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Wir schaffen Wissen – heute für morgen

SETAC Europe 25th Annual Meeting

Integrating LCA and Scenario Modelling of the Energy System for Sustainable Policy-making

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Outline

- Motivation
- Methodologies and concept
- Integration of Global MARKAL model and LCA
- Outlook

Motivation

- The world faces various challenges related to the energy system, e.g.
  - Climate change
  - Resource depletion
  - Energy access
  - Security of supply
  - Ecosystem damages
  - Human health damages

- Addressing one of the challenges mentioned above may influence (the solution of) other challenges. This leads to complex decisions for (energy) policy-makers.

- Therefore, integrated and consistent assessment methodologies are required for decision support and for the transition to sustainable energy systems.

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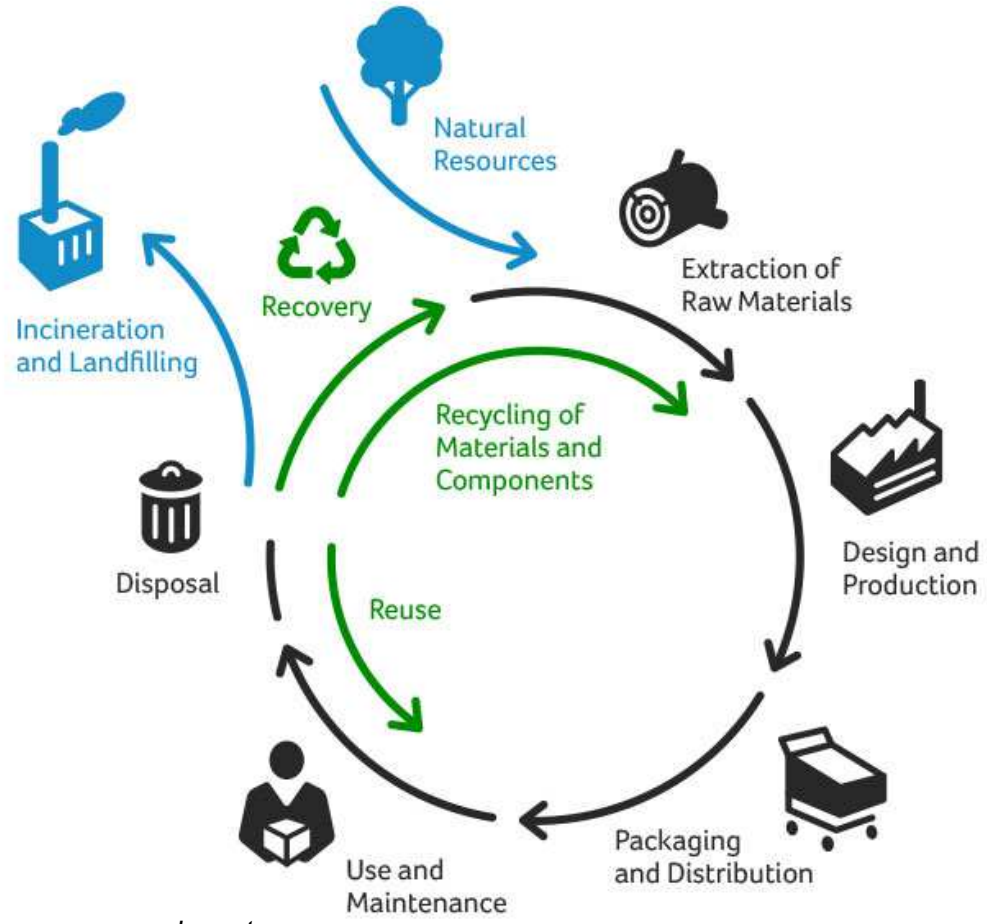
Life-cycle assessment (LCA)

Environmental assessment of single energy technologies and processes

- Included: detailed environmental and human health criteria
- Not included: dynamic temporal development, complete energy system

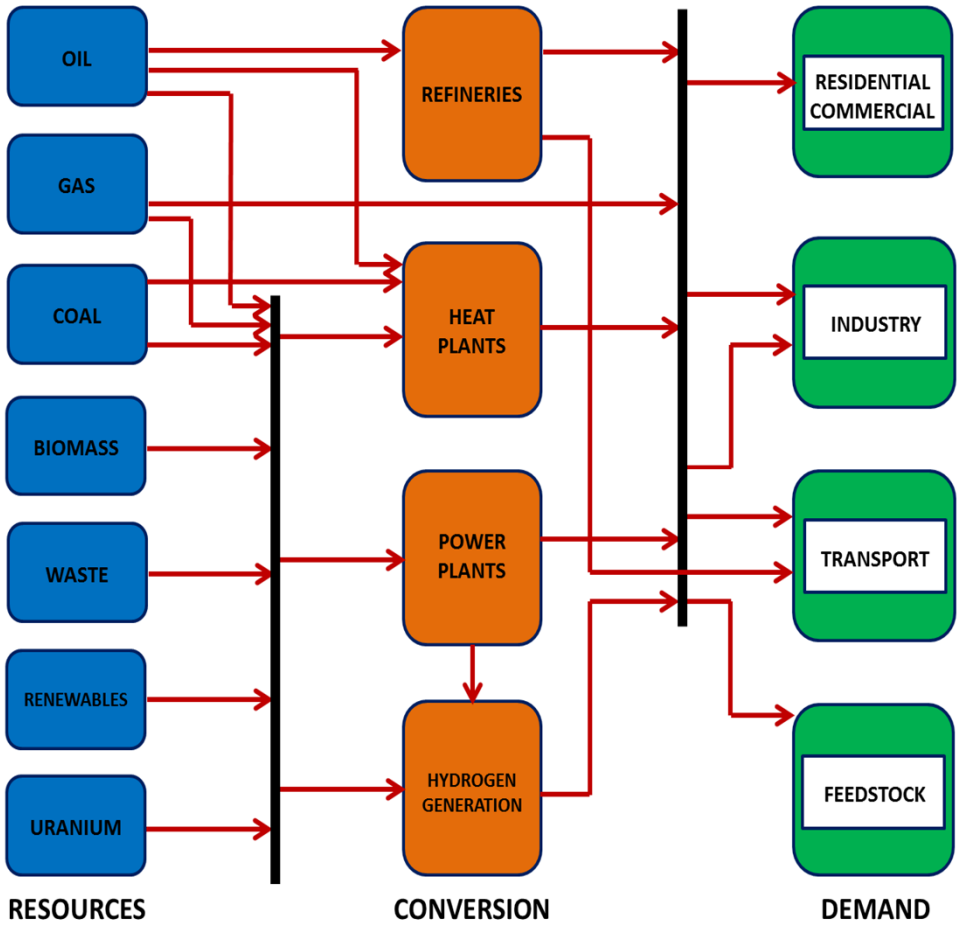


Source: www.ecoinvent.org

Energy-economic system modelling (EEM)

Developing, quantifying and analyzing scenarios of the energy system

- Included: system perspective, dynamic temporal development, techno-economic data
- Not included: other sustainability criteria (environment, human health)



Integration of EEM and LCA

- **Combination** of
  - system-wide and dynamic temporal perspective of EEM, and
  - detailed environmental and human health technology assessment of LCA

- Expected **knowledge gains and insights**
  - Integrated and consistent assessments of energy systems
  - Analysis of co-benefits and trade-offs between sustainability aspects of energy systems
  - Insights for energy policy-making

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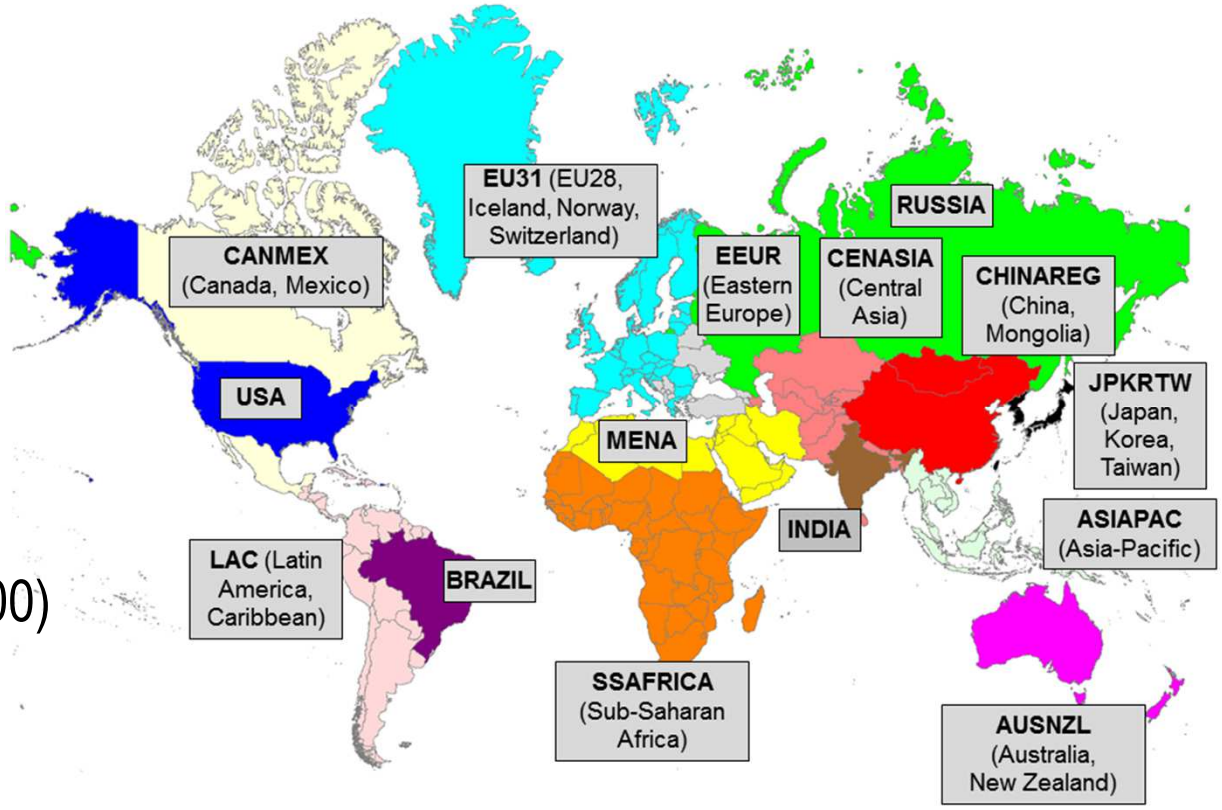
Integration of GMM model and LCA

Developing, quantifying and analyzing scenarios of the global energy system

- **Global**
  - All energy sectors
  - All energy resources
- **Multi-regional**
  - 15 world regions
  - Trade (not for electricity)
- **MARKAL**
  - Bottom-up, technology rich (> 300)
  - Perfect-foresight (2010 - 2100)
  - Least cost optimization
    (Total discounted system costs)



Integration of GMM model and LCA

Sub-ordination of the integrated models

Economy

- Education
- IT & Communication
- Entertainment
- Services
- Retail trade
- Real estate activities
- Accommodation
- …

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- Construction
- Plastics
- Metals
- Waste treatment
- …

GMM model

- Energy crops
- Fuel mining
- Fuel production
- Electricity
- Transport
- …

Integration of GMM model and LCA

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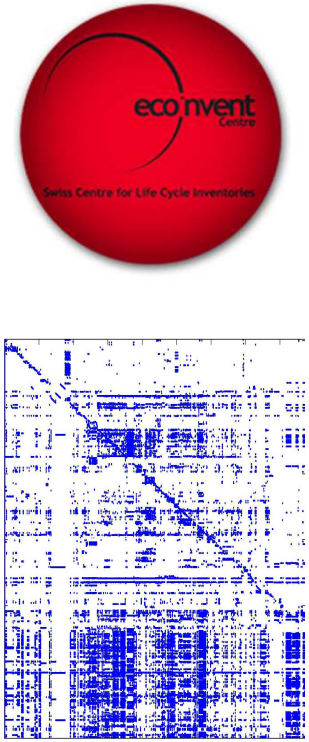
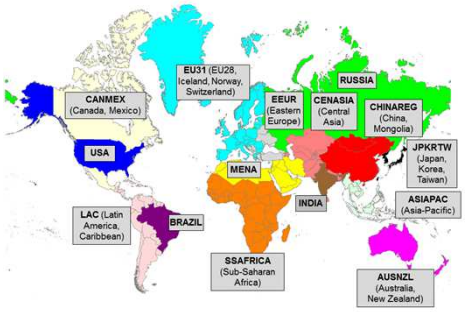
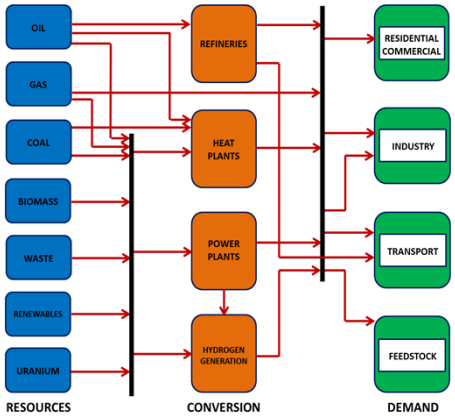


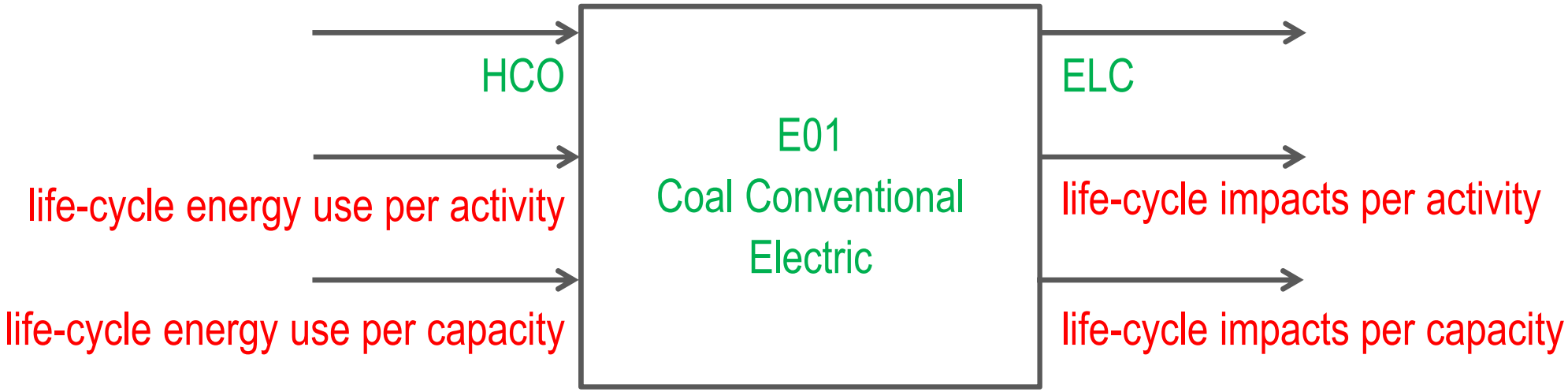
GMM model





Integration of GMM model and LCA

Concept of integrating ecoinvent data in the GMM model



→ (4 flows) x (>300 processes) x (15 regions)

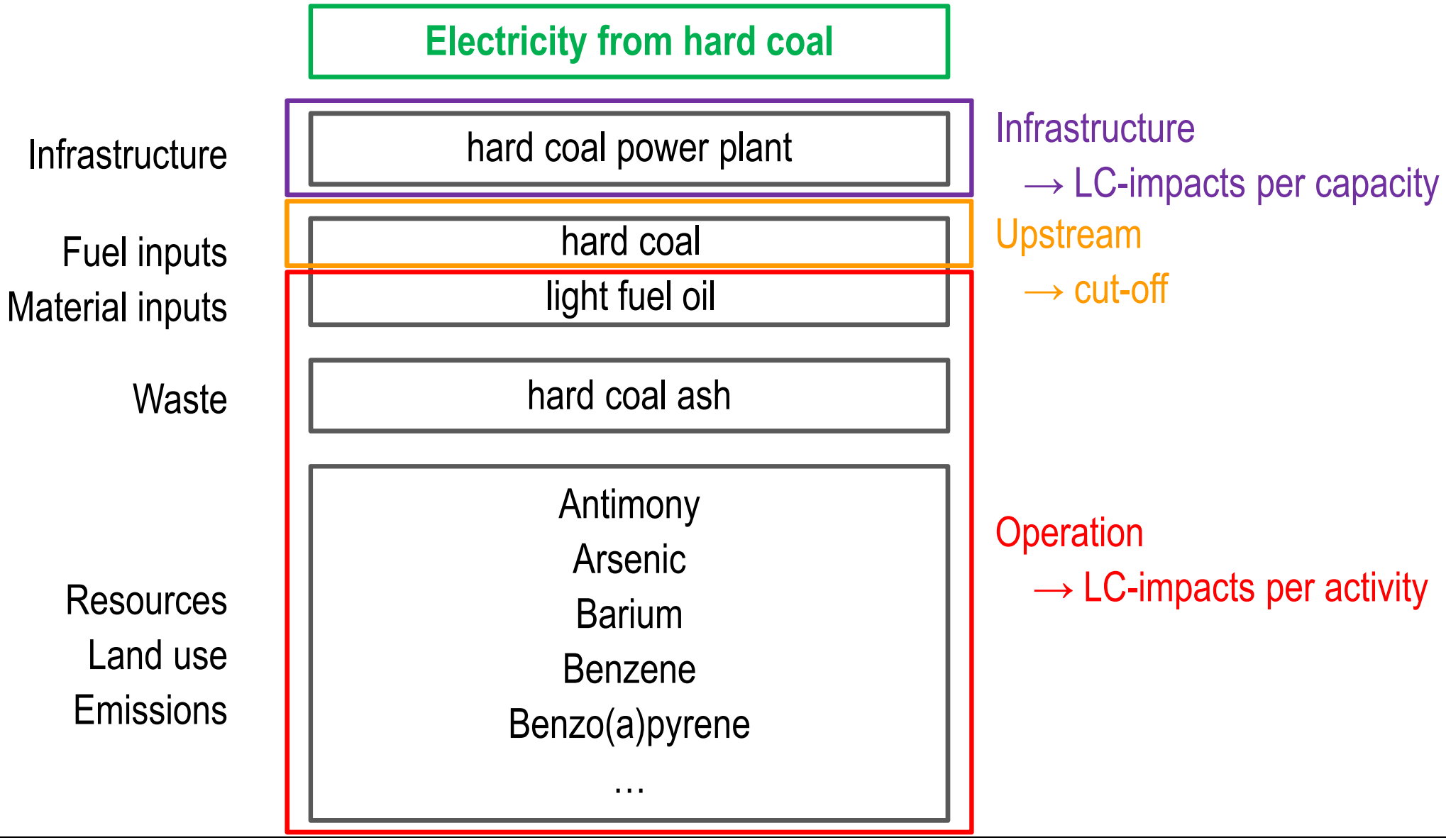
Integration of GMM model and LCA

Allocation of an ecoinvent dataset to each GMM process

GMM process	GMM description	ecoinvent v3 name	ecoinvent v3 regions
S12	Lignite Extraction	Lignite mine operation	RER, RoW
E01	Coal Conventional Electric	Electricity production, hard coal	ASCC, AT, AU, BA, BE, BG, BR, CA-AB, CA-NB, CA-NS, CA-ON, CL, CN, CZ, DE, DK, ES, FI, FR, FRCC, GB, HICC, HR, HU, IE, IN, IT, JP, KR, MRO, MX, MY, NL, NO, NPCC, PE, PL, PT, RFC, RO, RoW, RU, SE, SERC, SI, SK, SPP, TH, TR, TRE, TW, TZ, UA, WECC, ZA
…	…	…	…

Integration of GMM model and LCA

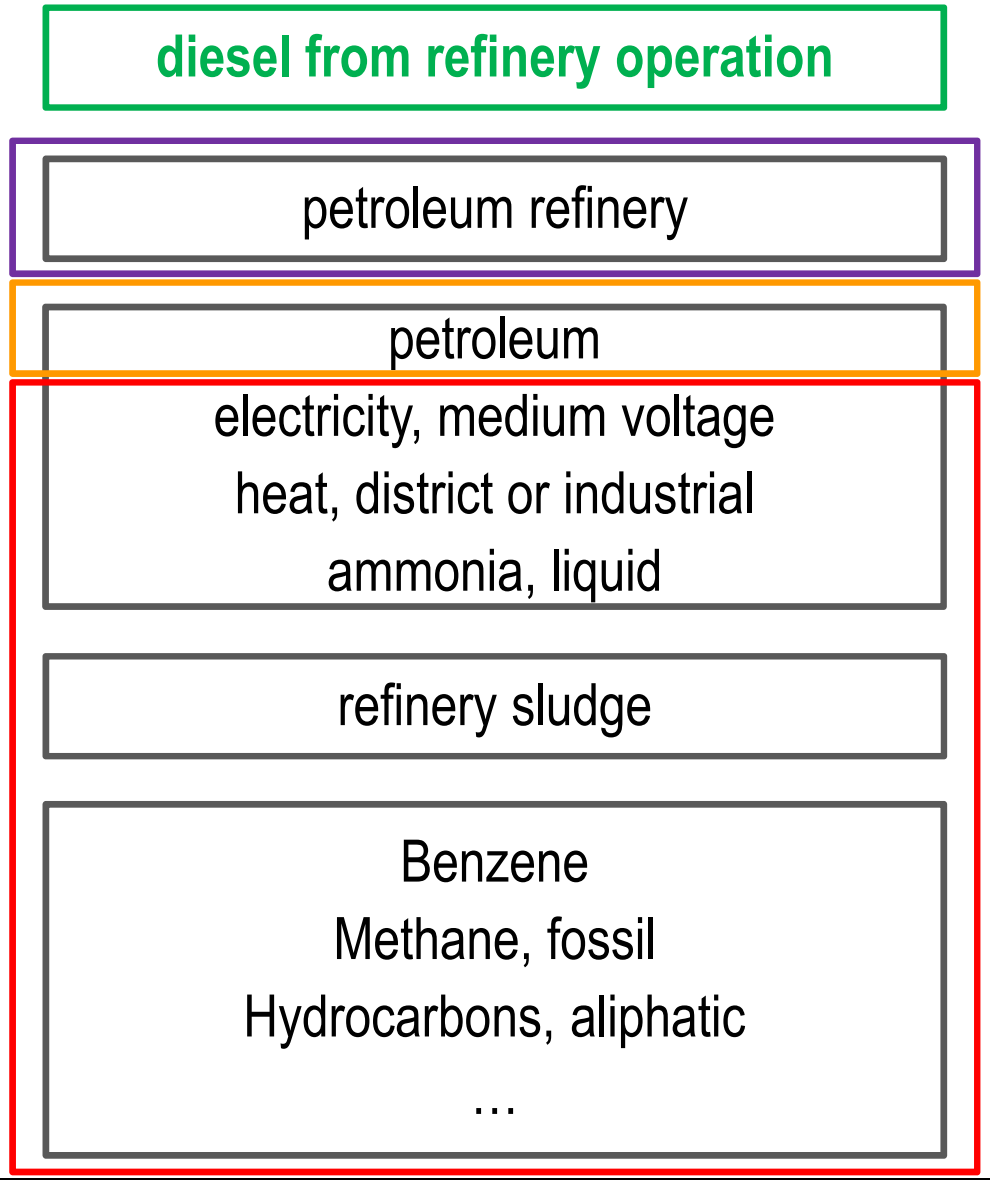
Definition of the life-cycle impacts per activity and per capacity



Integration of GMM model and LCA

Definition of the life-cycle energy use per activity and per capacity

- Electricity
- Heat
- Transport



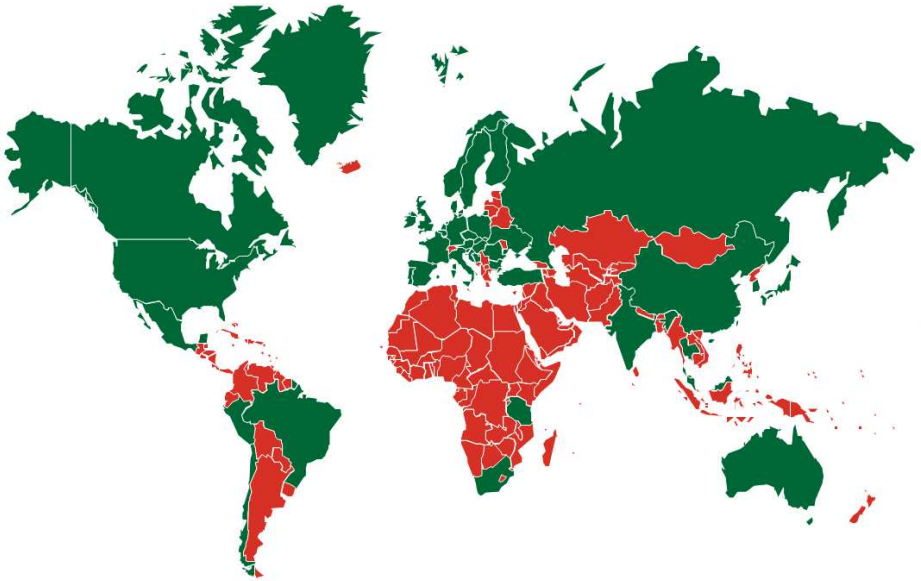
Infrastructure
→ LC-energy use per capacity

Upstream
→ cut-off

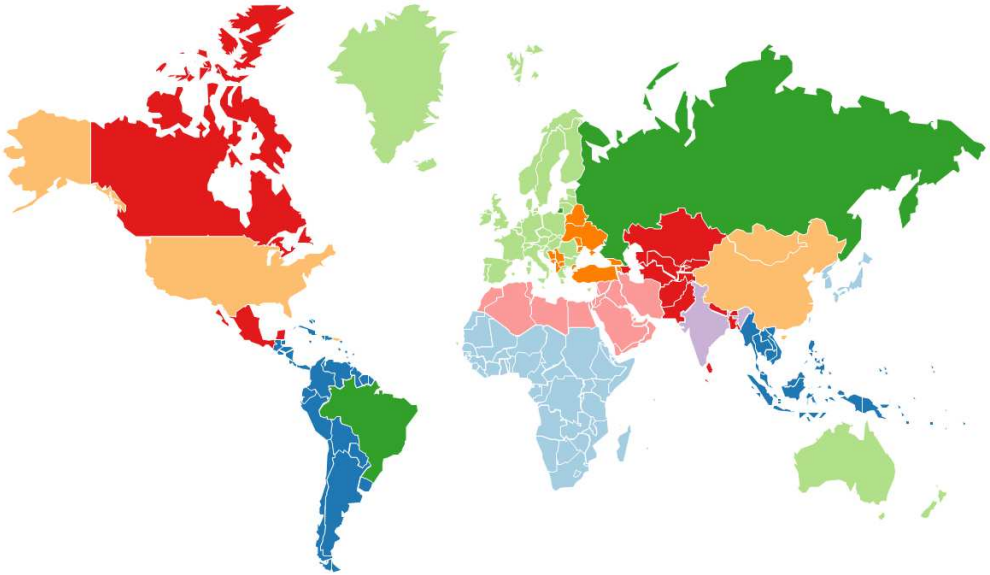
Operation
→ LC-energy use per activity

Integration of GMM model and LCA

Regional harmonization



Regional coverage for E01 in ecoinvent v3

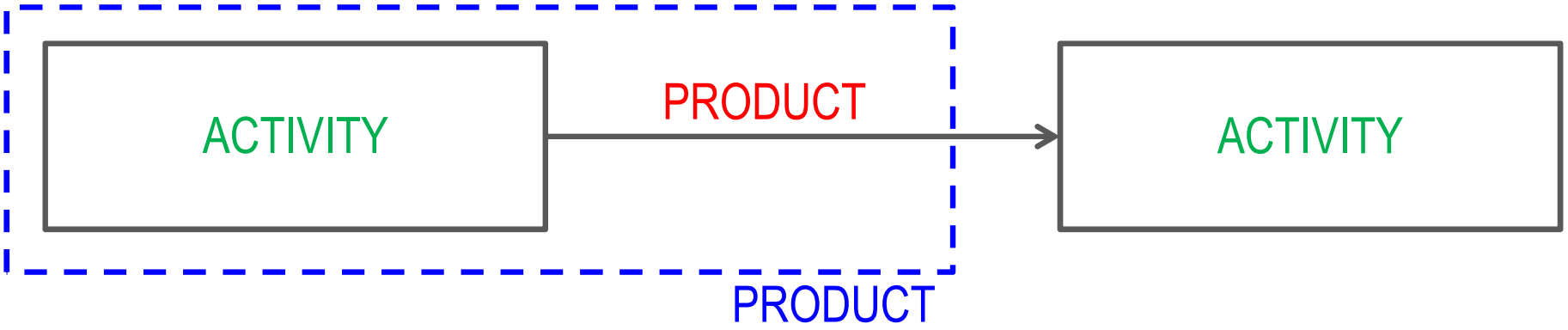


Regional coverage for E01 in GMM model

Integration of GMM model and LCA

Update of v2 datasets to v3

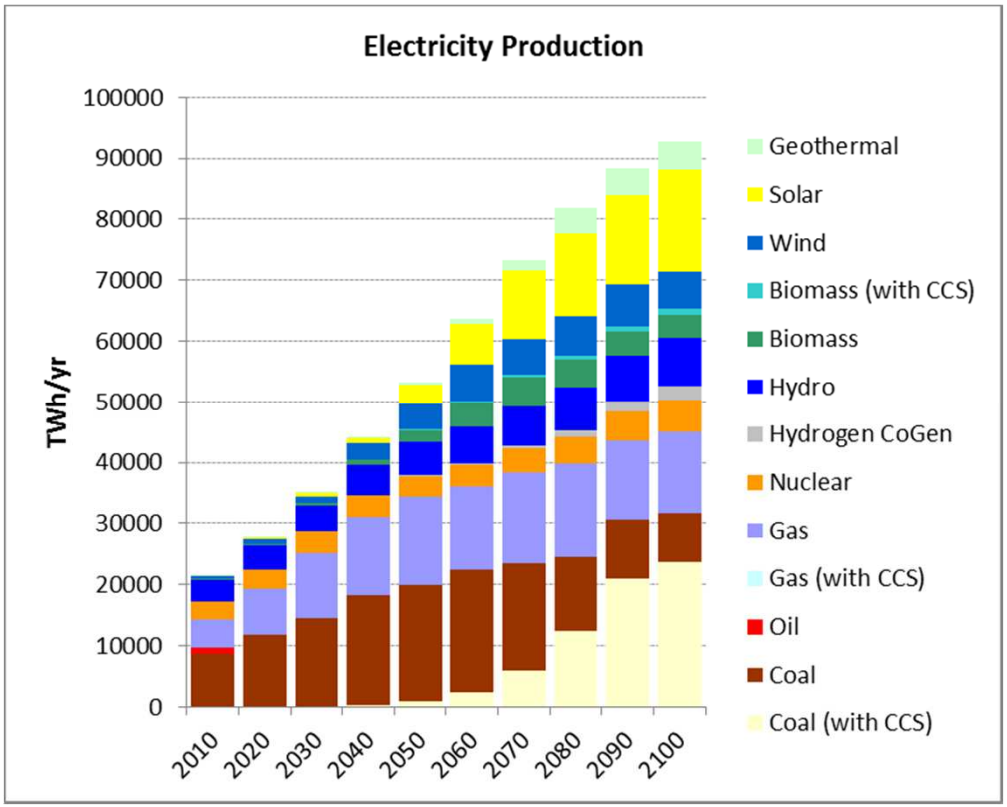
- ecoinvent v2 (direct linking)

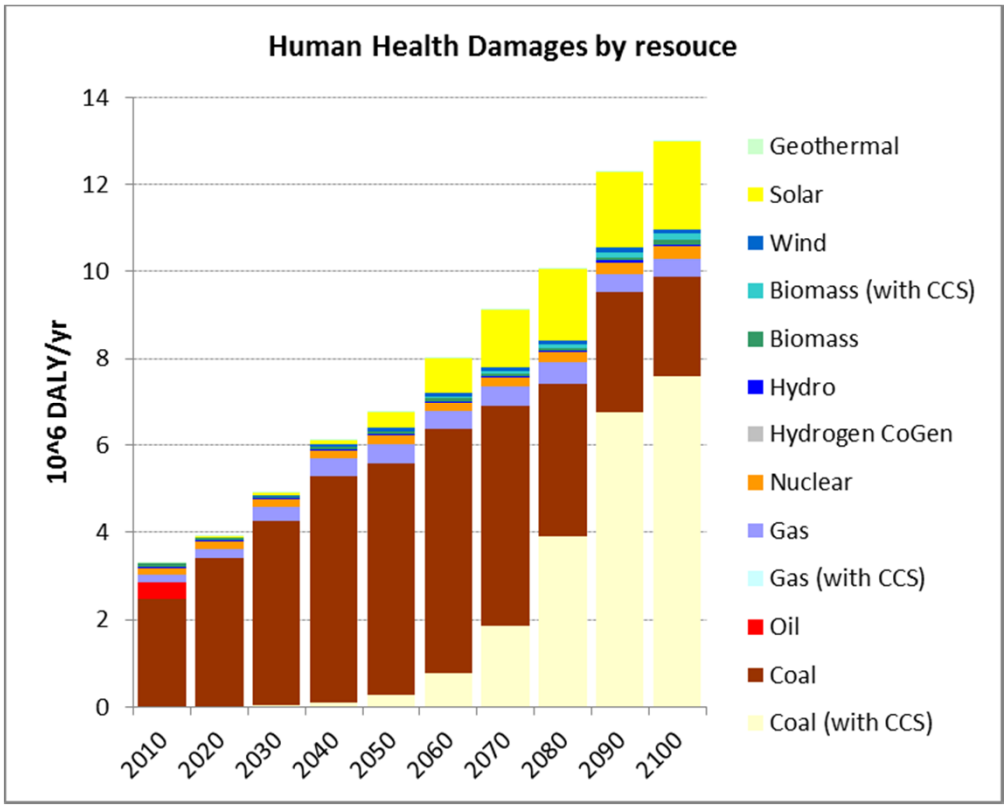


- ecoinvent v3 (indirect linking)

Integration of GMM model and LCA

Ex-post assessment of environmental burdens of delayed climate action scenario





- Current limitations:
  - electricity sector only
  - complete life-cycle calculation (no separation of the processes in the energy chain)
  - exogenous (ecoinvent) energy mixes

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External costs in the GMM model

Introduction of external costs to the GMM model

x external cost factor [$/t SO_2]

= external cost [$]

Integration of GMM model and MCDA

Introduction of other sustainability aspects for Multi-criteria decision analysis (MDCA)

$$\min(\text{cost}) \rightarrow \min(w_1 * \text{INDICATOR}_1 + w_2 * \text{INDICATOR}_2 + \ldots)$$

Environment

Economy

Society

Security of Supply

I would like to thank…

Martin Densing, Chris Mutel & LEA staff

Thank you for the attention

Are there any questions?