One Earth
Commentary

The Real Stranded Assets of Carbon Lock-In

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Climate debates over stranded assets are focusing on the wrong assets. Fossil-fuel companies and petrostates argue that they will suffer economic losses from climate policies. Although true, this ignores assets that will be stranded in the *absence* of climate policy. These are the real stranded assets of carbon lock-in and could prove much more costly.

Stranded Assets and Carbon Lock-In

"Stranded asset" is a financial accounting term describing an economic resource that has become non-performing before the end of its useful life. The argument behind stranding claims is that enacting climate policy amounts to changing the regulatory rules on established economic interests "mid-game." Corporations and petrostates have made long-lived capital investments on the expectation of stable policy regimes. Although it is true that climate policy will render much industrial infrastructure obsolete and leave national reserves in the ground, what is often ignored is that stranded assets will also arise in the *absence* of proactive climate policy. These are the stranded assets of carbon lock-in.

Carbon lock-in refers to the self-perpetuating inertia that is created by large fossil-fuel-based energy systems and that inhibits the emergence of alternative energy technologies.[1] Carbon lock-in intensifies through government involvement in the system for safety, universal service, or other national interests. This institutionalization overrides market forces and extends the system by state fiat, signaling the emergence of a techno-institutional complex. As these systems become ubiquitous, society co-adapts and integrates the system into routines and rituals, socializing them into everyday life.

Sectoral Stranding

Carbon lock-in creates the risk that entire industrial sectors become "creative destruction" stranded assets. Take the German auto industry. Germany is the leader in internal combustion engine (ICE) technology and has sustained over 130 years of private and public investment in know-how and infrastructure. Accounting for over 800,000 jobs and 2017 revenues of €423 billion, the industry is vital to the German economy. Government and industry have symbiotically co-evolved over decades, leading commenters to quip, "what is good for Volkswagen is good for Germany." Government ministers also acknowledge the close association by recognizing that the country will need to evolve alongside transformations of the automobile industry.

The Diesel-gate emissions scandals, where German car manufacturers invested in cheating and then covered up their emissions rather than transition to cleaner technological platforms, are a symptom of Germany's locked-in condition, as is the fact that the country has not yet produced a master plan for the future the automobile industry.

The techno-institutional complex is self-reinforcing in Germany, but the country does not exist in isolation. Germany exports 77% of its vehicle production, much of it to China, the world's largest market with 30 million new cars sold each year.[2] China does not have a century of investment in ICE technology, nor does it have major oil reserves. To address pollution and the costs of importing oil, Beijing wants 25% of cars sold annually to be electric vehicles (EVs) or plug-in hybrids by 2025. It aims to stop selling ICE cars altogether in 11 years. Already cities such as Shenzhen have all electric bus and taxi fleets.

How does this affect Germany? German carmakers command a market share of 23% in the ICE sector but just 0.4% in the EV sector. Without the inertia of a long-established techno-institutional complex, China is on track to lead the EV market, potentially leaving Germany's ICE assets, and the economically vital auto sector, stranded. Again, these are stranding risks that arise in the *absence* of climate policy.

Climatic Stranding

Other largely unrecognized classes of assets can be stranded by policy inaction. Northern California's electric utility PG&E, for example, has been voluntarily stranding its massive energy-grid assets by shutting down power and leaving some 2.5 million Californians in the dark. It's doing so to reduce the risk of sparking wildfires, such as the ones that wiped out entire Californian communities in 2017 and 2018 and forced the company to declare the largest US utility bankruptcy in history.[3]

PG&E's could be one of many climate bankruptcies to come. Its grids, like many technological assets, were built for a different climatic world. As climate change dries out the American west, the combination of drought, record katabatic "Santa Ana" winds, and an old spark-prone electrical infrastructure is a perfect disaster formula. And of course, the ubiquity of electricity has made society dependent on the grid, so when the power goes out it takes down public and private services such as hospitals, hotels, libraries, laboratories, and so forth. All of these dependent services become non-performing assets that hobble society.

Or consider Miami. The city is at risk of becoming stranded, both figuratively and literally, by climate change. How can an entire metropolis that encompasses the lives, culture, and well-being of millions be considered "non-performing"? Like PG&E, Miami's physical infrastructure was built on an assumption not of policy permanence but of climatic permanence. That assumption was flawed. The impacts of sea-level rise are already evident to Miami's citizens; for example, so-called "sunny day flooding" (tidal flooding without rain) predictably

inundates streets, corrodes infrastructure, contaminates groundwater, and reverses sewage systems. As sea-level rise worsens, the inescapable conclusion is that at some point Miami will be inundated and unlivable. In the absence of a civil-engineering miracle, the entire city will become a stranded asset that society will have to write off.

The financial consequences are large. Reuters estimates that at least $1.4 trillion in property is sitting within 700 feet of the US shoreline alone.[4] And those are just property values. City finances dependent on rising real-estate taxes are also put at risk. But the financial consequences are the lesser part of the story. A recent study in *Nature Communications*[5] indicates that current inundation assessments dramatically underestimate the problem. Sea-level inundation could be three times higher, flooding cities such as Ho Chi Minh, Bangkok, Mumbai, Alexandria, Basra, and more by 2050. Analysts say that the loss of urban assets to sea-level rise will foster social and political instability, increase migration, and reignite armed conflicts and terrorism.[6]

Ecological Stranding

So far, the stranded-assets debate has been treated as a solely human issue, and different stakeholder groups care about different asset classes. But humans are not alone on Earth. The planet is shared with millions of other species. They are stakeholder groups that cannot speak for themselves. Are they at risk of asset stranding? They are if we think in terms of stranded biological assets. Assets are resources that can be used for creating value. The biological equivalents are genes: species-specific technological assets that produce individual organisms. And, like cities, their viability depends to some extent on relative climate stability. Although genetic technology does have the capacity to innovate in response to changing environmental conditions, this adaptational technology works at an evolutionary pace that is slower than the pace of human-induced changes. Climate change is swamping the ability of many species to adapt, rendering their genetic assets "non-preforming," which in evolutionary terms means extinction.

Climate change is already claiming its first genetic victims. Earlier this year, the Bramble Cay melomys (*Melomys rubicola*), a rodent native to a single island off of Australia, became the first mammal to be officially recognized as an extinction casualty of climate change.[7] The mouse-like creature was last seen in 2009 and is hypothesized to have succumbed to habitat inundation from sea-level rise. This year's Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services report estimates that one million more plant and animal species are nearing extinction and that global warming is a major driver.[8] These are the planet's genetic assets that will become not only non-performing but also non-recoverable.

And of course, species don't exist in isolation but make up interdependent food webs that underlie entire ecosystems. Ecosystems can be themselves understood as assets that create value both for humans and for our non-human brethren on the planet. Part of the value comes as ecosystem services, including carbon sequestration, nutrient cycling, pollination, and disease control, not to mention clean food, air, and water. Loss of species can undermine food webs and result in ecological collapse, potentially rendering entire ecosystems as non-performing assets unable to produce the vital life-giving services upon which every human, and non-human, depends.

Wild fires are not restricted to California. Unprecedented wild fires induced by climate change are also wiping out London-sized sections of the Brazilian Pantanal and with them the ecosystem services they once provided. From a climate perspective, global ecosystems act as carbon sinks by absorbing about 55% of human CO_2 emissions,[9] a service we've thus far received for free. However, as climate change wipes out tropical rainforests, they become non-performing, and we lose their sequestration services and even risk the switching of these ecosystems from carbon sinks to net carbon sources, accelerating climate change.[10]

And it's not only forests. "Blue carbon" describes the large proportion of carbon dioxide sequestered by the world's oceans, again a free service from nature. But research shows that the ability of the oceans to keep up with human emissions is limited. Climate change disrupts aquatic ecosystems, undermining their ability to provide ongoing carbon sequestration.[11] The clear risk is that, in the absence of climate policy, entire aquatic and terrestrial ecosystems can become non-performing biospheric assets and have catastrophic results.

Fallacious Comparisons

Debates about stranded-asset policy are, at best, ignoring the scope of the stranded-asset problems or, at worst, treating them as equivalent. It has become commonplace to evaluate biological assets on economic grounds, but this is a fallacious comparison because there is no economy without a stable ecology. Even if we do compare asset stranding on purely economic grounds, biological assets still dominate by contributing more than twice as much to human well-being than global gross domestic product.[12] Therefore, preserving ecological assets always deserves precedence. The welfare of the human race, our progeny, and the rest of Earth's species is at risk. These are the real stranded assets of carbon lock-in, and they need to be put front and center as policy makers confront the climate challenge.

Although carbon lock-in inhibits the emergence of environmental and welfare-enhancing innovations, it is not a permanent condition. Eventually, technological alternatives with superior economic and sustainability performance will overtake established infrastructures. These alternatives tend to be commercialized not by incumbents but by entrepreneurial entrants often operating in regulatory regimes less invested in the incumbent techno-institutional complex. Established firms are thus displaced not by policy but by superior innovations and find their assets stranded by capitalistic "creative destruction." This means that, even in the absence of proactive climate policy, carbon-reliant assets will become stranded.

Without climate policy, an array of assets that affect not just locked-in fossil-fuel infrastructures but potentially also the whole of society and even the entire planet will become non-performing. If this is the case, then the current stranded-asset discussions are dramatically incomplete.

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