The GHG Protocol for Project Accounting: Example Using Project Specific Baseline Procedure

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GHG Protocol for Project Accounting: Cement Sector Example Using Project Specific Baseline Procedure

• Reference: WWW.ghgprotocol.org
GHG Project: GHG Reductions in a Hypothetical Cement Manufacturing Plant

- Company X produces Portland cement in three locations in Indonesia
- Reduce GHG emissions by
  1. reducing emissions associated with the cement clinker production
  2. reducing GHG emissions associated with energy production and consumption.
Portland Cement Manufacturing

- Raw Materials, limestone, silica sand, clay, blending materials are quarried and transported
- Raw materials are crushed, ground and homogenized
- Fuels are ground and dried
- In rotary kiln (2000 C), calcining and pyro-processing to form clinker nodules, burn fuels for heat
- Fuel used at about 3200-5500 MJ/tonne clinker
- Clinker is cooled, fine-ground, and blended with additives to make cement
- Ordinary Portland Cement (OPC)
GHG Project Description:

- Company X has 3 plants in Indonesia making OPC with cement kilns

Project Activity 1.
- Company X makes OPC with 95% clinker content
- Proposal to manufacture blended cement, which uses increased proportions of limestone and pozzolan additives in the fine-grinding (after kilns) process. The result is cement with a lower clinker fraction (81 percent) but same physical properties.
- Lowering the clinker-to-cement ratio reduces both process emissions (CO2 from kiln reactions) and associated fuel-related GHG emissions.
- Can reduce to clinker fraction of 91% with existing equipment

Project Activity 2.
- Company X will replace a portion (15%) of the coal with biofuels found near its plants (palm kernel and rice husk), and consequently reduce GHG emissions.
Steps for accounting and reporting GHG Reductions from a GHG project: Boundary

- Define each activity in the project
- ID all primary effects
- Consider all secondary effects
- Estimate relative magnitude of all secondary effects
- Assess the significance of all secondary effects
- Justify “significance”
Defining the GHG Project Boundary (5):

• Identify the activities (5.1)
  – Reduce clinker content
  – Switch fuels to incorporate biomass fuels

• ID primary effects and consider secondary effects %. (5.2, 5.3)

• Estimate the relative magnitude and assess the significance of secondary effects (5.4, 5.5)
  – Should any secondary effects be included in the GHG boundary?
Estimate the relative magnitude and assess the significance of secondary effects (5.2-5.5)

• Project activity 1: (reduced clinker)
  – Primary effects
    • Reduced process emissions from calcination
    • Reduced combustion emissions from energy for pyro-processing
  – Secondary effects
    • Reduced combustion emissions from reduced electricity needed in clinker production, positive effect is smaller than primary effects, to be conservative, not included in GHG boundary
    • Reduced transportation from reduced amount of raw materials, positive effect expected to be small, conservatively not included in GHG boundary
    • Increased transportation of additives, negative effect expected to be small, and counterbalanced by reduced transport of raw materials, not included in GHG boundary
    • Increased combustion emissions from increased electricity used in preparation of additive materials, negative effect expected to be small, and counterbalanced by reduced electricity of producing clinker, not included in GHG boundary
    • Possible increase at other cement mfg sites that use additives due to a shortage of additives, however, the additives are abundant and this is not included in GHG boundary
Estimate the relative magnitude and assess the significance of secondary effects (5.2-5.5)

- Project activity 2: (biofuels)
  - Primary effects
    - Reduced process emissions from calcination
    - Reduced combustion emissions from energy for pyro-processing
  - Secondary effects
    1. Increased transportation from biofuels, reduced amt of raw materials, positive effect expected to be small, conservatively not included in GHG boundary
    2. Reduced emissions from coal transport
    3. Reduced waste emissions from disposal or decomposing in landfills of biofuel materials
    4. Reduced electricity use for coal preparation
    5. Increase in combustion emissions caused by reduced availability of biofuels
  - Estimation is that 2+3+4 is greater than 1 and they contribute to a 4% reduction in GHG, for conservatism, will not be included in the GHG boundary
  - Research indicates that rice husks and palm kernel shells are 1.5 times greater than the demand, 5 is not significant and is not included in GHG boundary
Selecting a Baseline Procedure (6)

• **Project-specific procedure**—This procedure produces an estimate of baseline emissions through the identification of a *baseline scenario* specific to the proposed *project activity*.

• **Performance standard procedure**—This procedure produces an estimate of baseline emissions using a GHG emission rate derived from a numerical analysis of the GHG emission rates of all *baseline candidates*. It serves the same function as a baseline scenario, but avoids the need to identify an explicit baseline scenario for each project activity.

• The project-specific procedure was chosen to estimate baseline emissions for both project activities.

• The project-specific procedure was preferred over a performance standard approach because of difficulties in obtaining performance data on individual cement kilns in Indonesia.

• Further, the total number of comparable cement kilns in Indonesia is small, making it difficult to develop a robust statistical performance standard.
Identifying the Baseline Candidates: Define the service or product (7.1)

• Baseline candidates identified include representative types of plants, technologies, or practices that produce the same product or service as the project activities within a specified geographic area and temporal range.

• For Project Activity 1, the product is cement that is equally as strong as OPC.

• For Project Activity 2, the product is heat energy for kiln burning to create clinker.
Identifying the Baseline Candidates:

**Same service or product (7.2)**

- Activity 1.
- The range of technical options to produce cement equal in strength to OPC
  1. Current OPC with 95% clinker
  2. Produce OPC with 91% clinker
  3. Portland Pozzolan Cement (PPC), strength develops slower
  4. Produce OPC with new equipment with 81% clinker
Identifying the Baseline Candidates:  
Same service or product (7.2)

• Activity 2.
• The range of possible fuels to provide energy to produce clinker
  1. Coal
  2. Natural gas
  3. Industrial diesel oil
  5. Renewable energy fuels such as biomass
Identifying the Baseline Candidates: Define geographic area and time (7.3)

• Activity 1.
• Indonesia, cement must comply with local regulation, SNI 15-3500-1994
• Facilities must be close to cement demand locations
• 1997 to present, coincides with Asian economic crisis, in which most kilns were dry kilns

• Activity 2.
• Indonesia, all fuel is obtained domestically
• 1997 to present, coincides with Asian economic crisis
Identifying the Baseline Candidates: Other criteria (7.4)

- Activity 1.
  - Cement must comply with local regulation, SNI 15-3500-1994, thus no other legal requirements are pertinent, no other criteria identified

- Activity 2.
  - Indonesia does not have any legal requirements with respect to fuel used in clinker production, no other criteria identified
Identifying the Final List of Baseline Candidates (7.5)

• Activity 1.
  1. Current OPC with 95% clinker
  2. Produce OPC with 91% clinker
  3. Portland Pozzolan Cement (PPC), strength develops slower and is thus eliminated (not the same service, eliminated)
  4. Produce OPC with new equipment for a 81% clinker

• Activity 2.
  1. Coal, cheap
  2. Natural gas, since 1997 25% more expensive than coal
  3. Industrial diesel oil, 200% more expensive than coal
  4. Non renewable resources, tires, waste oil, hazardous waste. But not available in Indonesia so eliminated.
  5. Renewable energy fuels such as biomass (Activity 2)
Identifying Baseline Candidates of Common Practice (7.6)

• Activity 1.
  1. Current OPC with 95% clinker, research determines that 82% of cement in Indonesia is OPC in 2002

• Activity 2.
  1. Clinker production utilizes coal nearly 100%
Estimating Baseline Emissions-Project Specific Procedure (8)

• The project-specific procedure estimates baseline emissions by identifying a baseline scenario for each project activity (8.2):

• The list of possible alternatives for each project activity—the baseline candidates—is evaluated using a comparative assessment of barriers.
Estimating Baseline Emissions-Project Specific Procedure (8)

- Identify **barriers** to the project activity and baseline candidates (8.1):
  - Financial and budgetary
    - Investment risk
    - High cost
  - Technology and Operation and Maintenance
  - Infrastructure and Market Structure
  - Institutional, Social, and Cultural
  - Resources
Estimating Baseline Emissions - Project Specific Procedure (8)

- Identifying a baseline scenario: Activity 1 (8.2):
- The list of possible alternatives for each project activity—the baseline candidates—is evaluated using a comparative assessment of barriers.

<p>| TABLE E1.3 Rough ranking of baseline scenario alternatives by the cumulative importance of barriers |
|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|</p>
<table>
<thead>
<tr>
<th>BASELINE SCENARIO ALTERNATIVES</th>
<th>BARRIER 1: INVESTMENT/BUDGETARY (H)*</th>
<th>BARRIER 2: TECHNOLOGY O&amp;M (L)*</th>
<th>BARRIER 3: SOCIAL/CULTURAL (M)*</th>
<th>RANK BY CUMULATIVE IMPACT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Activity 1</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>Highest barriers</td>
</tr>
<tr>
<td>Baseline Candidate 1: Continuation of current activities</td>
<td>Not present</td>
<td>Not present</td>
<td>Not present</td>
<td>No barriers</td>
</tr>
<tr>
<td>Baseline Candidate 2: OPC production with 91% clinker-to-cement ratio</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low barriers</td>
</tr>
</tbody>
</table>

*The relative importance of the barriers compared to each other: H = Significant barrier; M = Moderately significant barrier; L = Less significant barrier.
Estimating Baseline Emissions-Project Specific Procedure (8)

- Identifying a baseline scenario: Activity 1 (8.2):
  - High barriers to Activity 1 prove additionality and reject it as the baseline scenario.
  - This comparative assessment of barriers doesn’t unambiguously identify a baseline scenario.

<table>
<thead>
<tr>
<th>BASELINE SCENARIO ALTERNATIVES</th>
<th>RANK BY CUMULATIVE IMPACT OF BARRIERS</th>
<th>CONCLUSION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Activity 1</td>
<td>Highest barriers</td>
<td>Reject as baseline scenario</td>
</tr>
<tr>
<td>Baseline Candidate 1: Continuation of current activities</td>
<td>No barriers</td>
<td>Could be the baseline scenario</td>
</tr>
<tr>
<td>Baseline Candidate 2: OPC production with 91% clinker-to-cement ratio</td>
<td>Low barriers</td>
<td>Could be the baseline scenario</td>
</tr>
</tbody>
</table>
Estimating Baseline Emissions-Project Specific Procedure (8)

- Identifying a baseline scenario: Activity 1 (8.2):
- A net benefits assessment indicates that baseline candidate 2 should be selected as the baseline candidate
- It has low barriers and offers financially attractive net benefits to Company X
- It is also conservative

Baseline candidate 2, 91% clinker is identified as the baseline scenario!!
Estimating Baseline Emissions-Project Specific Procedure (8)

- Identifying a baseline scenario: Activity 2 (8.2):
- The list of possible alternatives for each project activity—the baseline candidates—is evaluated using a comparative assessment of barriers.

<table>
<thead>
<tr>
<th>Baseline Scenario Alternative</th>
<th>Investment Cost</th>
<th>Fuel Cost</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Activity 2</td>
<td>U.S. $15 million</td>
<td>U.S. $0.007/Mcal*</td>
<td>Lower fuel costs but high up-front investment costs required, with limited access to capital due to the poor Indonesian investment climate.</td>
</tr>
<tr>
<td>Baseline Candidate 1: Continuation of current activities (coal)</td>
<td>None</td>
<td>U.S. $0.071/Mcal</td>
<td>Current activities have the least cost overall.</td>
</tr>
<tr>
<td>Baseline Candidate 2: Replacement of coal with natural gas</td>
<td>None</td>
<td>U.S. $0.089/Mcal</td>
<td>Significantly more expensive than using coal (U.S. $0.02/Mcal higher cost).</td>
</tr>
<tr>
<td>Baseline Candidate 3: Replacement of coal with fuel oil</td>
<td>None</td>
<td>U.S. $0.142/Mcal</td>
<td>More expensive than using coal or natural gas.</td>
</tr>
</tbody>
</table>

*Assuming weighted average of rice husk and palm kernel shell utilization. Utilization of renewable sources increases heat consumption per tonne of clinker produced. This heat consumption increase depends on the amount of biofuel used with the actual increase requiring monitoring.
Estimating Baseline Emissions-Project Specific Procedure (8)

- Identifying a baseline scenario: Activity 2 (8.2):
- Comparative assessment of barriers.
- Since Project activity 2 has high barriers, additionality is proven, and it is rejected as the baseline scenario.
- Baseline candidates 2 and 3 have significant barriers.
- Baseline candidate 1, continuation of coal firing involves no capital investment and faces no barriers and is identified as the baseline scenario.
Estimating Baseline Emissions - Project Specific Procedure (8)

- Estimating baseline emissions (8.3)

- Baseline emissions are estimated for each primary effect, based on the identified baseline scenarios for each project activity.
Estimating Baseline Emissions-Project Specific Procedure (8)

- Estimating baseline emissions (8.3)

- Project Activity 1 Primary Effect 1: reduced process emissions

- NOTE, WE USE 91% CLINKER CONTENT AS THE BASELINE, NOT THE CURRENT PRACTICE
  
  - Emission factor for calcination 0.525 t CO2e/ 1 tonne clinker
  
  - \((0.91 \text{ t clinker/t cement}) \cdot (0.525 \text{ t CO}_2/\text{t clinker})\)
  
  - 0.478 tonnes of CO2eq for every tonne of cement produced by Company X
Estimating Baseline Emissions - Project Specific Procedure (8)

- Estimating baseline emissions (8.3)

- Project Activity 1 Primary Effect 2: reduced combustion emissions

- Coal from Indonesia has an emission factor of 0.402 kg CO₂eq/Megacalorie (CO₂/Mcal).

- Clinker requires an energy input of 755 Mcal/t of clinker.

- \[ = (0.402 \text{ kg CO}_2\text{eq/Mcal}) \times (755 \text{ Mcal/t clinker}) \times (0.91 \text{ t clinker/t cement}) / (1,000 \text{ kg CO}_2 /\text{t CO}_2) \]

- \[ = 0.276 \text{ tonnes of CO}_2\text{eq for every tonne of cement produced by Company X} \]
EstimatingBaseline Emissions-Project Specific Procedure (8)

• Estimating baseline emissions (8.3)

• Project Activity 2 Primary Effect 3: reduced emissions from biomass fuel
  – Must base calculations based on results of Activity 1, ie., premised on 81% clinker content

• \[ = \left(0.402 \text{ kg CO}_2\text{eq/Mcal}\right) \cdot (755 \text{ Mcal/t clinker}) \]
  \[ \times (0.81 \text{ t clinker/t cement}) \div (1,000 \text{ kg CO}_2/t \text{ CO}_2) \]

• = 0.246 tonnes of CO$_2$eq for every tonne of cement produced by Company X
Monitoring and Quantifying the GHG Reductions (10)

• A detailed monitoring plan will include provisions for monitoring frequency, record keeping, and methods used to measure, calculate, or estimate data on GHG emissions and baseline parameters.
Monitoring and Quantifying the GHG Reductions (10)

- Activity 1
- GHG emissions are monitored by indirect measurement and calculations

<table>
<thead>
<tr>
<th>GHG EFFECT / SOURCE</th>
<th>DATA</th>
<th>LEVEL OF UNCERTAINTY</th>
<th>UNCERTAINTY FACTORS</th>
<th>HOW UNCERTAINTIES ARE ADDRESSED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Effect 1: Industrial process emissions</td>
<td>Clinker-to-cement ratio of blended cement</td>
<td>Low</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>CO₂ emission factor due to calcination process</td>
<td>Low</td>
<td>MgO and CaO content of raw material and clinker</td>
<td>Conduct a laboratory analysis using x-ray analyser.</td>
</tr>
<tr>
<td></td>
<td>Tonnes of cement produced by Company X</td>
<td>Low</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Primary Effect 2: Combustion emissions from generating energy for pyro-processing</td>
<td>CO₂ emission factor for coal used in clinker production process (tonnes CO₂/Mcal)</td>
<td>Low</td>
<td>Heat values for coal used</td>
<td>• Conduct a laboratory analysis to test the heating values for coal used.</td>
</tr>
<tr>
<td></td>
<td>Energy content of coal used in clinker production process (Mcal/tonne)</td>
<td>Low</td>
<td>Heat values for coal used</td>
<td>• In the absence of laboratory analysis, use IPCC default emission factors.</td>
</tr>
<tr>
<td></td>
<td>Amount of coal used in clinker production process (tonnes)</td>
<td>Low</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Monitoring and Quantifying the GHG Reductions (10)

- Activity 1
- Also need to monitor baseline parameters
- If additive materials become scarce, there might be secondary effects (others finding other substitutes with different GWP) then must reevaluate the baseline emissions
- If blended (81% clinker) becomes the norm (>30% market penetration, then the baseline scenario is no longer valid (no additionality, this is what the company would do normally) and the GHG reductions would not be valid!!!
- Project Risk!!!
Monitoring and Quantifying the GHG Reductions (10)

- Activity 2
- Also need to monitor baseline parameters
- If biofuel materials become scarce, rice husks and palm kernel shells available at less than 1.5 times amount currently demanded then possible secondary effects may arise (others finding other substitutes with different GWP)
- If true, then must reevaluate the baseline emissions, must estimate how other users of the biofuels will change their GWP emissions and alter the baseline!!

<table>
<thead>
<tr>
<th>TABLE E1.13 Data requirements and uncertainty levels for monitoring baseline parameters related to Project Activity 2 (switching fuels)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BASELINE PARAMETER/ASSUMPTION</strong></td>
</tr>
<tr>
<td>Energy input required to produce one tonne of clinker</td>
</tr>
<tr>
<td>Biofuels remain abundantly available</td>
</tr>
<tr>
<td>Biofuels used by other users</td>
</tr>
</tbody>
</table>
Monitoring and Quantifying the GHG Reductions (10)

• Identifying time period

• Activity 1:
  – Estimated at 5 years
  – Based on expectation that blended cement penetration in Indonesian market would be 30% in 5 yrs
  – India blended cement is 47% of market, took about 5 years (1999-2003)

• Activity 2:
  – Estimated at 15 years
  – Coal is available, cheap and used at almost 100%
  – Biomass collection is not common nor will it be in near future

• GHG Project overall time period is 15 yrs, shortest valid baseline scenario time length
Monitoring and Quantifying the GHG Reductions (10)

- Calculations for quantifying GHG reductions
- Project Activity 1, Primary Effect 1 (reduced clinker content)
  - \( (0.81 \text{ t clinker/t cement}) \times (0.525 \text{ t CO}_2/\text{t clinker}) \)
  - \( = 0.425 \text{ tonnes of CO}_2\text{eq for every tonne of cement produced by Company X} \)
- Baseline emissions, Primary Effect 1
  - 0.478 \text{ t CO}_2/\text{t of cement}
- GHG reductions will therefore be:
- \( = 0.478 - 0.425 = \textbf{0.053 t CO}_2\text{eq/t cement produced} \)
Monitoring and Quantifying the GHG Reductions (10)

• Calculations for quantifying GHG reductions
• Project Activity 1, Primary Effect 2 (reduction in combustion emissions from reduced clinker content)
• GHG emissions from Project Activity 1, Primary Effect 2 are:
  – \( = (0.402 \text{ kg CO}_2\text{eq/Mcal}) \cdot (755 \text{ Mcal/t clinker})(0.81 \text{ t clinker/t cement}) / (1,000 \text{ kg CO/t CO}) \)
  – \( = 0.246 \text{ tonnes of CO}_2\text{eq for every tonne of cement produced by Co. X} \)
• Baseline emissions for Primary Effect 2 were estimated as 0.276 t CO\(_2\)eq/t of cement.
• GHG reductions will therefore be:
  – \( = 0.276 – 0.246 = \textbf{0.03 t CO}_2\text{eq/t cement produced} \)
Monitoring and Quantifying the GHG Reductions (10)

- Calculations for quantifying GHG reductions
- Project Activity 2, Primary Effect 3 (reduction in combustion emissions from switch from coal to biofuels)
  - Will substitute 15% of the coal with biofuels (zero emission factor)
- GHG emissions from Project Activity 2, Primary Effect 3 are:
  - \[= (0.246 \text{ t CO}_2\text{eq/t cement}) \times (0.85) = 0.209 \text{ t CO}_2\text{eq/t cement}\]
- (NOTE, 0.246 IS BASED ON RESULTS FROM ACTIVITY 1, NOT BASELINE)
- Baseline emissions for Project Activity 2 were estimated as 0.246 t CO2eq/t of cement.
- GHG reductions will therefore be:
  \[= 0.246 – 0.209 = 0.037 \text{ t CO}_2\text{eq/t cement produced}\]
Monitoring and Quantifying the GHG Reductions (10)

• Calculations for quantifying GHG reductions
• Aggregating the GHG reductions associated with each primary effect together, total GHG reductions related to primary effects will be:
  \[ = 0.053 + 0.03 + 0.037 = 0.12 \text{ t CO}_2\text{eq/t cement produced} \]
• Company X expected to have an avg annual cement production of 2 million tonnes
  \[ = (2 \text{ million t}) \cdot (0.12 \text{ t CO}_2\text{eq/t cement}) = 240,000 \text{ t CO}_2\text{eq}. \]
• This is estimated before the project occurs, must also check the results during and after the project.
Monitoring and Quantifying the GHG Reductions (10), *ex post*

- Must quantify the GHG reductions during and after the project
- \[ R = BE - PE \]
  - \( R \) = Annual GHG reductions for the entire GHG project
  - \( BE \) = Total annual baseline emissions for all three GHG project primary effects
  - \( PE \) = Total annual GHG project emissions
- \[ R = [Cy \cdot CFb \cdot EFp] + [Cy \cdot CFb \cdot E \cdot EFc] - [Cy \cdot CFp \cdot EFp] + [Fy \cdot ECc \cdot EFc] \]
- \( Cy \) = Quantity of cement produced in year \( y \), in tonnes
- \( CFb \) = Fraction of clinker in cement, baseline scenario = 0.91
- \( EFp \) = Emission factor for process emissions from clinker production = 0.525 t CO\(_2\)/t clinker (WBCSD Cement Protocol 2001).
- \( E \) = Energy input from coal required to produce a tonne of clinker = 755 Mcal/tonne of clinker (as determined through pre-implementation monitoring)
- \( EFc \) = Emission factor for coal combustion = 0.402 kg CO\(_2\)eq/Mcal (as determined under the monitoring plan)
- \( CFp \) = Fraction of clinker in cement, GHG project = 0.81
- \( Fy \) = Amount of coal consumed in year \( y \), in tonnes
- \( ECc \) = Energy content of coal in units of Mcal/tonne, as determined under the monitoring plan
Questions???