26/peter-mansbridge-oil-speech\\_n\\_4861979.html](http://www.huffingtonpost.ca/2014/02/26/peter-mansbridge-oil-speech_n_4861979.html).

49 Pew Center for Global Climate Change, 'Fifteenth Session of the Conference of the Parties to the United Nations Framework Convention on Climate Change and the Fifth Session of the Meeting of the Parties to the Kyoto Protocol,' (2009), available at: <http://www.c2es.org/docUploads/copenhagen-cop15-summary.pdf>.

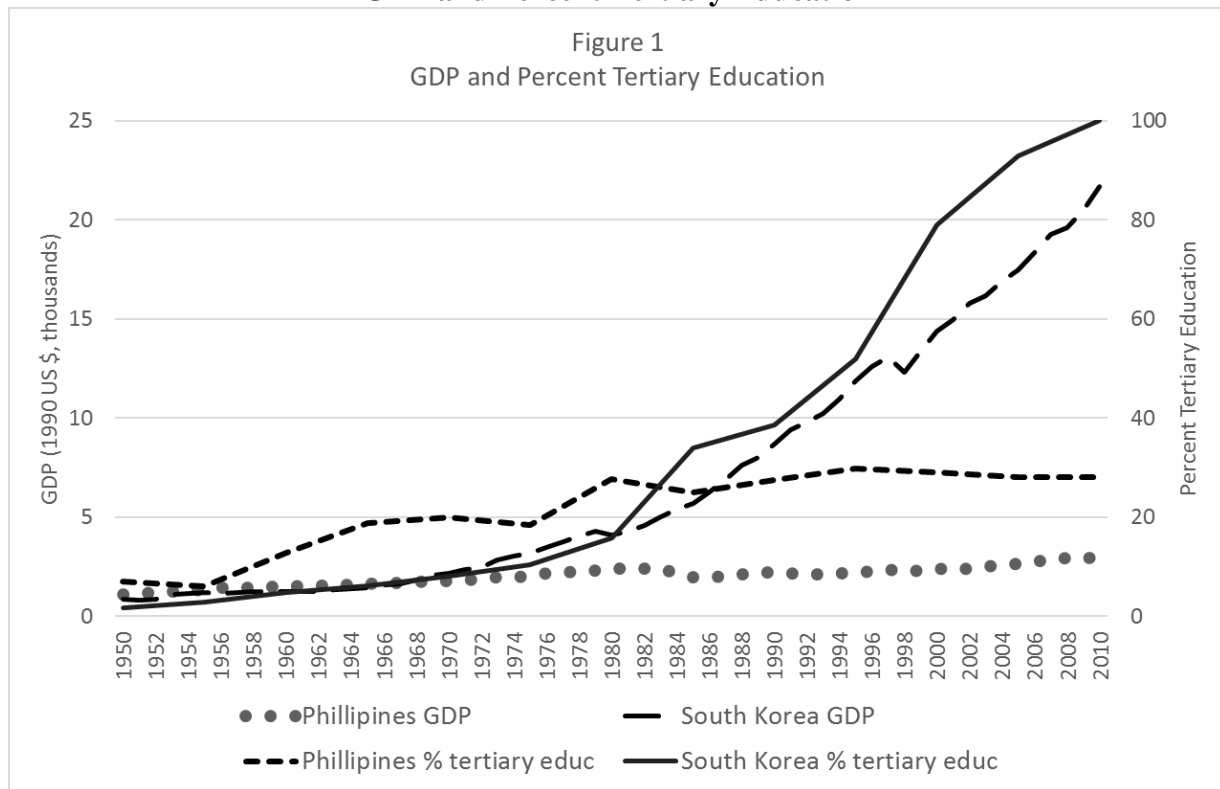
50 Coady, n. 40, at 7.

51 Examples abound, but the remarks of Robert Murray, the founder and CEO of Murray Energy, are exemplary. See, e.g., Robert E. Murray, 'Murray Energy's Strategy for Succeeding in Transitional Coal Markets' (2014), available at: [http://www.eenews.net/assets/2014/09/23/document\\_gw\\_01.pdf](http://www.eenews.net/assets/2014/09/23/document_gw_01.pdf) ("The insane, regal Administration of King Obama has ignored science, economics, our poorer citizens and those on fixed incomes, our manufacturers, and the Constitution, as it has by-passed our Congress.").

Odd as it may seem, the climate crisis is an appropriate time to reconsider the role of *human capital* in economic growth. Human capital is indisputably a critical driver for economic growth, and represents a much better investment than the large, expensive capital in the fossil fuel-centered industries. The climate crisis simultaneously forces developed societies to question the intrinsic value of fossil fuel-centered capital, and to cast about for a better path to economic prosperity, particularly for developing countries.

Economists have long recognized the central importance of human capital to economic growth.<sup>52</sup> Nobel Laureate Robert Lucas's seminal comparison of South Korea and the Philippines from 1960 to 1987 attributed the "miracle" of rapid South Korean economic growth to government policy focusing on broad and rigorous public education.<sup>53</sup> To illustrate Lucas's point, figure 1 below shows GDP levels and percentage of population with tertiary education (as a measure of human capital) in the two countries from 1950 to 2010:

**Figure 1**  
**GDP and Percent Tertiary Education**



While Lucas elides some obvious and important historical and cultural differences, his study continues to stand as a seminal work on the importance of education as the development of a stock of human capital. More recently, economists Claudia Goldin and Lawrence Katz, in their book

<sup>52</sup> See, e.g., Theodore W. Schultz, *Capital Formation by Education*, 68 J. POLIT. ECON. 571 (1960); Theodore W. Schultz, *Investment in Human Capital*, 51 A. Econ. Rev. 1 (1961).

<sup>53</sup> Robert E. Lucas, Jr. 'Making a Miracle' (1993) 61 *Econometrica* 251-272.

*The Race Between Education and Technology*,<sup>54</sup> argue that the economic dominance of the United States for the latter half of the twentieth century was largely due to its broad and compulsory public schooling system, which created an educated work force able to adapt to technological changes and increase productivity.<sup>55</sup> By contrast, American underperformance since 1970 relative to other countries is, argue Goldin and Katz, largely attributable to the American failure to maintain that educational advantage.<sup>56</sup>

Despite consensus among economists as to the value of human capital, it remains under-supplied for a number of reasons. First, all other things being equal, human capital is a riskier investment for an individual than an investment in physical capital. That is say, if an expected return on physical capital such as a hot dog stand is equal to the expected return on human capital such as a bachelor's degree in English, a risk-averse individual would be more inclined to invest in the hot dog stand. That is because human capital cannot be bought or sold like physical capital can, so diversifying a capital stock requires more time and resources normally available to an individual.<sup>57</sup> By contrast, the transferability of physical capital means that an individual does not need to diversify; a diversified economy does this.<sup>58</sup> In light of this individual bias towards physical capital, a capital policy should generally be more generous towards human capital than physical capital.

Secondly, human capital confers positive externalities in a way that physical capital generally does not. Human capital is knowledge, and the greater the stock of human capital, the greater the knowledge spillovers, and the higher the rate of accumulation of human capital. Knowledge begets more knowledge, and does so more easily if there is more knowledge to begin with. The formation of human capital should thus be made with a view toward taking advantage of positive consumption externalities. Estimates of the value of human capital bear this out: the value of human capital in the United States is in the neighborhood of 11 to 16 times the value of physical capital, but investment in human capital is only about four times that of physical capital.<sup>59</sup>

## 6. More Flexible Capital

It might seem odd to compare public investment in human capital with private investment in fossil fuel-centered capital. But in addition to being more effective in stimulating economic growth, human capital has one other critical advantage that happens to highlight, in contrast, the folly of fossil fuel capital: flexibility. Human capital is generally, by its nature, susceptible of multiple uses. Clearly, human capital could be specific – the knowledge of how to accomplish very specific tasks – or human capital could be general – broad understandings of some principles, without

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54 CLAUDIA GOLDIN & LAWRENCE F. KATZ, *THE RACE BETWEEN EDUCATION AND TECHNOLOGY* (Harvard Univ. Press, 2008).

55 GOLDIN & KATZ, *supra*, note 54, at 29.

56 GOLDIN & KATZ, *supra*, note 54, at 320-23.

57 David Levhari and Yoram Weiss, *The Effect of Risk on the Investment in Human Capital*, 64 *Am. Econ. Rev.* 950, 950 (1974).

58 *Supra*, note 57, at 950.

59 Dale Jorgenson & Barbara M. Fraumeni, "The Accumulation of Human and Nonhuman Capital, 1948-84," in R.E. Lipsey and H.S. Tice (eds.) *The Measurement of Saving, Investment, and Wealth* (Univ. of Chicago Press, 1989), pp. 227-286, at 228; Michael S. Christian, 'Human Capital Accounting in the United States, 1994-2006' (2010) *Survey of Current Business*, June 2010, at 34.

necessarily knowing how to accomplish specific tasks. Specific human capital, however, is built upon a foundation of general human capital. The ability to perform specific tasks is the ability to apply knowledge, which presupposes the more general form of knowledge. Basic principles of physics give rise to the ability to apply them to a wide variety of engineering disciplines; basic principles of biology give rise to the ability to apply them to a wide variety of life sciences, including agriculture. Most fundamentally, reading is a basic skill upon which almost all other forms of knowledge derive. Development of human capital is thus inherently development of a more flexible asset than the kind of expensive physical capital that has been invested in fossil fuel-centered industries.

Human capital in the fossil fuel-centered industries *could* be flexible, as other technical, engineering-heavy industries are. But here again, fossil fuel-centered industries have demonstrated no interest in making their labor force more flexible.<sup>60</sup> Workers on offshore oil rigs, for example, require no formal education; unskilled workers are required to take training courses certified by a trade association called the International Well Control Forum. After completion, "drillers," "rig mechanics," "subsea engineers," and "derrickmen" are among the crew of 80 workers that can earn \$50,000 to \$100,000 for six months' work.<sup>61</sup> But these workers are not equipped (at least not by their oil rig training) to do anything else. Most of the tens of thousands of laid-off workers in the struggling Canadian oil sands industry have not found re-employment.<sup>62</sup> Engineering principles learned by petroleum or power engineers *could* be portable, but fossil fuel-centered industries have eschewed more general training. In part because of the public good nature of human capital, fossil fuel-related industries have financed only that capital that serves their specific production needs, leaving the broader, more general educational tasks to formal schooling.<sup>63</sup> The narrowness of even the human capital in fossil fuel-centered industries is all the more reason to completely rethink the nature of capital.

It is difficult to predict what the most useful form of capital will be just a few years in the future. But the more *general* the capital, the more flexible it will be, and the more likely it could be redeployed should a product or process become obsolete. The mistake in developing through exploitation of fossil fuel sources was that the embedded capital was inflexible, and served to lock out alternative systems. For that matter, much international aid intended to relieve poverty in underdeveloped countries have been mis-spent on dubious capital projects, including dams, irrigation systems that ultimately prove culturally or geographically inappropriate.<sup>64</sup>

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60 See, e.g., *Skills Needs in the Energy Industry* (Energy Institute, 2008), available at: <https://www.energyinst.org/documents/5>.

61 See, e.g., Claire Calkin, 'Offshore Oil Rig Jobs Can Be Tough, But Very Rewarding' (no date), available at: [https://www.experience.com/alumnus/article?channel\\_id=energy\\_utilities&source\\_page=additional\\_articles&article\\_id=article\\_1128902416846](https://www.experience.com/alumnus/article?channel_id=energy_utilities&source_page=additional_articles&article_id=article_1128902416846).

62 Chester Dawson, 'Canadian Oil-Sands Producers Struggle' (2015) *Wall Street Journal*, 19 August 2015, at A1; available at: <http://www.wsj.com/articles/oil-sands-producers-struggle-1440017716>.

63 *Human Capital Strategies for Canada's Energy Sector* (Mercer, 2010), at 4, available at: <https://www.conference-board.org/retrievefile.cfm?filename=Human-Capital-Strategy-for-Canadas-Energy-Sector.pdf&type=subsite>.

64 See, e.g., Claudia R. Williamson, *Exploring the Failure of Foreign Aid: The Role of Incentives and Information* 23 REV. AUSTRIAN ECON. 17 (2010); Peter Boone, *Politics and the Effectiveness of Foreign Aid*, 40 EUR. ECON. REV. 289 (1996); Lavagnon A. Ika, Amadou Diallo, and Denis Thuillier, *Critical Success Factors for World Bank Projects: An Empirical Investigation*, 30 INT'L J. PROJ. MGMT. 105, 110-14 (2012).; Dana L. Clark, *The World Bank and Human Rights: The Need for Greater Accountability*, 15 HARV. HUM. RTS. J. 205, 211-19 (2002); ANNE

## 7. A Proposal

The climate crisis thus offers not only the opportunity, but the impetus to revisit the nature of development strategies, and of aid to countries that are likely to suffer disproportionately in a climate-changed world. It has certainly been argued that intergenerational justice does not *necessarily* militate in favor of minimizing risk, but of some combination of minimizing risk and enhancing resilience. In that light, low energy prices might not be such an inefficient state of affairs if economic prosperity can fund resilience.<sup>65</sup> But given the severity and immediacy of the fossil fuel-induced climate crisis, and given the readiness and superiority of an alternative development strategy – human capital development – continuing down a path of fossil fuel-centered economic growth seems foolhardy.

At least one simple link can be made between reform of fossil fuel-centered capital and a human capital strategy for development: at a minimum, the massive government subsidies for fossil fuel-centered capital – about \$3 trillion, not counting the uncompensated environmental costs<sup>66</sup> -- would unquestionably be better spent in enhancing public education. Even if developed countries suffer what is perceived as distortions and pathologies in public education funding,<sup>67</sup> it pales in comparison with the distortionary effects of fossil fuel subsidization. Removal of energy subsidies has been estimated to produce a \$1.8 trillion increase in global wealth, even fully accounting for the welfare effects of higher energy prices. No serious argument can be mounted against this \$3 trillion being better spent on public education. Moreover, no serious argument is made anywhere that government spends *too much* money on public education.<sup>68</sup> Outlays for subsidies for fossil fuels could be redirected to public education, a huge boon worldwide.

Moreover, any redistribution in the form of education should include a preference for human capital for younger people. Skills beget skills and learning begets learning, so that the earlier in life an individual acquires skills (i.e., forms human capital), the more likely she is to build on those skills to acquire other skills.<sup>69</sup> If resources are scarce, then the best investment of government dollars for human capital promotion would target young children for early childhood learning and social skill development.<sup>70</sup>

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DANAIYA USHER, ROUTLEDGE STUDIES IN DEVELOPMENT AND SOCIETY: DAMS AS AID (1) 5 (A. Usher, ed., Routledge, 2005).

<sup>65</sup> Louis A. Cox & Emiline D. Cox, *Intergenerational Justice in Protective and Resilience Investments With Uncertain Future Preferences and Resources*, 19 *Risk, Gov. & Soc.*, 173 (2016).

<sup>66</sup> Coady et al, n. 40, at 7.

<sup>67</sup> See, e.g., PAULINE LIPMAN, HIGH STAKES EDUCATION: INEQUAITY, GLOBALIZATION AND URBAN SCHOOL REFORM (2004); Mark Gradstein, *The Political Economy of Public Spending on Education, Inequality, and Growth* (World Bank Policy Research Working Paper No. 3162, 2003), available at <http://elibrary.worldbank.org/doi/pdf/10.1596/1813-9450-3162>.

<sup>68</sup> For a widely praised book on the role of education in economic growth, see, CLAUDIA GOLDIN AND LAWRENCE KATZ, THE RACE BETWEEN EDUCATION AND TECHNOLOGY (2008). See also, Lionel Artige & Laurent Cavenaile, *Public Education Expenditures, Growth and Income Inequality* (2016) available at: [http://papers.ssrn.com/sol3/papers.cfm?abstract\\_id=2759093](http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2759093).

<sup>69</sup> James J. Heckman, 'Policies to Foster Human Capital' (2000) 54 *Research Economics* 3-56, at 5 ("Early learning begets later learning...").

<sup>70</sup> Heckman, *supra*, note 69, at 5-6.

But even beyond the modest prescription of a one-for-one substitution in spending – public education for fossil fuel subsidies – it is worth considering the role of human capital in a broader context, and against the backdrop of climate justice. If developing countries clamor for an equalization of opportunity and an uplift in their standard of living, by far the best way to accomplish that is to directly fund public educational systems and not, as anachronistic development models would posit, low energy prices. Too often, foreign aid programs have failed to alleviate poverty because dollars spent in economic development have found their way into dubious ventures, and boosted economies only artificially, failing to improve the fundamentals of a populace.<sup>71</sup>

The climate crisis also provides an opportunity to rethink the nature of justice. To be sure, adaptive capacity must be a large part of relief for underdeveloped countries that will suffer disproportionate harms from climate change. And to be sure, developed countries benefiting from the fossil fuelled economic growth should take the lead in funding and finding the technological breakthroughs necessary to mitigate and adapt to climate change, and possibly even "geo-engineer" artificial changes to earth systems to reverse emissions by re-capturing and sequestering greenhouse gases already emitted. But a long and tortured history of largely unsuccessful uses of international aid to alleviate poverty and stir economic development provides a cautionary tale in terms of how to provide effective compensation for those suffering disproportionately from climate change.

Throughout economic history, only one use of money has proven to be reliable in generating economic growth. Ill-advised and culturally or geographically ignorant capital projects aimed at economic development have frequently failed to deliver on the promise of economic development, and have mostly left just different miseries in their wake.<sup>72</sup> Nothing has ever worked as well in lifting up a populace as broadly educating it.

## 8. Conclusion

A lawyer's call for "climate justice" is apt to include some demand for compensatory payment<sup>73</sup> or, on the fringes, injunctive relief for some greater governmental climate action.<sup>74</sup> While this could offer some visceral satisfaction in the unlikely case of success, it is not clear that recovering plaintiffs are ultimately much better off. It is as if, for lawyers, justice stops when a transfer of wealth is made; what happens after that is presumably left to others.

Such blitheness is likely to repeat the failures that have plagued previous international efforts to alleviate poverty in underdeveloped countries. Since there is a great deal of overlap between countries receiving foreign aid and those likely to suffer disproportionately from climate change, the climate crisis is an opportunity an opportunity to rethink the nature of economic development, and start anew. Effective compensation must take the form of capital – otherwise compensation is never sustaining – but it must take a particular form of capital. Compensatory capital must generate

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<sup>71</sup> *Supra*, note 64.

<sup>72</sup> *Supra*, note 64.

<sup>73</sup> *See, e.g.*, Daniel A. Farber, 'Basic Compensation for Victims of Climate Change' (2007) *University of Pennsylvania Law Review*, 155:1605-1656.

<sup>74</sup> John Schwartz, 'In Novel Tactic on Climate Change, Citizens Sue Their Governments' (2016) *New York Times*, May 12, 2016, at A6, available at: [http://www.nytimes.com/2016/05/11/science/climate-change-citizen-lawsuits.html?emc=edit\\_th\\_20160512&nl=todaysheadlines&nliid=66362416&r=0](http://www.nytimes.com/2016/05/11/science/climate-change-citizen-lawsuits.html?emc=edit_th_20160512&nl=todaysheadlines&nliid=66362416&r=0).

economic growth, and must be flexible. A human capital approach offers the best approach to leveling the benefits and burdens of climate change.

It has long been obvious that fossil fuel subsidies exacerbate pollution and reduce welfare. Of all of the negative externalities of a fossil fuel-centered energy industry, the emission of greenhouse gases is only the latest one. However, the severity and immediacy of the climate crisis can be the impetus for a re-imagining of the capital needed to sustain economic development. The climate crisis is a context in which a direct comparison of fossil fuel subsidization and human capital development becomes a logical one. Both are economic development strategies, and exchanging the former for the latter is also a compensatory mechanism for those countries that are likely to be disproportionately harmed by climate change. Certainly, much good could be done with the roughly \$3 trillion in global fossil fuel subsidies, but as a climate policy, such a direct transfer from one type of capital to another becomes a coherent, self-contained policy.