

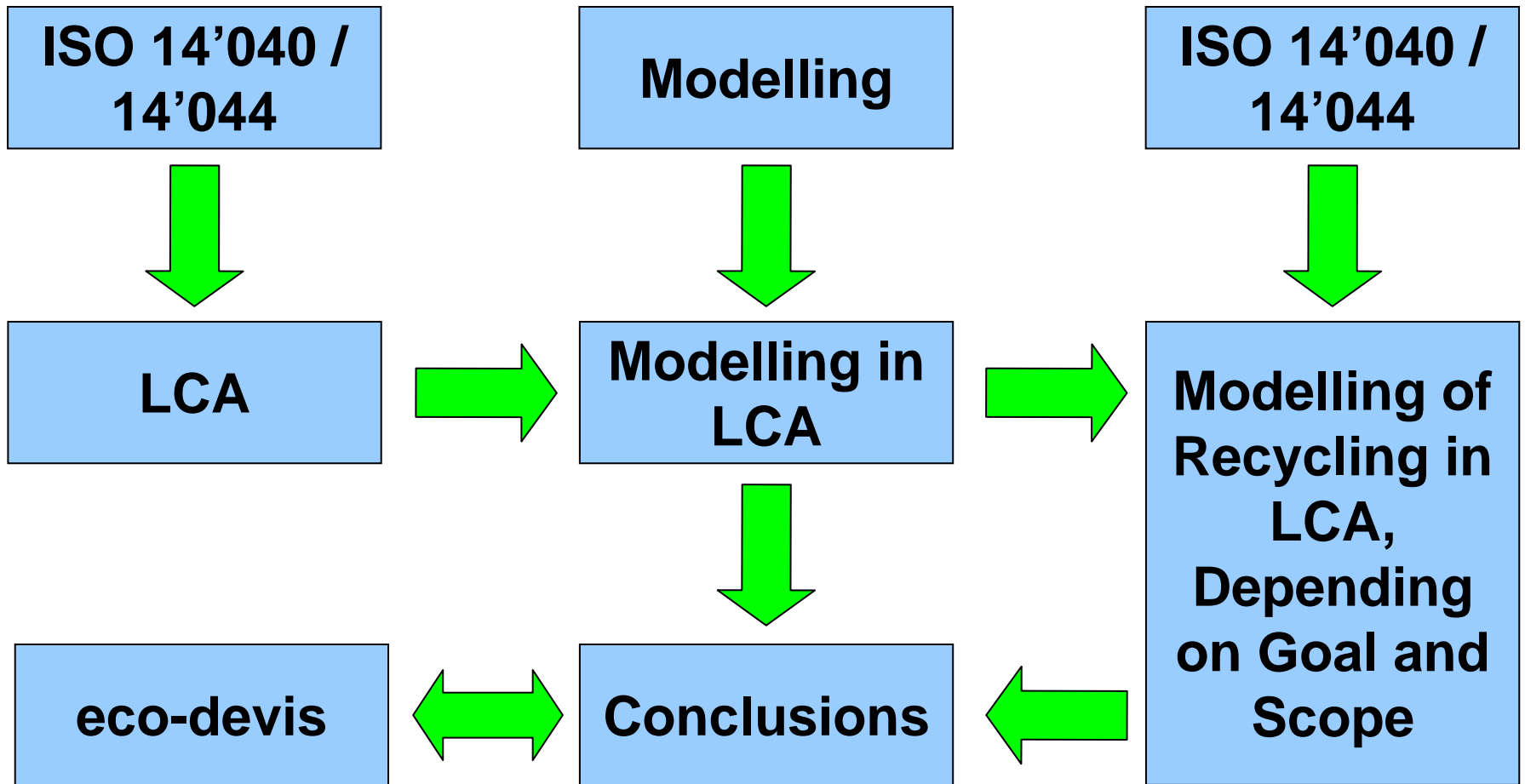


Materials Science & Technology

# **Recycling in LCA: Modelling Principles and their Relation to Goal and Scope**

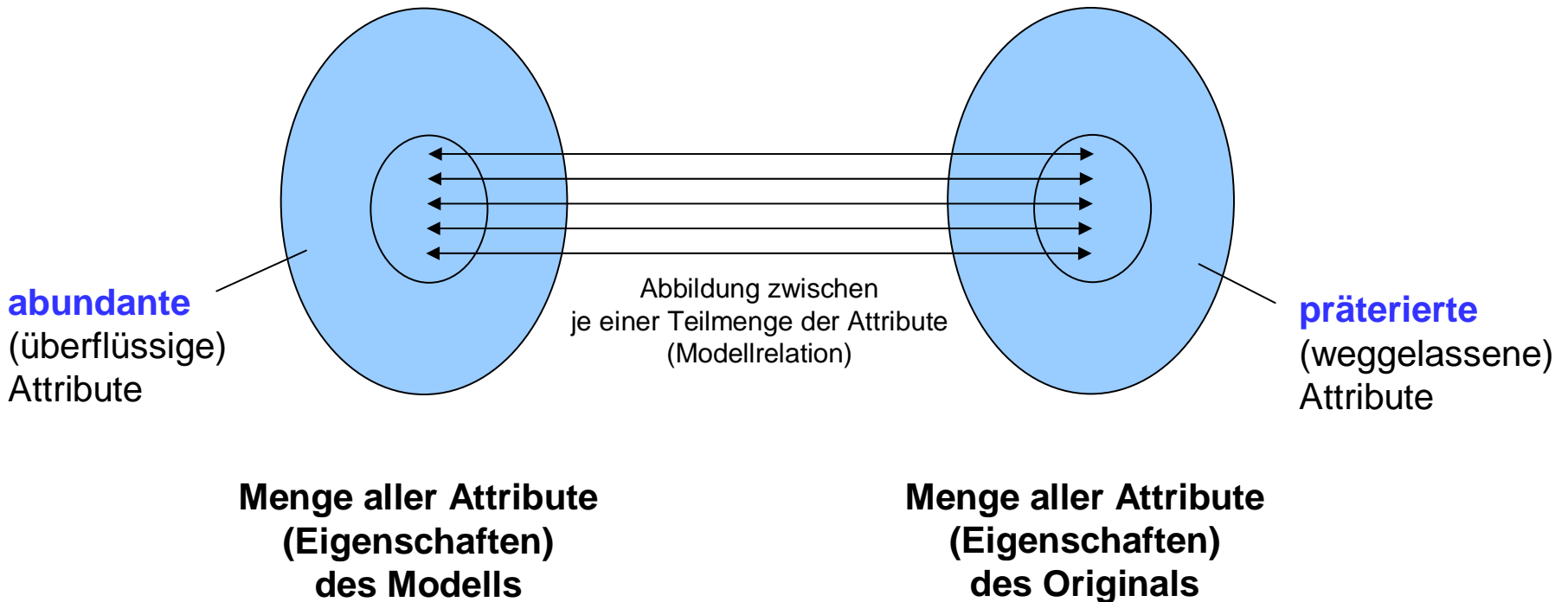
Hans-Jörg Althaus, Empa

# Structure of the presentation



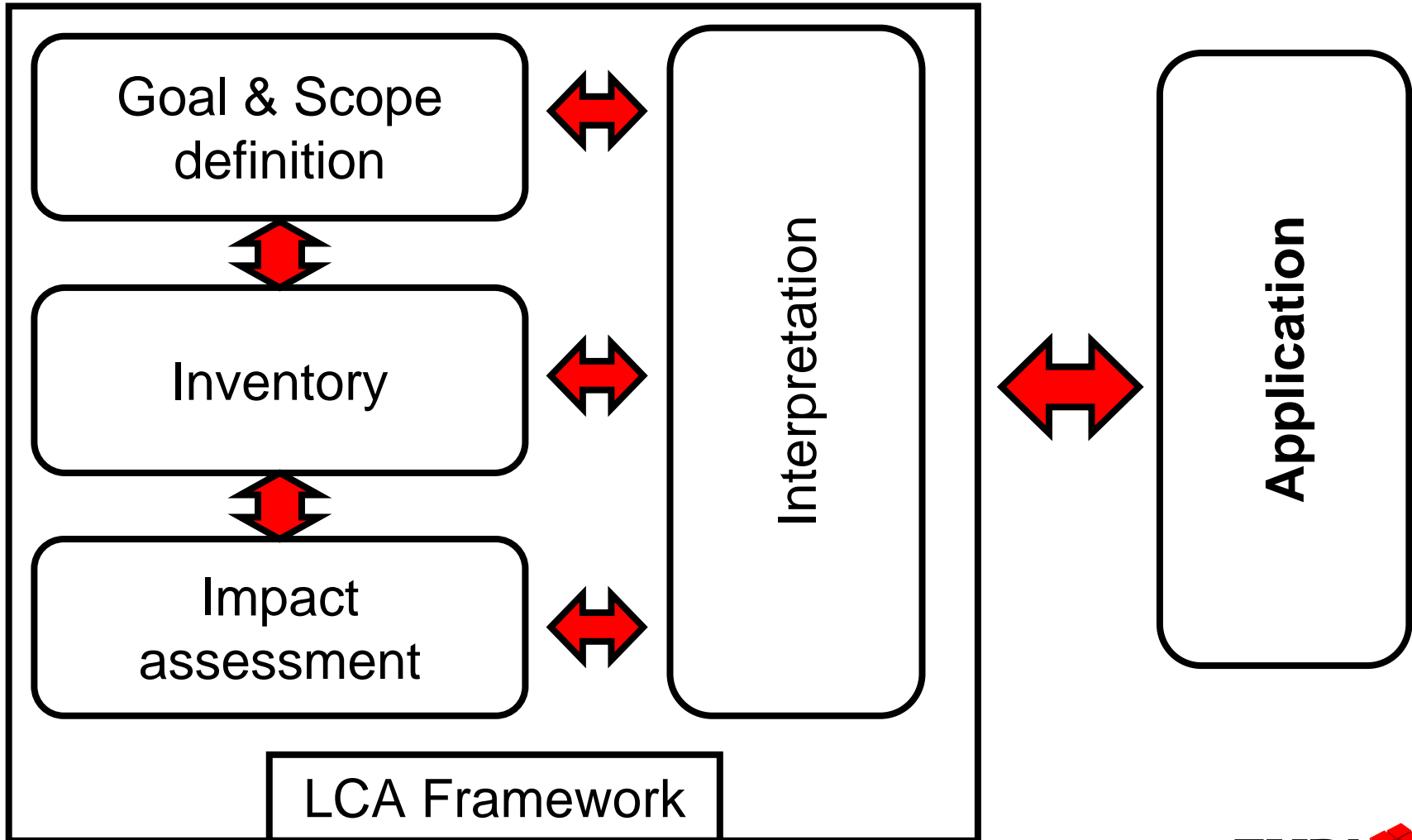
# What is a Model?

## Allgemeine Modelltheorie (Stachowiak)



Quelle: Stachowiak, 1973

# What is LCA?



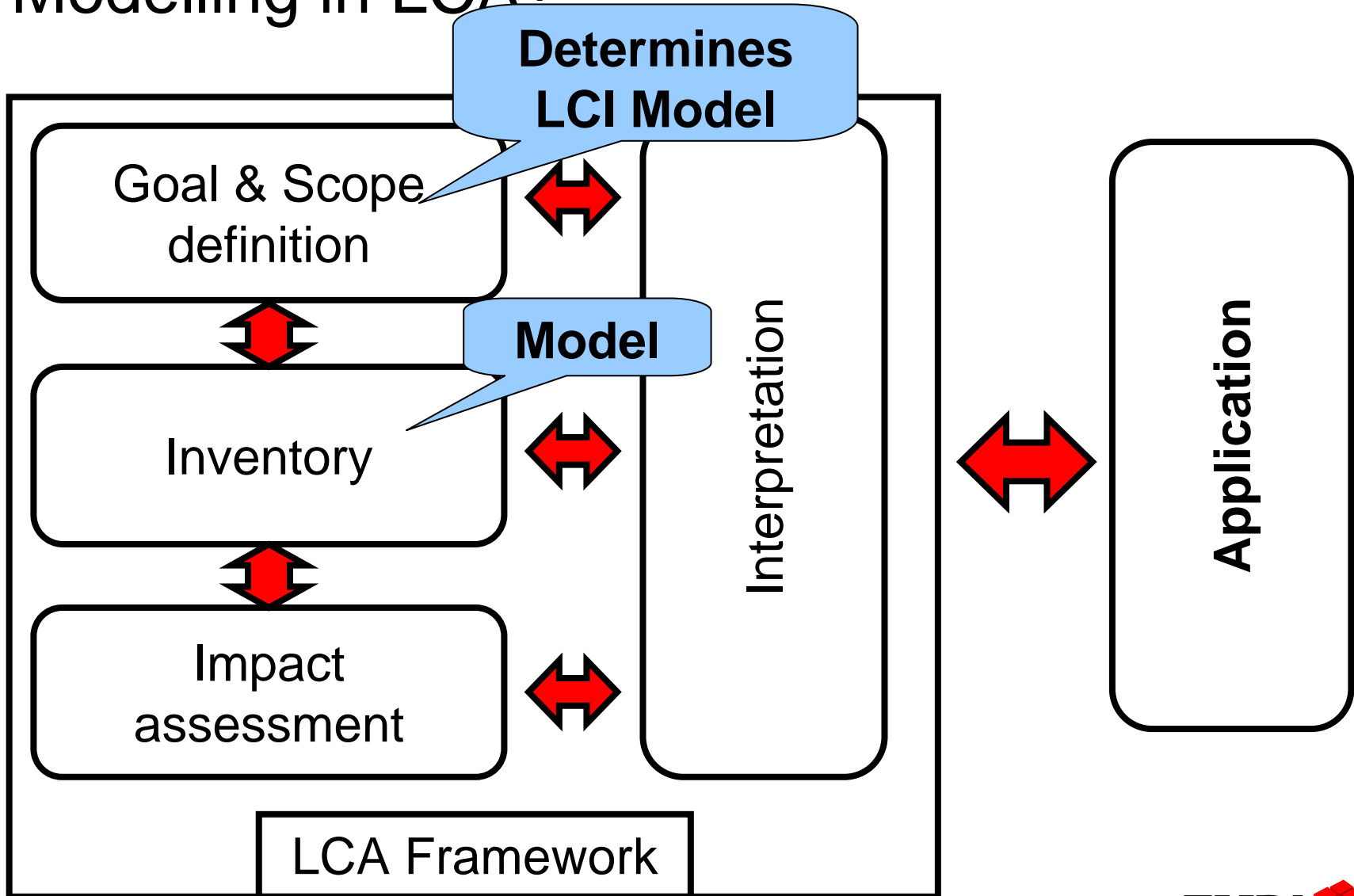
Source: ISO 14'040 (2006)

# What is LCA?

- The **scope**, including the system boundary and level of detail, of an LCA **depends on the subject and the intended use of the study**. The depth and the breadth of LCA can differ considerably depending on the goal of a particular LCA.
- The life cycle inventory analysis phase (**LCI** phase) is the second phase of LCA. It **is an inventory** of input/output data **with regard to the system being studied**. It involves collection of the data necessary to meet the goals of the defined study

Source: ISO 14'040 (2006)

# Modelling in LCA?



Source: ISO 14'040 (2006)

# Influence of Goal & Scope on Modelling

Is “e” better than “5”?

Different Questions:

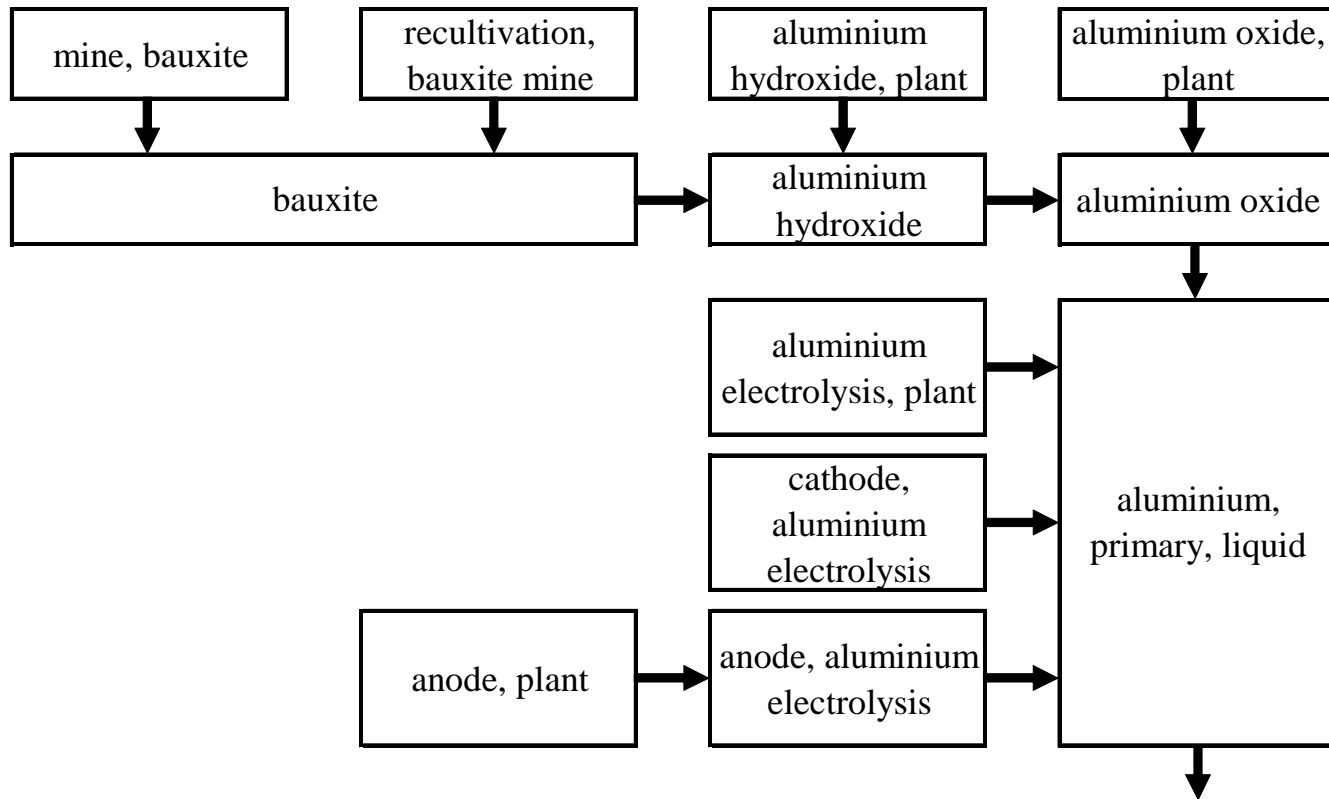
- ~~a) What material is environmentally better: aluminum, fiber cement or wood?~~
- b) What are the environmental burdens of today's aluminium production?
- c) What are the environmental consequences associated with the service provided by a aluminium façade cladding element?

# Influence of Goal & Scope on Modelling

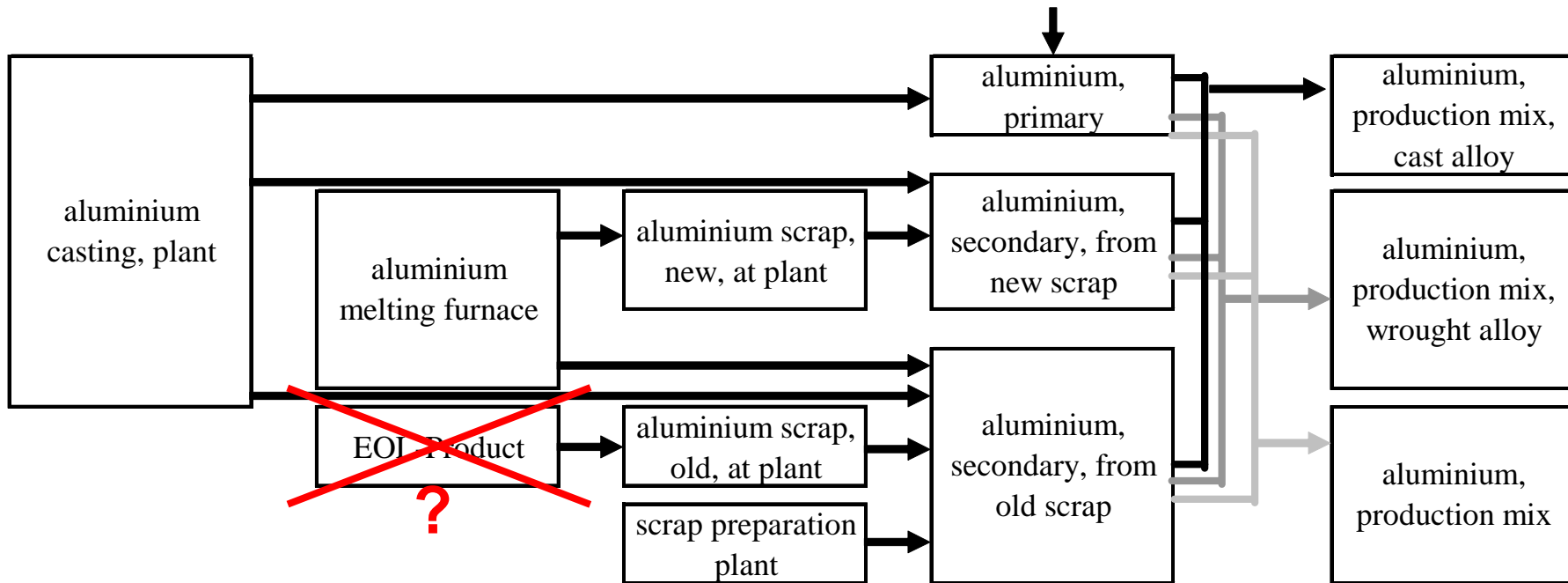
- Question b):  
What are the environmental burdens of today's aluminium production?
- What happens in the system?:
  - Virgin and recycling material is produced
  - Ore is mined and refined
  - Scrap is collected and prepared
- Answer:  
The burdens are those related to the production of virgin and recycling aluminium in 2007



# Environmental Burdens of Today's Aluminium Production



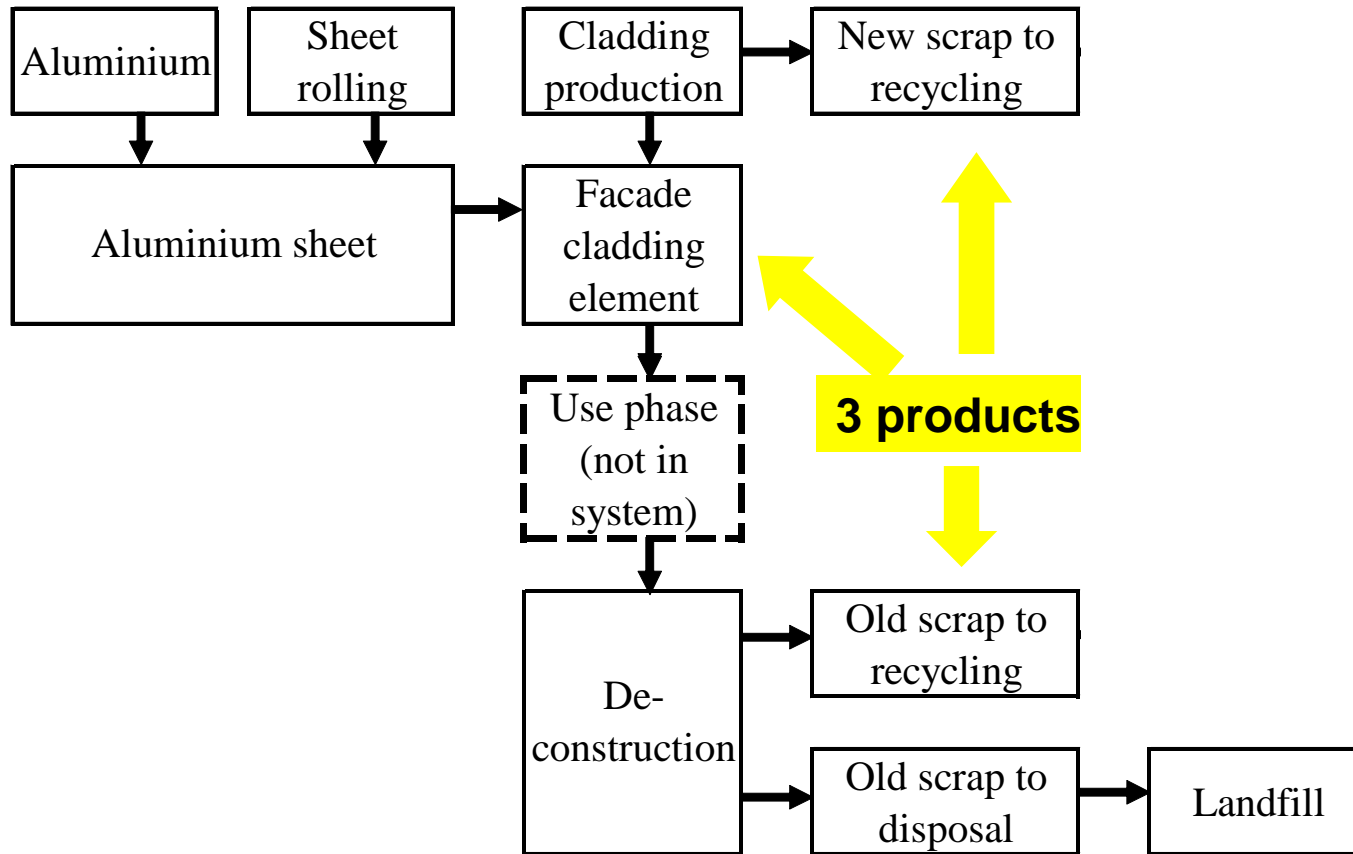
# Environmental Burdens of Today's Aluminium Production



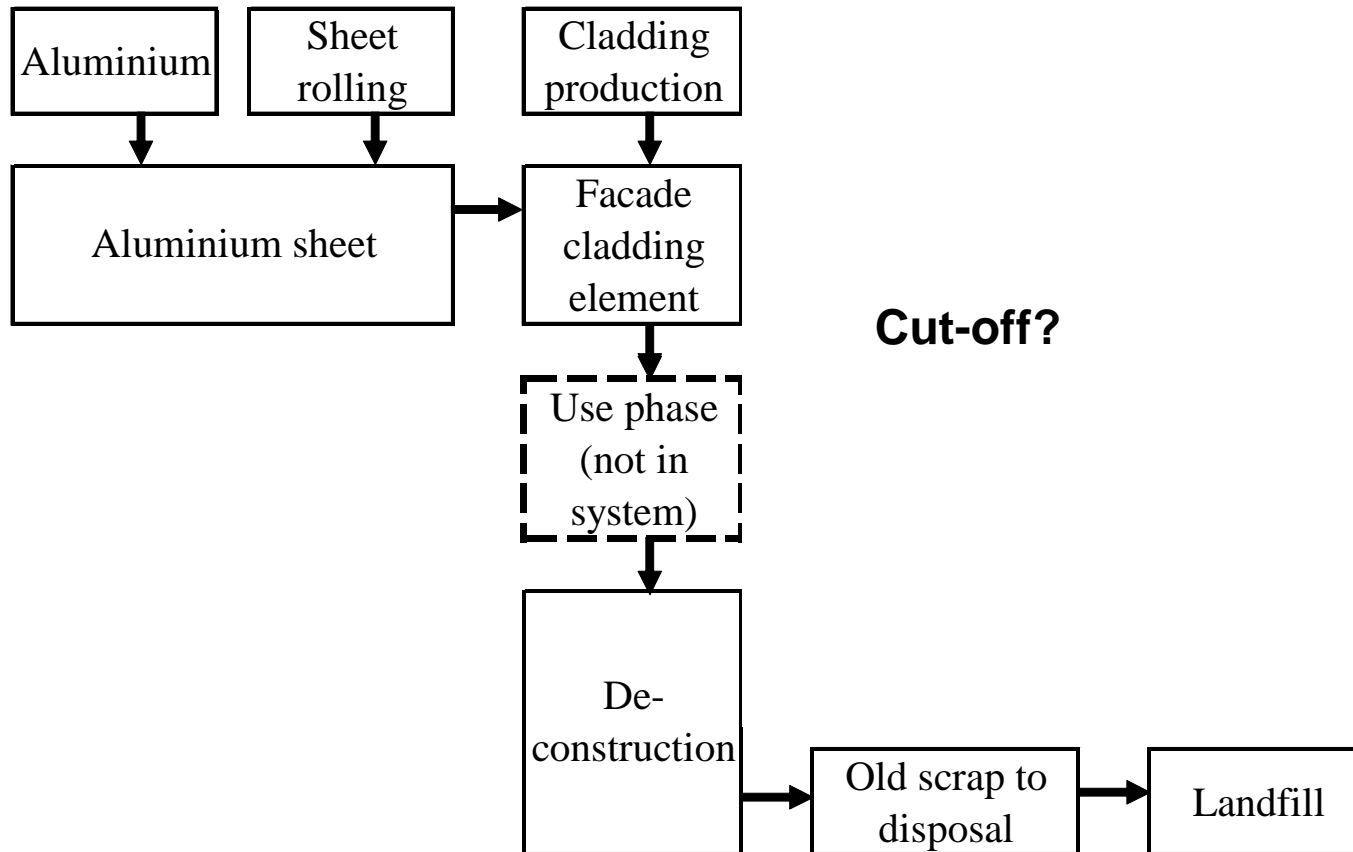
# Influence of Goal & Scope on Modelling

- Question c):  
What are the environmental consequences associated with the service provided by a aluminium façade cladding element?
- What happens in the system?
  - Materials and elements are produced
  - Elements are used and maintained
  - Elements are dismantled and recycled
- Answer:  
The consequences are those related to production, use and recycling of the elements

# Model of Production and End-Of-Life of a Aluminium Façade Cladding Element



# Model of Production and End-Of-Life of a Aluminium Façade Cladding Element

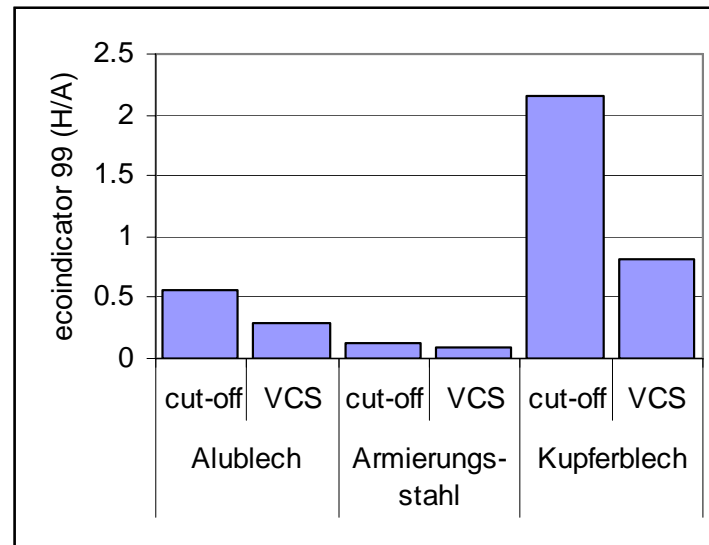
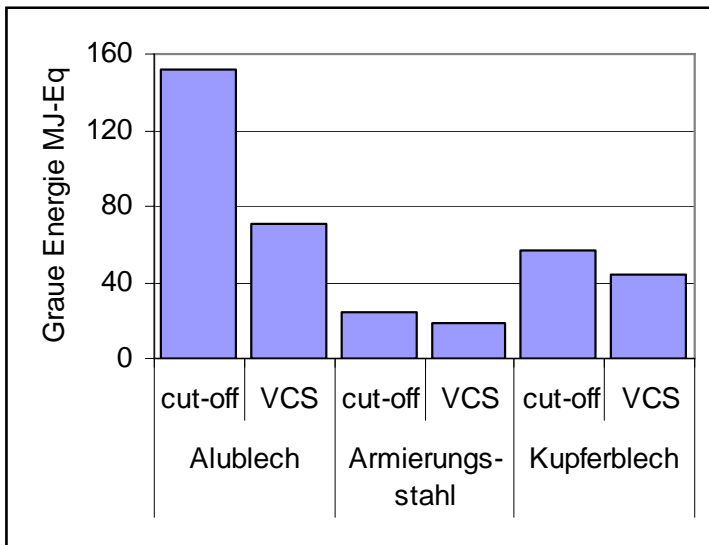
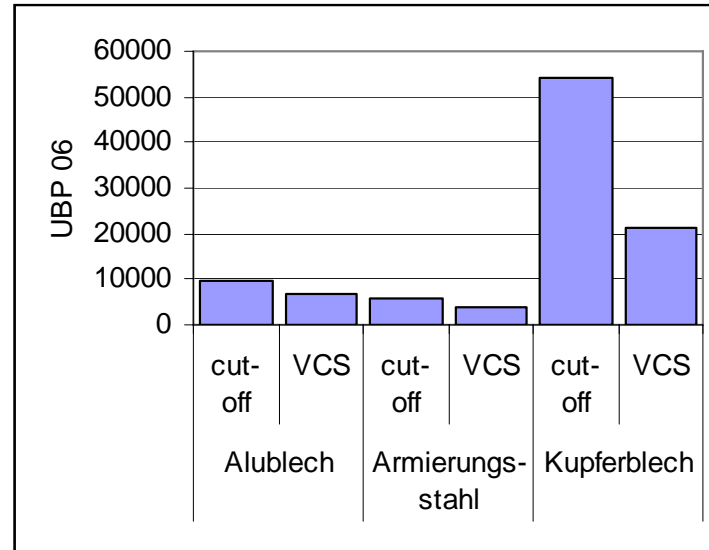
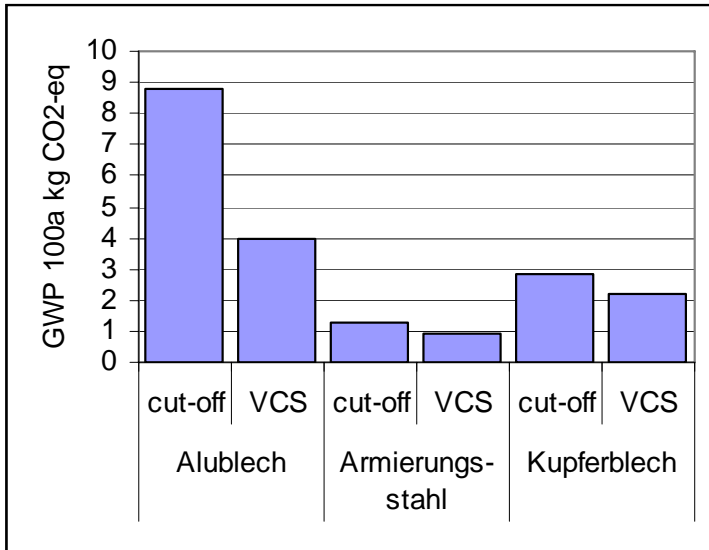


# System boundary / Cut-off criteria in ISO 14'044 (2006)

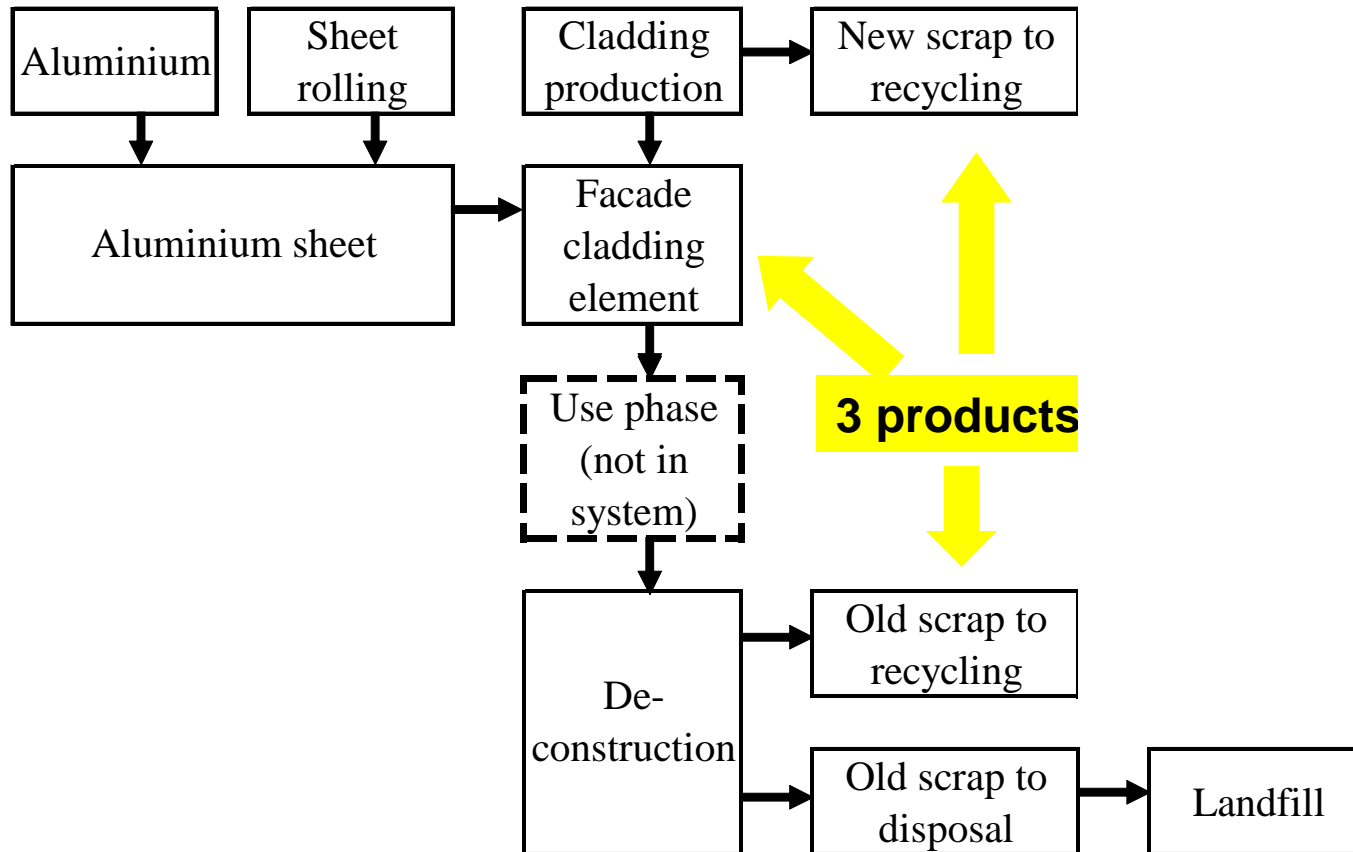
- The **deletion of** life cycle stages, processes, **inputs or outputs is only permitted if it does not significantly change the overall conclusions** of the study.
- The **cut-off criteria** for initial inclusion of inputs and outputs and the assumptions on which the cut-off criteria are established **shall be clearly described**. The **effect on the outcome** of the study of the cut-off criteria selected **shall also be assessed** and described in the final report.
- As cut-off criteria “should be used”:
  - mass
  - energy
  - environmental significance

Paragraph 4.2.3.3.1. / 4.2.3.3.3

# Effect of Cut-off



# Model of Production and End-Of-Life of a Aluminium Façade Cladding Element





# Recycling in ISO 14'044 (2006)

## 4.3.4.2 Allocation procedure

- a) **Step 1:** Wherever possible, **allocation should be avoided by**
  - 1) dividing the unit process to be allocated into two or more sub-processes and collecting the input and output data related to these sub-processes, or
  - 2) **expanding the product system to include the additional functions** related to the co-products, taking into account the requirements of 4.2.3.3.

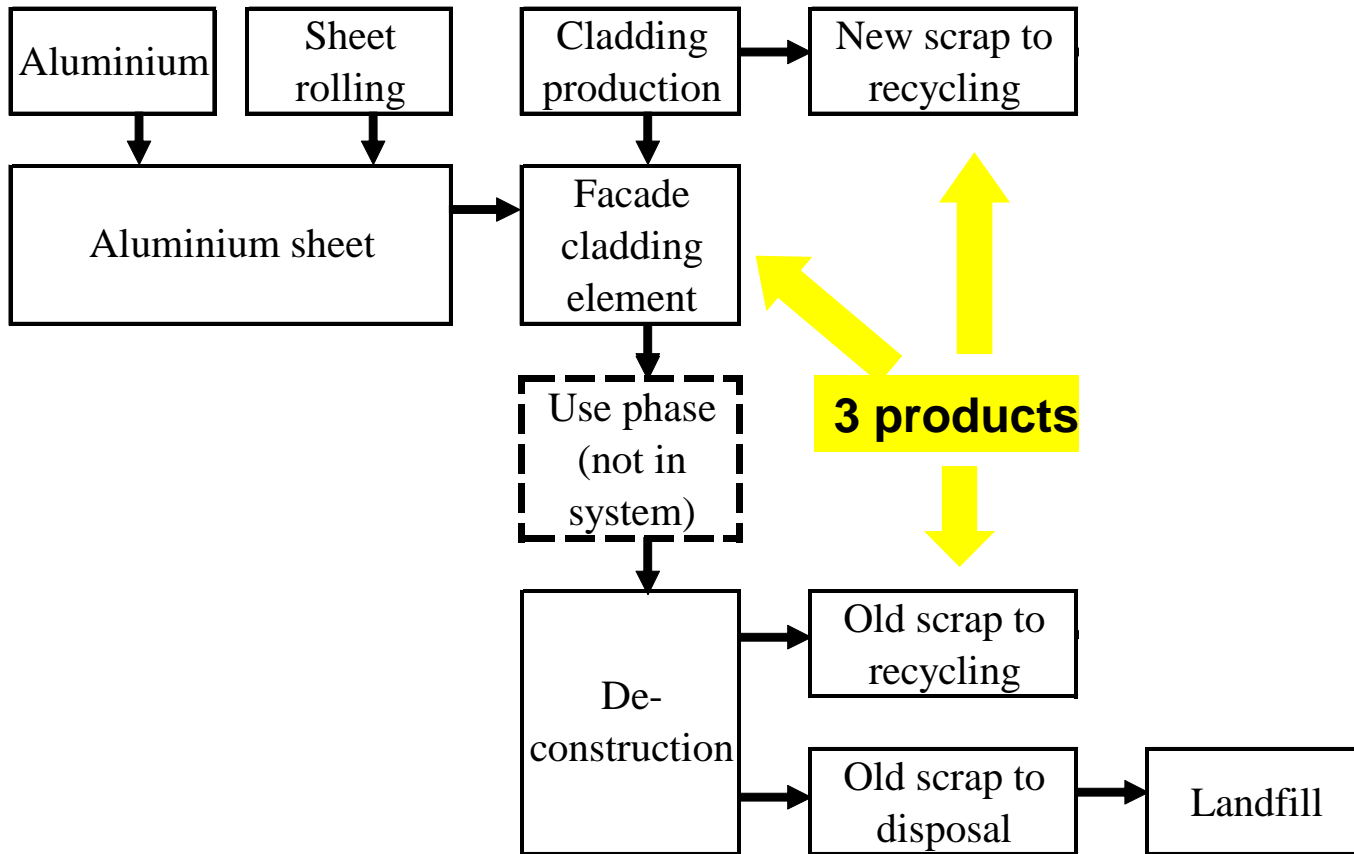
# Recycling in ISO 14'044 (2006)

Several allocation procedures are applicable for reuse and recycling...

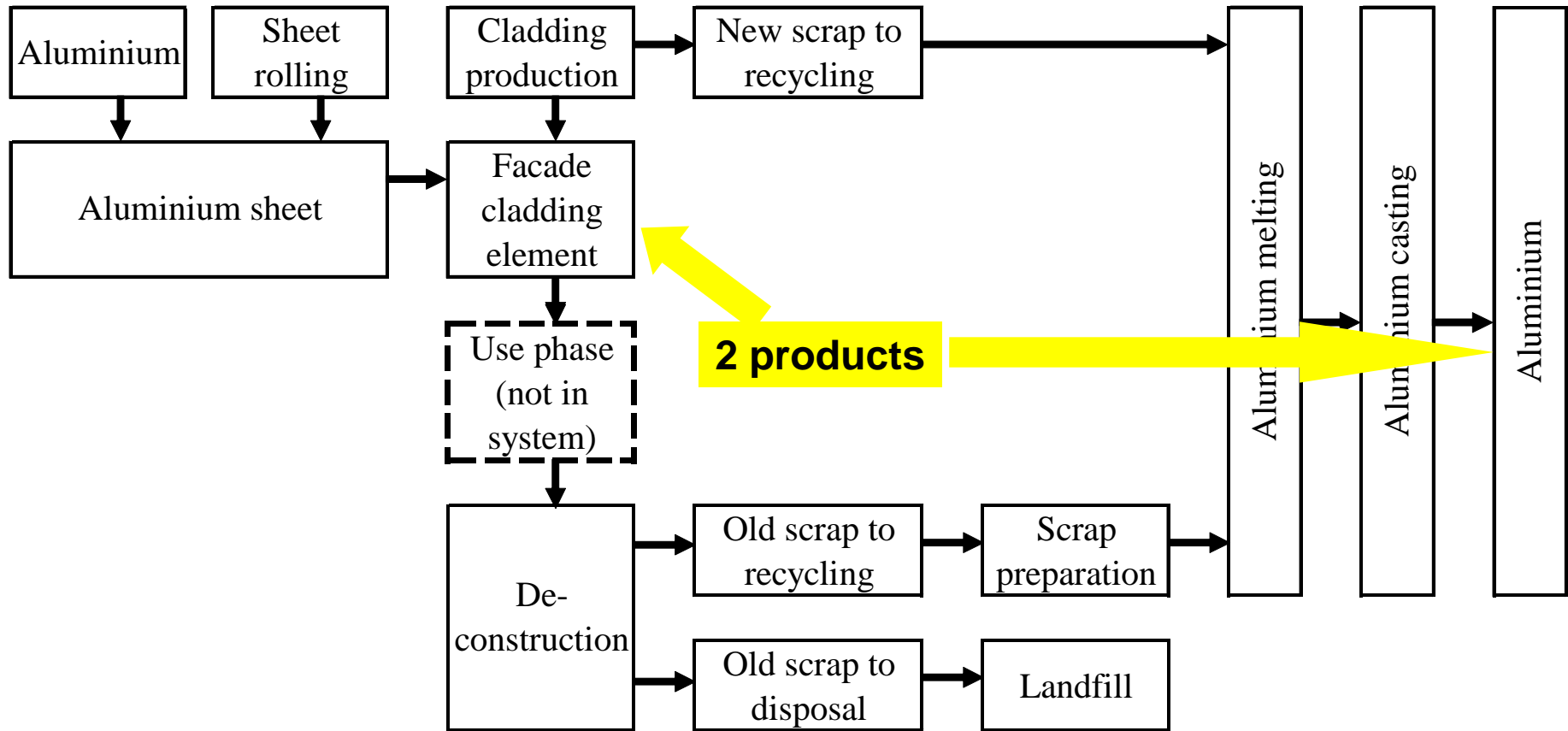
- A **closed-loop** allocation procedure ... also applies to open-loop product systems where **no changes** occur **in the inherent properties of the recycled material**. In such cases, the **need for allocation is avoided** since the use of secondary material displaces the use of virgin (primary) materials.
- An open-loop allocation procedure applies to open-loop product systems where the material is recycled into other product systems and the material undergoes a change to its inherent properties.

Paragraph 4.3.4.3.3

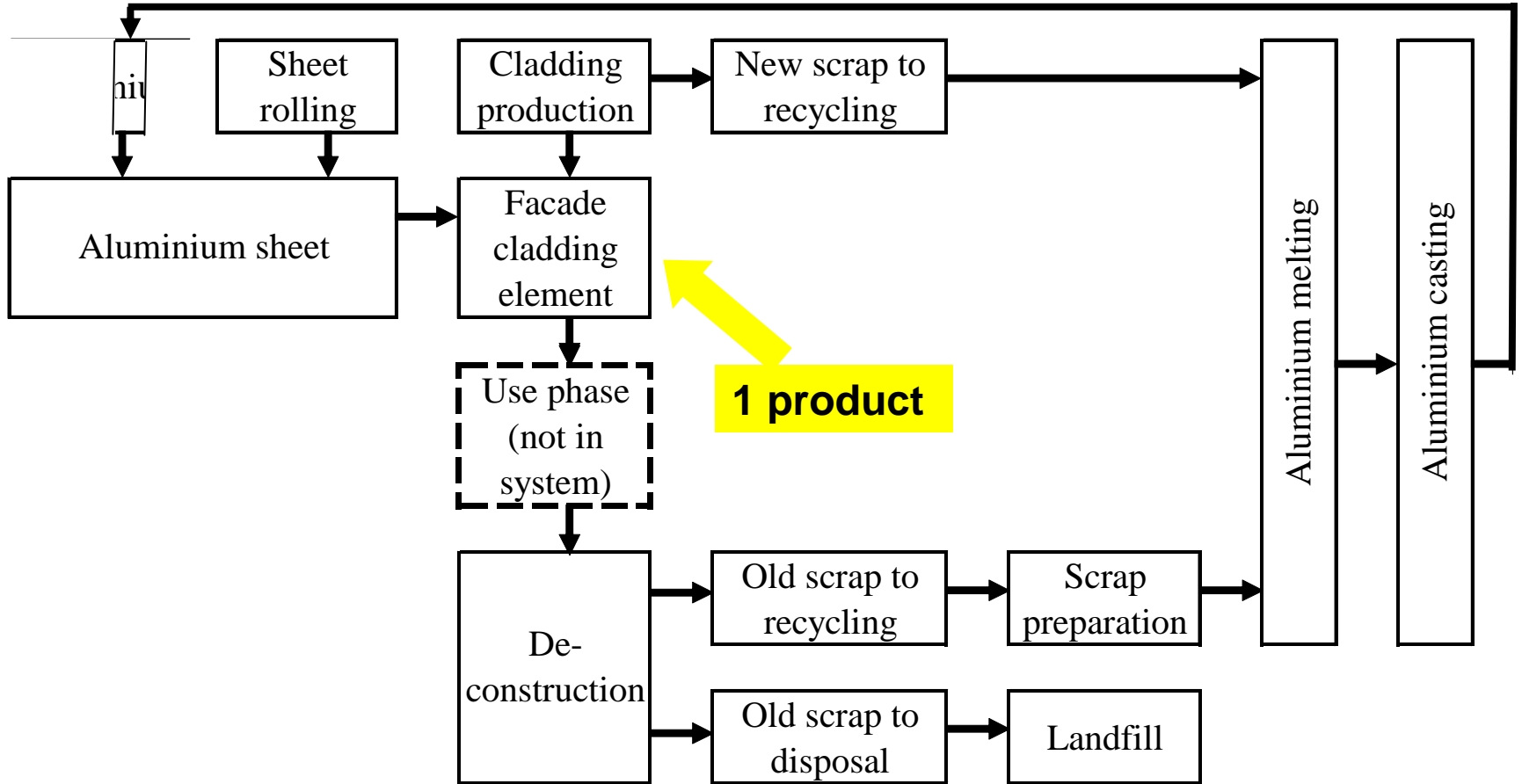
# Closed Loop Situation



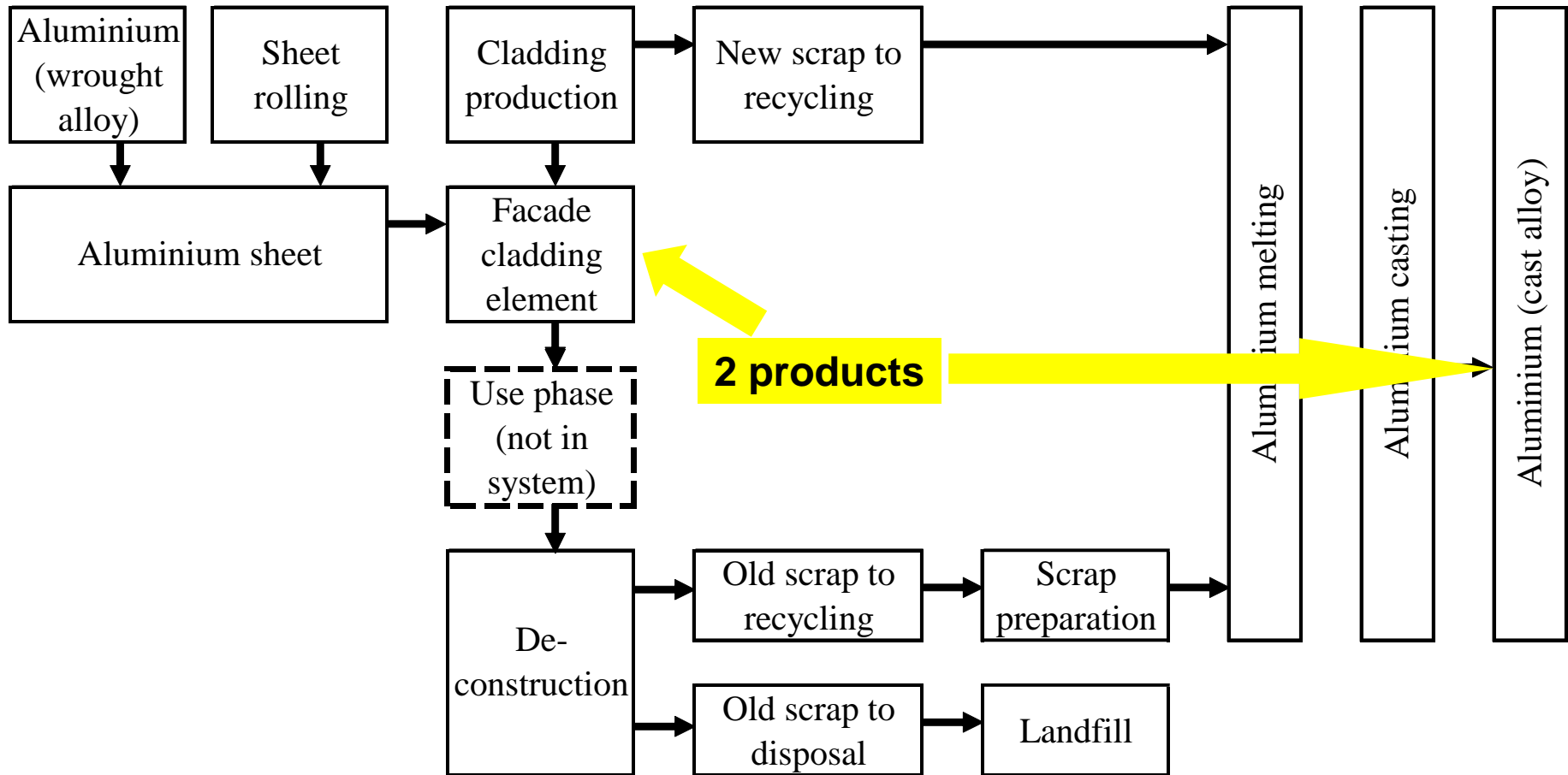
# Closed Loop Situation



# Closed Loop Situation



# Open Loop Situation



# Open Loop Situation: Further System Expansion

- Question: “By what would the recycled aluminium in the cast alloy production be substituted, if the façade cladding element would not be recycled?”
- Possible answers
  - a) by virgin aluminium
  - b) by additional recycling of other aluminium products
  - c) not at all (decrease in demand of cast alloy)
  - d) by a combination of a), b) and c)

# Open Loop Situation: Further System Expansion

- Question: What would be the result if we expand the system to include the recycling of other aluminium products and disposal of scrap?
  - Recycling avoids virgin aluminium (i.e. wrought alloy) production.
  - Result as if closed loop
- Possible answers:
  - a) by virgin aluminium
  - b) by additional recycling of other products
  - c) not at all (decrease in demand of cast alloy)
  - d) by a combination of a), b) and c)

→ Recycling avoids recycling of other aluminium products and disposal of scrap  
→ Result as if cut-off minus disposal

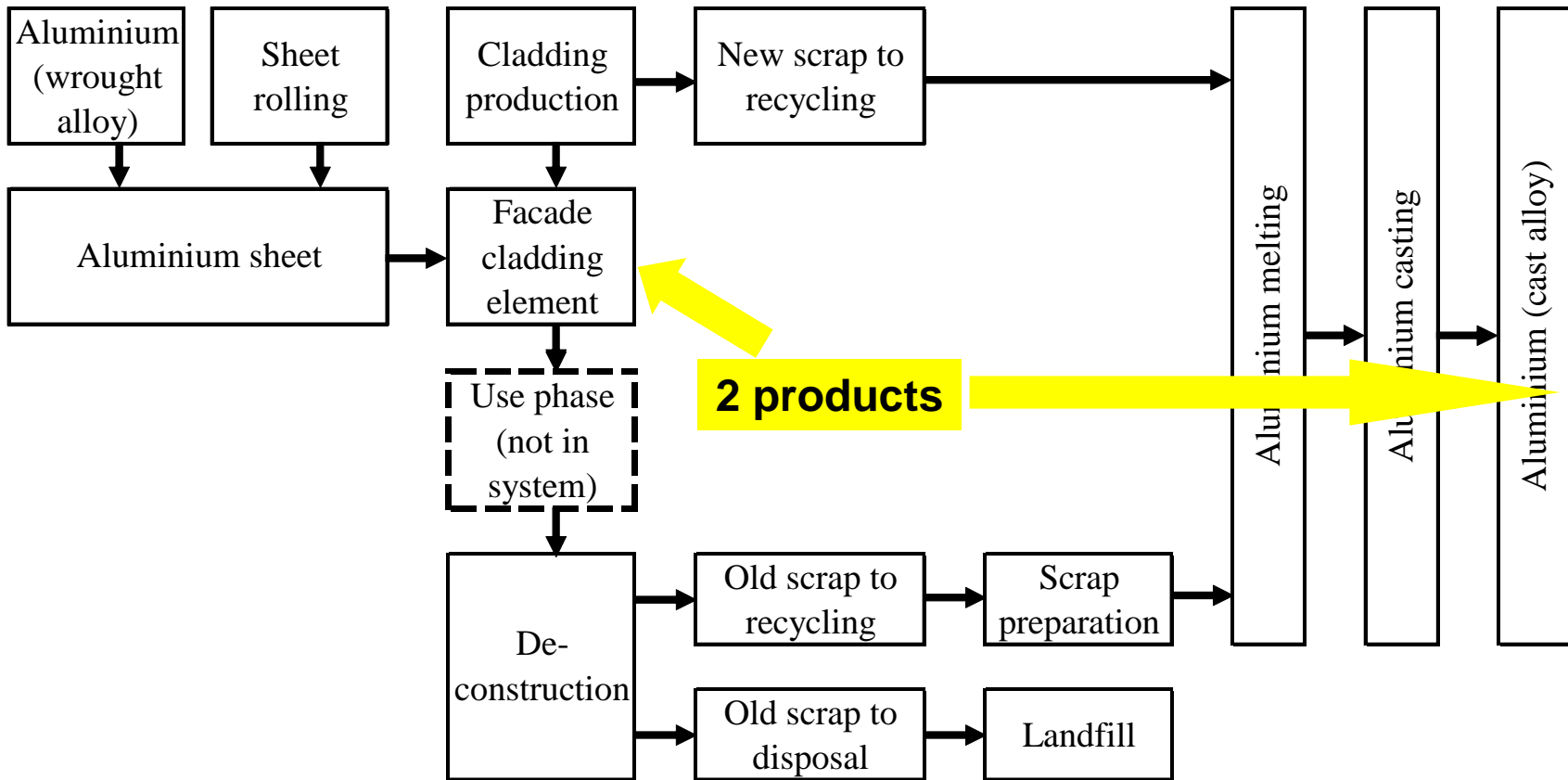
→ Recycling avoids completely other products  
→ Result depending



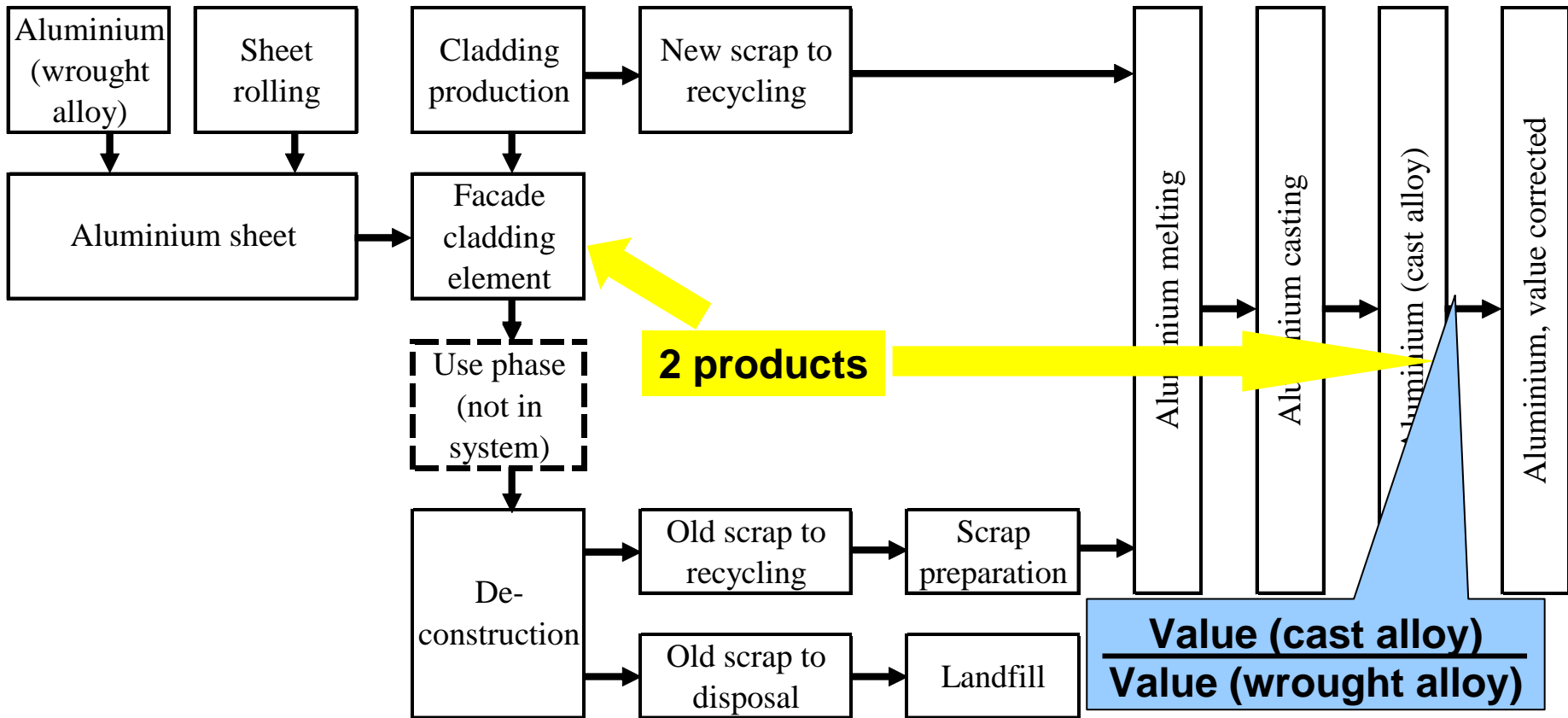
# Value Corrected Substitution: Thesis

- The difference in the economic values of virgin and recycled material represents the difference in the relevant inherent properties of these materials.
- ➔ Recycled material (from open loop recycling) is able to substitute for virgin material to the extent corresponding to the proportion of the recycled materials value to the virgin materials value.

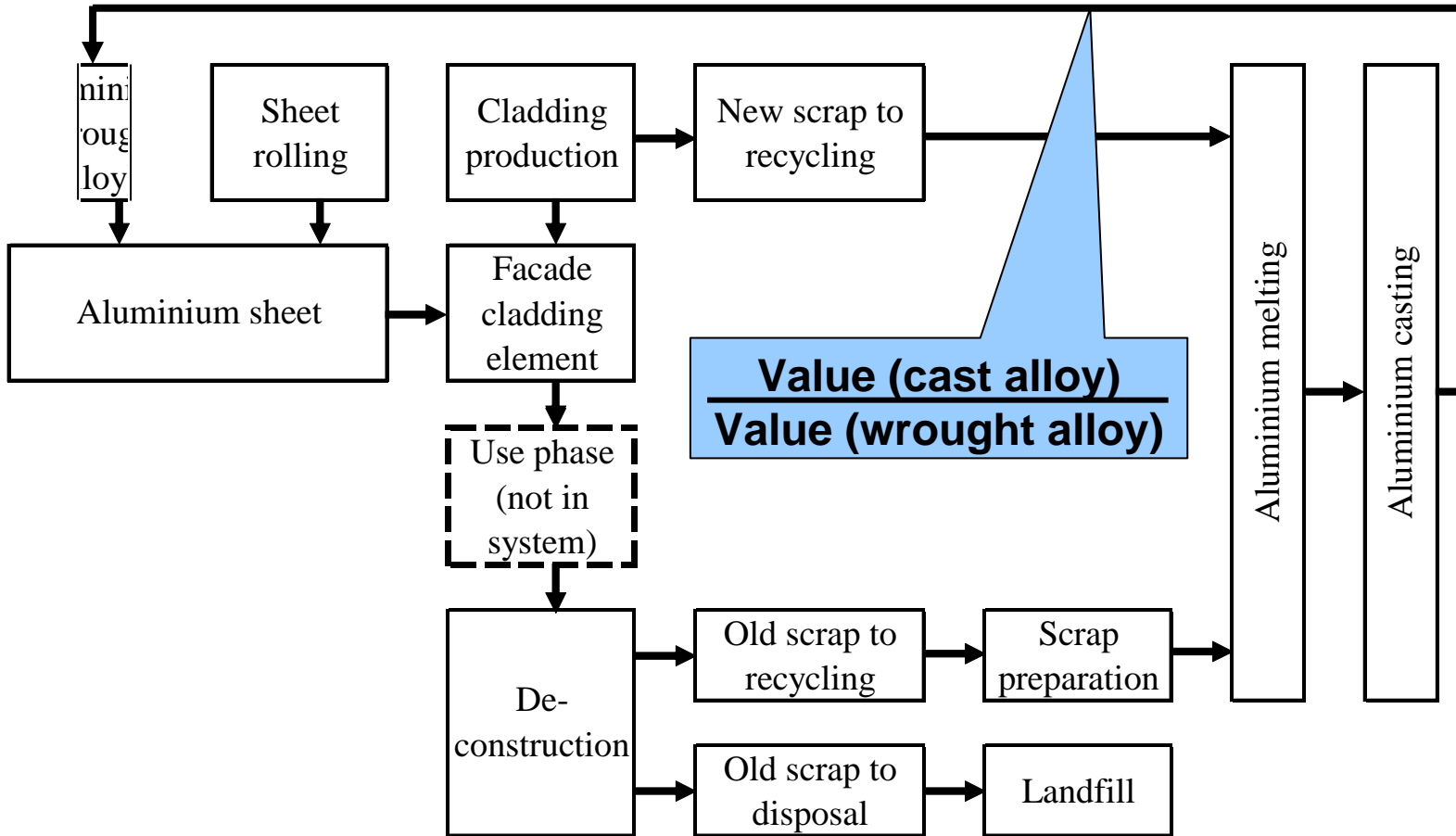
# Open Loop Situation: Value Corrected Substitution



# Open Loop Situation: Value Corrected Substitution



# Open Loop Situation: Value Corrected Substitution



# Recycling in ISO 14'040 / 14'044 (2006): Summary

- **Cut-off** of scrap to recycling is **only allowed** if scrap is **not relevant** from point of view of mass, energy or environmental significance
- **System expansion & substitution** is the first choice for dealing with recycling systems
- Straight forward for closed-loop recycling
- For open-loop recycling the choice of the substitute is ambiguous.  
→ Value correction as an alternative

# Goal & Scope in eco-devis

- “Das Ziel der eco-devis ist die Kennzeichnung von Baustoffen und Bauteilen innerhalb einer Funktionseinheit, die sich von anderen Varianten durch eine deutlich geringere Umweltbelastung auszeichnen.”
- “ökologisch interessante Materialien und Bauleistungen”
- “Vergleich innerhalb einer ganz bestimmten Anwendung und Funktion”
- “Sie [Die Beurteilung] umfasst alle wesentlichen Umweltauswirkungen während der Herstellung, der Verarbeitung, der Nutzung und der Entsorgung von Baustoffen”

**Source:** <http://www.ecodevis.ch/files/edMethD.pdf/>

# Goal & Scope in eco-devis

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- “ökologischer Vergleich von Baustoffen und Bauteilen innerhalb einer Funktionseinheit”
- “Vergleich von Baustoffen und Bauteilen innerhalb einer Funktionseinheit”
- “Sie [Die Beauftragten] sollen die Umweltbelastung der Verarbeitung von Baustoffen”

~~What are the environmental burdens of today's aluminium production?~~

~~or~~

What are the environmental consequences associated with the service provided by a aluminium façade cladding element?

Source: <http://www.ecodevis.ch/files/edMethD.pdf/>

# Valuation in eco-devis

Ökologische Merkmale	Charakterisierung	Bewertung und Gewichtung
<b>Herstellung</b>		
<b>Lösemittelemissionen</b> Beschichten und Befestigen	Menge pro Funktionseinheit, LRV-Klassen	Ausschluss der LRV-Klasse 1; Minimierung und spez. Bewertung gegenüber Grauer Energie
<b>Graue Energie</b> , Harmonisierte Werte	in MJ pro Funktionseinheit	Minimierung und spez. Bewertung gegenüber anderen Kriterien
<b>Verarbeitung</b>		
<b>Arbeitshygienische Risiken</b>	Giftklasse und/oder R-Sätze, Menge und Art	keine Bewertung; Hinweis auf Schutzmassnahmen als Zusatzbedingungen im eco-devis
<b>Lösemittelemissionen</b>	Menge pro Funktionseinheit, LRV-Klassen	Ausschluss der LRV-Klasse 1; Minimierung und spez. Bewertung gegenüber Graue Energie
<b>Nutzung</b>		
<b>Ökologisch und toxikologisch relevante Bestandteile</b>	Menge, Giftklasse und/oder R-Sätze	Ausschluss für gew. R-Sätze, spez. Risikoabschätzung und Gewichtung gegenüber anderen Merkmalen
<b>Emittierbare Schadstoffe</b>	Lignum CH 6.5, GuT, Menge Schwermetalle pro Funktionseinheit	Standards als Zusatzbedingung im eco-devis, spez. Risikoabschätzung und Gewichtung der Schwermetalle gegenüber anderen Merkmalen
<b>Entsorgung</b>		
<b>Verwertung</b>	verwertbar oder nicht verwertbar	Minimalanforderungen an Entsorgung: (mindestens ein Kriterium erfüllt)
<b>Verbrennung</b> Schadstoffgehalte	Höchstwerte unter- oder überschritten	a) entweder verwertbar oder b) Höchstwerte unterschritten oder
<b>Ablagerung auf Deponien</b>	Inertstoffdeponie, Reaktordeponie	c) Anforderung an Inertstoffdeponie erfüllt

**Source:**  
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# Valuation in eco-devis

Ökologische Merkmale	Charakterisierung	Bewertung und Gewichtung
Herstellung		
Lösemittlemissionen Beschichten und Befestigen	Menge pro Funktionseinheit, LRV-Klassen	
Graue Energie, Harmonisierte Werte	in MJ/m <sup>2</sup>	
Verarbeitung		
Arbeitshygienische Risiken	Giftklasse und R-Sätze, Menge und	
Lösemittlemissionen	Menge pro Funktionseinheit, LRV-Klassen	
Nutzung		
Ökologisch und toxikologisch relevante Bestandteile	Menge, Giftklasse und/oder R-Sätze	
Emittierbare Schadstoffe	Lignum CH 6.5, GuT, Menge Schwermetalle pro Funktionseinheit	
Entsorgung		
Verwertung	verwertbar oder nicht verwertbar	
Verbrennung Schadstoffgehalte	Höchstwerte unter- oder überschritten	a) Höchstwerte unterschritten oder b) Höchstwerte unterschritten oder
Ablagerung auf Deponien	Inertstoffdeponie, Reaktordeponie	c) Anforderung an Inertstoffdeponie erfüllt

“als Mass für den Ressourcenverbrauch und die Umweltbelastung **bei der Herstellung** eines Baumaterials werden die **Graue Energie** und die Lösemittlemissionen ... verwendet”

“**Bei vielen Baustoffen hat die Graue Energie eine vorrangige Stellung**, da die Herstellung mit Abstand der umweltrelevanteste ‘Lebensabschnitt’ ist.”

Source:  
<http://www.ecodevis.ch/files/edMethD.pdf/>



# Goal, Scope and Valuation in eco-devis Discussion

- Goal & Scope ask for a product specific LCA including production, use and EOL.  
“Graue Energie”, is not product specific but material specific.
- “Graue Energie” covers only the production, not use and EOL
- “Graue Energie” is often “the most important criterion”. This, of course is a valuation on no (scientific) basis!

# Goal, Scope and Valuation in eco-devis Discussion

- Goal & Scope ask for a product specific LCA including production, use and EOL.

“Graue Energie” is not product specific but material specific

- “Graue Energie” is not product specific but material specific

- “Graue Energie” is not product specific but material specific

**What are the environmental burdens of today's aluminium production?**

**or**

~~**What are the environmental consequences associated with the service provided by a aluminium façade cladding element?**~~

# Conclusions

- The goal & scope of eco-devis could be achieved by LCA.
- The application of LCA results (“Graue Energie”) in eco-devis today is not in accordance with the stated goal & scope of ecodevis
- LCA would need to cover not only the production, but also use and EOL
- LCA (explicitly LCI modelling) would need to look carefully at the issue of recycling

Thank you...  
...and sorry for the inconvenience

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