Uncertainty Analysis:

The other half or the story: the implications of system boundary incompleteness for LCA inventory data

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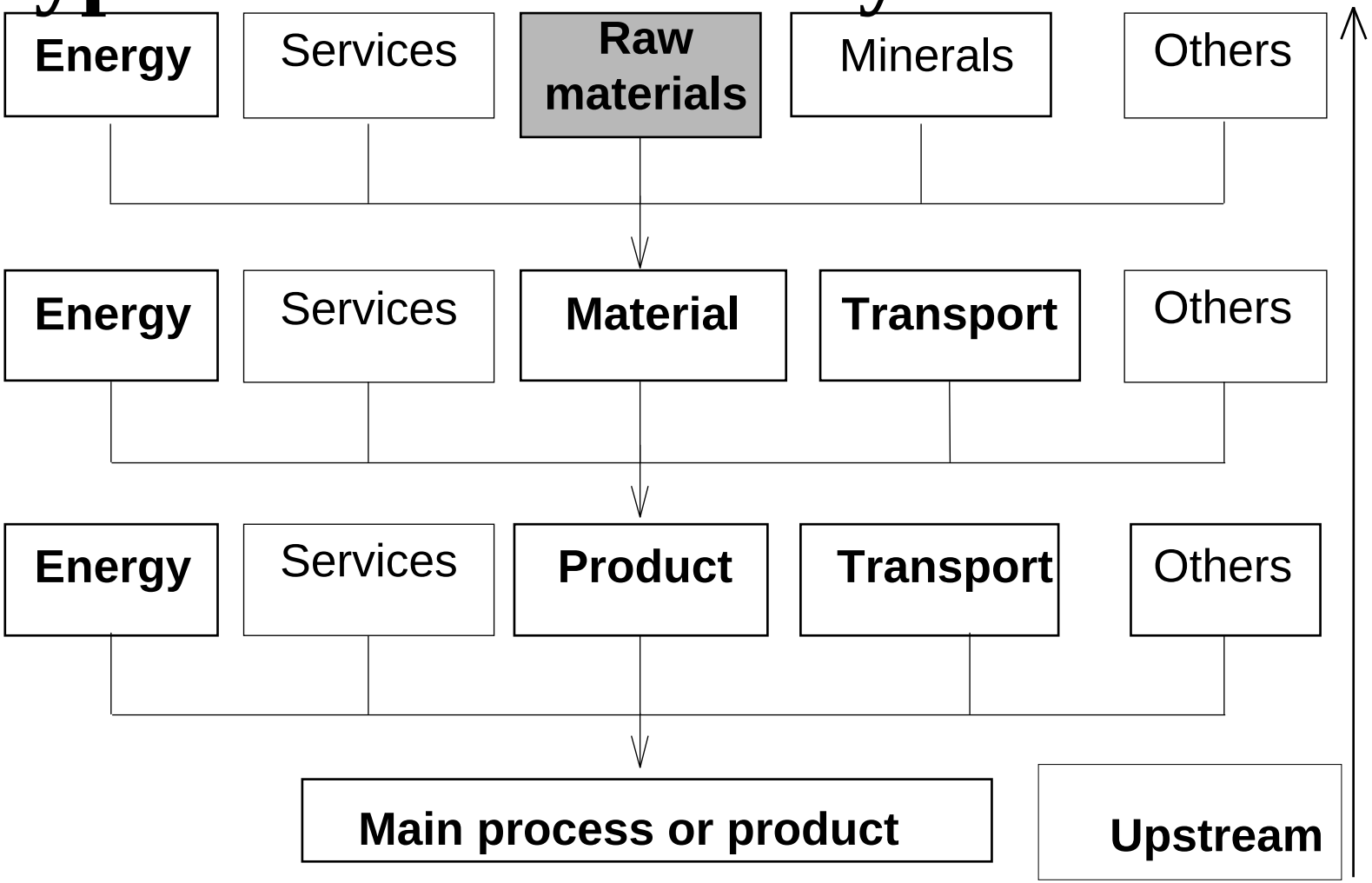
Introduction

- LCAs of buildings, other complex products
  - mainly focussed on basic materials
- Even for materials, system boundary is an issue
  - services and minor materials are often excluded
- Input-output analysis suggests that 50% is common
  - based on energy loadings only
- The case of PVC and Transport are used to demonstrate hybrid approachs

Unit process analysis

- LCA methods based on unit process analysis.
  - Good specific information on particular plants or product sectors particularly for the main measured flows.
  - Detailed data on a wide range of specific material inputs and pollutant outputs.
  - Useful for a broad range of environmental indicators

Typical LCA Inventory



Limitations to LCA via unit process analysis

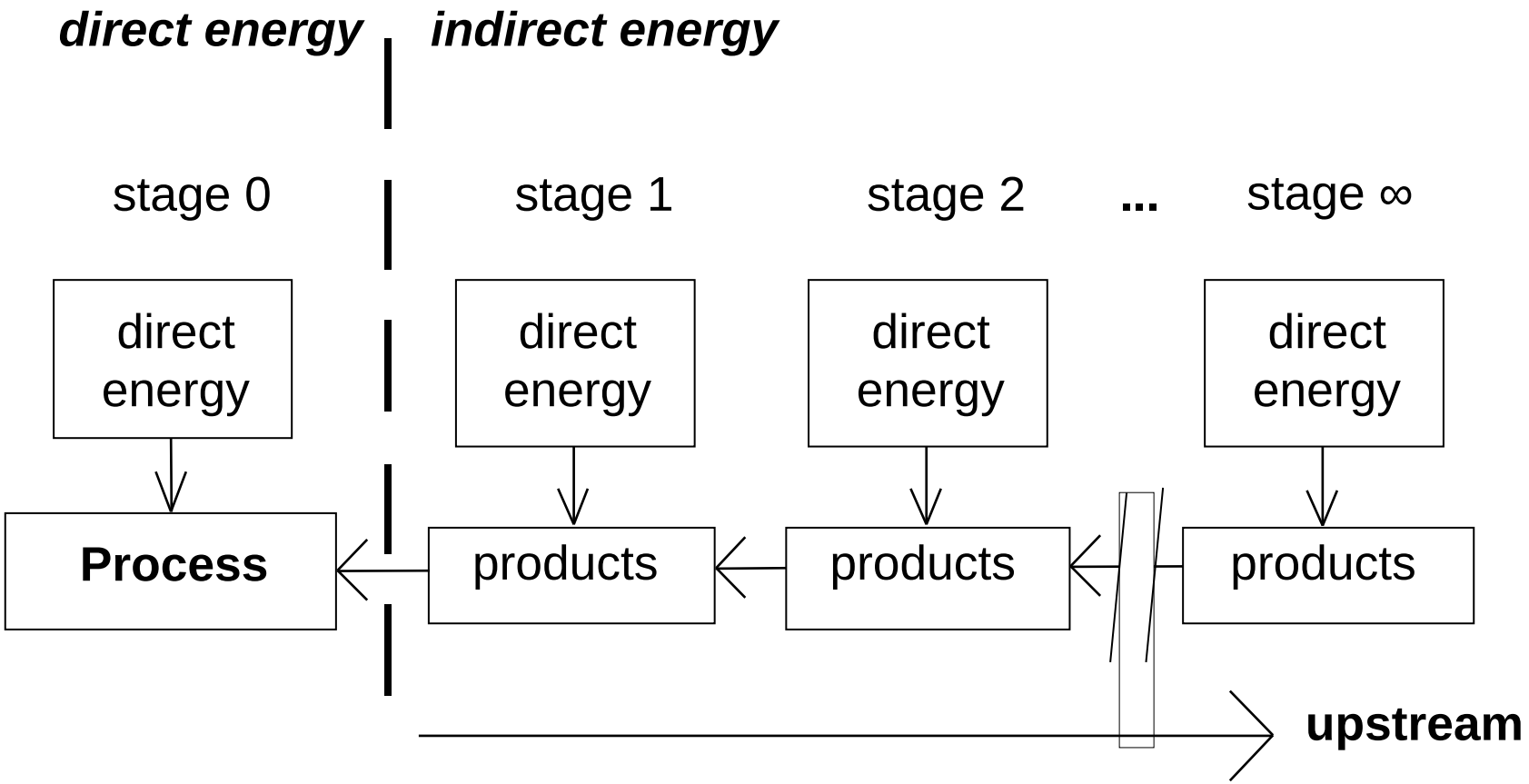
Typical ignored items include:

- Inputs of small items
  - eg, fixings and adhesives
- Ancillary activities
  - such as administration, storage - an ‘allocation” issue
- Inputs of services
  - such as banking and insurance
- Further processing
  - eg, of basic materials into complex products

LCA methods based on input-output analysis:

- eg, Lave et. al. (1995) [Carnegie Mellon]
- uses national average statistics (economic exchanges between industry sectors)
- subject to gross errors (not generally acknowledged)
- exhaustive system boundary (‘systemically complete’)

Manufacturing process inventory using I/O



(direct energy has to be in primary energy terms)

Hybrid LCA method

Two approaches

- Improve accuracy of the input output model by substituting important process data
- Improve system boundary of process inventory by including additional elements missed by process analysis

Hybrid LCA method – improving I/O model

1. Derive an input-output LCA model
2. Extract the most important ‘energy pathways’
3. Derive case specific LCA data

   prioritise, based on relative value of energy pathways
4. Substitute case specific LCA data
   - into the input-output model
5. Retain other energy pathways in input-output model
   - retains completeness of original input-output model
   - requires little effort to complete the system boundary

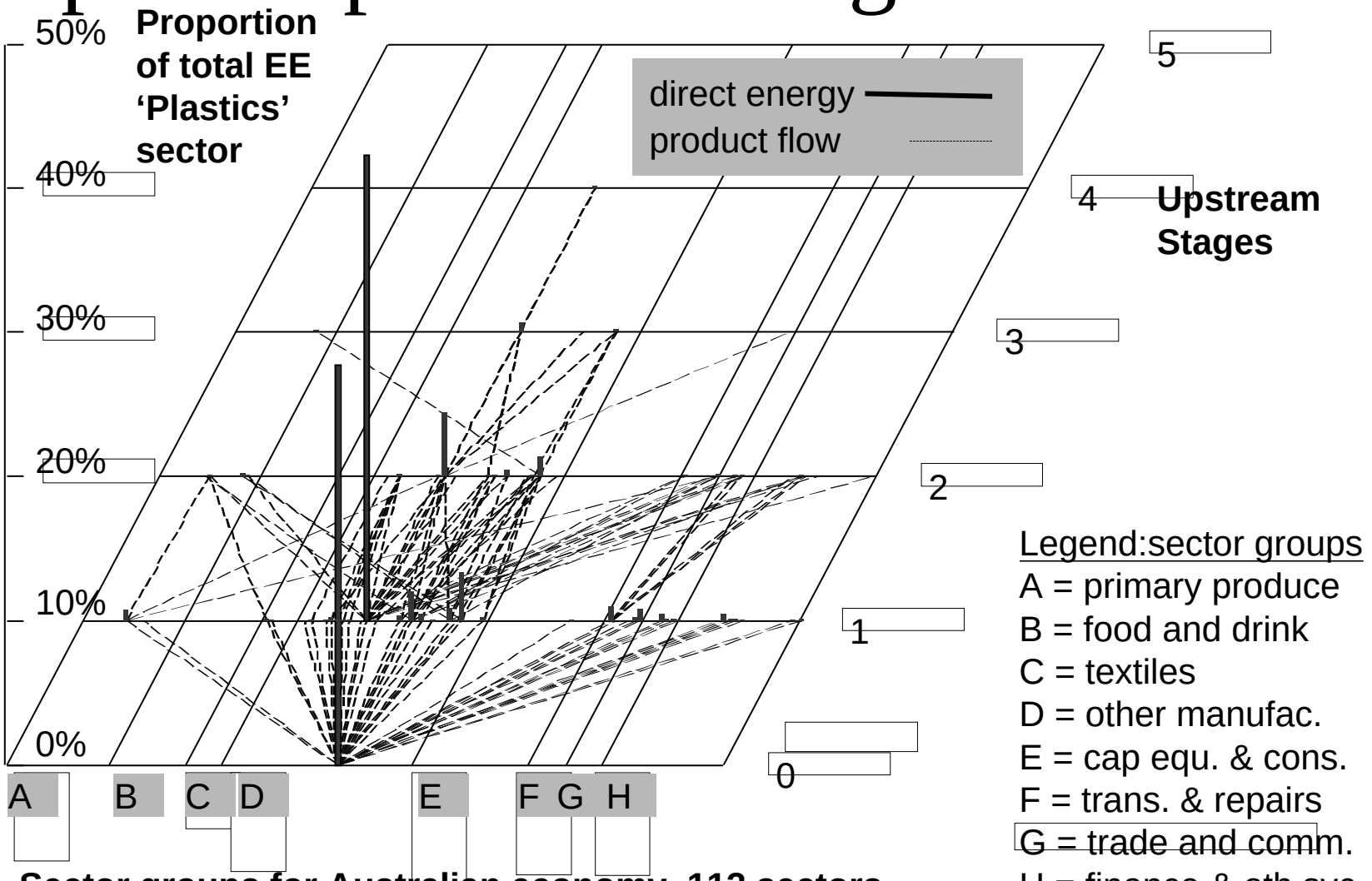
A demonstration for plastics

An input-output model was derived, comprising:

27.8%	Direct process energy (all in direct primary terms)
32.3%	Other basic chemicals (44.1% upstream)
3.33%	Basic non-ferrous metal and products (4.01% upstream)
2.03%	Plastic products (7.29% upstream)
0.99%	Wholesale trade (1.84% upstream)
0.89%	Other non-metallic mineral products (1.36% upstream)
0.87%	Road transport (0.99% upstream)
0.75%	Other agriculture (1.10% upstream)
0.52%	Scientific res., tech. and comp. serv. (0.79% upstream)
TOTAL nine processes at the 113 sector level	

Giving 67.5% directly and 89.3% in upstream processes from these
(see ‘tree’ diagram for 90% model next page, 115 processes)

Input-output ‘tree’ diagram



Sector groups for Australian economy, 113 sectors

A hybrid Embodied Energy model for PVC

Process analysis data (Australian data, 1995-9)

Direct energy:	61.0	MJ/kg
Indirect energy:	12.6	MJ.kg

- including a range of upstream process

Input-output data (Australia, 1992-93, fixed tariffs)

Direct energy:	85.7	MJ/kg (replaced)
Indirect energy (Process Analysis data):	163.8	MJ/kg (replaced)
Indirect energy (rem.):	78.2	MJ/kg (retained)

Hybrid analysis - new Embodied Energy

: 151.7 MJ/kg

Input-output data comprises 51.5% of hybrid EE figure

Hybrid Analysis Method 2- Improving process analysis data

- Based on inputting data for missing system elements from I/O data
- Good for infrastructure components.

PVC example

- Add 78 MJ for as missing system elements

Input-output data (Australia, 1992-93, fixed tariffs)

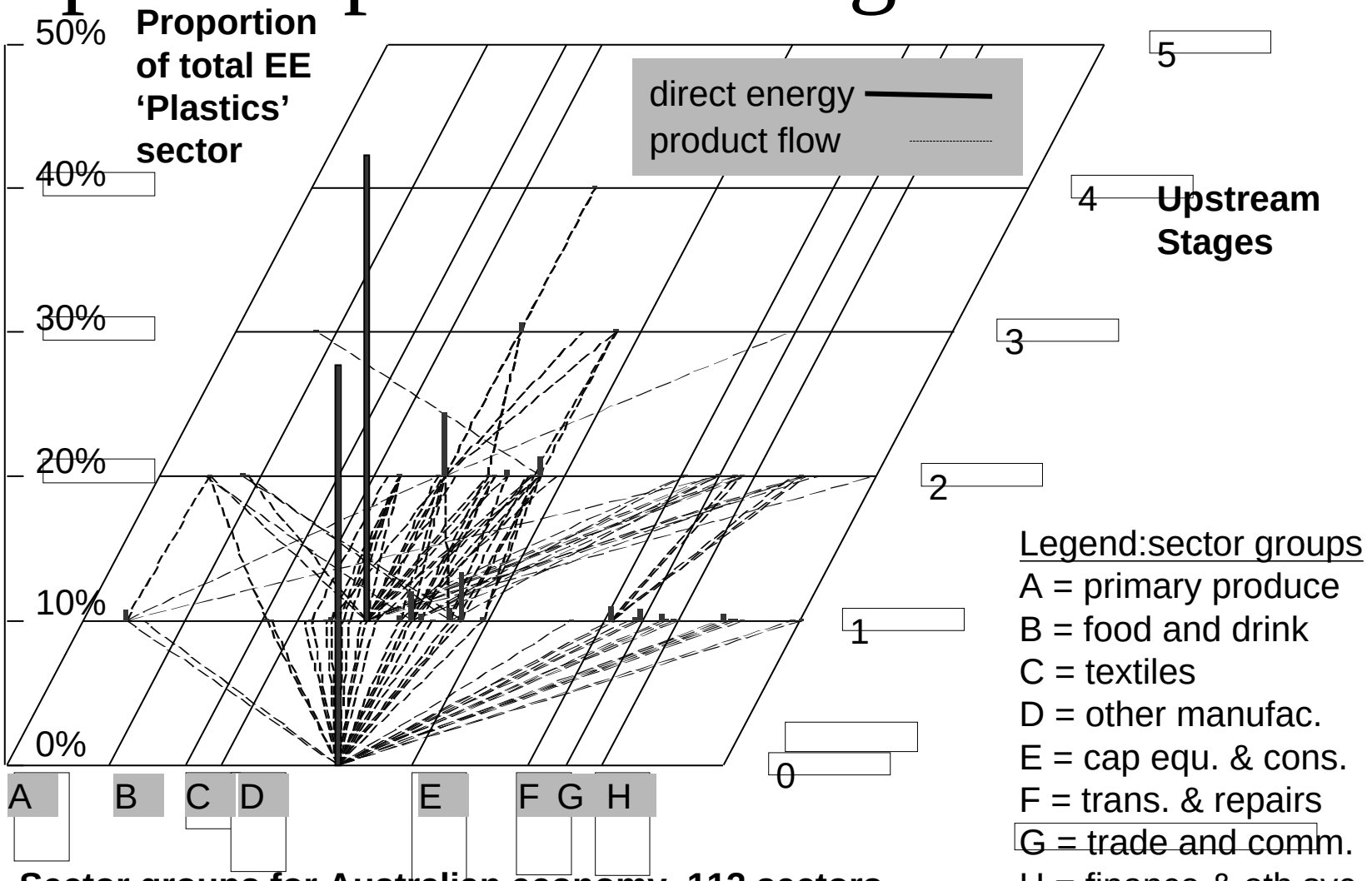
Direct energy:	85.7	MJ/kg (replaced)
Indirect energy (Process Analysis data):		
	163.8	MJ/kg (replaced)
Indirect energy (rem.):	**78.2**	**MJ/kg (retained)**

Need to carefully check sector assumptions

- Plastics are all amalgamated into plastic products – specific data can be corrected by other system elements cannot.

- Include finished product – both simple polymers and engineering plastics.

Input-output ‘tree’ diagram

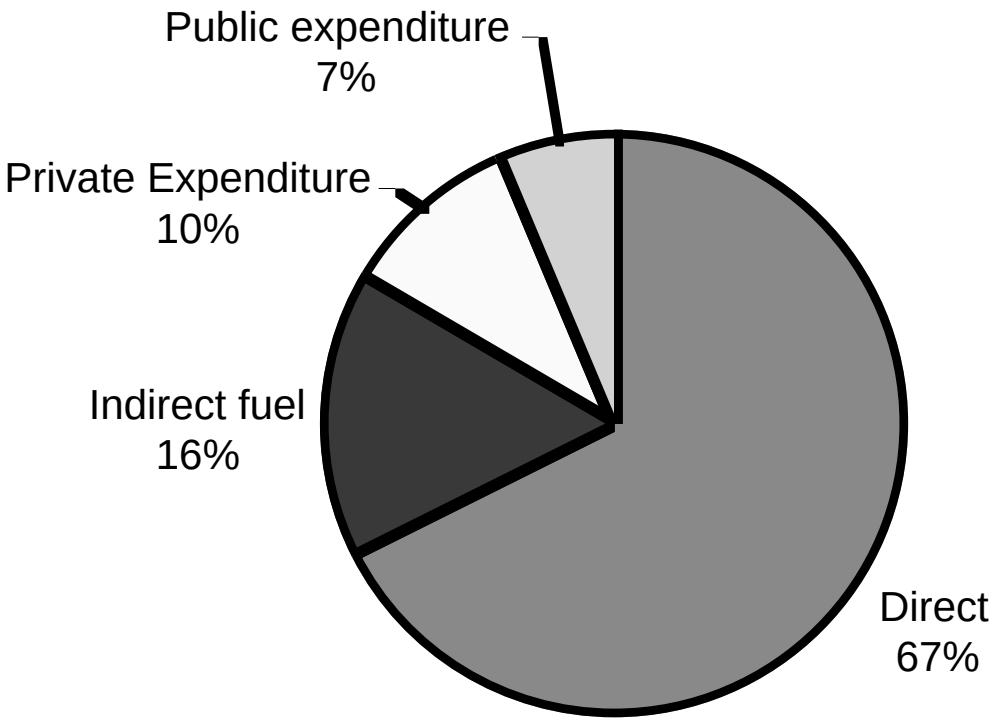


Sector groups for Australian economy, 113 sectors

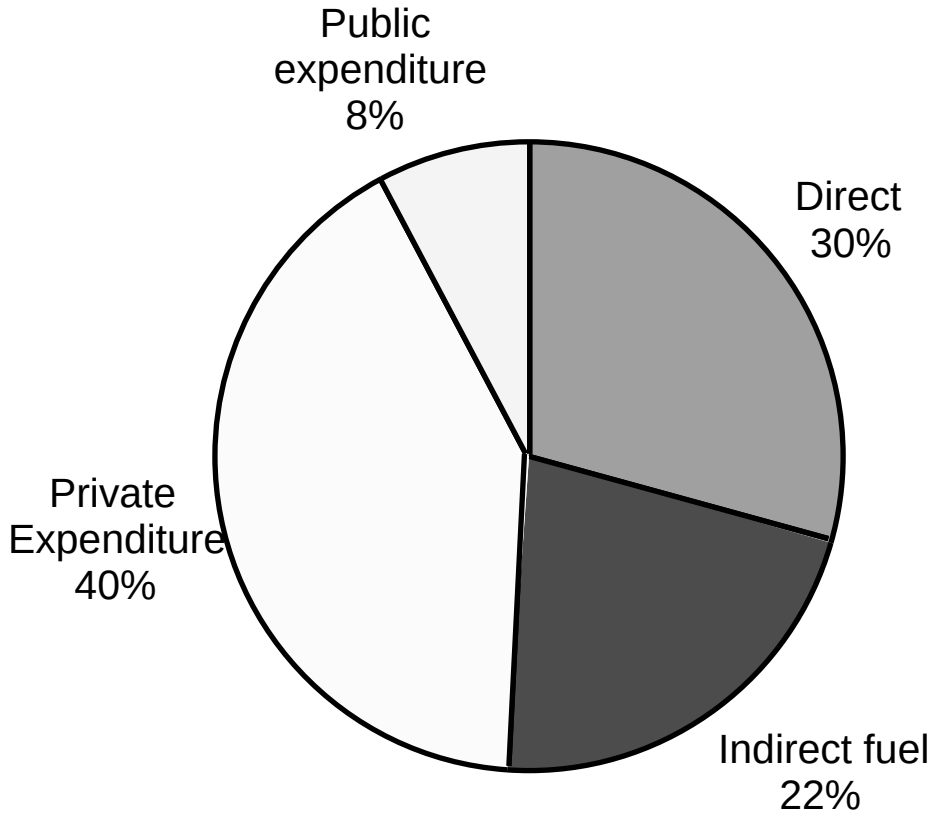
Why complete system boundary?

- If systems under comparison are similar – such as steel product vs plastic product it is unlikely inclusion of full system boundary will alter the results.
- Useful for capital intensive system such as transport where infrastructure may have a substantial effect.

Transport Articulated Trucks



Rail Freight



Indicators other than Embodied Energy

Work done by Manfred Lenzen, University of Sydney can be found at http//lca-conf.rmit.edu.au/papers/transport.zip

Conclusion

- Typical LCA process analysis fail to take account of many minor system flows
- These flows can be calculated from Economic Input/Output data.
- The two analysis techniques are complimentary and offer substantial possibilities for more complete LCA.
- The input output data is a cheap source of LVA data
- Input/output data can conceptualize flows and impacts identified by process analysis.
- Indicating which processes require more research