



Wir schaffen Wissen – heute für morgen

LCA XIV, 6 October 2014

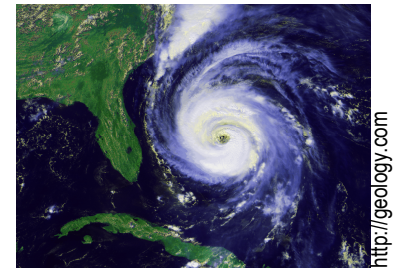
Kathrin Volkart (Paul Scherrer Institut, Switzerland)

**Development of a New Methodology for the Integration of
LCA and Energy-Economic System Modelling**

- In **energy systems analysis**, life cycle assessment (LCA) provides detailed environmental assessment of single energy technologies and services

 - **But:** what about the **system** the energy technologies are embedded in?
 - Potentials and **constraints** on the technologies
 - **Development** of the technologies over time
 - Changes in the **energy mixes** over time
 - **Costs** of the technologies

 - **Questions:**
 - How can LCA be applied on a **system level**?
 - How can **temporal** developments be integrated in LCA?
 - How can **economic aspects** be taken into account?
- **Integration** of LCA and energy-economic system models (EEM)...



Developing, quantifying and analyzing scenarios of energy systems

- **Global**

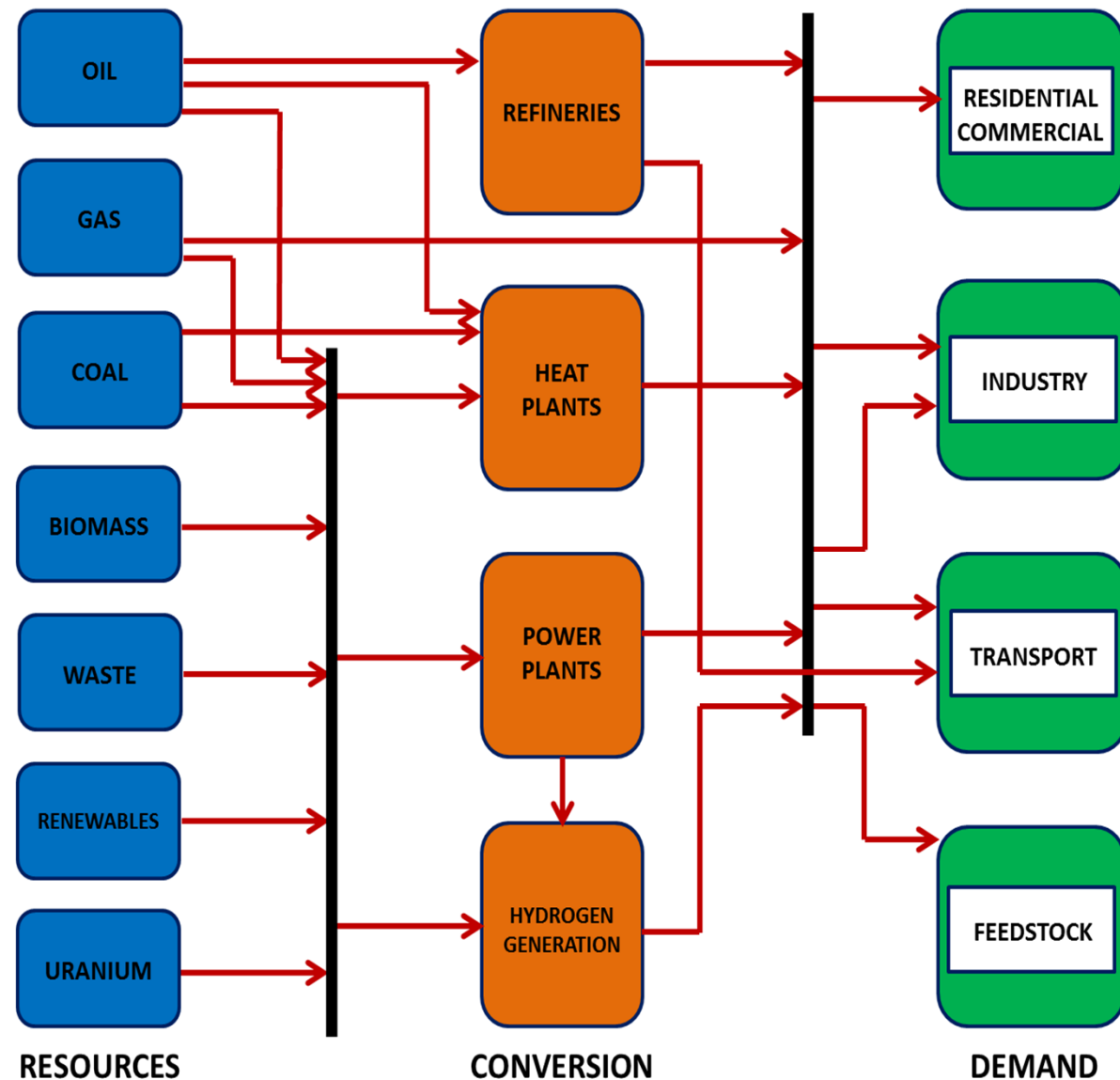
- All energy sectors
- All energy resources

- **Multi-regional**

- 15 world regions
- Trade (not for electricity)

- **MARKAL (MARKet-ALlocation)**

- Technology rich (> 400)
- Bottom-up
- Long-term modelling (2010 - 2100)
- Partial-equilibrium (“supply allocation”)
- Least cost optimization
(Total discounted system costs)



Environmental assessment of single technologies and services

1) Goal and scope definition

- System boundary
- Functional unit

2) Life-cycle inventory

- Data collection

3) Life-cycle impact assessment

- Determination of the impact of the product or service

4) Interpretation

- Assessment of the results

**ecoinvent
database**



<http://www.ecoinvent.org>

ecoinvent	Criterion	GMM model
single technologies/services	System	whole energy system
very detailed (~1700 processes)	Technology representation	detailed (~400 processes)
(mainly) current state	Temporal resolution	explicit consideration of future time periods
(mainly) regional	Spatial resolution	all world regions
very detailed (~1000 flows)	Environmental aspects	potentially detailed (1 flow: CO ₂)
prices of the products	Economic data	investment, fixed O&M, variable O&M and CO ₂ cost

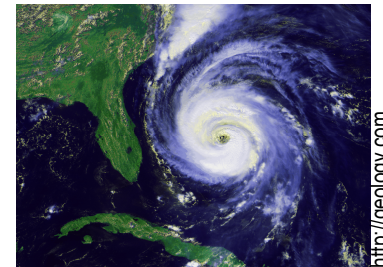
- **Goal:**

*Development of a new methodology for the combination of the **system-wide** and **temporal** perspective of energy-economic system models and the **detailed (environmental) technology assessment** of LCA*

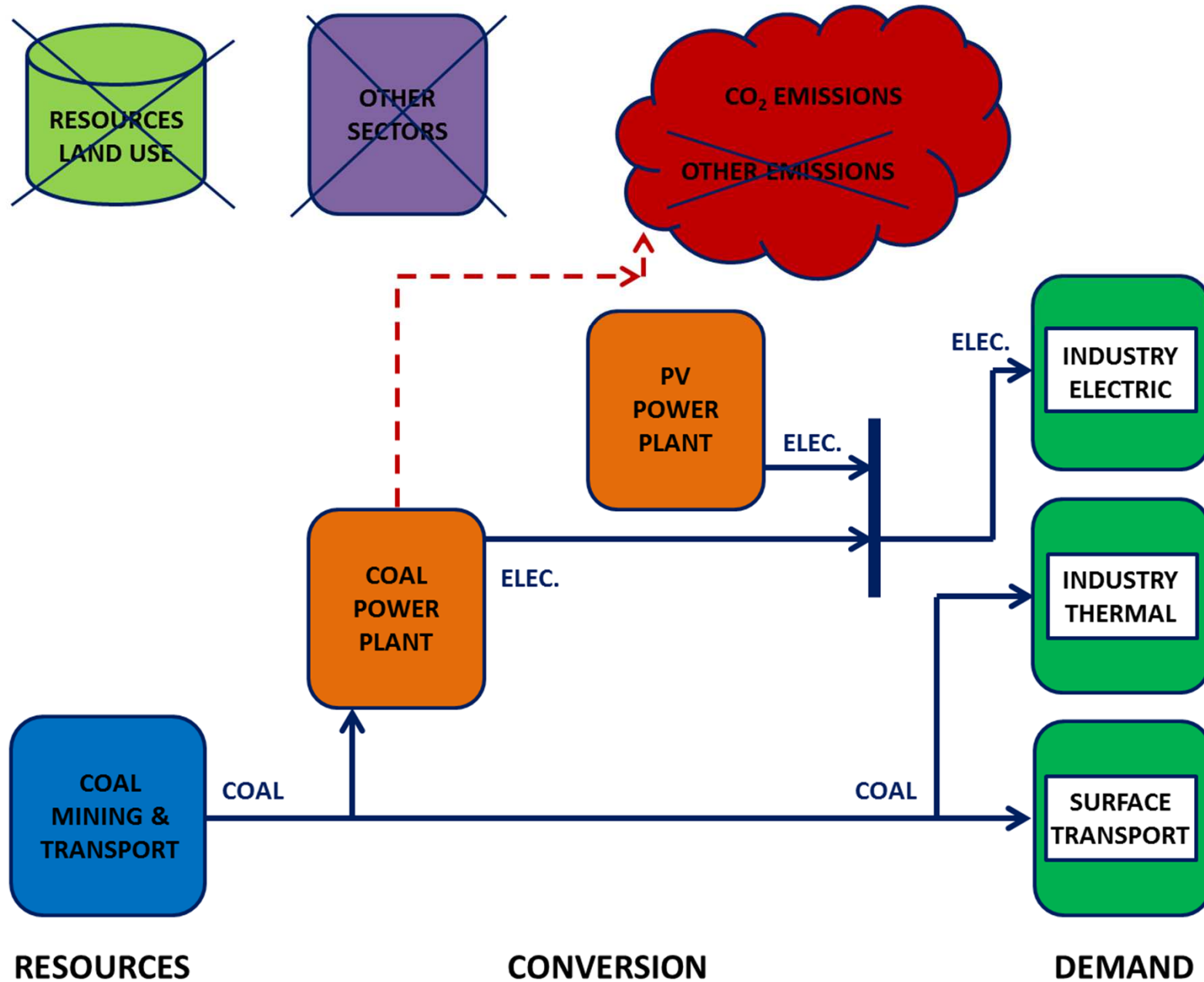


- **Expected insights:**

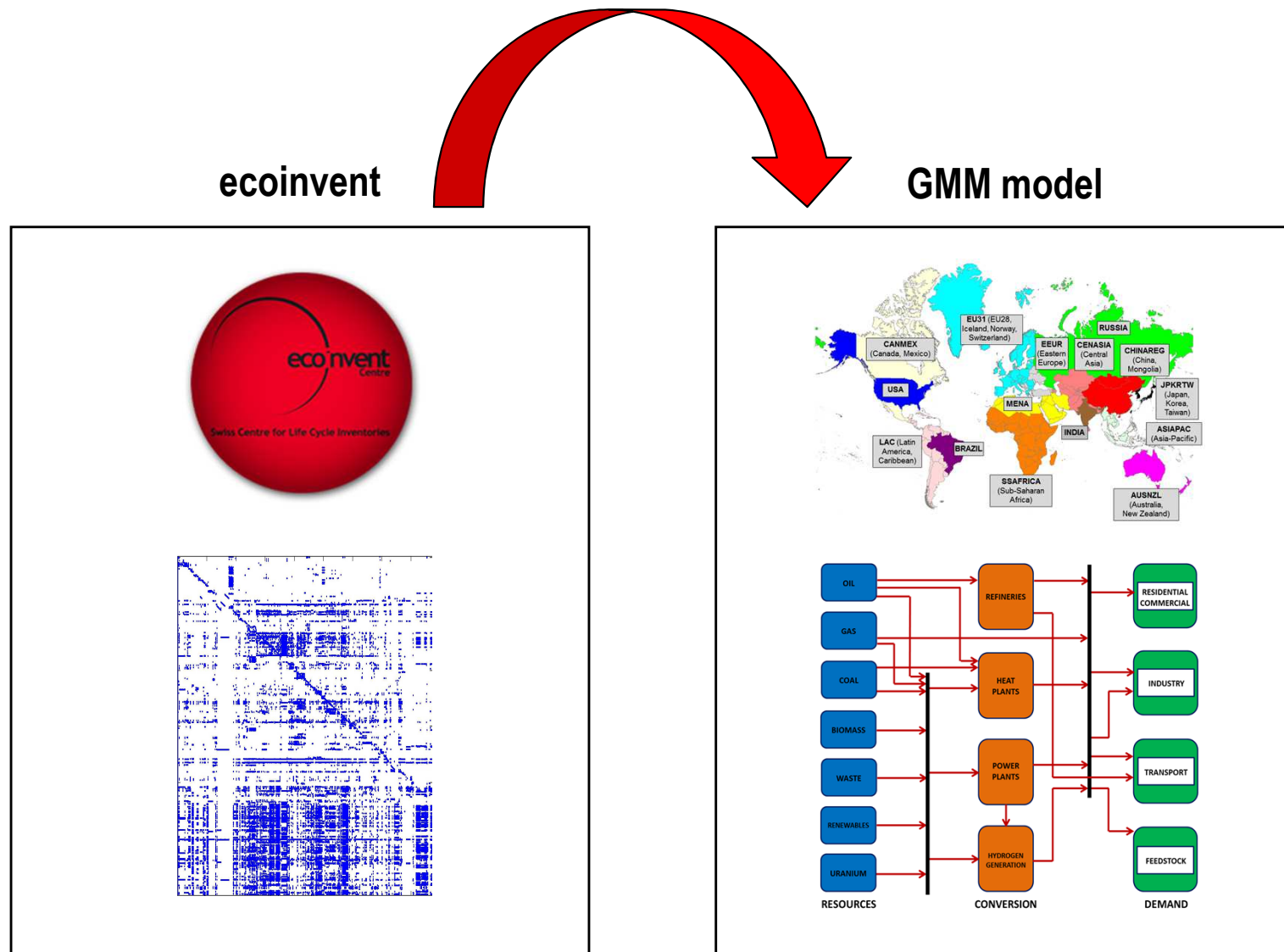
- Integrated and **consistent assessments** of energy systems
- Comprehensive assessment of **environmental burdens** of the whole energy system
- Analysis of **trade-offs** between environmental and economic aspects of energy systems
- Insights on the multitude of impacts from **energy policy-making**



Current state of the GMM model



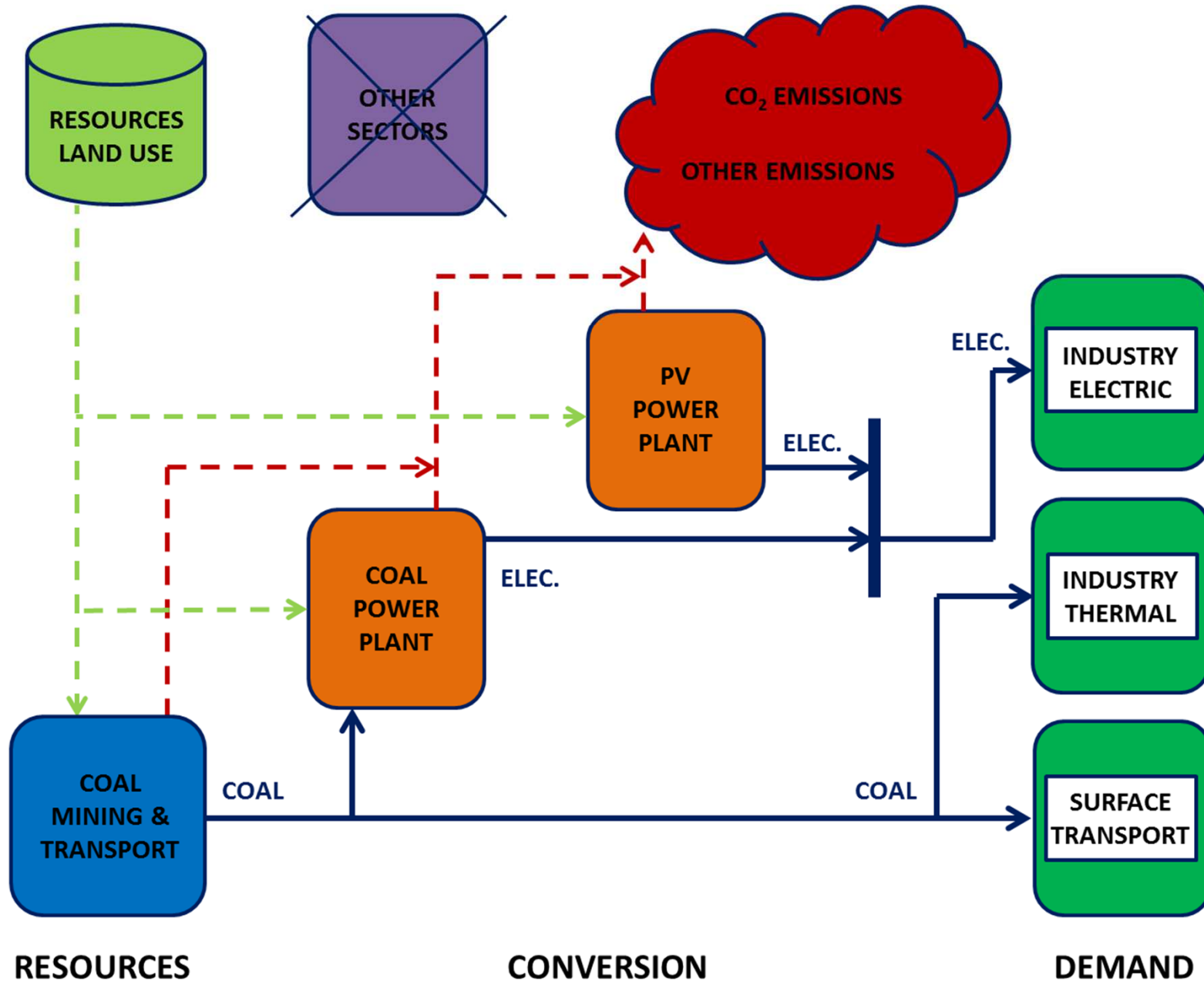
Integrating the information that is available in ecoinvent in the GMM model



The integration of ecoinvent and the GMM model requires several steps

- Harmonization of the modelling of the **processes & regions**
- Implementation of **direct environmental burdens** of the energy system
(*example: air emissions of power plants*)

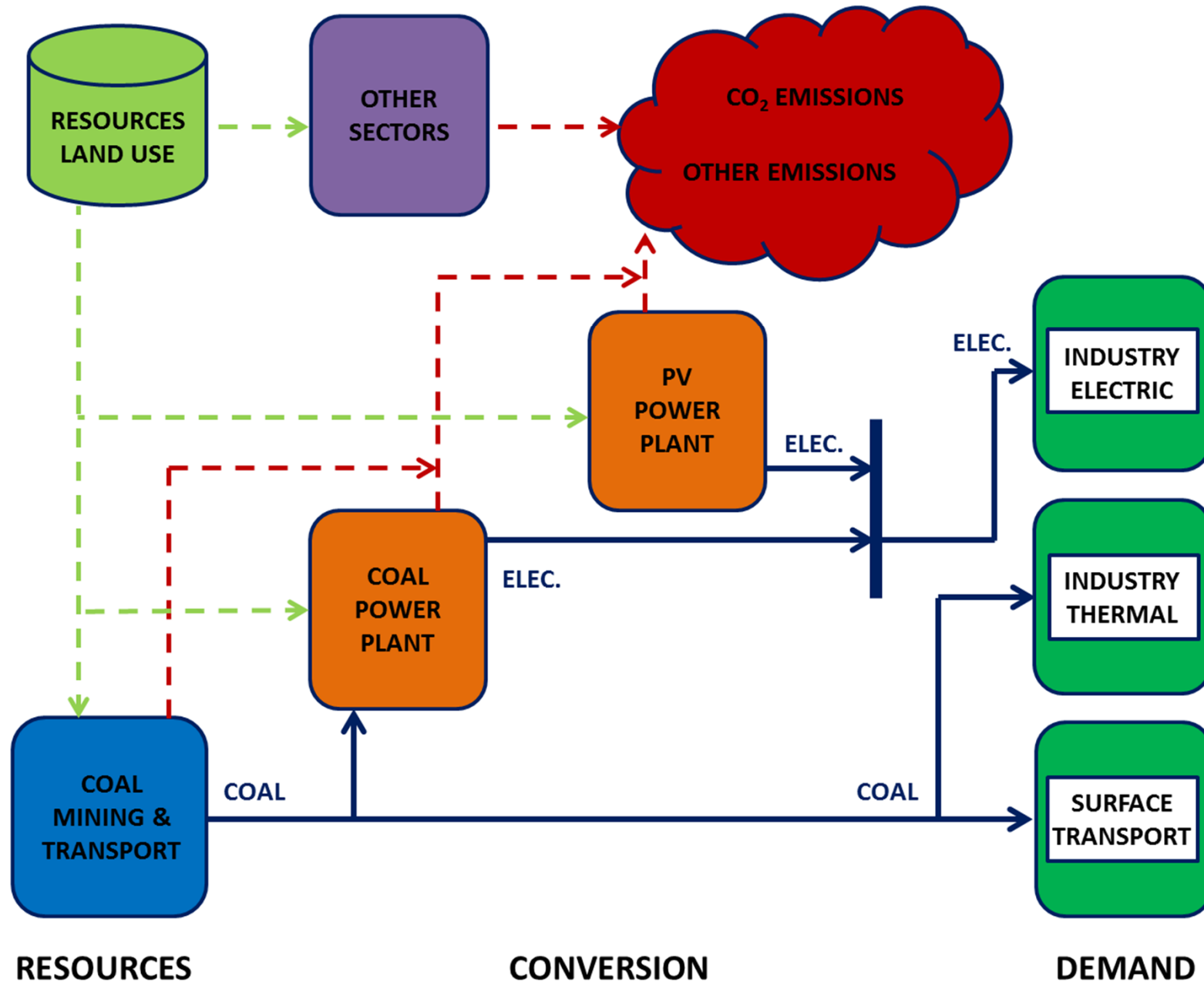
Direct environmental burdens



The integration of the two tools raises issues that need to be addressed

- Harmonization of the modelling of the **processes & regions**
- Implementation of **direct environmental burdens** of the energy system
(*example: air emissions of power plants*)
- Implementation of **indirect environmental burdens** of the energy system
(*example: silicon resource for the construction of PV cells*)

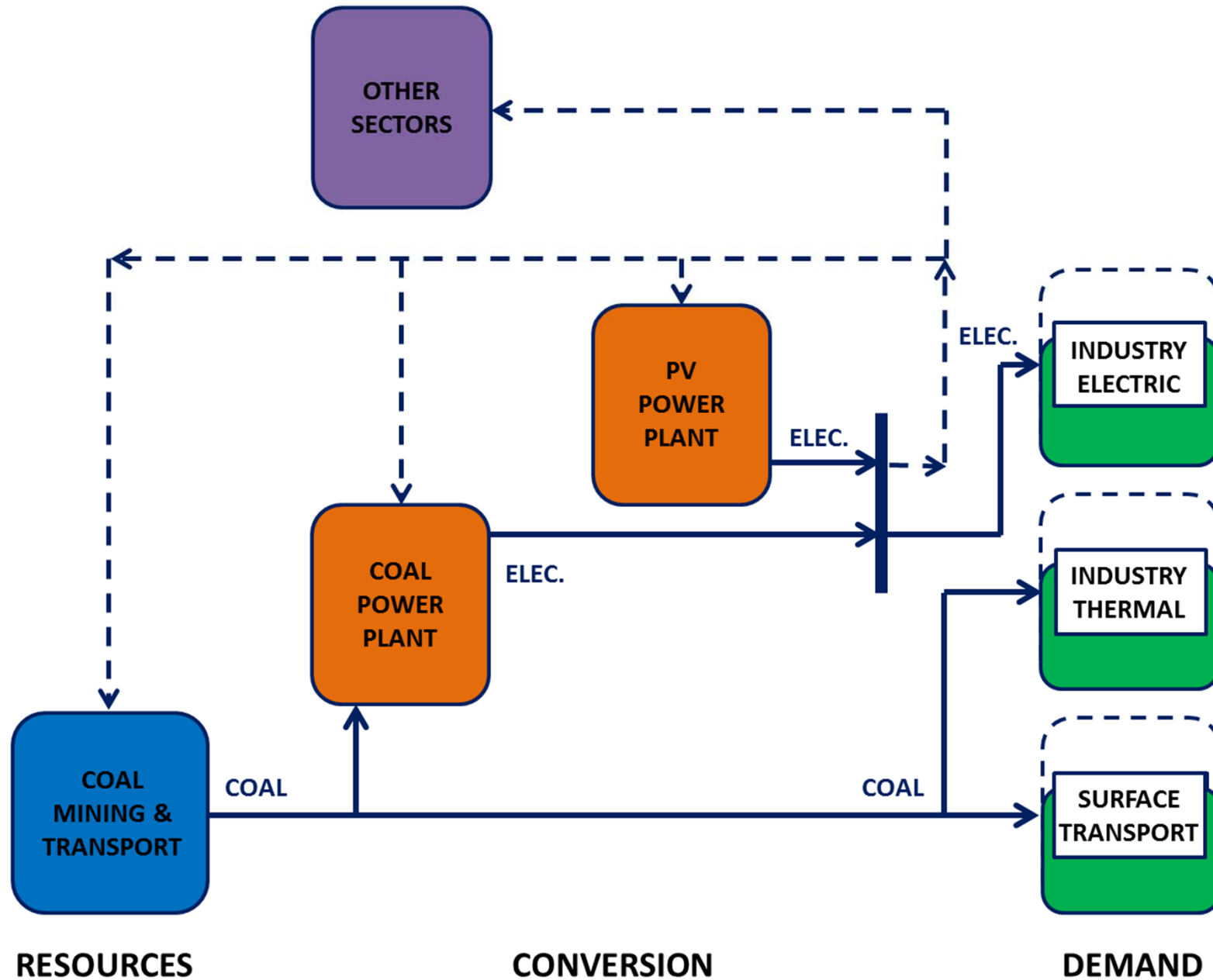
Indirect environmental burdens



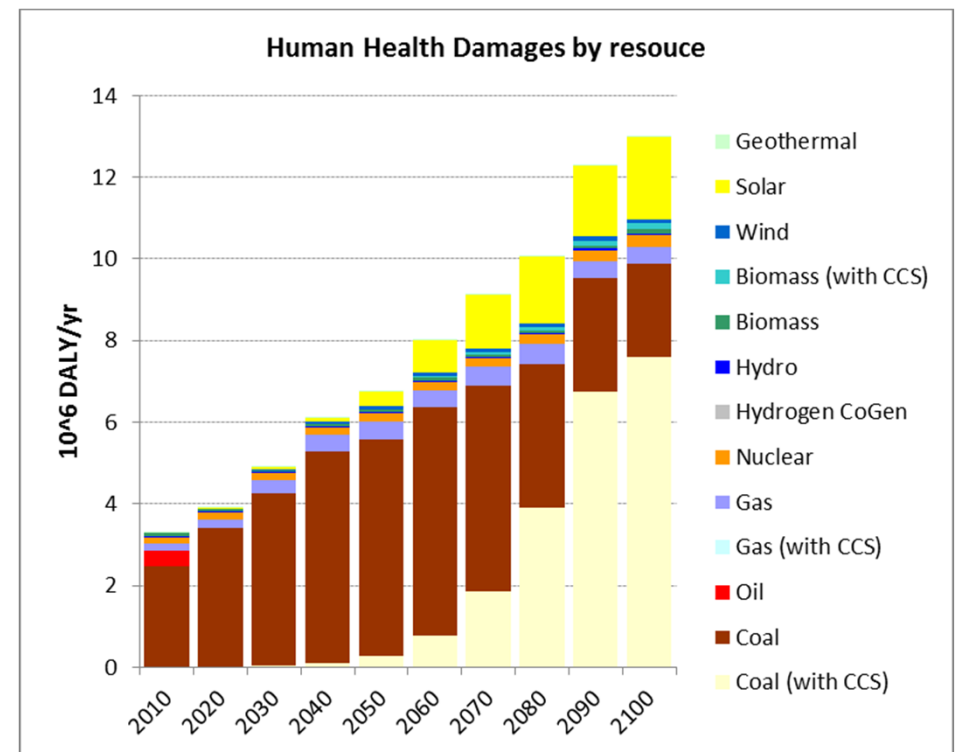
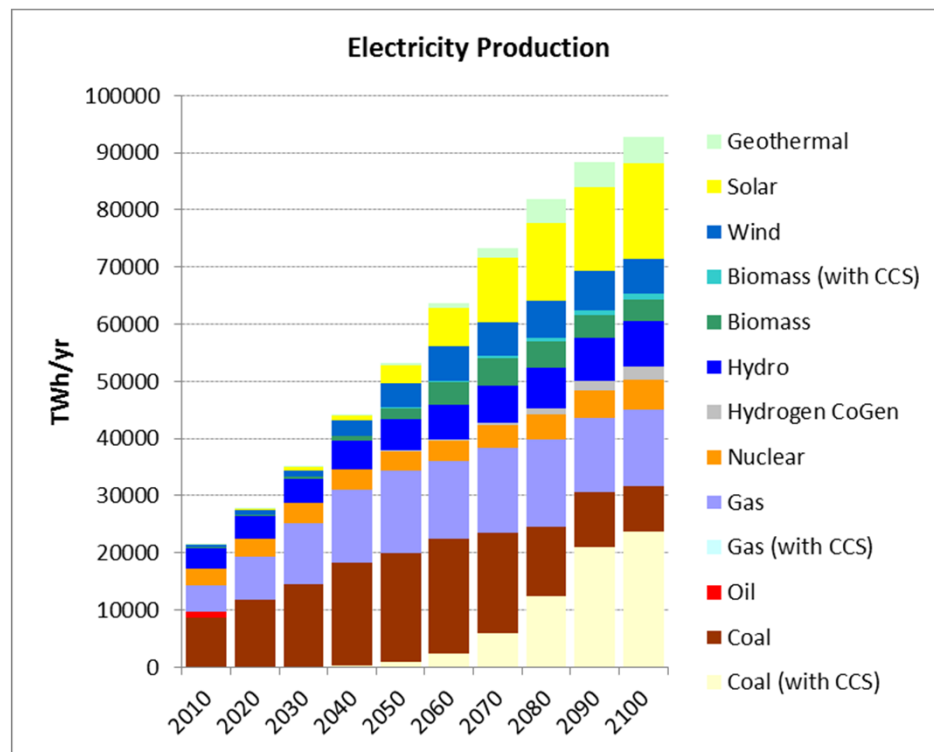
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- Representation of the **(endogenous) energy flows**

(Endogenous) energy flows



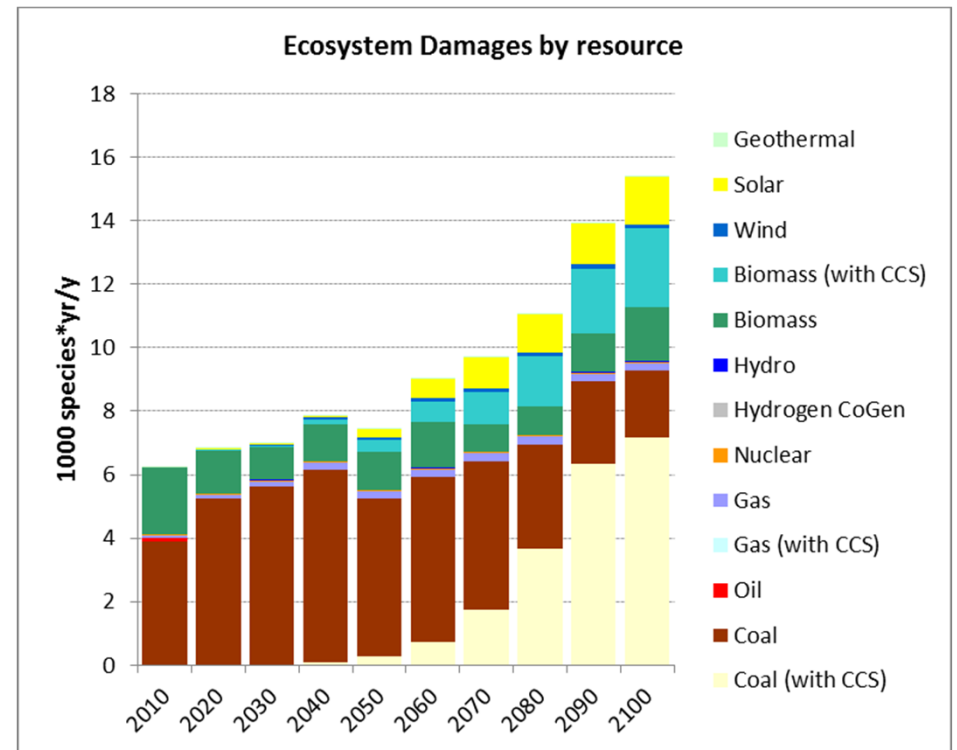
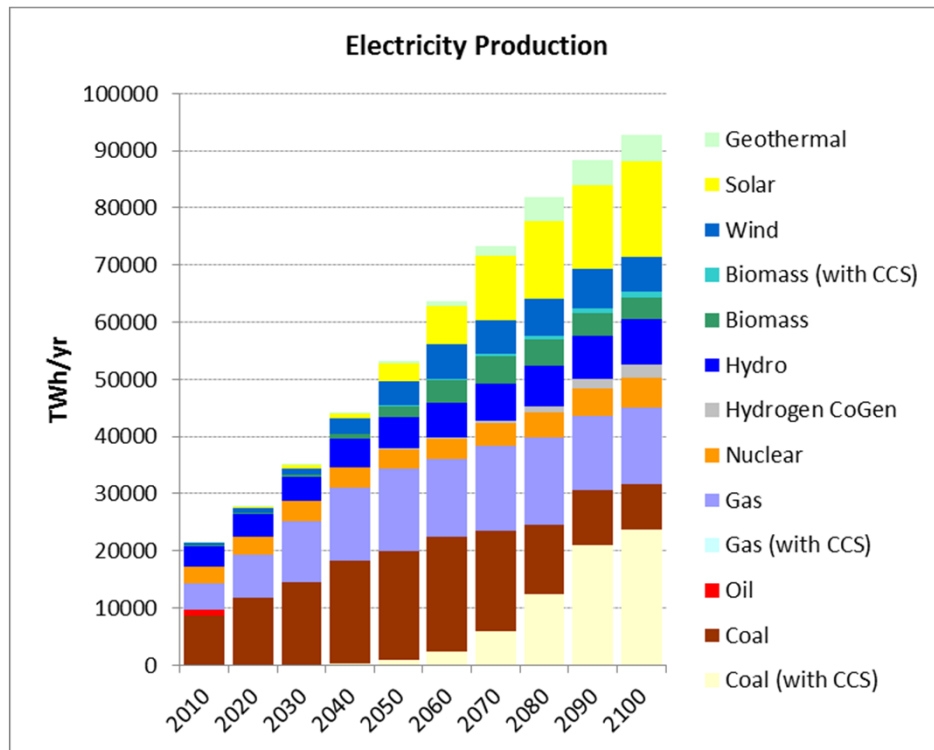
Environmental burdens of a selected scenario



Current limitations:

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

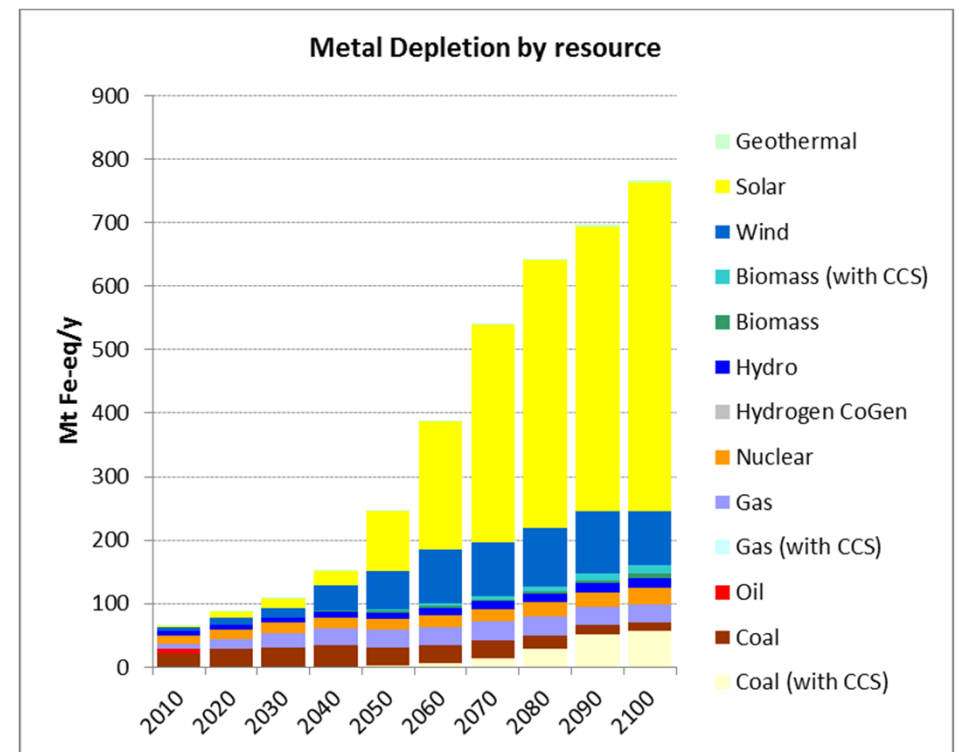
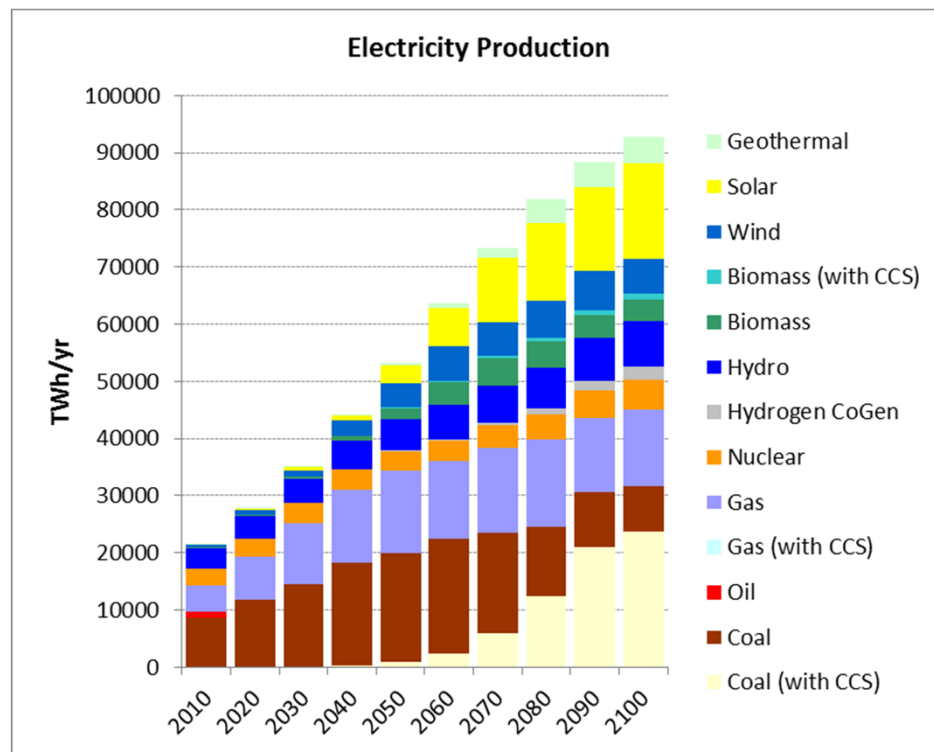
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Current limitations:

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

- Harmonization of the modelling of the **processes & regions** **Tedious**
- Implementation of **direct environmental burdens** of the energy system **Solved**
(example: air emissions of power plants)
- Implementation of **indirect environmental burdens** of the energy system **Solved**
(example: silicon resource for the construction of PV cells)
- Representation of the **(endogenous) energy flows** **In progress**
- **Non-cost optimization** **Solved**
min(cost) → min(impacts)

- **LCA challenges**

- LCI for future technologies
- Future background systems (“future ecoinvent”)
- Choice of the LCA system model

- **Economic challenges**

- Discounting of costs vs. discounting of environmental burdens (weighting of impacts across time)

- **Outlook**

- Environmental optimization in the GMM model
- Multi-objective optimization in the GMM model

I would like to thank

Martin Densing, Chris Mutel and Christian Bauer

