“Accelerating Climate Change or Climate Progress? -an optimistic, yet feasible and actionable proposal”

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Climate change is a substantial risk, and the risk of global inaction is real. In the long-term, for rapidly developing nations, carbon intensity targets are more feasible than absolute carbon caps. In the near-term, technology-driven carbon reduction capacity building is more important than absolute carbon reductions.

Global climate change continues to be a substantial risk. The United States has failed to enact a climate bill and international negotiations, post Cancun, are also struggling. Jonathan Pershing, US negotiator, observed, "some countries are walking back from progress made in Copenhagen, and what was agreed there."[1] Interestingly, while the international blame-game continues, some countries are accelerating concrete domestic actions designed to unleash broad-scale clean energy innovations. A "race for the clean energy future" is afoot. Meanwhile, driven more by the need for headlines than accurate reporting, the popular media (inaccurately) blames climate change for everything from record-breaking heat waves to epic floods. Away from the noise of the press, the scientific community continues to see mounting evidence of climate change, and more importantly median scientific assessment points increasingly towards amplified negative impact of climate change in the coming decades. Yet the likelihood of policy inaction is increasing rapidly. In our view, an immediate focused assault on climate change is akin to buying insurance to protect against other potential catastrophes such as terrorism (through security investments and military) or nuclear proliferation.

One must ask, what are the rules governing solutions to the global climate crisis and who makes them? The countries with the biggest bulk and heaviest sticks? Someone's moral and ethical principles? If so, whose morals and ethics? Do we consider a given country's ability to pay, its natural resources, and its rate of economic development important to their contribution to solutions? Given the global budget deficits and debt loads, additional spending seems very unlikely. Any solution towards climate risk reduction must necessarily operate within these constraints or be considered a dreamer's solution. A dose of pragmatism is vital – in most countries, immediate political and economic needs trumps the planet's needs in the year 2050.

Technology and economics will be the drivers of any relevant global climate change solutions that get past local interests, national politics and similar barriers to caring for the common good. A dynamic solution is critical; one that responds and morphs as global and regional circumstances change. It will need to dynamically react to costs, practicality of approaches, technology advances, and evolving climate change forecasts. Furthermore, it should include targets and mechanisms that allow developing countries to prosper while incentivizing improved emissions trajectories. The current approach of trying to plan for static targets at some date in the future, independent of changing technology, changing cost estimates or changing willingness to pay are, in my view, unlikely to succeed.

I have previously advocated the use of carbon intensity of GDP growth over absolute carbon caps. On the "global agreements' front perhaps the most significant advancement at Copenhagen last December was the adoption of voluntary emissions intensity targets by the largest developing nations: China, India, Brazil, South Africa, Mexico, South Korea, and Indonesia.[2] These "Emissions

[1] http://www.bbc.co.uk/news/science-environment-10900798
[2] For a summary of these commitments see: http://www.nrdc.org/international/copenhagenaccords/

Intensity Targets" represent a dynamic approach to developing a low carbon global economy and reducing emissions to avoid the catastrophic consequences, but don't penalize countries for rapid GDP growth. In fact, faster growth enables higher levels of investment in new technology, energy efficiency and improved carbon intensity of GDP. Countries which invest in efficiency and improved carbon intensity of GDP reward themselves with increased market competitiveness due to reduced energy costs. These targets also prevent the tragedy of the commons by addressing global carbon, and focus the best minds of each country on the challenge of achieving low carbon prosperity. Regardless, creating a low carbon, affluent world will not be free. Given the scale of capital needed, public funding is not enough and private capital (motivated by profit as opposed to "social goodwill") is essential. The global community can focus on action, instead of rhetoric, by building on commitments made at Copenhagen to prompt fast start funding and support intensity targets by revamping and creating financial instruments that integrate intensity target commitments to ultimately drive clean energy development and deployment.

To maximize investment impact, we must encourage basic R&D to develop true "Black Swan" technological disruptions: ultra-low carbon technologies which completely change conventional assumptions. These must obey the laws of economic gravity, which state that in order to deploy a technology widely, it must be market competitive unsubsidized against fossil competitors as it approaches scale. This is the only way to reduce the need for public funding, which is scarce in the debt-ridden western world. Many of the world's cleantech investments to date have been incremental improvements and dead-end technologies aimed at milking preferential regulatory regimes, and will never reach market competitiveness. Instead, we need to take more shots on goal by increasing focus on high risk (and high potential upside) technology development: Black Swans. The key insight is that improbable does NOT equal unimportant provided we take enough shots on goal. Though unlikely that any single shot works, even 10 disruptions out of 10,000 shots will completely upend conventional wisdom, econometric forecasts and most importantly our energy future. In everything from batteries, solar cells, LEDs, wind, and engines, innovation will upend conventional wisdom and forecasts, and will hopefully produce economically driven technology engines of growth, profits and carbon reduction. The direction and timing of innovation is hard to predict, so none of this is ever included in econometric models.

Ultimately, policy that encourages Black Swans also supports building critical "carbon reduction capacity" technologies that are on a path to at least 80% less carbon intensity than those they replace. Examples include economic carbon sequestration, 80% more efficient ICE drivetrains, biofuels with 80%+ lower lifecycle emissions than gasoline, appliances and lighting that are 80% more efficient, and 80% cheaper storage. If we focus on these rather than deploying marginally economic current technologies, early carbon savings will be lower; however, reductions will rapidly accelerate once these Black Swans are deployed. After all, technologies that start with economic carbon reductions around 50% have a fighting chance of reaching 80% reductions, as opposed to the 10-15% incremental reductions that are typically targeted. We should learn from Craig Venter: he sequenced the human genome faster and cheaper than the government-funded Human Genome Project by designing better tools for sequencing rather than spending his time on brute force sequencing that competitors were pursuing when he started. By building the tools for radical carbon reduction now, this "economic carbon reduction capacity" building will get us to our targets more quickly and cost effectively than the current focus on incremental reductions. Ultimately, some of these technologies

will scale and will have declining costs with scale while others won't scale or won't have declining costs with scale. This makes decisions tricky.

A New Paradigm

The traditional view surrounding the international impasse is simple: the US does not want to participate in a global treaty because China and India won't agree to binding targets. Until they know how the remaining "carbon space" will be carved up in the future, China and India won't commit to a binding agreement for political reasons. Furthermore, the developing world seeks economic growth parity to the developed world without any constraints placed on their growth rates by absolute carbon reduction targets. Absolute carbon caps are much harder for poor economies and fast growing economies to meet, and easier (but not easy) for slower growing rich economies. Complicating matters, carbon caps are less critical for poor, slow growing economies. This potential inequality leads to finger pointing between developed and developing countries.

"What is fair" and "what is pragmatic" are often inconsistent with each other, especially in democracies. Perhaps the only morally defensible "fair thing" to do is to give every human being an equal right to pollute the air. As of 2006, the approximately 1 billion-person population of the OECD emits roughly as much carbon dioxide equivalent as the remaining 5.5 billion people.[3] Besides, the developed world is mainly responsible for the current carbon levels in the atmosphere and should be held responsible. Why should developing economies be forced into the same carbon reduction targets given their low historical and currently lower per capita emissions? Hence developing nations reasonably argue that it is only fair that they [the OECD and the developed world] bear the principal burden for reductions, especially since they have the highest incomes and greatest capability to invest in the reduction of their carbon footprint. Unfortunately this fair formula does not work well for the planet. It also does not work for the politics, heavyweight clout and self-interest of the Western world, which would have to radically change its carbon emissions and hence its energy use profile, draining investment funds and causing significant business dislocations. Moreover, the common refrain (including in environmental circles) is that India and China don't want to do their part in global carbon emissions reduction, and that any coordinated action without them is doomed to failure. Of course, every country wants to continue its development priorities while pushing off the burden of carbon abatement to the "commons" – the classic "free rider" problem. Interestingly, a low carbon economy may not need to be "sold" to the public in the end; the argument for clean technology can be driven (or at least influenced) by self-interest, as we explain later. Self-interest driven policy is the only common policy I suspect major world powers, be they developed or developing, will be able to agree on.

In fact, countries including China and India are moving forward with actions at home to reduce their emissions trajectory and increase their industrial competitiveness. More and more countries are recognizing the environmental imperative and direct economic benefit to taking action on climate change.

A new paradigm has emerged in the past couple of years: developing countries moving forward to build low carbon economies because it is in their domestic interest, and developed countries

[3] http://www.eia.doe.gov/oiaf/ieo/pdf/highlights.pdf

supporting further emissions reduction because it is essential to solving climate change. Indian Prime Minister Manmohan Singh's remarks at Copenhagen frame the new paradigm:

> We in India, too, are vulnerable, but nevertheless as responsible citizens of the globe, we have agreed to take on a voluntary target of reducing carbon intensity between 20 and 25 percent by 2020 from 2005. We will deliver on this goal regardless of the outcome of this Conference. We can do even more if a supportive global climate change regime is put in place.[4]

There are at least four reasons why this should be the new paradigm for how countries engage on this issue and how to think about international efforts.

First, despite skepticism in Washington, the "race for the clean energy future" is real. The International Energy Agency estimates a $13 trillion global market for "low-carbon technologies" over the next two decades. Last year, according to Bloomberg New Energy Finance, clean energy investment climbed to over $160 billion – a 230 percent increase over the past four years.[5] The world's best minds are focused on this problem now, which was not the case a few years ago. In 2004 I gave energy lectures at Universities around the country, and the rooms were mostly empty; there were almost no PhD's interested in energy at MIT, Stanford, Caltech and other tier 1 schools. Just 18 months later, an informal survey showed 50 percent of the professors were interested in energy technologies. Energy is now the #1 priority at top tier institutions globally. Countries that are competitive in this race can expect cutting-edge innovation, job creation, new industries, and significant economic benefits. Over the next few decades, they can also expect to be the home of new Google and Apple-like companies in the energy space. The most impact will be created by the development of meaningful carbon reduction capacity: economic technologies that are radically more carbon efficient. Countries that enable these Black Swan technologies through R&D spending and then use gradually declining subsidies to scale them to meet the Chindia price point (the price at which India, China and other similar economies would adopt the technology with no subsidies) will be leaders in the new economy. Though investment in clean energy technologies has increased, we need to accelerate it substantially and direct it more effectively. Sustained subsidies or mandates are not scalable and should decline in about five to seven years after a technology starts scaling or when it reaches a few percent market penetration in its segment.[6] The increased cost of those few years and few percent should be viewed as an "investment" by society in technologies that will have returns through increased competition. This way, a small segment of each market can be viewed as the playground to nurture competition and continuous innovation. When technology takes the lead, it will enable entrepreneurs to repeatedly prove the market models, experts and pundits wrong and develop the best technologies we can within our financial constraints. I suspect that by 2040, or even earlier, this path will result in larger reductions in carbon emissions than the regulatory paths being attempted today by environmentalists.

Second, a taste of the potential impacts of climate change are being experienced in communities around the world. The popular media would have you believe everything weather-related is due to

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[5] See: http://www.pewglobalwarming.org/cleanenergyeconomy/pdf/PewG-20Report.pdf
[5] See: http://www.pewglobalwarming.org/cleanenergyeconomy/pdf/PewG-20Report.pdf
[6] http://www.foreignpolicy.com/articles/2010/12/10/long_shots?page=0,1;
http://www.greentechmedia.com/articles/read/corn-ethanol-time-to-move-on/

climate change (or none of it is). In reality, it is inaccurate and distracting to blame current events on climate change. To do so is to confuse climate (long-term trends) with weather (short-term trends). Still, these recent weather incidents echo the warnings of the IPCC on what we look forward to in the decades to come if we take no action – increased probability of extreme weather events. Last year, we have seen devastating events in Pakistan, Russia, China, and the United States, resulting in human suffering and economic losses. Monsoon flooding in Pakistan affected over 14 million people and left more than six million people homeless. The Russian heat wave and fires devastated over 15,000 lives, wiped out crops, and cost the economy $15 billion. Extreme rains left China ravaged by mudslides and floods. In the US, floods swept through Iowa and Tennessee while other regions had record-breaking temperatures. Russian President Dmitri Medvedev's statements calling for head of states and organizations "to take a more energetic approach to countering the global changes to the climate" following his country's tragedy provide a signal that even the greatest critics are beginning to take the longer view and recognize the need for action.

Third, there are real and meaningful "co-benefits" to building a low carbon economy. Reduced dependence on imported fuels (and petro-dictators), fewer power shortages, improved air quality, greater job creation, improved livelihoods, and reduced healthcare costs are some of reasons that many nations are taking domestic action to curb emissions. Every dollar that a country saves as a result of energy efficiency programs is a dollar that they don't send overseas and can be more productively used to employ someone domestically. Technology that delivers greater efficiency economically creates wealth for nations facing energy poverty. Consider India where nearly 400 million people lack access to modern electricity, introducing clean energy technologies is in that nation's own interest. Moreover, importing less energy also has national security implications for every nation, developed or developing. Not only that, increasing a country's efficiency through new technology lowers the effective cost of energy, increases their global competitiveness and can produce valuable exports.

Lastly, we must begin to take concrete actions. The value of insurance against climate change is huge, even if you're a skeptic. Based on a recent Swiss Re study, unabated climate change could create anywhere from 1% to 12% GDP penalty in many countries depending on the magnitude of the changes, so there are several trillion (US) dollars at stake.[7] While individuals may disagree on whether this century's probability of catastrophic climate change is 10% or 80%, we still need insurance. The greater the uncertainty and downside risk, the greater the need. If there is a 0.1% chance our home will burn down, we buy home insurance. Why not planet insurance? Instead of being mired in disagreement and finger-pointing, we need to focus on taking concrete steps now while building momentum for greater action in the future. The notion of "nothing is agreed, until everything is agreed" must be set aside; otherwise, everyone will be worse off as climate change will be even harder to reign in.[8] The moment a dynamic and forward-looking global policy is in place, far more private funds will flow into new technologies. By taking far more technology shots on goal, this will vastly increase the likelihood of disruptive Black Swan technologies.

Emissions Reduction and Black Swan technology development

[7] Economics of Climate Adaptation: Shaping Climate Resilient Development
[8] As discussed here: http://switchboard.nrdc.org/blogs/jschmidt/key_steps_on_global_warming_in_mexico.html

One of the most significant and perhaps the most underappreciated advancements at Copenhagen was the commitment of emissions intensity reductions by the largest developing nations. China pledged to reduce emissions per unit of GDP by 40 to 45 percent of 2005 levels by 2020, while India committed to a 20 to 25 percent reduction in emissions per unit of GDP by the same timeframe.[9] Both of these countries made it clear that these commitments would be achieved with no financial assistance from the outside.

These countries are effectively saying that they will reduce the rate of growth of their emissions in the near term—reflected in a commitment to reduce emissions intensity of their development— as they bring millions of people out of poverty. Given a 3.1 percent world GDP growth rate,[10] McKinsey has estimated that the carbon efficiency of the world GDP needs to grow at about 5.6 percent per year to meet their recommended set of global carbon reduction targets.

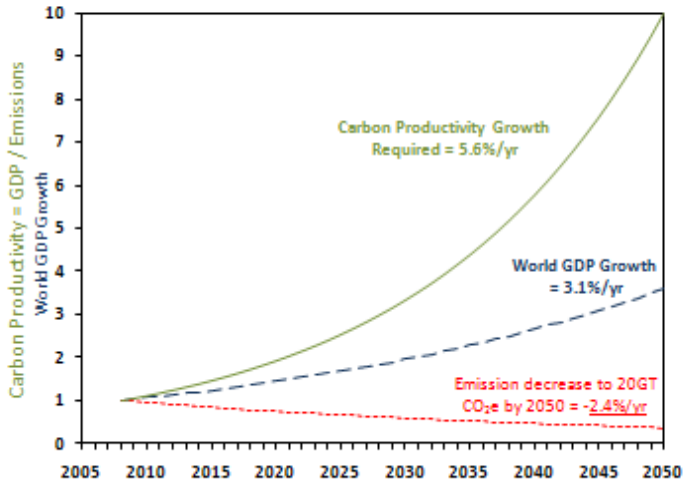

Figure 1: Scale of Emissions Productivity Required[11]

[9] http://www.nrdc.org/international/copenhagenaccords/
[10] McKinsey Global Institute, June 2008 – projection through 2037 from Global Insight, extrapolated to 2050
[11] McKinsey Global Institute, June 2008

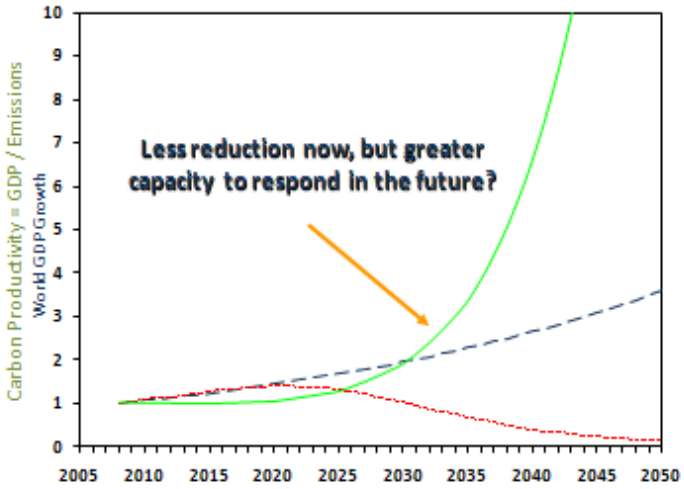

Figure 2: Carbon reduction Capacity Building alternative: Focusing on carbon reduction capacity (i.e., technology development) serves two purposes: it can achieve our goal of a low carbon economy more cheaply and quickly than expensive incremental reductions, and it has a lower upfront cost since the technologies need not be widely deployed until economics are proven when deployments are cheaper and have positive unsubsidized IRRs.

Working towards carbon intensity reductions now is important to build trust, confidence, and support for technological innovation to drive even deeper future action. It also enables key developing countries to become more efficient and competitive by initiating economically beneficial carbon reduction improvements that are in their best interest. In fact, it is well known that intensity reductions can be beneficial; Art Rosenfeld, the creator of Energy Star is a case example. As a result of his efforts, California's per capita energy consumption has not increased since 1973 while the economy has grown rapidly, an achievement now referred to as the Rosenfeld Effect. However, the state of clean technologies is not at a point where we can simply "deploy" ourselves all the way to an economic ultra-low carbon future. Given that some technologies are quite mature, some are still uneconomic, and others are still on the drawing board, we still need to make significant technology progress to completely address climate risk economically.

Therefore, it is critical that we build critical carbon reduction capacity. As shown in Figure 2, shifting upfront investments to radical and innovative technologies may provide less immediate carbon reduction, but will drive more cost-effective emissions reductions in the long term. This front-loaded R&D investment develops the complete set of "tools" to reduce carbon quickly. It is cheaper and more effective to fund R&D of radical carbon reduction technologies than to aggressively commercially deploy all of today's marginally cost effective or cost ineffective low-carbon technologies at very large scale (although many should still be deployed where economically viable, or in small mandated markets to test new technologies and incentivize development). To be fair, some mature technologies are quite cost effective, such as lighting, insulation and other efficiency related technologies, but they rely on consumer behavior, and are sensitive to consumer borrowing rates. The development of a full suite of carbon reduction capacity technologies gives the world the flexibility to rapidly drop emissions even further if climate science indicates larger, more catastrophic changes are imminent.

Taken as a whole, the landscape of clean technologies can be separated into three groups: mature technologies, early scaling technologies and potential Black Swan technologies. Mature technologies such as wind, conventional lithium ion batteries, and cane sugar/corn ethanol are at a point where they should not need continued subsidies. For economic mature technologies, it may make sense to provide low cost development funds and attractive interest rates for projects in developing countries (e.g., for wind projects and land and forest management) where capital is scarce. Meanwhile, lithium-ion batteries are still too expensive for both mass market electric vehicles and most of the energy storage market. Therefore, it appears to be a less effective use of funds to incentivize building significant capacity where technologies are marginal and not improving, as they are in the US and the developed world.

Second, there are technologies such as solar, next generation batteries and cellulosic fuels where the technology is still developing rapidly. These benefit from incentives and subsidies to build pilot and demonstration scale installations to march down the learning curve. Many of these technologies will not scale well and will fail, but enough of them will be successful and prove their economic scaling ability. They will graduate to the mature category and no longer need subsidies in the medium term. Most solar is squarely in the middle of this transition; subsidies are required to deploy solar thermal and PV in most locations, but we will know over the next few years which technologies work and will be market competitive without subsidies. As such, these solar subsidies should decline as early as 2015-2020, or whenever the cost curve flattens out. Likewise, LED lighting will not need subsidies or regulation as they become truly economic with rapid payback in the next few years.

Lastly and most importantly, there are new Black Swan technologies which have the power to reset assumptions in energy. Examples include advanced energy storage that is 5-10x cheaper (cheap enough to be paired with large scale renewables), solar cells with 30-40% efficiency and thin film solar costs, advanced drop-in biofuels that are competitive with oil sands and deep offshore oil, 50-80% more efficient air conditioning, and 50-100% more efficient internal combustion engines. We need as many shots on goal as possible and public-private partnerships modeled after ARPA-E and existing bi-lateral agreements to provide funding for ventures all over the world. Even if most of these projects fail, each success has the potential to dramatically improve our chances to address the twin challenges of climate risk and economic prosperity. At the very least we need multiple high risk and high reward shots on goal in all of the top ten areas of energy production and consumption.

Policy

To summarize, we see a few key criteria that any carbon emissions control system must achieve

- Meet global CO2 reduction targets – any scheme must converge upon this target value, be it 350, 450, or 550 PPM worldwide.
- Be politically acceptable in most countries – no scheme is likely to find global acceptance, but we must strive for an approach that is politically viable for most sovereign entities and thus minimizes opt-outs or “free-riders”.
- Morally acceptable – while the concept of “fairness” is open to debate, any system must be fair in assigning the responsibility for the problem in rough proportion to the primary pollution caused historically and prospectively by each country. Pragmatically, fairness will have to be defined to be maximally but not universally acceptable.

- Dynamic – working towards carbon reductions now is important, but the primary goal is to work towards significant carbon reduction capability/capacity in the future (even at some cost in terms of emissions today), and an ability to react more quickly as research improves and safe "targets" get defined with increasing certainty. In other words, investing in technology for future carbon emission reductions offers greater benefits than the "reduction" of carbon emission today.

A global framework can avoid many of the challenges that China and the US are so concerned about by incentivizing R&D investment in disruptive technologies, and including the ability to adjust targets as economies change, climate research matures, and technology evolves. There is no way to predict what technologies will be developed now that the world's best minds are focused revolutionizing energy and clean tech. In 5 years, the technologies available could be completely different; in 10 or 15 years, entire industries could be created (or destroyed) as a result of technology that has not yet even been dreamed. We have seen this time and time again, with the internal combustion engine, the airplane, the personal computer, the cell phone, telecom infrastructure, and the internet. A global climate treaty must have the flexibility to react to disruptive changes, and still provide a stable marketplace for monetizing low carbon advances. To use econometric models extrapolating past or current technologies is like making year 2000 forecasts for cell phones in the US in 1980's with assumptions of 1980 technologies, when cell phones still had handset cords! Case in point, a 1980's forecast of 0.9 million phones in the United States by 2000 was wrong by over 10,000%. We must invent the future we want by targeting R&D efforts at our end-goals. We have done this already in many other industries, disproving many pundits' forecasts.

Conclusion

Energy is an even bigger challenge and opportunity than information and telecom. If we harness and motivate these bright new minds with the right market signals, a whole new set of future assumptions, unimaginable today, will be tomorrow's conventional wisdom. I predict there will be 10 or more Google's in the energy space in the next two decades. None of us can predict what new technologies will change the world; it may take 10,000 different start-up efforts to find those 10 Google's. There is an easy way to predict these 10,000 new efforts as witnessed by the dotcom "Cambrian like" explosion. We have a "clean dozen" in our portfolio which we think each have a shot of being a Black Swan; the world would benefit from another 10-100 portfolios like ours.

In the end, while near term carbon reductions are nice, they are not as essential as what I call black-swan technologies—innovations that disrupt our current trajectory and build economically feasible "economic carbon reduction capability" technologies. These risky investments individually have a high chance of failure, but they also promise an earthshaking impact if successful. The best part is that developing Black Swan technologies is cheaper than deploying current "marginally economic if subsidized" technologies and can be almost entirely economically driven by private investments.

Making these innovations a reality will take a change of mindset. To date, most of the world's clean-tech investments have been aimed at taking advantage of government subsidies, tax breaks, and the like. We need to think much bigger, and invest in the blockbuster ideas that will rewrite the history of

climate change. In the end, black-swan innovations will reduce carbon economically on a scale that incremental innovations cannot.

The world's innovators are ready and willing. With the right policy framework and enough investment, they will create a low-carbon world that is vastly more prosperous within just a few decades. We can't write a global treaty to create clean cities and wealthy rural communities, but we can invent our way there on technologies that don't try to defy the laws of economic gravity. We can relegate petro-dictatorships to the history books and save millions from the ravages of rising sea levels and expanding deserts. Or we can keep on our current path of ineffective policy and face energy shortages and dwindling resources.