Demystifying Climate Change Markets

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Atmospheric CO₂ Concentrations and Associated Temperature Changes

Source: Based on IPCC 2003
GHGs

- Water vapor
- Carbon dioxide (GWP=1)
- Methane (23)
- Nitrous Oxide (296)
- Fluorinated gases
  - CFC-12 (10600)
  - Sulfur hexafluoride (22000)

Source: IPCC
A Few Examples ...

Emissions of greenhouse gases in the United States
(CO$_2$, CH$_4$, N$_2$O only)

The United States must introduce additional measures to reduce greenhouse gas emissions by 18.8% to fulfil the Kyoto Protocol between 2008 and 2012.

Río Azul Project
IPCC Chairman Presentation

Increasing Sea Level Rise

- Rate of global average sea level rise has risen from 1.8mm/yr to 3.1mm/yr from 1961 to 1993
- The reasons for sea level rise has been due to thermal expansion, melting glaciers & ice caps and the polar ice sheets
- Projected sea level rise at the end of the 21st Century will be 18-59 cm

Anthropogenic warming would lead to some impacts that are abrupt or irreversible

- Partial loss of ice sheets on ice polar land could imply:
  - metres of sea level rise
  - Major changes in coastlines and inundation of low-lying areas
  - Great effects in river deltas and low-lying islands
- Approximately 20-30% of species assessed so far are likely to be at increased risk of extinction
- Large scale and persistent changes in Meridional Overturning Circulation (MOC) will have impacts on marine ecosystem productively, fisheries, ocean CO₂ uptake and terrestrial vegetation
<table>
<thead>
<tr>
<th>Category</th>
<th>CO₂ concentration at stabilization (2005 = 379 ppm)</th>
<th>CO₂-equivalent Concentration at stabilization including GHGs and aerosols (2005 = 375 ppm)</th>
<th>Peaking year for CO₂ emissions</th>
<th>Change in global CO₂ emissions (2050 (% of 2000 emissions))</th>
<th>Global average temperature increase above pre-industrial at equilibrium, using “best estimate” climate sensitivity</th>
<th>Global average sea level rise above pre-industrial at equilibrium from thermal expansion only (m)</th>
<th>Numbe of assessed scenarios</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>350 – 400 ppm</td>
<td>445 – 490 ppm</td>
<td>2000 – 2015</td>
<td>-85 to -50</td>
<td>2.0 – 2.4</td>
<td>0.4 – 1.4</td>
<td>6</td>
</tr>
<tr>
<td>II</td>
<td>400 – 440 ppm</td>
<td>490 – 535 ppm</td>
<td>2000 – 2020</td>
<td>-60 to -30</td>
<td>2.4 – 2.8</td>
<td>0.5 – 1.7</td>
<td>18</td>
</tr>
<tr>
<td>III</td>
<td>440 – 485 ppm</td>
<td>535 – 590 ppm</td>
<td>2010 – 2030</td>
<td>-30 to +5</td>
<td>2.8 – 3.2</td>
<td>0.6 – 1.9</td>
<td>21</td>
</tr>
<tr>
<td>IV</td>
<td>485 – 570 ppm</td>
<td>590 – 710 ppm</td>
<td>2020 – 2060</td>
<td>+10 to +60</td>
<td>3.2 – 4.0</td>
<td>0.6 – 2.4</td>
<td>118</td>
</tr>
<tr>
<td>V</td>
<td>570 – 660 ppm</td>
<td>710 – 855 ppm</td>
<td>2050 – 2080</td>
<td>+25 to +85</td>
<td>4.0 – 4.9</td>
<td>0.8 – 2.9</td>
<td>9</td>
</tr>
<tr>
<td>VI</td>
<td>660 – 790 ppm</td>
<td>855 – 1130 ppm</td>
<td>2060 – 2090</td>
<td>+90 to +140</td>
<td>4.9 – 6.1</td>
<td>1.0 – 3.7</td>
<td>5</td>
</tr>
</tbody>
</table>

- Sea level rise under warming is inevitable
- Long time scales of thermal expansion & ice sheet response to warming imply that stabilisation of GHG concentrations at or above present levels will not stabilise sea level for many centuries
Figure TS.6. Projected risks due to critical climate change impacts on ecosystems

- 4°C: Major extinctions around globe (as exemplified for USA and Australia)
- ≥ 40% of global ecosystems transformed (culminating in biome changes)
- Few ecosystems can adapt; 50% of nature reserves cannot fulfill their objectives
- Extinction of 15-40% endemic species in global biodiversity hotspots

- Widespread coral mortality (reefs overgrown by algae)
- Major changes in polar systems; Globally, ~20-30% of species committed to extinction
- Extinction risk for polar species; Risk terrestrial biosphere becomes net C source
- ≥ 15% of global ecosystems transformed (culminating in biome changes)
- Major (~20-80%) loss of Amazon rainforest and its biodiversity
- Loss of ~50-65% fynbos, ~10-80% of various fauna in S. Africa
- ~40-50% loss of endemic plants in S. Africa, Namibia
- Major (~50%) loss of rainforest habitat in Queensland
- Coral reefs bleached
- ~10-15% of species committed to extinction
- Loss of 8% freshwater fish habitat in N. America
- Polar ecosystems increasingly damaged
- Increased coral reef bleaching
- Amphibian extinctions increasing on mountains
Equity Issues

• **Africa by 2020:**
  – Between 75 & 250 million people projected to be exposed increased water stress
  – In some countries, yields from rain-fed agriculture would be reduced by 50%

• **Asia by 2050s:**
  – Freshwater availability is projected to decrease
  – Coastal areas, especially heavily-populated mega delta regions will be greatest risk from sea flooding

• **Small Island States:**
  – Sea Level rise is expected to exacerbate inundation, storm surge, erosion and other coastal hazards threatening vital infrastructure
  – By mid-century reduced water resources in many small island states
Real Reductions in Industrialized Countries

25%, based on growth projections

1 billion tons of C/year
Reductions

**Reduction**
- Energy
  - Efficiency
  - Substitute fossil (for fossil or renewable)
- Methane
  - Land fills
  - Animals
  - Waste water
- Destruction of fluoridated compounds

**Fixing**
- Land use
  - Forestry
  - Tilling
  - others

• **All with “additionality”**
Annual Greenhouse Gas Emissions by Sector

- Industrial processes: 16.8%
- Power stations: 21.3%
- Waste disposal and treatment: 3.4%
- Land use and biomass burning: 10.0%
- Residential, commercial, and other sources: 10.3%
- Fossil fuel retrieval, processing, and distribution: 11.3%
- Agricultural byproducts: 12.5%
- Transportation fuels: 14.0%

Carbon Dioxide (72% of total)
- Industrial processes: 29.5%
- Power stations: 19.2%
- Waste disposal and treatment: 12.9%
- Land use and biomass burning: 8.4%

Methane (18% of total)
- Industrial processes: 40.0%
- Power stations: 29.6%
- Waste disposal and treatment: 18.1%
- Land use and biomass burning: 6.6%

Nitrous Oxide (9% of total)
- Industrial processes: 26.0%
- Power stations: 1.1%
- Waste disposal and treatment: 1.5%
- Land use and biomass burning: 2.3%
- Residential, commercial, and other sources: 5.9%
U.S. Situation (Domestic Only)

• Approx. 300 million TC/year of demand
  – first reductions are profitable (negawatts)
• Without forestry (conservation and fuel switching)
  – $75/ton to retire coal plants
  – $189/ton to justify nukes
• With forestry (conserv, forest, switching)
  – $42/ton for first 6MM (cons and forest)
  – $77/ton for next 470 MM (primarily forest)
Fuel Mix Switching

Table 4: Sensitivity Analysis of energy costs based on different costs of carbon offsets
(U.S. Cents per kwH)

<table>
<thead>
<tr>
<th>Cost of TM of Carbon (US$)</th>
<th>20</th>
<th>50</th>
<th>75</th>
<th>189</th>
<th>290</th>
<th>656</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renewables</td>
<td>10.53</td>
<td>10.53</td>
<td>10.53</td>
<td>10.53</td>
<td>10.53</td>
<td>10.53</td>
</tr>
<tr>
<td>US Mix</td>
<td>5.38</td>
<td>5.95</td>
<td>6.43</td>
<td>8.60</td>
<td>10.53</td>
<td>17.51</td>
</tr>
<tr>
<td>Coal PULV</td>
<td>5.57</td>
<td>6.27</td>
<td>6.86</td>
<td>9.53</td>
<td>11.90</td>
<td>20.47</td>
</tr>
<tr>
<td>Coal Depreciated</td>
<td>3.99</td>
<td>4.73</td>
<td>5.34</td>
<td>8.13</td>
<td>10.61</td>
<td>19.59</td>
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<tr>
<td>Gas</td>
<td>4.72</td>
<td>5.06</td>
<td>5.34</td>
<td>6.61</td>
<td>7.74</td>
<td>11.83</td>
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<tr>
<td>Nuclear</td>
<td>8.60</td>
<td>8.60</td>
<td>8.60</td>
<td>8.60</td>
<td>8.60</td>
<td>8.60</td>
</tr>
<tr>
<td>Solar Thermal</td>
<td>14.40</td>
<td>14.55</td>
<td>14.67</td>
<td>15.23</td>
<td>15.72</td>
<td>17.52</td>
</tr>
</tbody>
</table>
Latin America Issues

- Forestry, renewables, and conservation
- Mechanism to transact
- Credibility?
- Fossil fuel energy base (history and endowment)
- Heterogeneous region (pop, energy, forest, etc, etc)
Forest Based Carbon

• Tropical forest grows 4-5 TC/year*
• Protecting “saves” 135 tons/ha*
• conservation, managed, plantation, reforest
• links to land use planning/control/prot areas
• Risks (fire, encroachment)
• “Insurance”

* some uncertainty
Costa Rica’s Forest Production

• Cost competitive
  – forest management (preventing full forest from being pasture generates 135tons/ha) ==> Protected areas
  – at $10/TC ==> natural service payments of $50/ha/year ==> beats cattle ranching and is profitable

• High credibility
Petroleum Prices
## Energy Vulnerability: Impact of a US$10 increase in international petroleum prices

<table>
<thead>
<tr>
<th>Country</th>
<th>Impact on GDP</th>
<th>GDP per cápita (US$ 1999-2001)</th>
<th>Petroleum Vulnerability*</th>
<th>Petroleum Dependence**</th>
<th>Net Exports of Petroleum as % of GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nigeria</td>
<td>17.8%</td>
<td>328</td>
<td>-6.40</td>
<td>0.673</td>
<td>41.9%</td>
</tr>
<tr>
<td>Venezuela</td>
<td>7.8%</td>
<td>4837</td>
<td>-4.91</td>
<td>0.355</td>
<td>18.3%</td>
</tr>
<tr>
<td>México</td>
<td>0.8%</td>
<td>5733</td>
<td>-0.81</td>
<td>0.655</td>
<td>1.8%</td>
</tr>
<tr>
<td>Costa Rica</td>
<td>-1.0%</td>
<td>4222</td>
<td>1.00</td>
<td>0.506</td>
<td>-2.3%</td>
</tr>
<tr>
<td>Nicaragua</td>
<td>-3.0%</td>
<td>669</td>
<td>0.98</td>
<td>0.871</td>
<td>-7.1%</td>
</tr>
<tr>
<td>Honduras</td>
<td>-3.4%</td>
<td>917</td>
<td>1.00</td>
<td>0.730</td>
<td>-8.0%</td>
</tr>
<tr>
<td>Germany</td>
<td>-0.6%</td>
<td>23651</td>
<td>0.95</td>
<td>0.398</td>
<td>-1.3%</td>
</tr>
<tr>
<td>United States</td>
<td>-0.4%</td>
<td>34292</td>
<td>0.54</td>
<td>0.393</td>
<td>-0.9%</td>
</tr>
</tbody>
</table>

* (Consumption-Production) / Consumption
** Petroleum Consumption/ Total Primary Energy Consumption

Source: INCAE with data from UNDP/ESMAP (2005)
Two Development Paths?

CO₂ Emissions per capita vs. GDP per capita
Selected Latin America and OECD countries

Unsustainable Development

Greener Development

Two Development Paths?
Model:

“Environmental Service Payments”

Emission Source

“Credit” for emissions reduction

Mitigation project in other country

$$
Kyoto Markets vs. Voluntary

- Kyoto markets trade in Certified Emissions Reductions (CERS, and EUAs), driven primarily by European Union regulatory structure
  - Rules and standards from Kyoto Protocol, as implemented by EU

- All else is generally considered a Voluntary Emissions Reduction (VER)
Business Responses

- Automobiles
- Bananas
- Energy production and distribution
“Carbon-Neutral” Petroleum

• One barrel of carbon neutral petroleum = 1 barrel plus 0.104 MT of C (fixed)
• One cubic meter of carbon neutral gas = 1 cubic meter + 0.0005 MT of C (fixed)
Carbon-Neutral Cars

• Explosive growth in hybrids and hydrogen fueled
• Nobody is selling a “carbon neutral” car in terms of use.
• Opportunities?
Carbon-Neutral Cars

• USA: 12,000 miles/year average
  – Fleet average 16 mpg = 750 gallons/year
  – One gallon releases approx 2.5kg of C
  – Approx 2 MT of C per year
  – At $20/MT = $40/year or $400 for life of the car
  – $500 to produce a carbon neutral car

• Add “product tie-ins” with oil companies, service stations, environmental groups, local communities, etc. ==> $$
## Theoretical Price of Carbon Neutral Petroleum

<table>
<thead>
<tr>
<th>Oil Price bbl in $US</th>
<th>Carbon Price per Ton in $US</th>
<th>0</th>
<th>10</th>
<th>16</th>
<th>20</th>
<th>30</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>$20.00</td>
<td>$20.00</td>
<td>$21.04</td>
<td>$21.66</td>
<td>$22.08</td>
<td>$23.12</td>
<td>$25.20</td>
</tr>
<tr>
<td>% increase</td>
<td>0.0%</td>
<td>5.2%</td>
<td>8.3%</td>
<td>10.4%</td>
<td>15.6%</td>
<td>26.0%</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>30.00</td>
<td>30.00</td>
<td>31.04</td>
<td>31.66</td>
<td>32.08</td>
<td>33.12</td>
<td>35.20</td>
</tr>
<tr>
<td>% increase</td>
<td>0.0%</td>
<td>3.5%</td>
<td>5.5%</td>
<td>6.9%</td>
<td>10.4%</td>
<td>17.3%</td>
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<tr>
<td>40</td>
<td>40.00</td>
<td>40.00</td>
<td>41.04</td>
<td>41.66</td>
<td>42.08</td>
<td>43.12</td>
<td>45.20</td>
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<tr>
<td>% increase</td>
<td>0.0%</td>
<td>2.6%</td>
<td>4.2%</td>
<td>5.2%</td>
<td>7.8%</td>
<td>13.0%</td>
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</tr>
<tr>
<td>50</td>
<td>50.00</td>
<td>50.00</td>
<td>51.04</td>
<td>51.66</td>
<td>52.08</td>
<td>53.12</td>
<td>55.20</td>
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<td>% increase</td>
<td>0.0%</td>
<td>2.1%</td>
<td>3.3%</td>
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<td>6.2%</td>
<td>10.4%</td>
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<tr>
<td>100</td>
<td>100.00</td>
<td>100.00</td>
<td>101.04</td>
<td>101.66</td>
<td>102.08</td>
<td>103.12</td>
<td>105.20</td>
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<tr>
<td>% increase</td>
<td>100.0%</td>
<td>1.1%</td>
<td>1.7%</td>
<td>2.1%</td>
<td>3.1%</td>
<td>5.2%</td>
<td></td>
</tr>
</tbody>
</table>

Source: Castro, Pratt, "Green Petroleum in the Americas"
Effective Execution
Enhancing Demand Side Management

Peak Day

MW

Expected System Load

System Load

Hour Ending
Carbon Reductions

CO₂ Tons (Millions)

- Distribution Improvements
- MH
- Retire Plant X1
- Wind
- Upgrades
- MERP
- DSM
- Load Forecast

State CO₂ Objective
Reduction with Sales
Regulatory Standards/Markets

- European Climate Exchange ([http://www.europeanclimateexchange.com](http://www.europeanclimateexchange.com))
  - European Union Allowances (EUAs)
  - CERs (CDM compatible)
VER Carbon Standards/Registries

- Voluntary Carbon Standard (http://www.v-c-s.org/)
- Climate, Community & Biodiversity Alliance (http://www.climate-standards.org/)
- VER+ (http://www.tuev-sued.de/home_en)
VER Carbon Standards/Registries (2)

- CCX (http://www.chicagoclimatex.com/)
- RGGI (http://www.rggi.org/)
- California Climate Action Registry (http://www.climateregistry.org/)
US Trends

• Preference for Land-Use Change projects
• Quality matters
  – Unregulated market
  – Accredited standards
  – Credible NGOs and “brand-name” cache
• Pre-compliance (REGGI and CAL)
  – Near certainty of at least partial recognition