Carbon Intensity Bonds: Promoting Economic Growth Alongside Emission Reduction

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USAEE Case Competition 2014
3/10/2014
Summary of Findings

1. We recommend that Goldworthy Capital promote a Carbon Intensity Bond (CI-Bond) at the B20 summit. A CI-Bond is a green bond where bonds are evaluated based on both rate of return as well as the amount of carbon abated for a set of projects.

2. The current green bond market will take over a decade to provide capital at a scale similar to the proposed CI-Bond market.

3. CI-Bonds lower the cost of capital for carbon abatement projects. This is achieved by reducing income tax liability relative to the CI-Bond’s carbon abatement rating.

4. The carbon abatement level for a carbon abatement project is a determined, probabilistic value based on the following:
   - The risk of project failure
   - The uncertainty of direct carbon emissions
   - The uncertainty of indirect carbon emissions
   - The uncertainty of displacement of a standard project and associated rebound effects (% of a project displaced)
   - The uncertainty associated with project additionality

5. We expect countries to value carbon abatement projects at between $5 to $20 per tonne of CO$_2$e abated.

6. We expect 7 GT to 15 GT of CO$_2$e to be abated per year with implementation of the CI-Bond financing mechanism.

7. We expect this mechanism to attract $130 billion to $550 billion per year for investment in carbon abatement projects.

8. The U.S. has the potential to abate 0.6 GT of CO$_2$e per year through CI-Bonds, attracting $22 billion in carbon abatement investments per year.

9. China has the potential to abate 0.2 GT of CO$_2$e per year through CI-Bonds, attracting $7 billion in carbon abatement investments per year.

10. CI-Bonds will have lower risk for investors than corporate bonds.

11. CI-Bonds allow for governments to support green projects using a market-based, technology neutral mechanism that does not pick winners or losers.
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1. Introduction

This report was commissioned by Goldworthy Capital and contains detailed analysis and assessment of clean energy financing strategies to be promoted at the B20 Summit. All analysis presented in this report makes use of investment scenarios and sensitivity analysis around important variables to provide a robust document that may be used to inform decisions.

1.1 Scope
To date, International efforts to reduce carbon dioxide emissions have been limited to a patchwork of regional policy approaches, with no internationally agreed on mechanisms or binding agreements for emission reduction targets. Even where regional policies have been implemented, difficulties and meaningful policy outcomes have been limited. The cap and trade program instituted in the European Union, for instance, has failed to provide meaningful emission reductions given the 2008 economic recession which flooded the market with a surplus of carbon credits, resulting in little to no climate benefits [1].

Given the ongoing failure for international climate policies, we have looked to develop and assess carbon dioxide mitigation approaches that make use of financial instruments to promote carbon reductions alongside economic growth. The recommendations presented in this report by The Coalition for a Better Tomorrow, Today! are inline with the B20 goals of emphasizing “Green Growth” through the use of pricing mechanisms and investment grade sectoral policies that promote green products and services.

Our proposed financial instrument, which we refer to as Carbon Intensity Bonds (CI-Bonds), augments an already existing fixed income instrument known as Green Bonds. By introducing a tax reduction to green bonds that are proportional to the potential amount of carbon abatement for a given project, we create an instrument that effectively reduces the cost of capital for green projects. This allows governments to fund projects with high carbon abatement potential without explicitly “picking winners”.

We have utilized the carbon abatement data from McKinsey & Company to guide financing decisions and analysis [2]. These data allow for creation of the following marginal abatement cost (MAC) curves for carbon dioxide emissions. We assume a market exchange rate of 1.37 USD/Euro.
Figure 1.1: MAC curves for global carbon abatement

As evident from figure 1, the majority of lowest-cost investments will come from Latin America, Developing Asia, and Africa, primarily in the agricultural, forestry, and waste sectors. Given this distinction, many of the proposed projects for promoting energy efficiency improvements in the already developed world are likely to have minimal impact on global carbon emission reduction.

1.2 Discussion of China and the U.S.
China and the United States are the two largest emitters of GHG emissions. As such, there is considerable need for these countries to work to reduce emissions. Based on the McKinsey & Company China report, as well as the McKinsey & Company U.S. report, we can assess the potential for GHG emission reductions in these two economies [3, 4].

From Figure 1.1, it is apparent that the lowest-cost emissions are from agriculture, forestry, and waste. China has a thriving industrial sector that may benefit from improvements in operating efficiency as well as reductions in waste production or improvements in usage of waste products. These improvements account for 48% of China’s GHG emission abatement potential. Agriculture accounts for another 6% of potential GHG emission reductions. At positive social costs of carbon abatement that fall below $20/tonne-CO$_2$e, it is likely that China will be able to abate 0.22 GT of CO$_2$e/year from waste projects alone. Other abatement measures far exceed $20/tonne-CO$_2$e, or are already profitable and likely to happen without additional incentives.

At a positive social cost of carbon that is below $20/tonne-CO$_2$e, the U.S. has the potential to abate roughly 0.6 GT of CO$_2$e/year. Much of this abatement is expected to
come from improved efficiencies in agricultural land management and forestry practices. About 25% of the 0.6 GT abatement potential comes from new energy projects and building retrofits.

2. Design and Structure of the Clean Investment Mechanism

2.1 Green Bonds
Green bonds are a financial instruments which bundle several green projects together. By bundling heterogeneous green projects, green bonds reduce both the risk of project default as well as the transaction costs of investing in green projects. Green project included in the green bond generally fund infrastructure and energy efficiency improvements, and therefore yield moderate single-digit returns. These modest, low risk returns make green bonds a particularly attractive investment for fixed income investment entities such as pension funds, infrastructure funds, sovereign wealth funds, and insurance funds. Despite being a relatively new financial instrument, green bonds have experienced strong demand. A recent green bond issued by the Bank of America was heavily oversubscribed despite having a coupon price of a mere 0.625% [5].

While green bonds may help lower the cost of capital for some projects, they may not adequately target projects that are effective at reducing greenhouse gas (GHG) emissions. The reasons for this is twofold:

1) Green bonds directly target green projects as opposed to carbon abatement.

   Green bonds are generally defined by the type of green project to which they provide capital. Examples include: Renewable Fuels, Energy Efficiency, Clean Transportation, Sustainable Waste and Water Management, etc. Consequently, it is not possible to measure the environmental impact of a green bond. Further, and more importantly, green bonds do not directly incentivize green projects to abate carbon.

2) Green bonds reduce the cost of capital for green projects. However, for the bond to yield a healthy rate of return, the green projects that makeup the bond must also yield modest returns.

   This is problematic because there exist a of myriad of potential green projects such as forestry management, carbon capture and sequestration, or distributed photovoltaics, which yield large social benefits, but relatively small private benefits. Projects of this nature will always receive less capital than socially desirable in the absence of public sector interaction.

The mechanism we propose, CI-Bonds, overcomes these barriers by providing a carbon abatement potential (CAP) rating alongside general investment risk ratings. These ratings enable the provision of differential tax treatment to projects, with higher tax reductions for projects that abate more carbon. This tax reduction will effectively reduce the cost of capital that green projects face in accordance with the level of carbon the project will abate.

For this reason, CI-Bonds correct for the two aforementioned shortcomings of green bonds:
1) The cost of capital that green projects face is tied to the potential carbon abatement of that project and therefore directly incentivizes green projects to abate carbon.

2) Tax reductions allow a channel which governments can use to directly reduce the cost of capital for projects with high social benefits. By introducing public sector interaction of this type, we assure projects which yield large social benefits will receive capital at a rate which is socially optimal.

A CI-Bond operates as a standard bond that pays annually a fixed coupon rate, and repays the face value of the bond at maturity. However, owning a CI-Bond gives the owner of the bond a tax write-off. This tax write-off effectively subsidises the cost of capital for carbon abatement project, but the level of these subsidies are chosen so that the bondholder is indifferent between holding the CI-Bond or a similar AAA corporate bond.

The CI-Bond is supported by two classes of assets: standard AAA corporate bonds that are expected to earn the average rate of AAA corporate bonds, and carbon abatement projects which will generate government tax write-offs. The tax write-offs will be higher for projects that abate more carbon per dollar invested, which incentivizes the investment in more cost-effective carbon abatement projects.

Table 2.1: Effective annual subsidy to carbon abatement projects ($/bond-year for each carbon abatement project)

<table>
<thead>
<tr>
<th>Project's CAP Score (tonnes CO$_2$e abated per $1000$ bond)</th>
<th>Social Cost of Carbon</th>
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<tr>
<td></td>
<td>$10</td>
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<td></td>
<td>$16.74/bond-year</td>
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</tbody>
</table>

*Note: assuming a tax rate of 30% and AAA corporate bond return of 6%.*

The table above shows that, under this mechanism, projects that are more cost effective at abating carbon will receive a higher effective annual subsidy. In essence, the CI-Bond is a market-friendly way to maximize social welfare by minimizing carbon abatement at the lowest cost possible.

Different countries might have different willingness to pay to abate carbon. This is possible since we note that higher tax-write off rates will result in higher effective subsidy for carbon abatement projects. CI-Bonds can be classified under different classes, where some classes contain carbon abatement projects that require higher effective subsidies to operate. Governments that are willing to pay more to abate carbon can choose to accept CI-Bond classes that require higher effective subsidies, while government that are willing to pay less to abate carbon choose less restrictive classes.
2.2 Example of how the CI-Bond works
Let us consider an example of a bond that combines a standard corporate AAA bond that returns 10% with a carbon abatement project (CAP) that abates 10 tons of carbon per 1000 dollar invested. The tax rate is 30% and the government provides a tax reduction of 15$ for each ton abated.

If a bondholder purchases a bond that finances the standard project alone, she will receive $0.10 \times 1000 \times (1 - 0.3) = 70$ annually. If on the other hand she purchases a CI-Bond that satisfies the criteria set in Appendix E, namely the bundle is composed of 86% AAA corporate bond and 14% carbon abatement project which earns -11.4%, then her earning will be composed of three portions. From the standard project portion she will earn $60.2$. The carbon abatement project portion will lead her to lose $11.2$. Additionally, she will receive a subsidy amounting to $21$. Combining these payments together yields $70$, which makes the bondholder indifferent to holding either bond.

2.3 Discussion of Agents
There will be several agents that need to be involved in the administration of the CI-Bond. The flowchart below outlines these agents as well as how they interact with one another.
**Standard Project** - Projects that have a positive NPV at current interest rates.

**Carbon Abatement Project** - Projects that have a lower return on investment than a comparable standard project. Carbon abatement projects also differ from standard projects as they reduce the level of carbon emitted relative to the Business-as-Usual (BAU) case (e.g. a coal power plant with carbon capture and storage compared to a standard coal power plant)

**Carbon Dioxide Abatement Rating Agencies (CDARs)** - An agency which will determine the amount of carbon that will be reduced from a given project. Rating will take place by comparing the amount of carbon reduced by the project in comparison to a BAU case. The rating given to projects will be referred to as the Carbon Abatement Potential (CAP). The act of rating the potential product will be referred to as a CAP audit.

**Originator** - The agent that issues the loan to the project. Loans issued to carbon abatement projects are green loans whereas loans issued to standard projects are standard loans. Green loans are identical to standard loans expect that green loans also have a CAP attached to the loan. Further, green loans must be used to abate carbon through measures taken that are agreed upon in the CAP audit. Failure to do so will result in a punishment administered by the rating agency.

Likely originators consist of:

1) Private Banks that will likely concentrate their lending efforts in well established markets in developed countries.

2) International Institutions, such as the World Bank, that will focus their efforts in developing countries.

**Fund** - an institution or trust that will purchase standard and green loans from the originator. The Fund will in general provide three essential services in the construction of a green bond:

1) **Diversify default risk**

   Because the Fund is a large, central entity, it will buy loans issued in many different sectors across the world. It will consequently be in a better position to diversify the risk of loan default than the smaller, localized and specialized originators.

2) **Create CI-Bonds**

   The Fund creates the CI-Bond. This will be done by bundling various loans into different Carbon Abatement Classes, based on a project’s cap rating and an assumed Social Cost of Carbon.

3) **Assure bond payments**

   The Fund will be a large trusted entity with a strong balance sheet. Consequently, it will be able to credibly assure investors that bond payments will always be made.
There are four potential agents that could serve as the Fund:

1) An international climate trust - Participating countries would donate money into this trust and therefore provide the necessary funds to insure bond payments.

2) A national climate trust - If coordinating several countries to contribute into one trust proves to be infeasible, the Fund could be comprised of a single Government.

3) International Institutions – examples include the World Bank, the IMF, regional development banks, or a combination thereof.

4) Voluntary association banks - private banks and other entities can participate in financing the fund.

**Government Tax Credit**

The main difference between the CI-Bonds and current Green Bonds is the provision of a tax write-off to bondholders that acquire the CI-Bonds. Countries that participate in the program will effectively decrease the tax liability of CI-Bond holders by a predetermined amount per ton of carbon abated.

As discussed in section 2.1, to circumvent the possible disagreements between countries’ valuation of the social cost of carbon, different governments might elect to honor only certain classes of CI-Bonds.

**Bondholder** - Traditional investors of fixed-income investments, such as bonds, are pension funds, infrastructure funds, sovereign wealth funds, and insurance funds. These entities are generally willing to invest large amounts of money now, for relatively stable and safe single-digit returns. Other potential buyers include environmentally conscious investors.

**2.4 Assessing Carbon Dioxide Abatement**

Assessing carbon dioxide abatement is a non-trivial matter. However, similar to how the risk of an investment may be assessed through rating agencies, expected carbon emissions for a project may also be assessed through life-cycle analysis conducted by a rating agency. To assess the CAP of a project, the project must be compared against the project that would have been built under a “business-as-usual” (BAU) scenario. We are calling these BAU projects “Standard Projects.” To establish this baseline, we recommend that the CDARs create standard emission distribution metrics for project classes operating in given regions each year. For new projects, a life-cycle assessment will have to be conducted based on project parameters, or a default life-cycle rating will be applied to the project based on a set of project standards that the terms of the loan will require to be met.

The following list is a minimum set of considerations that must be accounted for to assess the overall abatement potential of a project:

1) The risk of project failure
2) The uncertainty of direct carbon emissions
3) The uncertainty of indirect carbon emissions
4) The uncertainty of displacement of a standard project and associated rebound effects (% of a project displaced)
5) The uncertainty associated with project additionality

Multiplying the probabilities of project failure, project displacement, and additionality by the difference in the carbon emission probability distributions for the standard project and the carbon abatement project provides a distribution for carbon abatement potential of a project (the CAP rating). This, in turn, can be used to provide an expected value for carbon abatement from a given project.

![Figure 2.1: Carbon abatement distribution from building a pulverized coal power plant with carbon capture and storage compared to a standard pulverized coal power plant](image)

We used a monte carlo simulations to determine the above distribution. For this simulation, we assume that a coal power plant with carbon capture and storage substitutes for a coal power plant. Depending on regions, this may not be a good assumption, as the standard project could have been a natural gas power plant, or some alternative power plant type. Given this specificity, projects must be evaluated on a regional basis by the ratings agencies to assess the value of the carbon abated.

2.5 Assessing Project Additionality
There has been concern over assessing project additionality, or the likelihood that a project would have been built. If a project would have been built regardless of this financing mechanism, then additional subsidies to the project through the CI-Bond would represent a social welfare loss. To prevent this from happening, a carbon abatement project’s profitability compared to a standard project is assessed. If the cost of carbon abated under the standard project is less than the probabilistic distribution for the social cost of carbon, then the project is likely to have been built. We are using the U.S. EPA’s social cost of carbon assessment to determine the probabilistic likelihood of a project being built [6]. See Appendix B for more detail.
2.6 Risk

To understand the risk of holding a CI-Bond, we first note that a CI-Bond’s return profile is composed of two components: standard return from an AAA corporate bond component and a government tax write-off component. The government tax write-off component is guaranteed, which implies that this portion of the CI-Bond is risk-free. The other part of the bond is simply return from a diversified AAA corporate bond, which has a low risk profile.

Since CI-Bonds combine a low risk bond with a risk-free component, it will have an even lower risk profile than an AAA corporate bond. In fact, the risk of a CI-Bond can be calculated as follows:

Risk of CI-Bond = proportion of CI-Bond invested in corporate bonds * risk of AAA corporate bonds.

2.7 Enforcement of abatement

The rating agency will have to conduct retroactive investigations on projects that have received a CAP audit. This investigation is critical. Borrowers will be tempted to use their low interest green loans on more profitable standard projects. Consequently, credible punishments must be present to dissuade borrowers from misappropriating green loans in this manner.

If a punishment is too severe, however, it will discourage potential borrowers from adopting Carbon Abatement Projects. Accepting a green loan introduces additional risk that the borrower must face. This is because the borrower of a green loan has agreed to not only repay the loan, but also to abate carbon by an amount consistent with the CAP audit.

It will be important for an effective punishment to consider these countervailing factors.
3. CI-Bond Analysis

3.1 Discussion of Energy Efficiency Projects and Carbon Abatement Potential
Ultimately, the amount of carbon that may be abated using this financial mechanism comes down to the cost of a project and the social cost of carbon that countries opt into to support project financing. Using the supply curves derived from McKinsey & Company data (see Section 1), we have determined the relative social cost of carbon (SCC) needed to abate a given level of carbon dioxide emissions per year.

Given the uncertainty associated with each country’s SCC and the McKinsey & Company marginal abatement cost curves, we anticipate that:

- Carbon abatement will be between 7 GT and 15 GT of CO$_2$e/year for a SCC of $5/tonne to $20/tonne respectively.
- Projects in this range will be able to raise an additional $35 billion to $300 billion annually through this mechanism due to their carbon benefits.

As the social cost of carbon increases, the amount of capital that can be directed to support carbon abatement projects further increases. This has implications directly related to economic growth (lowering the cost of project investment), especially in the developing world, where countries with lower marginal costs of abatement will attract increasing levels of capital for projects.

Because this Clean Investment Mechanism incentivizes project financing, local banks will be able to better find investment opportunities that promote carbon abatement at the lowest possible cost. By encouraging investments based on carbon emission reductions, the system will promote lowest-cost abatement options with the highest returns on investment, which may often be from efficiency projects, further spurring economic growth.

3.2 Investment Pool
To approximate investments and the size of the financial market, we have modeled the case where a coal power plant with carbon capture and storage (carbon abatement project) displaces a standard coal power plant without carbon capture and storage (standard project). We assume that the magnitude of capital needed to finance the project is indicative of the magnitude of carbon emitted (more capital-intensive standard projects are likely to be more carbon intensive). Given this assumption, we assume that these scale factors roughly approximate the global economy and its relative carbon intensity.

We have conducted sensitivity analysis on this standard project and displacement project where we varied the capital cost of the displacement project while holding all other financing aspects constant. We then minimized or maximized the ratio of the capital cost of the carbon abatement project to the carbon subsidy received. The optimal capital cost was found by varying the SCC and the carbon abatement project’s cost of capital. We left the standard project unchanged. This provides variability for the relative cost of carbon abatement and robust analysis based on a project’s CAP rating (See Appendix C).

From this analysis, we found that:
- The total capital pool is likely to be between 1.8 and 5.5 times the value of carbon abated
- Annual capital expenditure for green projects is likely to be between $130 billion and $550 billion for a SCC between $5/tonne-CO$_2$e and $20/tonne-CO$_2$e

This compares favorable to the current green bond market which is presently $72 billion in size, and likely to grow at 25% per year [7]. Given this growth rate, the existing green bond market size will only begin to capture the effect of the proposed CI-Bond mechanism between 2023 and 2030 (See Appendix D).

Applying this analysis to the carbon abatement potential for the U.S. and China as discussed in Section 1 corresponds to capital investment of roughly $22 billion per year for the U.S., and $7 billion per year in China.

3.3 Lowering the Cost of Capital
The CI-Bond effectively serves to lower the cost of capital for carbon abatement projects. Using our financial model for a standard coal power plant and a coal power plant with carbon capture and storage, we were able to evaluate how the cost of capital for carbon abatement projects will change relative to the social costs of carbon.

![Figure 3.1 - Reductions in the cost of capital for a given project versus a specific social cost of carbon](image)

3.4 Political Economy of CI-Bonds
A salient feature of the CI-Bonds is that it can achieve carbon abatement while being politically feasible in the United States due to the attractiveness of the instrument to both sides of the political spectrum.

For conservatives, the CI-Bonds are positive since it achieves its goal with minimal intervention from governments, it reduces the overall tax load on bondholders, and it operates within the framework of free market capitalism. Additionally, investors and market forces pick the investments to capitalize, and thus the government does not pick winners.
For liberals, the CI-Bonds presents a realistic way to achieve carbon abatement, which is a key issue in the liberal agenda. Additionally, CI-Bonds achieve this with the lowest cost possible, which maximizes social welfare.

3.5 Agent Scenarios
We have generally remained agnostic about the real world entities that will embody the Fund and Originator discussed in Section 2. Selecting the correct agents to command these roles is critical since there are potentially synergy gains present. We propose two different scenarios:

1) The Fund and the Originator are both embodied by an international institution such as the World Bank. As a matter of fact, green bonds with this structure are already issued by the World Bank. This scenario will be particularly adept at providing capital to projects in the developing world, which is a region that we have previously highlighted as having high carbon abatement potential.

2) The Originator will be a private bank and the Fund will be embodied by a climate trust or a private banks. As opposed to the above scenario, CI-Bonds organized in this fashion will likely focus on developed countries with well-established private banking sector. Determining exactly which agent among the two mentioned above will embody the Fund is important. Choosing between a climate trust and private banks present a tradeoff between political feasibility and credit rating.

3.6 Equity
Environmental policies have been criticized for having unfavorable redistribution effects. For example, policies which incentivize green transportation, whether they be a fuel tax or a tax credit for hybrids, favor the wealthy. To minimize any reduction in social equity attributed to the CI-Bond, it is clear that tax reductions should avoid cutting social programs, which favor the disadvantaged.

For countries that are concerned about cutting social programs to make up the deficit in tax revenues, they may instead consider imposing a carbon tax within their local jurisdiction. A carbon tax could be used to make up all funding deficits due to the implementation of CI-Bonds, and could further be selected to create a tax-neutral policy that directly promotes investment in green technologies.
5. References


6. Appendices

Appendix A - Additionality
The Social Cost of Carbon probability distributions from the EPA were approximated as normal distributions. We assume that whether or not a project is built is dependent on its overall profitability relative to a project without carbon benefits that would not have been built. The difference in carbon emitted between these two projects and the NPV difference between projects provides a required cost for carbon to build the abatement project. Using the SCC EPA distributions, it is possible to determine the probability that the social cost of carbon is greater than or equal to the cost of carbon to build the Carbon Abatement Project. If the carbon abatement project would have been built, then there is limited need to subsidize the project. As such, the SCC cumulative probability distributions acts as a proxy for the probability of a project being built, p. As such, the carbon abatement from a given project is equivalent to 1-p.

Using a monte carlo simulation, it is possible to account for the variability in a project’s cost of carbon relative to the project additionality distribution to better assess the expected value of abatement for a project.

Appendix B - Estimating Market Size
To estimate market size, we modeled a carbon abatement project and a standard project (coal w/ CCS compared to coal w/o CCS). From this model we have been able to estimate the market size for bond investments.

We assume that the level of carbon emitted relative to the capital cost of a standard coal power plant is representative of the carbon intensity of the economy as a whole. Given this assumption. We have held the expected level of carbon abatement from the carbon abatement project constant. By varying the capital cost of the carbon abatement project, we can determine what the capital cost of the carbon abatement project is relative to the amount of carbon abated. Using a standard financing model for the standard project, we assume a 20-year lifetime, a 6.94% cost of capital (the average industry cost of capital), and an electricity price of $80/MWh of generation for a 1000 MW plant.

Given the financing model, the point at which a developer would chose to develop the CCS project is where the ROI for each project is the same. Similarly, a lending agency would only lend to a carbon abatement project assuming they are indifferent to lending to a different project. Given these two constraints, the “cost of capital” for the carbon abatement project can be found if it has a given capital cost relative to carbon abated, and there is a given social cost of carbon (what the government is willing to subsidize carbon abatement by).

Rather than solving for the cost of capital, we have allowed the capital cost of the project to change, and instead sought to maximize the ratio of the capital investment per dollar of subsidy spent, or the investment ratio. This represents the total asset pool needed to achieve carbon abatement at a given cost of abatement.

We solved for the maximum and minimum investment ratio bounded by $5/tonne and $20/tonne costs for carbon. This lead to an investment ratio range between 1.79 and 5.54. Given the marginal abatement cost curves (see Section 1), we can estimate the
total size of carbon abatement. Multiplying the total carbon abatement cost by the investment ratio yields the total, expected cost of capital that will be raised by green investment bonds each year.

Appendix C - Existing Green Bond Market
Today's green bond market is 72 billion dollars, growing at a size of 25% per year. This allows us to calculate the annual investments in green projects per year.

<table>
<thead>
<tr>
<th>Current Green Bond Market</th>
<th>Cumulative Investments (Billion $)</th>
<th>Yearly Investments (Billion $/year)</th>
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</table>

Appendix D - The Criteria of a Bundle
In order for this mechanism to be economically efficient, the government should subsidize carbon abatement projects by the social cost of carbon abatement. To achieve this, we recommend the use of tax write-offs, or reduction in tax liability. The tax write-off for each bond is equivalent to the social cost of carbon multiplied by the amount of carbon abated for a given project.

The CI-Bond we propose will hold a rating of AAA since it is guaranteed by a well capitalized fund and the full faith and credit of several highly safe governments. Through arbitrage forces, the return on two similar risk bonds should be the same. Due to the tax write-off, investors will require a lower rate of return from the CI-Bond. This lower rate translates into lower cost of financing for capital abatement projects.
Table D.1 decrease in financing costs for carbon abatement project for different required rates of returns and CAP scores, assuming a social cost of carbon of $15

<table>
<thead>
<tr>
<th>Project's CAP Score (tonnes CO₂e abated per bond)</th>
<th>Required rate of return from CI-Bond</th>
<th>4%</th>
<th>6%</th>
<th>8%</th>
<th>10%</th>
<th>12%</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>17.43%</td>
<td>15.43%</td>
<td>13.43%</td>
<td>11.43%</td>
<td>9.43%</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>38.86%</td>
<td>36.86%</td>
<td>34.86%</td>
<td>32.86%</td>
<td>30.86%</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>60.29%</td>
<td>58.29%</td>
<td>56.29%</td>
<td>54.29%</td>
<td>52.29%</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>81.71%</td>
<td>79.71%</td>
<td>77.71%</td>
<td>75.71%</td>
<td>73.71%</td>
<td></td>
</tr>
</tbody>
</table>

*Note: Assuming a tax rate of 30%.*

The table above shows that as the CAP score of the project increases, the subsidy for the project increases. On the other hand, as the required return from the project increases, the smaller the subsidy is for these projects.

Table D.2 decrease in financing costs for carbon abatement project for different required rates of returns and CAP scores, assuming a social cost of carbon of $10

<table>
<thead>
<tr>
<th>Project's CAP Score (tonnes CO₂e abated per bond)</th>
<th>Required rate of return from CI-Bond</th>
<th>4%</th>
<th>6%</th>
<th>8%</th>
<th>10%</th>
<th>12%</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>10.28%</td>
<td>8.28%</td>
<td>6.28%</td>
<td>4.28%</td>
<td>2.28%</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>24.57%</td>
<td>22.57%</td>
<td>20.57%</td>
<td>18.57%</td>
<td>16.57%</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>38.85%</td>
<td>36.85%</td>
<td>34.85%</td>
<td>32.85%</td>
<td>30.85%</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>53.14%</td>
<td>51.14%</td>
<td>49.14%</td>
<td>47.14%</td>
<td>45.14%</td>
<td></td>
</tr>
</tbody>
</table>

The table above shows that if we assume a smaller social cost of carbon, the subsidy available for carbon abatement projects decrease.

Additionally, we need to insure that the tax write-off does not exceed the tax liability, which otherwise might deter investors that have limited tax liabilities (due to, for example, high losses in a certain year which eliminate tax liabilities). To do so, we must insure that
each CI-Bonds contain sufficient proportion of a standard bond (which generate a tax liability).

Table D.3. Proportion of standard projects for different required rates of returns and CAP scores, assuming a social cost of carbon of $15

<table>
<thead>
<tr>
<th>Project’s CAP Score (tonnes CO₂e abated per bond)</th>
<th>Required rate of return from CI-Bond</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4%</td>
</tr>
<tr>
<td>10</td>
<td>94.40%</td>
</tr>
<tr>
<td>20</td>
<td>97.20%</td>
</tr>
<tr>
<td>30</td>
<td>98.13%</td>
</tr>
<tr>
<td>40</td>
<td>98.60%</td>
</tr>
</tbody>
</table>

The table above shows that carbon abatement projects with higher CAP scores are bundled at a lower percentage. This is because high CAP projects produce more tax-write offs and thus must be bundled with a higher proportion of standard corporate bond to generate sufficient tax liability.

If we put these together we can translate the annual subsidy size that each $1000 deliver to a carbon abatement project. As we see from the table below, higher CAP score projects receive higher effective annual subsidies.

Table D.4. Effective annual subsidy for carbon abatement projects per $1000 invested in CI-bonds for different required rates of returns and CAP scores, assuming a social cost of carbon of $15

<table>
<thead>
<tr>
<th>Project’s CAP Score (tonnes CO₂e abated per bond)</th>
<th>Required rate of return from CI-Bond</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4%</td>
</tr>
<tr>
<td>10</td>
<td>$9.76</td>
</tr>
<tr>
<td>20</td>
<td>$10.88</td>
</tr>
<tr>
<td>30</td>
<td>$11.25</td>
</tr>
<tr>
<td>40</td>
<td>$11.44</td>
</tr>
</tbody>
</table>