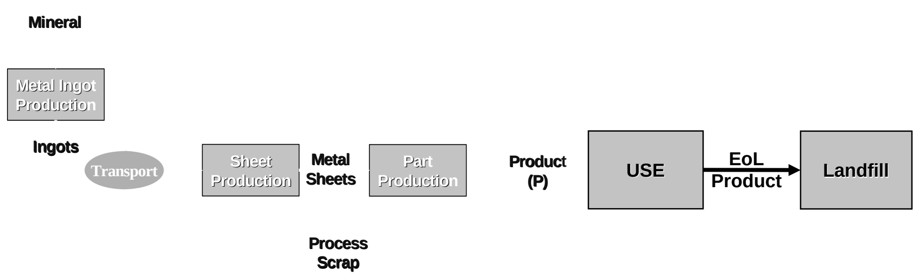
Session 4: Inventory Allocation

Issues in Calculating an Inventory -- Allocation

Consider adding two elements to the scope of the analysis

-- Use

-- Disposal



Environmental Data – Use

Summary

Products	EoL products of P
Raw Material	Products P

Inputs/Outputs

Description	Quantity	Units	Details
Annual Purchsed Nationwide	4.00E+07	kg / year	Product *P*
Annual Dispoal	4.00E+07	kg / year	EoL P
Emissions to air	1.00E+05	kg/year	HC

Environmental Data – Disposal to Landfill

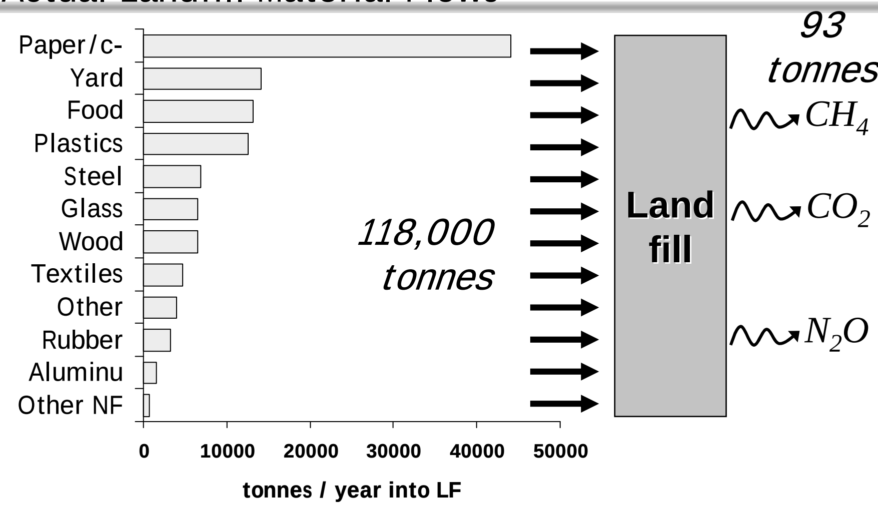
Summary

Products	Methane
Raw Material	EoL products of P, MSW

Inputs/Outputs

Description	Quantity	Units	Details
Total annual methane	93	tonnes/year	HC
Use of raw material	118000	tonnes/year	Solid Waste
Emissions to air	93	tonnes/year	HC

How Much Should be Allocated to Metal Wastes?
Actual Landfill Material Flows



How Much Should be Allocated to Metal Wastes?
Observed Landfill Emissions

(a)	(b) Net GHG Emissions from CH_4 Generation (MTCE/Wet Ton)				
Material	Landfills Without LFG Recovery	Landfills With LFG Recovery and Flaring	Landfills With LFG Recovery and Electric Generation	Year 2000 National Average	N (I
Aluminum Cans	0.00	0.00	0.00	0.00	
Steel Cans	0.00	0.00	0.00	0.00	
Glass	0.00	0.00	0.00	0.00	
Corrugated Cardboard	0.48	0.12	0.06	0.29	
Magazines/Third-class Mail	0.26	0.07	0.03	0.16	

"Solid Waste Management And Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks", EPA530-R-02-006, May 2002.

Courtesy of U. S. EPA.

Allocation Issues in Inventory Analysis

- **ISO Definition:**
  Inventory allocation :*Partitioning the input or output flows of a unit process to the product system under focus*
- **Emerges when a process within your product system is associated with a flow that is part of another product system (i.e., another life-cycle)**
  - **Multi-outflow**
  - **Multi-inflow**

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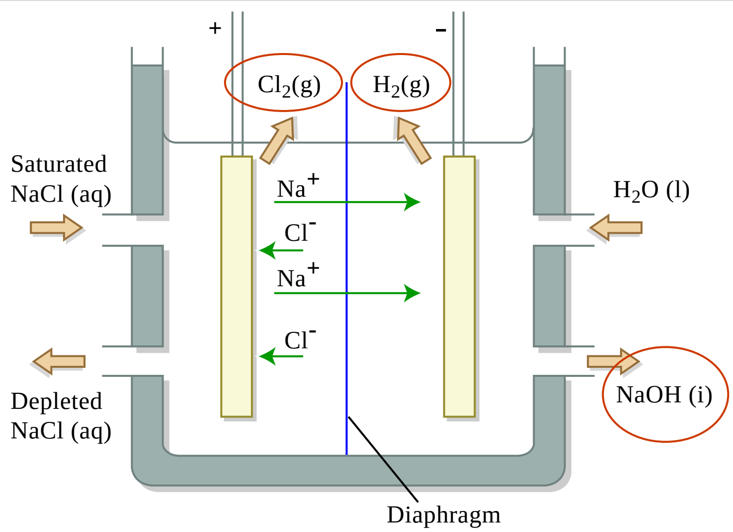
Allocation Examples: Chlor-Alkali Process



Schematic of a Diaphragm or Membrane Cell

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Figure by MIT OCW.

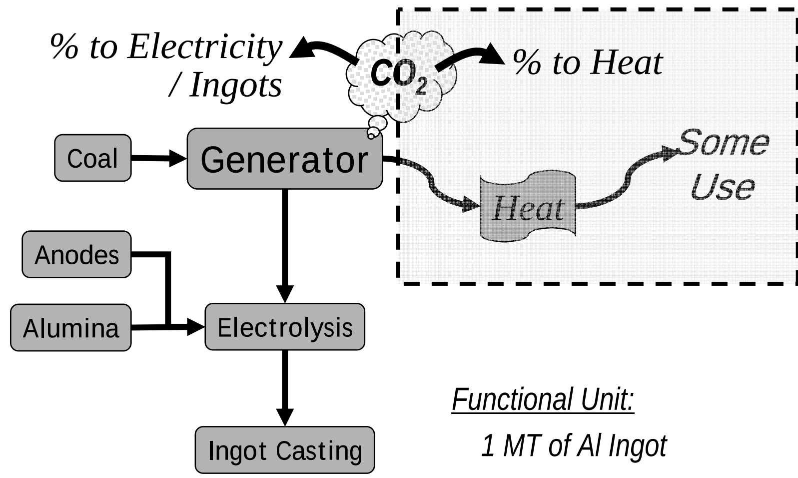
How can we handle allocation?

Addressing Allocation Approaches

- **Partitioning:**
  Method to apportion impacts between life-cycle under analysis and "other" flows
  - **More applicable to accounting-oriented analysis**
- **System expansion:**
  Avoiding problem by expanding scope of analysis to include "other" flows
  - **More applicable to change-oriented analysis**

Classic Allocation Example:

Electricity with Surplus Heat — **Partitioning**



Functional Unit:

1 MT of Al Ingot

Partitioning Strategies

- **Technical causality**
  - **Established relationship between magnitude of specific flows**
    - e.g., science based assessment of landfill emissions
  - **Usually requires treatment of intra-process flows to a great level of detail**
    - E.g., energy used only for HCl production in chlor-alkali
- **Physical quantity**
  - **Mass**
  - **Volume**
  - **Area**
  - **Energy content**
  - **Moles**
- **Social causality**
- **Arbitrary number**
  - **E.g., 50/50**

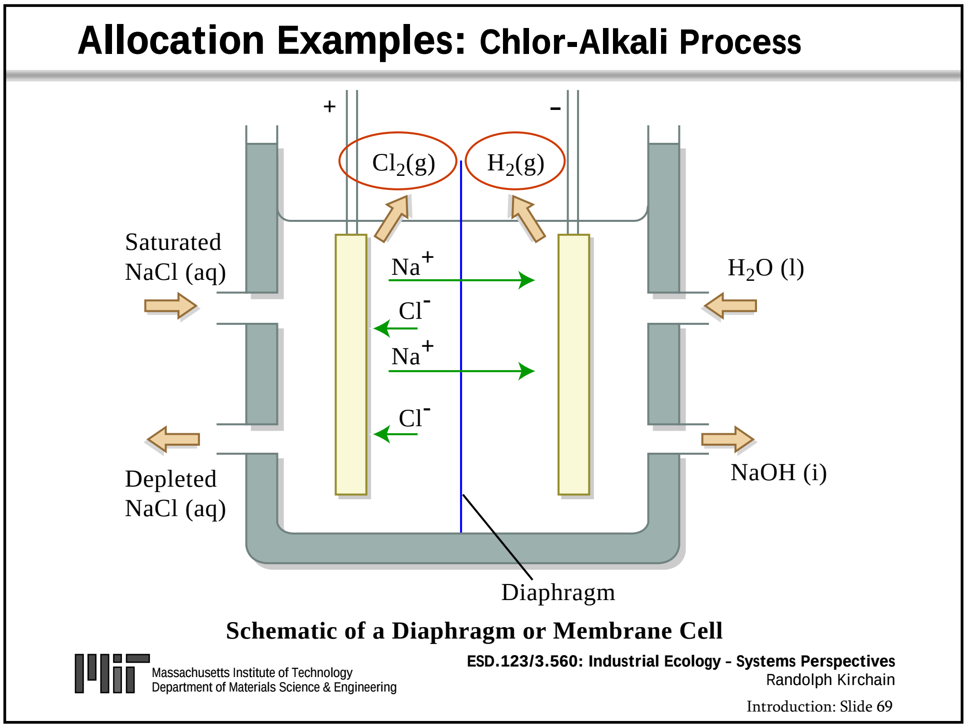
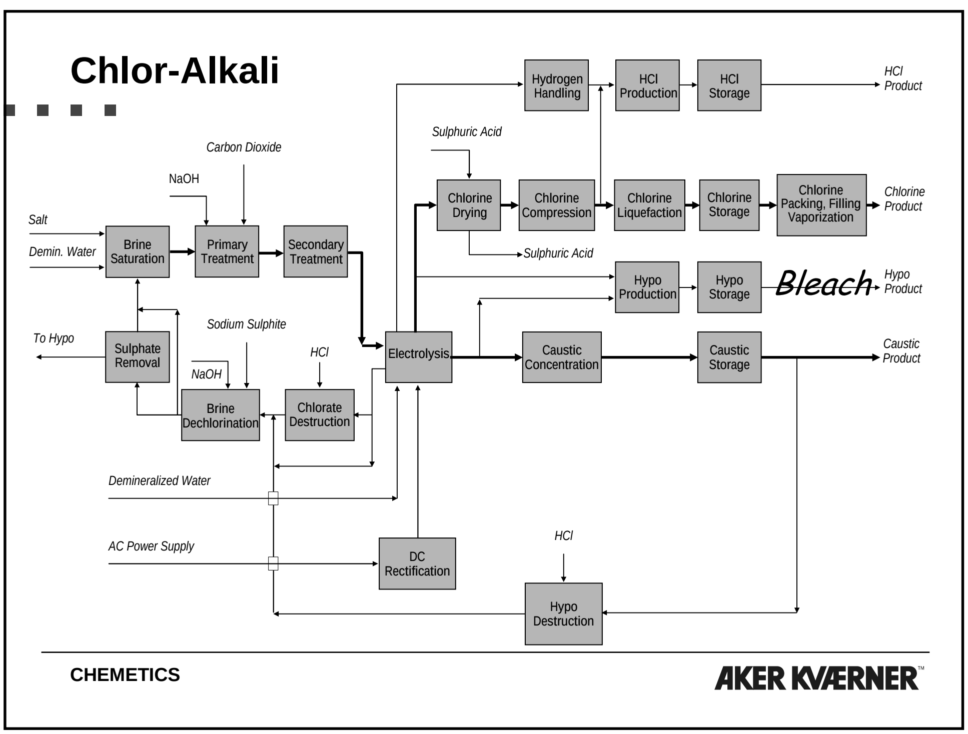


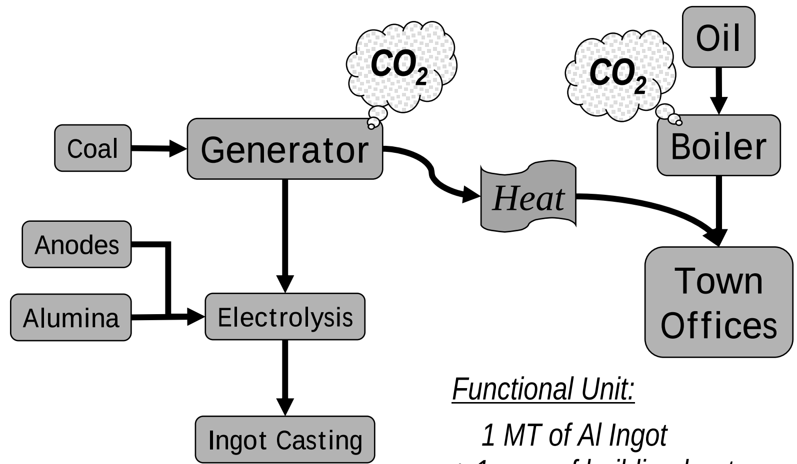
Figure by MIT OCW.



Courtesy of Aker Kvaerner Chemetics. Used with permission.

See http://www.akerkvaerner.com/Internet/IndustriesAndServices/Pulping/BleachingChemicals/ChloralkaliProcess.htm

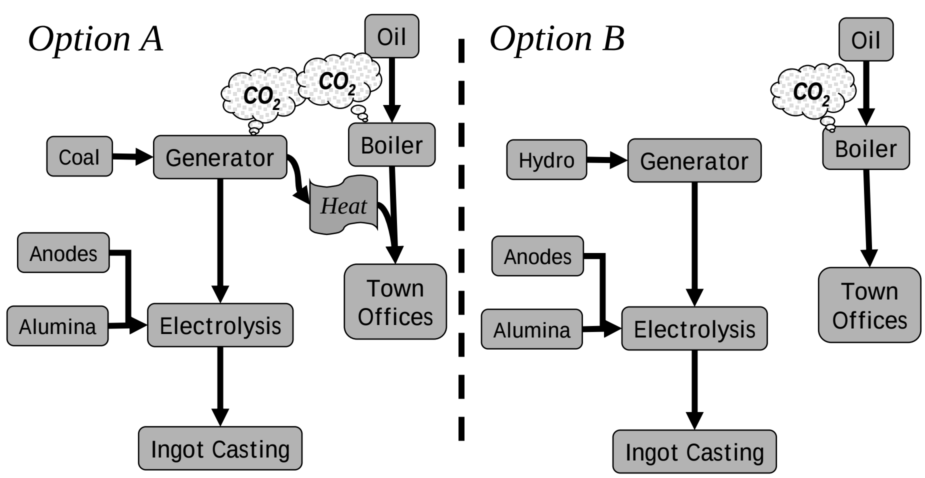
Classic Allocation Example:
Electricity with Surplus Heat — **System Expansion**



Functional Unit:

1 MT of Al Ingot
+ 1 year of building heat

Why System Expansion?



Why System Expansion?

- At first look, system expansion seems to greatly increase the scale of the analysis
- In fact, much of the implied expanded analysis can be excluded in a comparative analysis (i.e., change-oriented assessments)
- In practice
  - Scope should include activities required for credibility
  - Must be careful that activities are the same in different scenarios

Preferred Characteristics of an Allocation Scheme (Ekvall and Tillman 98, Klöpffer 96)

- Effect-oriented (non-perverse)
  - Activities with higher impact should receive higher load of inventory
- Politically acceptable to end-users
- Applicable with available information
- Consistent
- Prevents double counting

Preferred Allocation Approach

1. **System Expansion**
2. **Technical Causality**
3. **Social Causality**
4. **Physical Quantity**
5. **Arbitrary Quantity**

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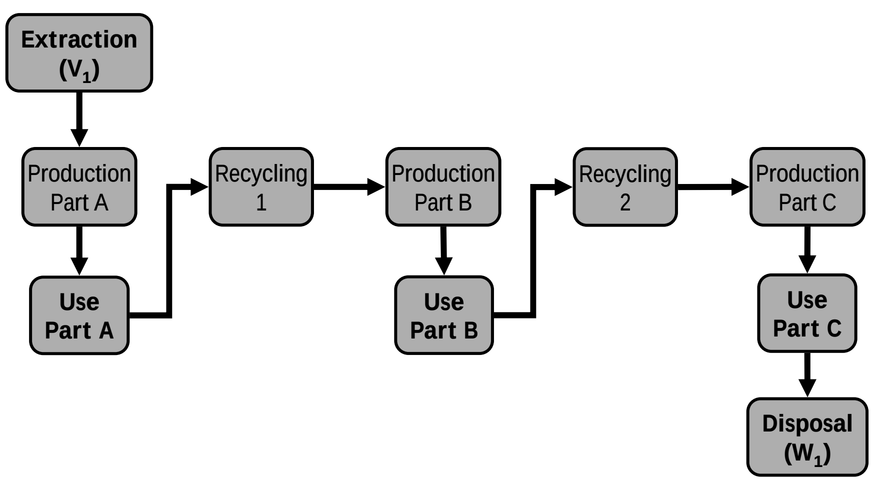
ESD.123/3.560: Industrial Ecology – Systems Perspectives
Randolph Kirchain

Introduction: Slide 75

Open-loop Recycling:
A common allocation challenge



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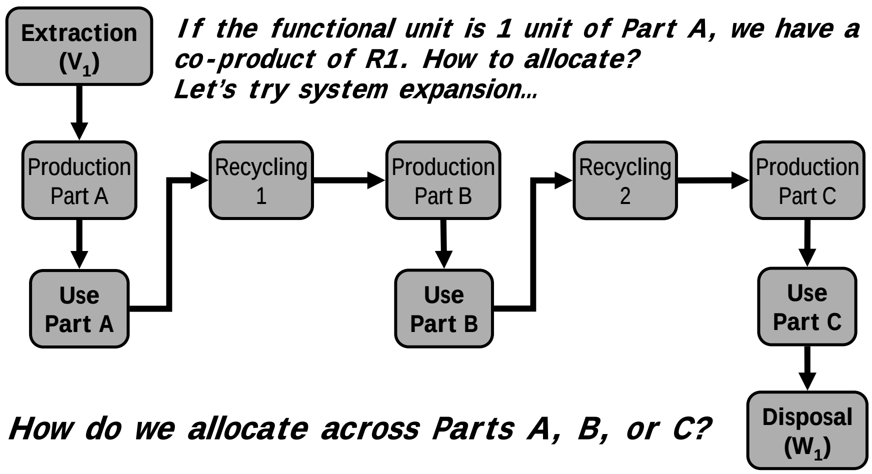
Open-loop Recycling:
A common allocation challenge



If the functional unit is 1 unit of Part A, we have a co-product of R1. How to allocate?
Let's try system expansion…

How do we allocate across Parts A, B, or C?

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Approaches to Open-Loop Allocations

- **Cut-off method**
  - **Only loads directly caused by a product are assigned to that product**
  - **No data from outside of life-cycle are required**
- **Loss of Quality**
  - **Allocated according to "quality" of material used**
- **Closed-loop Approximation**
  - **All activities are part of a general materials system**
  - **Allocation across products could follow any partitioning strategy**
    - Social causality, Mass
- **50/50 Approximation**
  - **Initial and terminal life-cycles share virgin production and disposal**
  - **Recycled life-cycles share recycling burden**

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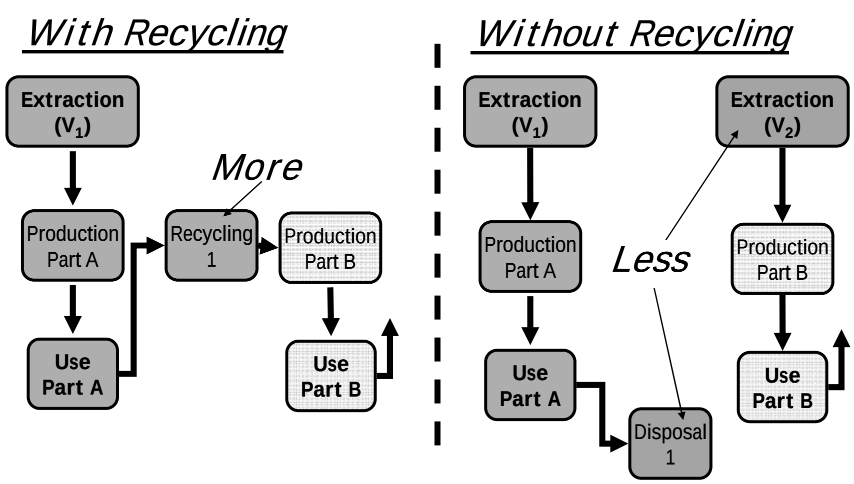
Common Open-Loop Recycling Method

- System expansion approximation
  - Compared against lack of recycling (or another disposal option)
  - Typically only one generation
  - Easily extensible to multiple generations, but requires data
  - Leads to credits given to inventory

  - Very widely applied
  - Implicitly gives significant credit to primary production for making recyclable resources available (Newell & Field 98)
  - In practice, often does not preserve additivity
  - Generally, should be reserved for comparitive assessments (change oriented LCA)

System Expansion Approximation



Preferred Allocation Approach

1. System Expansion
2. Technical Causality
3. Social Causality
4. Physical Quantity
5. Arbitrary Quantity