Summary Report
of the activities concernine Work Package 2
Anticipation of future energy demand
carried out during the year 2005

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WP-2

- All the activity concerning this WP was carried out during 2005, from the identification of the main specifications of the WP to the collection of bibliographic material and results of models to the production of the final report.
- The work was carried out by AIEE (Rome), KUL (Leuwen) and ICEPT (Imperial College, London).

Objectives of WP-2

The objectives of WP-2 were identified as follows:

1. Supply input data on: demography; economic evolution (GDP); price of primary fuel; other indicators to the Work-package 5, and in particular to the Subtask WP 5.3
2. Performing and interpretation of four (contrasting) scenarios with one or two of the most appropriate models (with ‘improved’ input data)”
3. Evaluate trends of demand for energy services and electricity demand (mostly by a top-down, macroeconomic approach)
4. Evaluate the effects of energy efficiency policies and DSM measures (particularly by using bottom-up models)

Scope, time, extension

- In consideration of the time and resources available for this Work-package, it was decided that recourse should be made as much as possible to the results already available from other projects modelling the energy and electricity scenarios for the European Union.
- The reference time horizon for this study is 2030. The geographical reference is EU-25, i.e. the 25 Member countries of the EU after the enlargement of 2004.
- Only aggregated data (not country-by-country) were considered

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).

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).

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

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

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

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**.

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

The ODYSSEE study

- The following section goes back to a more macroscopic examination of the trends of energy consumption in the EU, divided by sectors, based on the results of the ODYSSEE study of the EC.

  This section was provided by Imperial College

Externalities

The fact that externalities are not included (or at least not fully included) in the price paid for energy, makes it unlikely that the market, left to itself, will take these externalities into account. For this reason, most people consider it appropriate that governments regulate the energy market and introduce price signals that take into account the societal aspects of the energy cycle, such as the protection of the environment, the stability of global climate etc.

Energy policy instruments

- Many types of energy policy instruments to improve energy efficiency are available and have been used in different contexts. On overview of the variety of such instruments and some attempts to classify them are presented in the report. A brief history of the recent efforts in directing legislation towards the promotion of energy efficiency at the level of the European Union is followed by an overview of the status of legislation in the Member countries, based on the results of the ODYSSEE study.

DSM and IRP

The problem of the promotion of the improvement in the efficiency of final uses of energy is approached from a somewhat more general viewpoint, which discusses the theoretical approaches and the practical implications of **Demand Side Management** and **Integrated Resource Planning**: a view that may help in planning future moves towards converging instruments in the EU.

Most of this section was provided by KUL

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)

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; some clarification of these bases is attempted. Without taking side in this controversy, some general requirements are identified in order to arrive at reasonable conclusions.

Most of this part was fed-in by KUL.

MARKAL studies of the effectiveness of policy instruments

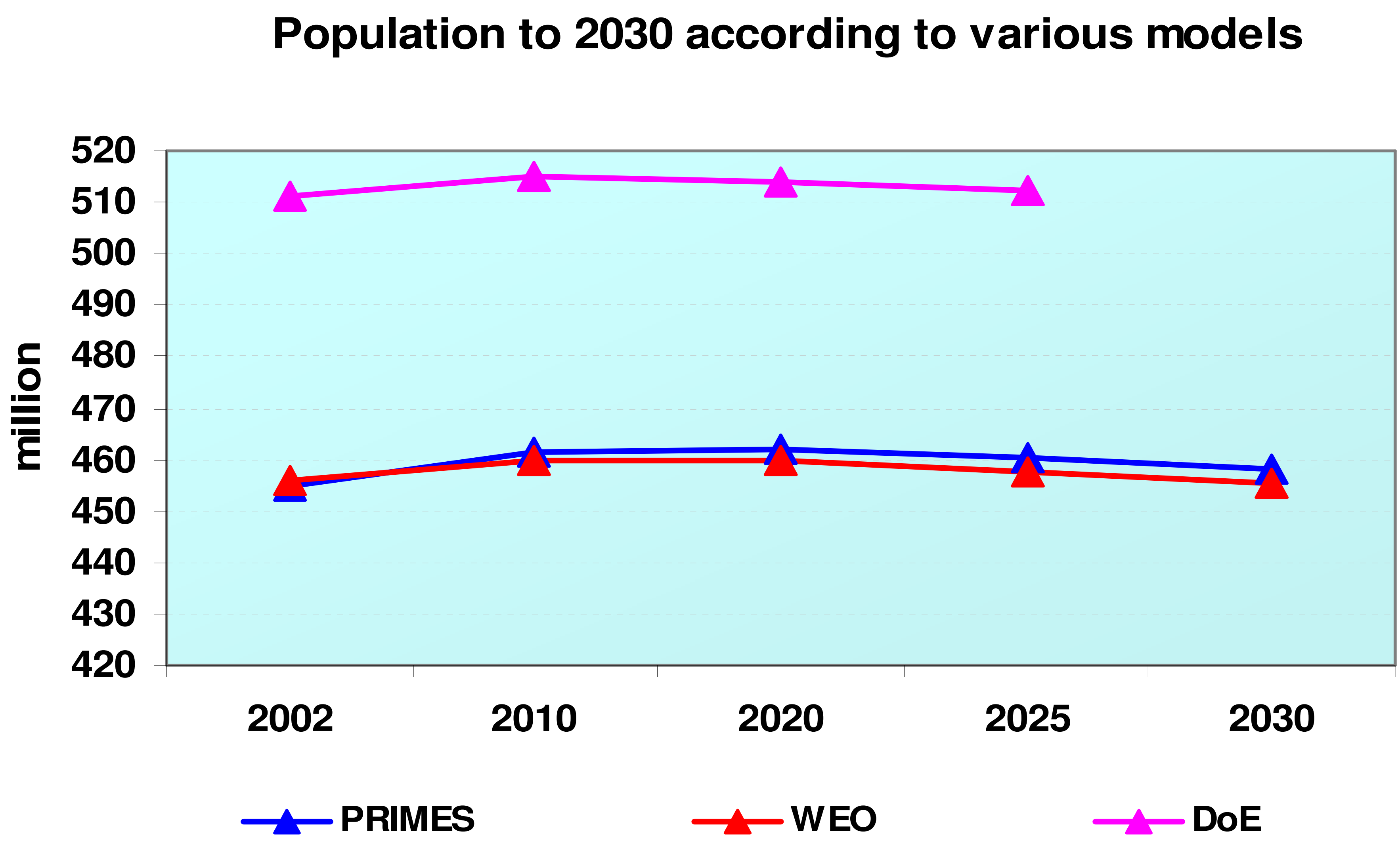
The representation of the policy instruments in the MARKAL models is then discussed. Although MARKAL, or other similar simulation instruments, are rather versatile and flexible, a sensible representation of the different policy instruments requires some care. Transaction costs are one of the elements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

Some results from “White and Green”

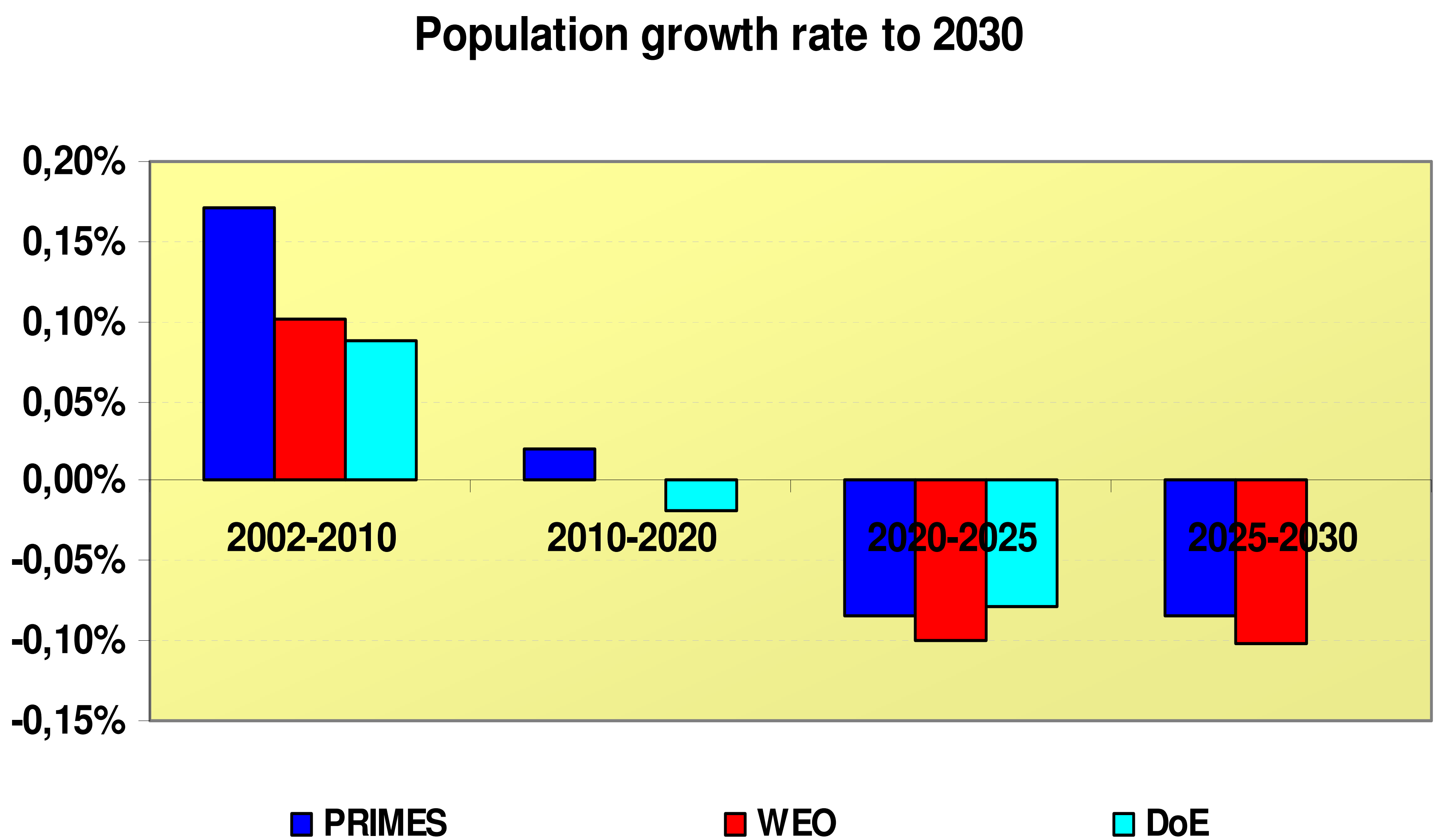
- Some results from the MARKAL EU simulation model obtained in the course of the White and Green Project are reported. They indicate that a saving of 15% in energy consumption would be economically possible even without considering indirect costs (externalities). If indirect costs are taken into account,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

Limits of the model

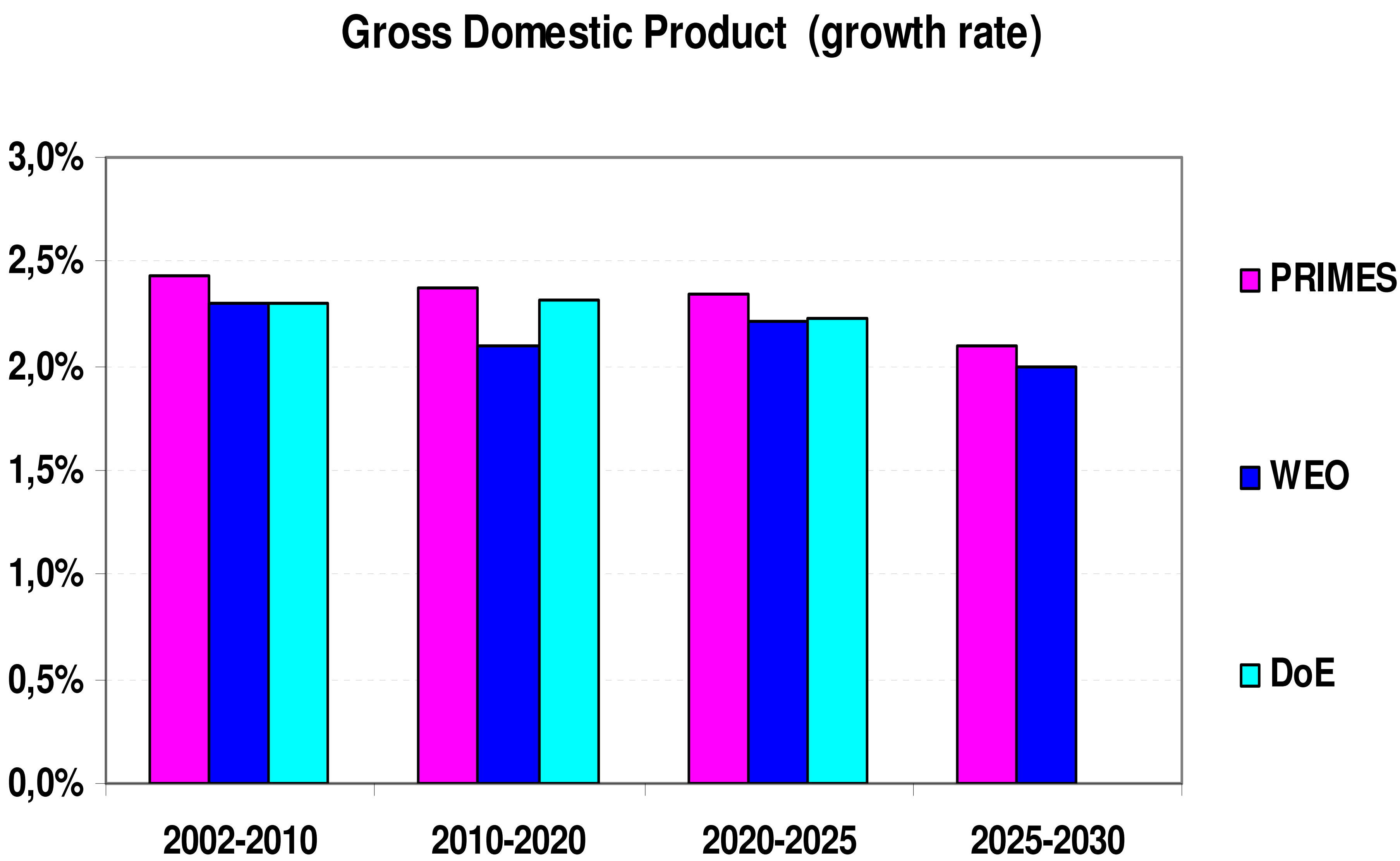
Some limits of the model are then discussed. They include rebound effects, transaction and administrative costs and the phenomenon of “free riders”. The main recommendations issuing from the White and Green project are then listed: they go very much along the same lines identified in the present work.

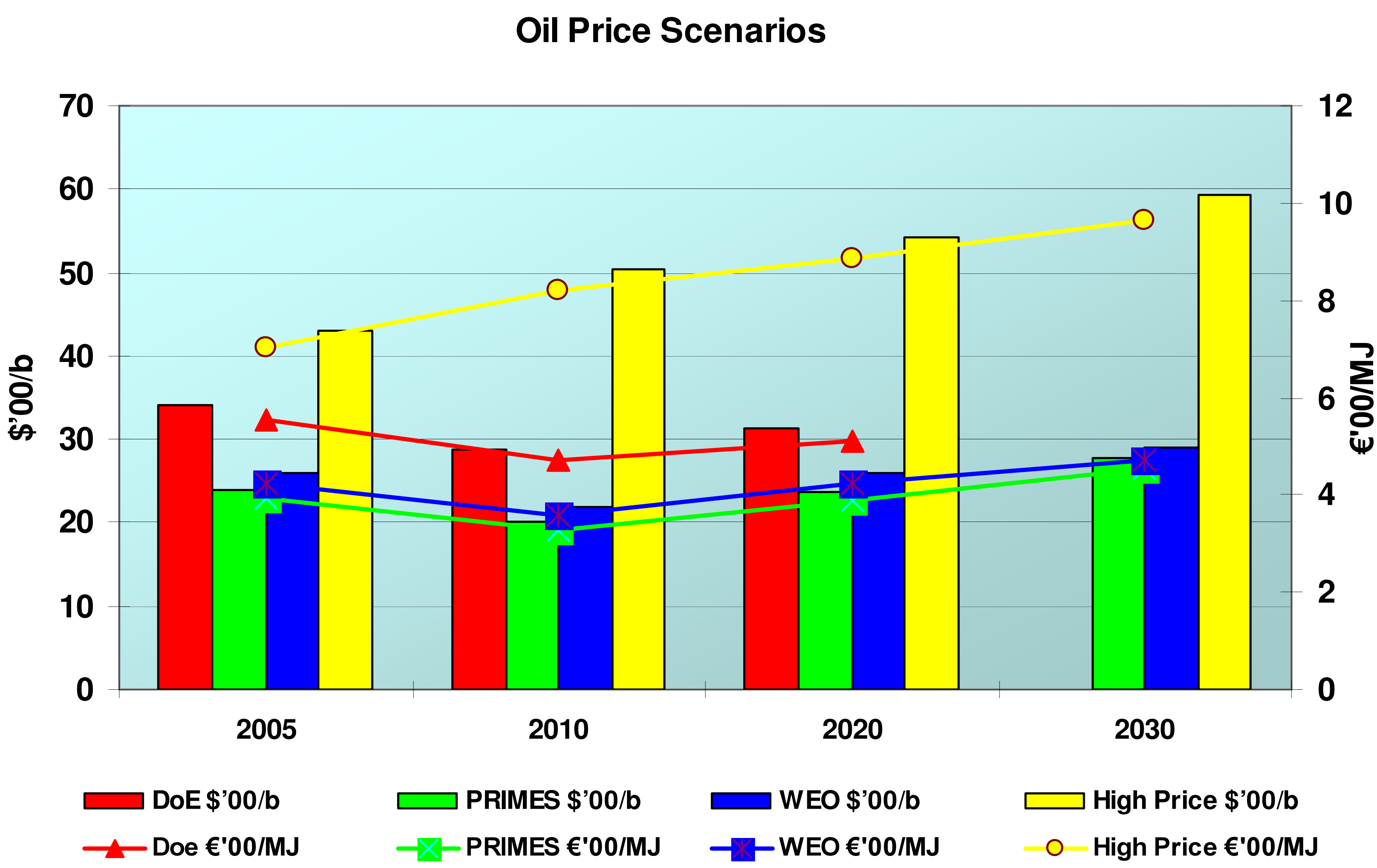


Population to 2030 according to various models
million
520
510
500
490
480
470
460
450
440
430
420
2002
2010
2020
2025
2030
PRIMES
WEO
DoE

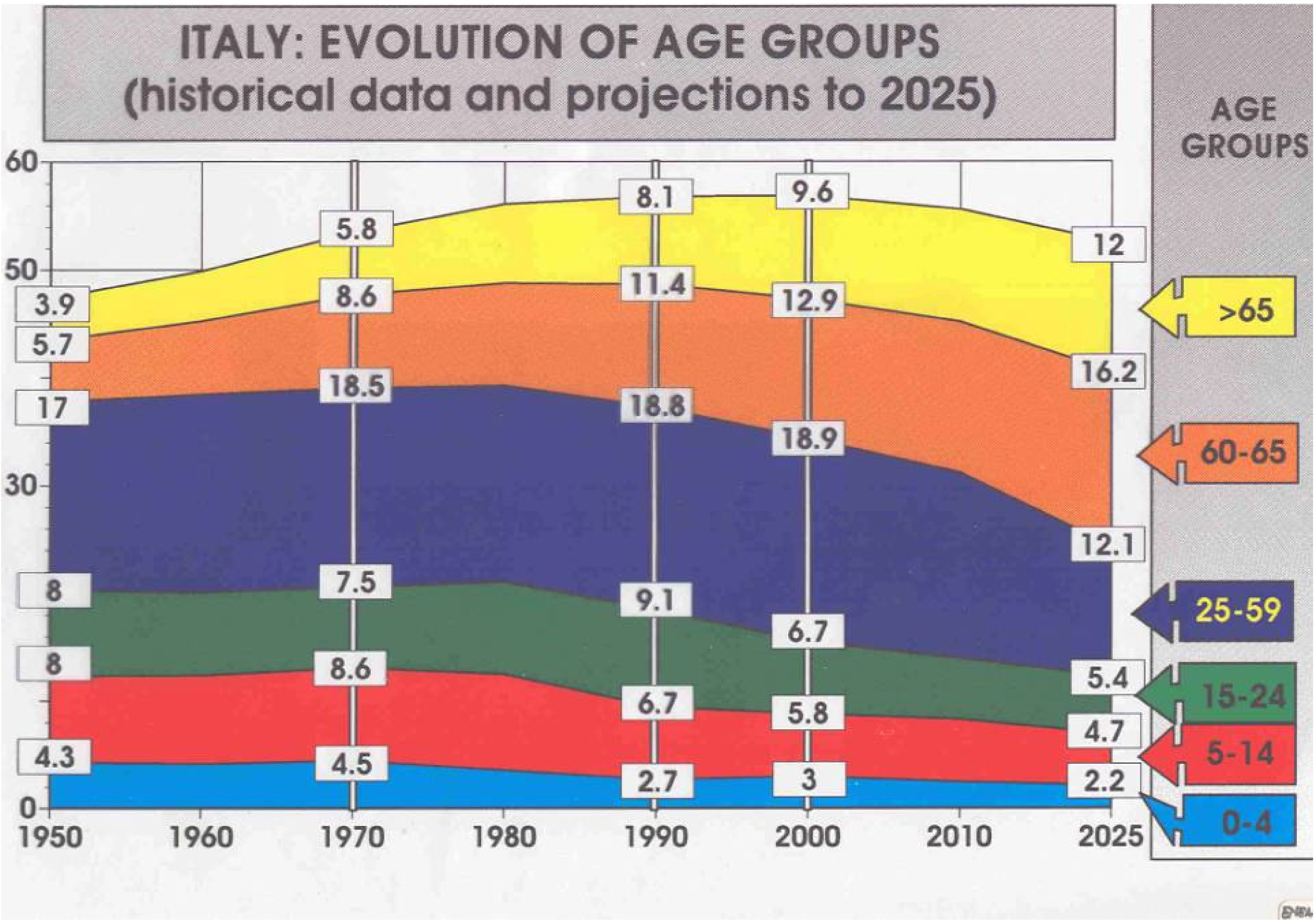


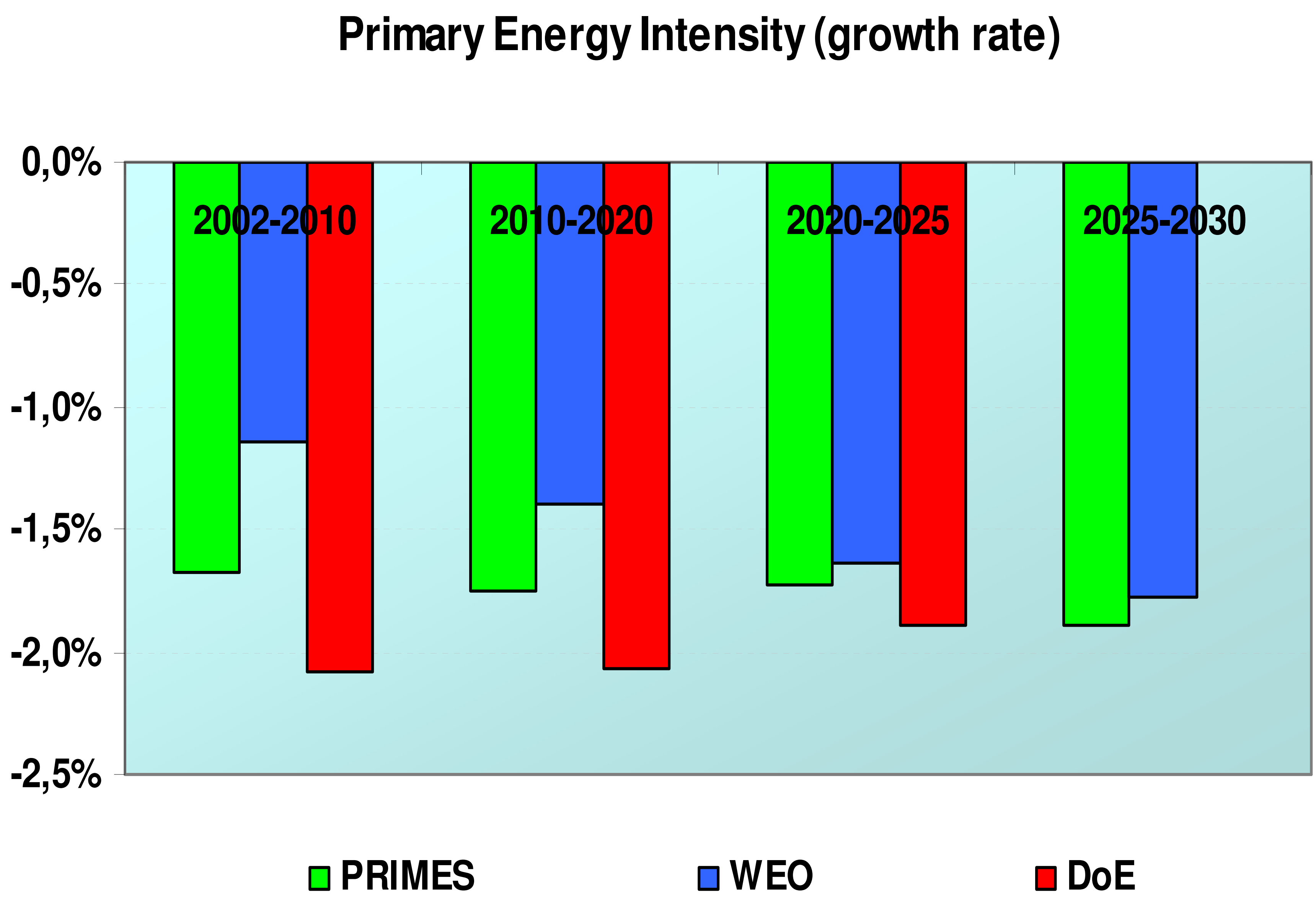
Population growth rate to 2030
0,20%
0,15%
0,10%
0,05%
0,00%
-0,05%
-0,10%
-0,15%
2002-2010
2010-2020
2020-2025
2025-2030
PRIMES
WEO
DoE

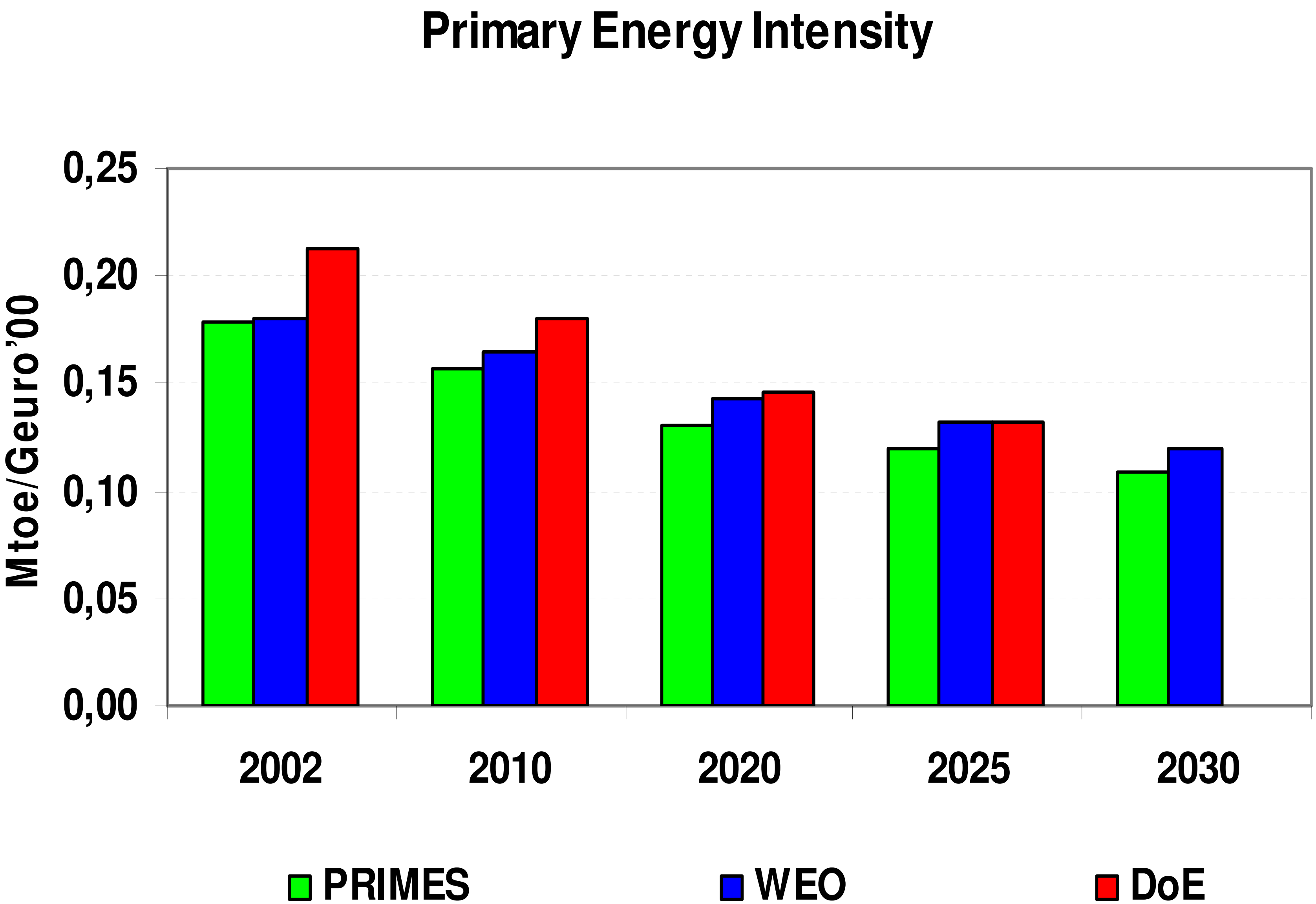

Gross Domestic Product (growth rate)
3,0%
2,5%
2,0%
1,5%
1,0%
0,5%
0,0%
2002-2010
2010-2020
2020-2025
2025-2030
PRIMES
WEO
DoE

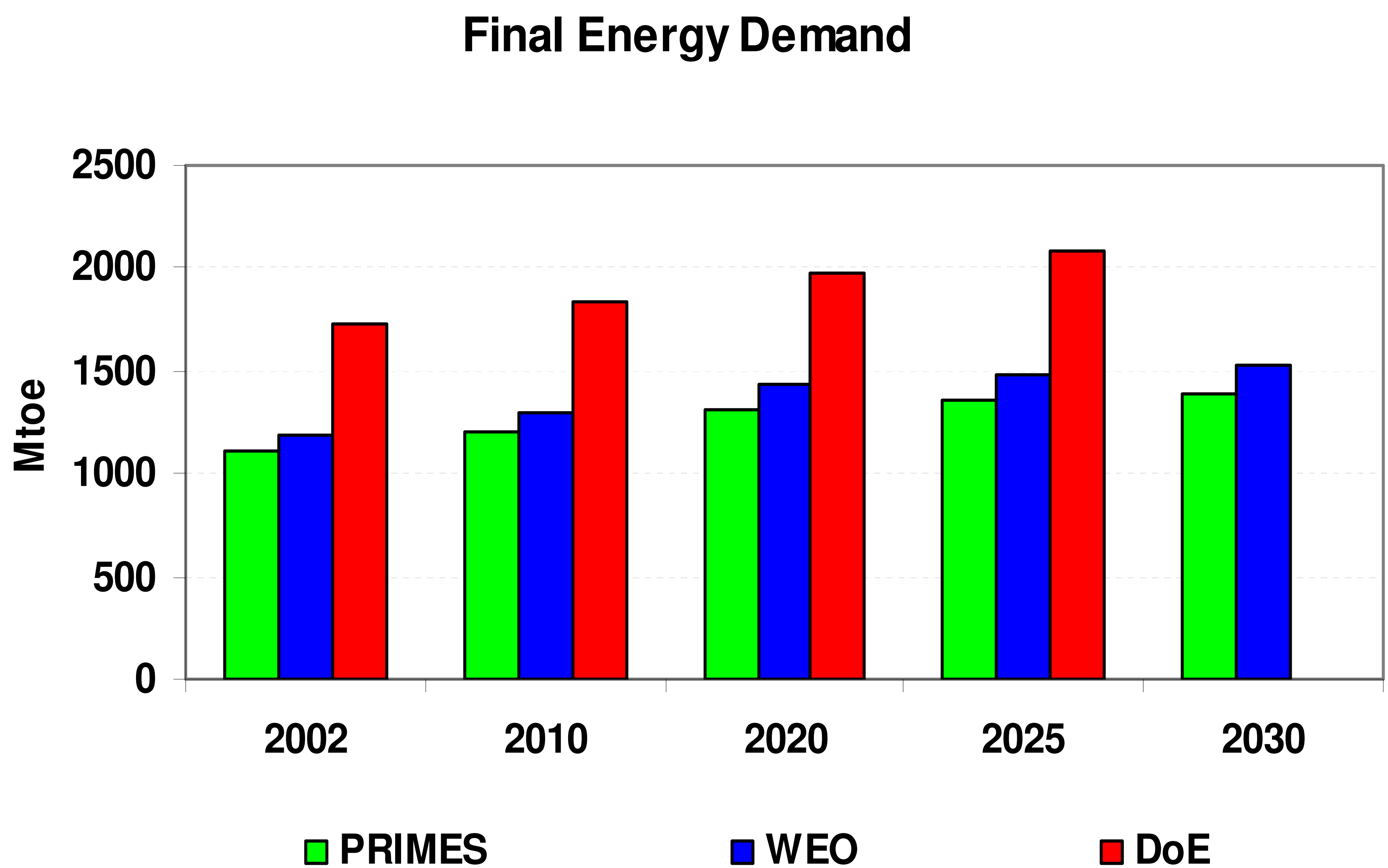


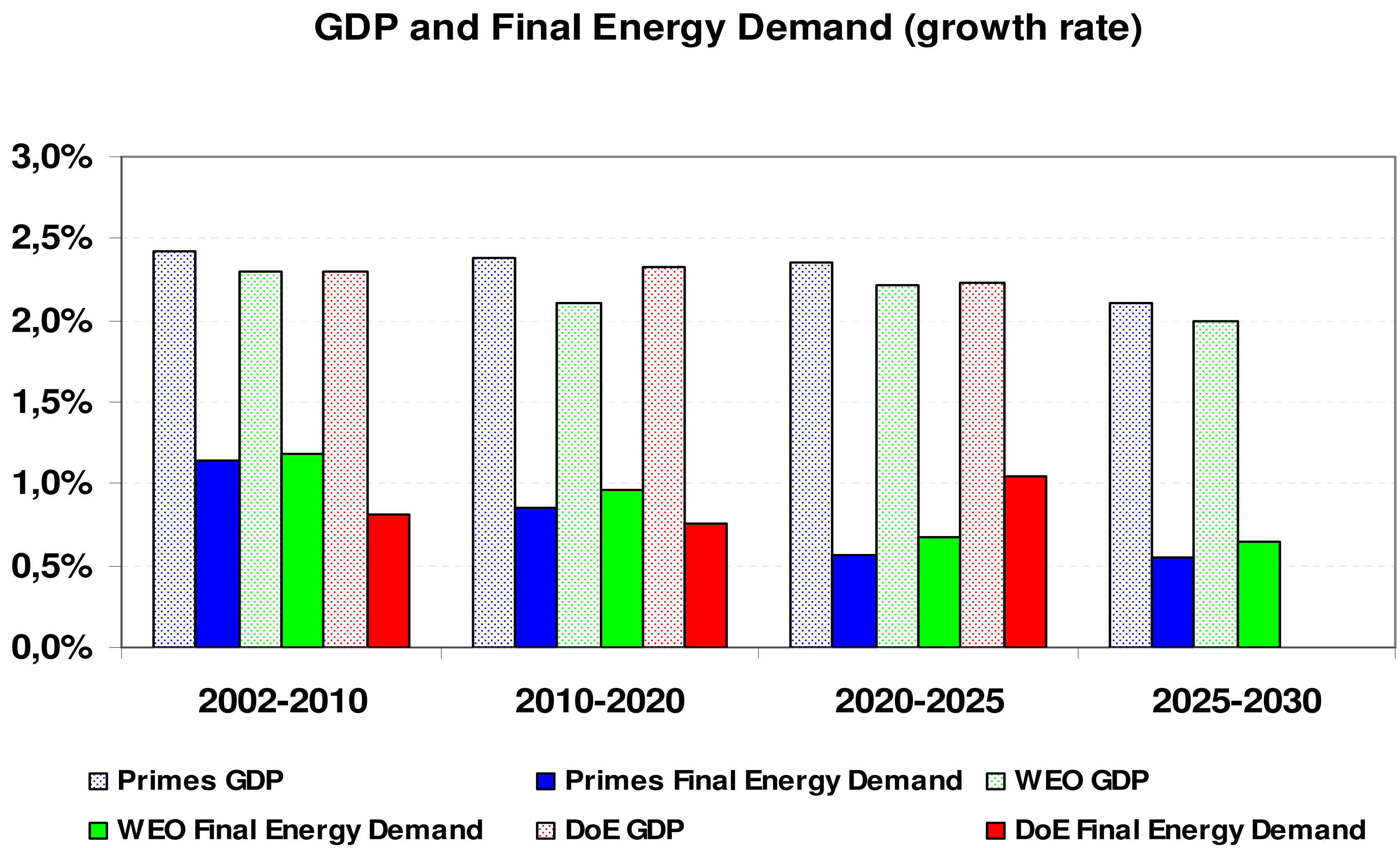
Oil Price Scenarios
$'00/b
€'00/MJ
0
10
20
30
40
50
60
70
0
2
4
6
8
10
12
2005
2010
2020
2030
DoE $'00/b
PRIMES $'00/b
WEO $'00/b
High Price $'00/b
Doe €'00/MJ
PRIMES €'00/MJ
WEO €'00/MJ
High Price €'00/MJ

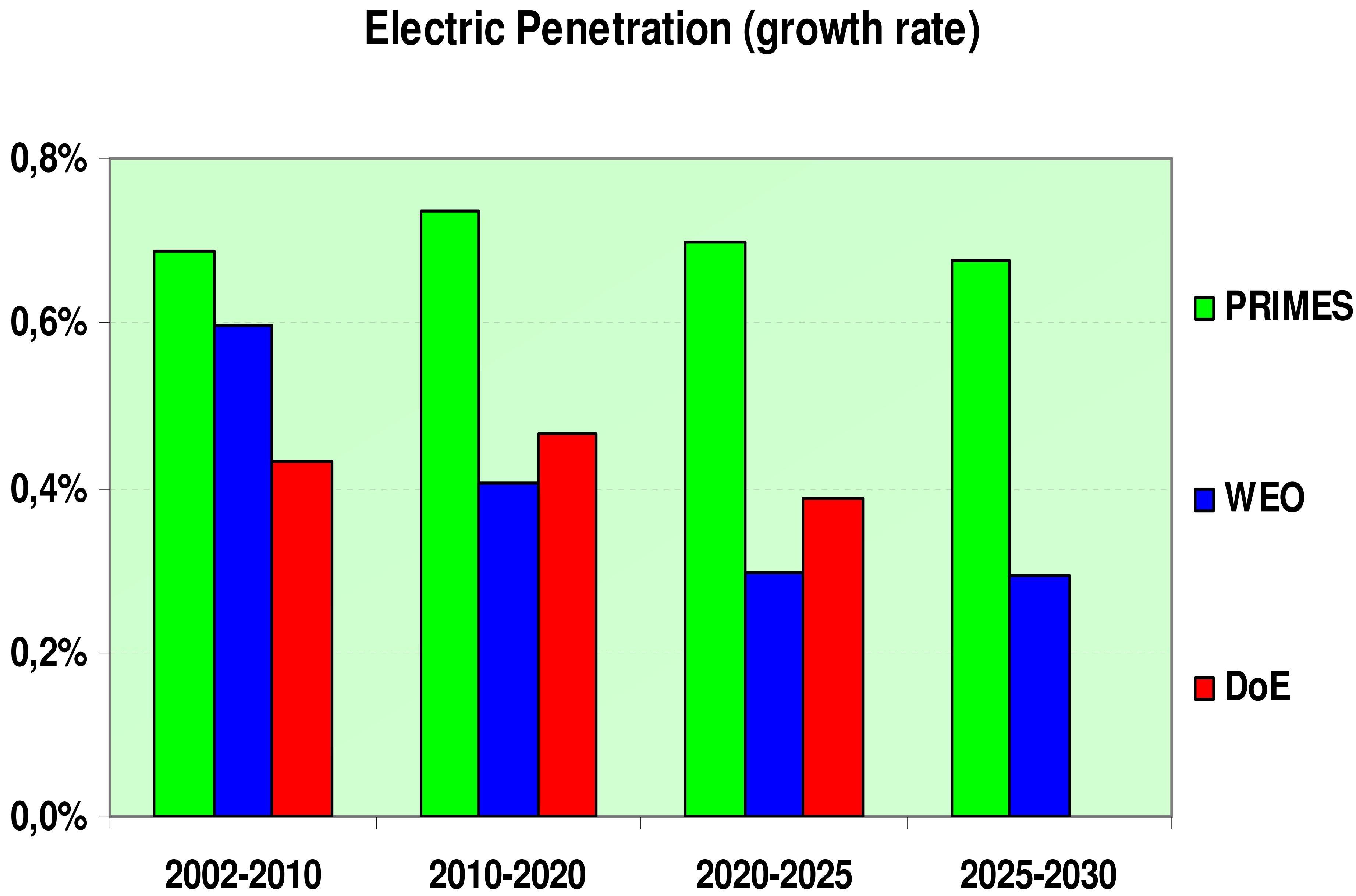

ITALY: EVOLUTION OF AGE GROUPS
(historical data and projections to 2025)
AGE GROUPS
>65
60-65
25-59
15-24
5-14
0-4
60
50
30
0
1950
1960
1970
1980
1990
2000
2010
2025
3.9
5.7
17
8
8
4.3
5.8
8.6
18.5
7.5
8.6
4.5
8.1
11.4
18.8
9.1
6.7
2.7
9.6
12.9
18.9
6.7
5.8
3
12
16.2
12.1
5.4
4.7
2.2


Primary Energy Intensity (growth rate)
0,0%
-0,5%
-1,0%
-1,5%
-2,0%
-2,5%
2002-2010
2010-2020
2020-2025
2025-2030
PRIMES
WEO
DoE

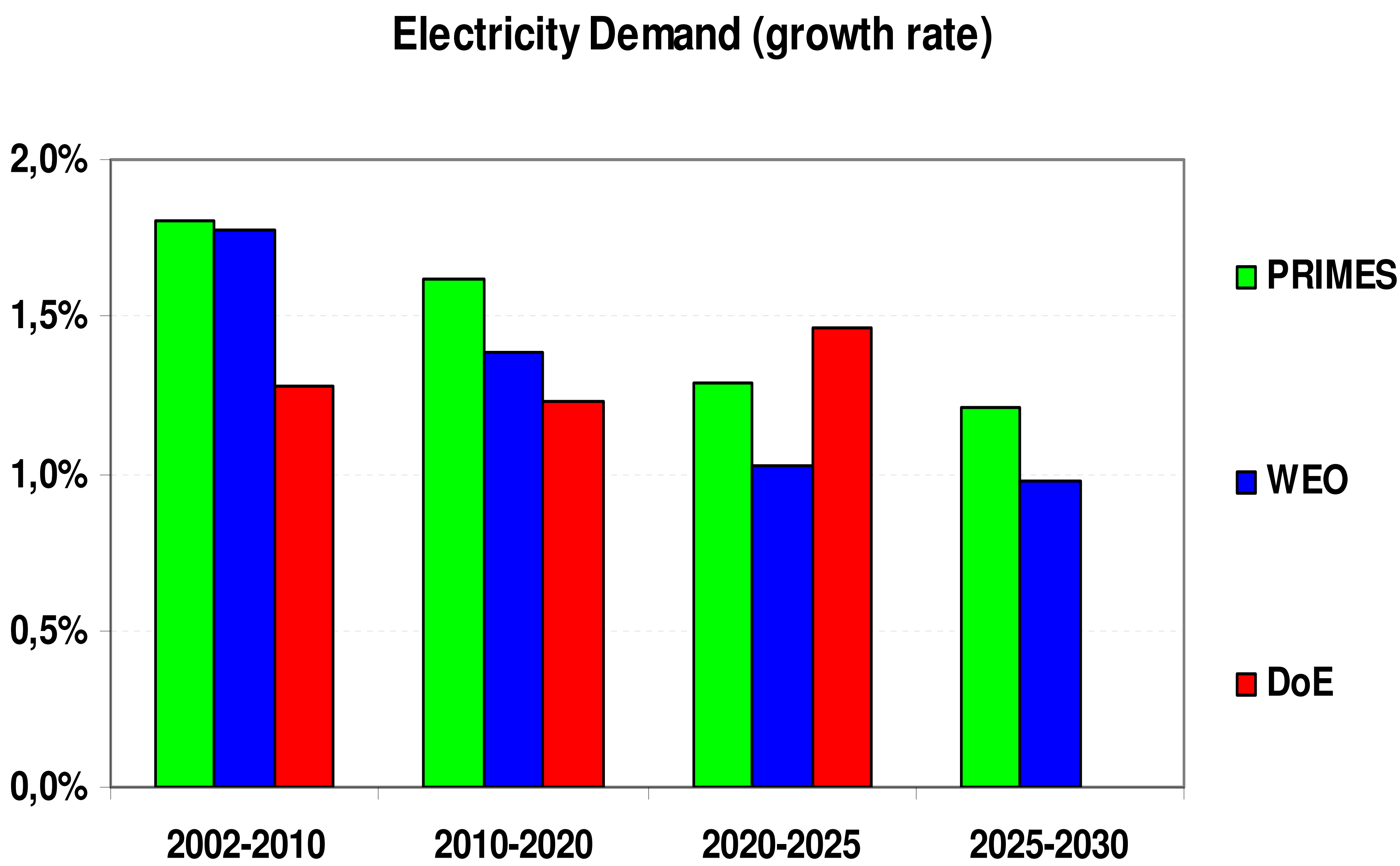

Primary Energy Intensity
Mtoe/Geuro'00
0,25
0,20
0,15
0,10
0,05
0,00
2002
2010
2020
2025
2030
PRIMES
WEO
DoE

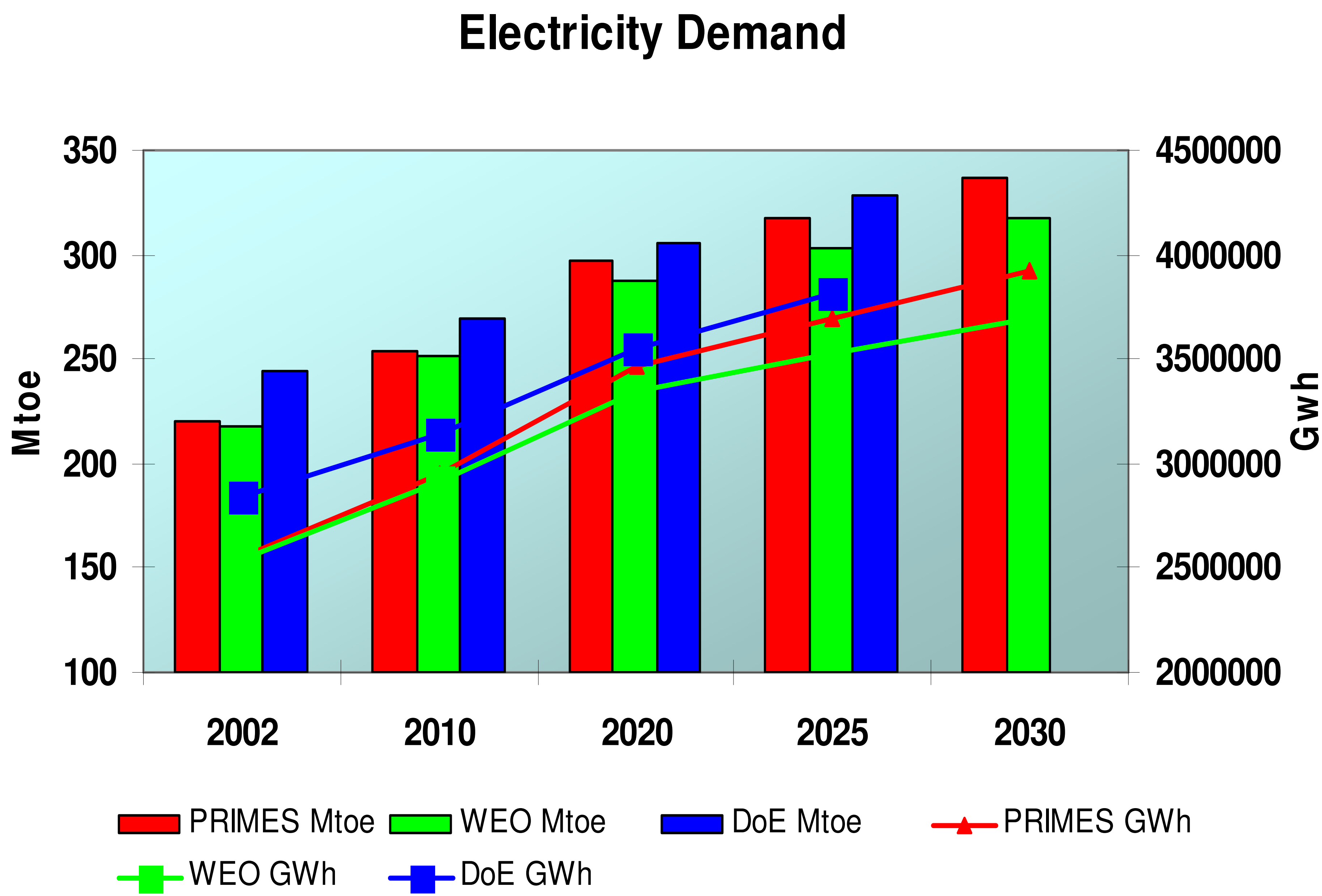

Final Energy Demand
Mtoe
2500
2000
1500
1000
500
0
2002
2010
2020
2025
2030
PRIMES
WEO
DoE

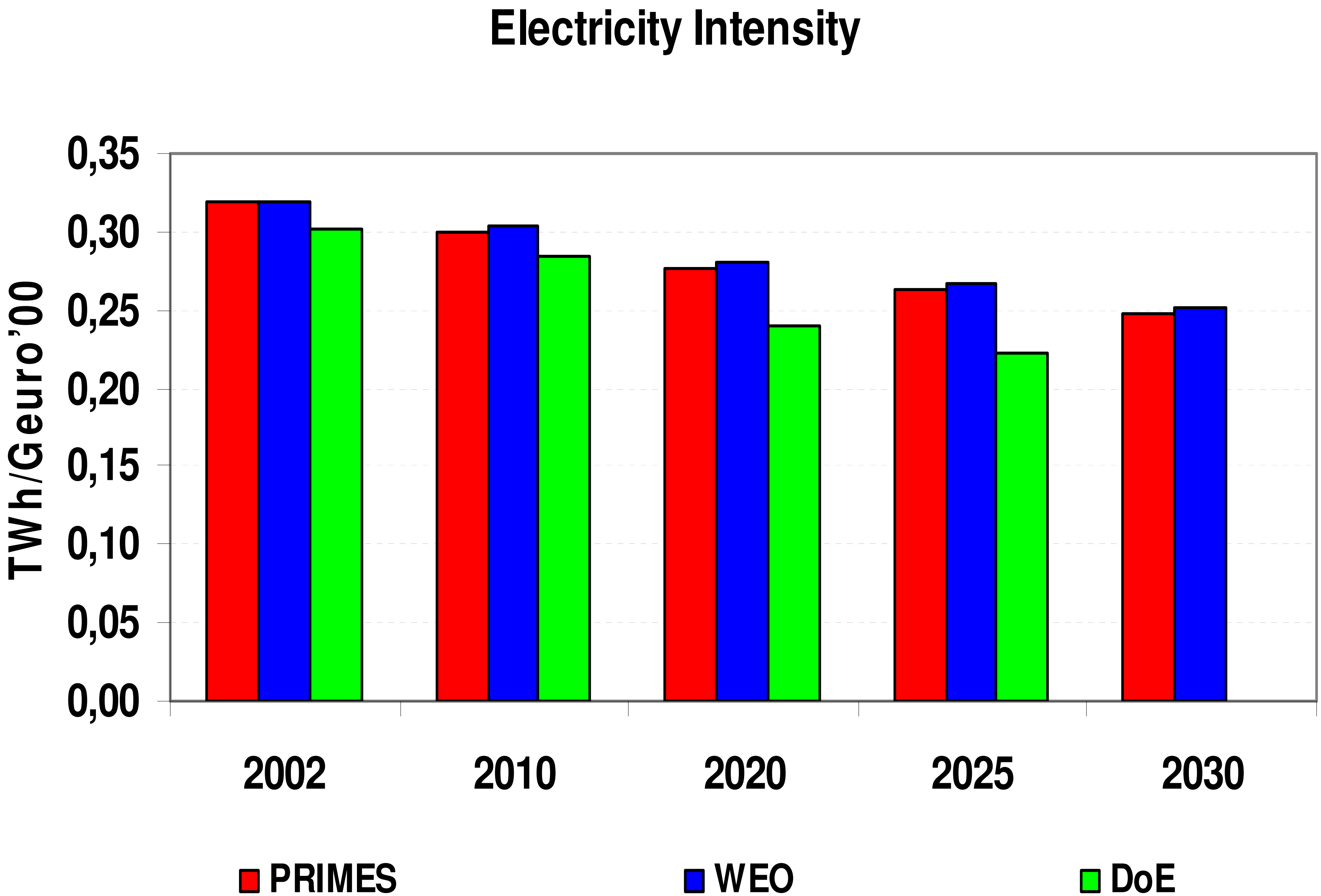

GDP and Final Energy Demand (growth rate)
3,0%
2,5%
2,0%
1,5%
1,0%
0,5%
0,0%
2002-2010
2010-2020
2020-2025
2025-2030
Primes GDP
Primes Final Energy Demand
WEO GDP
WEO Final Energy Demand
DoE GDP
DoE Final Energy Demand

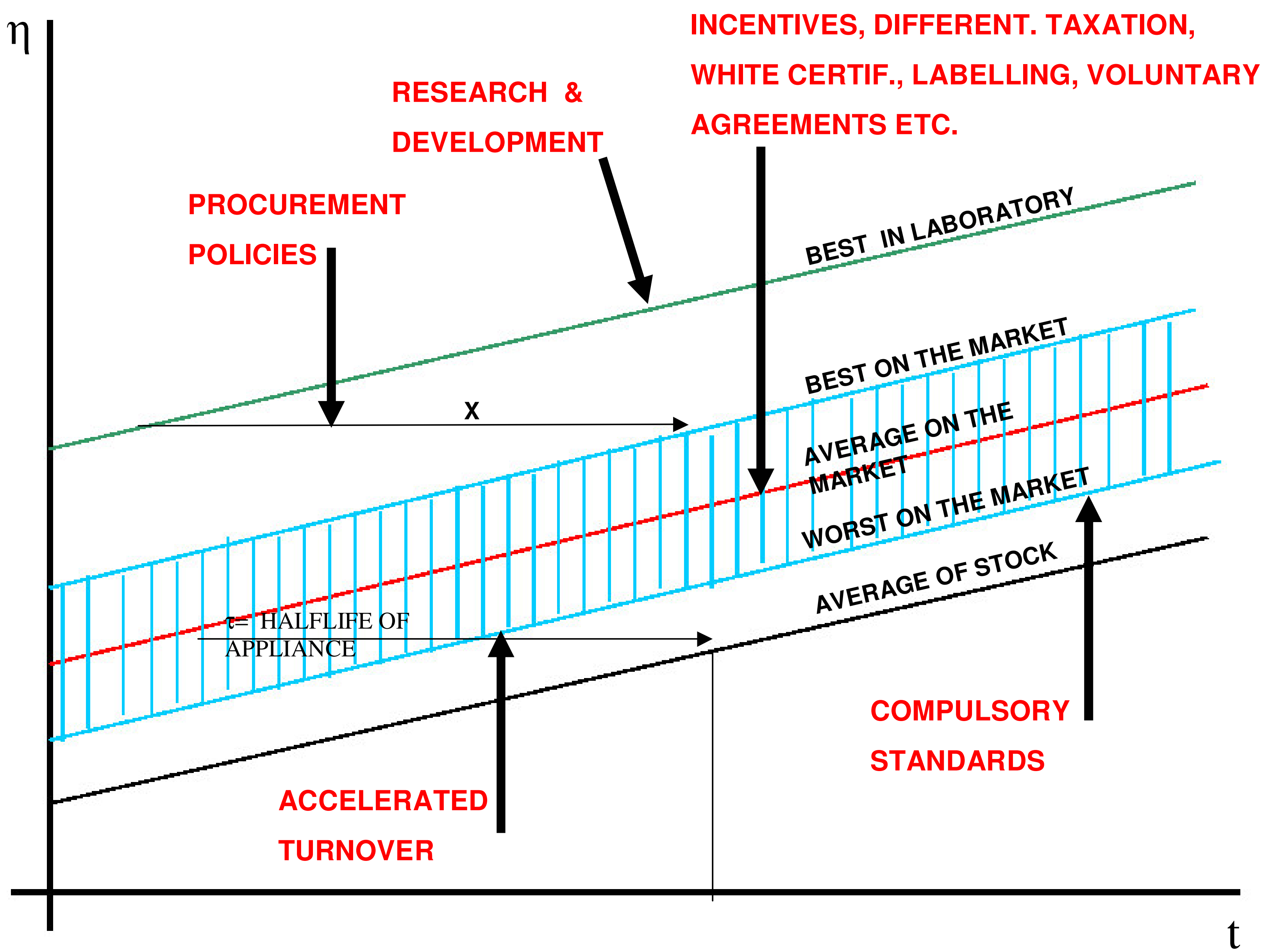


Electric Penetration (growth rate)
0,8%
0,6%
0,4%
0,2%
0,0%
2002-2010
2010-2020
2020-2025
2025-2030
PRIMES
WEO
DoE


Electricity Demand (growth rate)
2,0%
1,5%
1,0%
0,5%
0,0%
2002-2010
2010-2020
2020-2025
2025-2030
PRIMES
WEO
DoE


Electricity Demand
Mtoe
Gwh
350
300
250
200
150
100
4500000
4000000
3500000
3000000
2500000
2000000
2002
2010
2020
2025
2030
PRIMES Mtoe
WEO Mtoe
DoE Mtoe
PRIMES GWh
WEO GWh
DoE GWh


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


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

Classification of P&M in “White and Green”

Categories of P&Ms

1.) RD&D

2.) Awareness

3.) Capital incentives and remuneration
Investment schemes, fiscal measures, feed-in

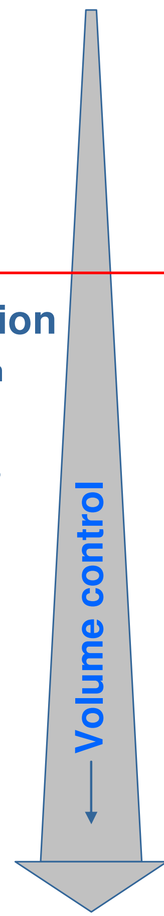
4.) Negotiated/voluntary agreements

5.) Labelling

6.) Standard setting

7.) Taxes

8.) Certificates



“Command & control”:
Prescribed macrogoals

“Upfront measures”

Subsidies

Organisational measures

Per se: Awareness, but
usually in symbiosis

Prescriptive

“Market-based”

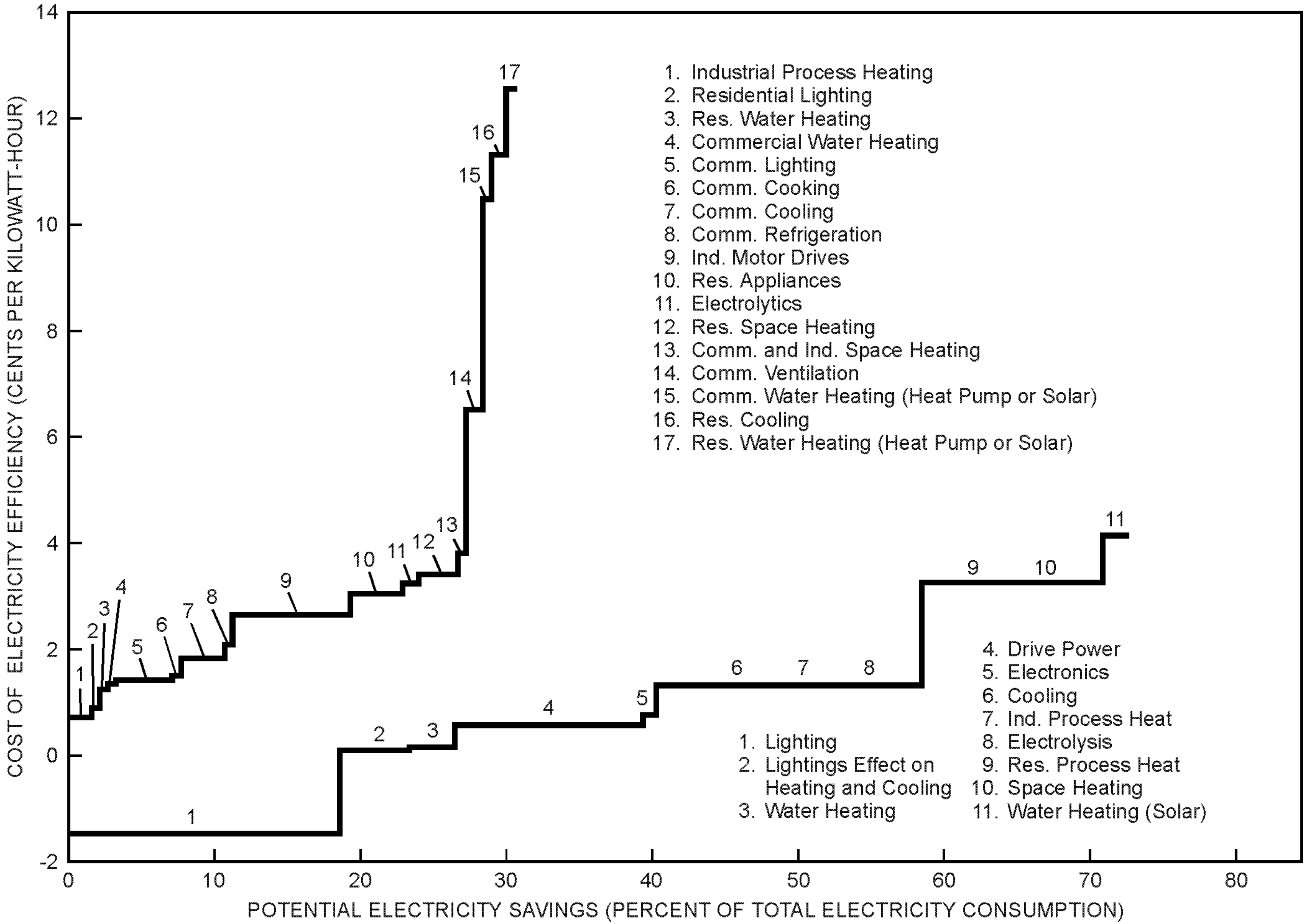
White&Green

Balance, showing the actors whose prosperity will increase (winners) or decrease (losers) by an energy efficiency retrofit

+	-
Winners	**Losers**
Consumers Manufacturers efficient equipment	Manufacturers conventional equipment Primary energy suppliers Utilities

Balance in which an ESCO installs efficient equipment

+	-
Winners	*Losers*
Consumers *ESCO* *Manufacturers efficient equipment*	*Manufacturers conventional equipment* *Primary energy suppliers* *Utilities*


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)
COST OF ELECTRICITY EFFICIENCY (CENTS PER KILOWATT-HOUR)
POTENTIAL ELECTRICITY SAVINGS (PERCENT OF TOTAL ELECTRICITY CONSUMPTION)

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