comet

CO_2 transport and storage

The TIMES-COMET Energy-Transport Technical-Economic Model: Purpose, Description, Functionalities, and Results

Helena Cabal, Maryse Labriet, Yolanda Lechón, Spain; Patrícia Fortes, João Gouveia, Júlia Seixas, Portugal; Amit Kanudia, India; Maurizio Gargiulo, GianCarlo Tosato, Italy

SEVENTH FRAMEWORK PROGRAMME

COMET – CO2PipeHaz - COCATE, Lisbon, December 12, 2012

Bridging the Gap in CCS Infrastructure:

Results from European Projects

Outline

1. Research questions
2. Functionality of the modelling tool
3. The TIMES-COMET energy-transport model
4. Result examples
5. Conclusion
6. Reference web sites

1. – Purpose of the modelling tool

- To represent the 3 national energy systems in technical economic models
- To represent in a TIMES-CCS model with spatial detail the geo-referenced CO2 emission and storage points, and the network of transport infrastructures,
- To hard-link the national energy models and the CCS model
- To compile scenarios of cost effective CO2 source-sinks combinations, according to different development and objective assumptions, and
- To assess the role of CCS in the national portfolio of mitigation measures under several scenarios assumptions.

The final aim of the modelling tasks in COMET research project is the evaluation of different possible developments of CCS in Morocco, Portugal and Spain, and their dependence on uncertain assumptions.

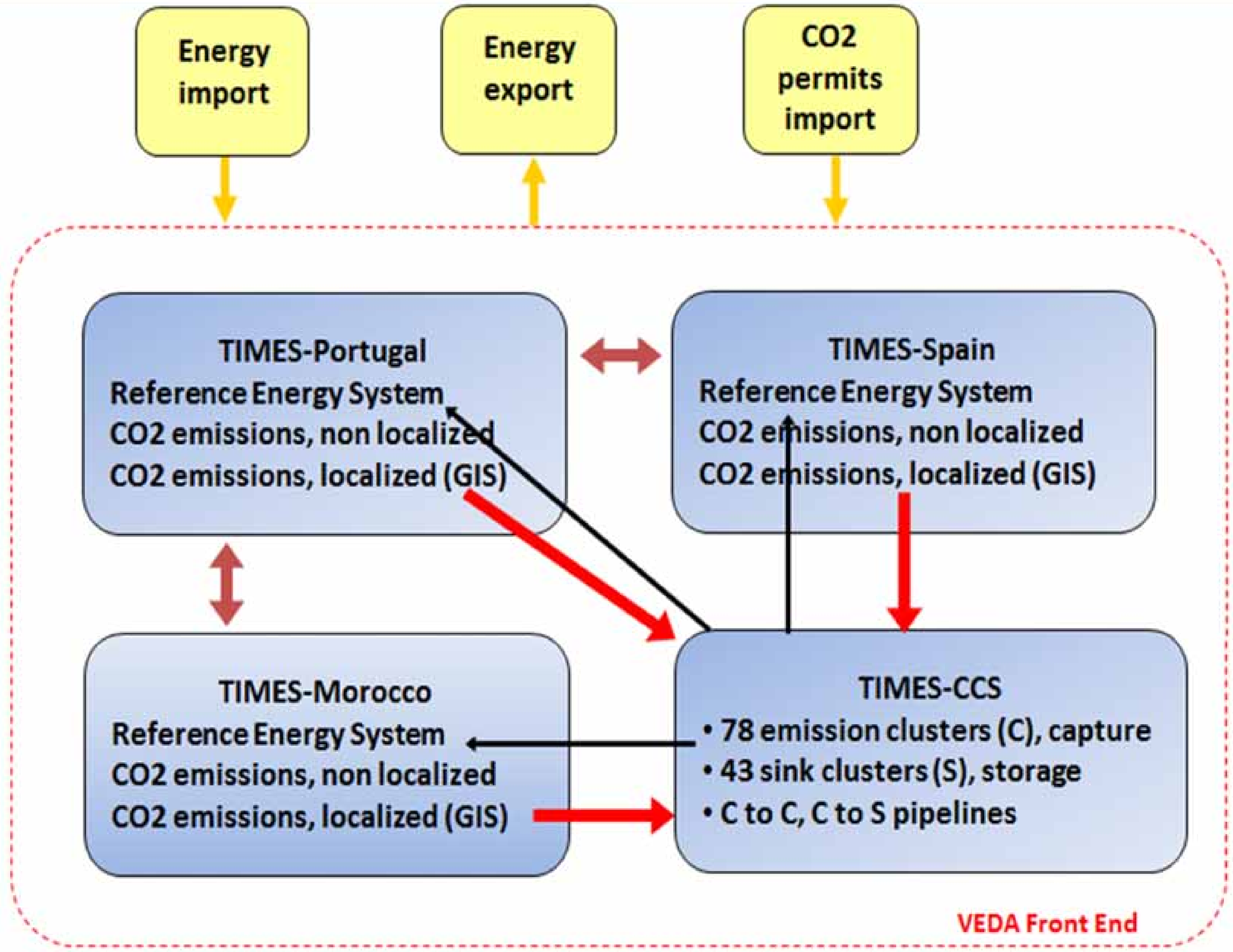
2. – Functionalities of the tool

- Quantitative, consistent, transparent, reproducible
- Integrates the elements in system analysis view *(for instance: if there is more wind power, there is less power from some other source)*
- Joins energy, environmental, technical and economic aspects *(but not safety, legal, administrative, political, or other social aspects)*
- Joins long term time developments and geographical aspects
- Joins energy system mitigation options and CCS options
- Compares options on the same 'level playing field'
- Responsive to different development assumptions

3. – The TIMES-COMET energy transport model

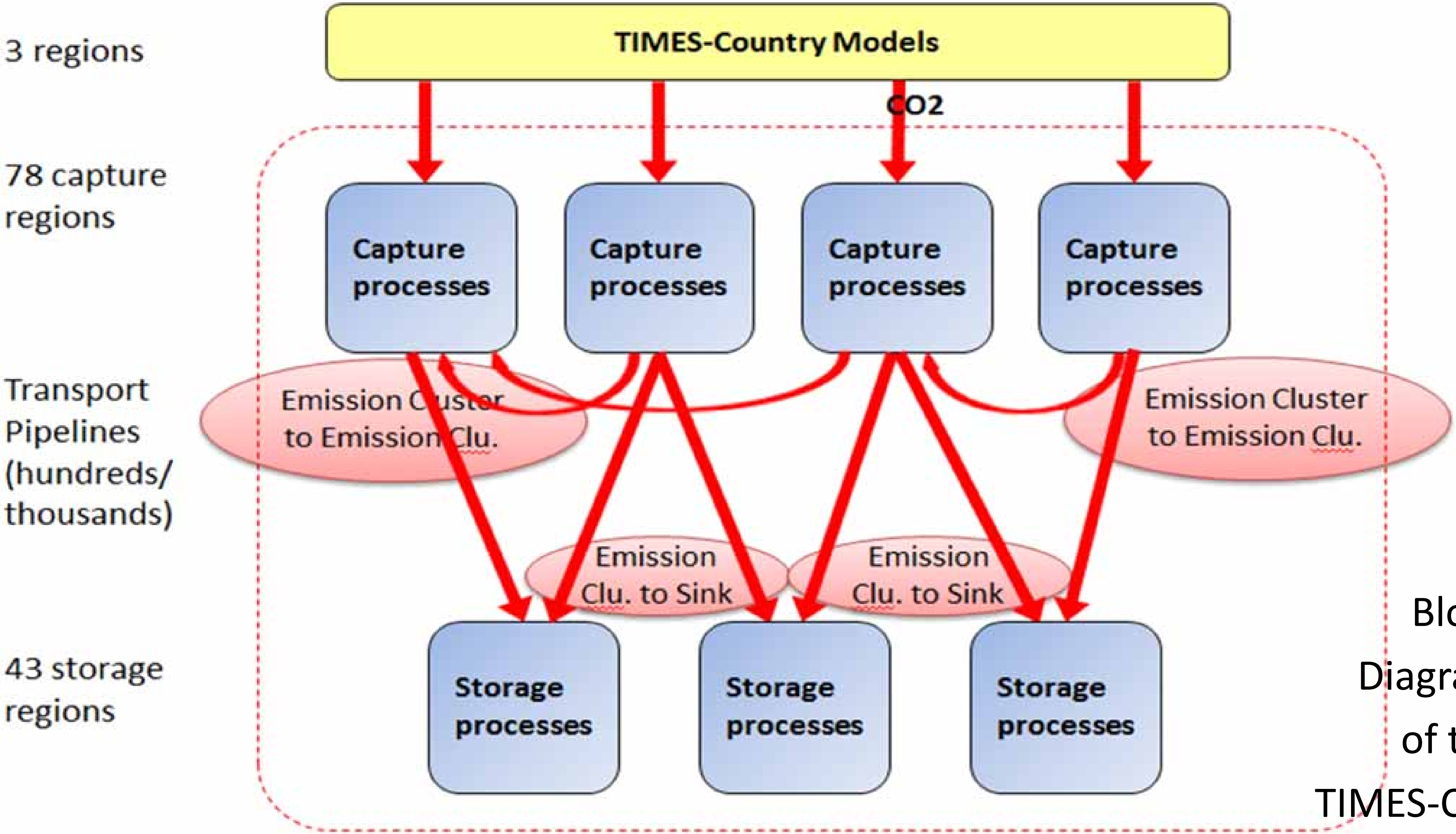
1. Composition scheme
2. General layout of the TIMES-CCS infrastructures model
3. General layout of the national models
4. Highlight of the national TIMES models
    1. Spain
    2. Portugal
    3. Morocco

3.1. – The TIMES-COMET model: composition scheme



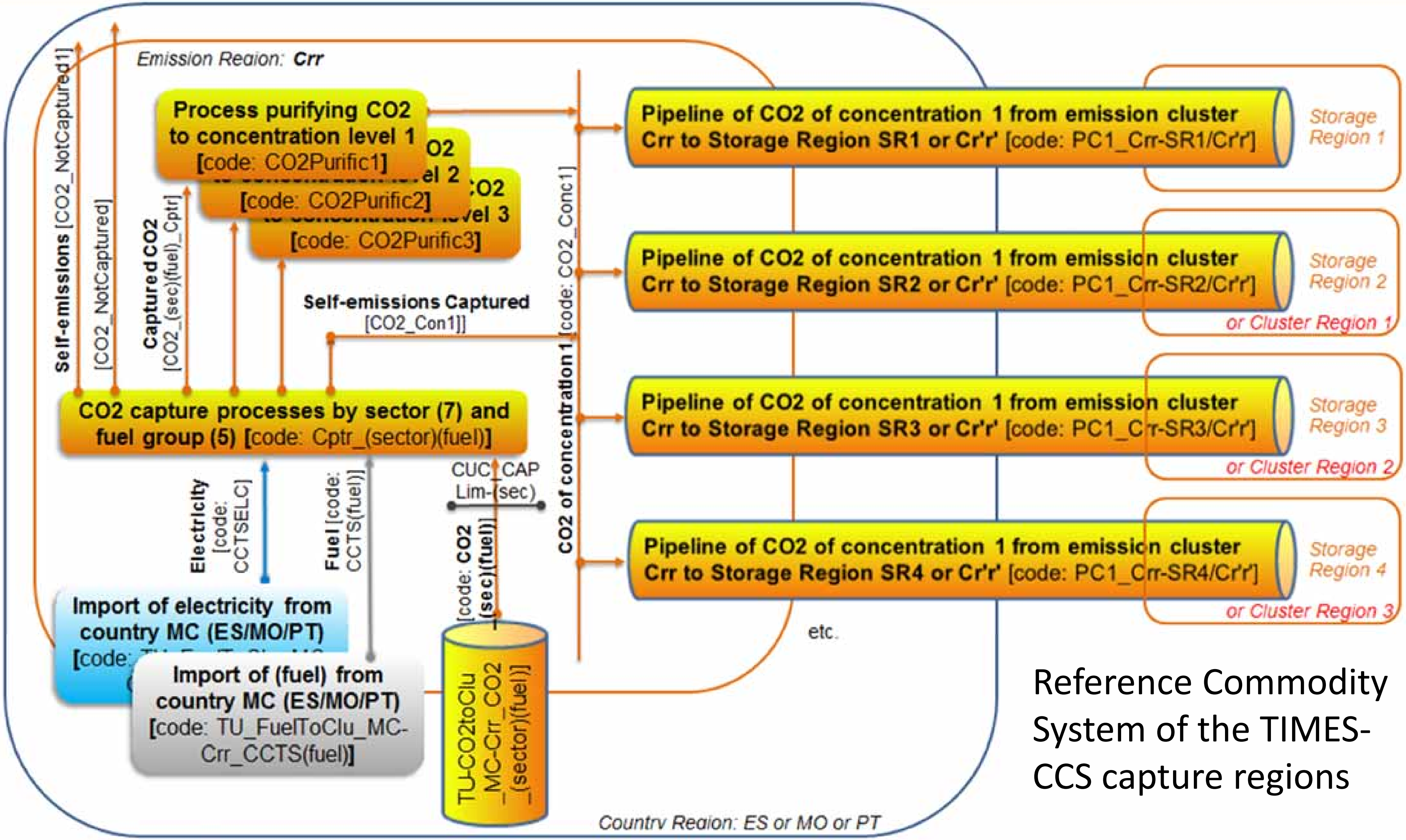
High level block diagram of the hard-linked TIMES-COMET model

3.2. – The TIMES-CCS model: general scheme



Block Diagram of the TIMES-CCS model

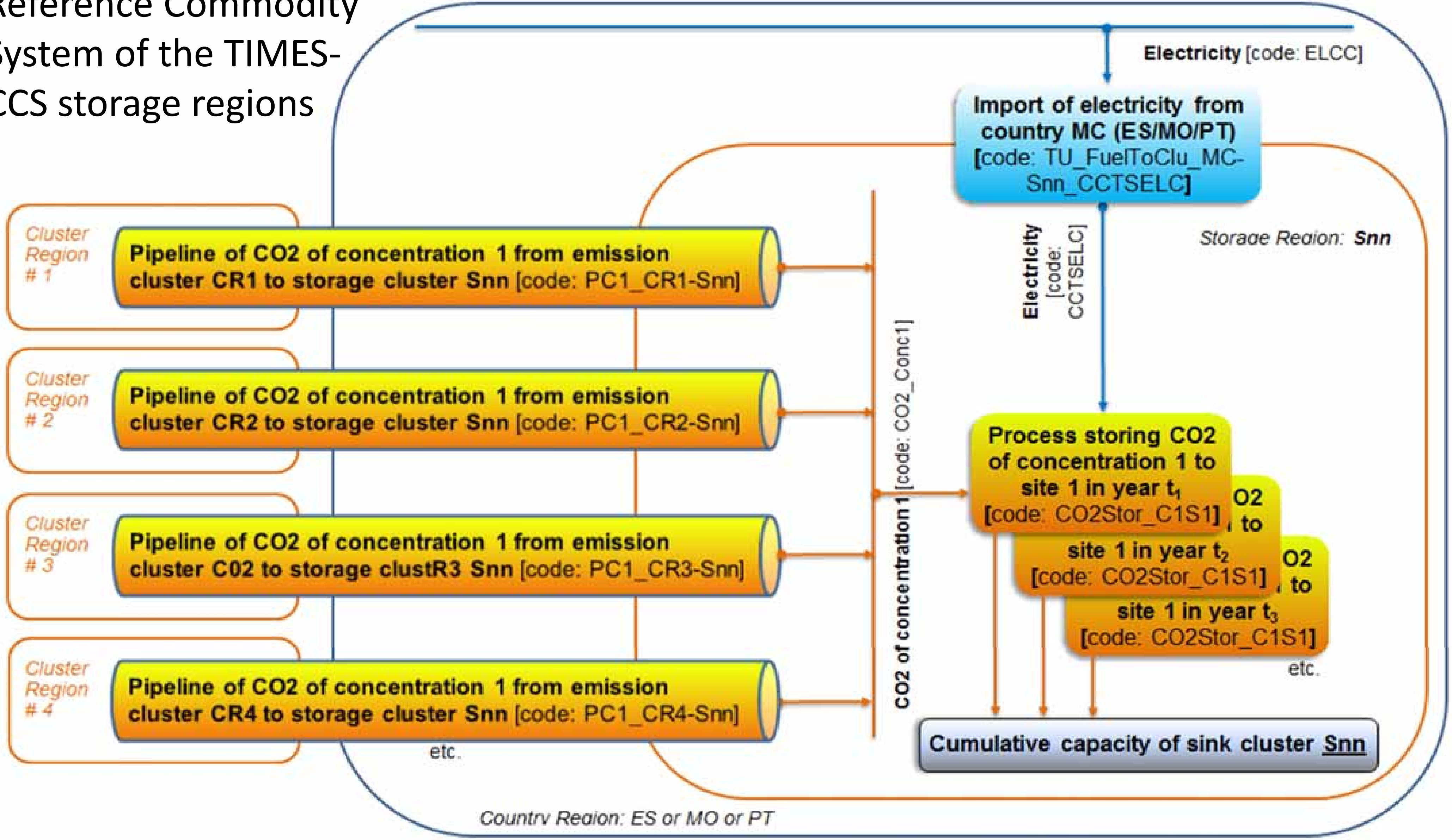
3.2.a – Flow diagram of the capture regions



Reference Commodity System of the TIMES-CCS capture regions

3.2.b – Flow diagram of the storage regions

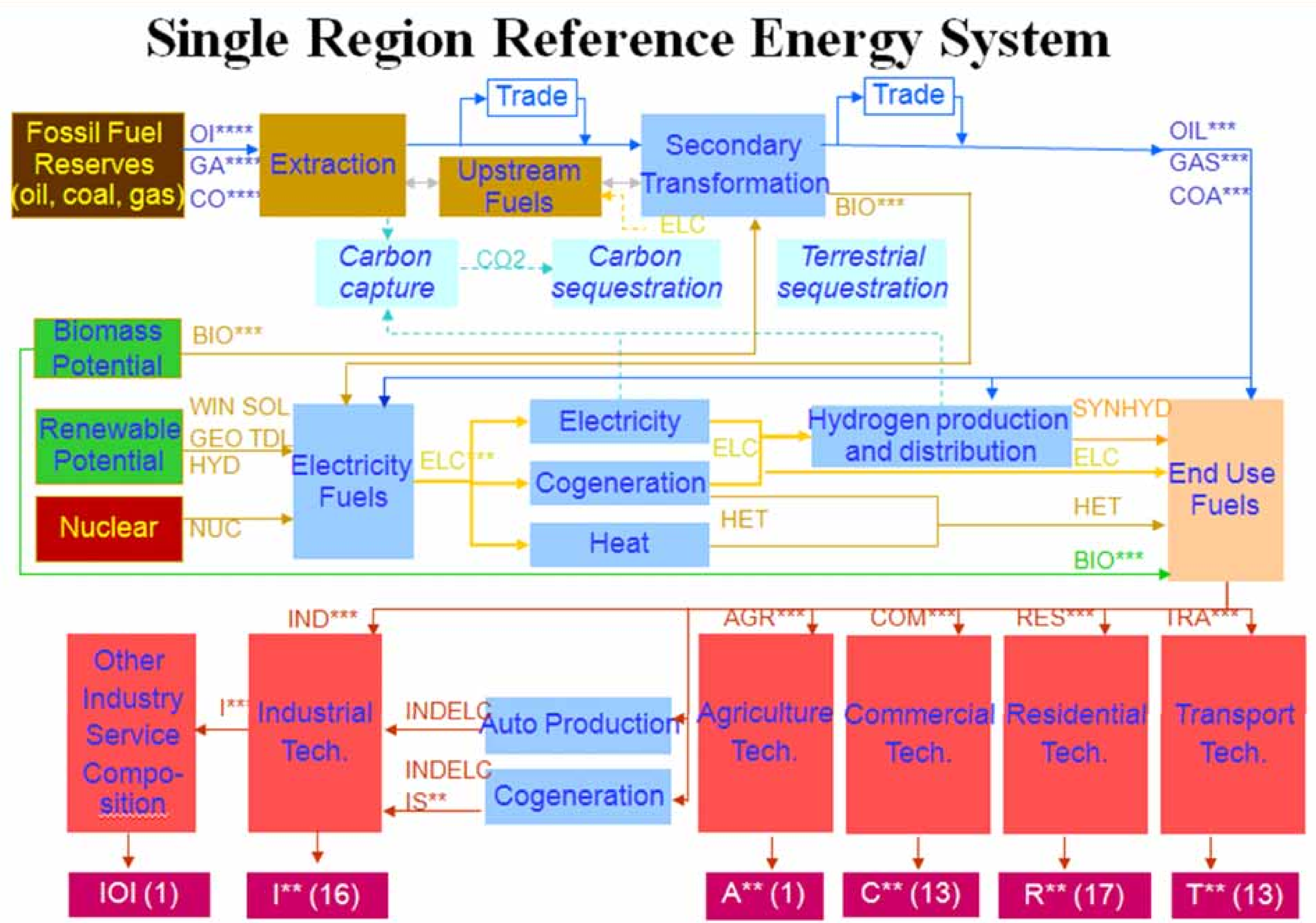
Reference Commodity System of the TIMES-CCS storage regions



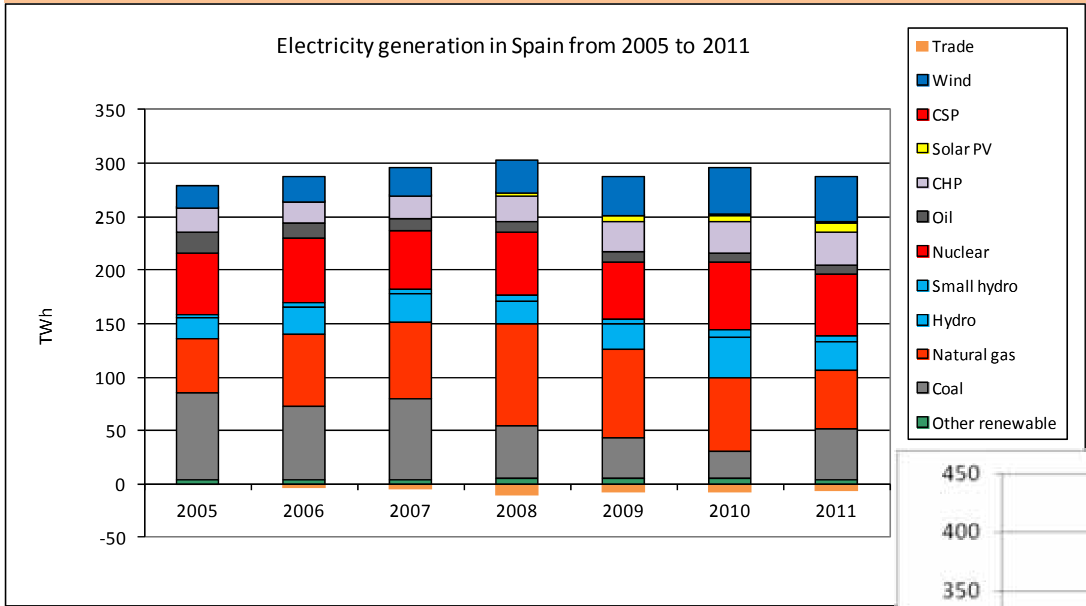
3.3.3 – High level scheme of the national energy models

High level block diagram (Reference Energy System)

of the national TIMES models



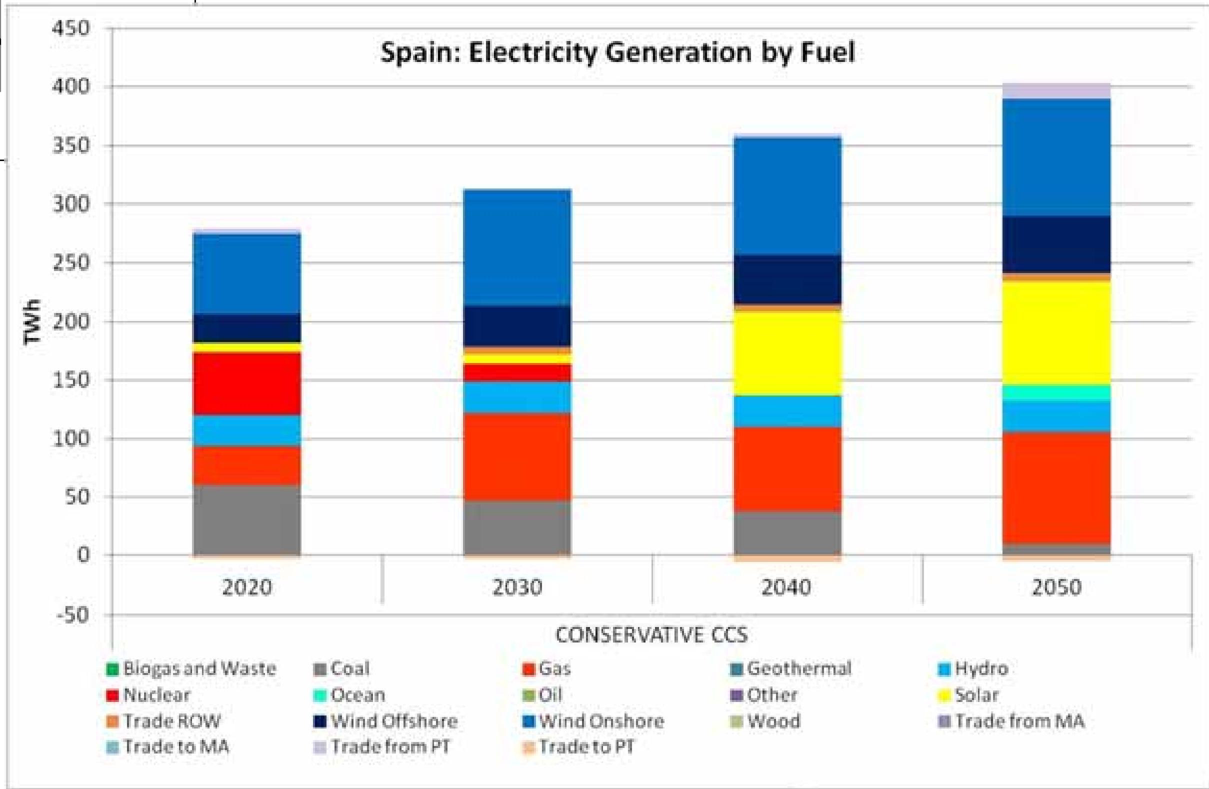
3.4.1a – TIMES-Spain: Electricity system evolution



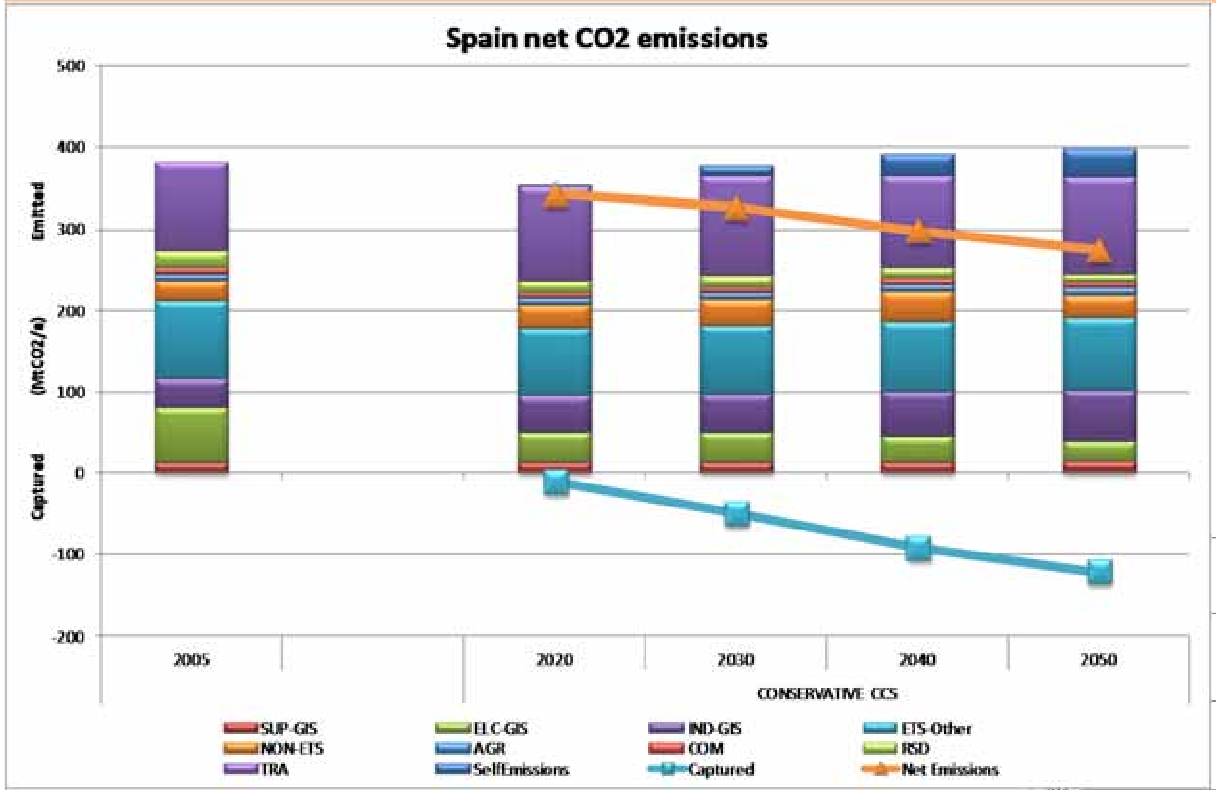
- Share of RES growing (31% in 2011)
- Fossil fuels trend strongly dependent on policy
- 20% nuclear but no plans for new plants

-40% CO2 in 2050 / 2005
and CCS possibility

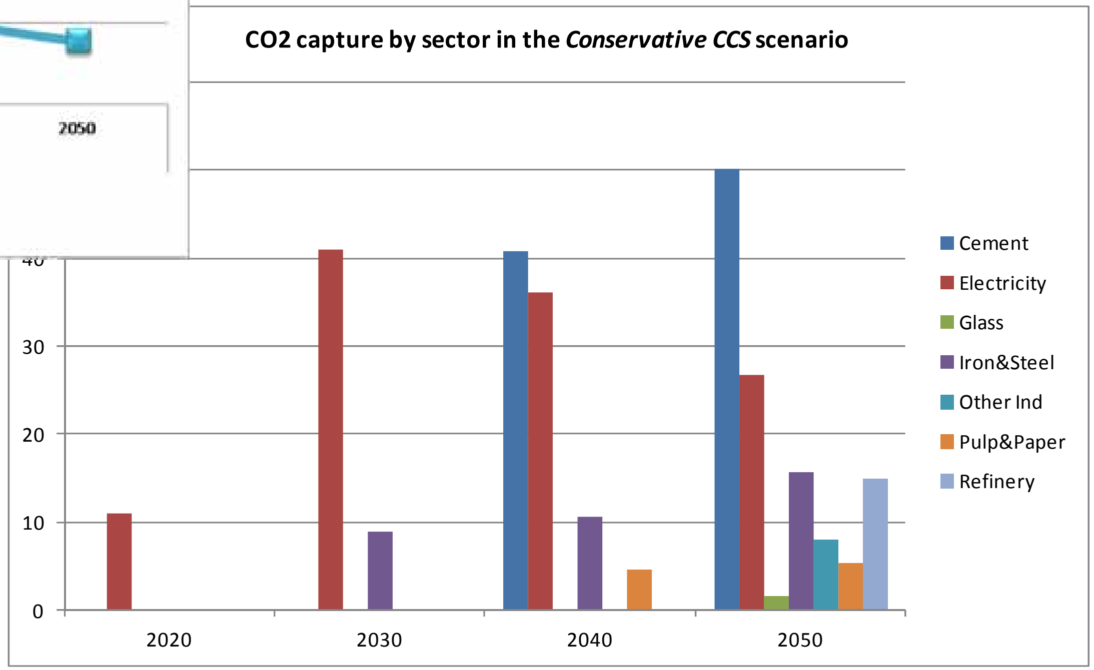
- Share of RES keeps growing (75% in 2050)
- Coal power plants decommission
- Gas power plants increase, 19% CCS in 2050



3.4.1b – TIMES-Spain: role of CCS

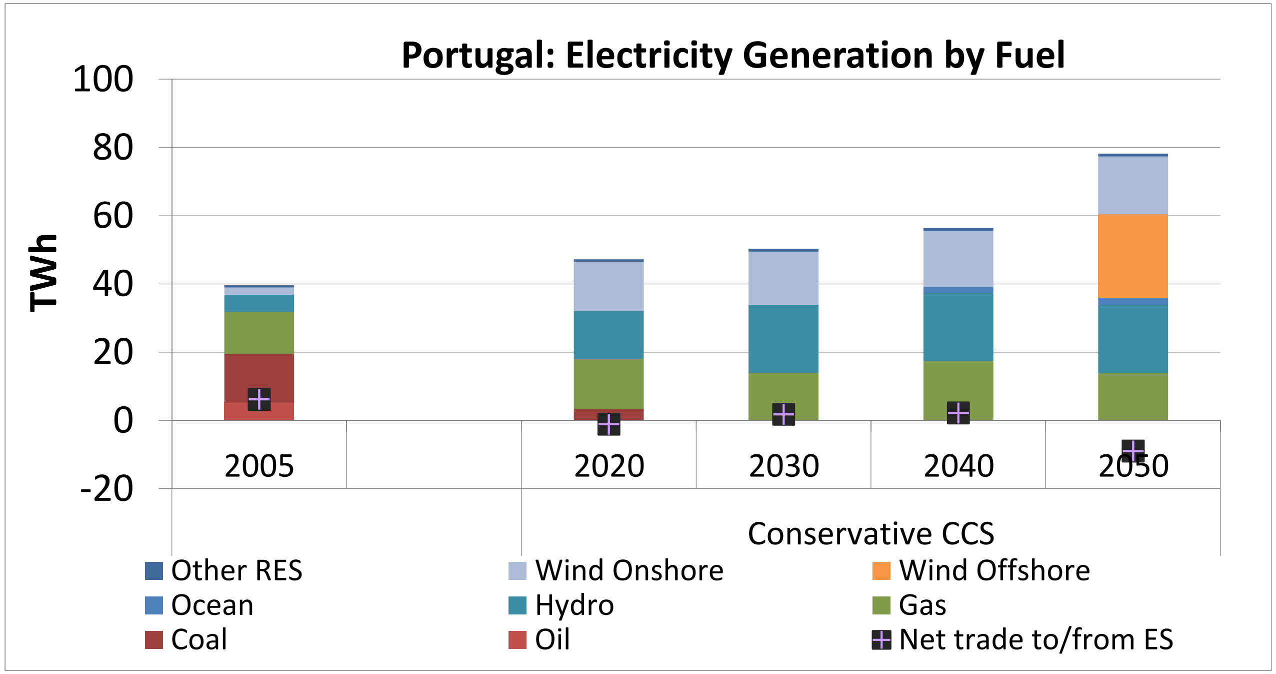


- Relevant role of CCS in net emissions reduction
- CCS starts in 2020 (3% gross emissions) and means 31% in 2050



- Main sectors: electricity and cement
- New sectors at long term

3.4.2a – Times Portugal: Electricity system evolution

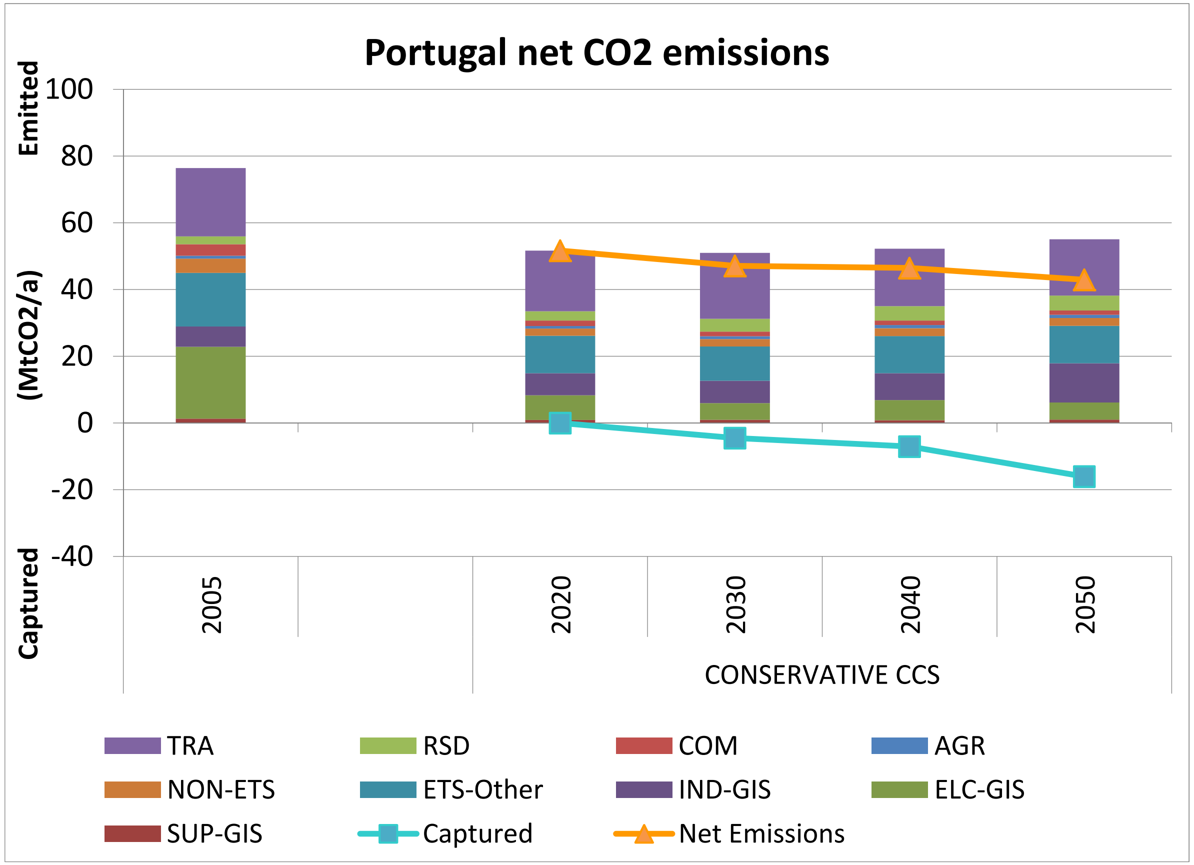


-40% CO_2 in 2050/ 2005 and CCS possibility

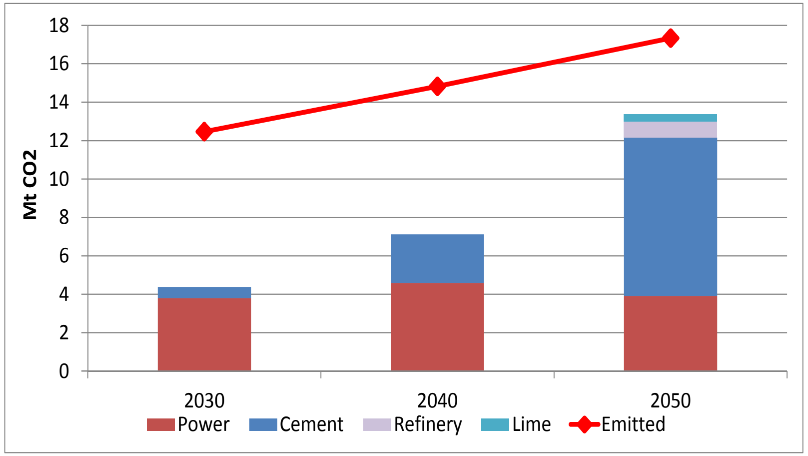
<u>Electricity generation: </u>+ 30% from 2005 to 2030 and almost 100% to 2050, (industry, commercial and residential);

- 2005: 80% of electricity from fossil fuels, 20% from hydro and wind onshore;
- 2030: CCS enter in gas represent 37% of total electricity production; electricity from fossil fuels without CCS will be insignificant (2% of overall electricity production). <u>**Carbon neutral kWh by 2030!**</u>
- 2040: Decommissioning of all gas power capacity without CO_2 capture.
- 2040 onwards: introduction of two new renewables, **ocean and wave energy technologies**.
- <u>**2050:**</u> wind offshore. Geothermal, MSW and solar technologies play a minor role. Electricity from RES is 80% and from fossil fuels (all with CO_2 capture) < 20%;
- <u>**2050:**</u> Portugal as a net export of electricity to Spain (9TWh, 11% of the total electricity production in the country.

3.4.2b – Times Portugal: role of CCS in energy system



-40% CO_2 in 2050/ 2005 and CCS possibility



CO_2 captured by sector and the total gross CO_2 emitted (Mt CO_2)

- **Role of CCS**: 10% in 2030 and 34% in 2050, of CO_2 emissions captured compared with total country emissions;
- **Power and Heat production**, CO_2 capture technology is cost-effective in 2030, capturing 69% of the sector emissions;
- **Industry,** CO_2 capture technology is cost-effective:
  - 2040 in cement sector, representing a capture of 12% of the industry emissions;
  - 2050 in other industry sectors, as glass, lime and refinery, capturing CO_2 emissions equivalent to 44% of the total industry emissions;

3.4.3a – TIMES-Morocco: construction of the model

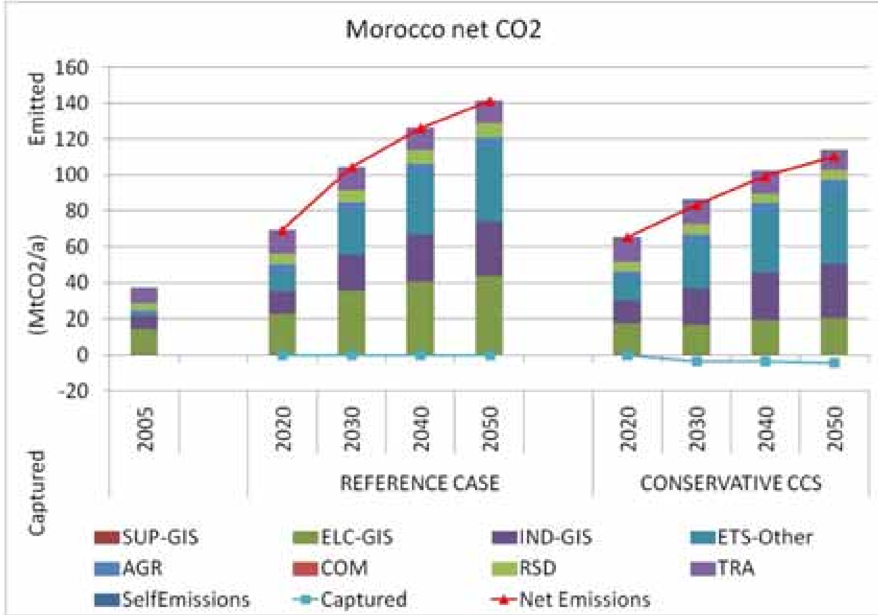
- Developed during COMET project, same structure (*reference energy system*) as other TIMES country models

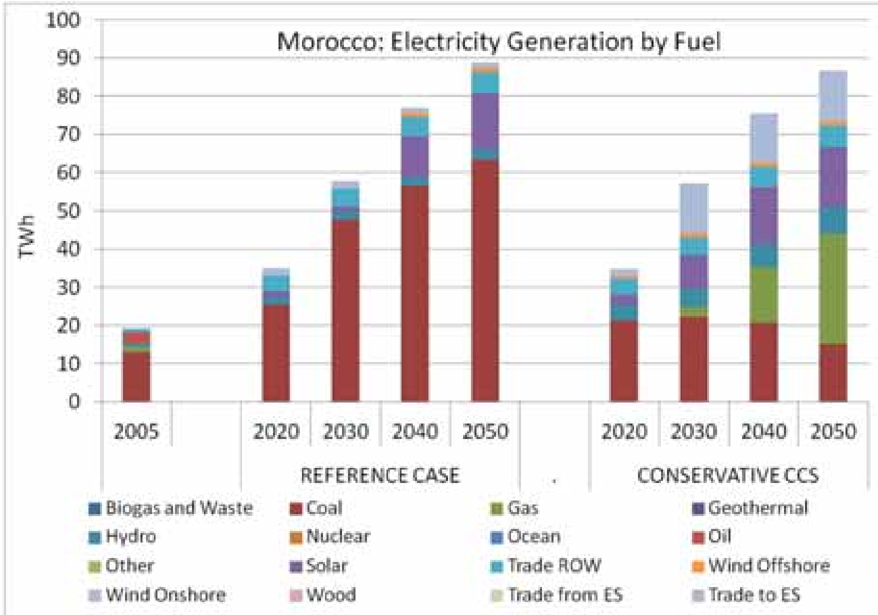
- Takes into account:
  - *Current characteristics of the energy system of Morocco, from end-use to supply-side*, such as: efficiency and capacity of installed power plants, solar and wind potentials, availability of oil shale reserves, possibility to build LNG terminal, industrial activity, etc.
  - *Future socio-economic trends* : pop and economic growth, high contribution of cement and phosphate sectors, future fossil fuel prices

- In COMET, no climate target imposed in Morocco, CDM is allowed: purchase of CO2 credits by ES+PT driven by mitigation costs

3.4.3b – TIMES-Morocco: energy and emission prospective

- Up to 22% emission reduction in Morocco wrt Reference case
- Cost efficient CDM portfolio:
  - *Low carbon power plants w/o capture:* solar and wind, gas (replacing coal)
  - *CCS mitigation (coal power plants)* "only" 10% of emission reductions
  - *Limiting factor for CCS*: cross-frontier CO2 pipeline availability or not
  - *No capture at cement plants*
  - *No change in end-use sectors*





TIMES-Morocco: prospective analysis tool for **energy planning** including Nationally Appropriate Mitigation Actions (NAMAs)

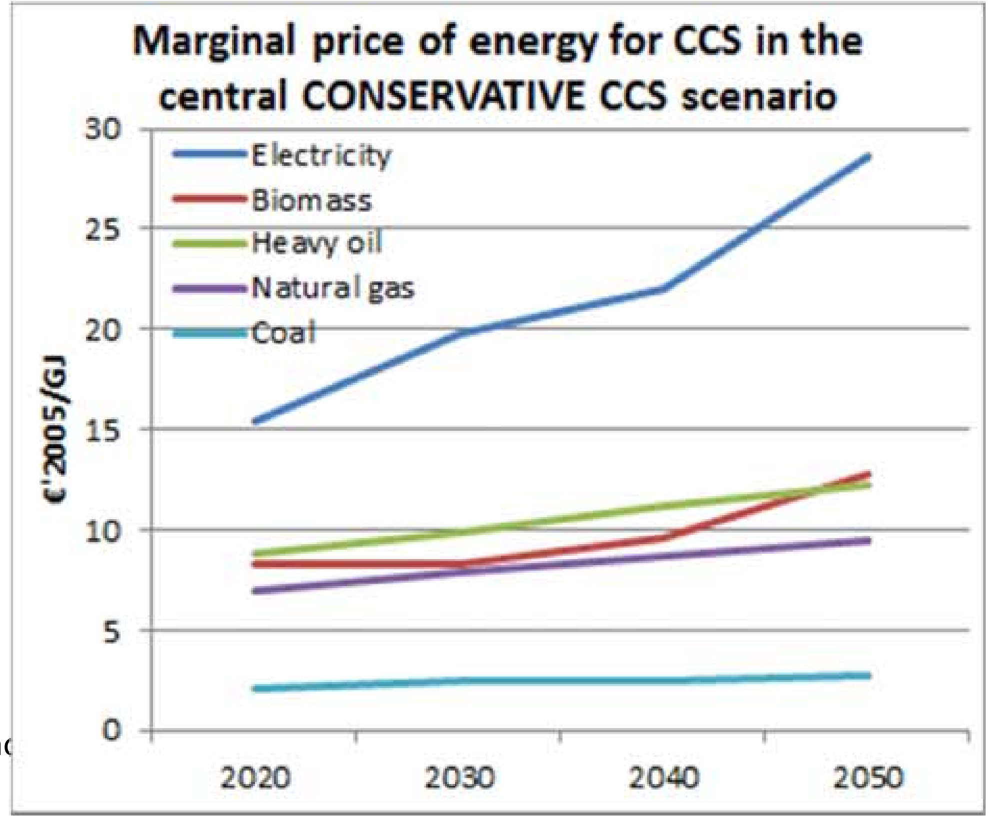
4. – Result examples

1. System costs and energy prices
2. Optimal mix of mitigation options and CO2 prices
3. Energy system mitigation options
4. Least cost CCS infrastructures

4.1. – Results: system costs and CCS

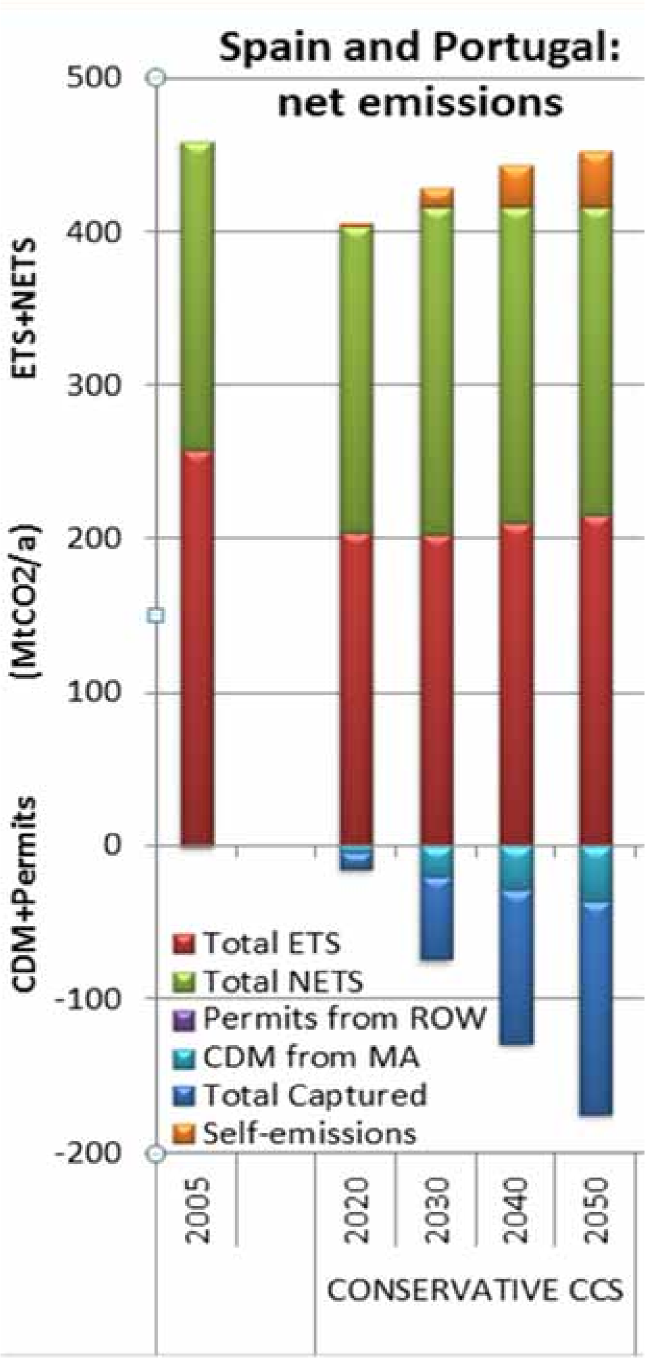
	2040	2050
Total system cost, ES+PT+MO (B€'2005/a)	*417*	*614*
Share of CCS (%)	0.98	1.38
Cost of CCS (B€'2005/a)	*4.1*	*8.6*
% Share: Capture	39	30
Storage	6	5
Transport	7	5
Energy vectors	48	60

The total system cost (TSC) is 22-25% of the GDP since it includes the traditional energy sectors (primary energy supply, power, refineries, etc., about 35% of TSC) and all the durable goods purchased by the final users (cars, trucks, heating systems, appliances, etc., about 65% of the TSC).



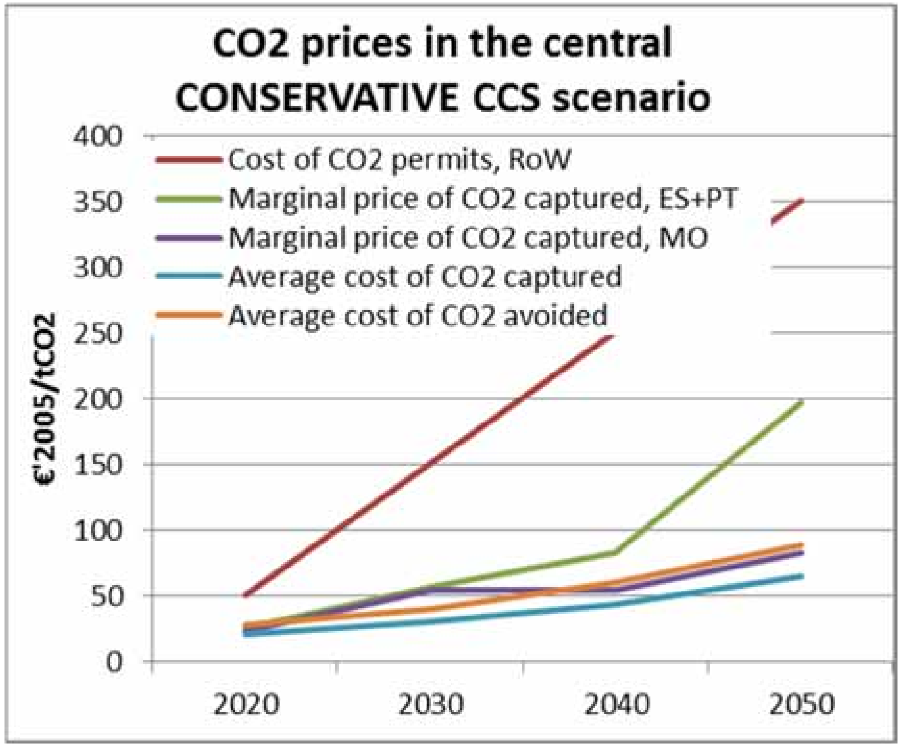
The 'energy vectors' component of CCS includes the amount of electricity generation lost in power plants with CCS.

4.2. – Results: optimal mix of mitigation options in 2040-50 in the central CONSERVATIVE CCS scenario

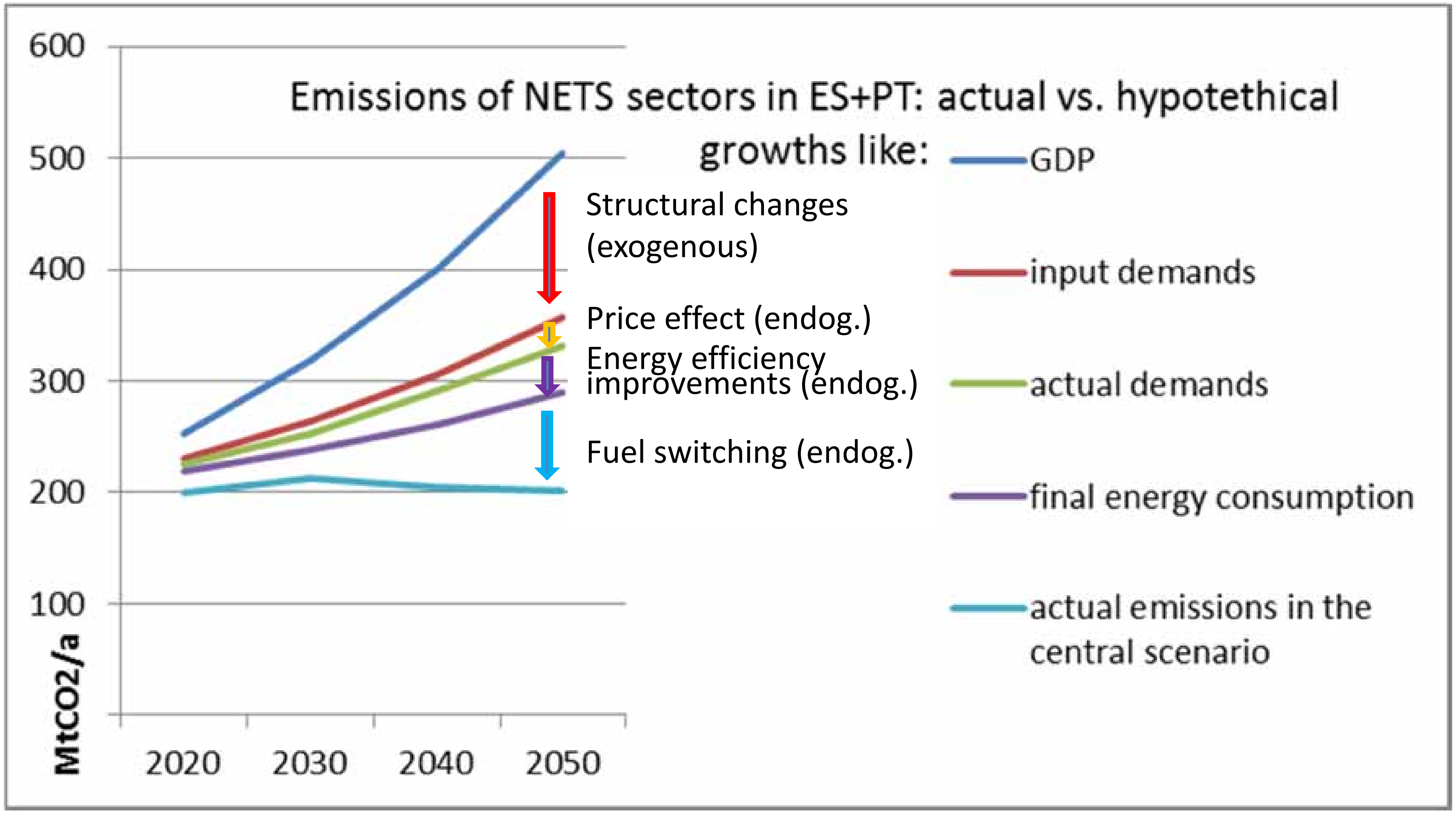


- 20% purchase of CDM permits from Morocco, 29-36 MtCO2/a
- 55% CCS in the Iberian Peninsula, avoiding 72-102 MtCO2/a, equivalent to a gross capture of about 100-140 MtCO2, and
- 25% implementation of domestic mitigation options, about 35-41 MtCO2/a.

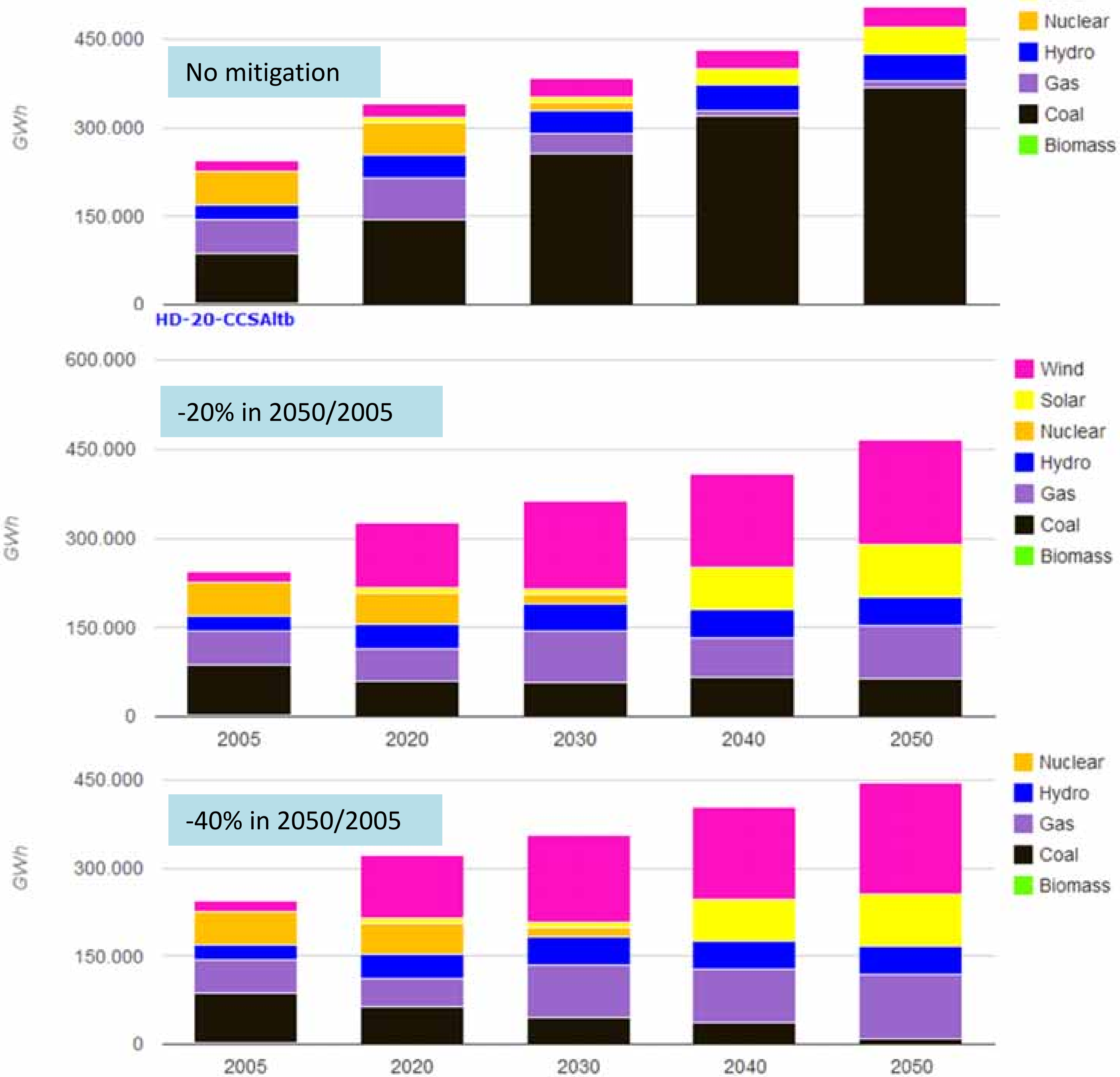
It is not necessary to buy permits From the Rest of The World (RoW).

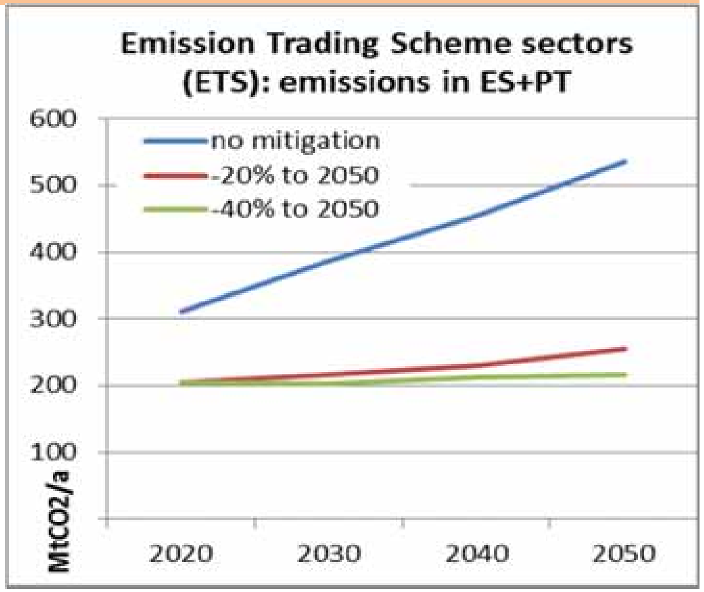


4.3a – Results: energy system mitigation options in transport residential & commercial, agriculture, small industry (NETS)



4.3b – Results: energy system mitigation options in the Emission Trading Scheme sectors (power, large industry)



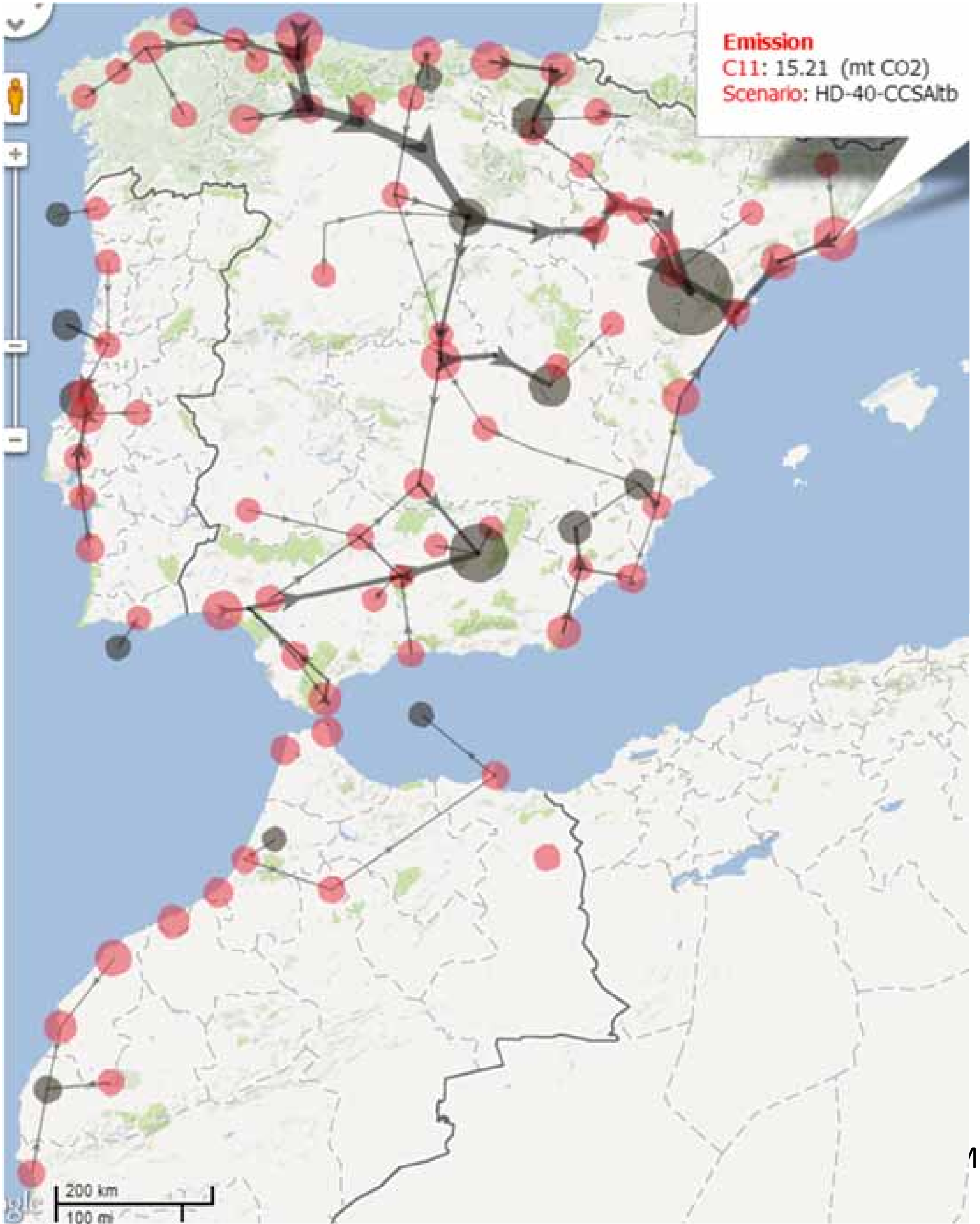


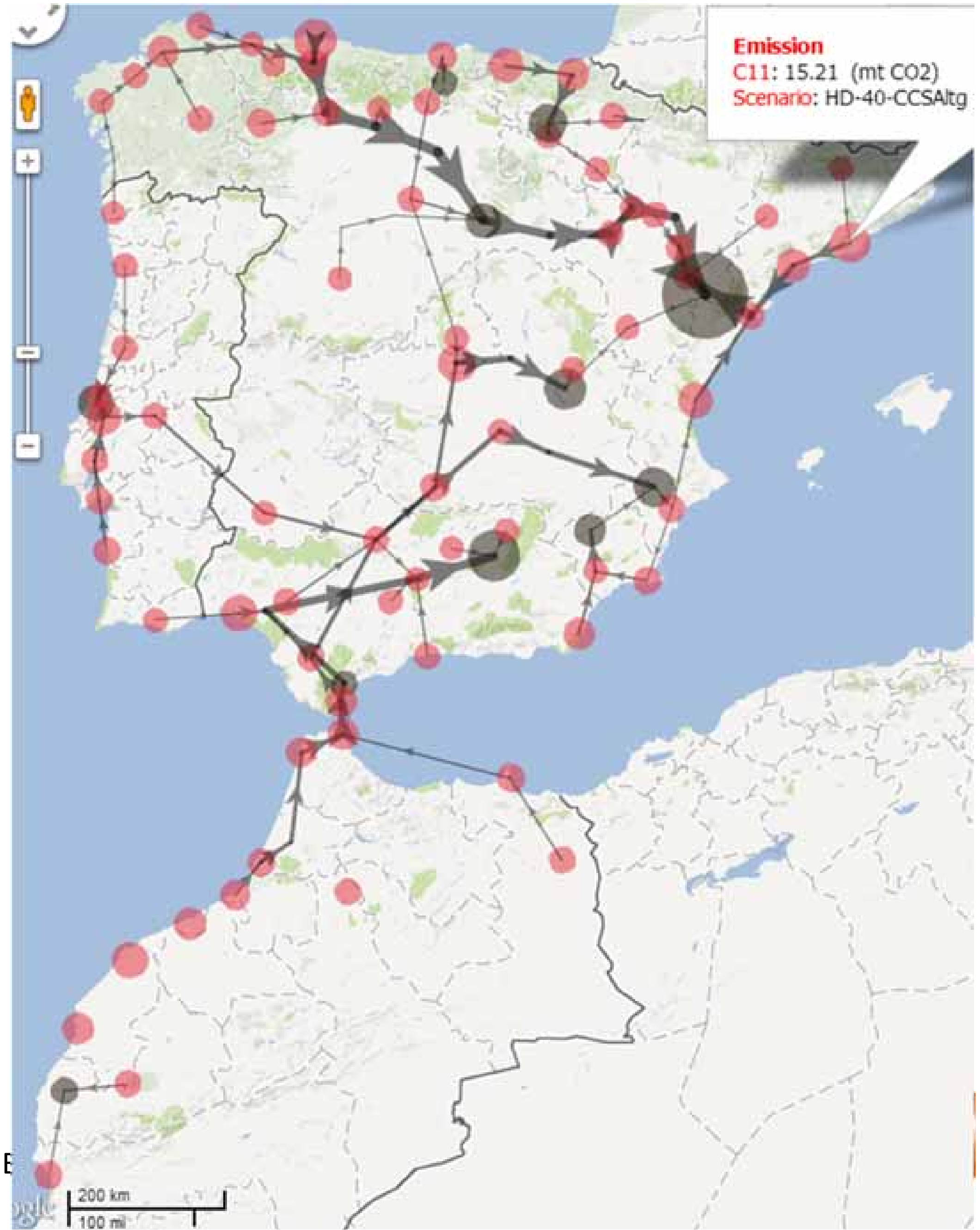
Mitigation forces coal out;

Renewables and gas in.

From http://www.kanors.com/vedaviz/TSV.aspx?Prj=comet02dec, table: Electricity Production by fuel ES+PT

4.4. – Results: least cost CCS infrastructures … (to be improved, comments added, etc.





4.3. – Results: … and differences across scenarios

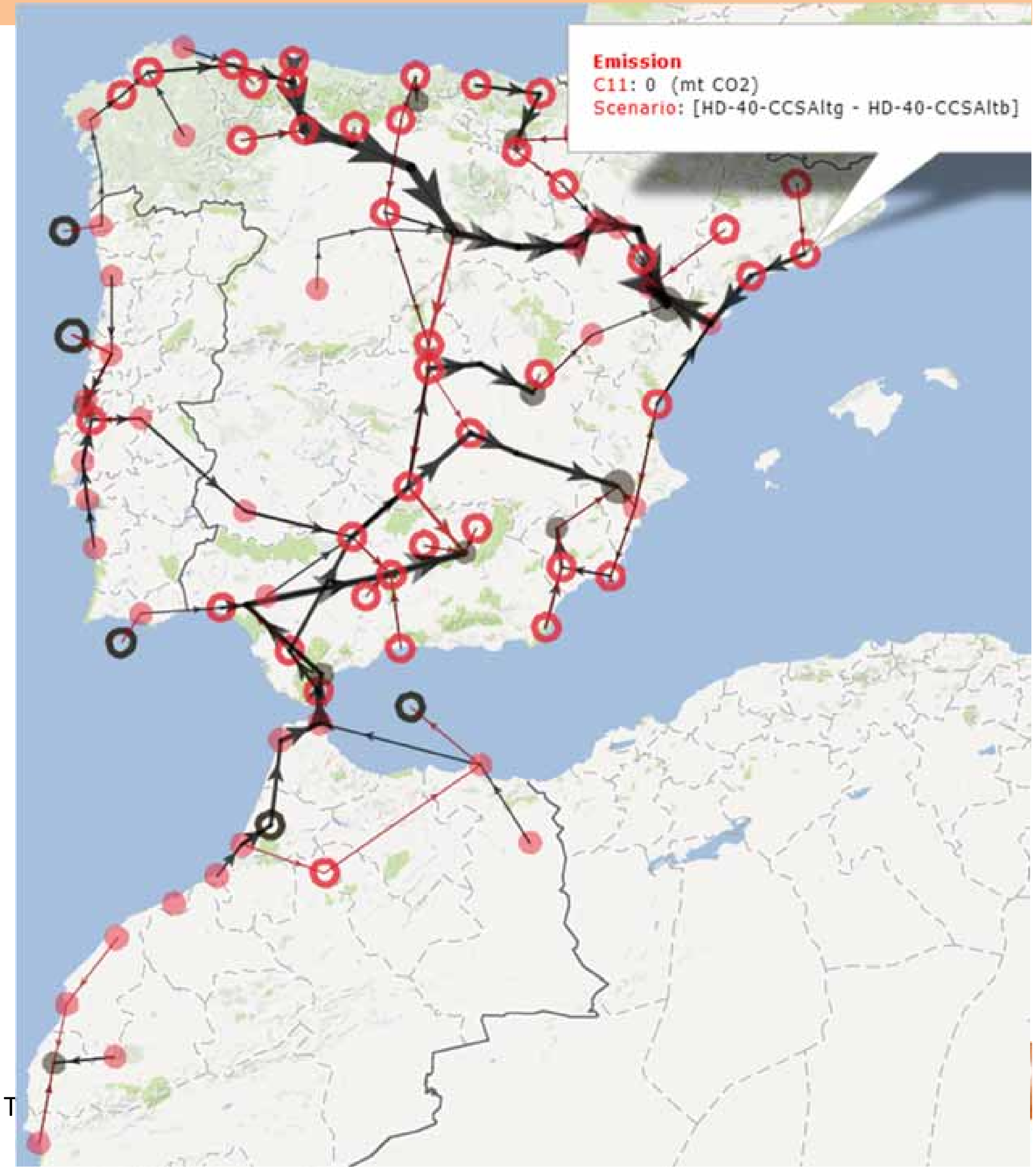
<u>Scenario difference</u>:

If it is possible to cross the boarder, onshore sinks in Spain are preferred to offshore sinks in Portugal and Morocco

Hollow circles: storage decreases

Red flows are negative and black are positive

http://www.kanors.com/vedaviz/TSV.aspx?Prj=comet02dec



5. – Conclusion

The methodology of technical-economic modelling identifies optimal emission reduction strategies and least cost CCS infrastructures layout with geo-referenced details.

The IEA-ETSAP TIMES platform generates technologically detailed partial economic equilibrium models of multi-regional energy systems and spatially detailed hybrid energy-transport models.

The VEDA user's interfaces guide the preparation of the input and illustrate the results with time and space details

The TIMES-COMET modelling tool is available for extensive use: update studies in the west Mediterranean area, new studies in different areas.

6. – Reference web sites

COMET project: at http://comet.lneg.pt

Documentation on The Integrated MARKAL-EFOM System (TIMES): at www.iea-etsap.org

Scenario results, in VEDA-BE format: at http://kanors.com/dcm/Results.asp?Fl=ShowAll&tab=thisweek&model=COMET

results by scenario, scenario difference, year, country, cluster, in tables, graphs and animated 'google' maps: at www.kanors.com/vedaviz/Login.aspx?prj=comet02dec (or the older version http://kanors.com/TSViewer/TSV.aspx?Prj=comet13Nov)