WP-2 : Input Data and Energy Demand

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Mandate of WP-2

- Supply input data for WP-5 on: demography; economic evolution (GDP); price of primary fuel; other indicators (?)
- Evaluate trends of demand for energy services and electricity demand
- Evaluate the effects of energy efficiency policies and DSM measures

Time and space

- The time horizon is 2050 (but as we shall see uncertainties beyond 2030 are big!)
- The geographical reference is EU-25; some extrapolations will be used from EU-15, EU-15+ (IEA), “Western Europe” and “Eastern Europe” (DoE/EIA)
- Effects of further expansion of EU (EU-30) will be briefly considered

Sources

The main sources used for this analysis will be:

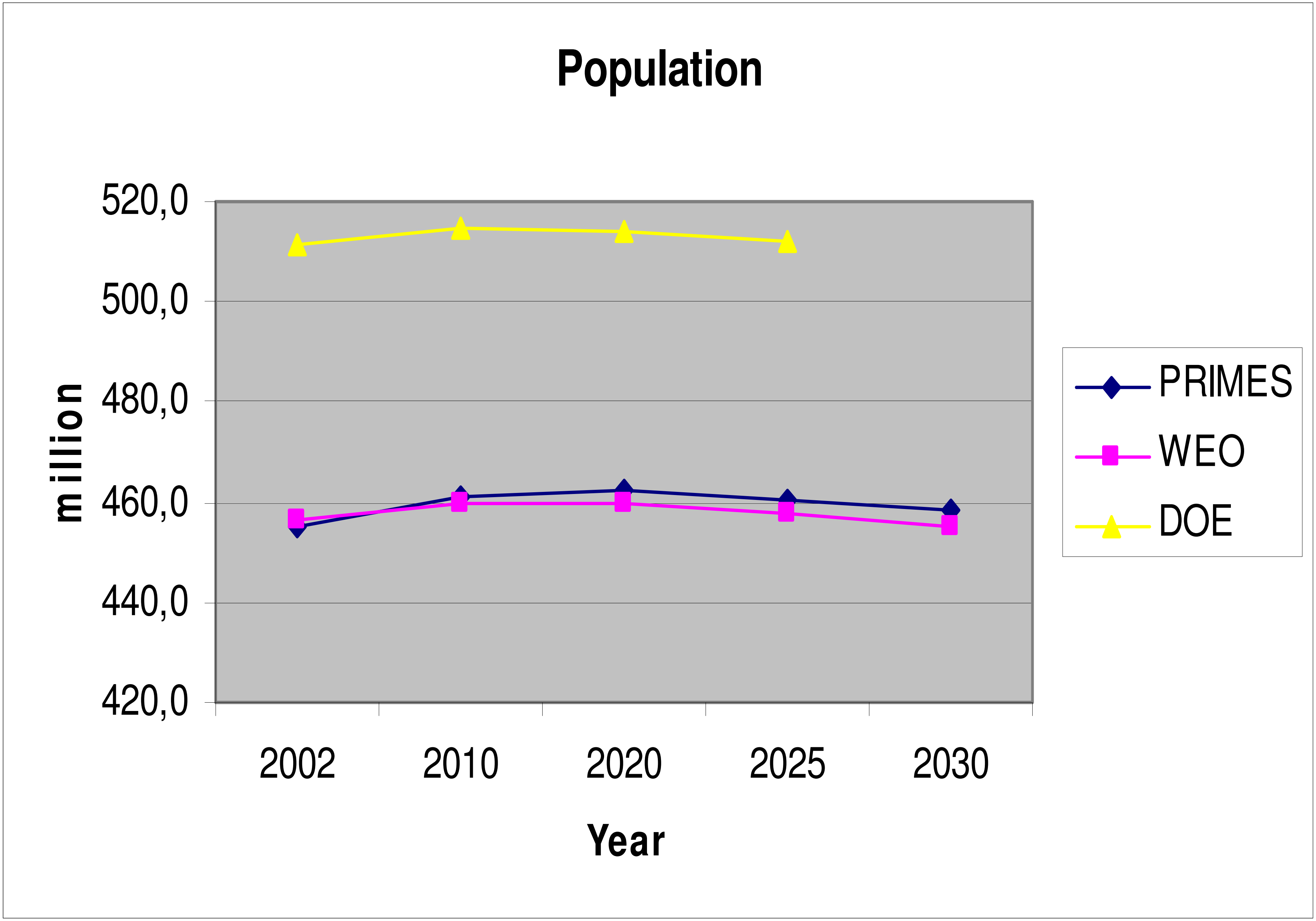
- EU-DG TREN European energy and transport trends to 2030 (PRIMES)
- IEA World Energy Outlook 2004 (WEO)
- US-DOE/Energy Information Agency, International Energy Outlook (2004 and 2005) (DoE)
- EU- DG RES, WETO-2030 World Energy Technology Outlook to 2030; WETO 2050
- EUROSTAT
- UN-Habitat
- EU-DG TREN White and Green Project results 2005
- IIASA
- World Energy Council (WEC)

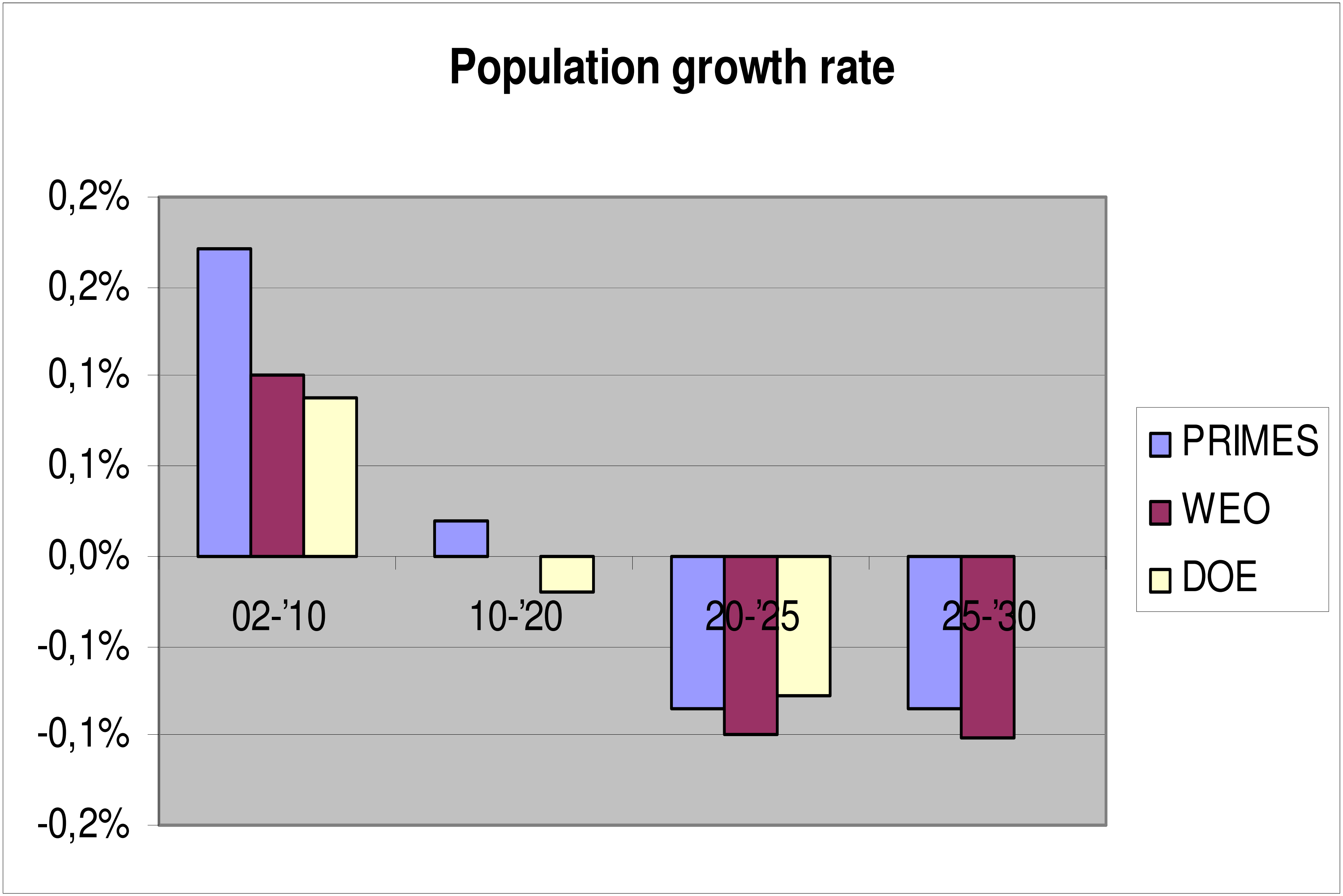
Demography

- All models predict a substantially stable population in EU-25 until 2030
- These predictions can be considered very reliable over this period (since the age distribution of population is predictable) at least for the internal evolution; contributions from immigration could be much more significant if policies or external conditions vary
- An extrapolation of constant population from 2030 to 2050 is reasonable but subject to increasing uncertainties.

EU-25 population
(from PRIMES until 2030)

Year:	2000	2010	2020	2030	2040	2050
Popul.: (million)	453.4	461.2	462.1	458.2	458.2	458.2
% per year		+ 0.2	0.0	- 0.10	0	0


Population
520,0
500,0
480,0
460,0
440,0
420,0
million
2002
2010
2020
2025
2030
Year
PRIMES
WEO
DOE


Population growth rate
0,2%
0,2%
0,1%
0,1%
0,0%
-0,1%
-0,1%
-0,2%
02-'10
10-'20
20-'25
25-'30
PRIMES
WEO
DOE

Long-term population evolution

- IIASA has a projection of world population from 2000 to 2100, divided by groups of countries and by age group.
- The European region (one of 16) includes Western Europe, Eastern Europe and former Soviet Union
- With some effort and a number of assumptions it would be possible to elaborate these data in a format compatible with ours (EU-25)
- However, it is doubtful this analysis would actually improve the credibility of our scenario

Age distribution

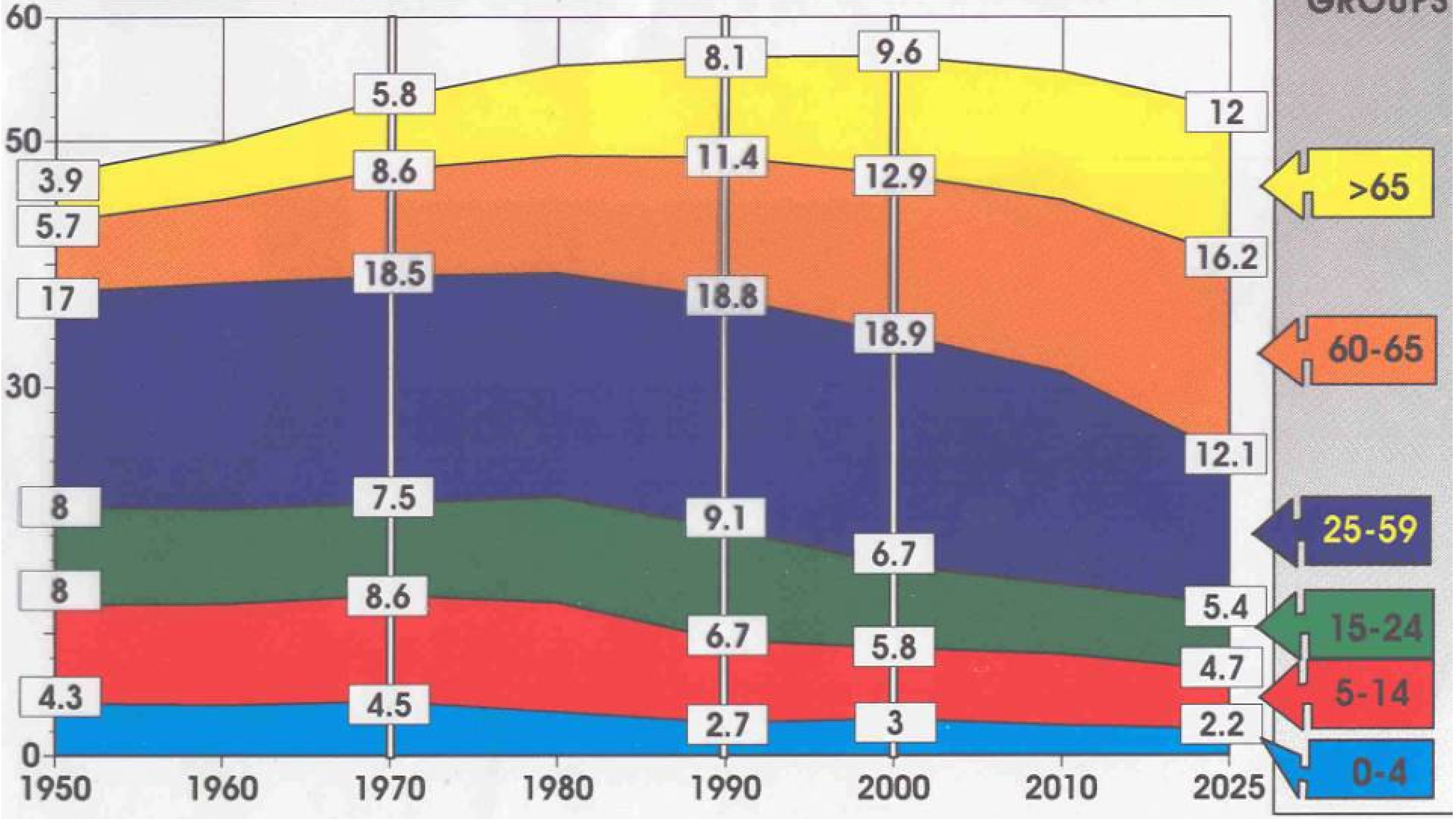
More important than the change in size of the population is the change in age distribution.

The trend toward stable or (slowly) decreasing population in Europe involves a progressively older population (see example for Italy).

This fact is relevant at least in two respects: it changes the distribution of the demand of energy services; it influences (negatively) the generation of GDP as it reduces the working proportion of the population.

No convincing analysis of the change in demand of energy services with age profile is known to us

ITALY: EVOLUTION OF AGE GROUPS
(historical data and projections to 2025)



The evolution of GDP

This is a much more difficult and sensitive prediction

All predictions assume a positive, but limited, growth of the economy

In most models, the growth rate decreases in the period from 2015 to 2025

The Eastern European component of EU-25 grows more than the West European countries (at least to recover a part of the large set-back of the last 15 years), but the Western EU countries, however, have a predominant weight

Since the population is substantially stable, it is not necessary to distinguish between the growth rate of total GDP and of GDP per capita.

GDP growth rate in EU 25

Year: 2000 2010 2020 2030 2040 2050

PRIMES:

GDP (G€) 8939 11433 14462 18020

% p.a. 2.5 2.4 2.2

WEO 04: 2.3 2.1 1.7

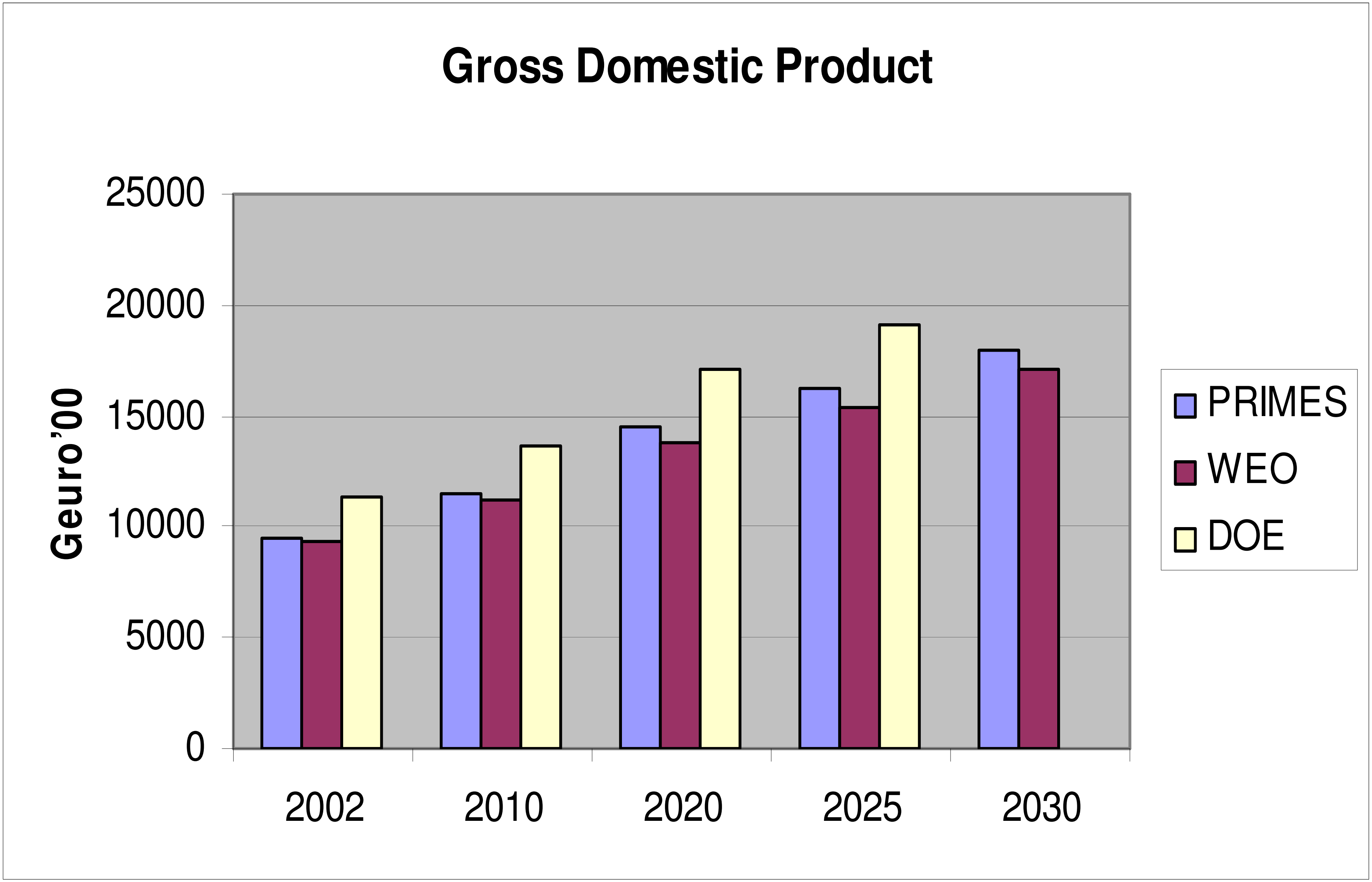
DoE ref: 2.2 2.3 2.2

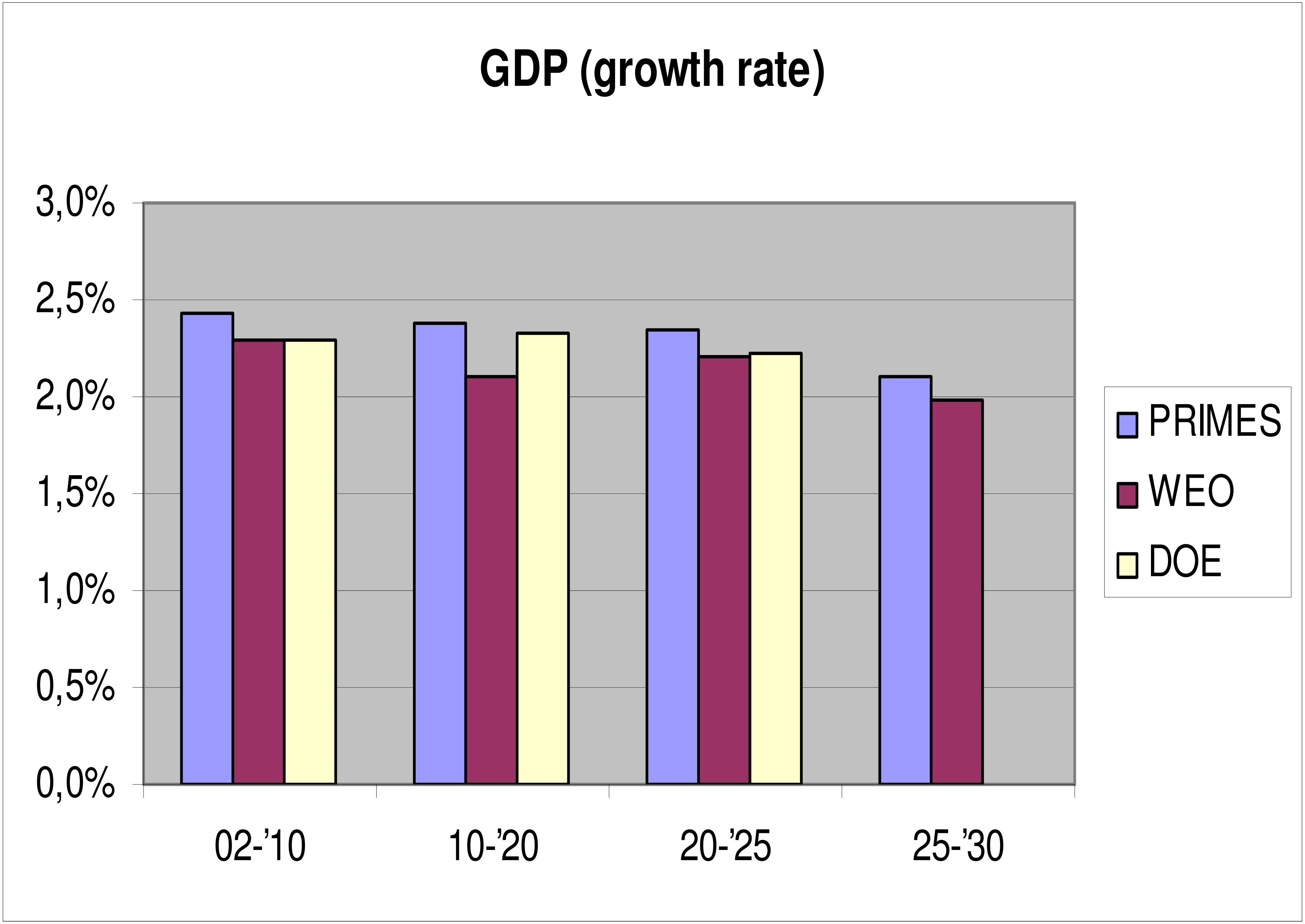
DoE high: 2.6 2.9 2.8

DoE low: 1.7 1.8 1.7

DoE data are calculated as averages of Western and Eastern Europe, weighted over GDP

The DoE time horizon is 2025, not 2030


Gross Domestic Product
Geuro'00
25000
20000
15000
10000
5000
0
2002
2010
2020
2025
2030
PRIMES
WEO
DOE


GDP (growth rate)
3,0%
2,5%
2,0%
1,5%
1,0%
0,5%
0,0%
02-'10
10-'20
20-'25
25-'30
PRIMES
WEO
DOE

Extrapolation of GDP to 2050

The simplest way to extrapolate the evolution of GDP to 2050, starting from the PRIMES values, is to assume that the growth rate will continue to decrease slowly.

We suggest to assume a GDP growth rate of 1.9% p.a. in the period 2030-2040, and of 1.7% p.a. in the period 2040-2050.

With these assumptions, the GDP would be:

Year	2030	2035	2040	2045	2050
GDP (G€-2000)	18,020	19,798	21,751	23,664	25,746

Price of primary fuels

This is the most difficult, critical and controversial prediction; for instance in 2005 oil prices have grown well beyond any forecast made one year before; some sources have already reevaluated predictions for 2010

In 2004 the world oil demand increased by 2.7 Mbbl/day (more than in 2000-2003); the OECD demand increased by 0.6 but its production <u>decreased</u> by 0.4 Mbbl/d with an increase of import of 1 Mbbl/d

In the same year the demand from emerging countries increased by 2.1 Mbbl/d, 0.9 of which from China alone

The demand of oil products has further shifted towards lighter products (gasoline and diesel), putting more pressures on refineries, which had been optimized for a different basket and are late in adjusting

Difficulties in predicting oil prices

The main problem is that there is no agreement on the relative weights of the possible reasons for the increase of oil prices: lack or delay of investments, expectation of dwindling resources, huge increase of the demand from rapidly developing countries, worries on geopolitical situations, etc.

Another controversial question: is there a stop-value for the price due to: non-OPEC supply; non-conventional oil; other energy sources?

Finally, the results may be sensitive to the projected exchange rate $ / €

A high-price scenario

For all these reasons, it seems necessary to consider – in addition to the prevalent forecasts of a limited increase of oil prices starting from values much lower than the present (seen as a fluctuation) – a high price scenario, accounting for a continuation of geopolitical problems, a delay in investments due to the uncertain environment, a further rapid growth of demand from developing countries.

Such a high growth (but by no means extreme) scenario would see the price of Brent oil (expressed in constant 2002 $ values) soar from 45.2 $/bbl in 2005 to 57 in 2020 to 62 in 2030.

Price of other fuels (1)

The price of gas is presently linked to the price of oil in supply contracts

A trend towards a greater independence of the gas market from the oil market has been envisaged and some signs have shown in this direction

As oil prices increase, however, there is more interest in transforming gas as well as coal into liquid products that could replace oil derivatives

Such increased possibilities of substituting one fuel for another involve large investments and require long lead times

Price of other fuels (2)

Of course, in the same way in which fuel substitution will put pressure on the coal and gas market as oil becomes more expensive and increase their prices, it will also, on the long term, put a cap on oil prices, especially in view of the utilisation of the large resources of coal.

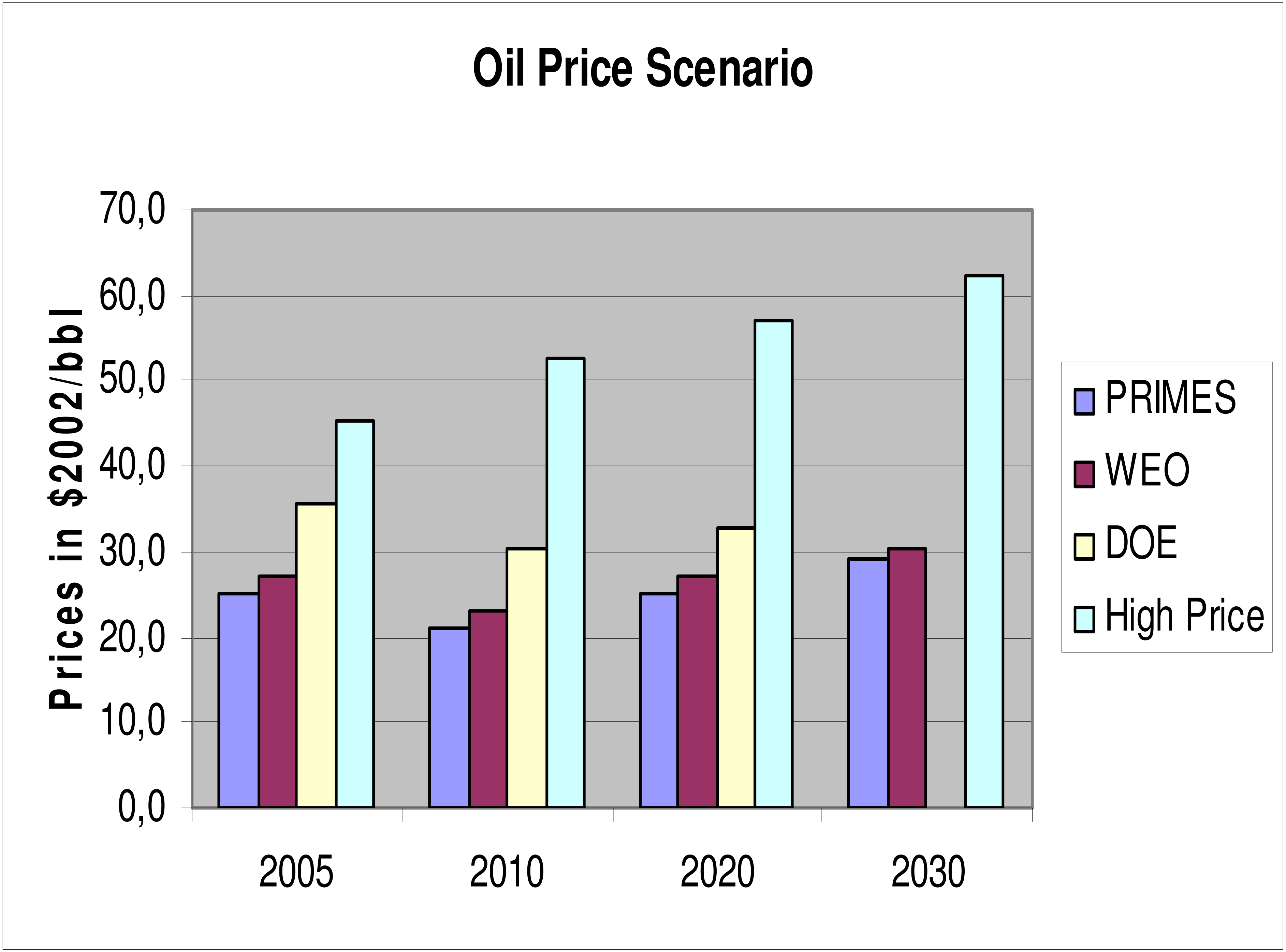
On this basis, a high energy price scenario has been imagined, involving also gas and coal.

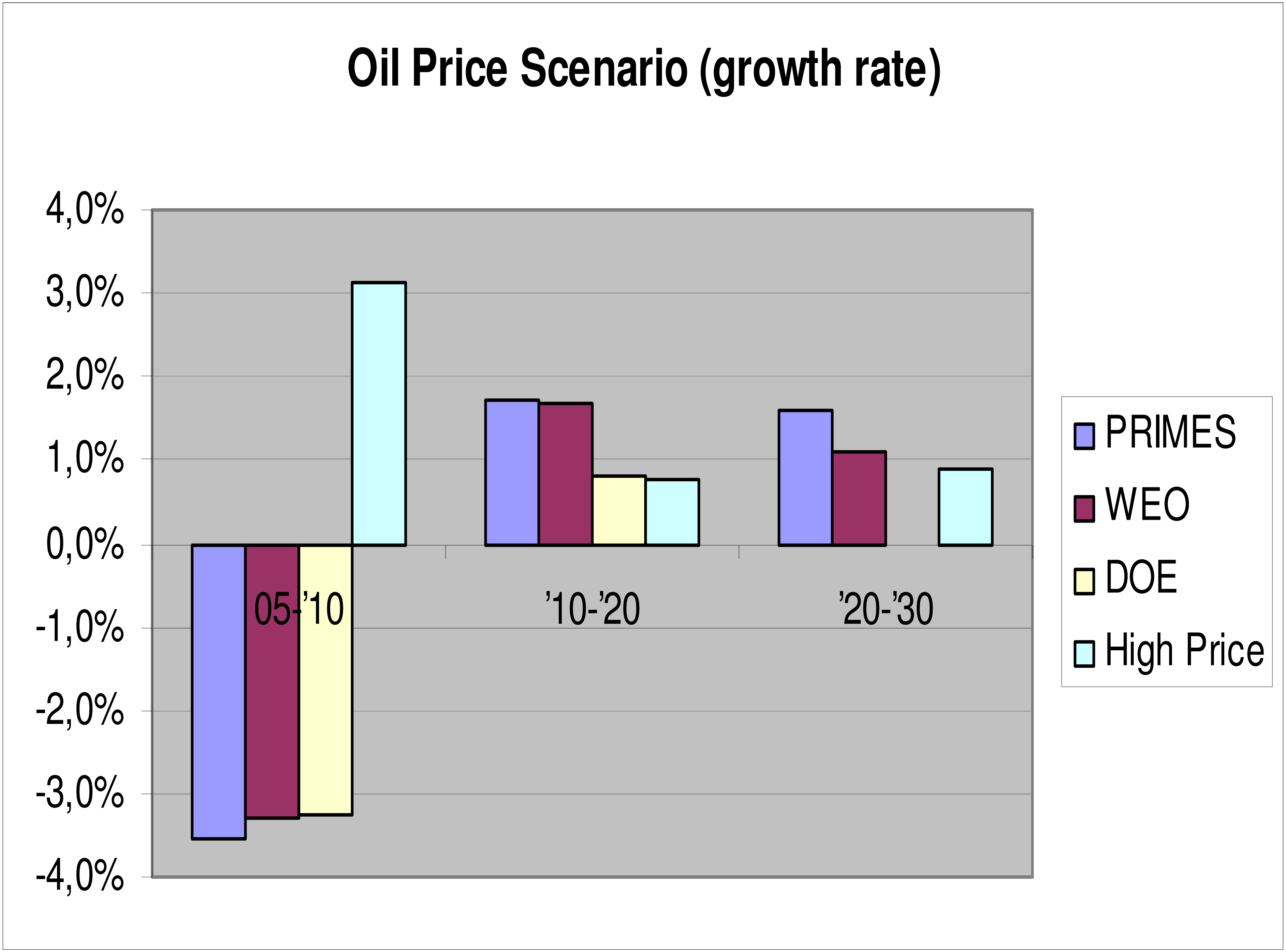
The high-price scenario

Year	2005	2010	2020	2030
Oil (Brent)	45.23	52.76	56.94	62.13
Gas	28.63	41.62	47.77	51.21
Coal	13.11	14.13	19.97	28.10

Prices in \$2002/bbl; Source: AIEE 2005

Extrapolation beyond 2030 becomes very uncertain


Oil Price Scenario
Prices in $2002/bbl
70,0
60,0
50,0
40,0
30,0
20,0
10,0
0,0
2005
2010
2020
2030
PRIMES
WEO
DOE
High Price


Oil Price Scenario (growth rate)
4,0%
3,0%
2,0%
1,0%
0,0%
-1,0%
-2,0%
-3,0%
-4,0%
05-'10
'10-'20
'20-'30
PRIMES
WEO
DOE
High Price

Connections between oil prices and GDP

In principle, the choice of an energy price scenario and a GDP scenario should go together in order to ensure consistency.

However, although it is undoubted that the price of energy may have a strong influence on the evolution of GDP, quantitative relationships are questionable and past experience is not easy to interpret. Recent events have shown the world economy more resilient to energy prices than in the past.

In general, it makes more sense to couple high-growth GDP scenarios with low energy price assumptions and vice versa.

Connections between energy prices and energy consumption

Although the energy demand can be expected to decrease for increasing energy prices, the elasticity of demand to (international) energy prices is lower than one could expect for two reasons:

1. Only a part of the changes in international prices for energy reach the final consumer, since a relevant fraction is damped by the fiscal charges
2. The demand for many energy services is rigid as the user considers them essential

Therefore the main link between energy prices and demand is through the GDP: higher prices = lower GDP = lower demand

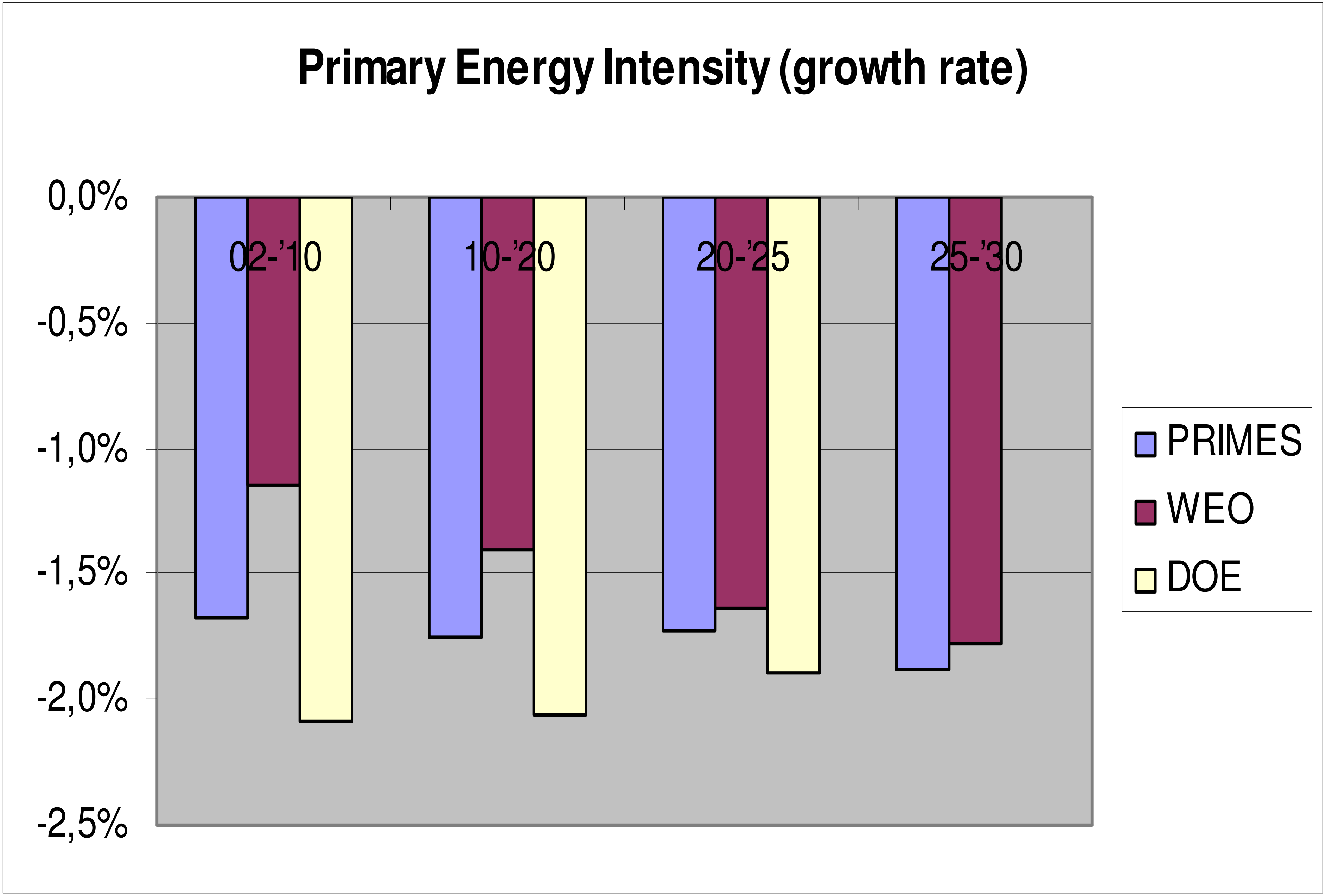
From GDP to energy demand to electricity demand

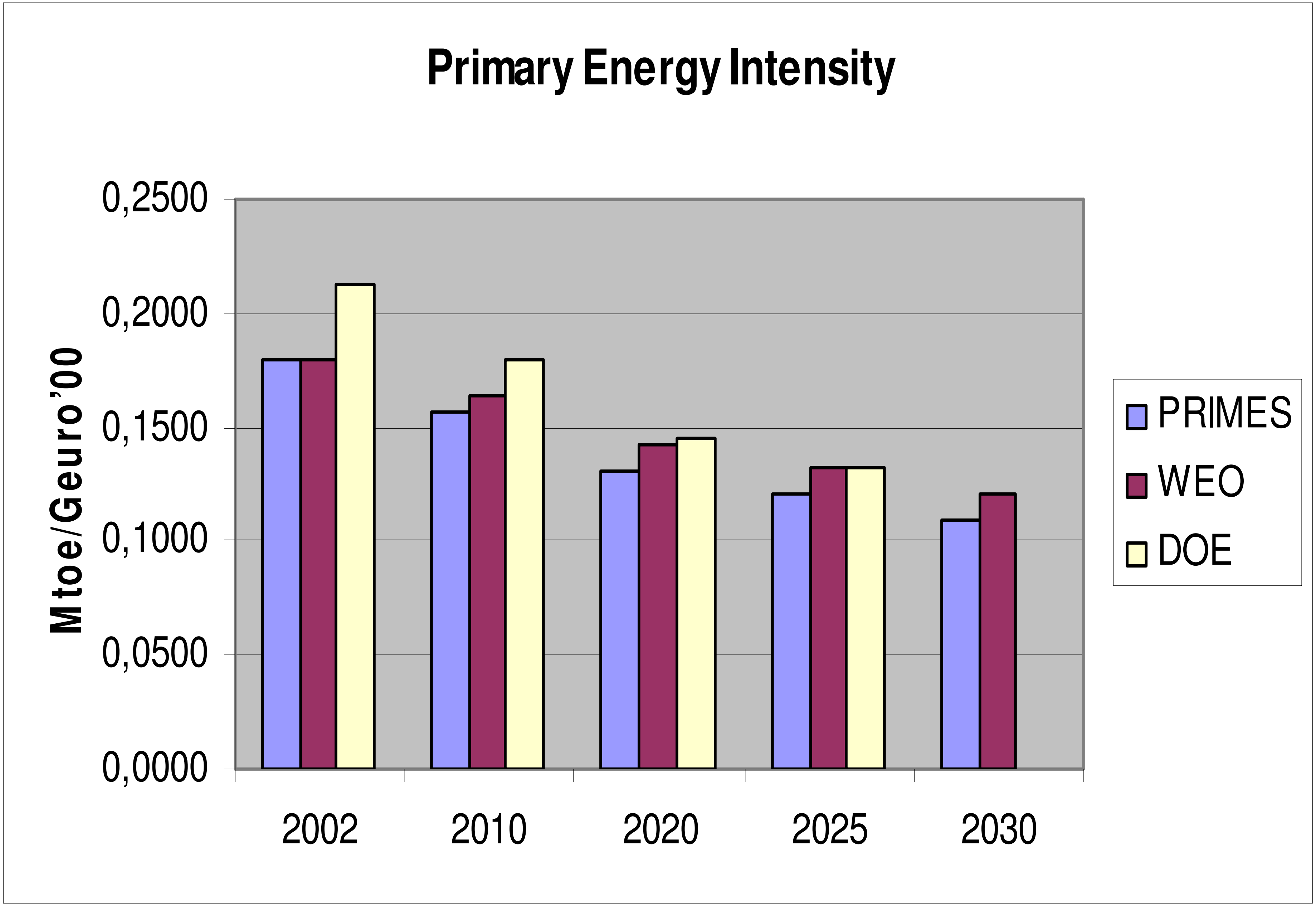
The main assumptions (common to all models) are as follows:

- The demand for energy services will grow at a rate somewhat slower than GDP (for instance because of saturation)
- A further reduction of growth rate in energy will be brought about by efficiency improvements
- The two phenomena will compound in a progressive decrease of the energy intensity of GDP
- The same will happen for electricity demand, but the electricity intensity will decrease less than the energy intensity because electricity penetration is expected to increase

Prediction of total energy demand

- All macroeconomic models assume that energy intensity (expressed as the ratio of energy demand to GDP, in Mtoe/G€) will continue to decrease with time, as a consequence of more efficient technology, miniaturisation, shifts in consumer's demand and behaviour, and economic pressure.
- Primary energy intensity is thus assumed to decrease at a rate between 1 and 2 % per year: this rate is different in the various models, and may vary with time.
- The assumption that this rate of decrease is of 1.5 % per year will be roughly in line with the models we have considered.

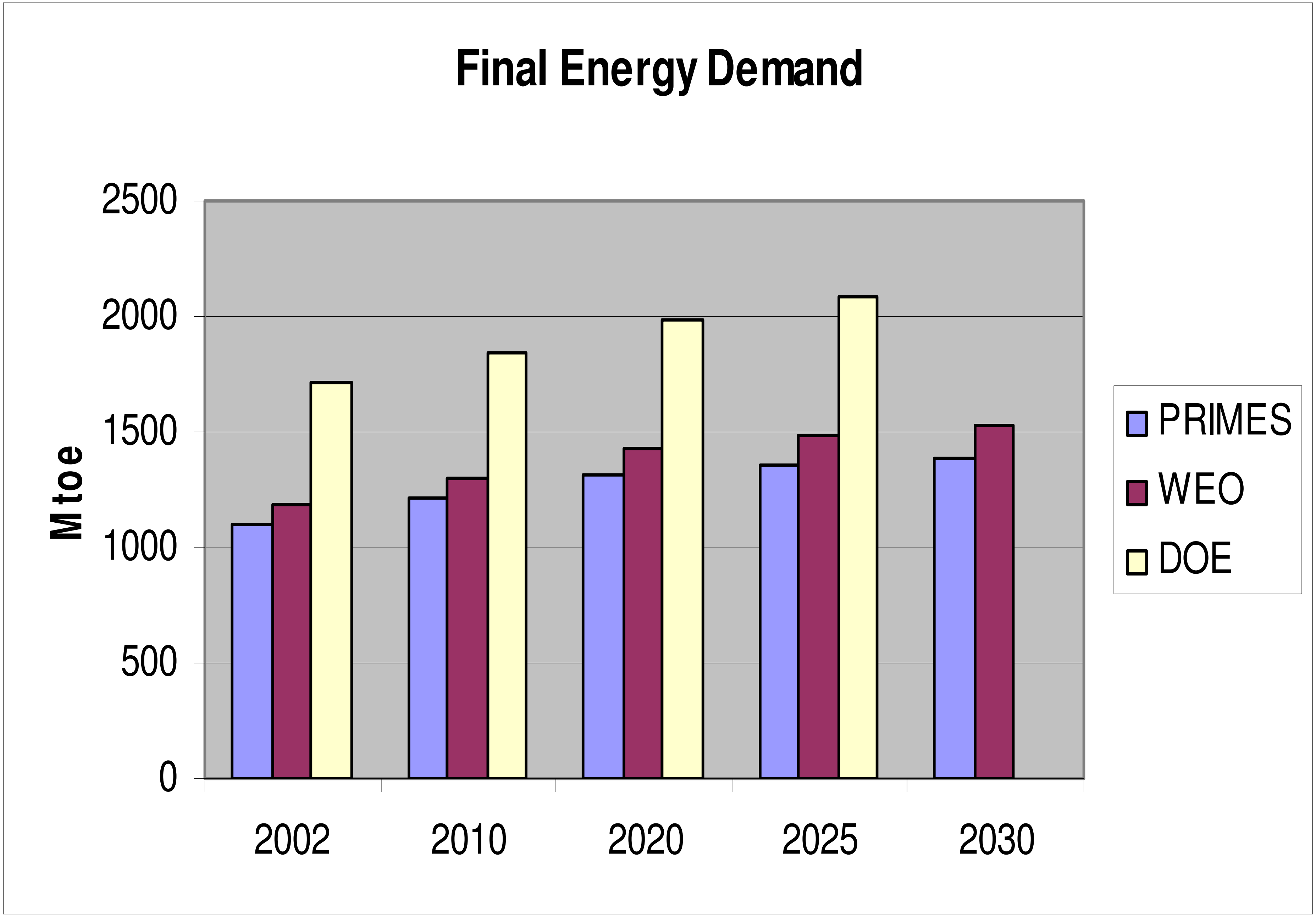

Primary Energy Intensity (growth rate)
0,0%
-0,5%
-1,0%
-1,5%
-2,0%
-2,5%
02-'10
10-'20
20-'25
25-'30
PRIMES
WEO
DOE

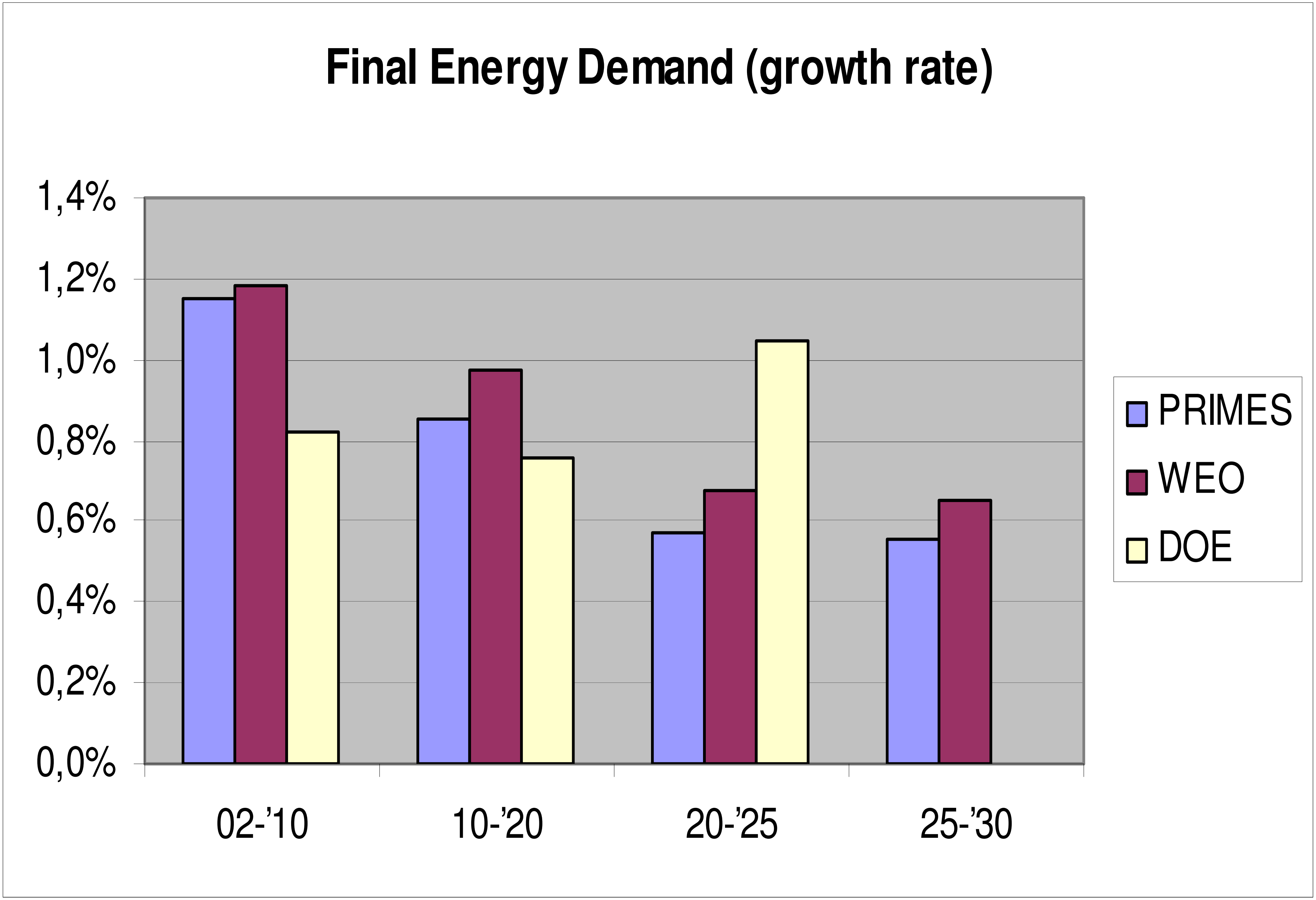


Primary Energy Intensity
Mtoe/Geuro'00
0,2500
0,2000
0,1500
0,1000
0,0500
0,0000
2002
2010
2020
2025
2030
PRIMES
WEO
DOE

Energy demand in absolute values

- **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.**


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

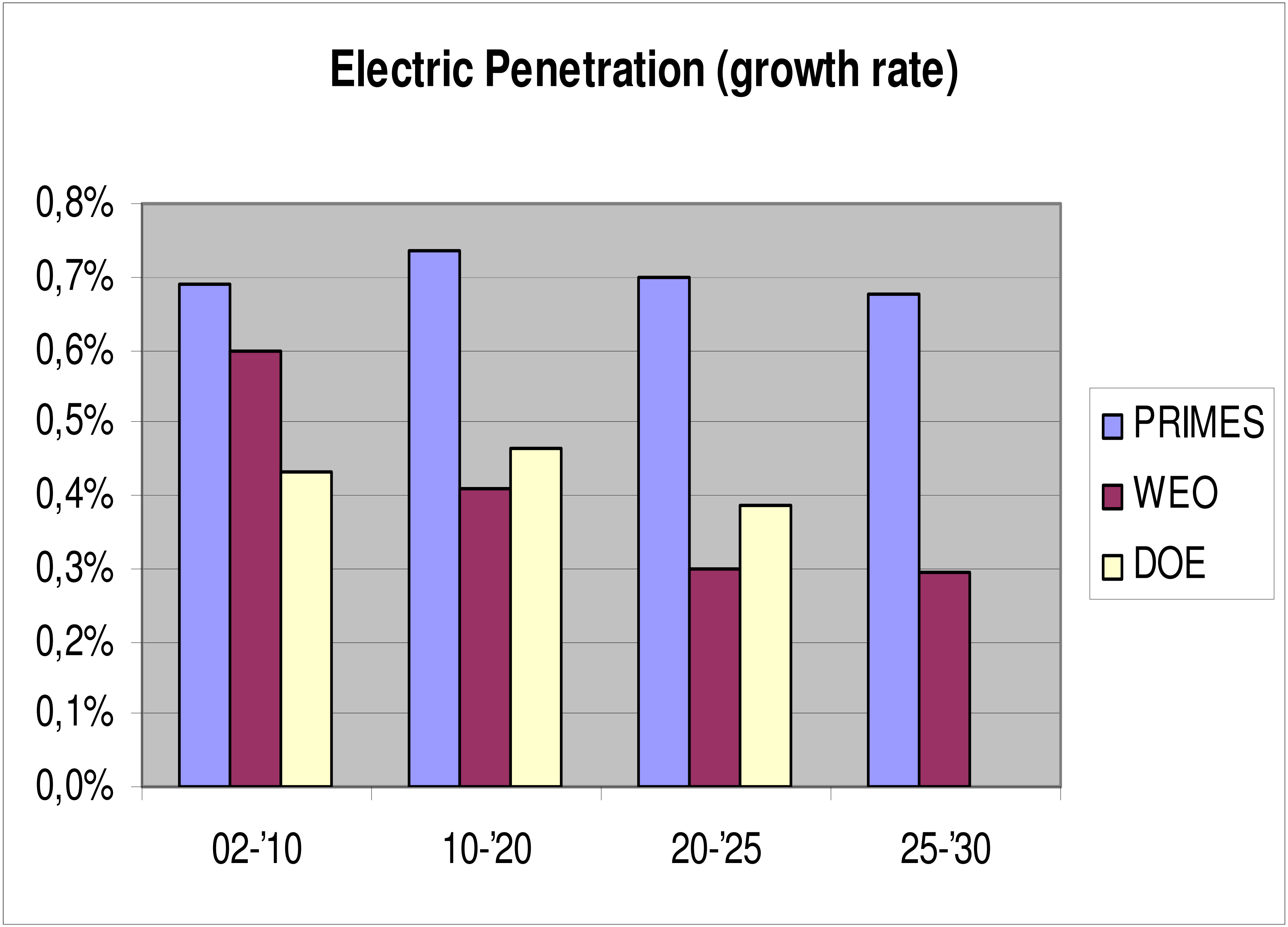

Final Energy Demand (growth rate)
1,4%
1,2%
1,0%
0,8%
0,6%
0,4%
0,2%
0,0%
02-'10
10-'20
20-'25
25-'30
PRIMES
WEO
DOE

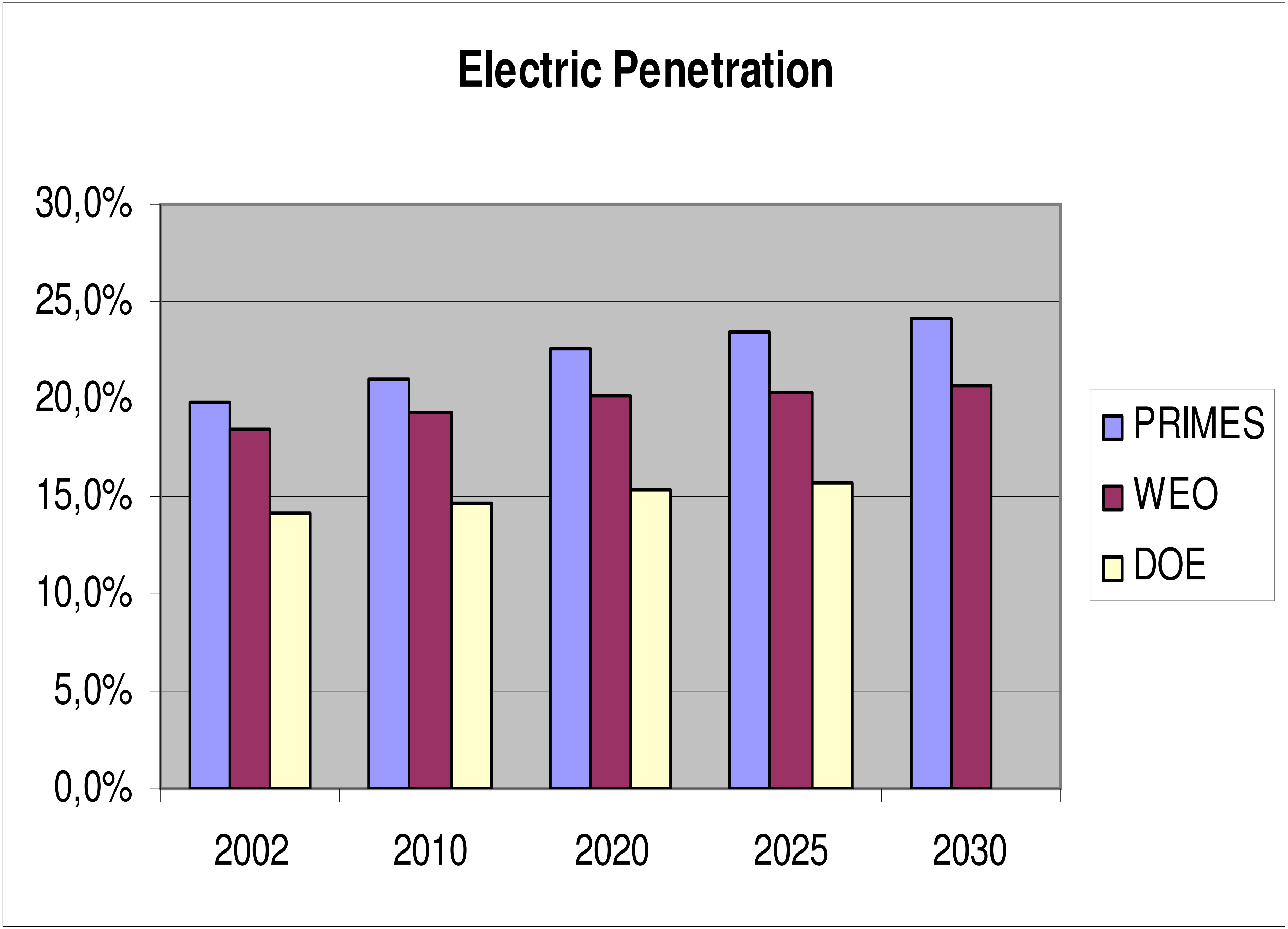
Electricity penetration

The share of the final demand that is covered by electricity (i.e. the “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.

There are substantial differences between the growth rates predicted by PRIMES and by WEO.


Electric Penetration (growth rate)
0,8%
0,7%
0,6%
0,5%
0,4%
0,3%
0,2%
0,1%
0,0%
02-'10
10-'20
20-'25
25-'30
PRIMES
WEO
DOE

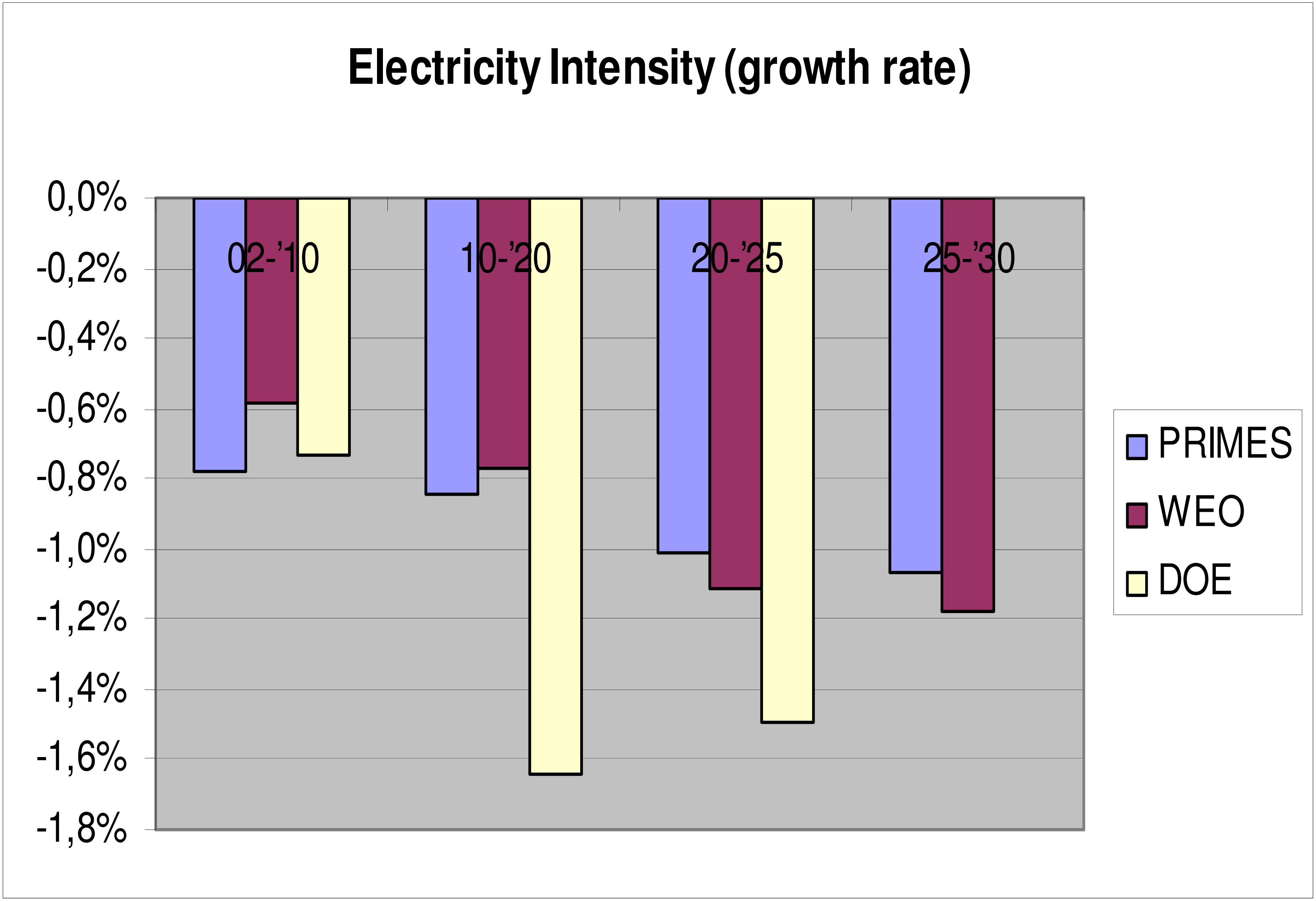

Electric Penetration
30,0%
25,0%
20,0%
15,0%
10,0%
5,0%
0,0%
2002
2010
2020
2025
2030
PRIMES
WEO
DOE

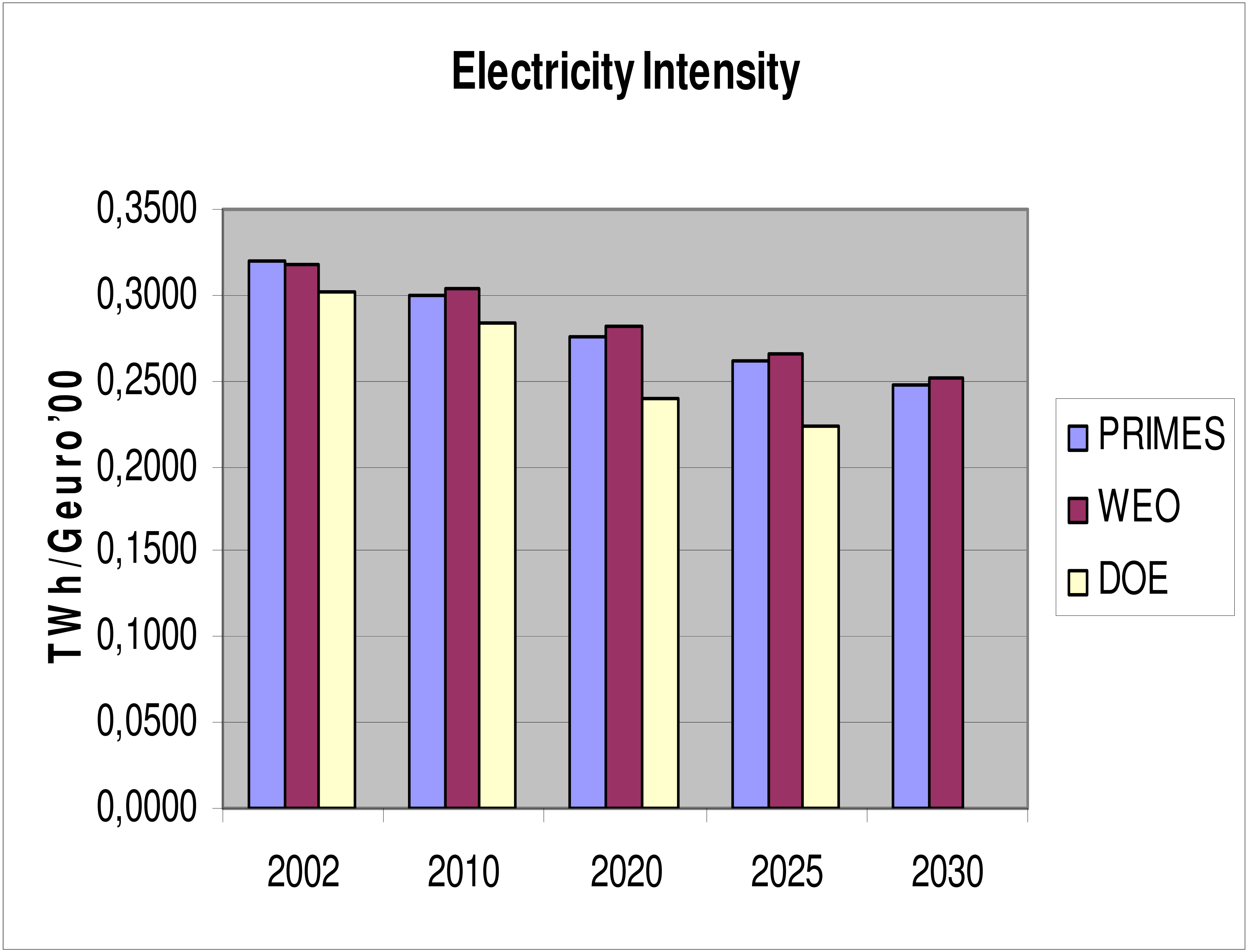
Trends in electricity intensity and in electricity demand

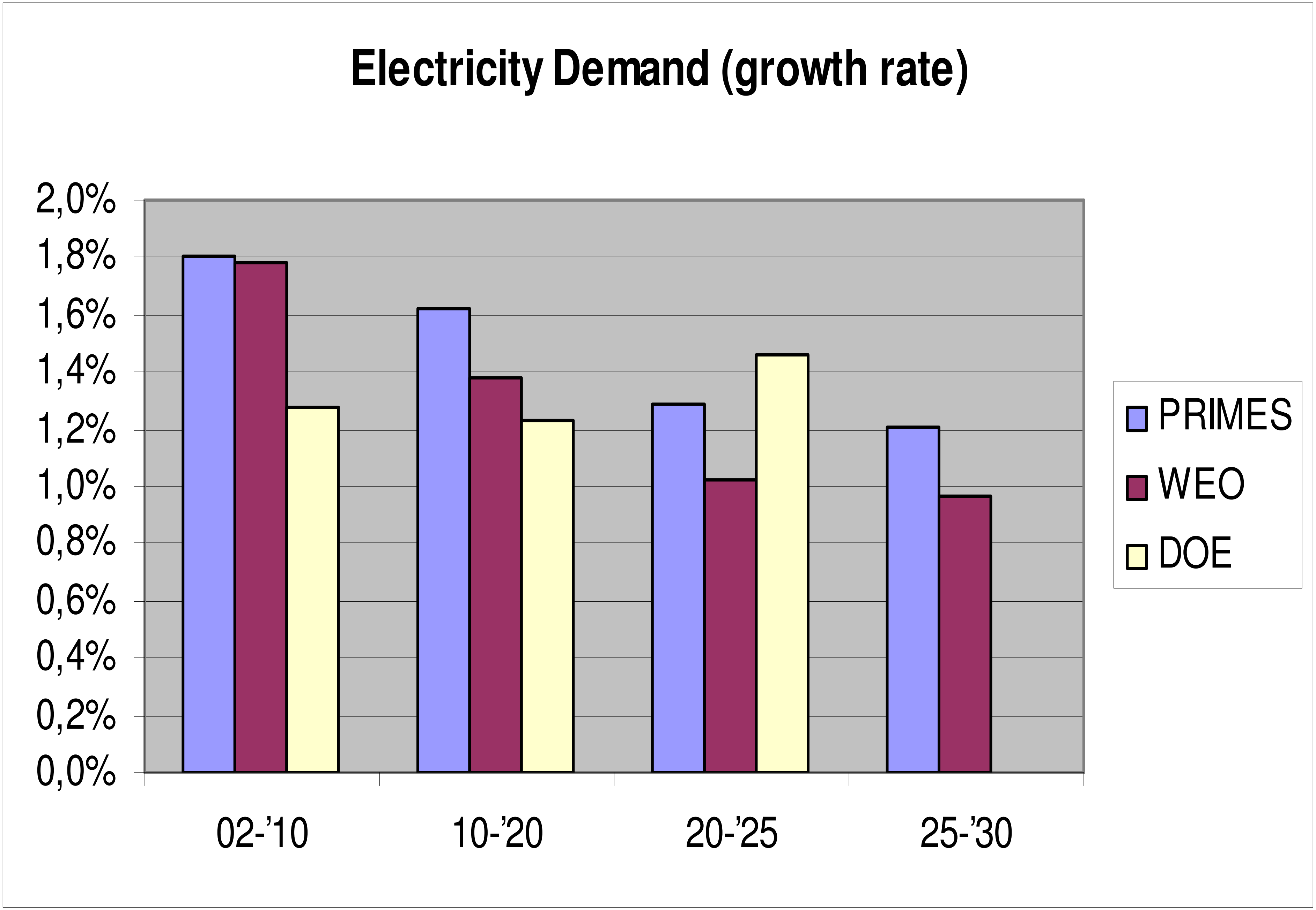
As a consequence of the increasing electricity penetration, the electricity intensity of GDP will decrease less steeply than the energy intensity of GDP.

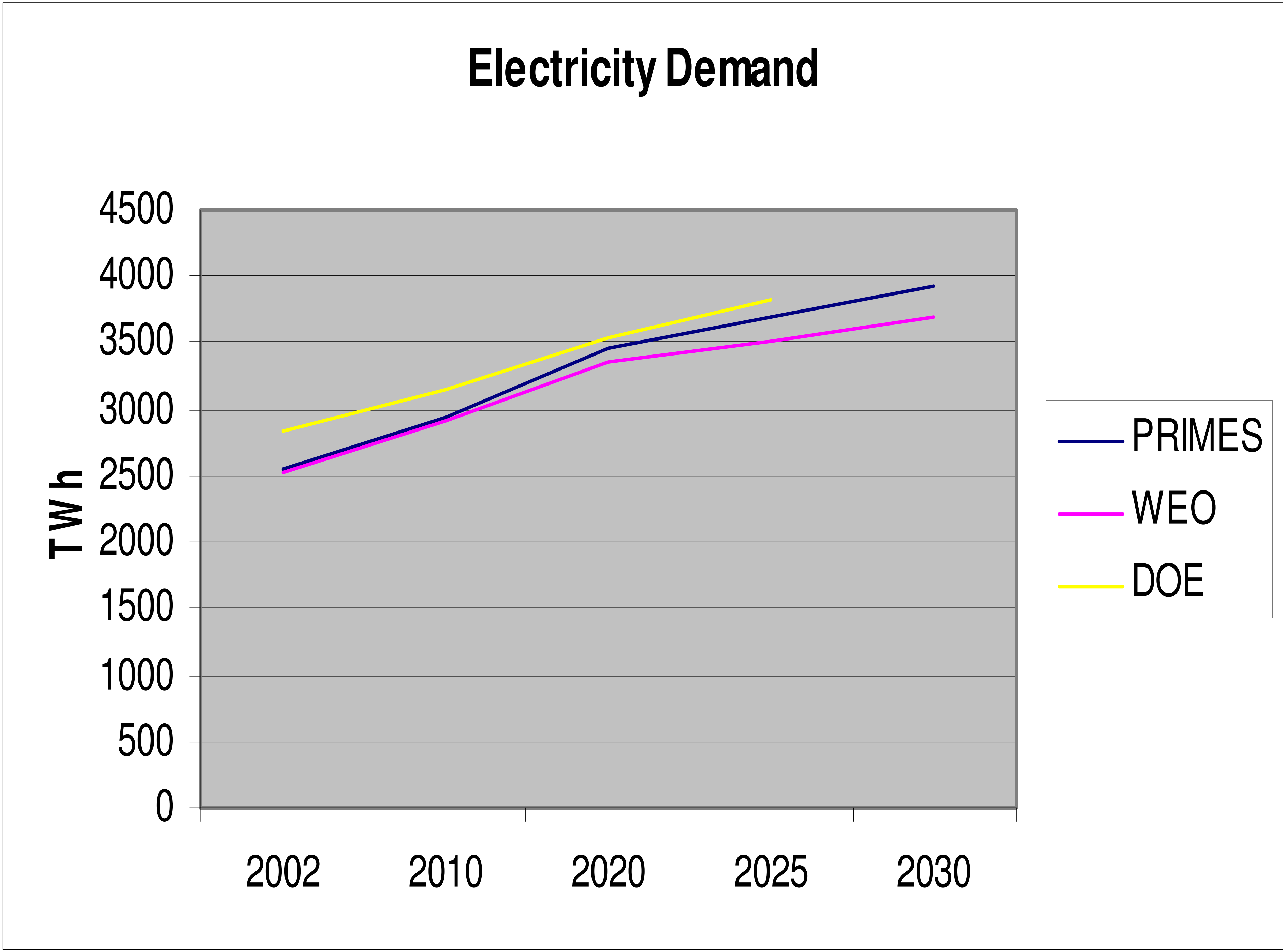
Once assumptions are made on the trends in electric penetration, it is easy to express the variations in electricity demand and its absolute values over time.

The discrepancies between models on the values of penetration between 2010 and 2030, however, are partly compensated by the variations (in the opposite sense) of total energy intensity, so that there is a certain convergence in the prediction of electricity intensity, at least between PRIMES and WEO, which may make an extrapolation to 2050 possible.


Electricity Intensity (growth rate)
0,0%
-0,2%
-0,4%
-0,6%
-0,8%
-1,0%
-1,2%
-1,4%
-1,6%
-1,8%
02-'10
10-'20
20-'25
25-'30
PRIMES
WEO
DOE


Electricity Intensity
TWh/Geuro'00
0,3500
0,3000
0,2500
0,2000
0,1500
0,1000
0,0500
0,0000
2002
2010
2020
2025
2030
PRIMES
WEO
DOE


Electricity Demand (growth rate)
2,0%
1,8%
1,6%
1,4%
1,2%
1,0%
0,8%
0,6%
0,4%
0,2%
0,0%
02-'10
10-'20
20-'25
25-'30
PRIMES
WEO
DOE


Electricity Demand
TWh
4500
4000
3500
3000
2500
2000
1500
1000
500
0
2002
2010
2020
2025
2030
PRIMES
WEO
DOE

Power requirements

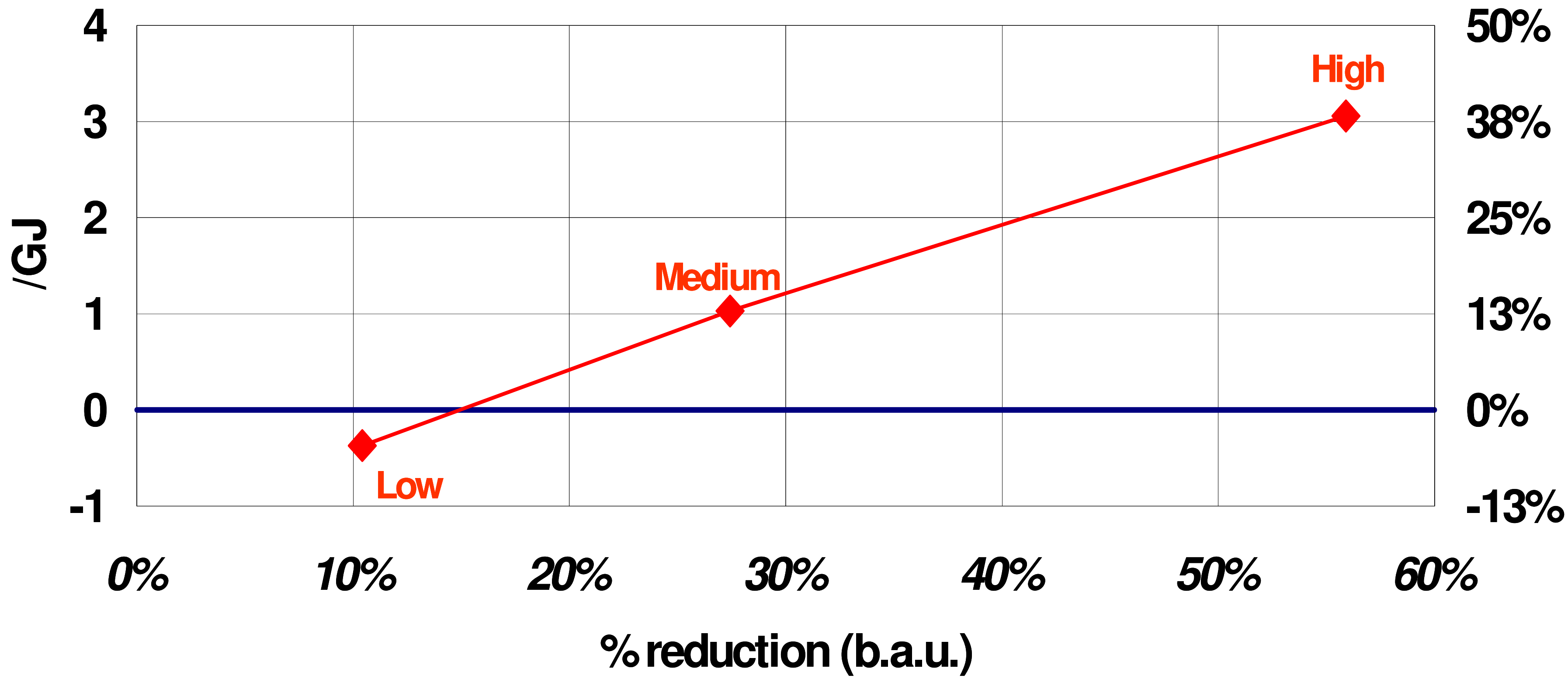
In addition to the forecast of energy demand, it is important to have ideas on the peak power demand, which, together with the reserve margin, actually determines the requirement of installed power.

This could best be done by knowing (or predicting) the load distribution by hours, day of the week, and month of the year; however, one can also directly assume from empirical observation a given ratio between peak load and average load, which can also be expressed as the ratio of the hours in one year (8760) and the equivalent number of hours worked at full power.

This ratio today is of the order of 1.65, and could be reduced by DSM interventions.

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



Some results: saving energy may save money…

- · For the EU-15+ market there is a financial potential of increasing energy efficiency by 15% until 2020 ("zero-cost target"); in other words, the average unit cost of the energy system, following the application of a WCS for a reduction of 15% (-3 EJ) of the overall energy consumption of residential and service sectors with respect to BAU, is equal to the average unit cost of the energy system in the BAU case; in other words, the increase of the energy efficiency is free of cost;
- For less ambitious targets, and in particular for the 1% per annum for 6 years target defined by the EU directive proposal, the cost of the energy savings is negative and, by freeing resources, it involves a positive impact on GDP growth
- If the target of energy saving in the residential and service sectors is greater than 1% per annum (cumulative) until 2020, the cost of the energy savings may become positive; for instance, a target of 1% until 2010, then of 2% from 2010 to 2020 ("medium target") implies for the year 2020 a reduction of consumption by 5 EJ (-27% of BAU) and an increase of the average unit cost of the energy system of 1 €/GJ (+13%)

…but one should also include externalities!

- Very ambitious targets have relatively high costs, but are technically possible; for instance, a target of 2% per annum until 2010 and of 4% per annum between 2010 and 2020 ("high target") brings to more than halving the energy consumption of the residential and service sectors with respect to BAU (-56%), with an increase of the average system unit cost of 38% (or 3 €/GJ).
- However, these evaluations do not include externalities. If the environmental and other externalities were taken into account, one would evaluate an economic potential of energy saving much higher than the 15% indicated above, which is "zero cost" only in strictly financial terms