

ANNEX 1

COMPARISON OF WORLD ENERGY STUDIES

Introduction

This appendix compares the WETO Reference hypotheses and results with the projections provided by other world energy studies. Three institutions carry out forecasts whose scope is comparable to WETO:

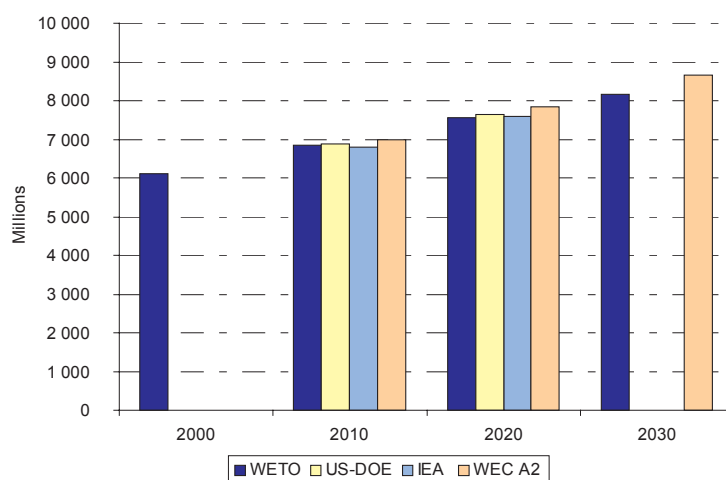
- The International Energy Agency (IEA) also produces a world energy outlook to 2020. Insofar as the 2001 report has been dedicated to energy supply issues, based on the projections of the World Energy Outlook 2000, we use this **IEA 2000** Reference Scenario for comparison.
- IIASA has developed for the World Energy Council a set of scenario projections to the year 2100. For this comparison, we use the **WEC 1998-A2** scenario, which assumes an oil and gas resource availability that is comparable to the one used in the WETO Reference.
- The Energy Information Administration of the U.S. Department of Energy provides yearly updated energy forecasts to 2020 in its International Energy Outlook. For this comparison we used the **US-DOE 2002** Reference Case projection.

The four studies compared here use database and conversion factors that may slightly differ from one model to the other. In order to reduce the resulting discrepancies and to improve the comparability of results, all data have been harmonised while applying the growth rates derived from each study to the initial 2000 values of the WETO study. This allows having a clearer view and a better understanding of the common outcomes and divergences between the studies.

1. World population

With a world population of slightly less than 7 billions in 2010 and around 7.5 billions in 2020, all four studies reflect very similar population projections until this time horizon. For the 2030 horizon, the downward revision of the World Population Prospects operated by the UN in recent years translates into the fact that the WETO study shows a significantly lower projection (8.2 billions) than the IIASA-WEC study of 1998 (8.7 billions).

Population	% / year			Millions			
	2000-10*	2010-20	2020-30	2000	2010	2020	2030
WETO	1.17%	0.98%	0.78%	6 102	6 855	7 558	8 164
US-DOE	1.21%	1.05%			6 882	7 642	
IEA	1.10%	1.10%			6 807	7 594	
WEC A2	1.34%	1.17%	1.00%		6 974	7 834	8 657

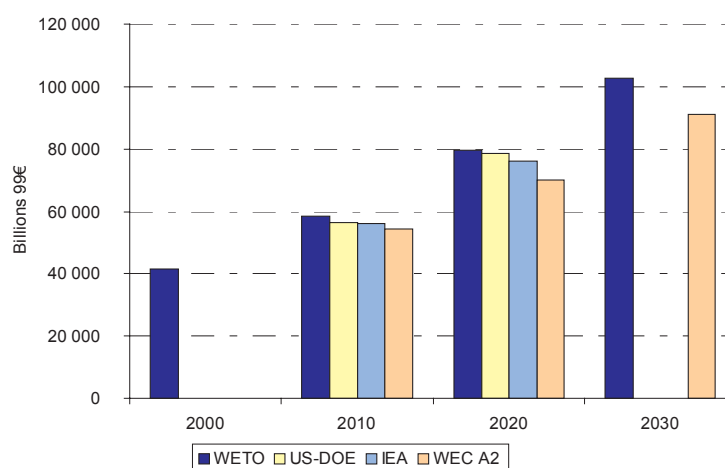


1999-2010 in %/year for US-DOE and 1997-2010 for IEA

2. World GDP

According to three out of the four studies, world GDP will grow, in the next two decades, at a yearly average rate between 3 and 3.5 %. This results in a world GDP of nearly 80 trillions € in 2020, i.e. almost a doubling, as compared with the 2000 level. In the WETO scenario, the continuous slowdown in the average growth rate translates into a linear-shaped GDP profile, with an increase of about 20 Trillions € per decade. As a result, world GDP overpasses 100 trillions € in 2030.

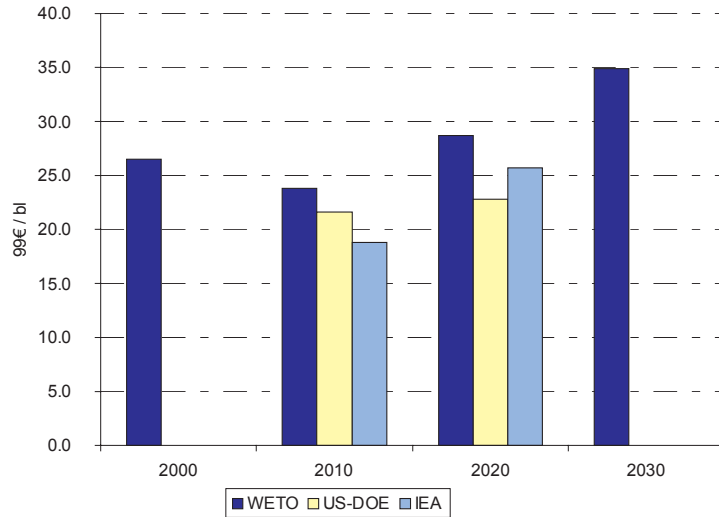
GDP	% / year			Billions 99Euros			
	2000-10	2010-20	2020-30	2000	2010	2020	2030
WETO	3.49%	3.13%	2.62%	41 407	58 350	79 400	102 788
US-DOE	3.17%	3.33%			56 565	78 462	
IEA	3.10%	3.10%			56 191	76 252	
WEC A2	2.74%	2.59%	2.67%		54 240	70 016	91 088



3. World oil price

After a ten years period during which world oil price stayed below 20 €/bl, in 2000 it reached a peak of 26.5 €/bl. The three studies elaborating price projections point to a lower oil price in 2010. In 2020 however, two out of three studies show a full recovery from the 2000 level. The WETO endogenous projection of prices shows the highest profile with 29 and 35 €/bl, in 2020 and 2030 respectively. These levels are deemed to be necessary – in the set of the WETO hypotheses and modelling framework – to balance world demand and supply, including that of non-conventional oil resources.

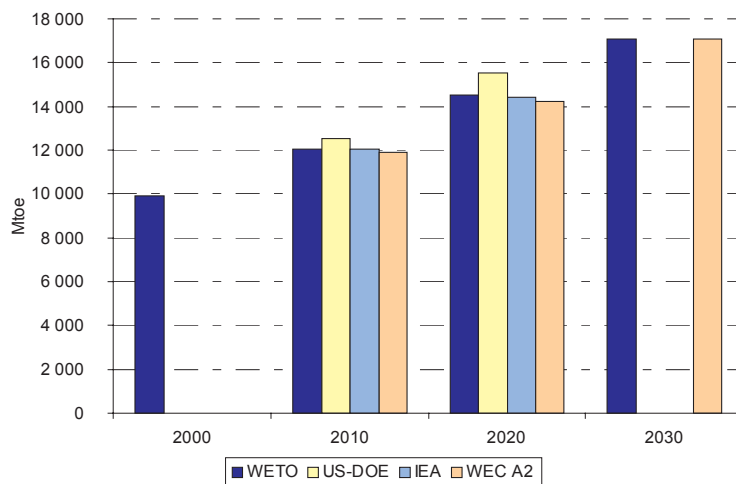
Oil Price	\$95/bl=€99/bl			
	2000	2010	2020	2030
WETO	26.5	23.8	28.7	34.9
US-DOE		21.6	22.8	
IEA		18.8	25.7	



4. World energy consumption

World total energy consumption levels, as they stem from the harmonisation process used here, show similar levels for the time-period considered, with a typical 12 Gtoe in 2010 and 14.5 in 2020 (only one study displays a significantly higher value, i.e. 15.5 Gtoe for that date) and 17 Gtoe in 2030. However, this proximity in total energy forecasts hides more important differences in the projections for individual energy sources, as analysed below.

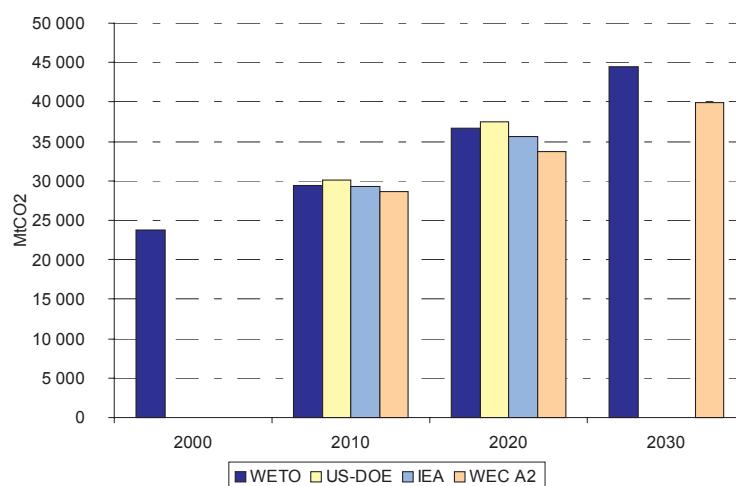
Primary Energy	% / year			Mtoe			
	2000-10	2010-20	2020-30	2000	2010	2020	2030
WETO	1.97%	1.88%	1.64%	9 927	12 062	14 536	17 100
US-DOE	2.34%	2.19%			12 512	15 532	
IEA	1.96%	1.79%			12 054	14 396	
WEC A2	1.84%	1.81%	1.82%		11 915	14 250	17 064



5. World CO₂ emissions

As for the energy consumption, the total projected CO₂ emissions from the combustion of fossil fuels show a reasonable proximity with about 30 Gt CO₂ in 2010 and 35 in 2020. For the last decade of the projection, the difference between the IIASA-WEC and the WETO projections (40 and 45 Gt CO₂ in 2030 respectively) turns out to be important. This reflects a much higher contribution of the traditional biomass and new renewable energy sources in the former study.

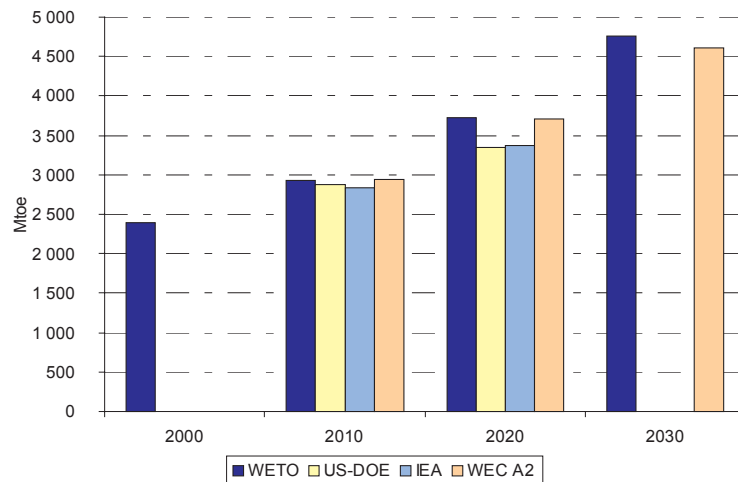
CO ₂	% / year			Mt CO ₂			
	2000-10	2010-20	2020-30	2000	2010	2020	2030
WETO	2.14%	2.26%	1.93%	23 781	29 376	36 738	44 498
US-DOE	2.39%	2.22%			30 130	37 520	
IEA	2.09%	2.00%			29 251	35 666	
WEC A2	1.89%	1.65%	1.66%		28 687	33 792	39 858



6. World coal demand

All four scenarios point to an increase in world coal consumption over the next decades, with a total consumption of about 3 Gtoe in 2010. For the longer term, the WETO and WEC-IIASA projections show structurally higher coal consumption than the IEA and DOE projections for 2020 and the rise of coal continues in the 2020-2030 decade, with average growth rates higher than 2 %/year. In both cases, coal consumption reaches a level of more than 4.5 Gtoe in 2030, corresponding to a doubling from current level. This reflects the assumptions used in these two studies for oil and gas resources and the fact that, in the long run, coal remains the only abundant and cheap fossil source, provided that environmental considerations do not dominate the scenario framework.

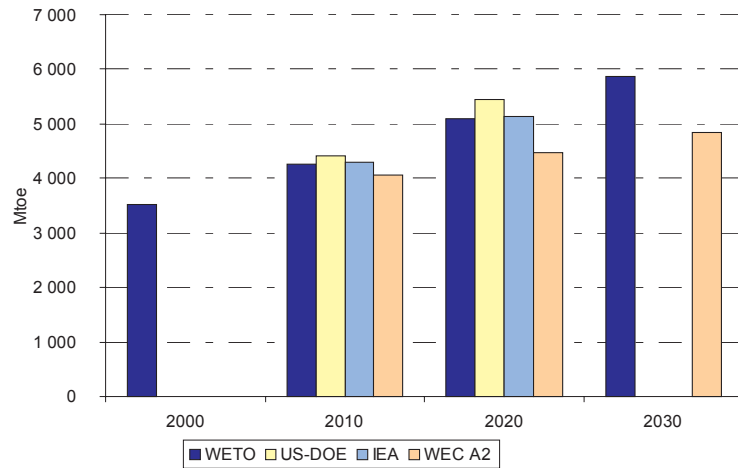
Coal	% /year			Mtoe			
	2000-10	2010-20	2020-30	2000	2010	2020	2030
WETO	2.07%	2.42%	2.48%	2 389	2 931	3 723	4 757
US-DOE	1.88%	1.50%			2 878	3 340	
IEA	1.74%	1.74%			2 837	3 370	
WEC A2	2.13%	2.31%	2.22%		2 949	3 707	4 616



7. World oil demand

World oil demand exceeds 4 Gtoe in 2010 in the four studies, and 5 Gtoe in 2020 in three of them. The corresponding growth rates are however at a relatively low level, between 1.5 and 2 %/year. The DOE forecast shows the highest level of world oil demand in 2020 and this is consistent, on the demand side, with the fact that this study also has the lowest oil price for that horizon (23 \$/bl).

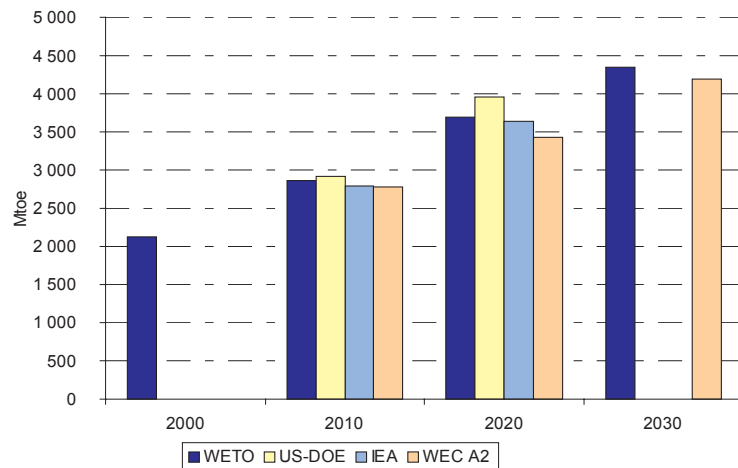
Oil	% /year			Mtoe			
	2000-10	2010-20	2020-30	2000	2010	2020	2030
WETO	1.91%	1.84%	1.43%	3 517	4 250	5 099	5 878
US-DOE	2.28%	2.14%			4 407	5 445	
IEA	2.01%	1.82%			4 293	5 139	
WEC A2	1.44%	0.97%	0.81%		4 057	4 470	4 846



8. World gas demand

The natural gas projections show the same differences and similarities than those observed for oil. World gas demand is in a range of 2.8-3 Gtoe in 2010 and 3.5-4 Gtoe in 2020. The average growth rates are however much higher than for oil, with values between 2.5 and more than 3 %/year at least until 2020. This is a clear indication of the strong dynamics that has to be expected for natural gas in the next twenty years.

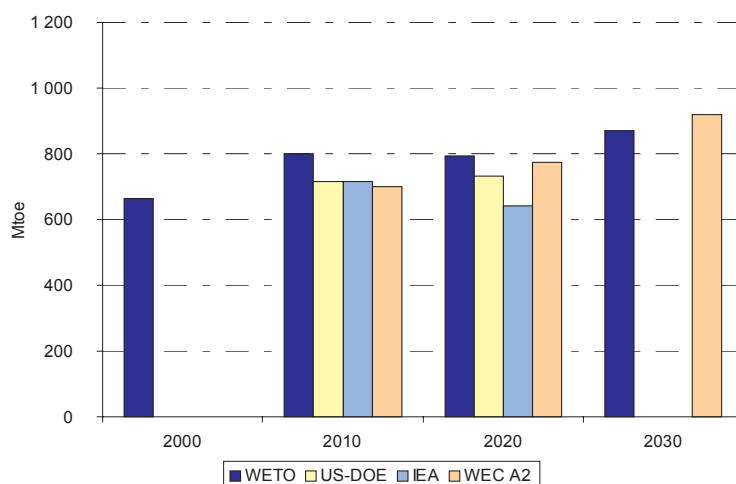
Natural Gas	% / year			Mtoe			
	2000-10	2010-20	2020-30	2000	2010	2020	2030
WETO	3.00%	2.59%	1.63%	2 129	2 860	3 693	4 340
US-DOE	3.19%	3.12%			2 916	3 965	
IEA	2.76%	2.69%			2 797	3 646	
WEC A2	2.72%	2.12%	2.02%		2 784	3 434	4 193



9. World nuclear electricity production

The prospects for nuclear electricity development in the next thirty years appear to be quite limited in the four projections. This is explained by the marked slowdown or even the halt in new plant orders since the 1980s. The WETO scenario however projects some increase in the nuclear power production for the next decade, due partly to the additions of new capacities and partly to improvements in existing plants management and load factors. Between 2010 and 2020 the production is expected to stabilise in the WETO projection before a modest growth recovery between 2020 and 2030, while the IEA outlook points for a rapid retirement of the so called “second generation” plants after 2010. In all cases the contribution of nuclear energy seems to be limited to less than 0.8 Gtoe before 2020 and less than 0.9 Gtoe before 2030.

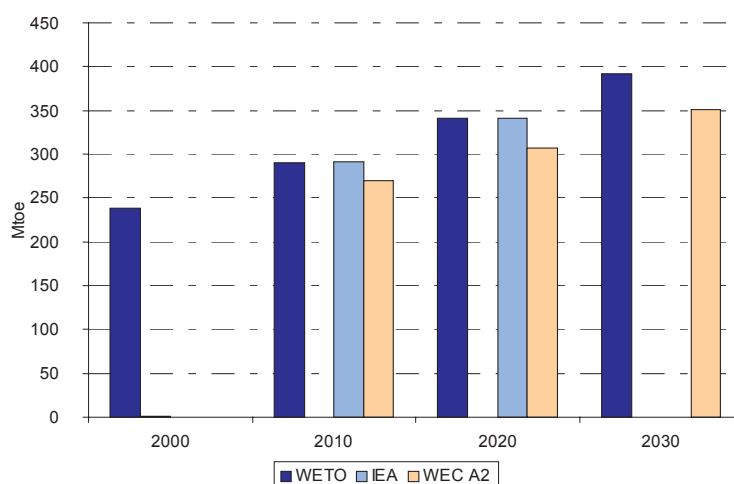
Nuclear	% / year			Mtoe			
	2000-10	2010-20	2020-30	2000	2010	2020	2030
WETO	1.89%	-0.09%	0.96%	663	799	792	872
US-DOE	0.78%	0.22%			717	732	
IEA	0.77%	-1.10%			716	641	
WEC A2	0.52%	1.05%	1.73%		699	776	920



10. World hydro-electricity production

World hydro power production is expected to rise relatively regularly over the period, with for the WETO and the IEA studies average rates of 2 %/year between 2000 and 2010 and 1.6 % p.a. between 2010 and 2020. If the same conversion factors were used for hydro power and for nuclear, then the contribution of hydro power to world energy supply would exceed 1Gtoe in 2020 and 1.4 Gtoe in 2030 according to the WETO projection.

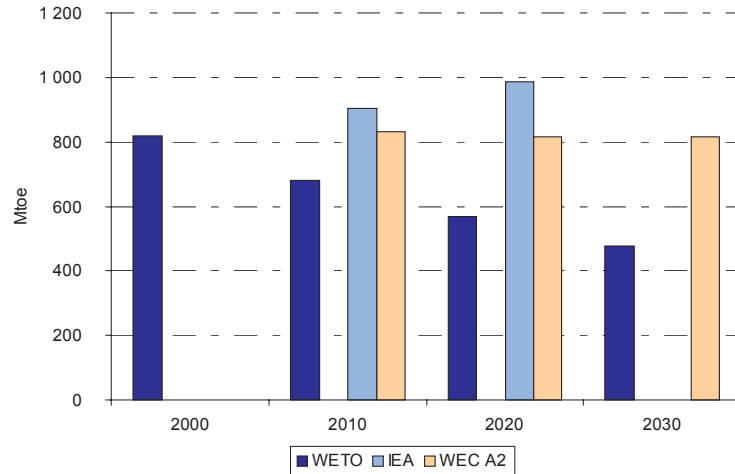
Large Hydro	% / year			Mtoe			
	2000-10	2010-20	2020-30	2000	2010	2020	2030
WETO	1.98%	1.65%	1.40%	238	290	342	392
IEA	2.05%	1.57%			292	341	
WEC A2	1.24%	1.31%	1.36%		270	307	351



11. World biomass production

By definition, the contribution of biomass to world energy supply is difficult to measure. It is also difficult to model as the proper dynamics of the corresponding energy sources as well as their links – in terms of substitution processes – with commercial fuels have hardly been explored, and only in field-studies. The three projections providing estimates for this category of fuels indeed show very contrasted profiles, with stability in the IIASA-WEC projection, an increase in the IEA outlook and a continuous decrease, based on the hypothesis of growing urbanisation, in the WETO projection.

Biomass (non comm.)	% / year			Mtoe			
	2000-10	2010-20	2020-30	2000	2010	2020	2030
WETO	-1.83%	-1.79%	-1.75%	820	682	569	477
IEA	0.98%	0.87%			904	986	
WEC A2	0.16%	-0.23%	0.01%		833	814	815



12. World other renewable production

The category of other renewable used for this comparison includes different energy sources from commercial biofuels to micro-hydro systems, wind and photovoltaic. Altogether, they represent not more than 0.17 Gtoe in 2000, with a clear predominance of commercial biofuels. The expected average growth rate is relatively high, i.e. above 3 %/year, for the first 2000-2010 decade. It then slows down in the WETO and IEA projections, while it increases significantly in the IIASA-WEC projection. In the two former studies, the Reference cases do not incorporate any particular emphasis on environmentally friendly policies.

Other Renewable	% /year			Mtoe			
	2000-10	2010-20	2020-30	2000	2010	2020	2030
WETO	3.87%	2.49%	1.87%	171	250	319	384
IEA	3.03%	2.61%			230	298	
WEC A2	3.53%	5.47%	4.70%		242	412	652

