SUSTAINABILITY ANALYSIS – CAPTURING LIFE CYCLE IMPACTS AND COSTS IN DEFENSE SYSTEMS

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SERDP • ESTCP SYMPOSIUM 2017 | Enhancing DoD's Mission Effectiveness

Disclaimer

The views expressed in this presentation are those of the authors and do not reflect the official policy or position of the institutions with which they are affiliated.

Introductions

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Professor
Concordia University

You
Title
Affiliation

Overview

- Describe Sustainability Analysis (SA) at the DoD
- Identify data, software, and other resources for SA
- Present results from SAs of DoD systems
- Present ideas for how to use SA for RDT&E projects

Chemical and Material Risk Management Program

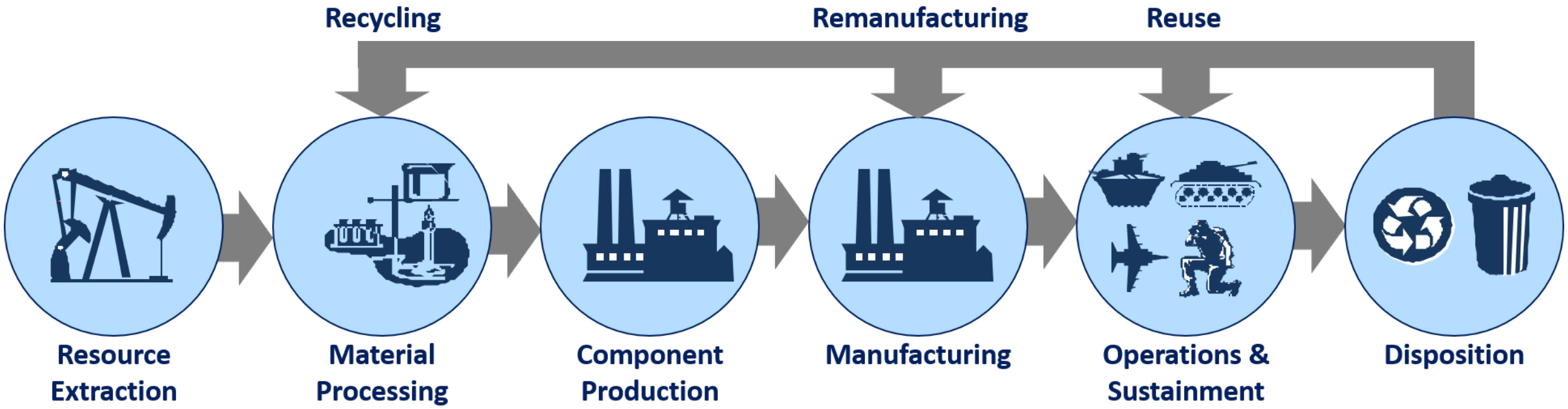
Our Mission

Protect readiness, people, and the environment by identifying and managing risks associated with the chemicals and materials DoD needs to accomplish its mission.

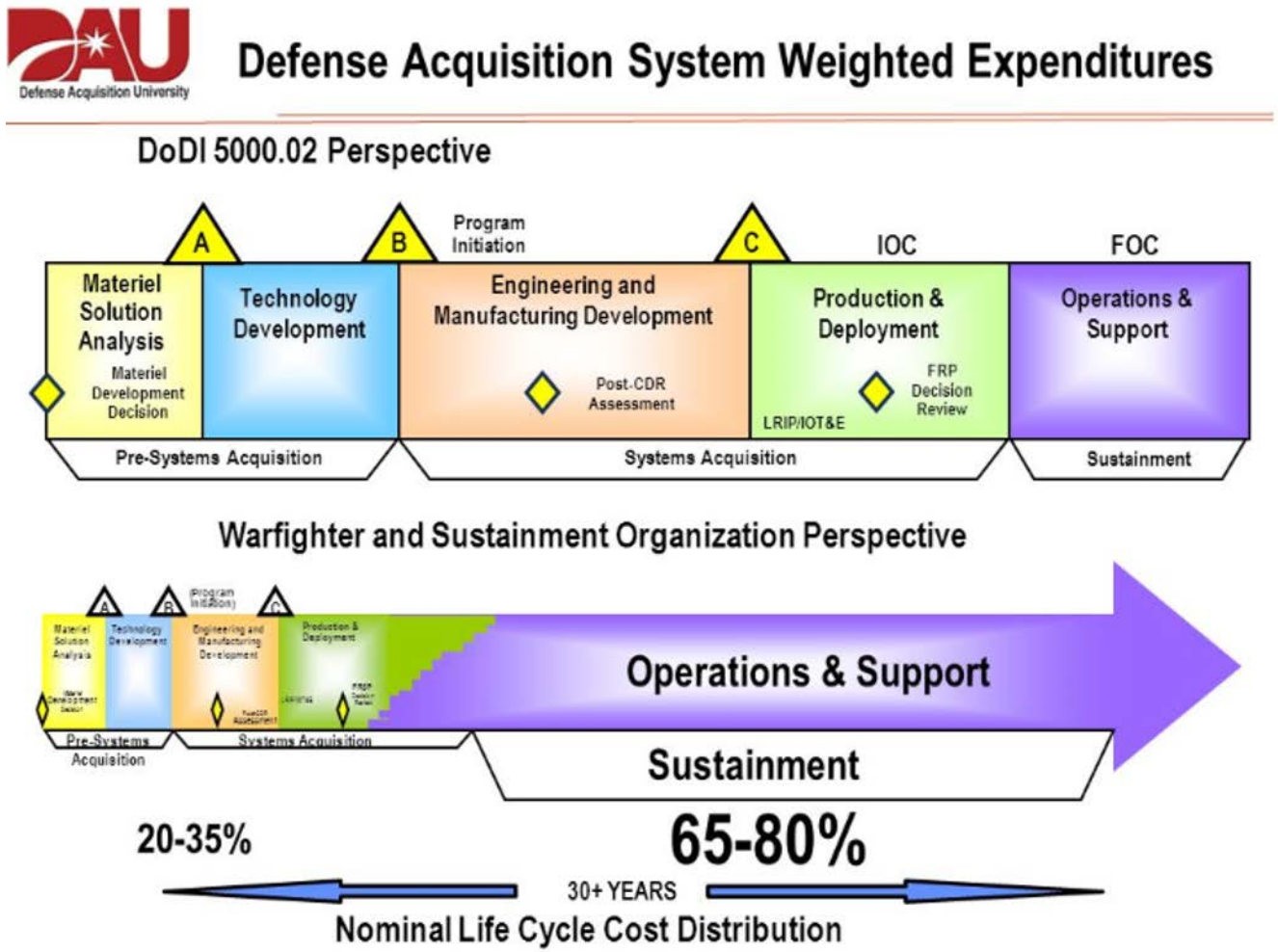
What we do

- Identify, assess, and manage emerging contaminants.
- Integrate science, technology, and policy to pursue sustainable use of chemicals and materials.
- Develop policies, procedures, and guidance for integrating life cycle ESOH considerations into the DoD acquisition process.

What do we mean by life cycle?



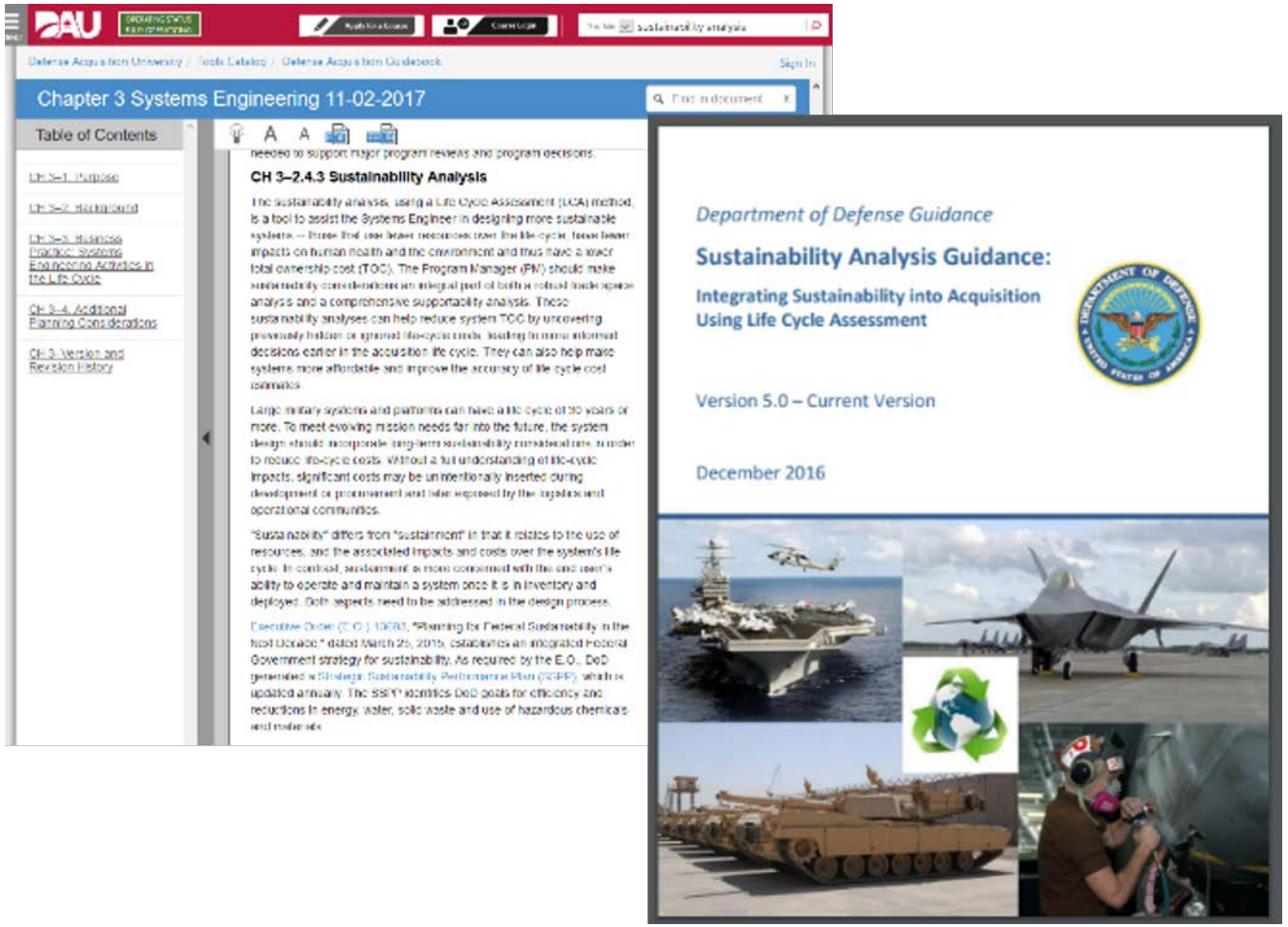
What is the DoD Acquisition Process?



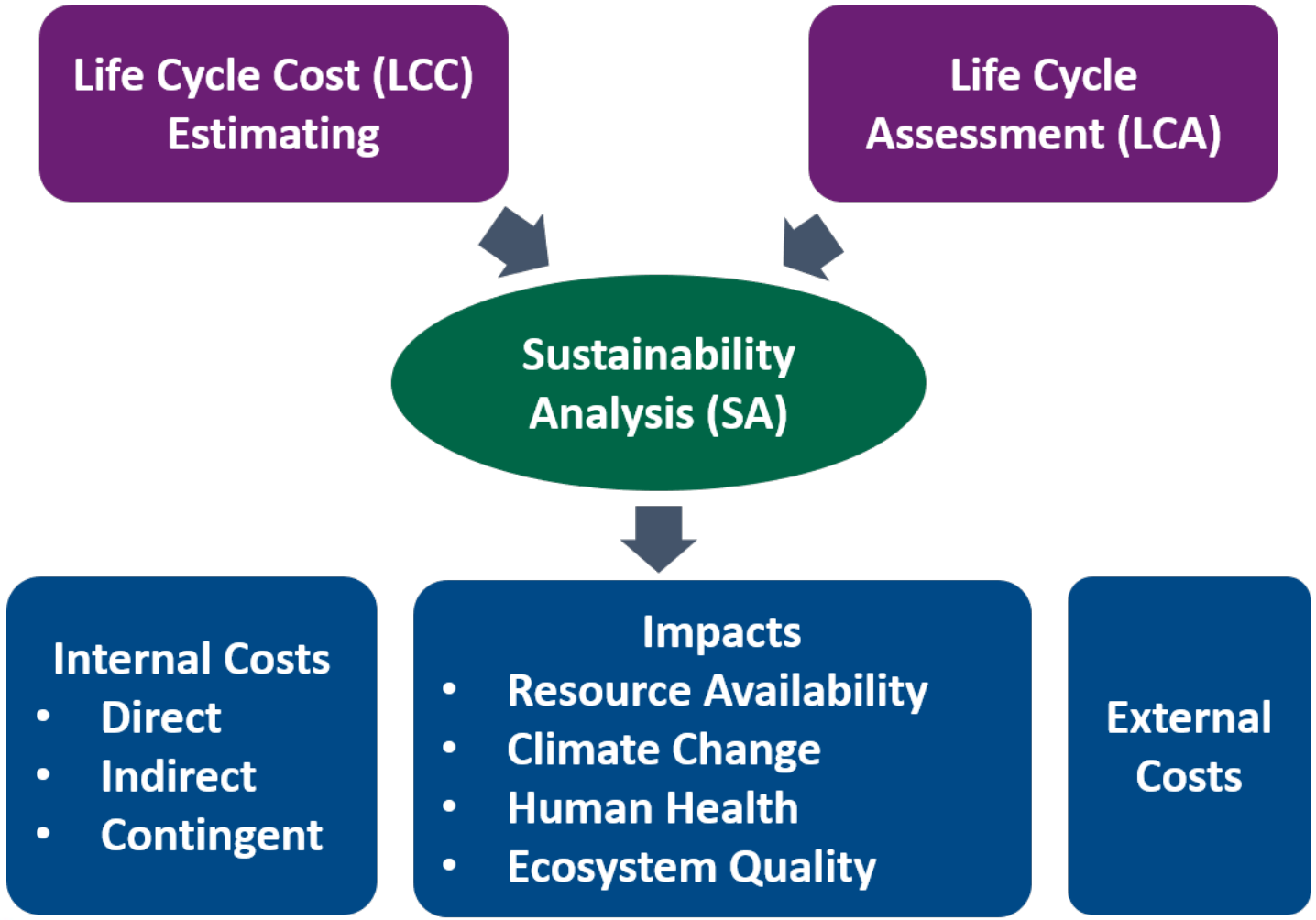
Sustainability Analysis Requirements

- The Defense Acquisition Guidebook requires performance of a **Sustainability Analysis** (SA) for all systems.

- The **Sustainability Analysis Guidance** describes the process for performing an SA



Sustainability Analysis Framework



Informed by Standard Practices

LCC Estimating

- DoD Instruction 5000.73, Cost Analysis Guidance and Procedures
- Operating and Support Cost-Estimating Guide
- DoD 5000.04-M-1, Cost and Software Data Reporting (CSDR) Manual
- DoD Instruction 7041.04, Estimating the Full Costs of Civilian and Active Duty Manpower and Contract Support
- DoD Instruction 7041.3, Economic Analysis for Decision-making
- DoD Product Support BCA Guidebook
- Etc.

LCA

- ISO 14040:2006, Principles and framework
- ISO 14044:2006, Requirements and guidelines
- ISO 14047:2012, Illustrative examples on how to apply ISO 14044 to impact assessment situations
- ISO 14048:2002, Data documentation format
- ISO 14049:2012, Illustrative examples on how to apply ISO 14044 to goal and scope definition and inventory analysis
- ISO 14071:2014, Critical review processes and reviewer competencies: Additional requirements and guidelines to ISO 14044:2006
- Etc.

Types of Costs Considered

Direct Internal Cost	Indirect Internal Cost	Contingent Internal Cost	External Cost (social cost)
• Procurement cost of material • System manufacturing	• Procurement cost of PPE • Hazardous waste management	• Clean up of pollution • Medical cost for DoD personnel • Substitute development and testing	• Damage to human health • Damage to ecosystem quality

Revealed and quantified using LCC estimating

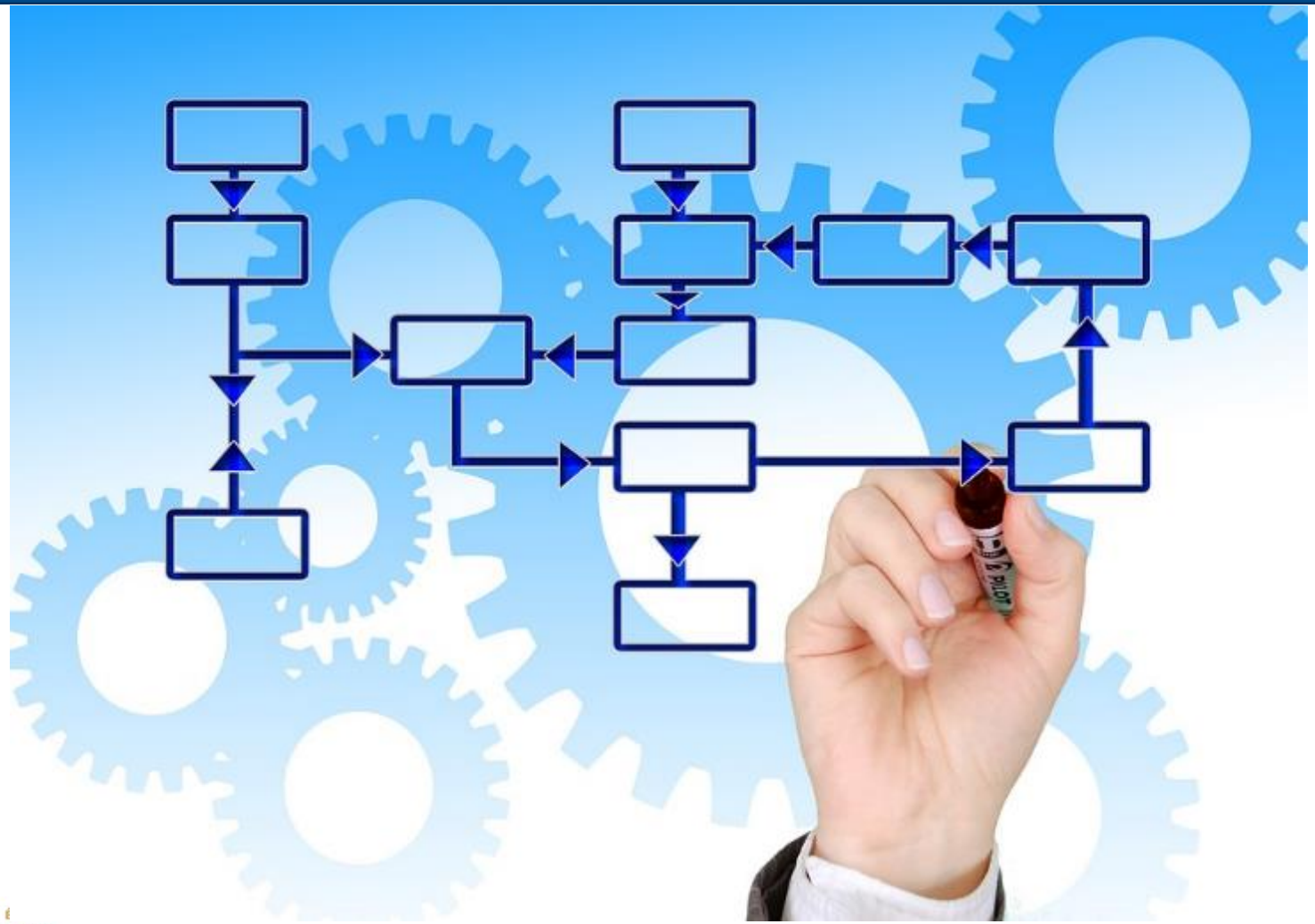
More fully revealed through LCA

Revealed and quantified through LCA

Why Monetize Social Costs?

- Used in regulatory impact analysis, value of statistical life
- Used to value damages, Social Cost of Carbon
- Indication of future government intervention
- An ounce of prevention is worth a pound of cure
- How else can we evaluate environmental and social sustainability?

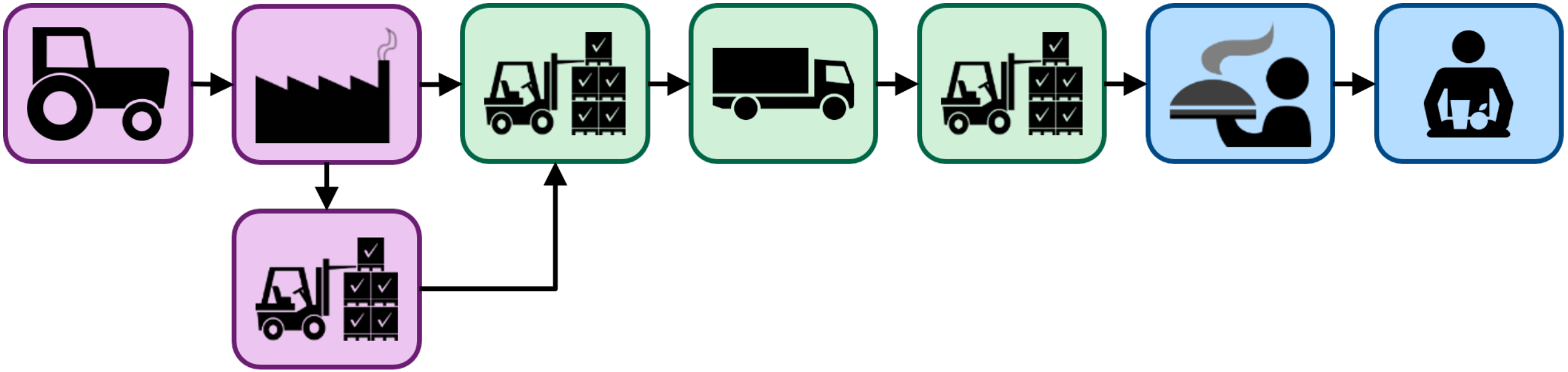
What is Life Cycle Assessment



Activity #1
Introduction to LCA

Objective: identify leverage points where a major food distributor can influence and improve the energy, environmental, and, ultimately, cost performance of its products

Life Cycle (or Value Chain)

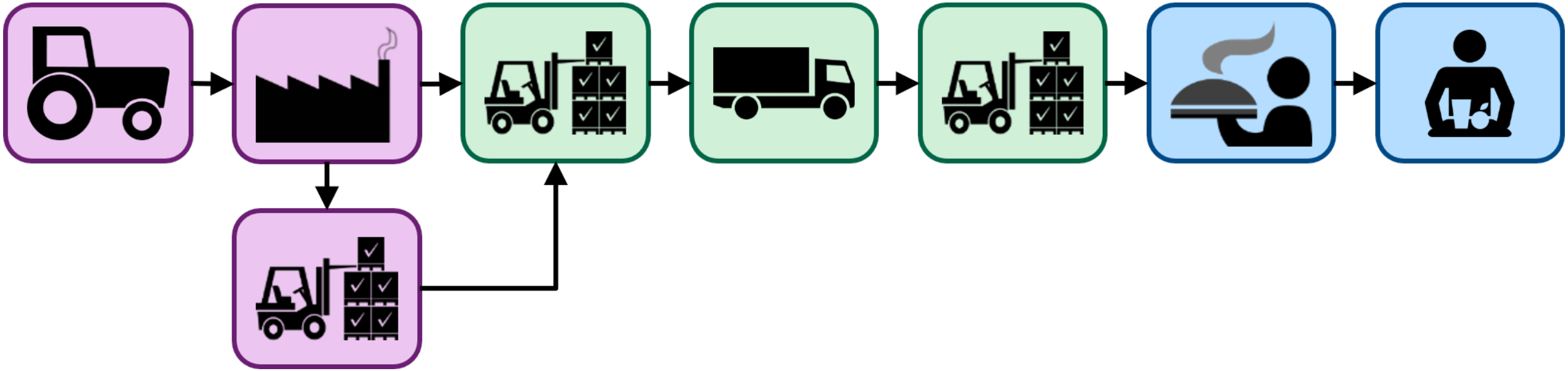


Recall Objective

Brainstorm

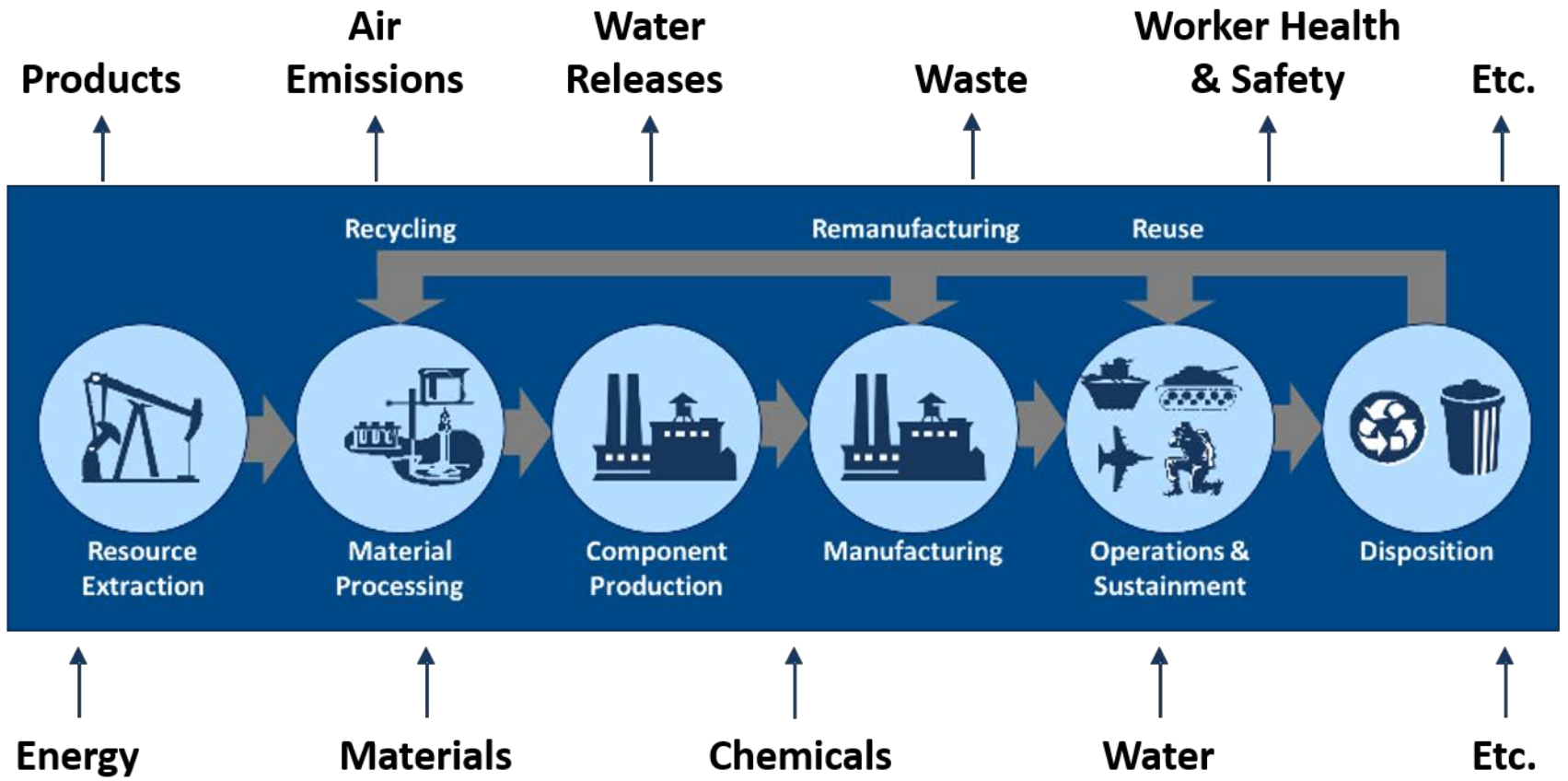
Recommend Approach

Objective: identify leverage points for improving the energy, environmental, and, ultimately, cost performance

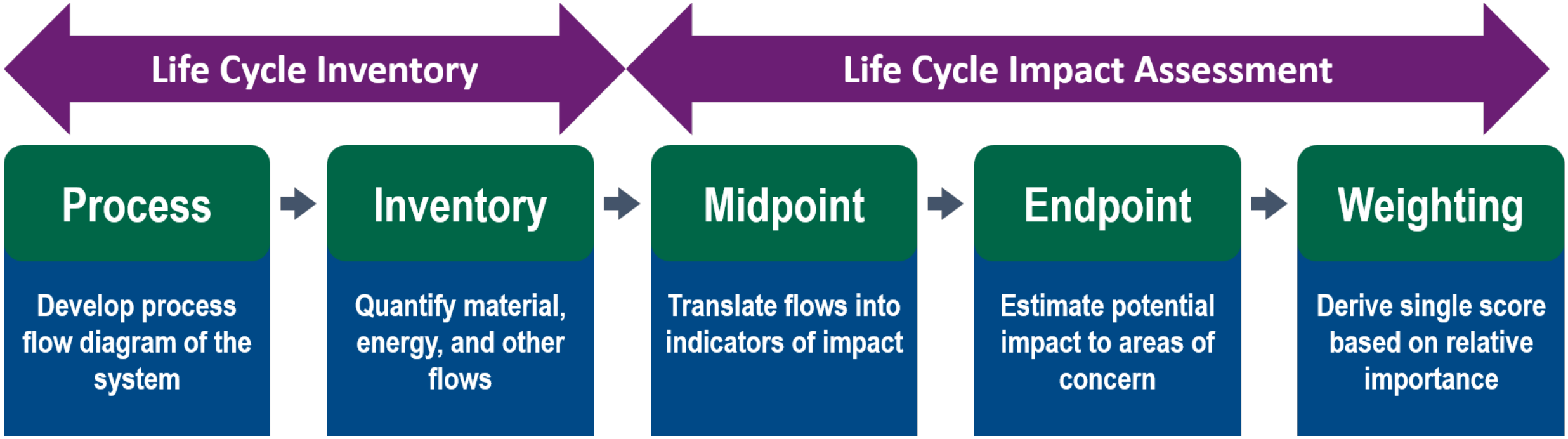


What is your recommended path forward?

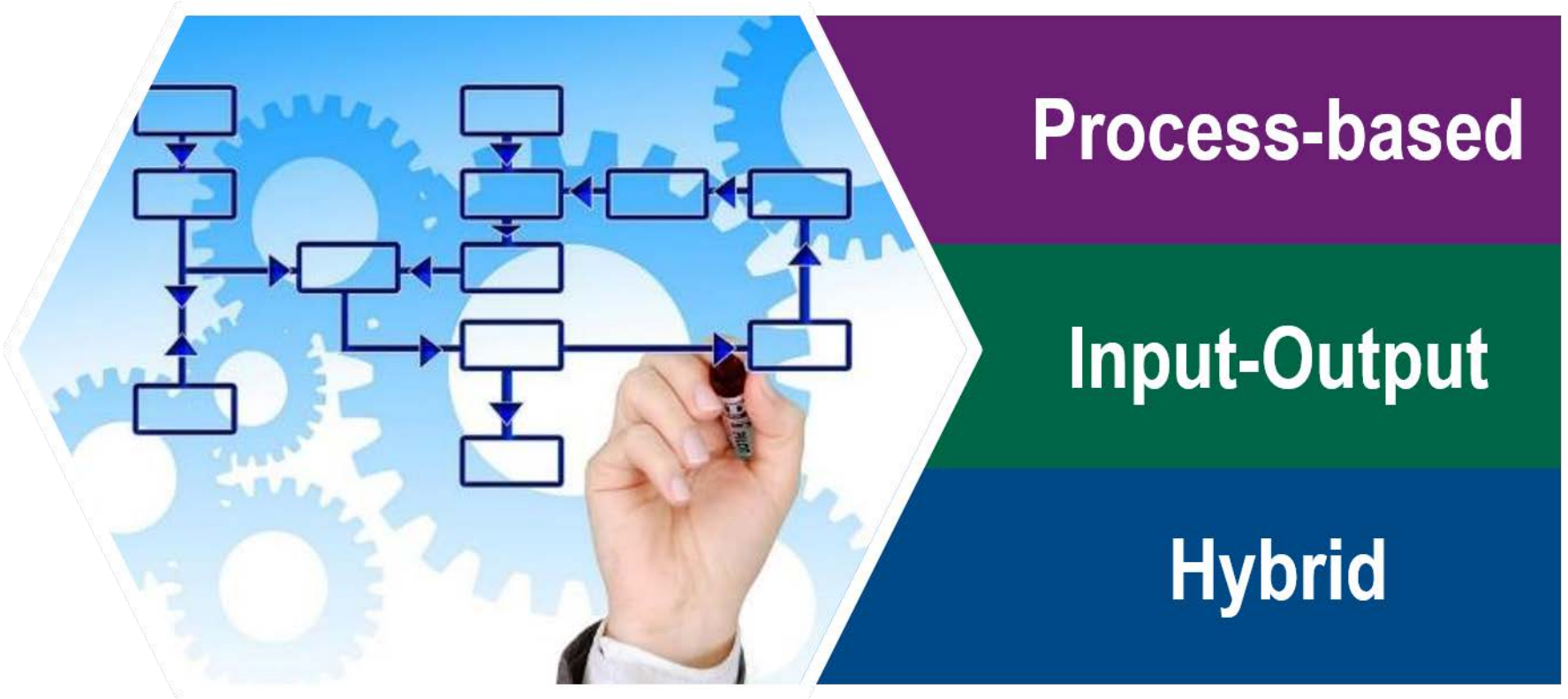
A Life Cycle Perspective



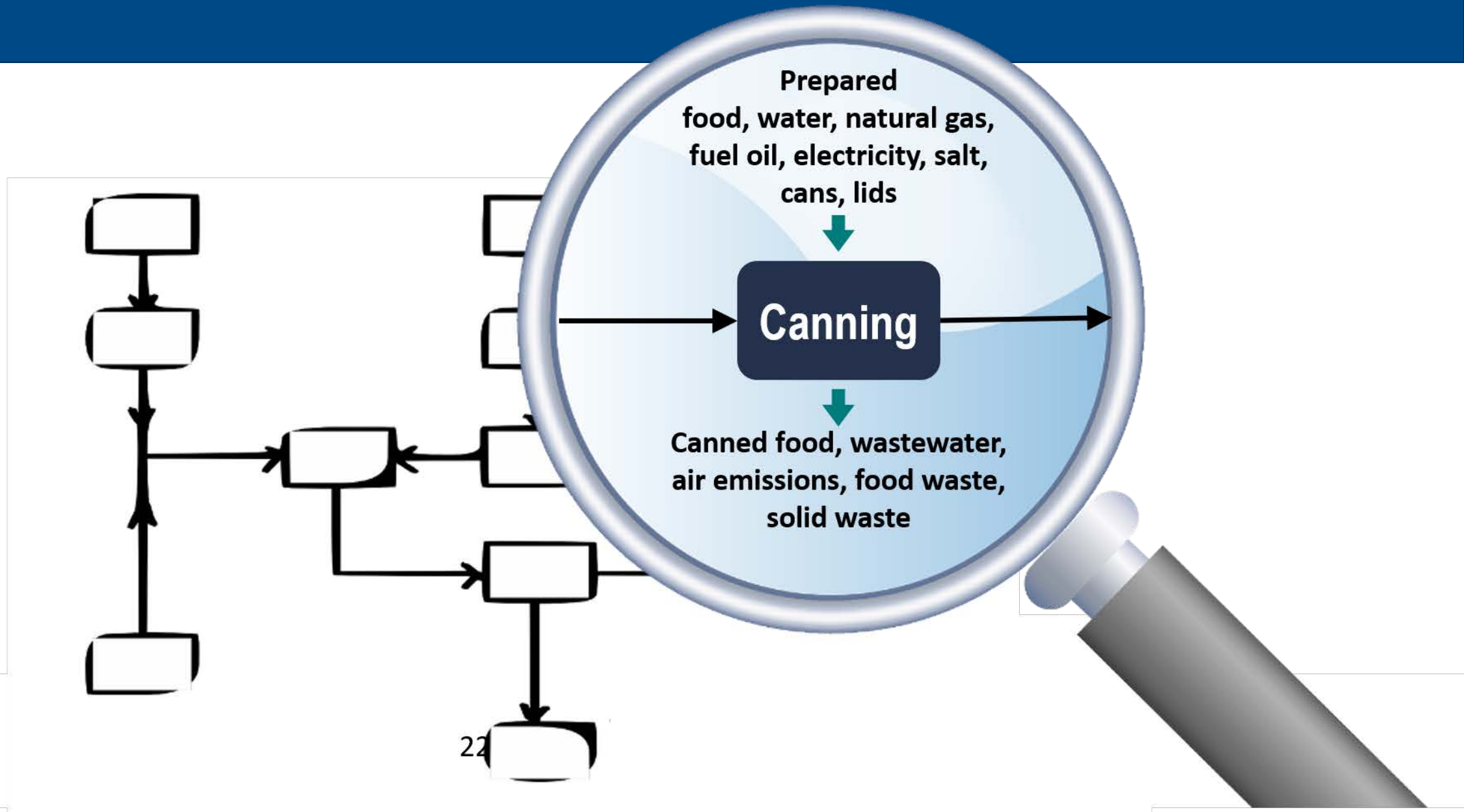
The LCA Framework



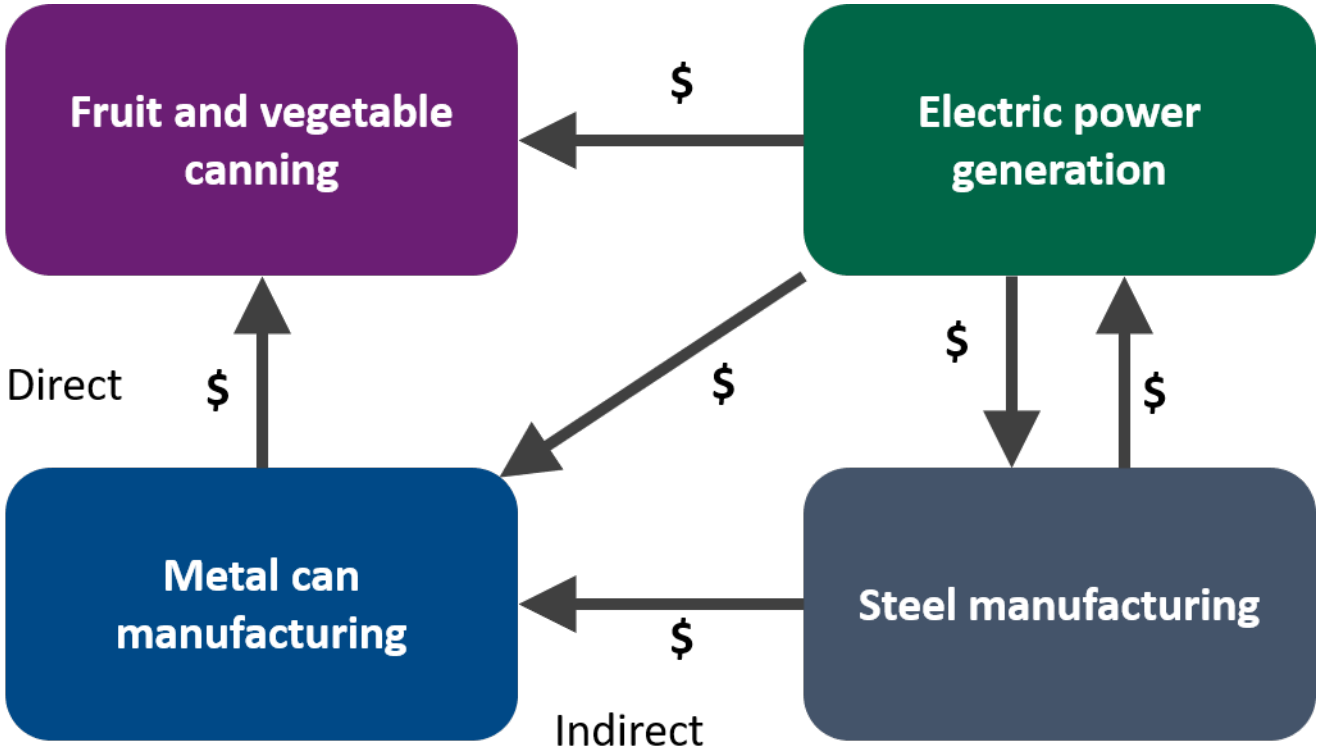
Life Cycle Inventory
(Quantifying material, energy, and other flows)



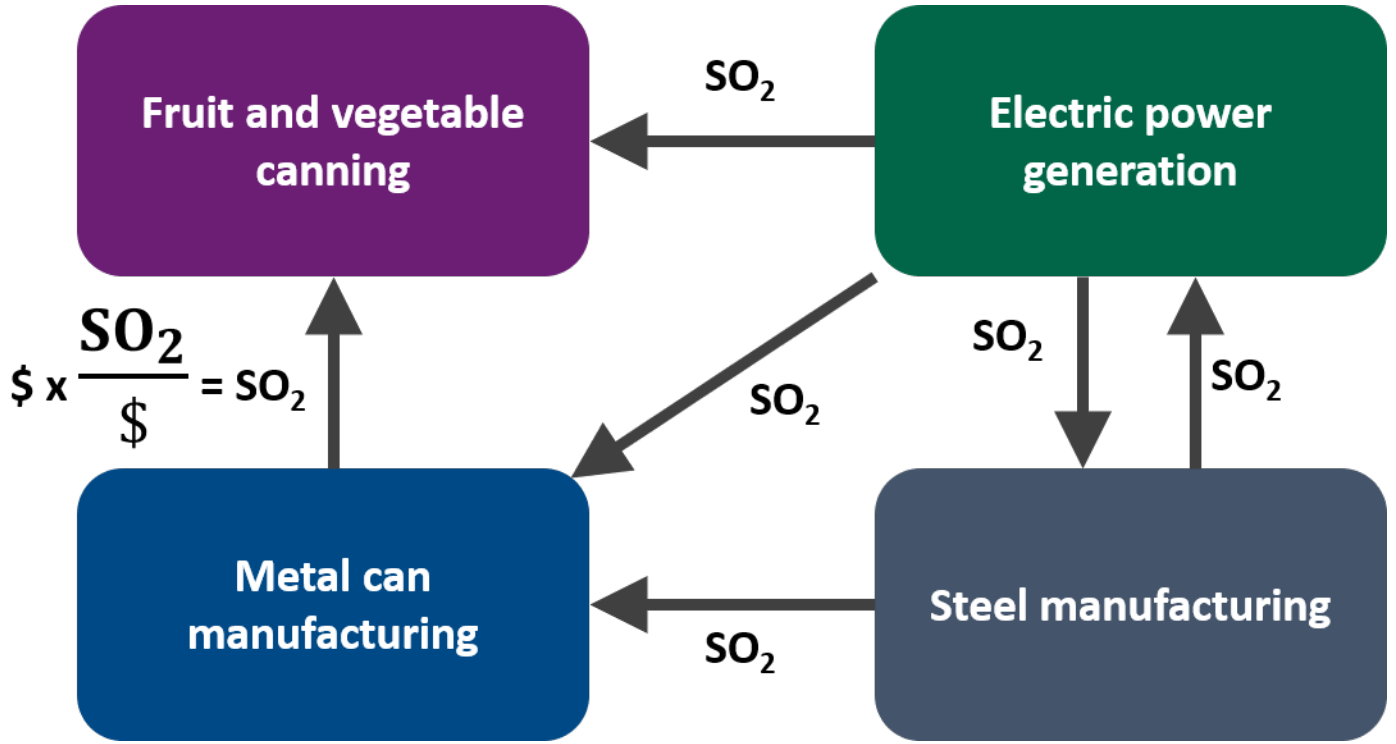
Process-Based Life Cycle Inventory



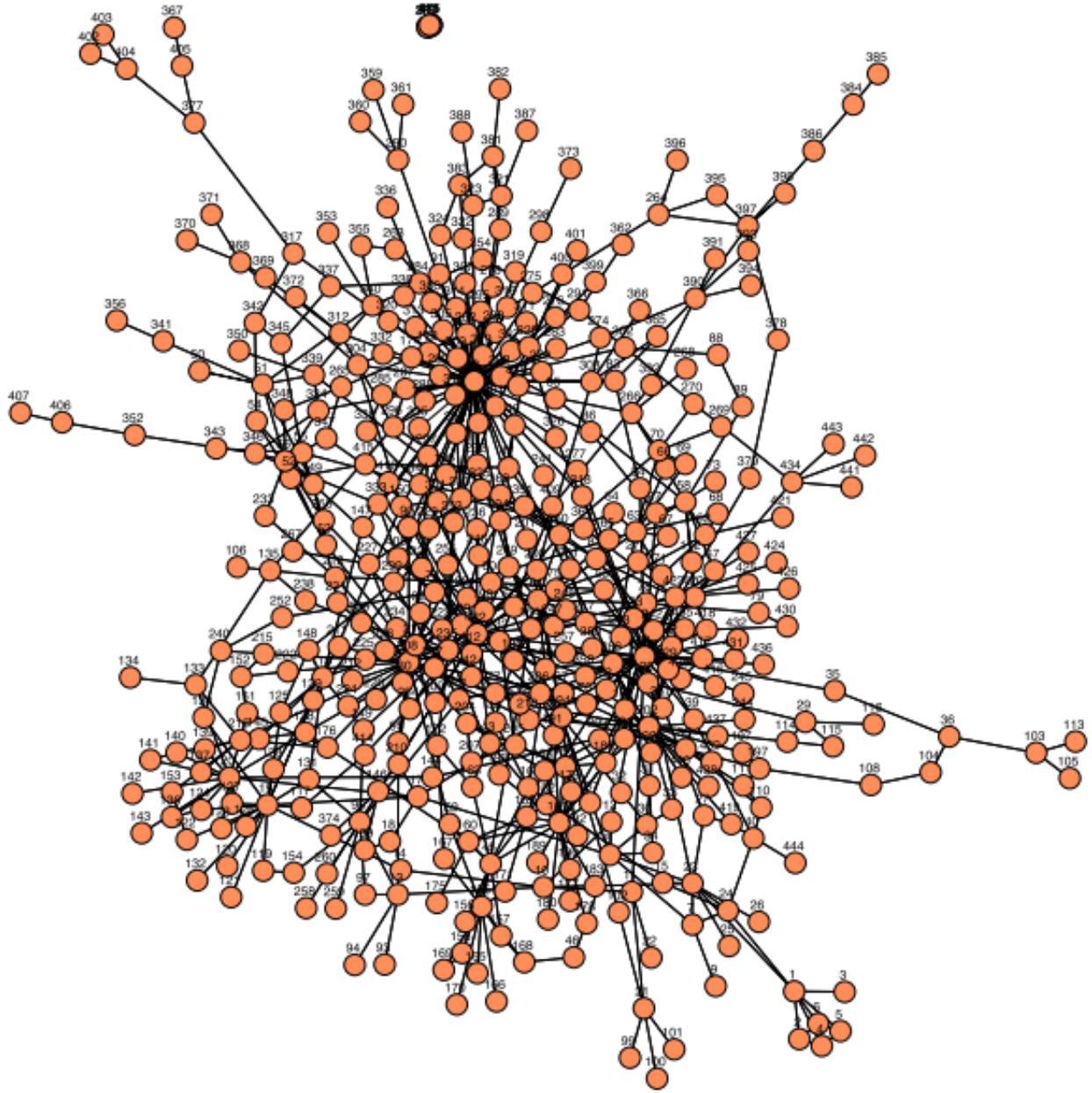
Environmentally Extended Input-Output (EEIO) Model



Environmentally Extended Input-Output (EEIO) Model (cont.)

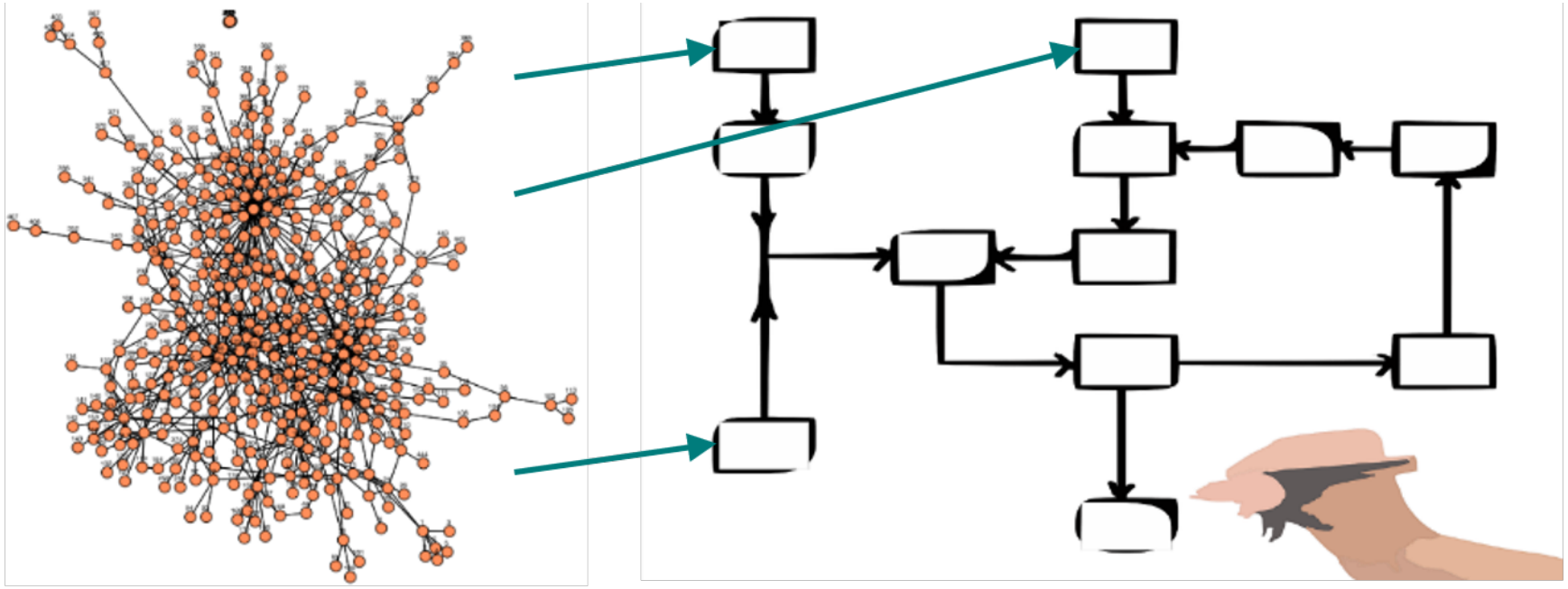


What would an inter-sectoral network corresponding to the U.S. economy look like?



Source: Acemoglu, D. et al. (2012) Econometrica, 80(5) 1977–2016

Hybrid LCA



• Screening analysis	• Detailed analysis
• Publicly available models	• Time and data intensive
• Aggregated data	• Data gaps
• Entire economy	• Truncation error

Upon completion of a life cycle inventory

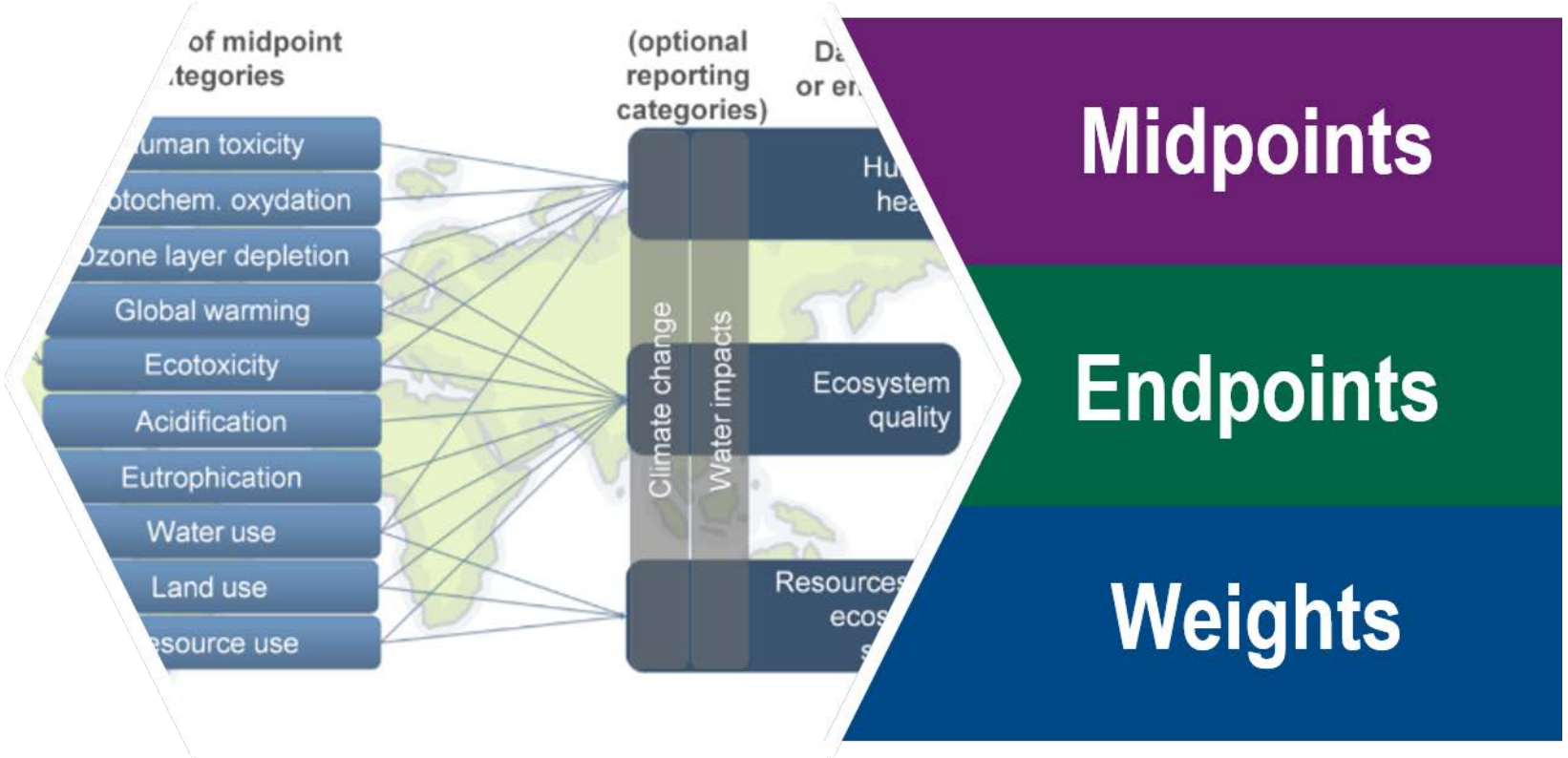
Inputs

- Raw materials
- Energy resources
- Water
- Land
- Expenditures
- Activities (e.g., labor)

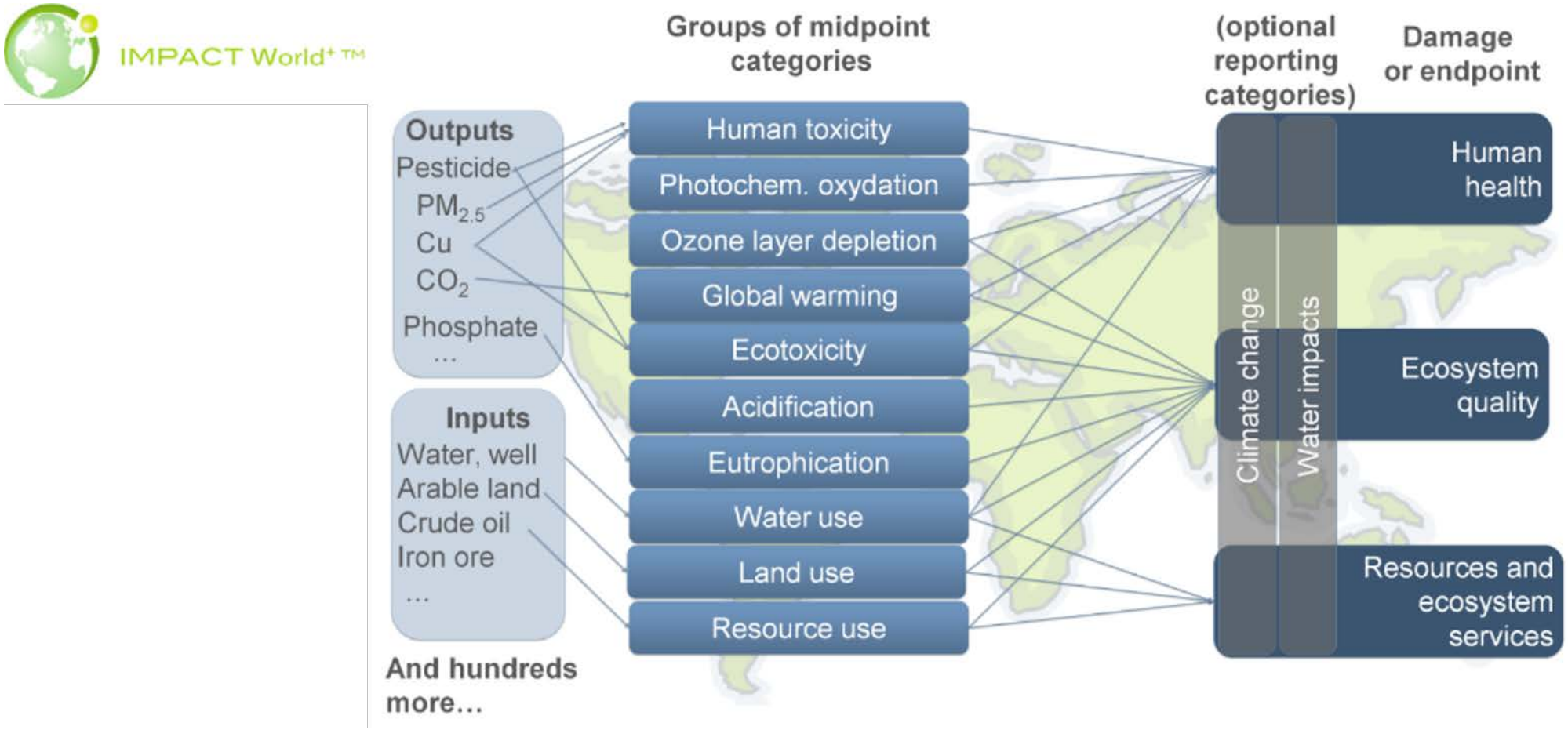
Outputs

- Products
- Air emissions
- Water releases
- Waste
- Noise
- Illnesses
- Injuries
- Fatalities

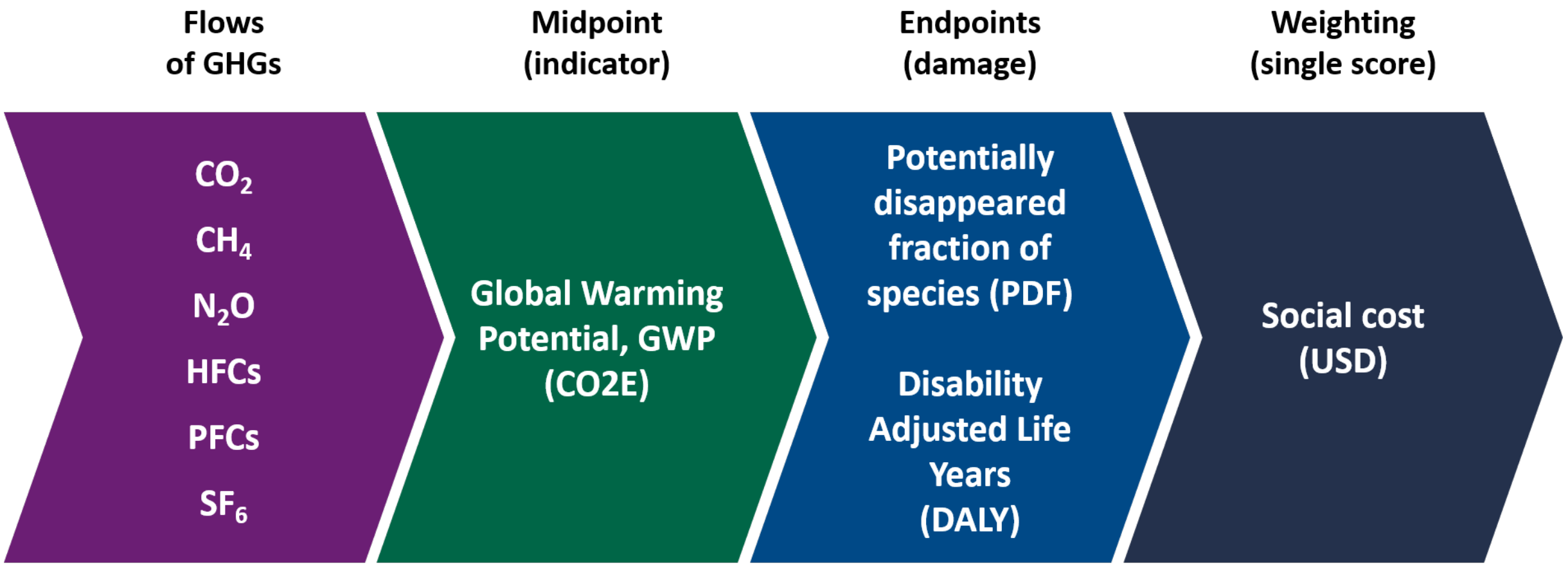
Life Cycle Impact Assessment
(Converting flows to potential impacts)



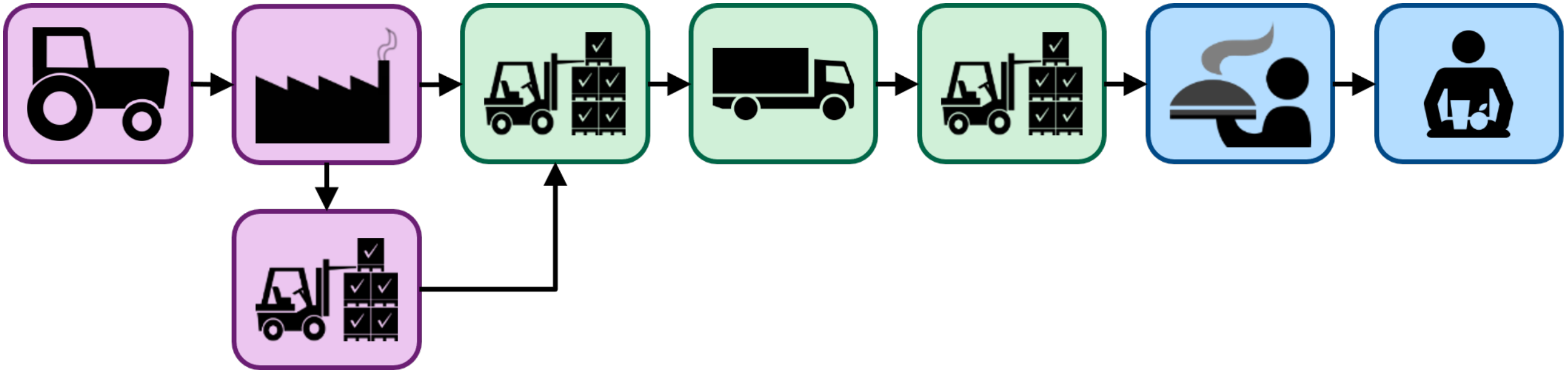
An Example Life Cycle Impact Assessment (LCIA) Method



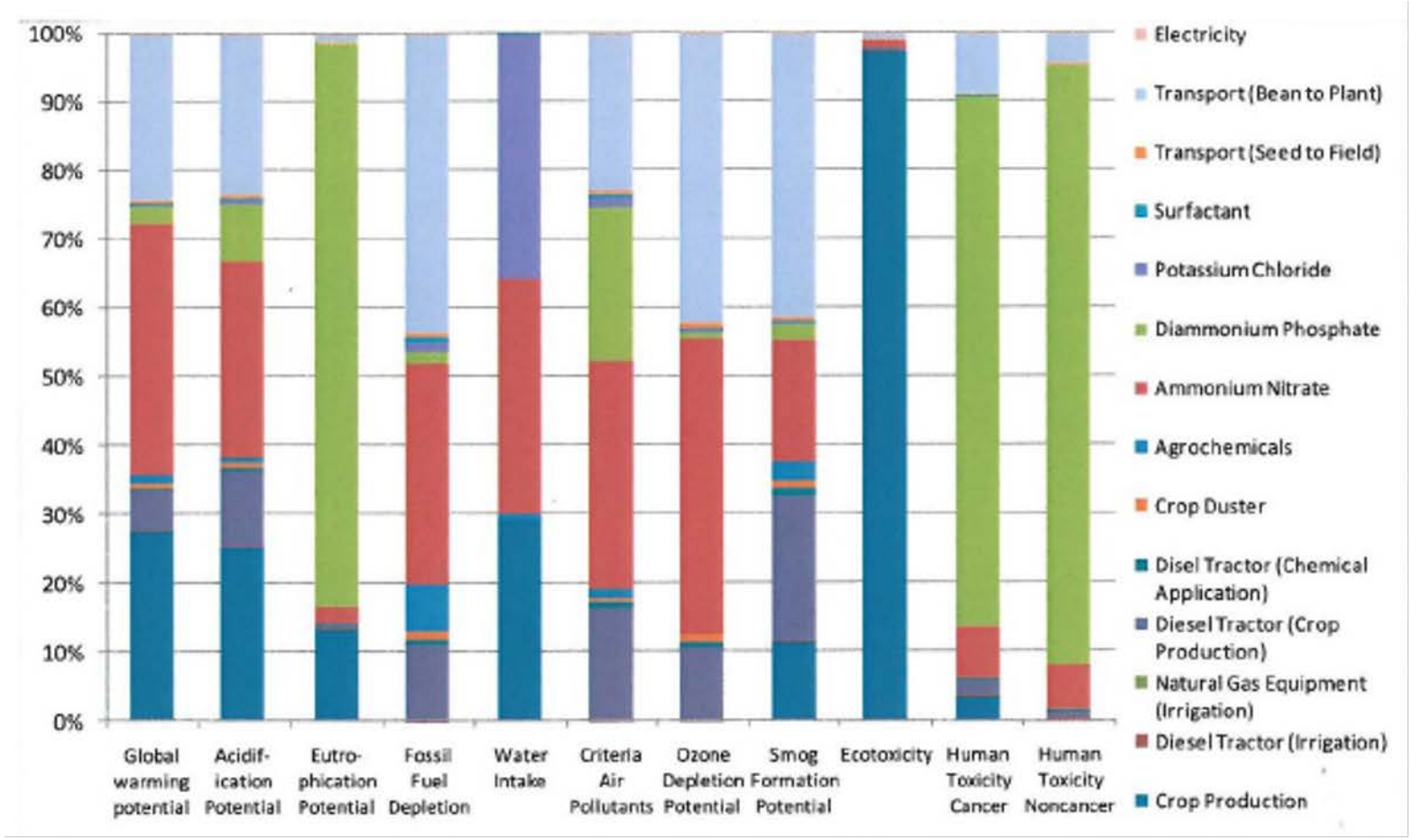
Example: Global Warming Potential



Recall our Activity … What were the results?



Results



From William Russell, "Allen's IPM/SA Program," IPM/Sustainable Ag Symposium, March 2012

Results (cont.)

Actions Taken	Savings
Avoid deep plowing; reduce tillage, fuel costs, carbon emissions, and erosion	$4-9/acre
Utilize process waste and organic fertilizers in place of commercial fertilizers	$25-40/acre
Collect storm water run-off in holding ponds, use for irrigation during dry periods	$4-7/acre

From William Russell, “Allen’s IPM/SA Program,” IPM/Sustainable Ag Symposium, March 2012

Activity #2
LED Lighting for Littoral Combat Ships

Scenarios

Scenario 1

Baseline

Use baseline fluorescent fixtures with NiCd battery backup units

Scenario 2

Drop-in Replacement

Replace fluorescent fixtures with equivalent LED fixtures and use NiMH backup units

Scenario 3

Optimal Design

Use appropriate number and type of LED fixtures for optimal lighting with NiMH back up units

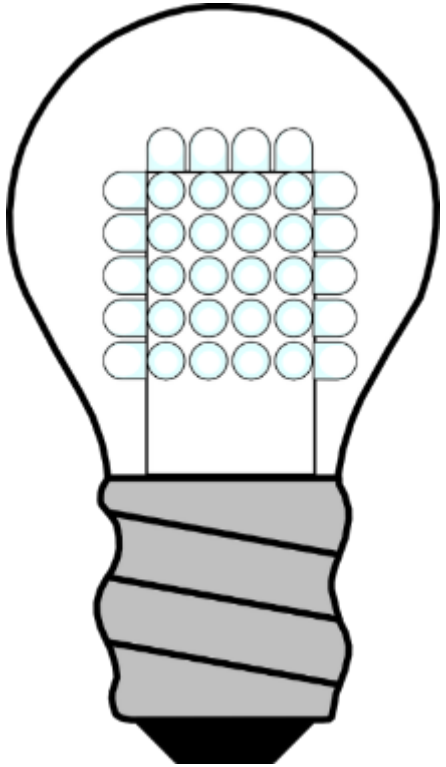
Life cycle stages?

Inputs and outputs?

Data sources?

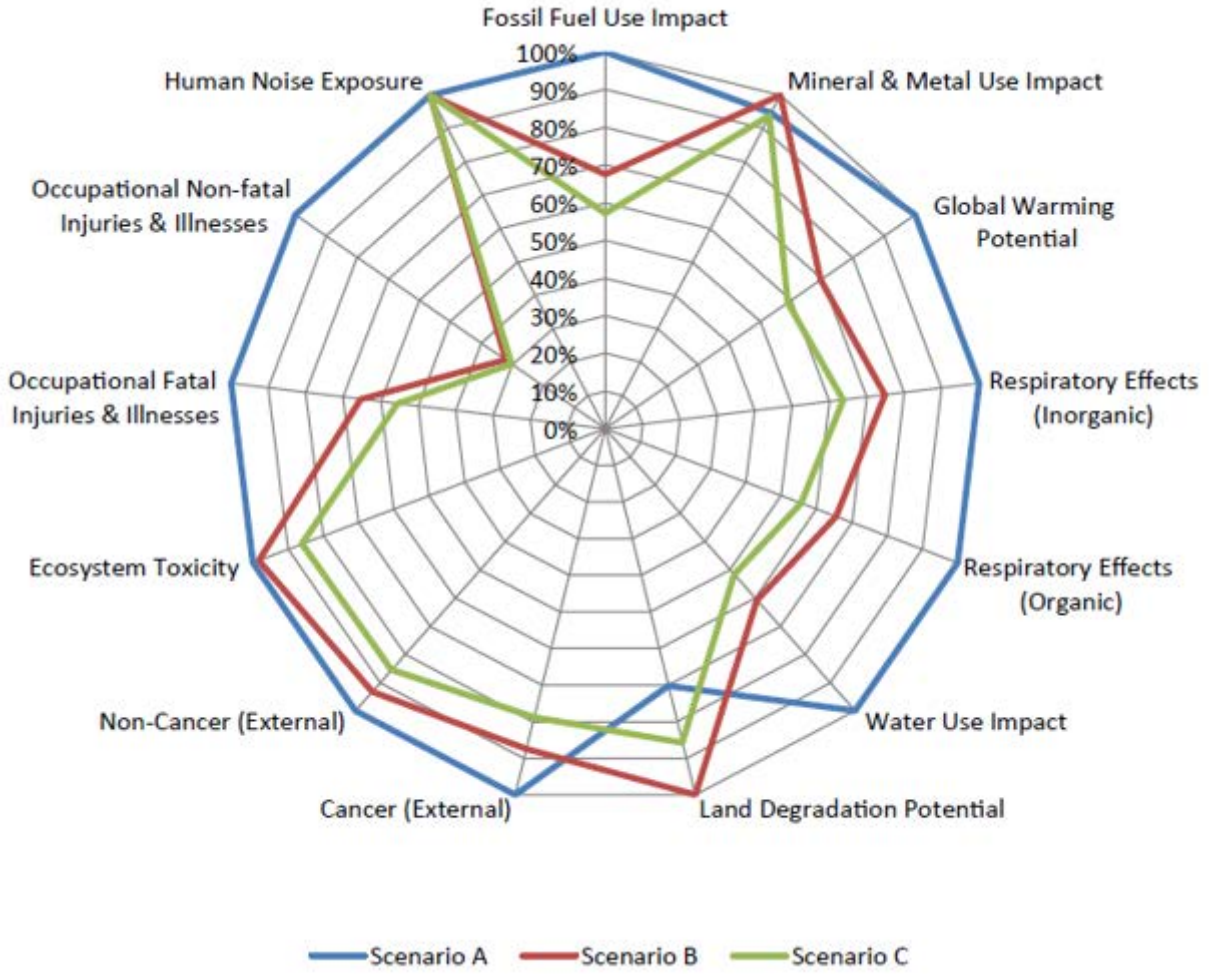
Impacts?

Key Features

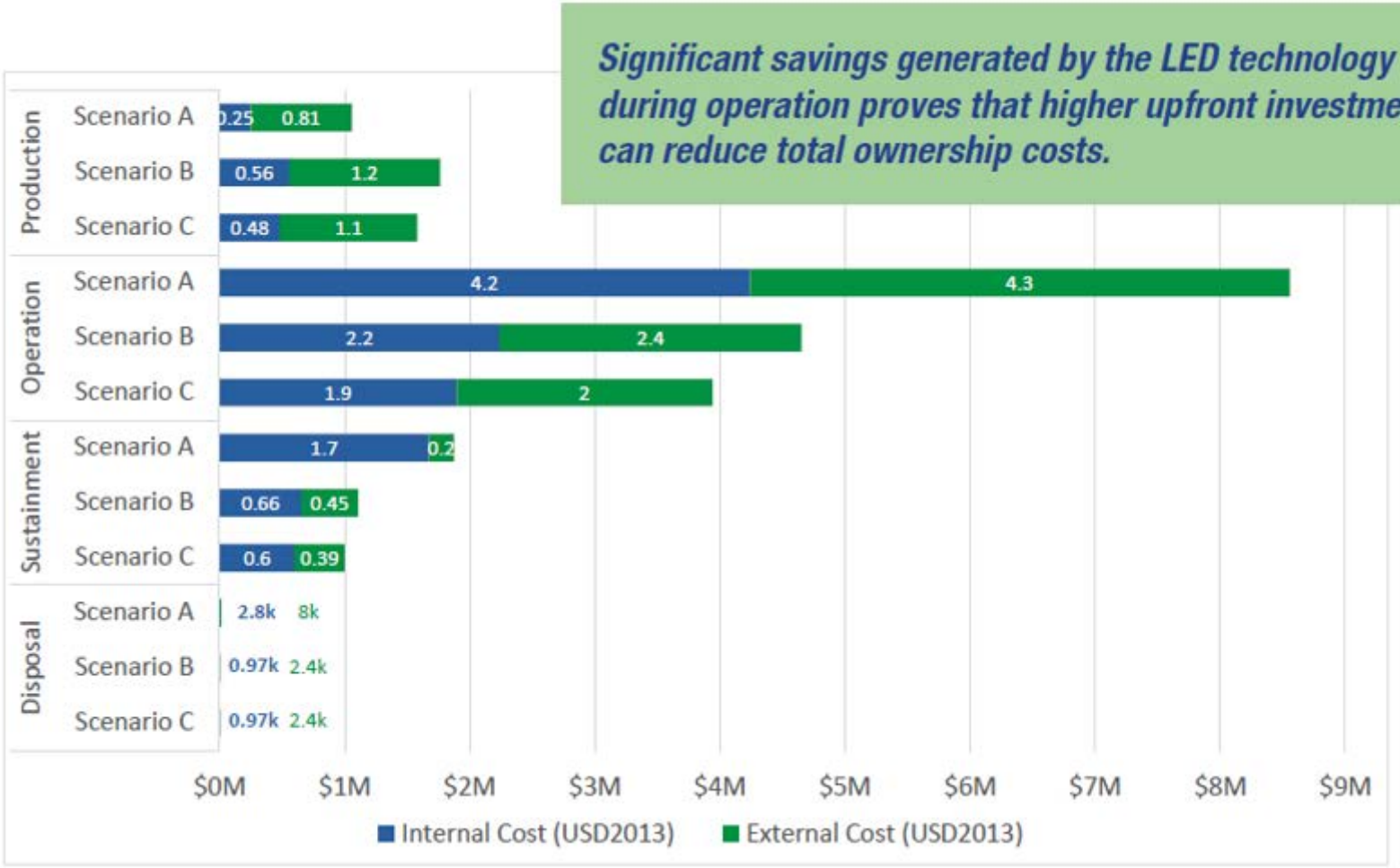


- Cost savings in ship construction
- Longer life & less maintenance
- Higher corrosion resistance
- Decreased ship's weight
- Elimination of all Hg and Cd
- Increased head-space
- Improved light levels and quality

Results



Results (cont.)



Sustainability Analysis Pilot Projects

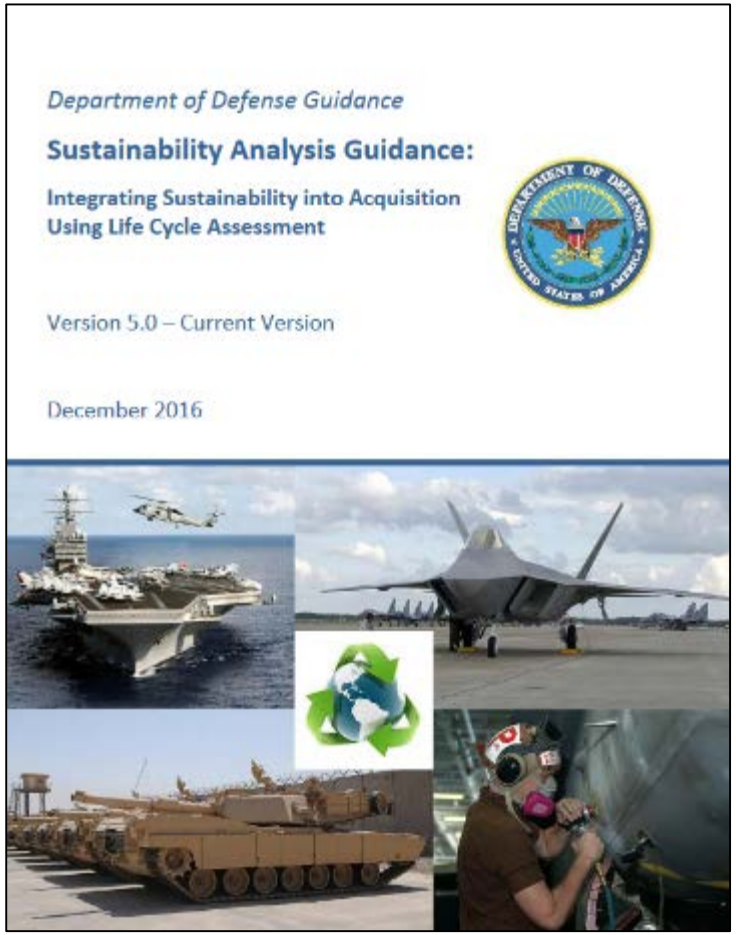
- Boeing P-8 Poseidon Aircraft (2013): exterior coatings with and without CrVI
- Sikorsky MH-60R Seahawk Helicopter (2013): exterior coatings with and without CrVI
- Superstructure Non-combat Ship (2015), notional example: steel and composite superstructure materials
- GE fuel nozzle for aircraft engine (2016): traditional and additive manufacturing
- AF brush plating for repair operations (2017): eliminate or reduce cadmium in repair process
- Navy anodizing for repair operations (2017): eliminate or reduce CrVI in coatings process
- AF paint removal from military components (planned 2018): eliminate or reduce methylene chloride, waste

Sustainability Analysis Resources for You

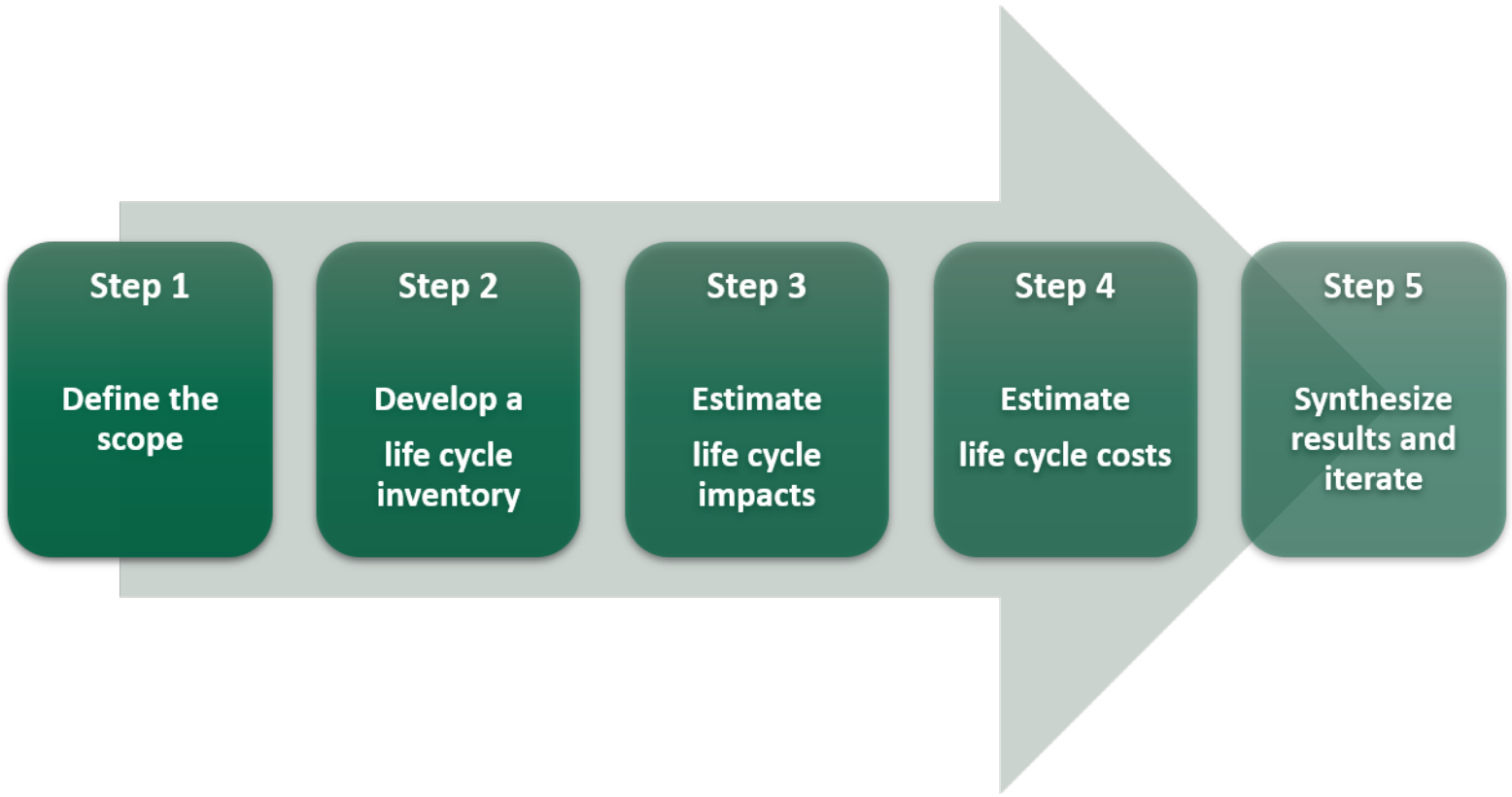
Sustainability Analysis Guidance Document

- Consistent, practical, flexible methodology
- Identifies most sustainable alternative among those that meet performance requirements
- Uncovers previously hidden human health and environmental impacts and their associated life cycle costs

- Available at http://www.denix.osd.mil/esohacq/home/



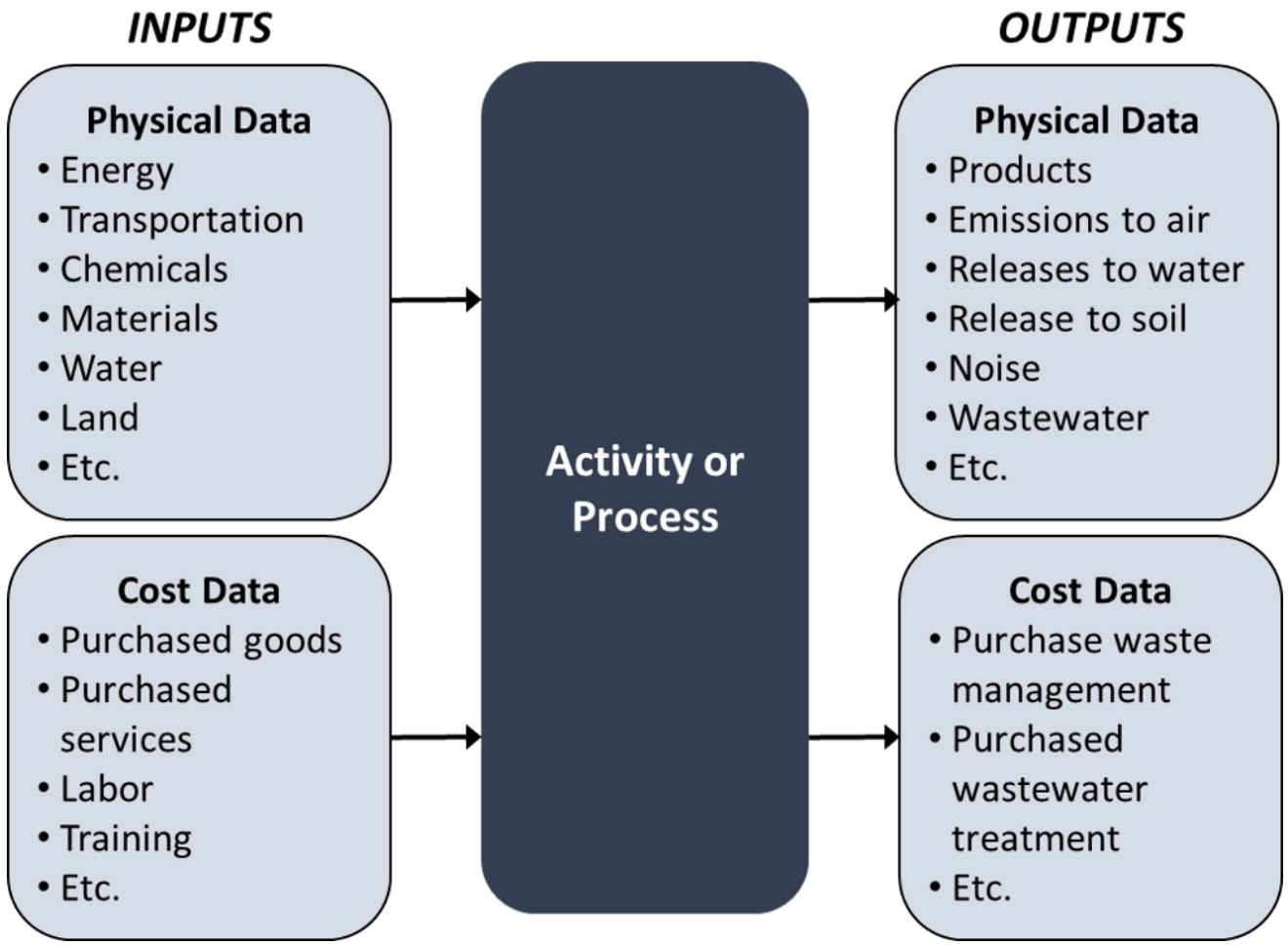
Sustainability Analysis Methodology



Sustainability Analysis Methodology (cont.)

- Step 1: Describe required performance, alternatives to be analyzed, life cycle stages; ensure all alternatives are compared on equivalent basis
- Step 2: Quantify all relevant system inputs, outputs, and internal DoD costs within the scope
- Step 3: Translate inventory into potential impacts with impact assessment models
- Step 4: Estimate life cycle costs
- Step 5: Analyze and interpret; identify life cycle activities that contribute to potential impacts and costs

General Data Requirements for an Activity included in a Sustainability Analysis



Sustainability Analysis
Impact Assessment Categories

Midpoint Categories

- Climate change
- Human health (including worker health & safety)
- Ecosystem quality
- Fossil energy use
- Mineral use
- Land use
- Water use
- Noise

Endpoint Categories

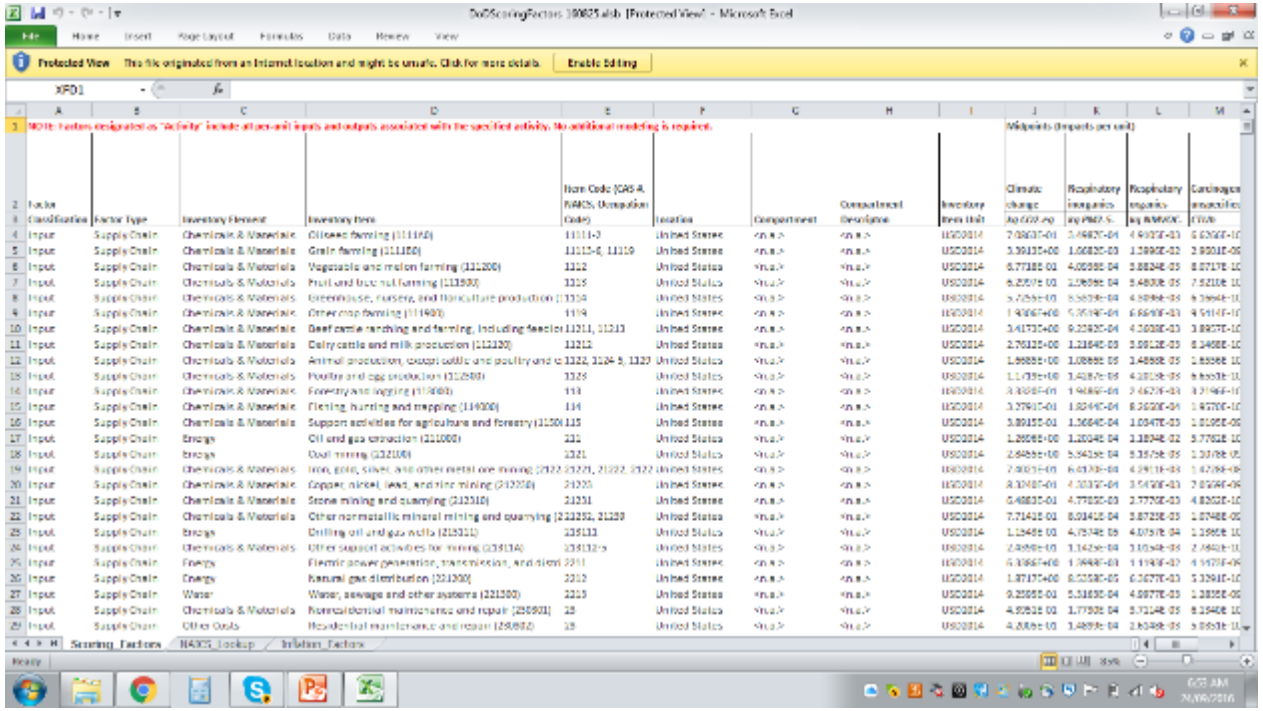
- Resource availability
- Climate change
- Human health
- Ecosystem quality

Defense Input-Output (DIO) Model

- Hybrid LCA Model
- Economic transactions
  - 2007 US produce price model (391 sectors)
- Process data currently included
  - Energy (on-site and purchased)
  - Military vehicles and weapon systems
  - Transportation

Scoring Factors

- Provides rolled-up midpoint, endpoint, and valuation results for 1 unit of all:
  - Sectors
  - Activities
  - Flows
- Can be used in parallel with LCC estimating
- Available at http://www.denix.osd.mil/esohacq/home/



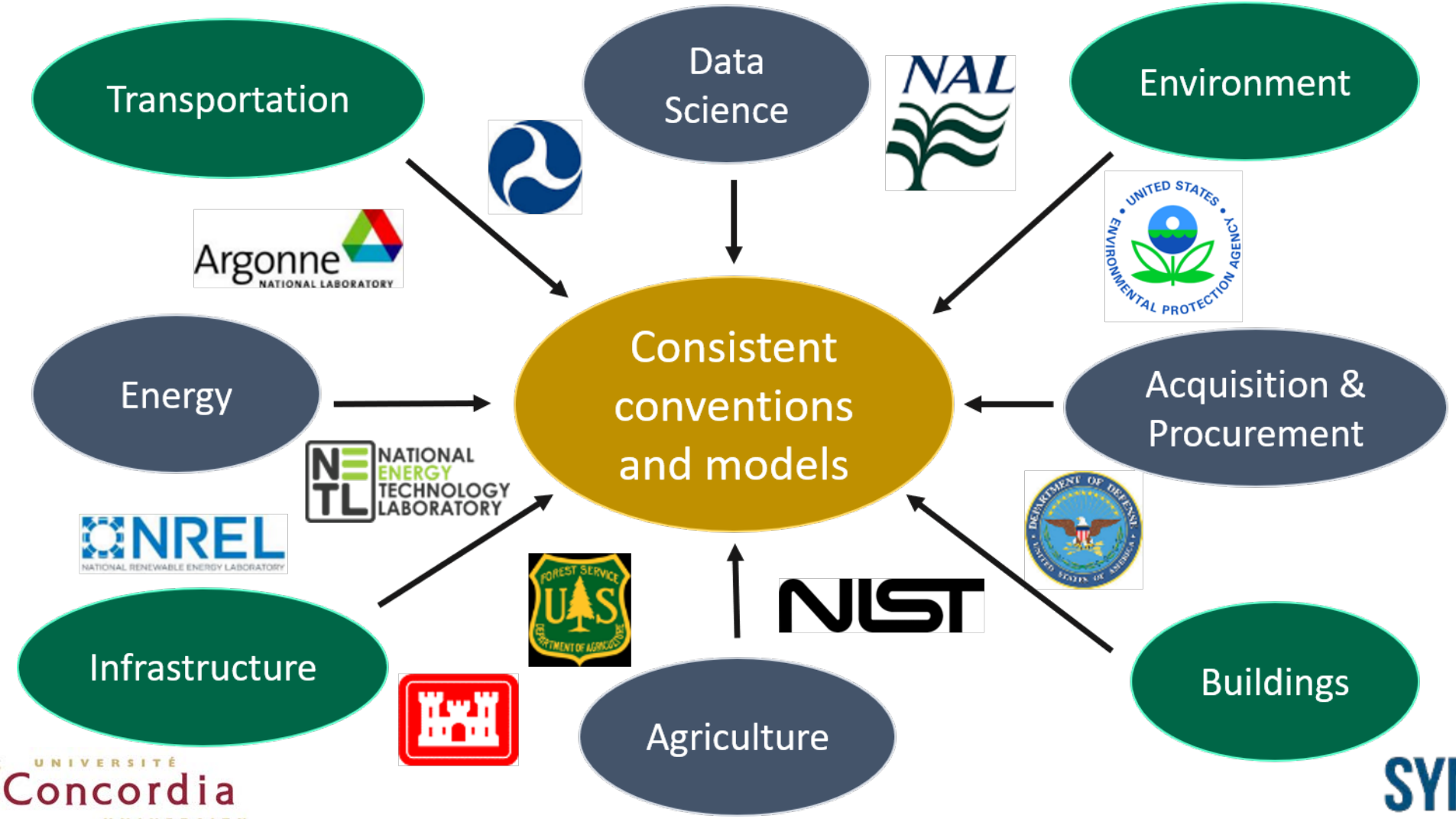
Examples of Publicly Available Data

- US Environmental Protection Agency, US Environmentally Extended Input-Output (USEEIO) Model
- USDA LCA Commons, Life Cycle Inventory database with agriculture focus
- US Life Cycle Inventory database, providing US based LCI data, polymers and more! available at https://uslci.lcacommons.gov/uslci/search
- NETL, Unit Process Library at www.netl.doe.gov/LCA
- NREL, Feedstock Production Emissions to Air Model (FPEAM) quantifying air emissions inventory for biofuels production system.
- ANL, GREET LCA model (with GREET1—fuel cycle model; GREET2—vehicle cycle model; CCLUB—land use change model for biofuels)
- Berkeley Lab, Lifecycle Industry GHgas Technology Energy through the Use Phase (LIGHTnUP) analysis tool available at https://eaei.lbl.gov/tool/LIGHTEnUP
- NIST, BIRDS and BEES for building sustainability associated with energy, environment, and costs

Expertise

- DoD
  - OSD Chemical & Material Risk Management Program
    - Pilot Projects with AFLCMC, FRCSE
  - USACE Engineer Research and Development Center
- Academia
- Industry
- Professional Organizations
  - SETAC
  - ACLCA

Expertise
Federal LCA Commons



Sustainability Analysis for RDT&E

Proposal

- Use SA to estimate the potential impacts of your proposed project
- Explain how SA will be used to inform decisions throughout your project

Project

- Use SA to inform decisions, i.e., reduce the negative impact on workers, the environment, and surrounding communities
- Use SA to communicate the benefits of your project

Data

- Develop process-based life cycle inventory data
- When possible, share data with DOD

FY 2019 Core Solicitation Statements of Need (SON)

- WPSON-19-C3 – Additive Manufacturing of Gun Propellants with Reduced Environmental Impact
- WPSON-19-C4 – Novel Pyrotechnics that Reduce Environmental Impact
- WPSON-19-C5 - Multifunctional Fibers and Textiles for Warfighter Integrated Protection

From WPSON-19-C3

"Proposals should include a plan to conduct a **Sustainability Analysis** of appropriate proportion to the proposed research and development. Proposals should establish a lifecycle framework that can mature as the technology or process advances through the acquisition process. This tiered approach aims to develop and document a minimum data set at each stage of research and development that can be used to make informed decisions and streamline transition to an acquisition program. The Sustainability Analysis may include varying depths of data and information that can inform: the goal and scope of an analysis; the identity and quantity of relevant inputs and outputs to the system; the estimation of life cycle impacts and costs."

From WPSON-19-C3 (cont.)

"The Weapons Systems and Platforms Program Area supports development of technologies and processes that are associated with the manufacture, operations, and maintenance of military equipment, weaponry, and munitions. These life cycle stages of a system may impact workers, the environment, and surrounding communities. Increasing the sustainability of these systems offers opportunities to identify and manage these impacts to lower associated life cycle costs and improve mission readiness. DoD's **Sustainability Analysis** uses a life cycle approach to evaluate potential impacts associated with costs, ecosystem quality, human health, and resource availability."

Recommendations for Investigators

Proposal

- If SON or Topic calls for SA, then include how you would address the five-step SA methodology
- Discuss expected results, possible data uncertainty, limitations
- Include references to data that can be used to build the inventory unique to your project; estimate what data you are likely to have at this stage of RDT&E
- Estimate time to conduct SA appropriate to the maturity of the RDT&E project

Project

- Use the methodology to complete an SA appropriate to the maturity of the RDT&E project; gather information on inputs, outputs, and costs appropriate to the life cycle stages of your project
- Document, to the extent possible, the Scope, LCI data, LCI results, Midpoint and Endpoint Impacts, and Life Cycle Costs
- Document data limitations and discuss data uncertainty

Future Directions for Sustainability Analysis

- Establish DoD Community of Practice for LCA users, practitioners, decision makers
- Continue with pilot projects internal and external to DoD
- Share results within the DoD community -- and beyond -- and making information readily accessible
- Refine SA methodology to ensure varying project maturities are accounted for and appropriate
- Ensure training is available to potential users to ensure consistency and success in achieving aims of SA as well as SON or Topic

Closing Remarks

- Action items and takeaways
- Survey reminder
- Kelly Scanlon, kelly.a.scanlon4.civ@mail.mil