EXHIBIT · SAMANTHA AKIHA

FOSSIL FREE SOMERVILLE

Informational Packet

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FOSSIL FREE SOMERVILLE

WHY DIVEST FROM FOSSIL FUELS?

THE BURNING OF FOSSIL FUELS IS DESTROYING THE CLIMATE.

The concentration of carbon dioxide in Earth's atmosphere reached 400 parts per million (ppm), the highest level in human history, on May 10, 2013. Most species on our planet depend on atmospheric carbon levels to be below 350ppm to ensure long term survival. Anthropogenic climate change is accelerating faster than previously expected and this unfortunate milestone was caused in large part by the burning of fossil fuels. Fossil fuel corporations have five times more oil, coal and gas in known reserves than climate scientists think is safe to burn.

EXTREME WEATHER EVENTS UNDERLINE THE URGENCY OF THE ISSUE.

In just the last year, the U.S. has struggled to contend with extreme weather events like Hurricane Sandy, the Midwest drought and the Colorado wildfires. These events are serious reminders of the need to take bold action to curb climate change now. In Massachusetts alone, a study has shown that by 2050 a sea level rise of 26 inches in Boston, from carbon pollution and unmitigated global warming, could damage assets worth an estimated $463 billion (Lenton et al., 2009).

DIVESTMENT FROM FOSSIL FUELS IS A MORAL ISSUE.

Just like in the movements to divest from the tobacco industry or to end Apartheid in South Africa, climate change is a deeply moral issue. Nationwide, colleges, religious organizations, cities and states are campaigning for divestment from fossil fuels on moral grounds: If it is wrong to wreck the planet, then it is also wrong to profit from that wreckage.

INVESTMENT IN FOSSIL FUELS PRESENTS RISK.

A report released by the Carbon Tracker Initiative and the London School of Economics shows that 60 to 80 percent of coal, oil and gas reserves held by the top 200 oil, gas and mining companies listed on the world's stock exchanges could be considered unburnable and therefore far less valuable than thought. This is because these reserves consist of five times the amount of carbon possible to emit without effectuating a two degree Celsius rise in the Earth's average temperature, causing climate change to tip out of control. The value of fossil fuel investments is predicted to implode, bursting the "carbon bubble," once investors are wary of this fact. News of the Carbon Bubble has begun to make headlines in media sources worldwide including The Guardian, Financial Times, The New York Times, and The Boston Globe.

DIVESTMENT PRESENTS INSIGNIFICANT RISK.

Recent studies have shown that divestment does not risk returns. One analysis by the Aperio Group, a group of investment advisors, shows that screening the top 200 fossil fuel companies only increased portfolio risk by an insignificant 0.01%. As Patrick Geddes, the former CFO for MorningStar and lead author of the report, told reporters, "Statistically, that's just noise." Another study conducted by investment management firm Phillips, Hager & North compares the performance of Domini, one of the top socially and environmentally screened funds in the world, to that of the traditional S&P 500 stock index. The report concludes: "the chief finding of this research is that socially responsible investing does not result in lower investment returns."

INVESTMENT IN FOSSIL FUELS STUNTS MASSACHUSETTS' OTHER GREEN EFFORTS.

By investing in clean energy and energy efficiency, Massachusetts has shown the nation that we can reduce our impact on the climate while creating jobs. Massachusetts is number one in the nation on energy efficiency. Investment in fossil fuels stunts those efforts. Big oil spends $167,000 *daily* lobbying the U.S. Congress, frequently to block clean energy solutions. On the other hand, divestment from fossil fuels is a logical extension of the Commonwealth's consistently green leadership. It's time to invest in our future.

THE DIVESTMENT ASK PRESENTS A REASONABLE TIMESCALE.

The resolution that Alderwoman Rebekah L. Gewirtz has committed to introducing does not mandate immediate divestment, but urges the Retirement Board to freeze new investments in 200 top fossil fuel companies and then gradually phase out all holdings over the next five years. This five-year time period is adequate time for the Retirement Board and its investment advisors to pursue divestment in a financially responsible manner. The towns of Truro and Provincetown have divested, Cambridge City Council passed a resolution in favor of divestment in July 2013, and Northampton City Council did the same in September 2013. There is a bill in the Massachusetts State House (S.1225) requesting the state pension fund divest from fossil fuels. As more cities join the divestment movement we anticipate that even more advice and options will become available to financial advisors to complete this task.

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RESOLUTION urging the Retirement Board of Somerville to divest its pension funds from publicly-traded fossil fuel companies.

WHEREAS the climate crisis is a serious threat to current and future generations here in Somerville and around the world;

WHEREAS, The Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report found that global warming is already causing costly disruption of human and natural systems throughout the world; and

WHEREAS, Almost every government in the world has agreed through the 2009 Copenhagen Accord that any warming above a 2°C (3.6°F) rise would be unsafe, and that humans can only pour about 565 more gigatons of carbon dioxide into the atmosphere to maintain this limit; and

WHEREAS, In its "Unburnable Carbon" report, the Carbon Tracker Initiative found that up to 80% of fossil fuel reserves must remain unburned to avoid a change in average global temperature of 2°C, making fossil fuel assets inflated and risky investments in the long term; and,

WHEREAS the mission of the City of Somerville is "to promote a thriving economy, healthy community, safe environment and quality lifestyle;" and,

WHEREAS the City of Somerville, issued in 2012 a "Climate Emergency Resolution to create a Somerville Climate Summit to determine the City's responses to climate change "on a scale proportionate to the emergency and consistent with the city's own climate goals;" and,

WHEREAS the Climate Emergency Facilitation Support document from the aforementioned Summit states that "The City of Somerville acknowledges the eminent threat of climate change and its potential to critically disrupt economic, social, natural, and cultural systems locally, regionally, and worldwide;" and that the city is "integrating the City's climate goals into municipal department planning and decision-making," and,

WHEREAS the City of Somerville has made it a priority to to pursue a sustainable future marked by strong environmental leadership, as mentioned in the Mayor's 2013 midterm address, and has taken steps to fulfill this goal, including the establishment of the Mayor's Office of Sustainability & Environment, making a commitment to reducing the City's carbon footprint by at least 10% by 2010, and increasing "green cover" in the City by increasing its tree inventory by 20%; and,

WHEREAS the City of Somerville believes that its investments should support a future where all citizens can live healthy lives without the negative impacts of a warming environment; and,

WHEREAS, students at more than two hundred colleges and universities in the United States, including Tufts University in Somerville have launched campaigns to have their institutions divest from fossil fuel companies; and,

WHEREAS, A recent report by the Aperio Group suggested that over the past ten years a carbon divested fund would have yielded higher returns than a non-divested portfolio; now,

THEREFORE, BE IT RESOLVED, That the Board of Aldermen of the City and County of Somerville urges the Retirement Board of the Somerville to review the Somerville investment portfolio to identify any holdings that include direct or indirect investments in fossil fuel companies; and, be it

FURTHER RESOLVED, That the Board of Aldermen urges the Retirement Board to immediately cease any new investments in fossil fuel companies or in commingled assets that include holdings in fossil fuel companies; and, be it

FURTHER RESOLVED, That, for any Somerville investments in commingled funds that are found to include fossil fuel companies, the Board of Aldermen urges the Retirement Board to contact the fund managers and request that the fossil fuel companies be removed from the funds; and, be it

FURTHER RESOLVED, That the Board of Aldermen urges the Retirement Board to ensure that none of its directly held or commingled assets include holdings in fossil fuel public equities and corporate bonds within 5 years as determined by the Carbon Tracker list; and

LET IT BE FURTHER RESOLVED that the Board of Aldermen urges the Retirement Board to prepare a report and options for investing the pension fund in a way that further maximizes the positive impact of the fund by seeking out investments that limit the effects of burning fossil fuels or help to mitigate its effects, such as clean technology & renewable energy, sustainable companies or projects, and sustainable communities. We request that the findings of said report be responded to in a manner consistent with the Retirement Board's fiduciary duty.

FURTHER RESOLVED, That the Board of Alderman urges the Retirement Board to release quarterly updates, available to the public, detailing progress made towards full divestment.

LET IT BE FURTHER RESOLVED that the Board of Aldermen urges the Massachusetts Senate and House of Representatives to pass bill S.1225, requiring the Massachusetts Pension Reserves Investment Trust (PRIT) to freeze any new investments in fossil fuel companies, and to divest from direct holdings in fossil fuel companies within 5 years. This would divest approximately $1.4 billion in state investments in fossil fuel companies.

Cities that have made a commitment toward divestment from fossil fuels:

Seattle, WA
San Francisco, CA
Portland, OR
Eugene, OR
Berkeley, CA
Richmond, CA
Santa Monica, CA
Boulder, CO
Santa Fe, NM
Madison, WI
Bayfield, WI
State College, PA
Ithaca, NY
Truro, MA
Provincetown, MA
Providence, RI
Northampton, MA
Ann Arbor, MI
Boxtel, NL
New London, CT
Amherst, MA
(Cambridge, MA)

From http://gofossilfree.org/commitments/, accessed March 11, 2013

Somerville Should Divest from Fossil Fuels

Somerville Journal
September 6, 2013

By Eric Fields

There is currently a global movement to get cities, universities, and other institutions to divest from the fossil fuel industry. Cities such as Seattle, San Francisco, Portland, Madison, Providence, and our neighbors in Cambridge have already agreed to do so. I and others in Somerville believe that our city should be at the forefront of this movement.

We have known for quite some time now that we cannot keep releasing carbon dioxide into the air indefinitely without terrible consequences for the ecosystem and the sustainability of our way of life. This point has recently been underlined by an analysis from the Carbon Tracker Initiative (carbontracker.org) showing that we can only burn around 20% of currently known fossil fuel deposits and keep climate change within internationally accepted limits.

And yet, despite this knowledge, fossil fuel companies continue to try to increase extraction, extract from currently untapped deposits, and find new deposits. This is their business model, this is their reason to exist, and their profitability depends on extracting the fossil fuel deposits they own and have rights to. They will continue to use their enormous wealth and power to make sure this happens.

If we want a better future, it is our responsibility to stop this. A good starting point is to extract ourselves and our communities from the fossil fuel industry. Somerville, like most cities, currently has pension funds invested in fossil fuel companies. To be invested in fossil fuel companies is to support, profit from, and even take ownership in continuing climate change. It deeply entangles our public institutions with the industry that is destroying the planet.

It is also a bad investment. If we begin to seriously tackle climate change—if we institute a carbon tax, ban new fossil fuel extraction, or any number of other responses—what is going to happen to the value of fossil fuel stocks? Some have termed this the "carbon bubble": a market bubble caused by large sections of stocks being valued based on profits that cannot be realized if we take climate change seriously. To stay invested in fossil fuel stocks is to assume we are going to do nothing about the greatest problem facing humanity today.

For these reasons, a group of Somerville residents is calling for the City of Somerville to divest its pension fund from the 200 largest fossil fuel companies. Somerville has shown itself as a city that takes climate change seriously in a number of ways including passing a Climate Emergency Resolution last year. We need to remain a leader on these issues by divorcing ourselves from the fossil fuel industry.

We are looking for people to join us in petitioning, meeting with Aldermen, and continuing to organize around this issue. If you are interested in getting involved in the campaign to divest Somerville, you can get in contact with the author of this article.

You can also sign our petition at: http://campaigns.gofossilfree.org/petitions/divest-somerville-massachusetts-from-fossil-fuels

Eric is a resident of Winter Hill and can be reached at ericcfields@gmail.com

Divest from fossil fuel investments

January 16, 2014
Somerville Times

By Joseph A. Curtatone

(The opinions and views expressed in the commentaries of The Somerville Times belong solely to the authors of those commentaries and do not reflect the views or opinions of The Somerville Times, its staff or publishers)

In my inaugural address, I called upon our community to set a citywide goal to reduce our net carbon emissions to zero by 2050. That's an ambitious goal, but by setting the bar high, we will not be content to nip and tuck around the edges, but will fervently take on the challenge of climate change. Our children and their children deserve no less from us, and Somerville can make a difference. Cities are collectively responsible for over 70 percent of greenhouse gas emissions across the planet, according to the United Nations. We must do our part and do it the same way we approach every issue facing our city. We will study the facts and make prudent, patient investments today with an eye on tomorrow.

However, some of our investments today are part of the problem. We are funding the problem through our pension fund's holdings in fossil fuel companies. So in my inaugural address, I also publicly supported the goal of the Somerville Retirement Board divesting from fossil fuel companies.

The city's retirement board's chief responsibility is to secure the highest rate or return possible for investments in our pension fund. In the case of fossil fuels, the moral imperative is so clear and unambiguous to warrant divestment, but this is not only a moral imperative. It's sound financial policy, too.

There is a looming $20 trillion carbon bubble, according to a report by London School of Economics' Grantham Research Institute on Climate Change and the Environment, in collaboration with nonprofit organization Carbon Tracker. That's because fossil fuel reserves are overvalued, and at least two-thirds of the reserves must remain untapped underground to prevent climate change from increasing the global temperature by more than 2 degrees Celsius, a target agreed to by the United States and 113 other countries.

This means that these reserves are essentially unburnable and subsequently worthless, which will lead to incredible market losses by fossil fuel companies. Yet instead of taking this into account, the top 200 fossil fuel companies spent $647 billion in 2012 to find more fossil fuels. That's

equivalent to 1 percent of the global gross domestic product, a figure that if spent annually on climate change mitigation would stabilize greenhouse gases by 2050, according to a report by London School of Economics professor Sir Nicholas Stern. Spending billions on finding more fossil fuels when currently held reserves are likely to lose their value is a financial waste that increases the risk for investors such as the Somerville Retirement Board.

The red flag raised about the carbon bubble is supported by other financial institutions, including Standard and Poor's, HSBC Holdings and Citi. A coalition of investors, politicians and scientists has gone so far as to warn the Bank of England that fossil fuel reserves held by companies invested in by the City of London are "subprime" assets. We remember what happened in 2008 with subprime mortgages. These fossil fuel companies are poised for a great fall, and our legal obligation to fully fund our pension system does not need to fall with them. Divesting from fossil fuels is not only the moral choice, it's the financially responsible choice.

We are not alone in this fight. Seattle, San Francisco, Portland, Madison and Providence have already agreed to divest from fossil fuels. These cities' investments in their pension funds are at less risk today because they've divested. And they have sent a message that they will not take ownership in the corporations who seek higher profits at the expense of our planet's future.

Our community has already led the way on taking responsibility for our environment, from increasing recycling and installing solar panels on our schools, to green building incentives in the rezoning of Union Square and Boynton Yards, to energy-efficient LED lights for our streetlights, to making sure that the Green Line Extension and Assembly Square Orange Line station become a reality. We will continue to lead the way in 2014 through citywide Climate Change Mapping Sessions, detailing everything in our city that affects greenhouse gas emissions and identifying what we need to do to reduce these emissions and reach our net-zero goal by 2050.

Even with all that, we must start with what we're doing right now to contribute to the problem. We are currently investing in the destruction of the planet. We need to divest from fossil fuel companies now.

Rolling Stone

Global Warming's Terrifying New Math

Three simple numbers that add up to global catastrophe - and that make clear who the real enemy is

by BILL MCKIBBEN

JULY 19, 2012

If the pictures of those towering wildfires in Colorado haven't convinced you, or the size of your AC bill this summer, here are some hard numbers about climate change: June broke or tied 3,215 high-temperature records across the United States. That followed the warmest May on record for the Northern Hemisphere – the 327th consecutive month in which the temperature of the entire globe exceeded the 20th-century average, the odds of which occurring by simple chance were 3.7 x 10-99, a number considerably larger than the number of stars in the universe.

Meteorologists reported that this spring was the warmest ever recorded for our nation – in fact, it crushed the old record by so much that it represented the "largest temperature departure from average of any season on record." The same week, Saudi authorities reported that it had rained in Mecca despite a temperature of 109 degrees, the hottest downpour in the planet's history.

Not that our leaders seemed to notice. Last month the world's nations, meeting in Rio for the 20th-anniversary reprise of a massive 1992 environmental summit, accomplished nothing. Unlike George H.W. Bush, who flew in for the first conclave, Barack Obama didn't even attend. It was "a ghost of the glad, confident meeting 20 years ago," the British journalist George Monbiot wrote; no one paid it much attention, footsteps echoing through the halls "once thronged by multitudes." Since I wrote one of the first books for a general audience about global warming way back in 1989, and since I've spent the intervening decades working ineffectively to slow that warming, I can say with some confidence that we're losing the fight, badly and quickly – losing it because, most of all, we remain in denial about the peril that human civilization is in.

When we think about global warming at all, the arguments tend to be ideological, theological and economic. But to grasp the seriousness of our predicament, you just need to do a little math. For the past year, an easy and powerful bit of arithmetical analysis first published by

financial analysts in the U.K. has been making the rounds of environmental conferences and journals, but it hasn't yet broken through to the larger public. This analysis upends most of the conventional political thinking about climate change. And it allows us to understand our precarious – our almost-but-not-quite-finally hopeless – position with three simple numbers.

The First Number: 2° Celsius

If the movie had ended in Hollywood fashion, the Copenhagen climate conference in 2009 would have marked the culmination of the global fight to slow a changing climate. The world's nations had gathered in the December gloom of the Danish capital for what a leading climate economist, Sir Nicholas Stern of Britain, called the "most important gathering since the Second World War, given what is at stake." As Danish energy minister Connie Hedegaard, who presided over the conference, declared at the time: "This is our chance. If we miss it, it could take years before we get a new and better one. If ever."

In the event, of course, we missed it. Copenhagen failed spectacularly. Neither China nor the United States, which between them are responsible for 40 percent of global carbon emissions, was prepared to offer dramatic concessions, and so the conference drifted aimlessly for two weeks until world leaders jetted in for the final day. Amid considerable chaos, President Obama took the lead in drafting a face-saving "Copenhagen Accord" that fooled very few. Its purely voluntary agreements committed no one to anything, and even if countries signaled their intentions to cut carbon emissions, there was no enforcement mechanism. "Copenhagen is a crime scene tonight," an angry Greenpeace official declared, "with the guilty men and women fleeing to the airport." Headline writers were equally brutal: COPENHAGEN: THE MUNICH OF OUR TIMES? asked one.

The accord did contain one important number, however. In Paragraph 1, it formally recognized "the scientific view that the increase in global temperature should be below two degrees Celsius." And in the very next paragraph, it declared that "we agree that deep cuts in global emissions are required... so as to hold the increase in global temperature below two degrees Celsius." By insisting on two degrees – about 3.6 degrees Fahrenheit – the accord ratified positions taken earlier in 2009 by the G8, and the so-called Major Economies Forum. It was as conventional as conventional wisdom gets. The number first gained prominence, in fact, at a 1995 climate conference chaired by Angela Merkel, then the German minister of the environment and now the center-right chancellor of the nation.

Some context: So far, we've raised the average temperature of the planet just under 0.8 degrees Celsius, and that has caused far more damage than most scientists expected. (A third of summer sea ice in the Arctic is gone, the oceans are 30 percent more acidic, and since warm air holds more water vapor than cold, the atmosphere over the oceans is a shocking five percent wetter, loading the dice for devastating floods.) Given those impacts, in fact, many scientists have come to think that two degrees is far too lenient a target. "Any number much above one degree involves a gamble," writes Kerry Emanuel of MIT, a leading authority on hurricanes, "and the odds become less and less favorable as the temperature goes up." Thomas

Lovejoy, once the World Bank's chief biodiversity adviser, puts it like this: "If we're seeing what we're seeing today at 0.8 degrees Celsius, two degrees is simply too much." NASA scientist James Hansen, the planet's most prominent climatologist, is even blunter: "The target that has been talked about in international negotiations for two degrees of warming is actually a prescription for long-term disaster." At the Copenhagen summit, a spokesman for small island nations warned that many would not survive a two-degree rise: "Some countries will flat-out disappear." When delegates from developing nations were warned that two degrees would represent a "suicide pact" for drought-stricken Africa, many of them started chanting, "One degree, one Africa."

Despite such well-founded misgivings, political realism bested scientific data, and the world settled on the two-degree target – indeed, it's fair to say that it's the only thing about climate change the world has settled on. All told, 167 countries responsible for more than 87 percent of the world's carbon emissions have signed on to the Copenhagen Accord, endorsing the two-degree target. Only a few dozen countries have rejected it, including Kuwait, Nicaragua and Venezuela. Even the United Arab Emirates, which makes most of its money exporting oil and gas, signed on. The official position of planet Earth at the moment is that we can't raise the temperature more than two degrees Celsius – it's become the bottomest of bottom lines. Two degrees.

The Second Number: 565 Gigatons

Scientists estimate that humans can pour roughly 565 more gigatons of carbon dioxide into the atmosphere by midcentury and still have some reasonable hope of staying below two degrees. ("Reasonable," in this case, means four chances in five, or somewhat worse odds than playing Russian roulette with a six-shooter.)

This idea of a global "carbon budget" emerged about a decade ago, as scientists began to calculate how much oil, coal and gas could still safely be burned. Since we've increased the Earth's temperature by 0.8 degrees so far, we're currently less than halfway to the target. But, in fact, computer models calculate that even if we stopped increasing CO_2 now, the temperature would likely still rise another 0.8 degrees, as previously released carbon continues to overheat the atmosphere. That means we're already three-quarters of the way to the two-degree target.

How good are these numbers? No one is insisting that they're exact, but few dispute that they're generally right. The 565-gigaton figure was derived from one of the most sophisticated computer-simulation models that have been built by climate scientists around the world over the past few decades. And the number is being further confirmed by the latest climate-simulation models currently being finalized in advance of the next report by the Intergovernmental Panel on Climate Change. "Looking at them as they come in, they hardly differ at all," says Tom Wigley, an Australian climatologist at the National Center for Atmospheric Research. "There's maybe 40 models in the data set now, compared with 20 before. But so far the numbers are pretty much the same. We're just fine-tuning things. I don't

think much has changed over the last decade." William Collins, a senior climate scientist at the Lawrence Berkeley National Laboratory, agrees. "I think the results of this round of simulations will be quite similar," he says. "We're not getting any free lunch from additional understanding of the climate system."

We're not getting any free lunch from the world's economies, either. With only a single year's lull in 2009 at the height of the financial crisis, we've continued to pour record amounts of carbon into the atmosphere, year after year. In late May, the International Energy Agency published its latest figures – CO_2 emissions last year rose to 31.6 gigatons, up 3.2 percent from the year before. America had a warm winter and converted more coal-fired power plants to natural gas, so its emissions fell slightly; China kept booming, so its carbon output (which recently surpassed the U.S.) rose 9.3 percent; the Japanese shut down their fleet of nukes post-Fukushima, so their emissions edged up 2.4 percent. "There have been efforts to use more renewable energy and improve energy efficiency," said Corinne Le Quéré, who runs England's Tyndall Centre for Climate Change Research. "But what this shows is that so far the effects have been marginal." In fact, study after study predicts that carbon emissions will keep growing by roughly three percent a year – and at that rate, we'll blow through our 565-gigaton allowance in 16 years, around the time today's preschoolers will be graduating from high school. "The new data provide further evidence that the door to a two-degree trajectory is about to close," said Fatih Birol, the IEA's chief economist. In fact, he continued, "When I look at this data, the trend is perfectly in line with a temperature increase of about six degrees." That's almost 11 degrees Fahrenheit, which would create a planet straight out of science fiction.

So, new data in hand, everyone at the Rio conference renewed their ritual calls for serious international action to move us back to a two-degree trajectory. The charade will continue in November, when the next Conference of the Parties (COP) of the U.N. Framework Convention on Climate Change convenes in Qatar. This will be COP 18 – COP 1 was held in Berlin in 1995, and since then the process has accomplished essentially nothing. Even scientists, who are notoriously reluctant to speak out, are slowly overcoming their natural preference to simply provide data. "The message has been consistent for close to 30 years now," Collins says with a wry laugh, "and we have the instrumentation and the computer power required to present the evidence in detail. If we choose to continue on our present course of action, it should be done with a full evaluation of the evidence the scientific community has presented." He pauses, suddenly conscious of being on the record. "I should say, a *fuller evaluation* of the evidence."

So far, though, such calls have had little effect. We're in the same position we've been in for a quarter-century: scientific warning followed by political inaction. Among scientists speaking off the record, disgusted candor is the rule. One senior scientist told me, "You know those new cigarette packs, where governments make them put a picture of someone with a hole in their throats? Gas pumps should have something like that."

The Third Number: 2,795 Gigatons

This number is the scariest of all – one that, for the first time, meshes the political and scientific dimensions of our dilemma. It was highlighted last summer by the Carbon Tracker Initiative, a team of London financial analysts and environmentalists who published a report in an effort to educate investors about the possible risks that climate change poses to their stock portfolios. The number describes the amount of carbon already contained in the proven coal and oil and gas reserves of the fossil-fuel companies, and the countries (think Venezuela or Kuwait) that act like fossil-fuel companies. In short, it's the fossil fuel we're currently planning to burn. And the key point is that this new number – 2,795 – is higher than 565. Five times higher.

The Carbon Tracker Initiative – led by James Leaton, an environmentalist who served as an adviser at the accounting giant PricewaterhouseCoopers – combed through proprietary databases to figure out how much oil, gas and coal the world's major energy companies hold in reserve. The numbers aren't perfect – they don't fully reflect the recent surge in unconventional energy sources like shale gas, and they don't accurately reflect coal reserves, which are subject to less stringent reporting requirements than oil and gas. But for the biggest companies, the figures are quite exact: If you burned everything in the inventories of Russia's Lukoil and America's ExxonMobil, for instance, which lead the list of oil and gas companies, each would release more than 40 gigatons of carbon dioxide into the atmosphere.

Which is exactly why this new number, 2,795 gigatons, is such a big deal. Think of two degrees Celsius as the legal drinking limit – equivalent to the 0.08 blood-alcohol level below which you might get away with driving home. The 565 gigatons is how many drinks you could have and still stay below that limit – the six beers, say, you might consume in an evening. And the 2,795 gigatons? That's the three 12-packs the fossil-fuel industry has on the table, already opened and ready to pour.

We have five times as much oil and coal and gas on the books as climate scientists think is safe to burn. We'd have to keep 80 percent of those reserves locked away underground to avoid that fate. Before we knew those numbers, our fate had been likely. Now, barring some massive intervention, it seems certain.

Yes, this coal and gas and oil is still technically in the soil. But it's already economically aboveground – it's figured into share prices, companies are borrowing money against it, nations are basing their budgets on the presumed returns from their patrimony. It explains why the big fossil-fuel companies have fought so hard to prevent the regulation of carbon dioxide – those reserves are their primary asset, the holding that gives their companies their value. It's why they've worked so hard these past years to figure out how to unlock the oil in Canada's tar sands, or how to drill miles beneath the sea, or how to frack the Appalachians.

If you told Exxon or Lukoil that, in order to avoid wrecking the climate, they couldn't pump out their reserves, the value of their companies would plummet. John Fullerton, a former

managing director at JP Morgan who now runs the Capital Institute, calculates that at today's market value, those 2,795 gigatons of carbon emissions are worth about $27 trillion. Which is to say, if you paid attention to the scientists and kept 80 percent of it underground, you'd be writing off $20 trillion in assets. The numbers aren't exact, of course, but that carbon bubble makes the housing bubble look small by comparison. It won't necessarily burst – we might well burn all that carbon, in which case investors will do fine. But if we do, the planet will crater. You can have a healthy fossil-fuel balance sheet, or a relatively healthy planet – but now that we know the numbers, it looks like you can't have both. Do the math: 2,795 is five times 565. That's how the story ends.

So far, as I said at the start, environmental efforts to tackle global warming have failed. The planet's emissions of carbon dioxide continue to soar, especially as developing countries emulate (and supplant) the industries of the West. Even in rich countries, small reductions in emissions offer no sign of the real break with the status quo we'd need to upend the iron logic of these three numbers. Germany is one of the only big countries that has actually tried hard to change its energy mix; on one sunny Saturday in late May, that northern-latitude nation generated nearly half its power from solar panels within its borders. That's a small miracle – and it demonstrates that we have the technology to solve our problems. But we lack the will. So far, Germany's the exception; the rule is ever more carbon.

This record of failure means we know a lot about what strategies *don't* work. Green groups, for instance, have spent a lot of time trying to change individual lifestyles: the iconic twisty light bulb has been installed by the millions, but so have a new generation of energy-sucking flatscreen TVs. Most of us are fundamentally ambivalent about going green: We like cheap flights to warm places, and we're certainly not going to give them up if everyone else is still taking them. Since all of us are in some way the beneficiaries of cheap fossil fuel, tackling climate change has been like trying to build a movement against yourself – it's as if the gay-rights movement had to be constructed entirely from evangelical preachers, or the abolition movement from slaveholders.

People perceive – correctly – that their individual actions will not make a decisive difference in the atmospheric concentration of CO2; by 2010, a poll found that "while recycling is widespread in America and 73 percent of those polled are paying bills online in order to save paper," only four percent had reduced their utility use and only three percent had purchased hybrid cars. Given a hundred years, you could conceivably change lifestyles enough to matter – but time is precisely what we lack.

A more efficient method, of course, would be to work through the political system, and environmentalists have tried that, too, with the same limited success. They've patiently lobbied leaders, trying to convince them of our peril and assuming that politicians would heed the warnings. Sometimes it has seemed to work. Barack Obama, for instance, campaigned more aggressively about climate change than any president before him – the night he won the nomination, he told supporters that his election would mark the moment "the rise of the oceans began to slow and the planet began to heal." And he has achieved one significant

change: a steady increase in the fuel efficiency mandated for automobiles. It's the kind of measure, adopted a quarter-century ago, that would have helped enormously. But in light of the numbers I've just described, it's obviously a very small start indeed.

At this point, effective action would require actually keeping most of the carbon the fossil-fuel industry wants to burn safely in the soil, not just changing slightly the speed at which it's burned. And there the president, apparently haunted by the still-echoing cry of "Drill, baby, drill," has gone out of his way to frack and mine. His secretary of interior, for instance, opened up a huge swath of the Powder River Basin in Wyoming for coal extraction: The total basin contains some 67.5 gigatons worth of carbon (or more than 10 percent of the available atmospheric space). He's doing the same thing with Arctic and offshore drilling; in fact, as he explained on the stump in March, "You have my word that we will keep drilling everywhere we can... That's a commitment that I make." The next day, in a yard full of oil pipe in Cushing, Oklahoma, the president promised to work on wind and solar energy but, at the same time, to speed up fossil-fuel development: "Producing more oil and gas here at home has been, and will continue to be, a critical part of an all-of-the-above energy strategy." That is, he's committed to finding even more stock to add to the 2,795-gigaton inventory of unburned carbon.

Sometimes the irony is almost Borat-scale obvious: In early June, Secretary of State Hillary Clinton traveled on a Norwegian research trawler to see firsthand the growing damage from climate change. "Many of the predictions about warming in the Arctic are being surpassed by the actual data," she said, describing the sight as "sobering." But the discussions she traveled to Scandinavia to have with other foreign ministers were mostly about how to make sure Western nations get their share of the estimated $9 trillion in oil (that's more than 90 billion barrels, or 37 gigatons of carbon) that will become accessible as the Arctic ice melts. Last month, the Obama administration indicated that it would give Shell permission to start drilling in sections of the Arctic.

Almost every government with deposits of hydrocarbons straddles the same divide. Canada, for instance, is a liberal democracy renowned for its internationalism – no wonder, then, that it signed on to the Kyoto treaty, promising to cut its carbon emissions substantially by 2012. But the rising price of oil suddenly made the tar sands of Alberta economically attractive – and since, as NASA climatologist James Hansen pointed out in May, they contain as much as 240 gigatons of carbon (or almost half of the available space if we take the 565 limit seriously), that meant Canada's commitment to Kyoto was nonsense. In December, the Canadian government withdrew from the treaty before it faced fines for failing to meet its commitments.

The same kind of hypocrisy applies across the ideological board: In his speech to the Copenhagen conference, Venezuela's Hugo Chavez quoted Rosa Luxemburg, Jean-Jacques Rousseau and "Christ the Redeemer," insisting that "climate change is undoubtedly the most devastating environmental problem of this century." But the next spring, in the Simon Bolivar Hall of the state-run oil company, he signed an agreement with a consortium of international

players to develop the vast Orinoco tar sands as "the most significant engine for a comprehensive development of the entire territory and Venezuelan population." The Orinoco deposits are larger than Alberta's – taken together, they'd fill up the whole available atmospheric space.

So: the paths we have tried to tackle global warming have so far produced only gradual, halting shifts. A rapid, transformative change would require building a movement, and movements require enemies. As John F. Kennedy put it, "The civil rights movement should thank God for Bull Connor. He's helped it as much as Abraham Lincoln." And enemies are what climate change has lacked.

But what all these climate numbers make painfully, usefully clear is that the planet does indeed have an enemy – one far more committed to action than governments or individuals. Given this hard math, we need to view the fossil-fuel industry in a new light. It has become a rogue industry, reckless like no other force on Earth. It is Public Enemy Number One to the survival of our planetary civilization. "Lots of companies do rotten things in the course of their business – pay terrible wages, make people work in sweatshops – and we pressure them to change those practices," says veteran anti-corporate leader Naomi Klein, who is at work on a book about the climate crisis. "But these numbers make clear that with the fossil-fuel industry, wrecking the planet is their business model. It's what they do."

According to the Carbon Tracker report, if Exxon burns its current reserves, it would use up more than seven percent of the available atmospheric space between us and the risk of two degrees. BP is just behind, followed by the Russian firm Gazprom, then Chevron, ConocoPhillips and Shell, each of which would fill between three and four percent. Taken together, just these six firms, of the 200 listed in the Carbon Tracker report, would use up more than a quarter of the remaining two-degree budget. Severstal, the Russian mining giant, leads the list of coal companies, followed by firms like BHP Billiton and Peabody. The numbers are simply staggering – this industry, and this industry alone, holds the power to change the physics and chemistry of our planet, and they're planning to use it.

They're clearly cognizant of global warming – they employ some of the world's best scientists, after all, and they're bidding on all those oil leases made possible by the staggering melt of Arctic ice. And yet they relentlessly search for more hydrocarbons – in early March, Exxon CEO Rex Tillerson told Wall Street analysts that the company plans to spend $37 billion a year through 2016 (about $100 million a day) searching for yet more oil and gas.

There's not a more reckless man on the planet than Tillerson. Late last month, on the same day the Colorado fires reached their height, he told a New York audience that global warming is real, but dismissed it as an "engineering problem" that has "engineering solutions." Such as? "Changes to weather patterns that move crop-production areas around – we'll adapt to that." This in a week when Kentucky farmers were reporting that corn kernels were "aborting" in record heat, threatening a spike in global food prices. "The fear factor that people want to throw out there to say, 'We just have to stop this,' I do not accept," Tillerson said. Of course

not – if he did accept it, he'd have to keep his reserves in the ground. Which would cost him money. It's not an engineering problem, in other words – it's a greed problem.

You could argue that this is simply in the nature of these companies – that having found a profitable vein, they're compelled to keep mining it, more like efficient automatons than people with free will. But as the Supreme Court has made clear, they are people of a sort. In fact, thanks to the size of its bankroll, the fossil-fuel industry has far more free will than the rest of us. These companies don't simply exist in a world whose hungers they fulfill – they help create the boundaries of that world.

Left to our own devices, citizens might decide to regulate carbon and stop short of the brink; according to a recent poll, nearly two-thirds of Americans would back an international agreement that cut carbon emissions 90 percent by 2050. But we aren't left to our own devices. The Koch brothers, for instance, have a combined wealth of $50 billion, meaning they trail only Bill Gates on the list of richest Americans. They've made most of their money in hydrocarbons, they know any system to regulate carbon would cut those profits, and they reportedly plan to lavish as much as $200 million on this year's elections. In 2009, for the first time, the U.S. Chamber of Commerce surpassed both the Republican and Democratic National Committees on political spending; the following year, more than 90 percent of the Chamber's cash went to GOP candidates, many of whom deny the existence of global warming. Not long ago, the Chamber even filed a brief with the EPA urging the agency not to regulate carbon – should the world's scientists turn out to be right and the planet heats up, the Chamber advised, "populations can acclimatize to warmer climates via a range of behavioral, physiological and technological adaptations." As radical goes, demanding that we change our physiology seems right up there.

Environmentalists, understandably, have been loath to make the fossil-fuel industry their enemy, respecting its political power and hoping instead to convince these giants that they should turn away from coal, oil and gas and transform themselves more broadly into "energy companies." Sometimes that strategy appeared to be working – emphasis on appeared. Around the turn of the century, for instance, BP made a brief attempt to restyle itself as "Beyond Petroleum," adapting a logo that looked like the sun and sticking solar panels on some of its gas stations. But its investments in alternative energy were never more than a tiny fraction of its budget for hydrocarbon exploration, and after a few years, many of those were wound down as new CEOs insisted on returning to the company's "core business." In December, BP finally closed its solar division. Shell shut down its solar and wind efforts in 2009. The five biggest oil companies have made more than $1 trillion in profits since the millennium – there's simply too much money to be made on oil and gas and coal to go chasing after zephyrs and sunbeams.

Much of that profit stems from a single historical accident: Alone among businesses, the fossil-fuel industry is allowed to dump its main waste, carbon dioxide, for free. Nobody else gets that break – if you own a restaurant, you have to pay someone to cart away your trash, since piling it in the street would breed rats. But the fossil-fuel industry is different, and for

sound historical reasons: Until a quarter-century ago, almost no one knew that CO2 was dangerous. But now that we understand that carbon is heating the planet and acidifying the oceans, its price becomes the central issue.

If you put a price on carbon, through a direct tax or other methods, it would enlist markets in the fight against global warming. Once Exxon has to pay for the damage its carbon is doing to the atmosphere, the price of its products would rise. Consumers would get a strong signal to use less fossil fuel – every time they stopped at the pump, they'd be reminded that you don't need a semimilitary vehicle to go to the grocery store. The economic playing field would now be a level one for nonpolluting energy sources. And you could do it all without bankrupting citizens – a so-called "fee-and-dividend" scheme would put a hefty tax on coal and gas and oil, then simply divide up the proceeds, sending everyone in the country a check each month for their share of the added costs of carbon. By switching to cleaner energy sources, most people would actually come out ahead.

There's only one problem: Putting a price on carbon would reduce the profitability of the fossil-fuel industry. After all, the answer to the question "How high should the price of carbon be?" is "High enough to keep those carbon reserves that would take us past two degrees safely in the ground." The higher the price on carbon, the more of those reserves would be worthless. The fight, in the end, is about whether the industry will succeed in its fight to keep its special pollution break alive past the point of climate catastrophe, or whether, in the economists' parlance, we'll make them internalize those externalities.

It's not clear, of course, that the power of the fossil-fuel industry can be broken. The U.K. analysts who wrote the Carbon Tracker report and drew attention to these numbers had a relatively modest goal – they simply wanted to remind investors that climate change poses a very real risk to the stock prices of energy companies. Say something so big finally happens (a giant hurricane swamps Manhattan, a megadrought wipes out Midwest agriculture) that even the political power of the industry is inadequate to restrain legislators, who manage to regulate carbon. Suddenly those Chevron reserves would be a lot less valuable, and the stock would tank. Given that risk, the Carbon Tracker report warned investors to lessen their exposure, hedge it with some big plays in alternative energy.

"The regular process of economic evolution is that businesses are left with stranded assets all the time," says Nick Robins, who runs HSBC's Climate Change Centre. "Think of film cameras, or typewriters. The question is not whether this will happen. It will. Pension systems have been hit by the dot-com and credit crunch. They'll be hit by this." Still, it hasn't been easy to convince investors, who have shared in the oil industry's record profits. "The reason you get bubbles," sighs Leaton, "is that everyone thinks they're the best analyst – that they'll go to the edge of the cliff and then jump back when everyone else goes over."

So pure self-interest probably won't spark a transformative challenge to fossil fuel. But moral outrage just might – and that's the real meaning of this new math. It could, plausibly, give rise to a real movement.

Once, in recent corporate history, anger forced an industry to make basic changes. That was the campaign in the 1980s demanding divestment from companies doing business in South Africa. It rose first on college campuses and then spread to municipal and state governments; 155 campuses eventually divested, and by the end of the decade, more than 80 cities, 25 states and 19 counties had taken some form of binding economic action against companies connected to the apartheid regime. "The end of apartheid stands as one of the crowning accomplishments of the past century," as Archbishop Desmond Tutu put it, "but we would not have succeeded without the help of international pressure," especially from "the divestment movement of the 1980s."

The fossil-fuel industry is obviously a tougher opponent, and even if you could force the hand of particular companies, you'd still have to figure out a strategy for dealing with all the sovereign nations that, in effect, act as fossil-fuel companies. But the link for college students is even more obvious in this case. If their college's endowment portfolio has fossil-fuel stock, then their educations are being subsidized by investments that guarantee they won't have much of a planet on which to make use of their degree. (The same logic applies to the world's largest investors, pension funds, which are also theoretically interested in the future – that's when their members will "enjoy their retirement.") "Given the severity of the climate crisis, a comparable demand that our institutions dump stock from companies that are destroying the planet would not only be appropriate but effective," says Bob Massie, a former anti-apartheid activist who helped found the Investor Network on Climate Risk. "The message is simple: We have had enough. We must sever the ties with those who profit from climate change – now."

Movements rarely have predictable outcomes. But any campaign that weakens the fossil-fuel industry's political standing clearly increases the chances of retiring its special breaks. Consider President Obama's signal achievement in the climate fight, the large increase he won in mileage requirements for cars. Scientists, environmentalists and engineers had advocated such policies for decades, but until Detroit came under severe financial pressure, it was politically powerful enough to fend them off. If people come to understand the cold, mathematical truth – that the fossil-fuel industry is systematically undermining the planet's physical systems – it might weaken it enough to matter politically. Exxon and their ilk might drop their opposition to a fee-and-dividend solution; they might even decide to become true energy companies, this time for real.

Even if such a campaign is possible, however, we may have waited too long to start it. To make a real difference – to keep us under a temperature increase of two degrees – you'd need to change carbon pricing in Washington, and then use that victory to leverage similar shifts around the world. At this point, what happens in the U.S. is most important for how it will influence China and India, where emissions are growing fastest. (In early June, researchers concluded that China has probably under-reported its emissions by up to 20 percent.) The three numbers I've described are daunting – they may define an essentially impossible future. But at least they provide intellectual clarity about the greatest challenge humans have ever faced. We know how much we can burn, and we know who's planning to burn more. Climate change operates on a geological scale and time frame, but it's not an impersonal force of

nature; the more carefully you do the math, the more thoroughly you realize that this is, at bottom, a moral issue; we have met the enemy and they is Shell.

Meanwhile the tide of numbers continues. The week after the Rio conference limped to its conclusion, Arctic sea ice hit the lowest level ever recorded for that date. Last month, on a single weekend, Tropical Storm Debby dumped more than 20 inches of rain on Florida – the earliest the season's fourth-named cyclone has ever arrived. At the same time, the largest fire in New Mexico history burned on, and the most destructive fire in Colorado's annals claimed 346 homes in Colorado Springs – breaking a record set the week before in Fort Collins. This month, scientists issued a new study concluding that global warming has dramatically increased the likelihood of severe heat and drought – days after a heat wave across the Plains and Midwest broke records that had stood since the Dust Bowl, threatening this year's harvest. You want a big number? In the course of this month, a quadrillion kernels of corn need to pollinate across the grain belt, something they can't do if temperatures remain off the charts. Just like us, our crops are adapted to the Holocene, the 11,000-year period of climatic stability we're now leaving... in the dust.

This story is from the August 2nd, 2012 issue of Rolling Stone.

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Associated Press

Northeast US could suffer most from sea rise

Add 8 inches for the region, new study says

By Seth Borenstein
Associated Press / March 16, 2009

WASHINGTON - The Northeastern US coast is likely to see the world's biggest sea level rise from man-made global warming, a new study predicts.

However much the oceans rise by the end of the century, add an extra 8 inches or so for New York, Boston, and other spots along the coast from the mid-Atlantic to New England. That's because of predicted changes in ocean currents, according to a study based on computer models published online yesterday in the journal Nature Geoscience.

An extra 8 inches - on top of a possible 2 or 3 feet of sea rise globally by 2100 - is a big deal, especially when northeasters and hurricanes hit, experts said.

"It's not just waterfront homes and wetlands that are at stake here," said Donald Boesch, president of the University of Maryland Center for Environmental Science, who wasn't part of the study. "Those kind of rises in sea level when placed on top of the storm surges we see today, put in jeopardy lots of infrastructure, including the New York subway system."

For years, scientists have talked about rising sea levels due to global warming - both from warm water expanding and the melt of ice sheets in Greenland and West Antarctica. Predictions for the average worldwide sea rise keep changing along with the rate of ice melt. Recently, more scientists are saying the situation has worsened so that a 3-foot rise in sea level by 2100 is becoming a common theme.

But the oceans won't rise at the same rate everywhere, said study author Jianjun Yin of the Center for Ocean-Atmospheric Prediction Studies at Florida State University. It will be "greater and faster" for the Northeast, with Boston one of the worst hit among major cities, he said. So, if it's 3 feet, add another 8 inches for that region.

The explanation involves complicated ocean currents. Computer models forecast that as climate change continues, there will be a slowdown of the great ocean conveyor belt. That system moves heat energy in warm currents from the tropics to the North Atlantic and pushes the cooler, saltier water down, moving it farther south around Africa and into the Pacific. As the conveyor belt slows, so will the Gulf Stream and North Atlantic current. Those two fast-running currents have kept the Northeast's sea level unusually low because of a combination of physics and geography, Yin said.

Slow down the conveyor belt 33 to 43 percent as predicted by computer models, and the Northeast sea level rises faster, Yin said. So far, the conveyor belt has not noticeably slowed.

A decade ago, scientists worried about the possibility that this current conveyor belt would halt altogether - something that would cause abrupt and

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catastrophic climate change like that shown in the movie "The Day After Tomorrow." But in recent years, they concluded that a shutdown is unlikely this century.

Other experts who reviewed Yin's work say it makes sense.

"Our coastlines aren't designed for that extra 8 inches of storm surge you get out of that sea level rise effect," said Jonathan Overpeck, director of an Earth studies institute at the University of Arizona.

While Boston and New York are looking at an additional 8 inches, other places wouldn't get that much extra rise. The study suggests Miami and much of the Southeast would get about 2 inches above the global sea rise average of perhaps 3 feet, and San Francisco would get less than an extra inch. Parts of southern Australia, northern Asia and southern and western South America would get less than the global average sea level rise.

This study along with another one last month looking at regional sea level rise from the projected melt of the west Antarctic ice sheet "provide a compelling argument for anticipating and preparing for higher rates of sea level rise," said Virginia Burkett, chief scientist for Global Change Research at the US Geological Survey.

Burkett, who is based in Louisiana, said eventually New Englanders could be in the same "vulnerability situation" to storms and sea level rise as New Orleans. ■

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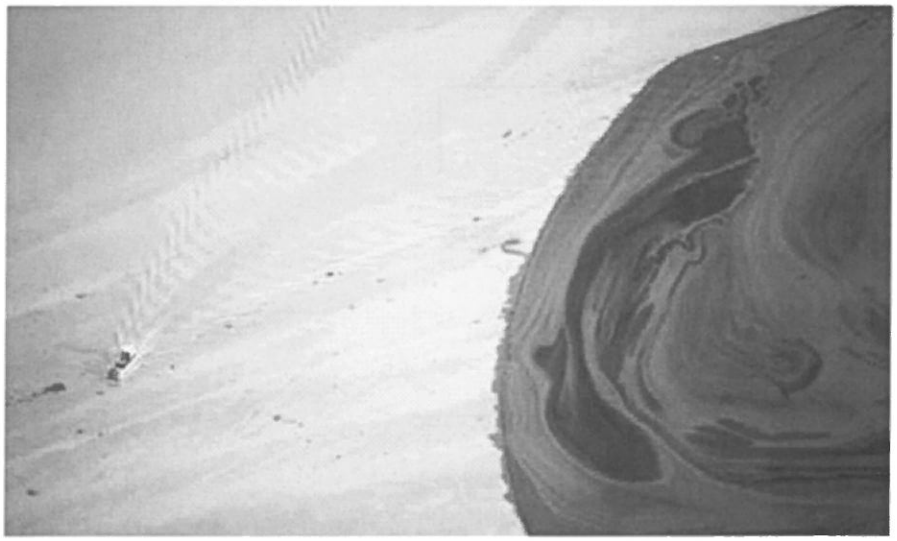
How your pension is being used in a $6 trillion climate gamble

Fossil fuel companies' bet that climate agreements won't stop them from burning carbon puts pension funds at risk



The tailings pond at the Syncrude mine north of Fort McMurray, Alberta, Canada. Tar sands could become a 'stranded asset', campaigners say Photograph: Ashley Cooper pics/Alamy

Suppose you weren't worried that we humans are destroying our water supply and eroding our ability to feed ourselves by burning coal and gas and oil and hence changing climate. Suppose you thought that was all liberal hooey. What might worry you about fossil fuels instead? How about a six trillion dollar bet, including a big slug of your own money, on people not doing what they have said they are going to do, and that some have already

sworn to do in law?

Six trillion dollars is what oil, gas, and coal companies will invest over the next ten years on turning fossil fuel deposits into reserves, assuming last year's level of investment stays the same. Reserves are by definition bodies of oil, gas or coal that can be drilled or mined economically. Regulators allow companies, currently, to book them as assets, and on the assumption that they are at zero risk of being stranded - left below ground, "value"unrealized - over the full life of their exploitation. Yet a report published today shows they are at very real risk of being stranded, and in large quantity.

Governments agreed in 2010 to keep global warming below two degrees. The Carbon Tracker Initiative, a group of concerned financial analysts based in London, has teamed up with the Grantham Institute, a climate research centre, to calculate how much carbon it would take to reach that two degree threshold, and what it means for the capital markets. By this calculation, fully 60 to 80% of oil, gas and coal reserves listed on stock exchanges are unburnable.

The six trillion dollar bet is that this calculation remains entirely theoretical, and that fossil-fuel companies will be allowed to keep pumping up the carbon bubble by investing more cash to turn resources into reserves, and continue booking them at full value, assuming zero risk of devaluation. It's a bet that effectively says to government: "nah, we don't believe a word you say. We think you'll do nothing about climate change for decades."

Yet the British government, for one, has signed its targets into law, and the Copenhagen Accord brokered by the Obama administration in 2009 specifically sets 2 degrees as its goal. And all governments at the most recent annual climate negotiations have agreed to set legally binding targets at the 2015 climate summit in Paris.

Both companies and ordinary citizens ought to be very worried by this disconnect between capital markets and climate policymaking. This is because so much of the value of stock exchanges involves pension money, and so much of peoples' prosperity hinges on the value of their pensions. HSBC recently calculated that shares in coal companies could be devalued by 40-60% in a world acting on the climate threat.

Yet vast pension assets are invested in coal. The ratings agency Standard and Poor's recently concluded that the business models of tar sands companies could be invalidated in a world acting to constrain carbon. Yet vast pension assets are invested in tar sands.

The six trillion dollar bet also involves two mandatory side bets. The first is that the news on climate change doesn't get worse than it already is, so putting governments under even more pressure to act on carbon than they already are.

Sadly, we and many like us think it will, especially as natural amplifiers to global warming, like melting permafrost, kick in. For this reason we think that the Carbon Tracker Grantham figures are conservative: if they are wrong, they are much more likely to be wrong on the down side.

The second side bet is that the new civil resistance to fossil fuels won't add significantly to the pressure on governments to act. We think it will, for reasons you can see on the 350.org website, and in the rising tide of peaceful direct action on streets, in campuses, on solar rooftops, and elsewhere across society.

The pooled message to regulators, from Carbon Tracker analysts and 350.org activists alike, is clear. Do your job. Start requiring recognition of stranded carbon-asset risk in capital-markets processes. Start deflating the carbon bubble before it pops.

The message to all the players across the financial chain, from ratings agencies through accountants, to actuaries, investment advisors and all the rest, is also obvious. If the regulators won't do their job, do it for them. Jump, before you are pushed.

• Jeremy Leggett is Chairman of Carbon Tracker.

• Bill McKibben is founder of 350.org and Schumann Distinguished Scholar at Middlebury College

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Carbon bubble will plunge the world into another financial crisis – report

Trillions of dollars at risk as stock markets inflate value of fossil fuels that may have to remain buried forever, experts warn

Damian Carrington
The Guardian, Thursday 18 April 2013

Global stock markets are betting on countries failing to adhere to legally binding carbon emission targets. Photograph: Robert Nickelsberg/Getty Images

The world could be heading for a major economic crisis as stock markets inflate an investment bubble in fossil fuels to the tune of trillions of dollars, according to leading economists.

"The financial crisis has shown what happens when risks accumulate unnoticed," said Lord (Nicholas) Stern, a professor at the London School of Economics. He said the risk was "very big indeed" and that almost all investors and regulators were failing to address it.

The so-called "carbon bubble" is the result of an over-valuation of oil, coal and gas reserves held by fossil fuel companies. According to a report published on Friday, at least two-thirds of these reserves will have to remain underground if the world is to meet existing internationally agreed targets to avoid the threshold for "dangerous" climate change. If the agreements hold, these reserves will be in effect unburnable and so worthless – leading to massive market losses. But the stock markets are betting on countries' inaction on climate change.

The stark report is by Stern and the thinktank Carbon Tracker. Their warning is supported by organisations including HSBC, Citi, Standard and Poor's and the International Energy Agency. The Bank of England has also recognised that a collapse in the value of oil, gas and coal assets as nations tackle global warming is a potential systemic risk to the economy, with London being particularly at risk owing to its huge listings of coal.

Stern said that far from reducing efforts to develop fossil fuels, the top 200 companies spent $674bn (£441bn) in 2012 to find and exploit even more new resources, a sum equivalent to 1% of global GDP, which could end up as "stranded" or valueless assets. Stern's landmark 2006 report on the economic impact of climate change – commissioned by the then chancellor, Gordon Brown – concluded that spending 1% of GDP would pay for a transition to a clean and sustainable economy.

The world's governments have agreed to restrict the global temperature rise to 2C, beyond which the impacts become severe and unpredictable. But Stern said the investors clearly did not believe action to curb climate change was going to be taken. "They can't believe that and also believe that the markets are sensibly valued now."

"They only believe environmental regulation when they see it," said James Leaton, from Carbon Tracker and a former PwC consultant. He said short-termism in financial markets was the other major reason for the carbon bubble. "Analysts say you should ride the train until just before it goes off the cliff. Each thinks they are smart enough to get off in time, but not everyone can get out of the door at the same time. That is why you get bubbles and crashes."

Paul Spedding, an oil and gas analyst at HSBC, said: "The scale of 'listed' unburnable carbon revealed in this report is astonishing. This report makes it clear that 'business as usual' is not a viable option for the fossil fuel industry in the long term. [The market] is assuming it will get early warning, but my worry is that things often happen suddenly in the oil and gas sector."

HSBC warned that 40-60% of the market capitalisation of oil and gas companies was at risk from the carbon bubble, with the top 200 fossil fuel companies alone having a current value of $4tn, along with $1.5tn debt.

Lord McFall, who chaired the Commons Treasury select committee for a decade, said: "Despite its devastating scale, the banking crisis was at its heart an avoidable crisis: the threat of significant carbon writedown has the unmistakable characteristics of the same endemic problems."

The report calculates that the world's currently indicated fossil fuel reserves equate to 2,860bn tonnes of carbon dioxide, but that just 31% could be burned for an 80% chance of keeping below a 2C temperature rise. For a 50% chance of 2C or less, just 38% could be burned.

Carbon capture and storage technology, which buries emissions underground, can play a role in the future, but even an optimistic scenario which sees 3,800 commercial projects worldwide would allow only an extra 4% of fossil fuel reserves to be burned. There are currently no commercial projects up and running. The normally conservative International Energy Agency has also concluded that a major part of fossil fuel reserves is unburnable.

Citi bank warned investors in Australia's vast coal industry that little could be done to avoid the future loss of value in the face of action on climate change. "If the unburnable carbon scenario does occur, it is difficult to see how the value of fossil fuel reserves can be maintained, so we see few options for risk mitigation."

Ratings agencies have expressed concerns, with Standard and Poor's concluding that the risk could lead to the downgrading of the credit ratings of oil companies within a few years.

Steven Oman, senior vice-president at Moody's, said: "It behoves us as

investors and as a society to know the true cost of something so that intelligent and constructive policy and investment decisions can be made. Too often the true costs are treated as unquantifiable or even ignored."

Jens Peers, who manages €4bn (£3bn) for Mirova, part of €300bn asset managers Natixis, said: "It is shocking to see the report's numbers, as they are worse than people realise. The risk is massive, but a lot of asset managers think they have a lot of time. I think they are wrong." He said a key moment will come in 2015, the date when the world's governments have pledged to strike a global deal to limit carbon emissions. But he said that fund managers need to move now. If they wait till 2015, "it will be too late for them to take action."

Pension funds are also concerned. "Every pension fund manager needs to ask themselves have we incorporated climate change and carbon risk into our investment strategy? If the answer is no, they need to start to now," said Howard Pearce, head of pension fund management at the Environment Agency, which holds £2bn in assets.

Stern and Leaton both point to China as evidence that carbon cuts are likely to be delivered. China's leaders have said its coal use will peak in the next five years, said Leaton, but this has not been priced in. "I don't know why the market does not believe China," he said. "When it says it is going to do something, it usually does." He said the US and Australia were banking on selling coal to China but that this "doesn't add up".

Jeremy Grantham, a billionaire fund manager who oversees $106bn of assets, said his company was on the verge of pulling out of all coal and unconventional fossil fuels, such as oil from tar sands. "The probability of them running into trouble is too high for me to take that risk as an investor." He said: "If we mean to burn all the coal and any appreciable percentage of the tar sands, or other unconventional oil and gas then we're cooked. [There are] terrible consequences that we will lay at the door of our grandchildren."

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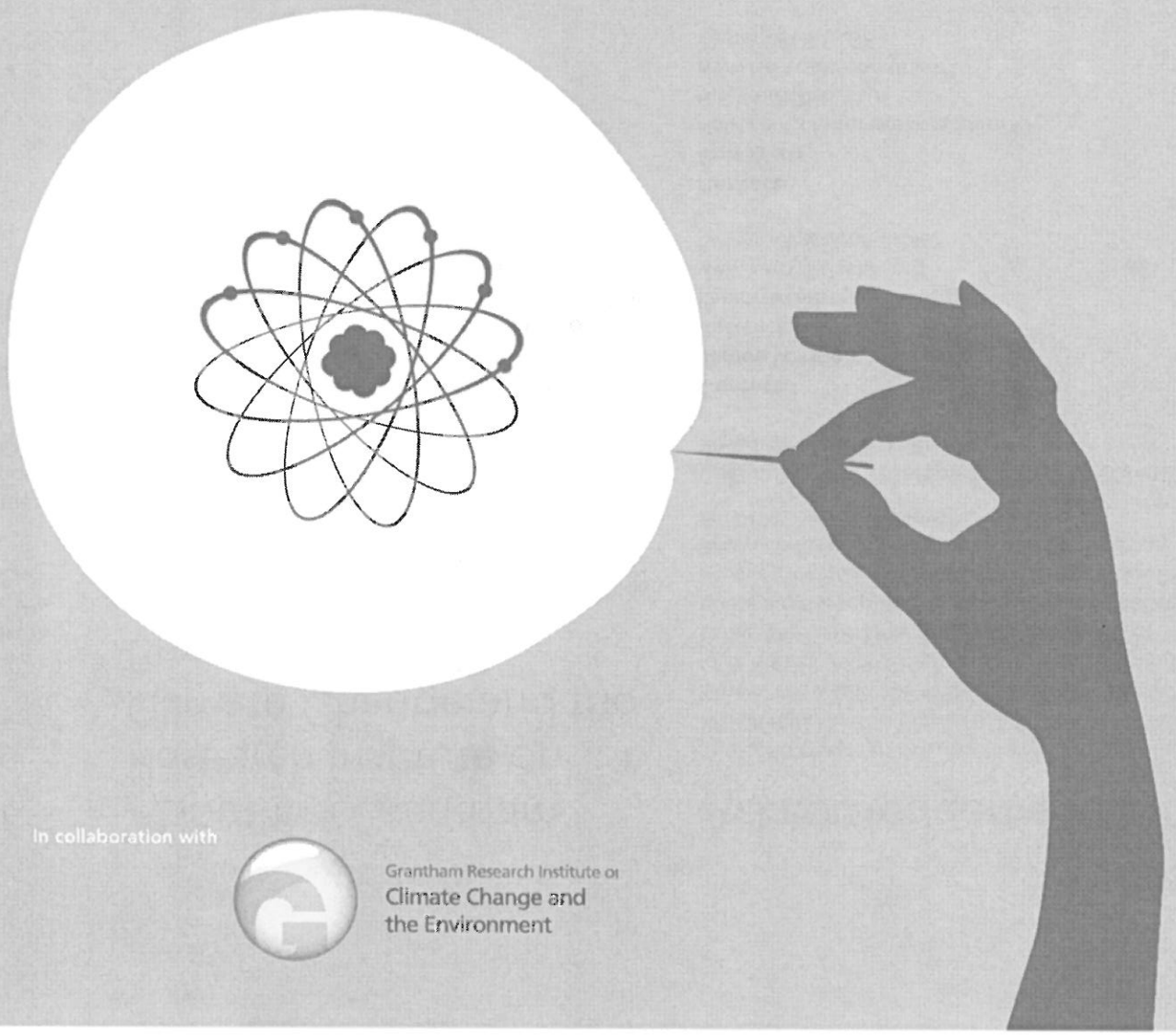
Unburnable Carbon 2013:
Wasted capital and stranded assets



Carbon Tracker initiative

In collaboration with

Grantham Research Institute on Climate Change and the Environment

About Carbon Tracker

Carbon Tracker is a non-profit organisation working to align the capital markets with the climate change policy agenda. We are applying our thinking on carbon budgets and stranded assets across geographies and assets classes to inform investor thinking and the regulation of capital markets. We are funded by a number of US and UK charitable foundations.

If you wish to explore our data visually; share the finding with others; or ask your pension fund how they are managing this risk, visit the online tool at www.carbontracker.org/wastedcapital

If you are an investor interested in the exposure of your portfolio to fossil fuel reserves, please contact us directly or through our Bloomberg page.

About the Grantham Research Institute on Climate Change and the Environment, LSE

The Grantham Research Institute on Climate Change and the Environment was established in 2008 at the London School of Economics and Political Science. The Institute brings together international expertise on economics, as well as finance, geography, the environment, international development and political economy to establish a world-leading centre for policy-relevant research, teaching and training in climate change and the environment. It is funded by the Grantham Foundation for the Protection of the Environment, which also funds the Grantham Institute for Climate Change at Imperial College London.

Acknowledgements

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Letter to readers

Our first report, in 2011, showed that based on current understanding of an allowable carbon budget to keep below two degrees of global warming, there is more fossil fuel listed on the world's capital markets than can be burned. Two degrees is a widely accepted danger threshold for global warming, and many governments have already started taking action. In our first report on unburnable carbon, we quantified for the first time how bad the overshoot is, company by company, and stock exchange by stock exchange. We showed that nowhere across the financial chain do players in the capital markets recognise, much less quantify, the possibility that governments will do what they say they intend to do on emissions, or some fraction of it. We noted how dysfunctional this is, and sketched what the players across the financial chain would have to do in order to deflate the growing carbon bubble, not least the regulators.

In this second report we dig deeper. In so doing we are particularly pleased to partner with the Grantham Institute and Lord Stern, a leading authority on the economics of climate change.

Carbon Tracker's work is now used by banks such as HSBC and Citigroup and the rating agency Standard & Poor's to help focus their thinking on what a carbon budget might mean for valuation scenarios of public companies. The IEA is conducting a special study on the climate-energy nexus which will consider the carbon bubble. Together with our allies, we have brought it to the attention of the Bank of England's Financial Stability Committee. We await their reaction to this analysis with great interest.

In view of all this, and mindful of the stakes in the carbon bubble issue, we hope that our second global report will prove useful to as wide as possible a constituency. We recognize that we are dealing with a risk mitigation exercise that begs involvement well beyond capital-markets research analysts and economists. Given the stakes for pension value, for example, should the carbon bubble go on inflating, the general public should certainly be concerned. Accordingly, we welcome wide echoing of the unburnable carbon message by campaigners since our first report, notably in Bill McKibben's much quoted August 2012 article in Rolling Stone Magazine, 'Global Warming's Terrifying New Math', and the '350.org' campaign based on it. We commend that public engagement. We hope our deeper analysis in this report will fuel more.

Jeremy Leggett and **Mark Campanale**
Chairman and Founding Director

Carbon Tracker

Executive Summary

Using all fossil fuels will breach the global carbon dioxide budget

In 2010, governments confirmed in the Cancun Agreement that emissions should be reduced to avoid a rise in global average temperature of more than 2°C above pre-industrial levels, with the possibility of revising this down to 1.5°C. The modelling used in previous analyses by Carbon Tracker and the IEA showed that the carbon budget for a 2°C scenario would be around 565 – 886 billion tonnes (Gt) of carbon dioxide (CO_2) to 2050. This outcome assumes that non-CO_2 greenhouse gas emissions (e.g. methane and nitrous oxide) remain high.

This budget, however, is only a fraction of the carbon embedded in the world's indicated fossil fuel reserves, which amount to 2,860GtCO_2. A precautionary approach means only 20% of total fossil fuel reserves can be burnt to 2050. As a result the global economy already faces the prospect of assets becoming stranded, with the problem only likely to get worse if current investment trends continue - in effect, a carbon bubble.

Stress-testing the carbon budgets

Carbon Tracker, in collaboration with the Grantham Research Institute for Climate Change and the Environment at the London School of Economics and Political Science, has conducted new analysis to stress-test the carbon budgets. This analysis estimates that the available budget is 900GtCO_2 for an 80% probability to stay below 2°C and 1075GtCO_2 for a 50% probability, confirming that the majority of fossil fuel remains are unburnable.

This CO_2 budget is higher as it assumes greater reductions in non-CO_2 emissions, such as methane, which have a higher global warming potential. In other words, applying larger CO_2 budgets depends on further action to reduce non-CO_2 emissions in areas such as waste and agriculture.

The research also examines what alternative temperature targets could mean for the amount of fossil fuels that can be burnt. The analysis concludes that even a less ambitious climate goal, like a 3°C rise in average global temperature or more, which would impose significantly larger impacts on our society and economy, would still imply significant constraints on our use of fossil fuel reserves between now and 2050.

Carbon capture and storage (CCS) doesn't change the conclusions

CCS technology offers the potential for extending the budgets for the combustion of fossil fuels. Applying the IEA's idealised scenario - which assumes a certain level of investment that is not yet secured - extends the budgets to 2050 only by 125GtCO_2.

The budget is constrained beyond 2050

Achieving a 2°C scenario means only a small amount of fossil fuels can be burnt unabated after 2050. In the absence of negative emissions technologies, the carbon budget for the second half of the century would only be 75GtCO_2 to have an 80% probability of hitting the 2°C target. This is equivalent to just over two years of emissions at current levels. As a result, the idea that there could be a fossil fuel renaissance post-2050 is without foundation.

Listed companies face a carbon budget deficit

If listed fossil fuel companies have a pro-rata allocation of the global carbon budget, this would amount to around 125 - 275GtCO_2, or 20 - 40% of the 762GtCO_2 currently booked as reserves. The scale of this carbon budget deficit poses a major risk for investors. They need to understand that 60 - 80% of coal, oil and gas reserves of listed firms are unburnable.

The London and New York stock markets are getting more carbon-intensive

The carbon embedded on the New York market is dominated by oil. The level of embedded carbon has increased by 37% since 2011. London is more coal focused, increasing its total CO_2 exposure by 7% over the same period. But other markets have higher levels of embedded carbon compared with their overall size, notably Sao Paulo, Hong Kong and Johannesburg. Markets in the south and east are raising capital primarily for coal development.

Capital spent on finding and developing more reserves is largely wasted

To minimise the risks for investors and savers, capital needs to be redirected away from high-carbon options. However, this report estimates that the top 200 oil and gas and mining companies have allocated up to $674bn in the last year for finding and developing more reserves and new ways of extracting them. The bulk of this expenditure was derived from retained earnings – pointing to the duty of shareholders to exercise stewardship over these funds so that they are deployed on financially gainful opportunities consistent with climate security.

New business models are required

At the current rate of capital expenditure, the next decade will see over $6trn will be allocated to developing fossil fuels. With a limited and declining carbon budget, much of this risks being wasted on unburnable assets. Listed companies have interests in undeveloped fossil fuel resources which would double the market burden of embedded carbon to 1541GtCO$_2$. The current balance between funds being returned to shareholders, capital invested in low-carbon opportunities and capital used to develop more reserves, needs to change. The conventional business model of recycling fossil fuel revenues into replacing reserves is no longer valid.

Risk needs redefining

Currently the investment process tends to define risk as deviation from the performance of market benchmarks such as indices. As a result, investors and their advisers fear underperformance of their portfolio (relative to a financial benchmark) far higher than the risk of absolute loss of value for fossil fuel sectors. More attention needs to be focused on the fundamental value at risk in the low-carbon transition.

Valuation and ratings aren't routinely pricing stranded assets

The 200 fossil fuel companies analysed here have a market value of $4trn and debt of $1.5trn. Asset owners and investment analysts have begun to investigate the implications of unburnable carbon. Analysis from HSBC suggests that equity valuations could be reduced by 40 - 60% in a low emissions scenario. In parallel, the bonds of fossil fuel companies could also be vulnerable to ratings downgrades, as recently illustrated by Standard & Poor's. Such downgrades would result in companies paying higher rates to borrow capital, or if the rating drops below investment grade they could struggle to refinance their debt.

Financial models that only rely on past performance are an inadequate guide for investors

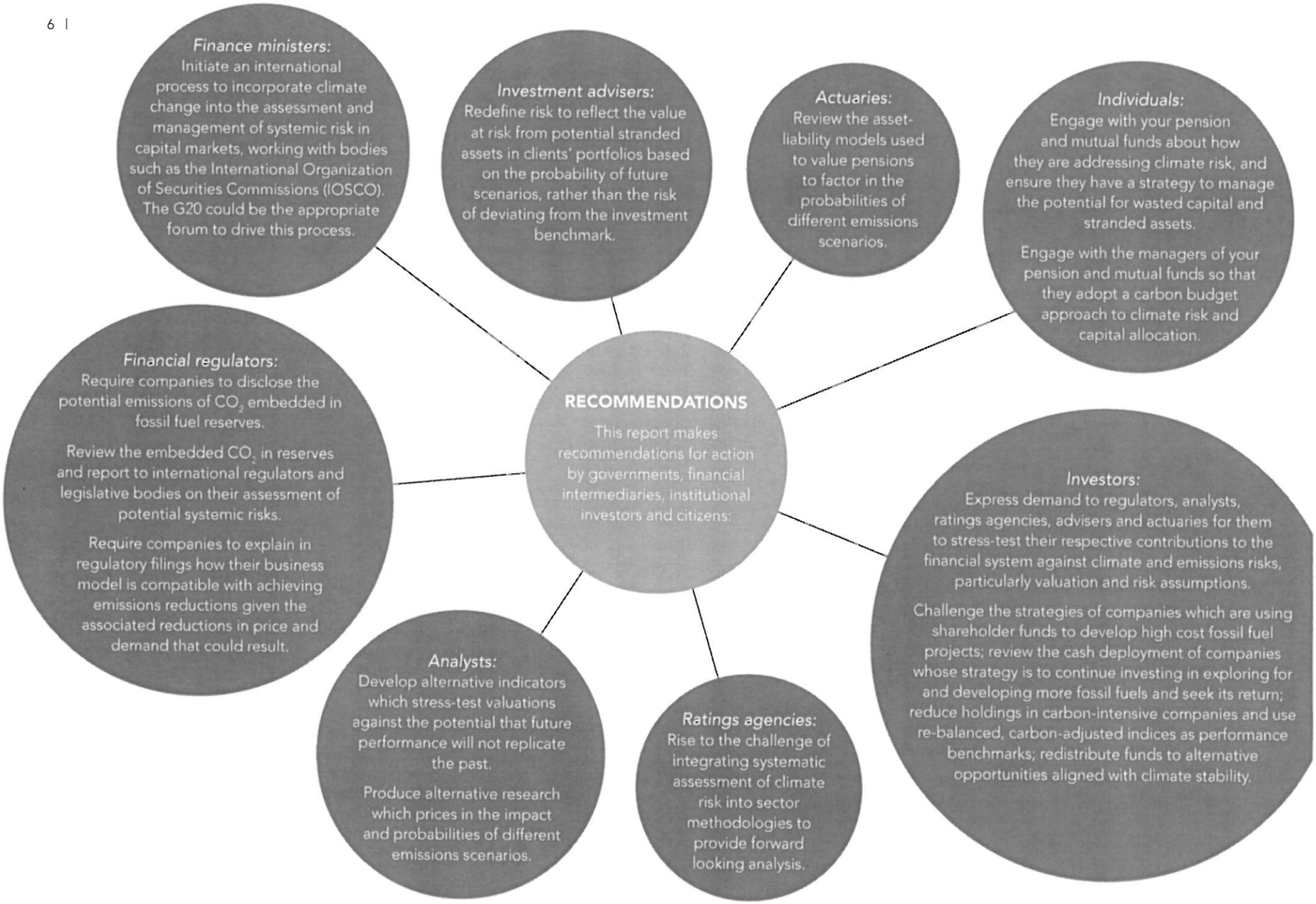
However, neither equity nor credit markets are systematically pricing in this risk in their financial models. An implicit assumption is that the fossil fuels owned by listed companies will go on to be developed and sold and the capital released used to replace reserves with new discoveries. In the context of a declining carbon budget, these valuation models provide an inadequate guide for investors and need to be recalibrated.

Do the maths better

Institutional investors need better and more future oriented investment appraisal to determine a fair assessment of their investment risks and opportunities. Reserves replacement ratios could become reserves redundancy ratios going forward. Performance metrics that have served in the past to value companies and incentivise management are being turned on their head. Financial intermediaries from analysts to actuaries need to stress-test the value at risk against a range of future emissions scenarios to give asset owners a more forward-looking risk analysis. This requires asset owners to demand valuation models from their investment advisers which address a range of potential outcomes, rather than just business as usual.

Regulators and investors need to review their approach to systemic risks

The systemic risks threatening the stability of financial markets related to unburnable carbon are growing more entrenched since 2011, not less. The markets appear unable to factor in the long-term shift to a low-carbon economy into valuations and capital allocation. In a context where market participants are driven by short-term metrics, there is a need for regulators to review their approach to the systemic risks posed by climate change. Improved transparency and risk management are essential to the maintenance of orderly markets, avoiding wasted capital and catastrophic climate impacts.


Finance ministers:
Initiate an international process to incorporate climate change into the assessment and management of systemic risk in capital markets, working with bodies such as the International Organization of Securities Commissions (IOSCO). The G20 could be the appropriate forum to drive this process.
Investment advisers:
Redefine risk to reflect the value at risk from potential stranded assets in clients' portfolios based on the probability of future scenarios, rather than the risk of deviating from the investment benchmark.
Actuaries:
Review the asset-liability models used to value pensions to factor in the probabilities of different emissions scenarios.
Individuals:
Engage with your pension and mutual funds about how they are addressing climate risk, and ensure they have a strategy to manage the potential for wasted capital and stranded assets.
Engage with the managers of your pension and mutual funds so that they adopt a carbon budget approach to climate risk and capital allocation.
Financial regulators:
Require companies to disclose the potential emissions of CO_2 embedded in fossil fuel reserves.
Review the embedded CO_2 in reserves and report to international regulators and legislative bodies on their assessment of potential systemic risks.
Require companies to explain in regulatory filings how their business model is compatible with achieving emissions reductions given the associated reductions in price and demand that could result.
RECOMMENDATIONS
This report makes recommendations for action by governments, financial intermediaries, institutional investors and citizens:
Investors:
Express demand to regulators, analysts, ratings agencies, advisers and actuaries for them to stress-test their respective contributions to the financial system against climate and emissions risks, particularly valuation and risk assumptions.
Challenge the strategies of companies which are using shareholder funds to develop high cost fossil fuel projects; review the cash deployment of companies whose strategy is to continue investing in exploring for and developing more fossil fuels and seek its return; reduce holdings in carbon-intensive companies and use re-balanced, carbon-adjusted indices as performance benchmarks; redistribute funds to alternative opportunities aligned with climate stability.
Analysts:
Develop alternative indicators which stress-test valuations against the potential that future performance will not replicate the past.
Produce alternative research which prices in the impact and probabilities of different emissions scenarios.
Ratings agencies:
Rise to the challenge of integrating systematic assessment of climate risk into sector methodologies to provide forward looking analysis.

Foreword by Lord Stern

This report shows very clearly the gross inconsistency between current valuations of fossil fuel assets and the path governments have committed to take in order to manage the huge risks of climate change.

If we burn all current reserves of fossil fuels, we will emit enough CO_2 to create a prehistoric climate, with Earth's temperature elevated to levels not experienced for millions of years. Such a world would be radically different from today, with changes in the intensity and frequency of extreme events, such as floods and droughts, higher sea levels re-drawing the coastlines of the world, and desertification re-defining where people can live. These impacts could lead to mass migrations, with the potential for widespread conflict, threatening economic growth and stability.

Governments have started to recognise the scale of the risks posed by unmanaged climate change and have already agreed to reduce annual global emissions to avoid global warming of more than 2°C. In late 2015, governments are expected to gather in Paris at the annual United Nations climate change summit to sign a treaty that will commit everyone to action that will achieve this aim.

Carbon capture and storage technology could, in theory, allow fossil fuels to be burned in a way that is consistent with the aim of reducing emissions. However, this report shows that even a scenario for its deployment that is currently considered optimistic would only make a marginal difference to the amount of fossil fuels that can be consumed by 2050.

Smart investors can already see that most fossil fuel reserves are essentially unburnable because of the need to reduce emissions in line with the global agreement. They can see that investing in companies that rely solely or heavily on constantly replenishing reserves of fossil fuels is becoming a very risky decision.

But I hope this report will mean that regulators also take note, because much of the embedded risk from these potentially toxic carbon assets is not openly recognised through current reporting requirements.

The financial crisis has shown what happens when risks accumulate unnoticed. So it is important that companies and regulators work together to openly declare and quantify these valuation risks associated with carbon, allowing investors and shareholders to consider how best to manage them.

If these valuation risks are made more transparent, companies that currently specialise in fossil fuels will be able to develop new business models that take into account the fact that demand for their products will decline steeply over the next decades, and to consider their options for diversifying in order to maintain their value. Investors will also be able to consider whether it is better to stay with high-carbon assets, or instead seek new opportunities in those businesses that are best positioned gain in a low carbon economy.

This report provides investors and regulators with the evidence they need that serious risks are growing for high-carbon assets. It should help them to better manage these risks in a timely and effective way.

Professor Lord Stern of Brentford, Chair, Grantham Research Institute on Climate Change and the Environment, London School of Economics and Political Science

The full report is available at:

http://carbontracker.live.kiln.it/Unburnable-Carbon-2-Web-Version.pdf

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THE APERIO DIFFERENCE

Do the Investment Math: Building a Carbon-Free Portfolio

As university endowments face pressure to divest stocks of companies contributing the most to climate change, much of the public discussion has focused on the looming math of the environmental impact of a carbon-based economy. As endowments decide whether or not to divest or implement screens, another kind of math is needed as part of the process: the math of portfolio analysis. (Note: this version updates an earlier paper from December 2012.)

Author

Patrick Geddes, Chief Investment Officer

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Do the Investment Math

In the past few months, a groundswell of public support has been pushing universities to divest their endowments of holdings in large fossil fuel companies. Writer and environmental advocate Bill McKibben has coined the phrase "Do the Math," referring to the dangers of rising levels of carbon dioxide in the atmosphere. This focus on the math of climate change has been catalyzed by the publication of his influential article in *Rolling Stone* magazine this past July, "Global Warming's Terrifying New Math." This has been followed up by a 21-city college campus tour encouraging carbon divestment by large endowments and pension funds.

While some endowments like that of Hampshire college have announced plans to change their investment approach, many fiduciaries sitting on endowment boards dismiss with skepticism the idea of a portfolio helping to serve environmental goals. These skeptics often claim that incorporating environmental screening, however well intentioned, simply imposes a tax on investment return. While their wariness reflects a genuine and valid desire to protect the returns earned by the endowments, outright dismissal of any screening ignores another kind of math, the kind that measures the risk to a portfolio rather than the effects of carbon dioxide on our planet.

When the idea of fossil fuel screening gets floated, the first thing an endowment committee would want to know is the impact on return, especially whether screening imposes any penalty. The research data on a wide range of social and environmental screening show no such penalty (nor any benefit either), although the results are mixed.[1] Given the lack of evidence of a return penalty, the focus then shifts to the impact of screening on a portfolio's risk, which is more predictable and easier to forecast than return. Skeptics are right when they claim that constraining a portfolio can only increase risk, but they frequently ignore the magnitude of the change in risk, which can be so minor as to be virtually irrelevant.

How can this risk impact best be estimated? For analysis, we'll use a computer program called a multi-factor model, in this case the Aegis model from the company Barra. Aegis uses both industry and fundamental factors like price-earnings ratios to measure stock risk. The model generates a forecast for tracking error, which is the statistical measurement of deviation from a target benchmark like the S&P 500 or Russell 3000 for domestic stocks or the MSCI All Country World index for global stocks. Tracking error is analogous to the concept of darts thrown at a dartboard, where the bull's-eye is the benchmark return and the measurement of the dispersion of dart throws around the bull's-eye is the tracking error over a particular time frame, e.g. monthly returns over the past three years. A small or tight tracking error means the darts (each representing one monthly return) are clustered around the bull's-eye, and a large or loose tracking error means the darts are all over the board.

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As an example of the impact of screening on tracking error, we'll analyze the extra risk of excluding a small sample of companies that the climate change advocates have identified as particularly harmful, the so-called "Filthy Fifteen," U.S. companies judged by As You Sow and the Responsible Endowment Coalition as the most harmful based on the amount of coal mined and coal burned as well as other metrics. To measure the impact of excluding these companies, we'll start with a broad-market U.S. benchmark, the Russell 3000, then exclude the thirteen publicly traded stocks of the Filthy Fifteen[2] and finally use the multi-factor model to create an optimized portfolio as close to the Russell 3000 as possible. Investors who want a portfolio free of the Filthy Fifteen can get a tracking error versus the Russell 3000 of only 0.14%, a very minor difference from the benchmark.

What Does Additional Tracking Error Cost the Investor?

If investors are to decide whether a tracking error of 0.14% to exclude the Filthy Fifteen seems reasonable or excessive, they need some context for what that number implies. First, tracking error has an expected value of zero, meaning that in a passive management framework a portfolio's return is just as likely to be above the benchmark as below. Second, the average expected tracking error for institutional active management is 5.0% according to a survey of large U.S. pension funds,[3] which means that investors already bear comparatively significant tracking error with their active managers. Third, in the language of statistics, tracking error is an estimate of standard deviation of returns versus a benchmark, which is in turn the square-root of variance. That means that tracking error cannot be simply added to overall portfolio risk (see Table 1). In other words, if the total market's risk is 17.67% (the Barra Aegis forecast standard deviation for the Russell 3000 as of December 31, 2012), the portfolio risk does not rise by another 0.14% to 17.81%. Instead, the impact of screening on absolute portfolio risk must be calculated using variance terms.

Table 1: Impact of Tracking Error for Exclusion of Filthy Fifteen

	Standard Deviation	Variance = (Std. Dev.)^2	Theoretical Return Penalty
Market Risk (Russell 3000)	17.6657%	3.1208%	
Tracking Error vs. R3000	0.1400%	0.0002%	
Screened Portfolio	17.6662%	3.1210%	
Incremental Risk	0.0006%		0.0002%

Source: Barra Aegis and Aperio Group

As Table 1 shows, adding 0.1400% of tracking error increases absolute portfolio risk by only 0.0006%, or about a half of one one-thousandth of a percent. In other words, the portfolio does become riskier, but by such a trivial amount that the impact is statistically irrelevant. In other words, excluding the Filthy Fifteen has no real impact on risk.

Skeptics could accurately point out that even for such a trivial amount, investors are technically bearing additional risk for which they are not compensated. Modern portfolio

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theory holds that any increase in risk should earn an investor a corresponding increase in return. That theoretical loss of return in this case can be measured by using historical data for the "market premium," i.e. the amount of extra return stock market investors have been paid historically for bearing extra risk. As shown in Table 1, the foregone return is 0.0002%, or two one hundredths of a basis point. Please see Appendix I for details on the calculation of the return penalty.

Having seen that excluding the Filthy Fifteen incurs virtually no risk penalty, we'll now turn to a stricter set of screens for those endowments who may want to divest a more comprehensive list of companies from an entire industry, Oil, Gas & Consumable Fuels.[4] Table 2 shows the naturally higher tracking error resulting from stricter screens.

Table 2: Impact of Tracking Error for Industry Exclusion

	Standard Deviation	Variance = (Std. Dev.)^2	Theoretical Return Penalty
Market Risk (Russell 3000)	17.6657%	3.1208%	
Tracking Error vs. R3000	0.5978%	0.0036%	
Screened Portfolio	17.6758%	3.1243%	
Incremental Risk	0.0101%		0.0034%

Source: Barra Aegis and Aperio Group. Numbers may not sum exactly due to rounding.

As Table 2 shows, adding 0.5978% of tracking error increases absolute portfolio risk by 0.0101%, with a theoretical return penalty of 0.0034%, or less than half a basis point. While that tracking error remains very low compared to active stock picking, the industry emphasis still means that if this industry outperforms the overall stock market, a portfolio with these exclusions will perform worse, while of course if those industries perform poorly relative to the market a screened portfolio would perform better.

The approach shown here of using a multi-factor model to manage risk in screened portfolios has been validated in a number of articles in academic finance journals that prove and explain this math in greater detail.[5] Furthermore, while this analysis shows the effects for U.S. stocks, the math looks very similar for non-U.S. and global portfolios as well. Excluding more industries increases the tracking error slightly, as presented in an earlier version of this paper, more details of which can be found in Appendix II.

Historical Back Test

The risk data discussed so far reflect estimates of future incremental impact on a portfolio's volatility. Another approach involves back testing hypothetical portfolios to see how they would have performed over different historical periods, i.e. looking backwards instead of forwards. Although such back testing should be taken with a healthy grain of salt, it can still provide at least some sense of how a screened portfolio would have performed. Using the same multi-factor Barra model used to create the portfolio shown in Table 2, the performance has been analyzed using historical return data. This screened portfolio has been optimized to track the Russell 3000 benchmark

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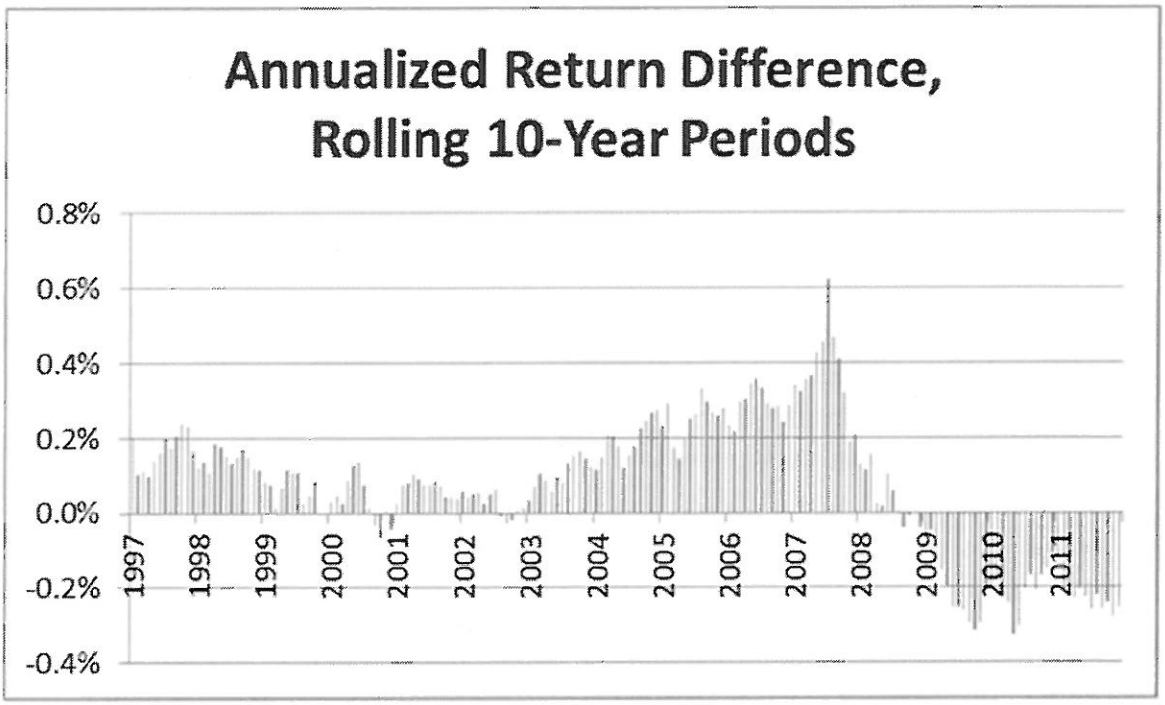
but with no stocks from Oil, Gas & Consumable Fuels. Shown below is a graph of rolling ten-year return periods from the end of 1987 through the end of 2012 for the screened portfolio, called Full Carbon Divestment. The blue bars above the 0.0% line indicate that the screened portfolio earned a higher average annual return over the trailing ten-year period, while those below the line indicate the periods for which the portfolio performed worse than the benchmark.



Return numbers show annualized return difference between Full Carbon Divestment portfolio and Russell 3000 for periods from Jan 1988 to Dec 2012.

Average Annualized 10-year Return Difference	+0.08%
Percentage of Periods Higher than R3000	73%
Percentage of Periods Lower than R3000	27%
Tracking error, current forecast	0.60%
Tracking error, historical simulation	0.78%

As the chart and table show, the average return for a 10-year rolling period over the past 25 years was slightly positive, with 73% of the ten-year periods earning higher returns. If there is no return bias, then theoretically such a screened portfolio would be expected to perform better than the benchmark only half the time. In other words, the historical data may show superior performance, but the model forecasts only risk, not any ongoing excess return. The hypothetical historical tracking error over the period was 0.78%, slightly higher than the currently forecasted 0.60%.

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Summary
In deciding whether to implement any divestment, university endowments face compelling arguments on both sides. From the advocates of divestment, endowments hear about the serious environmental damage already incurred, the frightening trajectory of the math and the benefit from taking a public stance on a critical ethical issue. From the skeptics they hear that screening will adversely affect risk and return and that the goal of any endowment should be to focus exclusively on returns. The math shown in Tables 1 and 2 does support the skeptics' view that screening negatively affects a portfolio's risk and return, but it also shows that the impact may be far less significant than presumed. It's beyond the scope of this paper to judge whether endowments should implement or avoid screening, but anyone on an endowment board facing that decision should at least do the math, in this case the investment math.

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Appendix I: Calculation of Theoretical Return Penalty

We can convert the uncompensated risk to a theoretical return penalty by using a simplified historical risk premium. Based on S&P 500 returns and risk (as a proxy for the U.S. stock market) from January 1926 to June 2011, we find a total market annual return of 9.88 percent versus T-bills over the same period of 3.60 percent for an excess return of 6.29 percent. From the same data set, the S&P 500 has had an annualized standard deviation of 19.14 percent, giving a simplified market Sharpe ratio of 0.33, calculated as follows: Market Sharpe ratio = $(r_m - r_f)/\sigma_m$, where r_m is return on market, r_f is risk-free rate, and σ_m is the risk of the market as measured by standard deviation. The simplified historical market Sharpe ratio is calculated as follows: (9.88% – 3.60%) / 19.14% = 0.33. The theoretical return penalty in Table 1 is calculated as follows: 0.0005% incremental standard deviation times a Sharpe ratio of 0.33 equals 0.0002%, or two one-hundredths of a basis point in theoretical foregone return. In other words, the impact on return, according to standard portfolio theory, is virtually nonexistent for eliminating the Filthy Fifteen.

Appendix II: Screening Impact of Broader Exclusions

In an earlier version of this paper, published in December 2012, Aperio Group analyzed a broader range of industry exclusions, as listed below.

Oil, Gas & Consumable Fuels
Metals & Mining
Electric Utilities
Independent Power Producers & Energy Traders
Multi-Utilities

To avoid penalizing cleaner companies in those industries, those scored by MSCI's environmental research as receiving 100% of their revenue from environmentally sustainable businesses have been added back and made available. Table 3 shows the naturally higher tracking error resulting from stricter screens.

Table 3: Impact of Tracking Error for Broad Carbon Exclusion

	Standard Deviation	Variance = (Std. Dev.)^2	Theoretical Return Penalty
Market Risk (Russell 3000)	17.9500%	3.2220%	
Tracking Error vs. R3000	0.6900%	0.0048%	
Screened Portfolio	17.9633%	3.2268%	
Incremental Risk	0.0133%		0.0044%

Source: Barra Aegis and Aperio Group. Estimates as of November 30, 2012.

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Disclosure

The information contained within this presentation was carefully compiled from sources Aperio believes to be reliable, but we cannot guarantee accuracy. We provide this information with the understanding that we are not engaged in rendering legal, accounting, or tax services. In particular, none of the examples should be considered advice tailored to the needs of any specific investor. We recommend that all investors seek out the services of competent professionals in any of the aforementioned areas.

With respect to the description of any investment strategies, simulations, or investment recommendations, we cannot provide any assurances that they will perform as expected and as described in our materials. Past performance is not indicative of future results. Every investment program has the potential for loss as well as gain.

Assumptions underlying simulated back test:

- Based on Barra Aegis multi-factor risk model
- Quarterly rebalancing.
- Exclude stocks from Oil Gas & Consumable Fuels industry as defined by MSCI Barra industry for back test.
- No transaction costs or management fees included.
- Benchmark returns are simulated using underlying holdings to ensure apples-to-apples comparison.

The benchmark for back-test simulation is the Russell 3000 total return index. The simulated portfolios are actively managed, and the structure of the actual portfolios and composites may be at variance to the benchmark index. Index returns reflect reinvestment of dividends but do not reflect fees, brokerage commissions, or other expenses of investing, which can reduce actual returns earned by investors.

Performance results from back tests of particular strategies exclude any trading or management fees that would reduce the return. Furthermore, future returns for any such strategies could be worse than the results shown or the identified benchmark. Back-testing involves simulation of a quantitative investment model by applying all rules, thresholds and strategies to a hypothetical portfolio during a specific market period and measuring the changes in value of the hypothetical portfolio based on the actual market prices of portfolio securities. Investors should be aware of the following: 1) Back-tested performance does not represent actual trading in an account and should not be interpreted as such, 2) back-tested performance does not reflect the impact that material economic and market factors might have had on the manager's decision-making process if the manager were actually managing client's assets, 3) the investment strategy that the back-tested results are based on can be changed at any time in order to reflect better back-tested results, and the strategy can continue to be tested and adjusted until the desired results are achieved, and 4) there is no indication that the back-tested performance would have been achieved by the manager had the program been activated during the periods presented above.

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Endnotes

[1] United Nations Environment Programme (UNEP) Finance Initiative and Mercer. 2007. Demystifying Responsible Investment Performance. http://www.unepfi.org/fileadmin/documents/Demystifying_Responsible_Investment_Performance_01.pdf. *

[2] The following companies incorporate the thirteen publicly trade stocks of the Filthy Fifteen:
Arch Coal Inc
Ameren Corp
American Elec Pwr Inc
Alpha Natural Resource
Consol Energy Inc
Dominion Res Inc
Duke Energy Corp
Consolidated Edison
Edison Intl
Firstenergy Corp
Genon Energy Inc
PPL Corp
Southern Co

[3] Based on a survey of Callan Associates, Inc., Mercer Investment Consulting and Watson Wyatt Worldwide. For details see GMO. 2007. White Paper, "What Should You Pay For Alpha?", https://www.gmo.com/NR/rdonlyres/F8E38661-0CD6-49EB-97DF-8D7B6AC32B43/1007/HowMuchPayForAlpha.pdf. *

[4] Based on the Global Industry Classification Standards developed by MSCI and Standard & Poor's.

[5] See the following articles:

Geddes, Patrick. 2012. Measuring the Risk Impact of Social Screening. *Journal of Investment Consulting* 13, no. 1: 45-53.

Jennings, William W., and Gregory W. Martin. 2007. Socially Enhanced Indexing: Applying Enhanced Indexing Techniques to Socially Responsible Investment. *Journal of Investing* 16, no. 2 (summer): 18–31.

Kurtz, Lloyd, and Dan diBartolomeo. 2011. The Long-Term Performance of a Social Investment Universe. *Journal of Investing* (fall): 95–102.

Milevsky, Moshe, Andrew Aziz, Al Goss, Jane Thompson, and David Wheeler. 2006. Cleaning a Passive Index. *Journal of Portfolio Management* 32, no. 3 (spring): 110–118.

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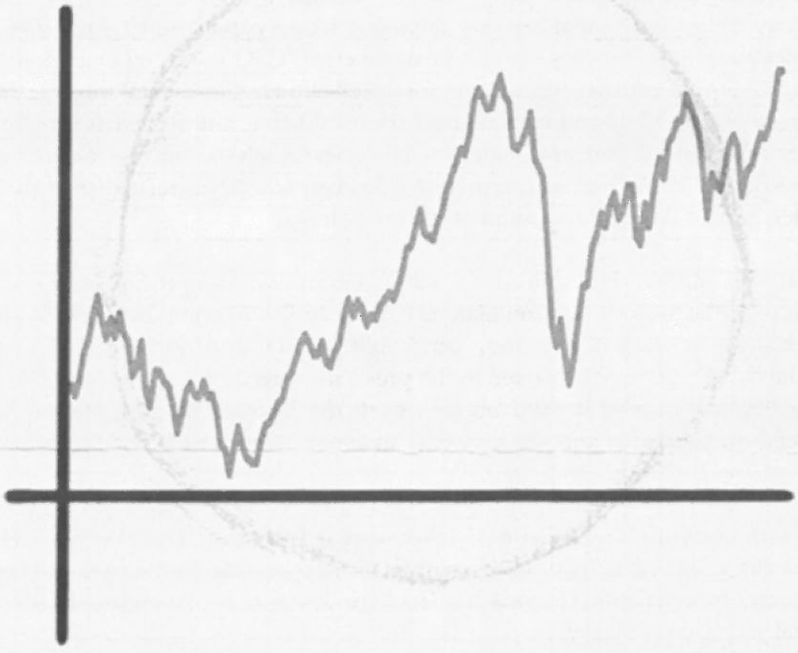
INSTITUTIONAL PATHWAYS TO FOSSIL-FREE INVESTING

Endowment Management in a Warming World

Joshua Humphreys



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About the Author

Joshua Humphreys, Ph.D., is a fellow at Tellus Institute. An historian of the social problems of capitalism, Dr. Humphreys is a leading authority on environmental, social and governance (ESG) investing, particularly among endowments. He has recently written or co-authored numerous studies on sustainability and capital markets, including recent papers on US investors in the global land rush, educational endowments and the financial crisis, ESG investing by colleges and universities, and "Total Portfolio Activation" for social and environmental impact. He has taught at Harvard, Princeton, and NYU and in the Bard Prison Initiative, and served as a Fulbright Scholar in Paris, associate fellow at the Rutgers Center for Historical Analysis, visiting research associate at the Johns Hopkins School of Advanced International Studies, scholar-in-residence at the Rockefeller Archive Center, and an Aspen Environment Forum Scholar.

For more than a decade, Dr. Humphreys has advised numerous nonprofits, businesses, community and labor groups, policymakers and multilateral organizations on complex issues in sustainability and finance. His insights on impact investing, sustainability, and foundations and endowments have been widely published and regularly cited in the press, most recently in *Bloomberg, The Boston Globe*, the *Chronicle of Higher Education*, *Pensions and Investments*, the *Journal of Investing*, and on NPR. He frequently speaks to audiences and has served as an expert witness in both litigation and policy arenas.

Dr. Humphreys is currently a member of the Advisory Board of the Dwight Hall SRI Fund at Yale University, the Board of Advisors of the Coalition for Responsible Investment at Harvard, and ELEEP, a forum of the Atlantic Council and Ecologic Institute for Emerging Leaders in Environmental and Energy Policy.

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350.org was founded in 2008 by writer Bill McKibben and a team of seven college friends. In less than five years, we've helped create a network of over 500,000 supporters and over 1,000 partner organizations in over 180 countries. 350.org exists to unite an international grassroots movement that can solve the climate crisis. Together, our movement works to change the world through bold and creative action. From our global mobilizations to the Fossil Free divestment campaign to stopping the Keystone XL pipeline, 350.org has shown that change often occurs when thousands of people rally together around a common demand and vision of a better world.

Responsible Endowments Coalition (REC) is the leading voice for responsible investment in higher education in the United States. REC educates and empowers students and campus communities on over one hundred campuses nationwide to encourage their institutions to incorporate environmental and social issues into investment practices. REC also trains the next generation of leaders on the importance of understanding money in creating change.

Sustainable Endowments Institute was founded in 2005 as a special project of Rockefeller Philanthropy Advisors. The Cambridge, MA-based nonprofit organization has pioneered research and education to advance sustainability in campus operations and endowment investment practices.

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