Sustainable Demand Chain Management: an Introduction

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Overview

In this stand-alone overview of analyzing how sustainability intersects with demand chains we address the following in order:

- Introduction to the Chain
- Chain Management and Strategy
- Introduction to Sustainability
- Modeling Fundamentals
- Logistics, Energy and CO_2 Emissions
- Analyzing our Chain's Energy and Emissions

What is a Demand Chain?

- Answer: it is a sequenced network of facilities and activities that support the production and delivery of a good or service
- Demand chains are sometimes referred to as *supply chains* or *value chains*
  - These terms are interchangeable
  - *Marketing* tends to view the chain as supporting demand pulls
  - *Operations* tends to view the chain as supporting supply pushes
  - The default term for the rest of this presentation will be “Supply Chain”

The Supply Chain Sequence

- A supply chain starts with basic suppliers and extends all the way to customers via *stages*
- Supply chains are directional: *Upstream* vs. *Downstream*
- Stages may include the following facilities:
  - Suppliers
  - Factories
  - Warehouses
  - Distribution centers
  - Retail outlets

Supplier Manufacturer Distributor Retailer Consumer

Supply Chains: Complex and Connected

- Not all supply chains include all stages, but all supply chains end with a consumer
- Supply chains may be interlinked
  - one supply chain's end consumer may be an intermediate link in another supply chain
  - Example: a consumer of cylinders of compressed CO_2 may be a soft drink producer, which then uses the gas to carbonate its drinks

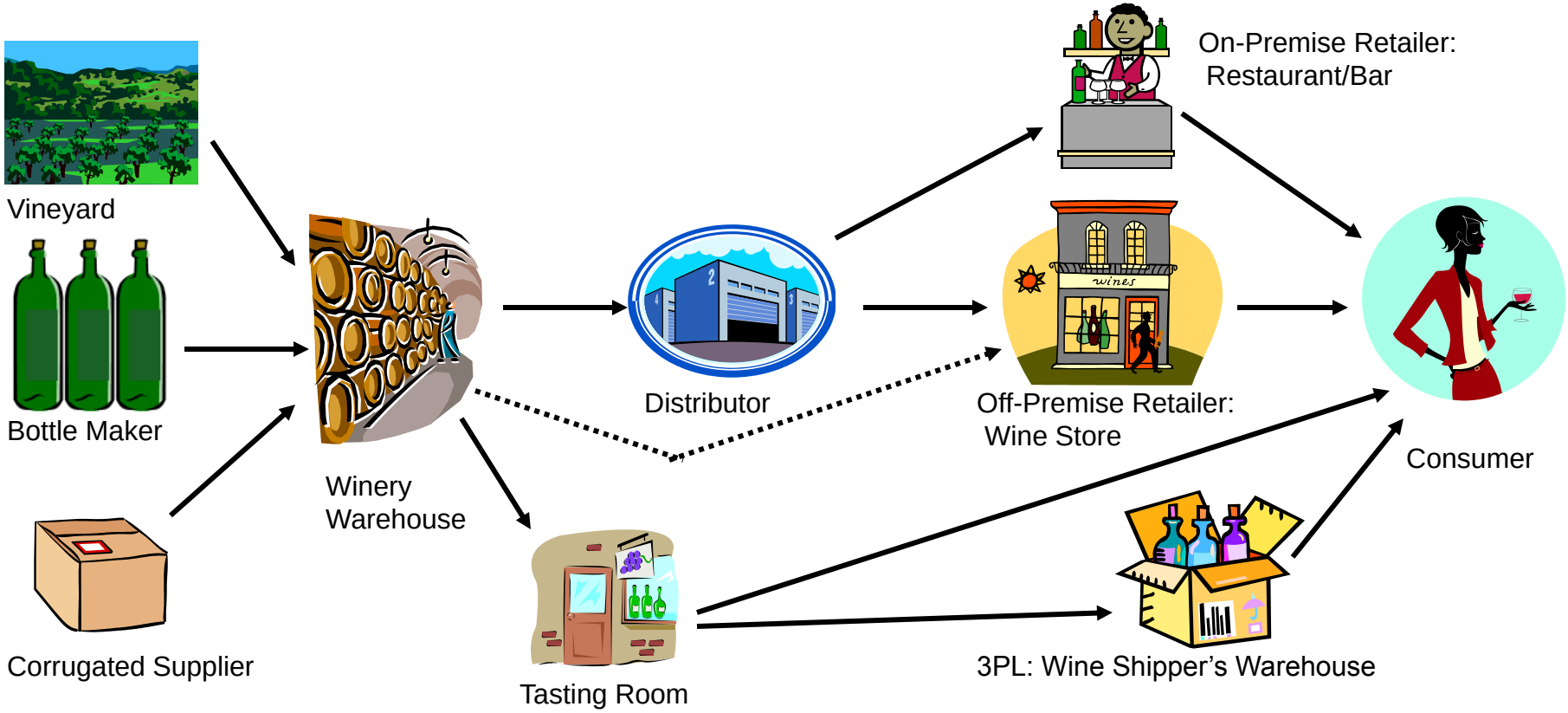
Supply Chain Activities

- Supply chains go beyond manufacturing, including such functions as:
  - Demand Forecasting
  - Purchasing (also known as Sourcing)
  - Customer Relationship Management (CRM)
  - Logistics: the movement and storage of goods, services and information, logistics is umbrella term for such important functions as:
    - Transportation
    - Inventory Management
    - Packaging
    - Returns/Reverse logistics
- These activities are often complex and interdependent…

Supply Chains Require Collaboration Across Organizations

- Few supply chains are vertically integrated, completely controlled by one company
  - Manufacturers and Retailers are typically different firms
- Companies may outsource supply chain activities
  - Many tech and electronics firms use contract manufacturers examples: Nintendo's Wii, Apple's iPhone
  - Transport and storage functions may be handled more effectively by Third Party Logistic Providers (3PLs)
- Outside firms that form part a company's supply chain are *channel partners*
  - *Extended Enterprise:* the network of channel partners

The Supply Network for a Winery



Supply Chain Management (SCM)

- SCM is the coordination of business functions within an organization and its channel partners in order to provide goods and services to fulfill customer demand *responsively*, *efficiently* and *sustainably*

Levels of Supply Chain Management Decisions

1. **Strategy**
   - Designing and building the appropriate supply chain for the good or service to be provided
   - *Long-term*, decisions made at the executive level
2. **Planning**
   - Leveraging the existing supply chain to support *medium-term* goals
3. **Operations**
   - *Short-term* monitoring and control to support the supply chain plan and any plan revisions

Supply Chain Strategy: Making Tradeoffs

- Traditional Focus: Balance **Customer Responsiveness** with **Cost Efficiency**
  - A firm's supply chain strategy must fit its overall competitive strategy
  - First, consider the customer needs and product attributes.
    - If product is more like a commodity, price may be the driver, necessitating a cost-effective supply chain
    - High level of product differentiation may require greater levels of customer responsiveness
    - Example: iPhone verses laundry detergent

Sustainability: the Third Dimension of Supply Chain Strategy

- Sustainability is an emotionally charged word that means different things to many people
  - Sustainable: “Able to keep in existence, maintain” (Webster’s Dictionary)
- Our definition: A sustainable firm is one that is able to produce and deliver its goods or services for the foreseeable future without causing degradation
- An effective supply chain strategy must explicitly address sustainability

Triple Bottom Line (3BL)

1) Social Responsibility
   - Does the firm provide a safe working environment, with appropriate compensation and benefits?
   - Does the firm avoid child labor, forced labor or discrimination in hiring or promotion?
   - Does the firm make a positive contribution to the communities in which it is located?
2) Environmental Stewardship
   - Can the firm avoid depleting resources, prevent pollution, or otherwise reduce its ecological footprint?
   - How is the product able to be reused, recycled or ultimately disposed of? Can the total cost of ownership be reduced?
3) Economic Viability
   - Is the firm profitable?
   - Can the firm be expected to grow and prosper, providing returns to investors?

A firm deficient in any of these three facets is ultimately not sustainable

Measuring Sustainability: Approaches

- There is no one universally acknowledged path to sustainability
- Mainstream discussion of sustainability in businesses is relatively recent, in both the classroom and the boardroom
- The following slides present some different frameworks for considering facets of sustainability

Total Cost of Ownership (TCO)

- The estimated sum of all costs: procurement, manufacture, distribution and usage (operation) to disposal and even beyond ….
  - Popularized in the 1980's for information technology investments, predating much of the current sustainability movement
  - Frame must be set:
    - Example: cradle-to-grave or cradle-to-cradle?

Life Cycle Assessment (LCA)

- An analysis of the environmental aspects and potential impacts associated with a product, process, or service
- Despite the inclusion of environmental management standards in ISO14000, no single universal standard exists for the impact categories evaluated:
  - Typically included: global warming, acidification, smog, ozone layer depletion, eutrophication, toxin release, habitat destruction, desertification, land use issues, resource depletion
  - Some categories are more relevant for certain firms than others
  - Occasionally has a social component
- Again, frame must be defined and appropriate for the situation: cradle-to-gate vs. cradle-to-grave

Ecological Footprint

- Quantifies the land and water area a population requires to produce the resources it consumes and to absorb its wastes.
  - Earth's "carrying capacity" is currently being exceeded
- Similar to LCA, except with a focus on consumers, not producers
  - Measures water usage, resource depletion, etc
  - Carbon Footprint is the largest component (over half)
- A U.N. study shows that development and footprint are highly correlated, but some countries with a High Development Index have a lower footprint than others
  - Footprint of the "average" American is approximately twice than of a Swiss

Carbon Footprint

- Component of LCAs and Ecological Footprints
  - One of the larger impacts, so often considered alone
- Other greenhouse gasses (methane, nitrous oxide) often included to provide a single aggregate measure: CO_2 equivalents, CO_2e
  - 95% of greenhouse gas emissions are CO_2
- Points of Confusion
  - Tons (US) vs. Tonnes (Rest of World)
  - Is it carbon emitted or CO_2 emitted? (only 30% of CO_2 by weight is carbon)
  - Scope 1, Scope 2 or Scope 3?
  - Include Radiative forcing for airplane emissions?

Food Miles

- Distance between the production source and retail store
  - Simple calculation: the further food travels, the more energy and emissions result
  - On average, domestically produced food items travel over 1000 miles before reaching the US consumer
  - Reliance on imported produce is growing
- Proponents of reducing food miles share many ideas with the Slow Foods Movement
  - Support neighboring farms
  - Access to fresher, less processed foods
  - Encourage pride in regional cuisine, sense of *terroir*
- Businesses are responding to consumer interest
  - More farmers' markets
  - UK supermarket chain Tesco provides food mile information
  - Safeway estimates up to 30% of produce is local in many stores
- A controversial measure that we will discuss later

Sustainability: Certification and Labels

- As previously mentioned, sustainability is a relatively new concept for mainstream society and no one single approach dominates
- Lots of labels
  - Food: industry estimate- over 300+ eco-labels
  - West Coast Wine: 5 different 3rd party certifications and labels
- Third party certifications hold more weight and recognition than company-created labels or other self-assessments
  - May lessen risk of “greenwashing”

Sustainability Certification and Labels What Does It All Mean?

- In order to make sense from this confusion, we must able to critically understand and analyze
- The next section will give us the background we need for making such analyses

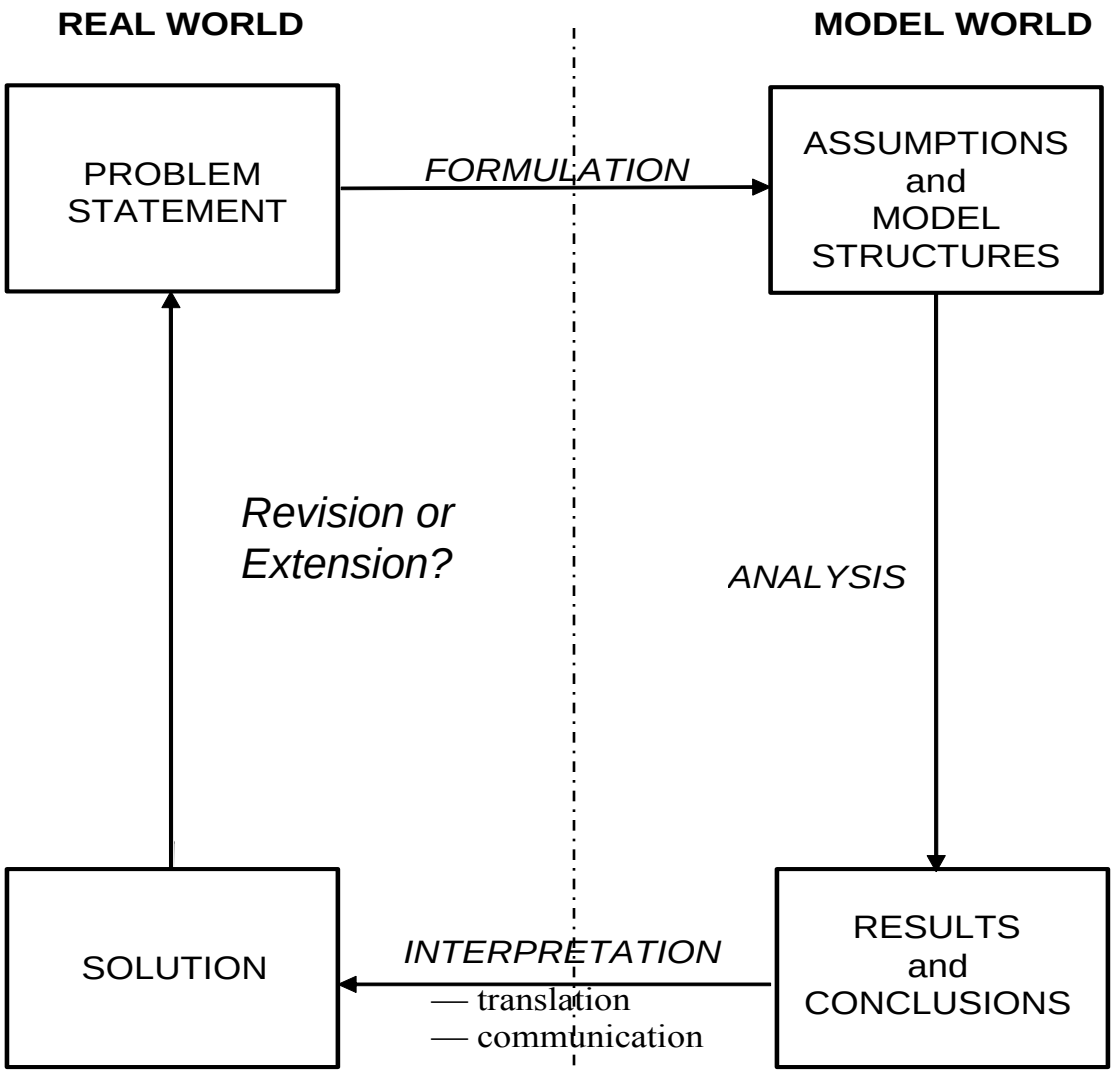
Modeling Fundamentals

- **Our Goal:** analyze a supply chain in order to assess current performance and make decisions that will improve sustainability
  - Typically we model the supply chain and measure aspects of it
- Before we start rolling up our sleeves and building models, let us review some fundamentals of modeling, including defining the frame, and establishing metrics, information and assumptions

Review: What is a Model?

- Models are quantitative, simplified representations of real world complex systems
  - These systems often have decisions that must be made
- Models represent critical characteristics of the decision problem
  - ignore the irrelevant details in favor of simplicity
  - require data and assumptions
- Modeling is a process…

The Real World and the Model World

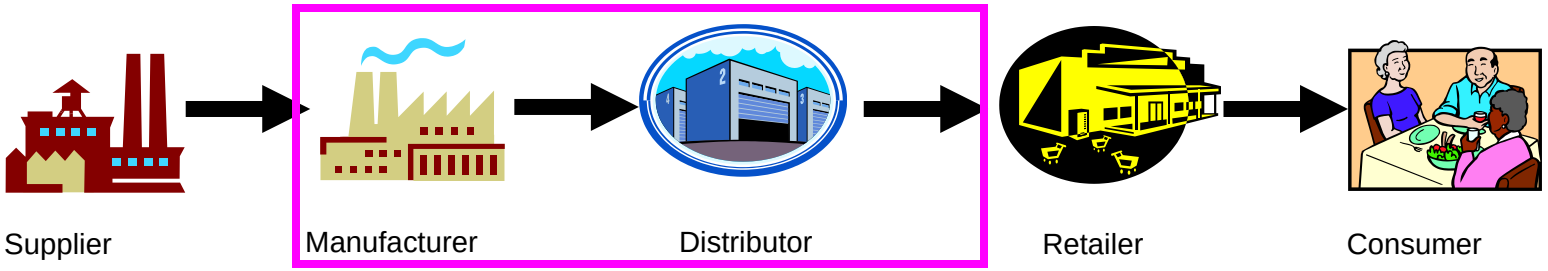


Important Model Components

- **Inputs*:*** *Parameters* (e.g. fuel usage rates) and *Data* (locations of facilities, distances between them)
  - If we do not have exact knowledge of these we may have to make approximations
- **Decision variables:** Possible choices or actions to take (e.g. What type of transport to use)
  - Must be something we have some control over
- **Output:** Consequences of the decisions (e.g. costs incurred, total energy used, emissions resulting)
- **Structure:** Logic and relationships that link the elements (inputs, decision variables, output) of the model together

Setting the Frame

- Multiple dimensions: geographic, temporal, and structural boundaries
- Inside the frame we have visibility and perhaps some ability to affect change
- Anything outside the frame is *exogenous*
  - beyond our control, at least for our current decision process
- Example: a Manufacturing and Distribution analysis



Framing Considerations

- Direct Control verses Influence
  - Wal-Mart owns less than 10% of their supply chain, but exerts a huge influence over channel partners
  - Independent retailers?
- Monitoring and enforcement for supply chain partners
  - Nike and IKEA's use of foreign manufacturers- child labor issues
- Crucial to assessing sustainability impacts
  - LCAs: When is cradle-to-cradle better than cradle-to-grave?
  - What if we only have control over our distribution processes?

Frame: Big or Small?

- **Too large** a frame:
  - we will be swamped with details
  - risk falling into “analysis paralysis” because the problem seems too big to solve
- **Too small** a frame:
  - Temptation to set the frame to include only the parts for which we have firm data
  - Can lead to sub-optimal decisions, “silos”
  - May miss real opportunities, lose the “big picture”
- **Compromise** may be necessary
  - Pilot studies may address a fraction of the supply chain. It is easier to start with a simple model
  - After a successful pilot, then expand model to include more detail or to broaden the scope.

Metrics

Are needed to translate performance into numbers and benchmark to a standard.

- The more widely used a metric, the more authority it carries

- Traditional Supply Chain Management: The Supply Chain Council has defined the SCOR reference model:
  - 150+ performance indicators
  - Depending on the supply chain strategy, some metrics may be more important to a firm than others
    - Perfect Order Fulfillment vs. COGS
- The latest iteration of SCOR has incorporated some environmental and risk-management measurements
- *However, there is not yet one universally adopted approach to measuring sustainability*

Metrics: Think Beyond the Numbers

- Food miles is an easily understood metric, measuring distance traveled from “Farm to Fork”
- Underlying idea: the less food has to travel, the less energy wasted in transit
- Food for thought:
  - What about the energy used to transport supplies to the farm from any processing or storage?
    - Example: Grass-fed lamb from New Zealand vs. Feed-lot “local” lamb
  - Transport modes such as ocean shipping and rail are efficient on a per-weight basis, even over long distances
  - Many African and South American farmers derive their livelihood on servicing export markets
- Simple metrics may be misleading, especially when used in isolation

Model Conclusions: Consider the Level of Enforcement

1) Mandatory Regulation
   - Oversight and enforcement by governmental agency
   - Failure to comply: fines or worse
     - Example: CARB: California Air Resource Board. *What happens if your car fails Smog Check?*

2) Voluntary Participation
   - Certification programs: LEED, EnergyStar, SmartWay etc
     - Typical benefits- logo, directory listing
     - Failure to comply: certification revoked
   - Often industry-initiated and run. Example: California Sustainable Winegrowing Alliance (CSWA)

3) Internal Initiatives
   - Companies define their own goals and measures of success
   - Efforts may or may not be published

More Thoughts on Enforcement

- Validating compliance by an external agent important for maintaining credibility
  - Inability to meet standard must have consequences
  - Important for Mandatory Regulation or Voluntary Certification
  - Not typical for internal initiatives
- Point of open consideration: What level of enforcement is appropriate?
  - Example: toxic waste disposal
  - Newer technologies, products or markets may need time to develop and mature. Example: should the US enforce a minimum percentage level of post-consumer recycled material for use in packaging?
  - Are companies or government agencies better able to innovate cost-effective solutions?
  - Evolution: Individual company initiatives may lead to industry-defined guidelines, which may eventually be codified into regulation

Logistics, Energy and CO_2 Emissions

- Paraphrasing CSCMP.org, logistics involves “the management of the flow of goods, services and related information between the point of origin and the point of consumption, in order to meet customer requirements”
- Succinctly, logistics entails *the movement and storage functions of the supply chain*
  - The amount of energy used in transport and in climate control for storage is often substantial
  - US transportation CO_2 emissions In 2007 surpassed 2.0 billion tonnes -1/3 of national total
  - Yet a survey of Fortune 500 companies found that under 10% of them have addressed the environmental impacts of transportation, and even fewer are actively implementing improvements.
- The focus of the rest of this module is on logistics and its requisite energy usage, and hence, resultant carbon emissions

Who is Doing What?

1. **Carrier**: transports the product
2. **Shipper:** initiates the movement of the product forward into the supply chain
3. **Consignee:** receives the shipment

- These parties may all be different entities
- Third Party Logistics Providers (3PLs)- carriers, warehouse owners, or coordinators who arrange for transport or storage services

à la Transport Mode

- Within the developed world, the four most common modes to ship large quantities of packaged products:
  1. Barge/Ship
  2. Rail
  3. Truck
  4. Air
- In the US, trucking dominates
  - Over 75% freight transit bill
  - Many configurations possible
    - 3PL providers vs. Own Fleet
    - Variety of truck sizes
    - TL vs. LTL

Motorcycles are *not* one of the predominant ways to ship cargo

Transport Modes: a Moving History

Transport mode usage has shifted over time

- Inland water (River/Canal) replaced animal caravans
- Mid 1800's Railroads displaced inland water
- Mid 1900's Truck displaced rail
- Air cargo small but growing
  - Popular for short life-cycle products like flowers, luxury food
  - 9% of US transportation fuel usage is for air
- Interestingly, water has started to make a comeback
  - Inland-water: In the UK, Tesco uses barge transport for many beverage products
  - Short Sea Shipping, using ocean-going vessels for domestic cargo, is popular in Europe and holds promise in the US

Transport Modes: Energy and Emissions

- Definition: 1 tonne-km as moving 1 metric ton of cargo 1 km
- Transport modes vary in energy and emissions profiles

	MJ/t-km	kg CO2e per t-km
International water-container	0.2	0.14
Inland water	0.3	0.21
Rail*	0.3	0.18*
Truck**	2.7	1.8
Air***	10	6.8

* May depend on whether diesel or electric power is used
** Depends on size and type of truck, power source

*** Includes effects from radiative forcing

- Caveats abound for exact figures, but what do you notice?

Intermodal Transport

- Definition: using more than one mode to move a shipment between two points (e.g. Water to Rail to Truck)
- Intermodal became practical with *containerization*
  - reduced unloading time at ports, boosting cost-efficiency of international trade
  - Products stay in container through entire journey
  - Containerization itself made possible through global standardization of containers (ISO.org)
- Advantages:
  - Utilize more efficient modes for major transport corridors, then unload to trucks for transport to more remote destinations
  - Shippers can use a 3PL to oversee the complete service
- Disadvantages:
  - Complexity of coordination, requires greater IT support
  - Movement of empty containers
  - Potential security issues: Theft? Terrorism? (C-TPAT)

Utilization and Backhaul

- Two considerations often overlooked
  - Utilization: How highly vehicles are *utilized?*
  - Backhaul: Is the return journey made while carrying freight?
- Fully laden vehicles use more fuel than nearly empty ones, but much of the energy used in a trip is for transporting the vehicle itself
- Consider weight and volume limits
  - All but the lightest, bulkiest cargo

    "weighs out" rather than "cubes out"

Climate Control

- A need for climate control may also increase energy usage and resultant emissions
  - Foods often require cooling, refrigeration or even freezing in transport
- Can significantly increase the energy usage associated with warehouse storage
- Even the location of facilities within the supply chain can effect emissions
  - Processing and storage facilities in countries where more electricity is generated from renewable fuels or cleaner energy sources will generate fewer emissions

Analyzing our Supply Chain's Energy and Emissions

- Now that we have reviewed some basics about Supply Chains (especially logistics), sustainability and model building we are ready to use some web-based software and come up with a definitive answer to "How much carbon does our supply chain emit?"

  Or are we?

First, a Cautionary Tale

- Let's say that you planned to take a trip flight to New York and wanted to purchase offsets for your round trip flight

- The web has free online carbon calculators, many with links to donations for offsetting one's carbon footprint

A Comparison of Carbon Calculators

- For a SFO->JFK round trip (~ 5100 miles / 8200km)

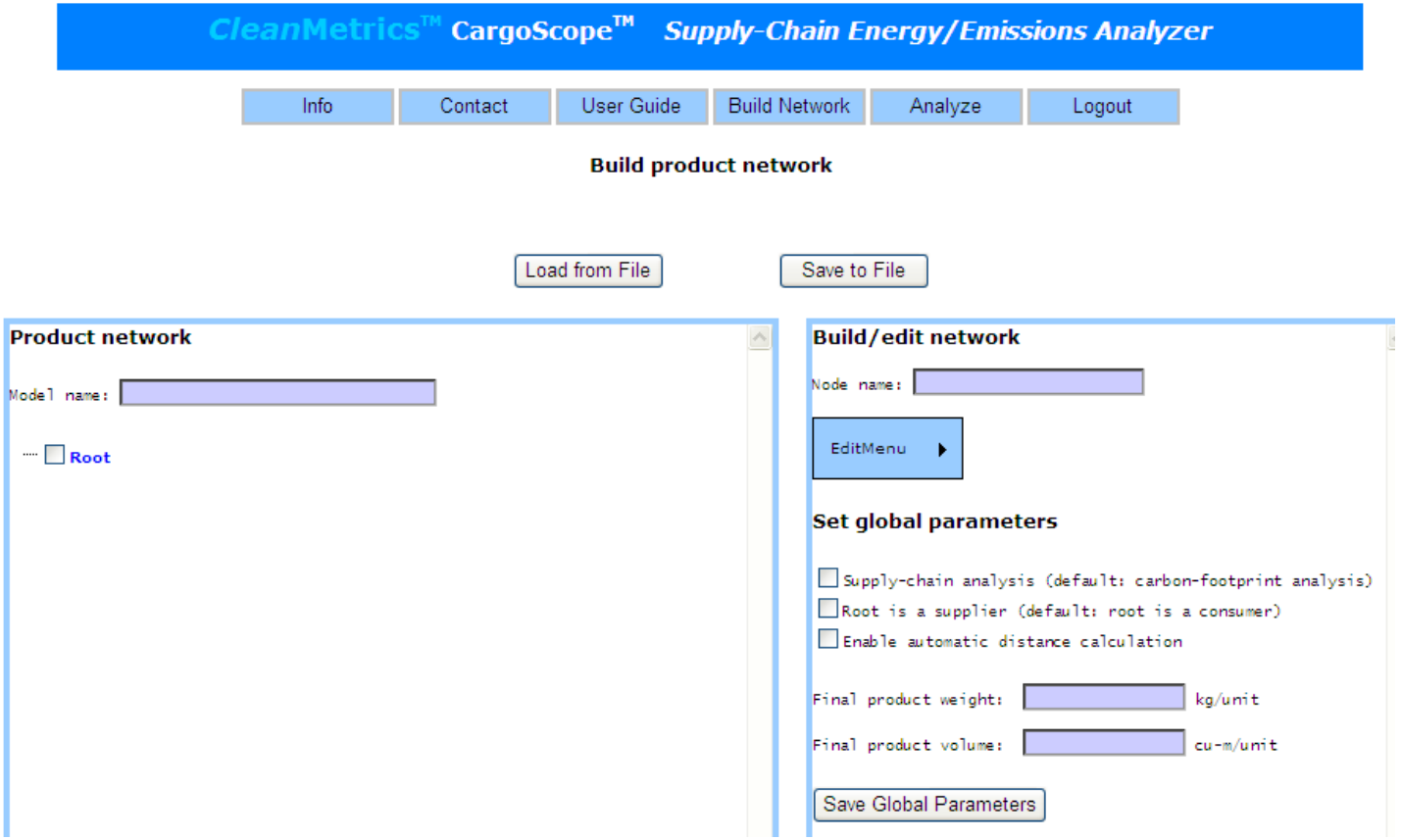
	tons CO2e	recommended offset	implied $ per ton
Carbonfund.org	0.93	$ 9.34	*$ 10.04*
adding radiative forcing)	2.52	$ 25.22	*$ 10.01*
Terrapass.com			
via Jetblue	1.462	$ 11.90	*$ 8.14*
via Virgin	1.584		
via United Airlines	2.215	$ 11.73	*$ 5.30*
Sustainabletravelinternational.org	1.86	$ 47.31	*$ 25.44*
Nativeenergy.com	2.055	$ 42.00	*$ 20.44*
Bonneville Education Foundation			
Greentagsusa.com	4.192	$ 56.00	*$ 13.36*

Carbon Calculator Confusion!

- A well-defined trip had great variety in emissions estimates, translating to wildly divergent offset recommendations
  - Results vary for reasons both logical (radiative forcing included) and obscure (JetBlue vs. United?!)
  - We didn't even consider other factors like plane age and model, weather, utilization, backhaul….
- Even for the same amount of emissions, the websites recommended different carbon prices
- Lessons Learned?
  - Expecting high **accuracy** for emissions may be beside the point
  - Be **consistent**, do not compare situations using different tools, frames or assumptions
  - Calculations and assumptions should be **sensible** and **transparent**
  - In making recommendations, consider the **audience**

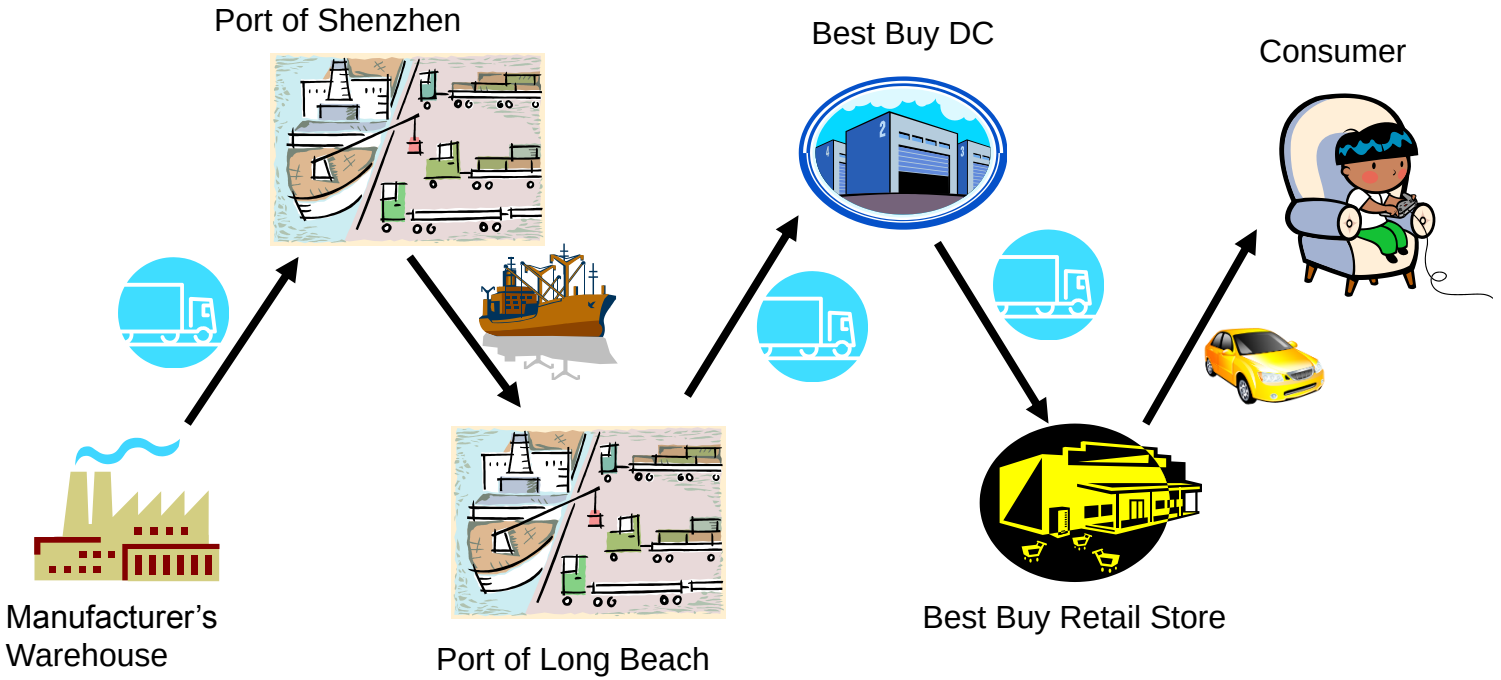
CargoScope: Our Modeling Tool

- Given these caveats, we now begin modeling
- A full walk-through with navigation help is available in a separate document, *Wii-CaseStudy.doc*



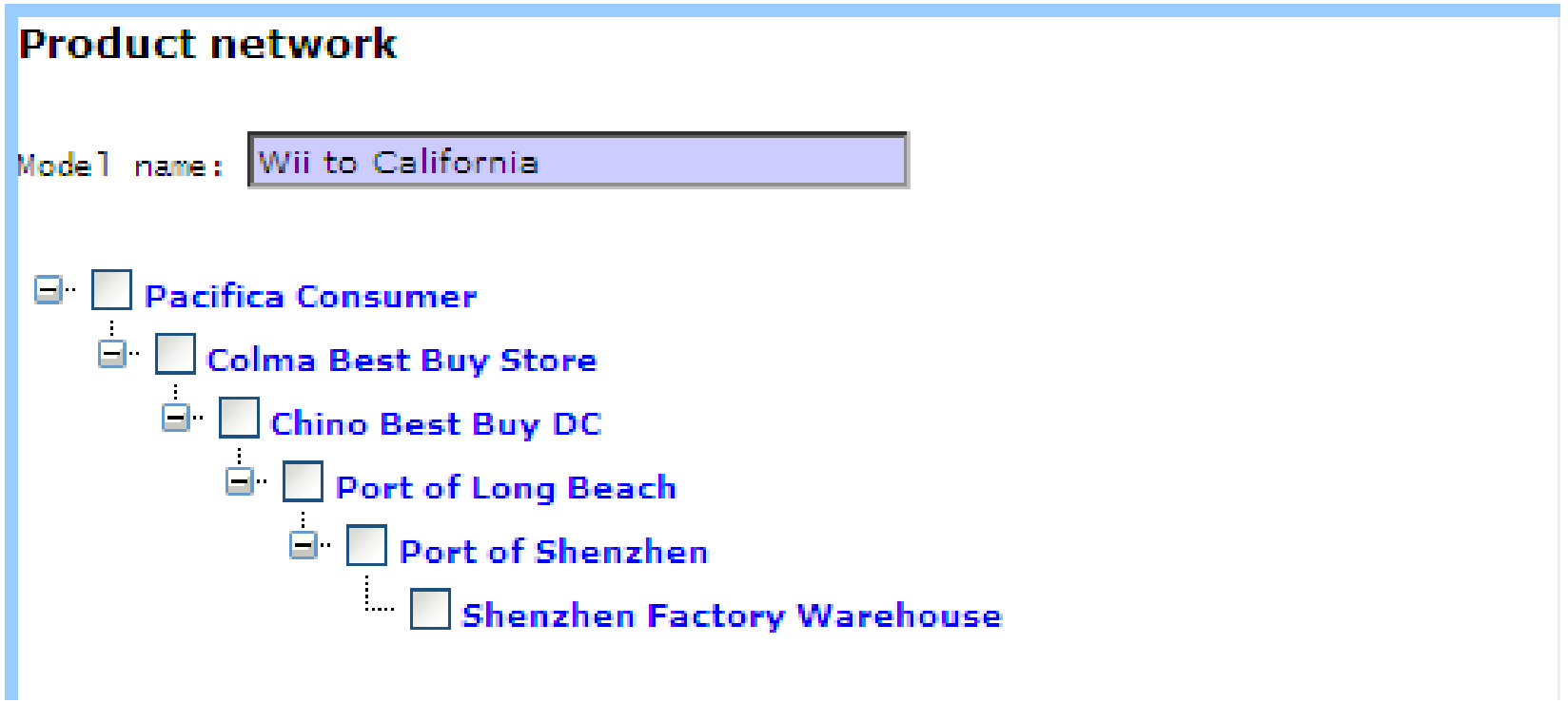
Our Example Supply Chain

- The Nintendo Wii: The **push** view from the Manufacturer *downstream* to the Consumer



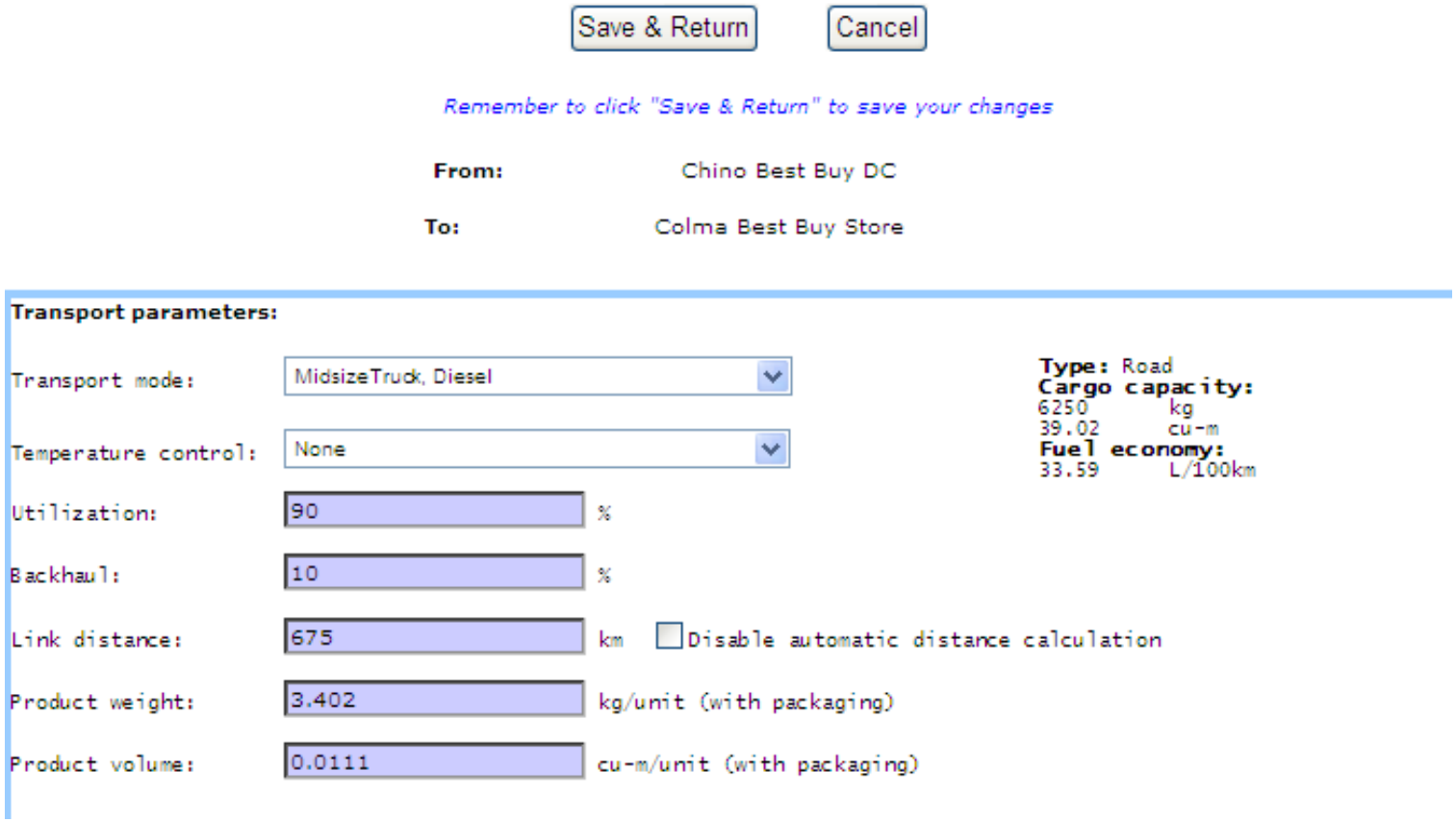
The Supply Chain in CargoScope

- We instead use a “pull” view: starting from the consumer, looking *upstream* towards the point of manufacture
  - Easier to analyze the energy and emissions impact of a single unit (1 Wii console) rather than the entire truckload of Wiis



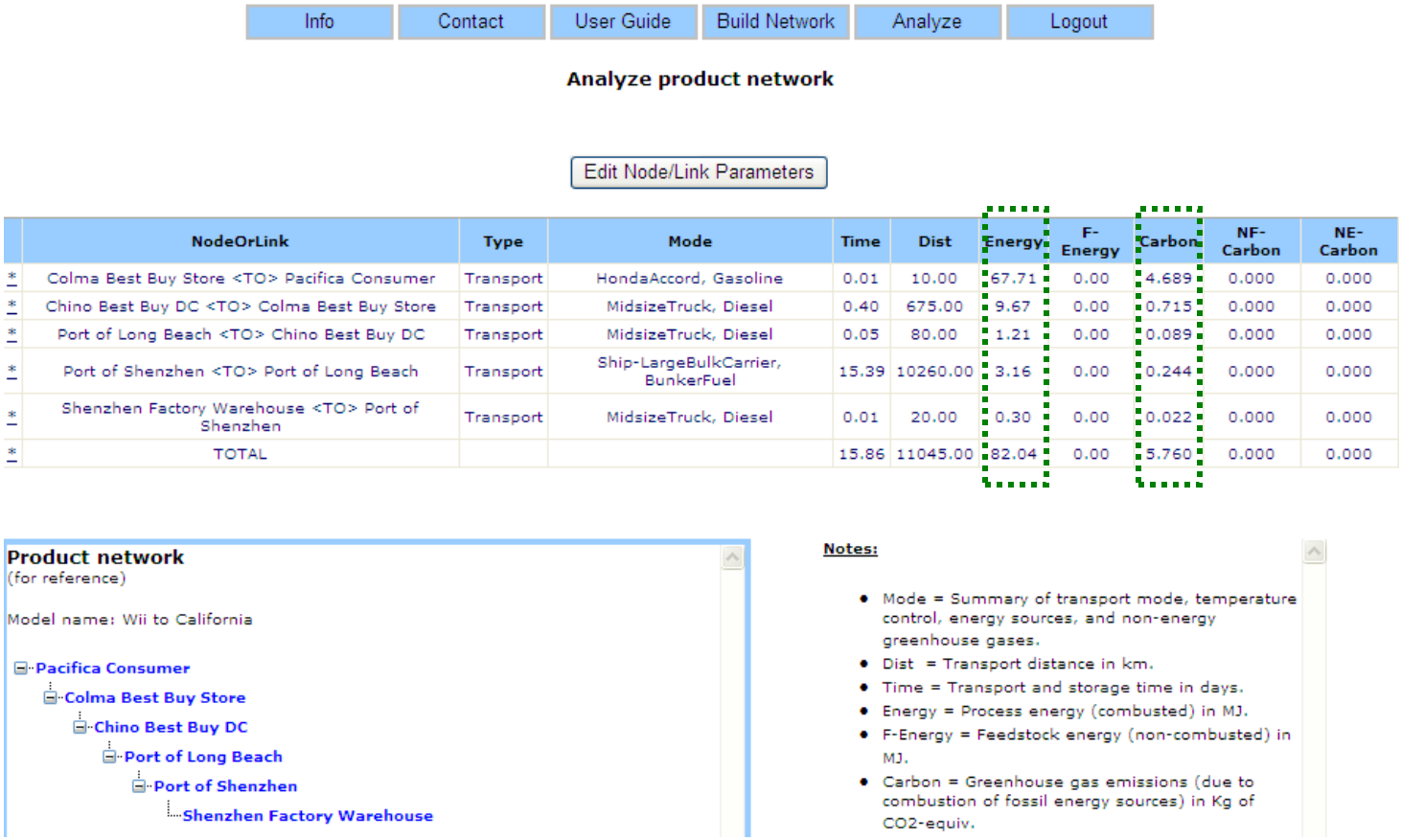
Formulating the Model

- We define nodes as storage or processing functions
- We define intra-node links by distance, transport type, temperature control, utilization, backhaul



Analysis and Results

- Once we have defined the supply chain structure and provided estimates for parameters and data, CargoScope will calculate energy usage and emissions in total and by stage



Info | Contact | User Guide | Build Network | Analyze | Logout

Analyze product network

Edit Node/Link Parameters

	NodeOrLink	Type	Mode	Time	Dist	Energy	F-Energy	Carbon	NF-Carbon	NE-Carbon
*	Colma Best Buy Store <TO> Pacifica Consumer	Transport	HondaAccord, Gasoline	0.01	10.00	67.71	0.00	4.689	0.000	0.000
*	Chino Best Buy DC <TO> Colma Best Buy Store	Transport	MidsizeTruck, Diesel	0.40	675.00	9.67	0.00	0.715	0.000	0.000
*	Port of Long Beach <TO> Chino Best Buy DC	Transport	MidsizeTruck, Diesel	0.05	80.00	1.21	0.00	0.089	0.000	0.000
*	Port of Shenzhen <TO> Port of Long Beach	Transport	Ship-LargeBulkCarrier, BunkerFuel	15.39	10260.00	3.16	0.00	0.244	0.000	0.000
*	Shenzhen Factory Warehouse <TO> Port of Shenzhen	Transport	MidsizeTruck, Diesel	0.01	20.00	0.30	0.00	0.022	0.000	0.000
*	TOTAL			15.86	11045.00	82.04	0.00	5.760	0.000	0.000

Product network
(for reference)

Model name: Wii to California

- Pacifica Consumer
  - Colma Best Buy Store
    - Chino Best Buy DC
      - Port of Long Beach
        - Port of Shenzhen
          - Shenzhen Factory Warehouse

Notes:

- Mode = Summary of transport mode, temperature control, energy sources, and non-energy greenhouse gases.
- Dist = Transport distance in km.
- Time = Transport and storage time in days.
- Energy = Process energy (combusted) in MJ.
- F-Energy = Feedstock energy (non-combusted) in MJ.
- Carbon = Greenhouse gas emissions (due to combustion of fossil energy sources) in Kg of CO2-equiv.

Conclusion

- The Wii Case Study can serve as both an introduction on how to use CargoScope and also an example how to formulate a model, interpret results, and make recommendations
- Consider the following:
  - The stages of the supply chain that are included in the frame and not included, with any justifications
  - Underlying documentation of the model data (including quality of sources)
  - Clearness and reasonableness of assumptions where data is not available
  - How results are presented and interpreted
  - The differences that result from any alternative scenarios
  - The quality of the recommendations – are they relevant and likely to be both effective and feasible?