LIFE CYCLE ASSESSMENT OF ELECTRICITY GENERATION AND STORAGE: A PRACTITIONER'S EXPERIENCE

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Chapter 1

Energy Transition, Revolution or industrial revolution?
Need for robust LCA studies

Chapter 2

Some Case studies: multi-criteria assessments, system boundaries, temporal and spatial resolution

Chapter 3

Conclusions
Energy Transition, Revolution or industrial revolution? Need for robust LCA studies
What is common for industrial revolutions?

- **Energy revolution**
  - Coal & steam engines

- **Communication revolution**
  - Telegraph

- **Manufacturing revolution**
  - Machines replacing manpower

First Industrial revolution
What is common for industrial revolutions?

- **Energy revolution**
  - Coal & steam engines
  - Electricity & oil

- **Communication revolution**
  - Telegraph
  - Telephone

- **Manufacturing revolution**
  - Machines replacing manpower
  - Assembly lines, conveyor belts

Second Industrial revolution
Today: Not an energy transition, not even an energy revolution but a true industrial revolution!

Energy revolution
- Coal & team engines
- Electricity & oil
- Cheap decentralised renewables; green (autonomous) mobility

Communication revolution
- Telegraph
- Telephone
- Internet of Things

Manufacturing revolution
- Machines replacing manpower
- Assembly lines, conveyor belts
- 3D printing / robotics

Today: Third Industrial revolution

NEED FOR ROBUST LCAs TO ENSURE WE DO BETTER THAN BEFORE WITH RESPECT TO ENVIRONMENTAL IMPACT!
Some Case studies: multi-criteria assessments, system boundaries, temporal and spatial resolution
Multi-criteria assessment
Combined Cycle Gas Turbines with cooling tower or aero-condenser: what is the best environmental option?

Cooling using air instead of water for CCGT’s is possible allowing the implementation of CCGT in either water scarce regions or at locations far from water sources

HOWEVER, it does imply a reduction in the efficiency of the CCGT....
Trade-off exists between Water consumption and GWP

Co-combustion of biomass* in coal fired power plants decreases many impacts; but not all

* Biomass = 83 % wood dust from Fr, Be, NI & 17 % olive cake from Es
Using endpoints not scientifically accepted!! Despite this, it is sometimes internally used to communicate…

In case endpoints are needed, not one method is adopted but usually three different ones…
Amine based carbon capture involves an energy penalty and gaseous emissions

\[
CO_2 + 2HNR_2 \leftrightarrow NR_2COO^- + H_2NR_2^+
\]

**CHALLENGES:**
Large energy penalty (25 %) & Organic emissions in water and gas phase
Carbon Capture and Storage reduces GWP to a large extent but increases all other impacts.

**WHY?**

1. Increased fuel supply chain contribution (+ 20 %)
2. More CO₂ & SO₂ produced because more coal used
Capture and Storage has an overall positive environmental impact since GWP is considered as very important in all endpoint methods.

→ Overall environmental impact ↓ with CCS using current internationally accepted methodologies to ‘normalise’, weigh and sum up the different impacts

→ because GWP is considered important in all methodologies
In comparison to renewables (wind and PV), overall environmental impact of CCS remains higher.

GWP ≠ environmental impact
System boundaries
Important to take entire system into account and compare against current situation

Substitution can only avoid 50% of emissions
CARBON LEAKAGE unless CO₂ comes from Air Capture

The environmental impact of the storage infrastructure is more important than the renewable electricity generation itself!

Temporal and spatial resolution
The environmental impact of the storage has a different temporal and spatial dimension than the electricity generation.

Carbon content of electricity differs from hour to hour, in between days and in between seasons...
Water footprinting: 1 L of water in the Middle East has not the same impact as 1 L of water in Belgium...

Local water scarcity is used to weight water consumption: 1 L used in Middle-East has not the same impact as 1 L used in Belgium ➔ Liters equivalent
Conclusions
Conclusions

1. In the context of the current energy transition to new processes, LCA is a crucial tool to ensure:
   1. no shifting of the environmental burden from one process to another and
   2. no shifting from one environmental impact to another

2. Most of the energy related H2020 calls require LCA to be part of the project proposal

3. Not only GWP is important, all impacts are and in particular water footprinting will gain in importance…

4. LCA allows evaluating ‘trade-offs’, eg. CCS, biomass, …

5. ‘Choices’ and assumptions (system boundaries, spatial and temporal resolution, allocation, …) crucial for final results → must be transparent!

6. Need for more applications of consequential LCA to the integration of new energy pathways