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
MODELLING APPROACHES TO COST ESTIMATION – Political relevance

### Table 1: Compliance Costs – €/yr, 2020

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Mitigation (M)</th>
<th>Proactive Adaptation (PA)</th>
<th>Reactive Adaptation (RA)</th>
<th>Remaining Ultimate Damages (UD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base-year without MITM Policy</td>
<td>112.3</td>
<td>49.7</td>
<td>12.5</td>
<td>3.7</td>
</tr>
<tr>
<td>Base-year with MITM Policy</td>
<td>94.2</td>
<td>41.6</td>
<td>3.7</td>
<td>3.7</td>
</tr>
<tr>
<td>Base-year with CEM Policy</td>
<td>94.1</td>
<td>41.7</td>
<td>3.7</td>
<td>3.7</td>
</tr>
<tr>
<td>Base-year with CEM and MITM Policy</td>
<td>76.1</td>
<td>41.0</td>
<td>12.7</td>
<td>12.7</td>
</tr>
<tr>
<td>CEM</td>
<td>90.2</td>
<td>40.1</td>
<td>3.7</td>
<td>3.7</td>
</tr>
<tr>
<td>CEM and MITM Policy</td>
<td>75.2</td>
<td>40.4</td>
<td>12.7</td>
<td>12.7</td>
</tr>
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| Source: Lecoq, Shalizi, World Bank 2007 |

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

By P. Capelo, L. Manzoni, V. Papandreou, N. Tatsis
- Primus Model – E3MLab/NTUA
- June 2006

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 latter zero-BAU case w/ CC (S1) and w/ CC (S2), with proactive adaptation only (S1), and with the full portfolio of action (cooperative adaptation, anticipative adaptation and mitigation) (S2)

Sources: Lecoq, Shalizi, World Bank 2007
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

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 (+)
**TOWARDS HYBRID FROM A B-U PERSPECTIVE – General equilibrium B-U: Markal-Macro**

- Even with a succinct 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)
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”

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)
### Scenario Analysis

<table>
<thead>
<tr>
<th>Reference</th>
<th>Current legislation, mid-term macroeconomic trend coherent with official government projections, demographic trend coherent with the projections produced by the National Institute of Statistics (ISTAT), energy prices coherent with IEA-RTO2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACT</td>
<td>Some medium-term set of efficiency measures included in the Energy Efficiency Action Plan (GEAP), with effects extended up to 2020 and beyond. Extension of the green electricity purchase obligation, increasing up to 2020, and (decreasing) substitution of RES continuing in long-term. Support to the use of biofuels to transportation. CO2 reduction measures 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 200-1000/ton of CO2 (like in ETP 2009 – ACT). But limited deployment of reduction potential from ‘energy saving’ options (i.e. through reductions of energy service demands)</td>
</tr>
<tr>
<td>BLUE</td>
<td>In medium-term, scenario involving 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 ref BLUE. Scenario ACT with the increase of CO2 reduction incentives up to 750/ton by 2020 and 1500/ton by 2030 and beyond. Significant deployment of reduction potential from ‘energy saving’ options.</td>
</tr>
<tr>
<td>ACT+</td>
<td>Scenario exploring the “trade-off” between strict achievement of medium-term objectives and the increase of system costs: similar to ACT up to 2020, same CO2 reduction incentives as scenario BLUE in 2040</td>
</tr>
</tbody>
</table>

### Compliance with Medium-Term Objectives

![Graph showing compliance with medium-term objectives](image)
**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 interesting 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+

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

Carbon price (€/ton CO2)
IMPACT ON THE ENERGY/ECONOMY SYSTEM: ECONOMY WIDE COST (MARKAL-MACRO) – SCENARIO ACT+

<table>
<thead>
<tr>
<th>GDP Change (min C)</th>
<th>2020 % GDP</th>
<th>2030 % GDP</th>
<th>2040 % GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP Change (%)</td>
<td>-2.475</td>
<td>-1.25%</td>
<td>-2.17%</td>
</tr>
<tr>
<td>Change in Consumption (%)</td>
<td>-0.23%</td>
<td>-1.29%</td>
<td>-2.10%</td>
</tr>
<tr>
<td>Change in Investment (%)</td>
<td>-0.55%</td>
<td>-0.57%</td>
<td>-2.57%</td>
</tr>
<tr>
<td>Change in Energy Costs (%)</td>
<td>-0.02%</td>
<td>4.69%</td>
<td>9.37%</td>
</tr>
</tbody>
</table>

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

MARKAL-ED

<table>
<thead>
<tr>
<th>Shadow prices</th>
<th>2020</th>
<th>2030</th>
<th>2040</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>-2.6%</td>
<td>-9.7%</td>
<td>-11.8%</td>
</tr>
<tr>
<td>Service</td>
<td>-0.9%</td>
<td>-3.4%</td>
<td>-6.4%</td>
</tr>
<tr>
<td>Residential</td>
<td>-0.2%</td>
<td>-0.9%</td>
<td>-0.6%</td>
</tr>
<tr>
<td>Electric uses</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Thermic uses</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Transport</td>
<td>-2.3%</td>
<td>-2.7%</td>
<td>-5.6%</td>
</tr>
<tr>
<td>Passengers</td>
<td>-2%</td>
<td>-3%</td>
<td>-2%</td>
</tr>
<tr>
<td>Freight</td>
<td>-3%</td>
<td>-2%</td>
<td>-9%</td>
</tr>
</tbody>
</table>

MARKAL-MACRO

<table>
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<td>Agriculture</td>
<td>-4.7%</td>
<td>-10.9%</td>
<td>-13.3%</td>
</tr>
<tr>
<td>Service</td>
<td>-2.5%</td>
<td>-2.4%</td>
<td>-4.8%</td>
</tr>
<tr>
<td>Residential</td>
<td>1.5%</td>
<td>-0.9%</td>
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<td>-2%</td>
<td>-1%</td>
</tr>
<tr>
<td>Freight</td>
<td>-2%</td>
<td>1%</td>
<td>-7%</td>
</tr>
</tbody>
</table>
ENERGY SYSTEM ADJUSTMENT IN MARKAL-ED

Reference Scenario

Scenario ACTPlus

ENERGY SYSTEM ADJUSTMENT IN MARKAL-MACRO

Reference Scenario

Scenario ACTPlus
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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
WHY FURTHER STEPS TOWARD BETTER COST ESTIMATIONS (2)

Those associated to sustainability 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.

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).
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

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

**Neoclassical growth models:**

- Mitigation policies generate expenditures, which are usually modeled by adding a drawdown $D_t$ 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.

\[
\begin{align*}
Y_t &= A_t F(K_t, L_t) = C_t + I_t \\
K_{t-1} &= (1-\delta) K_t + \delta L_t \\
L_{t-1} &= L_t (1+g)^t \\
Y_t &= F(K_t, L_t) = C_t - I_t - D_t \\
\hat{Y}_t &= \Omega_t F(K_t, L_t) = C_t + I_t
\end{align*}
\]

*Source: Lecocq, Shalizi, World Bank 2007*
SUMMARY

- Modelling approaches to cost estimation: reason for a bottom-up perspective
- **Pros** of a bottom-up/hybrid approach
  - 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

Thanks

(francesco.gracceva@casaccia.enea.it)