EUROPEAN SUSTAINABLE ELECTRICITY:
Future challenges and R&D priorities
EC, Brussels, 19 December 2006

Electricity demand, energy savings and energy efficiency

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How to forecast energy demand

There are essentially three ways to make predictions about the future demand for energy (and for electricity in particular):

1. The extrapolation of present trends with some provision for the possibility of major changes
2. A top-down approach, which considers an exogenous forecast of economic development, assumes an overall energy intensity of GDP (variable with time), and a “reasonable” curve of electricity penetration with time
3. A bottom-up approach, which again assumes some exogenous variables like GDP, population and international fuel prices, and starts from the evolution of the demand for energy <u>services</u>, applying predicted technology evolution that gradually improves energy efficiency.

A combination of top-down and bottom-up approaches

The extrapolation approach, while generally very useful for short to medium term predictions, fails to predict any non-linear trend and becomes utterly unreliable for long period of times (like the 25+ years we are considering here). Therefore it will not be taken into consideration here.

Both the top-down and the bottom-up approaches have their merits and their limitations.

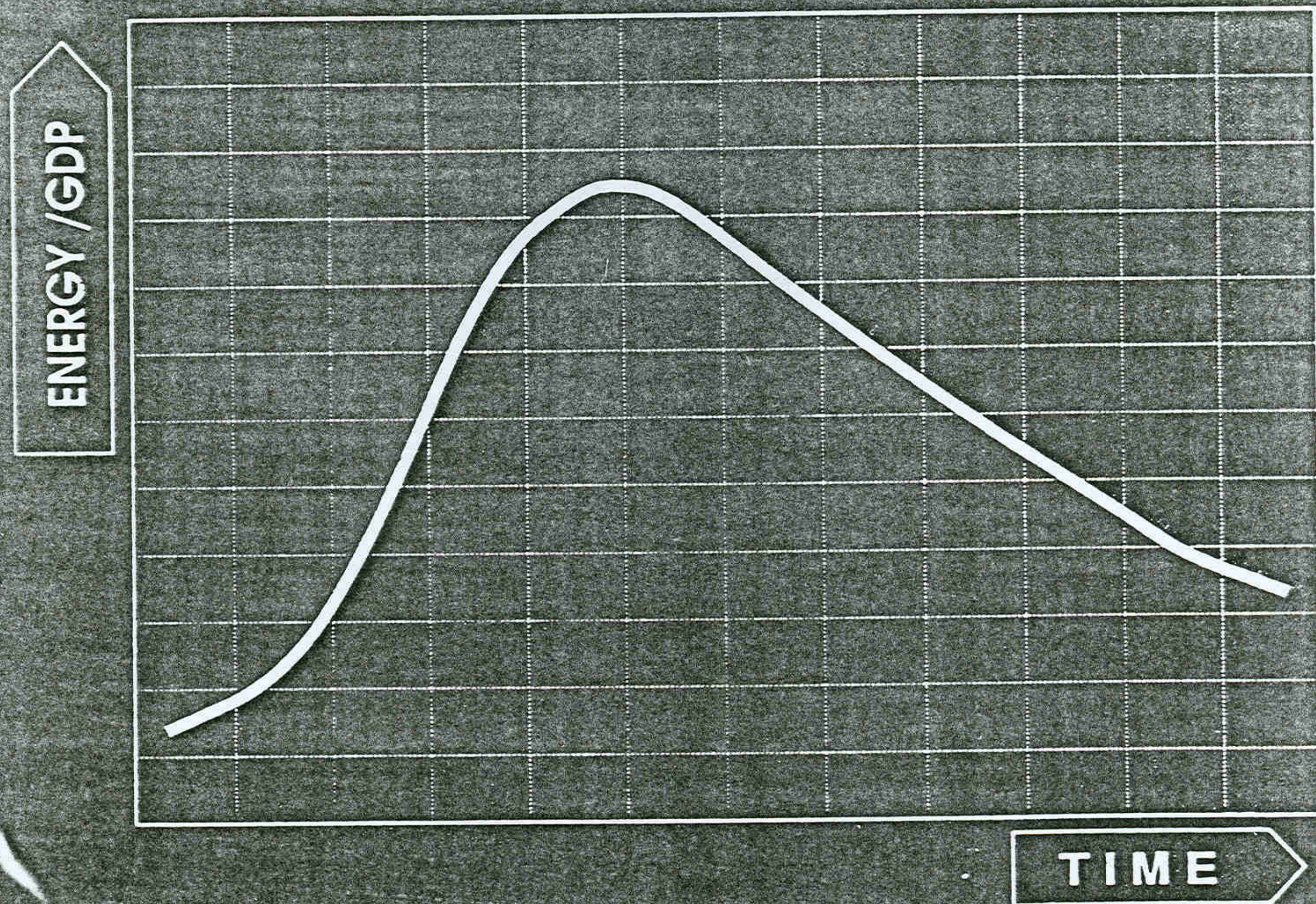
The approach that is suggested here is to use both methods, compare the results and try to sort out the reasons for possible discrepancies.

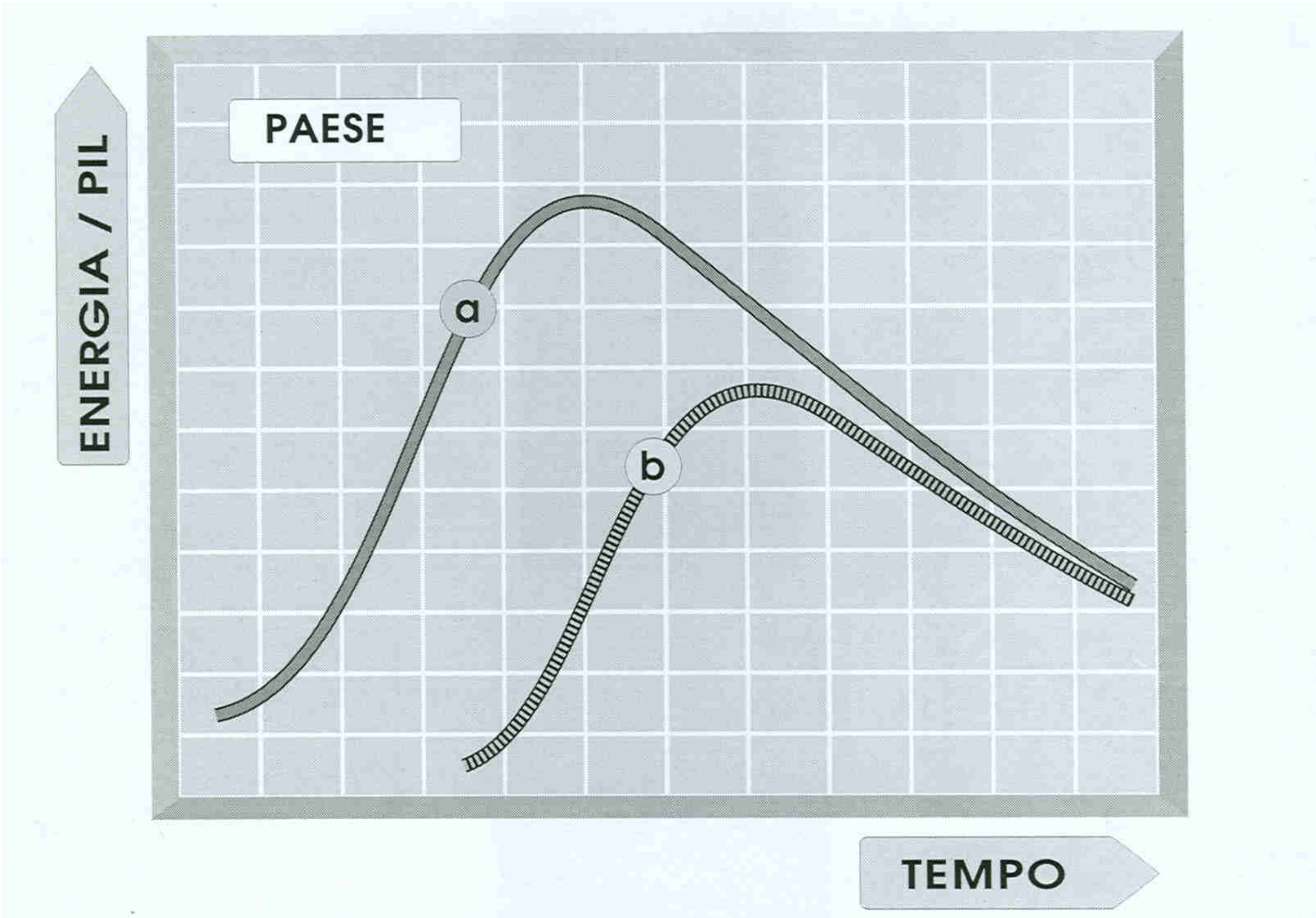
The top-down approach

- The curve connecting the energy intensity of GDP with the per capita GDP has been extensively studied for various countries, sectors and periods. The EU is certainly well into the descending part of the curve, and it can reasonably be predicted that the trend will continue in the future.
- Some caution must be applied to the case of the new-comers into the EU, especially those that used to belong to the Centrally Planned Economies. In that case, the far from optimum energy efficiency that prevailed in the past, and the economic crisis that has accompanied the transition to a market economy, will require a specific treatment for which expertise from those countries should be exploited.

OF GDP THROUGHOUT THE ECONOMIC
DEVELOPMENT OF A COUNTRY

ENERGY INTENSITY OF GDP THROUGHOUT THE ECONOMIC DEVELOPMENT OF A COUNTRY




PAESE
ENERGIA / PIL
a
b
TEMPO

Demand elasticity

- The demand for energy will be affected to some degree by the prices of energy. This can be taken into account at the macro level by introducing an elasticity of demand to price.
- A single value for the elasticity of (electricity) demand is probably too rough an approximation. It is suggested to take three different values for:
- The industrial sector
- The household sector
- The commercial and service sector

(typical values may be 0.3, 0.15 and 0.4 respectively)

(the transport sector does not seem to be relevant for electricity demand, unless one makes very optimistic assumptions on battery cars)

Scenarios used

Main scenario studies the results of which have been used for the present analysis were:

- EU-DG TREN European energy and transport trends to 2030 (PRIMES)
- IEA World Energy Outlook 2004 (WEO)
- US-DoE/Energy Information Agency, International Energy Outlook (2004 and 2005)
- EU-DG TREN White and Green Project results 2005

Other inputs

- Data and insights have also been derived from the following sources:
- EU- DG RES, WETO-2030 World Energy Technology Outlook to 2030; WETO 2050
- EUROSTAT
- UN-Habitat
- IIASA
- World Energy Council

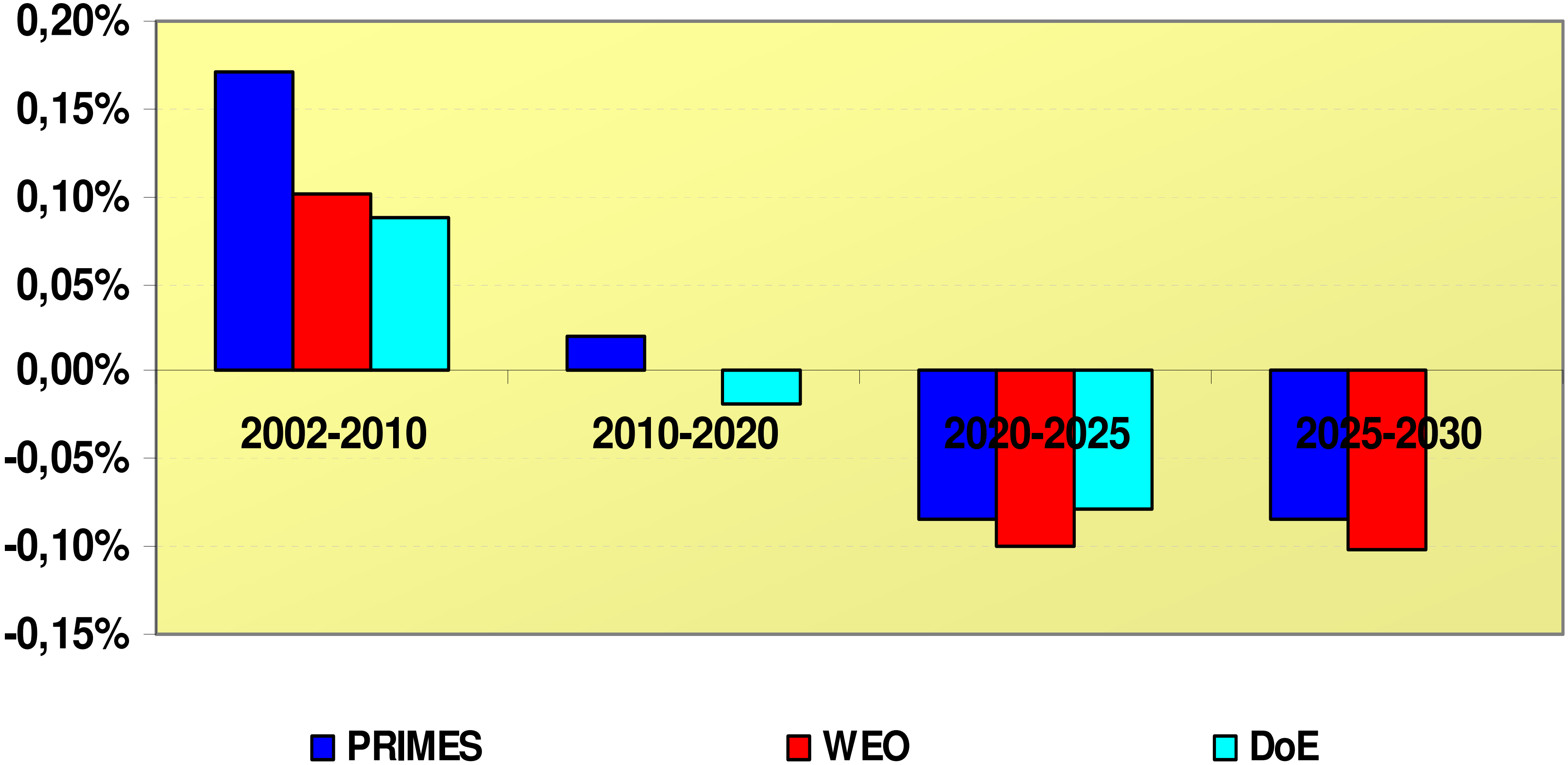
The final report analyses each of these models in terms of input, methodology etc.

Basic input data for the models

The inputs of the various models and in some cases their results have been analysed and compared in order to identify the most reasonable inputs to suggest for the modelling work to be carried out within EUSUSTEL (WP-5) concerning:

- Demography (where all models are very close to each other and predict a substantial stability of the population of the EU)
- Gross Domestic Product (where an yearly growth rate just above 2% is expected)
- Energy prices (where two scenarios are considered: a "low price" scenario that considers the present high prices as temporary and expects a return to the long-term trend, and a "high price" scenario where this rise is seen as structural).

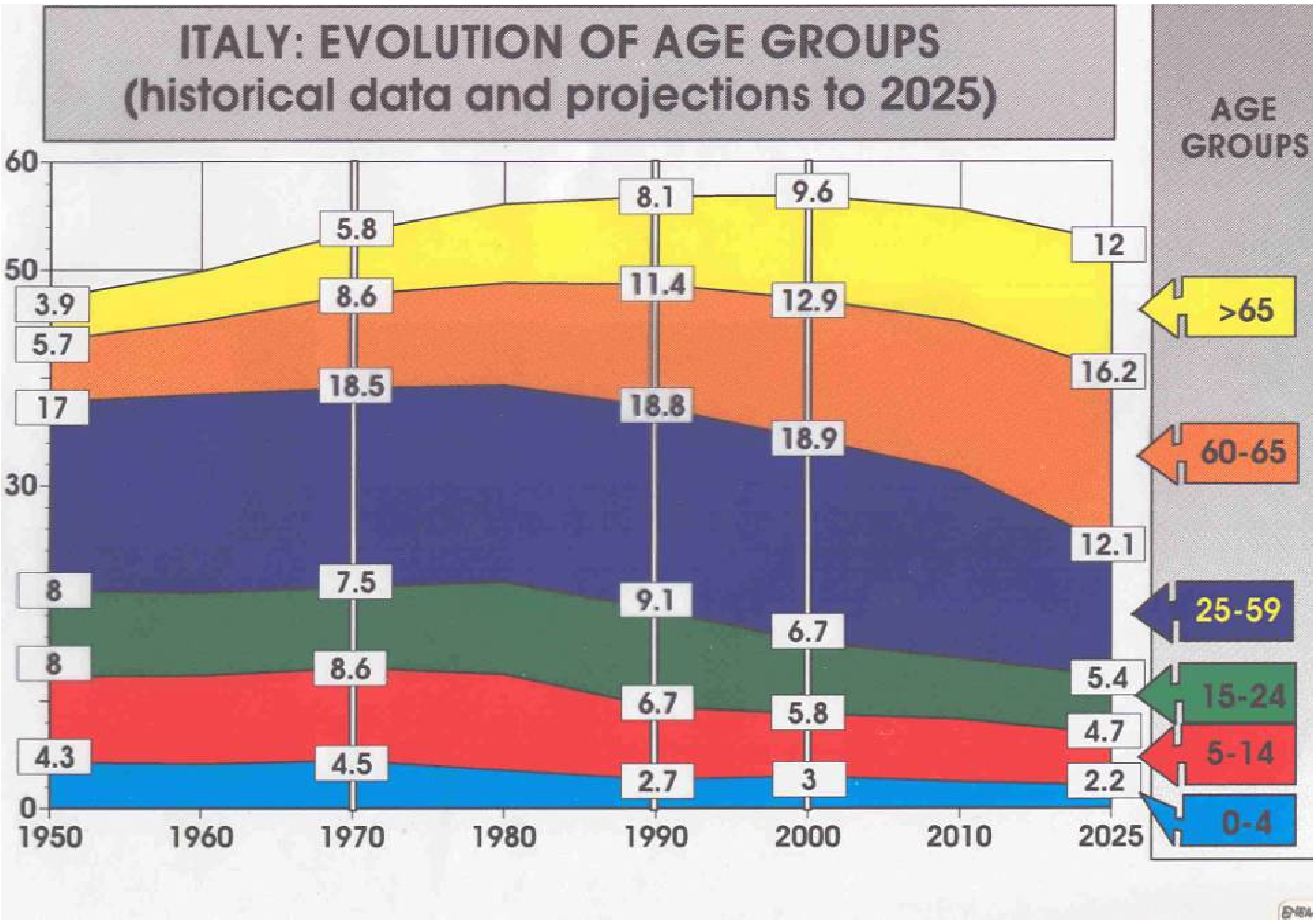
Population growth rate to 2030



Other inputs

Other inputs that have been considered include:

- The number of households (where the trend is toward an increase, even with a stable population, as the average number of persons per household tends to 2)
- The age distribution of the population (shifting to an older population in the EU, with possible repercussions on the type of energy services required).


ITALY: EVOLUTION OF AGE GROUPS
(historical data and projections to 2025)
AGE GROUPS
>65
60-65
25-59
15-24
5-14
0-4
60
50
30
0
1950
1960
1970
1980
1990
2000
2010
2025
3.9
5.7
17
8
8
4.3
5.8
8.6
18.5
7.5
8.6
4.5
8.1
11.4
18.8
9.1
6.7
2.7
9.6
12.9
18.9
6.7
5.8
3
12
16.2
12.1
5.4
4.7
2.2

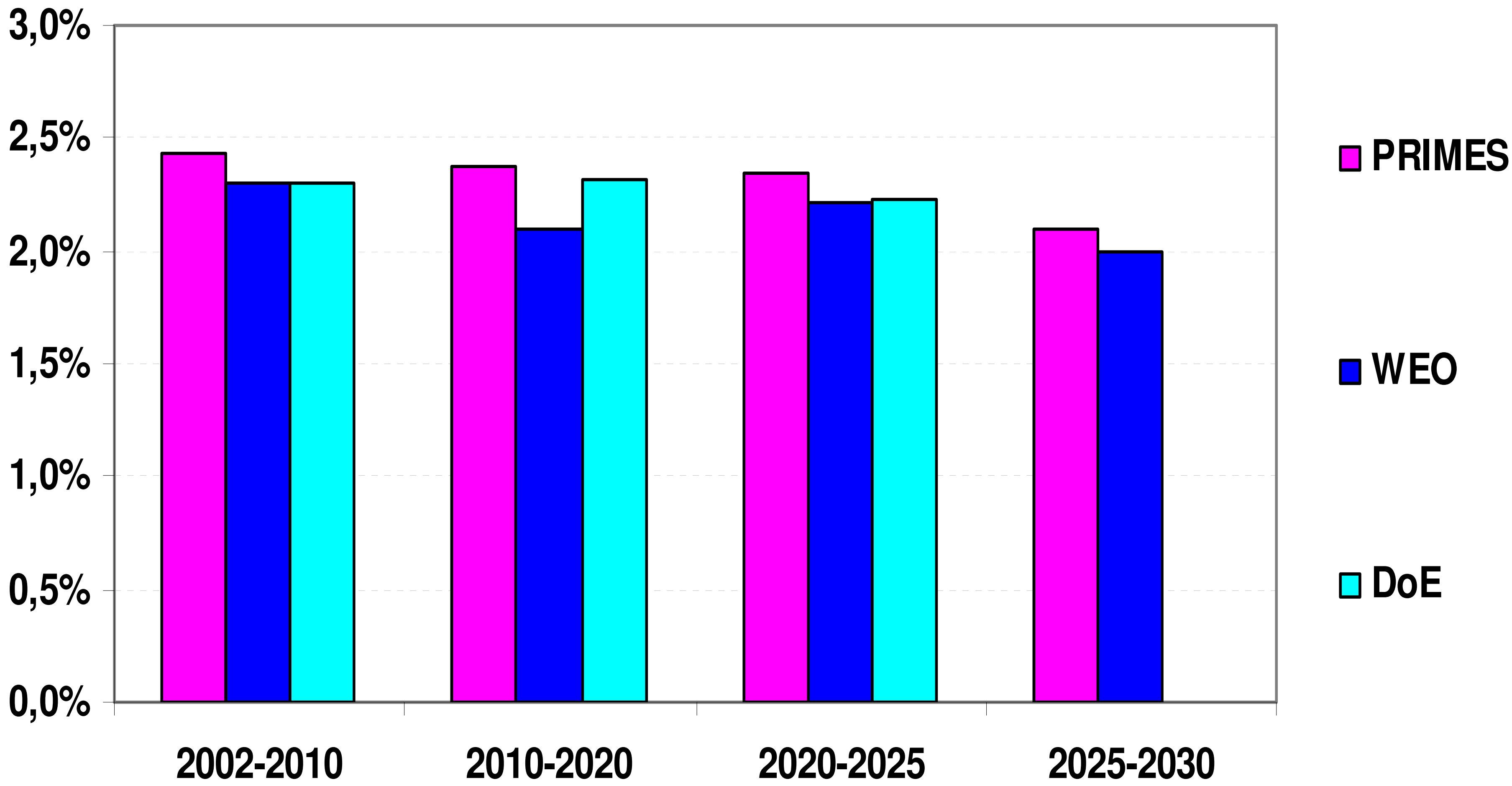
Top-down evaluation of energy demand

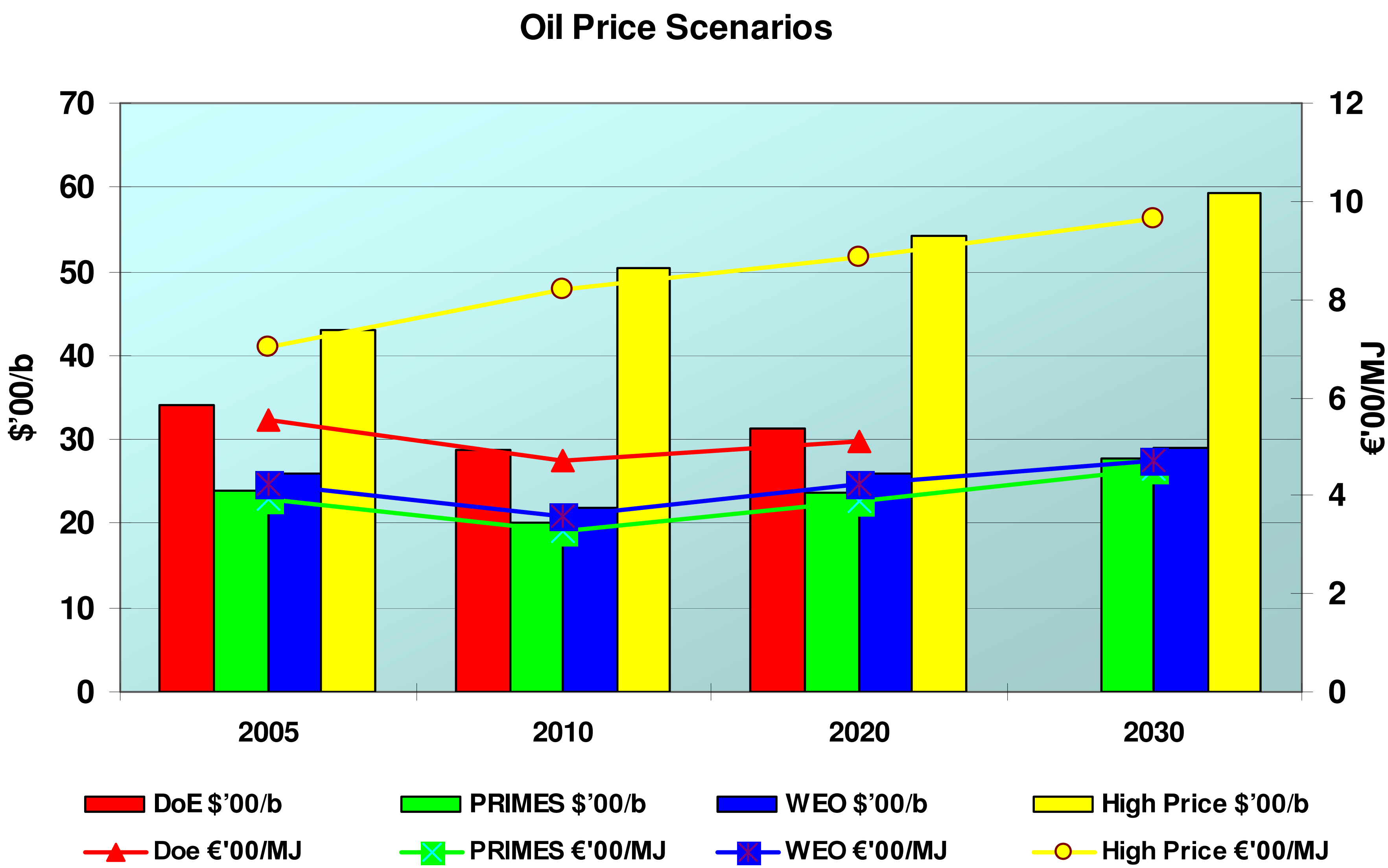
The energy demand is evaluated first in a macroscopic, top-down approach in a rather aggregated form. The method followed is to correlate energy demand with GDP (Gross Domestic Product) through the consideration of energy intensity (energy demand per unit of GDP)

The energy demand may be subdivided in sectors (such as industry, transportation, residential and commercial) but the demand is not examined in detail.

The projected EU energy demand by 2030 is just below 1500 Mtoe per year

Gross Domestic Product (growth rate)



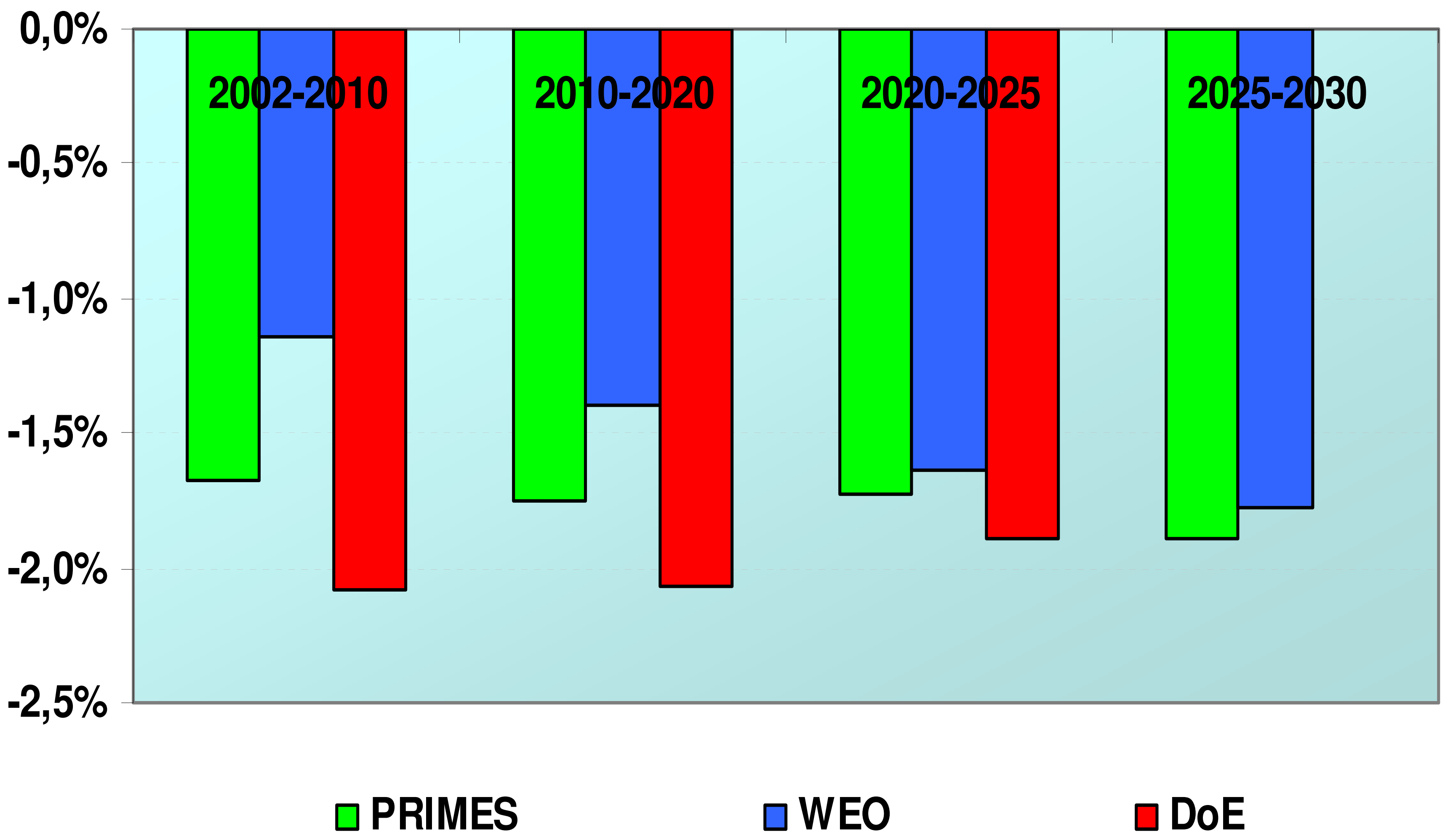

Oil Price Scenarios
70
60
50
40
30
20
10
0
12
10
8
6
4
2
0
$'00/b
€'00/MJ
2005
2010
2020
2030
DoE $'00/b
PRIMES $'00/b
WEO $'00/b
High Price $'00/b
Doe €'00/MJ
PRIMES €'00/MJ
WEO €'00/MJ
High Price €'00/MJ

Energy intensity

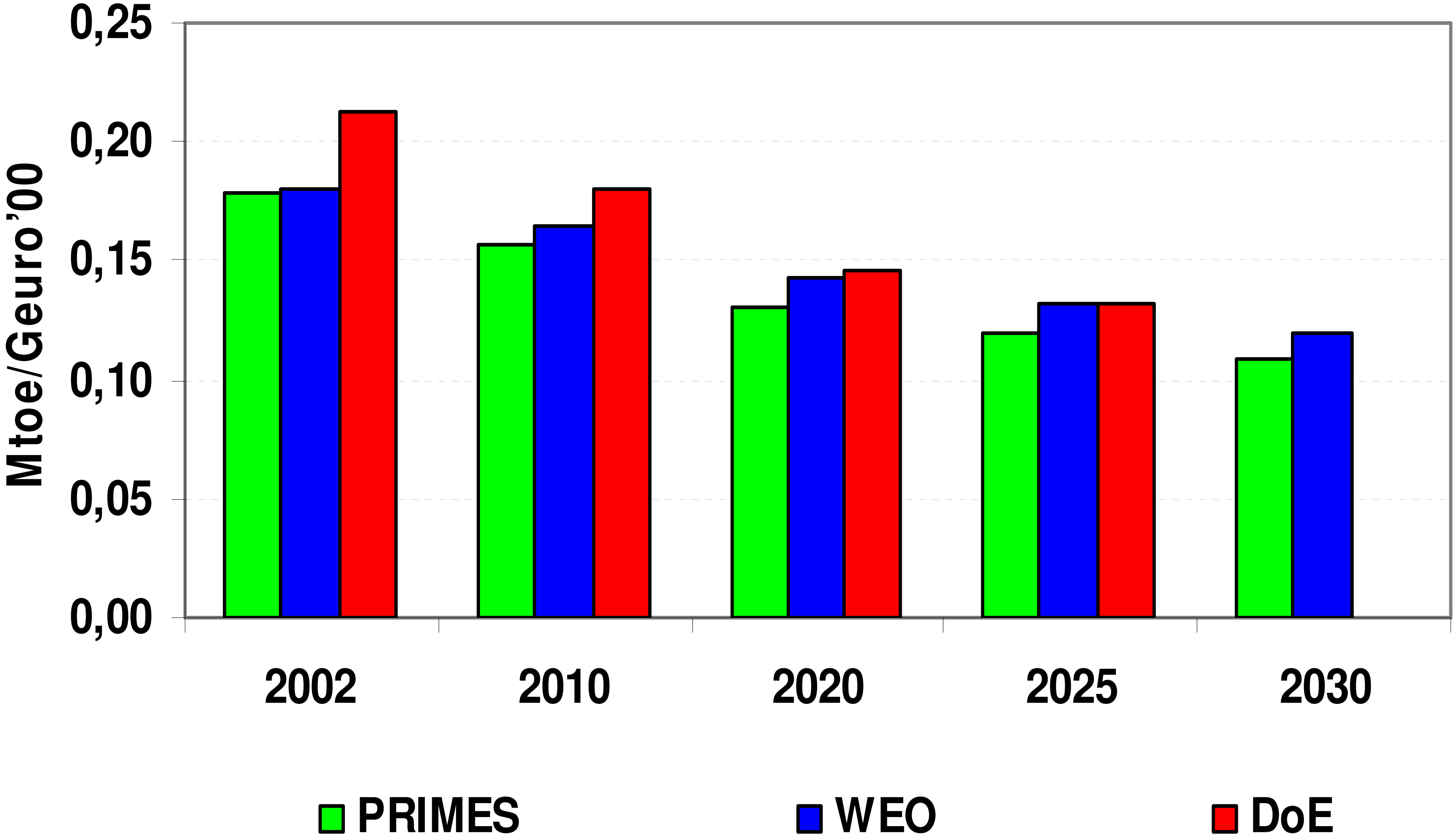
Energy intensity (in industrialised countries) is generally decreasing with time, both as a consequence of shifts in the composition of GDP towards less energy-intensive goods and services, and as a result of the introduction of progressively more efficient technology that allow to obtain the same (or equivalent) service or products with less energy

Although the energy intensity is expected to decrease with time, its rate of decrease will not compensate for the increase of GDP, so that in the reference scenarios (i.e. in the absence of new, stringent initiatives in favour of energy efficiency) the absolute value of energy demand will continue to grow, although more slowly than the economy as a whole

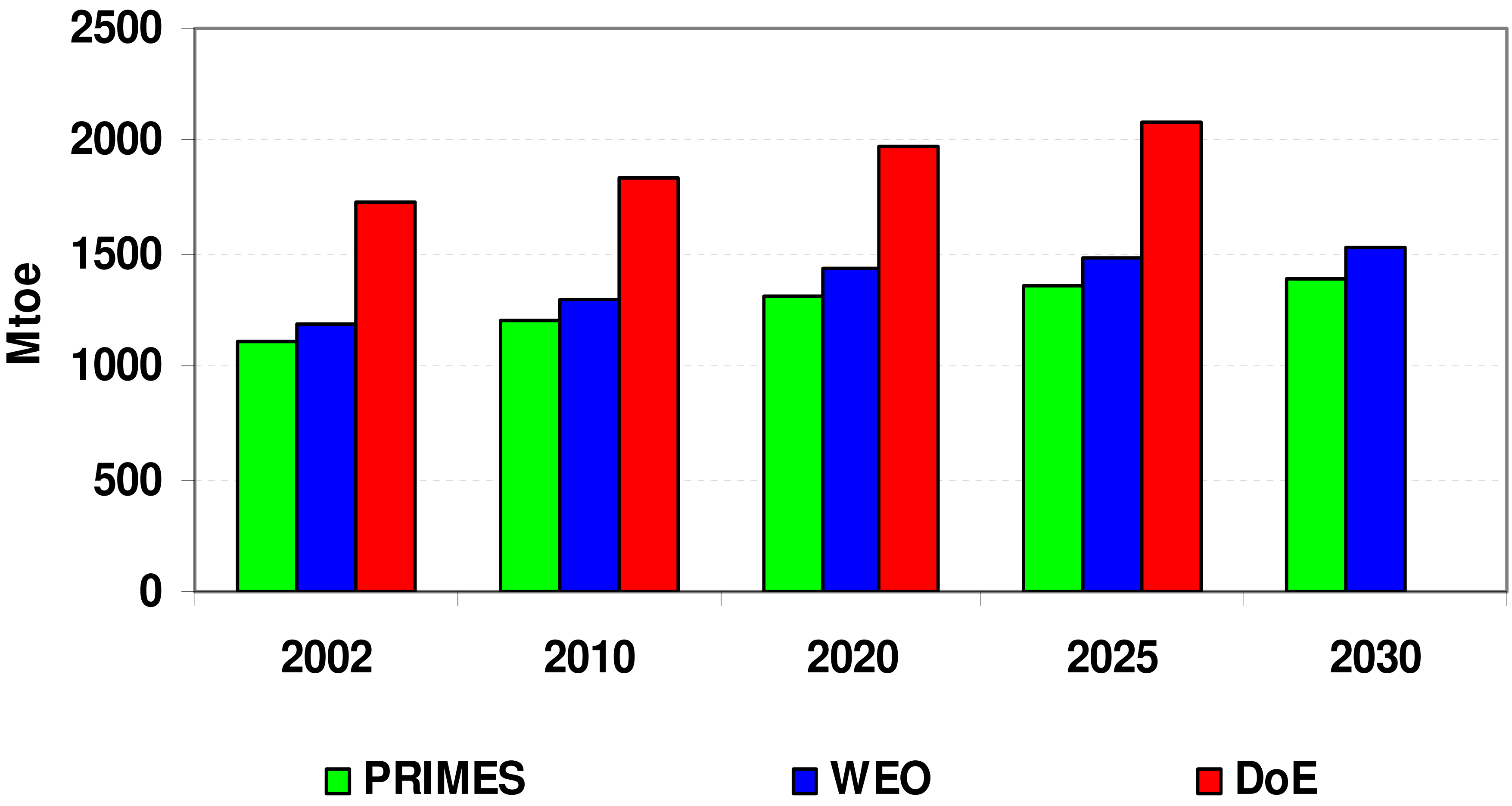
Primary Energy Intensity (growth rate)



Primary Energy Intensity



Final Energy Demand

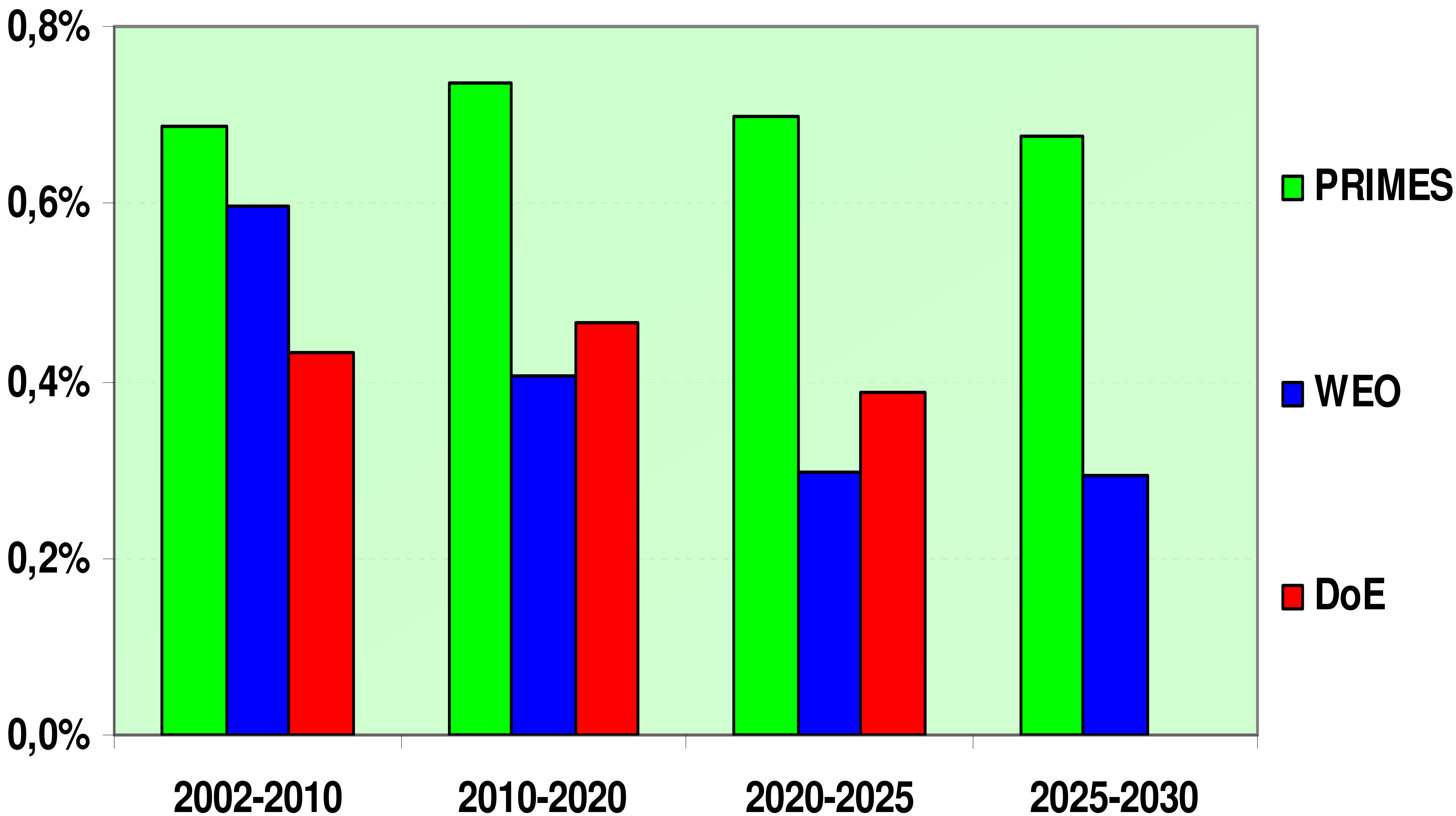


Top-down evaluation of electricity demand: electricity penetration

Electricity demand is calculated starting from the energy demand (discussed above) by means of the "electricity penetration", i.e. the share of the final uses of energy that is covered by electricity.

In the majority of EU member countries, electricity penetration grows with time, both because the demand shifts towards more sophisticated energy services that are more likely to involve electricity than fuel (such as informatics and telecommunication) and because higher efficiency and increased automation can be obtained through electricity-based processes. This trend is expected to continue in the future, and the EU is likely to reach values of electricity share closer to countries like US and Canada, which are at least 2 to 4 % higher than the average for the EU

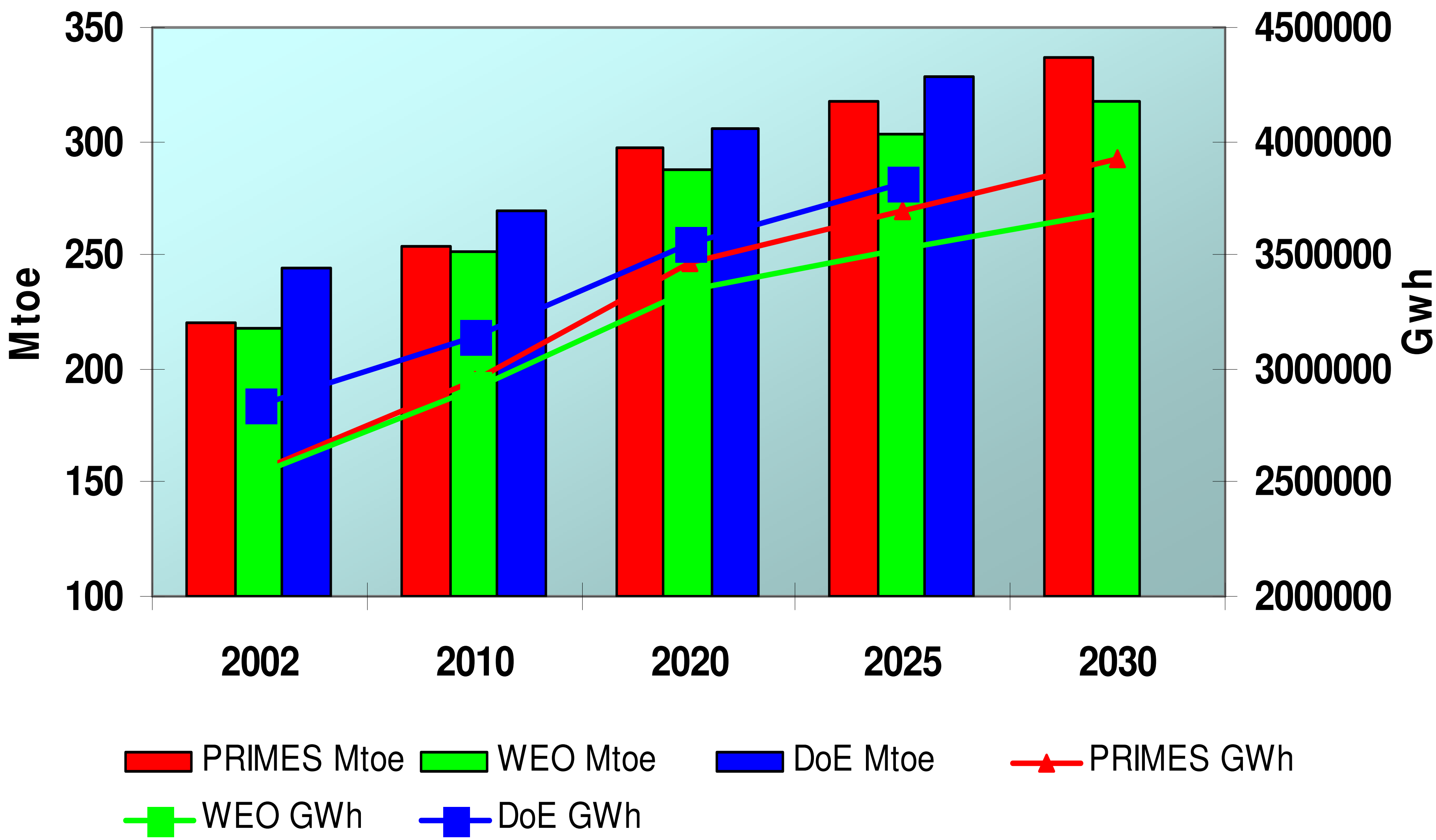
Electric Penetration (growth rate)

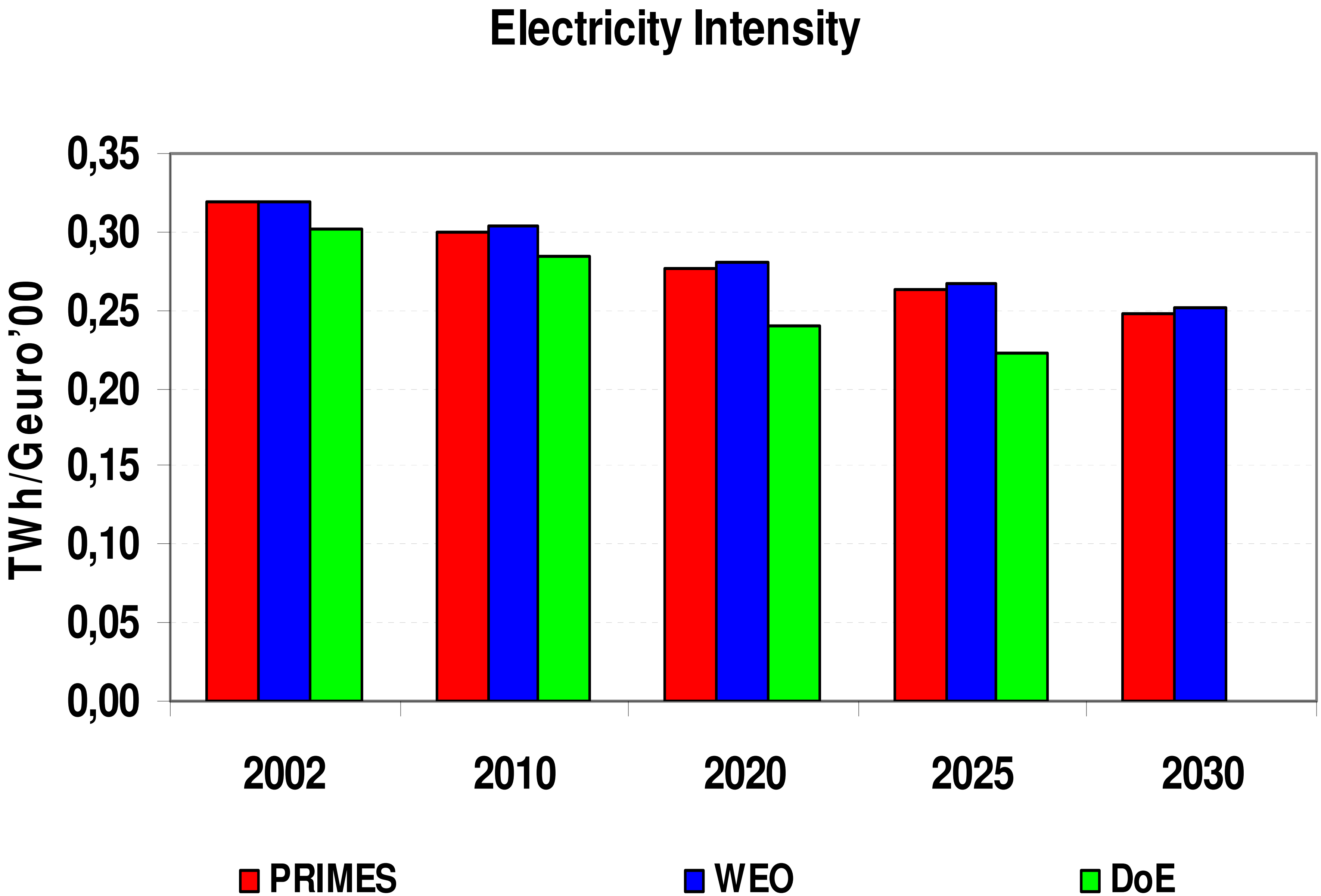


Electricity demand

With an electricity penetration growth rate of 0.2-0.3% per year, electricity demand is expected to grow at a rate of about 1.3-1.4% per year, slowing down with time. Electricity demand in **2030** is expected to be of the order of **4000 TWh**.

Electricity Demand




Electricity Intensity
TWh/Geuro'00
0,35
0,30
0,25
0,20
0,15
0,10
0,05
0,00
2002
2010
2020
2025
2030
PRIMES
WEO
DoE

Demand for energy services and bottom-up prediction of energy demand

Passing from the top-down approach to the determination of the energy demand to a more detailed analysis based on a “bottom-up” approach, one should start from the definition of the demand for “energy services” which is the basis of this demand.

Using indicators (such as population, GDP and number of households) as the starting point, the evaluation of the demand for energy services in the EU until 2025, calculated for each service by means of the WEU MARKAL model is presented.

These demand values, coupled with a detailed data base on end use technologies, can be used for a bottom-up prediction of the energy demand

From energy services…

- The bottom-up approach starts with the break-down of the energy demand into sectors, and for each sector into specific energy services (e.g. for the domestic sector the energy services required will include space heating and cooling, lighting, cooking, food refrigeration and freezing, dish and laundry washing, entertainment etc.)
- The demand for each service can be linked to an exogenous driver: population; GDP per capita; age distribution; family size etc.
- The first step is therefore the identification of these drivers, their links with demand for specific energy services, their evolution with time.

…to energy demand

- .Once one has the projection of the demand for energy services, one can look into the best way (from the point of view of the market) to satisfy this demand: by which energy carrier and by which end-use technology (either already on the market or supposed to come to the market as time goes by)

MARKAL studies of the effectiveness of policy instruments

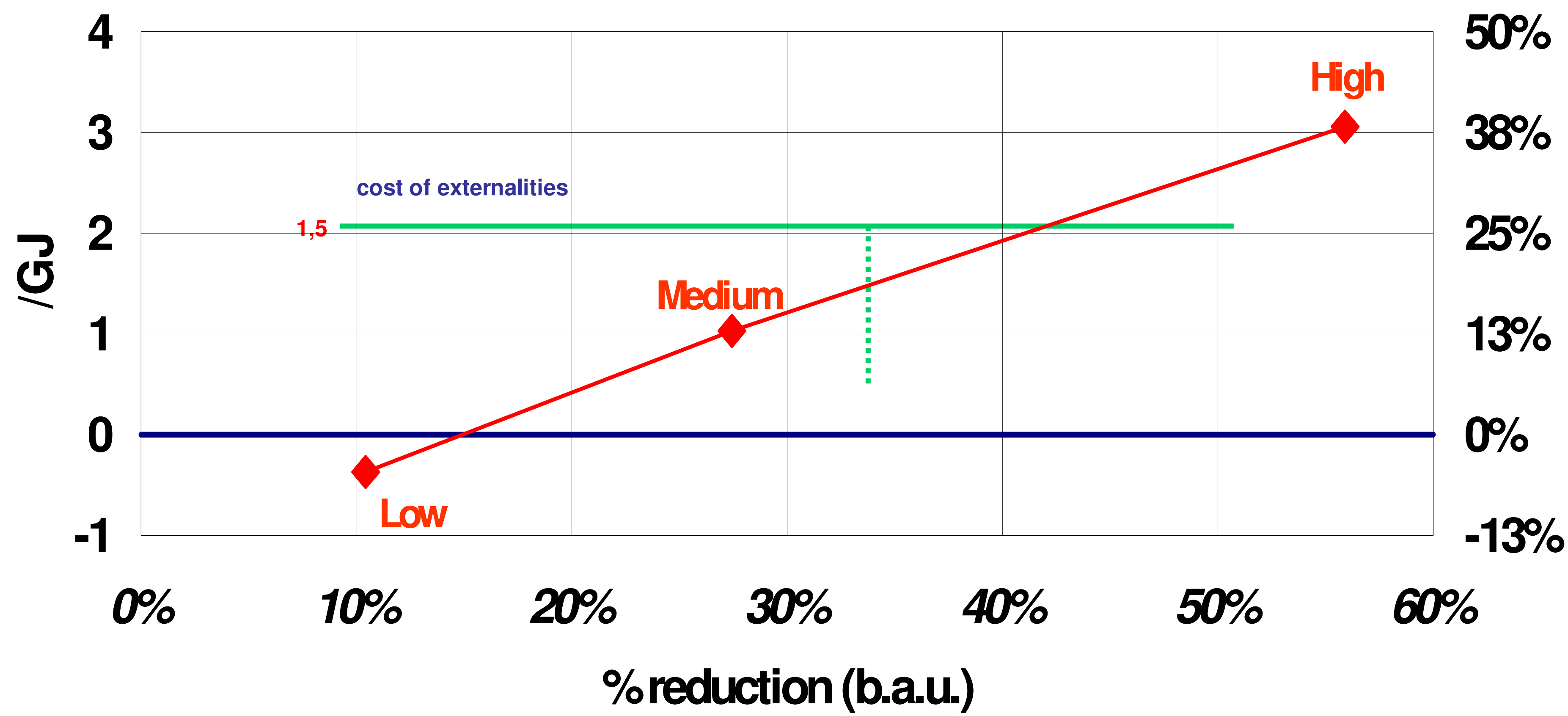
Although MARKAL, or other similar simulation instruments, are rather versatile and flexible, a sensible representation of the different policy instruments requires some care. Transaction costs are one of the elements that need to be taken into account.

Some results from “White and Green”

- Some results from the MARKAL EU simulation model obtained in the course of the White and Green Project are reported. They indicate that a saving of 15% in energy consumption would be economically possible even without considering indirect costs (externalities). If indirect costs are taken into account, this saving could reach 40%. Accompanying actions to remove market imperfections would be required.

WEU Markal model - White Certificates Scenarios
Residential and Commercial Sector

Trade-off curve:
total (R&C) final energy saved in 2020 (% of b.a.u. scenario) vs. average energy system cost increase (/GJ and %) in 2020



Obstacles to the introduction of a sustainable energy system (SES)

- A sustainable energy system starts from a disadvantage position because conventional energy is often heavily subsidised. Although this is more common in developing than in industrialised countries, there are several examples also in these last .
- Conventional energy systems are based on diffused and costly infrastructures (such as oil and gas pipelines, electricity and gas grids, power plants, dams etc.) which are already in place, and the marginal cost of using them is low. Large amounts of public money have been spent in the past to support research and development (for instance for nuclear energy) and in many cases also the deployment of conventional energy plants as direct investments by the governments or by facilitated public or private investments.
- Other obstacles are of a “cultural” nature, and derive from well-established habits, from lack of information, from the very structure of society, of finance, of politics

IRP – Integrated resource planning

Before the energy crisis of 1974 – actually for quite some time after that – energy utilities would assume that energy demand is an exogenous variable, an input to their planning.

Then they would optimise the production of energy looking at the cheapest opportunities, mostly independently of where the demand was located.

Once optimised the production, they would then design the energy transport infrastructure, and finally the distribution network.

The planning was done by large steps – typically 200 MW as the basis. The possibility of distributed, small-scale generation was not considered.

This approach was questioned in the late 1970s and early 1980, because:

1. The step-by-step optimisation does not necessarily bring to an overall optimisation (not only from the economic point of view but also from the environmental and social points of view)
2. The approach did not take into account the possibility of improving the efficiency of energy services as an alternative to increasing the production of energy.

Briefly, it is often less expensive to save a kWh than to produce it!

- This brought about the concept of IRP – Integrated Resource Planning – in which utilities would optimise simultaneously the production, transport, distribution and utilisation of energy, considering also small-scale plants and choosing the solution that would yield the overall minimum total cost for society.
- This would require the utilities to intervene “after the counter”, i.e. to supply efficiency improvement services to their clients when this corresponded to an economic improvement, through “demand-side management”.
- This was applied by some utilities and even required by some legislation, but it did not gain overall diffusion.

New difficulties for IRP

- Unfortunately, the move towards a liberalised energy market tends to discourage IRP. In the attempt to promote competition, the liberalisation process required the “unbundling” of utilities, i.e. the separation between production, transportation, distribution and sale of energy, which should be carried out by independent companies.
- This makes the possibility of an overall optimisation carried out by the different actors rather remote.
- Therefore, different legislative instruments have been designed to improve the situation, by imposing or supporting initiatives to improve energy efficiency in final uses.

Energy services are essential to development

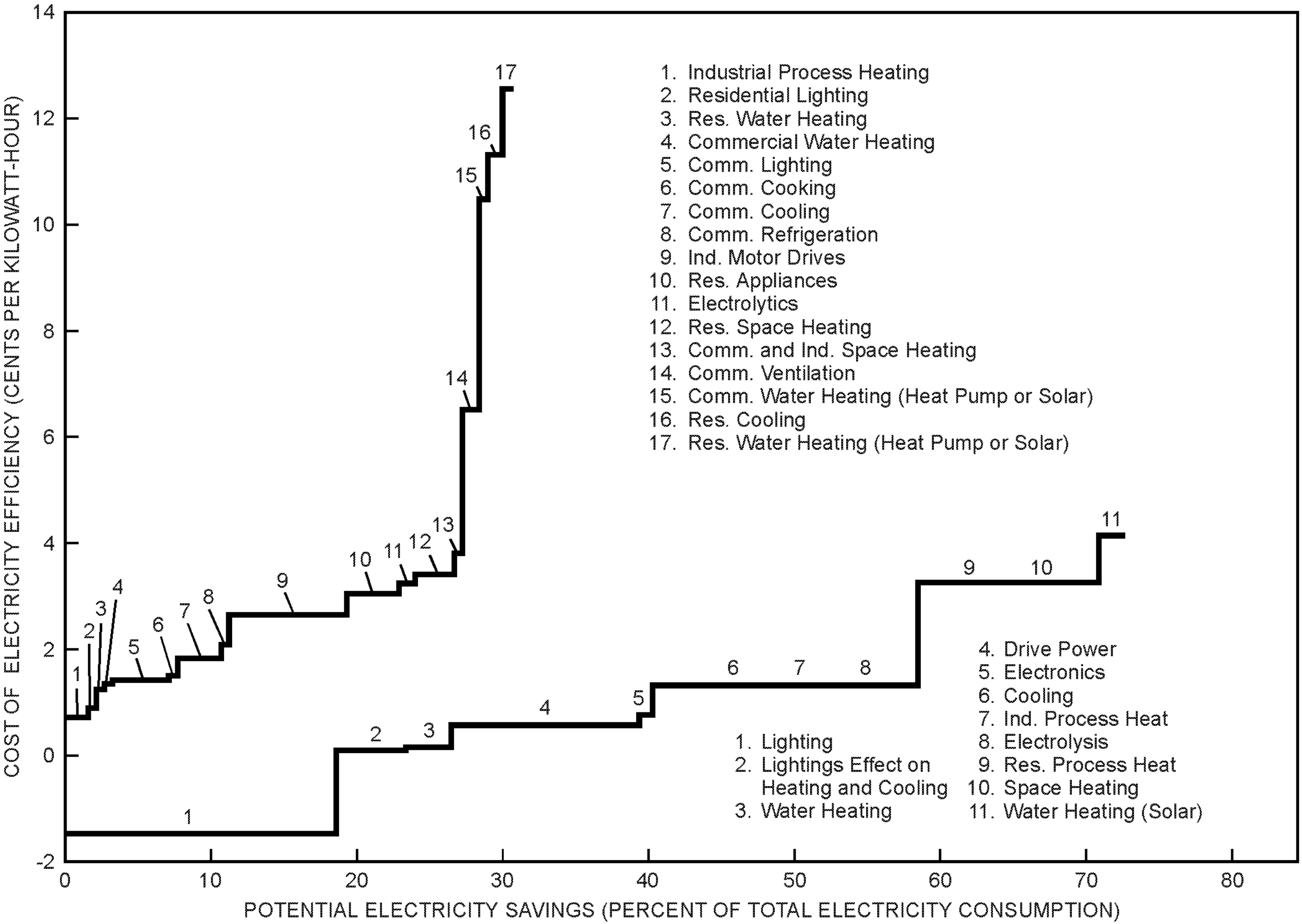
- First of all, we do not need energy per se, we need the **services** that energy can provide: energy is necessary to keep ourselves warm, or cool, to manufacture goods, to refrigerate food and medicines, to move from one place to another, to pump or to purify water etc.
- The availability of affordable energy, of the quantity and the type needed, at the “right” prices, is a prerequisite for **economic development** within a country, for its **competitiveness** on the international arena and for its balance of payments.
- Energy also has many important implications on **social development**: its links with **employment**, eradication of **poverty**, **demography**, **regional** development, **urbanisation** and rural-to-urban balance, **education**al opportunities, income **distribution**, **gender roles** (condition of women), and **peace**.

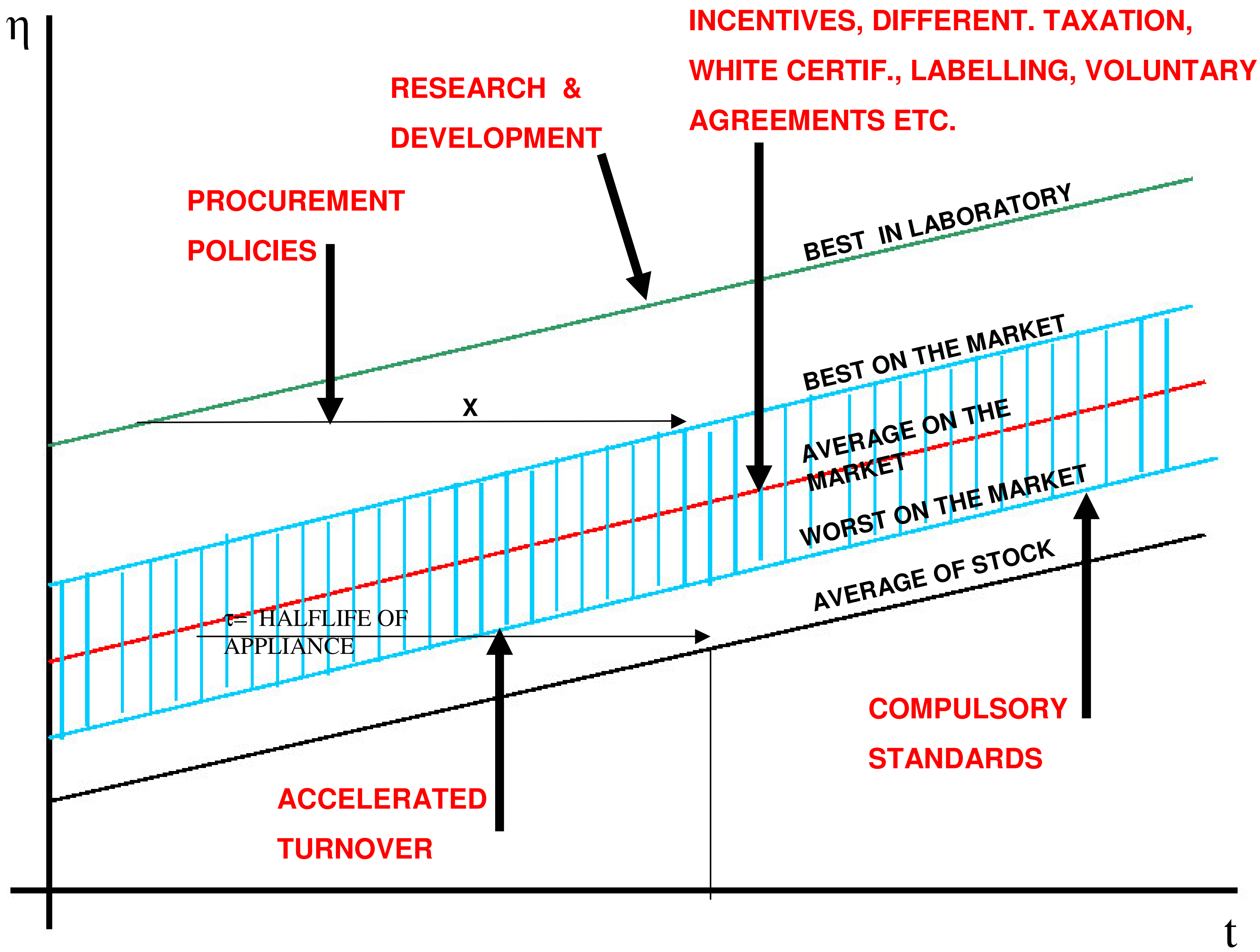
The “Negawatt” debate

What is the actual economical and practically achievable margin for improving the efficiency of end-uses of energy?

The so-called “Negawatt debate” has shown that one can reach very different conclusions according to the assumptions made; however, even with the more pessimistic assumptions, there appears to be always an important margin for improving energy efficiency in an economic way.

This margin is very much enhanced if one takes externalities into account.


COST OF ELECTRICITY EFFICIENCY (CENTS PER KILOWATT-HOUR)
POTENTIAL ELECTRICITY SAVINGS (PERCENT OF TOTAL ELECTRICITY CONSUMPTION)
1. Industrial Process Heating
2. Residential Lighting
3. Res. Water Heating
4. Commercial Water Heating
5. Comm. Lighting
6. Comm. Cooking
7. Comm. Cooling
8. Comm. Refrigeration
9. Ind. Motor Drives
10. Res. Appliances
11. Electrolytics
12. Res. Space Heating
13. Comm. and Ind. Space Heating
14. Comm. Ventilation
15. Comm. Water Heating (Heat Pump or Solar)
16. Res. Cooling
17. Res. Water Heating (Heat Pump or Solar)
1. Lighting
2. Lightings Effect on Heating and Cooling
3. Water Heating
4. Drive Power
5. Electronics
6. Cooling
7. Ind. Process Heat
8. Electrolysis
9. Res. Process Heat
10. Space Heating
11. Water Heating (Solar)


η
INCENTIVES, DIFFERENT. TAXATION,
WHITE CERTIF., LABELLING, VOLUNTARY
AGREEMENTS ETC.
RESEARCH &
DEVELOPMENT
PROCUREMENT
POLICIES
BEST IN LABORATORY
BEST ON THE MARKET
X
AVERAGE ON THE MARKET
WORST ON THE MARKET
AVERAGE OF STOCK
τ= HALFLIFE OF APPLIANCE
COMPULSORY
STANDARDS
ACCELERATED
TURNOVER
t

White certificate systems in Europe and preliminary indications from the EuroWhiteCert project on a white certificate system common to various EU countries

Nicola Labanca
end-use Efficiency Research Group
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Supported by Intelligent Energy Europe

ERMInE - Electricity Research Road Map In Europe

a co-ordination action supported by the European Commission under the 6th R&D Framework Programme

Starting date 1st January 2006 Duration 24 months

Consortium

CESI RICERCA (I) - Co-ordinator
ENEL PRODUZIONE S.P.A. (I)
EURELECTRIC - The Union of the Electricity Industry
KEMA NEDERLAND BV (NL)
ENERGIBEDRIFTENES LANDSFORENING KOMPETANSE AS (N)
INSTYTUT ENERGETYKI (PL)

Objective

To help the EU authorities:

- to get an exhaustive view of the recent and present situation of the electricity Research & Technology Development efforts in Europe
- to indicate specific RTD needs of the European utilities and plant/equipment manufacturers in the next 20-25 years.

Project boundaries

generation	distribution	environmental issues
transmission	end use	electricity markets and regulations

Project tools

Questionnaire addressed to Public regulators, Power producers, Transmission and distribution operators, Manufacturers, research institutes …

Four Workshops in the main European areas:

West (BE, DE, IE, LU, NL, UK) 11 – 12 Oct 2006, Brussels

North (DK, FI, NO, SE) 1 Nov 2006, Oslo

East (BG, CZ, HU, EE, LT, LV, PL, RO, SK), 30 Nov – 1 Dec 2006, Warsaw

South (AT, CH, CY, ES, FR, GR, IT, MT, PT, SI, Balkans) 1 – 2 Feb 2007, Rome

Focused meetings with a reduced number of participants, to discuss specific topics not completely dealt with, during workshops

Expected deliverables

Map of the recent and present RTD efforts in the EU electricity sector.

Road Map with indications of the possible evolution and of the needs of RTD efforts, specifically tailored to the European context for the next 20-25 years.

Project website http://www.ermine.cesiricerca.it

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