Eurelectric Project

The Role of Electricity Modelling Block

Prof. Pantelis CAPROS[1] and Paul BULTEEL[2]

World Energy Congress

Rome, 13 November, 2007

1: E3MLab, National Technical University Athens

2: Eurelectric

Scenarios for the "Role of Electricity"

Scenarios built with energy-system models

- EU-countries PRIMES Model 2000 - 2030
- EU and World Prometheus model 2030 to 2050

Inputs from bottom-up sections of the project

- Demand-side data on new electrical technologies, including heat pumps, efficient lighting, plug-in hybrid cars, etc.
- Supply-side data on new power generation technologies, including CCS

Scenario Inputs

- Common assumptions: Economic Growth of Europe and World Fossil Fuel Price
- Same CO2 Emission Targets but different Technology Deployment; no CO2 target in the Baseline

Baseline Scenario

A Business as Usual projection

- Current legislation applies but no new policies
- Technology and economy evolves
- No climate change policy
- Continuation of policies supporting renewable
- Nuclear phase out in some countries and no extension of lifetime

Economic growth 2% pa on average

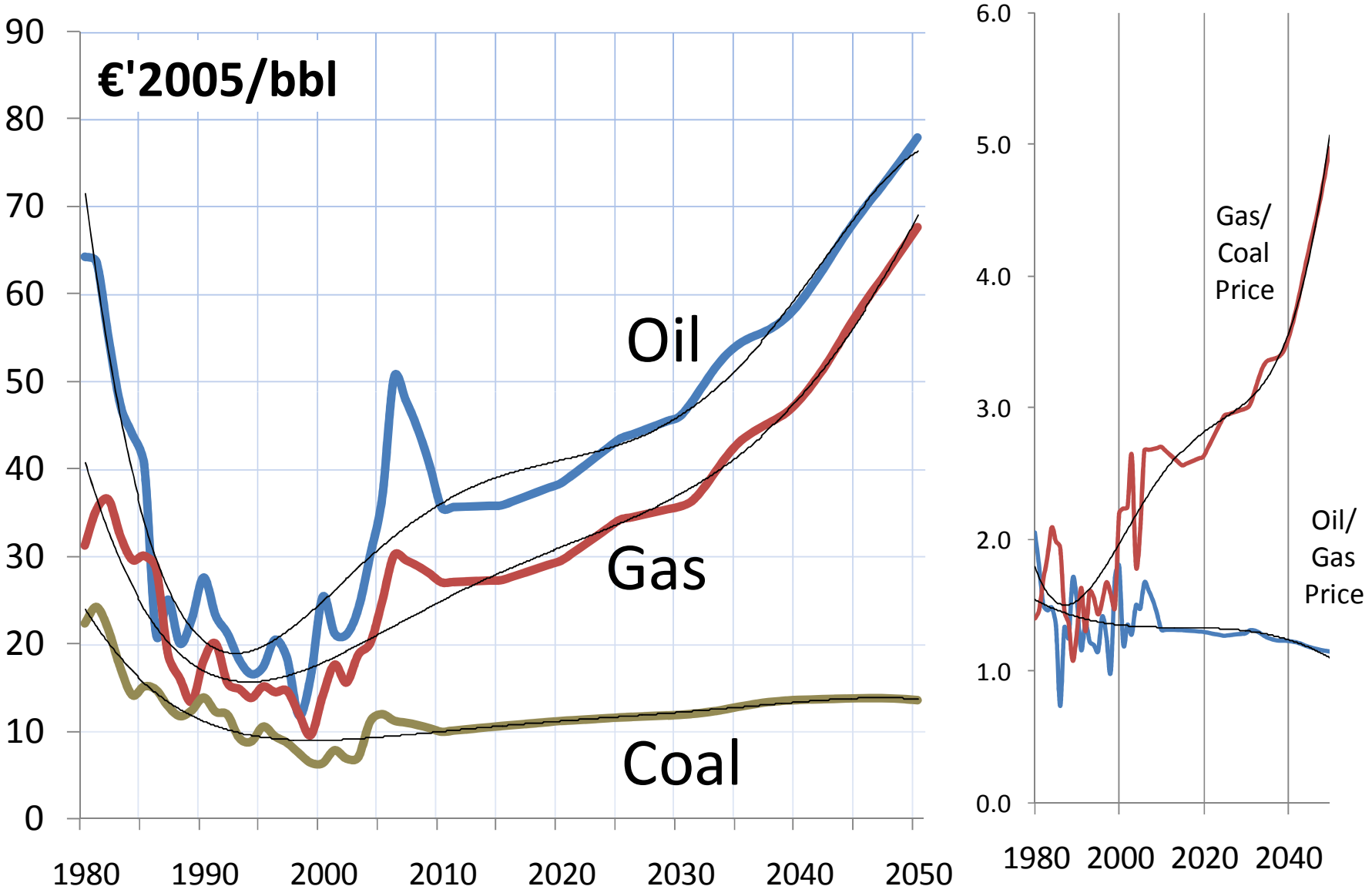
- Gradual restructuring of the economy towards services

High world oil and gas prices

- 2010-2030 slowly increasing in real terms
- 2030-2050 rising faster

Gas to coal competitiveness deteriorates

High Oil and Gas Prices

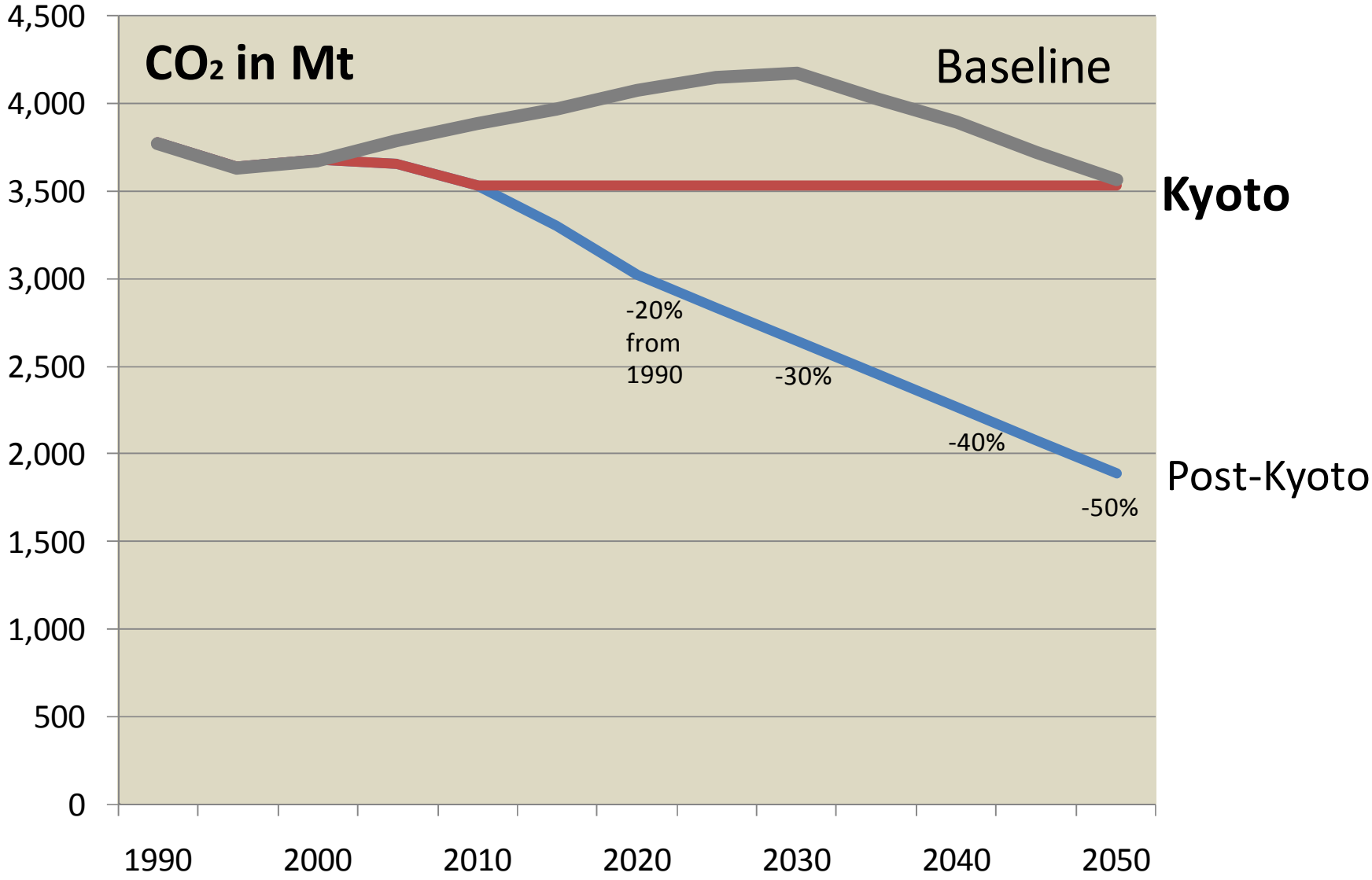


E3M - Lab

Baseline Outlook

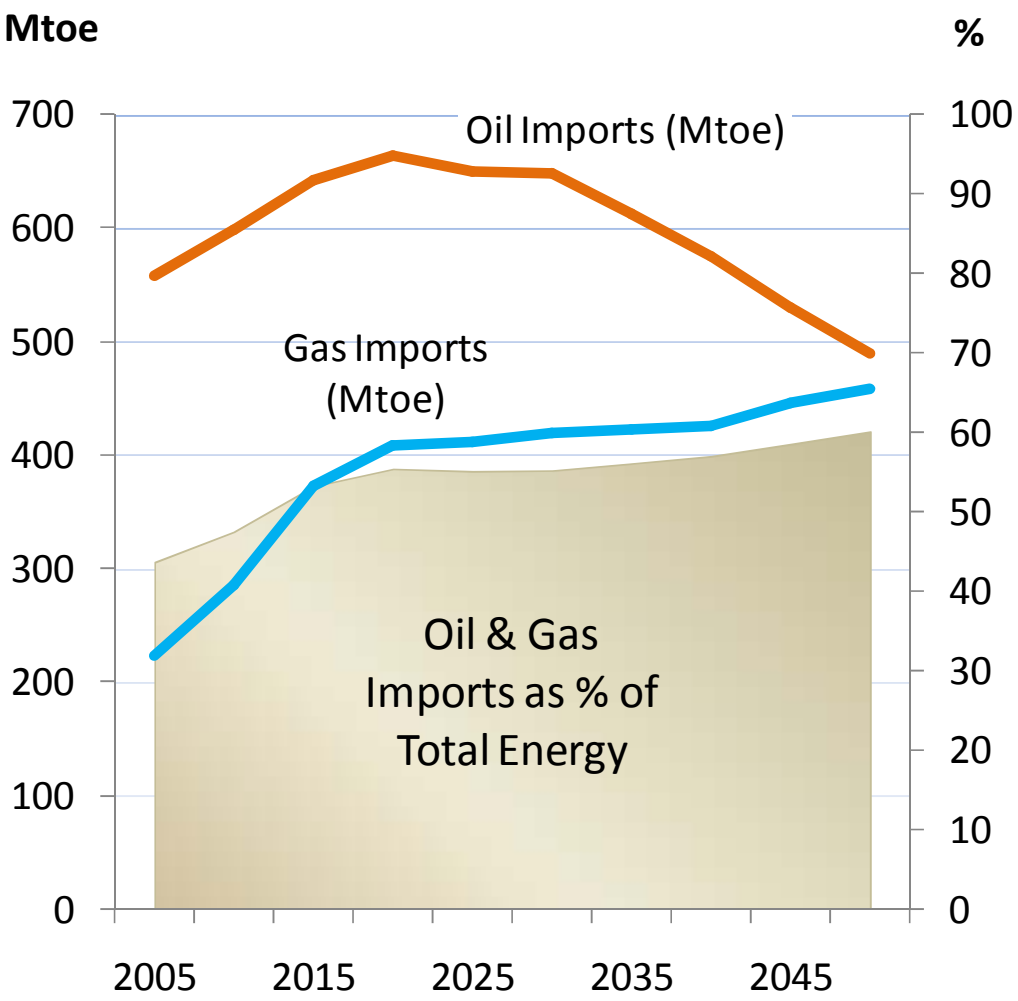
EU25 - Year 2005	2005 to 2030	2030 to 2050
460 million people	Stable	Small Decline
9.7 trillion GDP	2% per year	1.2% per year
1,744 Mtoe Gross Energy	0.3% per year	-0.09% per year
Energy Intensity (Energy/GDP)	*-1.7% per year*	*-1.3% per year*
904 Mtoe Imported Energy	+1.5% per year	-0.5% per year
Import Dependence : 50%	*68% in 2030*	*62% in 2050*
3,177 TWh Electricity	1.47% per year	+0.5% per year
726 GW Power Capacity	822 GW New	605 GW New
3,800 Mt CO_2 Emissions	0.4% per year	-0.78% per year
Index (1990=100) : 100.3	*110.5*	*94.5*

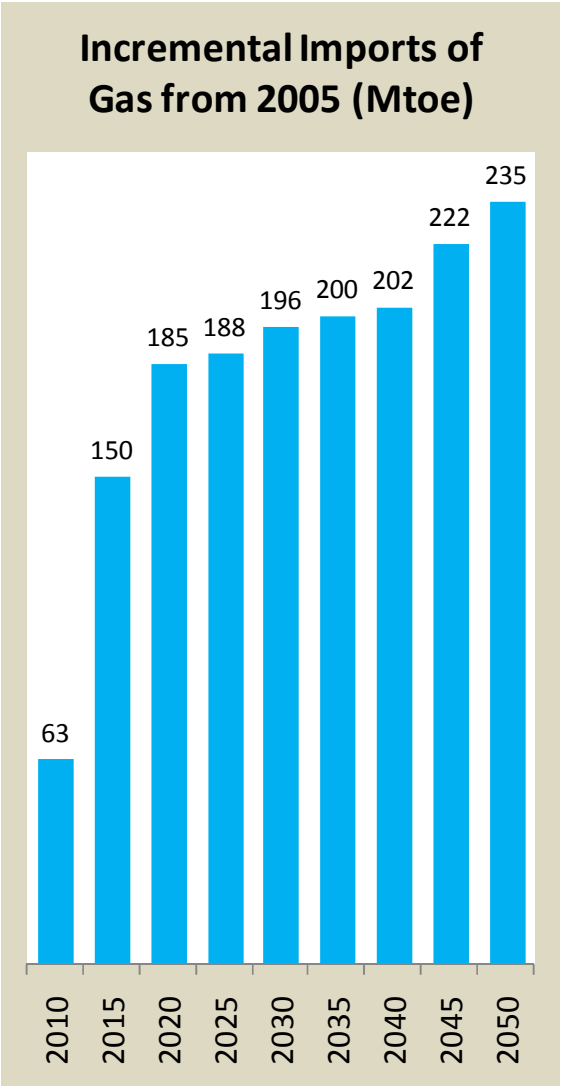
Baseline: CO_2 emissions deviate from targets



E³M - Lab

Baseline: Growing Dependence on Oil and Gas Imports





E3M - Lab

Alternative Scenarios

Three Goals

- Cap on CO_2 emissions (1)
  - from 1990: -20% in 2020, -30% in 2030, -50% in 2050
- Reduce security of supply vulnerability
- Least impact on energy costs and prices

Means

- Accelerated Energy Efficiency
- Higher Development of Renewables
- Demand-side electro-technologies
- Nuclear policy: no phase-out, extension of life time, new technology
- Carbon capture and storage technology

(1): The cap on emissions is imposed at the level of the whole of the EU; the model determines the "optimal" burden sharing by assuming as if a perfect ETS was operating over the entire system

Definition of Alternative Scenarios

Scenarios / *Policies*	Efficiency & RES	Supply Scenario	Role of Electricity
Energy Efficiency - policy package for all sectors	YES	NO	YES
Electro-technologies - lighting, appliances, motor drives, heat pumps, plug-in hybrid cars	NO	NO	YES
Renewables - supportive policies, no further subsidies	YES	NO	YES (*)
Nuclear Policy - no phase out, extension of lifetime, but no new nuclear country except the new MS	NO	YES	YES
Carbon Capture and Storage for Coal and Gas Plants and development of transport and storage	NO	YES	YES

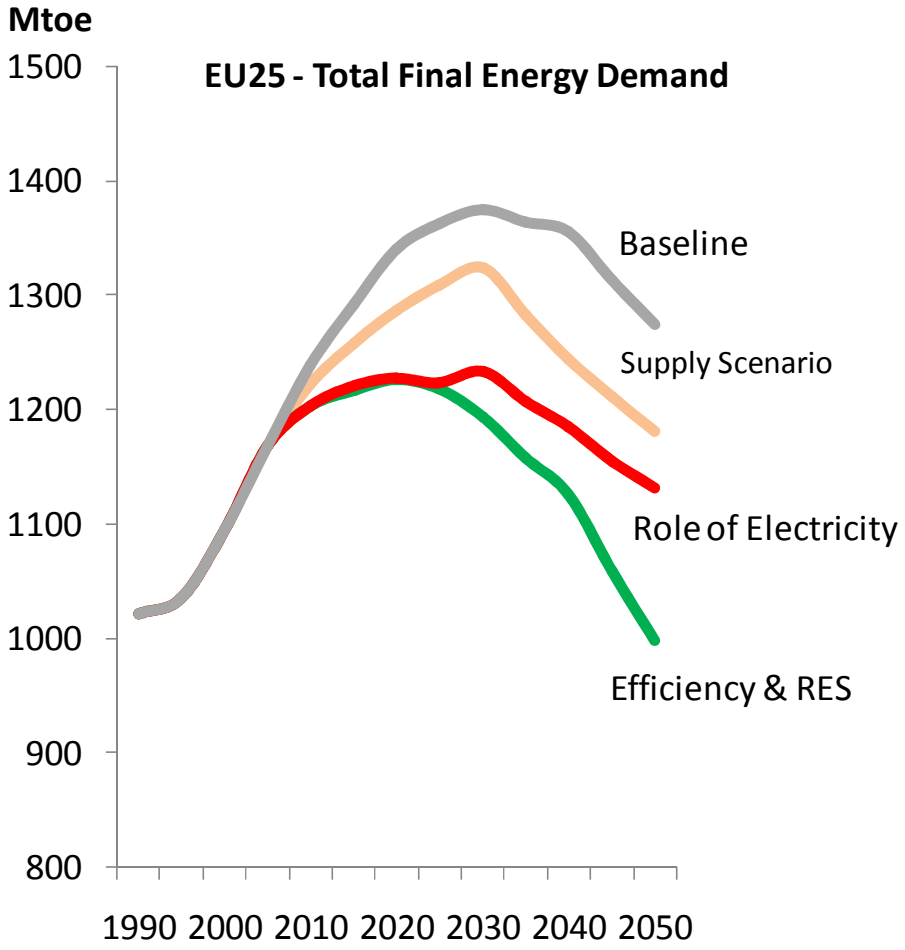
(*): Lower support for Biomass than "Efficiency & RES"

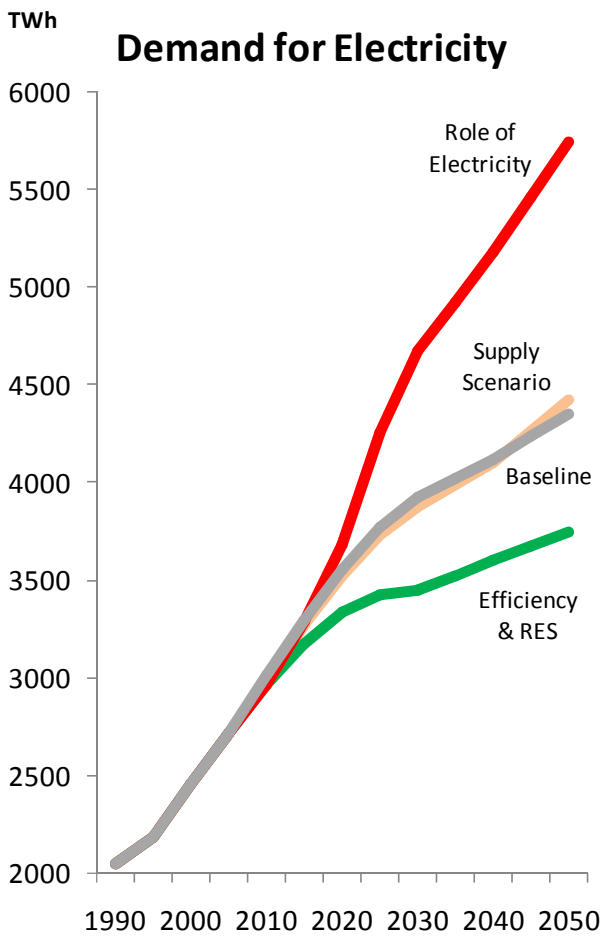
Performance of Scenarios

Index (2005=100)	Total Cost of Energy		Dependence on Imported Oil & Gas		CO_2 Emissions from Energy	
	2030	**2050**	**2030**	**2050**	**2030**	**2050**
Baseline	146	159	126	138	110	95
Efficiency & RES	156	164	128	137	70	50
Supply Scenario	161	169	115	114	70	50
Role of Electricity	**147**	**164**	**105**	**102**	**70**	**50**

For equal emission mitigation, “Role of Electricity” performs better :

Additional Costs are the lowest and reduction of Dependence is the highest

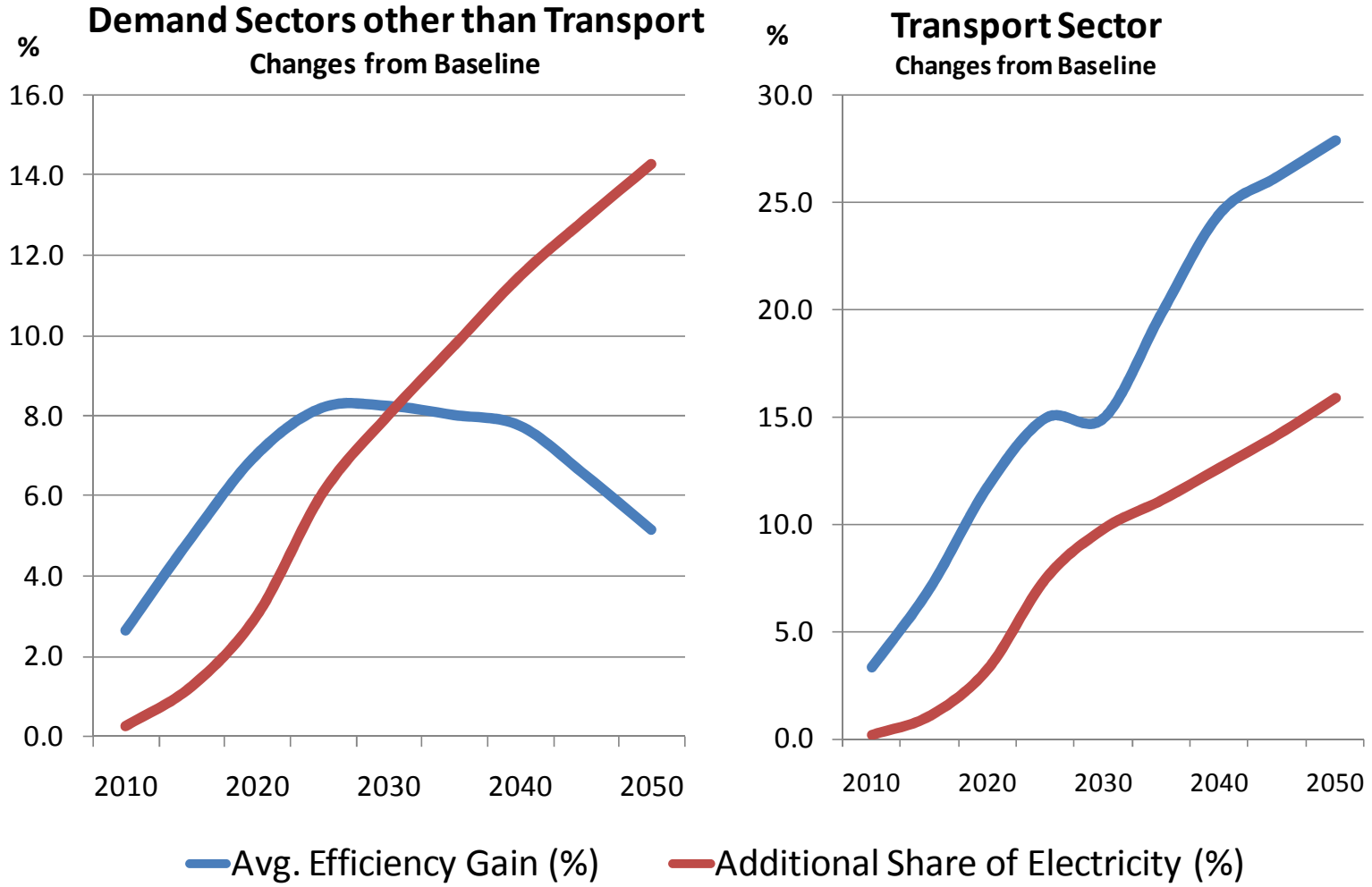




All Scenarios reduce energy demand from Baseline by improving energy efficiency – highest gains in "Efficiency & RES" followed by "Role of Electricity"

In the "Role of Electricity" Scenario, electricity substitutes for fossil fuels in end-uses (transport, heating and processing)

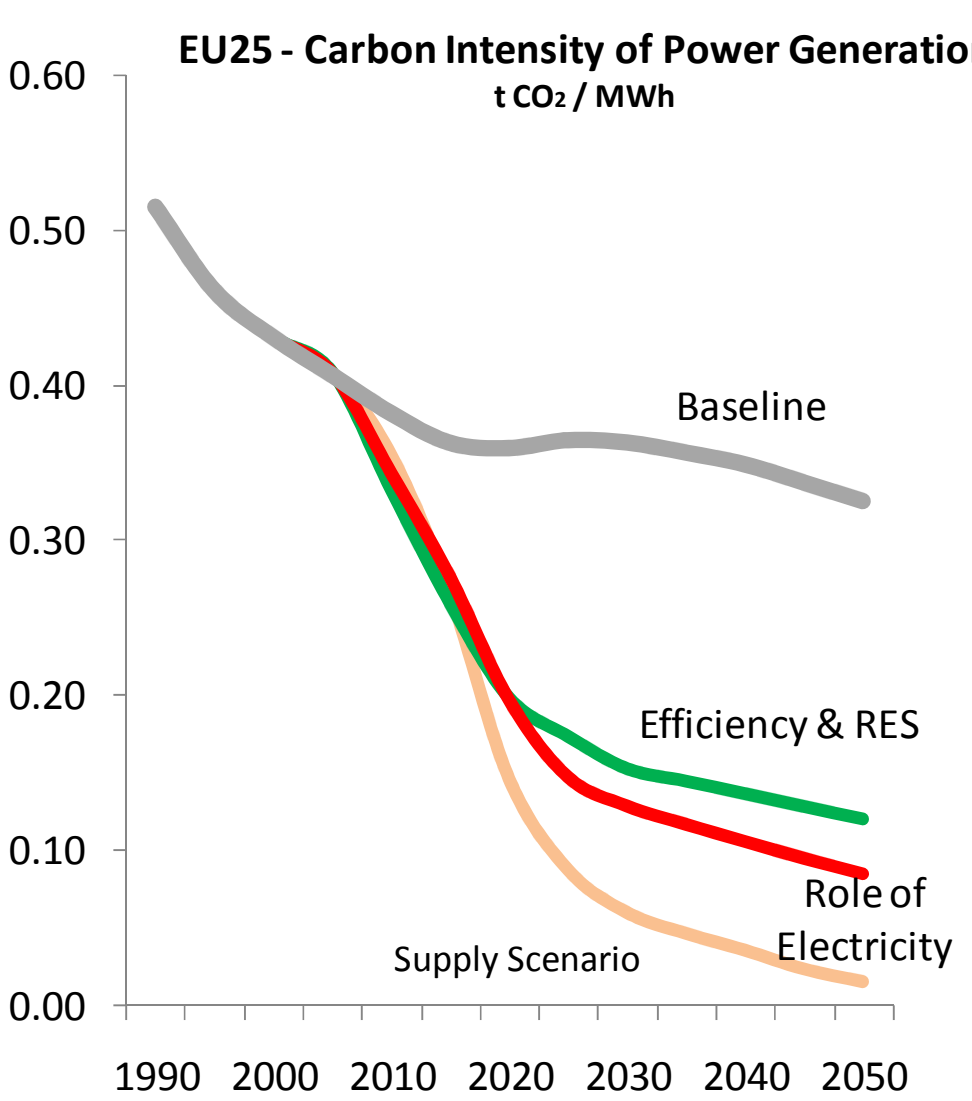
E3M - Lab

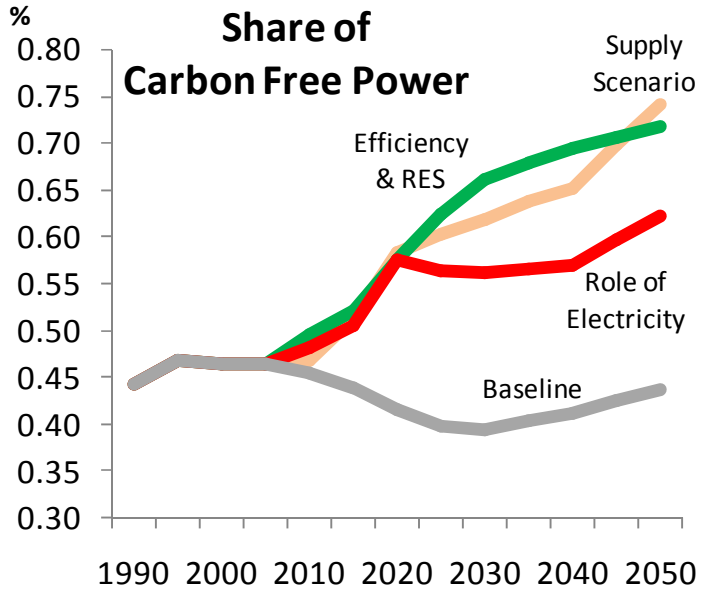


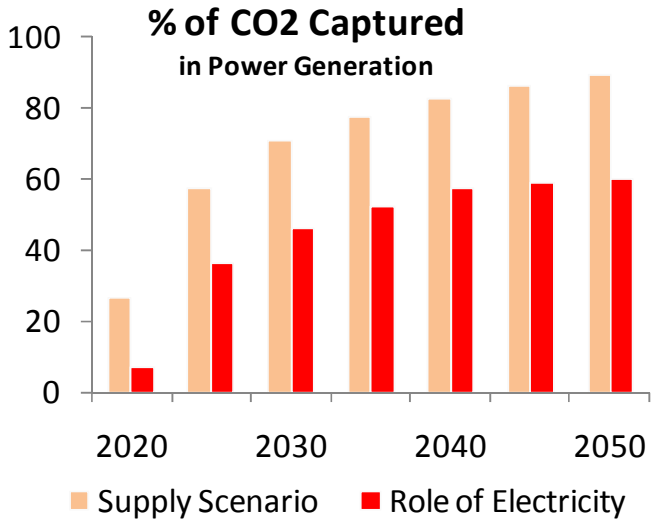
The "Role of Electricity" Scenario enables an Intelligent Use of Electricity:

- Energy Efficiency improves, also as a result of advanced electro-technologies
- Electricity penetrates heat and motion markets, facilitated by advanced electro-technologies

E3M - Lab

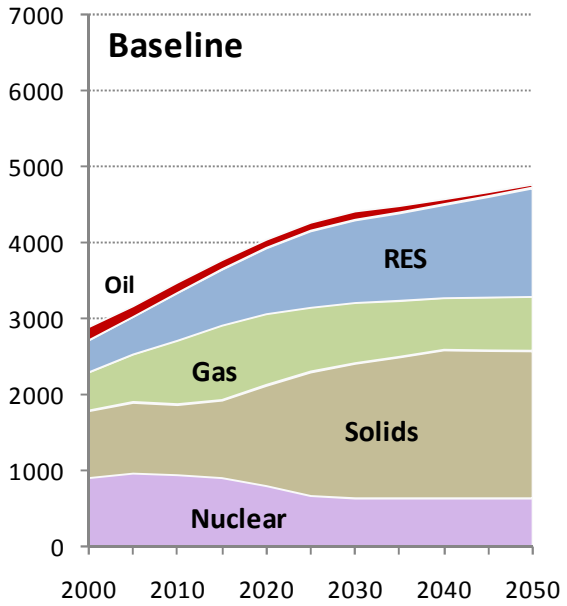


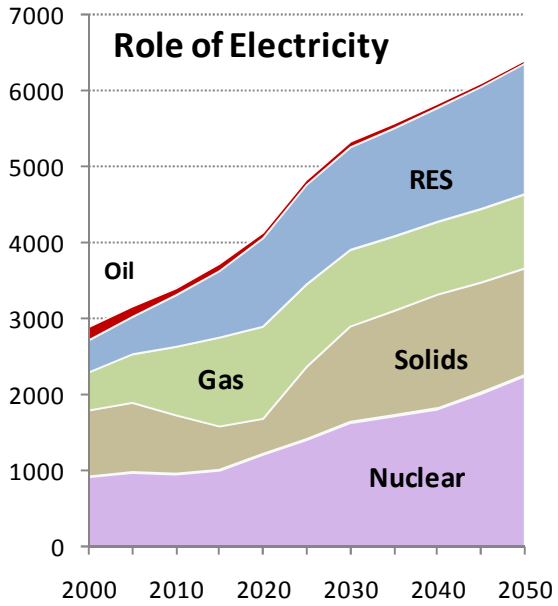


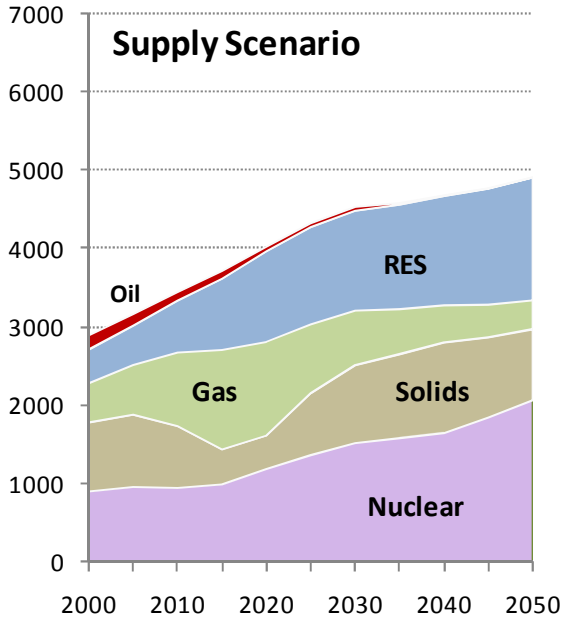


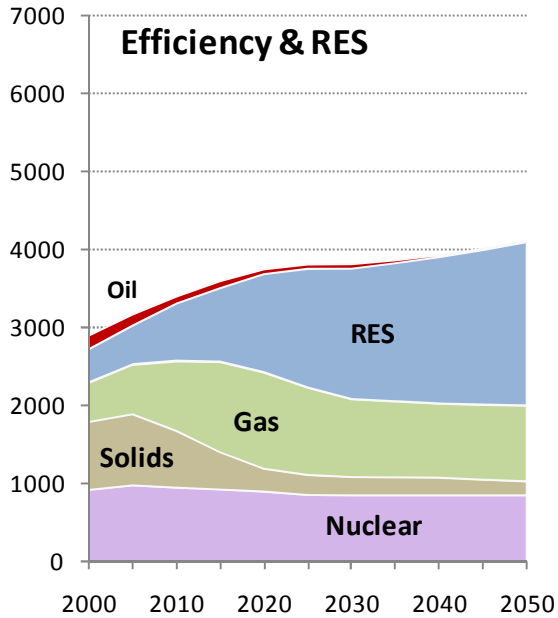
All Scenarios transform Power Generation lowering Carbon Intensity but they differ substantially in structure

E3M - Lab









Power Generation by Source in the EU25 (in TWh)

Efficiency & RES Scenario

- Lowest total power generation
- Highest development of RES
- Persisting dependency on Gas

Supply Scenario

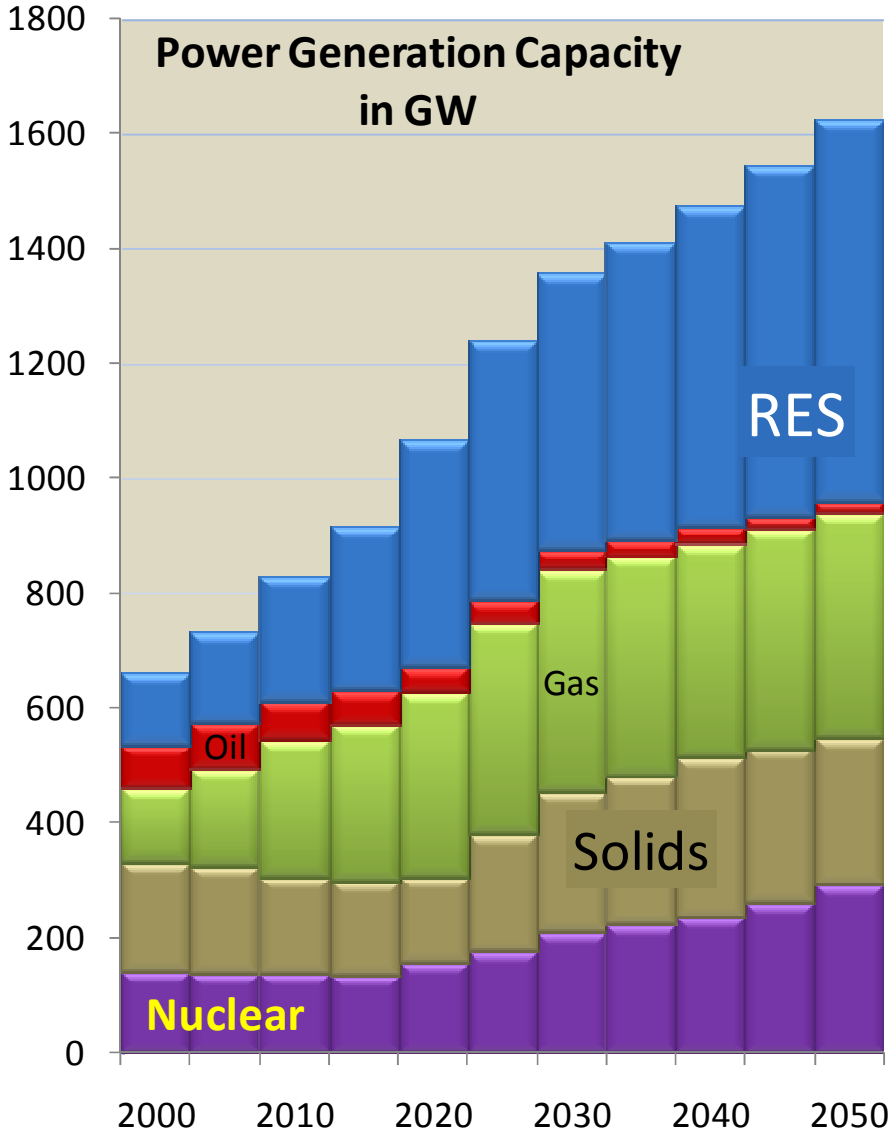
- High Development of Nuclear
- Coal re-emerges beyond 2020 based on CCS technology
- Significant use of RES
- Low generation from Gas

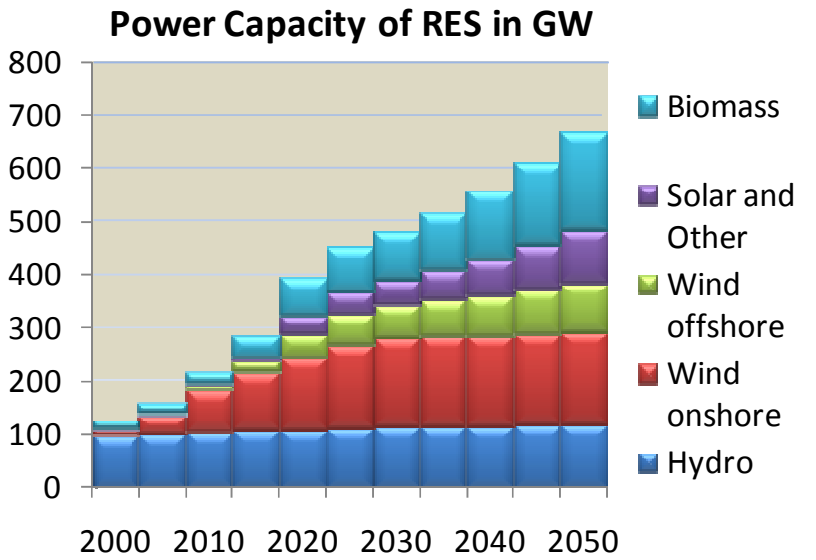
Role of Electricity Scenario

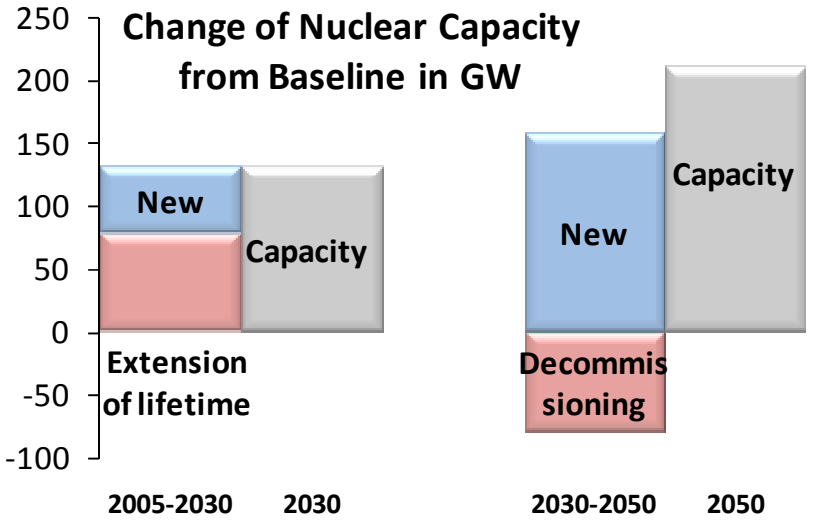
- Highest total power generation
- More balanced structure
- All sources develop: nuclear as in Supply, RES almost as in "Efficiency & RES", Solids with CCS as in Supply
- Persisting use of Gas

E3M - Lab

Role of Electricity Scenario – Power Capacity

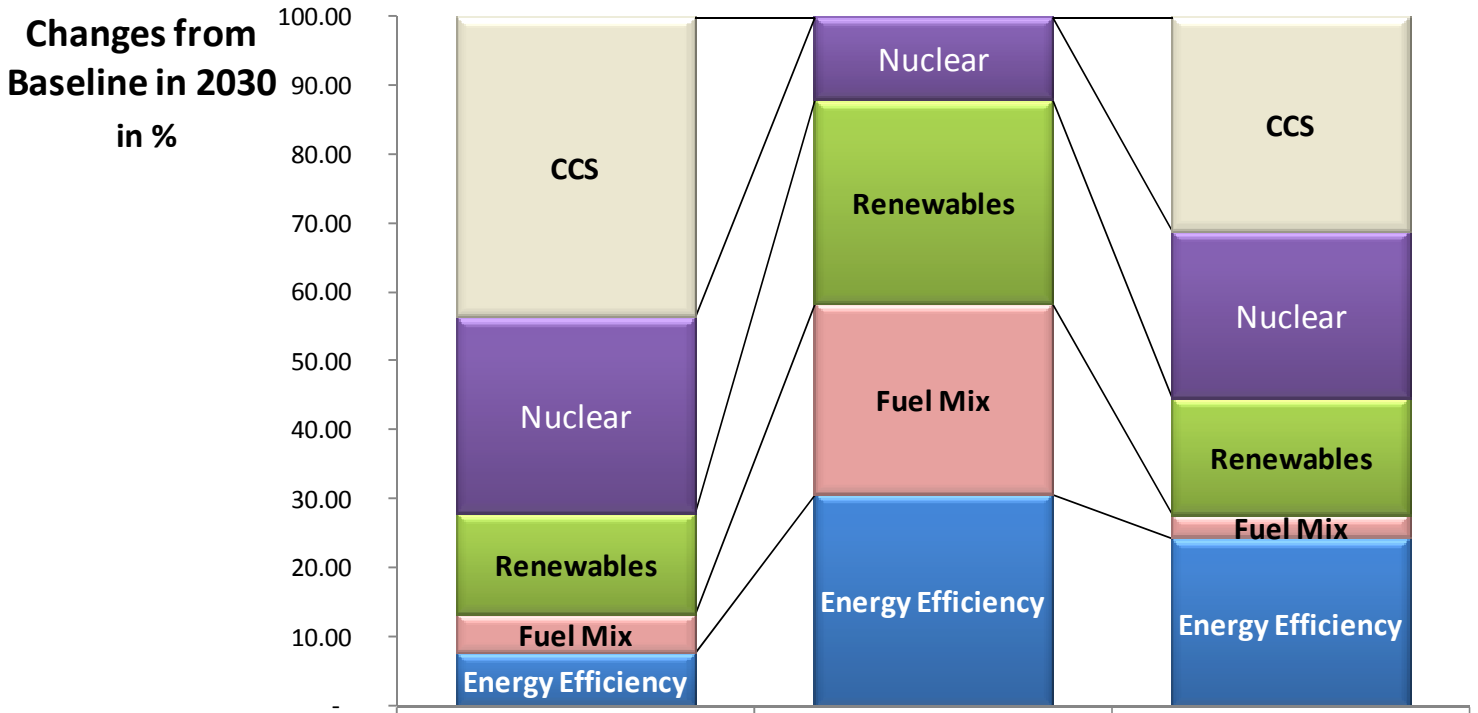






E3M - Lab

Decomposition of CO2 Emissions Avoided in each Scenario from Baseline in 2030



	Supply Scenario	Efficiency&RES	Role of Electricity
CCS	43.58	-	31.23
Nuclear	28.48	12.14	24.12
Renewables	14.55	29.57	16.96
Fuel Mix	5.74	27.42	3.42
Energy Efficiency	7.66	30.86	24.27

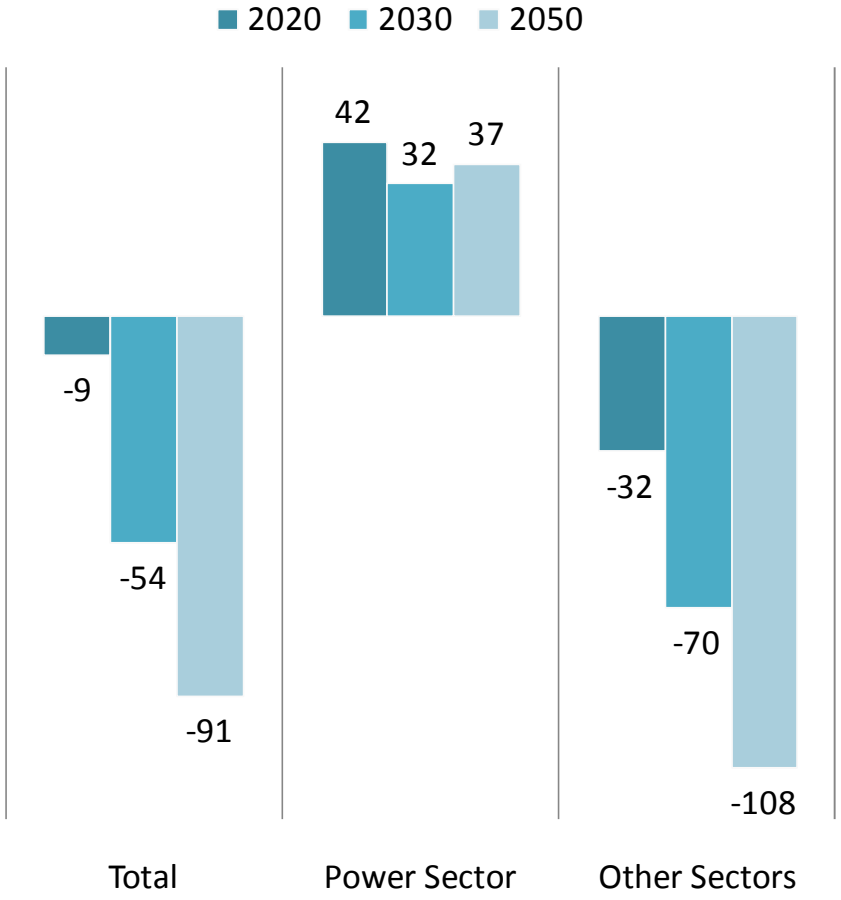
The Role of Electricity Scenario

has the most balanced structure in the reduction of emissions

E3M - Lab

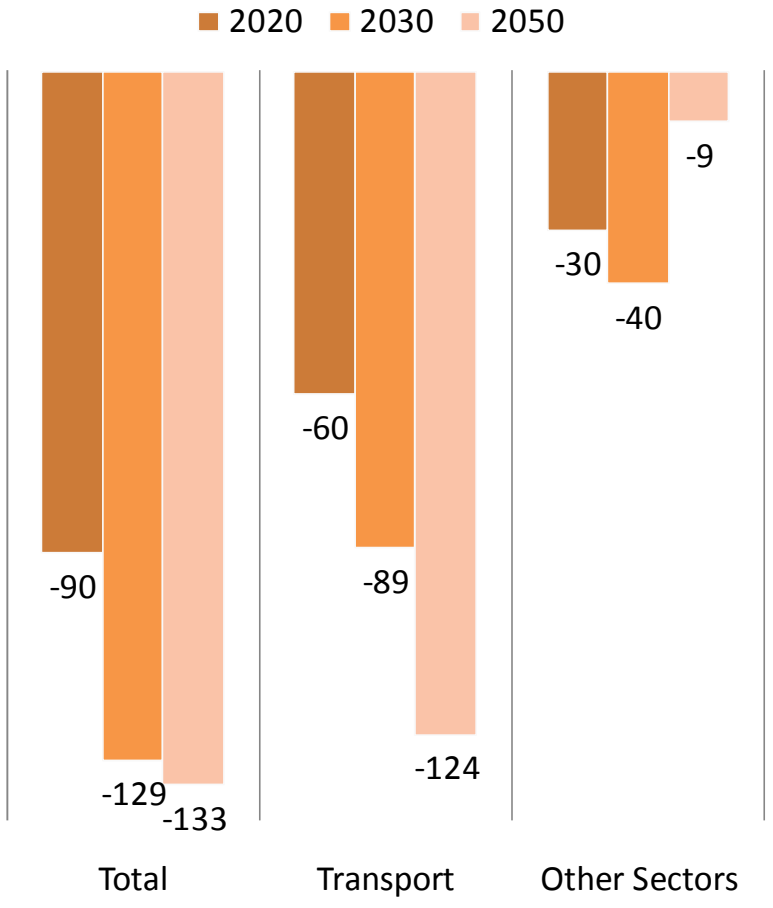
Use of Gas in the EU25 (Mtoe)

Differences of "Role of Electricity" from "Baseline"



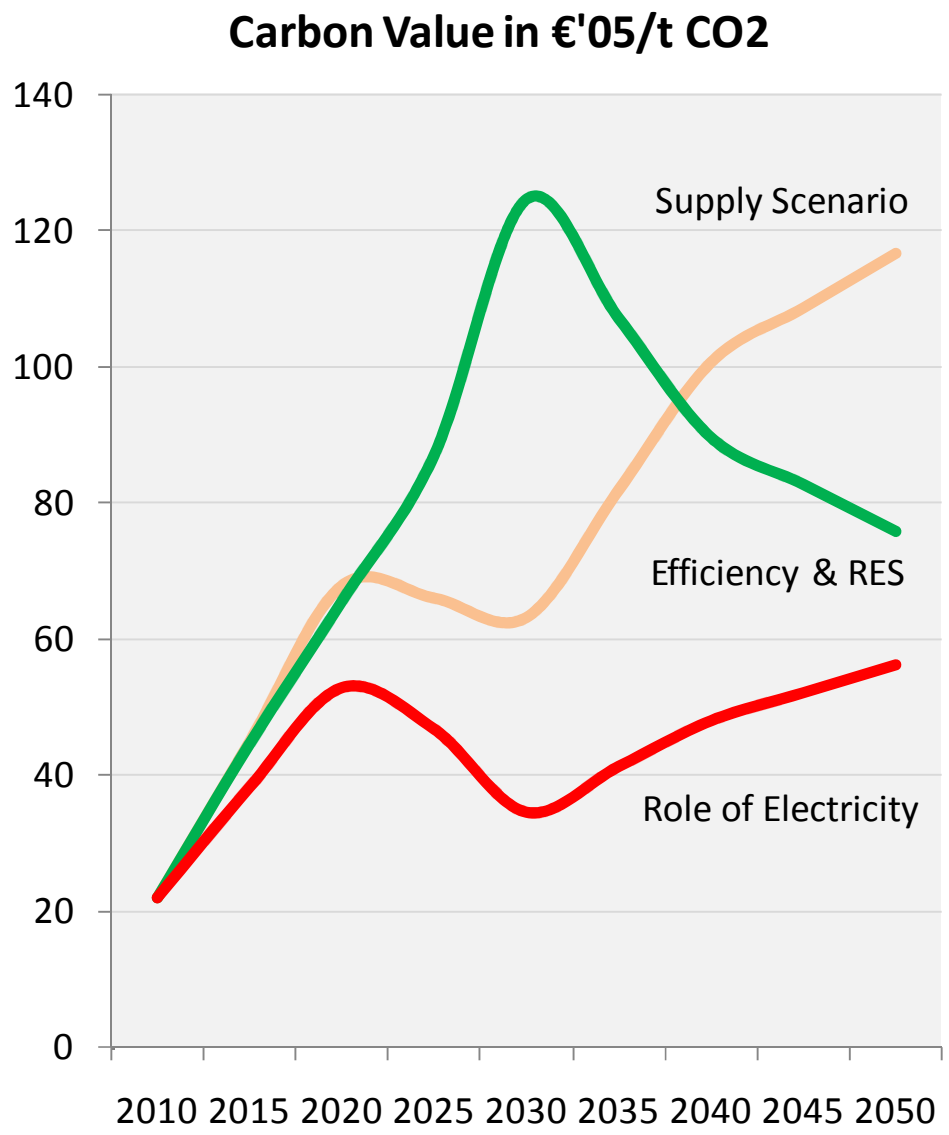
Use of Oil in the EU25 (Mtoe)

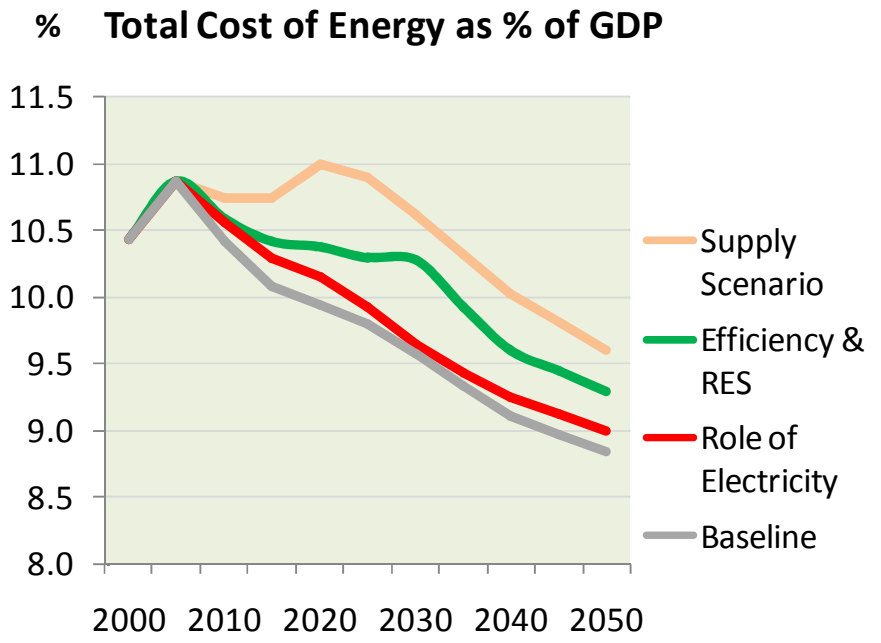
Differences of "Role of Electricity" from "Baseline"

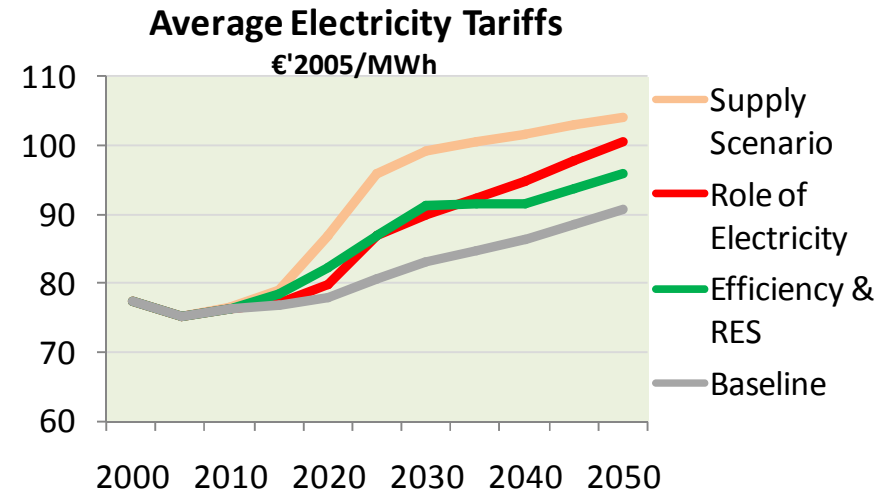


The "Role of Electricity" Scenario reduces dependence on oil and gas imports, more than any other scenario

E3M - Lab



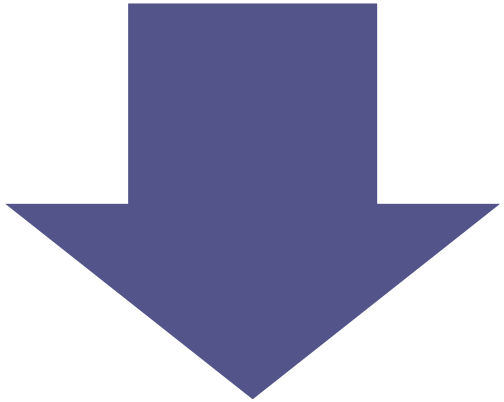




The Role of Electricity Scenario induces the lowest additional costs

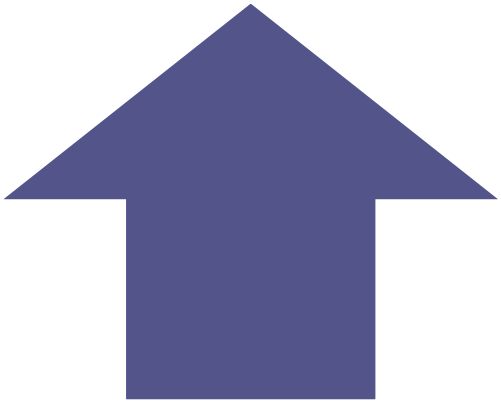
E3M - Lab

Conclusions – Baseline scenario



The baseline scenario clearly represents a non sustainable future in terms of environmental impacts (climate) and security of supply (import dependence)

The baseline scenario improves if the nuclear option is freed (no phase out and extension of lifetime) and if efficiency and renewables policies prove more effective



Conclusions – Role of Electricity

For ambitious reduction of CO_2

(*e.g. in 2030 30% down from 1990*)

An electricity-related package of options with changes in both demand and supply

can be very cost-effective

The package

- **reduces dependence** on imported oil and gas
- high technology progress and **positive** economic growth effects
- additional cost to consumers, but **lowest** among all carbon-reducing scenarios

Conclusions – Cost Effectiveness

Key to cost-effectiveness

Higher but intelligent electricity use on the demand-side combined with very low carbon-emitting power generation

Success of a series of technologies and policies

Plug-in hybrid cars and vehicles	Heat pumps, efficient lighting etc.	Ambitious development of energy efficiency	Higher development of renewables	Carbon Capture and Storage	Nuclear energy

Conclusions – Portfolio Approach

Cost-effectiveness of emission reduction relies on:

- a) the "**portfolio**" character of the electricity-related package and
- b) the **intelligent use of electricity**

All options, demand or supply, must be **open** so as to exploit their highest cost-effectiveness potential

- According to the model-based analysis, approaches that exclude certain options are not cost-effective

Model-based sensitivity analysis including scenarios assuming very high fossil prices:

- **the results are confirmed and are fairly robust**

Thank you for your attention

Web: http://www.e3mlab.ntua.gr
http://www.eurelectric.org
E-mail: kapros@central.ntua.gr
pbulteel@eurelectric.org