Total Cost Assessment History, Methodology, Tools, and a Case Study

Lise Laurin, Melissa Hamilton – Earthshift
Darlene Schuster - AIChE Institute for Sustainability
Greg Norris - Sylvatica
Sabrina Trupia - Vermont’s Alternative Energy Corporation

Prepared for ASME's IMECE 2005
Outline

- History
- Method & Tools:
  - Cost Types
  - Confronting Uncertainty Head-On
  - Scenario Analysis
  - Workshop at the Core
- Case Study – Biodiesel Refinery
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Total Cost Assessment—where it came from

- Developed in 1991 by the Tellus Institute for the EPA and New Jersey Department of Environmental Protection
- Based on methods and programs developed by GE. “GE developed its new environmental project analysis method to better select and justify waste management investment decisions that are environmentally sound and should reduce long-term liabilities.”
- Sequence of studies provided the theoretical background for Total Cost Assessment
AICChE CWRT Project

- In 1997, AICChE Members wanted a sound TCA methodology
- Embarked on a two-part project.
  - Part I: Survey of status and available methodologies world-wide
  - Part II: Development of industry validated methodology

Project Team
- AD Little
- DOE
- Eastman Chemical
- Georgia Pacific
- Merck
- Owens Corning
- SmithKline Beecham (Lead)
- Bristol-Myers Squibb
- Dow
- Eastman Kodak
- IPPC of Business Round Table
- Monsanto
- Rohm and Haas
- Sylvatica
Methodology Tested by Industry

- **Dow Chemical**
  “This is an incredibly useful tool for Dow and for the industry — helping us to understand the costs of making products and giving us additional information to make better business decisions from the beginning.”

- **Monsanto**

- **GlaxoSmithKline**
  “TCA’s greatest contribution to GSK is likely to be at the corporate policy/strategy level.” “TCA will be applied to R&D LCI/A tools under development.”

- **Eastman Chemical**
Methodology Launch and Post-launch history

- Methodology and Manual Tools Launched in July 1999
- TCAce commissioned and completed in 1999
- TCAce commercialized for consultant use in 2004.
- The methodology is in use by numerous organizations, especially in Canada, with widespread adoption in British Columbia.
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Five Cost Types Distinguished

- Type I: Direct
- Type II: Indirect
- Type III: Contingent Liability
- Type IV: Intangibles
- Type V: External
## Cost Types

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<tr>
<th>Cost Type</th>
<th>Description</th>
<th>Examples</th>
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<td>I. Direct costs</td>
<td>Manufacturing site costs</td>
<td>Capital investment, operating, labor, materials, and waste disposal costs</td>
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<tr>
<td>II. Indirect costs</td>
<td>Corporate and manufacturing overhead</td>
<td>Reporting costs, regulatory costs, and monitoring costs</td>
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<td>III. Future and contingent liability costs</td>
<td>Potential fines, penalties and future liabilities</td>
<td>Clean-up, personal injury, and property damage lawsuits; industrial accident costs.</td>
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<td>IV. Intangible internal costs (Company-paid)</td>
<td>Difficult-to-measure but real costs borne by the company</td>
<td>Cost to maintain customer loyalty, worker morale, union relations, and community relations.</td>
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<td>V. External costs (Not currently paid by the company)</td>
<td>Costs borne by society</td>
<td>Effect of operations on housing costs, degradation of habitat, effect of pollution on human health</td>
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Total Cost Assessment—How do you do it?

- Step 1 – define goal and scope
- Step 2 – streamline the analysis
- Step 3 – identify potential risks
- Step 4 – conduct financial inventory
- Step 5 – conduct impact assessment
- Step 6 – feedback to decision-making loop
TCAce Adds to the Robustness of the Method

Scenario Builder for Accidents/Liabilities, Possibilities, “Intangible” Outcomes, etc.

Integrate Functional Unit & Annual / Production Perspectives

Modeling, M/C Analysis

Results Reporting & Cause/Factor Exploration

Corporate Cost Analysis System Results: per year or per unit of production

LCA Results: per functional unit
Conventional (I & II) Costs

- Companies follow strict procedures for conventional capital allocation decisions:
  - Work flow / responsibilities
  - Conventions regarding
    - Discounting
    - Time horizons
    - Tax impacts in profitability analysis
- TCA Imports, integrates, meshes with existing corporate approaches to I & II
TCA Approach to Non-Conventional Costs: Match Company Conventional Approach

- Follow & Adapt to General and Company-Specific Accounting Conventions
  - Investment costs
  - Depreciation, salvage values
  - Impacts before- or after-tax
  - Discounting
  - Time Horizon
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Why “get into” uncertainty?

"Never make predictions, especially about the future."

Casey Stengel

Uncertainties are pervasive

- Prices
- Costs
- Sales
- Macro-economy
- Technological Change
- Decisions by Competitors
- Accidents
- Lifetimes of investments
- Timing of events
- Impact effectiveness
Approach to Uncertainty

- Take blinders off; acknowledge
- Ask subject experts what they know
- Brainstorm
- Model systematically
- Test for possible importance
- Refine if necessary
Outcomes of interest to Decision Makers

- Most likely outcome *Mode*
- Central, mid-ranked outcome *Median*
- How good/bad can it get? *Min/Max*
- What range are we pretty certain it will fall within? *Percentiles*
- What is the likelihood of a major impact? *Cumulative Density Function*
The Core: Scenario Analysis

Option A

Option B

Scenario A1

Cost A1a

Probability

Years

Probability

Cost 2yr later

Cost 1yr later

Cost in Year of Occurrence
Monte Carlo Analysis

- Structured sampling for A and B;
- Compute A*B each iteration;
- Create distribution for A*B
Alternatives → Scenarios

- How could decision or course of action impact *timing, likelihood, or relevance* of:
  - Future environmental regulations
  - Accidents, spills, equipment failures
  - Non-compliance incidents
  - Worker health/safety incidents
  - Interruption of supply for major inputs
  - Significant and long-term shifts of costs
  - Shifts in market share
  - Actions/pressure from one or more stakeholders
Scenarios → Costs

- For each possible event with altered timing, likelihood, or relevance:
  - What are the possible cost impacts?
    - Direct costs / impacts
    - Long-term / “secondary” impacts
      - Customer loyalty
      - Employee attraction/retention/morale/productivity
      - Brand value
      - “License to operate” (local, state, federal)
  - Timing, duration, magnitudes
Mechanics: “Workshop” Approach

- Workshops configured for 1-2 days - Key business and project people needed for TCA data/analysis have only limited time for TCA type analysis (current paradigm)

- Highly disciplined process with total focus on TBCA - due to limited time

- Scenarios used to clearly document key issues, data, judgements and decisions
Dow TBCA Process Overview

Problem Statement

What do we need to know?

Assemble Workshop Team and

Define & Develop Scenarios

Team members provide input on

Scenarios  Probabilities  Timing  Costs

Analysis Model
(TCAce™)

Review results with
team; modify if necessary

10-year Total Benefit  10-year Cash Flow

Communicate & use
results in decision making

Optional Spreadsheet Tracking/Recording of Inputs and Results

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Goals for Biodiesel Facility

- Community Goals
  - Maintain agricultural land
  - Minimize environmental impact
  - Add revenue stream

- Corporate Goals
  - Profitability
  - Sustainability
  - Use of economical raw materials
  - Safe and environmentally sound processes and practices.
Project boundaries

Seed Crops

Biorefinery

Biodiesel

Lubricants and glycerin

Used cooking oil

Fodder

EarthShift
**Scope**

- Plant to produce 2.5 million gallons biodiesel per year
- Design & construction to begin in 2005
- Operations to begin 18 months later
- Plant to be built on brownfields
- Up to 50% of feedstock to come from “yellow grease” (used cooking oil)
TCA Options

- Option 0. Do Nothing
- Option 1. Build Biorefinery with purchased virgin seed oil
- Option 2. Build Biorefinery as a cooperative with oil seed farmers
Type I & II Costs

- Plant construction
- Operational costs
- Feedstock costs (complex equation allowing 0-50% to come from less expensive, but price-volatile yellow grease)
- Licensing and Reporting
- Hazardous material handling
- Testing
- Revenues – modeled as negative costs (complex price distribution)
Distribution curve for biodiesel revenues

Lognormal Distribution with the Mean at 1.5 and a Standard Deviation of 1.5
Scenarios

1. Delay due to permitting or other regulatory requirements
2. Methanol discharge to air
3. Massive Methanol discharge to land
4. Employee exposure
5. Improper disposal by subcontractor
6. Plant Contamination
7. Union negotiation
8. Product does not meet test criteria
Results of Life Cycle Assessment (Virgin Oil only)

- 78% reduction in greenhouse gas production = -18 lbs CO₂ /gal (a)
- Nearly equal energy to produce: 0.23 MJ vs 0.20 MJ (b)
- 3.2 MJ produced per MJ of fossil fuel used (b)
- Fewer particles, CO, and, SOx by reducing levels at the tailpipe. (a & b)
- NOx and total hydrocarbons higher for biodiesel (tailpipe hydrocarbons lower) (a & b)

(a) Berlin-based Institute for Energy and Environmental Research (IFEU) “Life Cycle Assessment of Biodiesel: Update and New Aspects”,
(b) National Renewable Energy Laboratories (NREL) publication “An Overview of Biodiesel and Petroleum Diesel Life Cycles”
TCA Results

In both biorefinery options, the NPV calculated through 2008 is positive, showing rapid return on investment. Discount rate is set to 0.12.
Simulated NPV for the first biorefinery option shows a 95% probability of a positive NPV calculated through about 2009. Discount rate is set to 0.12.
Simulated NPV for the cooperative situation shows a high potential for excellent results.
The Decision

- LCA shows biodiesel lowers local environmental impacts
- TCA shows profitability for the company with little environmental risk
- Company looking at other tools to make their final decision