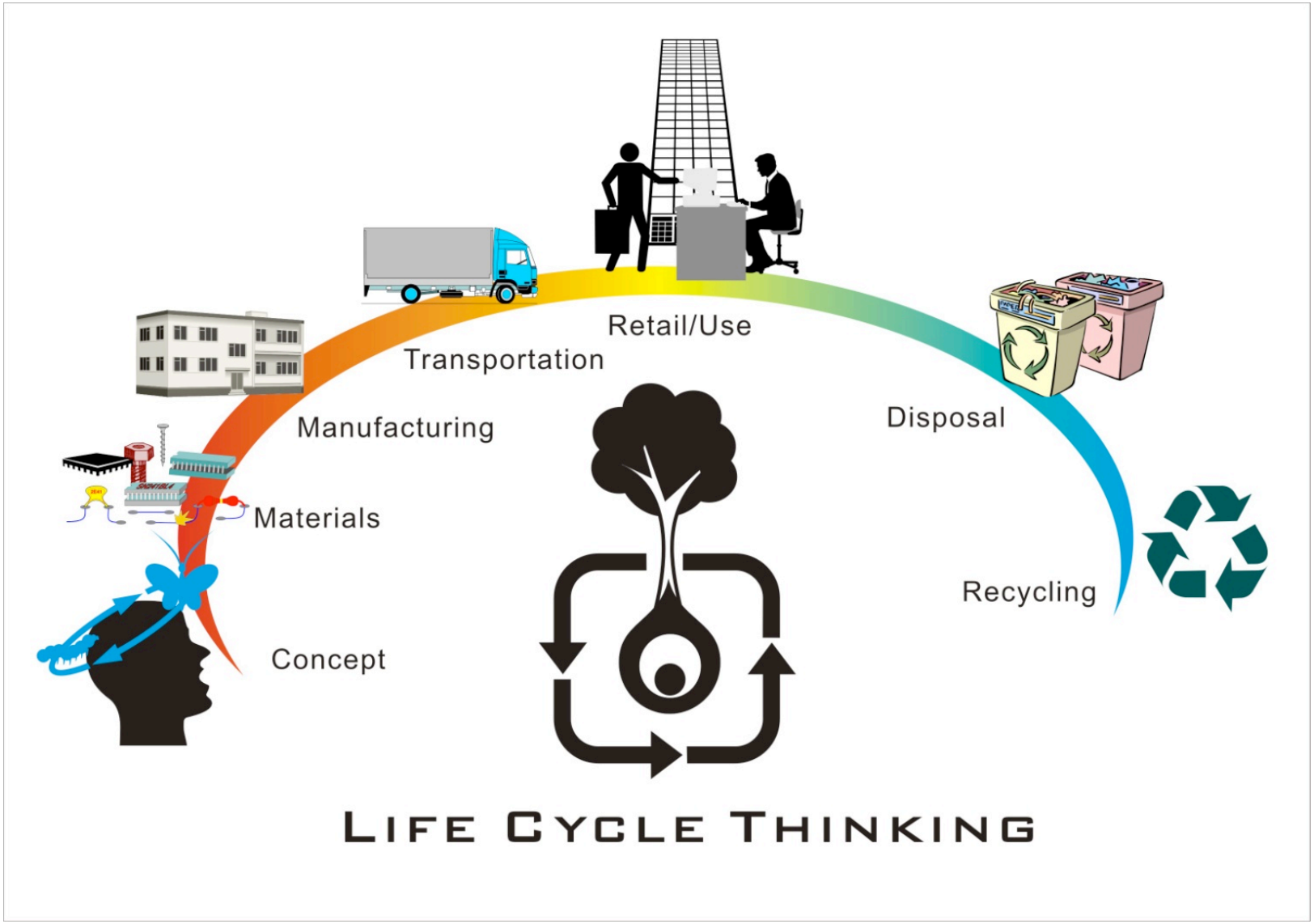
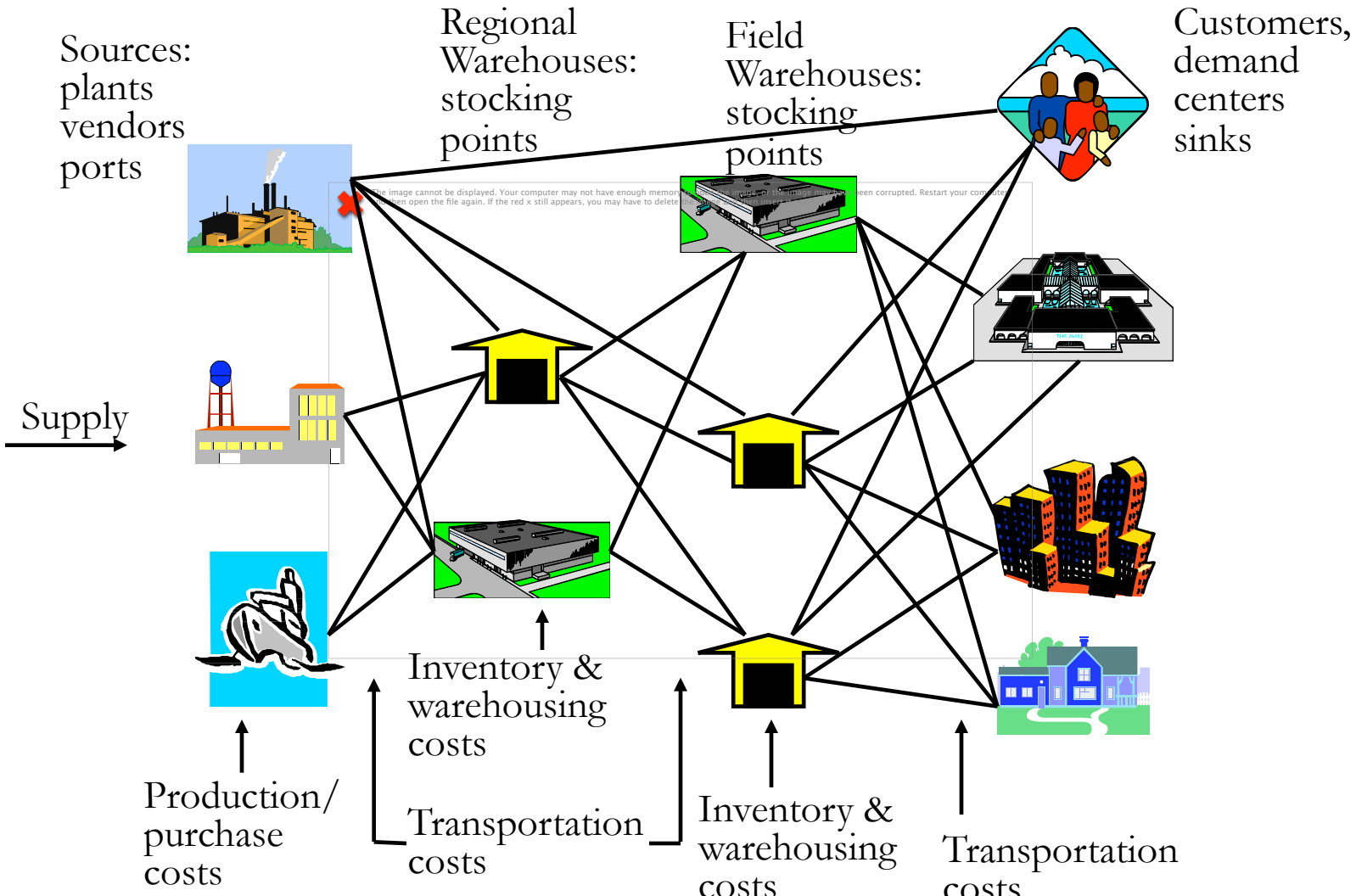


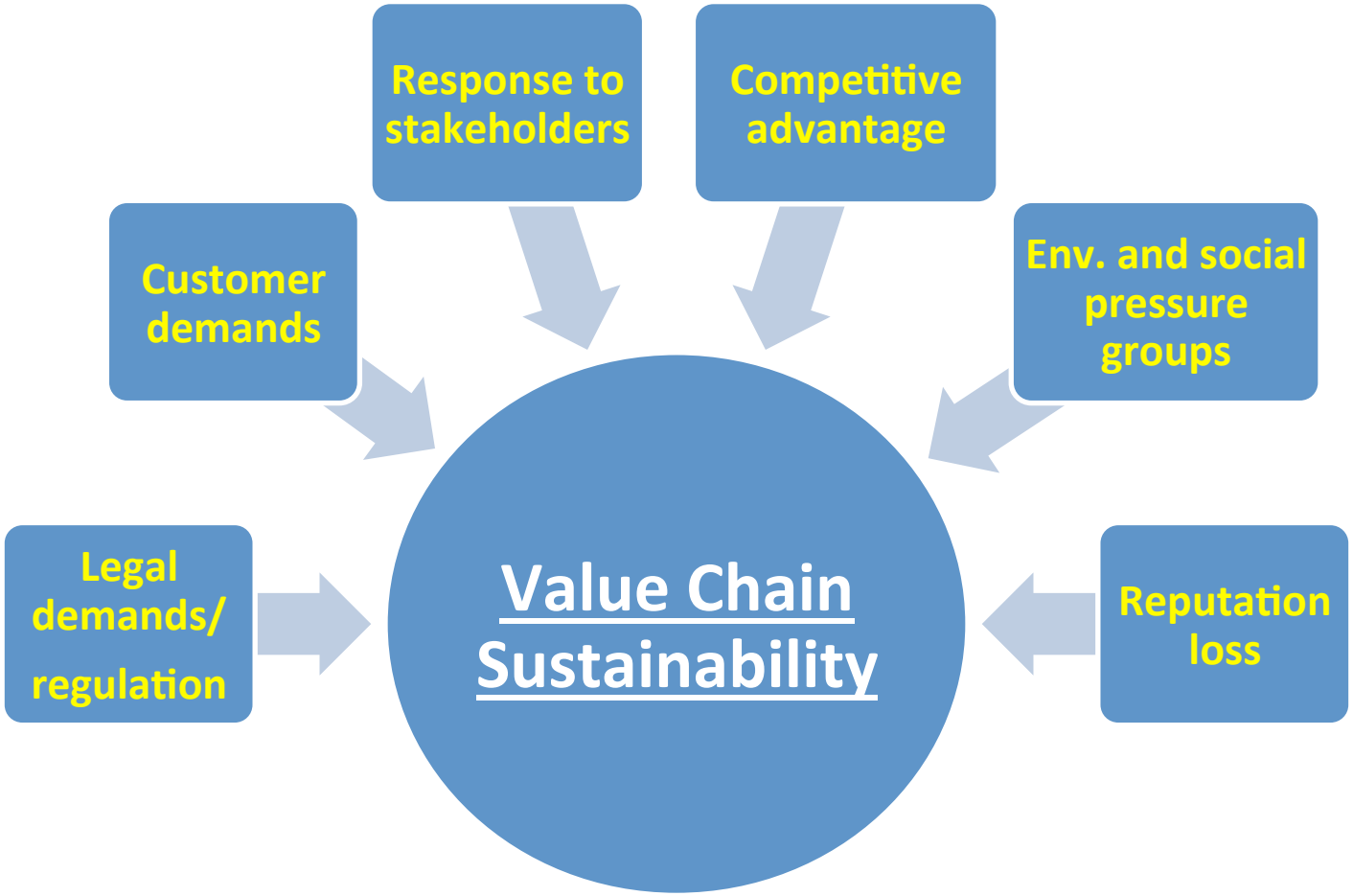
http://www.dlinkgreen.com/greensupplychainmanagement.asp

ENVIRONMENTAL, SOCIAL AND ECONOMIC IMPACTS EXIST THROUGHOUT EVERY STAGE OF SUPPLY CHAINS



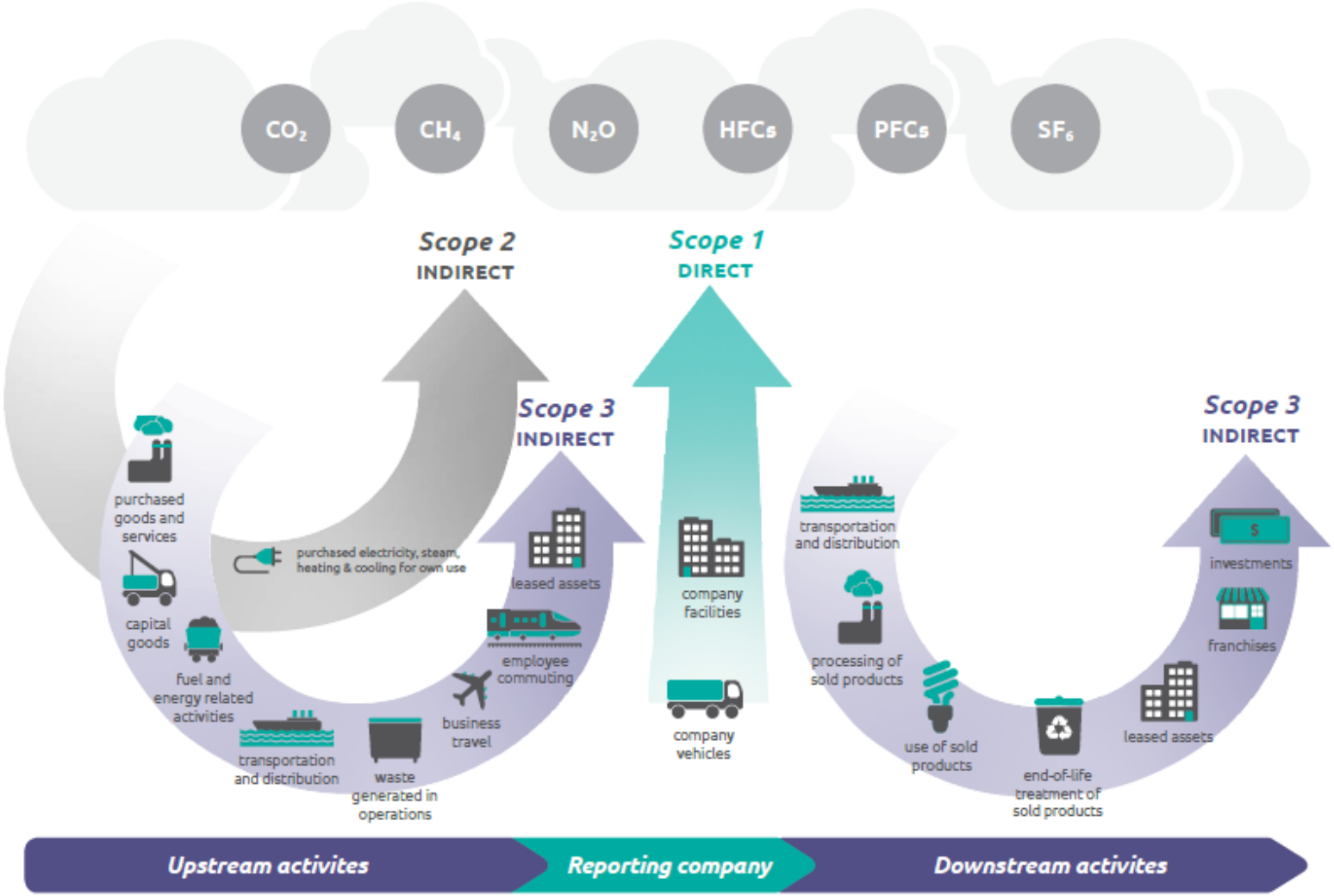
Adapted from: Supply Chain Management. Simchi Levi et al.

Pressures for supply chain sustainability



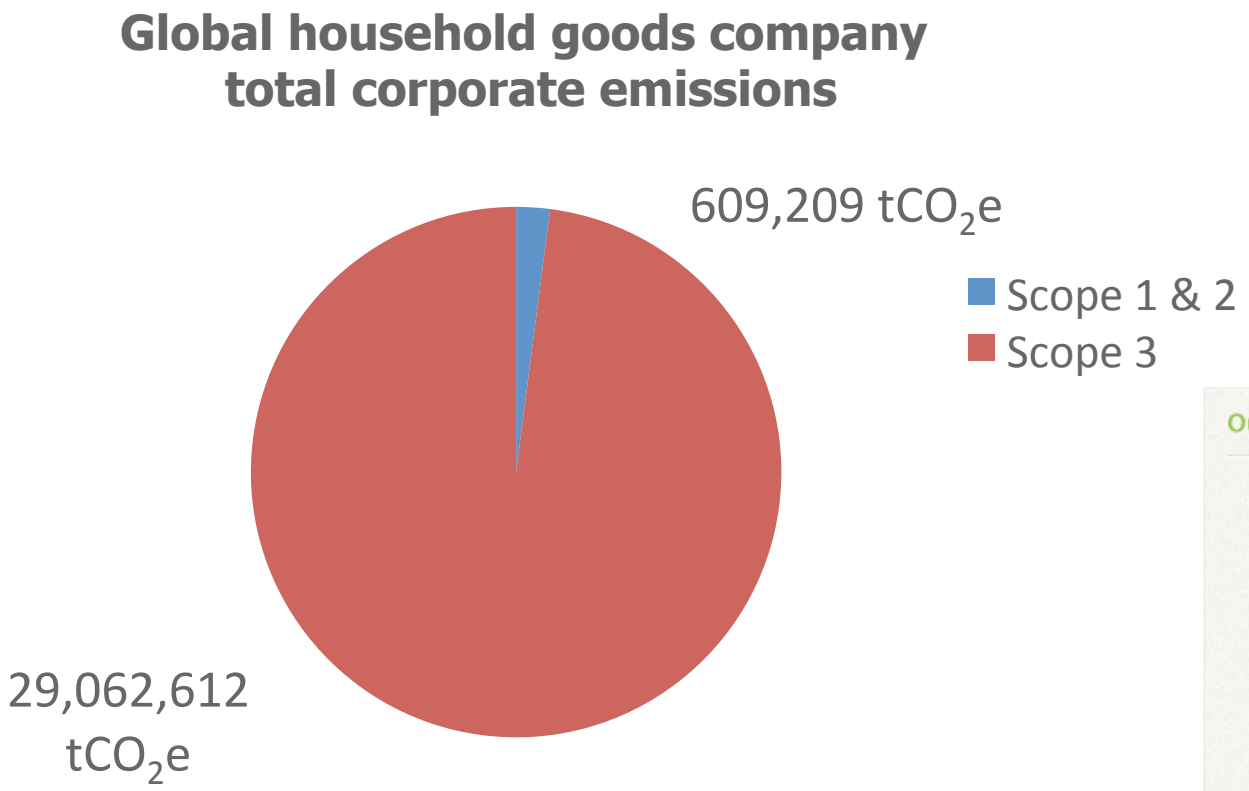
Source: Haas / CRB research project supported by the SPS Program

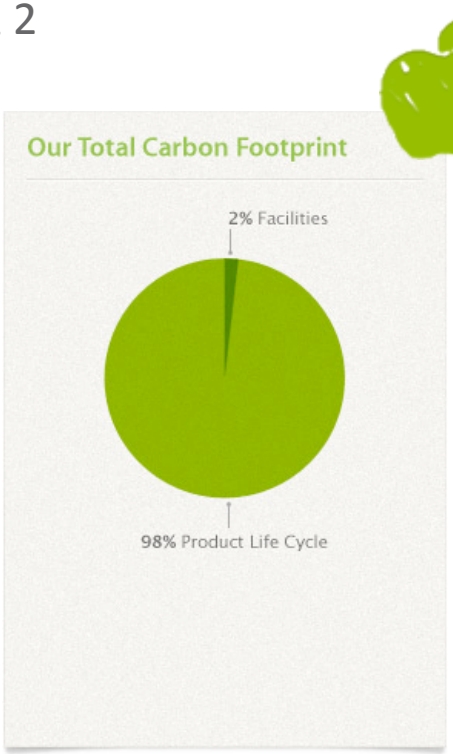
Green House Gas Protocol (Scope 1, 2, 3)



Source: WRI, Green House Protocol

Why is it important?





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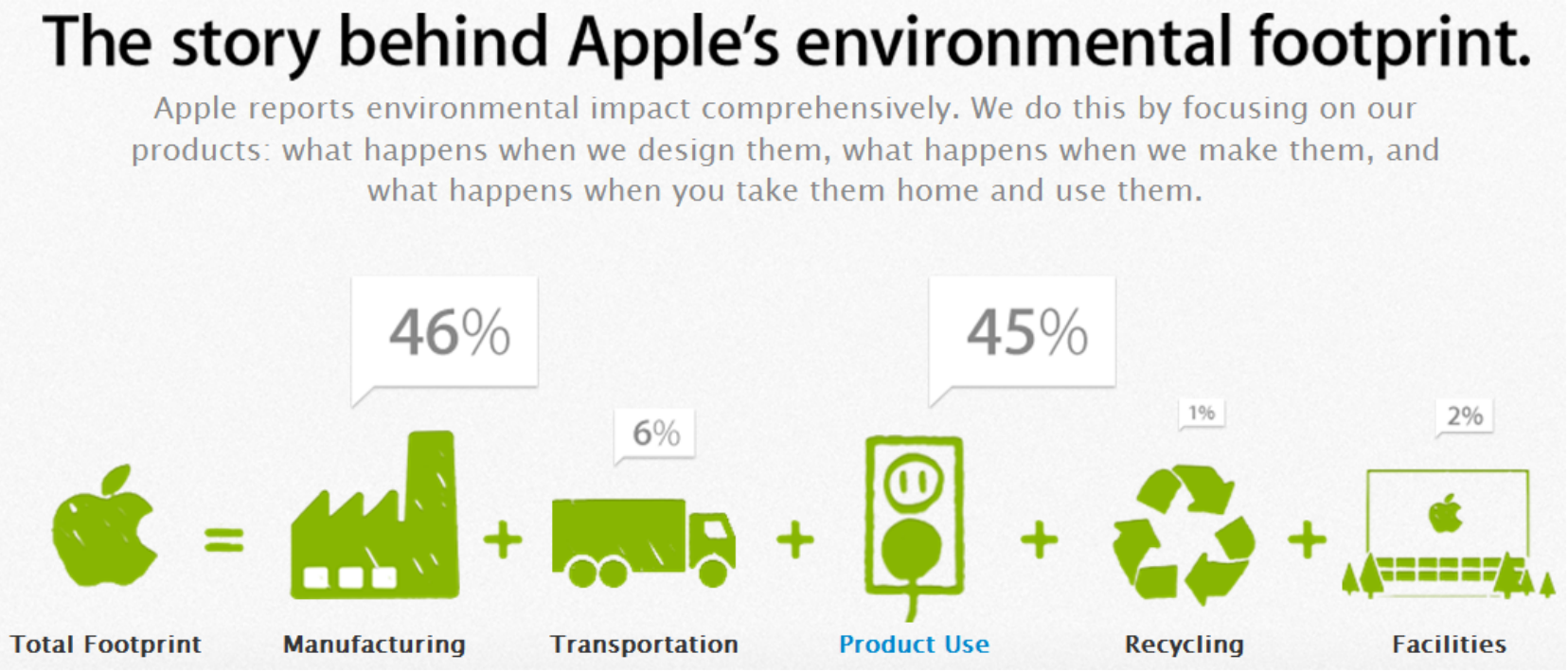


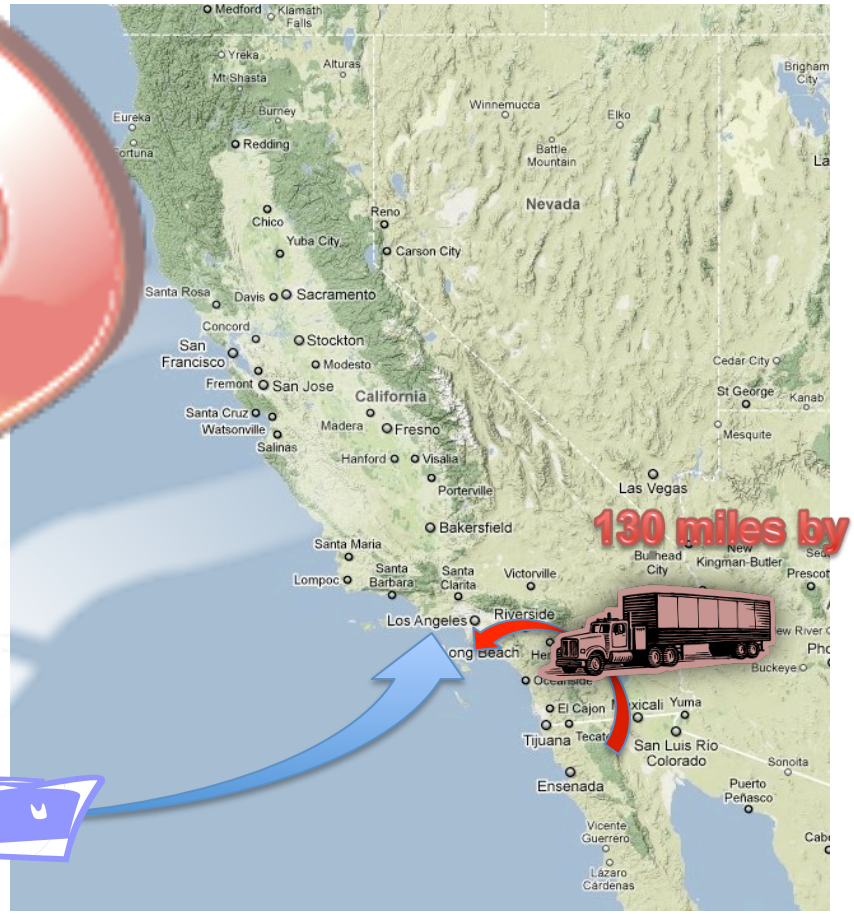
The environmental burden related to the trading of goods is not only composed by the materials and energy expend in their production. In fact, this may **only represents a small fraction of the total**. Significant improvements can arise if we take into account the whole supply chain, including manufacturing operations, transport, distribution to the final trade point and end of life.

CASE 1 – shipping goods to California

- **California** is constantly increasing the trade of goods from all over the world. This trade represents economical benefits for the State. In addition, the Government tends to be on the leading edge of environmental awareness in several areas, such as transportation, production, energy supply among many others.

- The differences among countries and the complexity of global supply chains require an extensive evaluation and analysis of the issues associated

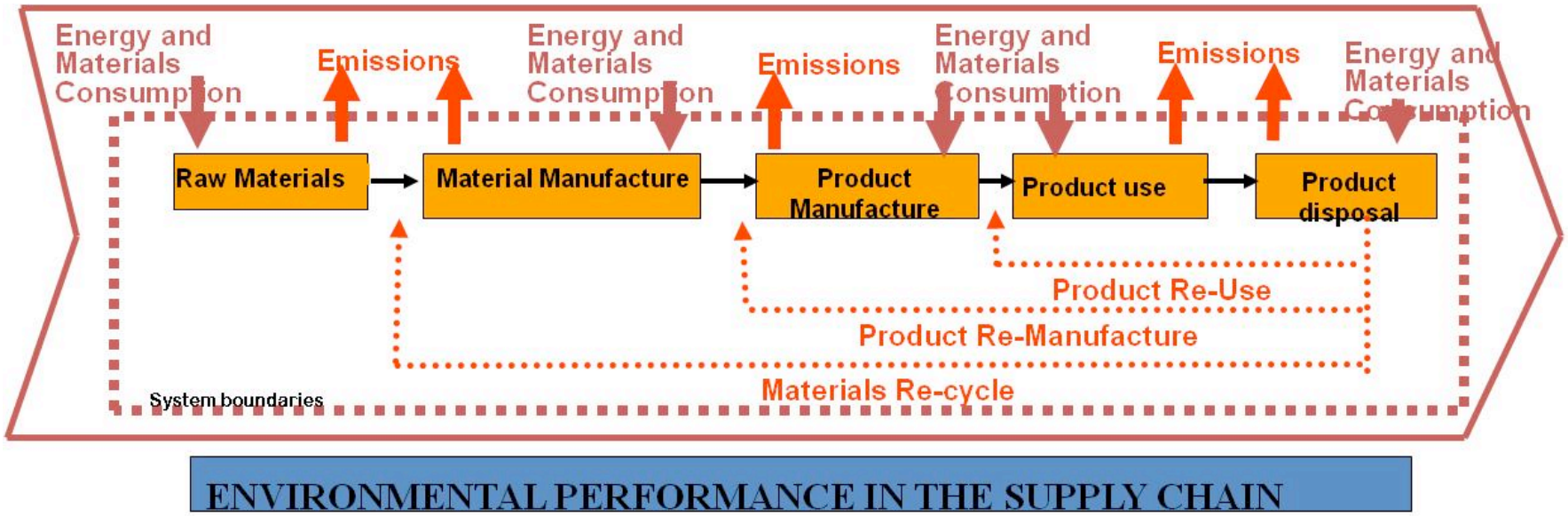
The Problem



- Shipping goods to the Californian market (e.g. LA area) from different manufacturing sites

Air cargo - 1.7739 lbs CO_2 per Ton-Mile
Truck - 0.3725 lbs CO_2 per Ton-Mile
Train - 0.2306 lbs CO_2 per Ton-Mile
Sea freight - 0.0887 lbs CO_2 per Ton-Mile

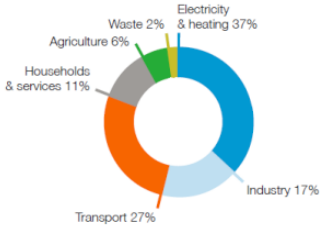
LCA Methodology



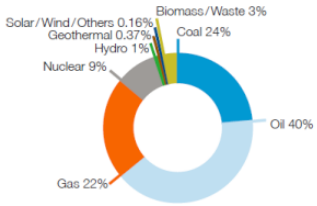
- Inventory analysis: identification and quantification of energy and resource use and environmental releases to air water and land.
- Impact analysis: the technical qualitative and quantitative characterization and assessment of the consequences on the environment
- Improvement analysis: the evaluation and implementation of opportunities to reduce environmental burdens

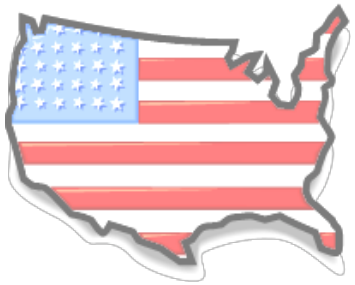
Regional Energy Comparison

EMISSIONS BY SECTOR



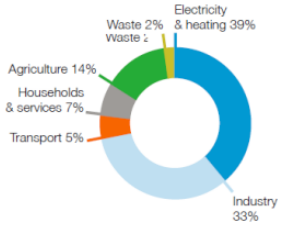
ENERGY SOURCES



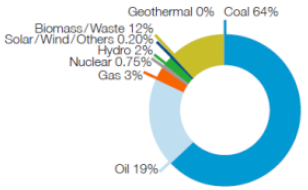


Emissions per GDP	**567 $tCO_2eq./M$**
CO_2 per kWh electricity	**625 gCO_2/kWh**

EMISSIONS BY SECTOR

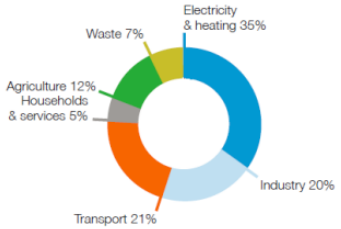


ENERGY SOURCES

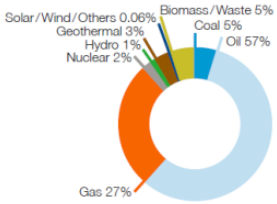


Emissions per GDP	**1337 $tCO_2eq./M$**
CO_2 per kWh electricity	**771 gCO_2/kWh**

EMISSIONS BY SECTOR



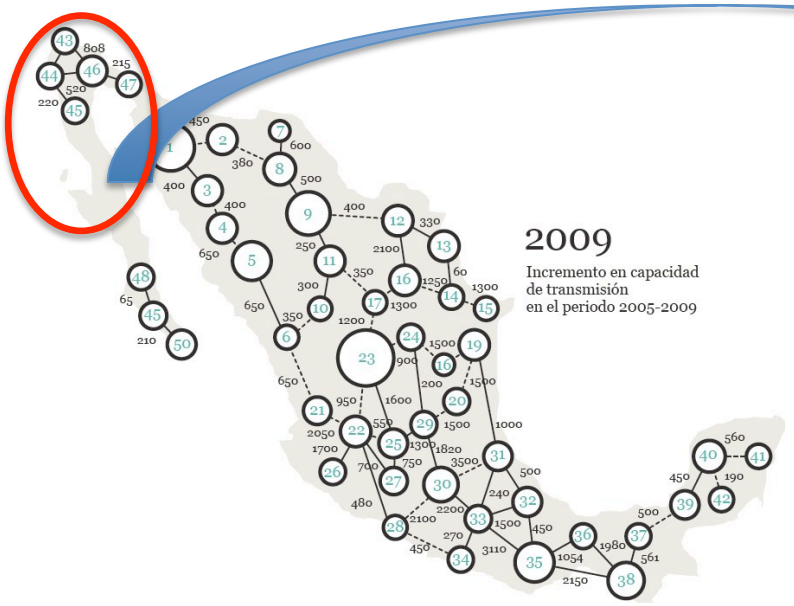
ENERGY SOURCES



Emissions per GDP	**549 $tCO_2eq./M$**
CO_2 per kWh electricity	**541 gCO_2/kWh**

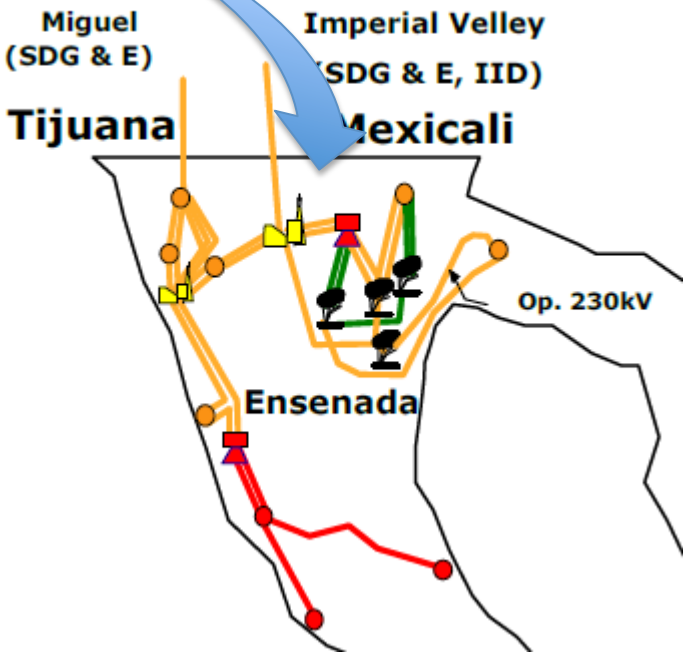
- Average nation values for emissions by productivity sectors.
- Energy mix values for primary energy

The Mexican Energy Case



- The Mexican northwest electrical sub-grid is separated from the national grid and has it´s own energy mix.
- The main manufacturing center for the Californian market is located in the Tijuana-Mexicali Region

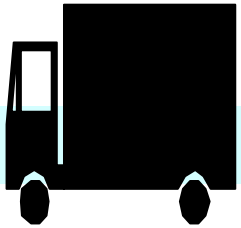
Northwest energy mix



TECHNOLOGY	No UNITS	CAPACITY [MW]	
Geothermal	13	720	35.14%
Combined Cycle	6	985	48.08%
Turbo Gas	8	343.86	16.78%
Total	27	2048.86	100.00%

- Taking into account the plant factors of all units, and their contribution, in average the Mexican northwest electricity has an emission of 298 g/kWh

Transport Processes for Mexico



Vehículo Gas LP

Name	Vehículo LPG		CONFORME A LA NOM-042-ECOL:	
	0.0614	kg	equivalente a (MJ): 3.06693	
Emissions to air			g/bhp*hr	
NOx	**0.81**	g	**0.709288**	NOx
CO2	166	g		
CO	**1.1**	g	**0.96323**	CO
soot	0.01	g		
N2O	0.06	g		
VOC	**0.35**	g	**0.306482**	HCT
non methane VOC	0.34	g		
methane	0.01	g		

TRAILER I

ACCORDING TO MEXICAN ESTANDARDS:

Datos actuales según Tabla 1:

	g / bhp*hr	Sima Pro
NOx	**4**	4.01
CO	**15.5**	0.88
HC	**1.3**	0.78
PST	**0.1**	0.31

Results of other transport vehicles have also been developed as part of ITAM's database. A couple of them appear in the electronic file of these LCA projects and in the open literature while results of (various) other transportation vehicles can be available upon request.

Test case: Polycrystalline silicon panels are the most common nowadays in the market

- The test case of Si-PV-panels is analyzed
- The analysis takes into account mass and energy flows over the whole production process starting from silica extraction to the final panel assembling.

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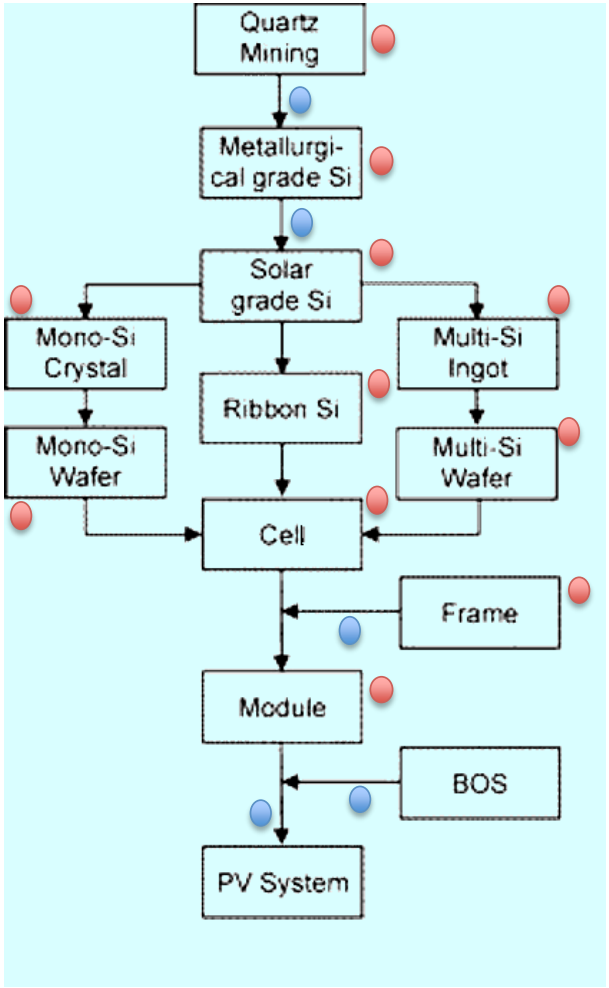
CRYSTALLINE SILICON MANUFACTURING PROCESS

- *1. Convert the metallurgical silicon into high purity Polysilicon*
- *2. Form the ingots*
- *3. Slice the ingot or block into wafers*
- *4. Transform the wafer into a solar cell*
- *5. Connect and coat the cells to form a module*

However, this is a simplified view of reality

PV panels Production process

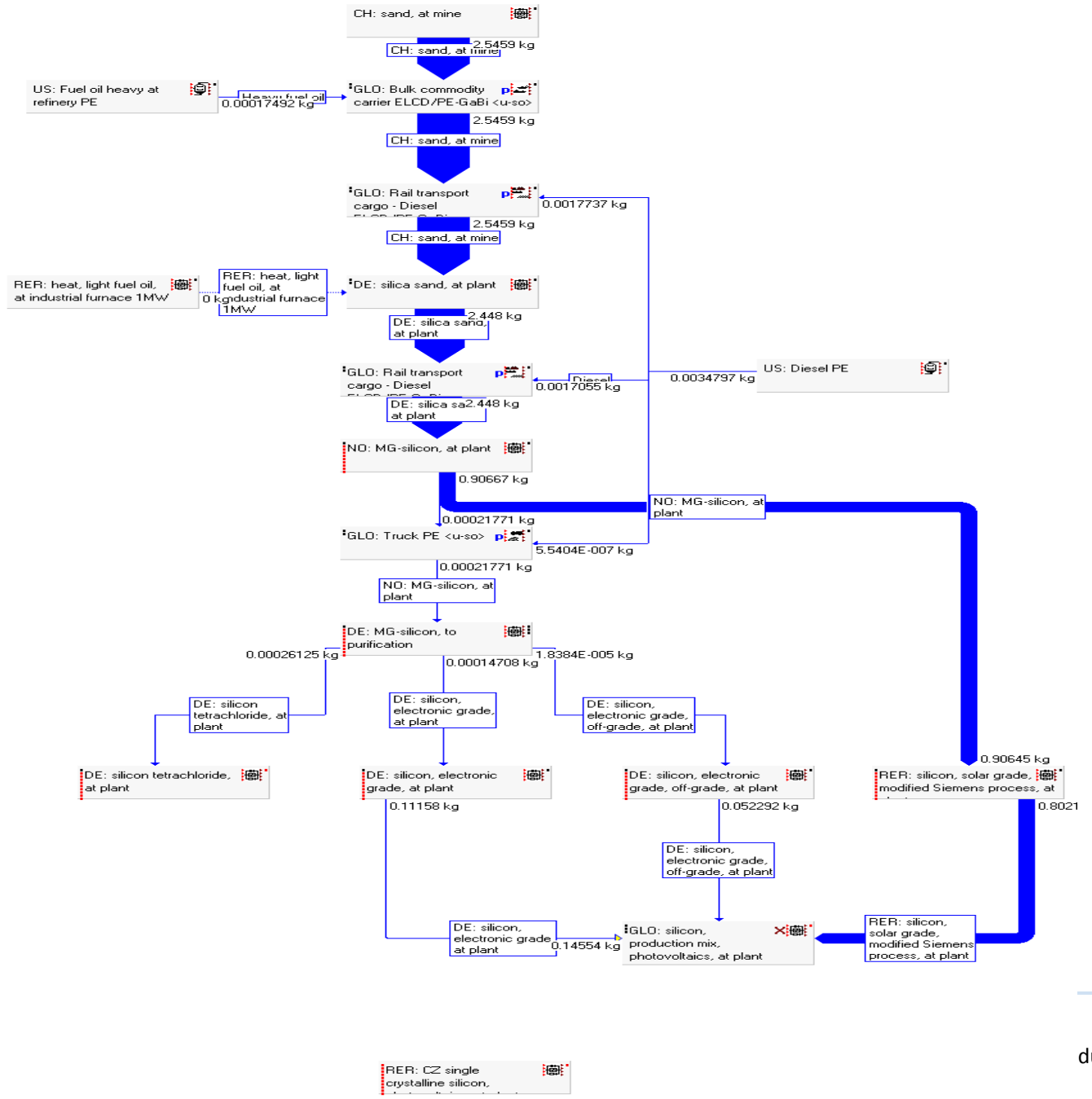


- There are several middle steps in the production process
- The regionalization affects in:
  - the energy mix used for electricity
  - The distance traveled for transport
  - The nature of the transport
  - The productivity related emissions
- If all this is included in the LCA

Transport
Energy

PV Sand to panels

GaBi 4 process plan: Mass [kg]
The names of the basic processes are shown.



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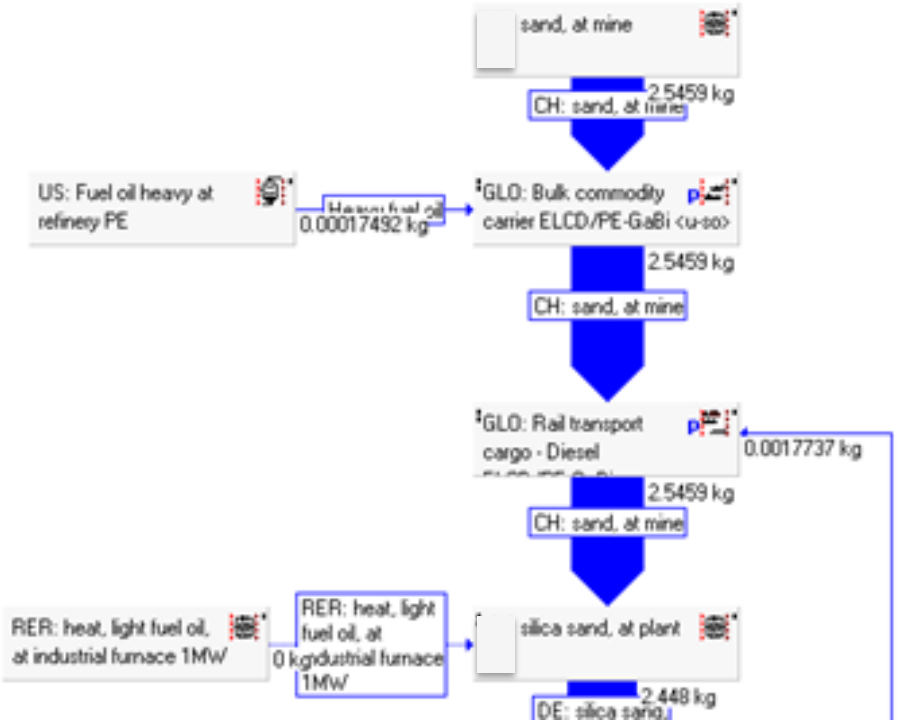
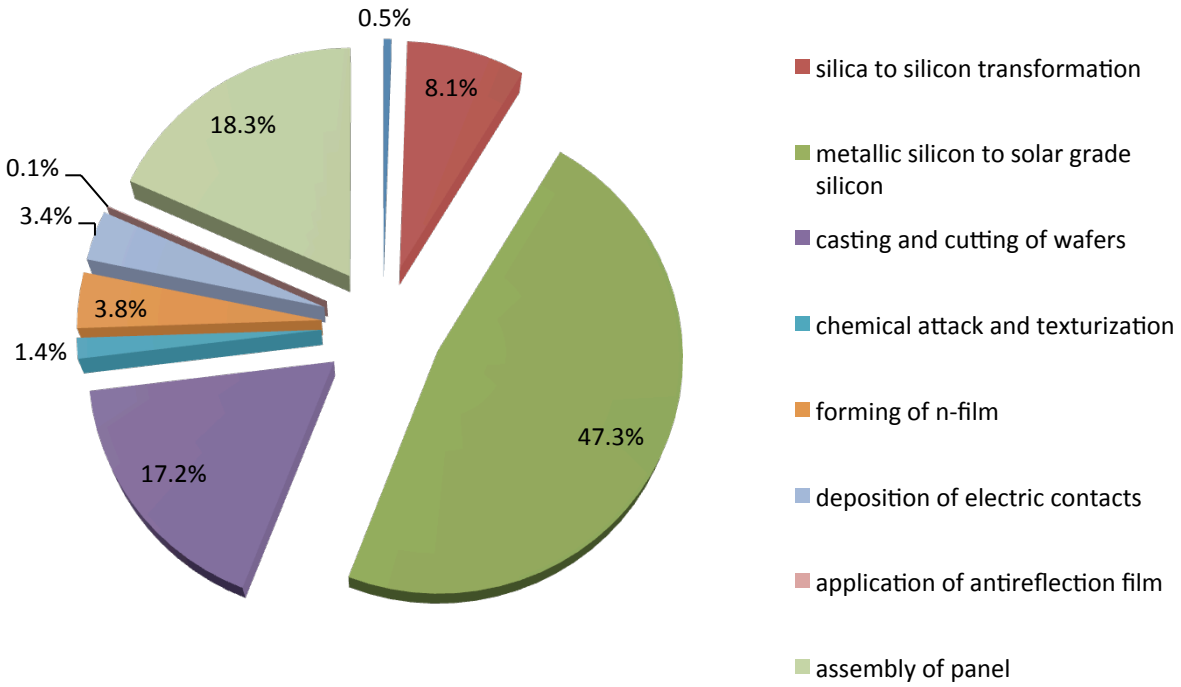
University of California Berkeley Haas School of Business

Example

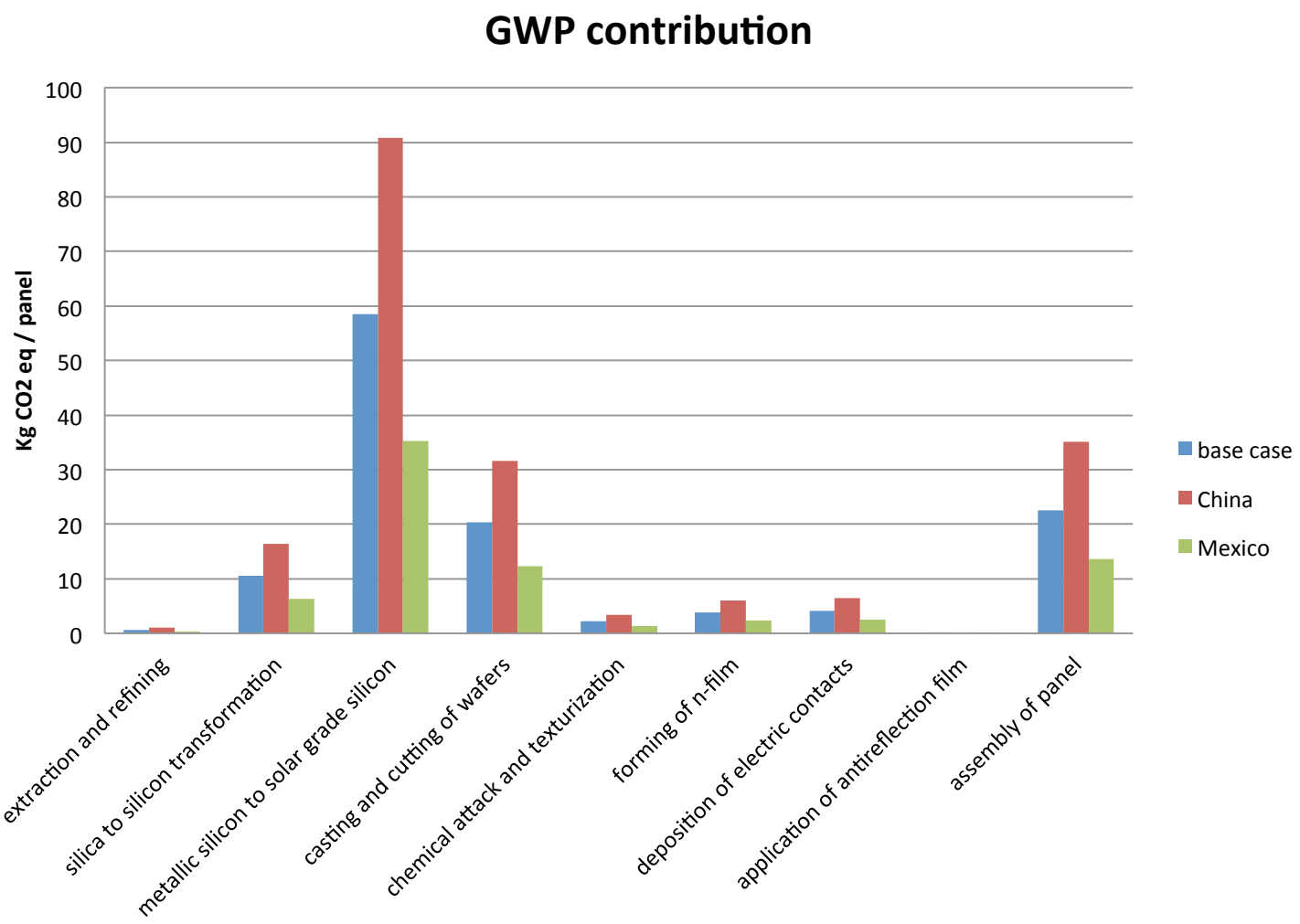


- Sand gets extracted at the mine which is in the coast
- Travels by freight and then by train to the silica plant
- Different fuels are used along the process

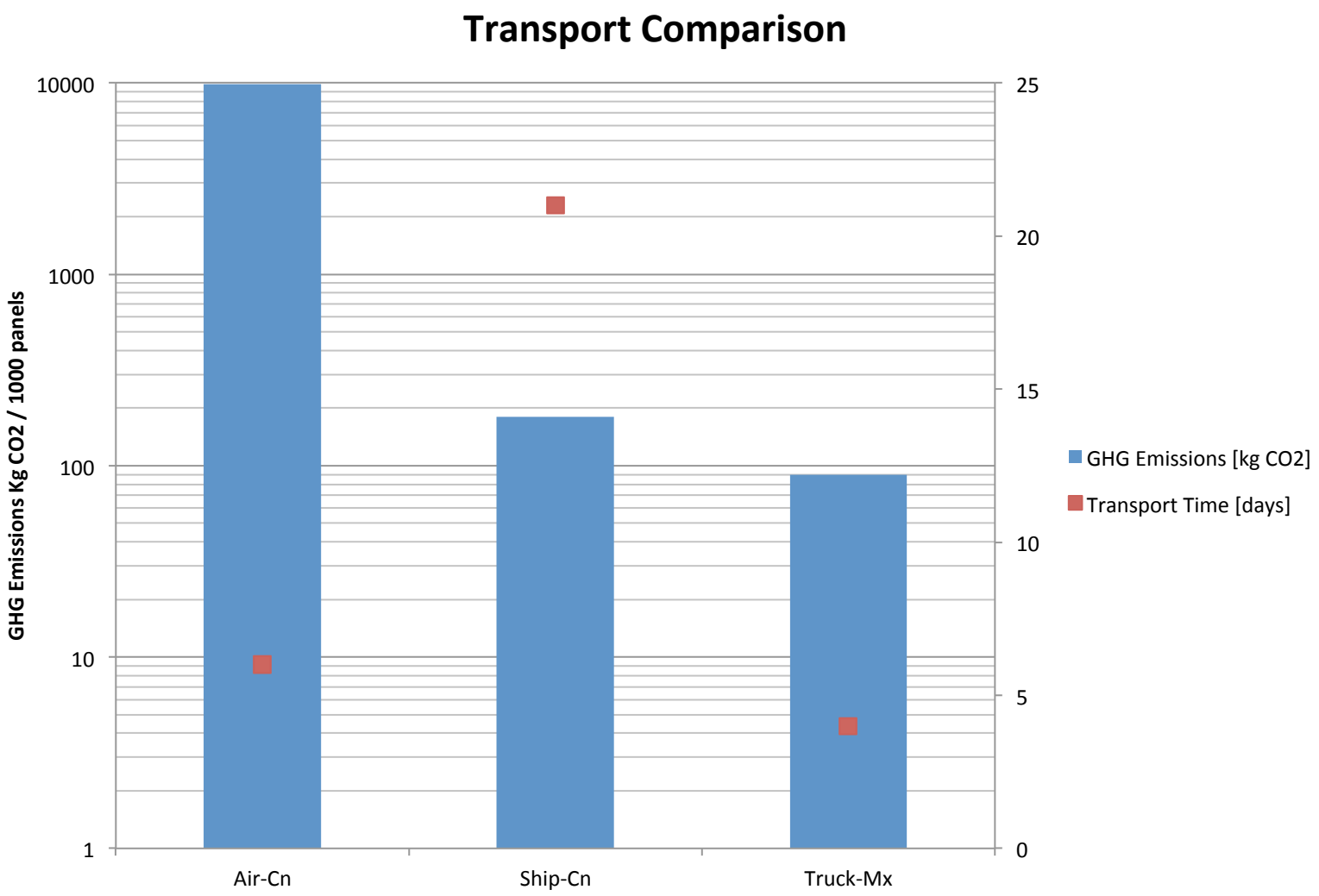
Energy requirements



- Gross energy requirements of production processes
- The functional unit is 1 m2 of solar panel
- The overall energy requirement is 2298 MJ/m2



Transport Considerations



- The environmental burden related to the trading of goods is not only composed by the materials and energy expend in their production
- Significant improvements can arise if we take into account the whole supply chain, including manufacturing operations, transport, distribution to the final trade point
- The test case of Si-PV-panels is analyzed for 1 m2 to be produced either in Mexico or China and traded in California

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CASE 2 – BIOFUEL SUPPLY CHAIN MODEL

Some parameters involved in the assessmer

- Location, energy mix
- Type of feedstock
- Chemical Inputs
- Cultivation / harvesting practices
- Transport options
- Process design

FERTILIZER
, P2O5, K2O, CaCO3…

HERBICIDES
yphosate, Atrazine, …

INSECTICIDES

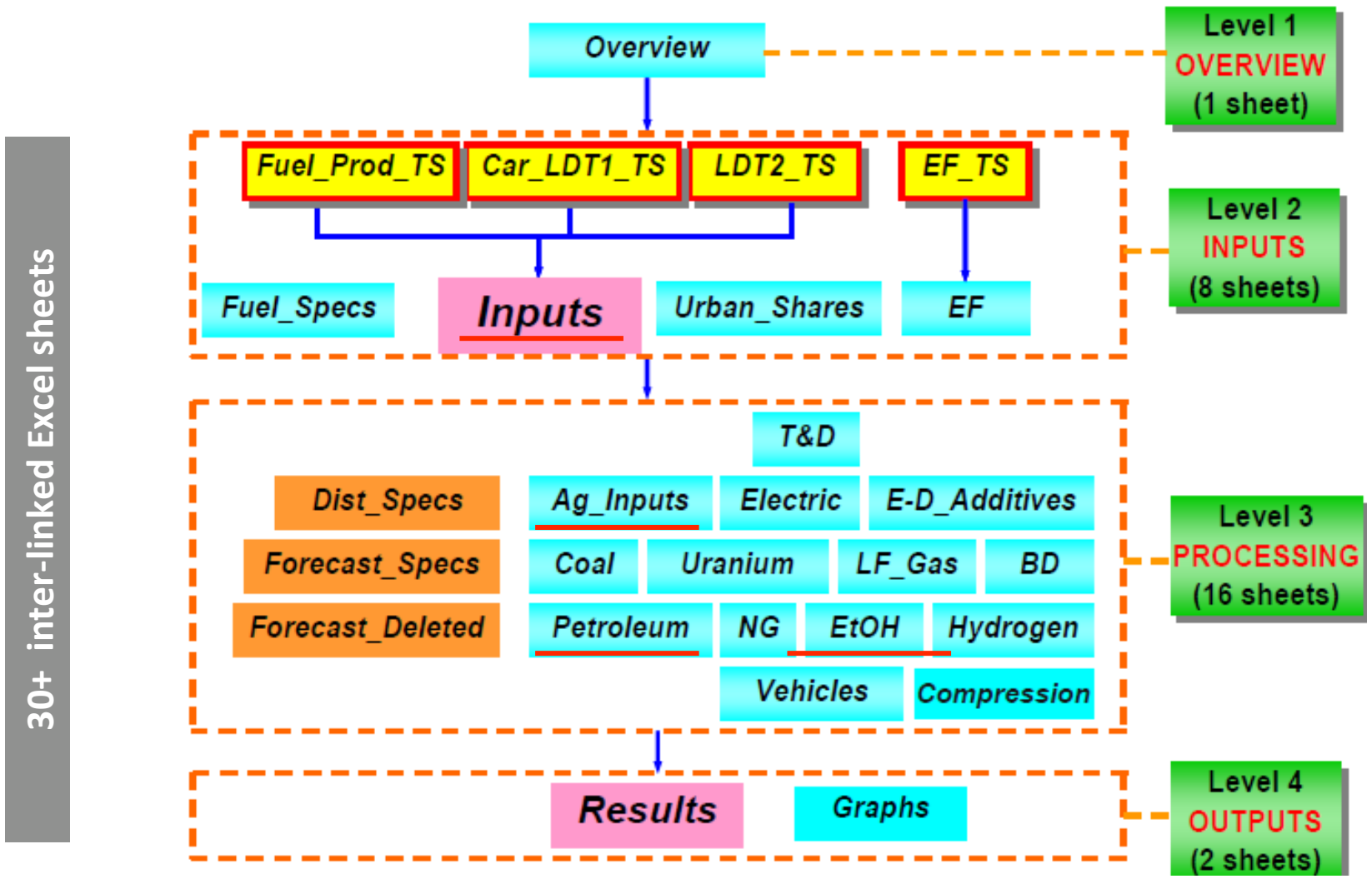
FEEDSTOCK CULTIVATION

ETHANOL PRODUCTION

ETHANOL
Transport & Distribution

GAS STATI

Introduction
Decoding GREET



Source: Argonne National Lab.

Modular modeling approach

Summary	Farming	Chemicals	_Transport	EtOH_Prod	EtOH_T&D	Constants

Sugarcane to Ethanol *

WTT Energy Balance and GHG emission analysis

by Omar Romero-Hernandez, Dominic Scalise, Amit Gokhale

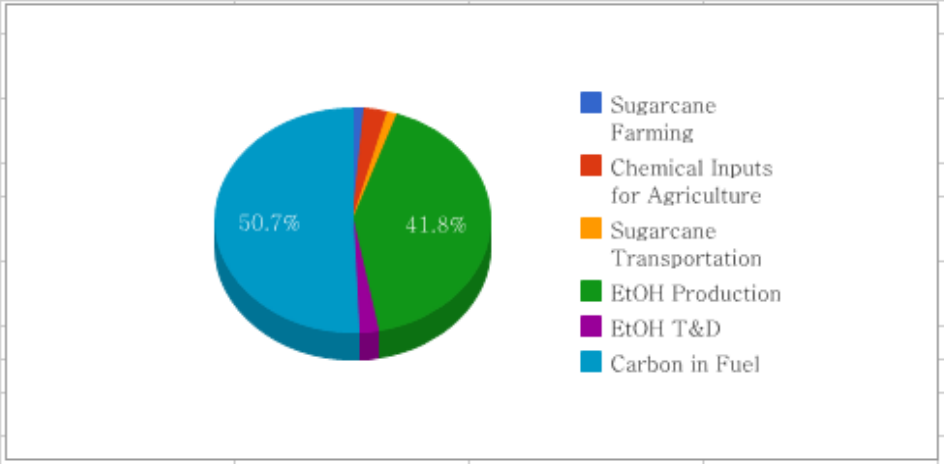
(*: this is an example based on a public document by CARB)

Bioenergy Analysis Team, EBI

Based on: CA_Greet & Greet Aug 2010

Summary	Energy Inputs [Btu/mmBtu]	GHG Emissions [gCO2e/MJ]
Sugarcane Farming	26,167	9.73
Chemical Inputs for Agriculture	55,788	8.53
Sugarcane Transportation	22,906	1.70
EtOH Production	824,881	
EtOH T&D	43,598	3.28
TOTAL	**973,340**	**23.24**

Energy Input Distribution



This is used to illustrate the phases included in the modular approach.

Wrap up

1. **Green Supply Chains**

   Complexities along the value chain

2. **Metrics of sustainability**

   Find the best *bang* for your *buck*

3. **We need your help:**

   Current project

   NSF proposal (policy, health effects, consumer behaviour...)

4. **Other projects...currently running**

   Environmental performance of second generation biofuels

   Green Business Strategies and Operations (Haas course)

Acknowledgements:

Big thanks to all team members (students and faculty) who contributed with this work:

Sergio Romero-Hernandez, David Dornfeld, Tony Kingsbury, Celeste Lindsay

UC Berkeley – Mech Eng and Haas

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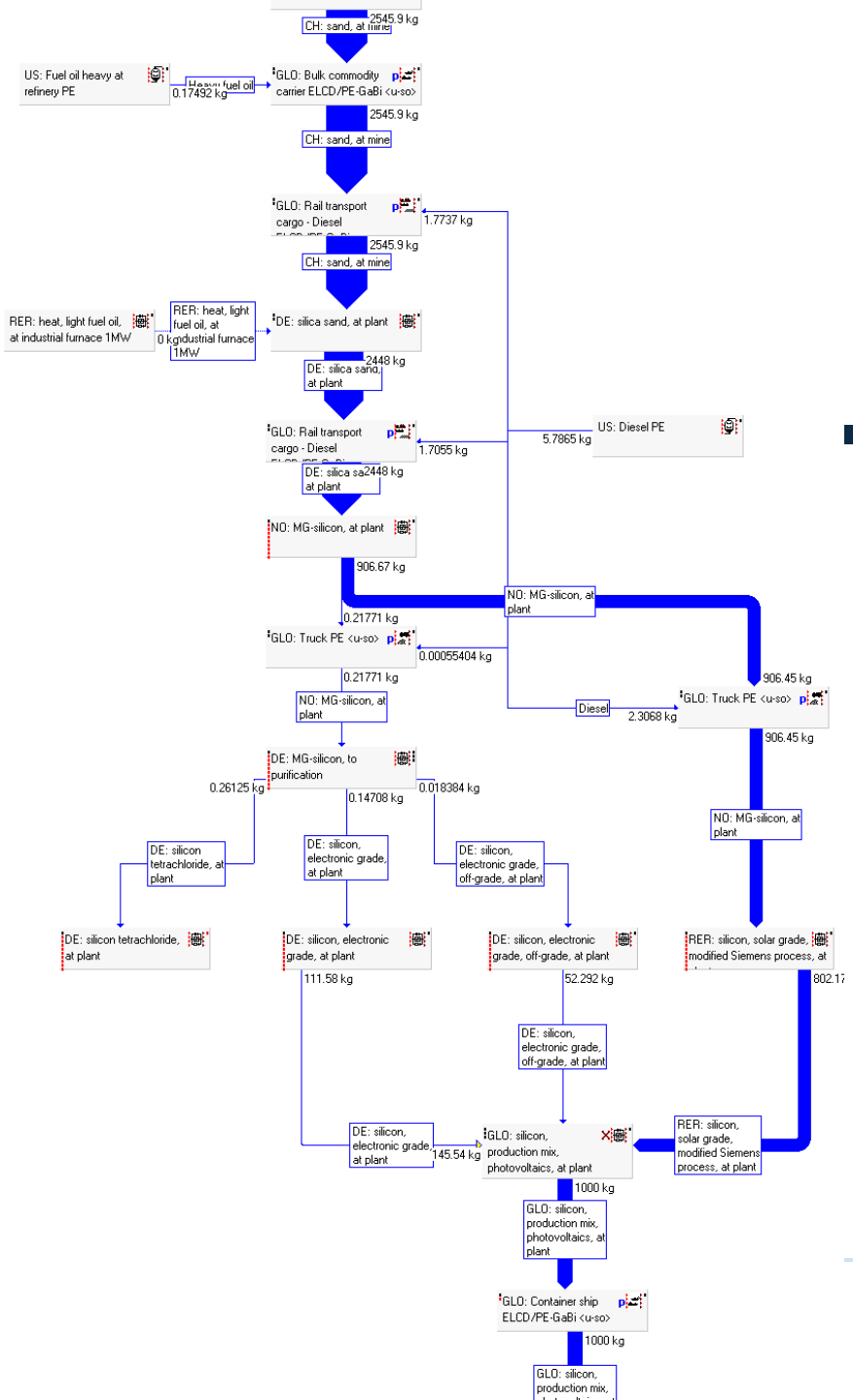
2545.9 kg
CH: sand, at mine
US: Fuel oil heavy at refinery PE
0.17492 kg
GLO: Bulk commodity carrier ELCD/PE-GaBi <u-so>
2545.9 kg
CH: sand, at mine
GLO: Rail transport cargo - Diesel
1.7737 kg
2545.9 kg
CH: sand, at mine
RER: heat, light fuel oil, at industrial furnace 1MW
0 kg
RER: heat, light fuel oil, at industrial furnace 1MW
DE: silica sand, at plant
2448 kg
DE: silica sand, at plant
GLO: Rail transport cargo - Diesel
1.7055 kg
5.7865 kg
US: Diesel PE
DE: silica sa2448 kg
at plant
NO: MG-silicon, at plant
906.67 kg
NO: MG-silicon, at plant
0.21771 kg
GLO: Truck PE <u-so>
0.00055404 kg
906.45 kg
0.21771 kg
NO: MG-silicon, at plant
Diesel
2.3068 kg
GLO: Truck PE <u-so>
906.45 kg
DE: MG-silicon, to purification
0.26125 kg
0.14708 kg
0.018384 kg
NO: MG-silicon, at plant
DE: silicon tetrachloride, at plant
DE: silicon, electronic grade, at plant
DE: silicon, electronic grade, off-grade, at plant
DE: silicon tetrachloride, at plant
DE: silicon, electronic grade, at plant
DE: silicon, electronic grade, off-grade, at plant
RER: silicon, solar grade, modified Siemens process, at
111.58 kg
52.292 kg
802.17
DE: silicon, electronic grade, off-grade, at plant
DE: silicon, electronic grade, at plant
145.54 kg
GLO: silicon, production mix, photovoltaics, at plant
RER: silicon, solar grade, modified Siemens process, at plant
1000 kg
GLO: silicon, production mix, photovoltaics, at plant
GLO: Container ship ELCD/PE-GaBi <u-so>
1000 kg
GLO: silicon, production mix,