Concept Paper

Climate Risk Bonds

A Potential Financing Mechanism for
Natural Disaster Response and Adaptation Investments in Alaska

By

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In Brief

Bonding requirements for risky industries are nothing new. The federal government and most states require one form or another to help them cover their costs in the event of oil spills, industrial accidents, abandoned infrastructure, or default on obligations to restore and reclaim mines and drilling sites once operations cease. For example, the State of Alaska requires operators of oil and gas wells to secure bonds intended to cover public costs associated with dismantling and removal of oil and gas infrastructure and rehabilitation of sites should companies default on their obligations. Bonds are also required to cover the public costs of reclamation that mining companies may leave behind. It is time to extend this concept to the unambiguous public financial risks associated with climate change.

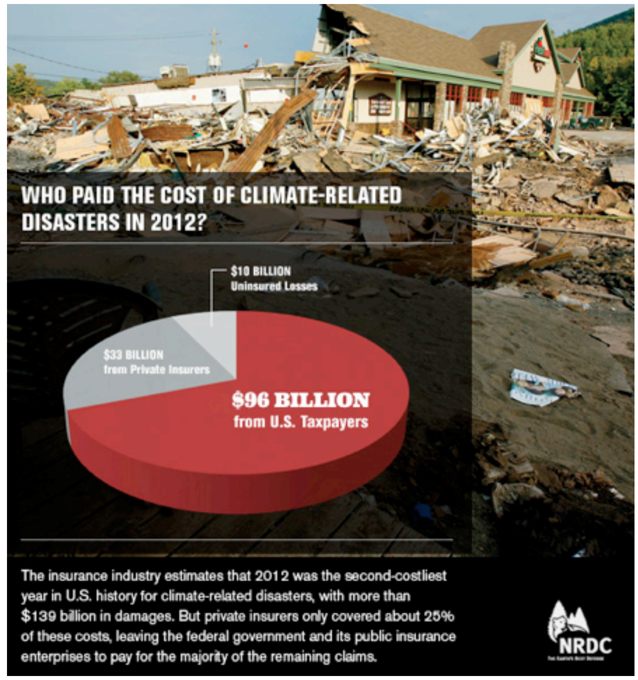
The concept of climate risk bonds is simple, and extends earlier work on assurance bonds for environmental damages in general. But the mechanics of operationalizing them will take much more research to refine. But here are the basics: Before issuing new permits to authorize extraction of oil, gas, or coal, relevant federal, state or local governments would require companies to post a climate risk bond to help offset economic damages expected from climate change disasters and to help fund adaptation measures such as moving infrastructure out of floodplains. The bond amount could be based on the social cost of carbon dioxide multiplied by the tons of carbon dioxide expected to be released over the lifetime of a coalmine, gas or oil well inclusive of emission and methane leakage during production and transport. Or it could be based on the amount of money governments need to have in reserve to deal with the expected costs of climate change as they unfold over the next several decades. As climate related disasters occur, or if communities decide they need to implement adaptation measures to protect themselves, claims against these bonds would be made either directly or through an entity with appropriate expertise and capacity.

Options for cooperative agreements with other jurisdictions that may or may not be engaged with fossil fuel extraction but nonetheless will suffer significant climate-related costs can be made to promote equity, to increase the pool of funds and to lower the risk to any particular corporation. After extraction activities cease, operators would be released from bonding requirements and the principal amounts returned with interest. Climate risk bonds provide a number of incentives to reduce marginal extraction, close wells ahead of schedule, and adopt cleaner production that reduces methane leakage and other forms of waste. They can be used in tandem with carbon taxes and other market mechanisms to fully internalize the costs of fossil fuel extraction now borne by the public.

In this brief, we introduce the concept of climate risk bonds using Alaska as a case study. By all accounts, Alaska´s melting sea ice, receding glaciers and warming salmon streams make it ground zero for rapid climate change in the U.S. It also lies at the frontiers of new fossil fuel extraction. Demonstrating the relevance of climate risk bonding in Alaska will create a model that can be used nationally and, ultimately, worldwide wherever significant extraction activities occur.

Motivation: The Staggering Public Costs of Climate Change

The motivation for climate risk bonds is simple. The public now faces enormous financial risks associated with climate change, risks that are wholly externalized to the public rather than incorporated into the costs of doing business. The *Stern Review on the Economics of Climate Change*, a 700-page report released for the British government in 2006 and authored by economist Nicholas Stern called climate change "the greatest market failure the world has ever seen."[1] According to the Review, without action, the overall costs of climate change will be equivalent to losing at least 5% of global gross domestic product (GDP) each year, now and forever. Including a wider range of risks and impacts could increase this to 20% of GDP or more, also indefinitely. A recent global assessment that added the specter of a decade long pulse of methane from the melting Arctic to standard climate impacts models found that net costs of climate change could range from $119 trillion to $458 trillion depending upon what emissions scenario unfolds.[2] Drought, storms, loss of agriculture productivity, extreme heat stress and flooding of low-lying areas are among the most significant costs anticipated. These costs are not speculative – they are already manifesting in a big way.



The insurance industry estimates that 2012 was the second costliest year in U.S. history for climate-related disasters, with more than $139 billion in damages—or close to 1 percent of U.S. GDP for 2012.[3] Private insurers picked up only 25% of this tab, leaving the other 75% for U.S. taxpayers to cover[4]. Taxpayers are also now wholly responsible for the costs of climate change adaptation – measures that must be taken now to protect communities and public infrastructure. Alaska is a prime example.

As noted by a recent climate assessment, "Alaska is ground zero for U.S. climate impacts."[5] The effects of climate change in Alaska are perhaps more stark and severe than in any other state in the union. Alaska is the only state with permafrost—until recently a type of soil considered "permanently" frozen—across vast swaths of the state. Due to the albedo effect of the rapidly melting Arctic ice cap, climate change is causing temperatures to rise faster in Alaska than any other state in the U.S., causing much of this permafrost to thaw. Alaska

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[1] Stern, Richard. 2007. Stern Review: The Economics of Climate Change. Cambridge University Press.
[2] Whiteman, Gail, Chris Hope and Peter Wadhams. 2013. "Climate science: vast costs of Arctic change." *Nature* 499: 401-403 (25 July 2013).
[3] Data from World Bank website: http://data.worldbank.org/indicator/NY.GDP.MKTP.CD
[4] Lashof, Daniel and Andy Stevenson. 2013. Who Pays for Climate Change? U.S. Taxpayers Outspend Private Insurers Three-to-One to Cover Climate Disruption Costs. Washington, D.C.: Natural Resources Defense Council.
[5] Risky Business Project. 2014. Risky Business: The Economic Risks of Climate Change in the United States. New York: Risky Business Project.

temperatures have risen by 3.4 degrees Fahrenheit over the past 50 years; winter temperatures have risen faster--by 6.3 degrees. The thawing permafrost is wreaking havoc on the built landscape in Alaska: roads are buckling and houses are sinking. Other types of infrastructure are also at risk from storm surges and flooding. Alaska has more coastline than the rest of the U.S. combined. As the state warms, much of Alaska's vast coastline, until recently protected by seasonal barrier ice, is steadily eroding. A recent analysis projected the cost of Alaska's public infrastructure at risk from continuing climate change at $3.6–$6.1 billion between now and 2030, and $5.6–$7.6 billion by 2080[6].

Native Alaskans are disproportionately affected by climate change. Alaska is home to the highest percentage of Native Alaskans or Native Americans of any state in the U.S. The 2012 Census shows that 19.6% (147,000) of Alaska's 735,000 people identified as American Indian and Alaska Native, alone or in combination[7]. Of the 200 coastal Alaska Native Villages, 90% have been affected by flooding, erosion and subsidence due to melting permafrost, melting ice barriers and rising sea levels[8]. Because most Native Alaskans live in coastal areas or near rivers, climate change will require many of these villages to be resettled. The costs of doing so are projected to be huge.

According to the U.S. Army Corps of Engineers, the estimated cost of relocation for Kivalina's 400 residents runs between $95 and $125 million. The Government Accountability Office (GAO) estimates it to be between $100 and $400 million[9]. Thus, on the low end, the cost to relocate Kivalina runs about $237,000 per resident and, at the high end, it could cost $1 million per resident. Newtok, Alaska, is in the process of relocating because of erosion that is expected to swallow up the town. But the cost of relocating just this one village could run as high as $130 million according to an estimate by the Army Corps of Engineers[10]. With 354 villagers in Newtok, that amounts to roughly $370,000 per person. There are 30 to 60 villages that will need to be physically relocated as ocean ice, sea levels, seasons become unpredictable in Alaska. At a cost of at least $100 million per village, that's $6 billion total. Resettlement may also be needed for those living in areas susceptible to melting permafrost. Although most Alaskans live in permafrost-free areas, an estimated 100,000 Alaskans (about 14% of the population) live in areas sensitive to permafrost degradation.[11] Assuming all 100,000 people would need to be resettled, and using the high end for costs of resettlement per person thus far, or $1 million per person—the worst case scenario—the resettlement cost alone due to melting permafrost could amount to $100 billion.

Climate change has also affected the supply of fish and game for Native Alaskans and other natives, food under threat due to a changing climate. Thus, an additional cost that must be accounted for due to climate change is the total cost of food per day to previously subsistence-based economies, again, assuming a worst-case scenario. A month's worth of food in Alaska

[6] Larsen, Peter H. et al. 2008. "Estimating Future Costs for Alaska Public Infrastructure at Risk From Climate Change." Global Environmental Change.

[7] American Indian census facts \available online from Infoplease.com at: http://www.infoplease.com/spot/aihmcensus1.html#ixzz33bopHcCK

[8] Patriot Daily News Clearinghouse. Sep 13, 2013 . "Hummingbirds: Native Villages Forced To Relocate Due To Climate Change Impacts."

[9] Abate, Randall S. 2010. Public Nuisance Suites for the Environmental Justice Movement: The Right Thing and the Right Time." Washington Law Review.

[10] Tribal Climate Change Profile: Relocation of Alaska Native Communities. April 2011. University of Oregon.

[11] US Army Corps of Engineers. 2003. Climate Change, Permafrost, and Impacts on Civil Infrastructure. Available online at: http://www.arctic.gov/publications/other/permafrost.html.
U.S. Arctic Research Commission, Arlington, VA, USA.

costs roughly $400 per person.[12] That price will surely go up. If all 147,000 subsistence-based Native people lost their wild food sources due to climate change or had to be relocated into areas where they could not fish, hunt or gather plant-based foods, the replacement cost could run upwards of $705 million per year. Taken together, all these preliminary estimates of climate change costs in Alaska suggest that the ultimate price tag could well exceed $120 billion by 2030.

Economic Rationale: Internalizing Climate Risks

Climate change is a classic case of an environmental externality being generated by economic activity. Externalities are costs associated with economic activity that are passed on to society or the environment that are not reflected in market prices – in this case, the market prices for fossil fuels. Externalities distort markets because production and consumption decisions do not account for all costs. As a result, fossil fuels are overproduced and over-consumed. Environmental taxes are the preferred tool for internalizing these externalities and correcting market prices so that they reflect all relevant costs. However, despite prominent supporters in both the Republican[13] and Democratic parties calling for a carbon tax, Congress is loath to act. Among the reasons for inaction: the negative effects of a tax are relatively easy to project, but the costs of climate change in any one congressional district are not. Additionally, climate change costs are complex: their timing, magnitude, geographic manifestation and distribution amongst various sectors are highly uncertain. In any particular region then, climate change is a risk rather than a certainty.

Pro-industry groups exploit this imbalance by targeting members of Congress with state-specific fact sheets on the economic costs of carbon taxes in their districts, mostly in terms of job loss.[14] On the other hand, cost projections for climate change are more generalized – typically reported as a range and as a percent of gross state product rather than in terms of costs to specific economic sectors in specific districts. Moreover, many advocacy organizations oppose carbon taxes on equity grounds. Without equity adjustments, carbon taxes could represent a higher share of household budgets for low-income families. Taking into account both direct and indirect energy costs, a recent Brookings report found that the carbon tax burden would comprise 3.5 percent of the income of the poorest decile of households and only 0.6 percent of the income of the highest decile.[15] However, most carbon tax proposals put forth embrace various tools to ensure costs do not fall disproportionately on those least able to pay.

Despite this opposition, there is nearly universal agreement that carbon emissions pose a significant economic risk that must be addressed. The US military, for example, considers climate change a severe risk to national security and a catalyst for global political conflict.[16] And

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[12] Market food prices are typically used to put a price tag on the replacement costs of subsistence foods. This figure is for illustration purposes only. Published by Numbeo.com at: http://www.numbeo.com/food-prices/city_result.jsp?country=United+States&city=Anchorage%2C+AK.

[13] Paulson, Henry. 2014. The Coming Climate Crash Lessons for Climate Change in the 2008 Recession. New York Times opinion editorial, available online at: http://www.nytimes.com/2014/06/22/opinion/sunday/lessons-for-climate-change-in-the-2008-recession.html?module=Search&mabReward=relbias&.

[14] See, e.g. American Energy Alliance fact sheets, available online at: http://americanenergyalliance.org/2013/09/17/aea-launches-phase-two-of-anti-carbon-tax-initiative-2/.

[15] Mathur, Aparna and Adele C. Morris. 2012. Distributional Effects of a Carbon Tax in Broader U.S. Fiscal Reform. Climate and Energy Discussion Paper. Washington, D.C.: The Brookings Institution.

[16] See, e.g. Davenport, Coral. 2014. "Climate Change Deemed Security Threat by Military Researchers." New York Times, May 13th, 2004, available online at: http://www.nytimes.com/2014/05/14/us/politics/climate-change-deemed-growing-security-threat-by-military-researchers.html?_r=0.

so a more politically palpable economic tool, at least in the near-term for internalizing the costs of climate change, is to focus on methods for internalizing this risk at the local or regional level. Bonding is a way to do that. For decades, environmental bonds have been suggested as a way to control the external effects from pollution and resource depletion in situations where future damages are uncertain.[17] In these situations, bonds are considered an attractive alternative to Pigouvian taxes[18] (like carbon taxes) and quantity constraints (like emissions limits). The goal is to internalize perceived or predicted (not actual) social costs into private resource allocation decisions.

As described by Costanza et al. (1990), environmental bonds would take the form of a dated assurance bond.[19] The size of the bond would be set to cover a worst-case scenario of public costs over a specified period. If estimates change, bond amounts would change along with them. The bonds would be refundable in whole or in part at the end of the specified period if the damages turned out to be less than those anticipated at the time of posting. The burden of proof for demonstrating that costs were less than anticipated would fall on the resource user. A bonding system set up along these lines would provide a “strong economic incentive for firms to research the future environmental costs of their activities, and so to improve environmental performance.”[20]

With respect to equity, bonding also has the advantage of being based on the principle of “polluter pays,” which resonates strongly with both policymakers and the public because of its inherent fairness.[21] The polluter pays principle is also generally regarded as a more efficient regulatory approach because polluters have lower costs of meeting pollution reduction goals themselves relative to a diffuse set of end use consumers whose options may be far more limited. Thus, climate risk bonds are both efficient and equitable – two key criteria for effective economic policy tools.

Legal and Regulatory Precedents

The legal underpinnings of climate risk bonds are well established. They are a form of financial assurance requirement common in environmental statutes at the federal and state level but extended to cover natural resource damages that arise in association with greenhouse gas pollution. In general, financial assurance requirements are “designed to ensure, through reasonable and cost-effective methods, that responsible parties assume the costs of closure and post-closure or remediation activities, and not transfer those costs to third parties (i.e., the general public) as a result of bankruptcy or insolvency.”[22] A number of federal environmental statutes employ financial responsibility standards. The Clean Water Act, Deepwater Port Act, Surface Mining Control and Reclamation Act, Comprehensive Environmental Response, Compensation, and Recovery Act, Price-Anderson Act, Motor Carrier Act of 1980 and the

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[17] Shogren, Jason F. and Joseph A. Herriges. 1991. The Limits of Environmental Bonds: Lessons from the Labor Literature. Working Paper 91-WP. Ames, IA: Center for Agricultural and Rural Development, Iowa State University.
[18] Pigouvian taxes are those designed to internalize social and environmental costs that distort markets: http://en.wikipedia.org/wiki/Pigovian_tax.
[19] Costanza, Robert and Charles Perrings. 1990. “A flexible assurance bonding system for improved environmental management.” *Ecological Economics* 2: 57-75.
[20] Ibid.
[21] Cordata, Roy E. 2001. The Polluter Pays Principle: A Proper Guide for Environmental Policy. Washington, DC: Institute for Research on the Economics of Taxation.
[22] Turner, John. 1998. Symposium Article: The U.S. EPA 40 C.F.R. Part 258 Financial Test/ Corporate Guarantee – New Environmental Protective, Cost-Effective Mechanisms for the Demonstration of Financial Responsibility. 9 Fordham Envtl. Law J. 567.

Resource Conservation and Recovery Act (RCRA) all reference financial responsibility mandates.

As an example, RCRA seeks to provide that adequate funds are available to "close waste management facilities properly, care for them after closure, undertake necessary corrective action, and compensate for releases from those facilities."[23] Such requirements are intended to force owners and operators of waste management facilities to recognize and 'internalize' the costs of third-party liability and site closure, post-closure, and cleanup costs so that public funds will not have to be called upon to cover these costs."[24] Congress provided that financial responsibility may be demonstrated by a variety of mechanisms, including "any one of any combination of the following: insurance, guarantee, surety bond, letter of credit, or qualification as a self-insurer."[25]

Financial assurance requirements to ensure environmental performance are also common at the state level. For example, in Alaska, financial assurance requirements are in place to ensure the "faithful performance of the requirements of approved reclamation plans" (AS 27.19.040; AS 27.21.160). To satisfy these requirements, miners must provide individual financial assurances or deposit money into a reclamation trust fund "for the purpose of protecting the public interest in reclaiming mine sites" (AS 37.14.800). Financial assurance requirements are also in place to cover dismantlement and removal of fossil fuel infrastructure and restoration of surface conditions on affected sites (20 AAC 25.005 – 25.172; 11 AAC 83.160).

Financial assurance obligations have already been extended to cover natural resource damages; in particular, for certain commercial operations that are liable for natural resource damages under the Oil Pollution Act (OPA) and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).[26] Natural resource damages are physical damages to land, fish, wildlife, biota, air, water, and groundwater. Liability for events that damage resources is well established in the United States. The goal of financial assurance mechanisms and other regulations establishing liability for natural resource damages is to "make the environment and public whole" following a pollution event.[27]

Climate risk bonds simply extend this concept further to cover the catastrophic costs associated with greenhouse gas (GHG) pollution. While pinning any particular climate related cost (natural disasters or essential adaptation expenditures) to the GHG emissions associated with combustion of fossil fuels extracted from any particular mine, oil or gas well is impossible, it is not essential for bonding purposes. All emissions from any source anywhere in the world generate social costs locally, and globally, and so to internalize these costs, it is reasonable to require bonding on fossil fuel extraction at the source. Moreover, as with taxes, fees and charges on pollution and harmful products and services that generate public costs (i.e. impervious surfaces for stormwater control, cigarettes) governments need not establish the connection between a an individual mine or well and climate change, just that the general activity of oil, coal, and gas extraction is something known to contribute to the problem and the inevitable public costs. Bonding requirements and associated annual payments to maintain them are really just another form of these fees or charges – but one that defers collection until such time as deemed necessary to cover the costs of climate disasters and adaptation as they occur. As such, public charges against bonds will be justified on the same legal grounds as all other environmental taxes, fees, and charges.

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[23] Ibid.
[24] Ibid.
[25] RCRA § 3004(t)(1), 42 U.S.C. § 6924(t)(1).
[26] Boyd, James. 2010. Lost Ecosystem Goods and Services as a Measure of Marine Oil Pollution Damages. Washington, DC: Resources for the Future.
[27] 15 CFR § 990.53.

Bonding at the extractive phase is essential, because once fossil fuels leave the source, their combustion is guaranteed. Moreover, the political consensus among negotiators at the international climate negotiations is that the upper limit of carbon dioxide emissions in the Earth's atmosphere should not exceed 2 degrees Celsius (3.6 degrees Fahrenheit). According to the International Energy Agency, we must leave roughly two-thirds to three-fourths of all known oil, gas and coal in the ground if we are to avoid exceeding this 2 degree C target. Thus, economic incentives must be focused directly at achieving that goal. Climate risk bonds are aimed at achieving this goal. And since financial assurance requirements and the bureaucratic infrastructure to enforce them already exist for extractive activities, it is an efficient regulatory approach to target climate risk bonds at the extractive phase as well.

Design Considerations for Effective Climate Risk Bond Programs

Designing effective climate risk bond programs at the state or local level will have to involve those with legal, technological, financial, climate science and economic expertise, the oil, gas and coal industry, and all stakeholders who are now bearing the full costs of climate change without recourse. There are several design considerations that will have to be researched before climate risk bond programs can be put in place:

(a) Applicability: Climate risk bond programs can potentially be put in place by any unit of government that leases lands for oil, gas, or coal extraction or otherwise approves operation permits in order to help reduce that jurisdiction's potential financial liability for climate damages caused by GHG emissions attributable to the regulated entity's production. In Alaska, oil, gas, and coal reserves are found both onshore and offshore on federal land, state land, private land, Mental Health Trust Lands, University of Alaska Lands, municipal and borough land, and lands owned by Alaska Native Corporations. Each of these owners has rights to impose climate risk bonds as a condition for leasing.[28] But not all owners may have the capacity to manage a regulatory program of this type. The State is a logical entity to manage one on behalf of all landowners, but political obstacles may exist for quite some time before the State can lead, while there may be many local jurisdictions ready to act now.

As for applicability on the producer side, climate risk bonds can apply to all producers of oil, gas, and coal, but there may be exemptions to consider – for instance, small producers that own a limited number of wells, mines that are small and approaching the end of their productive life, or producers who agree to phase out production at an accelerated pace may qualify for exemptions.

[28] For example, reclamation bonding regulations make it clear that additional restrictions (including bonds) could be required by other units of government: "Nothing in AS 27.19 precludes a federal or state agency (including the Department of Natural Resources), a state corporation, the University of Alaska, a municipality, or a private landowner, acting under its own regulatory or proprietary authority, from establishing and enforcing additional requirements or higher standards for reclamation. Compliance with this chapter does not waive or excuse compliance with those additional requirements or higher standards" (11 AAC 97.100).

(b) Amount of bond: Determining the appropriate amount of bonding required presents a number of complexities. While the goal of climate risk bonding is to reduce public exposure to the costs of climate change, the expected costs of climate change associated with combustion of fossil fuels derived from any particular production area are global in nature. Some regions – especially the Arctic and low-lying coastal zones – are expected to incur a disproportionate share of these costs. At any one time, fossil fuel production is not evenly distributed but instead concentrated geographically. There are production areas that will incur few climate related costs in the future, but also non-production areas that will incur tremendous costs. All these factors come into play in establishing bond amounts for any particular extraction operation.

In order to address this complexity, one approach is to base required bonding on the social cost of carbon (SCC). The SCC is an estimate of the economic damages associated with a small increase in carbon dioxide (CO_2) emissions, conventionally one metric ton, in a given year. The SCC is meant to be a comprehensive estimate of climate change damages and includes, but is not limited to, changes in net agricultural productivity, human health, and property damages from increased flood risk.[29] In reality, it is "very likely that [SCC] underestimates" the damages because the models on which SCC is based do not currently include all of the important physical, ecological, and economic impacts of climate change recognized in the climate change literature.[30] Nonetheless, the SCC is a useful measure that provides an indication of the price of global damage associated with emissions associated with any particular production operation.

EPA has published SCC figures for various future years (since it is expected that SCC rises with each passing year), for various discount rates, and for the 95th percentile at a discount rate of 3%.[31] The table below provides the most current estimates in 2011 dollars. In current (2014) dollars, the SCC at a discount rate of 3% is roughly $40 per metric ton of carbon.

Social Cost of Carbon Dioxide Per Metric Ton
2015 to 2050 (in 2011 dollars)

	Average Costs of Carbon Dioxide at Various Discount Rates			
Year	5%	3%	2.5%	95th percentile-3%
2015	$12	$39	$61	$116
2020	$13	$46	$68	$137
2030	$15	$50	$74	$153
2035	$17	$55	$80	$170
2040	$20	$60	$85	$187
2045	$22	$65	$92	$204
2050	$26	$70	$98	$220

Using the SCC, the requisite bond amount would be this value multiplied by the expected carbon dioxide emissions associated with combustion of fossil fuels derived from that mine, oil or gas well over its expected production lifetime or alternative bond period (after which the bond would need to be renewed). Bonds would also be inclusive of emissions and methane leakage during production and transport if they can be reasonably calculated. To illustrate, an

[29] EPA's discussion of the federal social cost of carbon (SCC) estimates is available on-line at: http://www.epa.gov/climatechange/EPAactivities/economics/scc.html.
[30] Intergovernmental Panel on Climate Change, Fourth Assessment. Available on-line at: http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_synthesis_report.htm.
[31] EPA, see Note 28.

estimate published last year for the Osprey platform suggested its production has now risen to roughly 2,500 barrels of oil equivalent (2,180 for oil) per day – or 795,700 barrels per year.[32] Over the next 10 years, this would amount to roughly 8 million barrels. When combusted, this production would generate 3,440,000 metric tones of carbon dioxide pollution.[33] At a SCC of $40 per ton, this would then justify a climate risk bond in the order of $137.6 million. To put this into perspective, the current spot price for West Coast crude is roughly $105 per barrel. If full payout of the bonds would be necessary, it would represent about 16% of the revenues generated over the next 10 years ($840 million).

(c) Types of bonding mechanisms and providers: Climate risk bonds represent a hybrid between insurance-based assurance mechanisms and bonding-based assurance mechanisms. Figuring out the precise form for climate risk bonds is complex, but can clearly draw on experience with the many forms of financial assurance of these two general types already in existence. As noted by Boyd (2001), "[t]he motivation for assurance in the bonding context is nearly identical to the motivation for assurance in the liability insurance context. In both cases, the assurance instrument guarantees that operator funds will be available in the future to internalize costs associated with their commercial operations."[34] The main substantive difference is that bond-based assurance guarantees performance to meet a relatively well known regulatory standard such as those related to mine reclamation whereas insurance-based assurance guarantees internalization of possible, but more uncertain, costs associated with future liability. Climate change costs are both well known (i.e., activities specified in climate adaptation plans)[35] and highly uncertain (i.e. natural disaster costs) and so a hybrid instrument that has aspects of both insurance and bonding assurance mechanisms may be most appropriate.

Most forms of financial assurance for environmentally risky activities take the form of surety bonds that ensure that regulated entities comply with various activities associated with clean up and restoration of affected sites once a facility is closed. The most common applications of surety bonds are for hazardous waste sites, solid waste sites, restoration of surface mines, and Dismantle, Remove and Restore (DR&R) for oil and gas facilities. In these contexts, surety bonds are a way to transfer public financial risk to private capital markets. Surety bonds are a contract between two parties (the Surety and the Principal) for the benefit of a third party (the Obligee). Surety companies are typically associated with insurance companies or other large financial institutions. In environmental risk settings, the Principal would be the oil, gas or coal producer or owner of another environmentally risky operation (like a solid waste facility) and the Obligee would be the public, represented by whatever unit of government has promulgated the bond requirements.

As an example, RCRA regulations allow for two major types of surety bonds: performance bonds and financial guarantee bonds.[36] With the former, the Surety guarantees that if the Principal has failed to meet its obligations under the terms of the bond, it will either: 1) perform the requisite closure/post-closure activity in accordance with the plan on behalf of the Principal; or 2) pay out the face value of the bond in the amount of the Obligee's expected

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[32] Daily production figures cited from Petroleum News, September 1st, 2013, available online at: http://www.petroleumnews.com/pntruncate/103159048.shtml.

[33] On average, a barrel of crude generates .43 metric tons of carbon dioxide emissions. [cite?]

[34] Boyd, James. 2001. Financial Assurance Rules and Natural Resource Damage Liability: A Working Marriage? Discussion Paper 01-11. Washington, DC: Resources for the Future.

[35] But whether or not a jurisdiction moves ahead with implementing elements of that plan in a particular producer's operations time frame is uncertain.

[36] The following description of performance and financial guarantee bonds is taken from EPA's RCRA Subtitle C Financial Assurance Instrument Fact Sheet. Available online at: http://www.epa.gov/osw/hazard/tsd/td/ldu/financial/fatools.htm.

liability into a standby trust fund. With the latter, the Surety guarantees that it is liable for the face value of the bond in the amount of the Obligee's expected liability if the Principal has failed to perform any of the conditions in the bond; and that the Surety will pay that amount into a standby trust fund when the relevant regulatory agency informs the Surety that the Principal has failed to perform. With either type of surety bond, the Surety retains the right to pursue reimbursement from the Principal for funds paid on its behalf. Similar to a bank with a Letter of Credit, the Surety provides the Company with its financial backing. In return for the Surety's guarantee, the Surety generally receives a premium based on the face value of the bond.

As with conventional surety bonds of either type, an important feature of climate risk bond programs would be establishing unambiguous performance standards. In particular, climate risk bond programs would need to specify that performance standards for owners of oil, gas, and coal operations include defraying climate change costs attributable to combustion of the Principal's fossil fuels that manifest in the relevant jurisdiction as well as what does and does not qualify as a legitimate climate change related cost. Rather than leaving the time frame open-ended, the bond can be set for a specified period that is based on the mine or well's expected life. This will be discussed in more detail below.

Because climate risk bonds will represent a regulatory program that may involve dozens of producers of various sizes in any given locality, one way to help streamline regulatory compliance is a statewide bonding pool and associated trust fund, much like the one that now exists in Alaska and other states for mine reclamation. Under this arrangement, rather than posting an individual performance bond, miners may participate in the bonding pool by depositing 15% of the bond amount plus an annual nonrefundable fee into the State's Mine Reclamation Trust Fund (11 AAC 97.425; AS 37.14.800). Bond amounts may increase or decrease if mine operations change and thus affect the total area needing to be reclaimed. Another option is a fund along the lines of the President's proposed Climate Resilience Fund, being set up as a one-stop shop for communities seeking assistance in adaptation finance.[37] Yet another option is for some form of mutual risk-sharing agreements and associated bonding requirements. For instance, in the U.S., the Price-Anderson Act requires the licensees of each of the 115 operating nuclear reactors to participate in a mutual risk-sharing agreement. In case damages from any one accident exceeds $200 million (the cap on insurance for an individual plant) each participant in the agreement is obliged to provide a pro rata share of indemnity up to $67 million per reactor.[38] Bonds could secure this additional obligation. The financial compensation available to any Obligee in the event of a nuclear accident is then increased from a limit of $200 million to $7.6 billion. In one form or another then, providing an alternative to individual bonding requirements may also present a more manageable regulatory alternative in the context of climate risk bond programs.

(c) Claims against bonds: Jurisdictions implementing climate risk bond programs would have to work out detailed rules for when and for what events claims against climate risk bonds could be made. The intent is for a system of claims to cover public financial liability for climate change-related costs in the event that coal, oil, or gas producers do not otherwise compensate public agencies for these costs as per their performance agreements or do not have current financial capacity to cover these costs. Claims would be made by Obligees directly, or by trusts on their behalf if bonding pool options are in place. Claims could be made for (1) natural disaster response costs for events consistent with climate change, and (2) the costs of

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[37] Discussed by CEQ online at: http://www.whitehouse.gov/blog/2014/03/04/preparing-now-our-climate-future.

[38] Radetzki, Marcus and Marian Radetzki. 2000. "Private arrangements to cover large-scale liabilities caused by nuclear and other industrial catastrophes." *The Geneva Papers on Risk and Insurance*. No. 2 (180-195).

infrastructure relocation, community resettlement, or other adaptation expenses necessitated by rising seas, melting permafrost, prolonged drought, or other manifestations of climate change in the jurisdiction. Climate risk bond programs will be more effective and more resilient against challenges if the rules for legitimate claims are worked out well in advance and specified with a high degree of detail.

Since climate risk bonds are now at the concept stage, there is little to draw upon for precedent to guide a system of claims. But recent innovations with parametric payout triggers may provide a way forward, at least with respect to natural disaster costs. Instead of being based on actual claims (i.e. the Division of Forestry's costs of fighting abnormally large wildfires), the trigger is indexed to a particular threshold where the climate signal is clearly manifested (i.e. a heat wave lasting 10 days or more with an average temperature of 95). The World Bank's Pacific Catastrophe Risk Insurance Pilot Program uses parametric triggers, which make payouts predictable and quick and "provide a valuable risk financing mechanism" for Pacific Island nations who are especially vulnerable to climate disasters.[39]

(d) Equitable sharing of climate finance: One of the most inequitable aspects of climate change is that its costs are disproportionately being felt by nations, state, regions, and people that are not in the business of fossil fuel production so, even if regions move toward clean energy alternatives, their climate change damages will continue to escalate. Because climate risk bonds are levied at the point of extraction, they would appear to do little to correct this inequity. However, there is nothing in the climate risk bond concept that would not allow jurisdictions to better distribute the climate financing available through climate risk bond programs by pooling regulatory authority, much as they already do – ironically – for the distribution of oil and gas revenues.

For example, Alaska Native Claims Settlement Act (ANCSA) contains revenue sharing provisions that ensure that when mineral or timber resources are developed on Native Corporation land, all Native shareholders benefit.[40] This principle could be extended to climate risk bonds to help distribute funds available for natural disaster response and adaptation in a more equitable manner. To do this, jurisdictions that have significant resource extraction activities and put climate risk bonds in place would permit non-producing jurisdictions to make claims (up to some capped amount) against climate risk bonds taken out by their producers since the costs of GHG emissions are distributed statewide regardless of whether a region is producing or not. Entry into this revenue sharing agreement could be made contingent on the non-producing jurisdiction agreeing to put climate risk bond programs in place. The concept of climate risk bonds could even be extended internationally to help with climate disaster and adaptation costs of, say, low-lying Pacific Island states. And of course the concept can be extended to other producing jurisdictions – again, on the condition they also have climate risk bond programs in place. By ensuring climate risk bonds are in place, these non-producing regions may ensure that they remain non-producing in the future.

(e) Return of bond principal, interest, and premiums on cessation of operations: As originally conceived by Costanza and Perrings (1990), principal and premiums paid for environmental bonds would be refundable in whole or in part at the end of the specified period if the damages turned out to be less than those anticipated at the time of posting.[41] Likewise, the

[39] Artemis, January 24th 2014: "Pacific Catastrophe Risk Insurance Pilot makes first payout," available online at: http://www.artemis.bm/blog/2014/01/24/pacific-catastrophe-risk-insurance-pilot-makes-first-payout.

[40] The relevant ANCSA provisions are discussed by the Resource Development Council online at: http://www.akrdc.org/issues/nativecorporations/overview.html.

[41] Costanza, Robert and Charles Perrings, 1990, Note 17.

principal and premium from climate risk bonds would be returned in whole if there were no legitimate claims against them during the specified coverage period, or in part if claims are less than the bond amount. Whether or not interest on bond principal is paid back is a design option that should be considered.

An alternative approach – one that incentivizes early closure of marginal mines or wells – would be to make bond principals and premiums refundable once operations cease. Although in reality the effects of climate change attributable to combustion of the regulated entity's emissions will occur well beyond this date, overall, the social and economic benefits of leaving as much fossil fuel reserves in the ground as possible as per scientific consensus may be more important than continuing liability through the end of the bond period.

What Climate Risk Bonds Would Mean for Alaska Climate Finance

To illustrate what climate risk bonds could mean for Alaska Climate Finance, consider the most recent projections of oil, gas, and coal production for the next 20 years, the carbon dioxide emissions associated with combustion of those fossil fuels, a commensurate level of bonding based on the social costs of carbon, and the State's expected costs of climate change.

For coal, Alaska has only one operating surface coal mine – the Usibelli Mine – that has averaged about 2 million short tons per year in production. Assuming no other mines come on line (although there are several in pre-permitting stages) and, if they do they merely compensate for reduced Usibelli production, the 20-year total coal produced would be 40,000,000 short tons.[42] Each short ton of coal, when combusted, releases 4,631.5 pounds of carbon dioxide, or roughly 2.1 metric tons.[43] Multiplying this out yields roughly 84,000,000 tons of carbon dioxide emissions associated with coal production in Alaska over 20 years.

According to the most recent estimates by the Energy Information Administration (EIA), crude oil production in Alaska was .53 million barrels per day (mbpd) in 2012, a rate that is expected to fall as low as .24 mbpd by 2030 but then rise sharply to .38 mpbd by 2035.[44] Interpolating between EIA's five-year increments yields a 20-year production estimate of 2,803,200,000 barrels. When combusted, each barrel releases .43 metric tons carbon dioxide, so emissions attributable to the next 20 years of oil production in Alaska are on the order of 1.2 billion tons.[45]

EIA also projects natural gas production, net of extraction losses. In 2015, Alaska is expected to produce .31 trillion cubic feet (tcf) of natural gas, falling as low as .26 tcf in 2025 but then rising steeply to 1.19 by 2030 and staying level thereafter.[46] Over the 20-year period, this translates into roughly 12.57 tcf. EIA estimates that each thousand cubic feet of natural gas combusted yields 117 pounds of carbon dioxide.[47] Doing the math, this means that if Alaska natural gas were developed and combusted as expected, it would be responsible for 667 million metric tons of carbon dioxide emitted into the atmosphere over 20 years.

Combining these estimates suggests Alaska production of coal, oil and gas over the next 20 years will be responsible for just over 2 billon metric tons of carbon dioxide emissions and associated climate change costs in Alaska, and worldwide. If the State implemented a climate

[42] Projections based on US Energy Information Administration, Alaska State Profile and Energy Estimates, updated June 19, 2014.
[43] US Energy Information Administration, Carbon Dioxide Coefficients by Fuel, February 14, 2013, available online at: http://www.eia.gov/environment/emissions/co2_vol_mass.cfm.
[44] US Energy Information Administration, Annual Energy Outlook 2014 with Projections to 2040, April 2014, p. 174. Available online at: http://www.eia.gov/forecasts/aeo/pdf/0383%282014%29.pdf
[45] US EIA, 2013, Note 41.
[46] US EIA, 2014, Note 42.
[47] US EIA, 2013, Note 41.

risk bond program soon, requisite bonding at today's social cost of carbon ($40 per metric ton) would represent an $80 billion source of potential finance for dealing with natural disasters attributable to climate change and paying for adaptation measures necessitated by rising seas, melting permafrost, and other manifestations of climate change. How does this compare with cost of climate change projections?

According to macroeconomic modeling by the Rhodium Group, LLC, the direct costs of climate change in the form of losses in agricultural and worker productivity, mortality, disease, rising energy costs, storms and coastal inundation will average 3.5% of GDP nationwide through 2100, with the hardest hit states experiencing costs approaching 10% of gross state product (GSP).[48] Although Alaska was not specifically modeled, a companion report identifies it as "ground zero" for climate change and so losses are likely to be at the upper end of the distribution.[49] Currently, gross state product in Alaska is roughly $56 billion.[50] Assuming a 2.5% growth rate over the next twenty years (in line with US projections) and applying a cost of climate change figure of 6.75% (halfway between the US average of 3.5% and the 10% high end) this translates into expected climate change costs over the next twenty years of roughly $96 billion, or $48 per metric ton of carbon dioxide emissions from Alaska coal, oil and gas production over this period.

While one can always take issue with climate models and their projections, what these figures suggest is that a climate risk bond program based on the social cost of carbon (SCC) of $40 per metric ton is reasonable because it is within the range of public financial liabilities expected in Alaska that have been quantified to date. However, estimates of climate damages are admittedly conservative. As we noted earlier, resettlement and infrastructure costs alone could well exceed $120 billion over 20 years. In addition, EPA recognizes that SCC does not currently include all of the important physical, ecological, and economic impacts of climate change recognized in the climate change literature and so it may well be that if a climate risk bond program is put in place bonding amounts should be based on a SCC significantly higher than $40 per ton.

Next Steps

Climate change is exacting a large and increasing toll on public finance, but to date, there are no mechanisms in place to shift the burden to where it belongs: on the polluter. Furthermore, despite claims that up to three-fourths of proven fossil fuel reserves must remain in the ground if we are to avoid dangerous and perhaps unstoppable climate change, the oil, gas and coal industries have little incentive to end their profitable extractive activities. Climate risk bonds may present an efficient and equitable option to achieve both goals in a way that recognizes the inherent uncertainties involved in projecting where, to what extent, and when climate change costs will manifest.

Based on the concept of environmental bonds first proposed by Costanza and Perrings in 1990 and financial assurance mechanisms for environmental hazards already in place, climate risk bonds can be required by any unit of federal, state or local government that authorizes fossil fuel extraction as a way to reduce public financial liabilities their jurisdictions may face in the future as climate change unfolds. Important design features for any climate risk bond program include specification of who is authorized to require bonds, what entities need to secure them, how they relate to regulatory performance standards, correct amounts of the

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[48] Rhodium Group, LLC. 2014. American Climate Prospectus. Economic Risks in the United States. Prepared as an Input to the Risky Business Project. New York: Rhodium Group, LLC.

[49] Risky Business Project, 2014, Note 5.

[50] According to the Bureau of Economic Analysis, Alaska's GSP in 2013 was $51 billion in 2009 dollars. That translates into $56.1 billion in 2014 dollars.

bonds, a system for claims against bonds, rules for return of bond principal and premiums and rules for sharing climate finance with other jurisdictions. While these design features have been discussed briefly in this concept note, an important next step would be to refine them on the ground with several jurisdictions in a diverse array of regulatory settings.

Concurrently, more research needs to be done on the legal basis for climate risk bonds so that they are firmly grounded not only in existing statutes but also in precedents established by case law. Additional research also needs to be completed on the economic feasibility of climate risk bonds from the perspective of private insurers. It may be that climate risk bonds are too risky for the private sector to handle alone, and that some other quasi-public entity needs to be the issuer. Once these and related issues are addressed in earnest and pilot programs established on the ground, a domino effect may result as more and more state and local jurisdictions and, eventually, the federal government and other national governments recognize the wisdom of reducing public liabilities for climate damages using longstanding regulatory mechanisms that are already in place based on principles that are universally accepted.