Agg Planning & Sustainability

SCM614

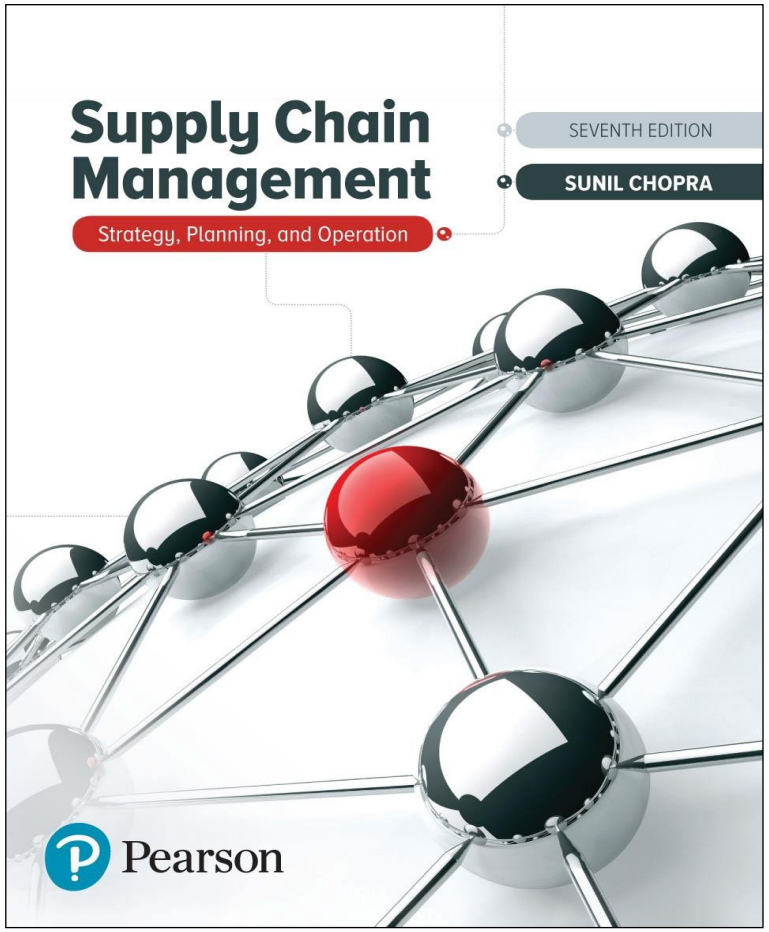
Week 3

Agenda

- Chapter 15: Sourcing (recap)
- Chapter 8: Agg planning, Linear Programming with Excel
- Break
- Chapter 17: Sustainability
  - Clean Trucks – my research focus
- Breakout (PP)
- Summary of upcoming class activities

Supply Chain Management: Strategy, Planning, and Operation

Seventh Edition



Chapter 15

Sourcing Decisions in a Supply Chain

Designing a Sourcing Portfolio: Tailored Sourcing (3 of 4)

Onshoring
(Same country)

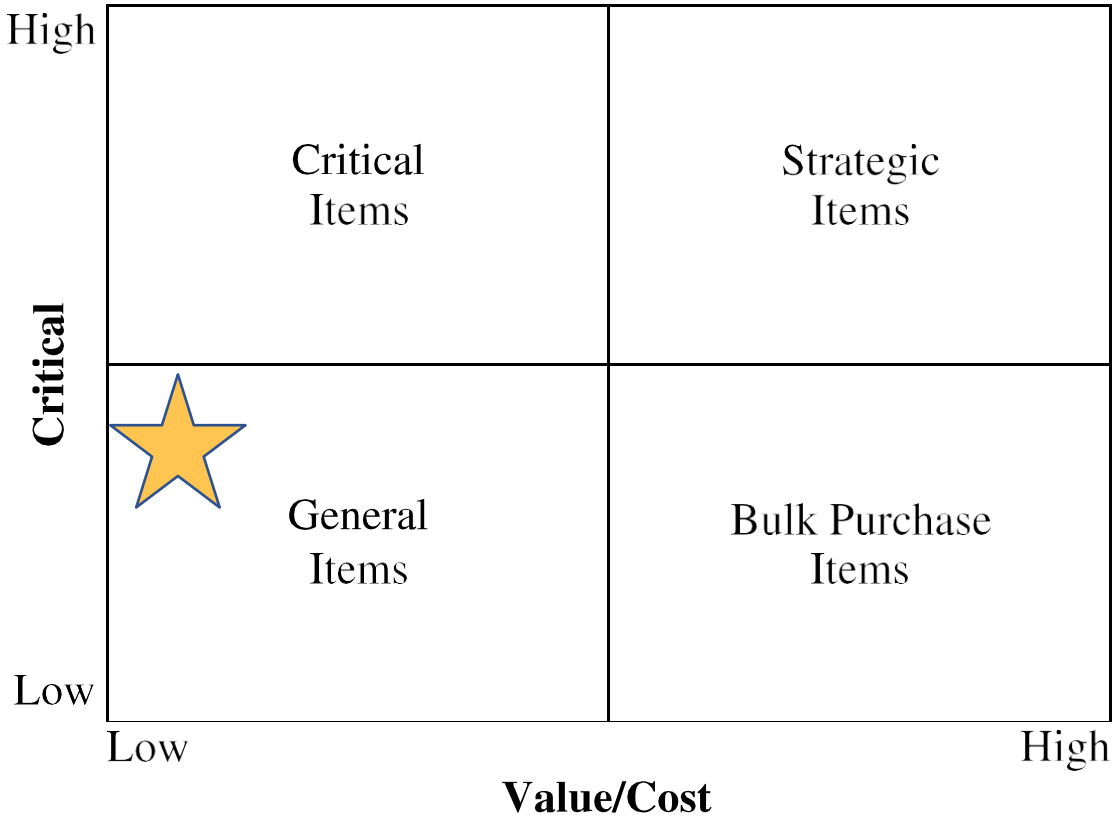
Nearshoring
(Neighboring country)

Offshoring
(Distant country)

Table 15.4 Factors Favoring Onshoring, Near-Shoring, or Offshoring

	Onshore	Near-Shore	Offshore
Rate of innovation/product variety	High	Medium to High	Low
Demand volatility	High	Medium to High	Low
Labor content	Low	Medium to High	High
Volume or weight-to-value ratio	High	High	Low
Impact of supply chain disruption	High	Medium to High	Low
Inventory costs	High	Medium to High	Low
Engineering/management support	High	High	Low

https://technofaq.org/posts/2020/08/why-nearshoring-is-an-effective-route-to-agile-development/

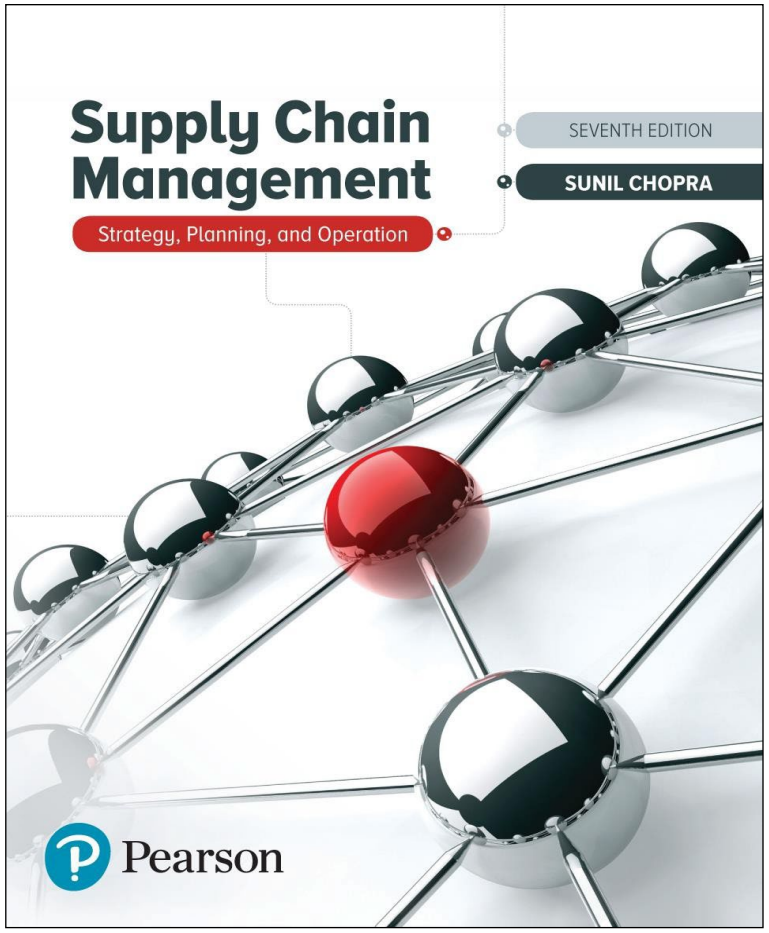


Product Categorization

Figure 15-1 Product Categorization by Value and Criticality

Supply Chain Management: Strategy, Planning, and Operation

Seventh Edition



Chapter 8

Aggregate Planning in a Supply Chain

https://singularityhub.com/2021/03/28/watch-a-robot-3d-printing-the-rocket-for-relativity-spaces-first-orbital-launch/?amp=1

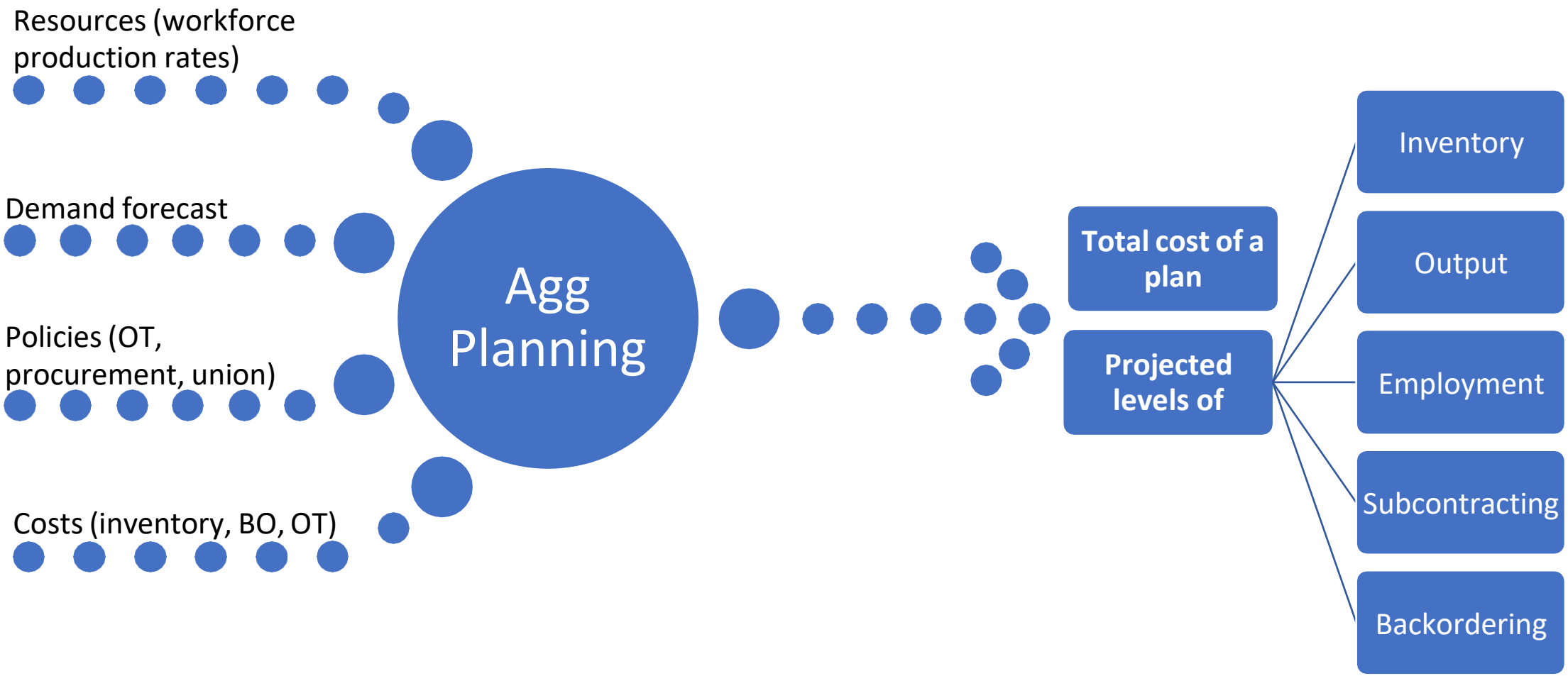
Role of Aggregate Planning in a Supply Chain

- Identify operational parameters over the specified time horizon
  - Production rate
  - Workforce
  - Overtime
  - Machine capacity level
  - Subcontracting
  - Backlog
  - Inventory on hand
- All supply chain stages should work together on an aggregate plan that will optimize supply chain performance

The Aggregate Planning Problem

- Given the demand forecast for each period in the planning horizon, determine the production level, inventory level, and the capacity level for each period that maximizes the firm's (supply chain's) profit over the planning horizon
- Specify the planning horizon (typically 3-18 months)
- Specify the duration of each period
- Specify key information required to develop an aggregate plan

Aggregate Planning
Inputs & outputs



Aggregate Planning Pure Strategies

- **Level capacity strategy:**
  - Maintaining a steady rate of regular-time output while meeting variations in demand by a combination of options:
    - Inventories, overtime, part-time workers, subcontracting, and back orders
- **Chase demand strategy:**
  - Matching capacity to demand; the planned output for a period is set at the expected demand for that period

https://www.marcopromos.com/product/magnetic-torpedo-level-9/od-15024?code=PPCProdCampaign&ex_phone=866.718.5692&gclid=Cj0KCQjw8fr7BRDSARIsAK0Qqr5eO1X-ZoXTyxPJwSPsjyrIDGspCVgOyynjNgNRd9IMtiGJGZCxT70aAnDrEALw_wcB, https://www.123rf.com/stock-photo/chasing.html?sti=m56rd084sbbxc00bsy|

Chase Approach

- Capacities are adjusted to match demand requirements over the planning horizon
  - **Advantages**
    - Investment in inventory is low
    - Labor utilization in high
  - **Disadvantages**
    - The cost of adjusting output rates and/or workforce levels

Level Approach

- Capacities are kept constant over the planning horizon
  - **Advantages**
    - Stable output rates and workforce
  - **Disadvantages**
    - Greater inventory costs
    - Increased overtime and idle time
    - Resource utilizations vary over time

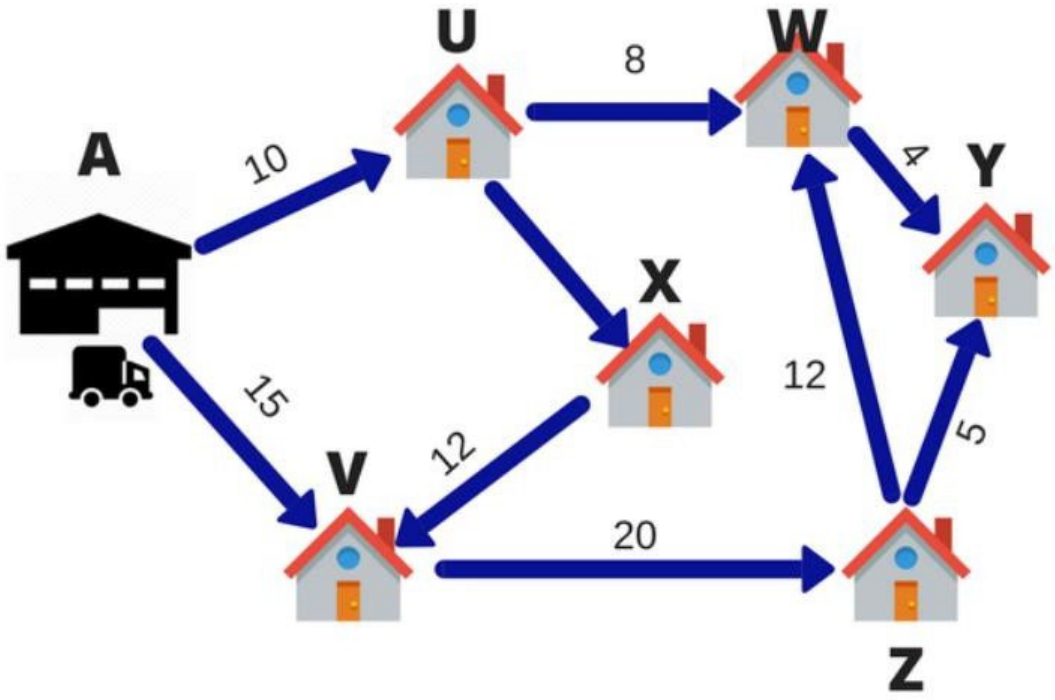
AGGREGATE PLANNING EXAMPLES!

	1	2	3	4
	200	200	300	400
	300	300	300	300
	100	100	0	-100
	0	100	200	200
	100	200	200	100
	50.0	150.0	200.0	150.0
	0	0	0	0

per unit

Linear Programming for planning

- Developed in WWII for army logistics
- Leads to an optimal solution (if one exists) for problems with restrictions or limitations
- Uses
  - Food and agriculture
  - Transportation optimization
  - Manufacturing/supply chain
- Problems
  - Optimal mix/blends
  - Aggregate planning
  - Location analysis



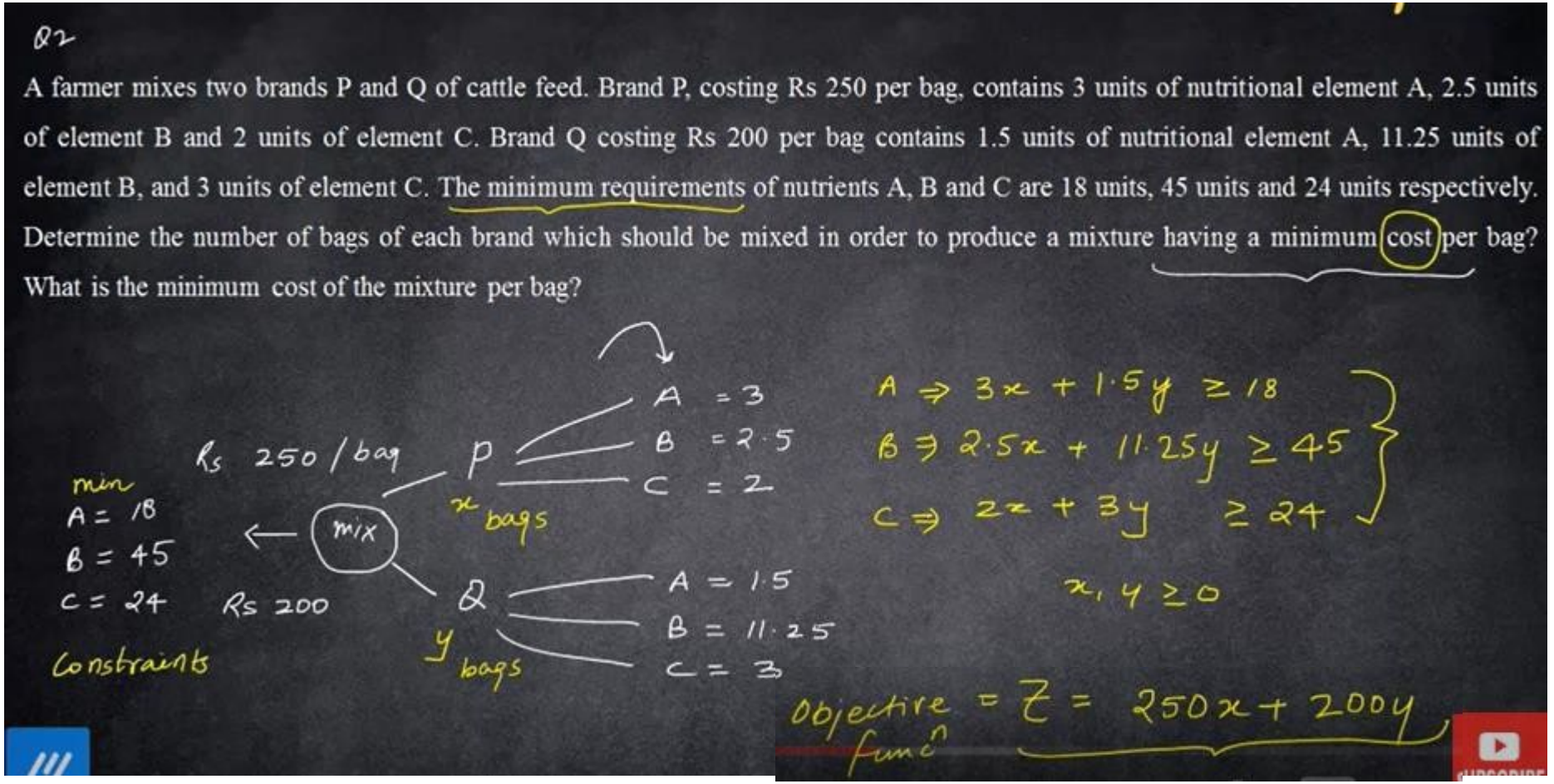
https://www.analyticsvidhya.com/blog/2017/02/lintroductory-guide-on-linear-programming-explained-in-simple-english/

LP Models

$$\begin{aligned} \text{maximize} \quad & z = x + 2y \\ \text{subject to:} \quad & 2x + y \leq 20 \\ & -4x + 5y \leq 10 \\ & -x + 2y \geq -2 \\ & x \geq 0 \\ & y \geq 0 \end{aligned}$$

- Mathematical representations of constrained optimization problems
- LP model components:
  - **Objective function**
    - A mathematical statement of profit (or cost, etc.) for a given solution
  - **Decision variables**
    - Amounts of either inputs or outputs
  - **Constraints**
    - Limitations that restrict the available alternatives

Example of LP: Diet



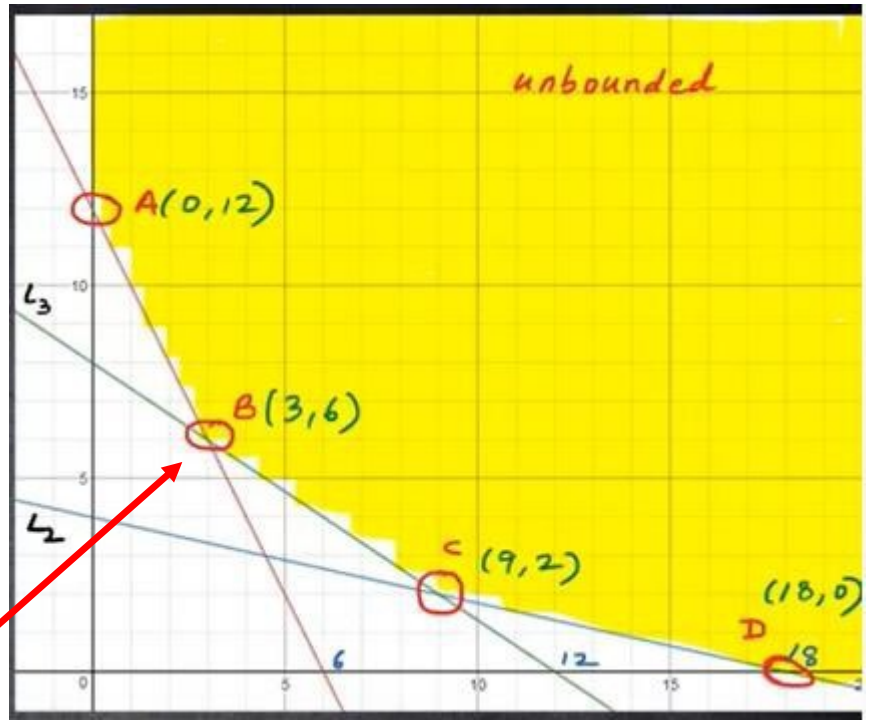
https://www.youtube.com/watch?v=AOpTPFjG8ug

Example of LP: Diet

$z = 250x + 200y$

subject to

$$\begin{cases} 3x + 1.5y \geq 18 \\ 2.5x + 11.25y \geq 45 \\ 2x + 3y \geq 24 \\ x, y \geq 0 \end{cases}$$



$z = 250x + 200y$

		z	
A	(0,12)	2400	
B	(3,6)	1950	min value
C	(9,2)	2650	
D	(18,0)	4500	

$250x + 200y < 1950$

$5x + 4y < 39$

https://www.youtube.com/watch?v=AOpTPFjG8ug

Example – LP Formulation

Decision Variables

$$\begin{cases} x_1 = \text{Quantity of product 1 to produce} \\ x_2 = \text{Quantity of product 2 to produce} \\ x_3 = \text{Quantity of product 3 to produce} \end{cases}$$

Maximize $5x_1 + 8x_2 + 4x_3$ (profit) **(Objective function)**

Subject to

Labor $2x_1 + 4x_2 + 8x_3 \le 250$ hours **(Constraints)**

Material $7x_1 + 6x_2 + 5x_3 \le 100$ pounds

Product1 $x_1 \le 10$ units

$x_1, x_2, x_3 \ge 0$ **(Nonnegativity constraints)**

Graphical LP

- A method for finding optimal solutions to two-variable problems
- Procedure
  1. Set up the objective function and the constraints in mathematical format
  2. Plot the constraints
  3. Identify the feasible solution space
     - The set of all feasible combinations of decision variables as defined by the constraints
  4. Plot the objective function
  5. Determine the optimal solution

Example – Graphical LP: Step 1, translate to math

Firm ABC assembles computers and will be producing two new products next month. The firm can sell as much as it can make of both machines. Each requires assembly & inspection time, as well as storage space. Profit of x1=$60 and x2=$50. Determine the optimal mix of x1 and x2 to max profit. x1 takes 4 hours to assemble, 2 hours to inspect, and 3 cubic feet of storage. x2 takes 10 hours to assemble, 1 hour to inspect, and also uses 3 cubic feet of storage.

$$\text{Decision Variables} \quad \begin{cases} x_1 = \text{quantity of type 1 to produce} \\ x_2 = \text{quantity of type 2 to produce} \end{cases}$$

$$\text{Maximize} \quad 60x_1 + 50x_2$$

$$\text{Subject to}$$

$$\text{Assembly} \quad 4x_1 + 10x_2 \le 100 \text{ hours}$$

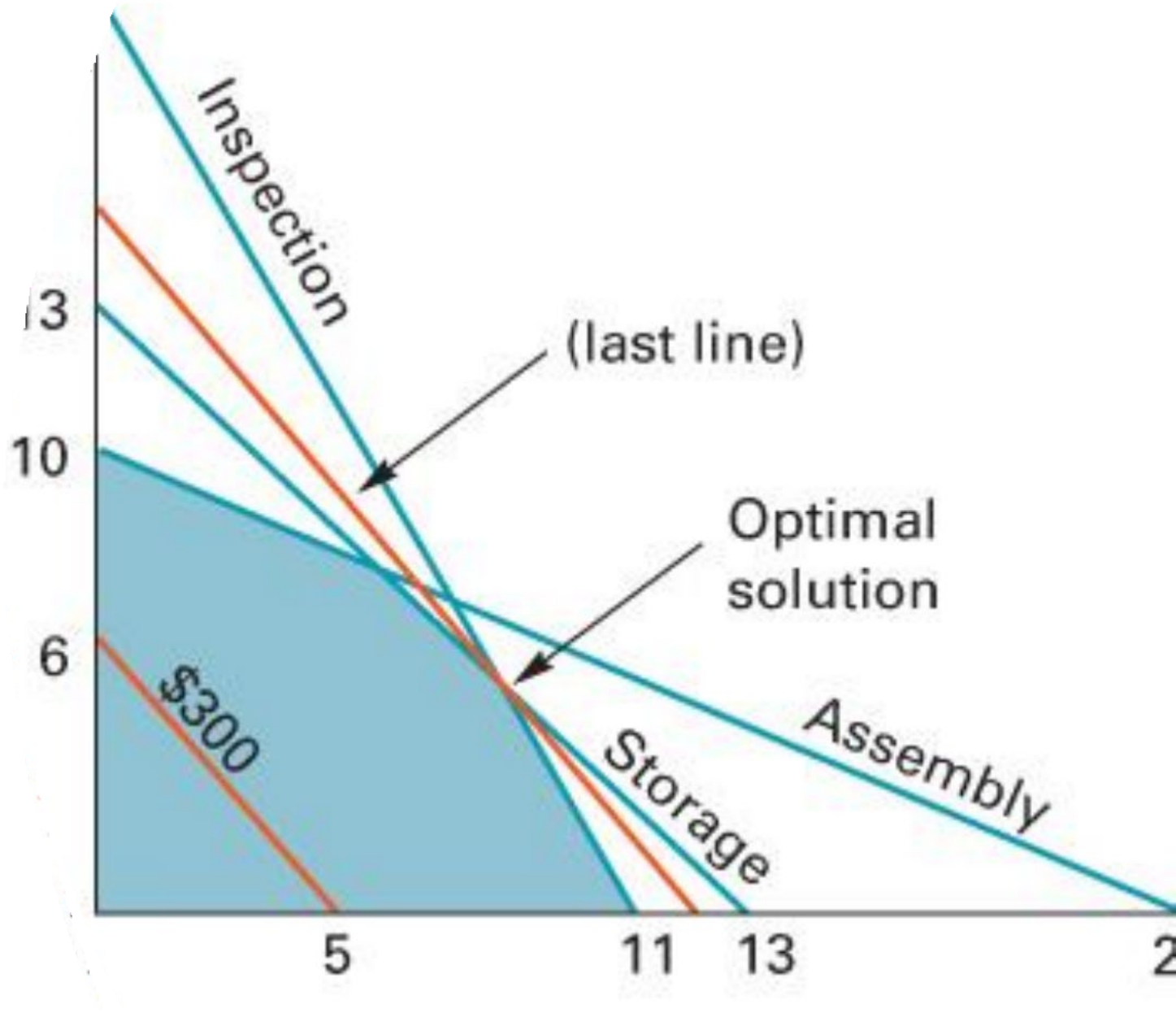
$$\text{Inspection} \quad 2x_1 + 1x_2 \le 22 \text{ hours}$$

$$\text{Storage} \quad 3x_1 + 3x_2 \le 39 \text{ cubic feet}$$

$$x_1, x_2 \ge 0$$

Example – Graphical LP

- Where is the optimal solution?
  - The optimal solution occurs at the furthest point (for a maximization problem) from the origin the isoprofit can be moved and still be touching the feasible solution space
  - This optimum point will occur at the intersection of two constraints:
    - Solve for the values of x_1 and x_2 where this occurs



Example – Graphical LP: determine opt soln

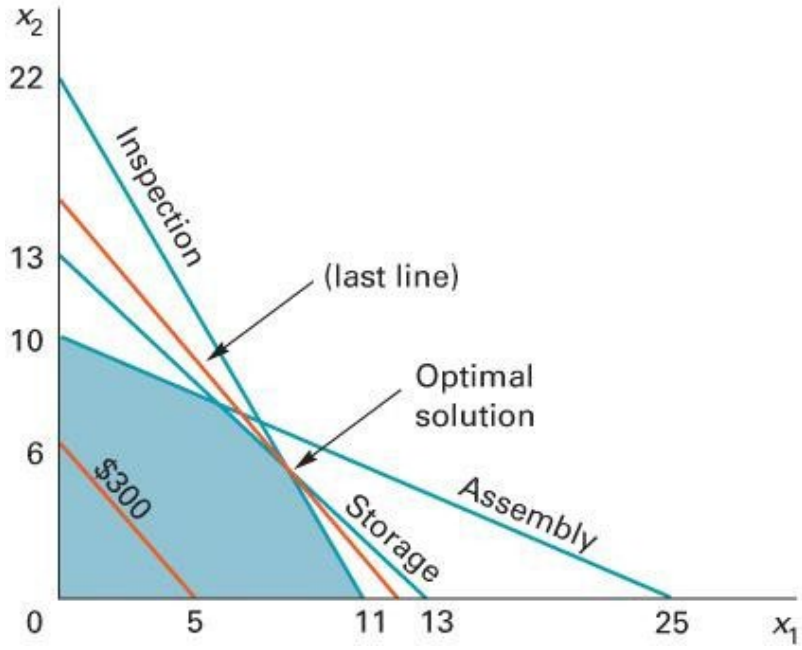
2x + y <= 22 hrs.
3x + 3y <= 39 cu ft

To get rid of x's, we could multiply the first by 3 and second by 2, but that would mean altering both.
Y is out better choice: multiple the first by -3

-6x -3y = -66
3x + 3y = 39
- - - - - - - - - -
-3x +0 = -27; x = 9

Put back x=9 into either of the equations and solve for y since this is at the intersection of the two lines
2*9 +y = 22
18 + y = 22
Y = 22-18 = 4

Solution (9,4)
Put this into the objective function 60x + 50y
60*9 + 50*4 = 540+ 200 = 740



Slack and Surplus

Binding constraint

- If a constraint forms the optimal corner point of the feasible solution space, it is binding
- It effectively limits the value of the objective function
- If the constraint could be relaxed, the objective function could be improved

Surplus

- When the value of decision variables are substituted into a ≥ constraint the amount by which the resulting value exceeds the right-hand side value

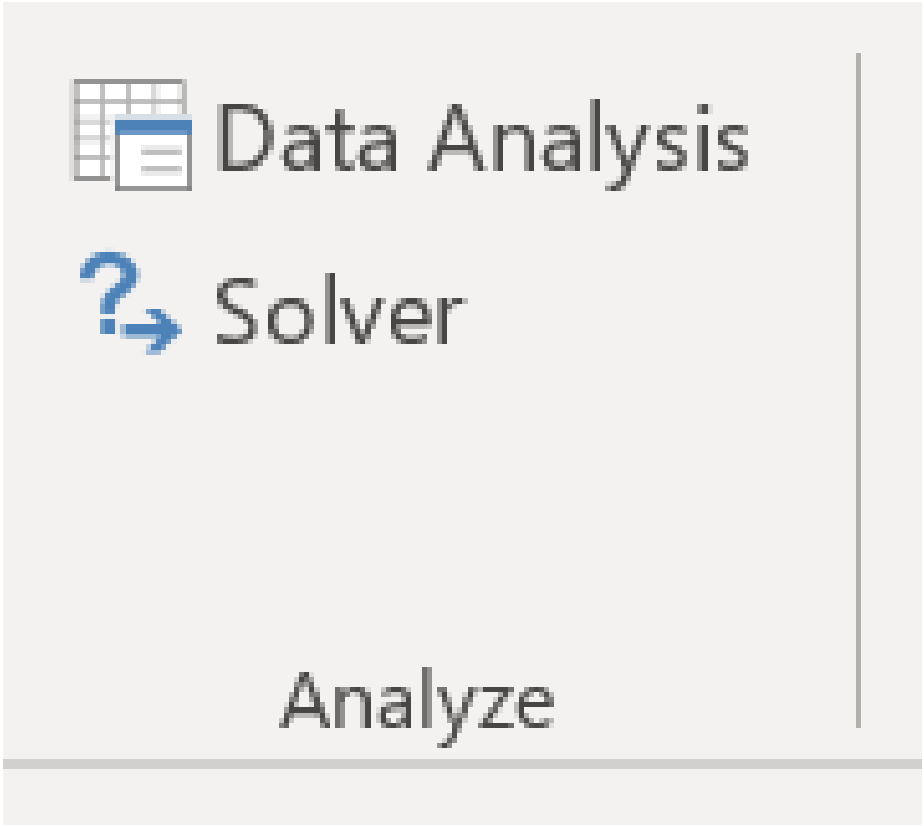
Slack

- When the values of decision variables are substituted into a ≤ constraint, the amount by which the resulting value is less than the right-hand side

Computer Solutions so much easier!

- MS Excel can be used to solve LP problems using its Solver routine
  - Enter the problem into a worksheet
  - You must designate the cells where you want the optimal values for the decision variables
  - Can solve for 2 or more variables

Excel Solver: load and practice

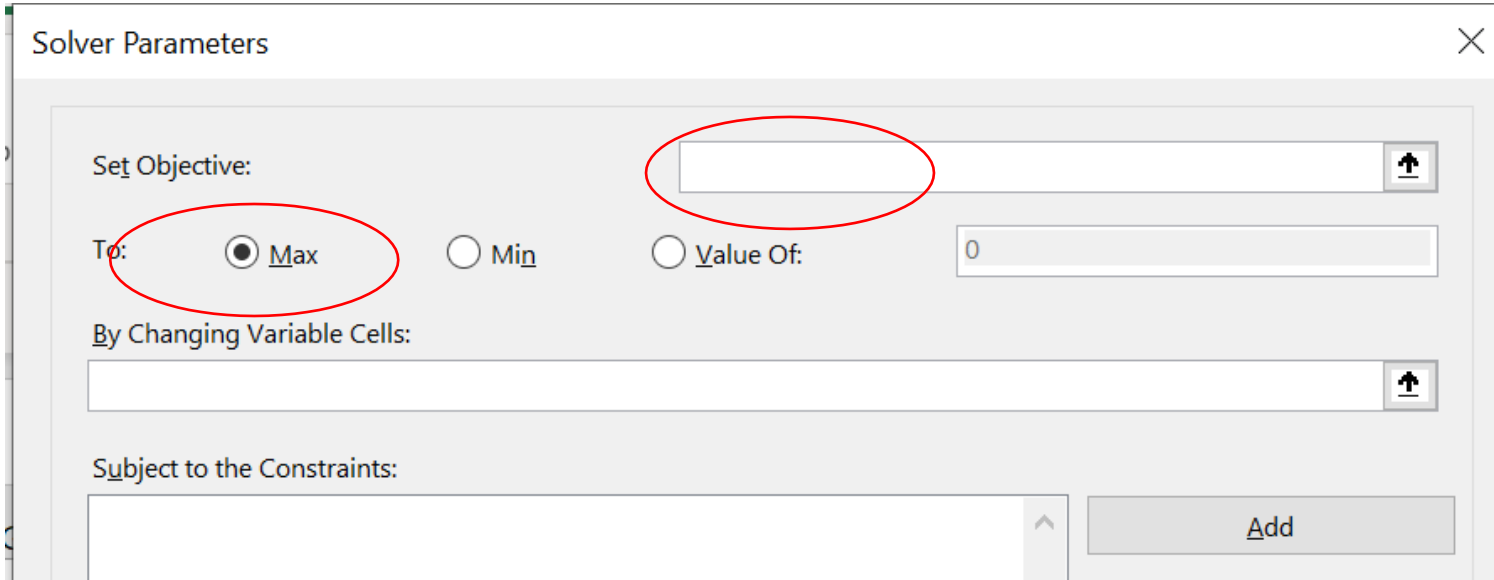


- Linear programming solver
  - https://www.excel-easy.com/data-analysis/solver.html
  - Developer/Excel Adds Ins/Solver (can then see in Data tab far right)
  - How to use:
    - https://www.youtube.com/watch?v=RicajFzoenk
    - Another for reference: https://www.youtube.com/watch?v=rQt_SWrOktg

There are lots of You Tube videos on this if you need more examples!

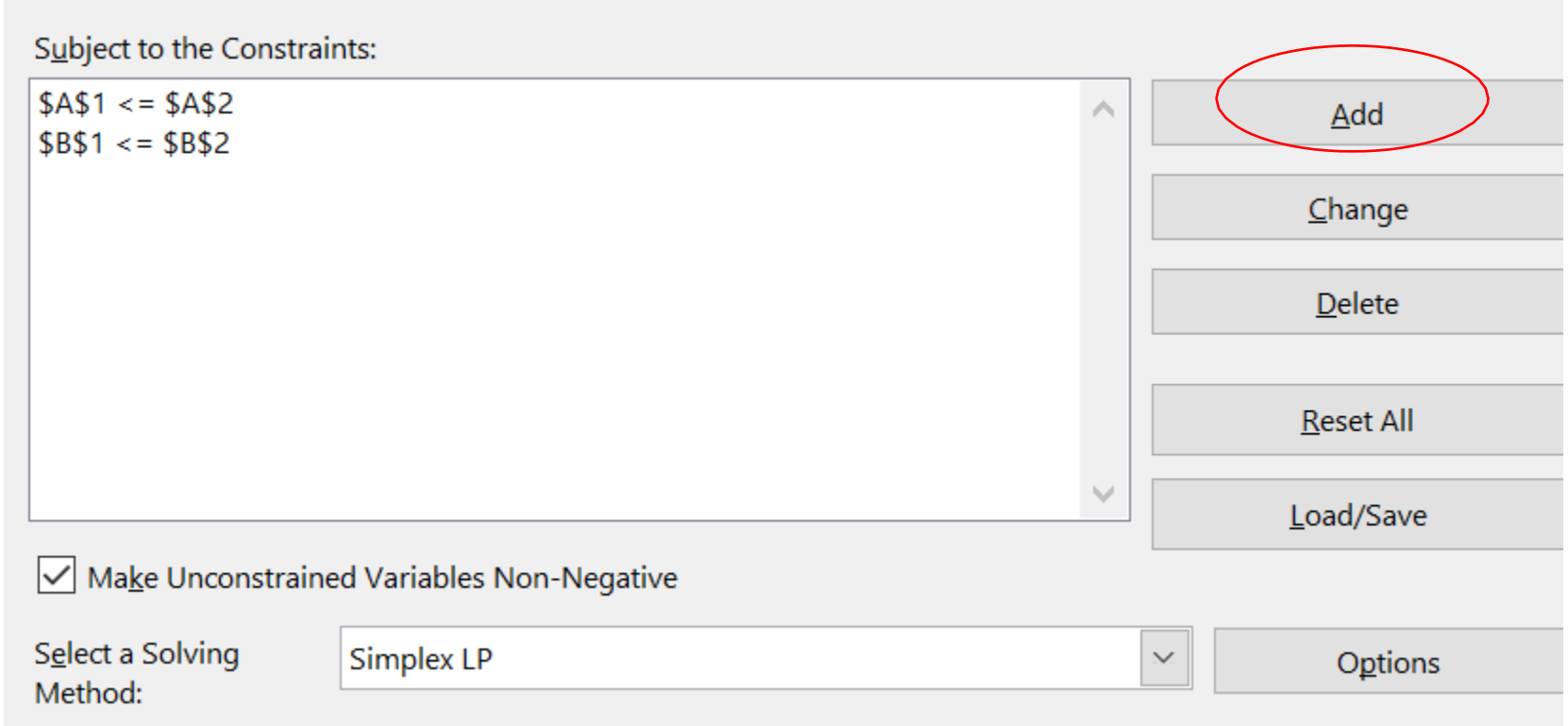
Excel Solver

- Click on Data/Solver
- Begin by setting the Target Cell
  - This is where you want the optimal objective function value to be recorded
  - Highlight Max (if the objective is to maximize)
  - The changing cells are the cells where the optimal values of the decision variables will appear



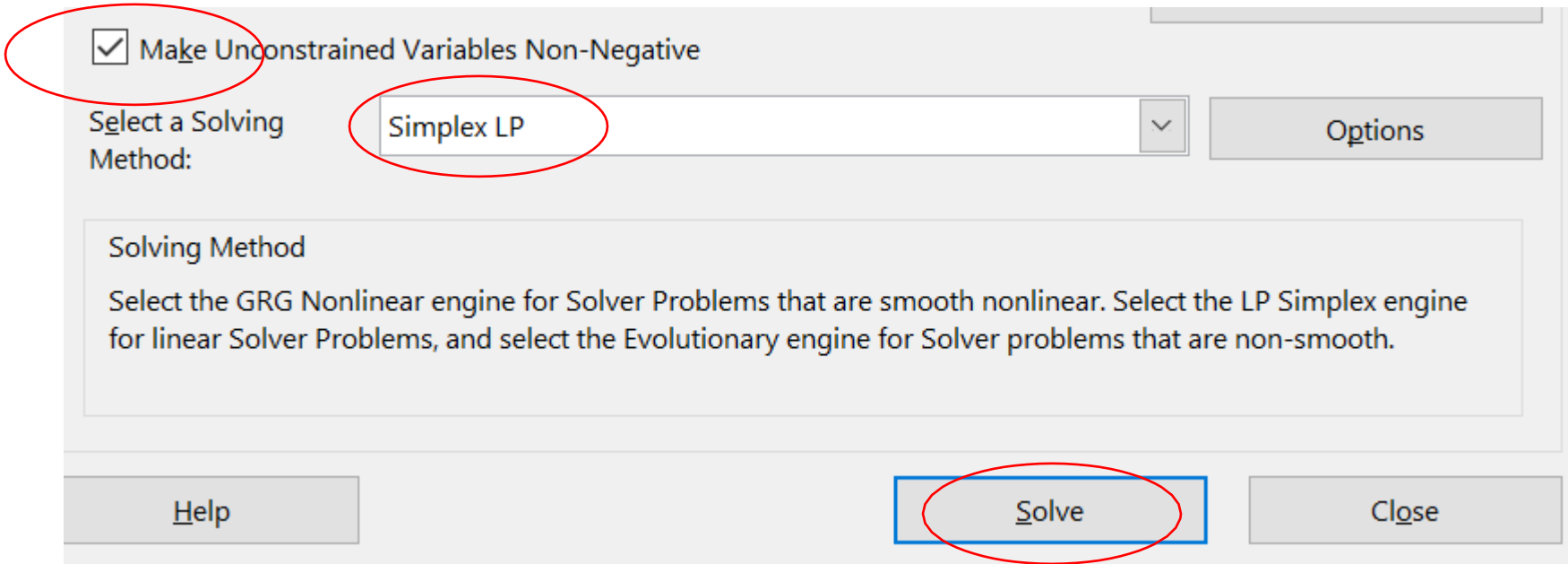
Excel Solver (cont..)

- Add a constraint, by clicking Add
  - For each constraint, enter the cell that contains the left-hand side for the constraint
  - Select the appropriate relationship sign (≤, ≥, or =)
  - Enter the RHS value or click on the cell containing the value
- Repeat the process for each system constraint



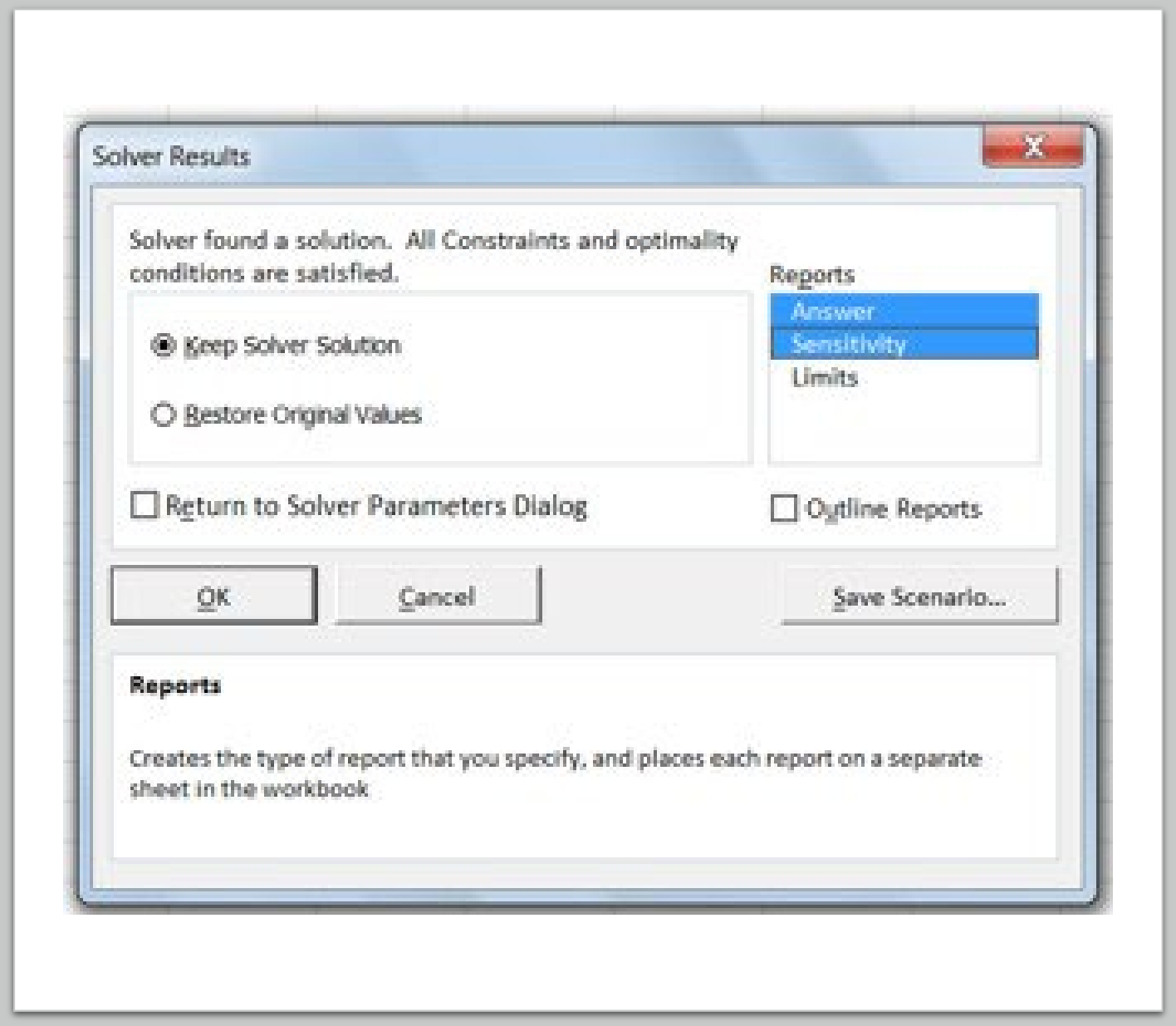
Excel Solver (cont..)

- For the non-negativity constraints, check the checkbox to Make Unconstrained Variables Non-Negative
- Select Simplex LP as the Solving Method
- Click Solve



Solver Results

- The Solver Results menu will appear
  - You will have one of two results
    - A **Solution**
      - In the Solver Results menu Reports box
        - Highlight Answer
        - Click OK
    - An **Error** message
      - Make corrections and click solve



Solver Results (cont..)

- Solver will incorporate the optimal values of the decision variables and the objective function into your original layout on your worksheets
- Time to practice!

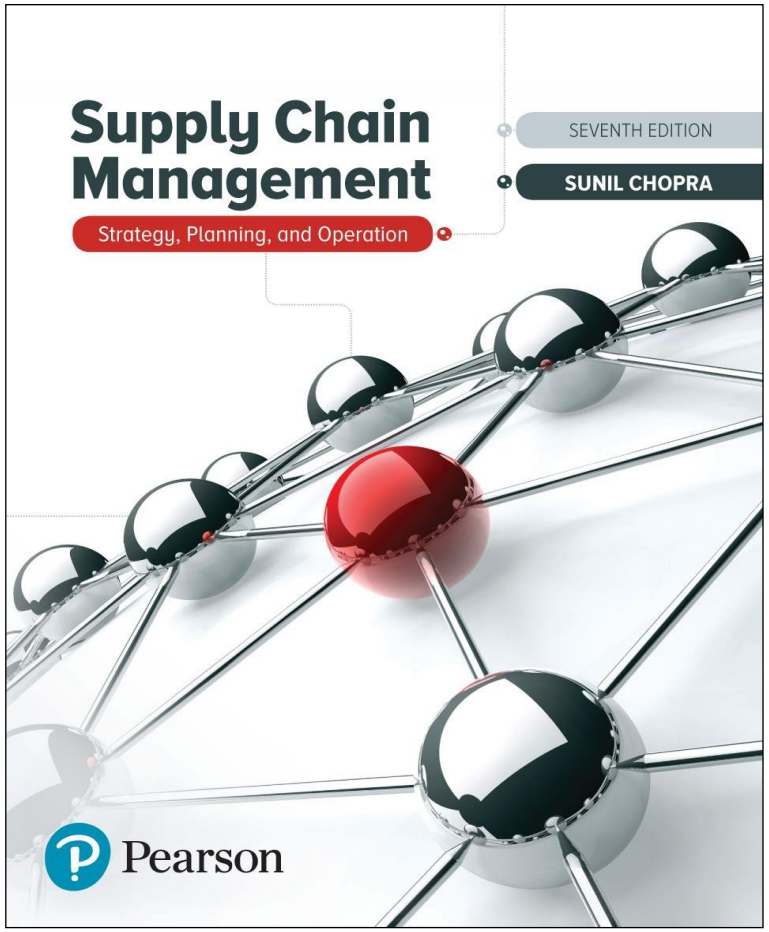
	H	W				
solver soln	132	36				
Unit Profit	40	30				
Total profit	6360					
				<=	H	W
Fabrication	600	600			4	2
Assembly	480	480			2	6

https://www.microsoft.com/en-us/microsoft-365/p/excel/CFQ7TTC0HR4R?ef_id=6fa0d2be82fc1b58e488b3344ce28ef7%3aG%3as&activetab=pivot%3aoverviewtab

https://oneeducatorsopinion.wordpress.com/2014/02/26/brain-breaks-are-good-for-teachers-too/

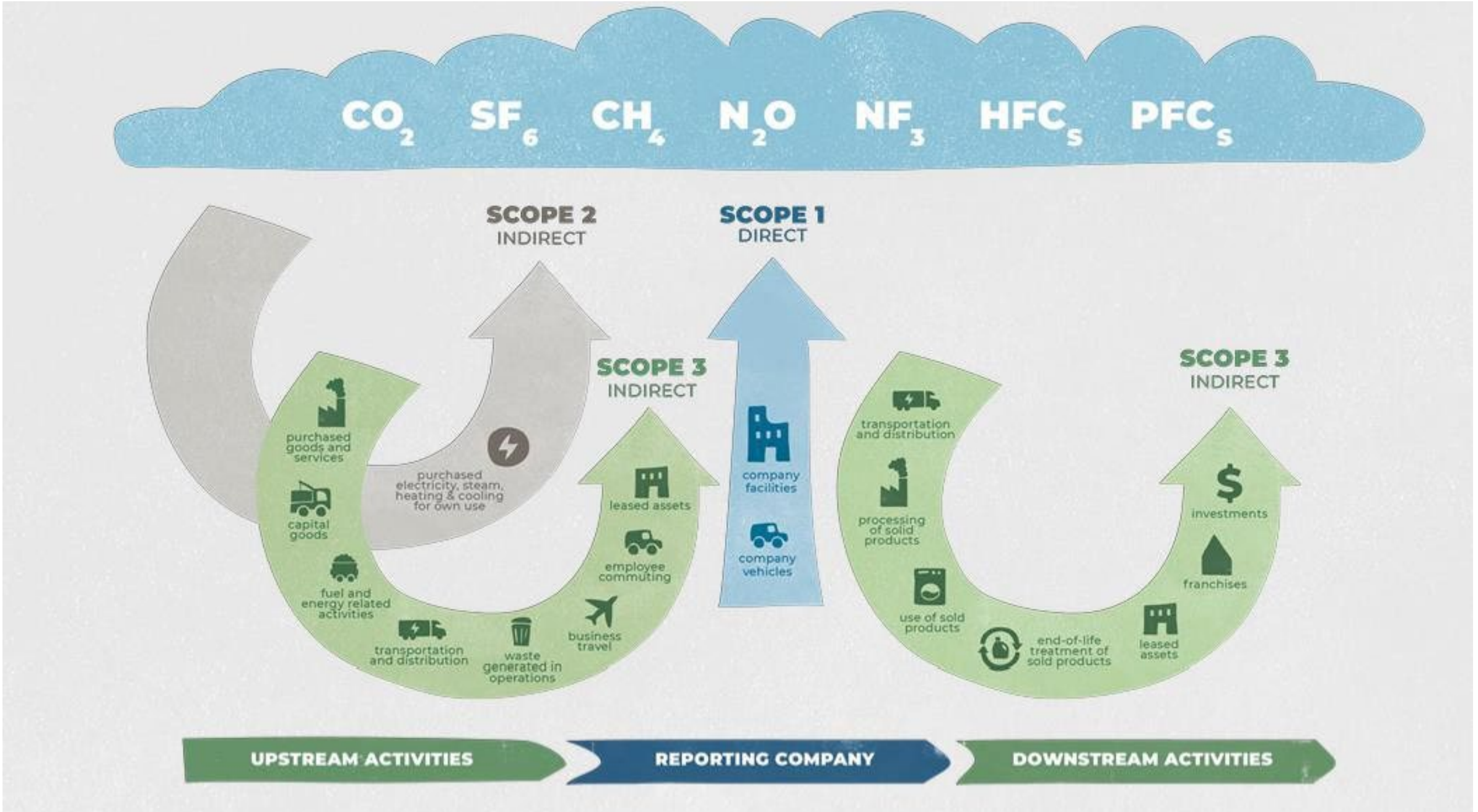
Supply Chain Management: Strategy, Planning, and Operation

Seventh Edition



Chapter 17

Sustainability and the Supply Chain



From: Corporate Value Chain (Scope 3) Accounting and Reporting Standard by WRI and WBCSD

Apple has set an ambitious goal to be carbon neutral across its global supply chain by 2030

200+ suppliers
committed to using clean energy like wind or solar for their Apple production

3,000 GWh
of new renewable energy across Europe per year by 2030 to address the electricity used by Apple devices on the continent

1 million metric tons
of carbon forecast to be removed in 2025 through Apple's Restore Fund

Supply Chain Emissions Reduction Goal

By the end of 2030, reduce emissions intensity (per metric ton of food and packaging) by 31% across our supply chain from 2015 levels.

P&G IT'S OUR HOME | NET ZERO 2040

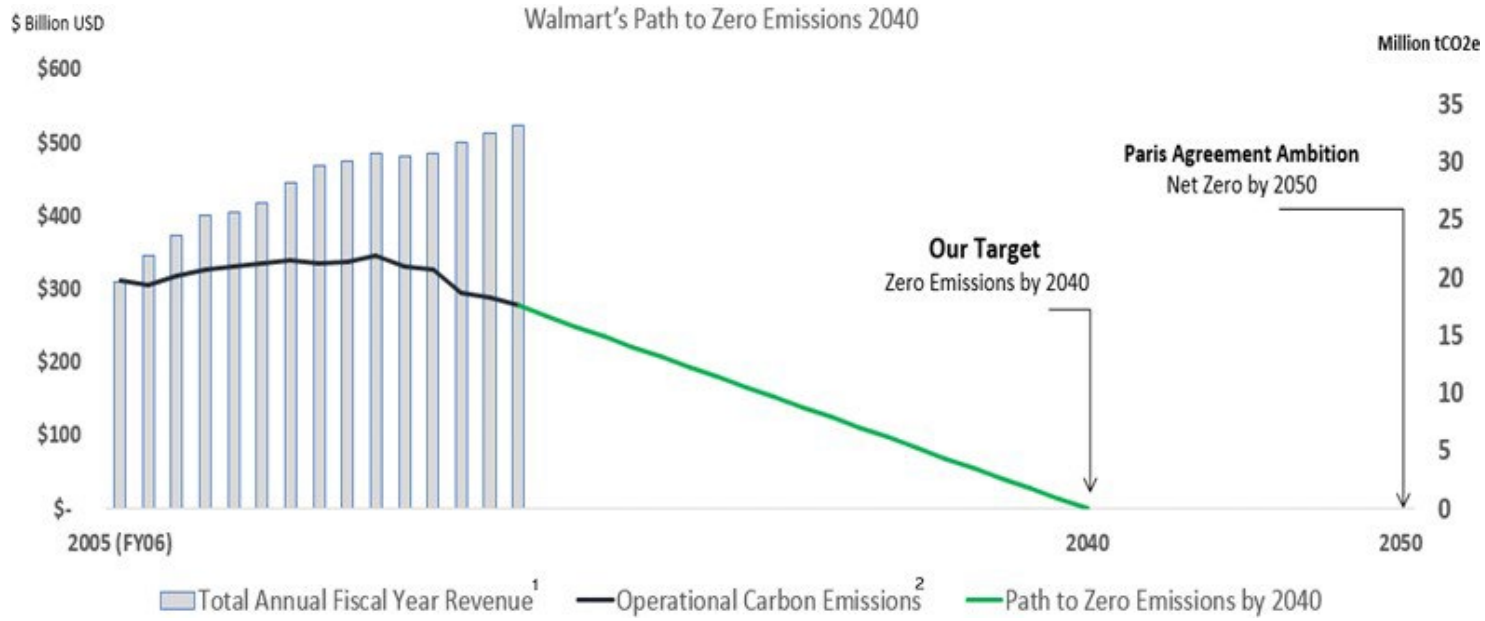
Materials & Packaging (Supply Chain)
16,760,000 (8.5%)

Operations
2,619,000 (1.3%)

Transportation
3,900,000[3] (2.0%)

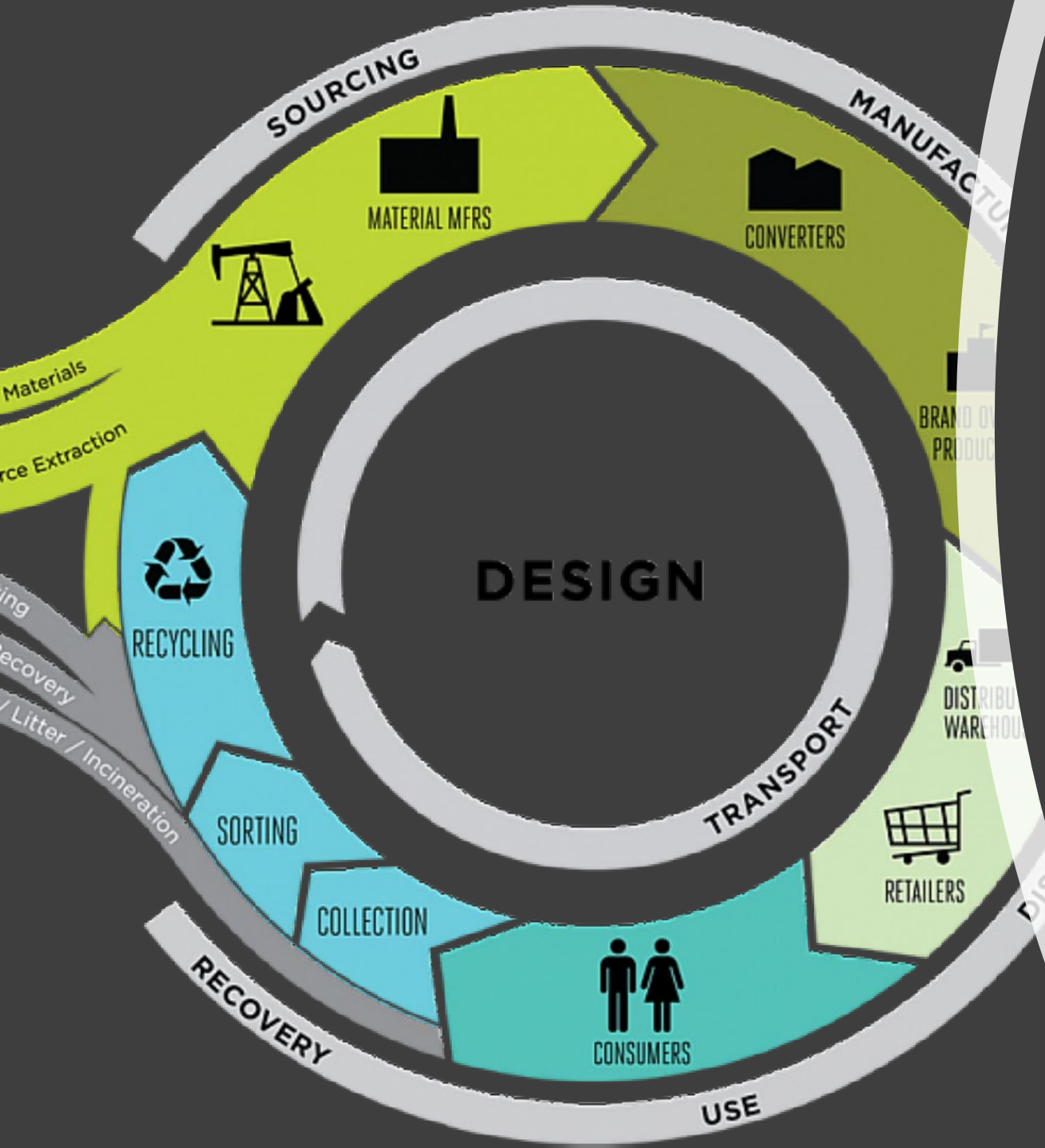
Consumer Use
164,000,000 (83.3%)

End of Life
9,382,000 (4.7%)



Role of Sustainability in a Supply Chain (1 of 2)

- The health and survival of every supply chain depends on the health of the surrounding world
- Expand the goal of a supply chain beyond the interests of its participants
- **Sustainable development** – development that meets the needs of the present without compromising the ability of future generations to meet their own needs
- Three pillars of sustainable development
  - Economic sustainability
  - Environmental sustainability
  - Social sustainability
- Factors
  - Reducing risk and improving the financial performance of the supply chain
  - Community pressures and government incentives and mandates
  - Attracting customers that value sustainability



Role of Sustainability in a Supply Chain (2 of 2)

- Most effort expended in reducing risk and improving financial performance
- Activity slow as actions may require upfront investment
- Barriers to increased focus on sustainability
  - Insufficient return on investment
  - Customers' unwillingness to pay a premium for green products
  - Difficulty evaluating sustainability across a product life cycle

Tragedy of the Commons

- Dilemma arising when the common good does not align perfectly with the good of individual entities
- Every company and supply chain faces the challenge of the tragedy of the commons as it operates in a global environment
- Difficult to imagine a sustainable solution emerging without some intervention
- Solutions
  - Choose from options that are unlikely to be supported by all of their own free will
  - Mutual coercion – social arrangements or mechanisms coerce all participants to behave in a way that helps the common good
    - Command-and-control approach: Government/ regulators set standards
    - Market mechanisms: Cap-and-trade, taxes

Image: David Cutler

https://medium.com/openforests/the-core-concept-of-sustainability-8facc0811f4f

Key Pillars of Corporate Social Responsibility

- Measuring performance along all three pillars may be required to evaluate the impact of sustainability-related efforts
  - Environmental
  - Social
  - Governance
- Two fundamental challenges
  - Scope of measurement
  - Absolute of relative measures

Environmental Pillar

- Firm's impact on the environment, including air, land, water, and ecosystems
  - Resource reduction
  - Emission reduction
  - Product innovation
- Not all "green" claims are valid
  - **Greenwashing**

https://sciencetrends.com/earths-many-different-types-ecosystems/

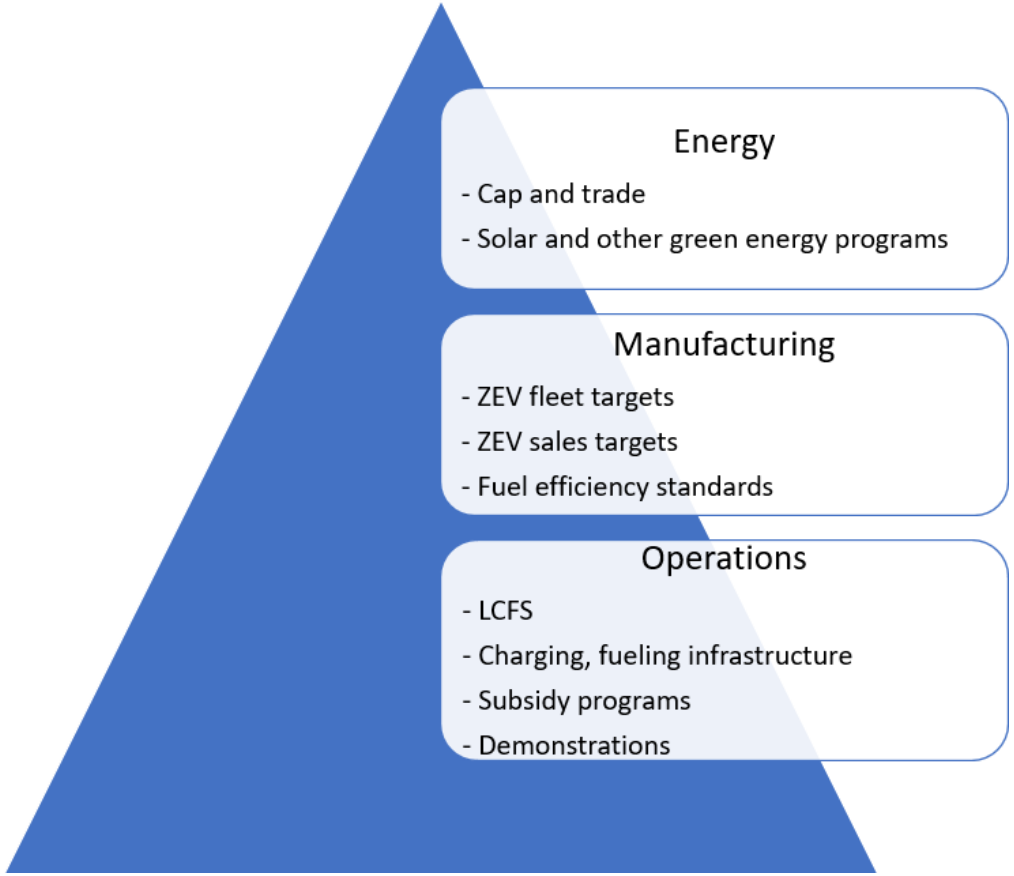
Social Pillar

- A firm's ability to address issues that are important for its workforce, customers, and society
- Audit and support suppliers
  - Supplier collaboration and capability building strongly associated with social and environmental responsibility performance improvement and lower operating costs
  - Benefits accrue to all customers of the supplier

https://globalcastaway.com/visiting-luxor-egypt/

Governance Pillar

- Firm's governance style based on best management practices
- Vision and strategy for environmental and social improvements must align with economic performance
- Hard to implement



California Heavy-duty Truck Emission Mandates

Facilities

Illustration by Skanska USA

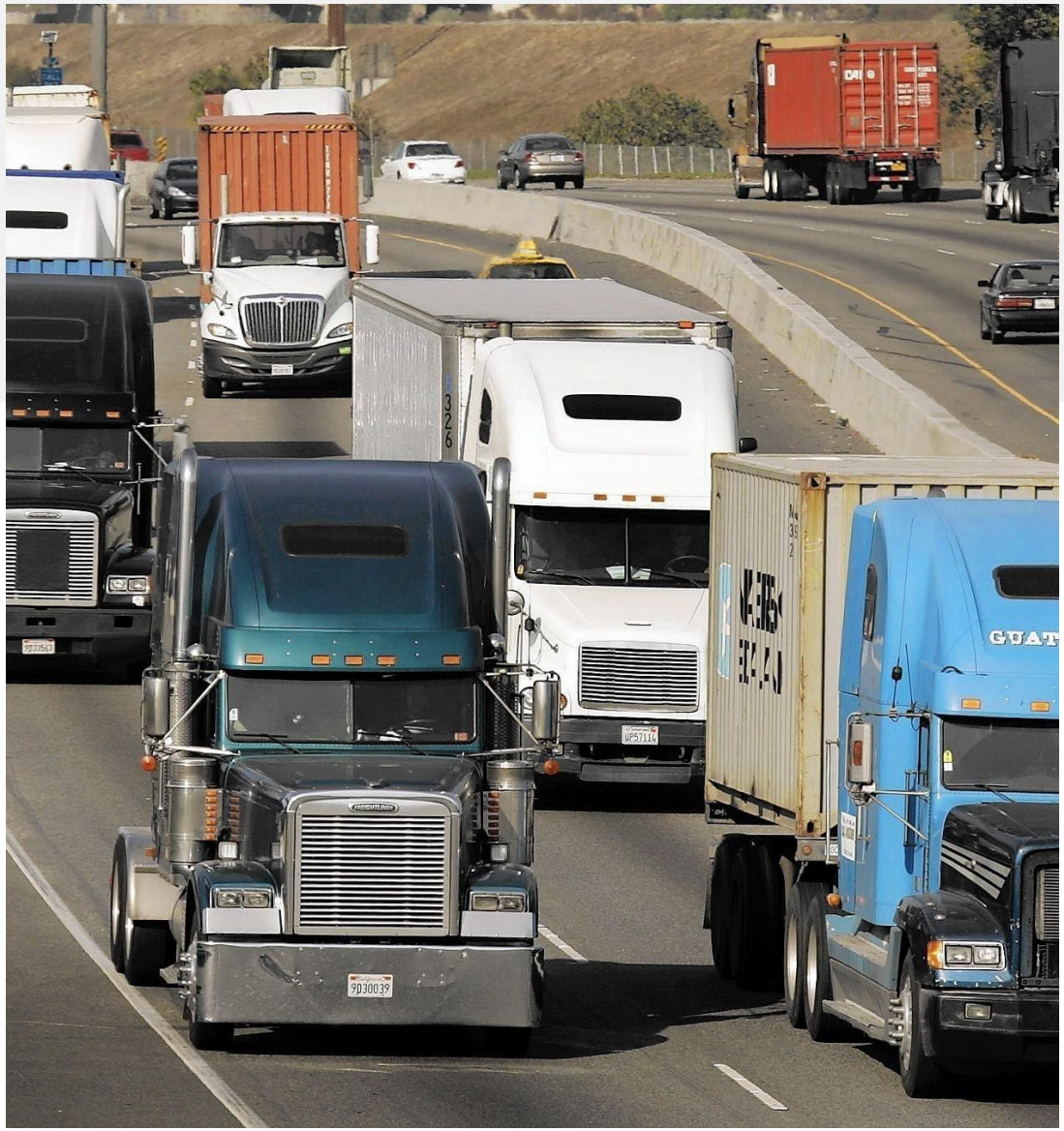
- Consumers of energy and water and emitters of waste and greenhouse gases
- Separate the improvement opportunities into those that generate positive cash flows and those that do not
- Facilities often offer the best opportunity to simultaneously improve the environmental and financial performances through innovation

Inventory

- Most supply chains focus on raw materials, work in process, finished goods
- Inventory in a landfill
- Cost borne collectively by society
- Reduce harmful inventory, unlock unused value
- “Cradle to cradle” design

Transportation

- Improve environmental performance through resource and emission reduction
- Product design can play a significant role



https://www.latimes.com/local/california/la-me-california-commute-20150317-story.html

Sourcing

- Greatest social and environmental impact occurs in the extended supply chain
- Impact has grown with increased global sourcing
- Verifying and tracking supplier performance with regard to sustainability a major challenge

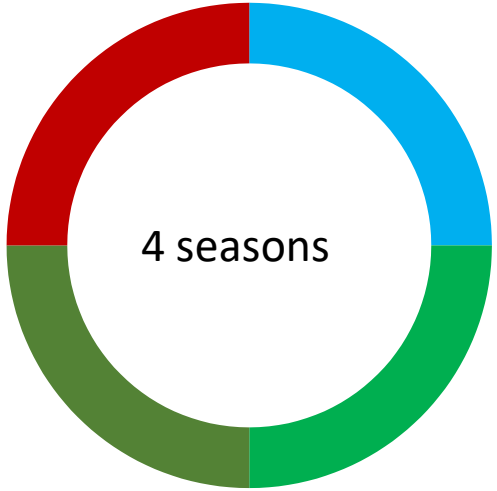
https://sourcingjournal.com/sustainability/sustainability-news/sustainable-sourcing-key-concern-brands-retailers-td-49539/

Pricing

- Differential pricing can improve the utilization of assets, leading to resource reduction
  - Delays the need for additional capacity
- Consumption visibility and differential pricing potentially lead to reduce resource consumption
- Biggest challenge is changing the customer's willingness to pay
- Government incentives can encourage customers and firms

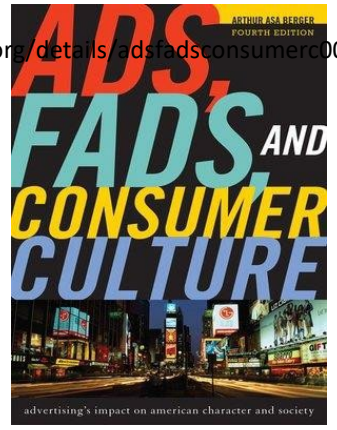
Design & process: a fast fashion example

What's Fast Fashion?



Before 1990 → 1990 +

https://archive.org/details/adsfadsconsumerc0000berg_p3s3



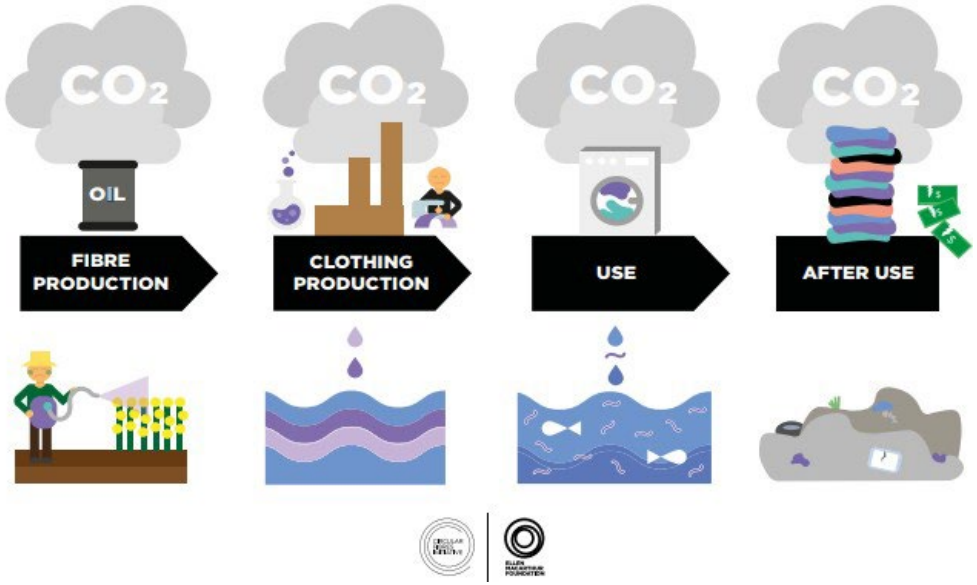
https://mopify.com/blog/fast-fashion

Design & process: a fast fashion example

The fashion industry produces 10% of all humanity's carbon emissions, is the second-largest consumer of the world's water supply and pollutes the oceans with microplastics.

It takes about 700 gallons of water to produce **one cotton shirt**. That's enough water for one person to drink at least eight cups per day for three-and-a-half years.

FIGURE 2: TODAY'S CLOTHING SYSTEM PUTS PRESSURE ON RESOURCES, POLLUTES THE ENVIRONMENT, AND CREATES NEGATIVE SOCIETAL IMPACTS



Washing clothes, meanwhile, releases 500,000 tons of microfibers into the ocean each year — the equivalent of 50 billion plastic bottles.

https://www.businessinsider.com/fast-fashion-environmental-impact-pollution-emissions-waste-water-2019-10?op=1
https://www.weforum.org/agenda/2018/08/clothing-rental-could-be-the-key-to-a-stylishly-sustainable-fashion-industry

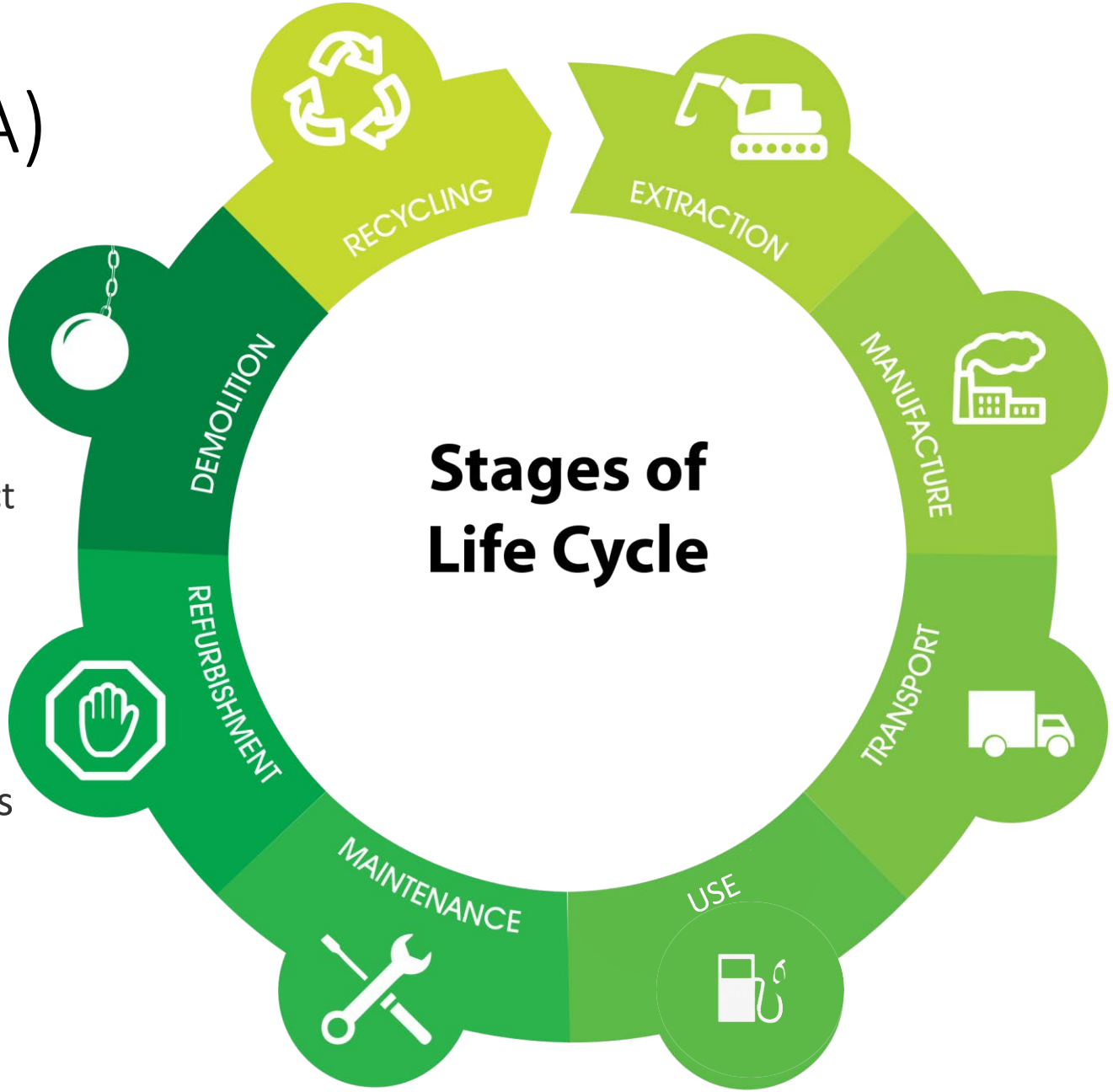
Breakout (PP)
Supply Chain Initiatives: Focus on Sustainability

- Investigate these resources in your teams and prepare to report back to the class.
  - What is CDP? What do they offer? What are the reasons they list for starting the sustainability journey? What areas do they focus on? Look up an “A” business. Any surprise you? https://www.cdp.net/en/
  - Report out on the Sustainable Development Goals (SDGs) from the UN. (I recommend showing the diagram) How can firms work towards these goals? https://sdgs.un.org/goals
  - Read the Clif Bar case study. What did they do and what was their outcome? What are they working with their suppliers to achieve? See content/module 3/week 3/reading
  - Find a company that is actively working to address sustainability. Describe the firm and its supply chain (briefly) and what specific actions have taken place, measurements, and results.

https://www.netclipart.com/isee/hmhJiJ_team-huddle-clip-art-huddle-clip-art/

Life cycle analysis (LCA)

- Cradle-to-grave approach for assessing the environmental impacts
  - It is not just about the use cycle!
  - What is the overall impact of a particular product
- Gain a broad and comprehensive perspective about a product footprint
- Ensures that an improvement in one area does not suboptimize the whole
- Compare between different materials, processes
- Everyone in the supply/use chain has a responsibility for environmental impacts
- Having standards can provide information to consumers, companies, and governments



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Dissertation research problem

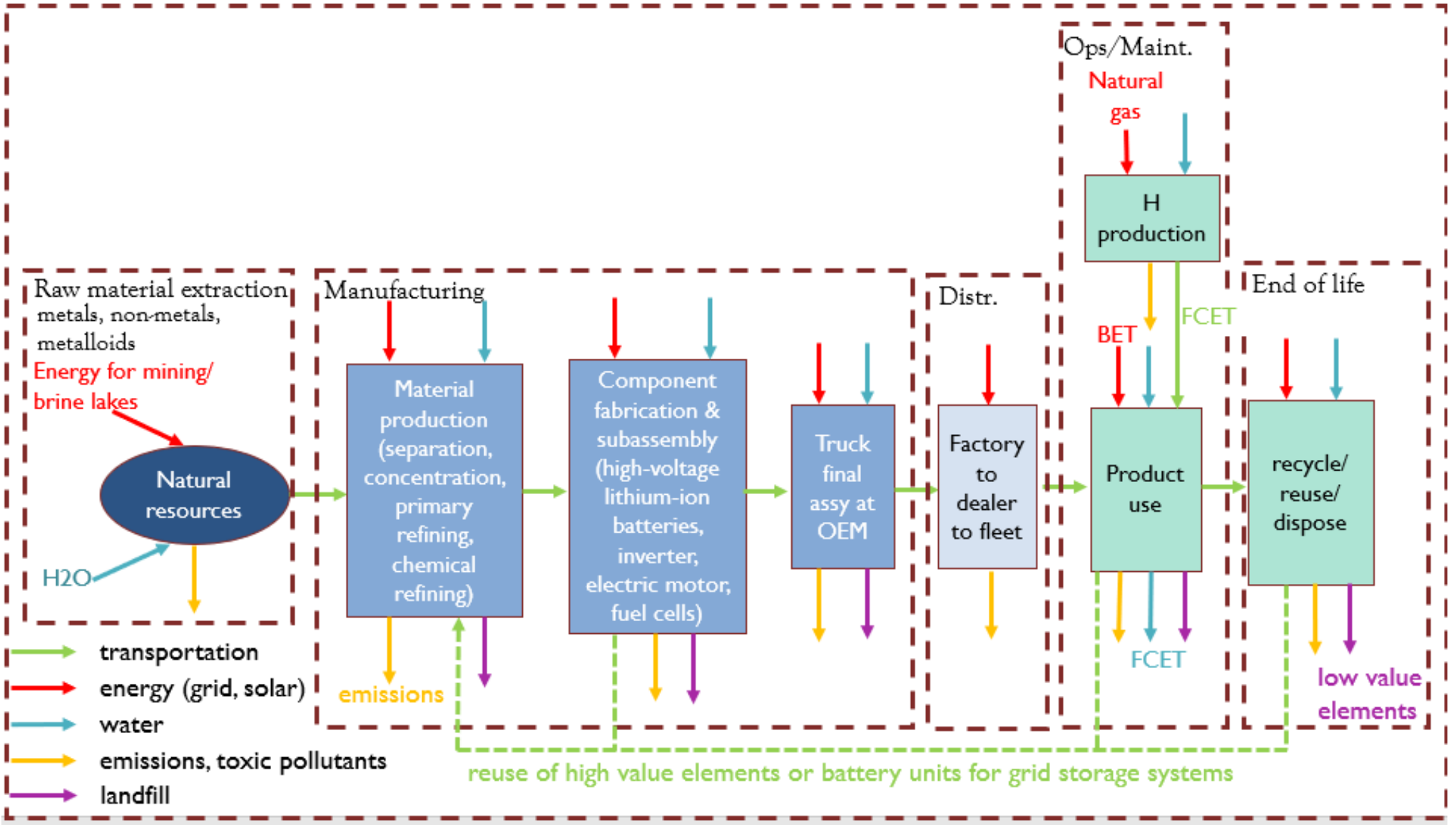
- **Research question: which type of engine/powertrain has the lowest carbon footprint? Electric (EV) or hydrogen fuel cell (FCV)?**
- Understand the life cycle impacts from all phases of alternative technology heavy-duty trucks
  - Compare all phases of the lifecycle
  - Mining, manufacturing, distribution, operation, and retirement/recycling
  - Focus on components which are different between models, not those items which are the same (e.g., a tire is a tire)
- Functional unit = 1 mile driven
- Main assumptions
  - Both class-8 trucks used in same region with same number of miles (48,360/yr., 10-year life, 300-mile range)
  - Information on vehicles gleaned from various sources since not in production
    - Kenworth/Toyota T680 in demonstration (CARB grant)
    - Tesla running tests, but access to test Semi not available to outside entities

EV Tesla Semi

vs.

FCV Kenworth/Toyota T680

System flow diagram & boundary (BET & FCT)

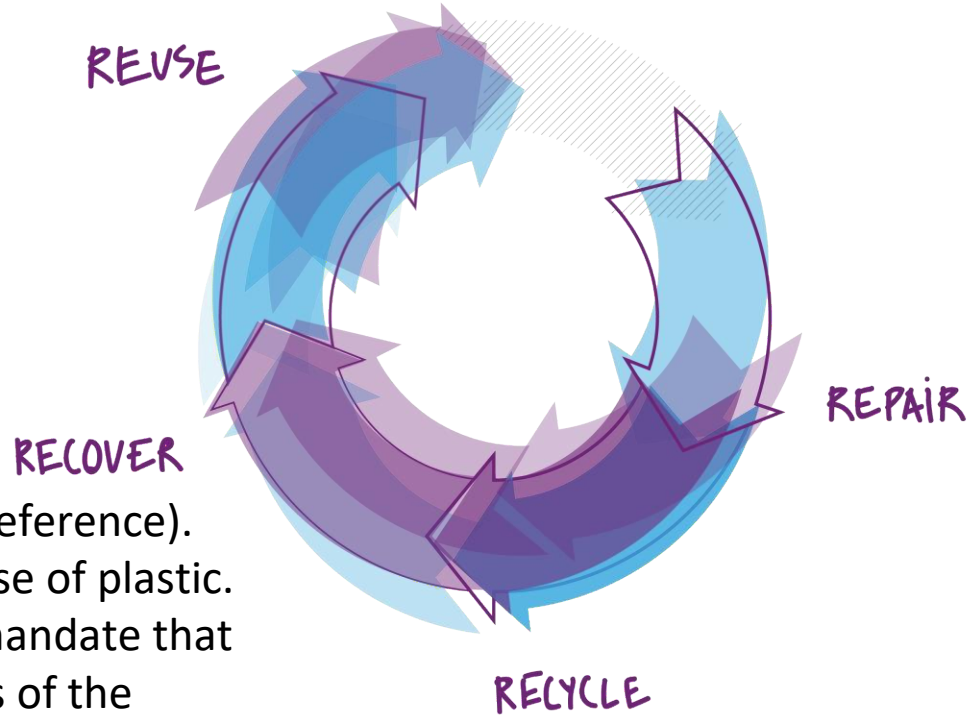


Summary of drivers to improve supply chain sustainability

- Facilities redesigned to reduce energy use and emissions
- Products designed to:
  - Decrease landfill inventory
  - Increase the reuse of material
  - Limit packaging
  - Improve transportation density (leading to cost reduction and lower emissions)
- Individual firms with great reach exert influence on their extended supply chains to improve sustainability
- Clearly defined standards for measurement and reporting of performance
- Customers' willingness to reward successful supply chains

https://thebossmagazine.com/green-supply-chain/

Case 3: Circularity **Due 4/27**



http://designfordemand.forumforthefuture.org/section/1-1-why-we-need-your-help-to-create-a-more-circular-economy/

- The report should be 5-6 pages in length, plus references.
- Include tables/charts/figures and explain calculations.
- Feel free to add information as necessary to make your case.

- Read the Oxford case on Dell Circular Case Study (go to content/cases/reference).
  - You work for a company that could benefit from the recycling/reuse of plastic. Assume that the Board of Directors of this company has issued a mandate that sustainability efforts begin in earnest within the year for all phases of the manufacturing/distribution of products containing plastic. Your team has been assembled to analyze the problem. (The team is not constrained to plastic and may choose another commodity.)
- To accomplish this goal, write a recommendation report for senior management on the supply chain transformation. Discuss:
  - What makes a circular economy possible? Who are the players? What type of cooperation is needed?
  - Why is circularity important to this company/industry? Be specific.
  - For a specific commodity/product, investigate the lifecycle and current end-of-life processes.
  - Discuss which phase(s) should be transformed and why.
  - What problems must be overcome to make your idea(s) work?
  - Determine the steps needed to reach this goal, including a cost-benefit analysis to sell the idea to senior management. (Not asking for detailed $ but directionality and considerations)

Case 3 Teams

Alramahi, Ehab	1
Euceda Iscoa, Marlon	1
Han, Chris	1
Lopez, Ruben	1
Galleta, Beda	2
Ghazaryan, Shushanik	2
Khachatryan, Marieta	2
Magallon, Dominick	2
Collier, Nicole	3
Dizon, Ric	3
Ramirez, Lizbeth	3
Wand, Kelly	3
Ahadiat, Parisa	4
Guelff, Michelle	4
Matthews, Olivia	4
Vidovich, Mikaela	4

Freeman, Annie	5
Joshua, Jonathan	5
Rodgers, Samuel	5
Sampson, Ivy	5
Bui, Cindy	6
Kariuki, Janet	6
Nguyen, Jessica	6
Redfearn, Joe	6
Alfaro, Marugenia	7
Contreras, Stephanie	7
Gonzalez-Aguayo, Gisela	7
Khafajizadeh, Bina	7
Ang, Paul	8
Beisecker, Kelsey	8
Perez, Melissa	8
Weiss-Varela, Samantha	8

Assignments

- Listen to sourcing video if you haven't already done so
- Team case study on Ukraine
  - Due 4/13 to dropbox (prior to class)
  - Team eval due 4/14 to dropbox (individual)
  - Next class team leader to report out on:
    - What commodity studied
    - Findings on SC disruption/impact
    - Surprises?
- Homework 2
  - Due 4/20 before class
  - Agg planning, LP, cycle stock, safety stock, EOQ, qty discounts, ROP
  - Can find questions in content/module 4/week 4/assignments

Office hours! Please join me on Tuesdays 1-2pm or by appointment!