Benchmarking of country MARKAL/TIMES models. Preliminary results from MARKAL-Italy

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ENEA

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OVERVIEW

- The Markal-Italy model
- Scenarios
  - *General assumptions*
  - *(Preliminary) results of sensitivity analysis*
- Benchmarking the model: assessment of the "rigidity" of the model
  - *Baseline*
  - *CO2tax vs. Reference*
- Towards TechPlus Plus: if, how, costs
- Some conclusions

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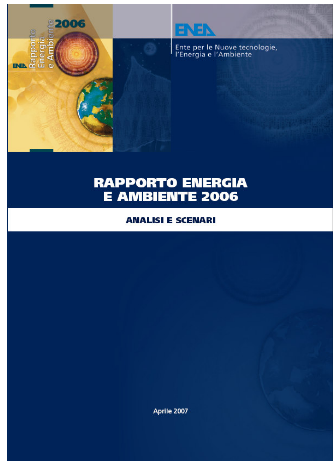
MARKAL-ITALY: MODEL CHARACTERISTICS

- *MARKAL-Italy developed since '90s*
- *Time horizon: 2004 – 2048*
- *Quantities and prices:*
  - *300 flows of energy / materials*
  - *One thousand technologies*
- *Industrial energy service demand is divided into the sub-sectors included in the National Energy Balance, with a detailed representation of the main energy-intensive materials*
- *Transport is divided between freight and passengers and the latter are divided between urban and intercity travel*
- *About one thousands technologies (about 50 in the electricity production sector)*
- *Detailed representation of refinery process, with "production" of secondary fuels from oil, and simplified simulation of import of natural gas, with pipeline/ships*

Agricolture (1)	*Value added*
Industry (43) - Pulp and paper (4) - Chemicals and petrochemical (3) - Iron and steel (5) - Building (7) - Non metallic minerals (7) - Non ferrous metals (5) - Mechanical - Texiles (3) - Food and drink - Other	*- Mton (material production of energy intensive sub-sectors)* *- Indexes (other sub-sectors)*
Tertiary (3)	*Indexes*
Residential (11) - Thermal uses (3) - Electric uses (8)	*- Number of devices* *- Mq* *- Mtoe useful*
Transport (9) - Passengers (4) - Freight (3) Off roads - Marine bunkers	*- Pass-km* *- Ton-km*

MARKAL-ITALY: MAIN CURRENT ACTIVITIES

- Support to the Italian government (both ministries of industry and environment): next negotiations for EU burden sharing
- 2nd/3rd/4th National Communication to UNFCCC
- National Conference on Energy and Environment 2008
- Annual ENEA Report on Energy and the Environment (plus contribution to several other ENEA publications)
- (IEA ETP 2008)



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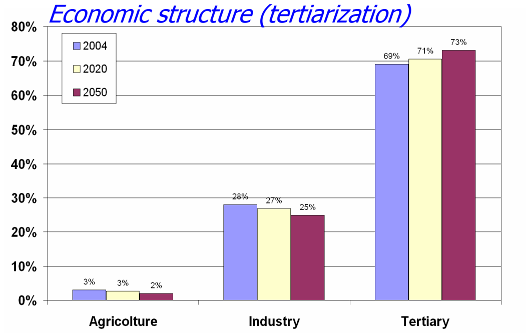
SCENARIOS: GENERAL ASSUMPTIONS

Economic growth

	1970-1980	*1980-1990*	*1990-2000*	*2000-2004*	*2004-2048*
Agricolture, value added	0,8%	-0,8%	1.9%	0.1%	0.6%
Industry, value added	3,1%	1,5%	1.1%	0.2%	1.3%
Tertiary, value added	4,0%	2,9%	1.8%	1.5%	1.7%
GDP	3,6%	2,3%	1.6%	0.9%	1,6%

Economic structure (tertiarization)



Service demand elasticities (demateraliz./saturation)

Industry	0.8/0.4
Tertiary	0.9/0.5
Residential	-
Transportation	<1

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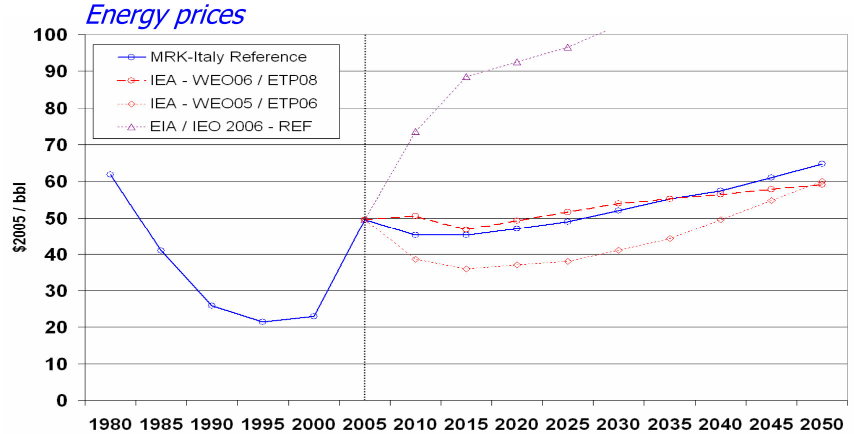
SCENARIOS: GENERAL ASSUMPTIONS

Energy prices



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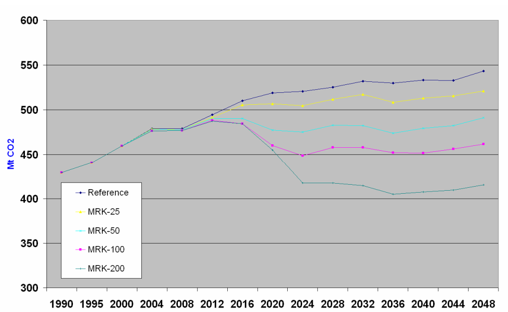
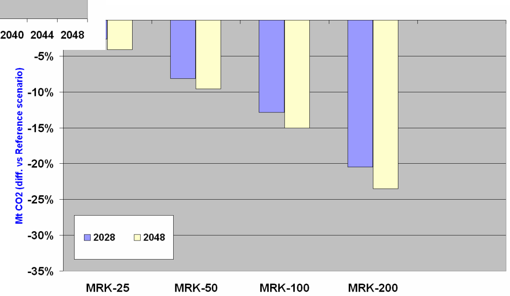
SCENARIOS

- Markal
  - CO2 tax = 10 (Reference), 25, 50, 100, 200 $/t
- Markal-ED
  - CO2 tax = 200 $/t
  - to explorate the possibility for cost reduction:
    - some tentative runs with “smooth” CO2 tax up to 200$/t
    - some tentative runs with cap on CO2 emissions, up to 50% vs. 2000

SCENARIOS: CO2 EMISSIONS

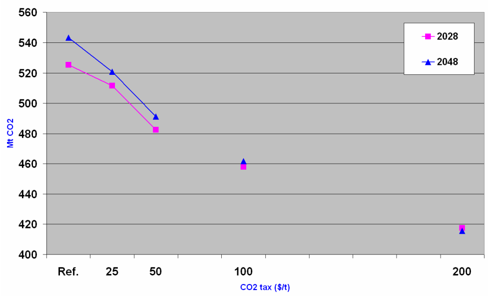


- At 200$/t reduction of about 130 Mt with respect to Reference
- Most of reduction in next 20 years
- After 2030/2035 CO2 increases again
- First signal, problems in the long run (up to now model used for 2000-2030)

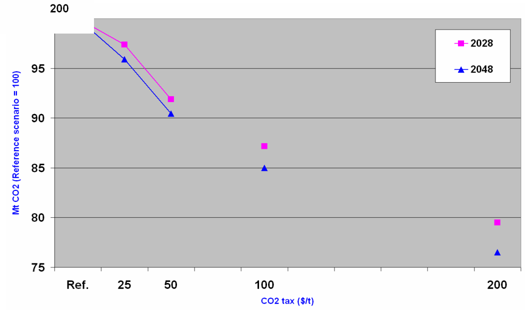


- At 200$/t about 25% reduction with respect to Reference
  - Only -10% with respect to 2000

SCENARIOS: COST CURVES



- After 100 $/t CO2 reductions are quite moderate
- Similar cost curves in 2030 and 2050
- Some very preliminary further runs shows costs up to 1000 $/t for much stronger reductions



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  - *General assumptions*
  - *(Preliminary) results of sensitivity analysis*
- **Benchmarking the model: assessment of the "rigidity" of the model**
  - ***Reference scenario***
  - ***CO2tax vs. Reference***
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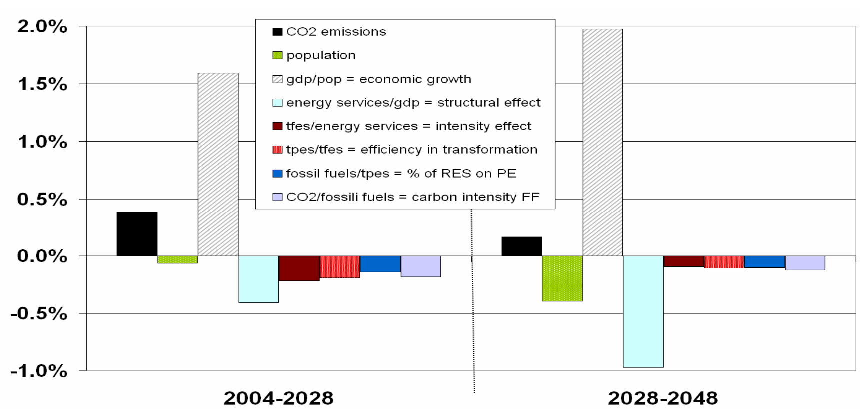
BENCHMARKING THE MODEL: METHODOLOGY

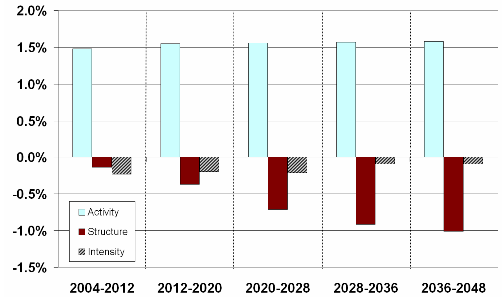
- Similarities
  - Most of the assumptions already similar
  - "Fine tuning" of assumptions
- Differences / problems:
  - Technology perspectives: improvement / penetration in the energy system.
  - Not explicit model boundaries: how much "freedom" for the model, and how "to measure" freedom: isolating efficiency from other factors
    - → Decomposition approach:
      - → "extended" Kaya identity
      - → energy intensity splitted in structure and intensity effect

BENCHMARKING THE MODEL: REFERENCE SCENARIO (1)

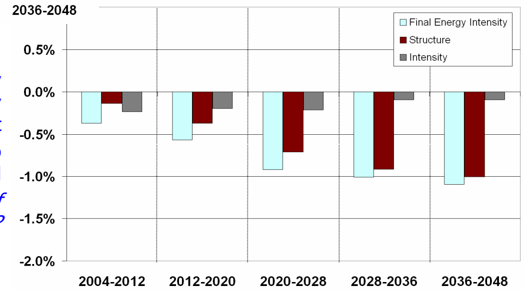
- Structure is by far the most important driver in reducing CO2 growth
- Other factors move quite low, even less in the long run (further signal of the modest "freedom" for the model in the long-run)



BENCHMARKING THE MODEL: REFERENCE SCENARIO (2)



- Structure is largely more important than intensity in slowing the impact of activity in energy demand
- Once isolated from structure, increase of efficiency (intensity effect) is very modest

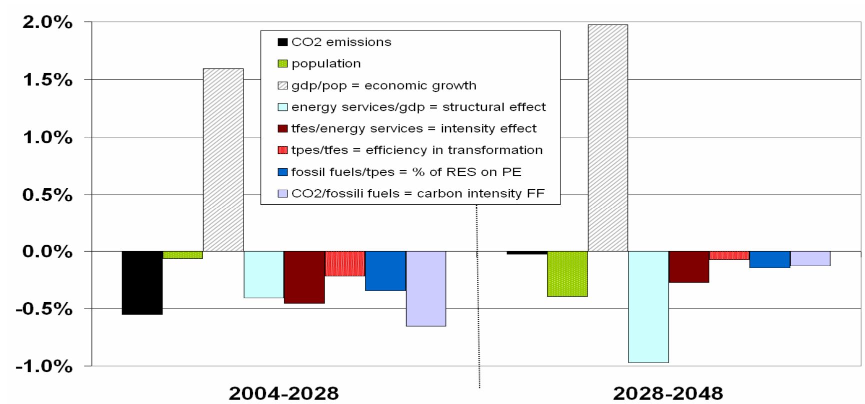


- Final energy intensity apparently reasonable, in fact low efficiency improvement
- Probably a signal that the model is too constrained

➔ a common range for the evolution of intensity effect (OECD country models) ?

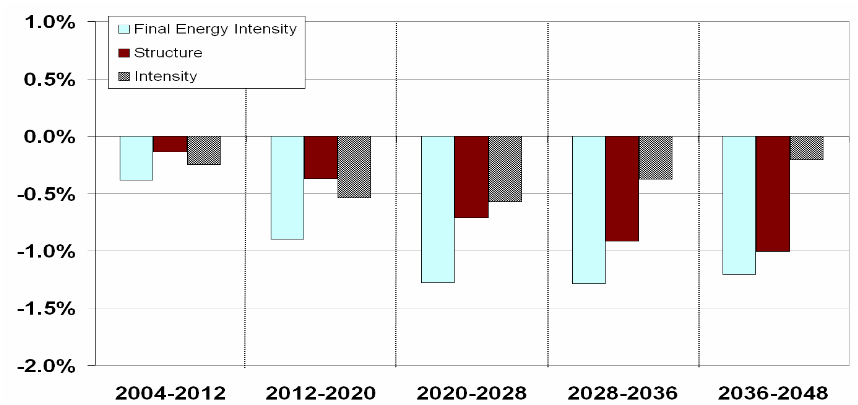
BENCHMARKING THE MODEL: RIGIDITY TO CO2 TAX (1)

- Most important change wrt Ref.: carbon intensity of fossil fuels (fuel switch + CCS, in the first part of the time horizon)
- Intensity effect move about twice than in Reference, but still less than -0.5%/yr.



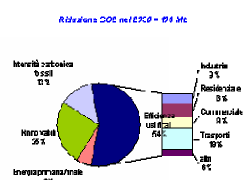
BENCHMARKING THE MODEL: RIGIDITY TO CO2 TAX (2)

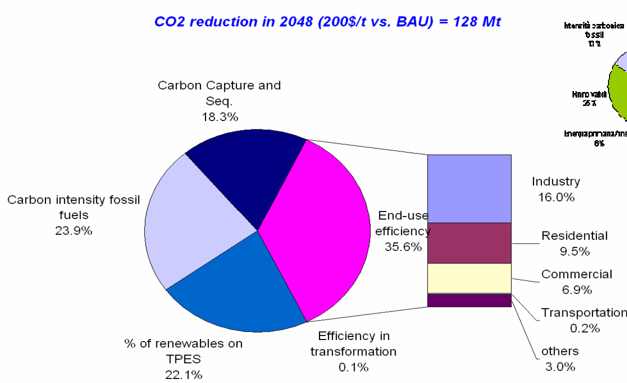
- Even in CO2tax-200 (inelastic demand), where reduction of intensity becomes more significant, structure remains the most important driver in reducing CO2 growth
- Final energy intensity apparently reasonable, in fact low efficiency improvement



BENCHMARKING THE MODEL: RIGIDITY TO CO2 TAX (3)

- (Often) huge number of hidden model boundaries ➔ transport sector is completely inelastic (both modal shift and mix of technologies are mostly exogenous)
- Very different contribution by different sector, how much of it due to different technological improvement ?





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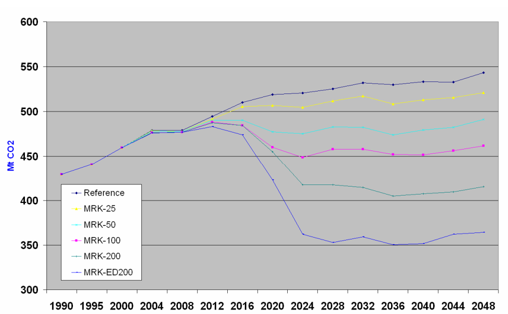
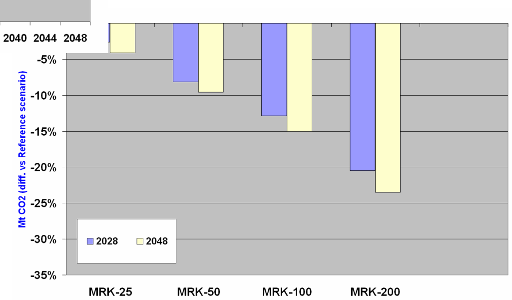
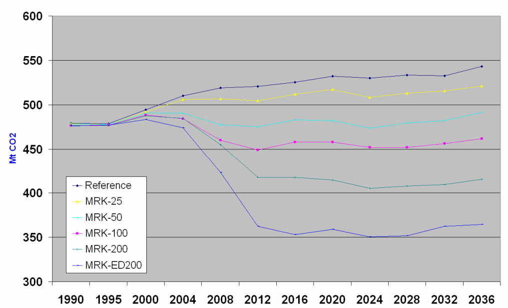
TOWARDS TECHPLUS PLUS: using the flexibility of the system (1a)



- MRK with inelastic demands: maximum reduction =
  128 Mt,
  -23% wrt Ref.,
  -10% wrt 2000

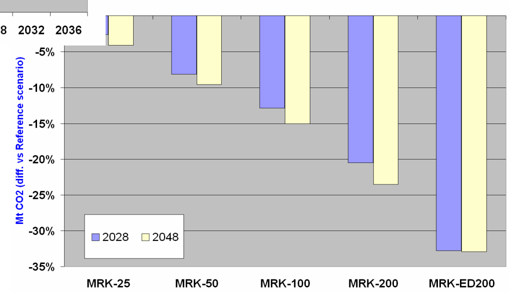


TOWARDS TECHPLUS PLUS: using the flexibility of the system (1b)



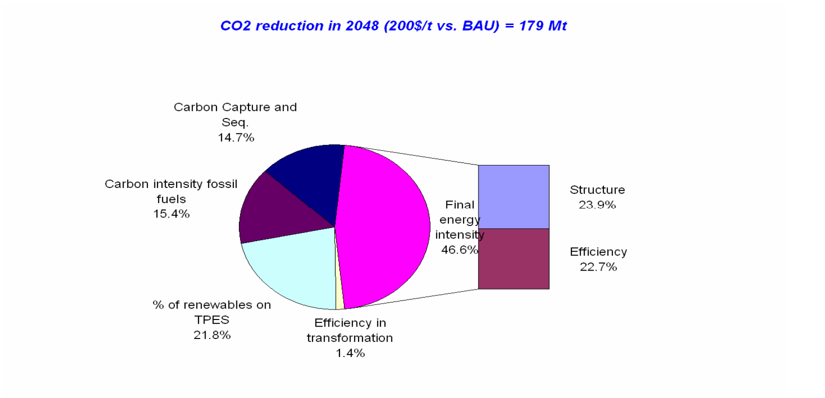
- MRK with elastic demands (conservative values): maximum reduction =
  - 178 Mt
  - -33% wrt to Ref
  - -21% wrt 2000

Price elasticities	
Industry	-0,2/0,4
Tertiary	-0,2
Residential	-0,2
Transportation	-0,2/0,3



TOWARDS TECHPLUS PLUS: using the flexibility of the system (2)

- Share of reduction due to energy intensity increases by about 10% (46% vs 36%), half of which due to structural change
- Still far from huge reductions (elastic demands (conservative values)
- Necessity to use the flexibility of the energy/economy system (and model)



TOWARDS TECHPLUS PLUS: using the flexibility of the system (3)

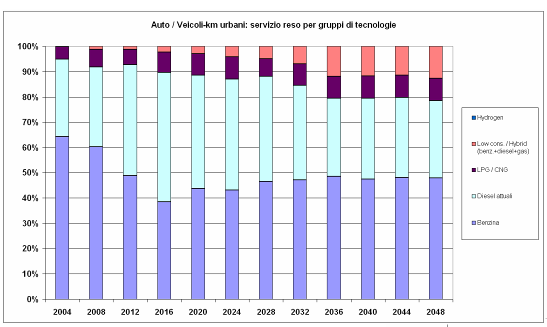
- Next step: exploration of the possibility for cost reduction:
  - *some tentative runs with "smooth" CO2 tax up to more than 200$/t*
  - *some tentative runs with cap on CO2 emissions, up to 50% vs. 2000*
- Some very preliminary further runs shows:
  - *costs up to 1000 $/t for much stronger reductions*
  - *some not marginal reduction of costs with better "calibrated" tax (better use of a further parameter, "time")*

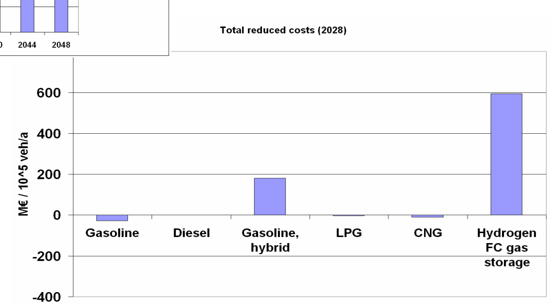
SOME CONCLUSIONS

- Scenarios
  - *(Preliminary) results of sensitivity analysis*
    - ➔ *high costs*
- Benchmarking the model: assessment of the "rigidity" of the model
  - *Baseline*
  - *CO2tax vs. Reference*
    - ➔ *"rigid" model in the long-run,*
    - ➔ *useful insights from decomposition*
- Towards TechPlus Plus: if, how, costs
    - ➔ *Significant improvement with MRK-ED*
    - ➔ *-50% seems far, and costs much*

APPENDIX:
CO_2-Tax vs Reference scenarios, results at technology level

BENCHMARKING THE MODEL: EFFICIENCY (AND HYDROGEN) TRANSPORT (2)

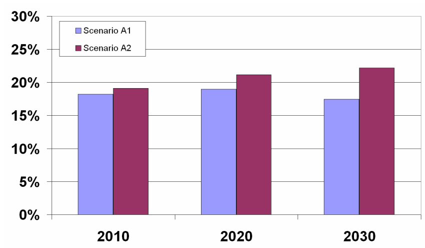


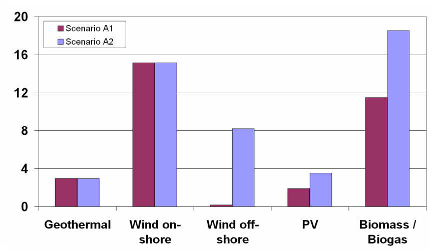


BENCHMARKING THE MODEL: RES

Policy scenario assumptions:

- *Price approach: different national developments*
- *Quantity approach: different costs at national level (risk of very high costs)*





BENCHMARKING THE MODEL: CCS

- *CCS presently modelled for electricity generation and hydrogen production technologies, with cost assumptions taken from the main international literature (among which IEA ETP and the HyWays project for hydrogen):*
  - *ICCG + CCS (Integrated coal Gasification Combyned Cycle turbine + carbon sequestration, from 2020)*
  - *Hydrogen production from hard coal/biomass/natural gas + CCS*
- *Storage assumptions not been defined yet: all sequestered carbon can be stored. But upper bound on ICCG+CCS: 5000 MW in 2020, 15000 MW in 2030*