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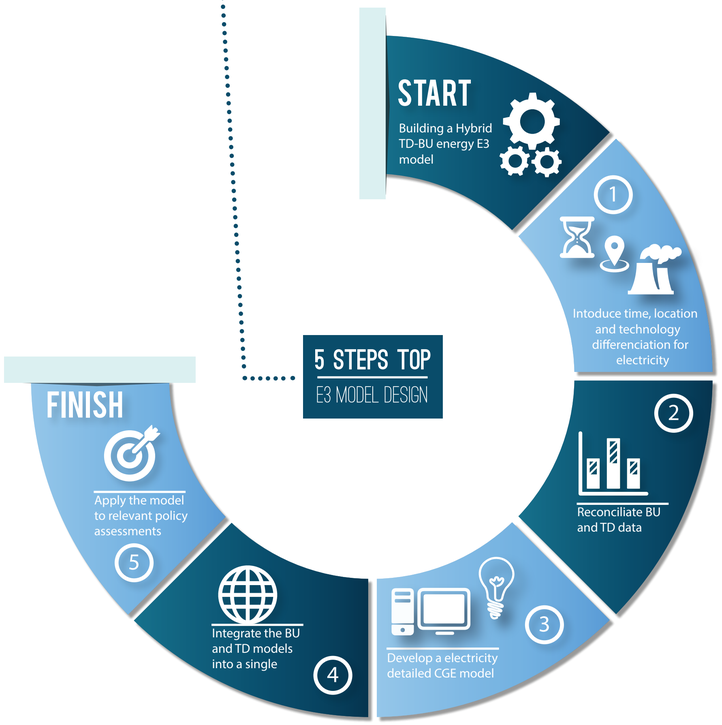
# HYBRID MODELING FOR ELECTRICITY POLICY ASSESSMENTS

## building a hybrid Top-down (TD) CGE and Bottom-up (BU) electricity operation and expansion model




Single country walrasian general equilibrium model

### TOP-DOWN MODEL
computable general equilibrium model

Mixed complementarity formulation of a traditional static CGE formulation of Spanish economy with behave equations for:
- 68 productive sectors,
- Government,
- Households,
- International relations.

General equilibrium model with special detail to the representation of the electricity sector and demand

### GEMED
electricity detailed computable general equilibrium model

Spanish economy CGE model with deep electricity sector disaggregation
Demand and supply products differentiated in time (multiple load blocks), location (network nodes) and technology
Multiple electricity production technologies with micro foundations
Variable number of load blocks

Bottom-up electricity model following enginneering tradition with high level detail of technology dispatch

### BOTTOM-UP MODEL
electricity operation and expansion model

Spanish electricity generation dispatch model for optimal operation and expansion decision.
Formulated as a mixed complementarity problem presenting:
- multiple production technologies,
- hydro reservoir management,
- wind production profiles,
- pumping economical dispatch,
- reserve requirements, ...

Macroeconomic and microeconomic data reconciliation based on engeneering microfoundations

### CALIBRATION MODEL
MinMax calibration model

Calibration model capable of building a social accountability matriz with:
- electricity products time differentiation,
- location disaggregation of different network nodes,
- multiple production technologies representation,
- electricity activies with micro foundations.

Formulated as a goal programing model, minimizing the maximun deviation of electricity technical parameters from the real world values.

Bottom-up electricity model and Top-down GEMED model solved simultaneously as a single mixed complementarity model

### H-GEMED
hybrid general equilibirum model with electricity detail

CGE model with the electricity sector formulated through a engeneering bottom-up set of equations to describe in detail the economic dispatch decision.

Demand and production dimensions:
- Time (multiple load blocks)
- Location (different network nodes)
- Electricity Technology disaggregation (ten technologies)

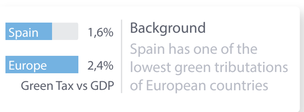
Demand:
Electricity services include different time of use: better representation of PHEV recharging effects, temperature-energy intensiveness relation, appliances time use, …

Production Structure:
Electricity -> Operation and Expansion model with complex technology constraints like reserve requirements, wind profiles, reservoir water management, pumping decision, …

Other sectors - >Traditional economy production function functional form (CES / Leontief)

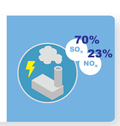
## 01 ELECTRICITY DEMAND RESPONSE

## 02 GREEN TAX REFORM




### Background
Spain has one of the lowest green tributations of European countries

### Sector importance
The electricity sector is reponsible to the majority of local polution emissions





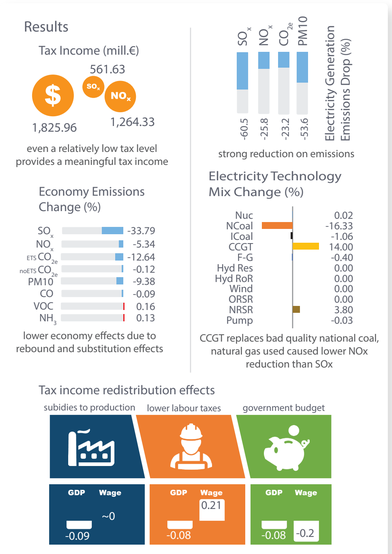
### Policy Proposal
We propose the introduction of a bland green tax reform

The policy is simulated using the H-GEMED model. The model has a hybrid formulation containing all equations pertaining to a TD CGE model representation of the Spanish economy and additionally all equations of a BU electricity operation and expansion model to represent the electricity sector in detail.

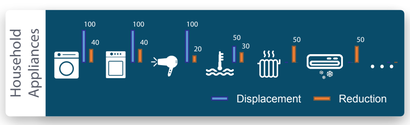
The CGE model component is necessary to evaluate possible rebound effects resulting from the changes in competitiveness introduced by the green tax. Additionally, the CGe model allows ther evaluiation of alternative ways to distribute the newer tax income to influenciaste directly the government budget, acts as productive sector subsidies or lower the social contributions burden to labor.

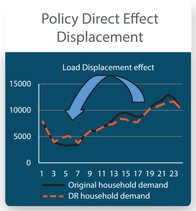
The BU electricity model component is crucial to represent endogenously the technological changes caused by the new competitive situation and changes on the electricity generation optimal decision. Moreover the electricity detail allows the modelling tool to represent the demand consequences of agents with diferent electricity profile behaviour.

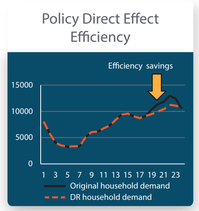
The results obtained comproves the perpetive and the possible economy repercusions of the alternative use of the tax income acquired.




### Background and Policy
Increase of consumer price awareness allow households to adopt more efficient home appliances use




The policy is simulated using the GEMED model. The model has a CGE traditional formulation, however it includes electricity product differentiation in time (load block) and location, multiple generation technologies and micro foundations for the electricity activities.

The load block disaggregation is specially important because it allows to represent endogenously the demand profile changes promoted by the increase in the consumer electricity price awareness due to recent developments on smart mettering and time of use tariffs for example.

Two main direct effects can be identified from an increase of households electricity demand response. The awareness of different hourly prices provide incentives to shift consumption to lower costly electricity hours. Meanwhile, the increase on consumer information about appliances economical use modes and saving labels could cause an electricity demand retraction.

The general equilibirum formulation used allows the estimatation of indirect effects like rebound effects that undermines the previous mentioned policy direct effects.

The policy results presented aim to compare the importance for using a model with the above described features when comparison with a traditional CGE or a pure BU formulation.