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Life Cycle Assessment of electricity generation: overview and methodological issues

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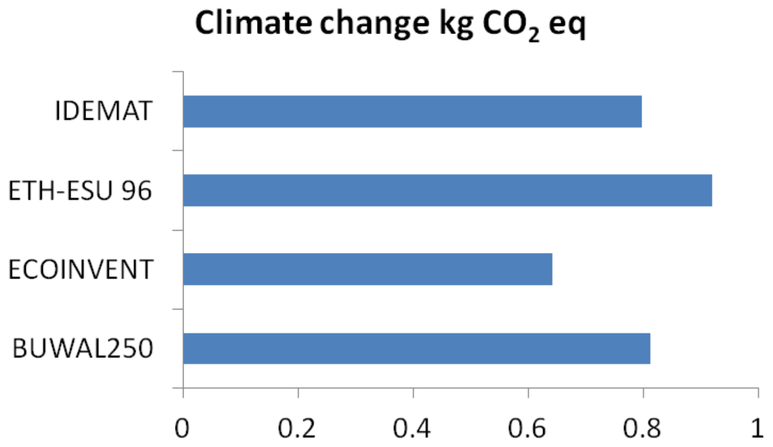
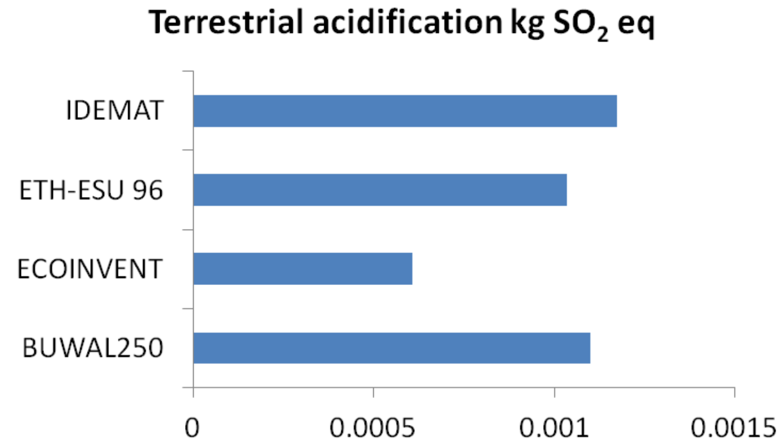
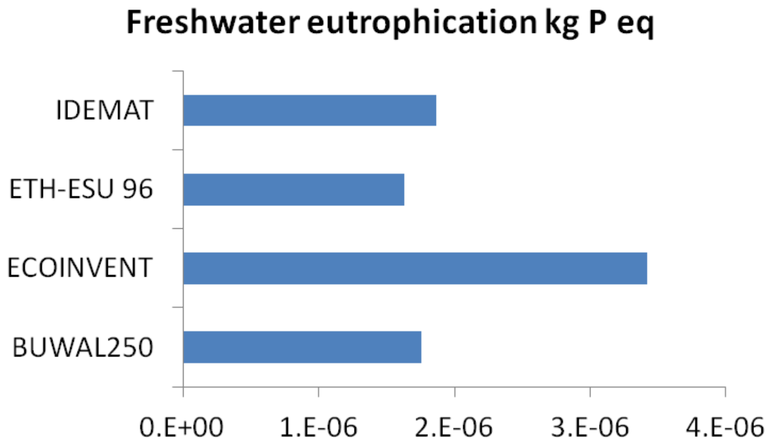
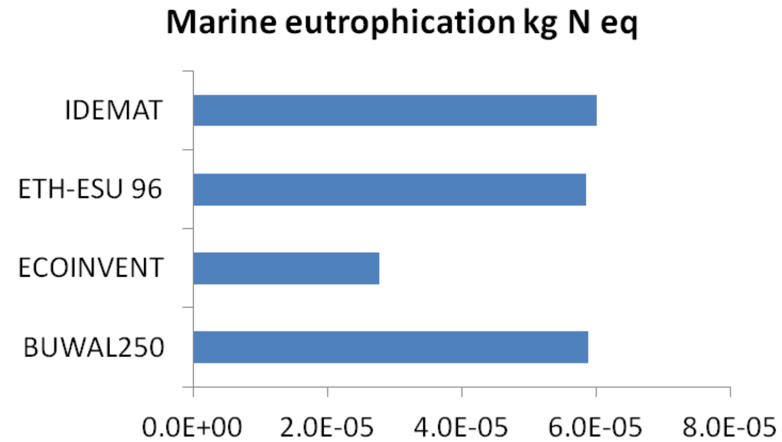
Background

Electricity from natural gas, avg. UCTE plant (impacts per kWh)









Objective of the study

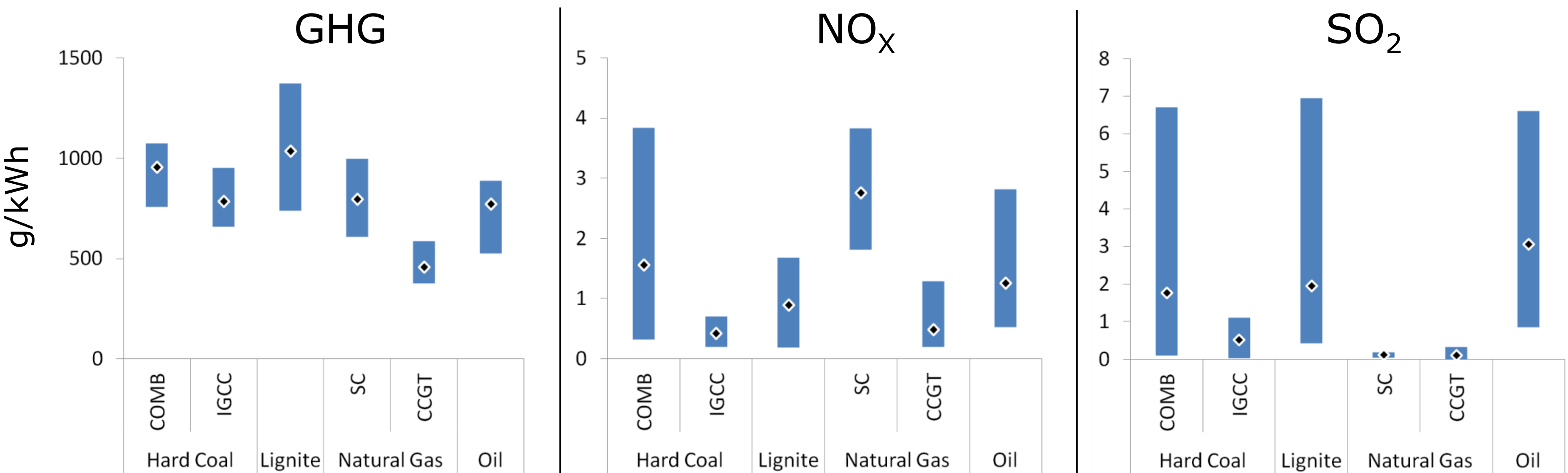
- Research question: **What are the key parameters determining the environmental impacts of an energy generation technology?**

- Complementary to **NREL Harmonization study**
  - NREL: "Energy modeler" point of view
    - (**GHG**) Reduce variability → Define average values
  - This study: "LCA practitioner" point of view
    - (**LCA**) Find key parameters to identify a specific technology for a case study

Methodology

- **Literature review**: 167 case studies included
- Technologies considered:
  - Hard Coal
  - Lignite
  - Natural Gas
  - Oil
  - Nuclear
  - Hydro
  - Solar PV
  - Wind
  - Biomass
- Emissions considered: GHG, NO_x, SO_2
- Focus on **technological** and **methodological** aspects

Results – Fossil Fuels



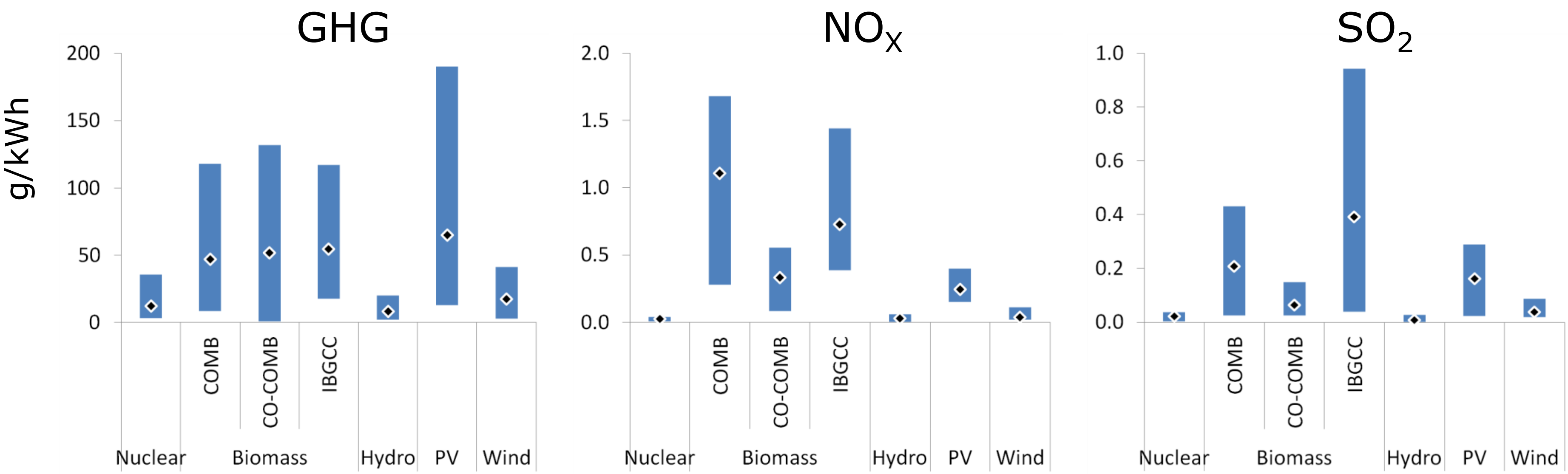
- Low variability
  - Plant efficiency

- High variability
  - Plant efficiency
  - FGC system

- High variability
  - Plant efficiency
  - FGC system
  - S in fuel

- Main contributor: Direct emissions
- No methodological issues

Results – Nuclear and renewables



Technology	Main contributor	Sources of variability
Nuclear	Fuel provision	Fuel enrichment, el. mix, methodology (IOA vs PCA)
Hydro, Wind, Solar PV	Infrastructures	Type, electricity mix, methodology (IOA vs PCA)
Biomass	?	Combination of methodology and technology

Why LCA rather than only GHG?

- **Hotspots definition**

  Example: Natural gas

  - GHG: Direct emissions 83%
  - NO_x: Fuel provision 54%
  - SO_2: Fuel provision 96%

- **Problem shifting**

Example:	Natural gas	vs	Oil	
GHG	380-1000	⇔	530-900	g/kWh
SO_2	0.01-0.32	⇒	0.85-8	g/kWh
	Solar PV	vs	Biomass	
GHG	8.5-130	⇔	13-190	g/kWh
NO_x	0.15-0.40	⇒	0.08-1.7	g/kWh

Discussion

Technology	Technological factors	Methodological factors
Fossil fuels	Efficiency, FGC (NO_x and SO_2), Fuel quality (SO_2)	-
Nuclear	Electricity mix, fuel enrichment	IOA vs PCA data
Hydro, Wind, Solar PV	Electricity mix, reference year	IOA vs PCA data
Biomass	Type, quality, origin of the feedstock	Multi input/output system, land use, constrained resource

Conclusions

- Existing literature: may be confusing

  → studies often built on different assumptions/approaches/technologies

- **What are the key parameters determining the environmental impacts of an energy generation technology?**

  - Technological and methodological aspects
    - Differ from one technology to another
    - Depend on the impact category

  - **LCA needs Transparency and Comprehensiveness**

Thanks for your attention.

Questions?

Turconi, R., Boldrin, A., Astrup, T. - **Life cycle assessment (LCA) of electricity generation technologies: overview, comparability and limitations.** *Submitted to Renewable and Sustainable Energy Reviews*.

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