Getting started with LCA for pavement, challenges and opportunities

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PAVEMENT RESEARCH CENTER

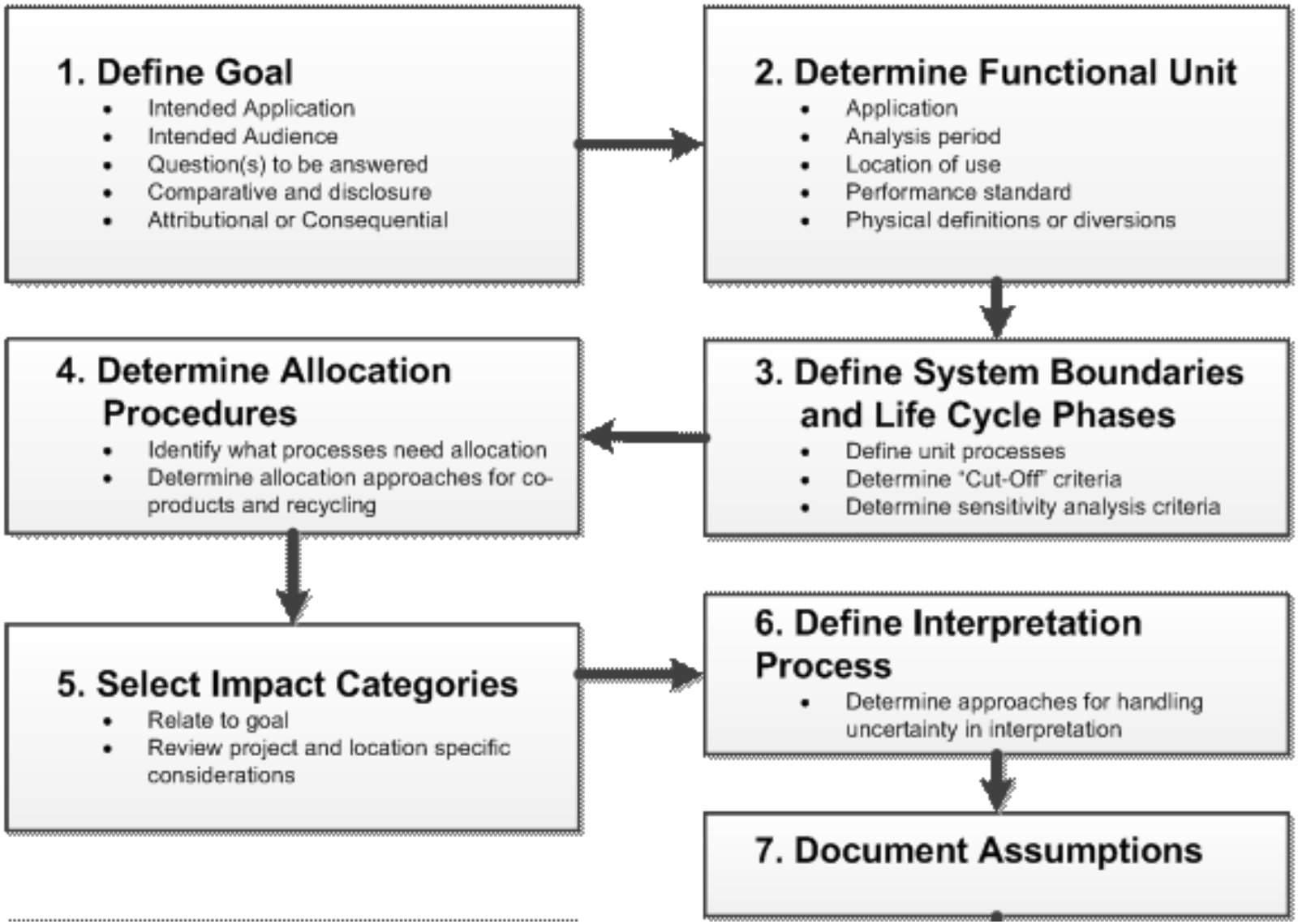
Outline

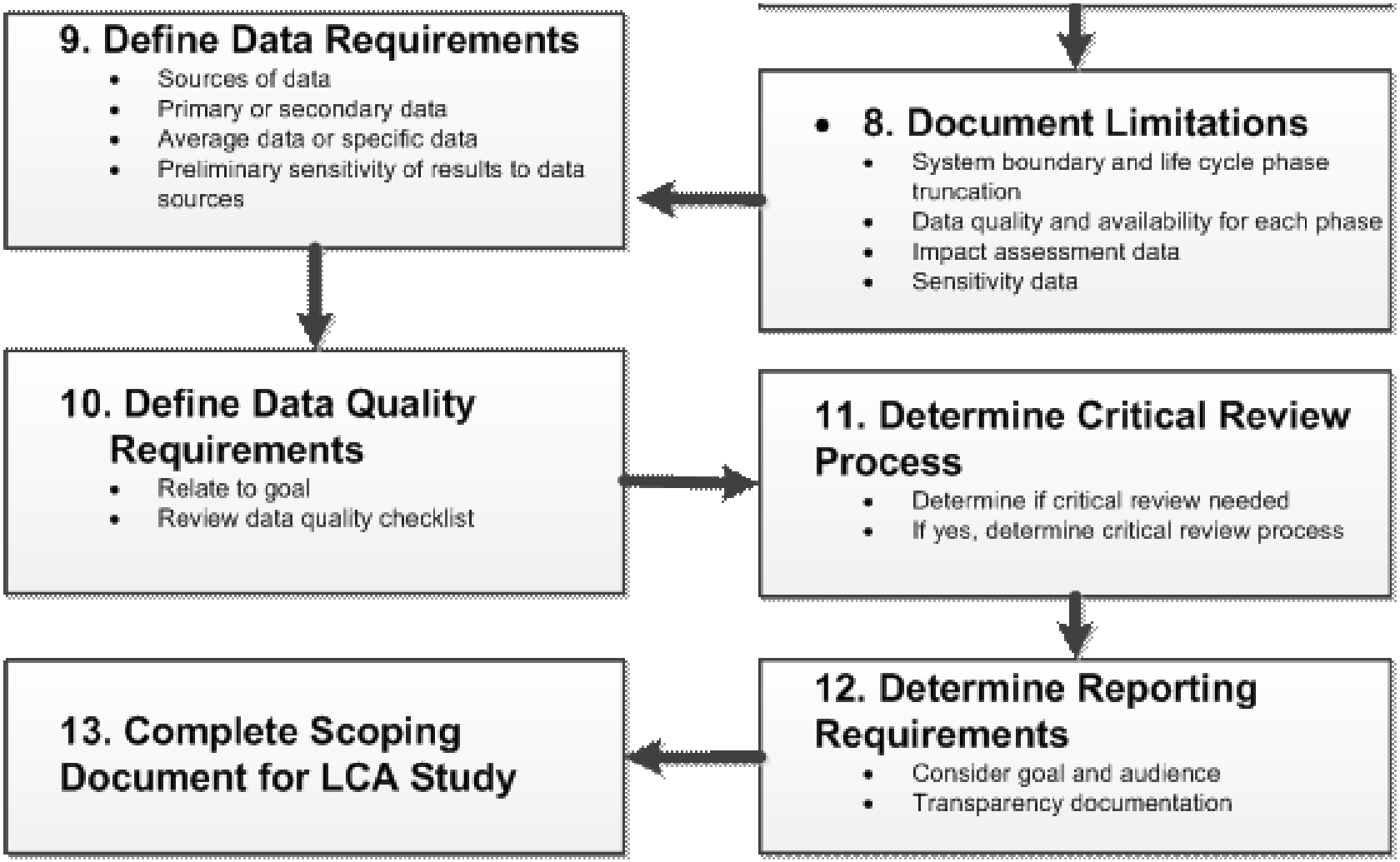
- Details of each step
- How to get started with “LCA thinking”
- Helpful guidelines

Goal Definition

- Goal states
  - the intended application
  - the reasons for carrying out the study
  - the intended audience
  - whether the results are intended to be used in comparative assertions intended for public disclosure
- Think about previous discussion
  - Resources available (data, LCA experience)
  - Look at type of question and level of precision needed in answer
    - Benchmarking studies (goal, scope, flows, no impact assessment)
    - Less than complete LCA
    - Complete LCA
    - EPD/LCA/PCR

Goal and Scope flow chart




9. Define Data Requirements
Sources of data
Primary or secondary data
Average data or specific data
Preliminary sensitivity of results to data sources
8. Document Limitations
System boundary and life cycle phase truncation
Data quality and availability for each phase
Impact assessment data
Sensitivity data
10. Define Data Quality Requirements
Relate to goal
Review data quality checklist
11. Determine Critical Review Process
Determine if critical review needed
If yes, determine critical review process
13. Complete Scoping Document for LCA Study
12. Determine Reporting Requirements
Consider goal and audience
Transparency documentation

Functional Unit

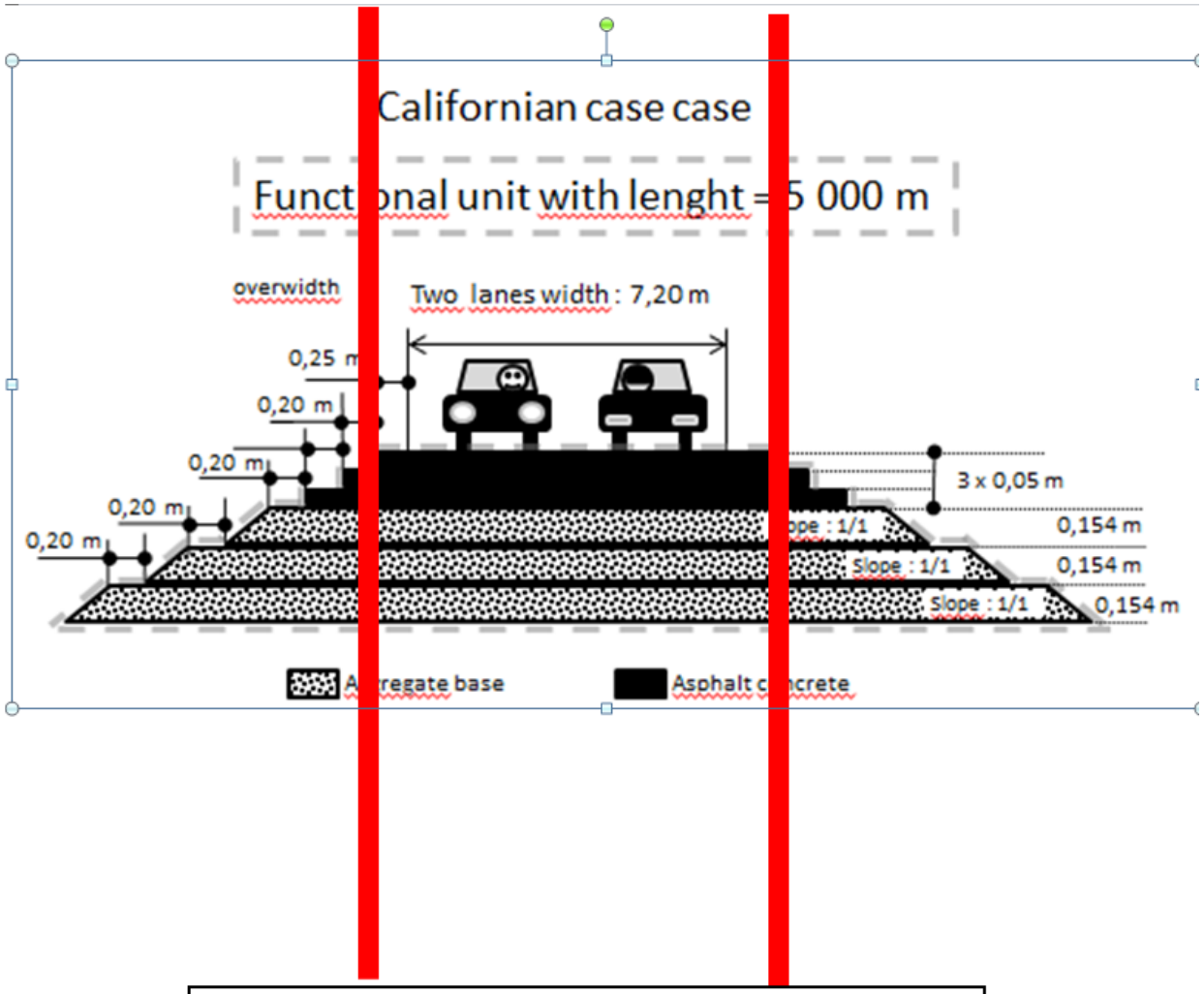
Functional Unit *– the unit in which the results of an LCA are reported. A functional unit provides a reference to which the input and output data are normalized. It needs to be a unit clearly defined and measurable. Comparisons can only be made for results expressed in the same functional unit.*

Questions when Defining a Functional Unit

- Refer back to the question of the Goal
  - Single product or comparison?
  - Life cycle stages: Cradle-to-gate or Cradle-to-grave or Other?
  - Service or performance requirements of the product?
    - If comparison must meet same requirements, examples:
    - Years of service
    - Equivalent axle loads
  - Scaling and normalization
    - For project analysis, use full project size
    - For generalized reporting or comparisons, do full project analysis and then normalize to a standard unit such as 1 lane-km or 1 m^2

System Boundaries and Pavement Life Cycles

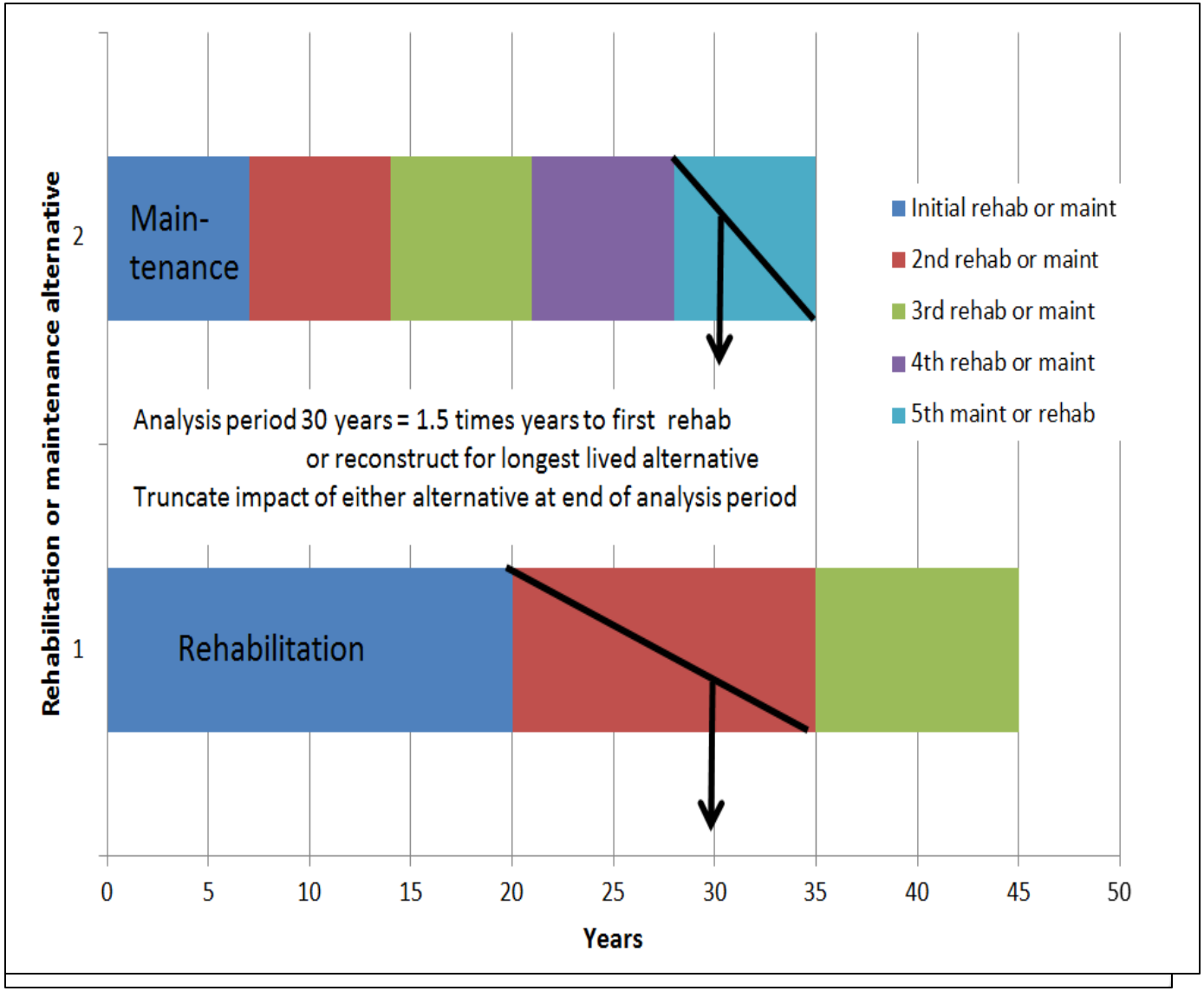
- Description of pavement life cycles and options for consideration of processes
  - Project level physical boundaries
    - What is in scope? What is not in scope?
    - Systems (Drainage? Lighting? Ramps? Shoulders?)
  - For network level studies
    - Analyzing every section in the network? Or sampling?
    - Include enough for sensitivity analysis
  - For policy level studies
    - Select sample of representative sections
    - Include enough for sensitivity analysis



Par le analysis, tout les nivels son 7.2 m du large; nous ne savons pas large ils sont (my bad French)

Bad results if system boundaries not well defined!

Analysis Period

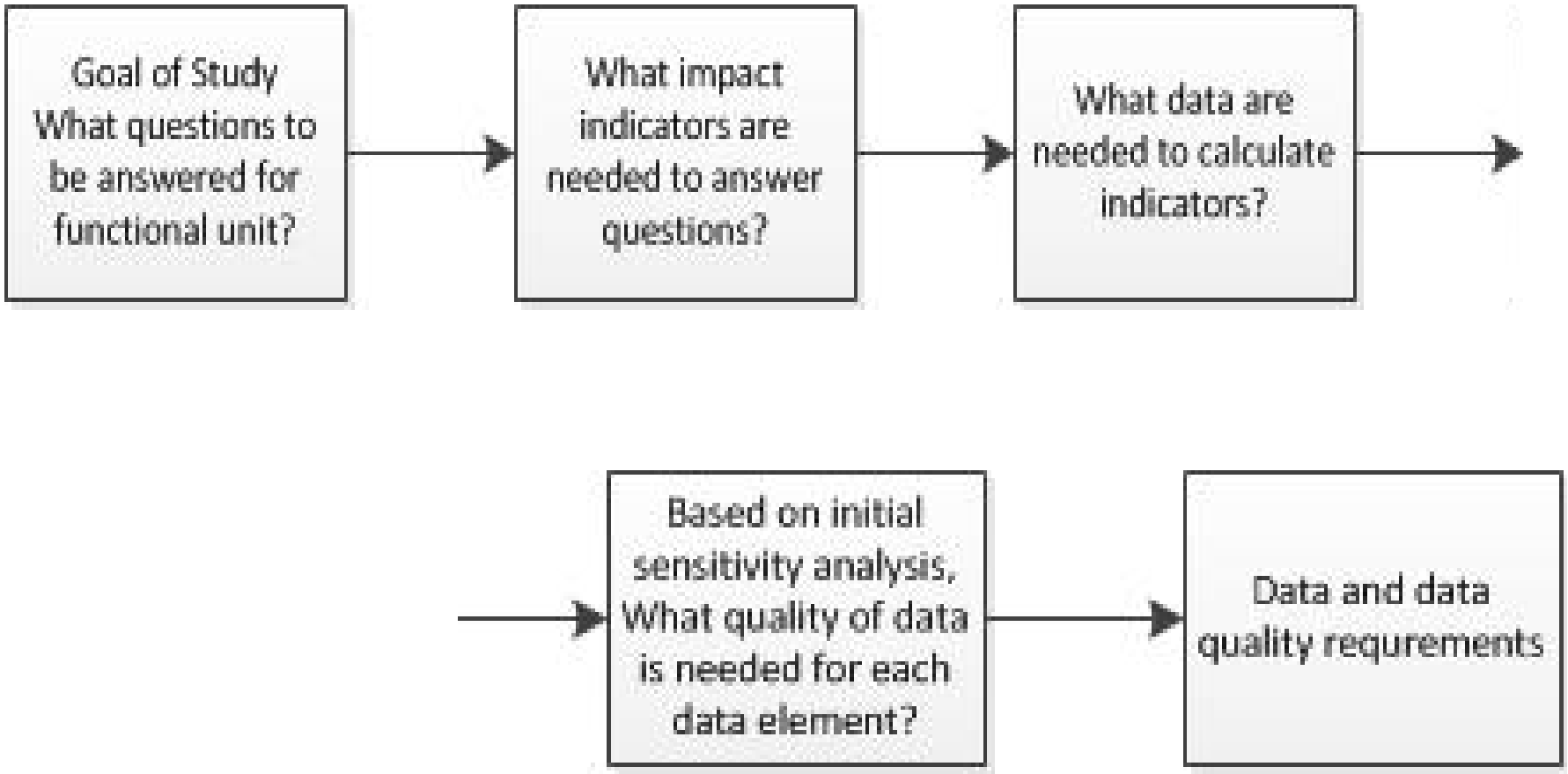


- Definition of analysis period
  - capture performance of the initial product or service and its effect through the next subsequent major treatment
  - If comparing two products needs to be equal length
  - How to handle "salvage value"

Scope the Assumptions and Limitations, Data Collection and Quality Needed, Critical Review and Reporting

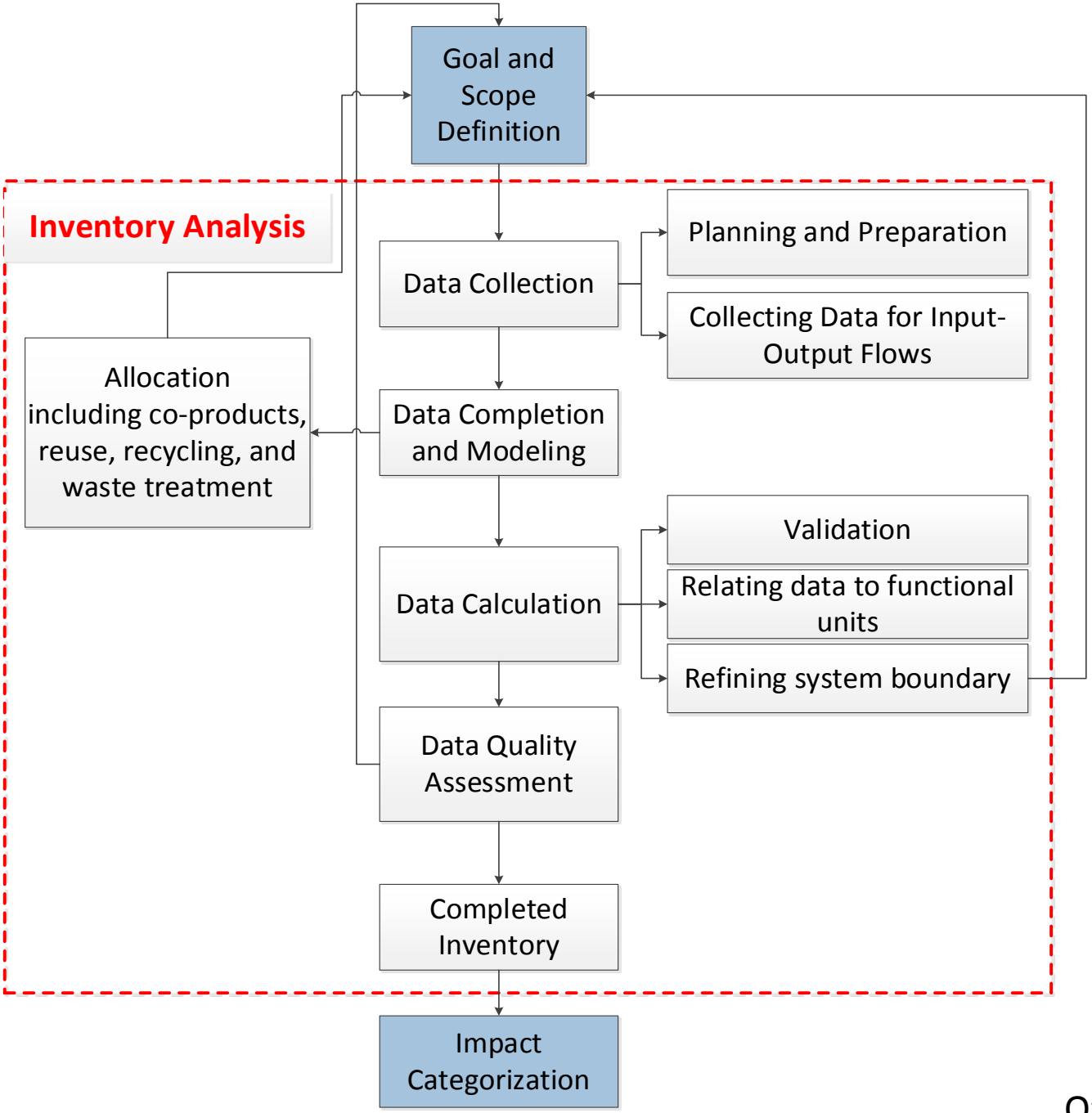
- Transparency in stating assumptions and limitations as developing scope
- Specification of data collection requirements to meet goal
- Data quality requirements definition to meet goal, handling of missing data
- Definition of critical review
  - Usually three independent review
- Scoping of final report to meet goal

Determining Data Needs



ISO

Life Cycle Inventory



Ozer and Al-Qadi after ISO

Where to get data
Cost and availability?

- Primary data (specific to process):
  - From direct measurements of input and output
  - Calculated from process flow data
    - Example: liters of fuel consumed translates into known amounts of pollution, etc
  - From questionnaires to producers
  - From EPDs
- Secondary data (averaged or calculated from averages):
  - From commercial databases
  - Calculated from process flow data and secondary data
  - From industry average EPDs
- From economic Input/Output estimates

Data Quality Assessment Considerations for Applicability to Study

- Age of data
- Geographical area from which data collected
- Technology coverage: specific technology or technology mix
- Precision: variability of data (is there more than one value?)
- Completeness: percentage of flow measured or estimated.
- Representativeness: qualitative assessment of the degree to which the data set reflects the true
- Consistency: qualitative assessment of whether the study methodology is applied uniformly to all of the analysis
- Reproducibility: qualitative assessment of the extent to which information is sufficient to would allow an independent practitioner to reproduce the results reported in the study
- Uncertainty of the information e.g., data, models, and assumptions

Example: Data Documentation including Quality

Table 2. A1 - Raw Material Supply

Materials	LCI Data Source	Geography	Year	Data Quality Assessment
Cement (lbs)	MIT 2014 paper, Update of Portland cement, at plant (USLCI). Modified to include upstream impacts of fuel and energy production	USA	2010	• **Technology:** good Process represents average cement production in the US • **Time:** Very good Data is within 4 years • **Geography:** very good • **Completeness** good Data is based on an average of national production • **Reliability:** very good
Fly Ash (lbs)	None, no incoming burden, only inbound transport was considered	N/A	N/A	• **N/A**
Silica Fume (lbs)	None, no incoming burden, only inbound transport was considered	N/A	N/A	• **N/A**
Slag cement (lbs)	LCI Slag Cement Manufacturing	USA	2003	• **Technology:** good Process models ground granulated blast furnace slag. • **Time:** fair Data is within eleven years. • **Geography:** very good • **Completeness:** good • **Reliability:** good

Central Concrete

Allocation

- ***Allocation*** *– Partitioning the input or output flows of a process or a product system between the product system under study and one or more other product systems. This is most relevant for valuing the production and use of recycled, co-product, and waste materials (RCWMs) in pavement LCA.*

Why does Recycling create an Allocation Issue in LCA?

Total: $4.4\ kgCO_2eq/kg$

Geyer Pavement LCA 2014

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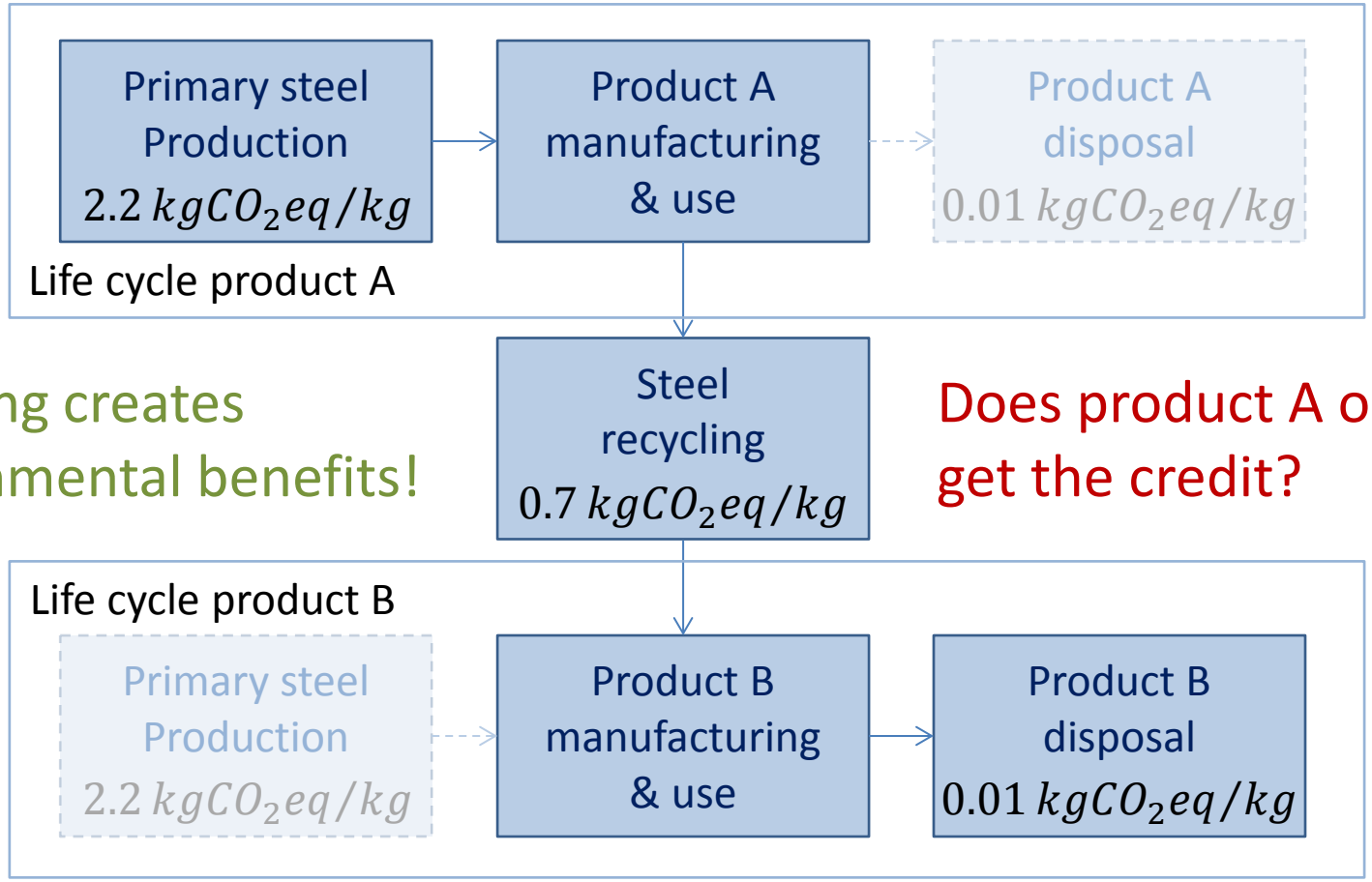


Recycling creates environmental benefits!

Does product A or B get the credit?

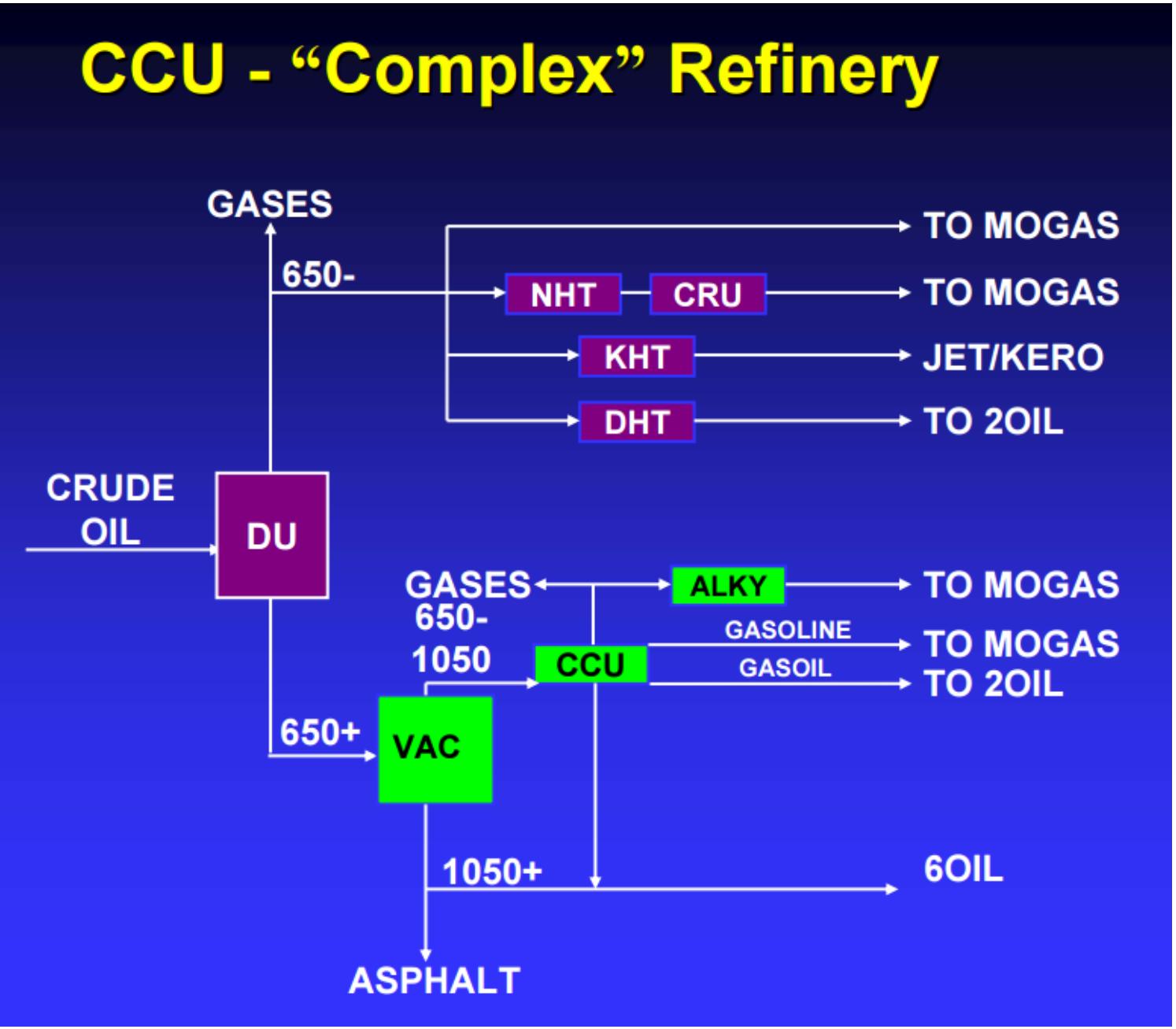
Total: $2.9\ kgCO_2eq/kg$ (34% reduction)

Geyer Pavement LCA 2014

What ISO 14044 says about Allocation

- ISO provides a rank-ordered list of allocation procedures
  - Some work well for pavements, some more difficult
  - Generally divide on mass or economic value (no allocation to items with no economic value)
- Whenever several alternative allocation procedures seem applicable, a ***sensitivity analysis*** with regard to allocation shall be conducted.
- Particular issue in pavement for:
  - Asphalt from refinery producing other products
  - Slag, fly ash and other supplementary cementitious materials in cement
  - Pavement materials recycling

After Geyer Pavement LCA 2014



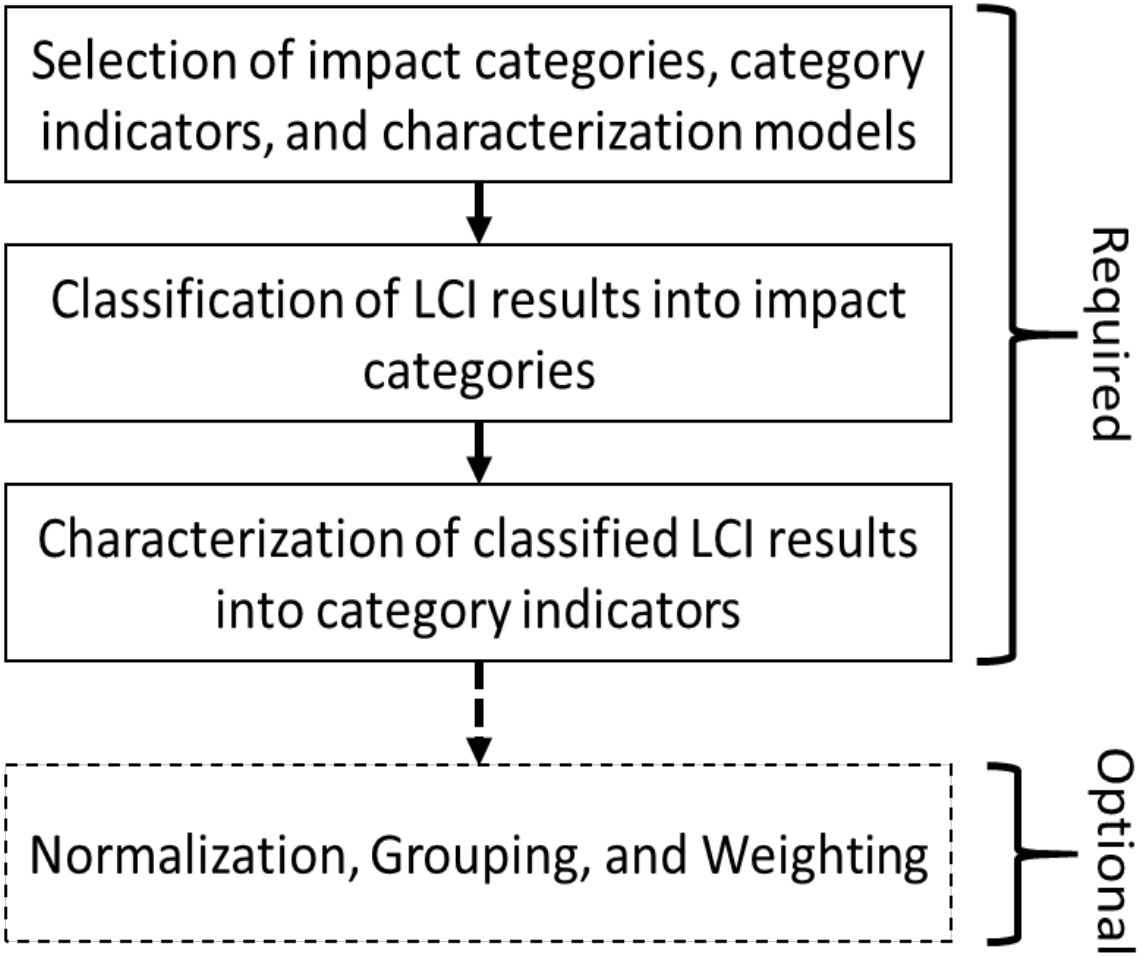
Difficult: oil refineries!

Haveland 2007

Impact Assessment

- ***Environmental Impact Category*** *– Class representing environmental issues of concern to which life cycle inventory analysis results (inputs from nature and output flows to nature such as extraction of material and energy resources, emissions to air, water and land and final waste) may be assigned. The selection of impact categories is important as it defines which environmental considerations are going to be addressed.*

Impact Assessment



- Models used to convert flows into impacts
- [1]CML (Europe), [2]TRACI (USA) in next table

ISO

Group	Impact Category	Comment
Energy use	Fuel, non-renewable[1] Resources, non-renewable Resources, nonrenewable, secondary Fuel, renewable Resource, renewable Resource, renewable, secondary	Small uncertainty, both energy use and feedstock energy should be addressed
Resource use	Resource, renewable Resources, non-renewable[2]	Small uncertainty
Emissions	Climate Change[1, 2] Ozone layer depletion[1, 2] Acidification[1, 2] Tropospheric Ozone[1, 2] Eutrophication[1, 2]	Small uncertainty, global, biogenic CO_2 requires special attention Small uncertainty, global Small uncertainty, regional Medium uncertainty, local Small uncertainty, local
Toxicity	Human toxicity[2], respiratory[1] Human toxicity, carcinogenic[1] Human toxicity, non-carcinogenic[1] Ecotoxicity[1], fresh water[2] Ecotoxicity, marine water[2] Ecotoxicity, soil[2]	High uncertainty, incomplete
Water	Fresh water use	Small uncertainty
Waste	Hazardous Non-hazardous	Small uncertainty

Interpretation

- The step in which the question posed by the goal gets answered
  - Identify significant issues
  - Check for completeness, sensitivity, consistency
  - Draw conclusions, state limitations, make recommendations
- After Interpretation
  - Report, submit to critical review, revise, finalize

LCA can be complicated
How to get started 1/2

1. Define question to be answered and specific environmental goals or decision to be made
   - Calculate total impact
   - What if analysis, comparisons
2. Define system boundaries
   - Identify items that are the same and do not need to be considered
3. Define the functional unit and approach
   - specific project variables, cases for impact calculation of comparison, analysis period
4. Model the system
   - specific project variables, cases for impact calculation of comparison, analysis period
   - Identify operations, materials, thicknesses, functional lives, materials production and construction processes, etc.

LCA can be complicated
How to get started 2/2

5. Quantify differences between alternatives over the life cycle

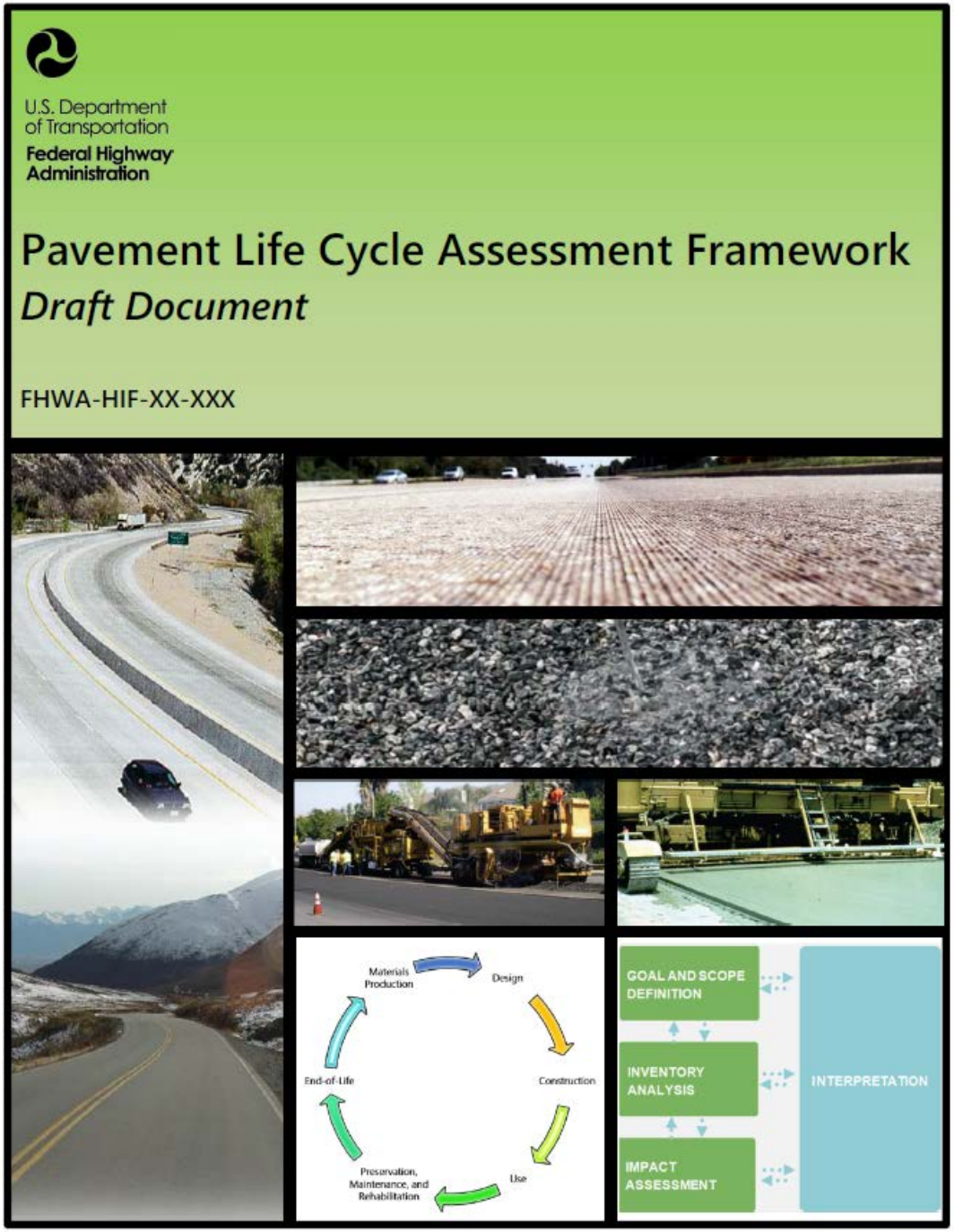
First five steps may be enough to determine whether full LCA needed

6. Identify appropriate environmental data sets (life cycle inventory data) needed and quantify the environmental impacts of differences, complete LCA

Guidelines Specific to Pavement Should be Available in early 2016

Main efforts to start:

1. LCA education
2. Begin life cycle thinking (Steps 1-4)
3. Inventory data?
   a. University research
   b. PCR/EPD?
   c. Commercial data for China



Questions?