Hydrocarbons in North America

By J. David Hughes
About the Author

David Hughes is a geoscientist who has studied the energy resources of Canada for nearly four decades, including thirty-two years with the Geological Survey of Canada as a scientist and research manager. Over the past decade he has researched, published, and lectured widely on global energy and sustainability issues within North America and internationally. He has been interviewed extensively on radio and television, and his work has been featured in *Canadian Business*, *Walrus* magazine, and Thomas Homer-Dixon’s book *Carbon Shift* (2009). Hughes is a Fellow of Post Carbon Institute.
North America is at the top of the food chain when it comes to consuming energy: Its inhabitants have nearly four times the average global per capita energy consumption.\(^1\) Although Mexicans consume less than the global average, Americans consume 4.5 times and Canadians nearly 6 times as much. In absolute numbers, we in North America consume one-quarter of the world’s primary energy production, even though we make up less than 7 percent of the world’s population.

North America’s massive energy diet is largely made up of hydrocarbons—a full 83 percent comes from oil, gas, and coal, and if we include nuclear energy, 91 percent comes from nonrenewable fuel sources. In 2008, North America consumed 27 percent of the world’s oil production, 25 percent of natural gas production, and 18 percent of coal production. Most of the rest of our energy consumption was derived from nuclear power and large hydropower, with renewable energy sources such as biomass, wind, photovoltaics, and geothermal making up less than 2 percent of our total. Moreover, despite a several-fold growth in non-hydropower renewable energy sources,\(^2\) nonrenewable sources are still forecast to supply 88 percent of our primary energy consumption by 2030 (figure 17.1).

The sheer scale of our dependency on nonrenewable, energy-dense “fossilized sunshine” is often lost on those who believe that renewable energy sources can supplant hydrocarbons at anything like today’s level of energy consumption. Thus it is prudent to examine the prognosis for fossil fuels within North America, as they will make up the bulk of our energy consumption for many decades to come.\(^3\) The North American fossil-fuel story is largely driven by consumption in the United States, the biggest user of energy in the world and, until China overtook it in 2006, the biggest carbon dioxide emitter. Also critical to this story is the vulnerability of the U.S. economy given its addiction to hydrocarbons. It is highly dependent on imported oil and may soon be dependent on imported natural resources.

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gas. For these reasons, this chapter will focus primarily on the future availability and vulnerability of supplies of hydrocarbons to the United States, and will look in detail at oil, natural gas, and coal.

**Oil**

Oil is a globally traded and priced commodity. Nonetheless, oil produced at home is much preferable from the point of view of one’s national trade balance, and imported oil from secure and reliable sources is much preferable to that from less reliable and potentially hostile sources. Oil consumption in the United States grew by 69 percent from 1965 through 2008, with notable drops following the oil embargo in the late 1970s and during the recession that started in 2008. Domestic oil production peaked in 1970, however, and in 2008 about 65 percent of U.S. oil consumption was imported.¹

New U.S. oil discoveries, such as “deep-water” offshore oil in the Gulf of Mexico and shale oil in the Bakken Formation of Montana and North Dakota, are sometimes touted as panaceas to offset declines in domestic production. In reality, however, these discoveries will add relatively little supply compared to the country’s massive annual consumption of 7 billion barrels, as the Gulf of Mexico is very expensive and time consuming to develop, and the Bakken Formation oil is produced at low rates and has been estimated to contain only 4.3 billion barrels or less of recoverable oil.² Oil shales in Colorado and Wyoming, although purported to have massive in-place resources, are expensive and logistically challenging to extract and process, and are expected to have limited flow rates and a very low net-energy profit, should they ever be proved to be commercially viable.³ Ultimately, the potential flow rate of a resource is more important than its purported size—and the reality is that the flow rates of North American unconventional-oil sources and oil in difficult locations (such as deep water offshore) cannot be scaled up rapidly enough to significantly compensate for declines in the flow rate of conventional oil.

There are geopolitical and economic risks to being dependent on imports for two-thirds of consumption. The Organization of the Petroleum Exporting Countries (OPEC) cartel provided 46 percent of U.S. oil imports in 2008 (table 17.1). Of the major non-OPEC exporters, only Canada and Brazil—comprising 21.3 percent of 2008 imports—likely have the ability to increase exports significantly. Although non-OPEC exporter Mexico is the third-ranked source of U.S. imports, it is in steep decline as its Cantarell field (formerly the second-largest producer in the world) has plunged from more than 2 million barrels per day (bpd) in 2005 to half a million bpd at present.⁴

Canada is the largest oil supplier to the United States.⁵ Canadian conventional-oil production peaked back in the 1970s, but Canadian oil production is still big business, and its future is focused on the tar sands of Alberta. As recently as 2007, Canada’s National Energy Board (NEB) was highly optimistic about the

### Table 17.1

<table>
<thead>
<tr>
<th>Country</th>
<th>Exports to U.S. in 2008 (thousand barrels per day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>2,499</td>
</tr>
<tr>
<td>Saudi Arabia*</td>
<td>1,534</td>
</tr>
<tr>
<td>Mexico</td>
<td>1,305</td>
</tr>
<tr>
<td>Venezuela*</td>
<td>1,192</td>
</tr>
<tr>
<td>Nigeria*</td>
<td>991</td>
</tr>
<tr>
<td>Iraq*</td>
<td>628</td>
</tr>
<tr>
<td>Algeria*</td>
<td>550</td>
</tr>
<tr>
<td>Angola*</td>
<td>514</td>
</tr>
<tr>
<td>Russia</td>
<td>466</td>
</tr>
<tr>
<td>Virgin Islands</td>
<td>321</td>
</tr>
<tr>
<td>Brazil</td>
<td>259</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>237</td>
</tr>
<tr>
<td>Ecuador*</td>
<td>221</td>
</tr>
<tr>
<td>Kuwait*</td>
<td>211</td>
</tr>
<tr>
<td>Colombia</td>
<td>201</td>
</tr>
<tr>
<td>Other (80 countries)</td>
<td>1,821</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>12,961</strong></td>
</tr>
</tbody>
</table>

tar sands, forecasting a near tripling of production from 1.4 million bpd at present to 4.15 million bpd by 2030. But in July 2009, owing to the suspension of several projects due to the 2008 economic downturn, NEB forecast a comparatively restrained doubling of tar-sands output by 2020. The Canadian Association of Petroleum Producers, noted for its bullish forecasts, is similarly now more restrained and forecasting an increase to 3.2 million bpd by 2025. Given some of the new environmental regulations being implemented for the tar sands, including tailings and carbon management (which will increase cost and make this poor net-energy source of liquids even worse), these forecasts are still highly optimistic.

Forecasts of future energy supply that merely extrapolate consumption trends from the past, with the assumption that new supplies will somehow miraculously be available, are trademarks of government energy reports such as those from the International Energy Agency (IEA) of the Organisation for Economic Co-operation and Development (OECD), the United States’ Energy Information Administration (EIA), and Canada’s NEB. One example is illustrated in figure 17.2, which is the EIA’s reference case for liquids supply (i.e., all liquid petroleum and natural gas liquid products) in the United States through 2035 compared to actual supply for the previous four decades. The EIA apparently assumes that the geology of the United States’ oil provinces, with production long in decline, will miraculously heal itself, and production will go up through 2035. This, coupled with a forecast rapid growth in biofuels (mainly ethanol of dubious net-energy content), serves to decrease imports in the forecast from 65 percent of consumption at present to 48 percent in 2035, even though consumption rises by 12.3 percent over this period. The old adage “if it seems too good to be true then it probably is” comes to mind.

The EIA’s forecasts are used to inform government and the general public on future energy-supply issues. In light of what we know of global peak-oil issues (i.e., the increasing cost and diminishing quality and deliverability of the world’s oil sources), these reports unfortunately promote complacency and hence squander valuable time to mitigate the impacts of declining supply in the belief that all is well on the energy front. Kjell Aleklett, leader of the Global Energy Systems research group at Uppsala University in Sweden, has stated that the head of the EIA is “one of the world’s most dangerous people.” A clear view of the realities of future oil supply is crucial—rosy forecasts may serve the immediate needs of bureaucrats and politicians but are a travesty when considering the consequences of the lost opportunity of time and capital in managing a transition to a more sustainable future.

**Natural Gas**

The United States consumed 22 percent of global natural gas production in 2008. Unlike oil, natural gas is not a globally priced commodity but rather is continentally priced because of the expense and logistical difficulty of moving it across oceans as liquefied natural gas (LNG). LNG accounted for about 8 percent of global gas consumption and less than 2 percent of U.S. consumption in 2008. Thus most natural gas consumption in the United States is from domestic production.
and pipeline imports from Canada. Gas consumption in the United States reached a recent peak of 23.3 trillion cubic feet in 2000. Consumption has declined in all sectors except electricity generation since then, although its use has been rising again recently. The industrial sector, comprising petrochemical, fertilizer, and other industries, declined the most as volatile and often high gas prices pushed factories offshore.

Gas production in the United States hit an all-time high in 1973 and then declined, but has been rising to near 1973 levels recently owing to the development of unconventional gas (i.e., shale gas) and unprecedented amounts of drilling. This does not imply a long-term solution to production declines, however. Depletion rates of gas wells are much higher than those of oil wells—overall decline rates averaged 32 percent per year for the lower forty-eight states in 2006. This means that one-third of gas production must be replaced each year by more drilling, and that 60 percent of current lower-forty-eight gas production comes from wells drilled and connected in the previous four years. Unconventional production from shale-gas wells has much higher decline rates than conventional-gas wells, typically in the range of 65 to 80 percent in their first year of production, suggesting that the increased reliance on shale gas going forward is likely to accelerate the overall rate of U.S. gas depletion.

This has contributed to what I refer to as the “exploration treadmill”: more and more drilling to keep production flat, let alone growing (figure 17.3). The number of successful gas wells drilled each year has tripled since 1999, yet production has grown by only 15 percent. Active-rig counts (the number of rigs drilling for gas) peaked in late August 2008 and had collapsed by 56 percent by the fall of 2009 (the drop in successful gas wells is just visible in the left-hand chart), a dip that will likely show up in declining U.S. gas production by mid-2010. This exploration treadmill is just as pronounced in Canada, which is the main source of gas imports to the United States. Even though Canadian successful gas-well completions are nearly triple what they were in 1996, and were at one point in 2004 nearly quadruple, Canadian gas production is now declining at 7.5 percent per year, and Canada’s ability to export any gas by 2030 is seriously in doubt.

Nonetheless, there is a wave of hype promoting natural gas as a panacea to offset the United States’ extreme vulnerability to imported oil. The natural gas industry has established a new lobbying group in Washington called America’s Natural Gas Alliance, in addition to the existing American Clean Skies Foundation, which was chaired by Chesapeake Energy’s CEO Aubrey McClendon until December 2009. This hype on the ability of natural gas to fuel business as usual for a very long time, including replacing imported oil, is based on shale gas, a resource made accessible by new technology involving horizontal drilling and multiple hydraulic fracture treatments. Chesapeake is a major shale-gas producer, and the ultimate natural gas optimist is McClendon himself, who testified to Congress on July 30, 2008:

**FIGURE 17.3**

Note: The level of effort quantified by the number of wells drilled has tripled, yet production has risen by only 15 percent.

I believe natural gas can and should be the driving force for how this Congress can take bold action to free our country from the death grip of high prices for imported oil, thereby improving our economy, enhancing national security and helping the environment. It’s a trifecta, triple play and hat trick all rolled into one.... I believe U.S. natural gas producers can increase supplies by 5% per year for at least the next decade and that assumes there is no more access to public lands and waters than there is today.17

The hype on shale gas as a silver bullet is pervasive. T. Boone Pickens and McClendon have promoted the natural gas panacea in ads on CNN and elsewhere for the Pickens Plan.18 Actor Tommy Lee Jones was even brought into the fray in 2008 promoting shale gas, and Shale TV, a station dedicated to promoting shale gas in Texas and funded by Chesapeake, was about to be launched until the economy rolled over in the fall of 2008. In Canada, even though gas production is dropping at 7.5 percent per year, Pacific Trail Pipelines is planning on building a 463-kilometer pipeline to connect to a proposed liquefaction facility on the West Coast to export gas it envisages coming from shale gas in northeastern British Columbia (which has little production at present).19

So what are the realities behind shale gas, which now accounts for 14 percent of U.S. production? As of mid-2009 the Barnett shale-gas play (i.e., the production operation), which in part underlies the Dallas–Fort Worth metro area in Texas, accounted for 64 percent of U.S. shale-gas production, a significant part of the remainder being Antrim shale gas in Michigan, which has been in decline for many years. The Barnett play peaked, as predicted, in the first quarter of 2009, by which time more than 12,000 wells had been drilled at a cost of $2 million to $4 million each. Decline rates in the Barnett are typically 65 percent in the first year but initial production rates are high. Other shale plays throughout the United States are having similar experiences of high initial productivities, but also high decline rates and challenging economics. The Haynesville play of east Texas and Louisiana, for example, experienced decline rates of over 80 percent in the first year, and a sky-high cost of up to $10 million per well.20 In addition, the environmental impacts of shale-gas drilling are coming under increasing scrutiny: Two to five million gallons of water are required per well in the Barnett, a third of which is recovered and must be disposed of, with potential impacts on aquifers.

Arthur Berman, a geological analyst formerly with World Oil magazine, has done some very insightful analyses of shale-gas potential in the Barnett, Haynesville, and other plays. He has found that decline rates, well lifetimes, and ultimate recoverable reserves for shale-gas wells in these plays have been
optimistically assessed, to say the least. Assumptions of production profiles over well life, compared to actual measurements, suggest ultimate recoverable reserves per well are a third of what is commonly quoted, and well life spans could average eight years, not forty years as is commonly assumed. Berman has stated, among other things:

I am disturbed that public companies and investment analysts make fantastic claims about the rates and reserves for new shale plays without calibrating them to the only play that has significant production history. Almost every assumption used by the industry to support predictions about the Haynesville or Marcellus shale plays is questionable based on well performance in the Barnett shale.

Berman was a contributing editor for *World Oil* magazine until November 2009 when he resigned after his column was canceled over protests from shale-gas producers, whose stock price and stock issues for raising capital depend on a gung-ho worldview of shale-gas potential. Berman’s editor was subsequently fired over the issue. Stifling analysis and debate on such a crucial issue is disturbing considering its importance for planning future energy security. Much more will be known about the true potential of shale gas in plays outside of the Barnett in two to four years.

When it comes to the forecasts our leaders use to assess what lies ahead in terms of natural gas supply, the situation is very similar to that previously described for oil. Figure 17.4 illustrates what has actually happened with natural gas in the United States over the past decade. Production (both conventional and unconventional) in Colorado, Wyoming, and Texas has been increasing, whereas production in Kansas, Alabama, Louisiana, New Mexico has been declining, and Gulf of Mexico production fell by more than 50 percent. But looking forward, the EIA provides basically another no-worries forecast (figure 17.5) through 2035, with shale gas growing more than fivefold, a miraculous reversal in the geological fortunes of the Gulf of Mexico, and...
an overall growth in lower-forty-eight production of 22 percent by 2035.

This forecast is based on the following premises, which may prove to be unwarranted:

1. Drilling rates after a decline due to the current economic recession will be ramped up to equal and higher levels than those at their all-time peak (more than 36,000 successful gas wells per year in 2008), resulting in nearly one million new gas wells drilled by 2035.

2. The observed “exploration treadmill” of declining average well productivity will cease to operate and in fact will reverse itself, as yet more wells are crowded into available prospects.

3. Shale gas will live up to the hype, despite high decline rates, high costs, and significant associated environmental issues.

Such forecasts do not reflect the underlying uncertainties controlling future gas supply and, in my view, are unhelpful in putting together a coherent plan for a sustainable energy future as they lull policy-makers into a false sense of security.

In the likely event that EIA forecasts of gas supply do not materialize, imports of LNG will be needed. Much new LNG receiving capacity has been built in the United States over the past few years and at present is highly underutilized. The real story of LNG, however, is global liquefaction capacity, which is much less than global re-gasification capacity. As well as adding geopolitical complications to the gas trade (complications that have long been a fact of life with oil but so far have not been a serious issue for gas), LNG will very likely be a higher-cost supply source because a spot market is developing and the gas will be sold to the highest bidder. LNG is also an unfriendly source of gas from the point of view of net energy and greenhouse gas emissions, as 15 to 30 percent of the energy in the gas is consumed in the liquefaction, transportation, and regasification process.

Coal

The United States could be said to be a Saudi Arabia of coal as it controls some 29 percent of world resources. The United States produces over a billion metric tons of coal per year, a distant second only to China, which produces more than 2.7 billion metric tons per year. Half of the electricity generated in the United States is fueled by coal, much of it in older plants with less-than-optimal controls on emissions. In addition, the United States produces more than 60 million metric tons of high-quality metallurgical coal each year, which is used in steel making. Metallurgical coal is indispensable in the steel industry, and hence underlies much of the infrastructure of modern society.

In the United States, much of the higher-energy-content coal is mined in Appalachia, which produces bituminous thermal- and metallurgical-grade coals from underground mines and by “mountaintop-removal” surface operations that have major environmental impacts. Declining Appalachian production is being made up from very large-scale and mainly surface mining operations in the West, in particular the Powder River Basin of Wyoming, which produces more than 400 million metric tons per year from very thick seams of low-sulfur, sub-bituminous coal. Owing to the decline in production of the high-heating-value coals of Appalachia and their replacement with the lower-heating-value coals of Wyoming and other regions, the United States experienced a recent peak in the energy content of extracted coal in 1998 even though the total amount of coal extracted increased through 2008 (although it dropped significantly in 2009).

Several studies have recently been published on “peak coal,” the point at which global coal deliverability will begin an inexorable decline, likely in the 2020–2030 time frame. These studies are nicely summarized in Richard Heinberg’s book Blackout and hence will not be dealt with further here, except to say that the conventional wisdom of coal being a fuel for the long haul has been found severely wanting. Another excellent
in-depth review of U.S. coal resources and other coal issues has been written by Leslie Glustrom. The United States has been a major coal exporter in the past (over 12 percent of total production in the early 1980s), but more recently it has been importing ever-larger quantities of mostly thermal coal (for power generation), mainly from Colombia and Indonesia, although it is still a minor net exporter (59 million tons in 2009). When it comes to future forecasts of coal production in the United States, the EIA provides, as with oil and natural gas, yet another no-worries forecast. Figure 17.6 illustrates the EIA’s reference-case forecasts for coal production by region compared to historical production. Coal production is forecast to grow from the lower-quality deposits in the West and decline in the mature mining region of Appalachia.

Whether U.S. coal production can be ramped up by 12 percent, as in the EIA forecast, or even maintained is questionable. It would certainly require major new investments in mines and transportation infrastructure as the infrastructure for moving coal from the Powder River Basin, for example, is at maximum capacity. Given the issues with supply of natural gas discussed earlier, and challenges with the scaling up of renewables, there will clearly be a role for coal in the transition to a more sustainable energy future. However, the current focus on carbon capture and storage (CCS) with its parasitic energy losses and high capital costs is, in my opinion, the wrong way to go. Energy losses for CCS amount to 30 percent of the energy produced in a typical coal plant, requiring an increased burn rate for the same amount of electricity, which accelerates the consumption of a nonrenewable resource. Moreover, the capital costs for CCS infrastructure can be 50 percent of the cost of a plant—money that could be better invested in infrastructure to provide an alternative to high-energy throughput lifestyles.

Coal is a low-value fuel compared to natural gas or oil because it is less versatile in its potential applications without significant energy-conversion losses and costs. High-efficiency configurations of coal-fired generation with heat capture (“combined heat and power,” or CHP) have the potential to double the efficiency of coal plants and eliminate the consumption of hydrocarbons that would otherwise be required to generate that heat (thereby also radically reducing emissions). The issue of coal use is often fraught with emotion. However, considering the scale of its contribution to U.S. energy supply, and the lack of scalable alternatives, it is unlikely that it can be completely phased out in the foreseeable future. Coal must therefore be used in its highest-efficiency and lowest-emitting configurations.

The Scaling Dilemma

Hydrocarbons have a role in every aspect of modern life, including building materials, transportation, food, communication, electricity, and so forth. The scale at which hydrocarbons are consumed to fuel the global economy as currently structured makes it impossible to conceive of alternatives to replace them at that scale; clearly a more sustainable future necessitates a radical reduction in the amount of energy consumed. Renewable sources of energy, which must contribute
to a solution, are still dependent on hydrocarbons for their manufacture.

Then there is the issue of energy quality. Renewable sources of energy such as wind or photovoltaics are intermittent and unpredictable—their actual generation is typically a third or less of their rated capacity, and hence they require backup by reliable generation sources, usually fueled by hydrocarbons. Our electricity infrastructure is tasked to provide uninterrupted service at all hours to all users, no matter how high the demand—it is highly unlikely that it can be converted to renewable energy at anything like the scale of electricity consumption we enjoy today because of the intrinsic limitations of renewables and the massive scale required. The concept that we can maintain our current massive transportation infrastructure by converting from vehicles that run on liquid petroleum products to those that use electricity or natural gas is likely doomed to failure—we need to rethink our transportation requirements to have a much lower energy footprint.

Although electricity generation is only a fraction of the work hydrocarbons perform for us, it is particularly instructive to examine the role of hydrocarbons in electricity generation to appreciate the daunting scale of replacing them with alternatives at present consumption levels going forward. The EIA forecasts U.S. electricity generation to increase by nearly 27 percent from 2007 to 2035 (figure 17.7). Hydrocarbons account for 71 percent of electricity generation at present, with coal being nearly half—and by 2035 they are expected to still be the main power source, at 65 percent of total generation and with coal comprising 44 percent. A massive 452 percent increase in the capacity of non-hydro renewables, if achieved, would make up only just over 11 percent of total electricity-generation market share. Large hydropower is also forecast to grow but lose market share owing to a lack of remaining developable sites, as is nuclear due to the enormous challenges and expense of refurbishing and/or replacing the aging U.S. nuclear fleet.

The prognosis for non-hydropower renewable sources is particularly at odds with the popular vision of our future economy being powered by wind turbines and solar panels (figure 17.8). The largest single source of renewable energy is actually forecast to be wood and other biomass, growing more than sevenfold to serve
5.5 percent of total market share, followed by a sixfold growth in wind to 4.1 percent of market share. Solar photovoltaics are forecast to grow by thirty times, but even then they would contribute only less than half a percent of forecast generation.

This illustrates the scaling dilemma society faces in replacing hydrocarbons in our current business-as-usual mode of energy consumption. Even with a radical scale-up, non-hydropower renewables are forecast to make up less than 12 percent of electricity generation in 2035, and a much smaller proportion of total energy consumption. The fossilized sunshine that hydrocarbons represent is an extremely convenient, dense form of energy for which there are no alternatives at the scale of energy throughput we enjoy at this point in humanity’s existence. Forecasts of continuing availability of hydrocarbons for the next couple of decades for business-as-usual levels of consumption are tenuous at best and wishful thinking at worst. Solutions to the pending decline in the availability of hydrocarbons rest on rethinking and radically reducing our levels of energy consumption and developing the infrastructure for alternatives to lifestyles now based on cheap energy.
Endnotes


2. A major portion of the renewable energy sector is large hydropower, which by some definitions is nonrenewable in the longer term, and certainly is not without its environmental impacts.


8. Canada is also an oil importer, as its east coast provinces are highly dependent on offshore oil. This makes Canada a relatively small net exporter of about 1 million barrels per day.


20. Nome and Johnson, From Shale to Shining Shale.


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The Post Carbon Reader
Managing the 21st Century’s Sustainability Crises
Edited by RICHARD HEINBERG and DANIEL LERCH

In the 20th century, cheap and abundant energy brought previously unimaginable advances in health, wealth, and technology, and fed an explosion in population and consumption. But this growth came at an incredible cost. Climate change, peak oil, freshwater depletion, species extinction, and a host of economic and social problems now challenge us as never before. The Post Carbon Reader features articles by some of the world’s most provocative thinkers on the key drivers shaping this new century, from renewable energy and urban agriculture to social justice and systems resilience. This unprecedented collection takes a hard-nosed look at the interconnected threats of our global sustainability quandary—as well as the most promising responses. The Post Carbon Reader is a valuable resource for policymakers, college classrooms, and concerned citizens.

Richard Heinberg is Senior Fellow in Residence at Post Carbon Institute and the author of nine books, including The Party’s Over and Peak Everything. Daniel Lerch is the author of Post Carbon Cities.

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