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In November 2009, former vice president Al Gore appeared on the *Late Show with David Letterman*, and declared that unless the people of the world take drastic action to curb global carbon dioxide emissions, it could be "the end of civilization as we know it."[i]

Over the past decade or so, Gore has been at the forefront of a campaign aimed at reducing global carbon dioxide emissions. His book, *An Inconvenient Truth*, along with a documentary of the same title, were part of a tidal wave of books, magazine articles, and studies which claimed that the world faces a risk of catastrophic climate change because of increasing levels of greenhouse gases in the earth's atmosphere. The United Nations has weighed into the discussion with numerous reports about the issue. And in December, the United Nations Framework Convention on Climate Change will meet in Durban, South Africa to hold yet another climate meeting. That meeting follows similar climate confabs that have been held in Rio, Kyoto, Copenhagen, and Cancun.

While the statements being put forward by the UN's Intergovernmental Panel on Climate Change which said in 2007 that "warming of the climate system is unequivocal" along with claims that carbon dioxide emissions are the chief culprit, may prove to be correct, we must also maintain the possibility that these claims are wrong.[ii]

Either way, a strong opinion about the claims matters very little because no matter how much the US may want to lead efforts to reduce carbon emissions, it cannot, and will not, be able to substantially slow the increasing use of coal, oil, and natural gas.

This paper will discuss two inter-related factors that are seldom discussed by politicians and pundits: the slow pace of energy transitions and the enormous scale of our energy use. By discussing those two factors, I will show why the countries of the world will not be able to agree on any plans to impose carbon limits or carbon taxes.

The Slow Pace of Energy Transitions

Given the ongoing political battles over what are commonly called "Big Oil,", "Big Coal," and more recently, "Big Gas," it's worth noting that the fuel source that has had the longest reign in the American energy business is plain old firewood.

Wood's reign as the most important fuel in the United States lasted longer than any other. For 265 years after the Pilgrims founded the Plymouth Colony, and for 109 years after the signing of the Declaration of Independence, wood was the dominant source of energy in America. It wasn't until 1885 – the year that Grover Cleveland was first sworn in as president – that coal finally surpassed wood as the largest source of primary energy in the US.

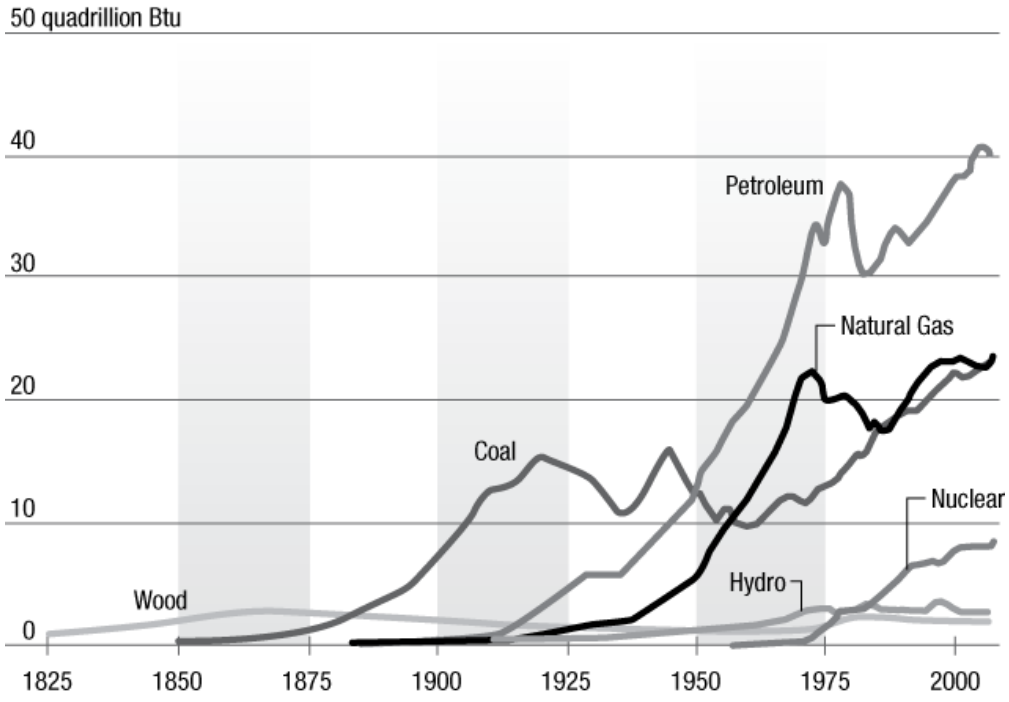
For the next 75 years, coal was king. During the first two decades of the 20th century, coal was supplying as much as 90 % of all the primary energy in the US, fueling factories, heating homes, and providing boiler fuel for essentially all of the nation's electric power plants. But coal's dominance was not to last. Thanks in large part to the booming demand for kerosene for lighting and more particularly, for gasoline to fuel automobiles, oil began whittling away at coal's market share.

World War II was a turning point. The massive production of airplanes, ships, and motor vehicles during the war years accelerated the demand for oil. And prolific oilfields in Texas and Oklahoma were ready and able to provide nearly all the gasoline and diesel fuel that consumers and industry wanted. Between 1945 and 1950, the number of cars on US roads increased by 60%. Over the next ten years, the US auto fleet grew by another 50%.[iii] The increasing mobility of the average American resulted in a huge increase in demand for oil. In 1949, coal accounted for about 37.4% of the US primary energy market, with oil trailing close on its heels with a 37.1% share. But in 1950, oil hit the tipping point, surpassing coal as the biggest source of US primary energy. And for the last 60 years, oil's primacy has not been challenged. In fact, in 2008, oil's share of the US energy market was at the exact same level as it was back in 1950: 38.4%.[iv]

While oil has been the undisputed champion, the jockeying for second place has been ferocious. In 1958, natural gas sped past coal to become the second-largest source of

primary energy in the US. And gas kept its second-place status behind oil for nearly two decades. By 1971, the US was consuming nearly twice as much energy in the form of natural gas as it was in the form of coal.[v] But Congress and federal regulators decided that the market couldn't be trusted. And thanks to their ham-handed interventions, coal rebounded in a big way. In 1986, coal overtook natural gas to re-claim second place in the US primary energy market. Since then, coal and natural gas have been running neck-and-neck with each claiming about 25% of the US primary energy market.

US Primary Energy Consumption by Source, 1825 to 2008



Source: EIA[vi]

The decades-long jousting for primacy among the various hydrocarbons provides more evidence for just how difficult it will be to replace them. As Vaclav Smil explains in his 2008 book, *Global Catastrophes and Trends*, there's no reason to expect that the

transition toward renewable sources like solar and wind will be done quickly. In fact, he says to expect the opposite:

> There is no urgency for an accelerated shift to a nonfossil fuel world: the supply of fossil fuels is adequate for generations to come; new energies are not qualitatively superior; and their production will not be substantially cheaper. The plea for an accelerated transition to nonfossil fuels results almost entirely from concerns about global climate change, but we still cannot quantify its magnitude and impact with high confidence.[vii]

Furthermore, the longer we use hydrocarbons, the more entrenched they become in our way of life. And the more energy we produce with hydrocarbons, the more energy we are able to produce.

That may sound like hyperbole, but it can be easily understood by looking back at the history of the coal business. The first railroads were built to haul coal, and the locomotives that hauled the coal, burned coal. As author Jeff Goodell writes in his book *Big Coal,* the railroads were a key invention that led to more coal production because, "In effect, coal hauled itself."[viii] Of course, the railroads were only part of the equation. By perfecting the steam engine, James Watt enabled British mines to produce coal more economically because his engines pumped water and lifted coal out of the mines.[ix]

The idea that hydrocarbons beget more hydrocarbons can also be seen by looking at the Cardinal coal mine in western Kentucky. The mine produces more than 15,000 tons of coal per day. And the essential commodity that facilitates the mine's amazing productivity is electricity. The massive machines that claw the coal from the earth run on electricity provided by power plants on the surface that burn coal. In fact, about 93% of Kentucky's electricity is produced from coal.[x] To paraphrase Goodell, at the Cardinal mine, the coal is, in effect, mining itself.

Hydrocarbons are begetting more hydrocarbons in the oil and gas business. Modern drilling rigs can bore holes that are five, six, or even eight miles long in the quest to tap new reservoirs of oil. And the energy they use to access that oil is…oil. Diesel fuel has long been the fuel of choice for drilling rigs around the world. On offshore drilling rigs,

the power is often supplied by diesel fuel. But in some cases, the power is provided by natural gas that the rig itself produces. In those offshore platforms, the natural gas is, in effect, mining itself.

The transition away from oil, coal, and natural gas will be a decades-long process because the companies that produce those commodities are getting ever-better at finding and exploiting them. The oil and gas industry provides a clear example of this. For about a century, analysts have been forecasting an end to the supply of petroleum. And they have consistently been proven wrong. Why? Because the companies that produce oil and gas continue innovating.

While environmental groups and energy analysts continually publicize the inventiveness of entrepreneurs working to improve wind, solar, and other alternative sources of energy, they seldom mention the ongoing innovations that are occurring on the hydrocarbon side of the ledger. And in doing so, they frequently forget the sheer size of the industry that is constantly searching for techniques that can get oil and gas out of the ground and do so faster and cheaper.

In the US, there are about 5,000 independent oil and gas companies, every one of which is continually spending money and testing new concepts that will wring yet more petroleum and natural gas out of their leases.[xi] In 2007 alone, those companies spent $226 billion drilling and equipping some 54,300 new wells.[xii] And that doesn't include the money spent on research and technology. All of the money spent on drilling and outfitting those wells, and the investment those companies have made in research and development, helps assure that the installed fleet of machinery that supplies us with horsepower will continue to be fueled primarily by hydrocarbons.

A final point regarding the slow pace of our energy transitions: In 2009, the US used less renewable energy as a percentage of hydrocarbon use, than it did back in 1949.

Yes, it's strange. But it's true. Back in 1949, the US derived 10.2% of its primary energy from renewables, which at that time, consisted solely of hydropower and biomass. Sixty years later, America's total energy use had more than tripled, and hydro and biomass were still the major factors in the renewable part of the equation. But in relation to

America's hydrocarbon use, by 2009, renewables' share of the market had fallen to about 9.9%.

One other remarkable fact about the 60-year period from 1949 to 2009 is this: oil's share of the market has stayed remarkably constant. In 1949, petroleum accounted for 37.1% of total primary energy. By 2009, that percentage stood at 37.2%.[xiii]

Few facts better indicate the slow pace of our energy transitions than that: for three generations, inventors, entrepreneurs, and governments have spent untold billions of dollars trying to find viable alternatives to oil. And what happened over that 60 year span? Not much.

Scale: The 24.5 Saudi Arabia problem.

The slow pace of our energy transitions is intimately connected to the vast scale of global energy use. The BP Statistical Review of World Energy estimates that in 2010, daily global commercial energy use was about 241 million barrels of oil equivalent. Of that quantity, hydrocarbons account for 210 million barrels of oil equivalent per day.

What is 241 million barrels of oil equivalent? Well, try thinking of it this way: it's approximately equal to the total daily oil output of 28 Saudi Arabias. Since the 1973 Arab Oil Embargo, Saudi Arabia's oil production has averaged about 8.5 million barrels per day.[xiv]

Over the past few years, numerous environmental activists and politicians have claimed that we must quit using hydrocarbons because their use releases so much carbon dioxide. But those activists and politicians never mention that doing so will require us to find 210 million barrels of oil equivalent -- about 24.5 Saudi Arabias per day – of energy every day, and all of that energy must be carbon-free.

Another factor that is never discussed: global consumption of energy is soaring as numerous countries around the world seek to bring their populations out of dire energy poverty and into the modern world. Over the past decade alone, global energy use

increased by 27 percent. That's equal to about 53 million barrels of oil equivalent per day. Put another way, over the past 10 years, global energy use has increased by the equivalent of six Saudi Arabias' worth of daily oil output.

The result of that huge surge in global energy consumption is easily seen: carbon dioxide emissions jumped by 28 percent over the past decade.[xv] Countries all over the planet are trying to overcome energy poverty. And the desire to escape energy poverty is trumping concerns about carbon dioxide. To drive that point home, let's try a short pop quiz.

Q: Over the past decade, which country has had the biggest percentage growth in carbon dioxide emissions?

A: Vietnam.

Q: Which country has had the biggest percentage growth in electricity generation?

A: Vietnam.

Q: Finally, which country had the biggest percentage growth in coal use?

A: Again, it was Vietnam

Indeed, over the past decade, only one country, China, had faster percentage growth in primary energy consumption than did Vietnam. And Vietnam stands as a proxy for many populous countries in the developing world, think Turkey, Egypt, and Pakistan. As those countries grow their economies -- their energy use and their carbon dioxide emissions -- the hope for any kind of a global cap, or tax, on carbon emissions becomes ever more remote.

To be sure, Vietnam's energy use is a tiny fraction of that used by countries like China and the US. In 2010, Vietnam's 90 million inhabitants consumed about 900,000 barrels of oil equivalent per day. That's a rounding error when compared to China's consumption of nearly 49 million barrels of oil equivalent per day or US consumption of nearly 46 million barrels of oil equivalent per day.

Put another way, the average resident of Vietnam now consumes about 0.4 gallons of oil equivalent per day. The average American consumes about 6.3 gallons of oil equivalent per day, while the average Chinese uses 1.3 gallons of oil equivalent per day. In fact, the average Vietnamese now consumes more energy on a daily basis than does the average Pakistani.

But with an average income of less than $1,200 per year, Vietnam is still racing to catch up to the rest of Asia. And with an annual GDP growth rate of nearly 7%, Vietnam has every reason to continue burning as much oil, coal, and natural gas as it possibly can.[xvi]

Energy use in Vietnam and other fast-growing countries is soaring and that's resulting in more carbon dioxide emissions. In 2010, those emissions totaled 33.1 trillion tons, which as I mentioned earlier, is an increase of 28% over 2001 levels.

Global carbon emissions are rising because coal consumption jumped by 175% over the past decade. That jump in coal use exceeds the percentage growth in Indonesia (134%) and China (128%). And nearly all of that coal is being used to produce electrons.

Over the past decade, Vietnam's electricity generation increased by a whopping 227%, the fastest growth on the planet. Again, the total amount of electricity used in Vietnam – about 100 terawatt-hours -- remains miniscule when compared to US consumption of 4,326 terawatt-hours. But the essentiality of electricity to modernity is incontrovertible. The countries that can produce cheap, abundant, reliable electricity can grow their economies, educate their citizens and pull their people out of poverty. And those that can't, can't. And for many countries in the developing world coal is the fuel of choice for electricity generation.

The latest BP data shows that over the past decade, global coal use is up 47%, that's faster growth than what was seen in electricity generation (up 36%), natural gas use (up 30%), and oil consumption (up 13%). Environmentalists around the world love to vilify coal. But for countries like Vietnam, Pakistan, China, and others, coal keeps the lights on. That's certainly true here in the US, but over the past decade, domestic coal consumption has fallen by 5%. And with that decline in coal consumption, US carbon dioxide emissions have also fallen – by 1.7% -- since 2001.

Like it or not, the world economy runs on hydrocarbons – coal, oil, and natural gas. And that will remain true for many decades to come. Energy transitions happen over decades or centuries, not years. Countries like Vietnam, China, and India, will never agree to any tax or limit on carbon dioxide. Nor does it make much sense at all to impose heavy levies on the US, and other developed countries as those taxes would have only a minute impact on total global carbon emissions.

Global leaders should give up their fixation on cutting carbon dioxide emissions. Significant cuts will not happen voluntarily, anywhere. Instead, leaders should be focusing on providing as much cheap, abundant, dispatchable power to their citizens as possible. Doing so will help more people come out of poverty and into the modern world.

I'll close with a quote from Freeman Dyson, a renowned professor of physics at the Institute for Advanced Study at Princeton University. In August 2007, Dyson wrote an essay for *Edge.org* in which he challenged the entire notion of cutting carbon dioxide emissions. "The greatest evils are poverty, underdevelopment, unemployment, disease and hunger, all the conditions that deprive people of opportunities and limit their freedoms," he wrote. "The humanist ethic accepts an increase of carbon dioxide in the atmosphere as a small price to pay, if world-wide industrial development can alleviate the miseries of the poorer half of humanity."[xvii]

To that, I say amen.

END

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[i] Late Show with David Letterman, November 3, 2009. Available: http://www.cbs.com/late_night/late_show/video/?pid=Pvb2AfVeGFHFfegRj7cbeENTolRNrecs&vs=Big%20Show%20Highlights&play=true

[ii] Intergovernmental Panel on Climate Change, "Climate Change 2007: Synthesis Report," 2007, http://www.ipcc.ch/publications_and_data/ar4/syr/en/spms1.html

[iii] US Census Bureau, Historical Statistics of the United States, "Series Q 148-162, Motor-Vehicle Factory Sales and Registrations, and Motor-Fuel Usage: 1900 to 1970," 716.

[iv] BP Statistical Review of World Energy 2009.

[v] EIA data. Available: http://www.eia.doe.gov/emeu/aer/txt/ptb0103.html

[vi] EIA data. Annual Energy Review 2008, Figure 5. "Primary Energy Consumption by Source, 1635-2008." Available: http://www.eia.doe.gov/emeu/aer/ep/ep_frame.html
[vii] Vaclav Smil, *Global Catastrophes and Trends*, 90.
[viii] Jeff Goodell, *Big Coal*, 75. He reports that the first significant rail line was built in the British coal town of Darlington to carry coal to the port at Stockton.
[ix] Peter Huber and Mark Mills, *The Bottomless Well*, 4-5.
[x] American Coalition for Clean Coal Electricity. Available: http://www.cleancoalusa.org/docs/state/
[xi] Jalal Torabzadeh, "A Message from the Chair," Los Angeles Basin SPE Section Newsletter, June 2009. Available: http://www.laspe.org/newsletters/june09nltr.pdf
[xii] Advanced Resources International, "Bringing Real Information on Energy Forward: Economic Considerations Associated with Regulating the American Oil and Natural Gas Industry," April 24, 2009, 2. Available: http://s3.amazonaws.com/propublica/assets/natural_gas/economic_consequences_report_april2009.pdf
[xiii] EIA data, http://www.eia.gov/emeu/aer/txt/ptb0103.html
[xiv] BP Statistical Review of World Energy 2009. See also: Jad Mouawad, "OPEC Plans Further Output Cut," *New York Times*, December 17, 2008. Available: http://www.nytimes.com/2008/12/17/business/worldbusiness/17opec.html?fta=y. Mouawad reports that the Saudis settled on a production rate of 8.5 million barrels per day in November 2008.
[xv] BP Statistical Review of World Energy 2010.
[xvi] US State Department data, http://www.state.gov/r/pa/ei/bgn/4130.htm
[xvii] Freeman Dyson, "Heretical Thoughts About Science and Society," Edge.org, August 8, 2007. Available: http://www.edge.org/3rd_culture/dysonf07/dysonf07_index.html