ABATEMENT COST CURVES BY (GROUP OF) TECHNOLOGIES FOR ITALY

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OVERVIEW

- Different approaches to build abatement cost curves (by technology)
- The Markal-Italy model
- Abatement cost curves by (group of) technologies for Italy

- **Different approaches to build abatement cost curves (by technology)**
  - The Markal-Italy model
  - Abatement cost curves by group of technologies for Italy

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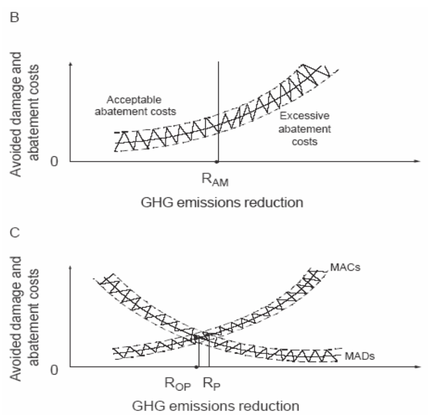
Motivation for (marginal) abatement cost curves

Optimality and Durability in Determining (Global GHG) Emission Target Levels

- In an economic optimizing framework, ideal solution is to estimate MACs/MADs: optimal emission levels where future benefits (in terms of damage avoided) are just equal to the corresponding costs (of mitigation measures required)
- Durable strategies when (mainly) MACs better defined than MADs ➔ target emissions set on the basis of the affordable safe minimum standard = the upper limit on costs that will still avoid unacceptable socioeconomic disruption



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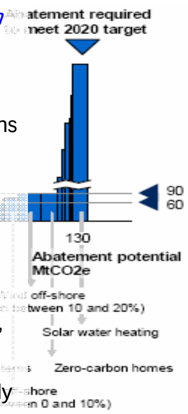
Practical application – (Marginal) abatement cost curves by technology as a tool for policymakers

McKinsey UK Cost Abatement Curve, for CBI (Confederation of British Industry)



- Tailored to UK a previous McKinsey study on global GHG, methodology developed with the assistance of leading institutions and experts: "over 120 different greenhouse gas abatement options that could help the UK meet its targets, represented in graphical form, ..., the first comprehensive UK marginal cost abatement curve"
- "Policy makers and business leaders can benefit from a thorough understanding of the relative economics of different possible approaches to abatement, i.e. the significance and cost of each possible method of reducing emissions, the prospective annual abatement cost as well as the abatement potential of each option"
- "Level of detail higher than anything produced before in the UK, offering important insights on the task that faces us" ➔ The supply of abatement options is then compared with any determined political determined target

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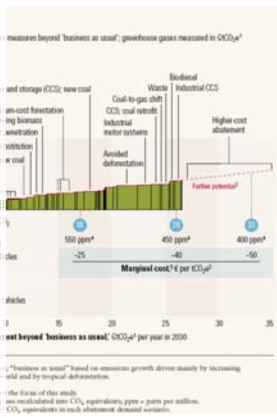
Approaches to the estimation of (M)AC curve by technology - Limitations of Engineering economic assessment tech-by-tech



- Technology-by-technology costs and reductions from large number of actions are aggregated into whole-economy totals. Each technology (or action) is assessed independently via an accounting of its costs and savings. A unit cost is computed for each action, then sorted in ascending order, from least expensive to the most expensive to create a cost curve.
- Requires very careful examination of the interactions between the various actions on the cost curve: often the cost and GHG reduction attached to an action depends on those of other actions in the same economy. Simpler interactions are easily accounted for, but there exist many other instances in which complex, multi-measure interactions are very difficult to evaluate without the help of a more complex model that captures the system's effects
- Problems with robusteness of estimations to various uncertainties

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Approaches to the estimation of (M)AC curve by technology - System analysis approach to curve by technology

- Integrated partial equilibrium models facilitate the integration of multiple GHG reduction options and the aggregation of costs
- Assessments are multidimensional: they require a detailed characterization of individual technologies as well as the economic and institutional factors that both drive and constrain their use
- "Systems perspective",
  - needed to capture the interaction of the diverse factors required by a complete technology assessment
  - captures both direct environmental impacts (e.g., the emissions generated by a particular technology) as well as indirect effects

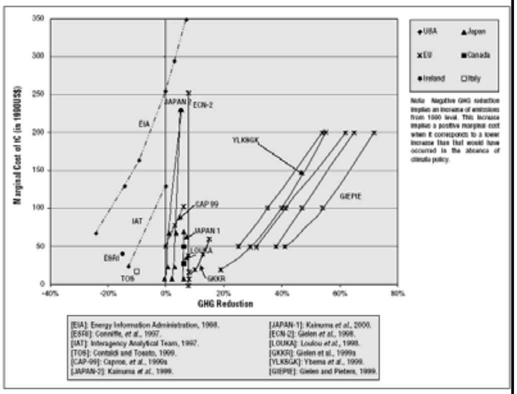

Figure 8.2: Country results with bottom-up studies using a crosscutting instrument.

Source: Encyclopedia of Energy

Approaches to the estimation of (marginal) abatement cost curve by technology - Problems with System Analysis approach

- Based on penetration of new technologies in the system ➔ the effective increase in emission reduction with progressively increasing emission penalty is strongly dependent on the "freedom" left to the model (usually with many "hidden" boundaries), maybe very different in different sectors (for instance, modal shift and mix of technologies in transportation are often exogenous)
- This "freedom" left to model is difficult "to measure", and it's difficult to harmonise different models ➔ how much of different abatement curves depend on the model, not on the system? (A useful proxy from decomposition analysis, isolating efficiency from other factors, i.e. energy intensity splitted in structure and intensity?)
- No abatement cost/potential by (group of) technologies
  - Possible approximate estimation of a given total reduction
  - Useful insights from reduced costs, but only for qualitative assessments, and no measure of abatement potential

- Different approaches to build abatement cost curves by technology
- **The Markal-Italy model**
- Abatement cost curves by group of technologies for Italy

The Markal-Italy model

- *Developed since '90s*
- *Time horizon: 2004 – 2048*
- *Quantities and prices:*
  - *300 flows of energy / materials*
  - *One thousand technologies*
- *Industrial energy service demand divided into the sub-sectors included in the National Energy Balance, with a detailed representation of the main energy-intensive materials*
- *Transport divided between freight and passengers, the latter 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*

Agricolture (1)	*Value added*
Industry (43) - Pulp and paper (4) Chemicals and petrochemica (9) - Iron and steel (5) - Building (7) - Non metallic minerals (7) - Non ferrous metals (5) - Mechanical - Textiles (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 (8) - Passengers (4) - Freight (3) - Off-roads - Marine bunkers	*- Pass-km* *- Ton-km*

Use of Markal-Italy to support policymakers

- Developed in the early '90 to evaluate GHG emissions reduction potential and costs, it has been used to prepare scenarios to evaluate mitigation policies in the 1st and 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 and 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)
  - Production 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)

- Different approaches to build abatement cost curves by technology
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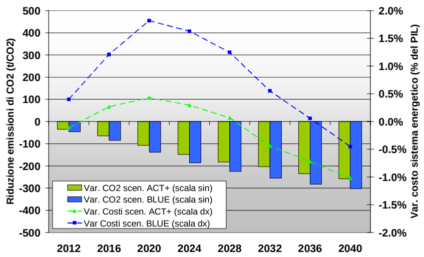
Abatement cost curves by group of technologies for Italy – Scenario analysis

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*

Abatement cost curves by group of technologies for Italy - Main results of the scenario analysis

Scenario **ACT+**:

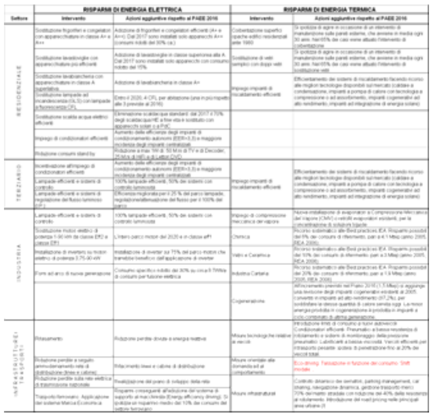
- Wrt to EU objectives
  - CO2 reduction only slightly lower than requested (-11% non-ETS sectors)
  - RES target reached (>17%)
- Wrt long-term objectives
  - Only a few percent lower reduction than in BLUE (-40% in 2040 wrt to 2005)
- Wrt economic costs
  - Increase in energy system costs similar to EU estimation for the whole EU-25 (source PRIMES) = 0.43% of GDP



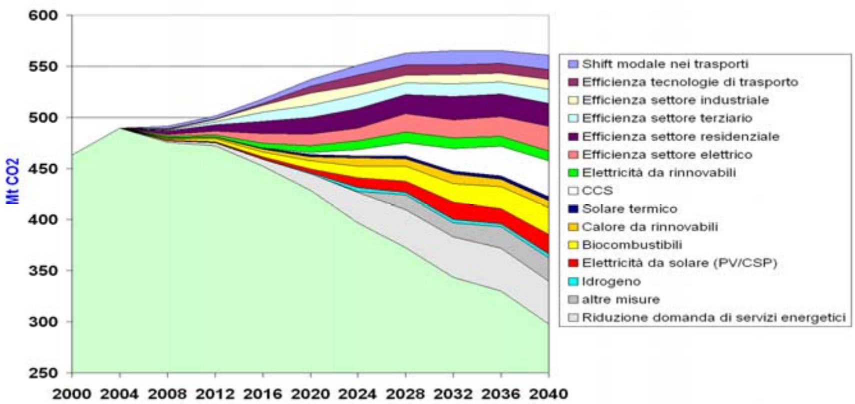
*One of the major findings in the economics of climate change has been that efficient or "optimal" economic policies to slow climate change involve modest rates of emissions reductions in the near term followed by sharp reductions in the medium and long term. We might call this the **climate-policy ramp**, 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).*

Abatement cost curves by group of technologies for Italy - Scenario ACT+ "decomposed"

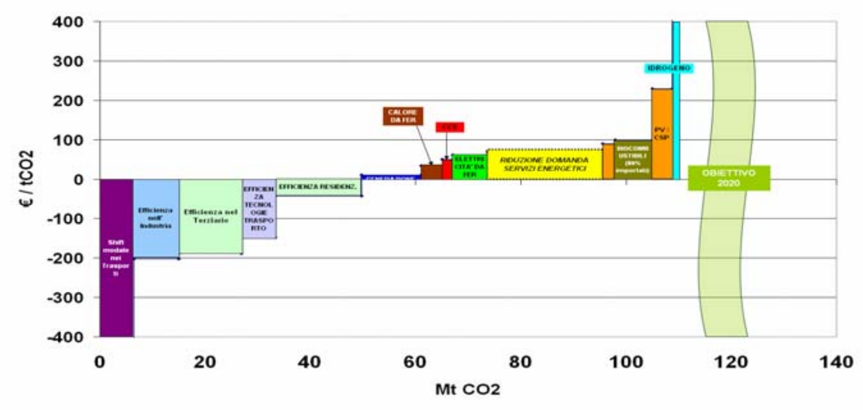
- Mainly detailed policy scenarios, simulating a wide range of policy measures, with high detail for end-uses (thanks to strict collaboration with the sectoral experts wich contributed to the EEAP)
- About 200 different "measures" decomposed in a set of 15 scenarios, each one run separately
- Cross-cut measures (CO2 tax) not included in any of the sectoral runs (only in the ACT+ scenario)
- Iterative process for coherence between sectoral results in ACT+ and in sectoral runs



Abatement cost curves by group of technologies for Italy - Scenario ACT+ "decomposed"



Abatement cost curves by group of technologies for Italy - <u>2020</u>



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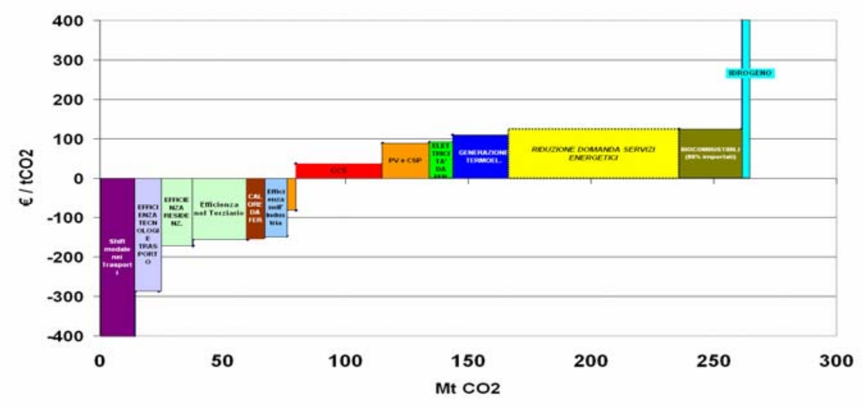
Abatement cost curves by group of technologies for Italy - <u>2040</u>



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Abatement cost curves by group of technologies for Italy – Key results

2020

- Whole set of measures not sufficient to reach EU objectives for 2020 (but very close)
- No sector/tecnology with dominant role
- The whole set of energy efficiency measures in end-use sectors gives more than half of total reuction, mostly with negative costs (long debate on this issue, rationality vs. non rationality, transaction costs, non economic barriers…)
- Mean abatement cost (much lower than the marginal one) about 70€/t CO2

2040

- Useful insights for selecting key technologies (and defining roadmaps?): in long-term CCS alone gives about 15% of total reduction, PV/CSP also assume a relevant weight
- CCS and PV appear to be the more intersting technologies, with regard to both the potential environmental benefits and as opportunity for the national economy (biofuels mainly imported, small potential for other RES, …)
- End-use energy efficiency becomes less relevant in the long-term (less than 30%)

Abatement cost curves by group of technologies for Italy

- Comparison with the wider/more recent review (IPCC 4° AR)
- Quite similar results, both with regard to potential impact of key technology/sectors (in percentage terms) and wrt to their abatement cost

	MARKAL ITALy			IPCC - 4th Assessment Report			
	Mitigation potential 2020 (MtCO2)	share on total (%)	Abatement cost (€/tCO2)	Mitigation potential 2030 in OECD (MtCO2-eq)	share on total (%)	Abatement cost (US$/tCO2-eq)	source
Modal shift passengers/freight transportation	6.5	7%	-1,167				
Energy efficiency in industry	8.5	10%	-202	725	7%	<50 per almeno 2/3 del totale	IPCC (2000) SRES B2 scenario; IPCC TAR, IEA ETP-2006, ABARE (2006)
Energy efficiency in buildings	28.2	32%	<0	4,800	46%	<0	varie
- Residenziale	16.3	19%	-43				
- Terziario	11.9	14%	-188				
Efficiency light-duty vehicles	6.5	7%	-147	571	6%	<0	IEA WEO 2006 Reference scenario + MIT (2000) Efficiency scenarios
Fuelswitch and plant efficiency	11.3	13%	10	390	4%	0-20	
Nuclear				930	9%	per metà <50, per metà 0-20	
Electricity generation from Hydro				390	4%	<0	IEA-WEO 2004 Reference + IEA-ETP 2006
Electricity generation from Wind/Geothermal	6.6	8%	61	540	5%	0-20	
Electricity generation from Bioenergy				200	2%	20-50	
Rinnovabili termiche	4.0	5%	34				
CCS+coal	1.9	2%	50	280	3%	35	
CCS+gas				90	1%	50-100	
Biofuels	7.0	8%	100	1,383	13%	<100	IEA ETP-2006, ACT Map e TECH Plus scenarios
Solar PV and CSP	3.8	4%	230	30	0.3%	>100	IEA-WEO 2004 Reference + IEA-ETP 2006
Solar thermal	2.4	3%	90				
Hydrogen	1.0	1%	1,691				
Total	87.8	100%		10,329	100%		
	21.9		70				

Conclusions

- Correct interpretation:
  - not *marginal* abatement cost curve,
  - but *specific policy scenario*
  - *mean* abatement cost curves
  - by *group of* technologies (max possible detail dependent on the complexity of the model)

- Correctly used, useful to aggregate in a single picture a huge amount of information of relevant interest for the policymakers

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