TECHNOLOGICAL SCENARIOS, CLIMATE CHANGE & EMISSION TRADING :

EC-IEA Study on Energy Technology and Climate Change

Simulations using the POLES World Model

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POLES 2 : Technology Stories

- «Technology stories» simulate the impacts of breakthroughs in five technology clusters :
  - 1. Nuclear technologies
  - 2. Clean-Coal technologies
  - 3. Gas Turbines in Combined Cycle
  - 4. Fuel-Cells
  - 5. Renewable

S1 - The nuclear scenario ...

- assumes a breakthrough in nuclear technology in terms of costs and safety and has an influence on standard large LWRs - NUC - but especially on a new « evolutionary » nuclear design - NND -

	NUC		NND	
	2000	2030	2000	2030
e90/kW ref	2 000	2 150	2250	2 050
e90/kW S1		1 500		1 400
O&M ref	75	75	75	60
O&M S1		50		30

S2 - The clean-coal scenario ...

- involves major improvements in solid fuel burning technologies like Super Critical Coal Plants - PFC Integrated Gasification Combined Cycles - ICG and Advanced Thermodynamic Cycles - ATC

	PFC		ICG		ATC	
	2000	2030	2000	2030	2000	2030
e90/kW ref	1250	970	1350	1100	1200	1000
e90/kW S2		750		825		780
eff. ref.	44%	49%	46%	50%	46%	50%
eff. S2		55%		54%		52%

S3 - The enhanced gas turbine scenario ...

- assumes a higher availability of natural gas and major improvements for gas turbine combined cycles - GGT - combined heat and power plants - CHP - and other gas turbine technologies - ICG -

	GGT	
	2000	2030
e90/kW ref	570	470
e90/kW S3		410
eff. ref	50%	59%
eff. S3		63%

S4 - The natural gas + fuel-cell scenario ...

- additionally to S3, involves a breakthrough in fuel cell technologies after 2010, with proton exchange membrane fuel cells for fixed applications - MFC solid oxyde fuel cell with cogeneration - SFC and a hydrogen fuel cell vehicle - FCV

	MFC		SFC	
	2000	2030	2000	2030
e90/kW ref	3 500	850	1700	800
e90/kW S4		283		600
eff. ref	55	60	60	70
eff. S4		63		70

S5 - The renewable scenario ...

- implies a major effort and resulting breakthroughs in renewable technologies, notably wind power - WND - biomass gasification - BGT - solar thermal power plants - SPP - small hydro - SHY - and photovoltaic cells - DPV, RPV -

	WND		PV	
	2000	2030	2000	2030
e90/kW ref	1 300	1 100	12 000	4 000
e90/kW S5		450		2 000
cap. fact. ref	20%	30%	15%	17%
cap.fact. S5		40%		17%

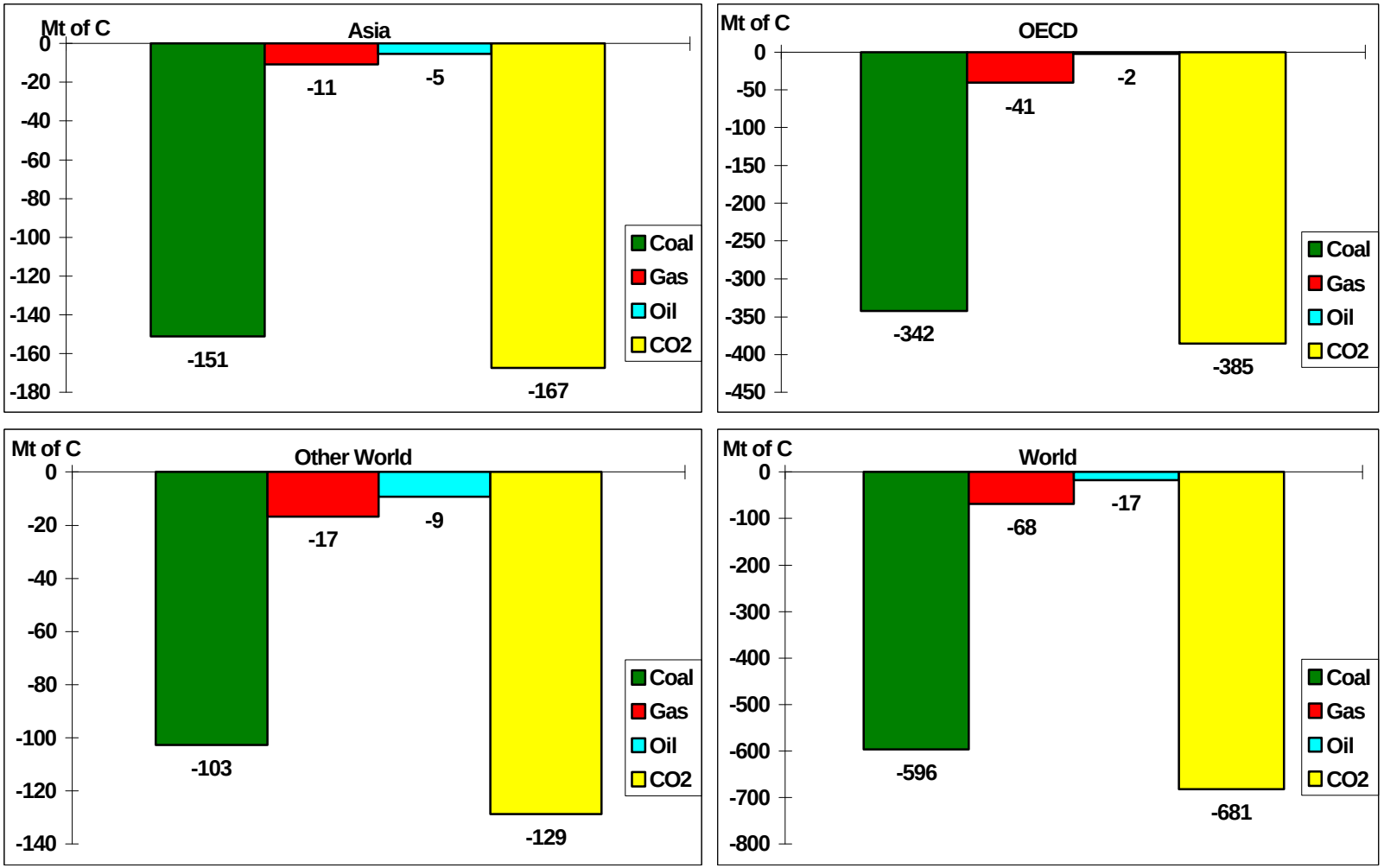
A pessimistic case, with no technological progress

- A pessimistic case also assumes that the technico-economic characteristics of the technologies are frozen at their 1998 values (except for nuclear which is deteriorating in the reference) for all the simulation period
- The main purpose of this scenario is to examine the significance of the technical progress already embodied in the reference case

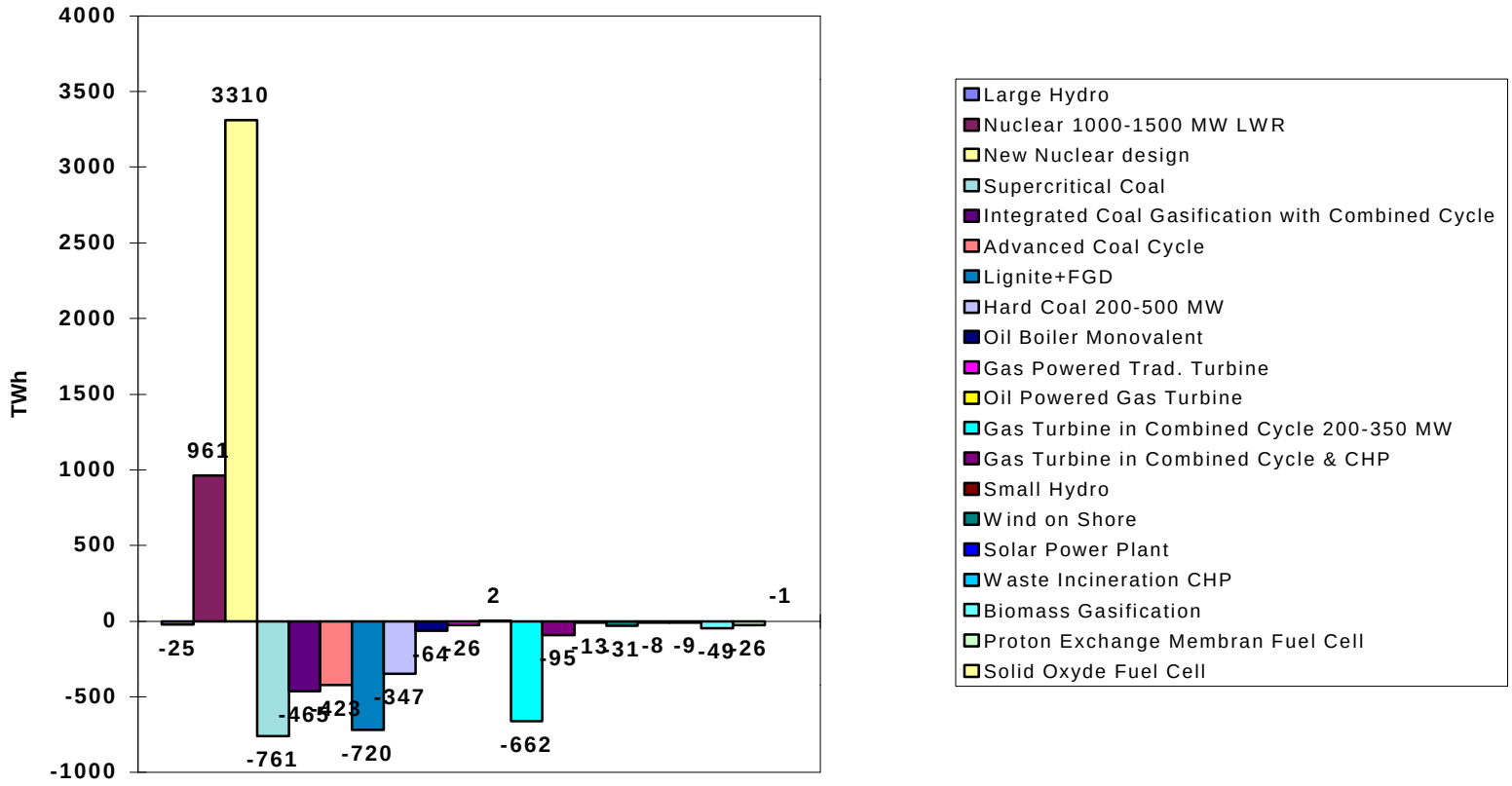
Impacts of the technological scenarios :
% variation from REFERENCE, World 2030

	Coal	Oil	Gas	Nuclear	Hydro	Elect.	CO_2 Emissions
Scenario :							
Nuclear	-9.9	-0.4	-2.3	116.7	-0.5	1.3	-5.0
Clean Coal	2.7	-0.8	-2.0	-9.9	-0.8	2.3	0.5
Gas & Fuel Cells	-18.0	-3.6	32.6	-16.5	-2.9	5.0	-2.2
Renewables	-9.5	-0.9	-3.2	-7.2	-0.8	-0.4	-5.2
Pessimistic	0.9	1.9	3.7	16.9	1.8	-3.8	1.8

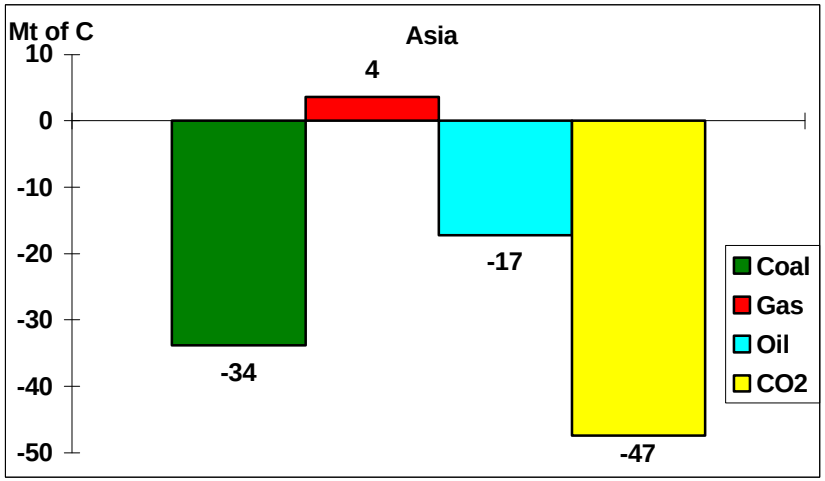
NUCLEAR SCENARIO (Sc1) - CO_2 REDUCTION RELATIVE TO REFERENCE

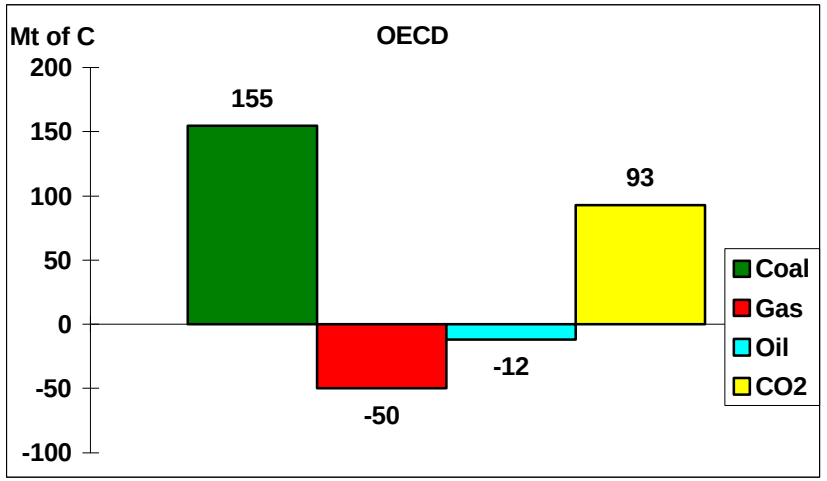


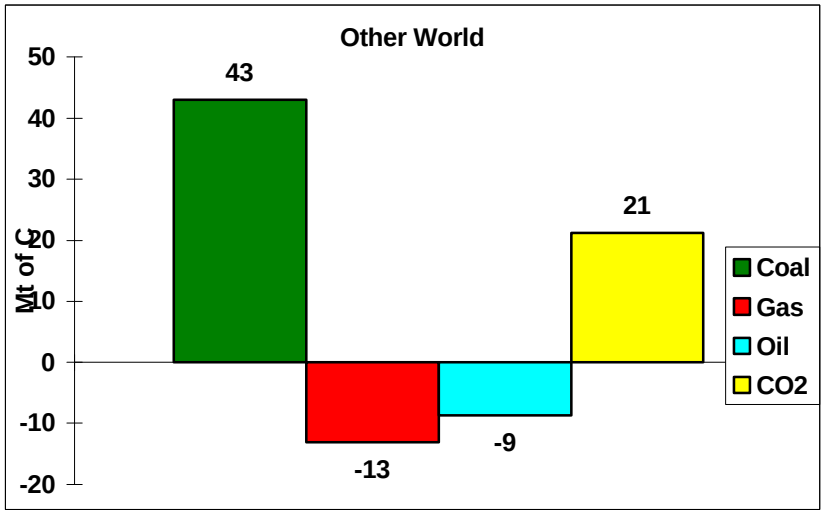
S1 - Nuclear : changes in World electricity relative to reference

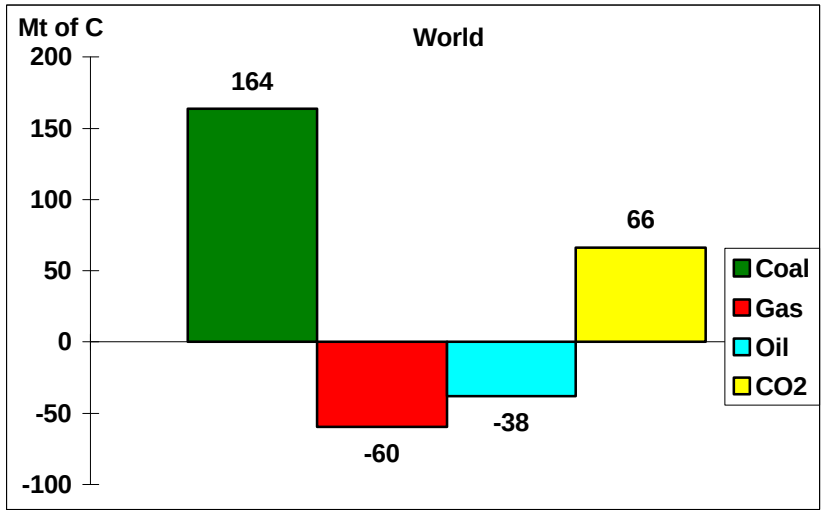


CLEAN COAL SCENARIO (Sc2) - CO_2 REDUCTION RELATIVE TO REFERENCE

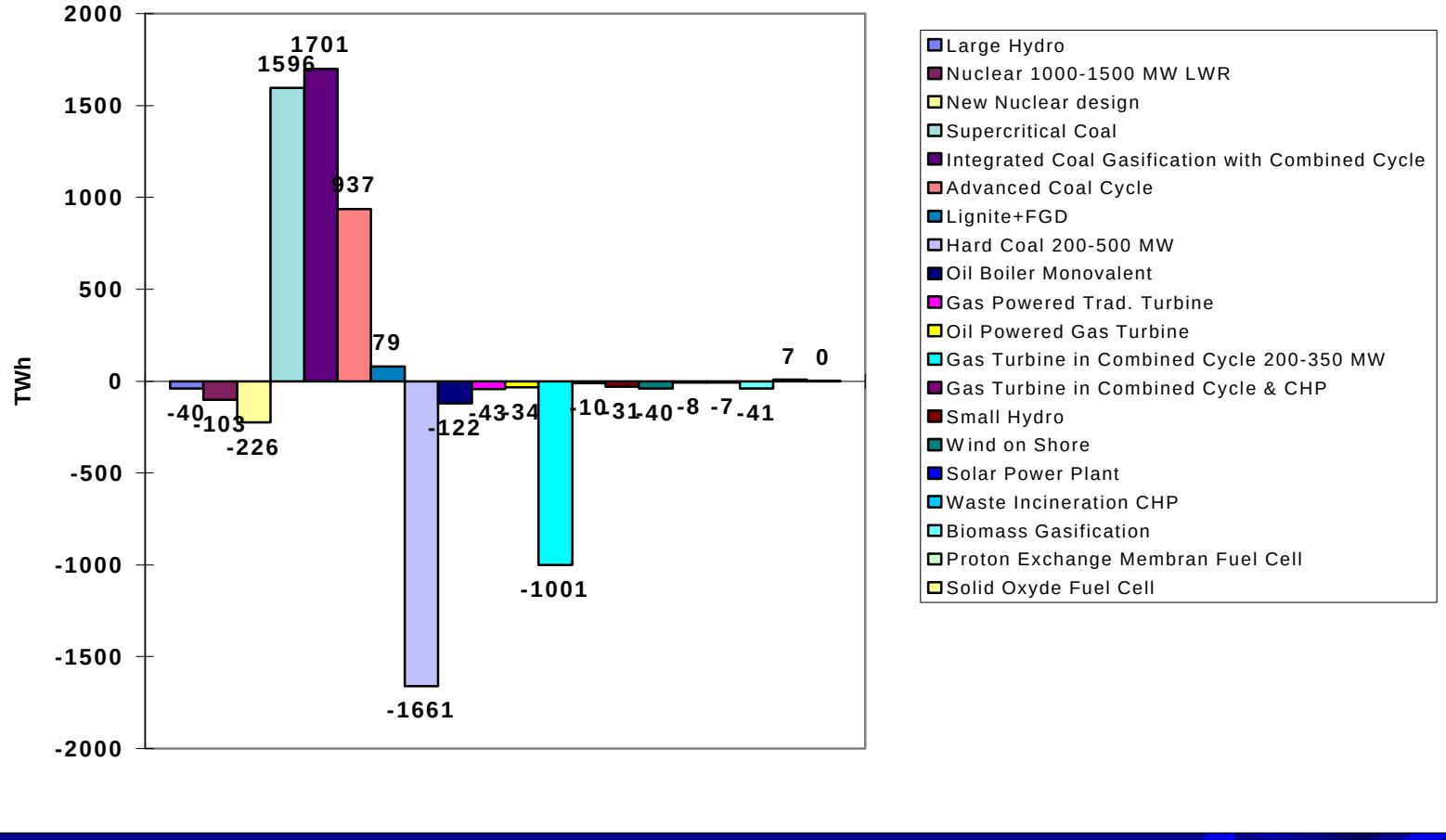




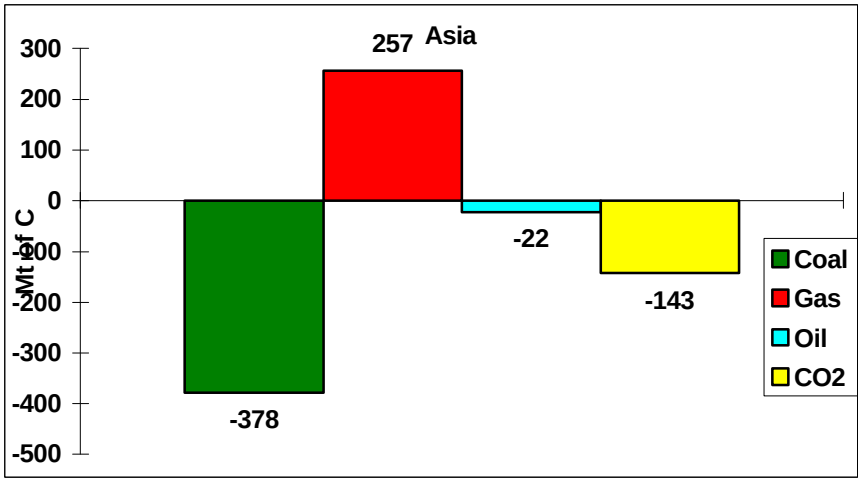


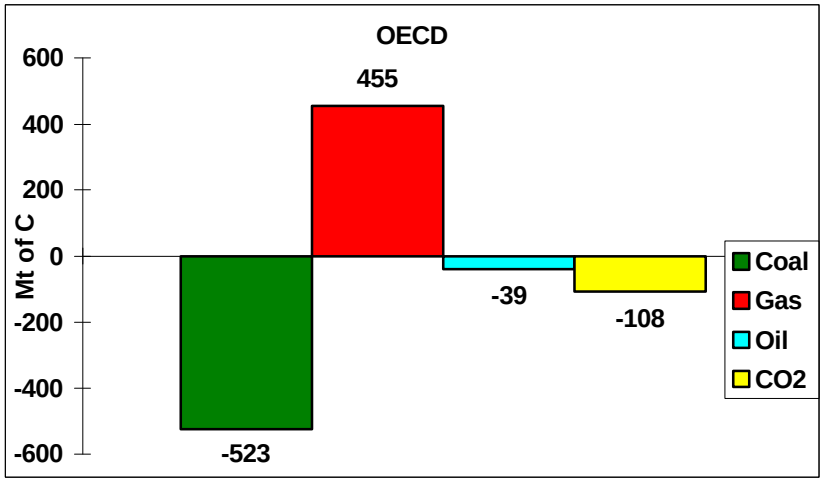


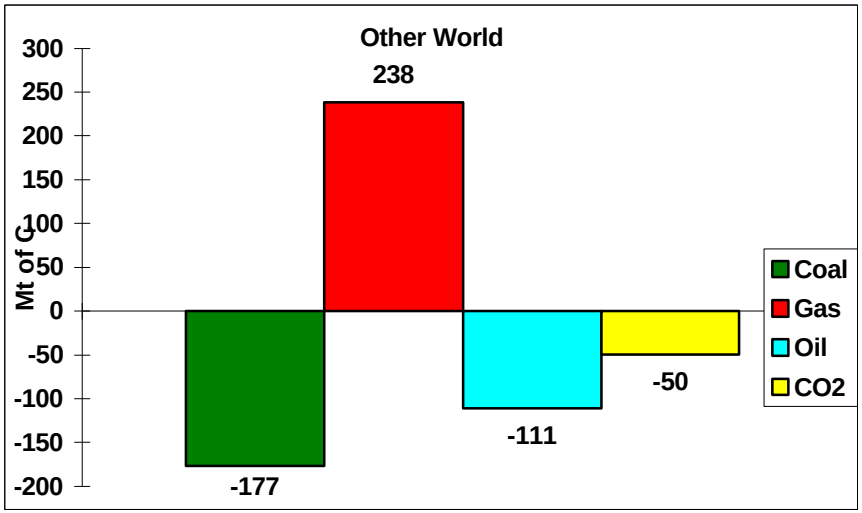
S2 - Clean-Coal : changes in World electricity relative to reference

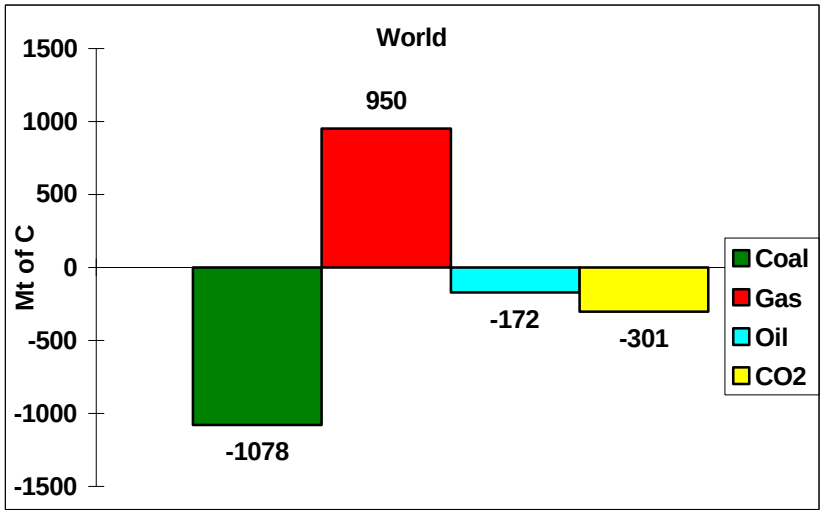


FUEL CELLS SCENARIO (Sc4) - CO_2 REDUCTION RELATIVE TO REFERENCE

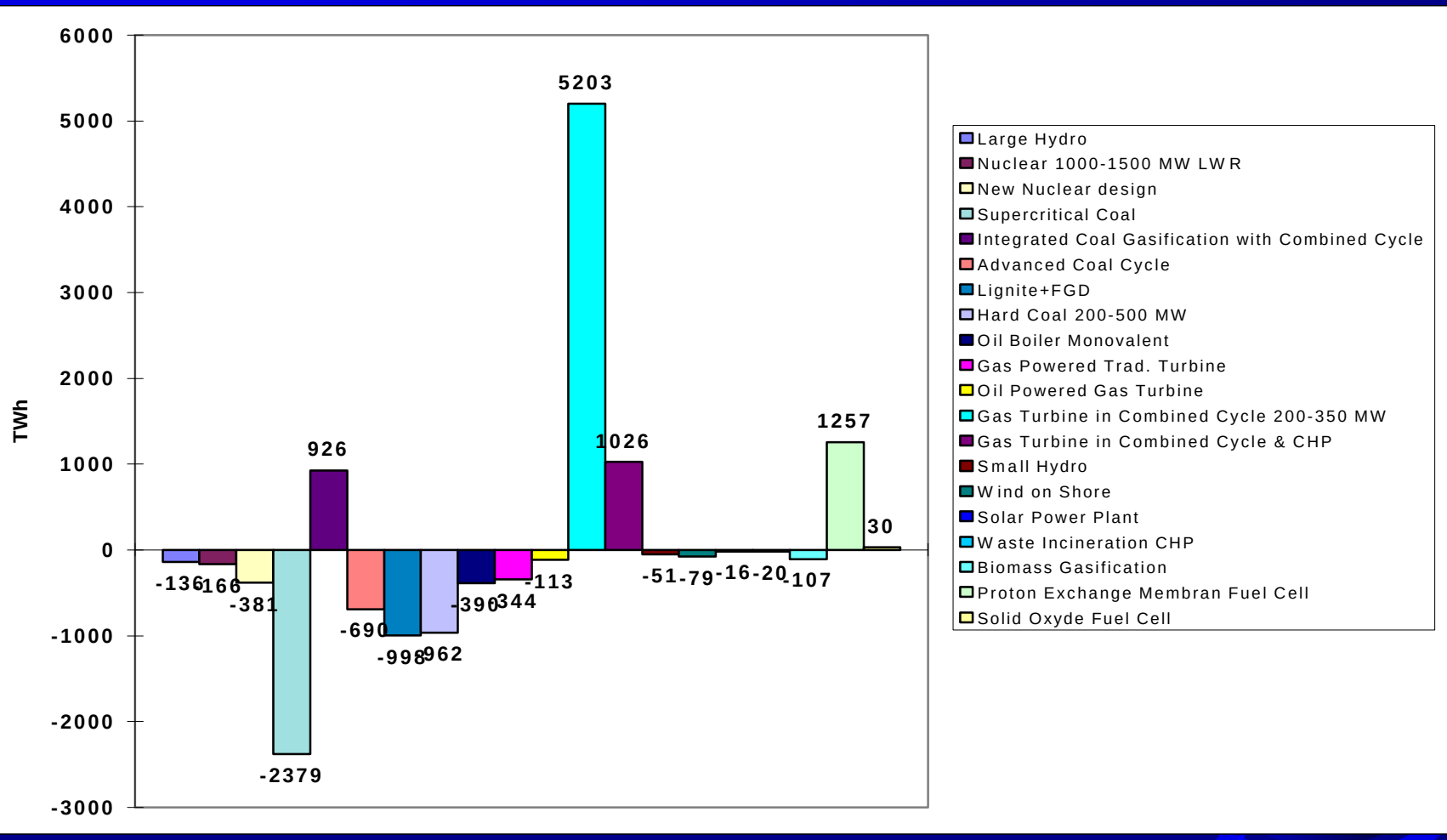




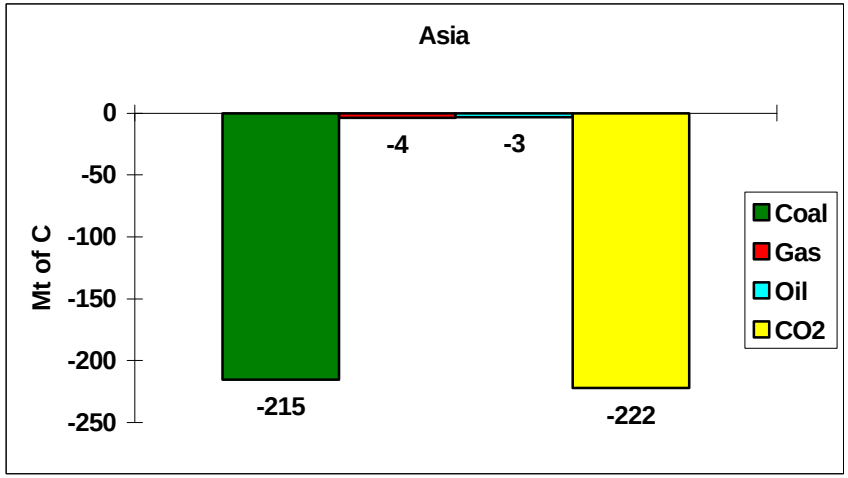


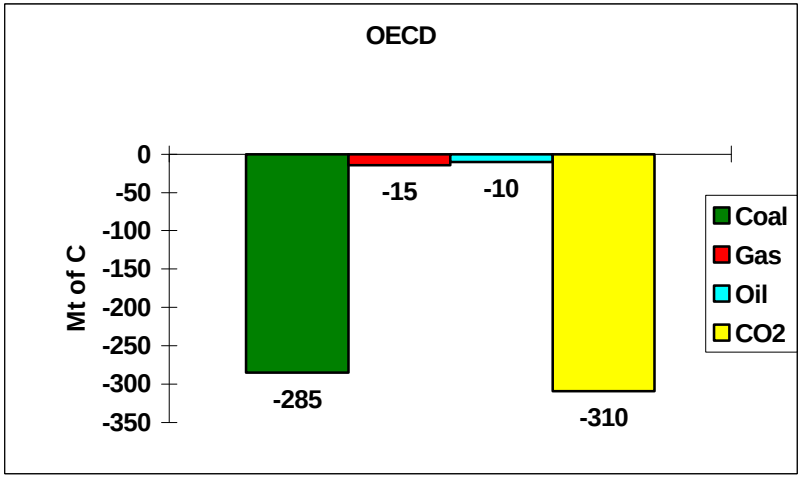


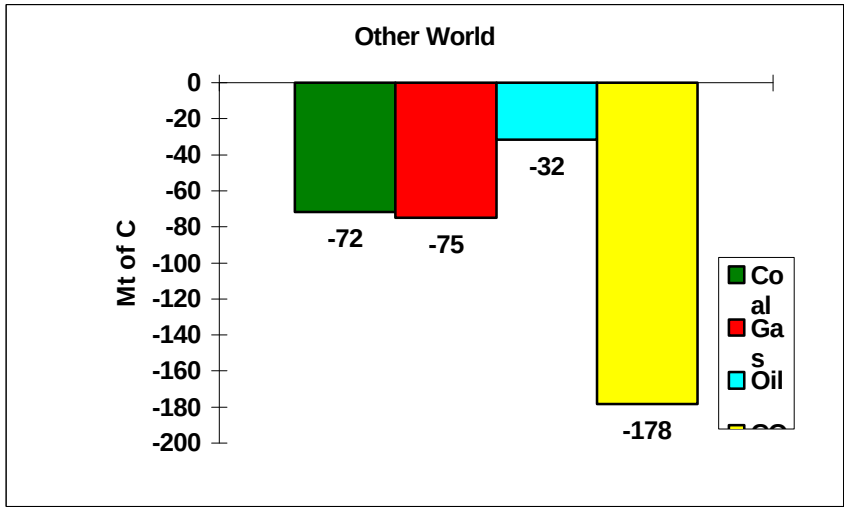
S4 - Fuel-Cells : changes in World electricity relative to reference

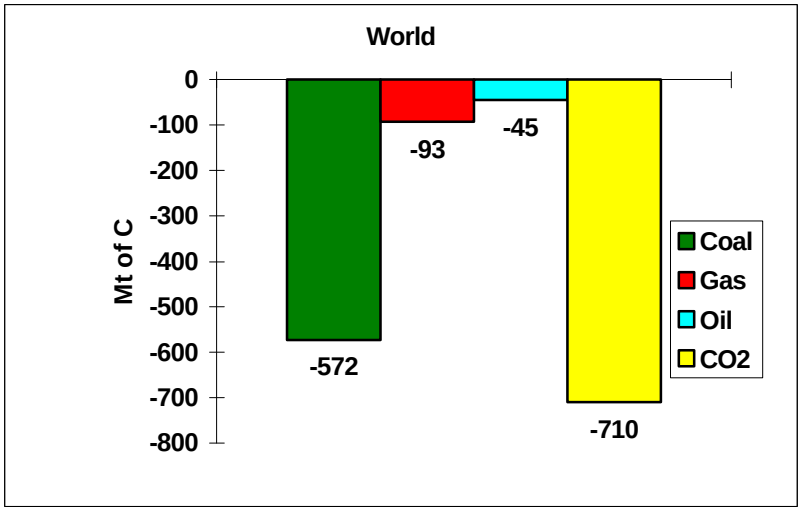


RENEWABLE BREAKTHROUGH SCENARIO (Sc5) - CO2 REDUCTION RELATIVE TO REFERENCE

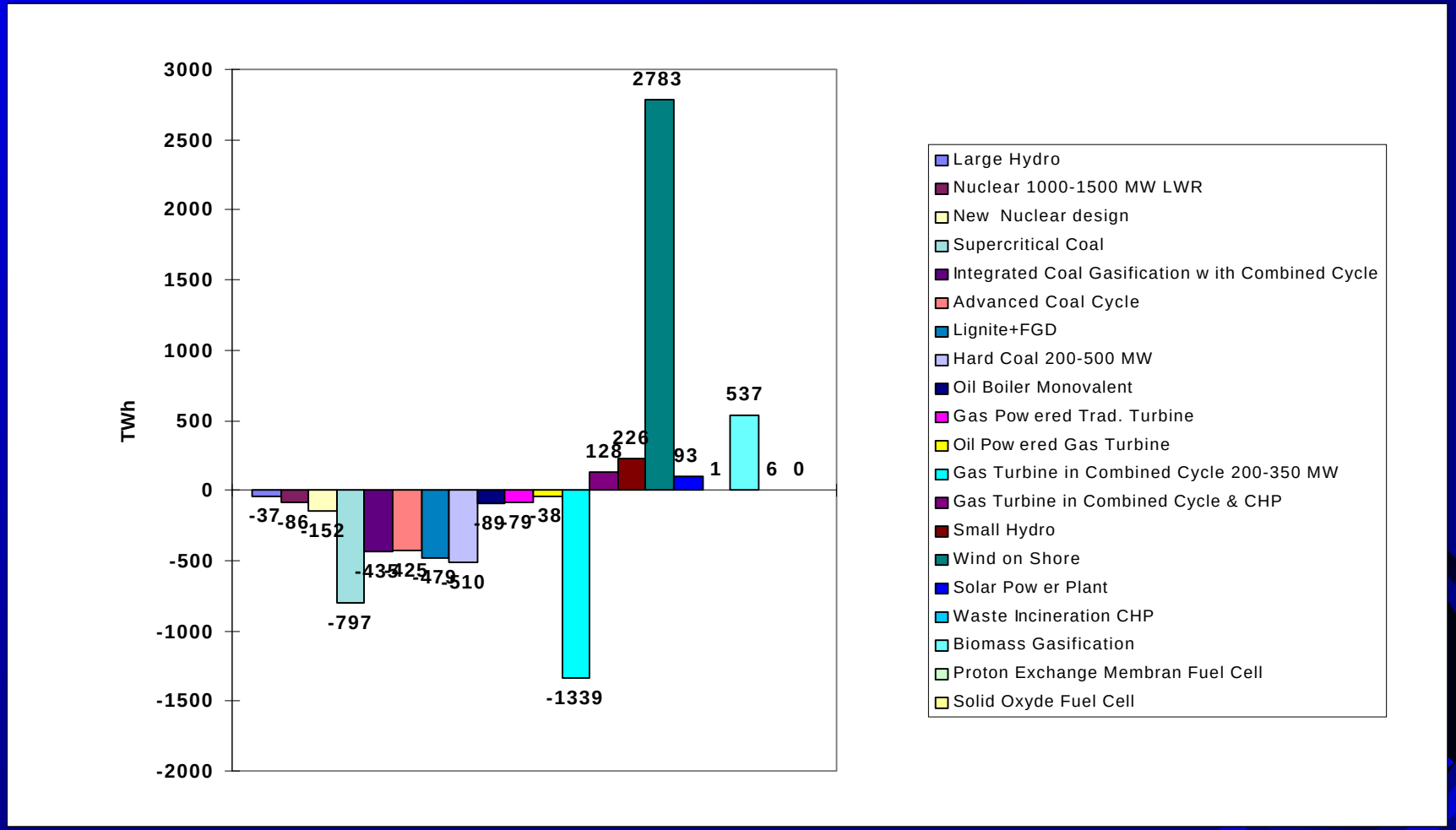




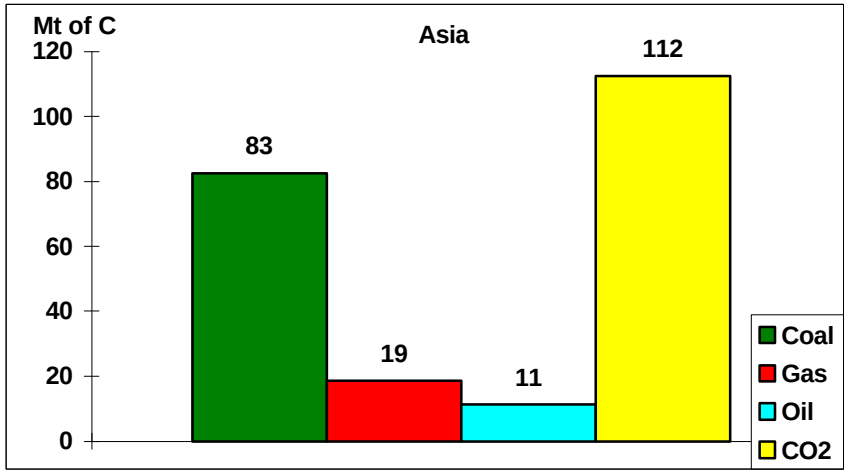


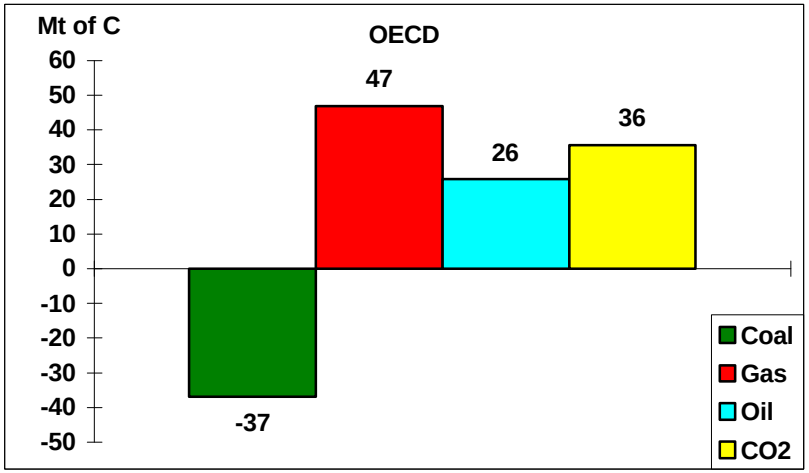


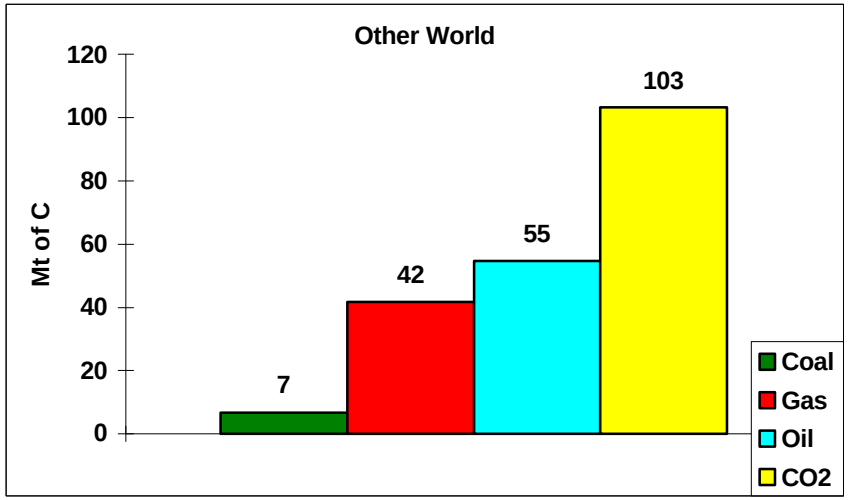
S5 - Renewable : changes in World electricity relative to reference

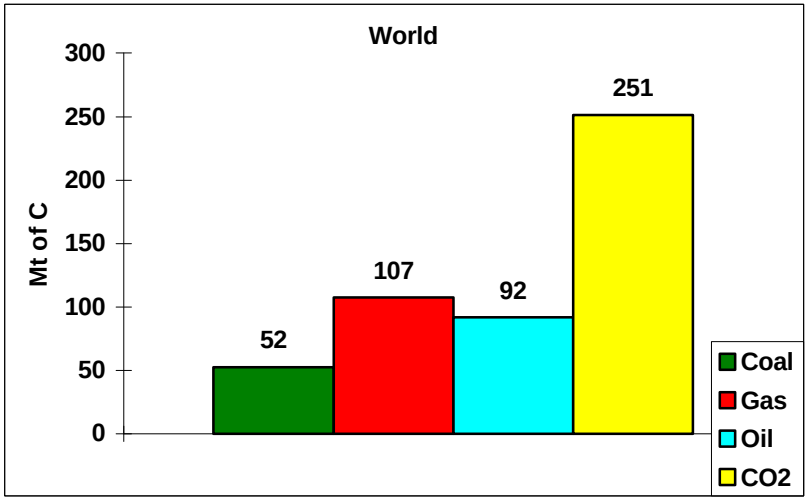


PESSIMISTIC SCENARIO (Pes) - CO2 REDUCTION RELATIVE TO REFERENCE

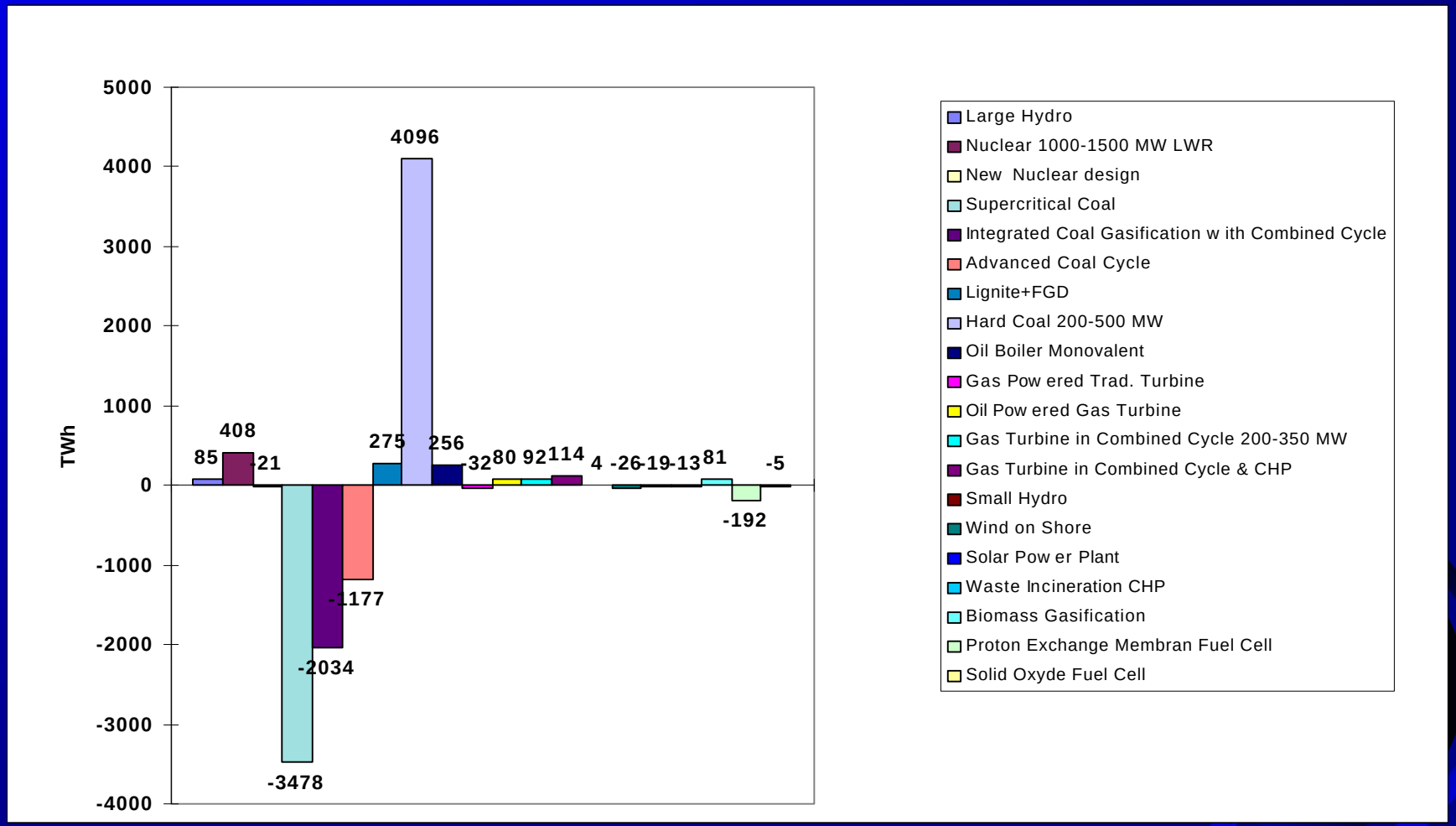








Pessimistic case : changes in World electricity relative to reference



World CO2 Emission Limitation Strategies :

- **Kyoto 2010 CO2 emission entitlements =**

  Kyoto entitlements for Annex B countries

  +

  Entitlements according to Reference for the analysis of the Market for Tradable Emission Permits

- **Kyoto II 2030 entitlements =**

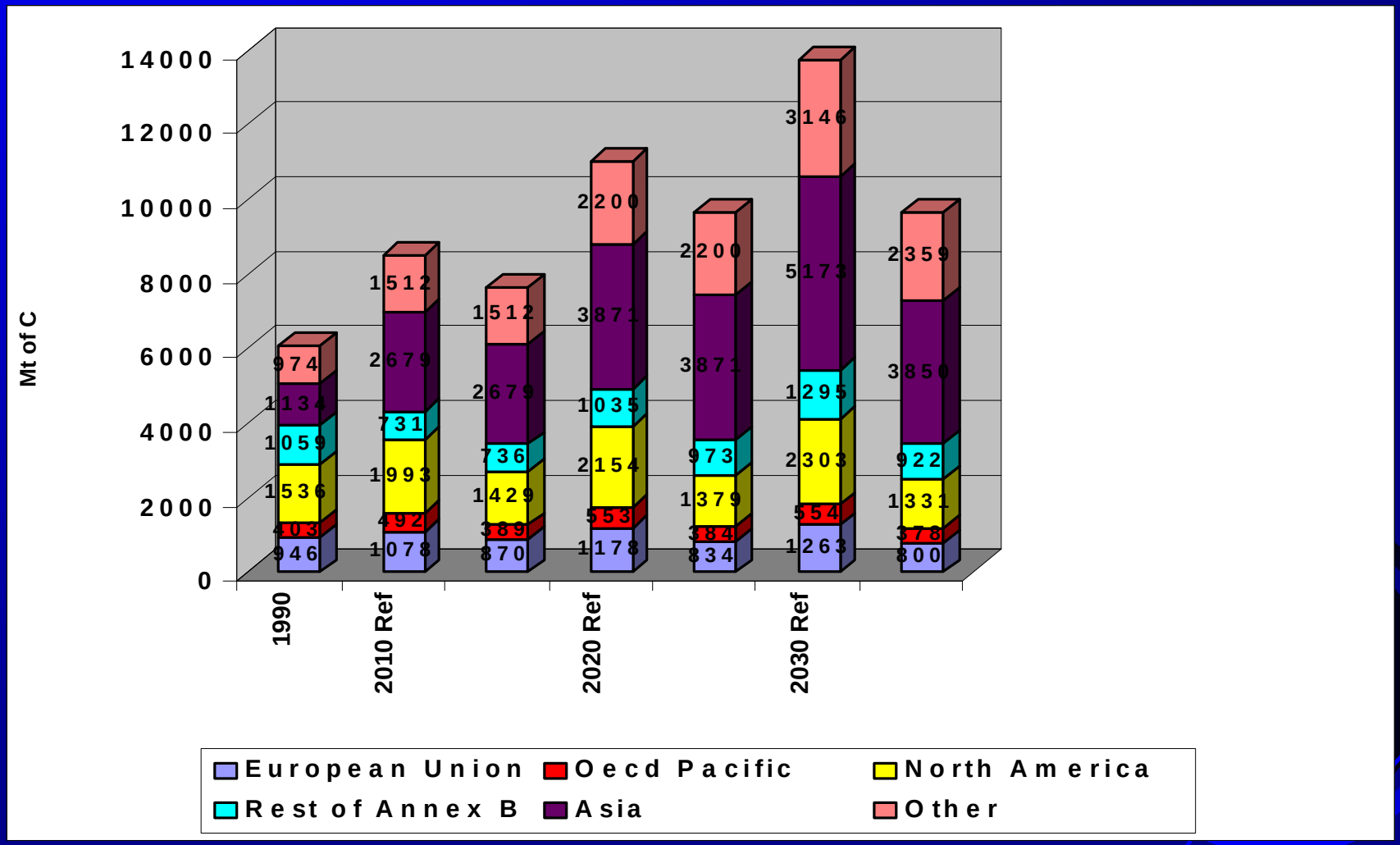
  Rule 1 : For all Annex B countries same reduction between 2010 and 2030 than between 1990 and 2010

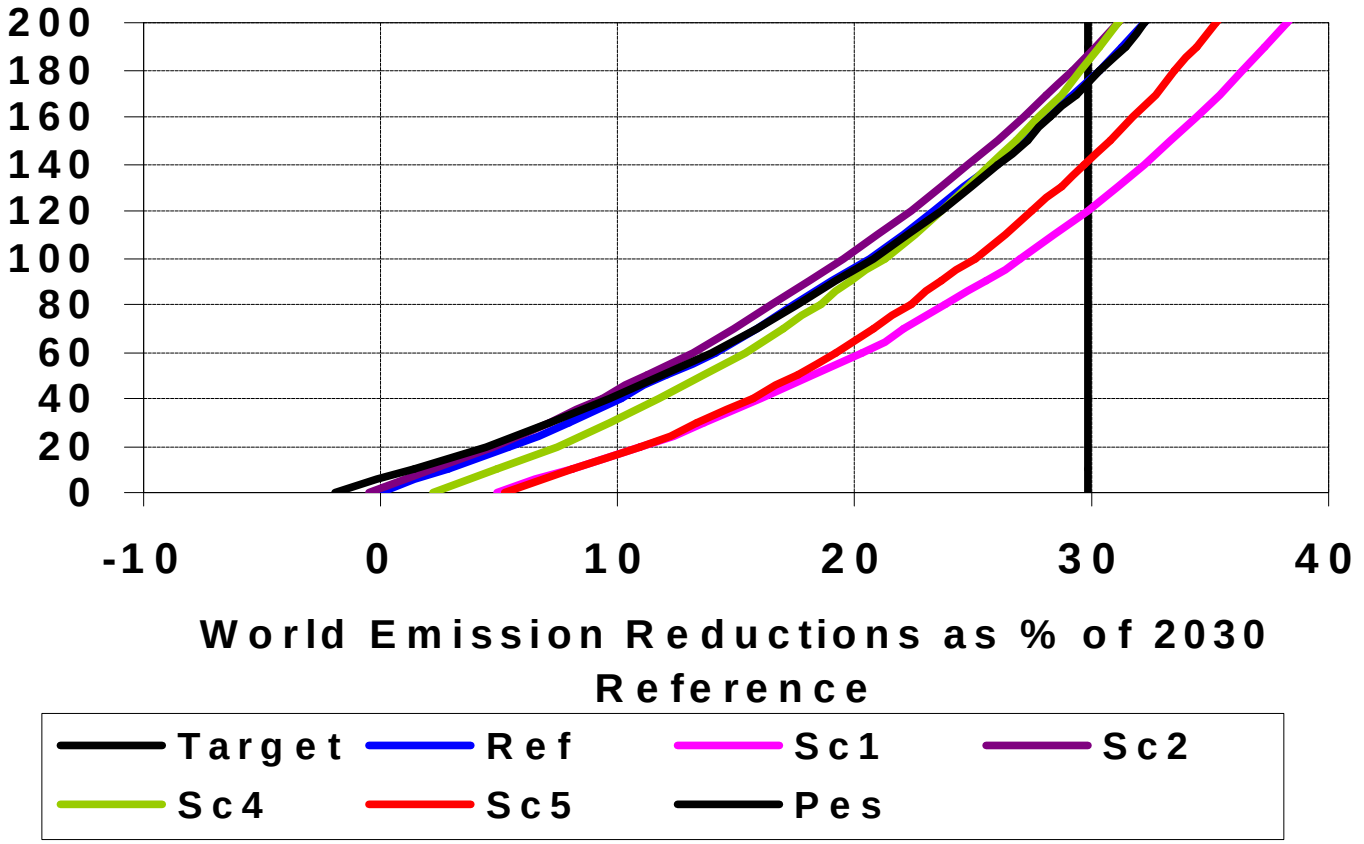
  +

  Rule 2 : <u>World CO2 emission stabilisation after 2020</u>

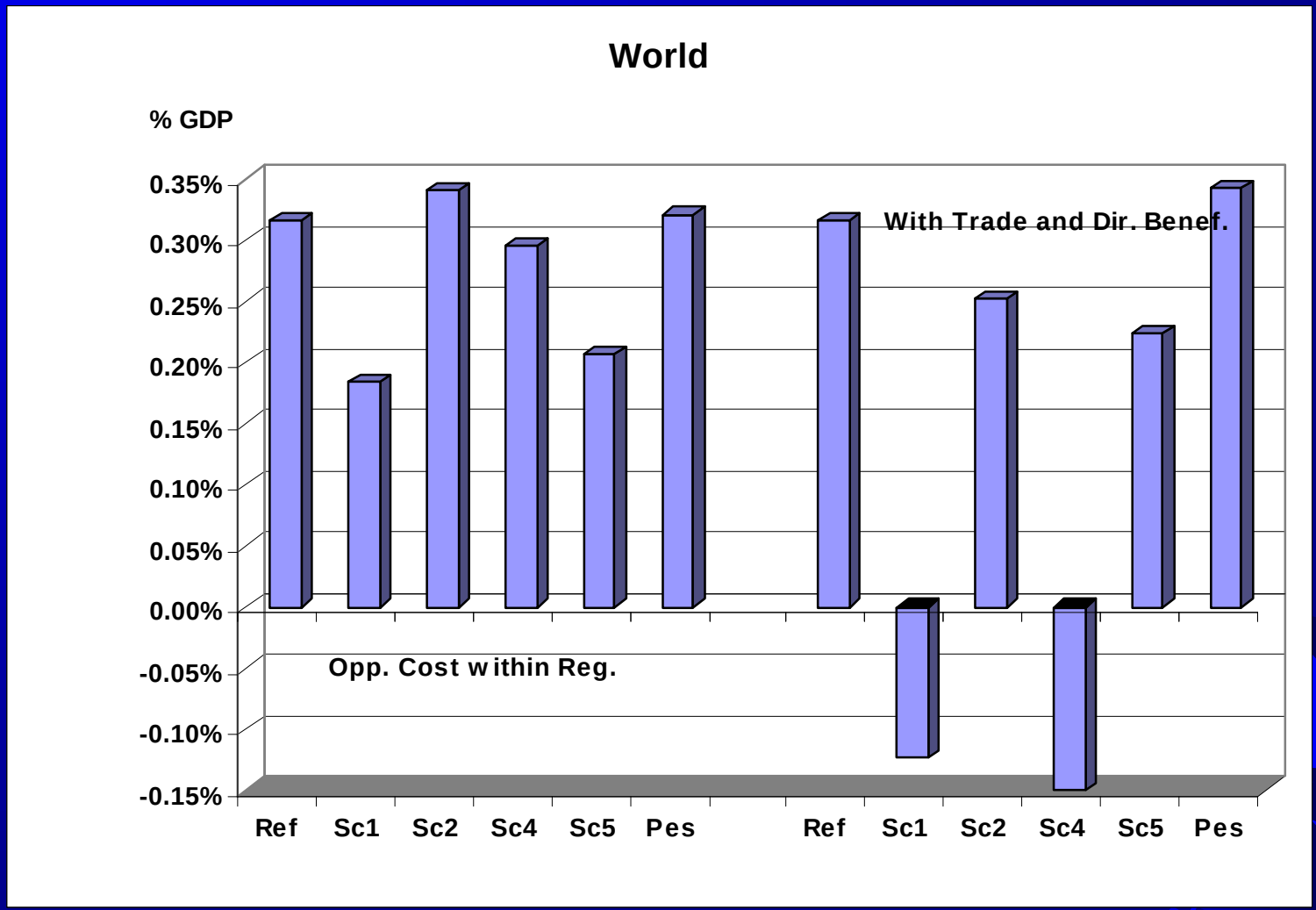
  => Non annex B 2020-30 increase = Annex B 2020-30 decrease

CO2 emission targets : « Kyoto II » rules for 2030

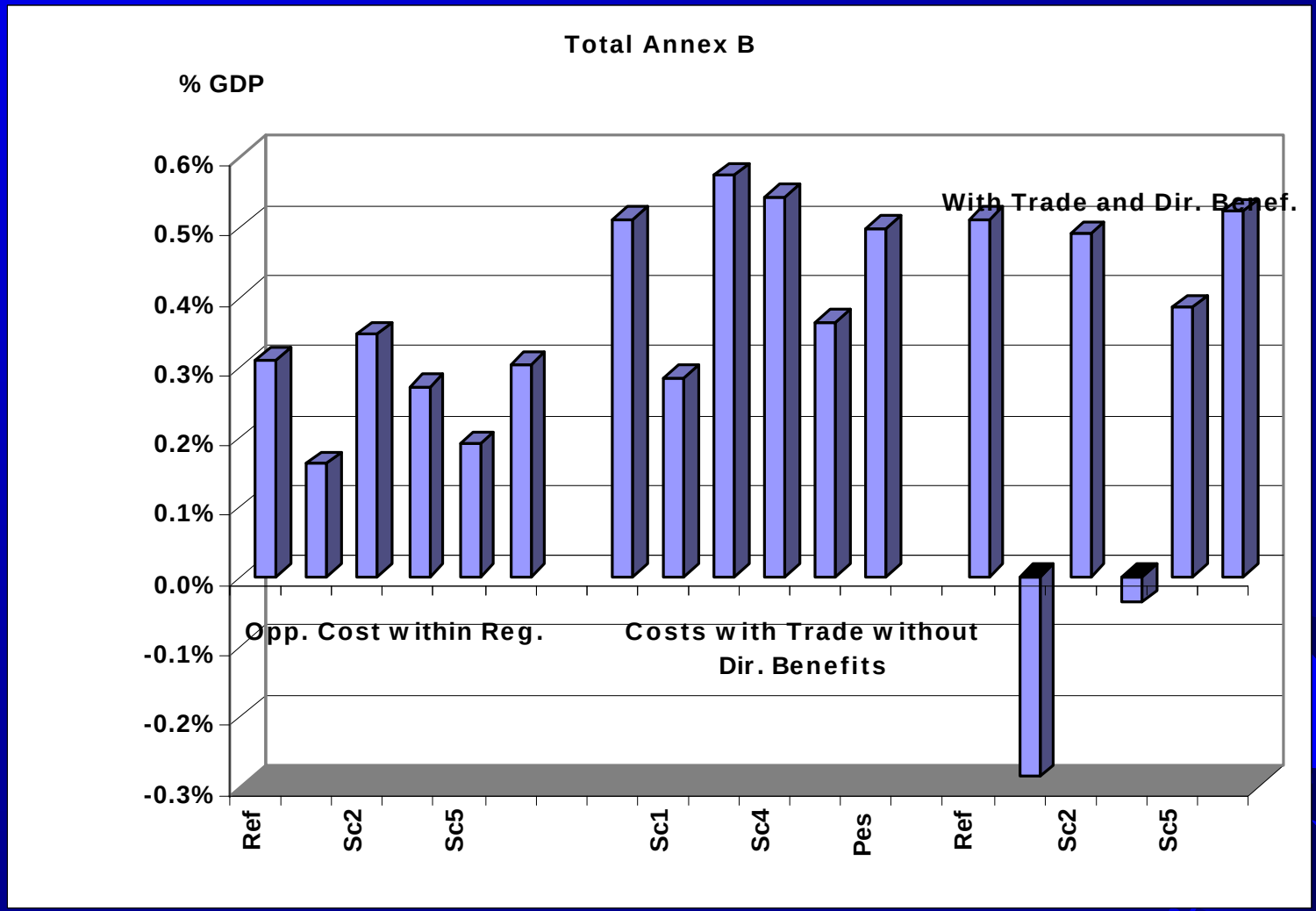



Marginal Cost of Emission Reduction
200
180
160
140
120
100
80
60
40
20
0
-10
0
10
20
30
40
World Emission Reductions as % of 2030 Reference
Target
Ref
Sc1
Sc2
Sc4
Sc5
Pes

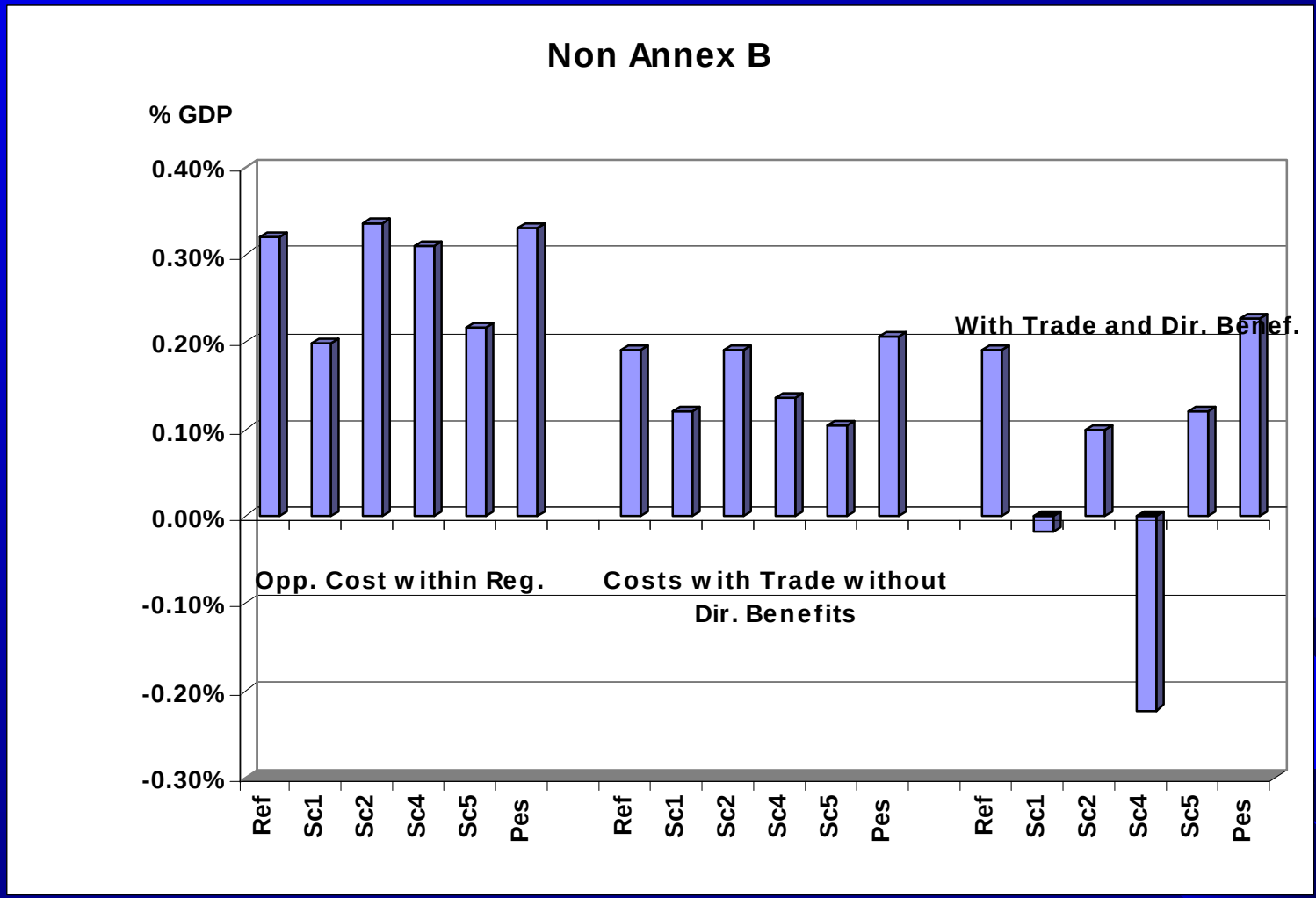
COST OF MEETING TARGETS as % of GDP



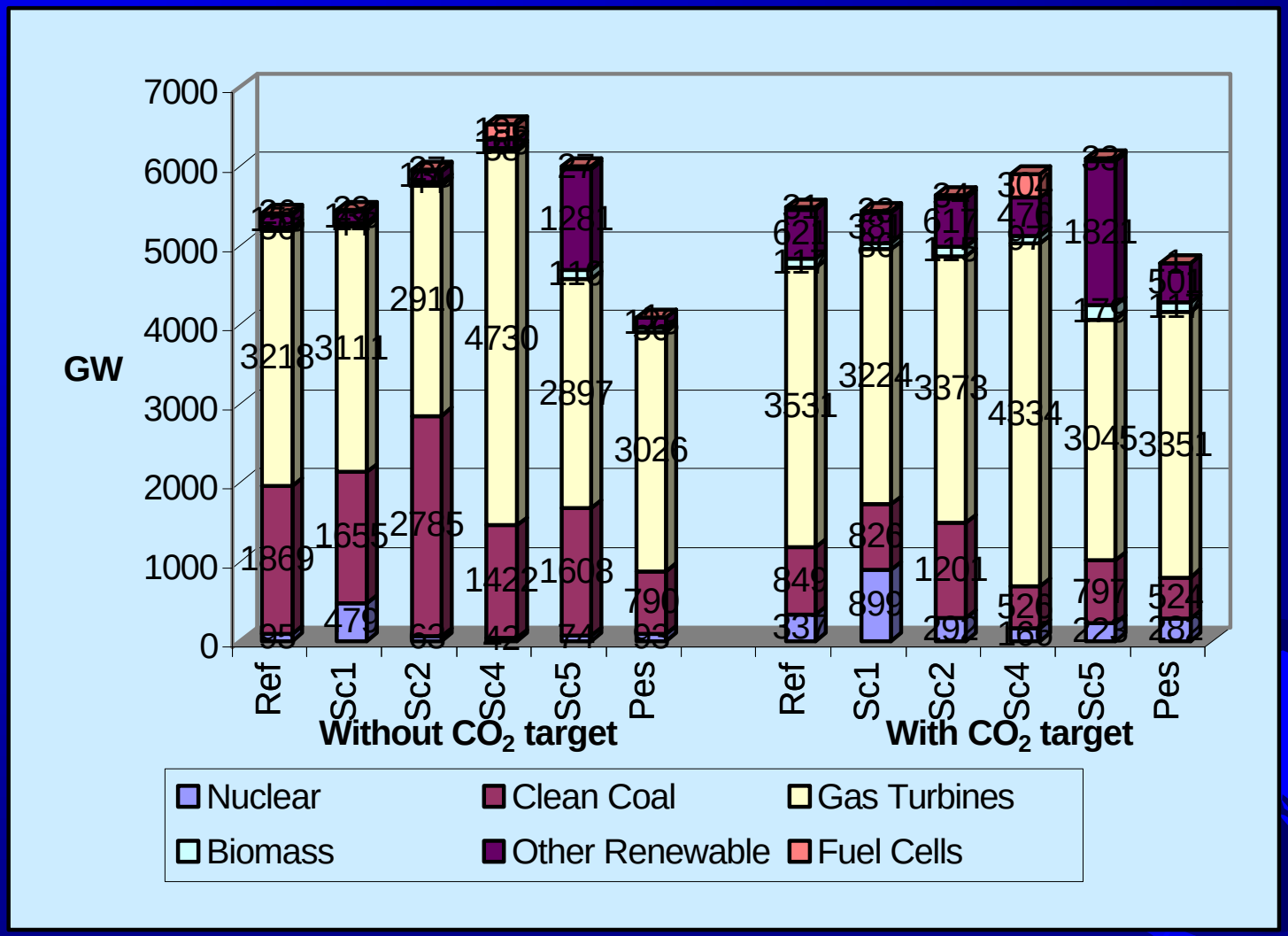
COST OF MEETING TARGETS as % of GDP



COST OF MEETING TARGETS as % of GDP



World power capacity installation (2000-2030)



World power capacity investment (2000-2030)