The use of LCA as a business opportunity and the MATHER approach

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ICT Applications for Monitoring Electrical & Electronic Appliances
Environmental Friendly & Sustainable Life Cycle
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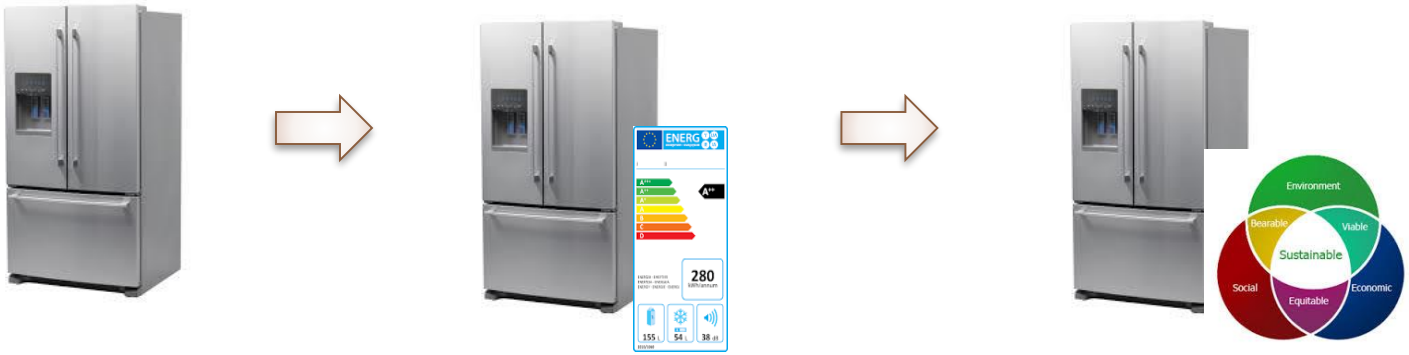
MATHER in a nutshell

Double business approach for consumer products' sustainability

- Use of **LCA as a business driver** & new eco-labeling technology



- **Re-engineer conventional functions** of LCA to motivate sustainable manufacturing

Outline

- Consumer awareness and green products
- Eco-labeling on electric appliances
- LCA for environmental control & monitoring
- The MATHER approach:
  - Steps of the methodological approach
- Reverse-engineer decision making
  - Use LCA as a decision support tool
- Introduction to the appliances of the future

Consumer products, public awareness

- Price first but environment matters, does it not?
- Climate change
  - Emissions from product manufacturing
  - *Does my product contribute to GHG?*
- Resource depletion
  - Energy consumption in manufacturing & use
  - Water depletion
  - *Does my product deplete planet resources?*
- Health impacts
  - Workers' exposure on chemicals
  - Hazardous materials
  - *How about a safer product?*
- Environmental impacts at disposal
  - Difficult disassembly
  - Hazardous materials
  - *How recyclable are the product components?*

Consumers are shaping up new attitudes!

Towards sustainable & green products

- What is the actual basis of “green" products?
  - Different perspectives and views
  - Is it all vague?
- Widely accepted ‘features’
  - Products reused without ‘effort’
    - recycled construction material
    - Ease to reassemble
    - Biodegradable
  - Production resources
    - natural resources
    - Renewable resources
  - Operational efficiency
    - Energy efficiency
    - Ease of maintenance

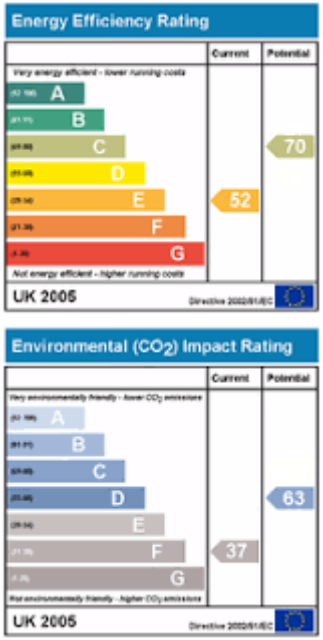
Still, a vague scope and description that is difficult to trade-off with costs and profits

Eco-labelling: the big picture

- Where applied: characteristics of a product or service
- Purpose:
  - indication of environmental impact
  - inform consumers and enhance business to business relationships
- International Standards Organisation (ISO) classification:
- Types of labeling
  - Ecolabelling –highest value
  - Type II - self-declaration claims
  - Type III -environmental declarations (e.g. report cards/information labels)
- Quantative reports: essential on eco-labelling, necessary to all types
- LCA – the widely accepted approach to quantitative analysis

Early eco-labelling: emphasis on efficiency

- Quantify appliance performance, efficiency and life-time with the user



- But how about the life-time of the
  - Manufacturing process
  - Materials and resources used in the production?

Life Cycle Assessment (LCA)

- What exactly is LCA, is it inclusive enough?
- How and when it started, how does it function?
- Is it enough to produce ‘green products’ or does it function as a monitoring approach?

LCA – what and when

LCA is the compilation and the evaluation of the inputs, outputs and the environmental impacts of a product system throughout its life cycle

- 1987, World Commission on Environment and Development, WCED
  - "Our common future", commonly known as Brundtland Report
- 1992, UN World Summit on Sustainable Development (UN WSSD), Earth Summit, Rio
- Sustainability and Chemical Engineering
  - 2001. World Chemical Engineering Council (WCEC), Melbourne communique
- 2002, UN World Summit on Sustainable Development (UN WSSD), Johannesburg

Connecting qualitative & quantitative features

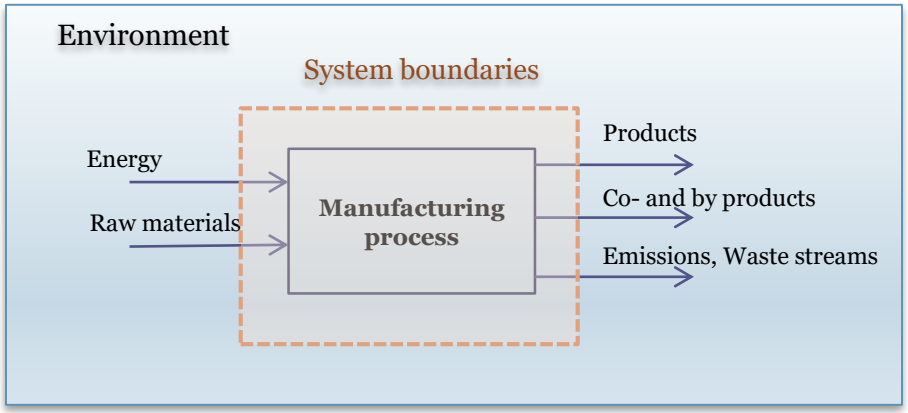
- Metrics, national scale
  - UK: Department of Environment, Food and Rural Affairs, Defra
  - 2005. Programme for securing the future, UK Government Sustainable Development Strategy
- Metrics, UN Commission
  - 1992. Metrics by on Sustainable Development (CSD)
- Metrics, European Union Council
    - 2001, 2006. Sustainable Development Strategy

Connecting qualitative & quantitative features (2)

- Metrics, corporate sustainability
  - 2000. World Business Council for Sustainable Development (WBCSD)
- Metrics, Institutional level
  - 2002. IChemE, Institute of Chemical Engineering
- Metrics and approach,
  - 2010. BASF, Chemical Industry on behalf of all industrial sectors (SEEBalance®)
- Global Reporting Initiative, GRI

LCA: changing a conventional perspective

Narrow-focused inventories: neglect upstream or downstream implications

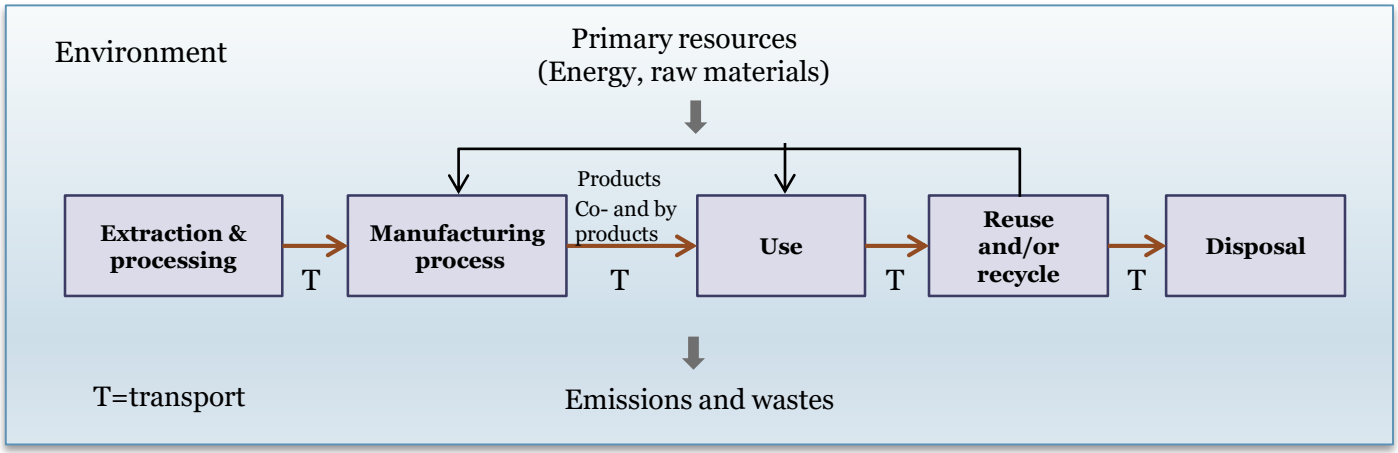


Emphasis on

- Proper utilization of co-products
- Reduction, recycling and reuse of waste flows
- Energy conservations and recovery
- Technological interventions such as CHP units

The alternative perspective

The "life cycle" point of view



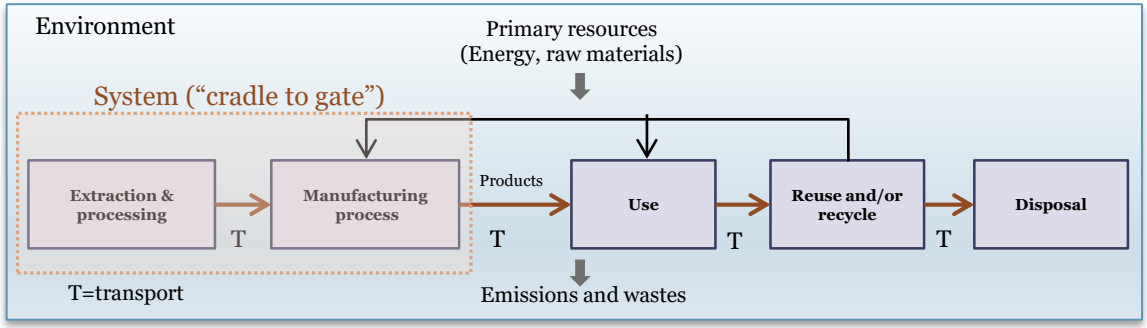
- Widen system boundaries including upstream and downstream processes/activities
- "Key" points in the approach
  - Starting point representing extraction and production of raw materials ("cradle")
  - Final point representing disposal activities ("grave")

Analysis based on mass& energy balances
Analysis based on third party solutions and approaches

Versions: upstream, downstream, holistic

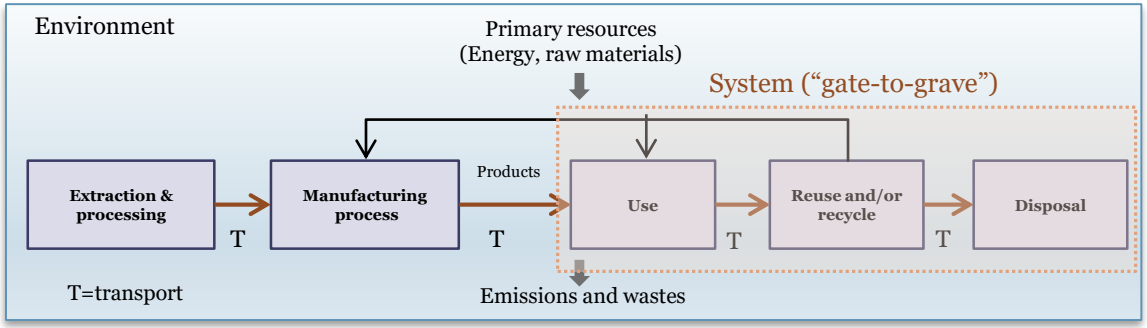
"Cradle-to-gate"

- Applications (e.g. commodities)
  - New sources of feedstocks and raw materials
  - Substitution of conventional products in the "use"stage and other downstream stages



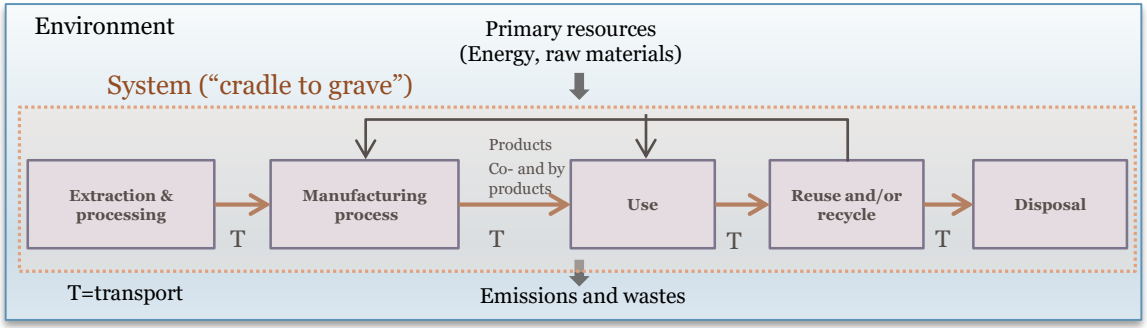
"Gate –to- grave"

- Applications (e.g. market studies)
  - Product portfolio produced from a particular raw material
  - Alternative technologies of raw material/intermediate product valorization

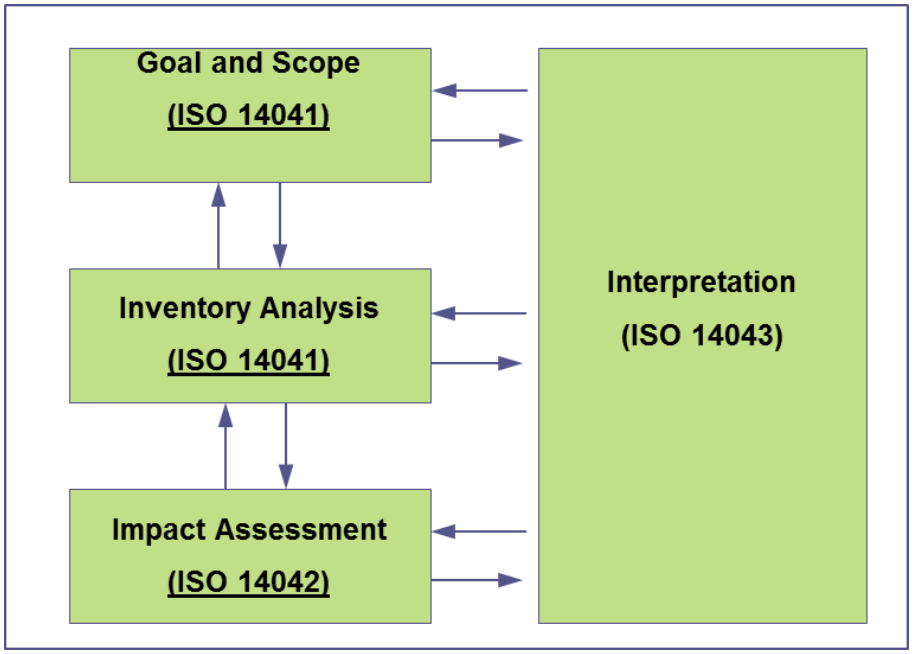


"Cradle-to-grave"

- Holistic approach
- Especially of new technologies, processes and products (e.g biofuels, PV solar panels)



LCA quantitative framework



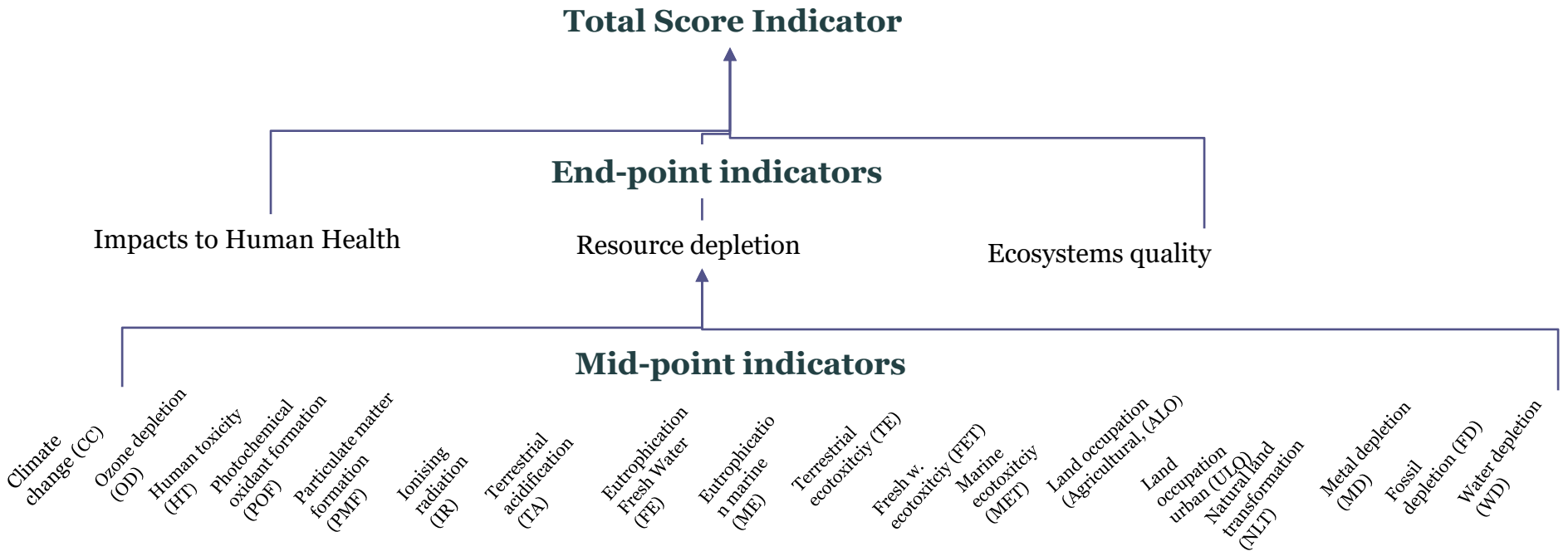
ISO 14040, four consecutive phases:

1. Goal and scope of LCA
2. LCI phase
3. LCIA phase
4. Interpretation phase

ISO implementation

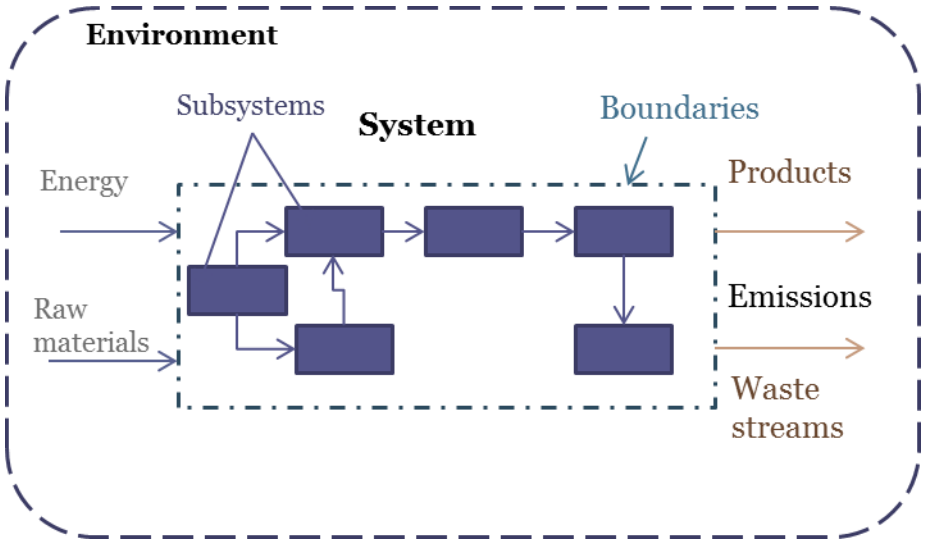
- *Step 1 Goal and scope*
  - Goal: guides analysis: Intended use, reasons for study
  - Scope: Functional unit, system boundary, methodological choices
- *Step 2 Inventory analysis*
  - *Data collection*
  - *Environmental burdens*
- *Step 3 Impact assessment*
  - *Classification: Impact assessment, category indicators and models*
  - *Characterization: calculation of category indicator results*
- *Step 4 - Interpretation*

Data flows and evaluation structure



Data flows and impact categories

Amount of a burden j produced from a system:



$$B_j = \sum_{i=1}^{I} bc_{j,i} \cdot x_i$$

- $bc_{j,\iota}$ - burden j from subsystem i
- X_i - mass or energy flow associated with subsystem i

Impact and midpoint categories

- inputs & outputs assigned to *impact categories*
- potential impacts quantified to *characterization factors*
- calculated relative to reference substances

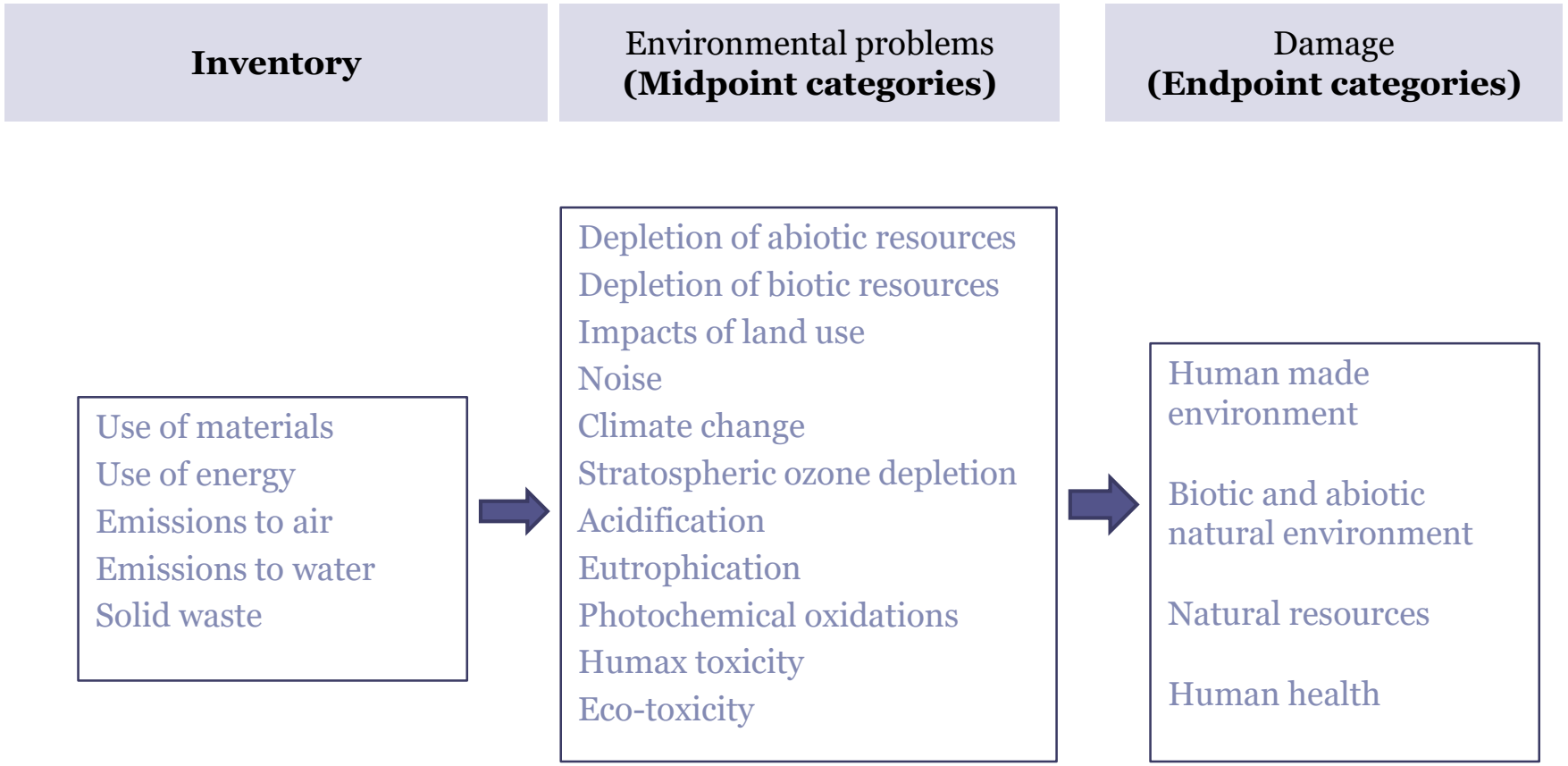
$$E_k = \sum_{j=1}^{J} ec_{k,j} \cdot B_j \qquad D_k = w \cdot Ek$$

- $ec_{k,j}$ - characterization for *Bj* with relative contribution impact *Ek*
- Bj - stream from inventory analysis
- w – weighting factor

Endpoint *damage categories*, D_k, are weighted sums of midpoint categories

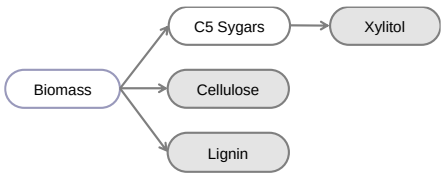
- Problem oriented approaches
  - CML 2 baseline 2000, Institute of Environmental Sciences Leiden University
  - TRACI (US EPA): Tools for the Reduction and Assessment of Chemical and Environmental Impacts
- Damage oriented approaches
  - Ecoindicator 99

From numbers to assessment

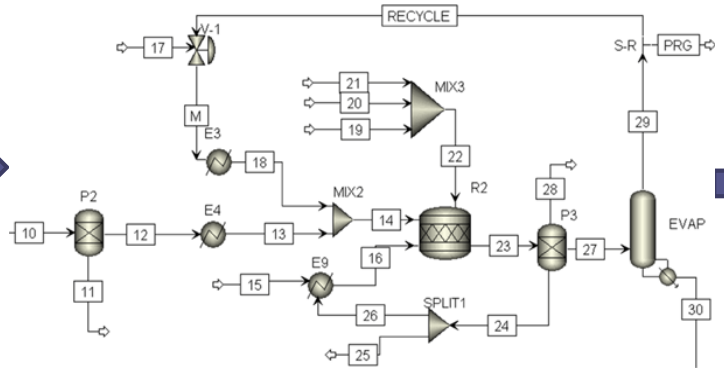


LCA use in industrial context

Background system

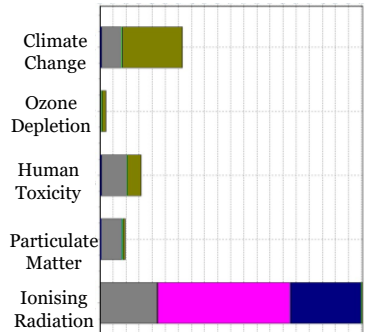


Foreground system

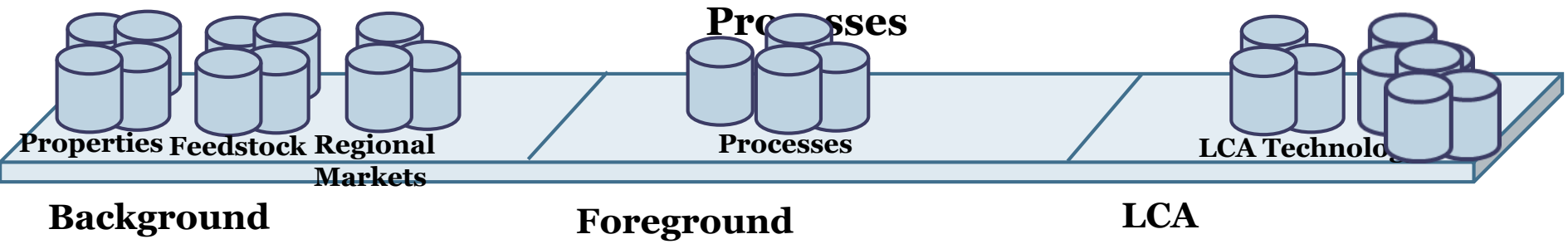


Chemicals

LCA performance



Background ⇨ **Foreground** ⇨ **LCA**



Work primarily focused on industrial plants…

How about consumer products?

Corporate data flows: the case of a blender

- Bill of materials (BoM)

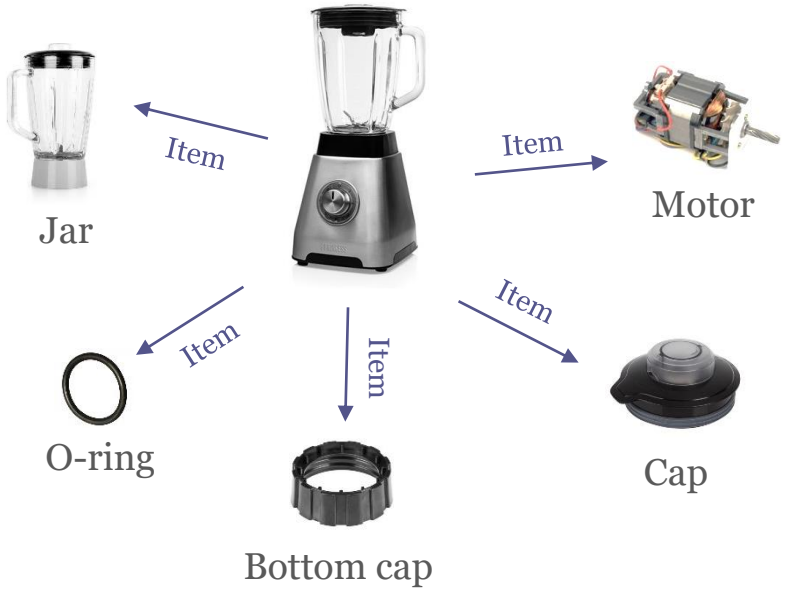
Items of the appliance through assembly

  - Item → Component → Material
  - e.g. Motor → rotor → steel

- Full material disclosure (FMD)

Construction material & source

- Item → Component → Material
- Material → Substance
- e.g. Motor → rotor → steel
- Steel → silicon, iron



- Manufacturing data

Obtained from manufacturing units

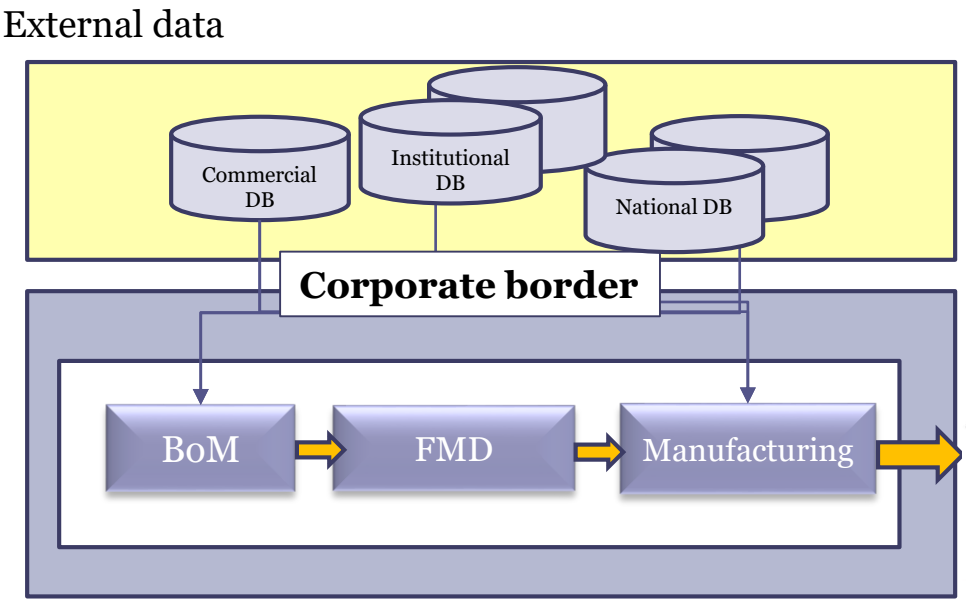
  - Natural gas, electricity, Municipal water, Wastewater, wastes

Cross-corporate data flows should fill in the picture!

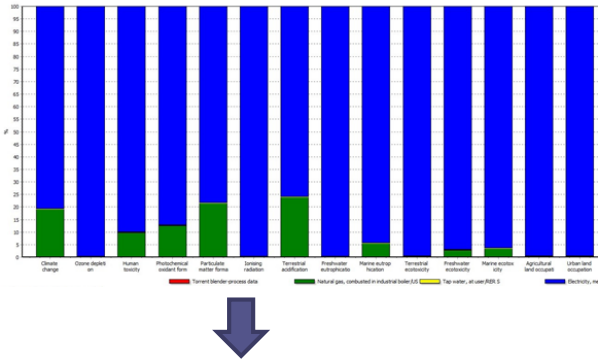
Open and commercial data sources

- Institutional data
  - materials, processes, energy use
  - Safety, health
- Open LCA or academic repositories
- Benchmark research and institutional studies
- Commercial software
  - Primary data (materials & processes)
  - SOPs for ISO implementation
  - Impact indicators
  - Mid and endpoint calculations
- SimaPro, Umberto, Gabi
- Ecoinvent database
  - Widely used in Europe
- USLCI database
  - US based

Integrated data flows: what is the purpose?

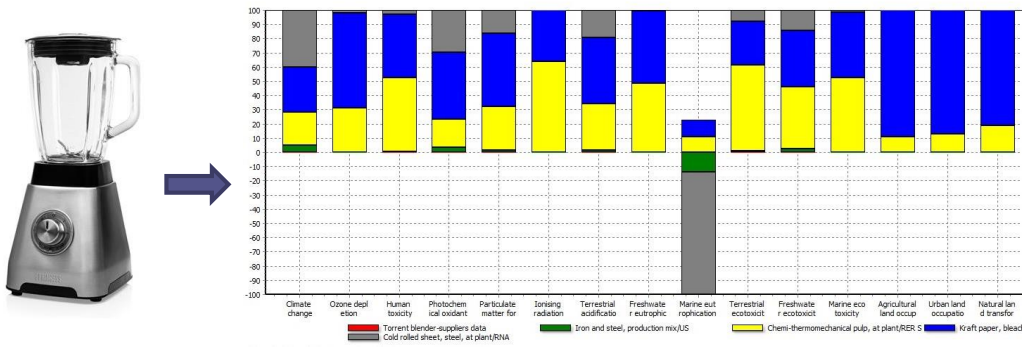


LCA performance



- New product features emerge as ‘new value’ (green value)
- Concept could
  - be **extended hundreds and thousands** of similar appliances
  - Motivate **better manufacturing** and **material selection**
  - Set a healthy basis for competition and transparency

Both corporate and social benefits



LCA results for items

- New concept is not a regulation!
- Means to promote/explain strengths of products
  - Can be used internally or externally
  - Internally: amend product lines
  - Externally: promote greener products
- Green does not always mean more expensive
- Social benefits
  - Transparent interaction with manufacturers
  - Means to connect environmental quality with price

Climate change
Ozone depletion
Human toxicity
Photochemical oxidant formation
Particulate matter formation
Ionising radiation
Terrestrial acidification
Freshwater eutrophication
Marine eutrophication
Terrestrial ecotoxicity
Freshwater ecotoxicity
Marine ecotoxicity
Agricultural land occupation
Urban land occupation
Natural land transformation
Water depletion
Metal depletion
Fossil depletion

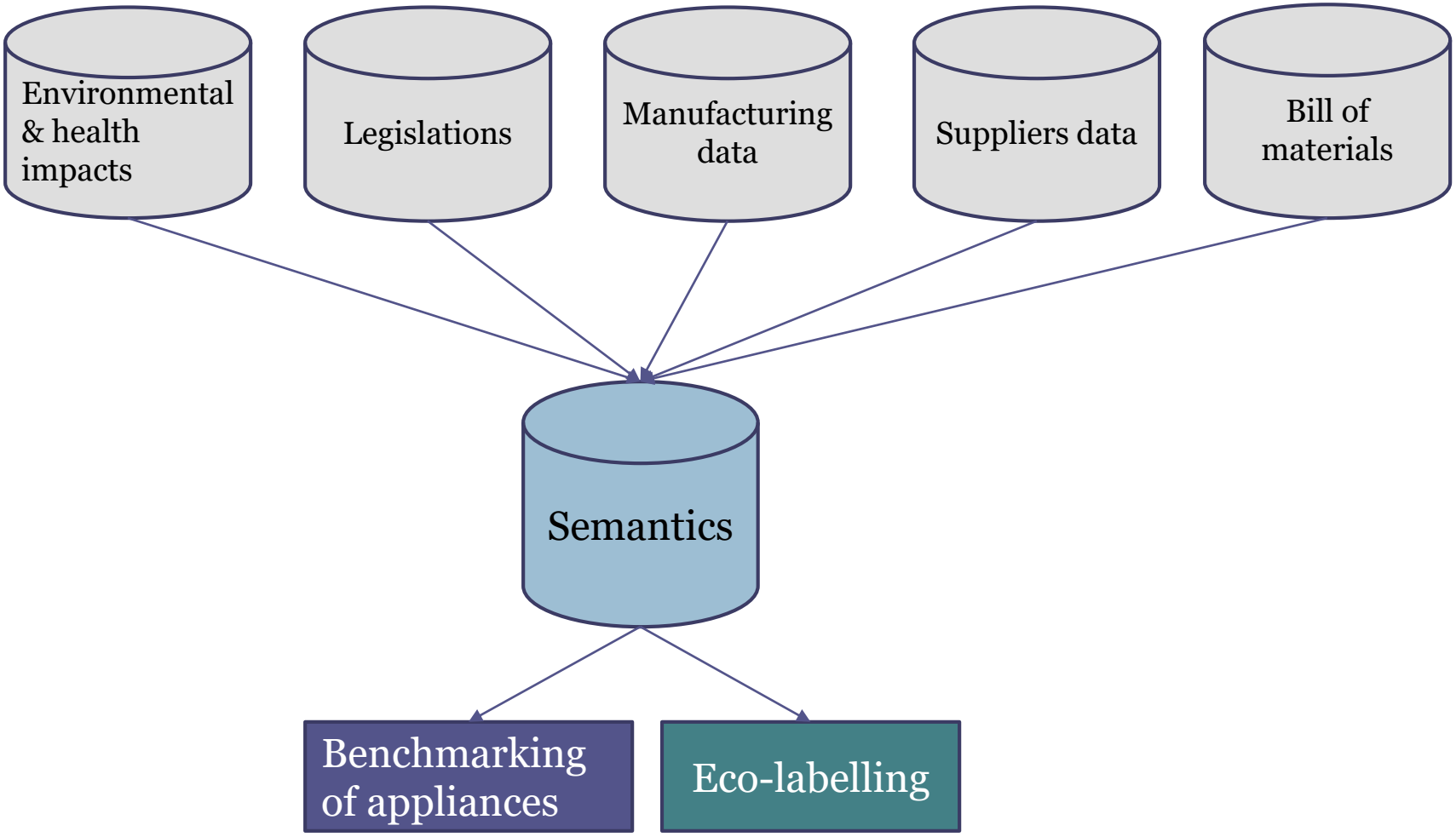
Technically feasible?

The MATHER approach: engineering green value chains in the digital era

Semantics and data integration

- Conceptualize environmental aspects using knowledge models
- Build properties, reasoning tools, and automated technology to screen and scope
- Enable high-throughput analysis
- Reverse-engineer paths to support manufacturing and design

Semantically enabled data & ontologies



MATHER CONSORTIUM PARTNERS

Whirlpool CORPORATION

COORDINATOR

Provides the LIFE MATHER Tool requirements, data on manufacturing processes and data on products and components. It will also validate the tool with a sample of its products.

t2i trasferimento tecnologico innovazione

Replication focuses activities to involve EU companies for the LIFE MATHER tool validation. Socio economic impacts analysis and dissemination

IPSEN Industrial Process Systems Engineering Unit

IT development of the LIFE MATHER Tool including DBs integration. Knowhow and tool integration of principles of LCA and impacts on the environment and chemicals data.

The MATHER sustainability workflow

Background system

Foreground system

LCA performance

Background data

- FMD data
- Manufacturing data
- Supplier data
- Legislation

Foreground analysis

- Decomposition analysis per material/item
- Waste streams
- Analytics per appliance

LCA analysis

- Health & environmental indicators
- Ecoinvent & SimaPro
- Comparison of materials profile

Consumer products

Supply lines Materials Legislation

Manufacturing

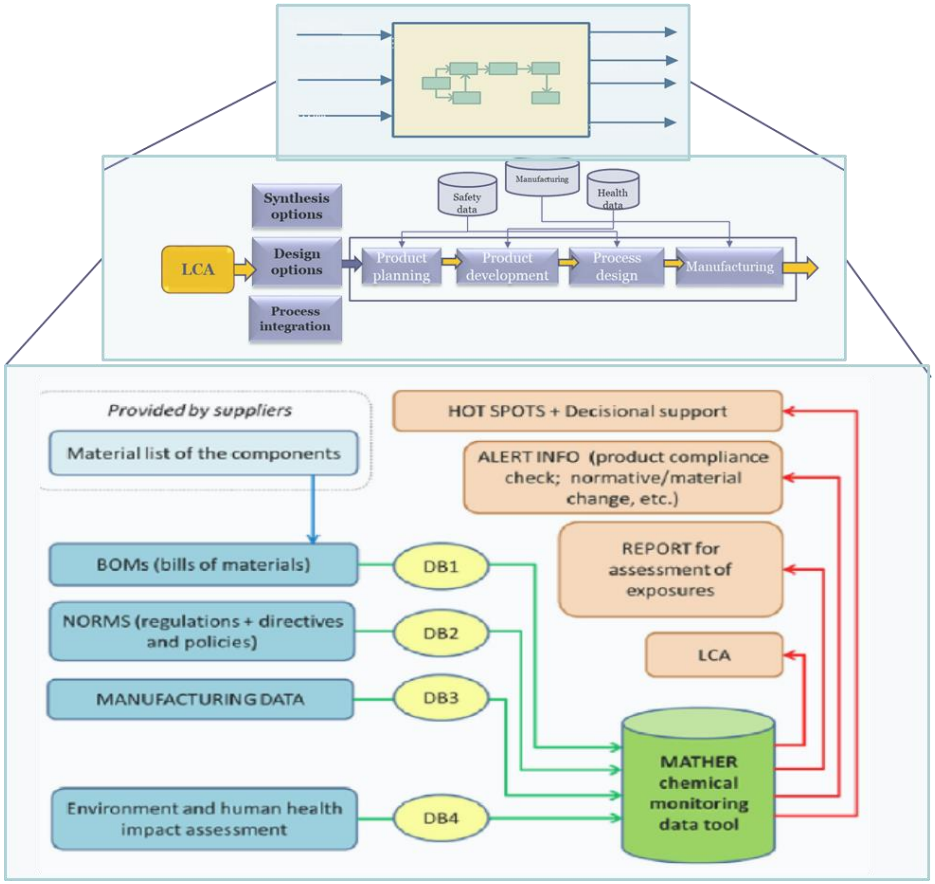
LCIs

Background

Foreground

LCA

The layered MATHER approach

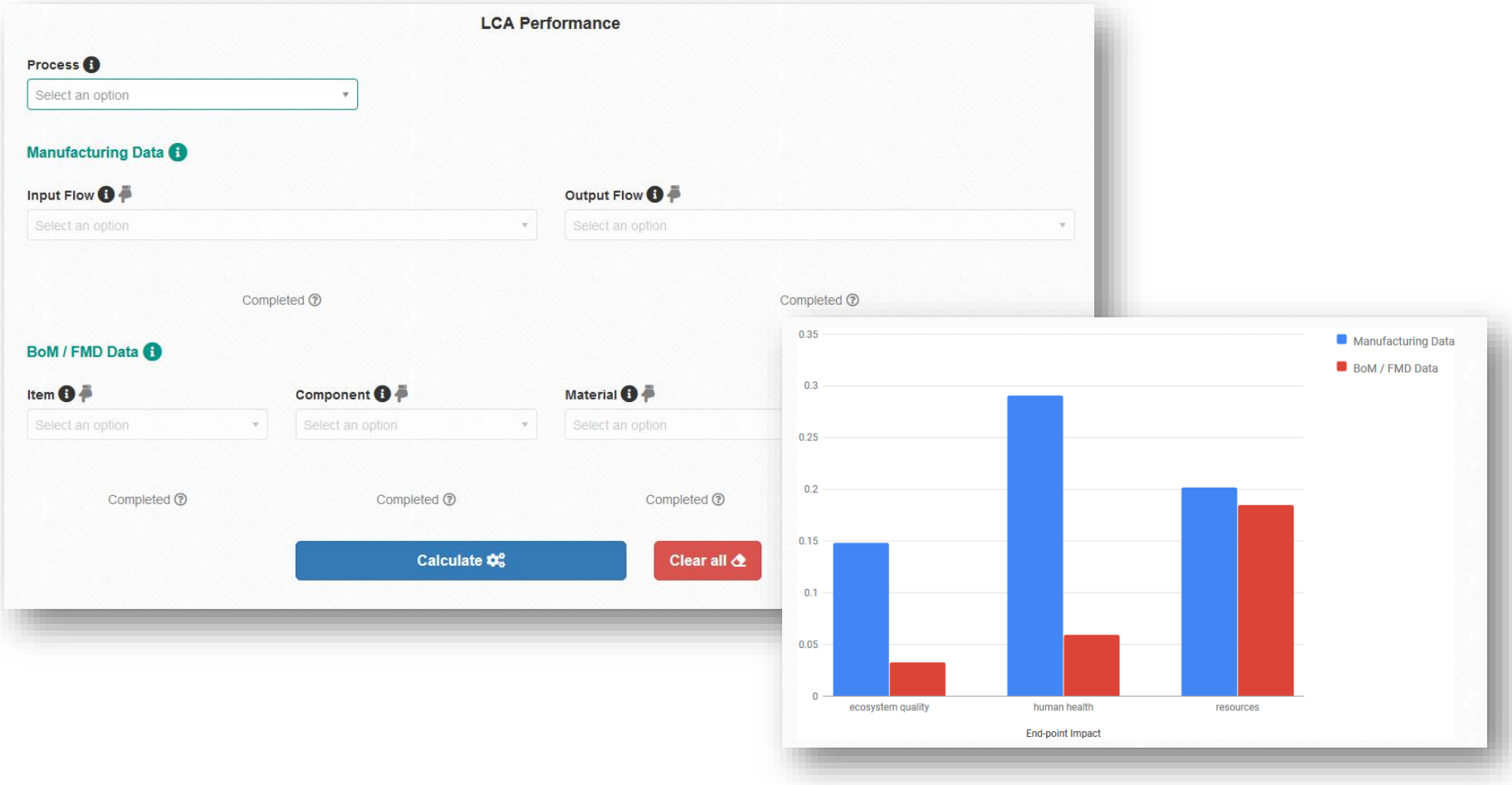


Capture external data & knowledge

Integrate data with internal databases

Enable reasoning and screening

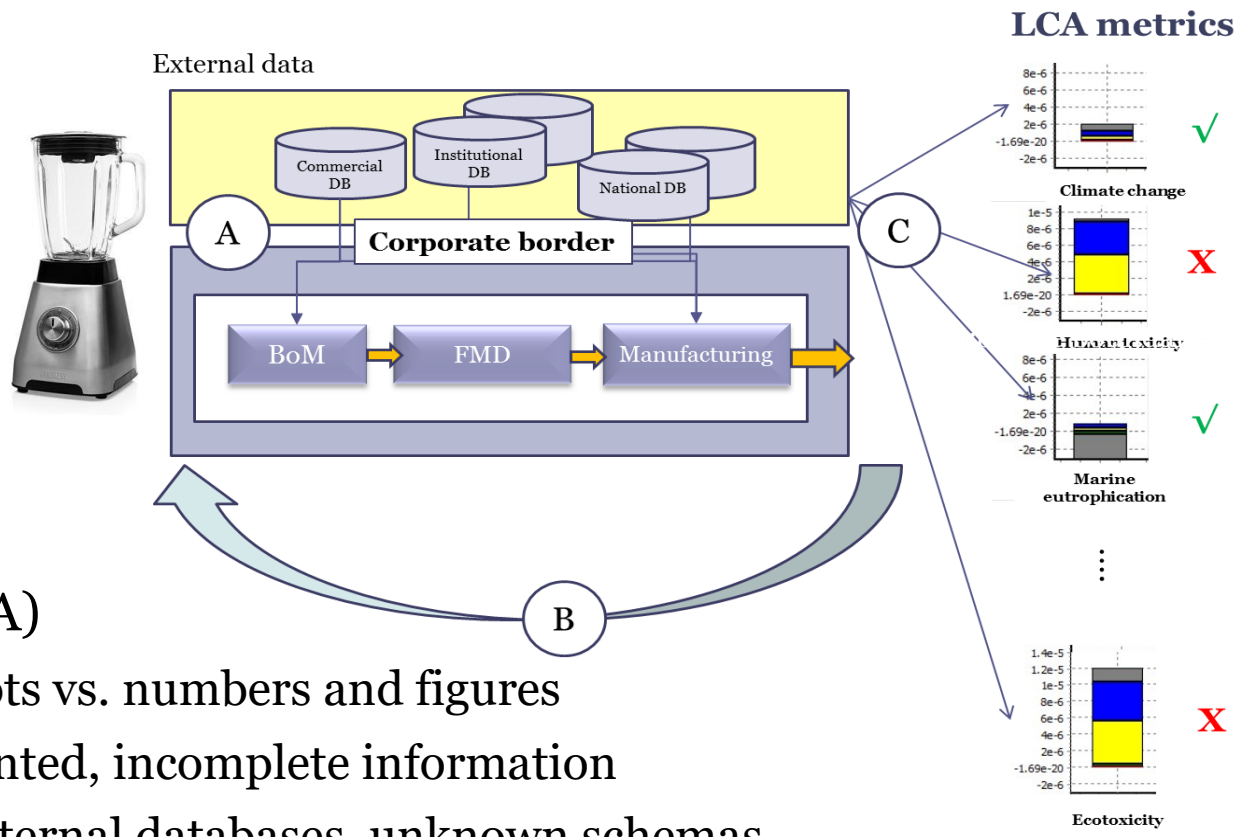
MATHER LCA tool



Future path: Ex-ante LCA

- *Anticipatory*: integrate with decision-making tools
- *Prospective*: projected future of emerging technologies
- *Consequential*: introduction of new technologies and technology landscape
- *Dynamic*: address temporal components
- *Mixed*: combine above criteria

Major challenges and opportunities



- Cross border flows (A)
  - Dealing with concepts vs. numbers and figures
  - Distributed, fragmented, incomplete information
  - Interactions with external databases, unknown schemas
- Ex ante LCA and reverse data flows (B)
  - Hot spots can be diagnosed but is not clear how to repair
  - Re-engineering depends on reasoning (or AI)?
- Stakeholder involvement would need new eco-labels (C)

Generic features

- The approach could be generalized to the general class of appliances (and even beyond appliances)
- Data could be used as dynamically available
- Scope to improve and amend knowledge layers
- Prepared to handle large volumes of data streams (big data) as may be available from customers or external providers

The trail of LCA within Industry 4.0 has only started…

…enjoy this MATHER trip!