Social, economic and environmental impacts of the promotion of renewable energies in Spain

Ex Post and Prospective Analysis

H.Cabal, Y.Lechón, N.Caldés, C.de la Rúa, D.García-Gusano, E.López-Bernabé, I.López-Dóriga and M.Santamaría

67th SEMI-ANNUAL ETSAP MEETING

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MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD
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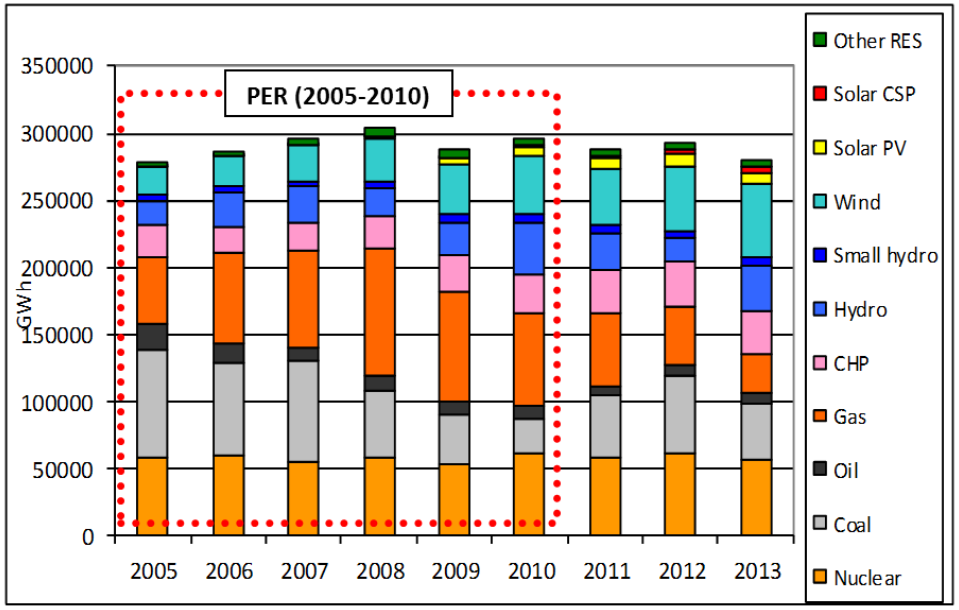
Background

- INER project, Spanish R+D Plan

- PER 2005-2010. Objectives: 12.1% Gross energy consumption
  30.3% electricity production; and
  5.83% biofuels of the consumption in transport
  Instruments: fiscal support, tax exemptions and FIT

Evolution of the Spanish electricity system from 2005 to 2013



40% in 2013

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Scope

1. Ex Post analysis

Cost assessment of the most recent energy policies in Spain not only considering the private costs of electricity production but also the environmental and socioeconomic costs

2. Prospective analysis

Optimal electricity system in the medium and long term under different scenarios

Ex Post analysis- Methodological approach

Steps

1. Levelised Electricity Costs (LEC)
2. Environmental externalities (LCA and ExternE)
3. Socioeconomic externalities (I-O, WIOD)

Total (LEC+CA+SEB) costs by technology in 2010

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Ex Post analysis- Methodological approach

Partial Cost Benefit Analysis

Relevant factor	Cost or benefit for society	Measurement indicators	Monetized (method)
Electricity generation costs	Private cost	LEC	Yes
Economic activity	Socio-econ externality	Value Added	Yes
Local environ effects	Environ externality	Various environ impact indicators/Kwh	Yes (Extern-E & Cases)
Global environ effects	Environ externality	CO2 equivalent emiss/khwh	Yes (Extern-E & Cases)
RES Support expenditures	Public cost	Feed in Tariff expenses	Yes

Not considered: employment, tax revenues, fossil fuel imports, other renewable support policies, transaction costs, merit order effects, increase in RES exports, rural development

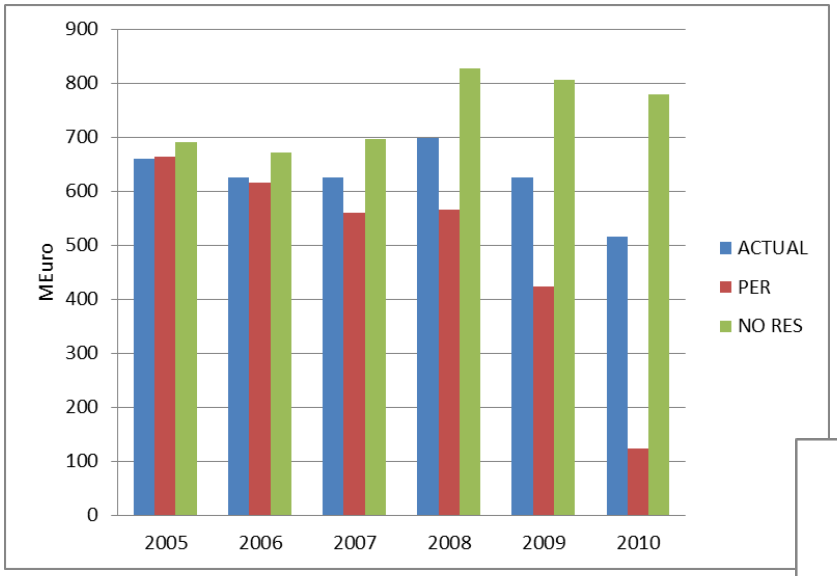
Ex Post analysis- Scenarios

SCENARIOS considered (2005-2010)

Scenarios	Description
ACTUAL	The RES deployment throughout 2005-2010
PER	Spanish energy mix matches the PER objectives
NO RES	No additional RES plants are installed since 2004 and electricity is now produced with natural gas combined cycle (NGCC) plants

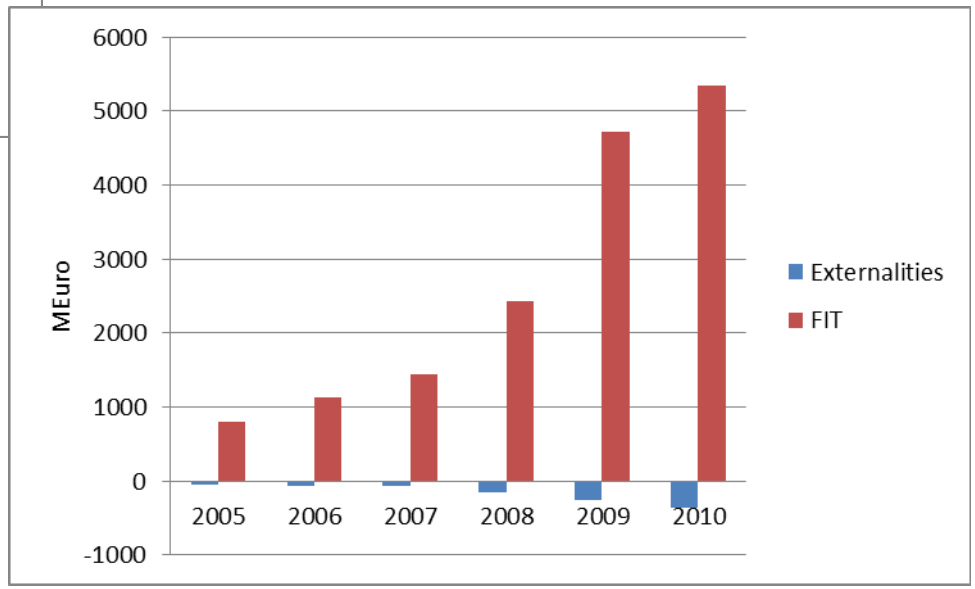
Ex Post analysis- Results

Total costs (private + social)



Huge installation of solar PV technologies from 2007 led to higher cost in ACTUAL scenario

RES support expenditures vs avoided external costs



The costs of FIT exceeded the net environmental and socioeconomic externalities

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Prospective analysis- Methodological approach

TIMES- Spain

National energy model built in the framework of the NEEDS project and improved in RES2020, COMET and INER projects. Part of the PET model

One region

Time horizon 2050. In this study, 2035

Twelve time slices: four seasons and day/night/peak

Five demand and two supply sectors

Demand scenarios: energy demand driver projections from the GEM-E3 updated with national data

Trade: electricity exchange with France, Portugal and Morocco

Recently recalibrated to 2005 and updated

Prospective analysis- Scenarios

SCENARIOS considered

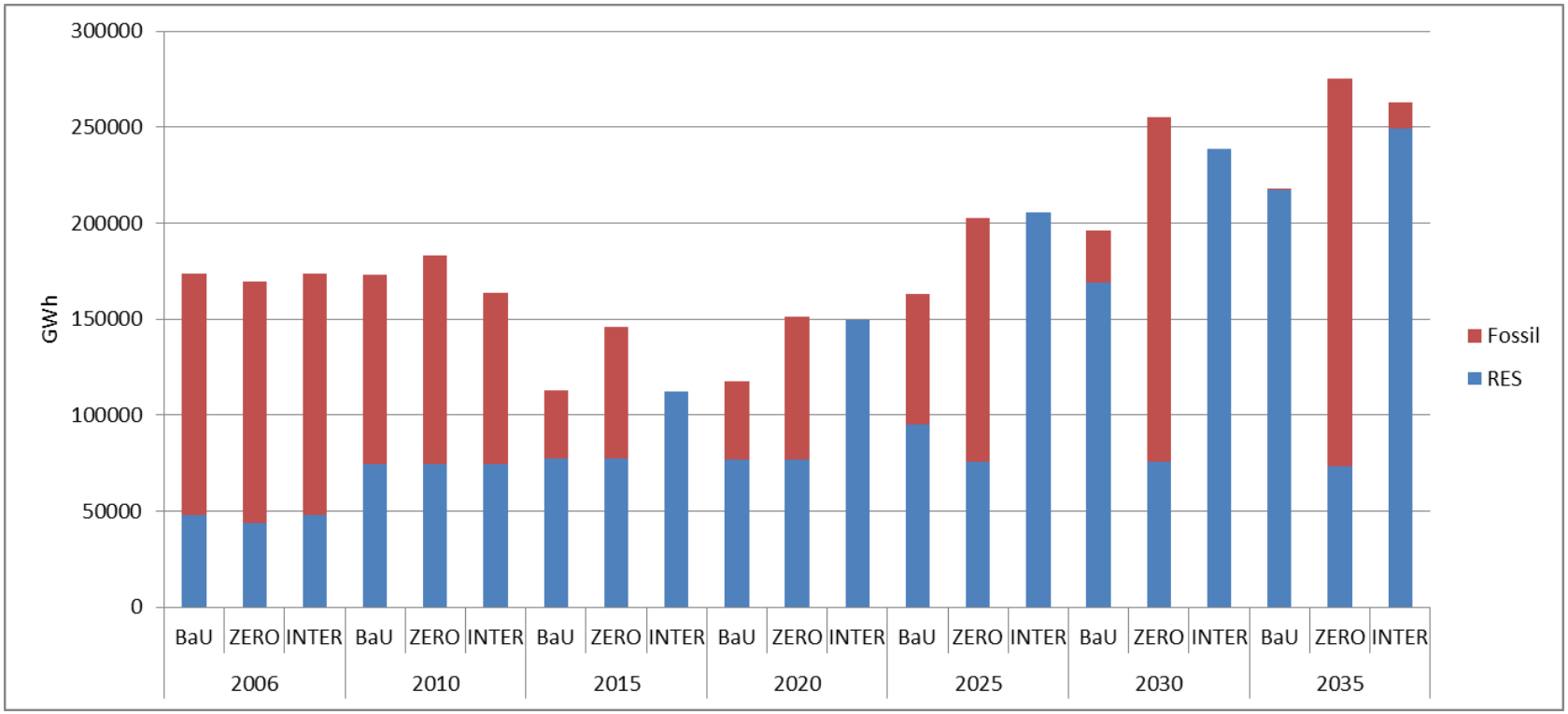
Scenarios considered	Description
BASE	National and international energy and environmental policies and commitments
ZERO	No restrictions or targets to emissions and renewable technologies penetration
INTER	Internalization of the environmental and socioeconomic external costs for all the technologies

PER 2011-2020 objectives

GWh	2015	2020
Hydro	31,371	32,814
Solar PV	9,060	12,356
CSP	8,287	14,379
Wind onshore	55,538	70,734
Wind offshore	66	1,822
Biomass	7,142	12,200

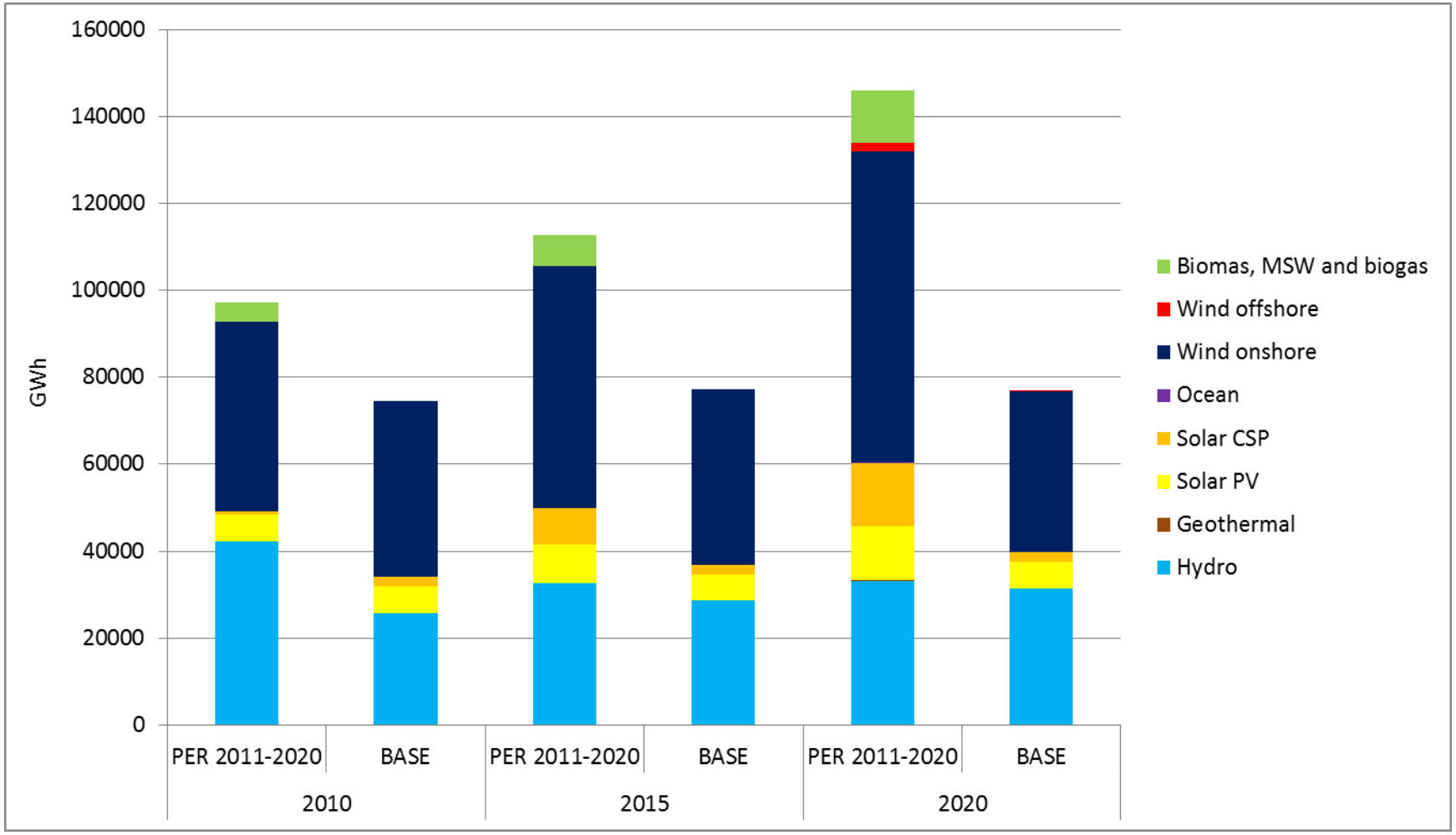
Prospective analysis- Results

Fossil and renewable technologies production



Prospective analysis- Results

BASE scenario vs PER 2011-2020 objectives



Conclusions and recommendations

Ex Post analysis

RES support policies in Spain have been indeed effective but not cost-efficient. Public support expenditures largely surpassed the avoided external costs considered in the analysis.
FIT should be reestablished and better defined according to the external benefits of the technology or/and setting a cap for the installed capacity

Prospective analysis

It is possible to meet the objectives of renewable technologies penetration and emission reductions set by the European Directives.
The internalization of the external costs would anticipate meeting those targets

This study is being continuously updated introducing new factors in the partial CBA, doing sensitivity analysis for instance in the origin of the goods and services in renewable technology development and other

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Thank you

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Anexes

CBA data sources and working assumptions

Costs and benefits	What?	Methodology	Data
Private costs	Electricity generation costs (c €/Kwh)	LEC	Spanish data International data (OECD, others)
Socio-economic externalities	Value added	I-O	Spanish I-O (WIOD) Investment and O&M cost vectors (final demand)
Environmental externalities	CO2 and other local pollutants	LCA & Extern-E	CASES Intern. literature review
Res Support expend	FIT expenditures		Official figures APPA (autoproducers)

PRIVATE COSTS: Levelized Electricity Cost

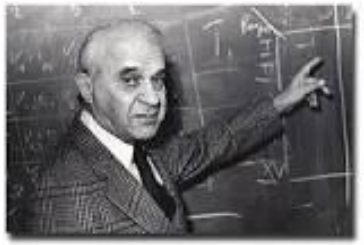
$$\mathrm{LEC} = \frac{\sum_{t=1}^{n} \frac{I_t + M_t + F_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{E_t}{(1+r)^t}}$$

Where:

- LEC= Average lifetime levelized electricity generation cost
- I_t= Investment expenditures in the year t
- M_t= Operations and maintenance expenditures in the year t
- F_t= Fuel expenditures in the year t
- E_t= Electricity generation in the year t
- r= Discount rate

n= Life of the system

SOCIO-ECONOMIC BENEFITS: Input-Output (W. Leontief, 1939)



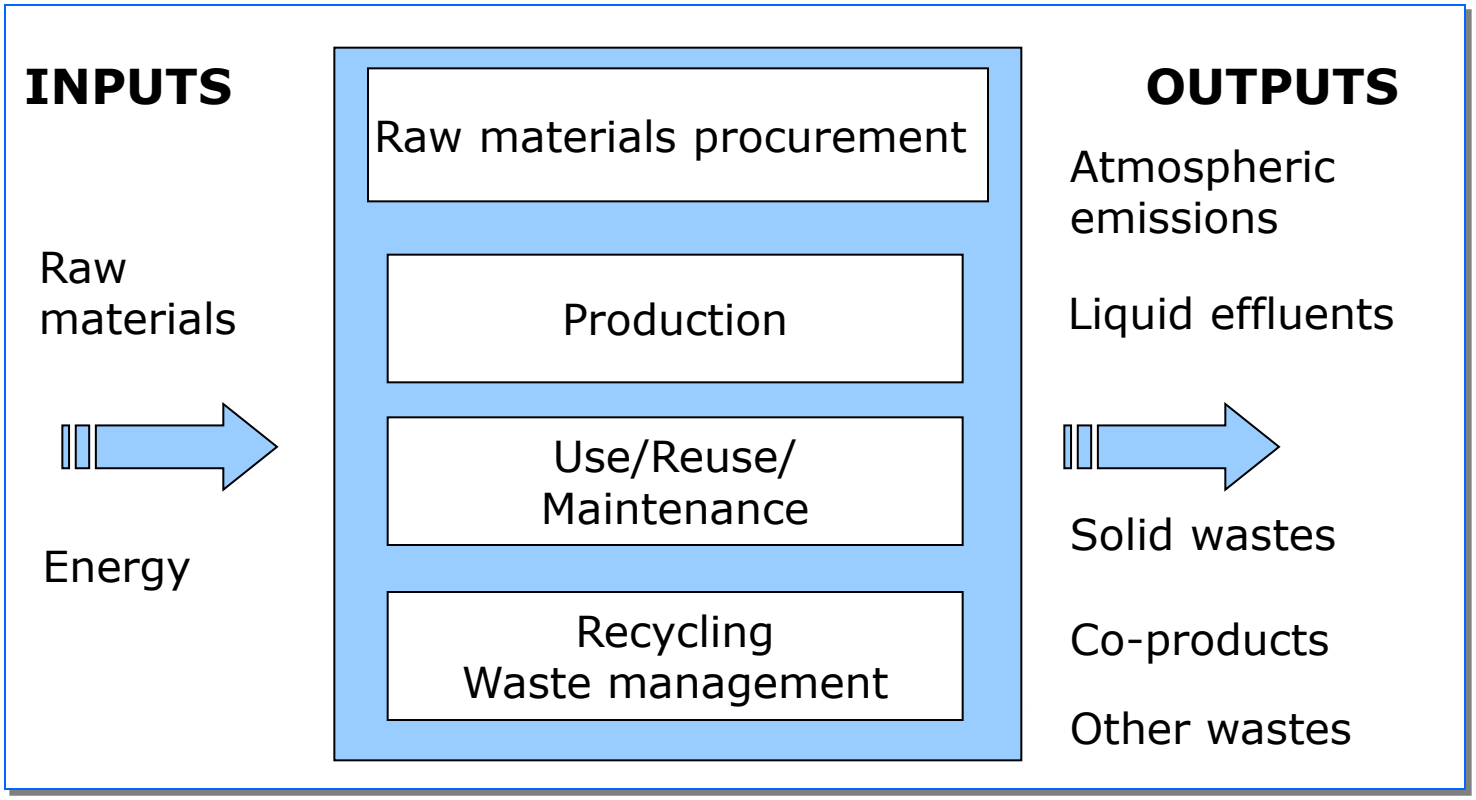
-Accounts for the direct and indirect effects
-Captures impacts on economic activity, V.A., employment, etc
-Investment and O&M cost vectors for all technologies & input-output table
-Important advantages & limitations

$$X = (I - A)^{-1} Y$$

$$L_i = R(I - A)^{-1} Y$$

	Consumo de los sectores				Demanda final Y	Producción total X
Producción de los sectores	1	2	3	n		
1	X_{11}	X_{12}	X_{13}	X_{1n}	Y_1	X_1
2	X_{21}	X_{22}	X_{23}	X_{2n}	Y_2	X_2
3	X_{31}	X_{32}	X_{33}	X_{3n}	Y_3	X_3
n	X_{n1}	X_{n2}	X_{n3}	X_{nn}	Y_n	X_n
Consumo intermedio I	I_1	I_2	I_3	I_n		
Valor añadido V	V_1	V_2	V_3	V_n	GDP	
Producción total X	X_1	X_2	X_3	X_n		

Life Cycle Assessment. LCA.

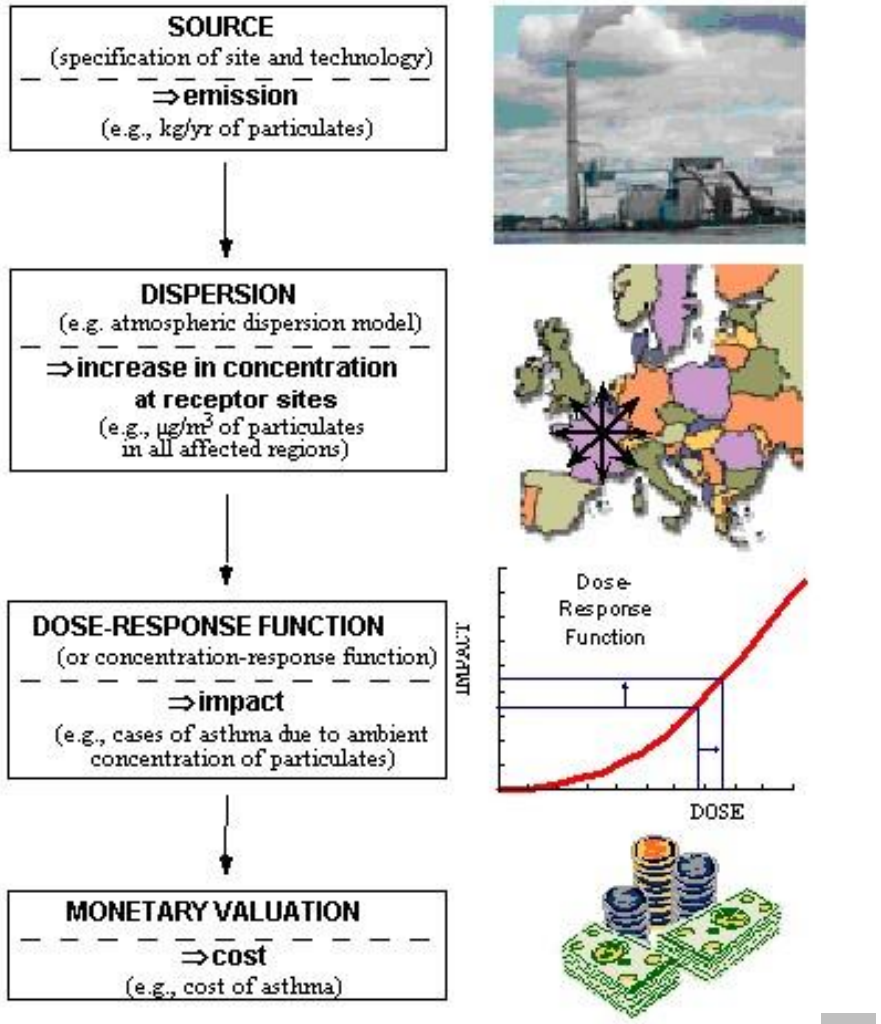


ExternE.
Impact pathway approach

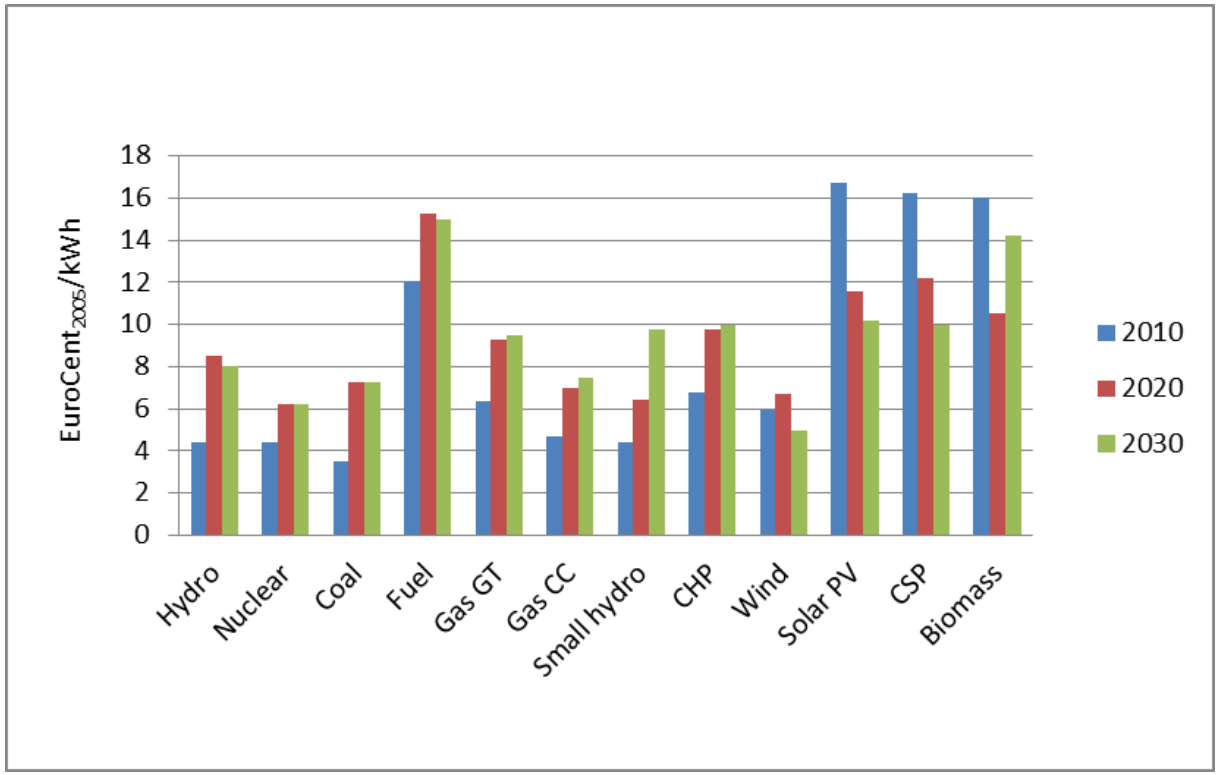
Starting from the emission of a pollutant, the ExternE methodology simulate the transport and transformation in the atmosphere using atmospheric dispersion models

Impacts in physical terms are then calculated using dose response functions

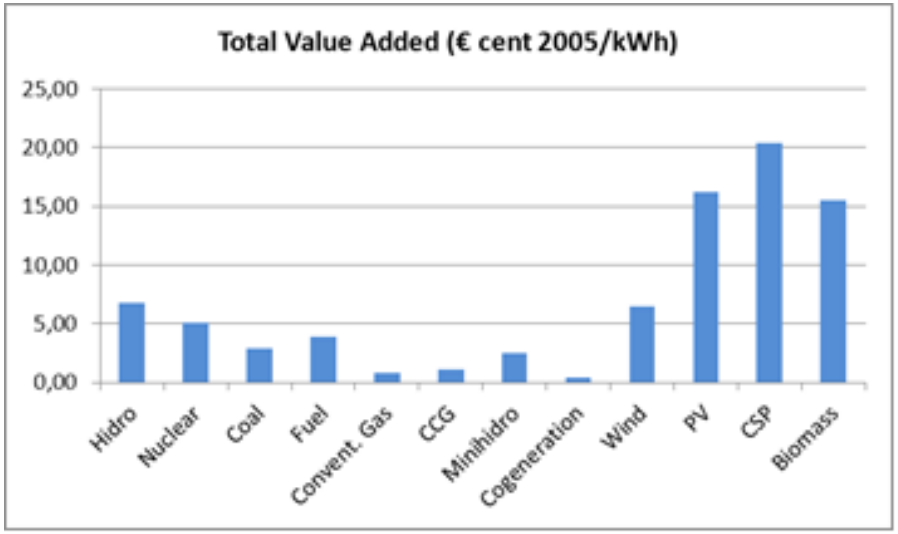
Monetary valuation of different impacts is used to estimate externalities in monetary units

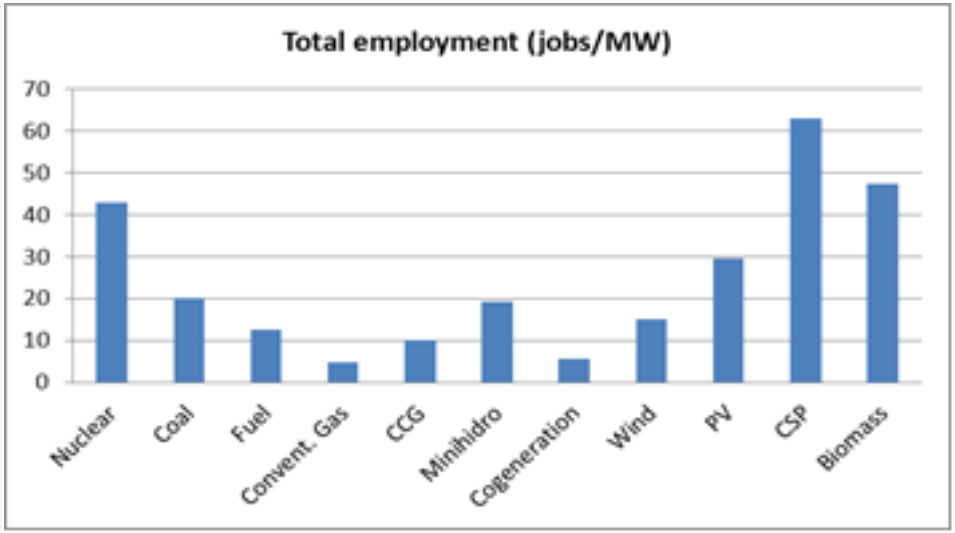


LEC projection



Total socio-economic impacts for different electricity technologies (2010)





Environmental impacts for different electricity technologies (2010)