

Climate Change: THE REAL INCONVENIENT TRUTH



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Consumers choose economic development over serious climate initiatives. Corporations don't invest in meaningful change because consumers won't pay for it. And governments cannot lead if citizens won't follow. The battle to prevent climate change through behavior modification, regulation, or personal deprivation has already been lost. Yossi Sheffi explains why the solution is collaborative investment in developing technologies that can reverse climate change.

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1. The Inconvenient Root Causes

Although 195 countries signed the 2016 Paris Accord, the world has failed to stay on track to meet the agreed upon goals.¹ Germany, once seen as a green leader, is almost certain to miss its original Paris commitments for 2020 by 7 to 8 percent.² In fact, in 2018 the partners in the German coalitions agreed to relax the 2020 emissions target to which the country committed in Paris.³ Furthermore, it is clearly evident that emissions will continue to increase as a result of consumer behavior and the march of economic development.⁴

When it comes to sustainability, people claim one thing but do another. This tendency is known as the “attitude-behavior gap” in marketing and economic literature.⁵ In a Nielsen survey, 66 percent of global consumers said they were willing to pay more for sustainability,⁶ and other surveys produce similar results.⁷ Yet studies of actual consumer purchasing behavior find that only 5-12 percent of consumers buy sustainable products,⁸ despite the typically small price differences. I confirmed this finding in a study my students and I conducted in 2019 using “consumer observation and intercept” in the aisles at four supermarkets in New England. Worse still, the changes that some conscientious consumers do make to their lifestyles may make them feel better but won’t move the needle on sustainability. In fact, consumers who make green choices have been found to have similar environmental footprints to non-green consumers.⁹

Most consumers also show their true colors (not green) at the ballot box. One of the most promising avenues for reducing emissions is a carbon tax because it aligns economic and environmental incentives. Yet

even in Washington State, one of the most progressive states in the US, a carbon tax referendum failed for the second time in 2018. Australians voted to repeal their carbon tax and to replace the labor government when the opposition campaigned on the slogan “axe the tax.” People want good jobs, affordable products, and a better life for their children right now, not sacrifice and deprivation in service of a hazy future. And where carbon taxes have been implemented, it turns out that they don’t work very well.¹⁰ While the most successful carbon tax, enacted in British Columbia, did reduce emissions by 5 to 15 percent,¹¹ other carbon taxes, levied in sixteen countries, one other Canadian province (Quebec) and one US city (Boulder, Colorado), have reduced annual emissions by only 0.1 to 0.8 percent.¹² Of course, most of these involve relatively small taxes which, while politically feasible, were never likely to be very effective. Indeed, enacting modest carbon taxes serves primarily to placate an environmental minority by making them feel that governments are doing something, regardless of the tax’s impotence.

The current scale of the climate change challenge suggests that, despite setbacks at the ballot box, governments will ultimately try to bite the bullet and enact both high taxes and tough regulations in order to force a green economy. Yet the choices their citizens make bind the hands of governments on climate-related matters. And people who are thwarted at the ballot box will use more forceful methods, like the months-long violent demonstrations in Paris and other French cities which were triggered by a proposed carbon tax of only twelve cents per gallon on fuel (about a two percent increase). The French made it clear that they were not willing to shoulder a higher tax burden in the name of the environment. Voters’ displeasure at stagnant standards of living

also affected both the Brexit vote and the 2016 US presidential election. Carbon taxes are unfortunately seen as impeding the growth of standards of living. And when standards of living do not rise, the ugly heads of nationalism and radicalism rise in their place. So governments, too, prize short-term economic growth and jobs over long-term prognostications of planetary peril.

And sometimes environmentalists are their own enemies. Nuclear energy can be an important part of reducing greenhouse gas emissions. Unfortunately, environmentalists have consistently fought against building more nuclear plants on the grounds that the waste generated by nuclear plants remains radioactive for tens of thousands of years. Two of the leading candidates for the 2020 Democratic presidential nomination call for banning new nuclear plants and phasing out all existing ones. Yet it seems odd to worry about 10,000 years in the future when climate scientists warn of catastrophic consequences only decades from now. Nuclear power could at least be part of an interim solution until either clean energy becomes widespread or new research on scrubbing carbon out of the atmosphere at scale yields workable solutions. Another component to a long-term solution would be focusing nuclear research on fusion, in which isotopes are merged, rather than fission, in which uranium 235 isotopes are split. Fusion is what powers the sun. It produces far more energy than fission and creates considerably less radioactive material. Unfortunately, at the moment, fusion barely works in the lab; scientists are still working to control the process in a contained space and make it create more energy than its containment consumes.¹³

2. Corporate Initiatives

Without the benefits of fiat currency and the strong arm of the tax collector to amass money for sustainability, companies face even tighter

constraints than governments. Consumers who don't like the price and performance of a company's products can switch suppliers far more easily than citizens can change home countries. Business is therefore even less able to pick up the climate change slack left by apathetic consumers and politically-constrained governments.

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To placate a vocal green minority, most companies offer “sustainability theater,” highly visible but relatively minuscule improvements. Restaurants stop using plastic straws, though the environmental effect is negligible¹⁴ and paper straws cannot be easily recycled¹⁵ (unlike plastic ones); hotels ask guests to reuse towels (but still don't charge for fresh ones); and retailers eschew single-use bags, even though reusable bags are not always the best environmental choice¹⁶ – all of which amounts to “pretend sustainability.” Companies tout their commitment to reducing carbon footprints and other environmental impacts, but most of these programs are just cost saving initiatives with a green marketing veneer. These much-publicized incremental solutions are a fig leaf which corporations and governments use to cover their lack of substantive action. And by promoting these initiatives, companies give the public a false sense of progress, counteracting the effects of social pressure.

Still, some companies do try... and yet:

- As part of its “fuel sense” program, FedEx initiated 45 fuel-conserving projects, such as requiring pilots to taxi on a single engine

and ground crew to keep gates clear and quickly connect ground power to incoming aircraft. The company boasted that, through these programs and aircraft modernization, it saved 177,000 gallons of fuel in the 2017 fiscal year. While these efforts are certainly commendable, 177,000 gallons is a mere 0.1 percent of the jet fuel FedEx Express used that year.¹⁷

- In 2015, at the same time that Greenpeace was lauding Apple for embracing clean energy,¹⁸ the online investigative organization Truthout, was vilifying the company for its high CO₂ emissions.¹⁹ That two NGOs could arrive at such diametrically opposed conclusions about the company illuminates an important fact about corporate claims and supply chains. Greenpeace's analysis focused on Apple's internal operations: buildings, data centers, and retail outlets owned by the company. Truthout, by contrast, took a holistic approach that included the emissions of both the upstream and downstream supply chains associated with the manufacturing and use of Apple's products. Apple's two leading Chinese suppliers, Foxconn and Unimicron, were accused not only of creating deplorable working conditions which led to employee suicides,²⁰ but also of polluting rivers and ground water with factory chemicals.²¹
- Truthout estimated that the vast majority (72.5 percent) of Apple's life cycle carbon footprint was in its suppliers' operations.²² This conclusion is not surprising. Like Microsoft, Cisco, and many others, Apple does not make any of its products; it outsources all manufacturing to contract suppliers, many of them in China. Truthout went on to assert that Apple's products had a high ongoing footprint during use. Although Apple did create energy-efficient data

centers, iPhone owners use apps produced by Facebook, Google, Samsung, Twitter, and millions of other websites and services that run on carbon-intensive, non-Apple servers. From Apple's own reporting, Truthout estimated that Apple's own facilities represented a puny 1.2 percent of the company's supply chain emissions.

- FIJI Water's sustainability efforts include changing its distribution patterns, using square (plastic) bottles, and pursuing community initiatives.²³ However, the company still transports its water more than 10,000 miles by ship and thousands more by truck all over the United States. Any other attempts to cut emissions are dwarfed by the emissions inherent in transporting water over long distances. FIJI's slogan, “Good for the environment,” while lauded by the media,²⁴ was proven empty when two different California lawsuits forced the company to rescind its environmental sustainability claims.²⁵
- While commercializing the building blocks of a renewable economy, companies like General Electric and Siemens continue to support the growing emissions of the old economy. They build wind turbines and tout their environmental credentials in slogans like GE's “Eco-magination” and Siemens's “Ingenuity for Life.” Yet, both companies continue to build and service coal and gas-fired power plants around the world. Indeed, GE's entire Eco-magination effort was dubbed “greenwashing.”²⁶

All of these are examples of what David MacKay calls “twaddle emissions” in his analytical book *“Sustainable Energy: Without the Hot Air.”*²⁷

Many other companies are even less scrupulous. In its environmental reports, Volkswagen boasted that it “develops its products and services in the most environmentally compatible way.” Although some of Volkswagen's

efforts may actually have been beneficial, they must be balanced against its massive outright emissions fraud. VW engineers deliberately rewrote the engine management software in their cars to detect laboratory testing conditions and retune the engine in such a way that it would test well, but be no fun to drive. After testing, the software would revert to driving (and polluting) mode. Between 2009 and 2015, VW installed this “test defeat” software in some 11 million cars. The company’s diesel Jetta, for example, produced emissions 4,000% higher than US regulations allowed.²⁸ I mention this episode not in an effort to shame one company, but to suggest that even in a country awash in green education, media, and culture, engineers and executives not only contemplated but engaged in such anti-green activities.

For the poor half of the world, environmental sustainability is a luxury.

3. The Developing World

Even if the developed world suddenly and wholeheartedly embraced emissions-restricting measures, nearly half of humanity still struggles on less than \$5.50/day, accord-

ing to the World Bank.²⁹ For the poor half of the world, environmental sustainability is a luxury. In addition, there are many people in the developed world in the same situation. For example, 50 million Americans now live below the federal poverty line.³⁰

Moreover, as the poor improve their lot, they will expect to live in concrete buildings, use air conditioning, have home appliances, eat more meat, and drive cars – changes that inevitably increase carbon emissions.

The “China miracle” shows both the human gains and the environmental costs of this progress. China moved from a staggering 99 percent extreme poverty rate in 1978 to essentially eliminating extreme poverty by 2014. However, as the country industrialized, lifting hundreds of millions of people into the middle class, CO₂ emissions surged by more than 2,000 percent between the 1960s and 2017. In January 2018, the *New York Times* reported that China’s emissions were more than those of the US and Europe combined and were still rising.³¹ And China is not alone; most countries that have reduced poverty rates have also substantially increased their emissions.³² In India, the government plans to continue producing

electricity from coal “for decades to come.” In 2017 it issued a nine-point plan to increase coal production³³ in order to provide electricity to an additional 304 million people.

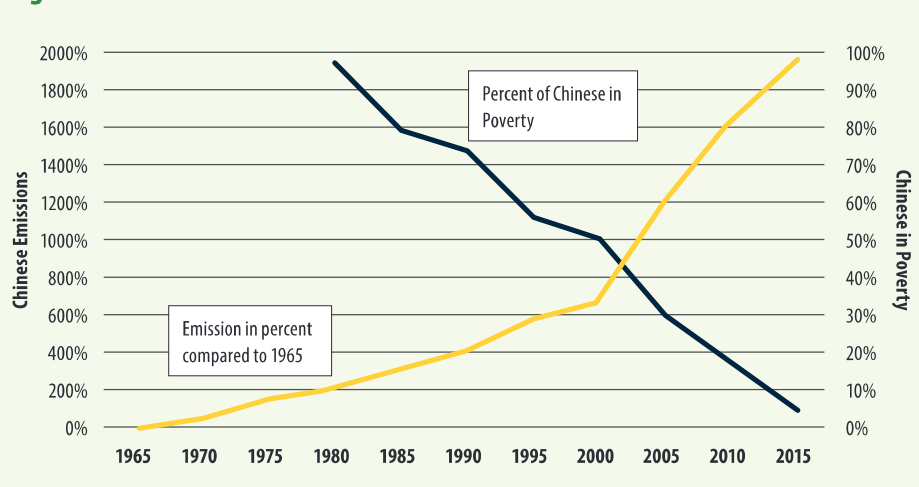
One can only imagine the environmental impact of bringing the world’s remaining 3.4 billion impoverished people into the middle class. Naïve insistence on aggressive sustainability initiatives is perceived by consumers as hardship, by companies as lost market share, and by politicians as instability. The root cause of all parties’ insufficient action is their universal quest for a better life through growth. People seek higher standards of living; companies seek better returns; politicians seek power by promising prosperity.

These natural preferences ensure that nobody will sacrifice much for the climate. Companies cannot make real (and expensive) change until consumers are willing to pay for it. Governments cannot legislate real change lest they be voted out of office. Most countries will therefore not hit their 2020 and 2030 Paris emission targets, and global emissions will keep growing.³⁴ China is still firing up new coal plants; its CO₂ emissions grew by 4.7 percent in 2018, while India’s emissions grew by 6.3 percent in the same year. And 2018 also saw global emissions rise by 2.7 percent.³⁵

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self-imposed austerity, like flight shaming, selecting slower e-commerce delivery, and so forth, seem to have no discernible effect. Something else needs to be done.

4. What Should Companies Do?

In the short-term, companies should focus on several categories of initiatives:

- **Eco-business** – companies in the business of environmental sustainability are “riding the wave” of interest in the fight against climate change. Their products include solar panels, wind turbines, energy-efficient appliances, LED lighting, and so forth.
- **Eco-efficiency** – these are the sustainability initiatives that reduce cost (or improve service) and should thus be enacted anyway. Johnson Controls, the largest supplier of automotive batteries, operates a closed loop of recycling, recovering 99 percent of the materials from used batteries. This operation isolates it from the volatility of commodity prices; for example, between 2000 and 2010 world lead prices oscillated between \$500/ton and \$2,000/ton.³⁶ Companies like Walmart will adopt initiatives that pass their internal hurdle rate. Others, such as Staples, set a hurdle rate for sustainability initiatives that is somewhat lower than their standard one.
- **Eco-hedging** – some companies believe that as millennials enter their prime earning and spending years, they will demand more sustainable products. These companies have begun to experiment with introducing green products: getting familiar with the materials, the suppliers, the manufacturing techniques, and the market segment that may look for such products in the future. For example, The Clorox Company developed *Green Works*, a family of sustainable

cleaning products. While small and not profitable, it provides the company with data about suppliers and consumers while allowing it to understand the products’ chemistry and efficacy, in case the market changes.

- **Eco-risk-mitigation** – is the motivation for most corporate sustainability initiatives today.³⁷ Brand name companies don’t want to be the nail that sticks out and gets hammered down. Attacks by NGOs, consumer groups, and the media can damage sales and stock prices. As a result, companies want to at least be perceived as “doing something.”

Beyond these short-term initiatives, companies should realize that current actions are not likely to reverse climate change and start adapting: shifting offices, factories, warehouses, and suppliers away from locations likely to be disrupted by climate change and closer to the most probable eventual sources of low-carbon energy. By so doing, they will also naturally attract others — their employees, families, and supporting businesses — to safer and lower-carbon locations.

The Way Forward

The world faces an impasse – a tragedy of the commons on a planetary scale. Consumers, companies, and governments insist on ever-better living conditions while driving the planet to ever-worse environmental conditions.

The environmental movement’s multi-decade educational and persuasion efforts have met with limited success. While CO₂ emissions *per dollar of GDP* have declined in many countries, global GDP has been rising at a faster rate. Efforts to live sustainably may have achieved some minimal reduction of emissions in the developed world, but the billions of poor and lower middle-class

people in the world cannot conserve their way to prosperity.

Corporations have likewise enacted only limited conservation efforts, except where these efforts also happened to reduce costs, improve service, or satisfy other economic goals. These efforts are also not likely to make a big difference; sustainability programs large enough to move the dial will require substantial changes in products and processes, and require consumers to accept higher prices, inconvenience, limited choices, and other service degradation. In addition, most of the low-hanging fruit in fuel- and energy-efficiency has already been claimed during the decades of competitive cost pressures and social pressure for corporate sustainability. Once a company has replaced incandescent bulbs with LED bulbs, it can’t just do it again. Each efficiency improvement is a single step “win,” and subsequent steps become harder to find and more expensive to deploy.

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In the absence of a global cultural change in people’s expectations, making them willing to live with (a lot) less, we must rely not on policy or behavioral changes, but on technological advances that can be adopted on a large scale. Renewable technologies are, in several cases, already cheaper than fossil fuels, but their use is limited. Only 11 percent of US energy production comes from renewables³⁸ despite

significant government support, such as a 30 percent tax credit for solar photovoltaics, accelerated depreciation for businesses, and the option of selling unused power back to the grid. With these federal subsidies about to shrink³⁹ (the tax credit will be only 10 percent by 2022), the rate of conversion to renewables is likely to slow down. The US has also phased out the production tax credit available, until 2019, to utilities that invest in renewable technology. And even as the economics of renewables become more favorable, the inherent intermittence of sun and wind power may limit their use at scale. Meanwhile, fossil fuels are still getting massive government subsidies. In fact, an International Monetary Fund study shows that fossil fuel subsidies represented a staggering 6.5 percent of global GDP in 2017, a fact which can be deplored, but not ignored, and another reason why we cannot rely on government actions.

As this article is going to press, the world is in the midst of the novel coronavirus pandemic. What we are going through is likely to exacerbate the problem of long-term sustainability efforts (even though emissions are likely to improve with the recession in the short term). Not only will many of the world's citizens end up poorer as a result, the massive bailouts enacted by governments around the world (the initial US bailout is more than a quarter of the country's annual GDP), will drain government coffers, limiting any other investments and further reducing citizens' willingness to pay for sustainability.

I believe that the solution will be technological. Technology is driving the increasing efficiency of renewable energy production and the reduced cost of some components. To appreciate the impact of technological change, note that be-

tween 2007 and 2016, the country that reduced its emissions more than any other country in the world was... the United States!⁴⁰ This surprising achievement was not caused by low-carbon policies, by a shift to renewables, or by conscientious consumers. It was caused by fracking technology. The shale boom caused the price of natural gas to drop by about 60 percent,⁴¹ making it cheaper than coal and driving a massive conversion of US heavy industry and power generation from coal to gas. Natural gas has half the carbon footprint of coal or oil so US carbon emissions decreased. Fracking (essentially an eco-efficiency initiative) was relatively easy to adopt on a large scale because it delivered something consumers and companies actually wanted: cheaper energy. And importantly, it was a technological breakthrough, not a political or cultural one.

This history hints at the direction needed for future environmental solutions. Emissions will continue to grow. And even if renewables continue to seep into electricity production, the change will not be nearly enough to reverse climate change.

Neither the developed nor the developing world will sacrifice their standard of living and aspirations to the extent that many green plans require. Future large-scale technological solutions will thus have to mitigate and reduce new emissions while economic activity goes forward.

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Unfortunately, even if all current emissions reduction processes could be inexpensively scaled up, they would not halt climate change. Indeed, even if all emissions around the world suddenly ceased this afternoon, the atmosphere would still be burdened with all the CO₂ which has accumulated since the industrial revolution (about 1652 GtCO₂⁴² or ~220 tons per capita by 2019⁴³). That accumulated CO₂ would continue to drive inexorable changes to the climate for years or decades to come.⁴⁴ So the earth *will* continue to warm, the ice sheets *will* continue to melt, the oceans *will* rise, and mega storms *will* get bigger. Our greatest efforts, therefore, should be focused on taking carbon out of the atmosphere in order to halt and reverse climate change. Researchers trying to develop such solutions on a practical scale have dubbed the field *carbon capture and storage*. The goal is to capture, transport, and store atmospheric CO₂ securely, and to do it at scale. In many ways, the easiest way to make carbon capture technology work is at the source of emissions, capturing the CO₂ from power generation and industrial processes before it reaches the atmosphere.⁴⁵ Still, while smokestack CO₂ sequestration helps to reduce new emissions, it does nothing to remove old CO₂ from the atmosphere.

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Researchers at leading universities are now working on various methods to remove the CO₂ already in the atmosphere.⁴⁶ The most promising strategy, known as *direct air capture*, involves circulating air over

chemicals which absorb carbon dioxide, preparing it for sequestration. This method succeeded in the lab and several companies are trying to commercialize it.⁴⁷ However, it is still expensive, and it remains to be seen whether it can be used economically on a large scale. The price of carbon sequestration must, of course, be balanced against the potential cost of not reducing the carbon in the atmosphere and continuing to add more. Still, putting large sums into research and development could yield significant results.

5. Making It Happen

It is certainly possible that the ongoing UN Conference of Parties (COP) events, pressure from environmentalists, and the views of young people will motivate governments to act on a scale commensurate with the threat. These actions could include significant carbon taxes, constraints on the mining and use of coal, limitations on travel, curbs on the sale and consumption of meats, and limits on economic growth. They would also have to involve tough moral choices by or about the developing world. But none of this is very likely to happen. The fracturing of political willingness to cooperate worldwide, as blatantly demonstrated during the Madrid COP in December 2019,⁴⁸ has left governments not just unable to convince their citizens to make do with less, but actively suggesting that taking substantial initiatives will leave them unable to compete with countries that do not enact such regulations.

As a result, many environmentalists now feel that the burden falls on responsible companies to act, arguing that because they profess concern about global warming, they should turn from “sustainability theater” to real efforts to combat global warming. Still, no single company can act alone without consumers who are willing to pay directly for sustainability. It will put them in an

uncompetitive situation and endanger their business. By working together, though, companies *can* make a difference. First and foremost, they must stop the pretend sustainability efforts that amount to sophisticated greenwashing. Instead, leading multinationals should pool their resources to invest in research on carbon sequestration and removal, which seems to me to be the only feasible path forward.

In August 2019, the Business Roundtable released a new statement of the purpose of the corporation. In it, 181 CEOs committed their companies to work for the benefit of all stakeholders – customers, employees, suppliers, communities, and shareholders. As I and many others have pointed out, the statement was largely devoid of substance.⁴⁹ The total revenue of the participating companies is \$7 trillion, with a pre-tax profit of more than \$800 billion and tax payments of about \$150 billion. The group could comfortably contribute hundreds of billions of dollars to an international fund for research into technologies to reverse climate change, which would be far more powerful than rhetoric and symbolic green initiatives. Moreover, the companies listed in the Business Roundtable are a small fraction of companies worldwide which could jointly generate billions of dollars for such a research fund. Combine this with philanthropic contributions, matching government funds and prestigious international prizes and one can imagine a massive international fund dedicated to this research. Naturally, enacting such a collaborative effort would face many hurdles. Governments and other donors will need encouragement to join corporations in the effort. If certain corporate leaders will show the way, though, they will influence the public to demand collective action.

Although some companies may be freeloaders, examples of

successful international cooperation do exist. These include the Montreal Protocol to ban substances that deplete the ozone layer, and the MARPOL convention to limit maritime pollution from ships. Many international organizations also foster constraints on and payments to collective bodies working for the common good. These include the EU, OECD, the World Bank, the World Health Organization, a range of UN organizations, and many more. All of these organizations and agreements required countries and companies not only to contribute monetarily, but also to agree to abide by certain principles that limited their own influence or power in the name of a shared objective.

Even though it is clearly smarter to produce energy without emitting CO₂ than it is to emit CO₂ and try to capture it, the world has to embark on an R&D path dedicated to actively removing carbon from the atmosphere. So much CO₂ has accumulated in the atmosphere already and we are nowhere near ending the growth of emissions.

6. Conclusion

We may not know all the personally, politically, or commercially palatable solutions to climate change at this time. It is obvious, though, that addressing climate change by trying to influence people toward personal sacrifice and deprivation isn't working now and doesn't seem likely to work in the future. Our efforts to increase the proportion of renewables in energy production should continue and accelerate, but these largely affect electrical power generation and not other energy uses, nor do they address the carbon already in the atmosphere. Furthermore, it is not clear that the rate of adoption of renewables will outpace the rate of growth of GHG (greenhouse gas) emissions in the developed and developing world.

Companies, which look to the long term, can lead the way by contributing the anchor funding for a massive, international, research effort – a moonshot – to bring the current technologies up to the necessary scale and develop new ones that will reverse climate change and enable humanity to continue improving its standard of living.

Companies which look to the long term can help society create the economic resources to address the global challenge of adaptation, emissions reduction, and atmospheric carbon removal. To do so, they must end their fake sustainability campaigns and turn their focus to funding the development of new scalable carbon sequestration and storage technologies. These companies can lead the way by contributing the anchor funding for a massive, international, research effort – a moonshot – to bring the current technologies up to the necessary scale and develop new ones

that will reverse climate change and enable humanity to continue improving its standard of living.

The obstacles, of course, are considerable. Some activists may delay and obstruct short-term measures with long term benefits, as they did by opposing nuclear power. Others may object to solar power for its use of large land tracts, or wind farms which may obstruct natural views.⁵⁰ NIMBY (Not In My Back Yard) people will oppose green infrastructure built near them⁵¹ and economic conservatives will oppose government intervention in the economy and its accompanying price. Lobbyists for legacy high-carbon industries will attempt to burden low-carbon technologies with regulations. Investors will lament the reductions in corporate profits (and therefore share prices) as well as cuts in dividends. All sides will wallow in fake news and confirmation bias. Many of my readers today will chuckle at an MIT engineering professor calling for more technology-based research. Any large multinational technology research effort will have to wade through all these obstacles. However, for those not willing to sit through another toothless COP, this approach offers some hope.

The ever-increasing evidence of the effects of climate change has

yet to drive most people to alter their behavior and demand meaningful changes in products, services, and policies. While some believe that the technologies to solve the climate challenge exist,⁵² this view ignores the fact that these technologies are not being adopted at the rate and scale that would make a difference in time. As long as current efforts and trends continue, the climate battle has already been lost in the short-to-medium term. Even though renewables keep getting cheaper and some governments have enacted modest carbon taxes, the scale of the actions is nowhere near matching the urgency and magnitude of the problem. It is high time we apply human ingenuity and the global industrial network to adapt to the inevitable and invest real resources in developing long-term solutions. ■



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THE CASE FOR CLIMATE OPTIMISM: A Response

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In response to Yossi Sheffi's article, "The Real Inconvenient Truth," Mayers and Koomey argue for the use of a variety of urgent measures to address climate change, rather than focusing primarily on long-term development and dependency on carbon capture and storage. Citing the now competitive cost of renewable power and the success of several countries in enacting programs that address climate change, they urge the need for optimism.

We would like to respond to Yossi Sheffi's article, "The Real Inconvenient Truth," which pessimistically suggests that most current efforts to reduce carbon emissions will be unsuccessful and will involve too much "sacrifice and deprivation" for consumers to stomach. Sheffi's article argues that nuclear power expansion could have played an important role if campaigning environmental activists had not acted as "their own enemies." In the short term Sheffi recommends that, ideally, companies should focus on developing ecotechnology (including renewables and energy efficiency measures) but suggests that the effectiveness of such technologies will be limited by consumer willingness to pay. Sheffi argues that the solution is a longer term "moon shot" investment in the capture and storage of carbon from fossil fuel power generation, industrial processes, and the atmosphere itself (direct air capture). This perspective is not particularly new; it's fairly common amongst sceptics of current climate action.¹

Although carbon capture and nuclear power are both important in tackling climate change, ultimately they can only produce part of the necessary reduction in emissions, and expanding renewable energy is cheaper, hands down.

Fortunately, for those who look beyond anecdotal examples, there is reason for greater optimism. Although carbon capture and nuclear power are both important in tackling climate change, ultimately, they can only produce part of the necessary reduction in emissions, and expanding renewable energy is cheaper, hands down. The United

Nations has identified a number of additional means of reducing emissions and meeting climate targets.² These measures can all be achieved without bringing misery to consumers:

- Expand renewable energy e.g. wind, solar, and biofuels
- Electrify end use of energy e.g. transport, heating
- Improve energy and fuel efficiency e.g. transport, industry, buildings
- Incentivise use of low carbon products and services e.g. public transport
- Increase efficiency of using materials with high carbon impact e.g. cement, iron, and steel
- Phase out energy production from coal
- Link energy access to emission reductions for 3.5 billion 'energy poor' people
- Prevent clear-felling of forests
- Reforest and grow plantations on unforested lands
- Adopt soil conservation practices in farming

These are undoubtedly big tasks to organise on a global scale and will require international financial investments. But they will not cause economic development to grind to a halt. According to estimates from the Intergovernmental Panel on Climate Change (IPCC), taking steps to address climate change would reduce annual global economic growth by only a tenth of a percent, roughly (about 0.04%-0.14% per year).³ This expense would be considerably less than the substantial and incalculable economic damages of a 3°C warming scenario.⁴ The current COVID-19 crisis provides a stark example of how an uncontrolled global crisis can play out, with the global economy predicted to actually shrink (-3% GDP growth) in 2020.⁵ By contrast, these proposed steps will create employment opportunities and marketable innovations while reducing smog

and pollution. Although these benefits are difficult to estimate precisely, they are expected to help counterbalance mitigation costs and support alternative economic growth.

Generating and storing electricity from wind and solar power installations is now cost-competitive with power generation from fossil fuels.

Renewable Power

The improved economic outlook for renewables is particularly encouraging and is only getting better. Over the last decade the cost per unit of renewable energy has fallen rapidly as we have gained experience and learned from new innovations (see figure below). Generating and storing electricity from wind and solar power installations is now cost-competitive with power generation from fossil fuels.⁶ If we take an only slightly optimistic view, at the current trajectory of adoption, renewables have the technical and economic potential to deliver a substantial chunk of the reductions needed.⁷ Targeted use of natural gas also plays an important role, because it is highly efficient, relatively inexpensive, and responds quickly to demand. It is therefore an excellent counterbalance to the variability of renewable power generation.

Carbon Capture and Storage

The various technologies for capturing and storing carbon dioxide are still in their infancy and are comparatively expensive. Their widespread development and adoption would substantially increase the cost of fossil fuel fired energy generation, and with it the cost of energy to consumers:

- Carbon capture from coal-powered electricity generation: In 2019, building new coal plants with carbon capture and storage cost about \$152 per MWh. Installing new commercial solar and onshore wind generation cost only \$32-42 and \$28-54 per MWh respectively.⁸
- Direct carbon capture from air: Coal plant chimney gases can have CO₂ concentrations of around 15 percent.⁹ In contrast, CO₂ is present in the atmosphere only at a trace levels (around 0.04 percent by volume),¹⁰ which makes it difficult and expensive to extract directly from air. The extraction alone can cost up to \$1,000 per ton of CO₂ captured *before* the additional costs of storage!¹¹ To put this price in context: even by a recent optimistic estimate,¹² meeting 2030 global emissions reduction targets through direct capture would incur costs equivalent to as much as 4 percent of the worldwide economic output before storage. It would also consume the equivalent of a quarter

of the global electricity supply.¹³ These demands make the widespread adoption of carbon capture almost inconceivable.

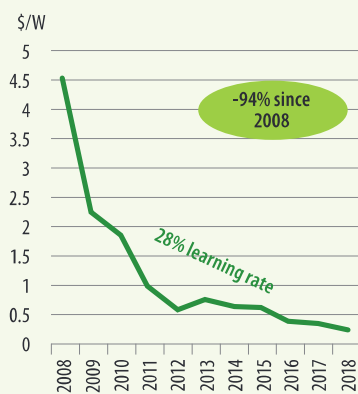
- Carbon capture from bio-energy fuels: Carbon capture from biofuels (not specifically mentioned in Sheffi's article) could remove CO₂ from the atmosphere more economically than direct air capture. Plants capture carbon, which is burned to produce energy, and the resulting CO₂ is then captured and stored. In theory, this approach could reduce emissions by up to 22.5 Gt of CO₂ equivalent¹⁴ (out of 33 Gt of total energy-related emissions in 2019).¹⁵ It would also, however, require the conversion of 80 percent of cropland and would push the planet's limits for freshwater use, soil health, and biodiversity. Consumers would also see a substantial increase in energy costs because biofuels are persistently more expensive than gas and diesel.¹⁶ Meanwhile the additional costs of carbon capture are estimated at \$30-280 per ton.¹⁷

Nuclear Power Generation:

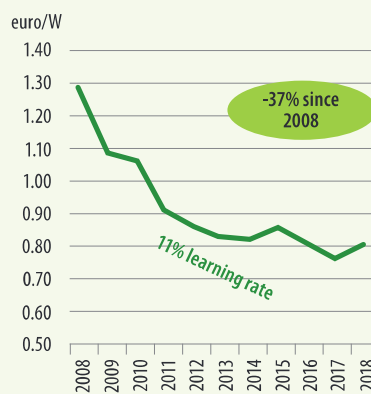
Admittedly, it is relatively cheap to generate electricity with existing nuclear reactors (around \$29 per MWh).¹⁸ Shutting down those reactors would certainly slow progress towards emissions reduction targets. The main barrier to nuclear expansion, however, is the rising cost of new reactors, not a minority of environmental naysaying campaigners and NIMBYists. Reactor costs have increased by 20 percent over the last decade, largely because of industry specific expenses like the need for better safety measures. The cost of electricity from new nuclear installations is therefore much higher than that of electricity from new wind and solar facilities (at \$118-192 per MWh).⁸ Furthermore, the International Energy Agency (IEA) estimates that doubling nuclear energy output globally would produce only one seventh of the carbon emission reductions needed.¹⁹ Nuclear fusion, rather than fission, might theoretically do better, but it does not present a foreseeable solution anytime soon.²⁰

Figure 1: Transitions driven by technology

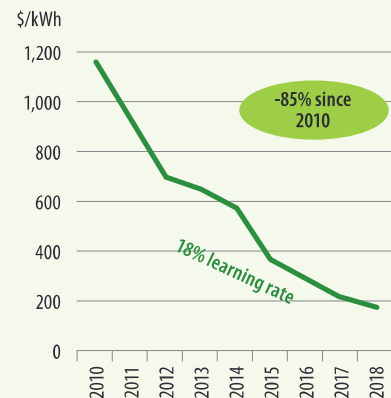
Solar PV module prices



Onshore wind turbine prices



Lithium-ion battery prices



Bloomberg's Energy and Mobility Transitions.

Carbon capture is not a magic bullet that can solve climate change by itself; we must acknowledge the interdependency of our paths towards a solution.

Sheffi's article presents a relatively pessimistic view of our current efforts to reduce carbon emissions, even going so far as to label them "pretend sustainability." It advocates the long-term research and development of carbon capture and storage as the solution. If, as Dr. Sheffi suggests, emissions continue to rise despite our best efforts, then carbon capture will not be able to run on renewable power and will, itself, generate additional snowballing emissions that must be captured. In this eventuality, the costs of halting climate change would escalate to truly untenable proportions. Carbon capture is not a magic bullet that can solve climate change by itself; we must acknowledge the interdependency of our paths towards a solution. Sheffi's article also misses a very important point: we can't wait for an expensive long-term gamble on carbon capture and storage - we need urgent action in the short term. Let us consider the impact of climate change on living standards if we *don't* take sufficient action over the next few years. This impact is proportional to the overall accumulation of CO₂ in the atmosphere. If we are to avoid an escalation of the type of crises prevalent all over the world in recent years, substantial reductions in carbon emissions are needed soon (50 percent over the next decade to keep warming from rising more than 1.5 or 2C from pre-industrial levels).²¹ It is not only a minority of passionate environmental activists that recognise this need. Blackrock, a company managing \$6.47 trillion in assets (as of March

31st, 2020),²² decided to remove from its portfolio all companies generating more than a quarter of their revenue from thermal coal production, and to push for the removal of CEOs who fail to act on climate risks.²³

The book "*Cold Cash, Cool Climate: Science-based Advice for Ecological Entrepreneurs*" is a useful reference for anyone looking to navigate this field and plot a serious course to tackle climate change.²⁴ We can and are redesigning systems. We can improve both products and services, like electric vehicles or intelligent heating / cooling systems, while simultaneously lowering emissions. These improvements are not one-off reductions, as Dr. Sheffi's article suggests, but will continue to keep emissions low for years to come. Meanwhile, innovation is opening new markets while new knowledge is reducing the cost of adopting new emerging technologies at scale. Addressing climate change does require urgent commitment and action by governments, industry, and *individuals* (as highlighted at the recent United Nations Climate summits in New York and Madrid in 2019). We do need to move our discussions beyond 'sustainability theatre,' as Dr. Sheffi rightly points out, and it's true that current commitment and action fall short. But none of this means that our actions have been or will be entirely futile. For example, the failure of any regulation to hold individuals or companies to account, like the emissions scandals in the automotive sector, does not justify inaction. Instead, it underlines the need for more effective government policy and enforcement. Regulators have certainly not been idle in this regard. In the case of VW, executives have resigned and been charged with criminal offences, fines and car rework costs have run into several billions of dollars, and VW share prices fell by more than a third as the news broke in September 2015.²⁵

Encouragingly, entire countries have enacted successful efforts and, in so doing, provided leadership on how to proceed. For example, the latest third quarter figures from 2019 show that renewable energy accounted for 38.9 percent of the UK's electricity supply and that the percentage supplied by coal was in single digits.²⁶ Costa Rica has been recognised as UN Champion of the Earth for its ambitious commitments to the Paris Climate Agreement. Ninety-eight percent of its energy is renewable, and its forest cover has been restored to 53 percent of its land area after decades of intense deforestation.²⁷ These achievements prove that there is a way, where there is political will. We consider that good enough reason for optimism over pessimism, for action over inaction. Let us then proceed on the basis of both empirical evidence and scientific expertise. Academic research gives us vital insights with which to better inform and educate governments, industry, and society on the path ahead. ■



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