Recent results with TIAM 500 and 550 ppm targets

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ETSAP workshop, Stanford, June 2007

Objectives

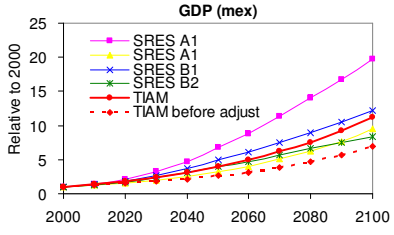
- Present main recent model modifications
- Present new results obtained after modifications and learn from them
  - Deterministic Scenarios only + sensitivity analysis on climate
- Present Ongoing and Future Projects involving TIAM
- Propose Future work on TIAM

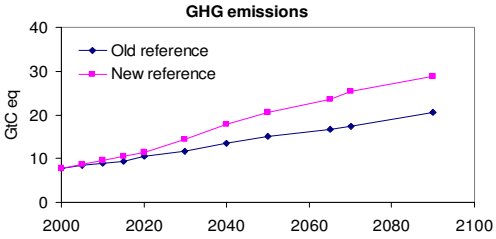
I. Recent modifications and modeled scenarios

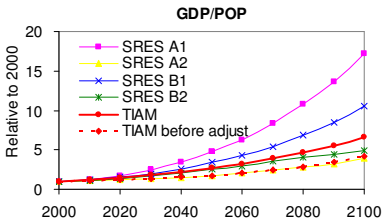
NEW GDP and OIL&GAS PRICES

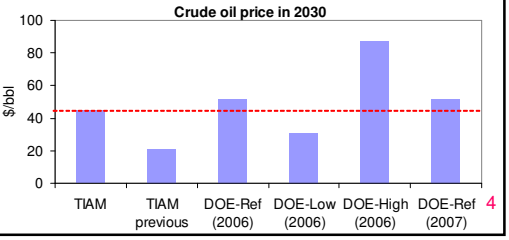
To be closer to international projections

- Higher GDP projections
- Higher oil&gas prices









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RECENT CORRECTIONS

- Observed early periods jump in primary energy, and missing emissions in 2000
  - TPES observed in 2005 was smaller than TPES in 2000, and smaller than IEA statistics
  - Several corrections : relax 2000 activity, technology corrections
  - Industry consumption seems to be too small (to explore)
- Bugs
  - Underestimation of emissions in industry due to CO2 free consumption of gas
  - Missing emissions related to feedstocks in chemical sector
  - Free production of natural gas and without emission by Canada
- Other corrections
  - Cost for Sequestration in aquifers
  - Costs of CH4 mitigation options
  - Peak electricity
  - Removed associated gas from oil sands - mined and in-situ
  - Improved LNG trade

POLICY SCENARIOS

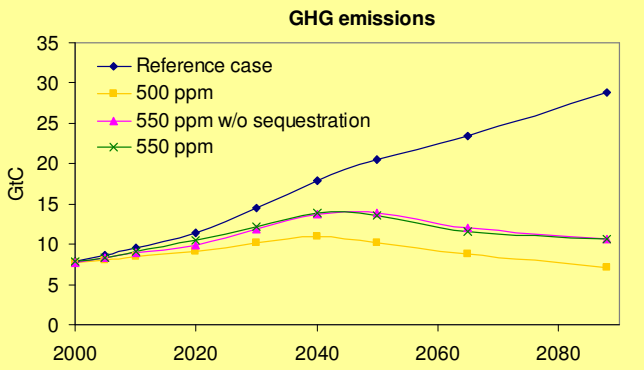
- 9 milestoneyears: 2000 to 2088 (cover 1998-2100 horizon)
- Base Case:
  - **Moderate to high GDP growth (X 12 over horizon)**
  - **GHG emissions: X 4 in 2100 (28 GtC)**
  - **Moderate to large Wind, Nuclear potentials**
  - **Large Solar electricity potential (but high cost)**
- Policy Scenarios:

	Normal	No Sequestration	Reduced nuclear in IC
500 ppm	YES	infeasible	YES
550 ppm	YES	YES	NO

• SENSITIVITY ANALYSES ON Cs, Nuclear, and Elasticities

Climate results

GHG EMISSIONS



Comment: emissions peak around 2040-2050, but never drop much below 1990 level during 21st century (Contrast with '50% IN 2050' proposal)

8

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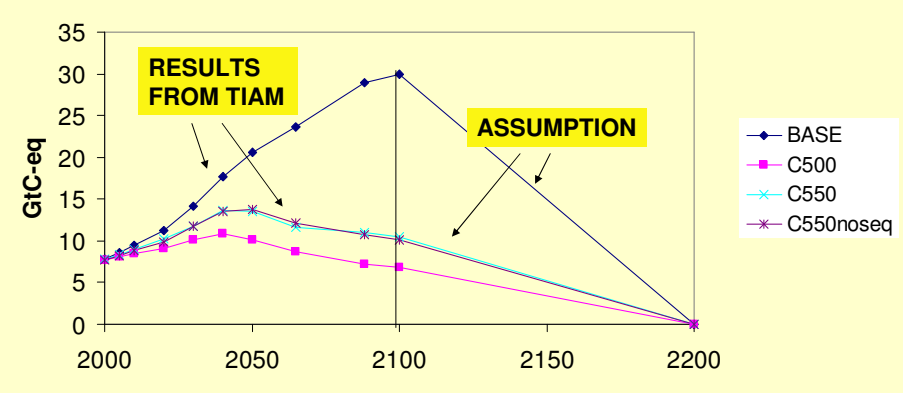
EMISSIONS OVER LONG TERM?



ASSUMPTION 1: Decline over 2100-2200 period
OR
ASSUMPTION 2: Decline over 2100-2300 period

9

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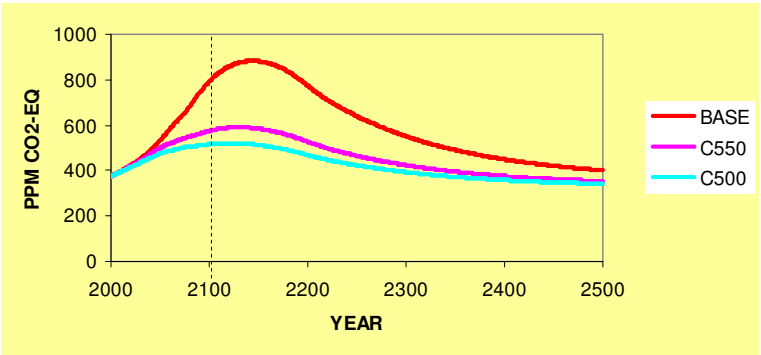
GHG CONCENTRATION OVER LONG TERM



Note: C550-NoSeq is identical to C550

10

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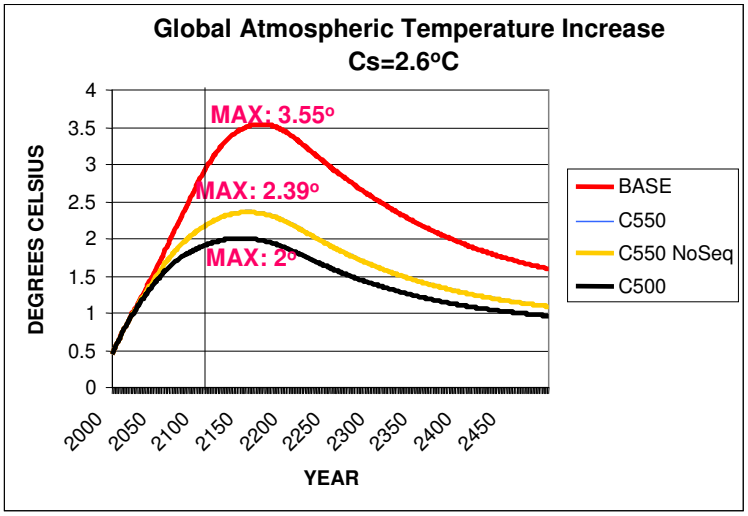
TEMPERATURE CHANGE Cs=2.6°C

Assumption 1: Post 2100 Emissions decrease to 0 by 2200



11

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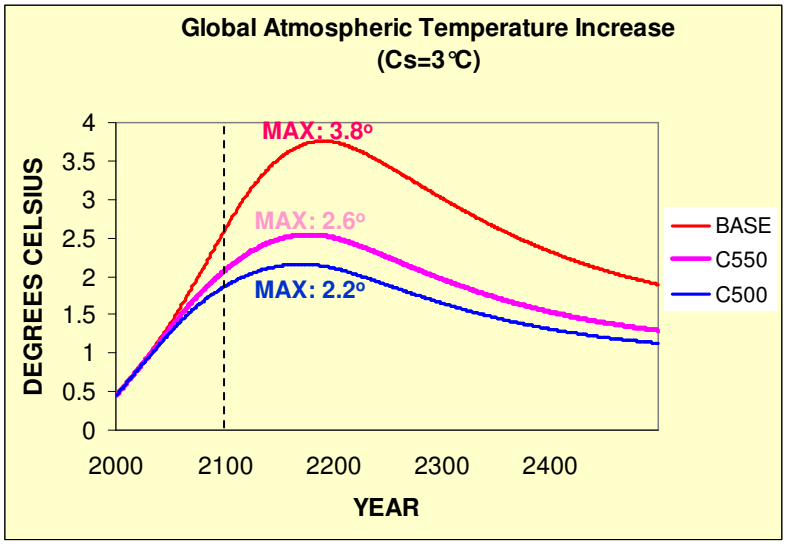
TEMPERATURE CHANGE Cs=3°C

Assumption 1: Post 2100 Emissions decrease to 0 by 2200



12

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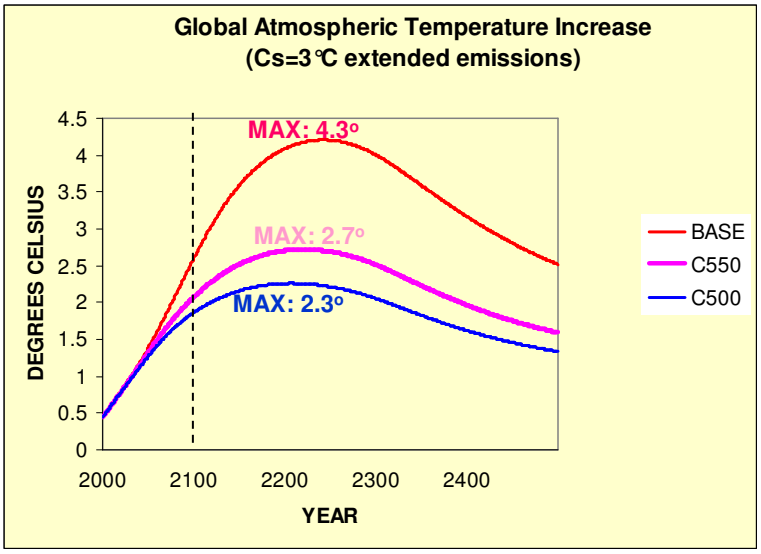
TEMPERATURE CHANGE Cs=3°C

Assumption 2: Post 2100 Emissions Decrease to 0 by 2300



13

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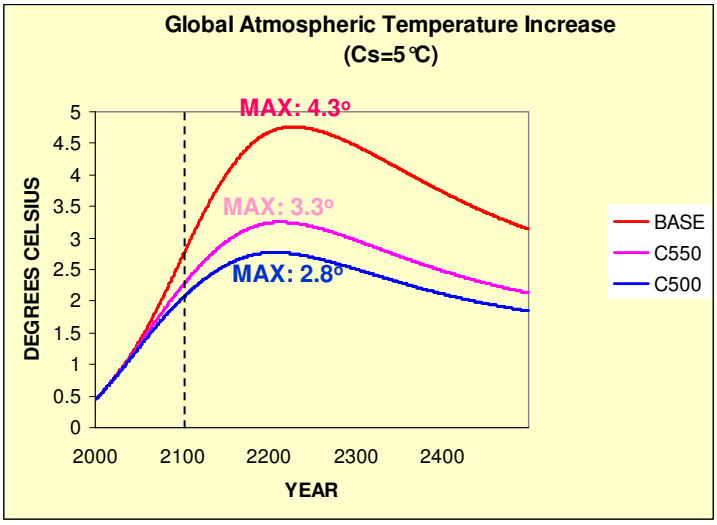
TEMPERATURE CHANGE Cs=5°C

Assumption 1: Post 2100 Emissions Decrease to 0 by 2200



14

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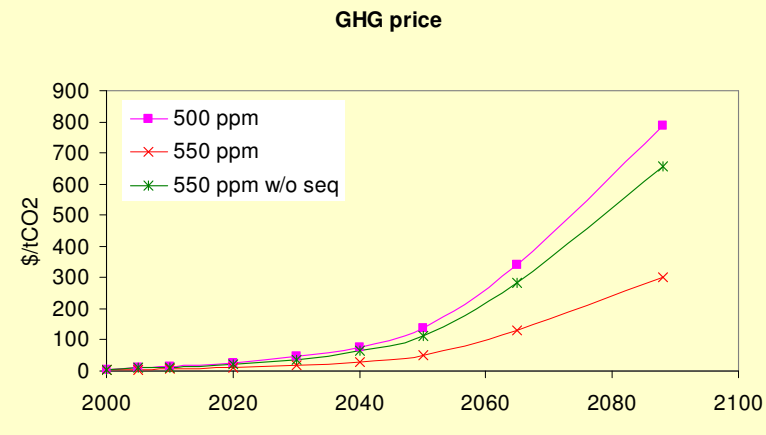
GHG SHADOW PRICE



- Sequestration plays a big role
- C500 is most expensive even with CCS

15

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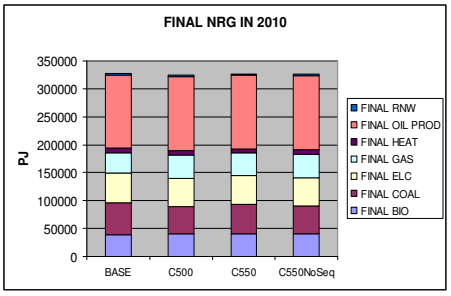
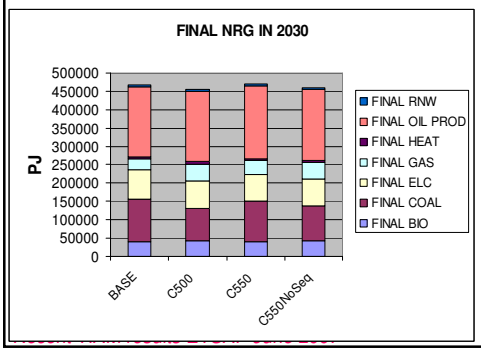
Energy results

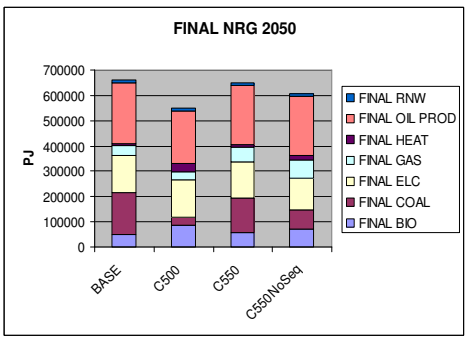
FINAL ENERGY: SUMMARY



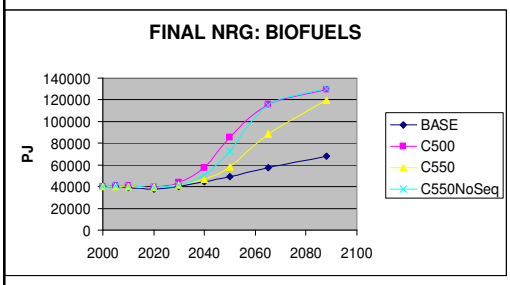
RESULTS for 2050 : C500
- **Less final energy (demand reduction)**
- **Less Coal, Oil, and even Gas**
- **More Electricity, Heat, Biomass**

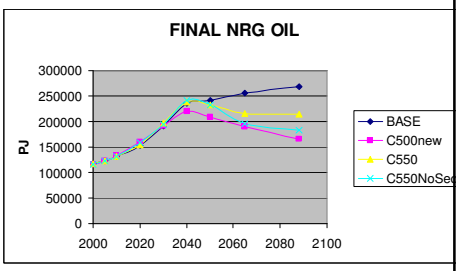
RESULTS for 2050: C550 NoSeq
- **Less Final energy**
- **Less Coal, Elec**
- **More Gas, Heat, Biomass**

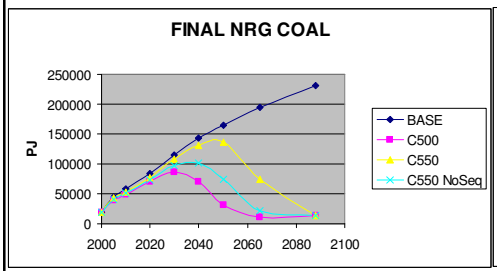


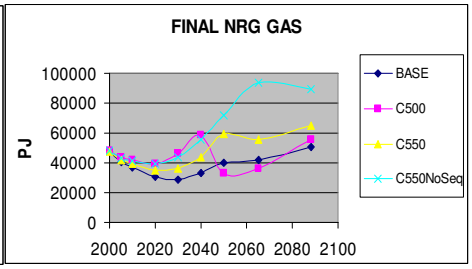


FINAL ENERGY: DETAILS









18

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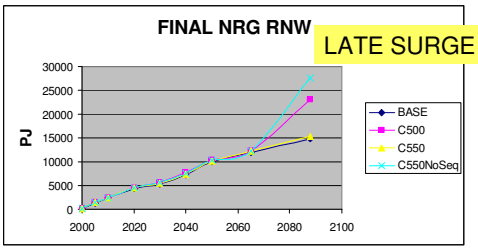
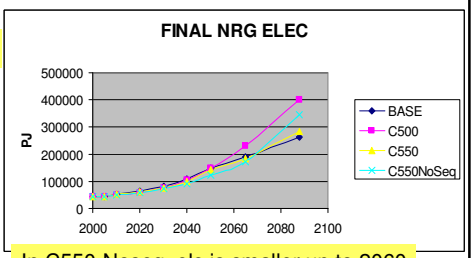
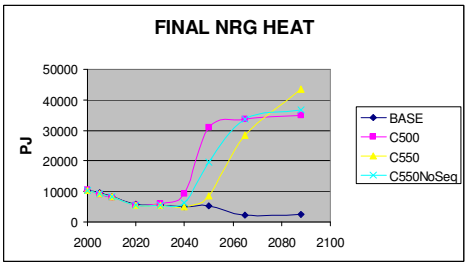
FINAL ENERGY



LATE SURGE



In C550-Noseq, elc is smaller up to 2060
Then larger, due to RNW use



Note : Hydrogen appears timidly and very late in C500 scenario

19

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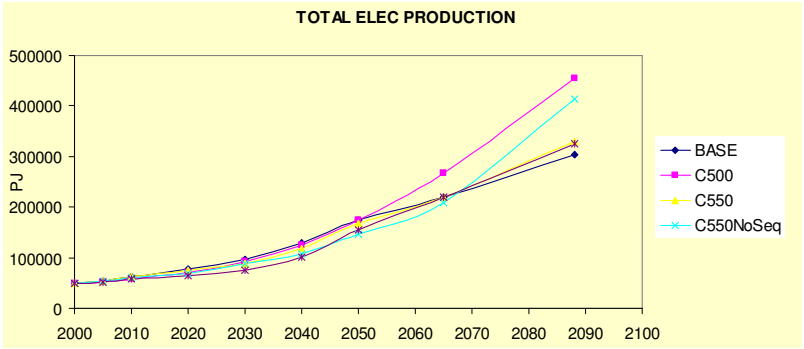
ELECTRICITY PRODUCTION



ELECTRICITY LARGER FOR 500 ppm CLIMATE CONSTRAINT

20

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ELECTRICITY: SUMMARY

BASE	• COAL, NUCLEAR, GAS dominate
C550	• CCS, HYDRO strong • COAL, GAS low
C550 NoSeq	• RNW (late), HYDRO, BIOMASS strong • Some GAS • Coal low
C500	• CCS, RNW (late), HYDRO, BIOMASS strong • COAL, GAS low

21

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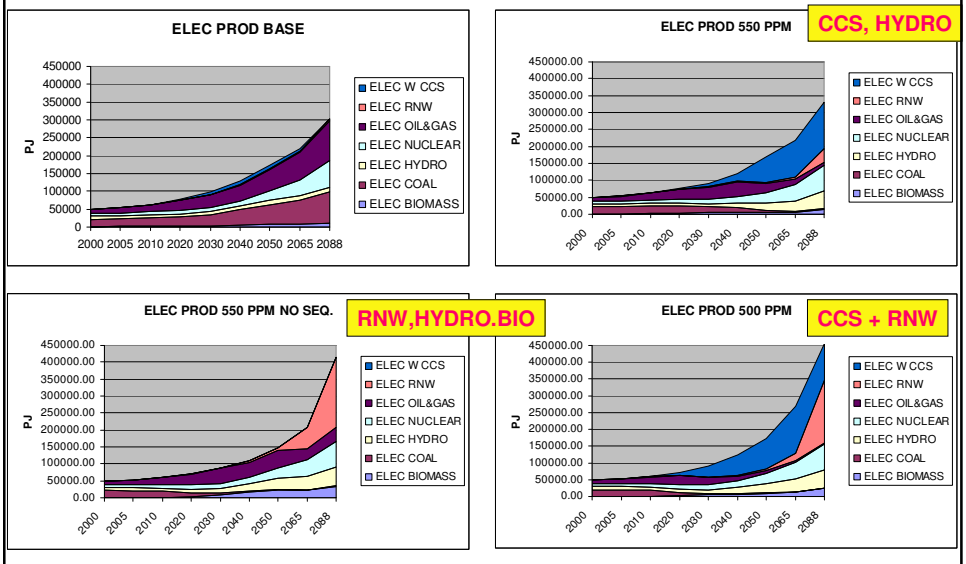
ELECTRICITY MIX



22

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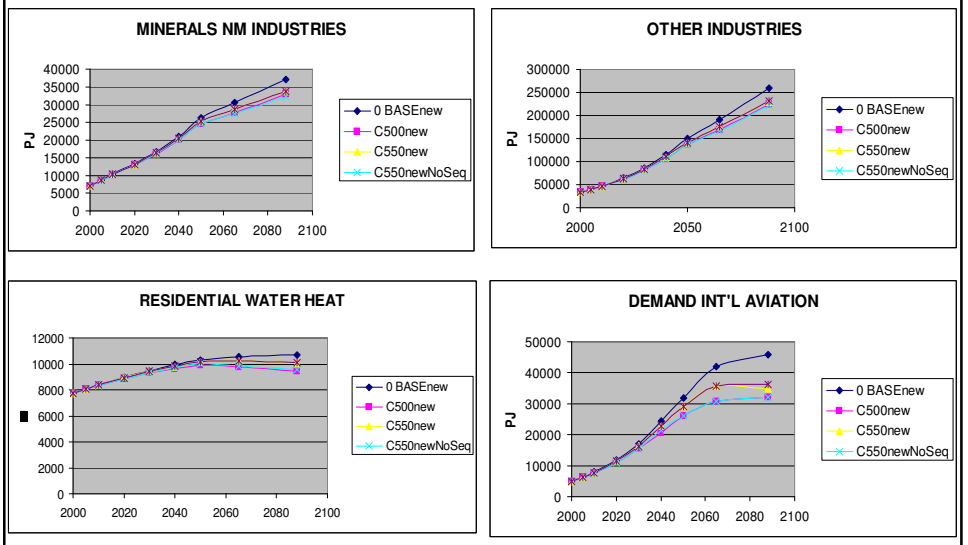
DEMAND REDUCTIONS



Significant reductions appear after 2040

23

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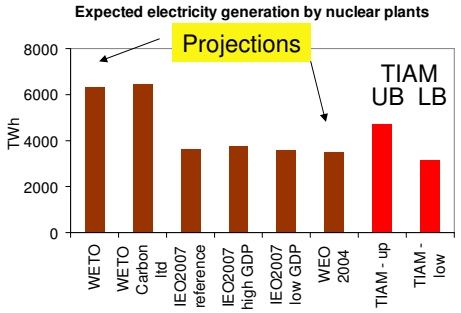
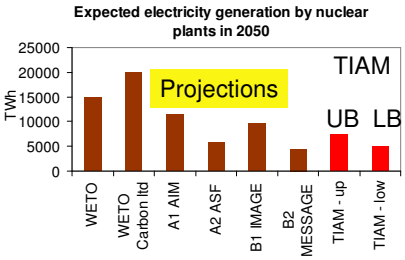
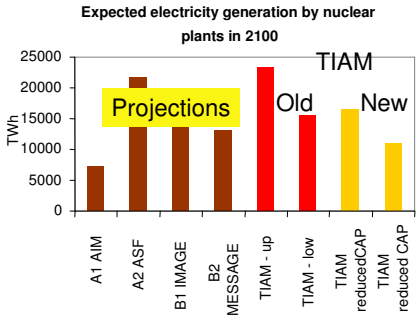
Two Sensitivities
- Nuclear Capacity Bounds
- Price Elasticities of demands

Sensitivity to Nuclear generation





Nuclear Cap Upper and Lower Bounds were reduced starting in 2050. Reduction reaches

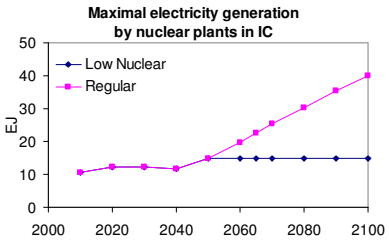


Recent TIAM results ETSAP June 2007

Reduced nuclear generation in industrialized countries

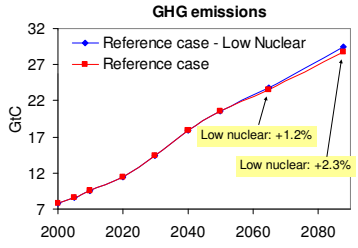
Assumption

Maximal installed capacity in industrialized countries after 2050 is fixed at 2050 level (equiv. to a 25% reduction in 2060, 68% in 2100) ????????????



Reference case impacts

- Relatively small impact on total GHG
- Nuclear plants are replaced mainly by coal and gas plants

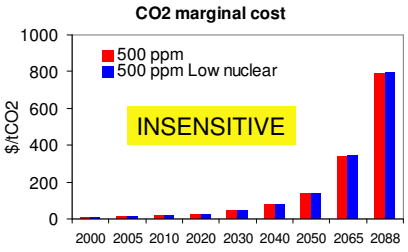


Recent TIAM results ETSAP June 2007

Reduced nuclear generation in industrialized countries

Impacts on 500ppm case

- Nuclear plants are replaced mainly by renewable and, to a lesser exte by fossil plants with CCS
- No change before 2050
- Negligible impact on emission price and on total system cost



- Emission reductions (relative to Base):
  - IC's reduce more due to lack of nuclear capacity
  - DC's also reduce more : evidence of emission leakage from IC's to DC's

27

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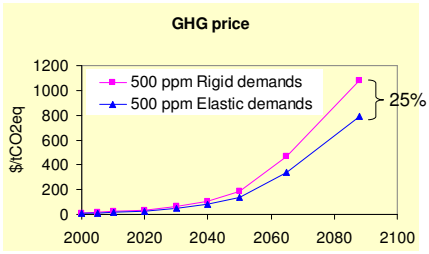
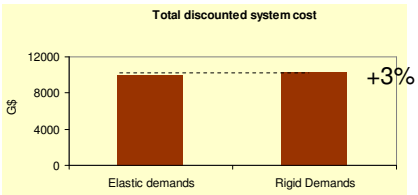
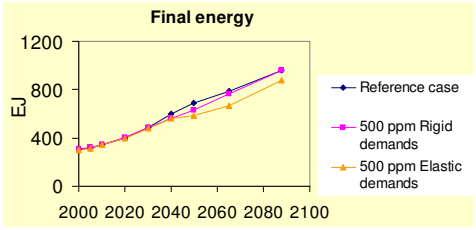
Sensitivity to price elasticities of demands







28

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CONCLUSION

- Model responds generally well to climate targets and sensitivity analyses
- Some exceptions:
  - End-use efficiency improvements are sluggish even in severe policy cases
  - Nuclear relatively insensitive
- These runs (and otehrs) are very useful to suggests where the model should be improved

II. Current and Future Projects involving TIAM

- EMF-22:
  - WG on Hedging reconvenes in Fall 2007
  - WG on Transition Policies was somewhat delayed: reconvenes in September, work to extend to 2008
  - General EMF-22 meeting planned in 2008

- TOCSIN (technology oriented policies to involve large DC's – China and India, in Climate Change mitigation). The project also provides excellent testing ground for several model features:
  - Oil pricing capability
  - Linkage with CGE's
  - Revised data for China and India

Publications and Presentations

- ***Hedging Policies under Climate Uncertainty (EMF-22 WG).*** A paper was written and submitted to *Climate Policy*.
- ***Analysis of the role of nuclear energy in long-term climate scenarios.*** A paper was submitted to *Energy Policy*
- ***Recent exploratory analyses***
  - New runs with Concentration targets (this workshop)
  - ***Capital rationing:*** Impact on adoption of GHG friendly technologies in Developing Countries. Preliminary analysis presented at the 9th IAEE-EU-2007 Conference, and at IEW-2007, June 2007. Complete analysis requires linkage with CGE model to be done within the TOCSIN project. Effort: large, but covered by external funding.

- New FP7 proposals involving TIAM
  - PLANETS
  - REACCESS
  - METEORITE
- Potential Applications: New country models to disagregate TIAM:
  - South Africa: In progress
  - Brazil ?
  - Russia ?

III. Proposed Improvements

High Priority changes

TASKS	IMPORTANCE	EFFORT	Uncertainty
Recalibration to 2004-2005	High	Medium	Medium
Review / Revise Power plants Correct installed capacities, insure smooth transition after calibration period, check costs and eff of CCS (Uwe), Steam plants efficiencies (Uwe)	High	Medium	None
Investigate exo-endo-genous energy efficiency improvements observed in results. This task will extend over a longer time Introduce more e.e.i. options if needed	High	Large	Medium
Remove all UC's from Templates Remove useless info from scenario files	Medium	Small	None
Put emission coeff. on input fuels	Medium	?	None
Include Biomass Power Plants with CCS	Medium	small	None
Modify Oil Sands Extraction processes Distinguish Mining and In Situ, and introduce fuel	Medium	small	None

Other Tasks

TASK	IMPORTANCE	EFFORT	UNCERTAINTY
Review all end-use sectors with focus on improving the representation of e.e.i.	High	Large	Medium
Make fuel technologies more flexible	Medium	Medium	None
Non CO2 emissions: Review post-2020 projections include the non-CO2 emissions not yet included (eg. N2O from agriculture, F-gases). Adjust the exogenous forcing accordingly.	Medium	Small to medium	None
Uranium supply curves and trade	Medium	Medium	Small
Biomass, biofuels and fossil fuels	Medium	Small	Small
Introduce new fuel pathways (Uwe's proposal) DONE (Uwe)	Medium		
Market Share algorithm in all end-use sectors	Large	Large	Small
~~Growth Constraints for selected techs~~	~~Medium~~	~~Large~~	~~Small~~