



## European energy policy analysis with GTAP model in a consequential prospective LCA framework

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**Swiss LCA Forum**  
**9 September 2016**

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**POLYTECHNIQUE  
MONTRÉAL**

WORLD-CLASS  
ENGINEERING



# PRESENTATION OUTLINE

## Introduction

- 🌐 **Assessing policies with LCA**

## Method

- 🌐 **Objectives**
- 🌐 **Case study: 2005-2025 European energy policies**
- 🌐 **Prospective LCA: technological and economic background**
- 🌐 **Consequential LCA: direct and indirect consequences**

## Results

- 🌐 **Comparison of two European energy policies**
- 🌐 **Environmental impacts of the economic growth**
- 🌐 **Uncertainty analysis**

## Conclusion

# INTRODUCTION

**Large scale policies may harm the environment and the human society**

- 🌐 **Example: national biofuel policies may cause indirect land use changes emitting significant amounts of CO<sub>2</sub> and increase prices of food products**

**There is a need to assess large scale policies from a global perspective**

**What are the characteristics of policies?**

**and what are the needs to conduct LCAs of policies?**

- 🌐 **May have indirect effects** → **Consequential LCA**
- 🌐 **Cause large changes in many life cycles** → **Non-marginal variations**
- 🌐 **Over a long period of time** → **Prospective LCA**

# INTRODUCTION

**Consequential LCA is based on economic modeling, therefore an international policy assessment requires an economic model able to:**

- **Investigate prospective scenarios**
- **Handle non-marginal variations**
- **Model all economic sectors to cover indirect effects**

**General equilibrium economic models meet these criteria**

Especially:



Hertel (1997)  
(GTAP7)

- 57 economic sectors
- 113 regions
- Semi-dynamic
- Open source
- Many applications

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# METHODOLOGY – PROJECT OBJECTIVES

**PhD Project (2007-2012) = scientific development + case study**

## **Scientific objective**

-  **Develop a method based on consequential and prospective LCA to study large changes occurring in several life cycles on the long term**

## **Case study objective**

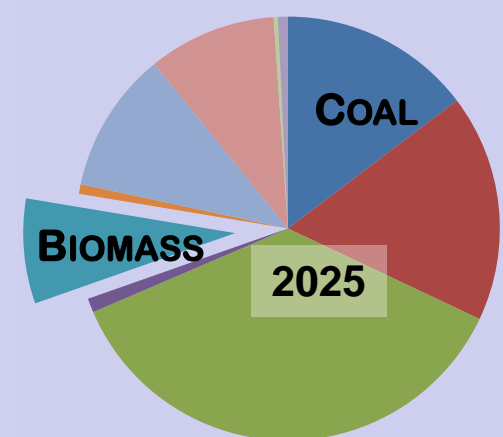
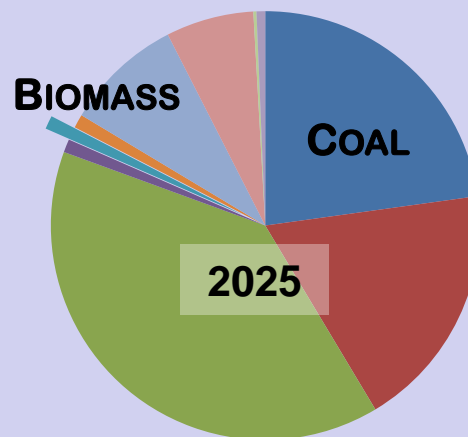
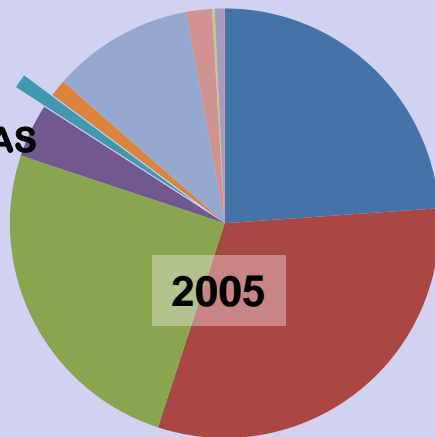
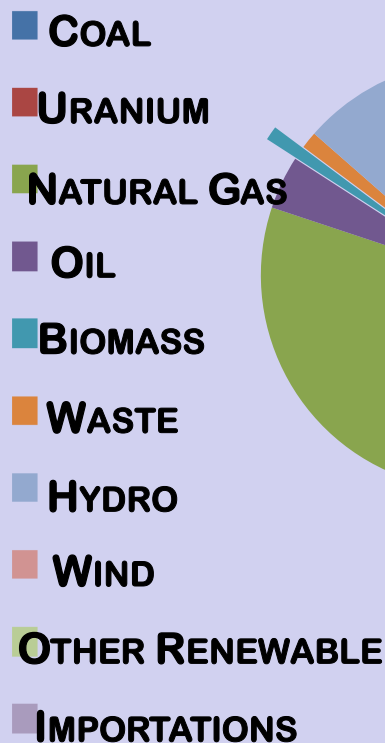
-  **Evaluate environmental impacts of a significant development of wood-bioenergy in Europe (heat and electricity sectors)**

# METHODOLOGY – CASE STUDY

## What policies?

### 2 European energy policies implemented during 2005-2025

- A baseline policy (business as usual) and a bioenergy policy (large increase of biomass use for heat and electricity generation)



Prospective scenarios for electricity generation  
(adapted from Mantzos et al. 2004)

## Prospective scenarios

### **Baseline and bioenergy scenarios (PRIMES/POLE)**

Describe evolution of European energy sector

## Prospective data

### **Economy forecast (macroeconomic drivers of GTAP)**

- Population
- Gross domestic product (GDP)
- Capital
- Skilled and unskilled labor forces

### **Technological innovation**

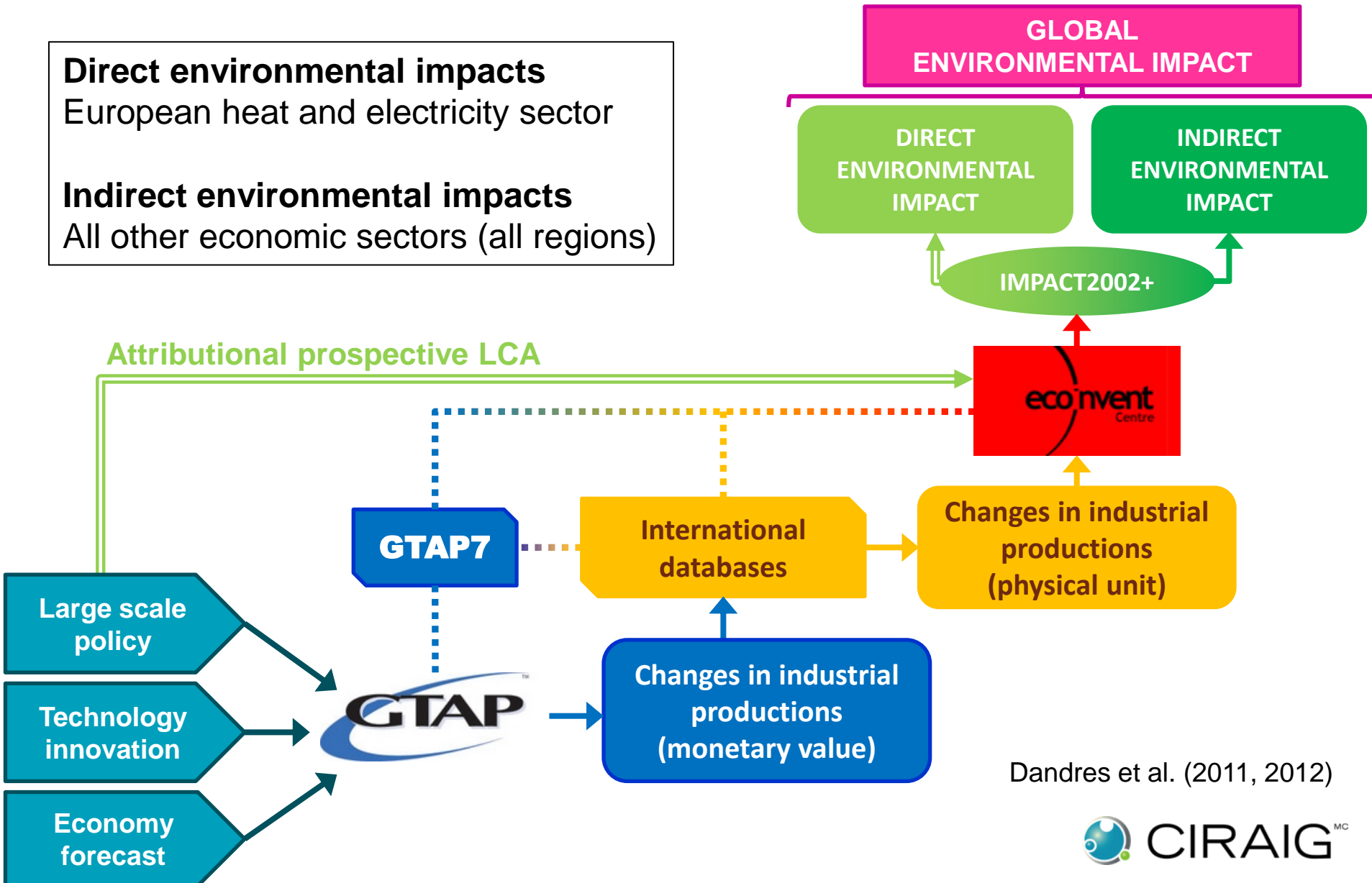
- European energy sector: literature and experts
- Other economic sectors: extrapolation from total factor productivity (TFP)



# METHODOLOGY – CONSEQUENTIAL PROSPECTIVE LCA

**Direct environmental impacts**  
European heat and electricity sector

**Indirect environmental impacts**  
All other economic sectors (all regions)



Dandres et al. (2011, 2012)

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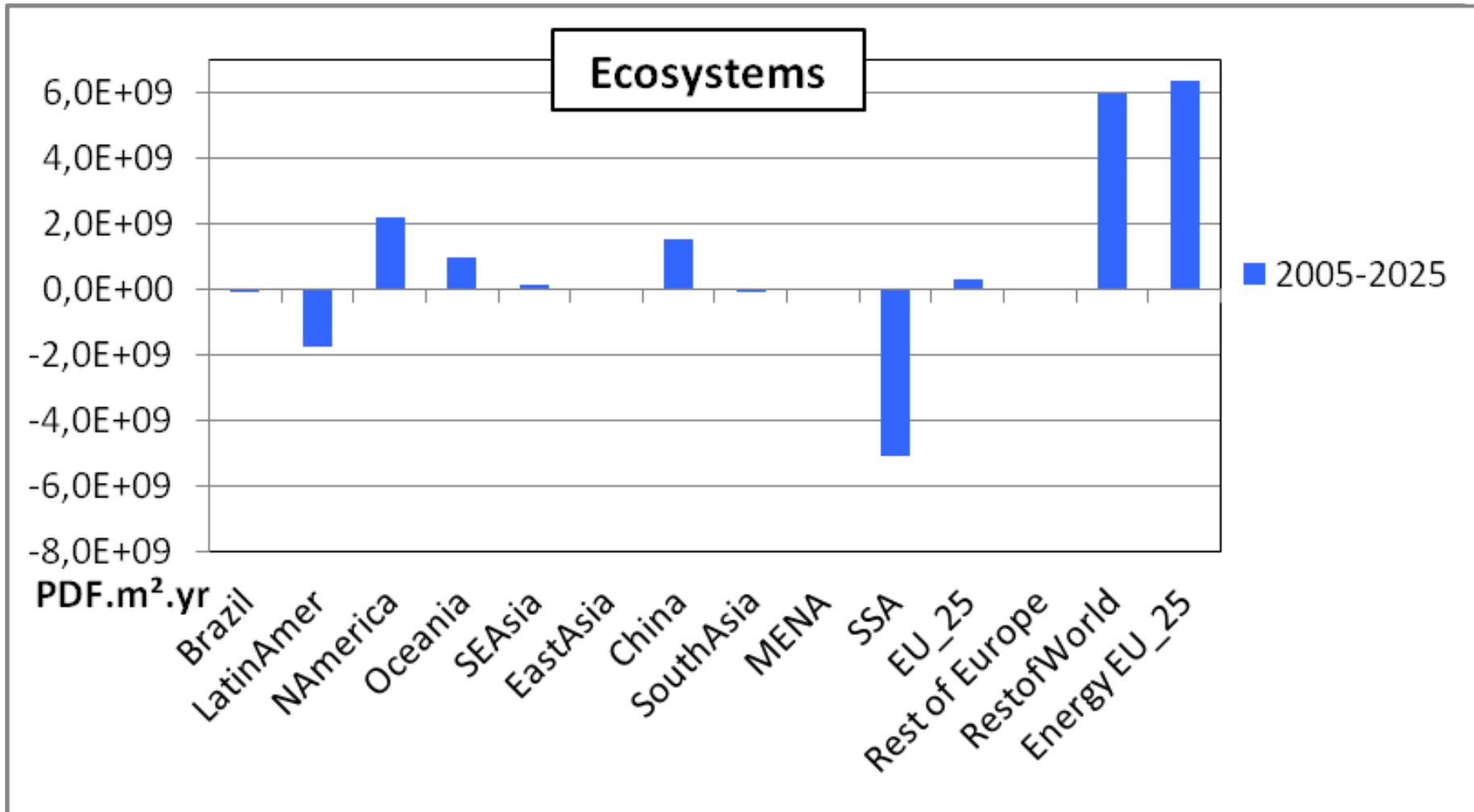
## Conclusion

# RESULTS – COMPARISON OF TWO EUROPEAN ENERGY POLICIES

**Environmental impacts can be expressed**



-  **By region and by period (example: ecosystems)**

# RESULTS – ENVIRONMENTAL IMPACTS BY REGION AND BY PERIOD

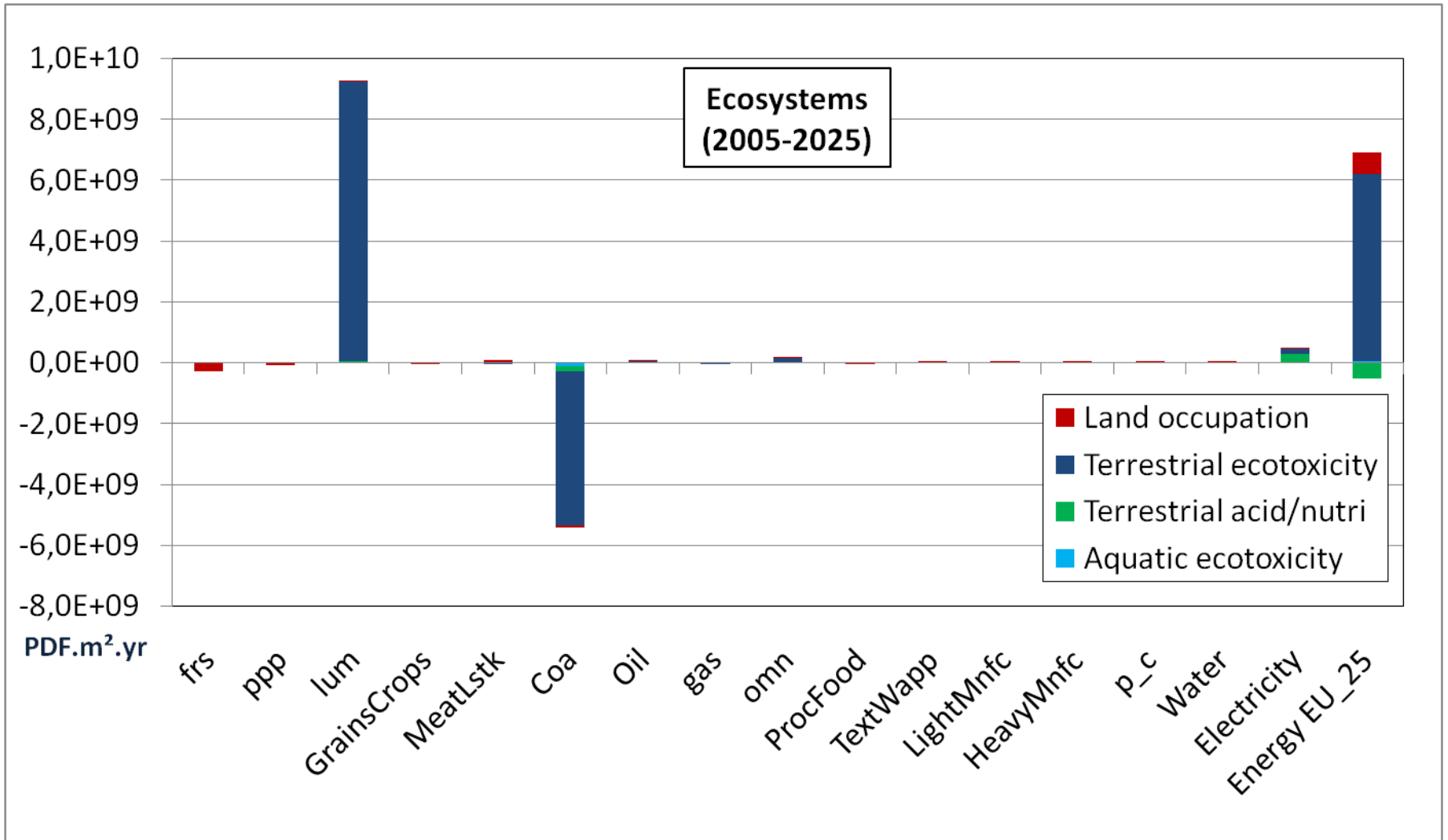


# RESULTS – COMPARISON OF TWO EUROPEAN ENERGY POLICIES

## Environmental impacts can be expressed




-  **By region and by period (example: ecosystems)**
-  **By economic sector and midpoint category (example: ecosystems)**

# RESULTS – ENVIRONMENTAL IMPACTS BY SECTOR AND MIDPOINT CATEGORY

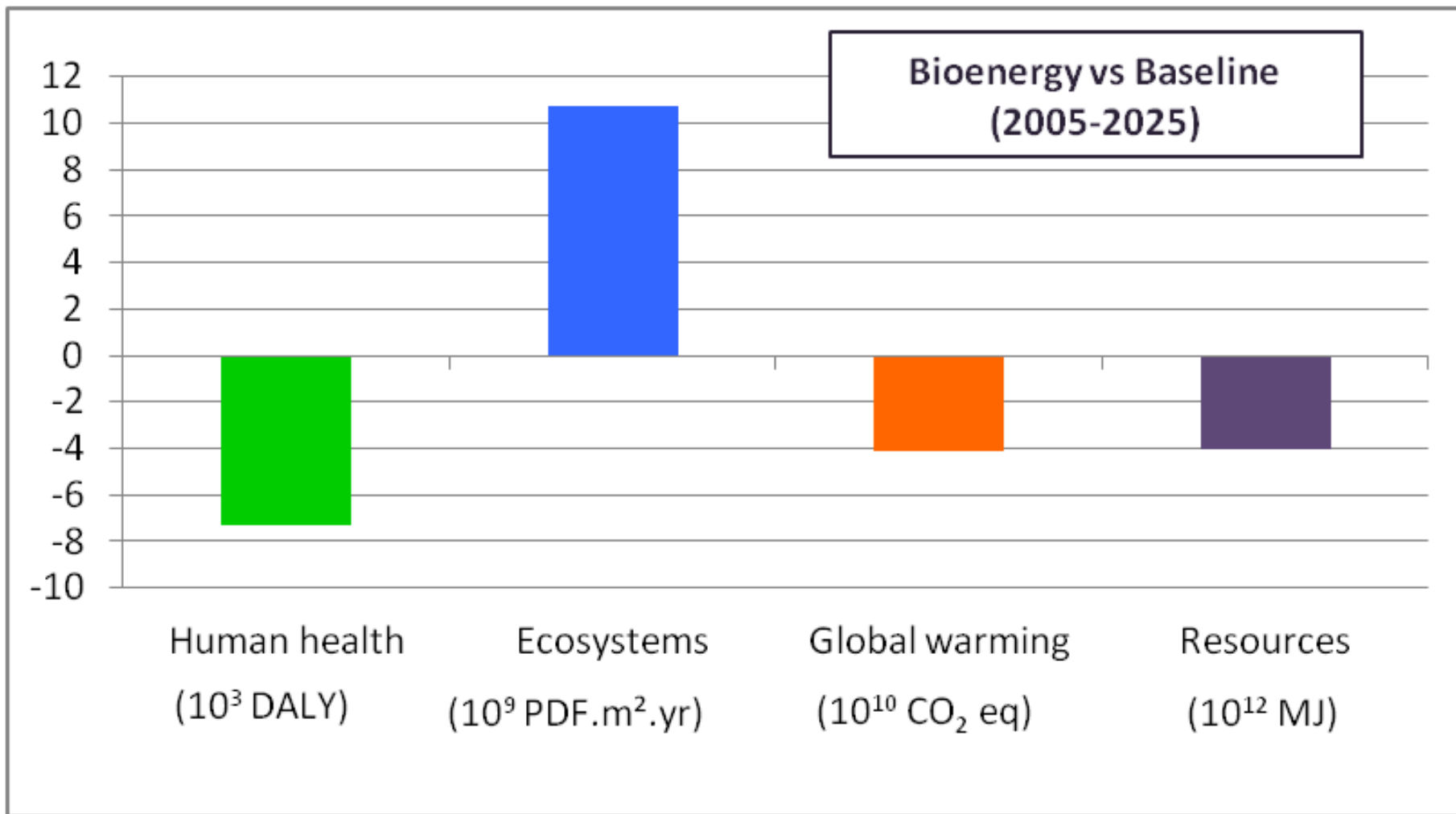


# RESULTS – COMPARISON OF TWO EUROPEAN ENERGY POLICIES

## Environmental impacts can be expressed

-  **By region and by period (example: ecosystems)**
-  **By economic sector and midpoint category (example: ecosystems)**
-  **By endpoint category (world scale)**




## RESULTS – ENVIRONMENTAL IMPACTS BY ENDPOINT CATEGORY





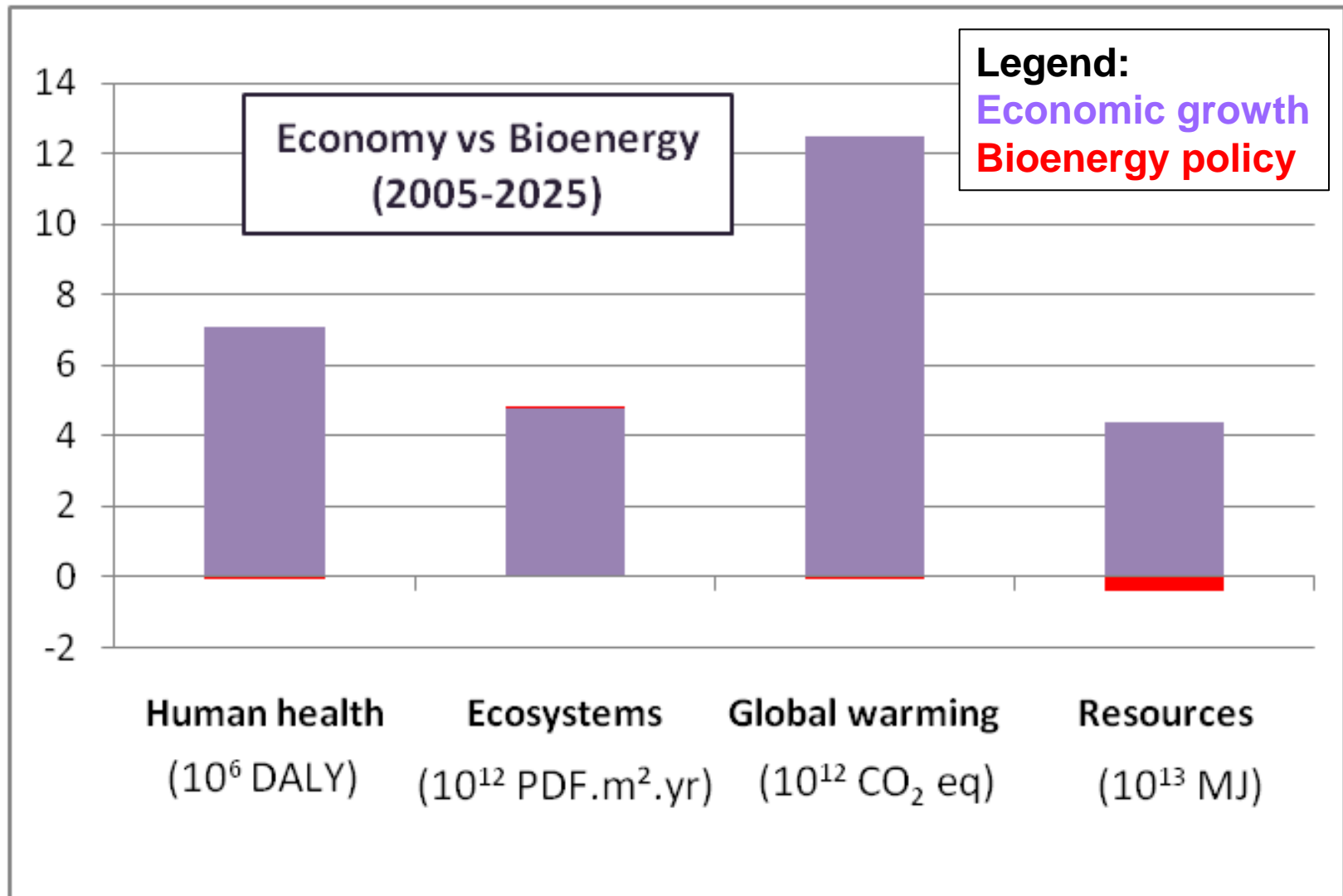
# RESULTS – COMPARISON OF TWO EUROPEAN ENERGY POLICIES

**Environmental impacts can be expressed**

-  **By region and by period (example: ecosystems)**
-  **By endpoint category (world scale)**
-  **By economic sector and midpoint category (example: ecosystems)**

**Environmental impacts due to economic growth and benefits/impacts of the bioenergy policy**

# RESULTS – ENVIRONMENTAL IMPACTS DUE TO ECONOMIC GROWTH



# RESULTS – UNCERTAINTY

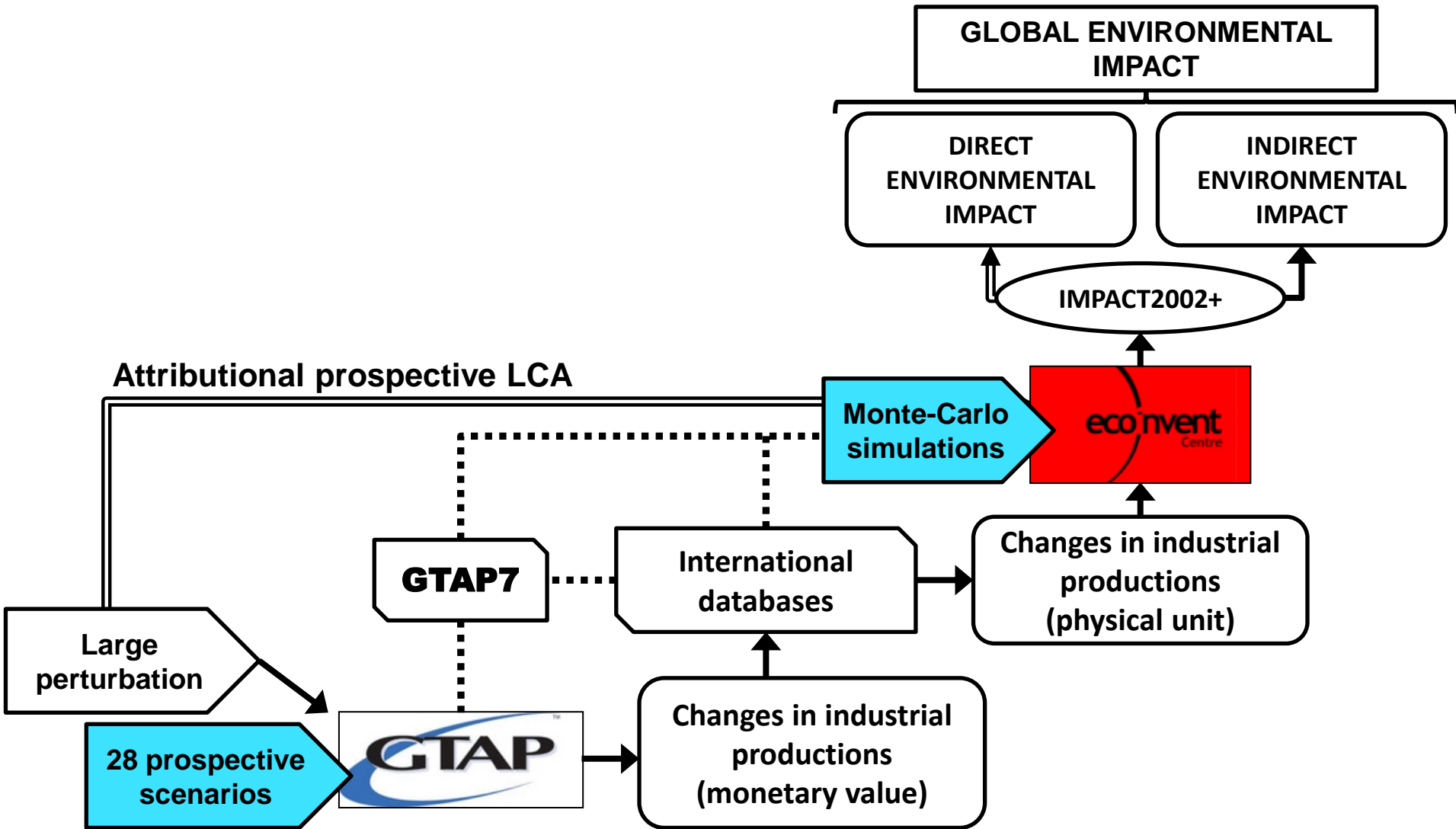
## Many sources of uncertainty

- 🌐 Economic and technological forecasts
- 🌐 GTAP database and parameters
- 🌐 GTAP model
- 🌐 Databases mapping (GTAP ↔ UNDATA ↔ ecoinvent)
- 🌐 Ecoinvent data and IMPACT2002+ method

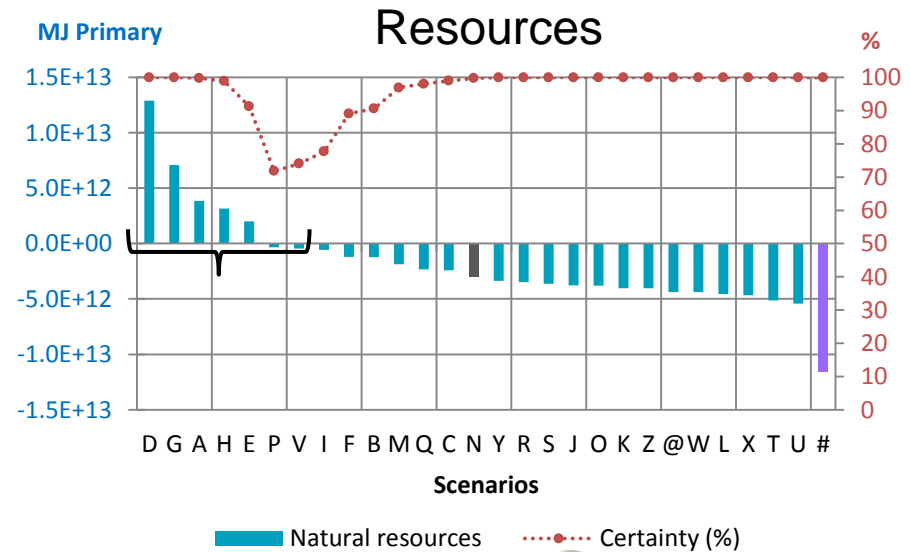
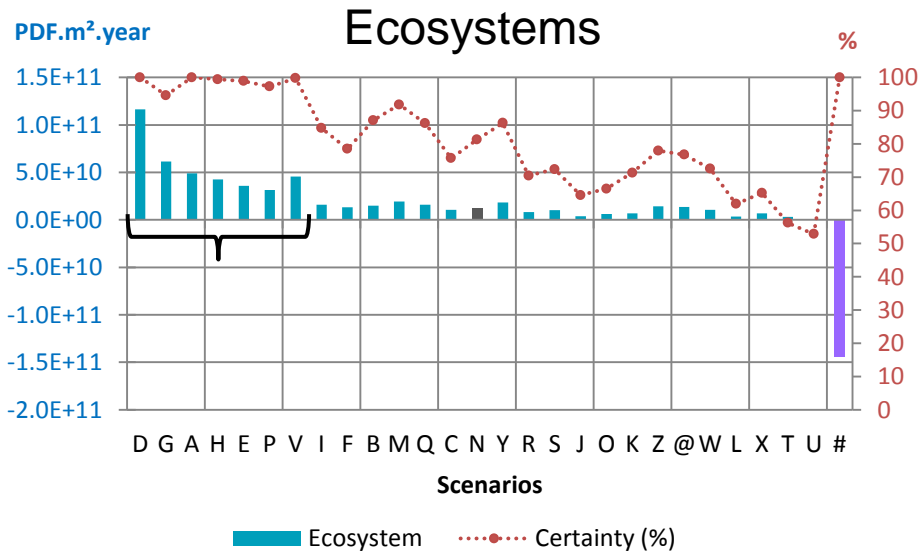
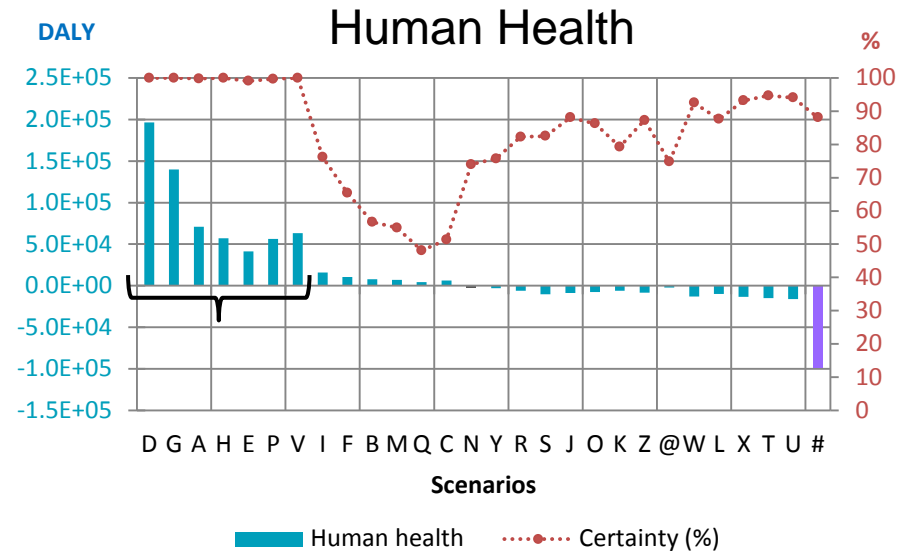
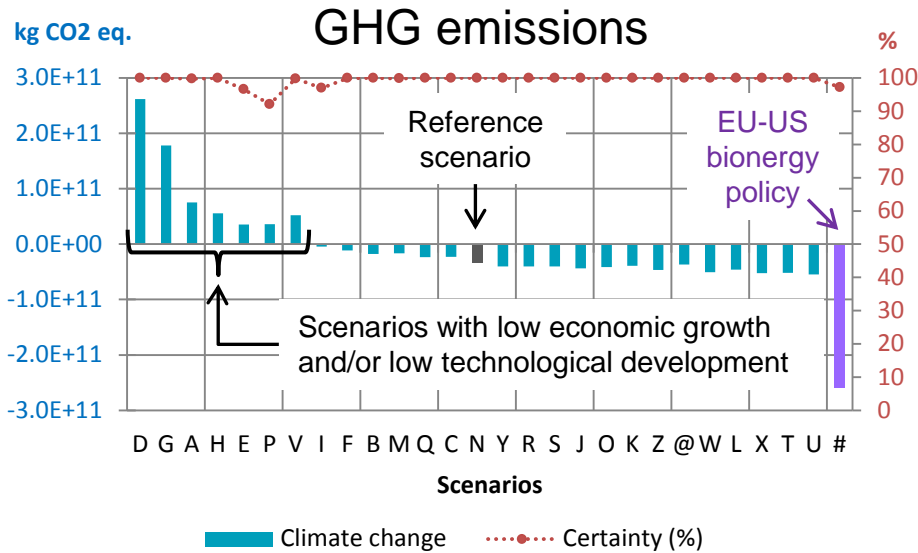
## Uncertainty analysis

- 🌐 27 prospective scenarios (GTAP simulations)
  - combination of economic, technological and GTAP parameters changed by: +50%; +0%; -50%
- 🌐 1 what-if scenario: EU-US joint bioenergy policy
- 🌐 Monte-Carlo simulations (LCA uncertainty)

# RESULTS – UNCERTAINTY ANALYSIS



# RESULTS – UNCERTAINTY ANALYSIS



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# CONCLUSION

## Macro LCA approach

- 🌐 Consequential prospective LCA made to study large scale policies (with non-marginal variations)

## Policy assessment

- 🌐 European bioenergy policy (heat and electricity) is better than the baseline policy for human health, climate change and natural resources but not for ecosystems

## Uncertainty

- 🌐 Modeled uncertainty does not really affect the comparison of the two policies

## PUBLICATION AND REFERENCES

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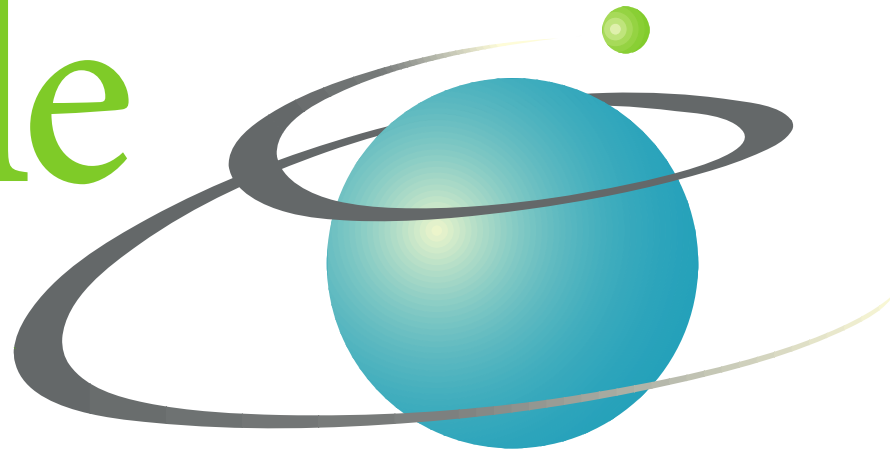
# ACKNOWLEDGEMENT – Project Partners



# CYCLE 2016 - 5<sup>th</sup> international Forum on the life cycle management of products and services

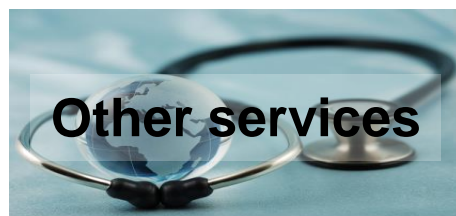
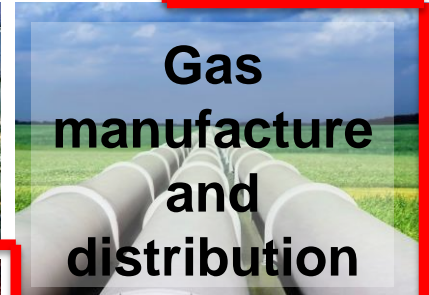
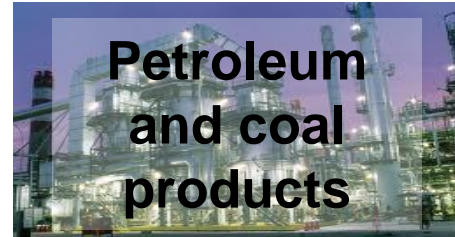
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# METHODOLOGY – GTAP SETUP (20 ECONOMIC SECTORS)





# METHODOLOGY – GTAP SETUP (13 REGIONS)

