Measuring Sustainability with Life Cycle Assessment (LCA) and Life Cycle Costing (LCC)

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Life Cycle Thinking to Avoid Problem Shifting

Businesses using paper instead of plastic? Not necessarily better for the environment, experts say

According to a 2018 life cycle assessment (LCA) study by the Danish Environmental Protection Agency, to break even against a single-use plastic bag:

- A polypropylene bag should be used 37 times.
- A paper bag should be used 43 times.
- A cotton bag should be used 7,100 times.

Without life cycle thinking, what may seem like a solution, could actually shift or create a new problem.
Life Cycle Assessment (LCA) and Life Cycle Costing (LCC)

- LCA is an evidence-based approach to measure sustainability of products, services and systems.
- LCC, employed in tandem, assesses the economic performance and is able to internalise environmental impacts as financial costs.

Step 1: Framing the Study
- Purpose of the study
- Target audience/stakeholders
- Questions to be answered..?
  ✓ Define functional unit and system boundary

Step 2: Building the Model
  ✓ Model and collect data on the flows of resources into, within and out of the system

Step 3: Computing the KPIs
  ✓ Convert the Life Cycle Inventory Analysis into relevant indicators (e.g. carbon footprint and net present value)

Step 4: Utilising the Findings
  - Sensitivity and uncertainty analyses
  - Scenario analysis
  ✓ Answer questions asked in step 1
# Life Cycle Assessment and GHG Protocol Standards

## Life Cycle Assessment (Consequential Approach)

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<thead>
<tr>
<th>GHG Protocol Corporate Standard</th>
<th>Avoided Impact</th>
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<tbody>
<tr>
<td><strong>Scope 1</strong></td>
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<td>Direct on-site greenhouse gas emissions</td>
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<tr>
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<tr>
<td>Mobile combustion from company owned vehicles</td>
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<td><strong>Scope 2</strong></td>
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<td><strong>Scope 3</strong></td>
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## Emission sources

- Direct on-site greenhouse gas emissions
- Direct emissions from on-site stationary combustion
- Mobile combustion from company owned vehicles
- Embodied emissions of purchased utilities (electricity, water, steam, heating, and cooling)
- Embodied emissions of purchased goods and services
- Upstream and downstream transportation, not controlled by company
- Avoided embodied emissions resulting from displaced activities as a consequence of the existence of the current system under study

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Key findings:

- The **biodiesel has significantly lower environmental impact** than diesel (>82% across the board).
- **Carbon footprint from the use of the biodiesel** is 0.006 kg CO$_2$-eq per km; which is **180 times less than diesel** at 1.08 kg CO$_2$-eq per km.

LCA – Environmental Impact of Reusable vs Disposable Masks

Assumptions:
- The masks provide a comparable function, i.e. similar efficacy in reducing the spread of respiratory droplets.
- The disposable mask is used for a day; while the reusable mask is used for 30 days.
- 1/3 of SG population returns to work and school post-circuit breaker.

Key findings of using the reusable vs disposable mask (over a 30-day period):
- Has **3.3 times less carbon footprint** and generates **5 times less solid waste**.
- Has a **lower carbon footprint after only 8 days** and generates **less solid waste after only 6 days**.
- Can **avoid a total carbon footprint of 590 tonnes of CO₂-eq** and **220 tonnes of solid waste** over the 30-day period.

Key findings:

• Taking into account life cycle GHG emissions and avoidance of import sand, a net abatement of 115.78 kg CO$_2$-eq per tonne of CO$_2$ sequestered can be achieved when minerals are imported from Australia and heating energy is not optimised.

• Transportation (land and sea) of mineral feedstock (raw serpentine) contributes significantly (~47%) to life cycle GHG emissions.

• If the mineral feedstock can be sourced from a neighbouring country, and industrial waste heat utilised, the net abatement can increase up to 903.59 kg CO$_2$-eq per tonne of CO$_2$ sequestered.

Key findings:

- **Carbon footprint of tap water is only about 60% that of NEWater** as tap water has a large mix of local catchment and imported water.
- Conversely, piped **NEWater has significantly lower water depletion potential** as it virtually does not abstract water from freshwater bodies.
- In water-scarce Singapore, this is a **trade-off in moving towards water self-sufficiency**.

Key findings:

• GHG emissions of **beef is the highest** on a per kg basis while **pork is the highest** based on a per capita consumption.

• Increasing local food production (i.e. 30 by 30) can **offset GHG emissions** from the **transportation** of food over longer distances.

• However, to more meaningfully **reduce total GHG emissions** of food consumed in Singapore, **local diet** needs to shift to one which is **more plant-based**.

LCC – Cost-Benefit Analysis of Circular Production/Recycling of Flat Panel Display (FPD) Monitors

Key findings:
• Closed-loop recycling of end-of-life (EoL) FPD monitors will be a cost incurring activity despite recovery of some valuable metals (e.g. aluminium, silver and gold).
• However, the circular production system will still be profitable (i.e. positive NPV) as a whole.
• The major cost driver is the treatment of the LCD panel containing mercury in the backlights, which is hazardous and laborious to handle.

LCC – Designing a Remanufacturing System for Used PC for the Cambodian Market

Key findings to optimise system:

- Despite the risks, the benefits of setting up the main remanufacturing activity in Cambodia outweigh the costs due to much lower CAPEX and OPEX in the long-term.
- A system designed with lower initial capacity – but with allowance to expand – will be effective in mitigating market risks.
- Implementing a flexible shift policy will further enhance the system’s ability in mitigating such risks as well as agility in capturing the upsides of market volatility.

Enabling Quantitative Measurements in the Green Compass

Taking the value chain or life cycle perspective, the Green Compass aims to enable businesses and industries to transition towards low-carbon and circular economy.

### Qualitative Measurements

<table>
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<tr>
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Businesses are assessed qualitatively and quantitatively.

Tools implemented aim to achieve tangible improvements.
Without **life cycle thinking**, what may seem like a solution, could actually shift or create a new problem.

**Life Cycle Assessment (LCA) and Life Cycle Costing (LCC)** incorporates life cycle thinking to measure sustainability of products, services and entire ecosystems.

Applied systematically, they can **support collective and decisive action** towards green transformation.