EERA
European Energy Research Alliance

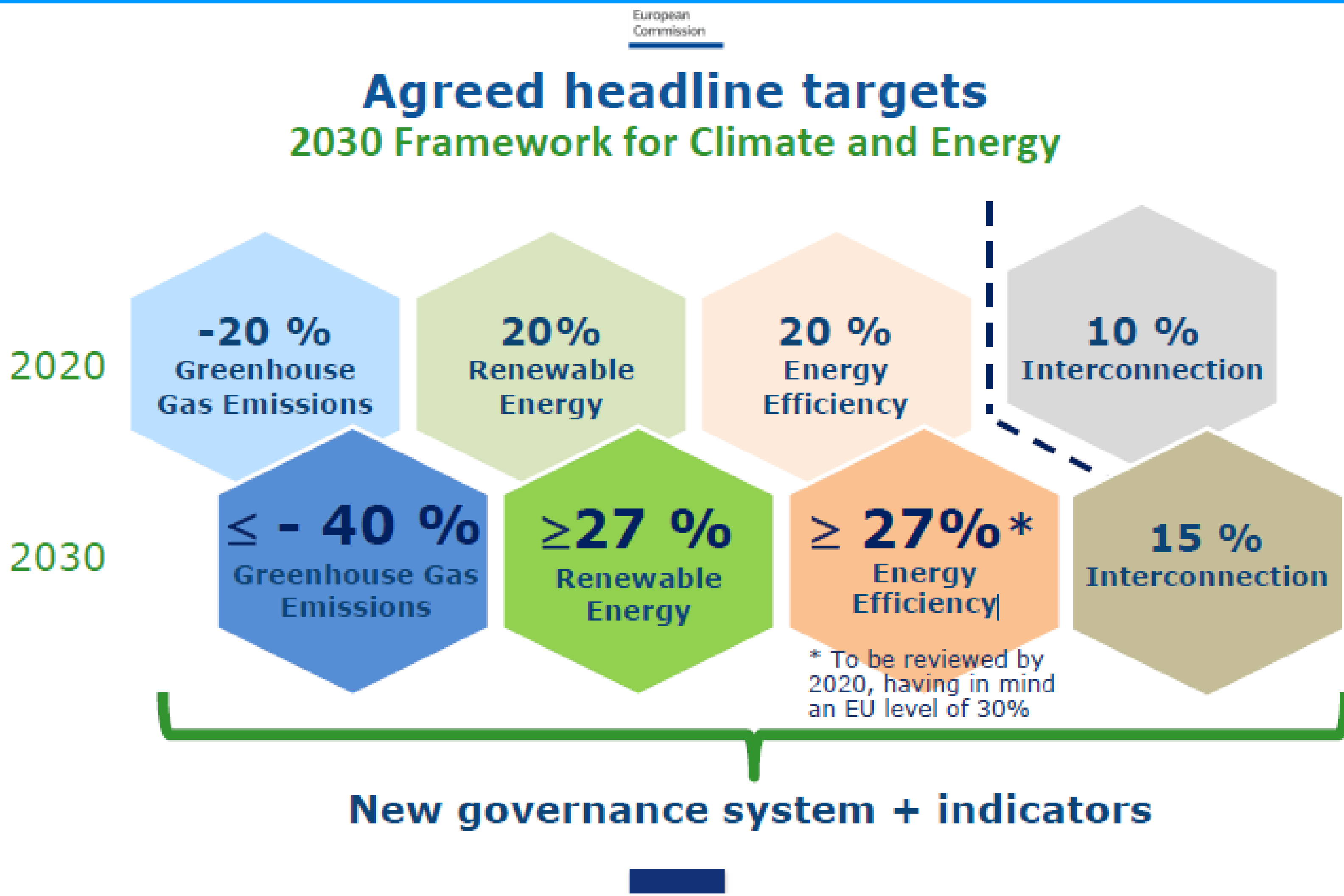
GOBIERNO DE ESPAÑA
MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD
Ciemat
Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

Impact of the EU 2030 Climate and Energy Framework on the Nexus Water-Energy-Land in Spain

Helena Cabal, Yolanda Lechón and Cristina de la Rúa
Energy Systems Analysis Unit
CIEMAT

International Energy Workshop 2016
Cork, 1-3 June 2016

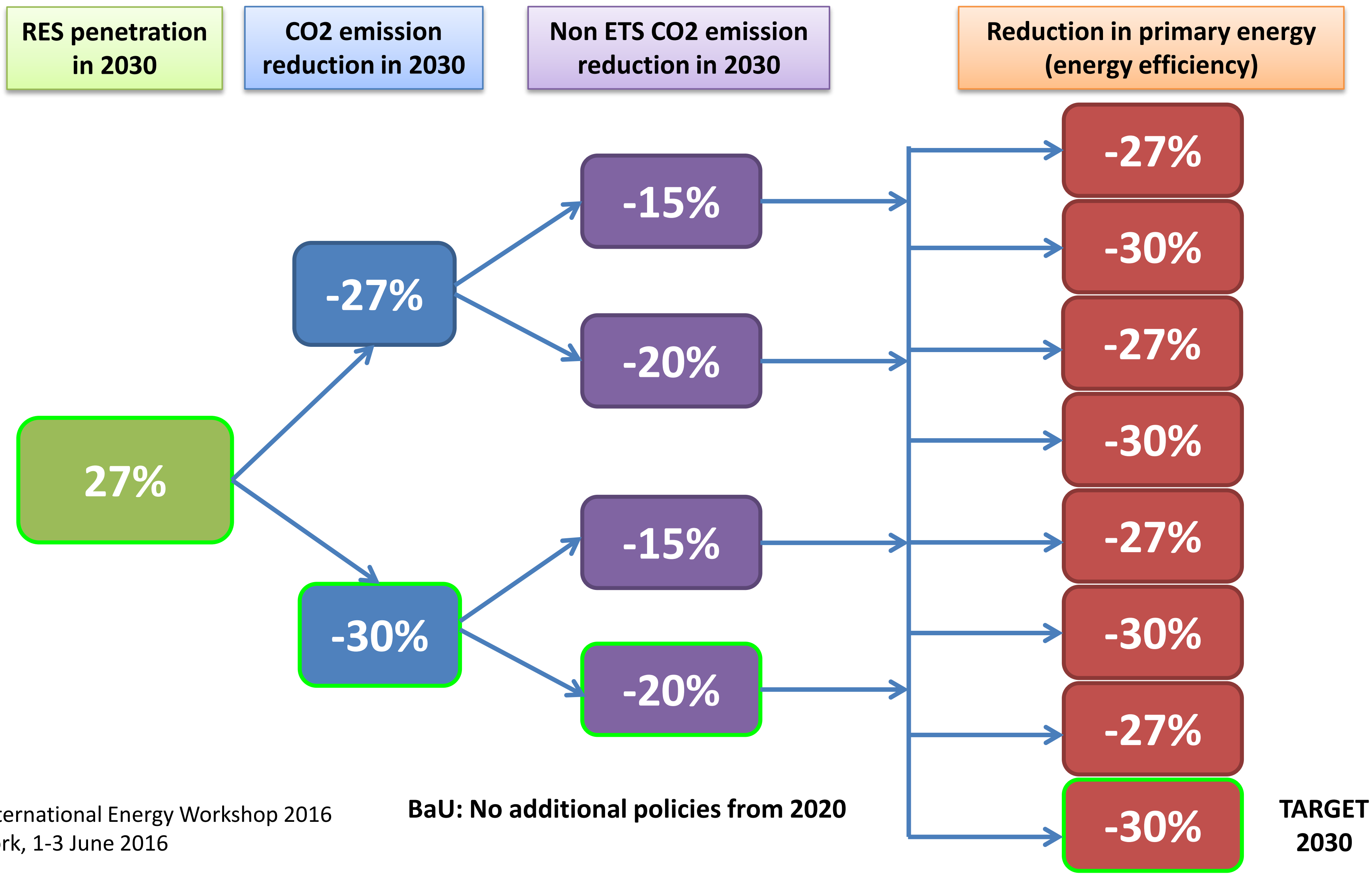
INTRODUCTION
2030 Framework for Climate and Energy



INTRODUCTION
Assumptions for Spain

GHG emissions	2020 : 21% reduction on total emissions compared to 2005 2030: 27%-30% reduction on total emissions compared to 2005	2020 : 10% reduction on nonETS emissions compared to 2005 2030: 15%-20% reduction on nonETS emissions compared to 2005
Renewable energy share	2020 : 20% share 2030: 27% share	
Electricity interconnection	2020 : 10% of the total installed capacity -> interconnection 2030: 15% of the total installed capacity -> interconnection	
Efficiency	2020 : 20% share 2030: 27% share	

INTRODUCTION
Scenario tree



METHODOLOGY

TIMES-Spain energy model

- Optimisation model -> optimum energy system at minimum cost and maximum social welfare and sustainability
- Covering the whole energy system
- Technology rich
- 1 region
- Time horizon 2050
- 12 Time slices
- Interconnections with France and Portugal for electricity exchange

LCA

To assess the potential environmental impacts and resources used throughout a product's life cycle from raw material acquisition, via production and use phases, to waste management
UNE-EN-ISO 14040-44

Phases
a) Goal and scope definition
b) Inventory analysis
c) Impact assessment
d) Interpretation

METHODOLOGY

TIMES-Spain energy model

1. Identification of the different current and future technologies in the Spanish electricity system

3. Evolution of the electricity technologies portfolio until 2030

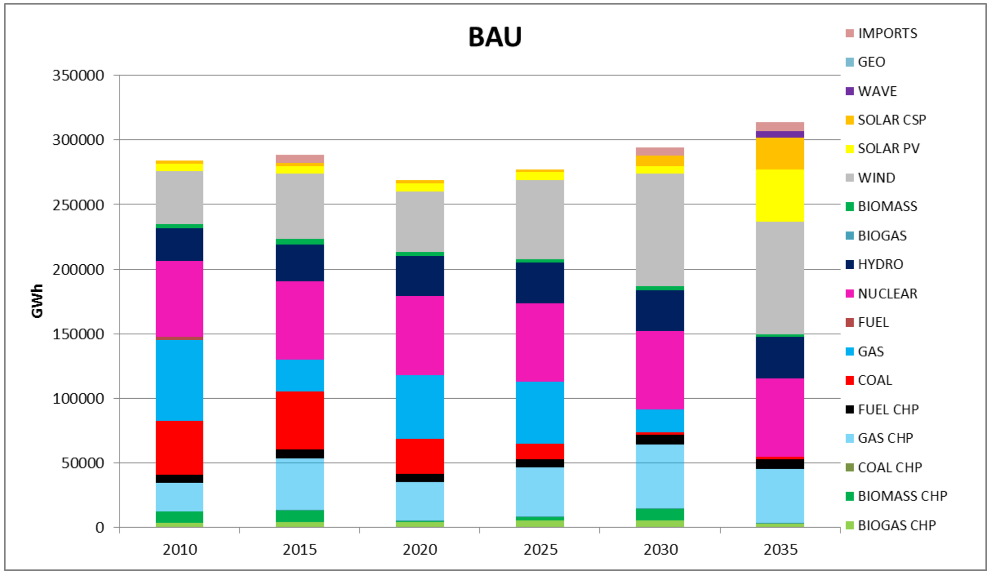
- EU 20-20-20 energy and climate package
- EU 2030 climate and energy strategy

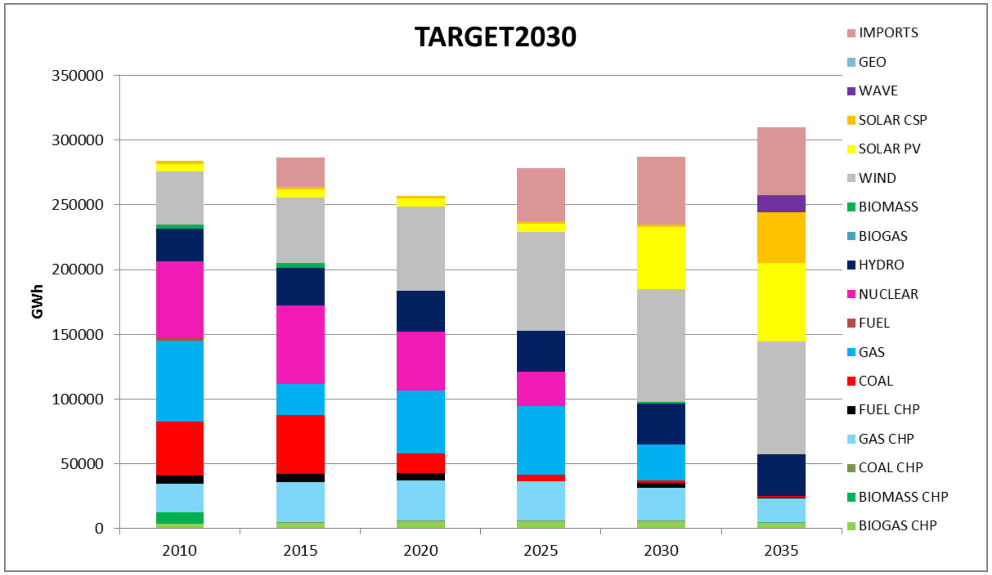
Life Cycle Assessment

2. Environmental impacts of each technology per kWh
Acidification, eutrophisation, toxicity, resource depletion, land use and water consumption

Estimation of the impact that different electricity generation scenarios might have of different aspects of the W-E-L nexus

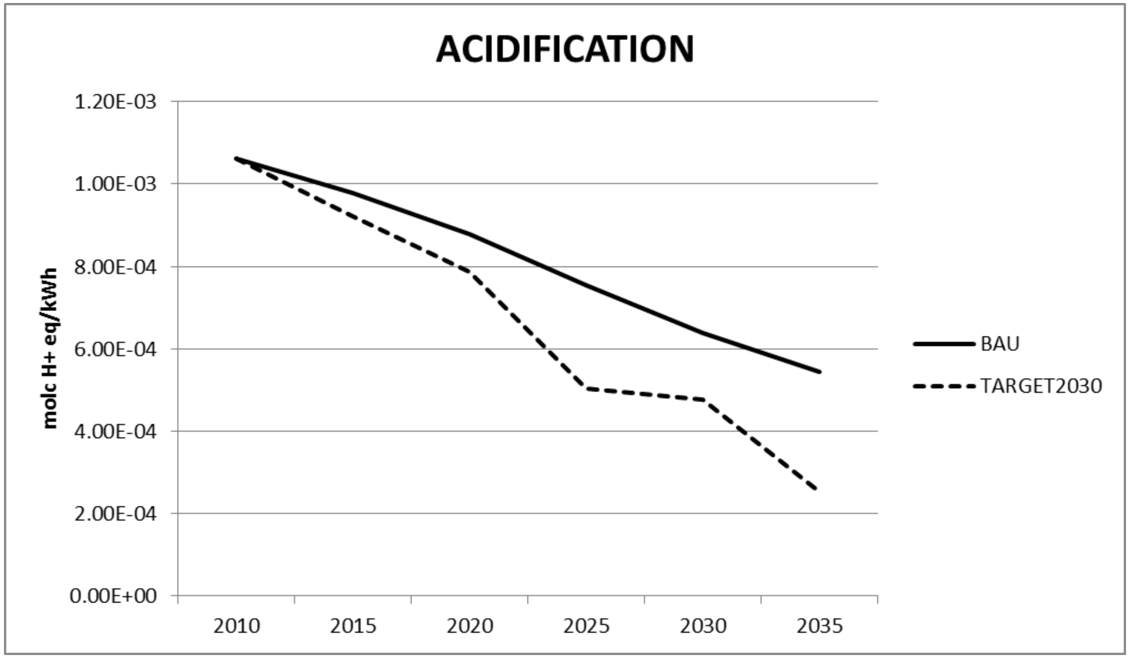
RESULTS
Electricity production





RESULTS
Acidification

Potential increase in water and soil acidity caused by sulphur and nitrogen oxide emissions

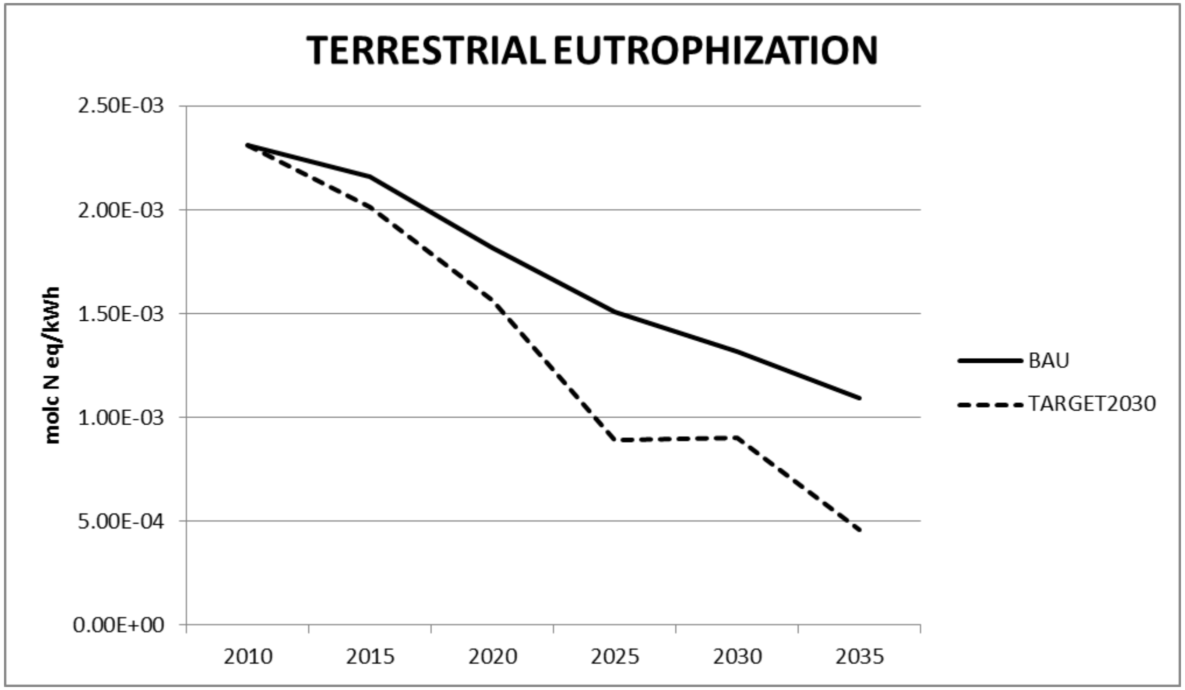


Impact method: Accumulated excess (Seppala et al., 2006, Posch et al., 2008)

Main technologies contributing: coal, gas and oil power plants

RESULTS
Eutrophization

Potential accumulation of nutrients (nitrogen and phosphorus) in water and soil

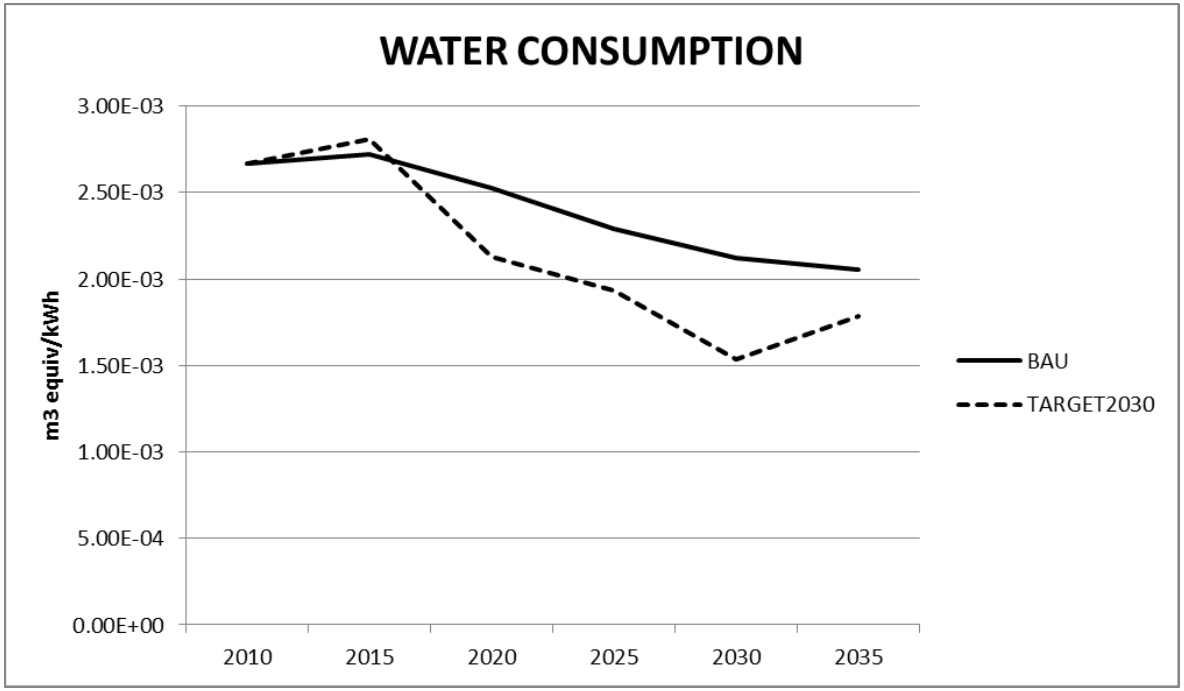


Impact method: Accumulated excess (Seppala et al., 2006, Posch et al., 2008)

Main technologies contributing: coal and oil power plants

RESULTS
Water consumption

Water consumption in relation to water availability



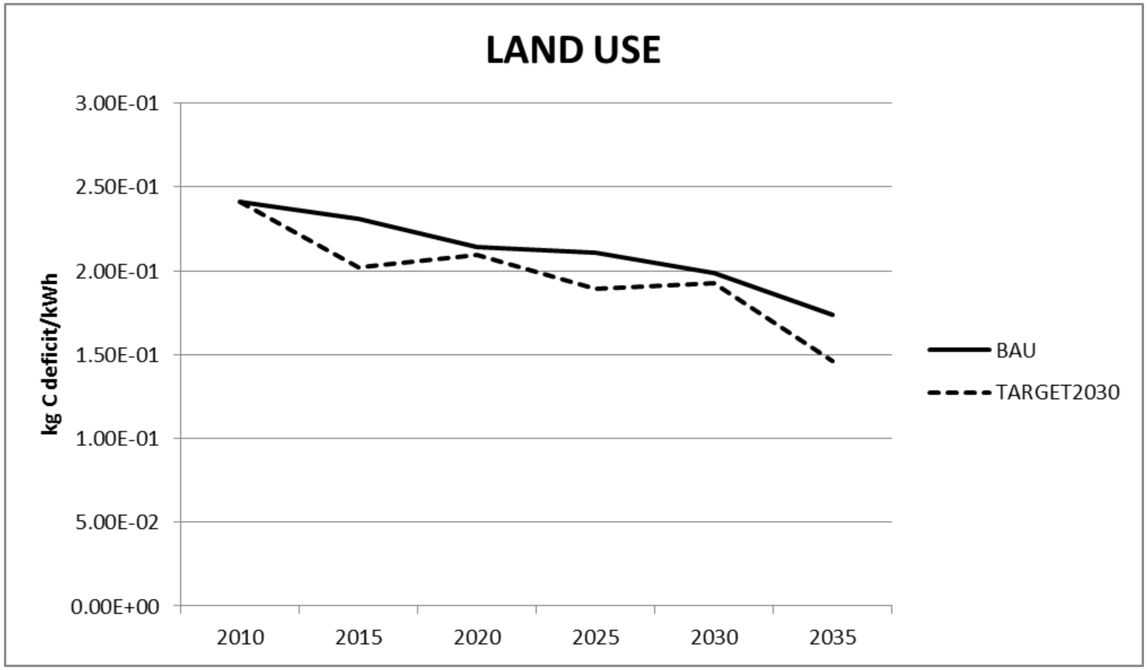
Impact method: Swiss Ecoscarcity model (Frischknecht et al., 2008)

Main technologies contributing: coal, solar and nuclear power plants

RESULTS
Land Use

C released from vegetation and soil as a consequence of a change in land use

Only direct impacts considered



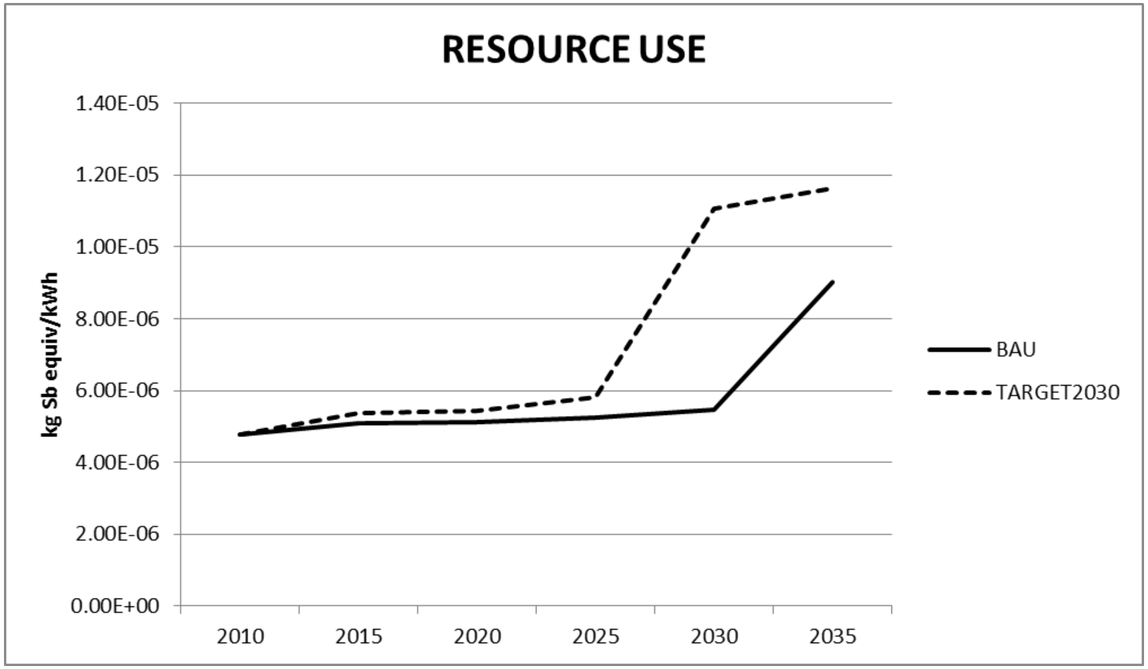
Impact method: Model based on the organic material in soil (Mila I Canals et al., 2007)

Main technologies contributing: biomass CHP, gas, and oil power plants

RESULTS
Resource use

Resource scarcity

Strongly dependent on the characterisation methodology



Impact method: CML 2002 (Guinée et al., 2002)

Main technologies contributing: solar PV power plants

CONCLUSIONS

The reduction in electricity production with coal and the renewable technologies penetration lead to lower acidification and eutrophication impacts

Impacts on land use and water consumption are also reduced but the second starts increasing from 2030 mainly due to CSP penetration

Finally, impacts on the use of resources increase due to the use of scarce materials such as silver or zinc in PV panels manufacture

THANKS FOR YOUR ATTENTION

helena.cabal@ciemat.es

Impact of the EU 2030 Climate and Energy Framework on the Nexus Water-Energy-Land in Spain

Willaarts, B.A; De la Rúa, C; Cabal, H; Garrido, A; Lechon, Y (2016). **El Nexo Agua-Tierra-Energía en España**. Fundación Canal Isabel II. Book (in Spanish) available at:

http://www.fundacioncanal.com/cat/publicaciones/?categoria=Publicaciones%20cient%C3%ADfico-divulgativas

This presentation has been elaborated using the information generated by the authors during the development of the Research Project "Caracterización del nexo agua-energía-tierra en España" funded by Fundación Canal de Isabel II during 2014 and 2015

	ACIDIFICATION	TERRESTRIAL EUTROPHIZATION	FRESH WATER EUTROPHIZATION	MARINE EUTROPHICATION	FRESH WATER ECOTOXICITY	LAND USE	WATER CONSUMPTION	RESOURCE USE
	molc H+ eq	molc N eq	kg P eq	kg N eq	CTUe	kg C deficit	l water eq	kg Sb eq
BIOGAS	1.31E-03	4.18E-03	5.37E-05	2.20E-04	1.78E+00	4.47E-01	4.08E-01	3.95E-06
BIOGAS CHP	3.77E-04	1.20E-03	1.55E-05	6.34E-05	5.12E-01	1.29E-01	1.17E-01	1.14E-06
NATURAL GAS CHP	1.70E-03	2.98E-03	3.51E-05	2.78E-04	6.50E-01	5.93E-01	4.75E+00	1.14E-06
NATURAL GAS CC CHP	1.19E-03	1.82E-03	2.36E-05	1.71E-04	3.77E-01	3.94E-01	1.57E+00	7.20E-07
BIOMASS CHP	9.26E-04	3.58E-03	4.10E-05	1.94E-04	5.10E-01	6.21E-01	3.21E+00	1.56E-06
COAL	2.57E-03	6.21E-03	4.25E-04	6.30E-04	3.42E+00	3.31E-01	3.79E+00	1.48E-06
LIGNITE	1.57E-03	3.92E-03	2.92E-03	9.48E-04	1.89E+01	1.66E-01	1.11E+01	8.63E-07
CSP CURRENT TECH	5.97E-04	1.23E-03	2.30E-05	1.03E-04	4.28E-01	2.14E-01	8.19E+00	1.20E-06
CSP FUTURE TECH WITH GAS	6.90E-04	1.39E-03	2.65E-05	1.19E-04	4.81E-01	2.43E-01	3.88E+00	1.33E-06
CSP FUTURE TECH WITHOUT GAS	7.08E-05	1.50E-04	3.25E-06	1.18E-05	9.66E-02	6.76E-02	4.93E+00	3.11E-07
NATURAL GAS COMBINED CYCLE	9.67E-04	1.48E-03	1.92E-05	1.38E-04	3.06E-01	3.20E-01	1.46E+00	5.84E-07
MINIHYDRO	1.74E-05	5.91E-05	1.03E-06	5.44E-06	2.70E-02	9.75E-03	1.07E-02	1.87E-07
HYDRO DAM	2.19E-05	7.02E-05	1.34E-06	6.45E-06	2.99E-02	2.79E-02	1.74E-02	2.68E-07
NUCLEAR	1.11E-04	2.00E-04	6.00E-06	2.13E-05	4.32E-01	1.44E-02	4.93E+00	5.12E-06
WAVES	2.13E-05	9.82E-05	3.26E-11	7.84E-06	2.08E-03	-8.11E-03	0.00E+00	0.00E+00
OIL	7.46E-03	1.81E-02	1.35E-05	1.66E-03	6.74E-01	5.45E-01	3.51E+00	1.63E-06
PV CURRENT TECH MIX	5.73E-04	7.84E-04	4.56E-05	8.08E-05	4.27E+00	4.50E-01	3.17E+00	7.63E-05
PV ROOF CURRENT TECH	7.99E-04	9.88E-04	7.92E-05	1.08E-04	1.09E+01	8.84E-02	4.22E+00	9.85E-05
PV ROOF FUTURE TECH	2.71E-04	3.78E-04	2.05E-05	3.86E-05	1.68E+00	2.50E-01	1.51E+00	3.67E-05
PV PLANT CURRENT TECH	5.43E-04	7.57E-04	4.10E-05	7.71E-05	3.36E+00	5.00E-01	3.02E+00	7.33E-05
PV PLANT FUTURE TECH	3.09E-04	3.74E-04	3.11E-05	4.16E-05	4.58E+00	3.44E-02	1.31E+00	4.56E-05
WIND CURRENT	1.28E-04	2.44E-04	1.08E-05	2.42E-05	3.97E+00	1.59E-01	1.68E-01	7.74E-06
WIND MEDIUM TERM	1.09E-04	2.07E-04	9.11E-06	2.05E-05	3.37E+00	1.35E-01	1.43E-01	6.56E-06
WIND FUTURE	1.00E-04	1.91E-04	8.40E-06	1.89E-05	3.10E+00	1.24E-01	1.31E-01	6.05E-06
IMPORTS 2015	1.39E-04	3.01E-04	6.81E-06	2.75E-05	5.76E-01	4.03E-02	4.09E+00	5.32E-06
IMPORTS 2020	1.42E-04	3.17E-04	7.84E-06	2.77E-05	8.92E-01	6.04E-02	3.68E+00	6.10E-06
IMPORTS 2025	1.53E-04	3.50E-04	8.64E-06	2.98E-05	1.13E+00	7.59E-02	3.40E+00	6.71E-06
IMPORTS 2030	1.57E-04	3.53E-04	9.20E-06	3.02E-05	1.26E+00	8.39E-02	3.28E+00	7.61E-06
IMPORTS 2035	1.57E-04	3.54E-04	9.23E-06	3.03E-05	1.27E+00	8.44E-02	3.28E+00	7.63E-06