Estimating the Levelized Cost to Sequester Carbon ($/ton CO$_2$e) in Four Different Types of Forest Carbon Sequestration Projects

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Topics

• The Analytic Challenge
• EPRI Model Overview
• Forest Carbon Accounting
• Quantitative Results & Summary
The Analytic Challenge

• How can electric companies decide on the best approach to use to invest in forest carbon sequestration projects?

• How can they calculate the cost-effectiveness of different ways to implement forest carbon sequestration projects so they can be compared?

• EPRI recently developed a computer simulation model to estimate the cost-effectiveness forest carbon sequestration projects.
Forest Carbon Management Options

- **No Harvest**
  - Buy land & plant trees
  - Retain ownership for 100 years
  - No timber harvest allowed

- **Donate**
  - Buy land & plant trees
  - Donate land in year 5 to land management agency or non-profit
  - Company retains carbon rights over 100 years

- **Thin**
  - Buy land & plant trees
  - Retain ownership for 100 years
  - Thin forest in year 50, 60, and 70

- **Harvest**
  - Same as “Thin”
  - “Optimal” final timber harvest between years 71-100.
GHG-CAM v1.0 Overview

- Greenhouse Gas Cost Analysis Model (GHG-CAM v1.0)
  - Excel®-based spreadsheet model
  - Incorporates “Real Options Calculator” (ROC¹) add-in
  - Developed by EPRI in conjunction with Cinergy Corp. in 2004

- Version 1.0 includes three analysis “modules”
  - Biomass Cofiring
  - Heat Rate Improvement
  - Forest Carbon Sequestration

- Version 1.1 now in development includes:
  - New Wind Generation
  - New Solar Generation

¹The “ROC” is available from Onward, Inc. at www.onwardinc.com.
GHG-CAM Purpose

- Analyzes and compares on a financial basis different GHG emissions reduction actions.
  - Calculates the present value after-tax net income of the proposed project, including the expected future value of carbon “credits” and any required carbon “buyback” for thinning and harvest.
  - Calculates the GHG emissions reductions for each GHG abatement action over a defined project time horizon.
  - Calculates the cost-effectiveness of each abatement action on the basis of the levelized cost of emissions reductions ($/ton CO$_2$e).

- Analysis Methods
  - Based on modern finance & statistical methods
  - Uses advanced discounted cash flow (DCF) approach
  - Monte-Carlo simulation is used to reflect uncertainty in the “real” values of key variables (e.g., carbon prices, electricity prices, …)
  - Calculates real option values, and derives optimal exercise strategy
GHG-CAM Analysis “Perspectives”

• Deterministic
  – Uses “best guess” estimates for key uncertain variables
  – Results are shown as a single number (e.g., $10/ton CO\textsubscript{2}e$)
  – Includes $0$ and $+$ expected future carbon prices

• Stochastic
  – Describes key uncertain variables probabilistically
  – Monte-Carlo simulation is used to generate uncertain input values
  – Outputs include: expected value, range, frequency, and value at risk
  – Includes $0$ and $+$ expected future carbon prices

• Real Options
  – Same features as stochastic analysis perspective
  – Project value also includes real option value and key price uncertainties
  – Determines optimal option “exercise” strategy to implement project
  – Expected future carbon prices is the “monitored” forecast
Forward Prices (1 of 2)

• GHG-CAM incorporates user-defined forward prices for fuels, commodities and emissions allowances, including:
  – Expected carbon prices ($/ton CO$_2$e)
  – Expected timber prices ($/mbf)
  – Biomass fuel prices ($/MMbtu)
  – Wholesale electricity prices ($/MWh)
  – NO$_x$ allowance prices ($/ton)
  – SO$_2$ allowance prices ($/ton)
  – Coal fuel prices ($/MMbtu)

• To incorporate key uncertainties into forward prices over the time horizon of a proposed GHG abatement project (e.g., 100 years), GHG-CAM uses sophisticated statistical tools to generate probability-based forward price curves.
  – User-defined statistical process (GBM, EMR, MR, other)
  – User-defined statistical parameters (std. dev./ volatility, half-life, etc.)
Forward Prices (2 of 2)

CO2 Emissions Price Forecast

Note: This is solely an illustration and does not represent the official views of EPRI.

Notes:
- **Blue Line**: Mean Price
- **Black Line**: Median Price
- **Orange Lines**: 10-90 confidence interval
Forest Carbon Accounting

- Based on regional per-acre data (Birdsey 1996\(^1\))
- Carbon accounting is done across all acres planted
- Calculates dollar cost of carbon “buyback” when the forest is thinned or harvested
- Is based on “net carbon sequestered”
- The quantity of carbon expected to be sequestered in the forest is discounted back to its present value when calculating levelized cost.

Forest Carbon Project Example

- Location: Corn Belt
- Species: Mixed Hardwoods
- Management: Even-Aged
- Site Index: All Sites

Data Source:
- Richard Birdsey (1996), USDA Forest Service
- Land Type: “Regional estimates of timber volume and forest carbon for managed timberland”
- Species and Management Intensity: “Corn Belt, mixed hardwoods, former pasture, even-aged management, all sites”
### Example “Birdsey” Data

#### Regional Estimates of Timber Volume and Forest Carbon for Managed Timberland, Corn Belt, mixed hardwoods, former cropland, even-aged management, all sites

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<tr>
<td></td>
<td>Timber Volume</td>
<td>Carbon Storage</td>
<td>Carbon Storage</td>
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<tr>
<td></td>
<td>Standing Volume</td>
<td>Carbon in Live Vegetation</td>
<td>Other Organic Carbon</td>
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## Project Specific Assumptions

<table>
<thead>
<tr>
<th>Project Specific Assumptions</th>
<th>No Harvest</th>
<th>Donate Land</th>
<th>Thinning</th>
<th>Harvest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tons C to Tons CO2e</td>
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<td>3.67</td>
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<td>3.67</td>
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<tr>
<td>Option period (Yrs)</td>
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<td>50</td>
<td>71-100</td>
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<tr>
<td>Project Lifetime (Yrs)</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
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<tr>
<td>Local Property Tax Rate</td>
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<td>2.50%</td>
<td>2.50%</td>
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<td>Receive Tax Benefits for Donation?</td>
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<td>No</td>
<td>No</td>
<td>No</td>
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<tr>
<td>GHG Buyback (%)</td>
<td>0%</td>
<td>0%</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td># of Acres Planted</td>
<td>500</td>
<td>500</td>
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<td>500</td>
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<tr>
<td>Construction Period (Years)</td>
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<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Annual Forest Management Cost ($ / acre)</td>
<td>$5.00</td>
<td>$5.00</td>
<td>$5.00</td>
<td>$5.00</td>
</tr>
<tr>
<td>Annual Fire Protection Cost ($ / acre)</td>
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<td>$0.00</td>
<td>$0.00</td>
<td>$0.00</td>
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<tr>
<td>Annual Insurance Cost ($ / acre)</td>
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<td>$0.75</td>
<td>$0.75</td>
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<tr>
<td>Annual Carbon Monitoring Cost ($ / acre)</td>
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<td>$0.50</td>
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<tr>
<td>Annual Carbon Verification Cost ($ / acre)</td>
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<td>$0.50</td>
<td>$0.50</td>
<td>$0.50</td>
</tr>
<tr>
<td>Annual Carbon Certification Cost ($ / acre)</td>
<td>$0.75</td>
<td>$0.75</td>
<td>$0.75</td>
<td>$0.75</td>
</tr>
<tr>
<td>Expected Net Lumber Price (Thinning) ($ / mbf)</td>
<td>NA</td>
<td>NA</td>
<td>$370.00</td>
<td>$370.00</td>
</tr>
<tr>
<td>Expected Net Lumber Price (Harvest) ($ / mbf)</td>
<td>NA</td>
<td>NA</td>
<td>$370.00</td>
<td>$370.00</td>
</tr>
</tbody>
</table>

**Note:**
- Yellow-colored cells are user-defined.
- Red-colored cells are user-defined but in a different location in the model.
- Black-colored cells are locked to user input.
Forest Carbon Module Scenarios (1 of 3)

- **“Base Case”**
  - **No Harvest**: Company buys land, plants trees and retains ownership for 100 years; no timber harvest.

- **Multiple “Project Cases”:**
  - **Donate**: Company buys land, plants trees, and donates land in year 5 to a qualified land management agency or non-profit; company retains carbon rights over 100 years.
  - **Thin**: Company buys land, plants trees and retain ownership. Forest is thinned in year 50, 60, and 70.
  - **Harvest**: Same as “Thin”, and forest is “optimally” harvested between year 71-100.

- **“All Options” Case**
  - Base case is No Harvest
  - ROC determines optimal forest management regime based on all available management options (i.e., Donate, Thin and Harvest)
Forest Carbon Scenarios (2 of 3)

- Donate, Thin and Harvest are “real options”
  - For an electric company that owns forest land, these land management actions are real options that can be “exercised” anytime during the forest rotation.
  - The “exercise price” for each of these real option is the present value of the discounted capital costs associated with conducting the specific activity.

- Option Exercise Rules
  - “Donate” option only can be exercised in project year 5.
  - “Thin” option only can be exercised in year 50.
  - “Harvest” option can be exercised in any year 71-100.

- Carbon “Buyback”
  - “Buyback” refers to the amount of CO$_2$e an electric company may need to purchase, or otherwise acquire, to “net out” the CO$_2$e released into the atmosphere from timber harvesting and related post-harvest activities.
  - GHG-CAM incorporates carbon buyback for thinning and final timber harvests.
  - Users can choose buyback percentage (e.g., 0-100% buyback).
Forest Carbon Module Scenarios (3 of 3)

Base Case

- NoHarvest

Project Cases

- Donate
  - (Yr 5?)

- Thin
  - (Yr 50-70?)

- Harvest
  - (Yr 71-100?)
### Analytic Results

### Summary of Analytic Results -- Forest Carbon Sequestration

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Stochastic</th>
<th>Real Option</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No Harvest</td>
<td>Donate Land</td>
</tr>
<tr>
<td><strong>Expected Carbon Price Year 0 ($/ton CO2e)</strong></td>
<td>$3.00</td>
<td>$3.00</td>
</tr>
<tr>
<td><strong>GHG Emissions Reductions (tons CO2e)</strong></td>
<td>13,212</td>
<td>13,212</td>
</tr>
<tr>
<td>GHG Emissions Reductions (2010-2012)</td>
<td>405,535</td>
<td>405,535</td>
</tr>
<tr>
<td>PV GHG Emissions Reductions (2004-2104)</td>
<td>59,852</td>
<td>59,852</td>
</tr>
<tr>
<td><strong>Levelized GHG Abatement Cost (After-Tax)</strong></td>
<td>$(7.68)</td>
<td>$(5.33)</td>
</tr>
<tr>
<td>PV $ Net Income / PV Ton CO2e (2004-2104)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Analysis Perspectives** – Final results are displayed for deterministic, stochastic, and real-options analysis perspectives.
- **Carbon Prices** – Final results also are displayed based on:
  - $0 / ton CO2e expected future carbon prices (“compliance cost” perspective)
  - $+ / ton CO2e expected future carbon prices (“market” perspective)
GHG Emissions Reductions

Forest Carbon Sequestration
GHG Emissions Reductions
(Stochastic & Real Options Analysis Results)
Summary

• Forest C sequestration leads to **indirect** GHG emissions offsets
  – C sequestration is relatively slow during the early years of the rotation.
  – Discounting reduces the present value of the “back loaded” C sequestration that takes place in the later years.

• “Levelized cost” provides a powerful, analytically consistent metric that can be used to compare different GHG emissions reduction options. Levelized cost” depends on which analysis “perspective” is used.

• “Donate” appears to be the best option for forest sequestration in our example of mixed hardwoods planted in the Midwest U.S.
  – Levelized cost = ~$5.33 **loss** of net income per ton CO$_2$e ($5.33$/ton CO$_2$e).
  – This option would be exercised 100% of the time.
  – Levelized cost is between $6-$8.00/ton CO$_2$e for the No Harvest, Thin and Harvest scenarios.

• Real options analysis can help an electric company to select the optimal strategy for implementing each type of GHG abatement.
Contact Information

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