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Development and deployment of clean electricity technologies in Italy: a preliminary assessment of the EU climate and energy framework using a CGE model

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Outline

1. Objectives
2. Background and Review of relevant literature
3. Model description
4. Scenarios
5. Results
6. Conclusions

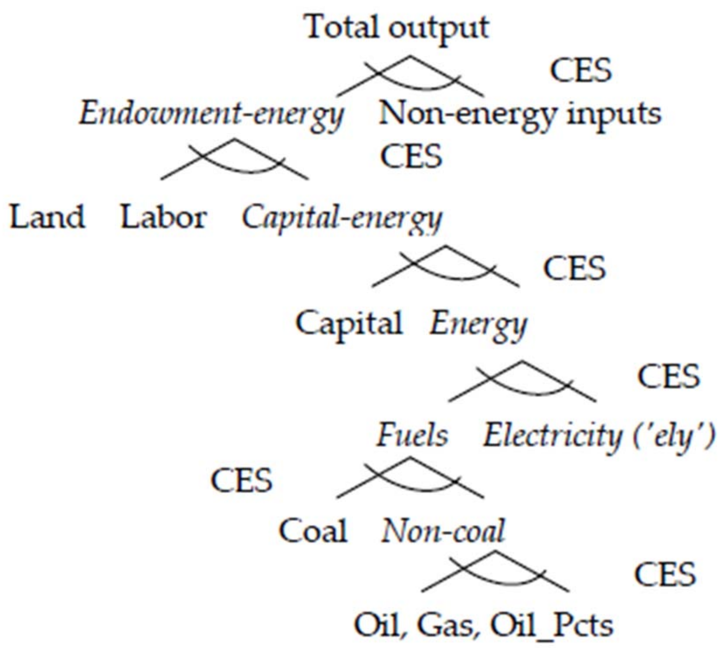
Objectives

- Disaggregate electricity generation technologies in a CGE model
- Revise the technology bundle approach
- As an application, provide an assessment of the 2030 EU Climate and energy policy framework

Background

* In many CGE models specific electricity generating technologies are not identified.
* There are large differences in terms of costs and emissions profile of different electricity generation technology.
* LCOE for a conventional coal power plant is much lower than that of a comparable solar one.
* But electricity generated through solar power is emissions-free.

Background (2)



Review of existing approaches (1)

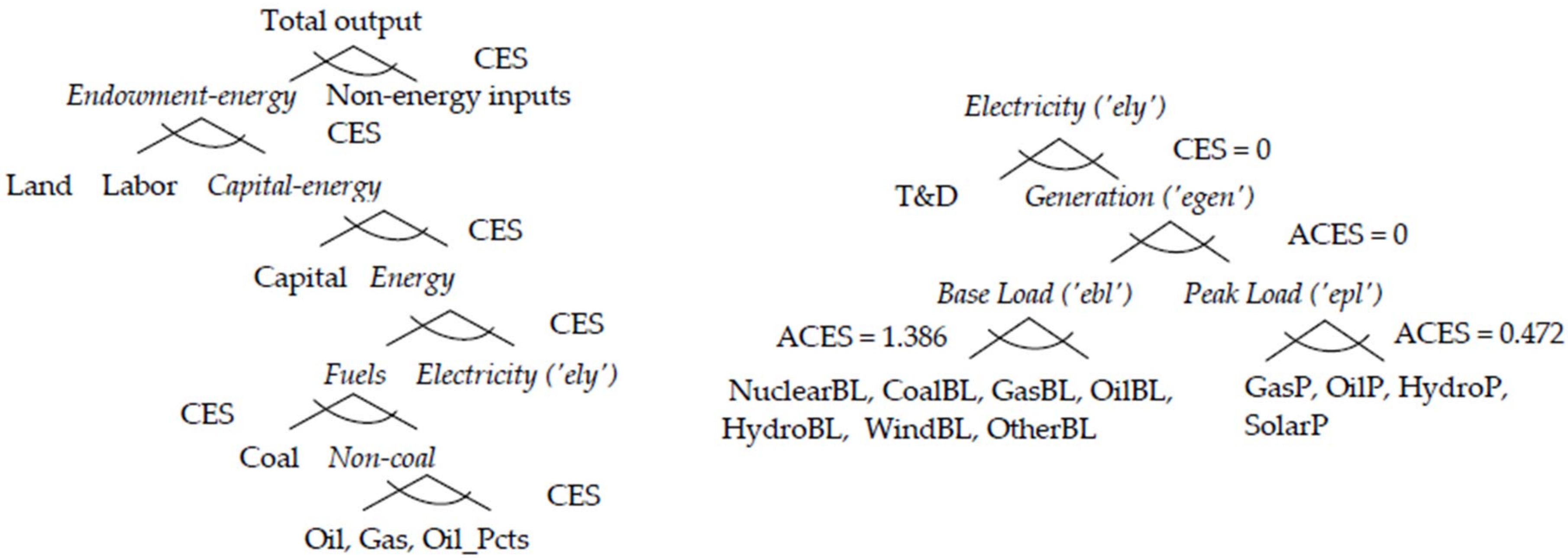
MIT – Joint Program (Paltsev et al. 2005, pg. 19, 37)	Electricity CES >0 *Output of perfect substitutes* — Wind & Solar CES = ∞ Conventional fossil*, Nuclear, Hydro, Various advanced generation technologies
JGCRI - Phoenix (Sue Wing, 2011, pg. 30--31)	Electricity CES = 0.7 Transmission & Distribution — *Generation* CES = 1 *Base Load* — *Intermediate Load* — *Peak Load* CES = 4 — CES = 4 — CES = 4 Coal, Nuclear, Hydro, Natural Gas, NGCC, IGCC, Geothermal — Biomass, Natural Gas, Refined Oil, NGCC — Solar, Wind, Natural Gas, Refined Oil, NGCC

Review of existing approaches (2)

GEM-E3 (Capros et al. 2013, pg. 43, Annex VIII)	Electricity CES = 0 Distribution *Technologies* CES = 0 Coal, Gas, Oil, Nuclear, Hydro, Biomass, Solar, Wind, CCS Coal, CCS Gas
GTEM/CTEM (Arora and Cai, 2015, pg. XX)	Electricity CES = 0 O&M and Distribution *Generation* CRESH = *many parameters* Coal, Gas, Oil, Nuclear, Hydro, Wind, Solar, Biomass, Waste, and Other Renewables
OECD ENV-Linkages (Château et al. 2014, pg. 23, 32)	Electricity CES = 5 Fossil-fuel based*, Hydro & Geothermal, Nuclear, Solar & Wind, Biomass & Waste

Review of existing approaches (3)

- In a recent paper, Peters (2016) develop the Gtap-Power model
- Building on the GTAP-E model, propose the following structure:



Model description

* We modified the GTAP-E model (McDougall and Golub 2007) with endogenous dynamics for capital accumulation.

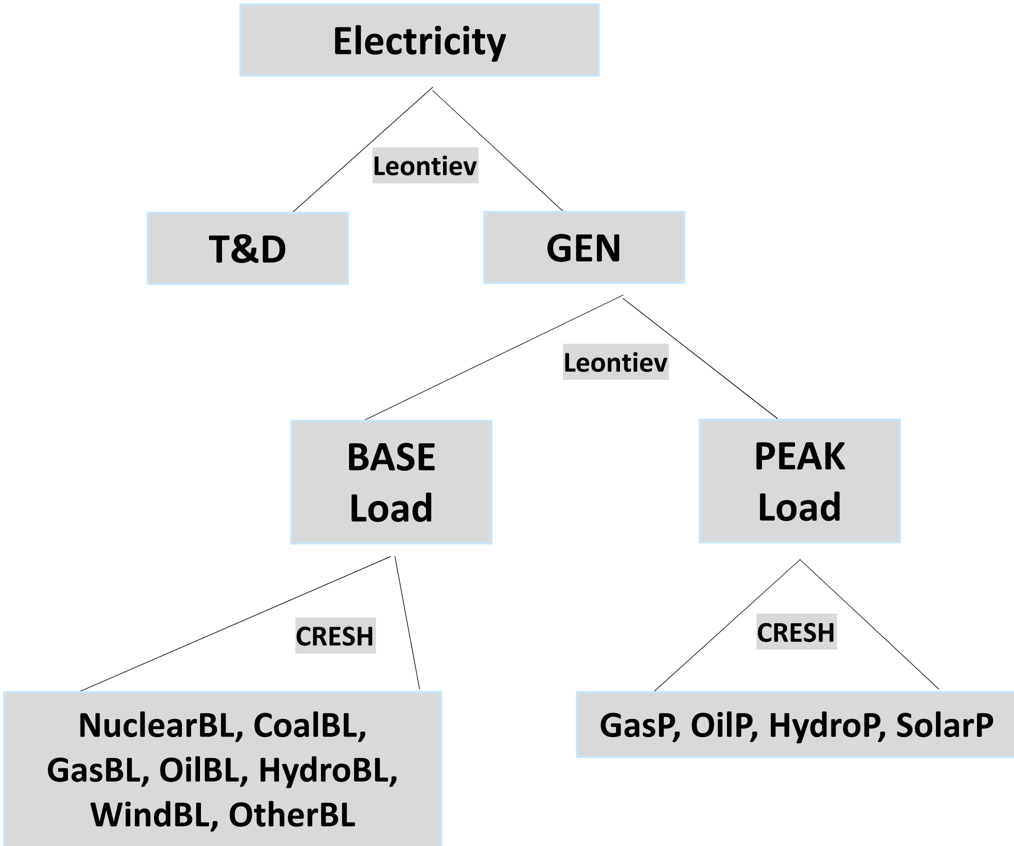
* The dynamics of the model rely on the idea of “recursiveness” where a sequence of static equilibria are connected by the process of capital accumulation. Capital growth is standard along exogenous growth theory models and follows:

  * $QK_t = I_t + (1 - \delta)\, QK_{t-1}$

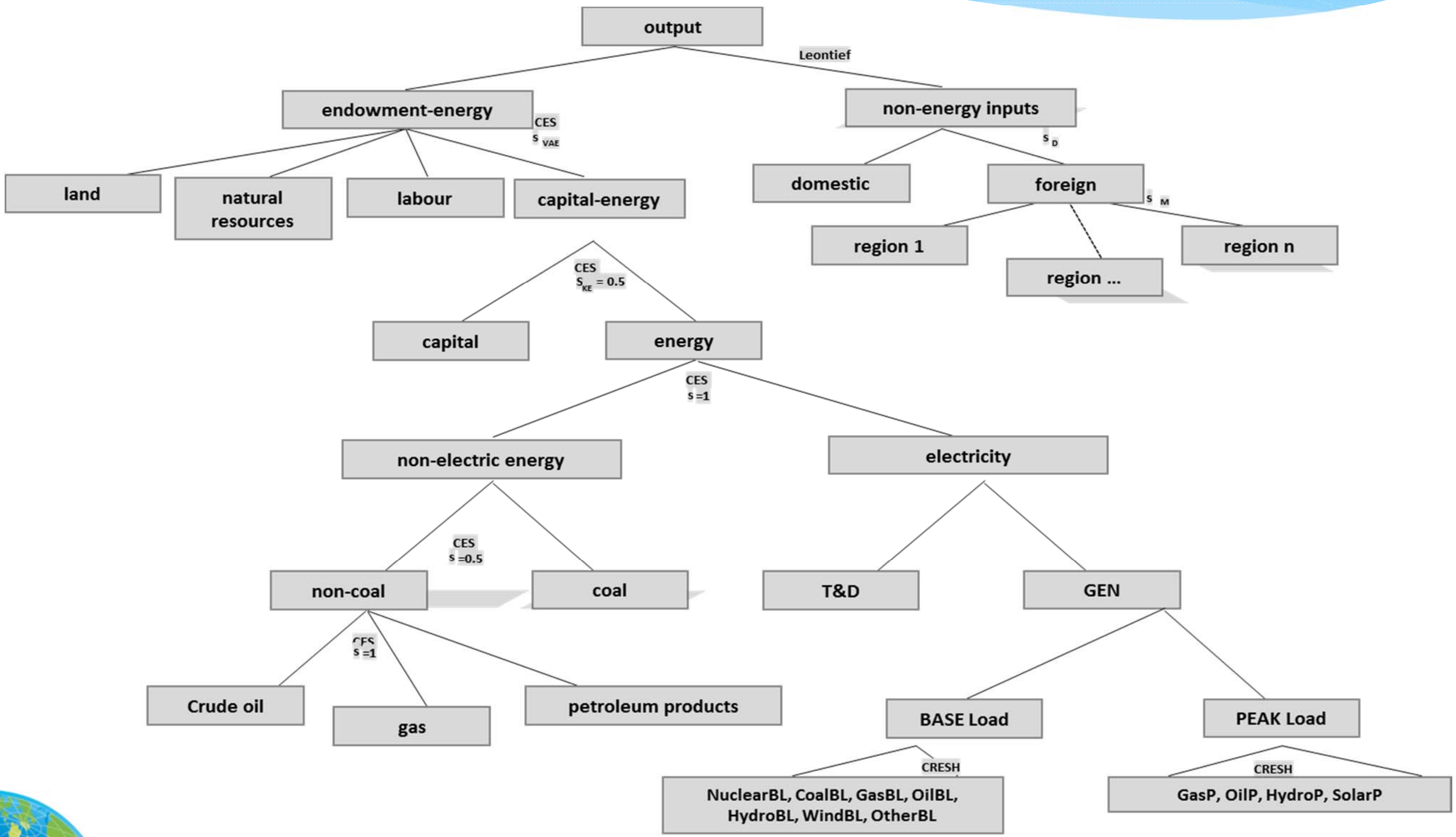
Model description

* We modified the production structure following Peters 2016.
* We used the CRESH function as in Arora and Cai (2015) to model substitution between different technologies.
* The use of the CRESH function allows for differing levels of substitution between each of the generation technologies.
* We assume that the electricity sector is composed of generation (i.e. production), transmission and distribution to firms and households.
* Firms and household demand individual technologies as opposed to an aggregate national electricity good.

Electricity sector



Production Structure



Data description

* Data come from the GTAP9 database (Narayanan et al. 2015)

* Disaggregated electricity sector using the **Gtap-Power** database (Peters, 2016).

* 68 sectors of the economy and 15 regions/countries of the World

* The calibration year is 2011 and the simulation time is 2012-2030.

Scenarios: the EU ROADMAP

2020

CLIMATE & ENERGY PACKAGE
20/20/20

2030

CLIMATE & ENERGY FRAMEWORK
40/27/27

emissions reduction by 43% on ETS sectors

2050

LOW-CARBON ECONOMY + ENERGY ROADMAP
80 emissions
55% RES

Scenarios (2)

CES function		CRESH function	
01 BAU	02 POLICY	03 BAU	04 POLICY

Elasticities of substitution:

Base	Peak
1.4	0.5

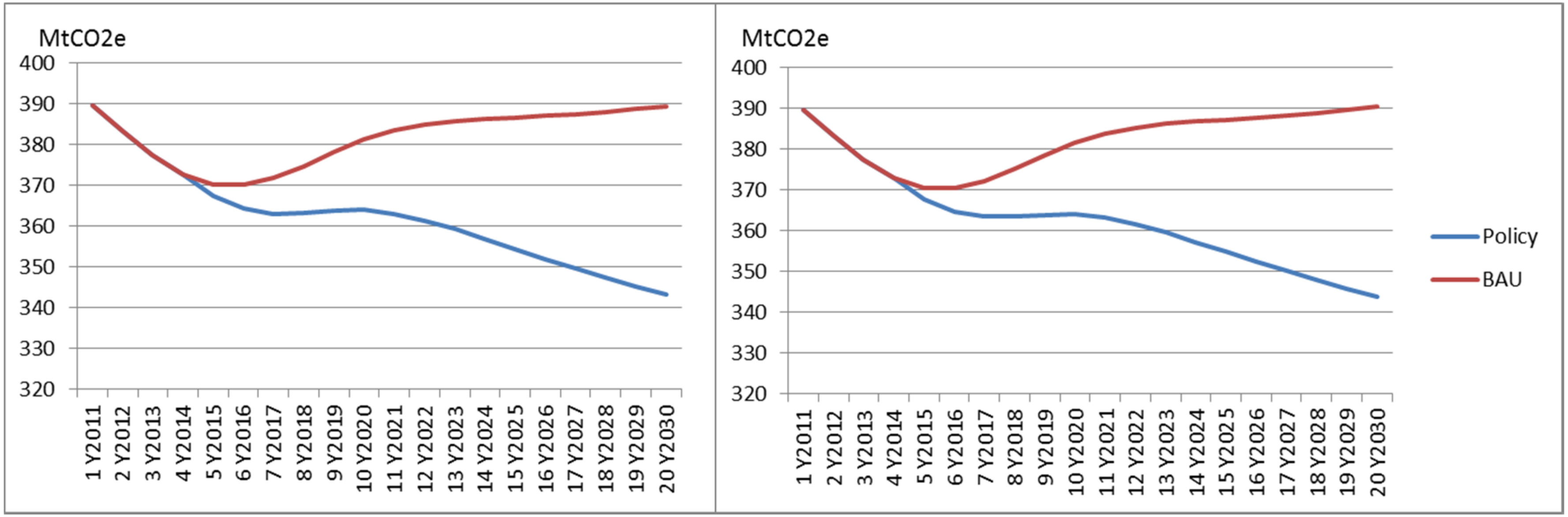
Base Load		Peak Load	
NuclearBL	1.4	GasP	0.5
CoalBL	1.4	HydroP	0.5
GasBL	1.4	OilP	0.5
WindBL	2.8	SolarP	1
HydroBL	1.4		
OilBL	1.4		
OtherBL	1.4		

Scenarios

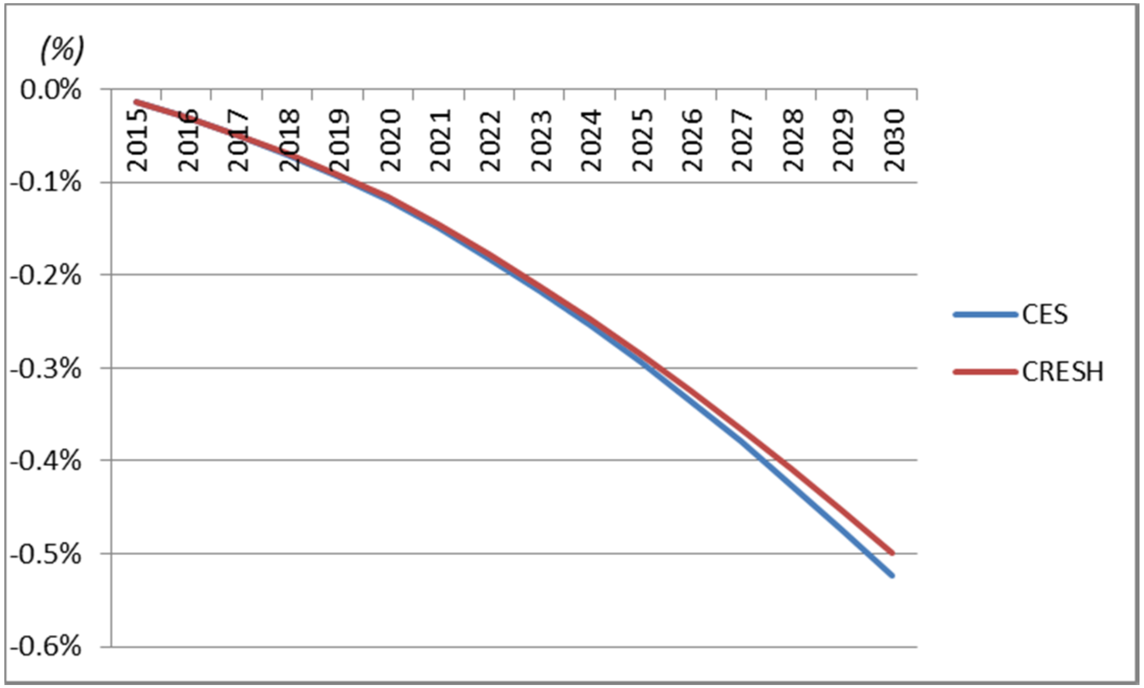
* Cap and trade on emissions
* linear annual reduction of 1.74% until 2020 and 2.20% until 2030
* Only on CO_2 emissions from burning of fossil fuels
* Only on ETS sectors

Results: Emissions

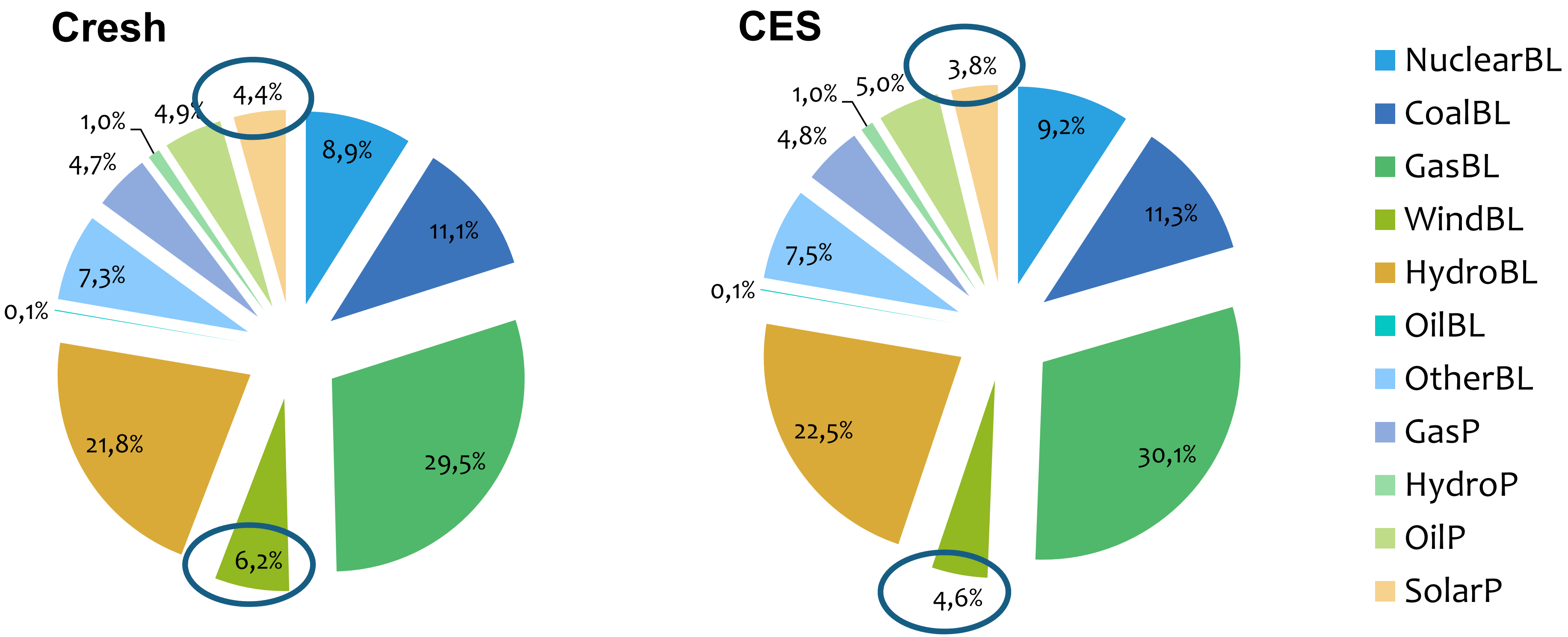
Cresh **CES**



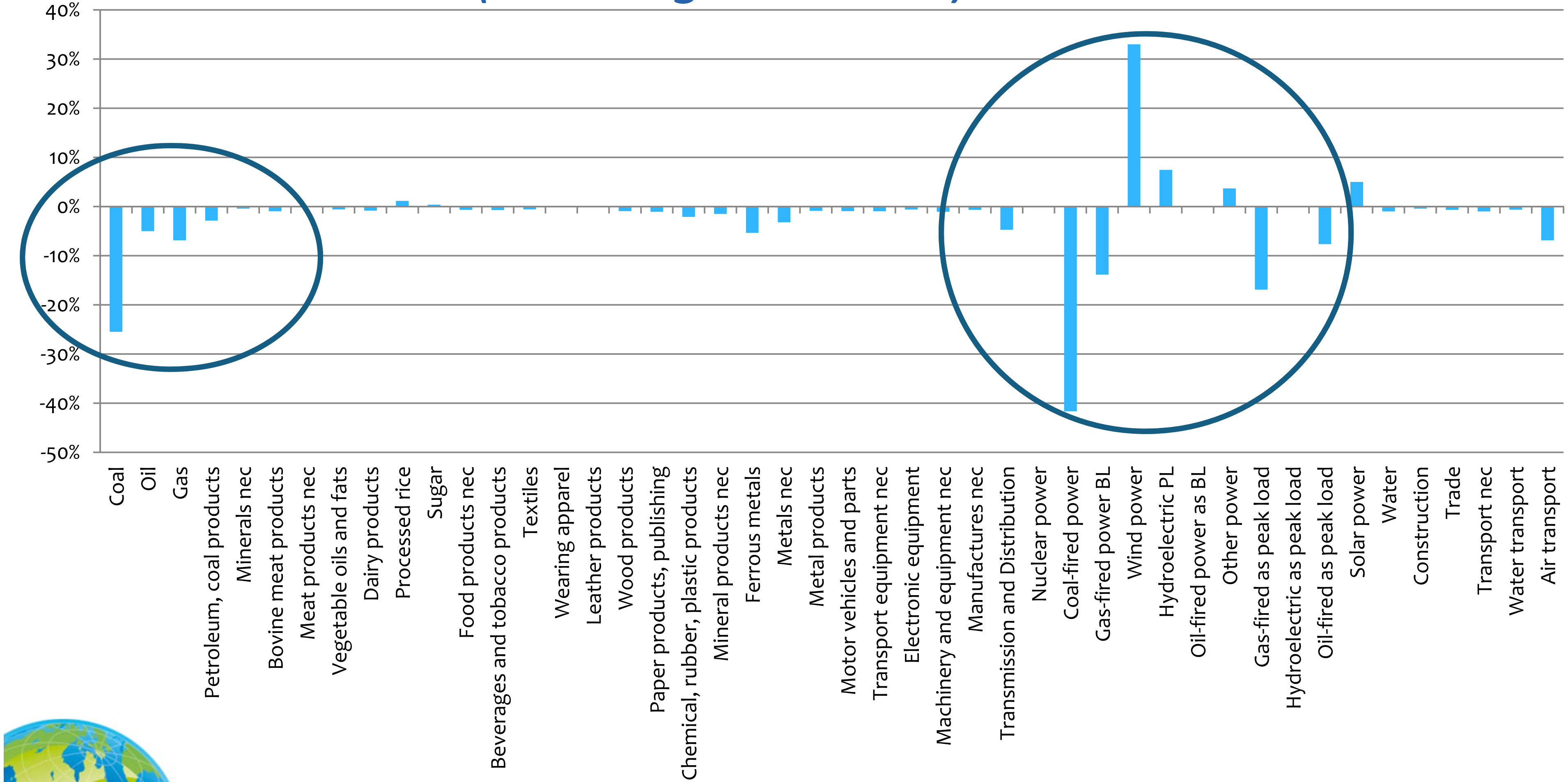
Results:
GDP *(% change wrt BAU)*



Results:
Electricity mix



Results:
Production *(% change wrt BAU)*



Conclusions

* The manner in which electricity generation is modelled can determine different results of the costs and benefits of environmental policies.
* To demonstrate this approach, we simulate the EU Climate and energy framework at 2030 with different functional forms (CES vs CRESH)
* Allowing for different level of substitution can change results.
* The size of such differences is highly uncertain.
* As a step forward, we will try to estimate econometrically these elasticities.