COST ESTIMATIONS OF MITIGATION POLICIES FOR 20-20 AND BEYOND

Experiences (and ongoing research) in supporting italian policymakers

Francesco Gracceva

ENEA

Italian Agency for Energy,
New technology and Environment

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OVERVIEW

1. **Modelling approaches to cost estimation**
2. A scenario analysis of climate policies for Italy
3. Cost estimations
   - Impact on the energy system
   - Impact on the economy
4. A further step toward better cost estimations: soft-linking Markal with SAM / CGE

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MODELLING APPROACHES TO COST ESTIMATION – Political relevance

Model-based Analysis of the 2008 EU Policy Package on Climate Change and Renewables

By P. Capros, L. Mantzos, V. Papandreou, N. Tasios
Primes Model – E3MLab/NTUA
June 2008

Table 8: Compliance Costs – EU27 - 2020

Scenarios	Name	Compliance Cost (*) (billion €)	Compliance Cost as % of GDP	% change from Cost Efficiency (CES)
RSAT	EC Proposal without RES trading	111.2	0.71	22.5
RSAT-CDM	EC Proposal with CDM without RES trading	93.2	0.59	2.7
NSAT	EC Proposal with RES trading	94.1	0.60	3.7
NSAT-CDM	EC Proposal with CDM and with RES trading	70.1	0.45	-22.7
CES	Cost-Efficiency Scenario	90.8	0.58	
CES-CDM	Cost-Efficiency Scenario with CDM	75.2	0.48	-17.1
pure-GHG	Pure Carbon case	78.9	0.50	-13.0
pure-RES	Pure RES case	29.1	0.19	-67.9
HOG-BL	Baseline scenario with high oil & gas prices (**)	275.5	1.76	
HOG-CES	Cost Efficiency scenario with high prices (***)	59.8	0.38	

(*) Total energy system costs after payments for CDM (where applicable), net of payments to buy emission allowances in auctions

(**) For the HOG-BL cases the costs shown are not compliance costs but are additional energy systrem costs from Baseline with moderate prices reflecting the consequences of high prices

(***) For the HOG-CES scenario the costs shown are relative to the high oil and gas prices baseline scenario (the HOG-BL)

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MODELLING APPROACHES TO COST ESTIMATION – The Total Climate Change Bill

Effort on economies imposed by climate change, **4 components**:

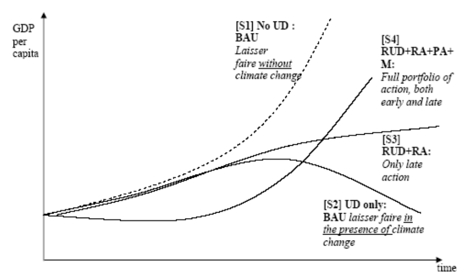
- Mitigation (M),
- Proactive Adaptation (PA)
- Reactive Adaptation (RA)
- Remaining Ultimate Damages (UD)

➔ The correct counterfactual scenario to measure (gross) costs is a BAU *in the presence of climate change*, i.e. *no action* is taken and full 'ultimate damages' are incurred

➔ Difficult to estimate size/timing of damages, but even evaluating (gross) costs/benefits of actions separately may be misleading, they are not independent

➔ Most analysis, only Mitigation Costs

Figure 1: **Growth over time in the *laisser faire* BAU cases w/o CC [S1] and w/ CC [S2], with reactive adaptation only [S3], and with the full portfolio of action (reactive adaptation, anticipative adaptation and mitigation) [S4]**



Source: Lecoq, Shalizi, World Bank 2007

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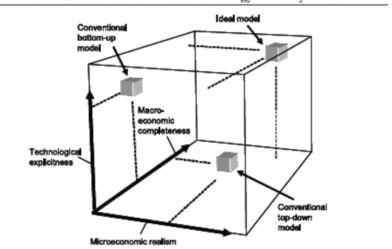
MODELLING APPROACHES TO (MITIGATION) COST ESTIMATION - Modelling Energy/Economy interactions

- **Ideal** energy-environment policy model:
  - technologically explicit,
  - behaviorally realistic,
  - macroeconomic feedbacks
- **Hybrid** models: B-U or T-D that have made at least one modification that shifts them away from their conventional placement
- Reasons for moving toward hybrid from a B-U perspective

Figure 1. Three-dimensional Assessment of Energy-economy Models



Source: Hourcade et al., Energy Journal, 2006

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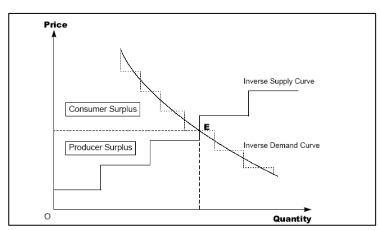
TOWARDS HYBRID FROM A B-U PERSPECTIVE - Partial equilibrium: Markal-ED, Primes

Energy related system costs

- In **MRK-ED** Total Costs = Investments + Net import + Other (including welfare loss)
- Total compliance cost **NOT net loss in GDP**, but the incremental cost that the rest of the economic system would be required to pay in order to comply with the targets (1st order approximation of economic costs)
- Mitigation and Proactive Adaptation likely to result in a **reallocation of expenditures** towards less carbon-intensive technologies/sectors



- *In neoclassical growth models additional expenditures have limited impact on long-term economic growth, apart from implications for transitional growth (+)*

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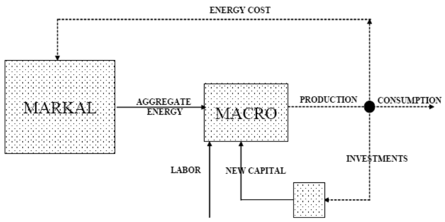
TOWARDS HYBRID FROM A B-U PERSPECTIVE – General equilibrium B-U: Markal-Macro

- Even with a succint representation of the economy-wide perspective ➔ transfer of the total compliance cost to the rest of the economic system
- Re-adjustment of the economy ➔ estimation of the **overall economic cost** of a policy package, expressed by the **change of GDP and of its main components (C, I, EC)**
- *IPCC 4AR on economic impact of stabilization policies (+)*



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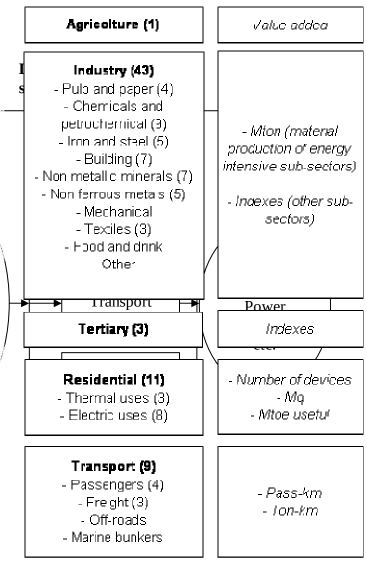
MARKAL-ITALY

- *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*
- *More than 50 technologies 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*



USE OF MARKAL-ITALY TO SUPPORT POLICYMAKERS

- Developed to evaluate GHG emissions reduction potential and costs, it has been used to evaluate mitigation policies in the 1st/2nd NC to UNFCCC, to assess effectiveness and impact of different carbon tax schemes, to set up reference scenarios for the National Conference on Energy-Environment
- In recent years, widely used to support policymakers:
  - Analysis of EU package 20/20/20 for the Italian government (as support to negotiations for EU burden sharing)
  - Periodical elaboration of scenarios for the Ministry of Economic Development
  - Reference and Alternative scenario of the 4° NC to UNFCCC
  - Energy input scenario to be used by Rains model at IIASA for National Emission Ceiling directive update and CAFE program
- National detail for IEA ETP 2008
- Annual ENEA Report on Energy and the Environment (plus contribution to several other ENEA publications)

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MEDIUM-TERM GOALS – EU ENERGY POLICY

In March 2007, the European Council approved an ambitious climate change and energy package to build a low carbon economy in Europe, confirmed in December 2008. EU as a whole must:

- cut GHG emissions by 30% by 2020 (wrt 1990) in the context of a global international agreement; and make a firm independent commitment to cut GHG by at least 20% by 2020
- implement the EU's energy efficiency action plan as the means of reducing the EU's energy consumption by 20% by 2020
- reach a binding target of a 20% share of renewable energies in overall EU consumption by 2020, and a 10% minimum binding target for the use of biofuels

- EU Commission: European firms must gain the leadership in the rapidly growing sector of low carbon technologies, because otherwise there is the risk to that "others will benefit of the transition to a low carbon economy"

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LONG-TERM GOALS – IPCC ASSESSMENT / G8

- Leaders of G8 have stated (Heiligendamm) that they will "seriously consider" a 50% CO2 emissions reduction target by 2050
- IPCC has concluded that a 50 to 80% reduction of global CO2 emissions by 2050 (wrt to 2000), can limit long term global mean temperature rise to less than 2 degrees Celsius. Higher emission levels ➔ more significant climate change
- Economic impacts of a 2 degrees scenario are limited (<-5.5% of GDP; 295% growth instead of 300% growth between now and 2050)

IPCC 4th Assessment Report and ETP

Temp. increase	All GHG	CO2	CO2 emissions 2050 (% of 2000 emissions)
(ºC)	(ppm CO2 eq.)	(ppm CO2)	(%)
2.0-2.4	445-490	350-400	-85 to -50
2.4-2.8	490-535	400-440	-60 to -30
2.8-3.2	535-590	440-485	-30 to +5
3.2-4.0	590-710	485-570	+10 to +60
4.0-7.0			+135 (ETP-Reference)

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SCENARIO ANALYSIS

REFERENCE	*Current legislation, mid-term macroeconomic trend coherent with official government projections, demografic trend coherent with the projections produced by the National Insitute of Statistics (ISTAT), energy prices coherent with IEA-ETP2008*
ACT	*Same medium-term set of efficiency measures included in the Energy Efficiency Action Plan (EEAP), with effects extended up to 2020 and beyond.* *Extension of the green electricity purchase obligation, increasing up to 2020, and (decreasing) subsidization of RES continuing in long-term. Support to the use of biofuels in trasportation.* *CO2 reduction incentives to encourage the adoption of low-carbon technologies: policies and measures are assumed to be put in place that would lead to the adoption of low-carbon technologies with a cost of up to 30€/ton di CO2 (like in ETP 2008 - ACT). But limited deployment of reduction potential from "energy saving" options (i.e. through reductions of energy service demands)*
BLUE	*In medium-term, scenario exploring the potential contribution of different technological options to reach the EU 20-20-20 targets and its impact on Italy. In long-term, same philosophy of etp BLUE* *Scenario ACT with the increase of CO2 reduction incentives up to 75€/ton by 2020 and 150€/ton by 2030 and beyond.* *Significant deployment of reduction potential from "energy saving" options.*
ACT+	*Scenario exploring the "trade-off" between strict achievement of medium/long term objectives and the increase of system cost: similar to ACT up to 2020, same CO2 reduction incentives as scenario BLUE in 2040*

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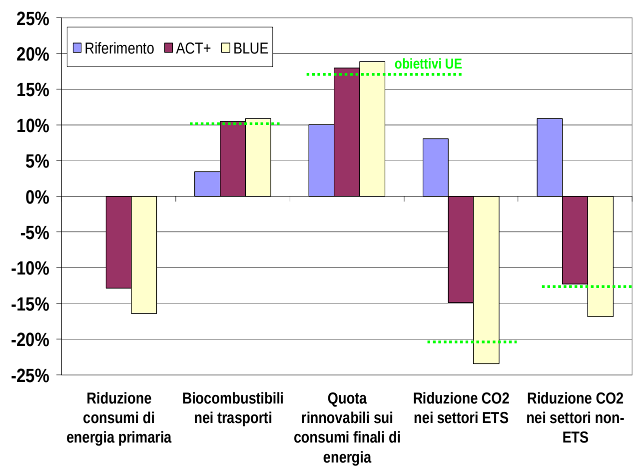
COMPLIANCE WITH MEDIUM-TERM OBJECTIVES



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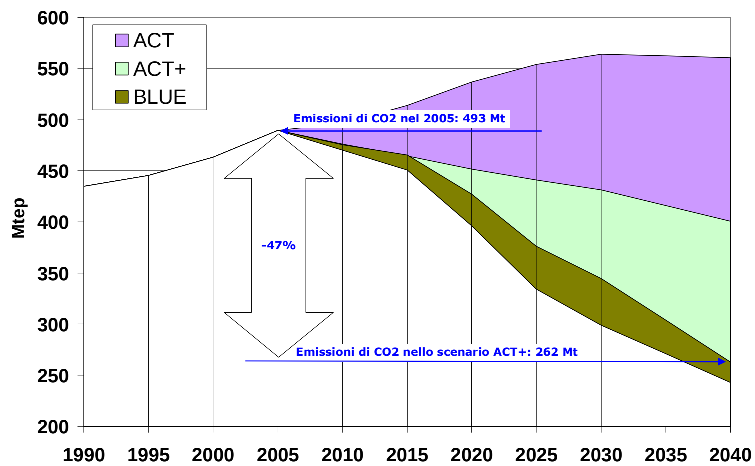
COMPLIANCE WITH LONG-TERM OBJECTIVES



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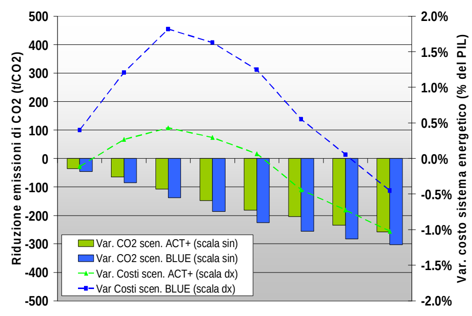
MAIN RESULTS OF THE SCENARIO ANALYSIS (1) - Optimal timing of emission reductions

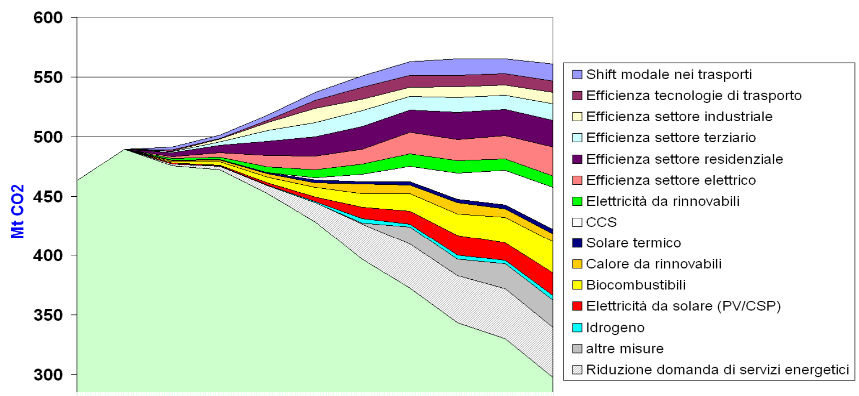
Scenario **ACT+**:

- Wrt to EU objectives
  - CO2 reduction only slightly lower than requested (-11% non-ETS sectors)
  - RES target reached (>17%)
- Wrt long-term objectives
  - Only a few percent lower reduction than in BLUE (-40% in 2040 wrt to 2005)
- Wrt economic costs
  - Increase in energy system costs similar to EU estimation for the whole EU-25 (PRIMES) = 0.4% of GDP



*One of the major findings in the economics of climate change has been that efficient or "optimal" economic policies to slow climate change involve modest rates of emissions reductions in the near term followed by sharp reductions in the medium and long term. We might call this the **climate-policy ramp**, in which policies to slow global warming increasingly tighten or ramp up over time. The exact mix and timing of emissions reductions depends upon details of costs damages and the extent to which climate change and damages are irreversible (W. Nordhaus 2007).*

MAIN RESULTS OF THE SCENARIO ANALYSIS (2) – Role of technologies



- *No sector/technology with dominant role*
- *Energy efficiency measures more than half of total reduction in medium-term, less than 30% in longer-term*
- *CCS and PV the more intersting technologies, wrt both the potential environmental benefits and as opportunity for the national economy*

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IMPACT ON THE ENERGY SYSTEM: DIRECT ENERGY SYSTEM COSTS (MARKAL-ED) - SCENARIO ACT+

	2008-2020 (mln €)	2020	2030	2040
Change in energy system direct costs (wrt to Base)	**90,047**	**3.4%**	**2.5%**	**0.1%**
Change Investments in energy technologies	*84,766*	*5.3%*	*7.5%*	*-5.3%*
Change Energy Imports	*-31,592*	*-8.7%*	*-11.4%*	*-14.4%*
Change Other Operating expenditure	*36,873*	*3.2%*	*5.3%*	*6.5%*
Change Direct Energy system costs (% of GDP)		**0.52%**	**0.45%**	**0.0%**
Carbon price (€/ton CO2)		**85**	**27**	**1**

SUMMARY ENERGY BALANCE AND INDICATORS (B)							Italy: EC proposal without RES trading					
	1990	2000	2005	2015	2020	2030	2015	2020	2030	2015	2020	2030
							Difference from Baseline			% Change from Baseline		
Main Energy System Indicators												
Population (Million)	56.694	56.929	58.462	58.630	58.300	57.071	0.000	0.000	0.000	0.0	0.0	0.0
GDP (in 000 M€05)	1172.7	1372.9	1417.2	1704.6	1864.3	2168.0	0.0	0.0	0.0	0.0	0.0	0.0
Gross Inl. Cons./GDP (toe/M€05)	130.5	125.7	131.8	107.7	99.3	88.4	-15.8	-19.3	-18.4	-12.8	-16.3	-17.2
Carbon intensity (t of CO_2/toe of GIC)	2.53	2.44	2.41	2.20	2.05	1.95	-0.16	-0.29	-0.36	-7.0	-12.4	-15.7
Import Dependency %	84.8	87.3	84.4	81.9	81.0	78.8	-3.2	-4.9	-6.6			
Total Energy-related Costs [B] (in 000 M€05)		136.2	146.1	204.1	231.1	263.1	14.9	20.7	28.5	7.8	9.8	12.2
as % of GDP		9.9	10.3	12.0	12.4	12.1	0.9	1.1	1.3			
Total Compliance Costs [D] (in 000 M€05)				15.1	21.2	29.1						
as % of GDP				0.89	1.14	1.34						

IMPACT ON THE ENERGY SYSTEM: DIRECT ENERGY SYSTEM COSTS (MARKAL) - SCENARIO ACT+

	2008-2020 (mln €)	2020	2030	2040
Change in energy system direct costs (wrt to Base)	**36,375**	**0.8%**	**0.1%**	**-1.8%**
Change Investments in energy technologies	*112,238*	9.8%	11.7%	0.2%
Change Energy Imports	*-24,634*	-6.4%	-6.1%	-5.7%
Change Other Operating expenditure	*-51,229*	-3.9%	-4.0%	-2.1%
Change Direct Energy system costs (% of GDP)		**0.13%**	**0.11%**	**-0.21%**
Carbon price (€/ton CO2)		**22**	**2**	**-20**

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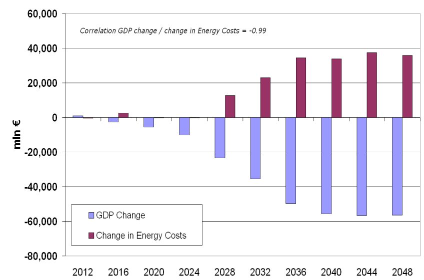
IMPACT ON THE ENERGY/ECONOMY SYSTEM: ECONOMY WIDE COST (MARKAL-MACRO) – SCENARIO ACT+

	2020 % GDP	2030 % GDP	2040 % GDP
GDP Change (mln €)	-5,473	-29,415	-55,678
GDP Change (%)	**-0.28%**	**-1.25%**	**-2.17%**
Change in Consumption (%)	*-0.23%*	*-1.29%*	*-2.10%*
Change in Investment (%)	*-0.55%*	*-0.97%*	*-2.57%*
Change in Energy Costs (%)	*-0.02%*	*4.69%*	*9.37%*



ENERGY SYSTEM ADJUSTMENT IN MARKAL-ED AND MARKAL-MACRO – SCENARIO ACT+

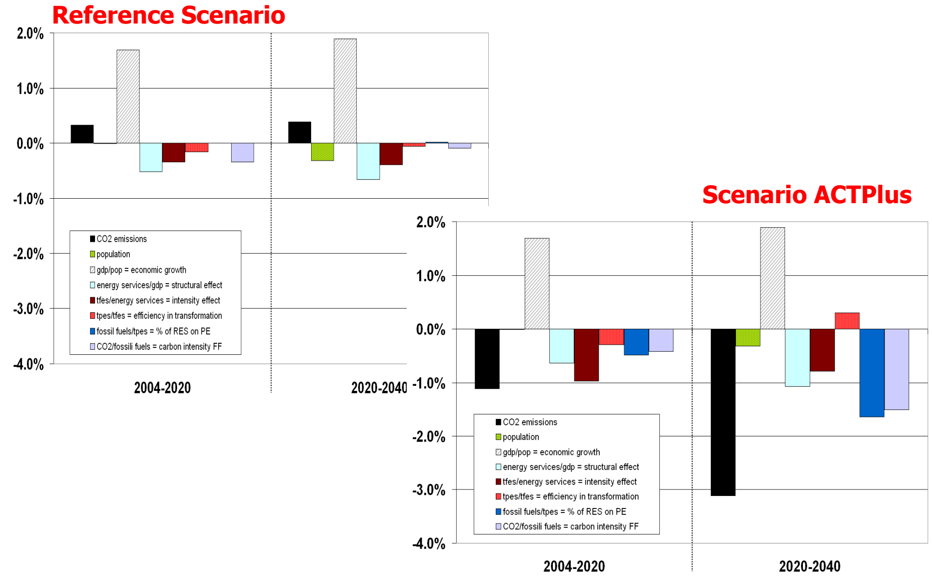
MARKAL-ED

Shadow prices	***2020***	***2030***	***2040***
Agricolture	66.4%	221.6%	310.6%
Industry	2.8%	16.0%	19.0%
Service	2.1%	4.9%	10.8%
Residential	-3.8%	0.6%	0.2%
Electric uses	*-7.8%*	*-2%*	*-2.9%*
Thermic uses	*6.9%*	*9%*	*8.2%*
Transport	6.4%	4.0%	12.2%
Passengers	*7.2%*	*6%*	*5.6%*
freight	*5.4%*	*2%*	*20.8%*
Service demands	***2020***	***2030***	***2040***
Agricolture	-5.9%	-11.1%	-22.2%
Industry	-2.6%	-9.7%	-11.8%
Service	-0.9%	-3.4%	-6.4%
Residential	-0.2%	-0.9%	-0.6%
Electric uses	*0%*	*0%*	*0%*
Thermic uses	*-2%*	*-3%*	*-3%*
Transport	-2.3%	-2.7%	-5.6%
Passengers	*-2%*	*-3%*	*-3%*
freight	*-3%*	*-1%*	*-9%*

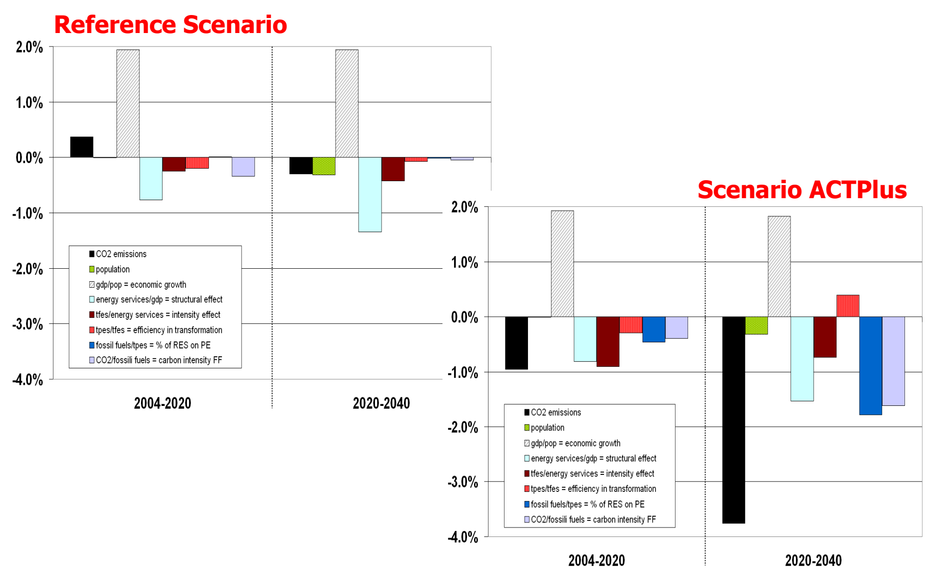
MARKAL-MACRO

Shadow prices	***2020***	***2030***	***2040***
Agricolture	65.6%	198.3%	186.3%
Industry	1.3%	17.0%	20.8%
Service	0.8%	3.2%	13.8%
Residential	-3.1%	3.7%	1.3%
Electric uses	*-5.9%*	*0%*	*-0.3%*
Thermic uses	*4.5%*	*12%*	*5.5%*
Transport	5.3%	1.1%	9.5%
Passengers	*5.6%*	*5%*	*0.3%*
freight	*4.9%*	*-4%*	*21.9%*
Service demands	***2020***	***2030***	***2040***
Agricolture	-17.6%	-30.0%	-33.3%
Industry	-0.7%	-5.5%	-7.3%
Service	-2.5%	-2.4%	-4.8%
Residential	1.0%	-0.9%	-0.4%
Electric uses	*2%*	*0%*	*0%*
Thermic uses	*-3%*	*-4%*	*-3%*
Transport	-1.9%	-0.5%	-2.4%
Passengers	*-2%*	*-2%*	*1%*
freight	*-2%*	*1%*	*-7%*

ENERGY SYSTEM ADJUSTMENT IN MARKAL-ED



ENERGY SYSTEM ADJUSTMENT IN MARKAL-MACRO



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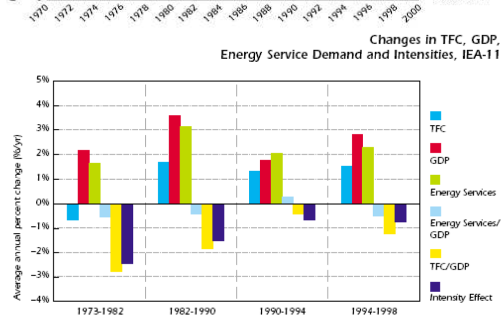
WHY FURTHER STEPS TOWARD BETTER COST ESTIMATIONS (1)

1. Impacts of energy price signals on the rest of the economy in very aggregate way. No impact on:
   - non energy goods prices
   - sectoral growth
   - distributional issues: labor / capital costs

2. Elephant and Rabbit stew assumption: still valid with ambitious long-term objectives?



Source: IEA, 2004

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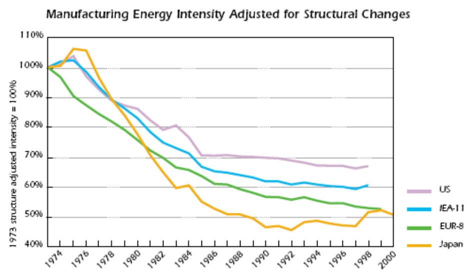
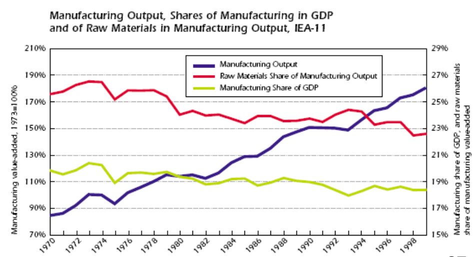
WHY FURTHER STEPS TOWARD BETTER COST ESTIMATIONS (2)

Those associated to sustainbility strategy are "net costs"?

- If mitigation strategies imply adjustments of the whole economic system (far from "marginal"): can they stimulate innovative changes of social/economic systems that make crisis/policies a mechanism of economic dynamics?
- Cost of sustainability is in fact an investment cost: significant adjustment costs, but ultimate extensive and positive changes of the economic systems





Source: IEA, 2004

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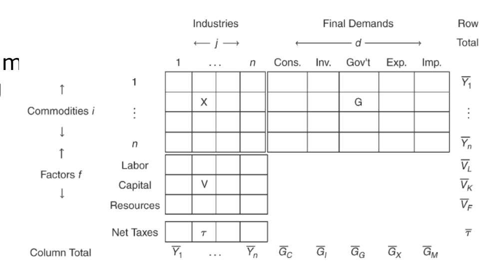
A FURTHER STEP: SOFT-LINKING MARKAL/TIMES WITH SAM

- A "snapshot" of the economy in the base year: the production side is aggregated into a set of sectors, each of which usually produces a single good
- Row: amount of good produced must be sufficient to serve the sum of demands from other producing sectors plus the final demands of G, I, C, net EXP
- Column: the amount of the good produced by an industry is just exhausted in the payments to its inputs, plus taxes
- X is the technology in use in the benchmark year ➔ amounts of various inputs applied to produce a unit of each sector's output (Leontief-type representation at sector level)



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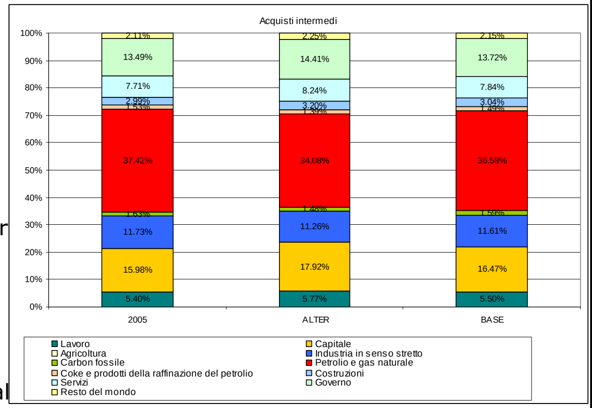
A FURTHER STEP: SOFT-LINKING MARKAL/TIMES WITH SAM

- Consistent/harmonised framework to analyse sectoral macroeconomic effects (growth, jobs creation, invest./cons. path, distributional issues) of technological changes in the energy sector
- Tool kit enabling end-user to routinize analysis:
  - output of MRK-It as input for SAM, to modify its structure
  - extension of SAM to better fit technological detail of MRK-It



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A FURTHER STEP: SOFT-LINKING MARKAL/TIMES WITH CGE

Neoclassical growth models:

- Mitigation policies generate expenditures, which are usually modeled by adding a drawdown Dt on the consumption side of the output–expenditure balance
- Temporary changes in expenditures, or permanent but independent of the level of production, do not affect the steady-state growth, apart from implications for transitional growth
- Changes proportional to output, i.e. amounting to a loss of global productivity of the economy, affect both the transition to and the composition of the steady-state growth path.

$$Y_t = A_t F(K_t, L_t) = C_t + I_t$$

$$K_{t+1} = (1-\eta)K_t + I_t$$

$$L_{t+1} = L_t (1+g)^t$$

$$Y_t = F(K_t, L_t) = C_t + I_t + D_t$$

$$Y_t = \Omega_t F(K_t, L_t) = C_t + I_t$$

Source: Lecoq, Shalizi, World Bank 2007

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SUMMARY

- Modelling approaches to cost estimation: reason for a bottom-up perspective
- Pros of a bottom-up/hybrid approach
  - o Mitigation cost estimations for Italy: different perspective of Mrk-Ed and M-M, similar results
- Cons of a bottom-up/hybrid approach
  - Need for further steps: current research activities

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Thanks

(francesco.gracceva@casaccia.enea.it)

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