CENSE center for environmental and sustainability research

FACULDADE DE CIÊNCIAS E TECNOLOGIA UNIVERSIDADE NOVA DE LISBOA

HYBTEP
HYBRID TECHNOLOGICAL ECONOMIC PLATFORM

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Motivation

Top-down models

+ Describe the interaction between the energy system and the economy as a whole

– Do not contain technological detail, representing the energy sector in aggregate form

Bottom-up models

+ Represent the energy system with great detail

– Ignore the full macroeconomic feedbacks of different energy system pathways

Policy makers need clear and consistent information concerning the real **impact of policies in the economy** and the most **cost-efficient technology portfolio** to achieve a low carbon future

Context

Hybrid approaches to assess economic, environmental and technological impacts of long term low carbon scenarios - The Portuguese case:

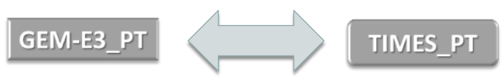
The objective of **HybCO2** research project is to advance on modelling tools and improve impact assessment and energy and climate policy design:

- **HYBTEP (HYBrid Technological Economic Platform)** supported by a soft-link between the bottom-up model, TIMES_PT and the top-down GEM-E3_PT;
- HYBGED (HYBrid General Equilibrium Dynamic) model sustained by Mixed Complementarity Problem.

HybCO2 is a research project funded by:

FCT Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR

HybTEP - Hybrid Technological Economic Platform



Goal:

- Obtain a modelling platform with the detailed technological information of TIMES_PT;
- Explicit representation of economy and its factors (production, consumption, labour) from GEM-E3_PT.

Approach

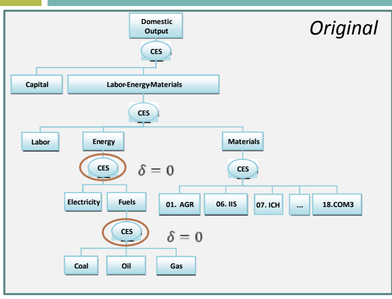
- Fuel substitution and energy prices are driven by technological decisions within the framework of the TIMES-PT model.
- GEM-E3_PT model receives energy demand and the resulting changes in economic output growth are used as adjusted exogenous drivers to the TIMES-PT model.

Models Harmonization

GEM-E3_PT productive sectors/household expenditure category	TIMES_PT sectors
01. Agriculture	Agriculture
02. Oil	Oil Refinery
03. Coal	Other energy supply
04. Natural Gas	
05. Power sector	Electricity
06. Ferrous and non-ferrous metals	Iron and Steel; Non-ferrous metals
07. Chemical	Ammonia; Chlorine; Other chemicals
08. Energy intensive sector	Cement; lime; hollow glass; flat glass; other non-metallic minerals; high quality paper; low quality paper
09. Electric and Other equipment goods; 10. Transport equipment; Other Industries; 11. Consumer Goods Industries; 12. Food and textile; 13. Construction	Other industries
14. Land transport;	Road freight, rail freight; buses, intercity coaches, heavy rail passengers, subway
15. Other transport;	Aviation; navigation
16. Services of credit and insurances; 17. Other Market Services; 18. Non Market Services	Services (space heating and cooling, water heating, cooking, refrigeration, electric appliances, public lighting)
Households operation of transport associated with Operation of transport	Car short distance; car long distance; moto
Households Fuels and power associated with Heating and cooking appliances	Residential (heating, cooling and water heating, lighting, refrigeration, cooking, electric appliances)

- Defining correspondent sectors and energy commodities

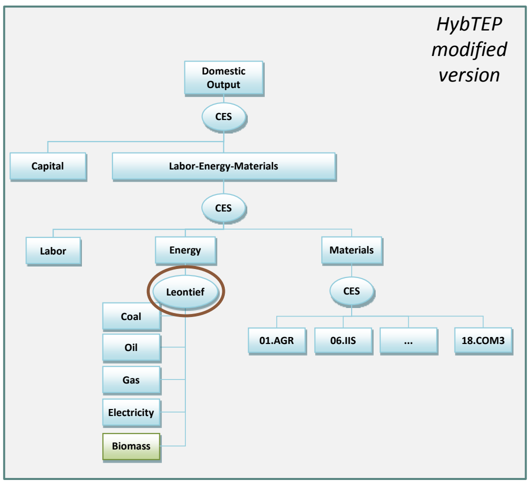
GEM-E3 changes



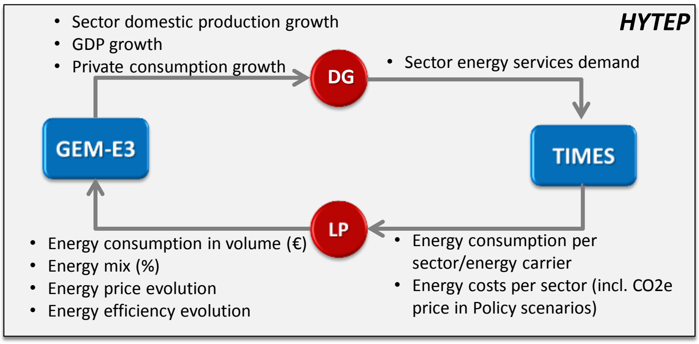
i. Energy consumption and fuel mix defined exogenously;

ii. New energy commodity: biomass;

iii. Energy prices evolution defined exogenously;



Coupling Framework



Each cycle represents 1 iteration

Convergence criteria: *Min* **energy services demand** difference (Euclidean function)

DG Demand generator

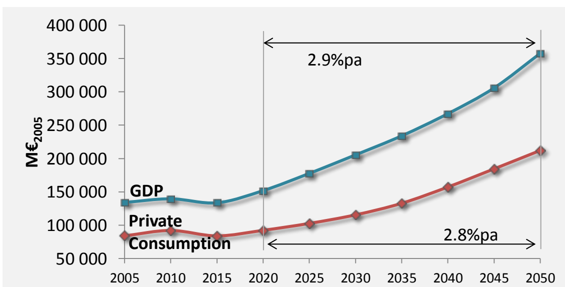
$$DEM_{i,t} = DEM_{i,t-1} \cdot (1 + DRGR_{i,t} \times ELAS_{i,t})^{period\ length} \cdot (1 - AEEI_i)$$

LP Linking Process

$$ELFU_{PR,AN} = \sum_E (E_{E,PR,AN} \cdot PRICEPJ_E) \quad \Big| \quad PELFU_{PR,AN} = \frac{COSTS_{PR,AN}}{ELFU_{PR,AN}} \quad \Big| \quad \alpha_{PR,E,AN} = \frac{(E_{E,PR,AN} \cdot PRICEPJ_E)}{ELFU_{PR,AN}}$$

Scenarios

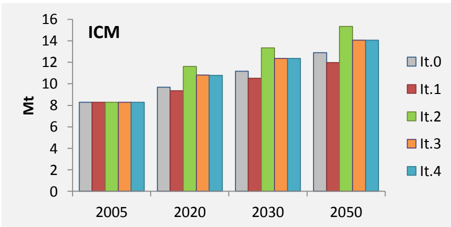
- **Reference scenario:** no energy/climate policy

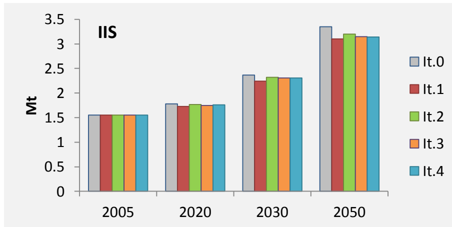


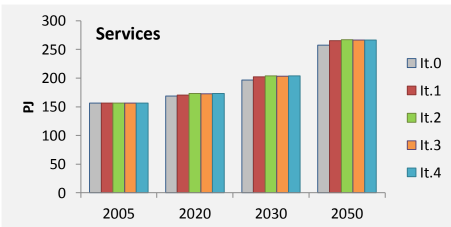
- **Policy scenario:** CO_2 tax to induce a GHG emissions reduction in line with EU goal (EU Energy Roadmap: 2020: 25€7ton, 2030: 52€/ton, 2050: >265€/ton)

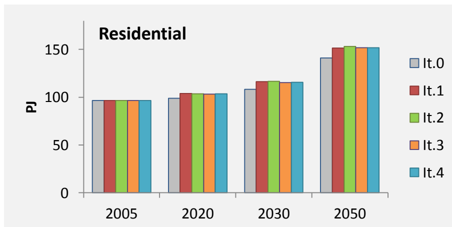
Reference Scenario

- **Demand Convergence:** achived after 5 linking cycles

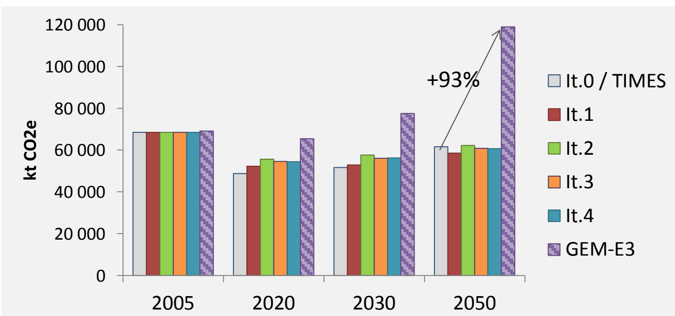






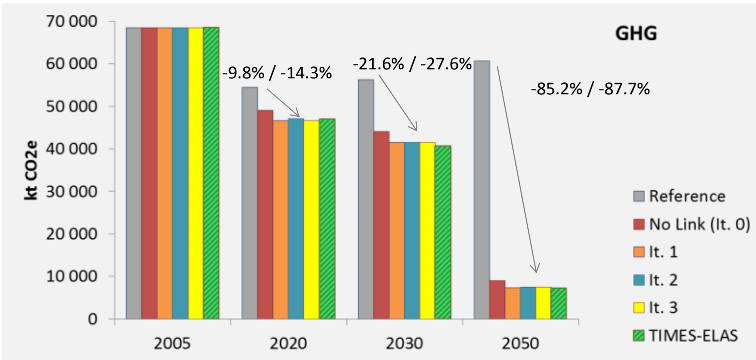


Reference scenario - GHG



- In 2050 the difference between TIMES it.0 and GEM-E3 GHG emissions is 93%
- GEM-E3 reduces energy intensity less than 1% per year and no significant change in the fuel mix is observed
- TIMES reduces energy intensity at around 2% per year and increases the share of electricity (+9%) from 2005 to 2050

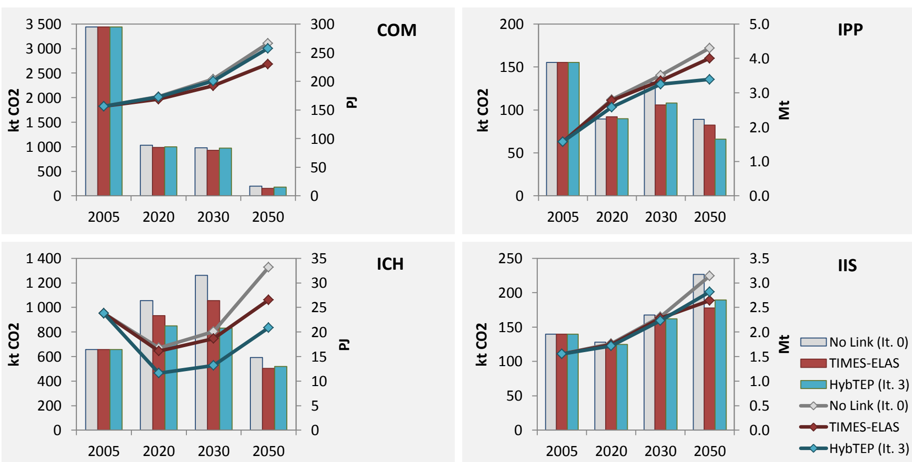
Policy scenario



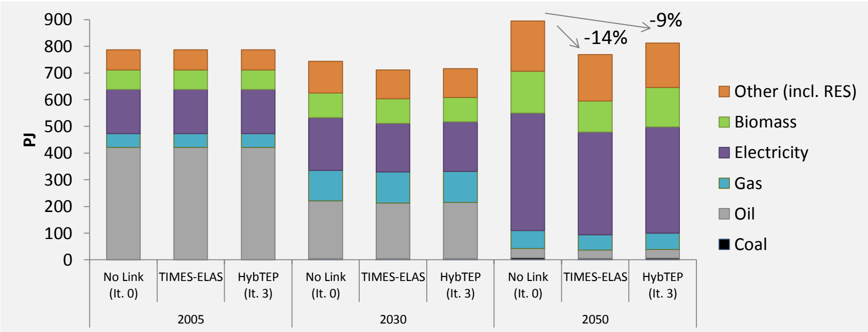
- Convergence is achieved after 4 linking cycles
- In 2050 the national GHG emissions are reduce: 80.4% with no Link, 83.7% with full iteration (HybTEP) and 84% with TIMES-ELAS, comparing with 1990

Policy Scenario - GHG

- **No linking versus Hytep versus TIMES-ELAS**

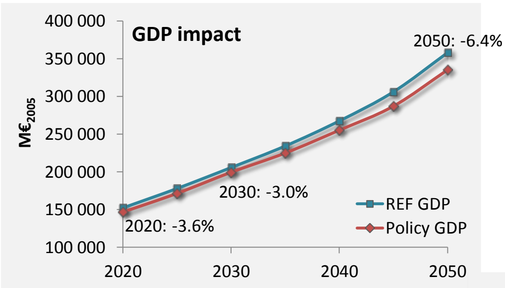


Policy Scenario – Final Energy



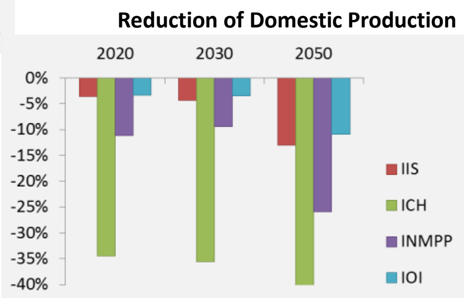
- In 2050, TIMES-ELAS reduces more the final energy consumption than HybTEP
- The fossil fuels consumption between TIMES-ELAS and HybTEP is almost the same justifying the close GHG emissions

Economic Impact



Policy scenario induces a reduction of annual GDP around 4.5% between 2020 and 2050

- Chemical is the industry with higher domestic production reduction comparing with Reference scenario
  - Domestic Demand: -8% in 2050
  - Imports: +13% in 2050.
  - Exports: -69% in 2050



Conclusions

- Modelling energy and/or climate policies with HybTEP allows to:
  - Obtain the most cost-effective technology portfolio and simultaneously;
  - Understand in a clear way the macroeconomic impact of such policies (e.g. in production, domestic demand, exports, imports)

- Further Work
  - Replicate energy technologies investment patterns of TIMES_PT on GEM-E3_PT
  - Include other energy carriers on GEM-E3_PT (e.g. H_2);

Thanks for your attention

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