A preliminary exploration of multi-model results for PLANETS Climate scenarios

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Issues

- One of PLANETS objectives is to explore and analyze results for several Policy Scenarios, using an array of models (GEMINI-E3, TIAM, WITCH, TIAMEC, DEMETER, PEM)
  - The global fundamentals (GDP, POP) have been harmonized for the Reference Scenario (WP1), but not for each region
- The models differ in many ways:
  - economic paradigm: technological detail, discount rates
  - geographic disaggregation, representation of climate, etc.
- Methodological issues:
  - Understand the main differences present in the results, and trace them back to one or more model characteristics and assumptions.
  - Discover policy insights that are robust across models
  - There is no intention to fully harmonize the models

Objectives

1. Is it feasible to attain a severe long term climate target when region specific, differentiated **commitments** (i.e. emission quotas) are agreed upon in the transitional period to 2050 ?
2. What are the global and regional impacts of two contrasted sets of emissions quotas ?
3. What is the impact of a **subsidiarity** clause that would limit emission trading to 20% of emission reductions ?

This presentation: comparison of **global** results only, from 5 models (DEMETER, WITCH, GEMINI-E3, TIAM, TIAMEC)

Next 4 presentations: specific **detailed** results/analyses from 4 models (WITCH, GEMINI-E3, TIAM, PEM)

The six PLANETS Models

- Three CGE's:
  - DEMETER (U. Manchester, UK): single region, with very long term climate module
  - WITCH (FEEM, IT): multiregional, with climate module, technology diffusion and learning
  - GEMINI-E3 (CEA, FR and ORDECSYS, CH): Multiregional CGE, no climate module
- Three technology rich partial equilibrium models based on TIMES paradigm:
  - TIAMEC (ECN, NL): another version based on TIAM
  - ETSAP-TIAM (ETSAP and KANLO, FR): global multiregional + climate module
  - PEM (Univ.Stuttgart, DE): E.U.$^{+}$ TIMES model with 30 countries (focus on EU)

Work in Progress

- Timeline:
  - First tests (Dec 2008),
  - Definition of the Policy scenarios (Jan 2009)
  - First round of results + analyses (March-June 2009)
  - Final adjustments and Final Report (Summer-Fall 2009)

- **Current results are partial and tentative**

Ten Scenarios

Scen	Summary	Targets	Codes
First Best (FB)	All regions cooperate fully (and trade) from 2012 onward to achieve the target(s) efficiently	Two targets: • 3.2 W/m2 • 3.5 W/m2	FB-3p2 FB-3p5
Second Best (SC)	• Global ETS starts in 2020 • 4 groups of countries: OECD, Energy EXporters, DEVeloping Asia, ROW • Each group of countries has an emission commitment until 2050, with different starting date of committment, and then all countries join the global climate coalition • Two different series of commitments (SC1 and SC2)	Until 2050: Fixed committments After 2050: Two targets • 3.2 W/m2 in 2100 • 3.5 W/m2 in 2100	SC1-3p2 SC1-3p5 SC2-3p2 SC2-3p5
Variant (Var)	Same as Second Best, but Trading limited to 20% of reductions	Until 2050: Fixed committments After 2050: Two targets • 3.2 W/m2 in 2100 • 3.5 W/m2 in 2100	Var1-3p2 Var1-3p5 Var2-3p2 Var2-3p5

The two alternate commitments

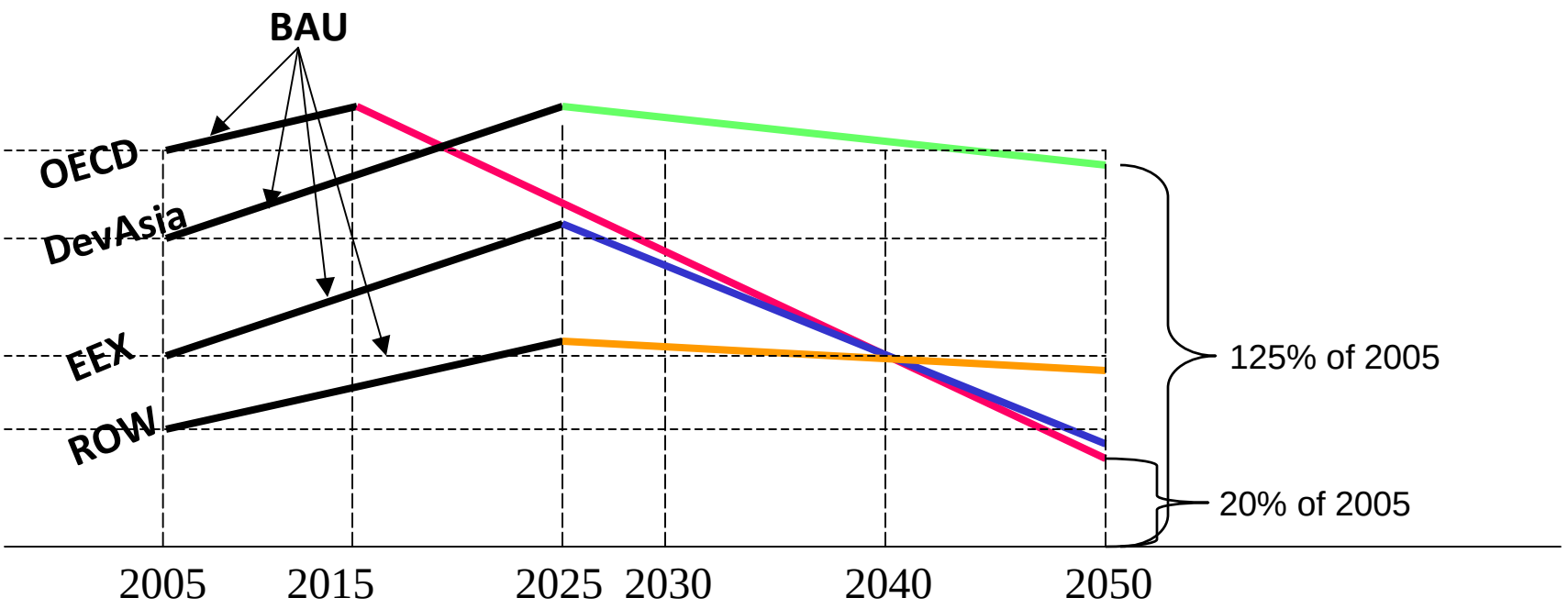
	STARTING DATE OF COMMITMENTS	COMMITMENTS SC1 & Var1 in 2050 wrt 2005	COMMITMENTS SC2 & Var2 in 2050 wrt 2005
OECD	2015	-80%	-90%
ENERGY EXPORTING EEX – Russia and Mid East	2025	-50%	0%
DEVELOPING ASIA	2025	25%	0%
ROW	2025	55%	100%
WORLD w.r.t. 2005		***-27%***	***-27%***

Note: EU implements some actions before 2020

Comments:

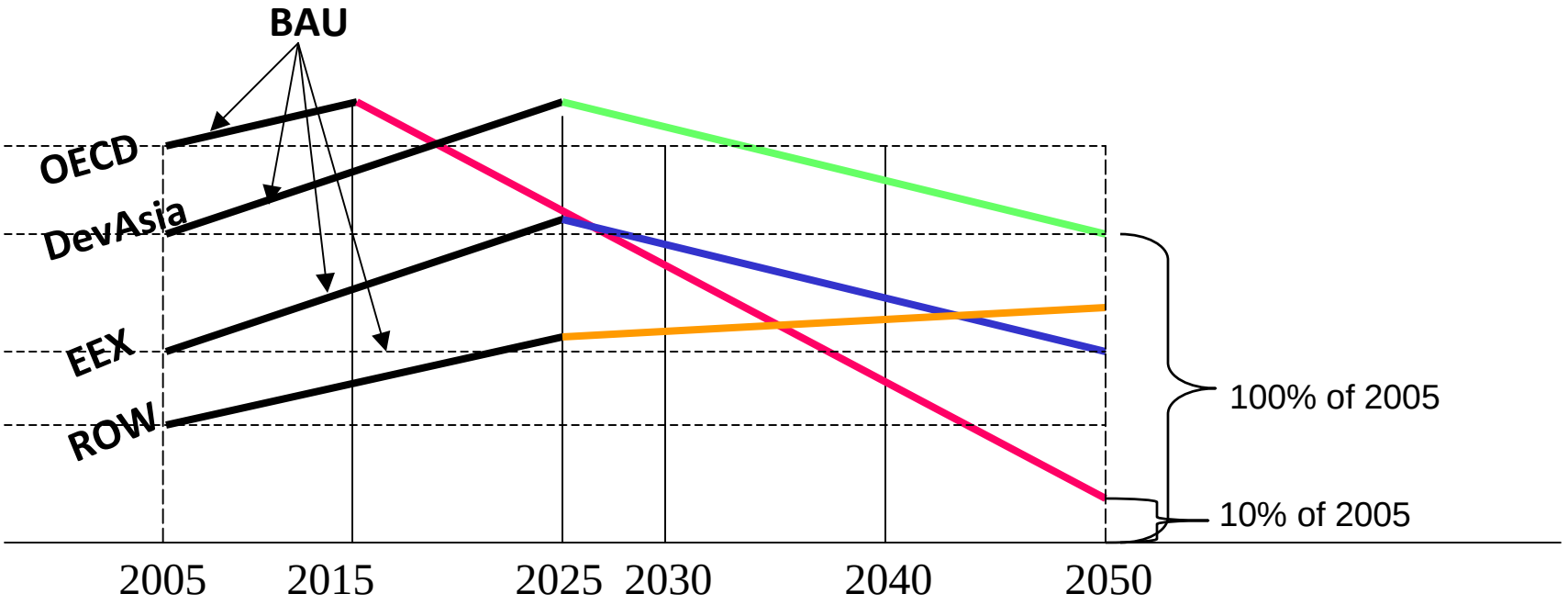
- SC1 and SC2 are very close globally, but regionally different
  - (SC2 is easier than SC1 for EEX and ROW but harder for DevAsia and OECD)
- VARx differs from SCx only due to less emissions trading. Hence, should have higher global cost
- All commitments allow banking and borrowing (thus are cumulative commitments)

Illustration of commitment SC1



Commitments may use Banking and Borrowing, so that only **Cumulative** Commitments matter

Illustration of commitment SC2



Commitments may use Banking and Borrowing, so that only **Cumulative** Commitments matter

The 2 Targets and the 10 Scenarios

- Remark 1: the 2 alternative commitments imply the same global emissions up to 2050. Moreover, the global cumulative emissions under SC1 or SC2 are the same as for the First Best scenario with 3.5 W/m2 target and no overshoot
- Remark 2: the two SC scenarios with 3.2 target are less demanding than the FB-3p2 scenario, because overshoot is allowed.

Model runs

	REF	FB-3p2	FB-3p5	SC1-3p2	SC1-3p5	SC2-3p2	SC2-3p5	VAR1-3p2	VAR1-3p5	VAR2-3p2	VAR2-3p5
WITCH 2100	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
GEMINI 2050	Y	Y**	Y	INFEAS	Y	INFEAS	Y				
DEMETER 2100	Y	Y	Y	INFEAS	Y	INFEAS	Y				
TIAM 2100	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
TIAMEC 2050	Y	INFEAS	Y	INFEAS	Y	INFEAS	Y				

** This run is infeasible in 2050 only

Comments

1. SC1 and SC2 are very close globally, but regionally different.
2. VARx differs from SCx only due to less emission trading.

Hence, should have higher cost globally, but perhaps not for all regions

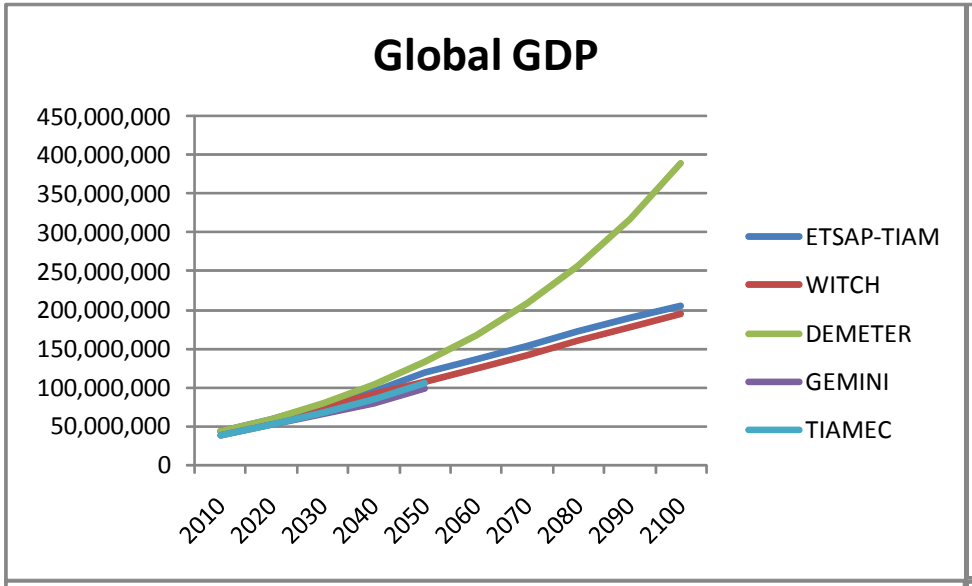
Representation of Emissions and Forcing

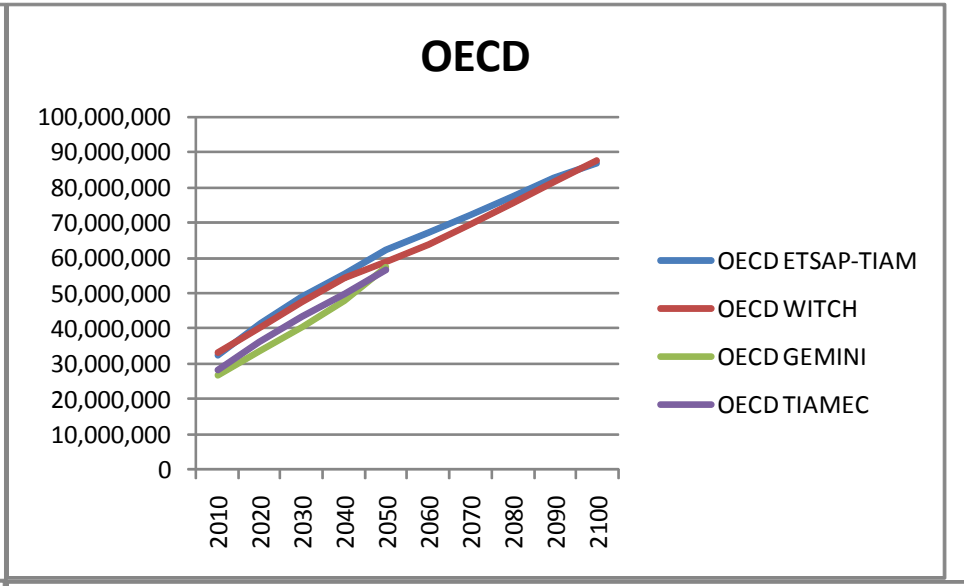
	emissions covered					Forcings	Bounds on:
	CO2 NRG	CO2 LU	CH4	N2O	other LLGHG's		
WITCH	Y	N	Y	Y	Y	LLGHG	LLGHG Forcing
GEMINI	Y	Y	Y	Y	N	N/A	emissions from TIAM
DEMETER	Y	Y	N	N	N	LLGHG	LLGHG Forcing
TIAM	Y	Y	Y	Y	N	LLGHG	LLGHG Forcing
TIAMEC	Y	Y	Y	Y	N	All GHG's	Total Forcing

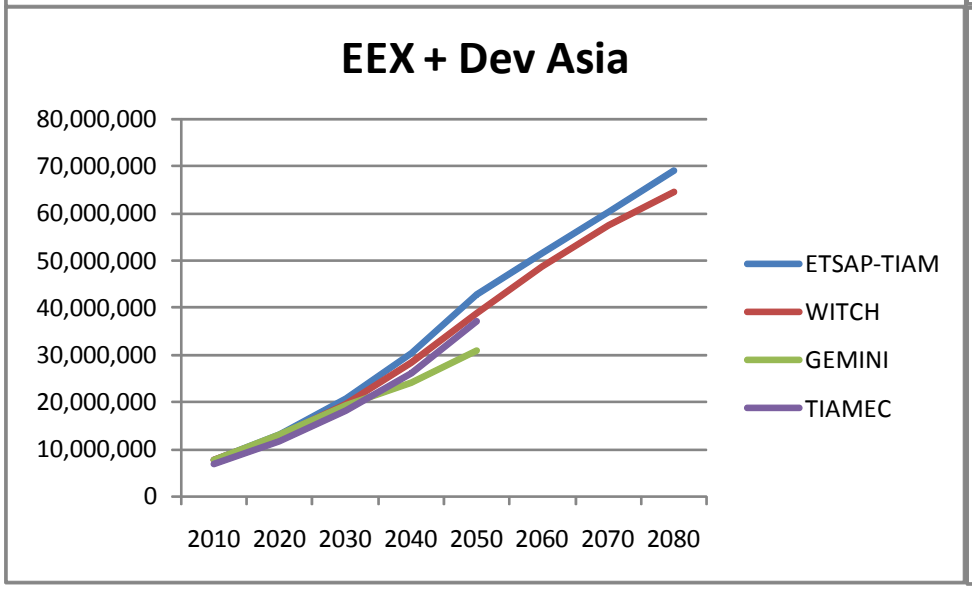
Comments:

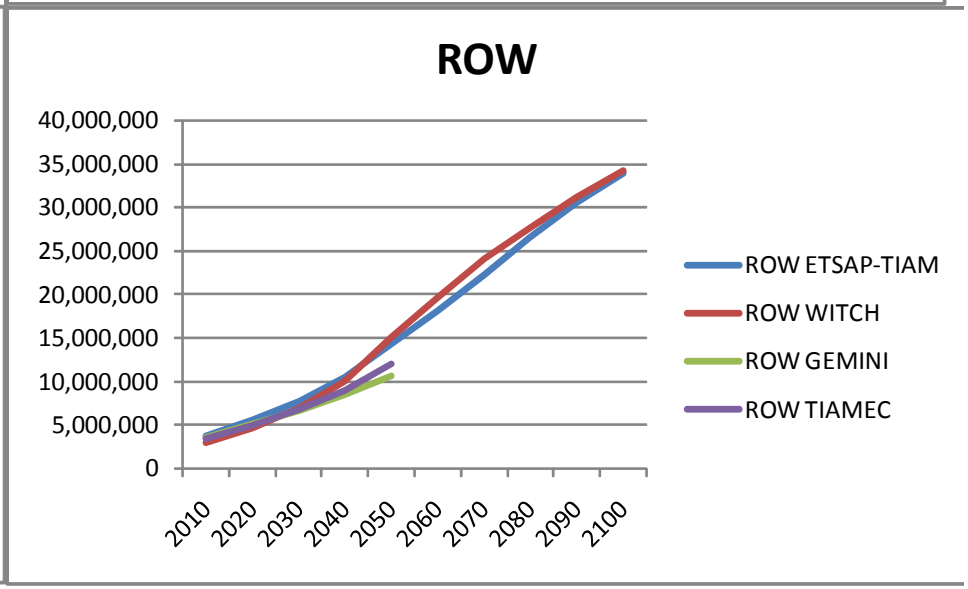
1. TIAMEC has tighter constraints than other models
2. Assumptions on LU emissions differ in models
3. When comparing emission paths, keep in mind different coverages of LLGHG's, and different assumptions on LUCO2 emissions.

Reference GDPs (M$/yr)

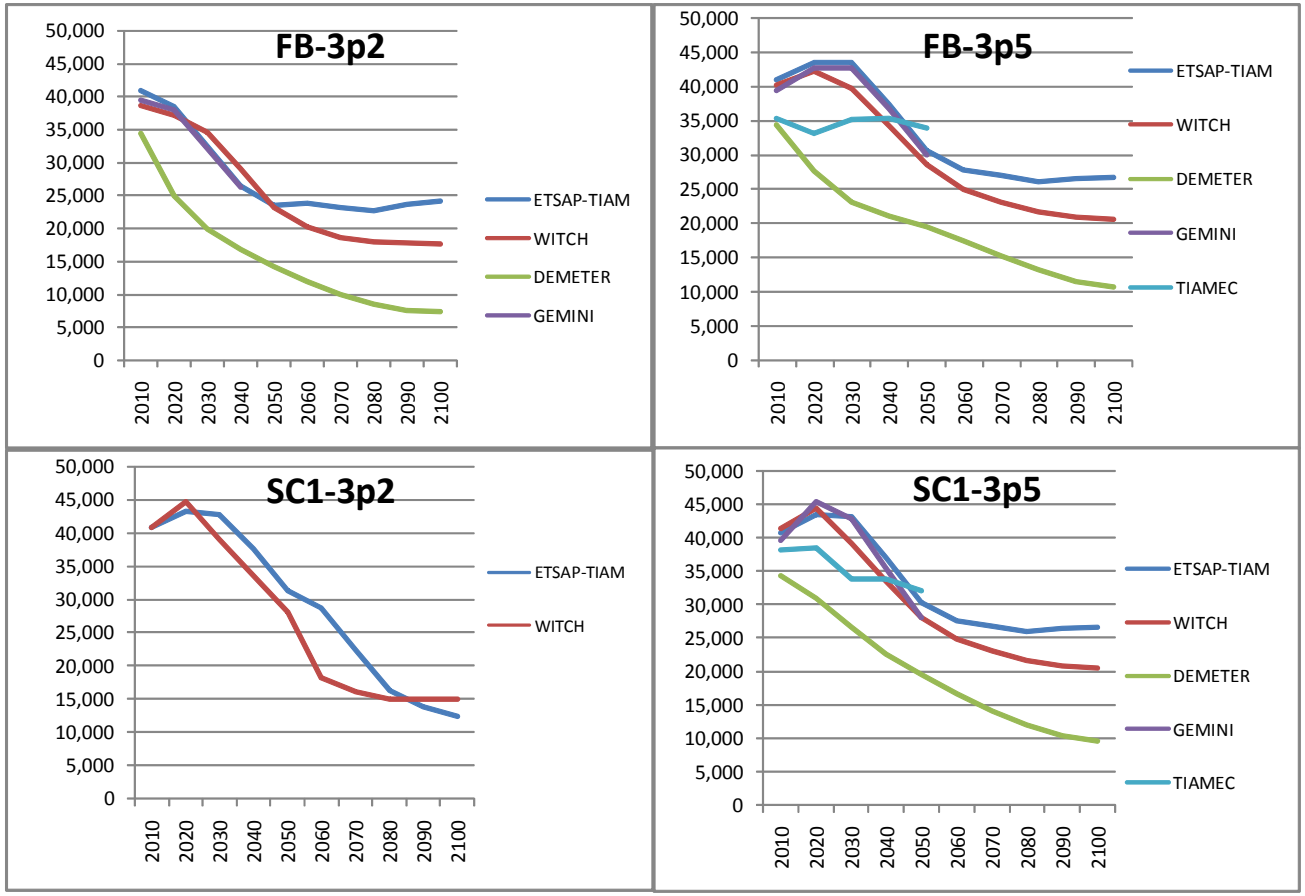








Emissions (Mt CO2-eq /yr)



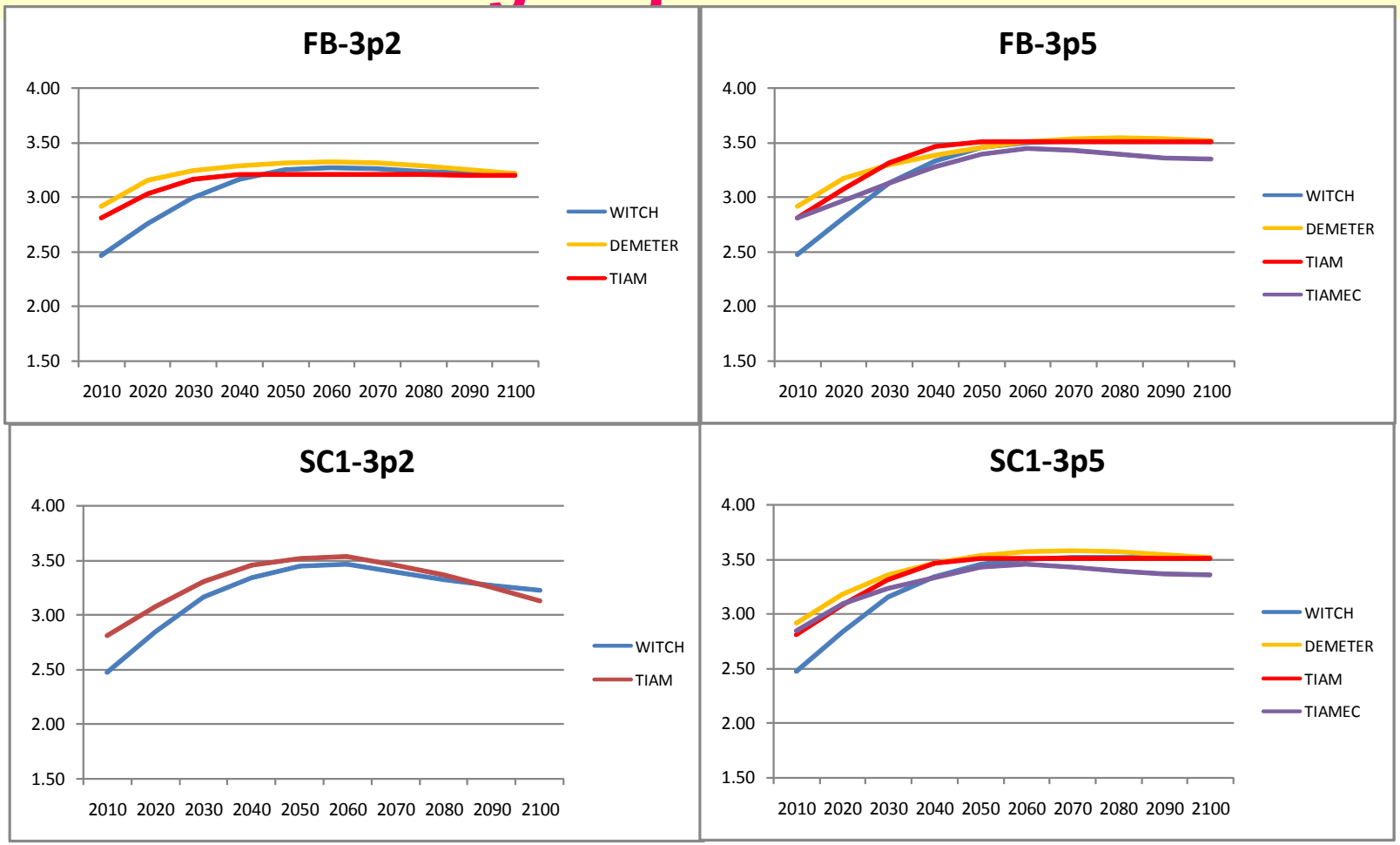
Early WITCH emissions are lower than TIAM's because of missing LUCO2

DEMETER low emiss. because only CO2 is included

TIAMEC low emiss. because of more severe targets

Important: Whenever a model misses some emissions, an additional Forcing term is added to represent the forcing due to missing gases. However, TIAMEC's extra forcing overestimates the missing gases.

Forcing trajectories W/m2

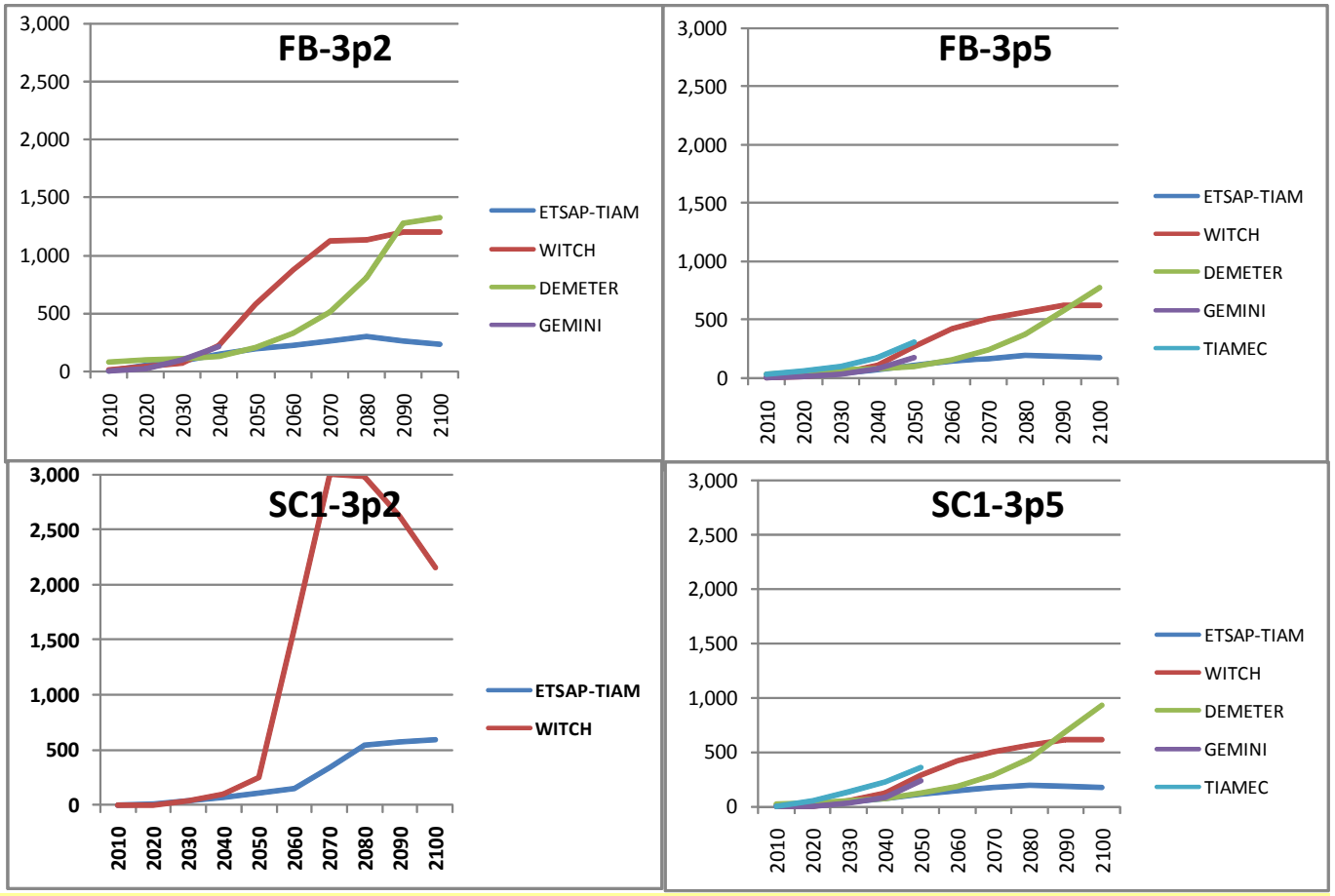


Comments:

- The overshooting of the 3.2 forcing varies according to model, thus explaining further some differences in results.
- Note that TIAMEC's 3.5 target is more stringent than for other models, thus explaining TIAMEC's high costs (and infeasibility of the 3.2 target)

GHG prices ($/t CO2eq)

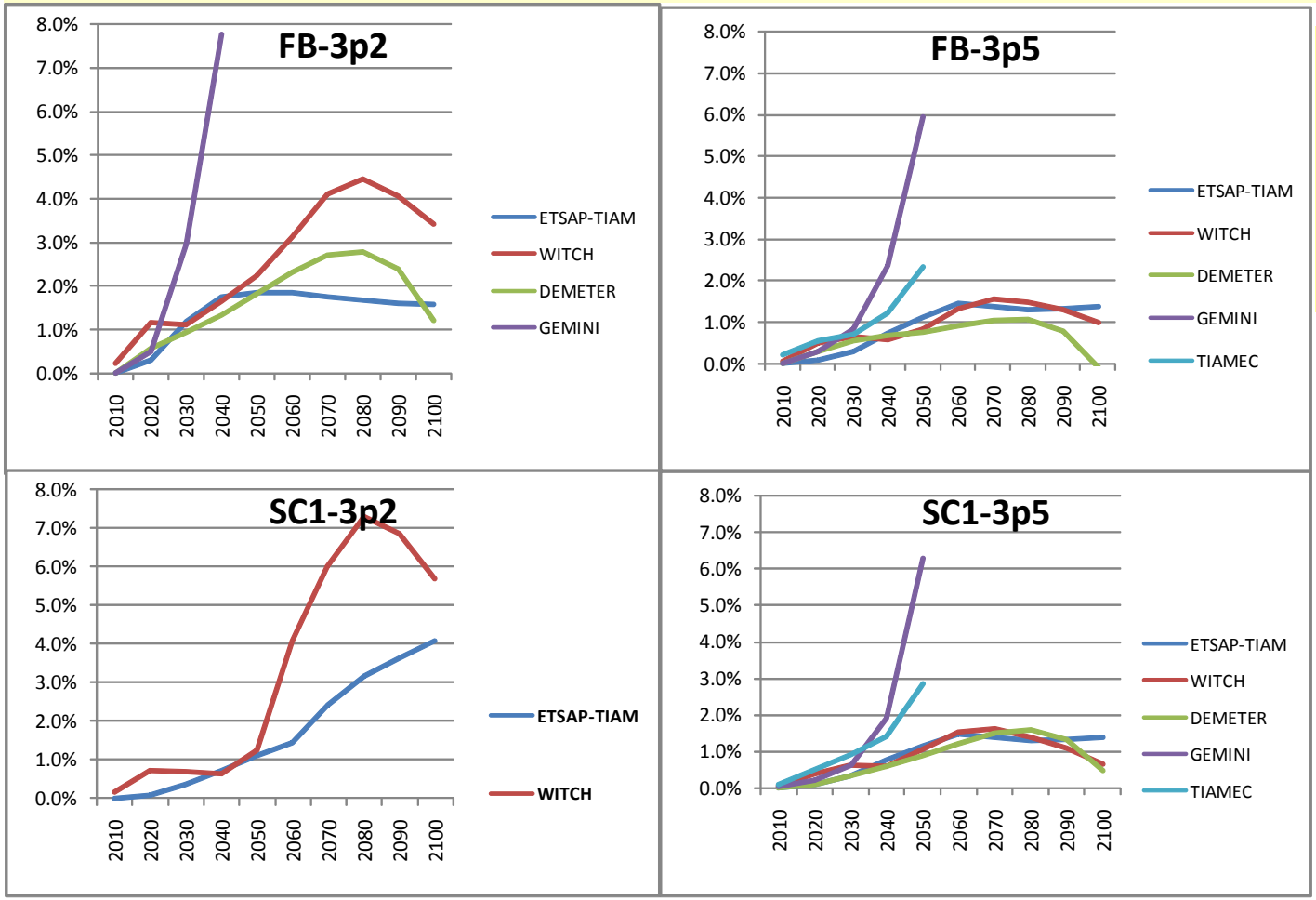
After 2050, WITCH prices are high for SC1-3p2, because they are sensitive to the **pace** of emission reductions: Once some delay is incurred (due to the pre-2050 commitment), it becomes costly to catch-up. Technically, this is caused by the convex cost structure in WITCH).



Comments:

- Good agreement until 2040-2050.
- TIAM's lower prices after 2040 due to large, cheap potential for abatement: Biomass+CCS = negative emissions.
- DEMETER high price due to high GDP growth
- TIAMEC high prices due to more stringent targets.

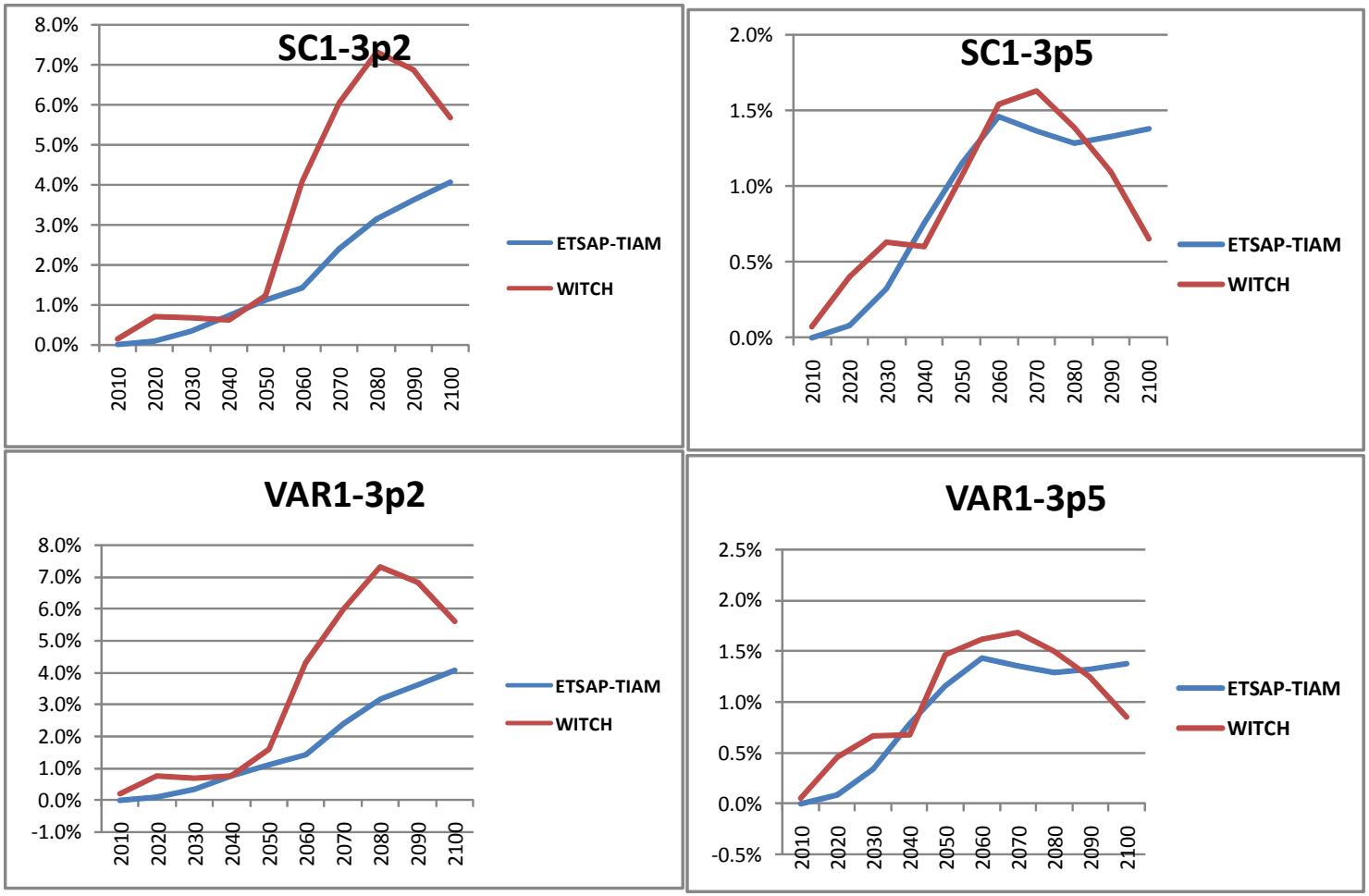
Policy Costs as % of GDP



<u>Caveat</u>: Models have different cost measures (total surplus loss, equivalent consumption loss)

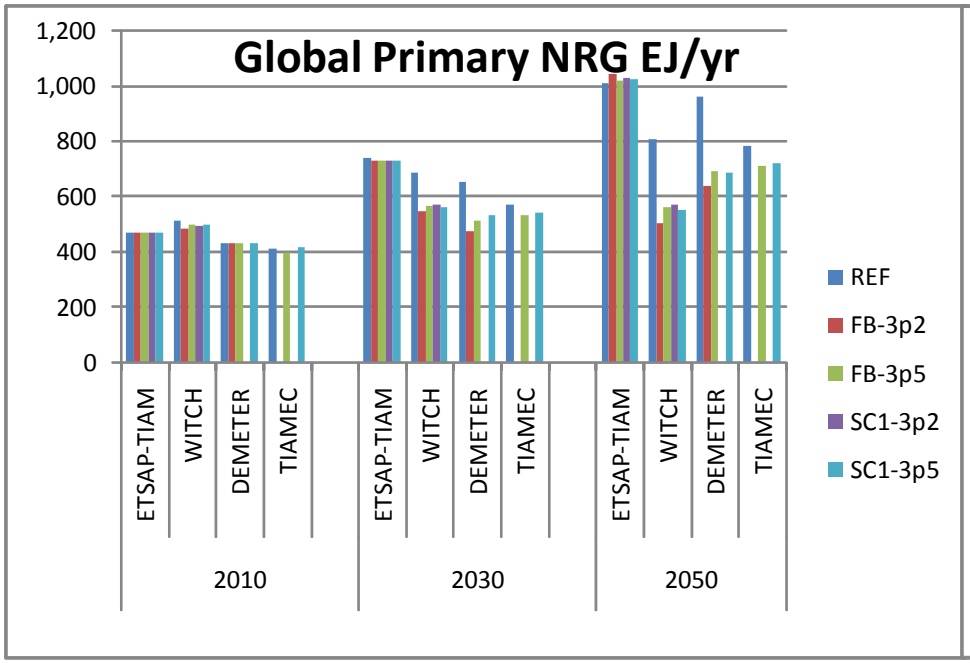
- Costs agree well for the 3p5 target (except GEMINI and TIAMEC),
  - GEMINI's costs are of a different nature from those other models'
  - TIAMEC's larger costs due to more stringent targets
- For the 3p2 target, the results differ: models with large potentials for low (even negative) emissions have smaller costs than models with fewer options

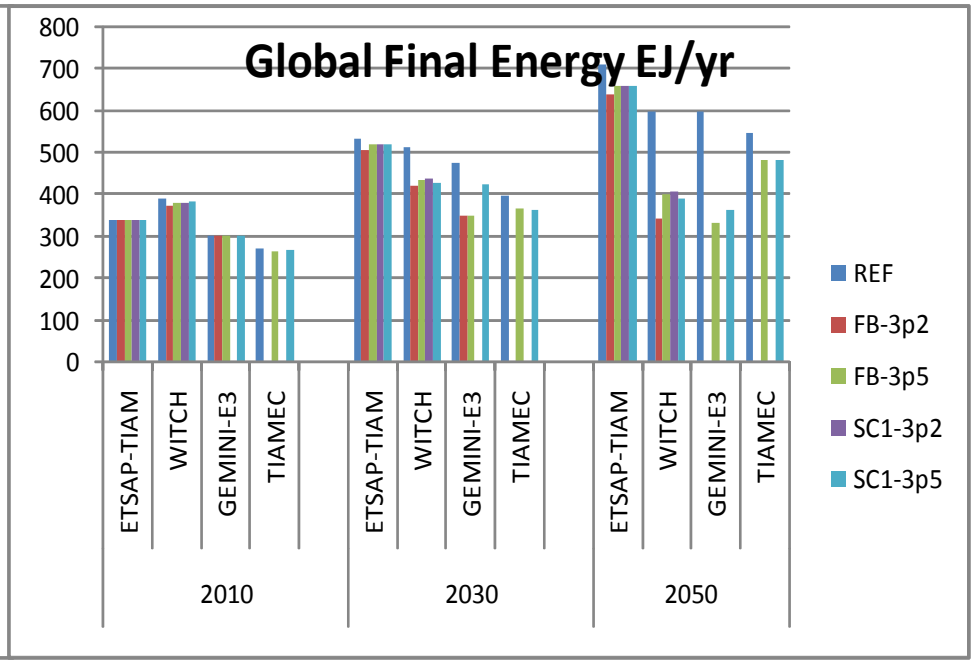
Cost impact of the Variant



Limiting Emission trading to 20% of reductions has a small impact of **Global** Costs (but more pronounced impacts on **regional** costs, though not shown here)

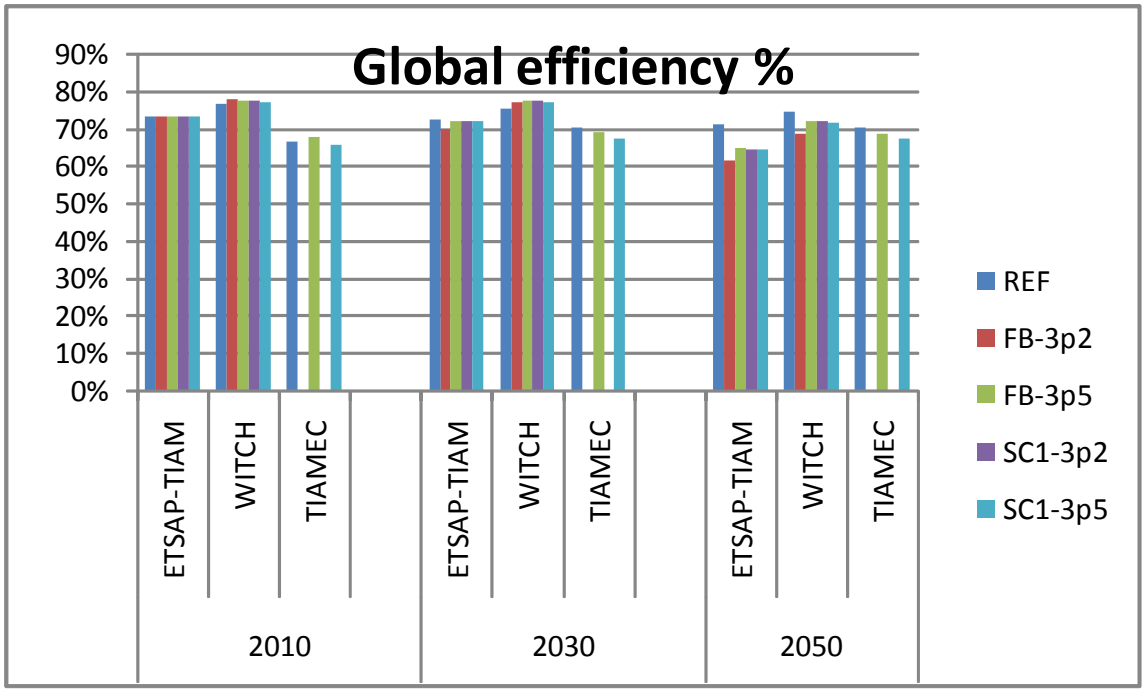
Primary and Final Energy





- TIAM's high energy in 2050 due to assumptions on demands
- Climate policies induce:
  - small decreases or small increases in Primary energy,
  - significant decreases in Final energy.

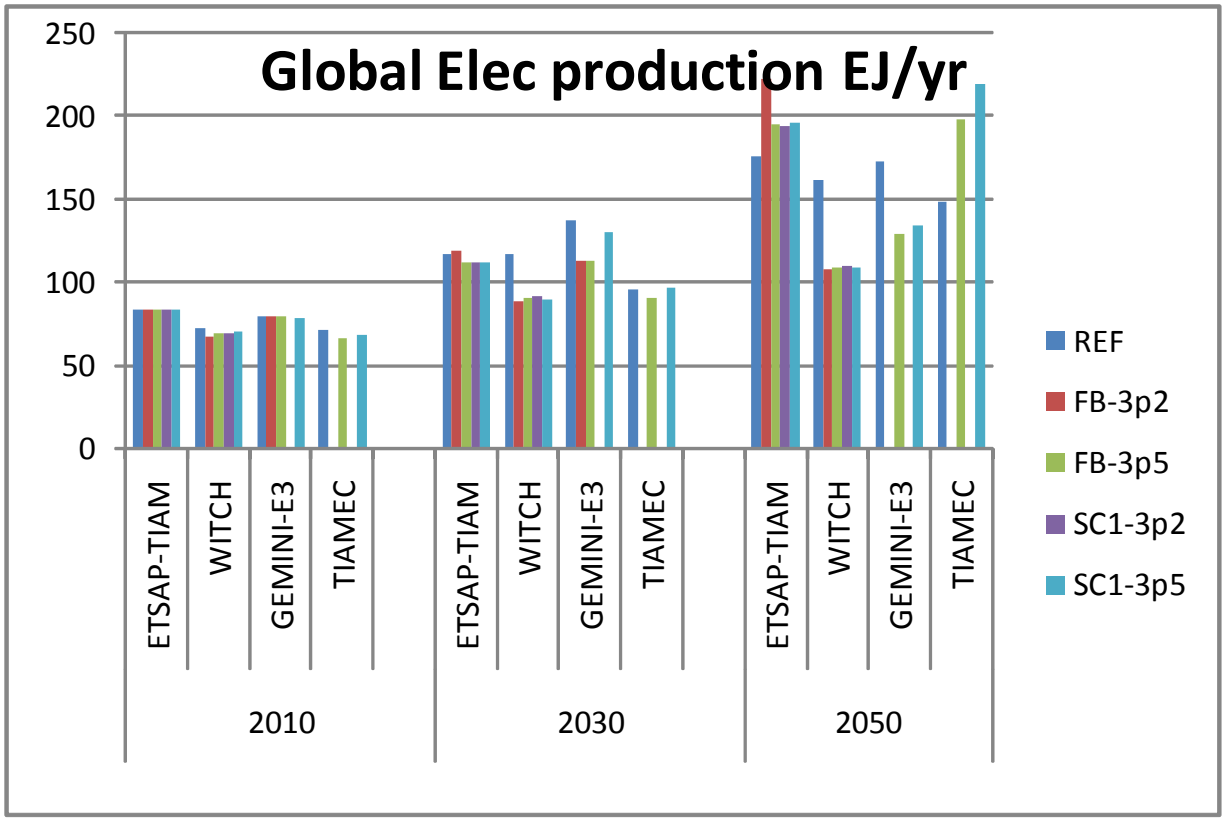
Overall system efficiency



1. **Overall efficiency** (i.e. final/primary) **decreases** a little with Climate policies, why?
   - Biomass and coal plants with CCS are less efficient than gas plants
   - Electricity end-uses increase (and elec production less efficient)
   - Lesson: Climate efficiency distinct from Energy Efficiency

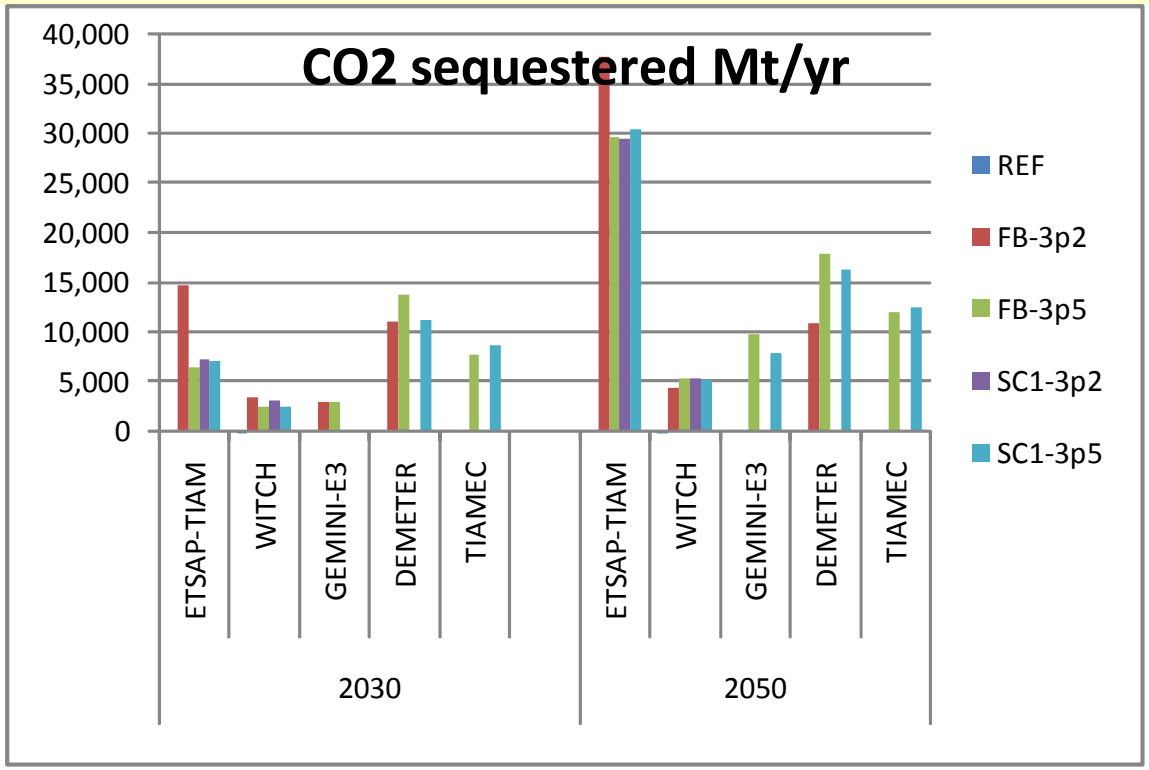
2. However, **end-use efficiency** does increase, as expected (previous slide)

Electricity Generation



- **Models respond differently to climate policies**:
  - CGE's: less electricity
  - TIMES models: More electricity, due to larger potentials for CCS and renewable
  - Producing more electricity (and using less other end-use fuels) represents a strategy to reduce emissions

CO2 sequestered Mt/yr



<u>Differences are due to different assumptions on CCS potentials</u>

- TIAM: high potentials, limited only by Storage potentials (IEA report),
  - also the only model that has the Biomass+CCS technology
- TIAMEC: high CCS potentials but no Biomass+CCS technology
- GEMINI and WITCH have low potentials
- DEMETER: upper limit on **percentage** of coal plants with CCS: this constraint discourages CCS when target is stringent, because it forces some coal plants w/o CCS along with coal plants + CCS

Conclusions so far

- The 3p5 target is reachable at moderate costs
  - Commitments till 2050 do not make a large difference, but this is no surprise, since Commitments were **designed** to be compatible with 3p5 optimal trajectory
- The 3p2 target is much more demanding:
  - With First Best: costs are 2x to 3x larger than 3p5 costs
  - With Commitments: costs are 3x to 5x larger
- Why?
  - With SC-3p2, the World is on a 3.5 path till 2050, but must then "catch-up" in order to reach 3.2 in 2100.
  - This is a **costly but perhaps realistic** scenario: agreements are made till 2050 but must be then revised if and when a severe climate threat materializes.

Conclusions continued

- Remarkable similarity of results from different models, with some significant differences:
  - Bottom-up models with a lot of technological flexibility achieve targets with lower global costs. In particular, Coal+CCS and Biomass+CCS play large roles and help reduce policy costs and GHG prices.
- A few Policy insights:
  - Availability of CCS highly desirable, and would reduce policy costs considerably
  - Rapid global diffusion of key technologies is important, especially in EPG sector (CCS, RNW, Nuclear)
  - The policy of restricted permit trading does not affect significantly the cost of the scenarios
- Add'l insights from detailed models' results (next PPT's)