



Future Energy Policies in Spain given the European Energy and Climate Policy Framework

Maryse Labriet*, Helena Cabal, Yolanda Lechon,
CIEMAT, Madrid, Spain

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Objective

Policy-making : How can the Spanish energy system be adapted to reduce the greenhouse gas emissions and satisfy the domestic and the European climate and energy targets?
How do the existing domestic policies contribute to the targets? Remaining gap?



*Spanish TIMES techno-economic model
used in a standalone manner*



Spain and Europe frameworks

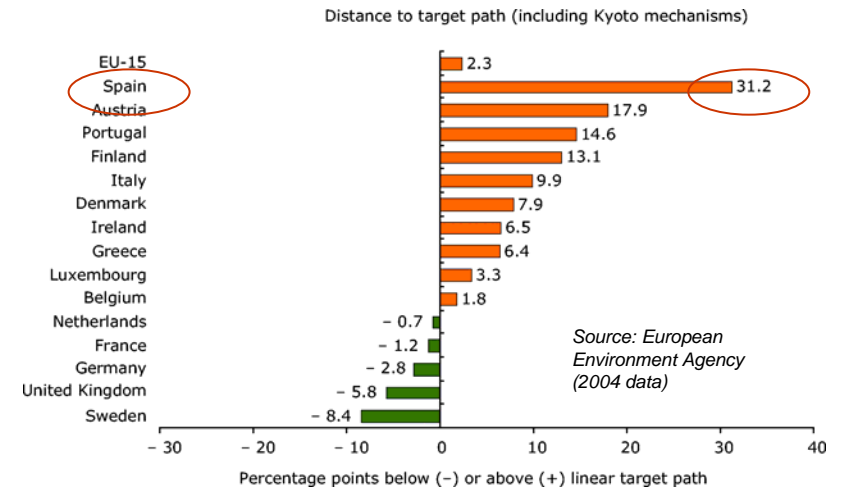


The Spanish energy/climate context

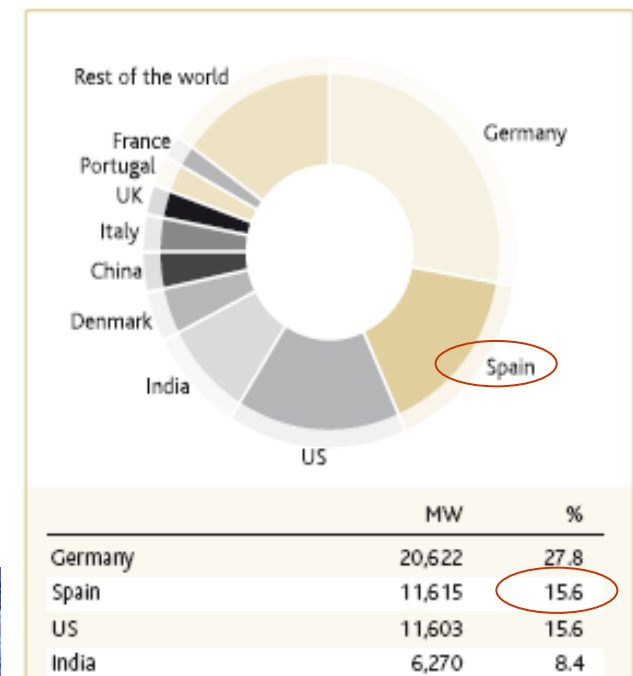
- **Strong increase of emissions:** GDP (2.5-4%), increasing energy intensity
- **Electricity generation** dominated by fossil power plants and hydro but investments in RNW and CCGT
- **Strongly dependent on energy imports** (75% of primary energy): Very scarce in domestic fossil resources, energy security risks
- **Uncertain future nuclear policy:** no clear position by the two most important political parties



How to fulfill the Kyoto and European commitments?



TOP 10 TOTAL INSTALLED CAPACITY WIND



The Spanish policies

- **Kyoto target** : +15% above 1990 emissions by 2008-2012
National Climate Change and Clean Energy Strategy 2012 (*under dev*)
 - ▶ Cut the GHG emissions to 37% above 1990 level by 2008-2012
 - ▶ Offset the gap with Kyoto target with international carbon permits*Eq. phase-out of domestic coal-fired heating boilers, vehicle taxation, new building standards etc.*
- **Renewable Energy Plan 2005-2010**
RNW=12% of the total consumed energy
RNW= 30% of the total electricity produced
Biofuels = 6% of the total gasoline and diesel consumed by transport
- **Fiscal incentives** for renewable-based electricity and biofuels use and production
- **Strategy for Energy Saving and Efficiency 2004-2012**
Total energy savings target for 2005-2007: 500 PJ
Eq. Urban mobility plans, incentives for efficient appliances, building efficiency standards, etc.



Renewable at the heart of the Spanish energy policy

Main drivers

- ▶ *regional and agriculture sector development*
- ▶ *energy security*
- ▶ *climate change*

The European energy and climate package (2007)

- At least **20% reduction in GHG by 2020** compared to 1990 (up to 30% within an international agreement)
- Improving **energy efficiency by 20%** by 2020
- Raising the share of **renewable energy** in the energy mix to 20%
- Increasing the level of **biofuels to 10%** of gasoline and diesel consumed in transport by 2020



The modeling exercise

Model and evaluate these domestic and European policies/targets with the TIMES-Spain model

The TIMES-Spain model

(The Integrated MARKAL-EFOM System)

- **TIMES is a bottom-up, technology rich model** for representing, optimizing and analyzing the production, conversion, trade and end-use of various forms of energy
- Driven by the demands for disaggregated **energy services** (eg. Mt iron and steel, short distance Pass-km by cars, etc.) themselves resulting from macro-economic drivers (GDP, POP, etc.)
- Supply-demand **partial equilibrium** on energy markets
- **Perfect foresight & information** : 2000-2050
- Greenhouse gases (CO₂, CH₄, N₂O...) and other pollutants (NO_x, particulates, ...). The current study focuses on **CO₂ only**.

The TIMES-Spain model

TIMES PAN-EUROPEAN MODEL (PEM)

NEEDS project

*New Energy Externalities Developments for
Sustainability
(6th Framework Programme)*



Country Model SPAIN

used in a standalone manner

Mitigation options available

- Energy and technology substitution
- Capture and sequestration of CO₂
- Biological absorption of CO₂
- International carbon credits (optional)



- ▶ Evaluate the impacts (energy mix, technology, emissions, costs) of specific policies or environmental constraints
- ▶ At both local (this presentation) or European (NEEDS project) or World (TIAM) levels

Some assumptions

Data / Policy	Modeled	Approach
Renewable Energy Plan 2005-2010	Minimal installed capacity of hydro, solar, wind and biogas power plants. Minimal share of biofuel in transport. Waste power plants not yet implemented.	Scenario
Spanish Strategy of Energy Saving and Efficiency	NO : Optimization model \Rightarrow Cost-efficient decisions	-
National Climate Strategy	NO : Under development	-
Fiscal incentives (electricity, biofuels)	NO: Taxes are not included in the model	-
Recent technology developments	YES: Wind, PV roof panels, PV centralized, new combined cycle power plant, etc.	In BASE
Nuclear power plants	YES: No new plants, lifetime 60 yrs	In BASE
International energy trade	YES: Prices provided by the IEA	In BASE
International carbon permit trade	Scenario-based: Before 2020 = 50 €/tCO ₂ From 2020 = 50, 100, 300 or 500 €/tCO ₂	Scenario
Target: Kyoto forever	Scenario: Emi 2010-2050 < 1990 x 1.15	Scenario
Target: EC 2020	Scenario: Emi 2020-2050 < 1990 x 0.9, 0.8, 0.7	Scenario
Driver: Population	YES: Increases until the mid-horizon, back to 2005 levels by the end of the horizon	In BASE
Driver: GDP	YES: Average annual growth of 3% on the horizon	In BASE



Some results

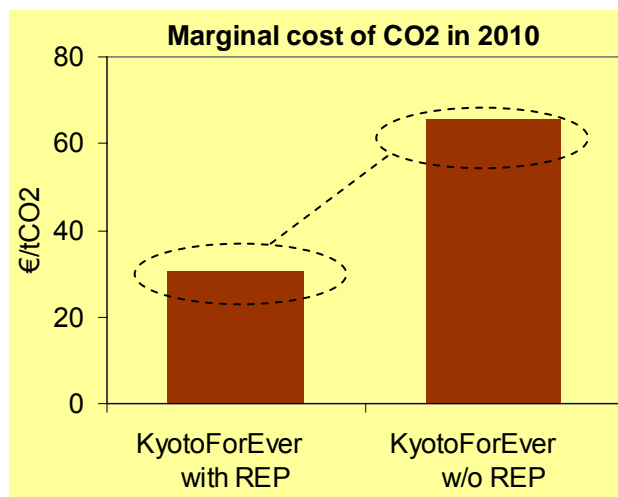
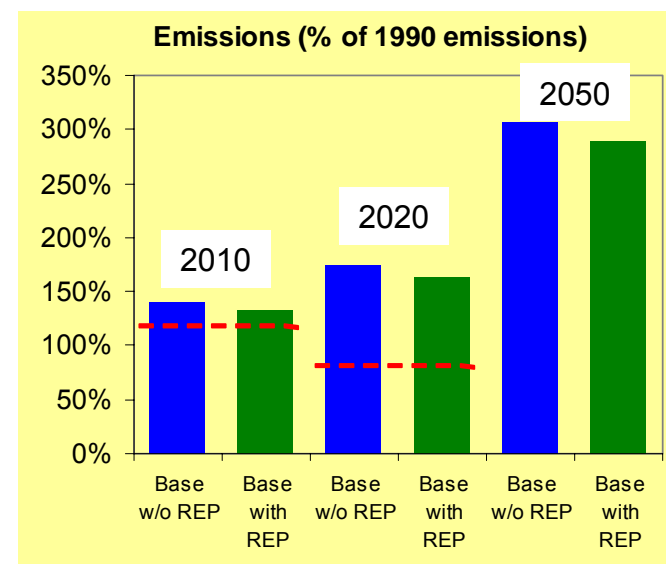


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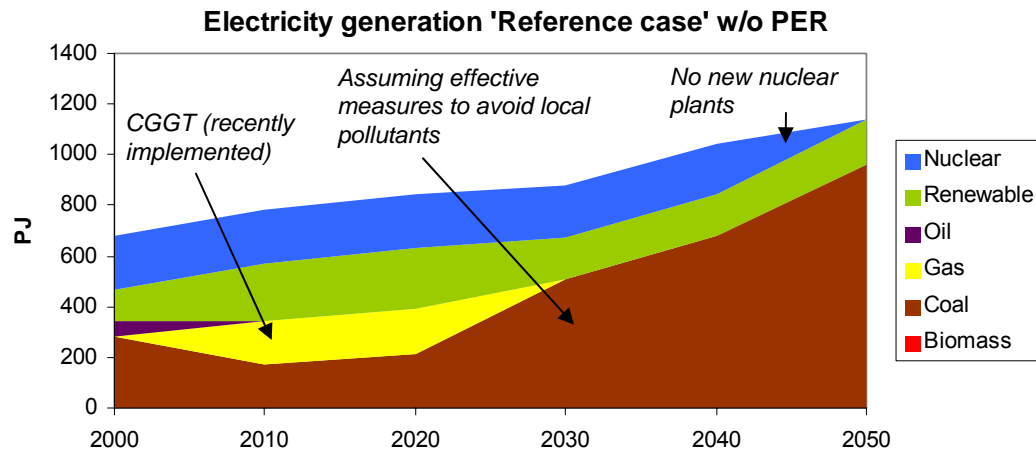
Local policy: What is the impact of the REP wrt Kyoto target?

- **Helps reduce emissions: 33%** above 1990 (41% without): direct result of the forced renewable power plants (shutdown coal plants) and biofuels in transport, no effects in other sectors
- **What about the CO₂ marginal cost with domestic actions only?**



► No need for international carbon permit if the permit price exceeds 30 – 70 €/tCO₂ in 2010

How to satisfy the 'Kyoto for ever' target with domestic actions only?



Zero emission power plants:
coal/gas plants with CCS and wind power plants, phase-out of conventional coal

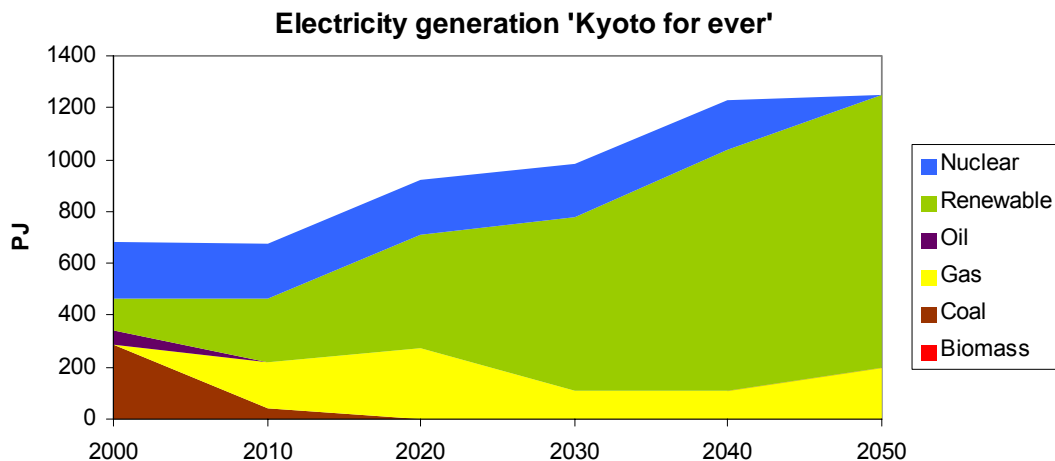
Sequestration (up to 10%)

Fuel substitution in end-use

Biofuels in transport

Biofuels and elc in buildings

Oil and coal substitution by biofuels, elc and gas with CCS in industry (amonia)



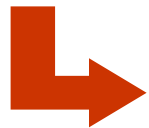
No surprise, expected mitigation options

Local policies: What is the long term cost-efficiency of the REP?

- The total discounted system cost of 'Kyoto with REP' is higher than the one of 'Kyoto w/o REP'

	TOTAL billions €	Annualized cost billions €	Energy system costs	
			% GDP 2010	%GDP 2050
KyotoForEver with REP	284	13.2	1.2%	0.4%
KyotoForEver w/o REP	256	11.9	1.1%	0.3%
REP (no Kyoto target)	40	1.8	0.2%	0.1%

} 36 G€



Kyoto commitment increases the 'profitability' of the REP

However, the latter might **not be the most efficient option package** to meet the scenario 'Kyoto for ever'

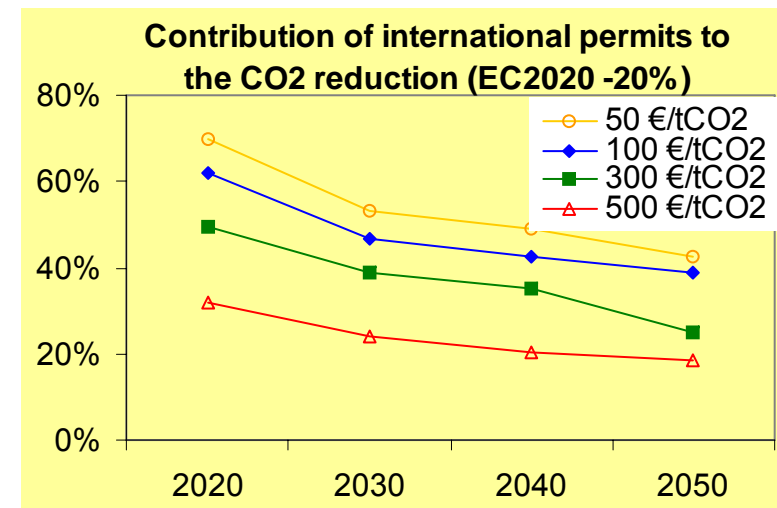
⇒ *Delay in the Wind power development*

More biomass in industry, less electricity

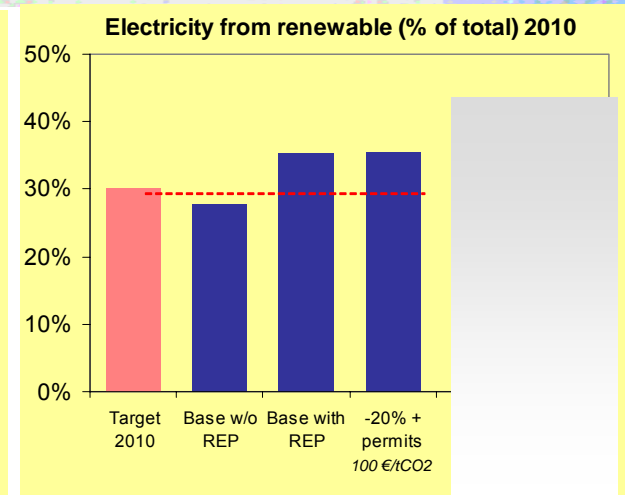
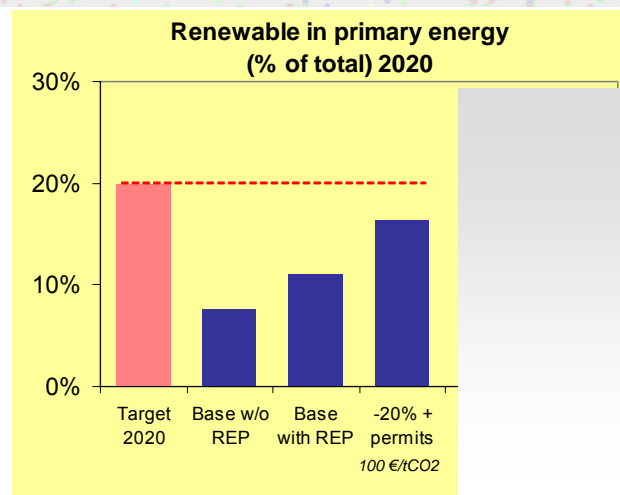
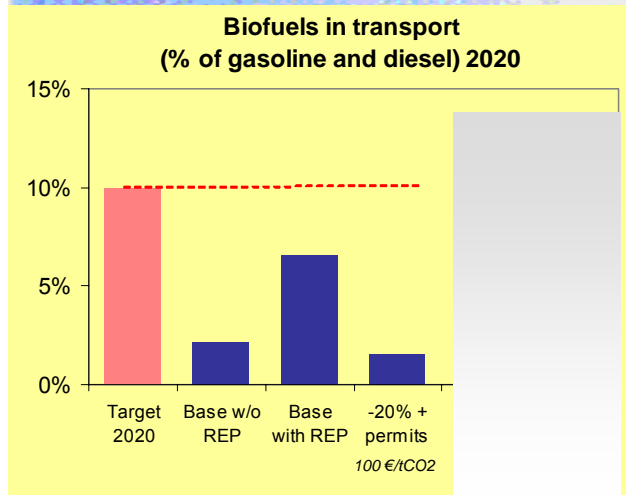
More solar water heaters in residential, less electricity

How to satisfy the 2020 European climate targets?

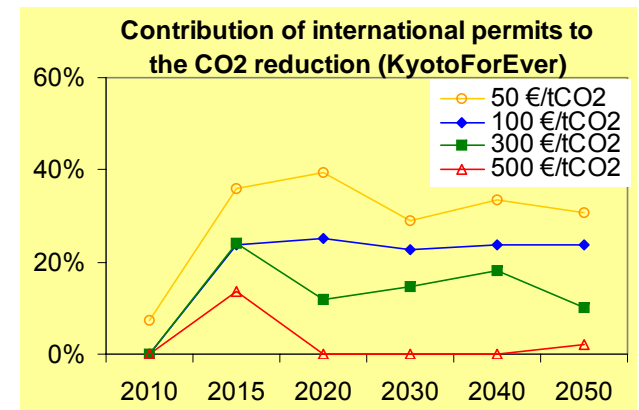
- **Any target (-30%, -20%, -10% relatively to 1990) fixed in 2020 and kept constant until 2050: impossible with only domestic measures \Rightarrow international carbon permits are required**
- Attention: **international aviation** emissions are included here (not in the KP)
- **Breakpoint** between +10% and +15% over 1990
- Given the data included in the model



How far are we from the EC targets?



- *All scenarios:* Difficult to satisfy the **European 2020 energy targets**
- *Kyoto forever:* **Negative impact** of permits on the “sustainability” of the energy system (permits are preferred to non-emitting power plants and to biofuels in transport). **Reduction of the total system cost** from 4 to 67%, depending on permit price



Trade-off between emission and energy targets

What if...

Oil prices are higher? (reference case only)

- Reduced imports \Rightarrow good for energy security
- Increase of electricity consumption \Rightarrow higher capacity of coal power plants \Rightarrow higher emissions
- The REP helps limit this impact by promoting non fossil energy
- To relate energy security priorities with appropriate energy/climate policies
- (Kyoto forever: no realistic given the reduced demand for oil)

Cheap biomass is available without limit?

- No impact on the reference case
- Large reduction of the CO₂ marginal cost (-35% in the shorter term) and of the total system cost (-13%)

Sequestration is not available?

- Impossible to satisfy 'Kyoto forever' with only domestic actions

Conclusion

- **Challenge ahead for Spain** in reducing its CO₂ emissions and developing a sustainable energy system
- Kyoto target can be reached at a marginal cost of 30-70 €/tCO₂ in 2010 with domestic actions
- The **Renewable Energy Plan** is useful. However, more efficient options might be available + gap with EC targets
- **Carbon permit trade** is crucial for any CO₂ level lower than 10% above 1990 such as the EC 2020 objectives
- **Synergies** between emission targets, energy policies and energy security.
- What are the **risks** inherent in a high reliance on gas (import dependency) and wind and hydro (climate dependency)?

Conclusion

- What is the option value of renewables if **nuclear** is available as a mitigation option?
- Potentials for **CCS, forestry?** Availability and price of **sustainable biomass?**
- What will happen if one country **can not reach** the European targets?
- What will happen with **international aviation emissions?**



*More sensitivity analyses
Interest for multi-regional modeling
(endogenous energy and carbon trade)*

Other related projects

- **NEEDS project:** Review of the regional models. Pan-European modelling
- **RES2020 project:** Refine the modeling of renewable energy
- **REACCESS projet (?):** Evaluate energy security aspects

More information

CIEMAT

www.ciemat.es

TIMES projects

www.needs-project.org

www.res2020.eu

www.etsap.org

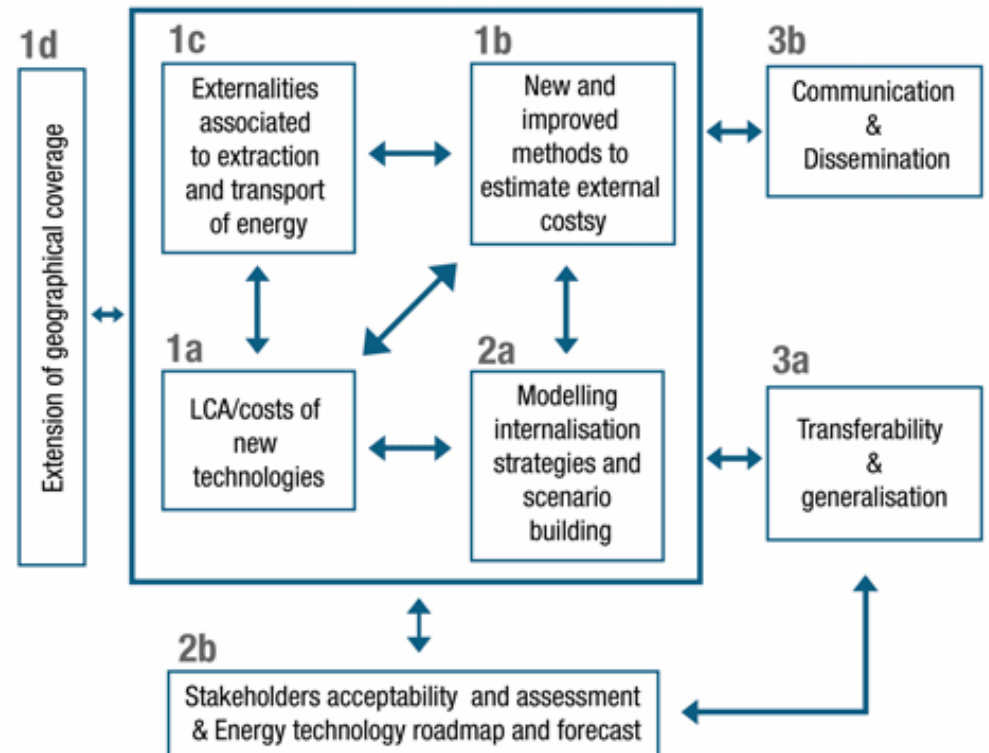
Questions or comments

maryse.labriet@ciemat.es

Appendix

NEEDS project: New Energy Externalities Developments for Sustainability

- **Objective:** To evaluate the full costs and benefits (direct + external) of energy policies and of future energy systems, both at the level of individual countries and for the enlarged EU as a whole
- **6th EU Framework Programme**



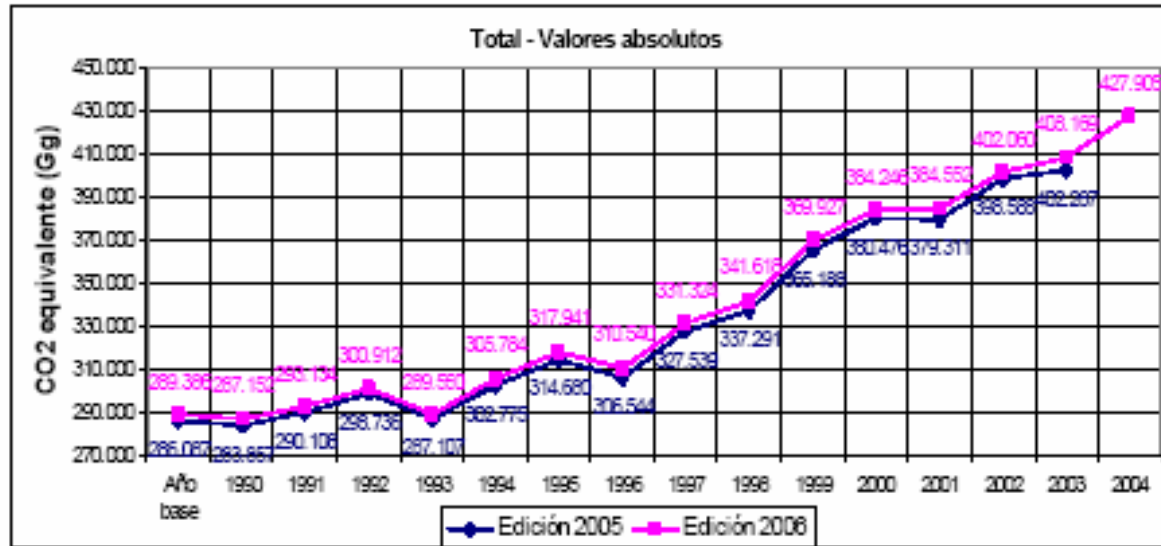
RES2020 project

- **Objective:** To monitor and evaluate the RES directives implementation in EU27 and policy recommendations for 2020
- **Intelligent Energy Europe Programme**
- **Main objectives and innovation:**
A detailed energy model covering EU27. Update of the Pan-European TIMES model.
 - ▶ Detailed modelling of **biomass** (resources and transformation)
 - ▶ Detailed modelling of other renewable resources (**wind, solar, hydro**)
 - ▶ Detailed modeling of **electricity networks** and **distributed electricity generation**

REACCESS (Risk of Energy Availability: Common Corridors for Europe Supply Security)

- **Objective:** To study, measure and assess security of energy supply in the EU energy system
- **7th EU Framework Programme** (submitted, not yet accepted)
- **Detailed description** of the energy import framework for EU27+
- **Analysis** of the EU security of supply and environment policies vs energy routes
- **Modelling** the EU energy system supply corridors
- **Scenario analysis** and result reporting
- Update and use of the Pan European Model and the TIMES Integrated Assessment Model

SPAIN emissions



Source: Ministerio de Medio Ambiente



Source: Spanish National Statistics Institute

TIMES-SPAIN: End-use demands

Table 10. Residential and commercial end-use demands

Residential segment	Code	Unit
Space heating		PJ
Rsd.Space Heat.Single.Rural.Existing.	RHRE	
Rsd.Space Heat.Single.Urban.Existing.	RHUE	
Rsd.Space Heat.Multi.All.Existing.	RHME	
Space cooling		PJ
Rsd.Space Cool.Single.Rural.Existing.	RWRE	
Rsd.Space Cool.Single.Urban.Existing.	RWUE	
Rsd.Space Cool.Multi.All.Existing.	RWME	
Water heating		PJ
Rsd.Water Heat.Single.Rural.Existing.	RCRE	
Rsd.Water Heat.Single.Urban.Existing.	RCUE	
Rsd.Water Heat.Multi.All.Existing.	RCME	
Rsd.Cooking.Existing.	RCOK	PJ
Rsd.Refrigeration.Existing.	RREF	PJ
Rsd.Cloth Washing.Existing.	RCWA	PJ
Rsd.Dish Washing.Existing.	RDWA	PJ
Rsd.Cloth Drying.Existing.	RCDR	PJ
Rsd.Lighting.Existing.	RLIG	PJ
Rsd.Other Electric.Existing.	ROEL	PJ
Rsd.Other Energy.Existing.	ROEN	PJ
Commercial segment		
Space heating		PJ
Com.Space Heat.Small.Existing.	CHSE	
Com.Space Heat.Large.Existing.	CHLE	
Space cooling		PJ
Com.Space Cool.Small.Existing.	CWSE	
Com.Space Cool.Large.Existing.	CWLE	
Water heating		PJ
Com.Water Heat.Small.Existing.	CCSE	
Com.Water Heat.Large.Existing.	CCLL	
Com.Cooking.Existing.	CCOK	PJ
Com.Refrigeration.Existing.	CREF	PJ
Com.Lighting.Existing.	CLIG	PJ
Com.Public Lighting.Existing.	CPLI	PJ
Com.Other Electric.Existing.	COEL	PJ
Com.Other Energy.Existing.	COEN	PJ
Other sector consumption	ONE	PJ
Agriculture segment		
Agriculture useful energy demand	AGR	PJ

Table 11. Industry end-use demands.

Description	Code	Unit	Modeled by:
Iron and steel Demand	IIS	Mt of Steel	Process
Aluminium Demand	IAL	Mt of Aluminium	Process
Copper Demand	ICU	Mt of Copper	Process
Other Non Ferrous Metals Demand	INF	PJ	End-use
Ammonia Demand	IAM	Mt	Process
Chlorine Demand	ICL	Mt	Process
Other Chemicals Demand	ICH	PJ	End-use
High Quality Paper Demand	IPH	Mt of High Quality Paper	Process
Low Quality Paper Demand	IPL	Mt of Low Quality Paper	Process
Cement Demand	ICM	Mt of Cement	Process
Glass Flat Demand	IGF	Mt of Glass Flat	Process
Glass Hollow Demand	IGH	Mt of Glass Hollow	Process
Lime Demand	ILM	Mt of Lime	Process
Other Non Metal Minerals Demand	INM	PJ	End-use
Other Industries and Adjustment	IOI	PJ	End-use
Non Energy Uses - Chemicals	NEC	PJ	Fuel
Non Energy Uses - Others	NEO	PJ	Fuel

Table 14. Transport end-use demands

Description	Code	Unit
Cars, short distance	TCS	10E9 passenger-kms
Cars, long distance	TCL	10E9 passenger-kms
Freight (long distance)	TFR	10E9 ton-kms
Buses, Urban	TBU	10E9 passenger-kms
Buses, Intercity	TBI	10E9 passenger-kms
Motos, Three wheelers, Off road	TMO	10E9 passenger-kms
Rail Freight	TRF	10E9 tonne-km
Rail Passengers Light	TRL	10E9 passenger-kms
Rail Passengers Heavy	TRH	10E9 passenger-kms
Generic aviation	TAV	PJ
Generic navigation	TNA	PJ

TIMES-SPAIN: Emissions

Code	Description
CO2	Carbon Dioxide
COX	Carbon Monoxide
CH4	Methane
SO2	Sulphur dioxide
NOX	Nitrogen Oxides
N2O	Nitrous Oxide
PMA	Particulate 2.5
PMB	Particulate 10
VOC	Volatile Organic Compounds
SF6	Sulphur hexafluorides
CXF	Fluoro Carbons

Each run of the model is driven by...

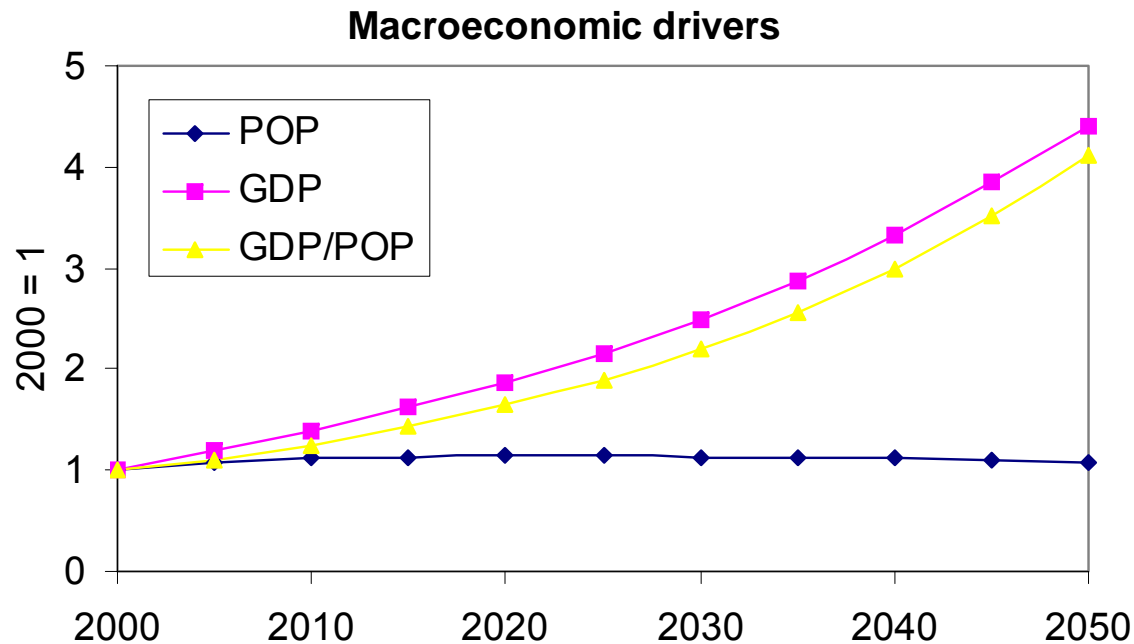
- **Demands** for energy services, themselves driven by socio-economic drivers
- **Technologies** (technical and economic characteristics)
- **Assumptions** on energy resources, imports/exports prices (endogenous in the World version), behaviors, non-economic policies (eg. Nuclear), etc.
- **Existing or intended policies** and measures
- **Exogenous targets**: Environmental targets, Energy security (fossil dependence), etc.

Each run of the model produces...

- A coherent and detailed evolution of **technological** adoption, abandonment and operation in all sectors
- The energy **extraction and trade** levels
- The **prices** of all energy forms (and emissions if constrained)
- The **emission** trajectory
- The **overall cost** (loss of surplus) of the entire system

Macro-economic data for Spain

(used to compute the demands)



**Annual growth
2000-2050**
POP +0.13%
GDP +3.00%
GDP/POP +2.87%

TIMES-Spain: Sources of data

- **Base-year (2000) energy balance:** EUROSTAT database (<http://epp.eurostat.ec.eu.int>) provided by the Statistical Office of the European Communities
- **Existing energy system:** many domestic and international sources
- **Resource potentials**
 - Renewable resources: Greenpeace Renovables 2050.
 - Fossil resources: EIA, IGME

PER 2010

PLAN DE ENERGÍAS RENOVABLES EN ESPAÑA 2005-2010							
Electricity generation	2004 situation			Goal for 2010			% INCREASE MW
	POWER (MW)	PRODUC (GWh)	KTEP	POWER (MW)	PRODUC (GWh)	KTEP	
<i>Hydraulic (>50Mw)</i>	13521	25014	1979	13521	25014	1979	0%
<i>Hydraulic (10-50 Mw)</i>	2897	5794	498	3257	6480	557	12%
<i>Hydraulic (<10 Mw)</i>	1749	5421	466	2199	6692	575	26%
<i>Biomass</i>	344	2193	680	2039	14015	5138	593%
<i>Biomass centrals</i>	344	2193	680	1317	8980	3586	
<i>Co-combustion</i>	0	0	0	722	5036	1552	
<i>SUR</i>	189	1223	395	189	1223	395	0%
<i>Wind</i>	8155	19571	1683	20155	45511	3914	249%
<i>Solar P.V.</i>	37	56	5	400	609	52	1081%
<i>Bio-gas</i>	141	825	267	235	1417	455	167%
<i>Thermosolar</i>				500	1298	509	500%
TOTAL	27032	60096	5973	42494	102259	13574	157%