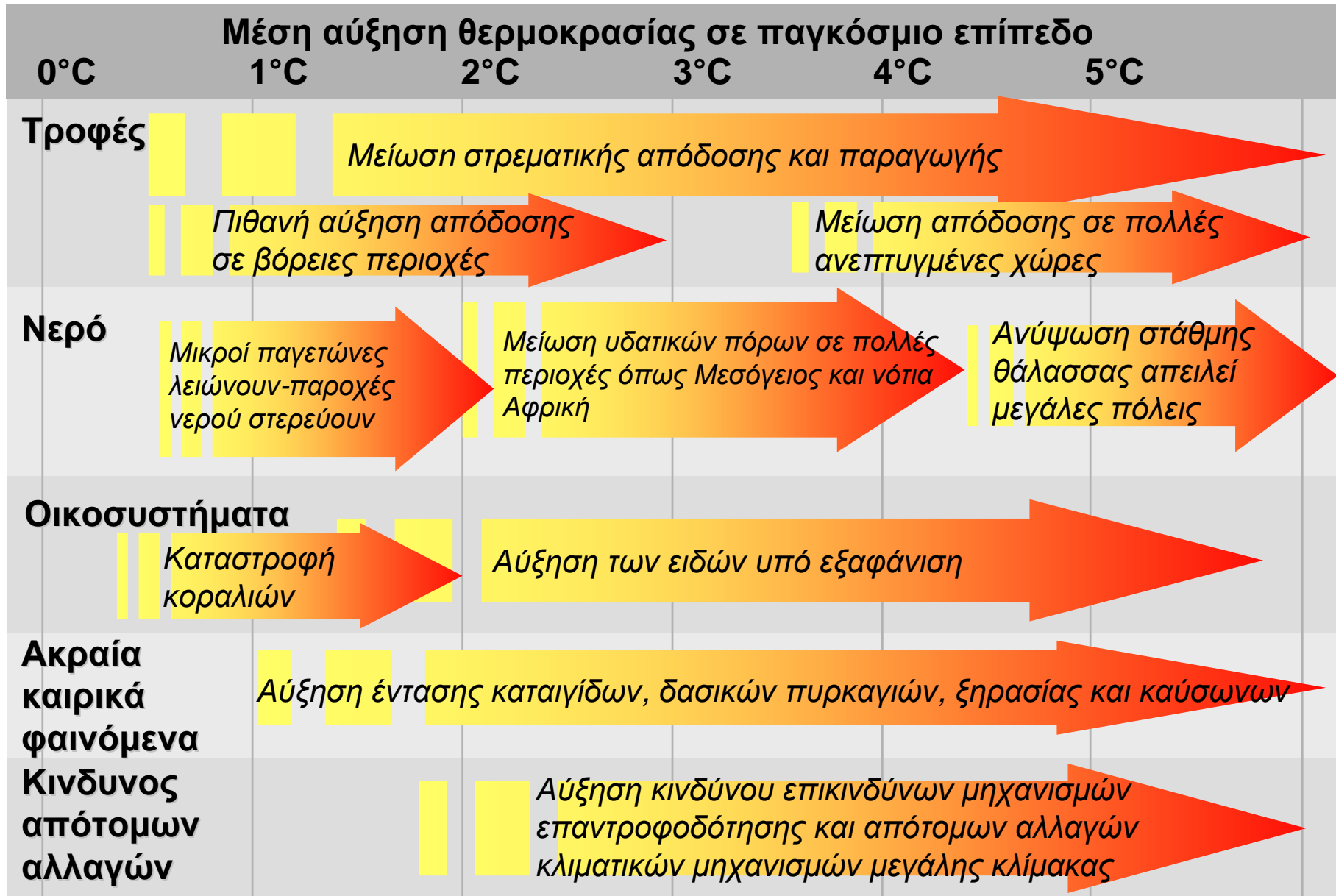


Φωτοβολταϊκά και Ανάπτυξη
1^η «Εβδομάδα Ενέργειας»
Ημερίδα IENE 26 Οκτωβρίου 2007

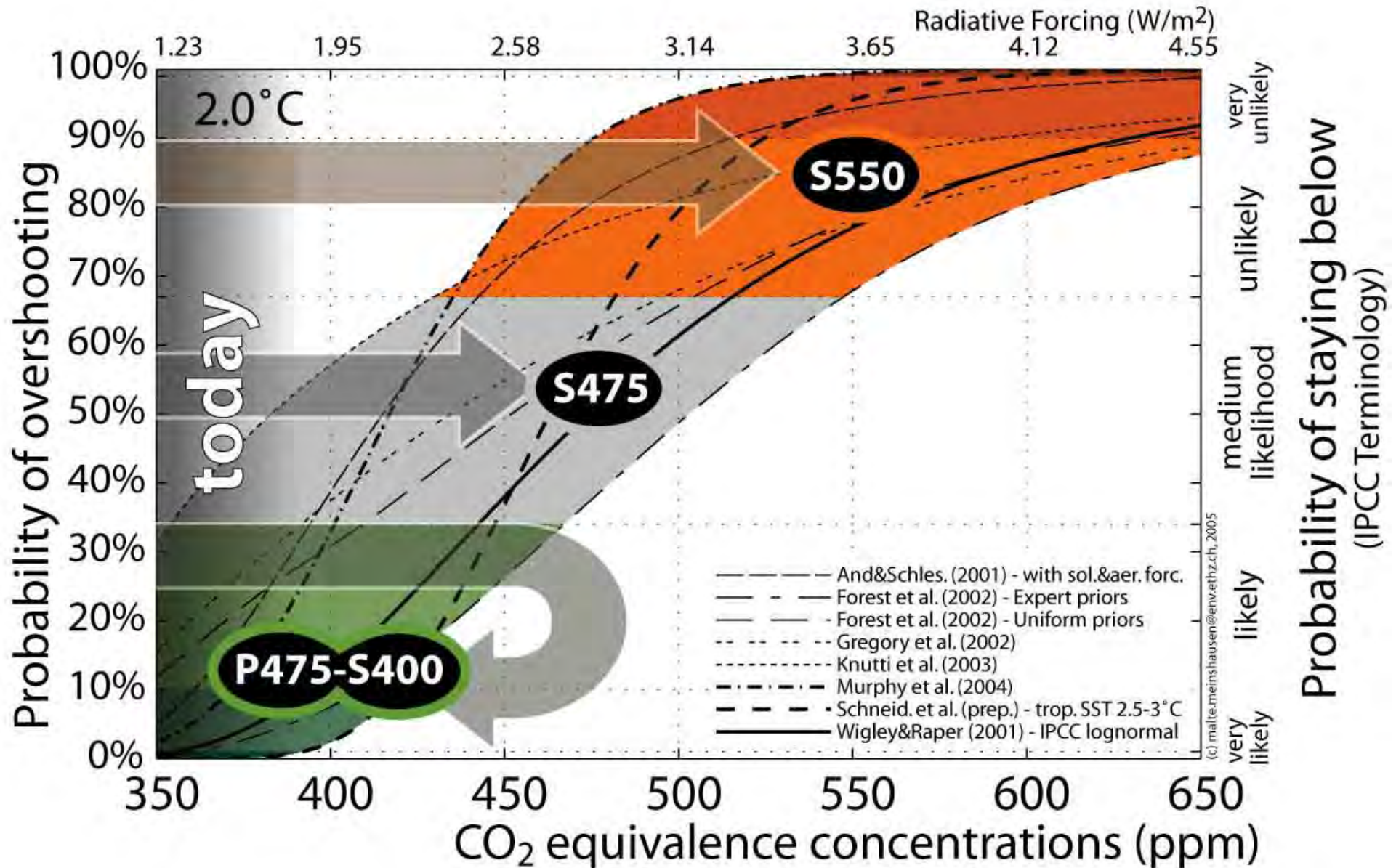
Το Πρωτόκολλο του Κυότο και οι επιπτώσεις στην
Αγορά των Φωτοβολταϊκών

Δημήτρης Λάλας
FACE³TS ΕΠΕ

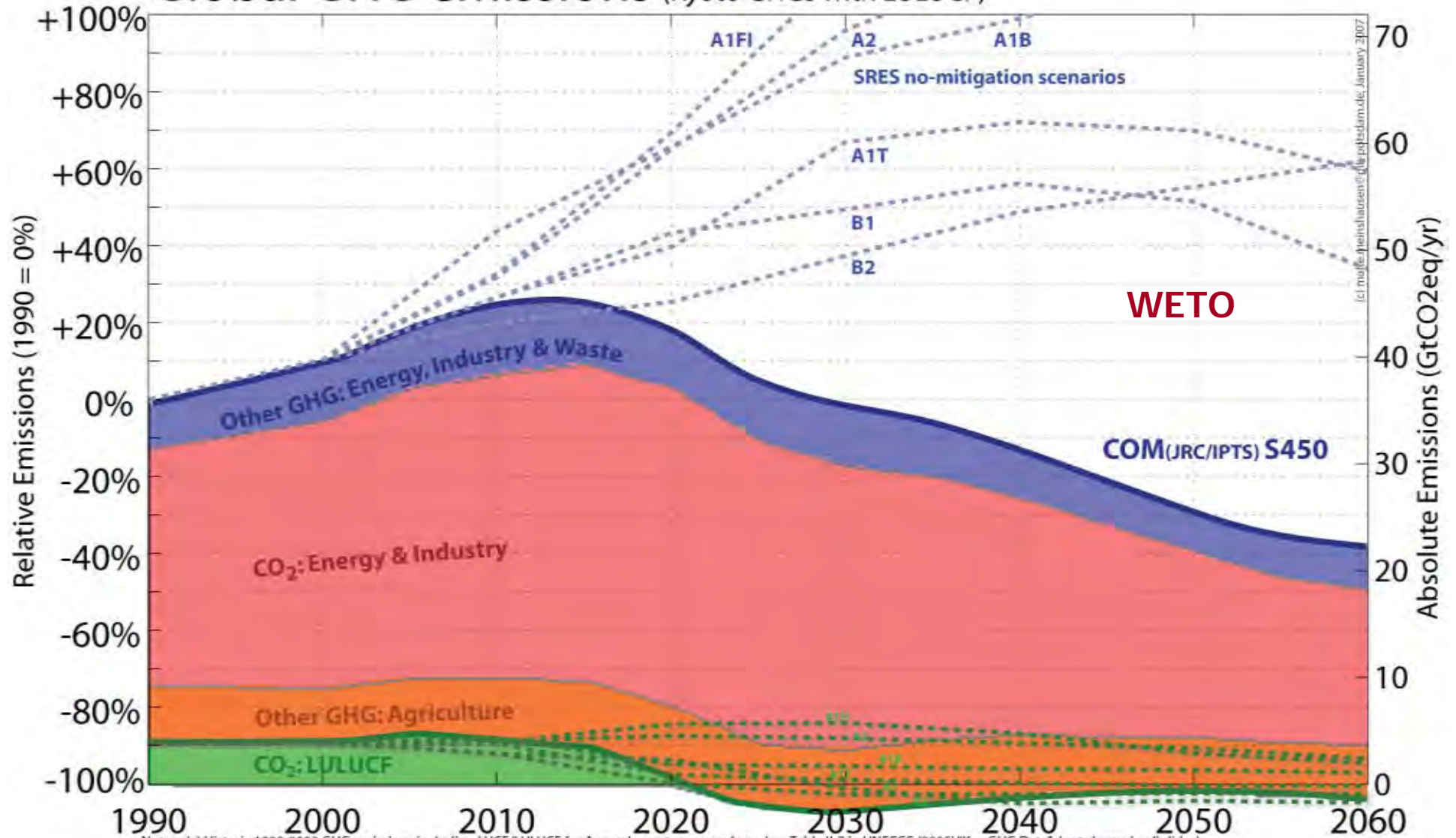
Επιπτώσεις Κλιματικής Αλλαγής



Επιτυχαίνοντας <2°C: απίθανη, 50:50 και πιθανή τροχιά

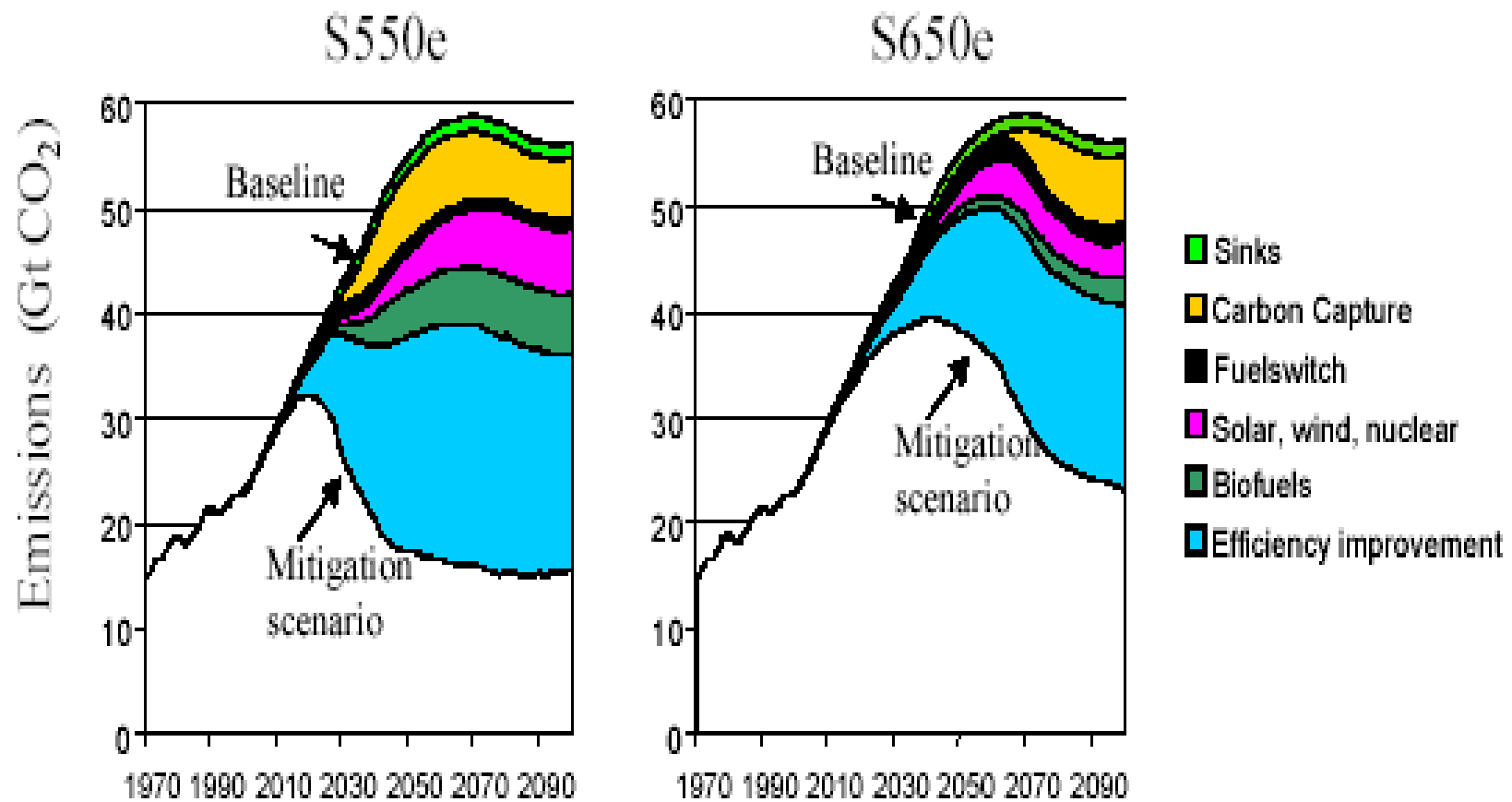


Global GHG emissions (Kyoto GHGs with LULUCF)

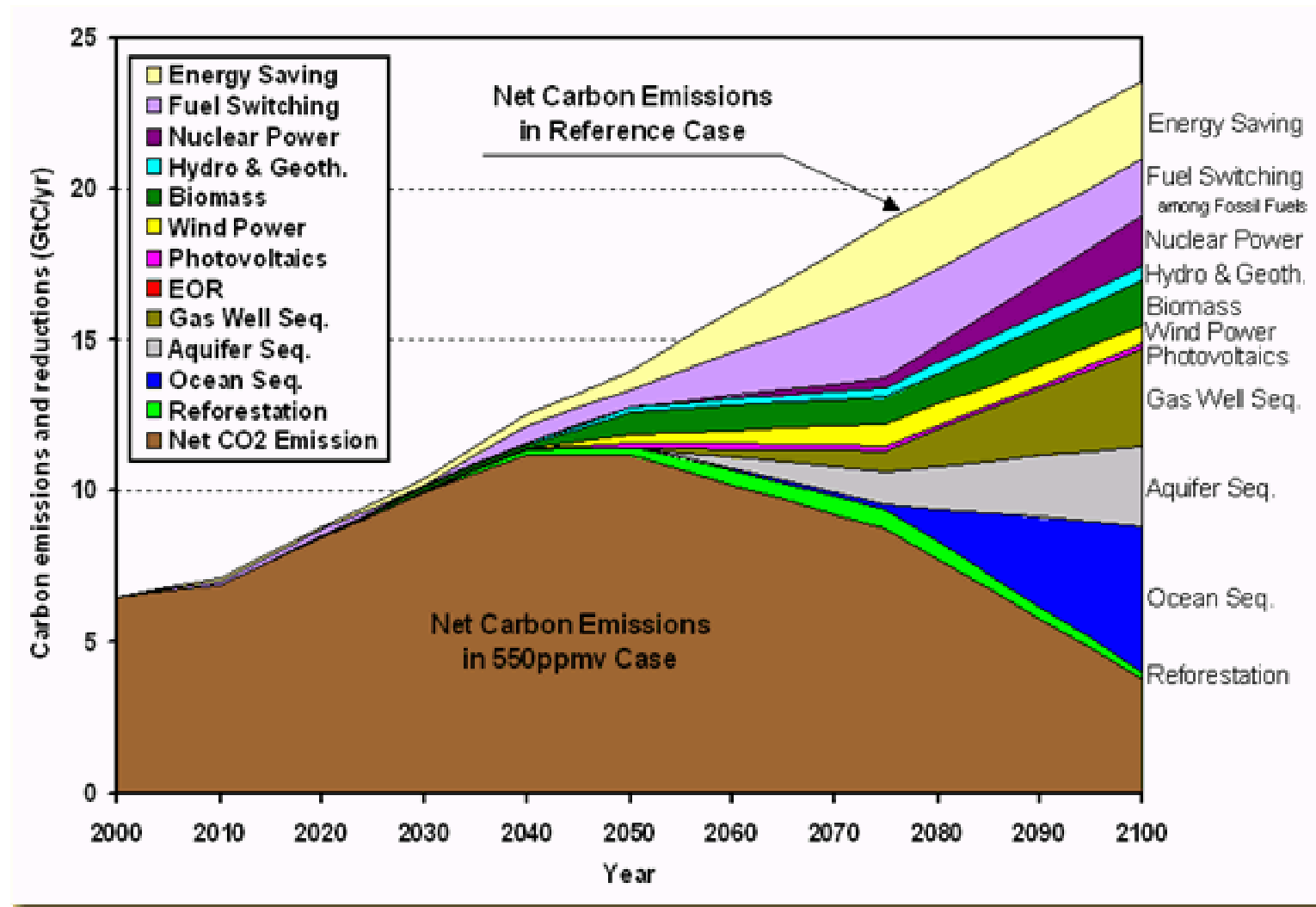


Notes: (a) Historic 1990-2003 GHG emissions including LUCF/LULUCF for Annex I country groups based on Table II-7 in UNFCCC (2005) "Key GHG Data"; (not shown in all slides)
 (b) Shown are various multi-gas FAIR-SIMCaP (den Elzen & Meinshausen, 2006) and EQW pathways (Meinshausen et al. 2006) relative to 1990 for peaking at approximately 500 ppm and stabilizing at 450ppm CO2eq (grey pathways) and peaking at 475 with subsequent stabilization at 400ppm CO2eq (green pathways).
 (b2) Shown are as well SRES scenarios (Nakicenovic and Swart, 2000), emission pathways used in the STERN review (2006), and the scenario presented by EU Commission COM(2007)2, Fig11, 10th January
 (c) The here shown pathways comprise the SRES country groups OECD90 and REF (Economies in Transition). Note that the absolute GHG emission data is (~15%) higher compared to absolute Annex I emissions reported to the UNFCCC, partially due to non-reported sources, as landuse related emissions, and slight differences in countries (Turkey, some REF).
 (d) The probabilities are given to stay below 2°C global-mean warming relative to preindustrial levels, assuming an IPCC consistent climate sensitivity pdf with a 90% confidence that climate sensitivity lies between 1.5°C and 4.5°C (for details see Chapter 28 in Schellnhuber et al., "Avoiding Dangerous Climate Change", 2006)
 (e) The light and dark patches show the mean plus / minus one and two standard deviations, respectively, for the set of analysed FAIR-SIMCaP and EQW pathways.
 (f) The calculations imply default MAGICC carbon cycle feedbacks, comparable to approximately the mean across the C4MIP studies (Friedlingstein et al. 2005).

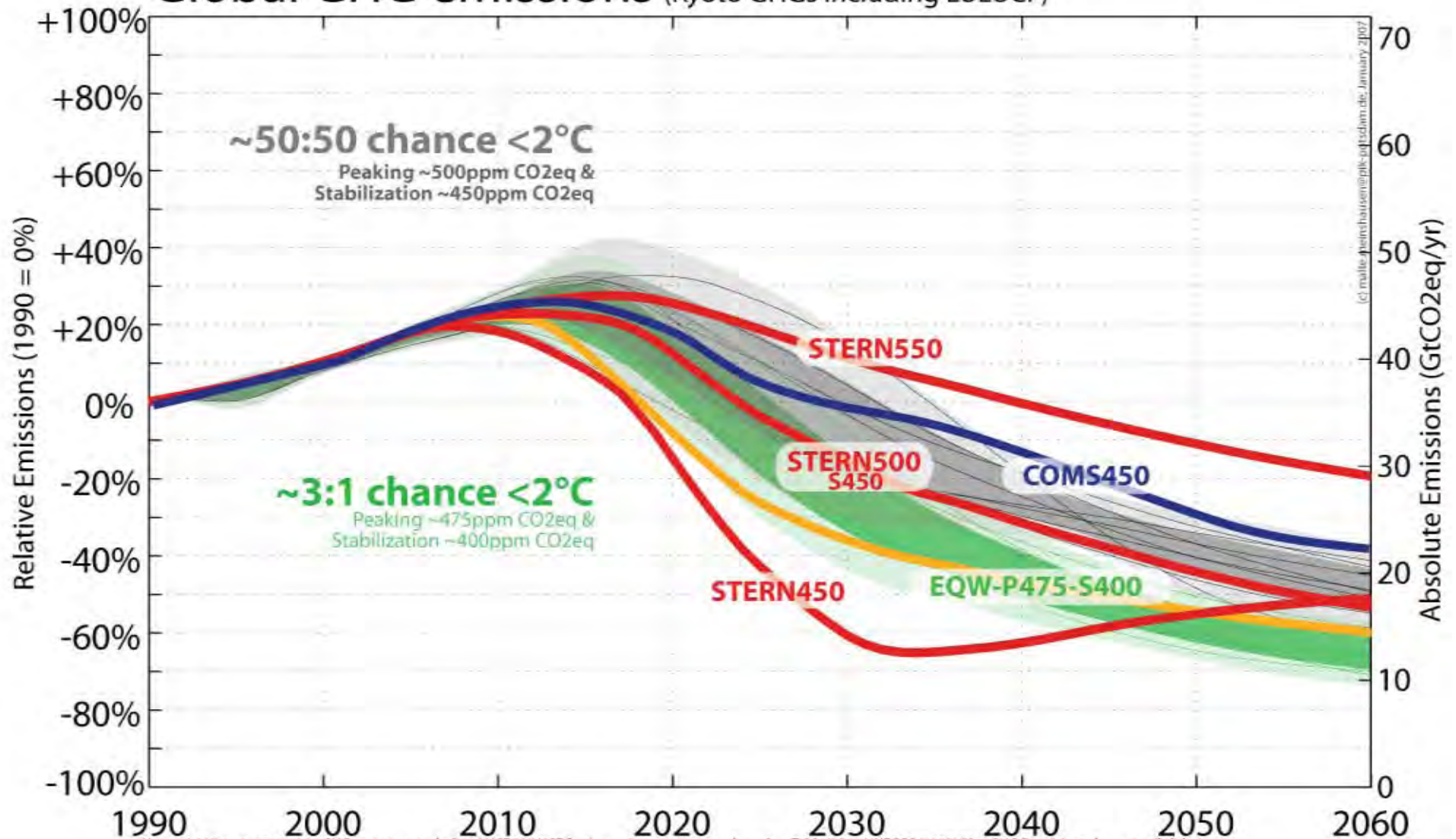
Απαιτούμενη μείωση των εκπομπών για την επίτευξη συγκέντρωσης 550 & 650 ppm ισοδ. CO₂



Σενάριο Μείωσης Εκπομπών CO₂ για σταθεροποίηση στα 550 ppmv (RITE)



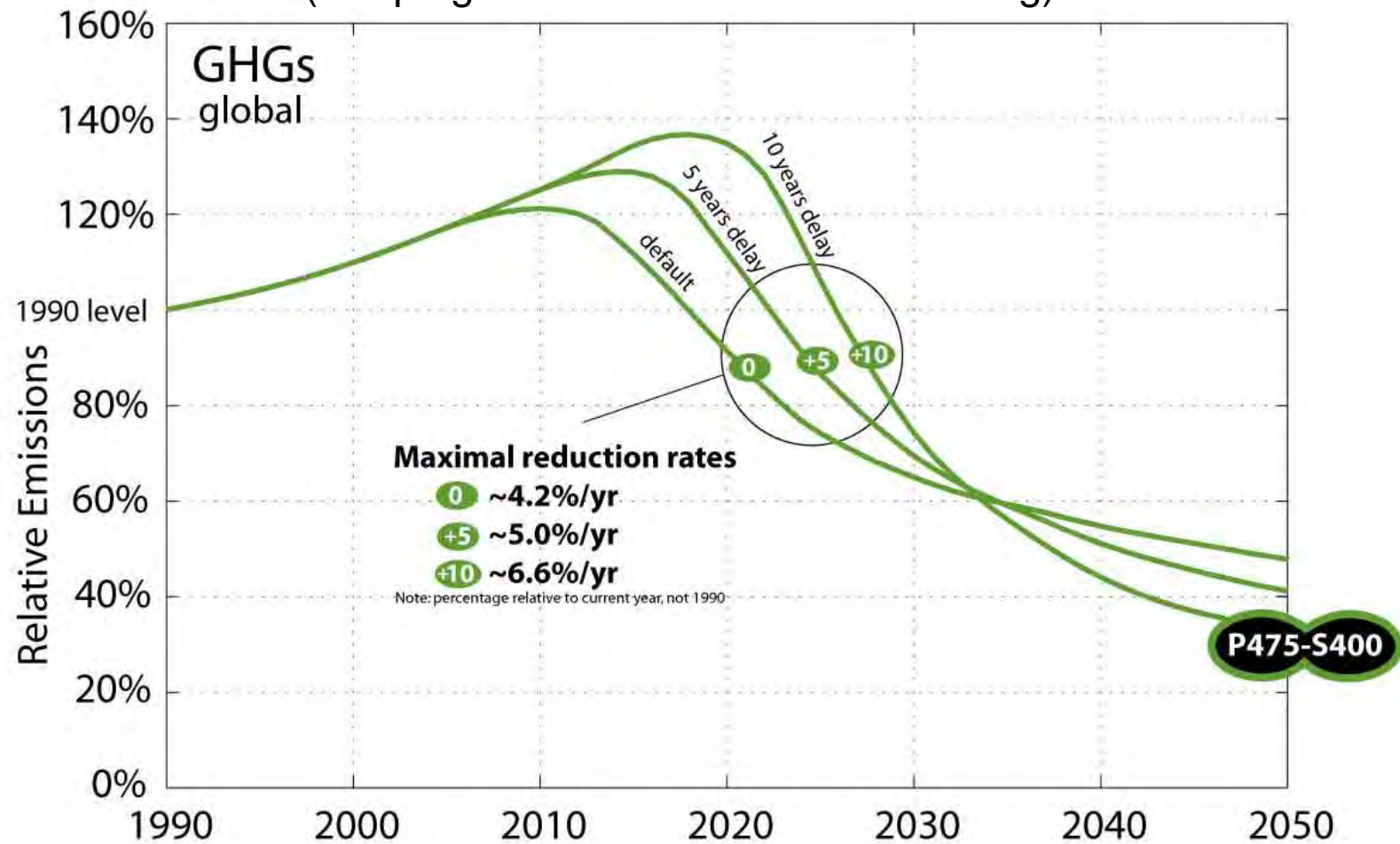
Global GHG emissions (Kyoto GHGs including LULUCF)



Notes: (a) Historic 1990-2003 GHG emissions including LUCF/LULUCF for Annex I country groups based on Table II-7 in UNFCCC (2005) "Key GHG Data"; (not shown in all slides)
 (b) Shown are various multi-gas FAIR-SiMCAp (den Elzen & Meinshausen, 2006) and EQW pathways (Meinshausen et al. 2006) relative to 1990 for peaking at approximately 500 ppm and stabilizing at 450ppm CO₂eq (grey pathways) and peaking at 475 with subsequent stabilization at 400ppm CO₂eq (green pathways).
 (b2) Shown are as well SRES scenarios (Nakicenovic and Swart, 2000), emission pathways used in the STERN review (2006), and the scenario presented by EU Commission COM(2007)2, Fig11, 10th January
 (c) The here shown pathways comprise the SRES country groups OECD90 and REF (Economies in Transition). Note that the absolute GHG emission data is (~15%) higher compared to absolute Annex I emissions reported to the UNFCCC, partially due to non-reported sources, as landuse related emissions, and slight differences in countries (Turkey, some REF).
 (d) The probabilities are given to stay below 2°C global-mean warming relative to preindustrial levels, assuming an IPCC consistent climate sensitivity pdf with a 90% confidence that climate sensitivity lies between 1.5°C and 4.5°C (for details see Chapter 28 in Schellinghuber et al. "Avoiding Dangerous Climate Change", 2006)
 (e) The light and dark patches show the mean plus / minus one and two standard deviations, respectively, for the set of analysed FAIR-SiMCAp and EQW pathways.
 (f) The calculations imply default MAGICC carbon cycle feedbacks, comparable to approximately the mean across the C4MIP studies (Friedlingstein et al. 2005).

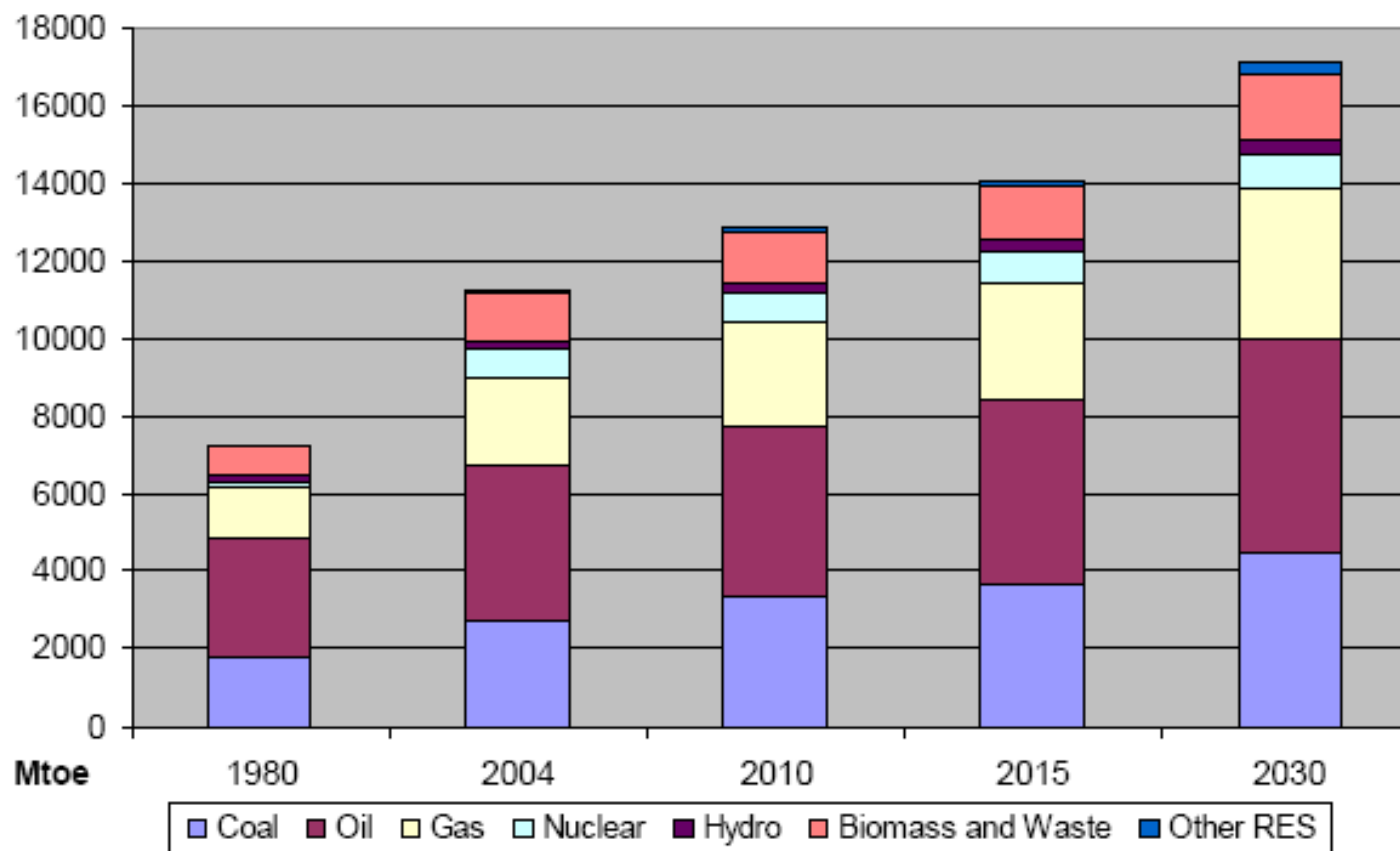
Οι επιπτώσεις της καθυστέρησης

(Keeping the same risk of overshooting)



“Delay now – pay later!”

IEA Παγκόσμια πρωτογενής παραγωγή ενέργειας - Reference

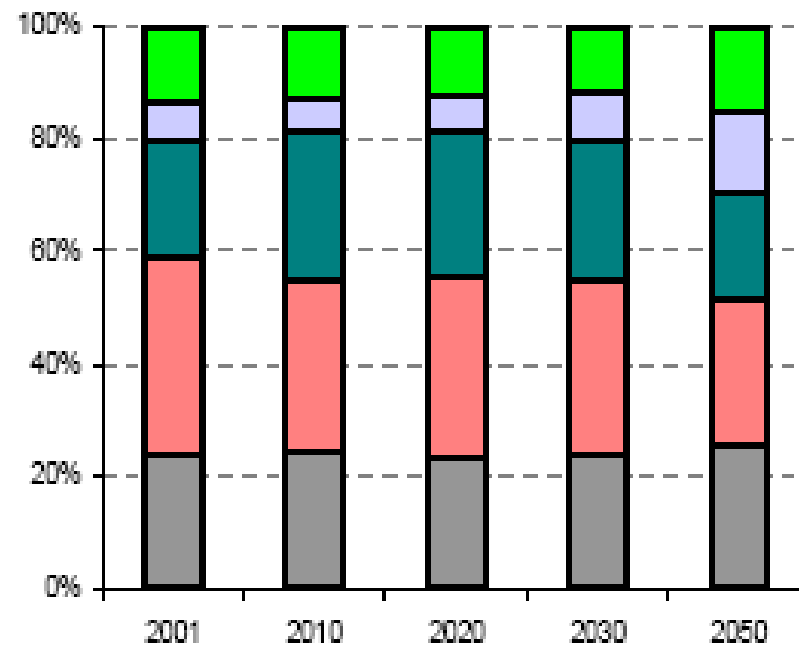
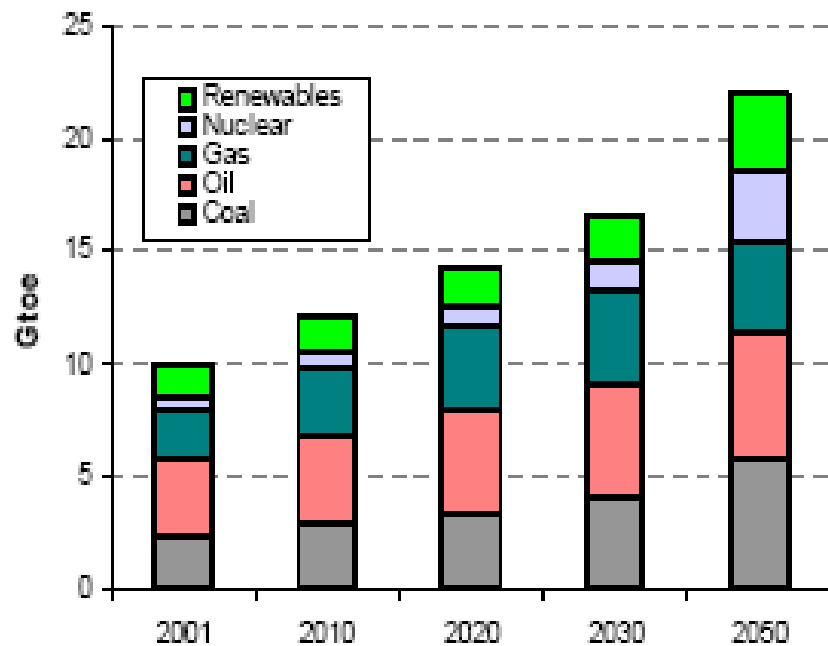


Source: WEO 2006, OECD/IEA 2006

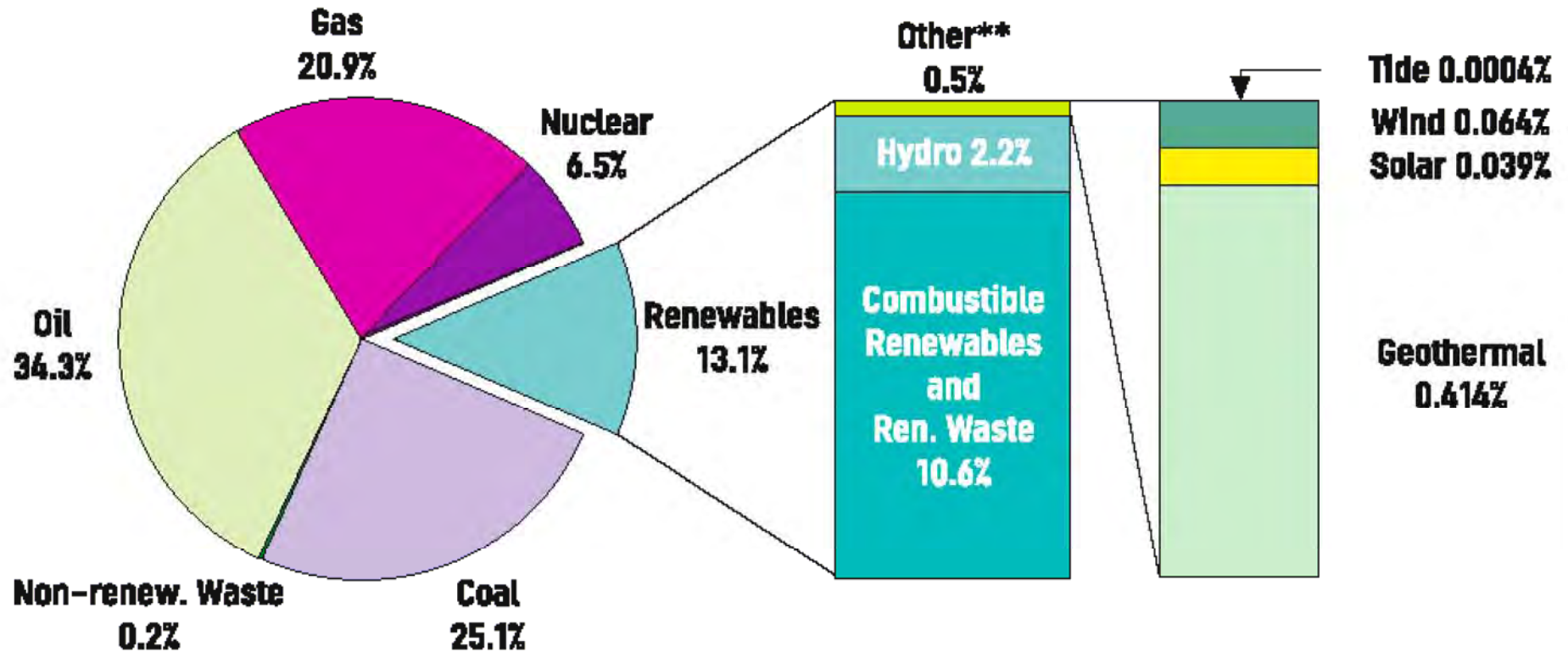
EU World Energy Outlook (WETO) Reference Scenario 2006 (POLES)

WORLD	1990	2001	2010	2030	2050	Annual % change		
						1990/10	2010/30	2030/50
Key Indicators								
Gross Inland Cons/GDP (toe/M\$95)	290	238	205	157	134	-1,7%	-1,3%	-0,8%
Gross Inland Cons/capita (toe/cap)	1,6	1,6	1,8	2,1	2,5	0,4%	0,7%	0,9%
Electricity Cons/capita (kWh/cap)	1 832	2 077	2 554	3 688	5 529	1,7%	1,9%	2,0%
Transport fuels per capita (toe/cap)	0,3	0,3	0,3	0,3	0,3	0,0%	0,4%	0,5%
CO2 emissions/capita (tCO2/cap)	3,8	3,9	4,3	4,8	5,0	0,5%	0,6%	0,2%
% of renewables in Gross Inland Cons	13,4	13,5	12,8	12,0	15,3	-0,2%	-0,3%	1,2%
% of renewables in electricity	20,1	18,7	18,2	20,6	25,0	-0,5%	0,6%	1,0%
Primary Production (Mtoe)								
Coal, lignite	8 834	9 836	12 346	16 853	22 276	1,7%	1,6%	1,4%
Oil	2 207	2 408	2 937	3 976	5 678	1,4%	1,5%	1,8%
Natural gas	3 234	3 487	3 951	5 385	5 984	1,0%	1,6%	0,5%
Nuclear	1 708	1 929	3 184	4 075	4 084	3,1%	1,3%	0,0%
Hydro, geothermal	525	671	739	1 425	3 185	1,7%	3,3%	4,1%
Biomass and wastes	218	232	275	357	417	1,2%	1,3%	0,8%
Wind, solar	939	1 101	1 281	1 462	2 261	1,5%	0,7%	2,2%
	0	7	21	174	686	21,9%	11,2%	7,1%
CO2 Emissions (MtCO2)								
of which:	20 161	23 566	29 055	38 749	44 297	1,8%	1,4%	0,7%
Electricity generation	7 433	8 932	10 562	13 747	16 065	1,8%	1,3%	0,8%
Industry	4 653	4 812	6 045	7 656	7 971	1,3%	1,2%	0,2%
Transport	3 982	5 056	5 461	6 815	7 263	1,6%	1,1%	0,3%
Household, Service, Agriculture	3 191	3 198	4 128	6 488	7 891	1,3%	2,3%	1,0%
CO2 Sequestration (Mt CO2)								
	0	0	0	271	2 545	na	na	11,8%

Παγκόσμια πρωτογενής παραγωγή ενέργειας (EU WETO)



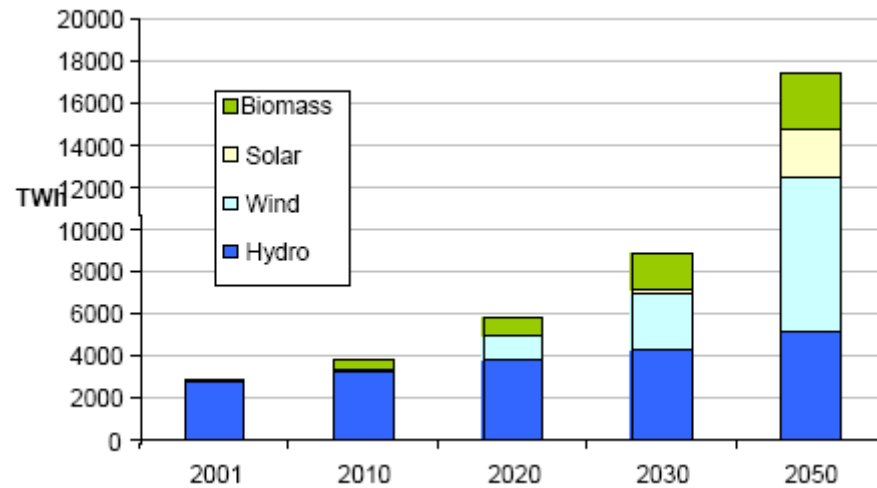
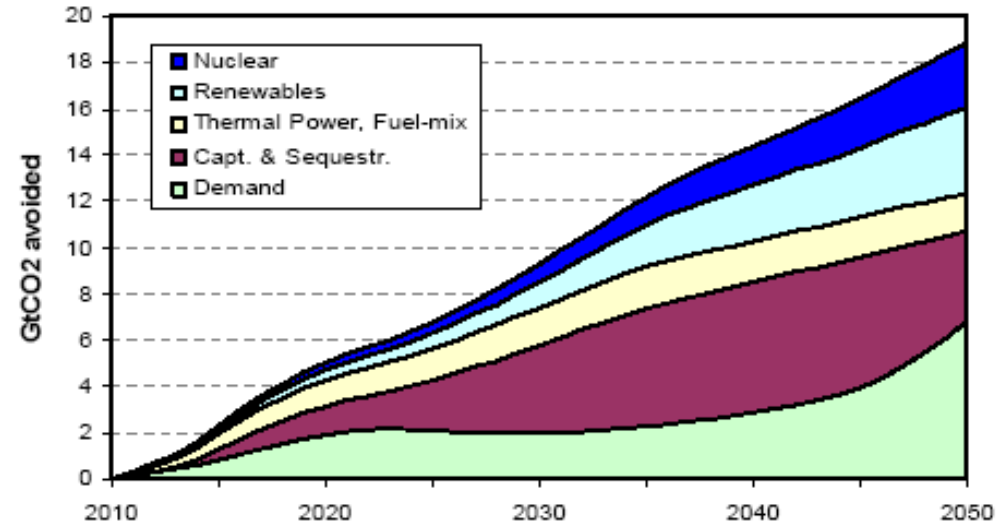
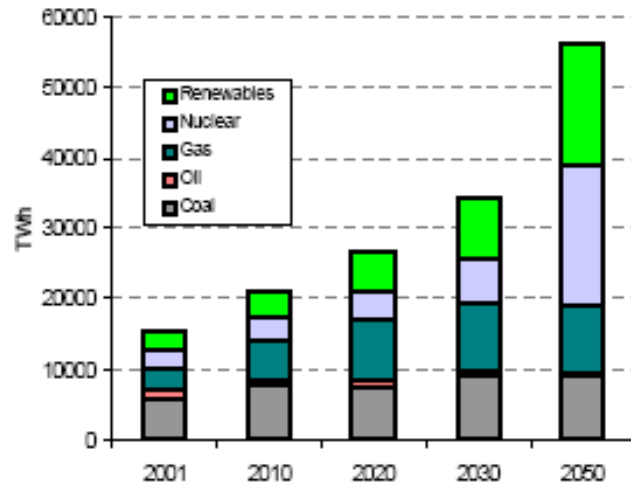
Κατανομή παραγωγής ενέργειας σε παγκόσμιο επίπεδο (2004) IEA



EU WETO-2050 Base Scen. (POLES 2006): Electricity

WORLD	2001	2010	2030	2050	Annual % change		
					2001/10	2010/30	2030/50
Electricity Production (TWh)	15468	21113	36295	60040	3,5%	2,7%	2,5%
Thermal, of which :	10074	14669	23809	31584	4,3%	2,5%	1,4%
Coal, lignite	5848	7600	12689	19066	3,0%	2,6%	2,1%
<i>of which advanced coal</i>	0	2022	9122	15964	192,7%	7,8%	2,8%
Gas	2934	5823	8760	9072	7,9%	2,1%	0,2%
<i>of which combined cycle</i>	944	2885	5233	4300	13,2%	3,0%	-1,0%
<i>of which cogeneration (industry)</i>	250	356	865	1954	4,0%	4,5%	4,2%
Oil	1136	804	988	1200	-3,8%	1,0%	1,0%
Biomass	155	442	1372	2246	12,3%	5,8%	2,5%
Nuclear	2653	3049	6328	14866	1,6%	3,7%	4,4%
<i>of which new design</i>	0	0	0	3401	na	na	na
Hydro (large)	2613	3088	3943	4588	1,9%	1,2%	0,8%
Hydro (small)	90	110	205	265	2,3%	3,1%	1,3%
Wind	37	188	1880	6433	19,9%	12,2%	6,3%
Solar	1	7	91	1493	19,7%	13,9%	15,0%
Hydrogen	0	2	39	811	na	15,3%	16,4%

Factor 2 Carbon Constraint Case (EU WETO) - Electricity



Κατανάλωση Ενέργειας (PJ/yr) - Σενάριο 2οC

	2003	2010	2020	2030	2040	2050
Total	435,120	428,060	421,580	414,800	420,920	422,430
Fossil	348,560	333,200	303,450	269,410	239,370	212,000
Hard coal	107,900	90,130	70,860	51,530	39,720	31,820
Natural gas	93,230	98,990	103,980	107,020	100,820	93,050
Crude oil	147,430	144,080	128,610	110,860	98,830	87,130
Nuclear	28,810	22,840	14,520	710	0	0
Renewables	57,750	72,020	103,610	144,680	181,550	210,430
Hydro	9570	11,260	13,160	14,520	15,850	16,950
Wind	230	1250	8380	16,180	21,120	25,730
Solar	160	1740	6920	17,910	30,230	42,280
Biomass	46,450	54,700	68,470	84,730	97,680	105,140
Geothermal	1340	3050	6570	11,110	16,270	19,790
Ocean Energy	0	20	110	230	400	540
Share renewables (%)	13	17	25	35	43	50
Savings compared to 'Reference'		59,260	141,740	224,870	296,210	386,780

(Krewitt et al., 2007)

Παραγωγή Ηλεκτρισμού (TWhr/yr)- Σενάριο 2οC

	2003	2010	2020	2030	2040	2050
Total generation	16,662	17,314	20,250	23,290	27,020	30,940
Fossil	11,015	11,110	1,1220	10,630	10,000	94,90
Coal	5841	5560	4760	3500	2970	2690
Lignite	714	580	360	160	35	0
Natural gas	3295	4180	5670	6760	6920	6780
Oil	1165	790	430	210	70	20
Nuclear	2641	2090	1330	70	0	0
Renewables	3007	4114	7700	12530	17020	21450
Hydro	2659	3130	3660	4030	4400	4710
Wind	64	350	2330	4490	5870	7150
PV	0.6	30	270	1000	1840	2840
Biomass	228	480	1000	1700	2350	2940
Geothermal	54	110	210	360	560	730
Concentrating Solar power	0.5	9	200	950	1890	2930
Ocean energy	1	5	30	60	110	150
Share renewable electricity (%)	18	24	38	54	63	69
Share CHP electricity (%)	10	12	13	15	16	16

(Krewitt et al. 2007)

Δηλαδή 2.2ΕκατMW ήτοι 1988MtCO₂ μείωση ή 4.5%

Αναμενόμενες Τιμές Ενεργειακών Συστημάτων (\$/MW)

	2010	2030	2050
Coal condensing power plant	1050	930	880
Natural gas combined cycle	440	400	395
Wind	1140	950	890
Photovoltaic	3450	1420	1060
Biomass CHP	2890	2140	1920
Geothermal CHP	9510	5350	4560
Concentrating solar power plant	2700 ^a	4000 ^b	3600 ^b
Ocean energy	3900	1930	1610

(Kriwett et al. 2007)

ΦΒ που βρισκόμαστε σήμερα;


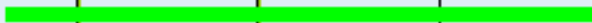
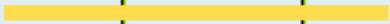


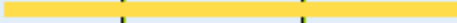
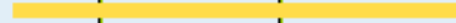
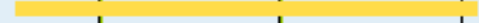
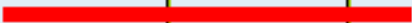


facets

further action on climate, environment, energy, economy, technology & sustainability

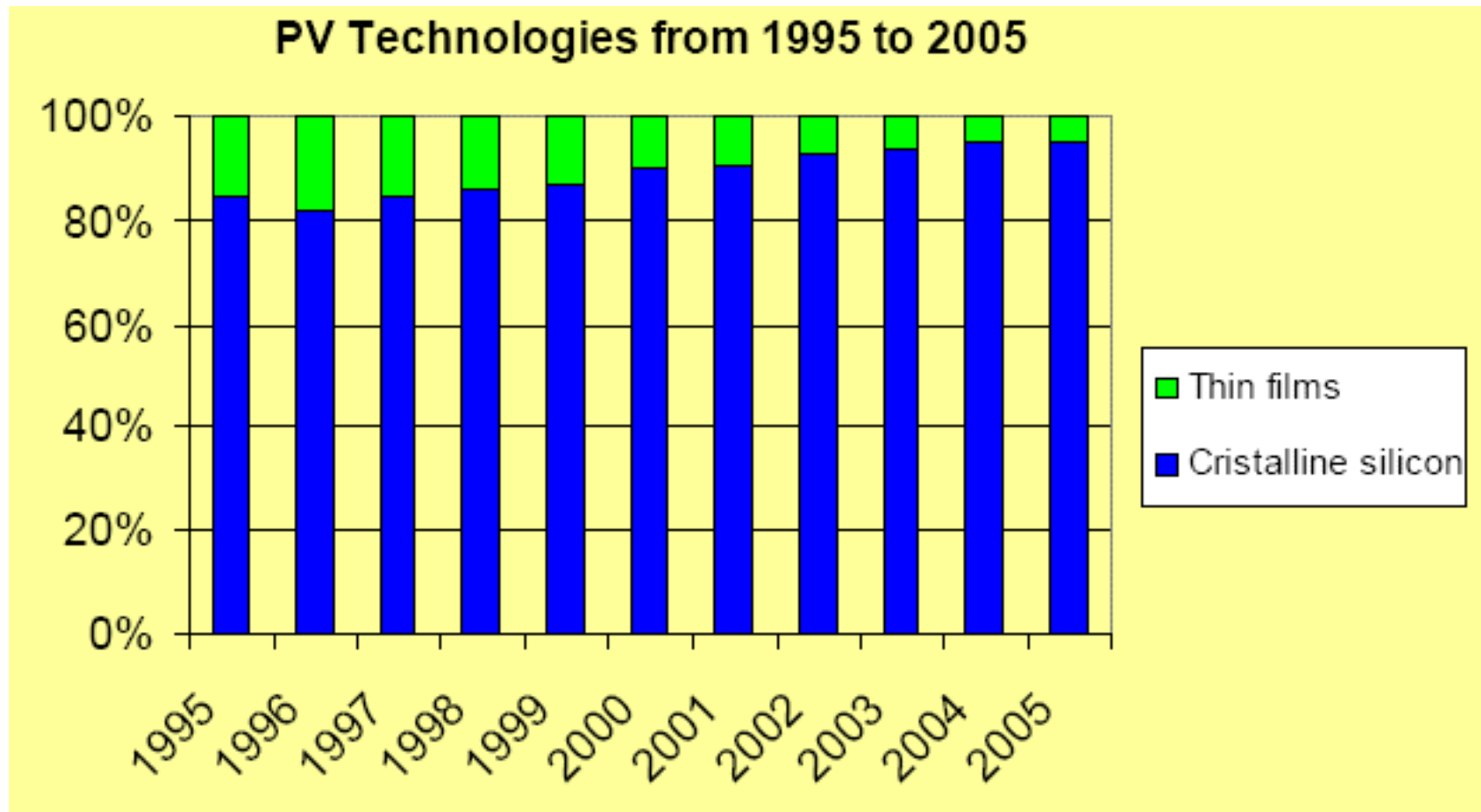


Τεχνολογίες ΦΒ σήμερα

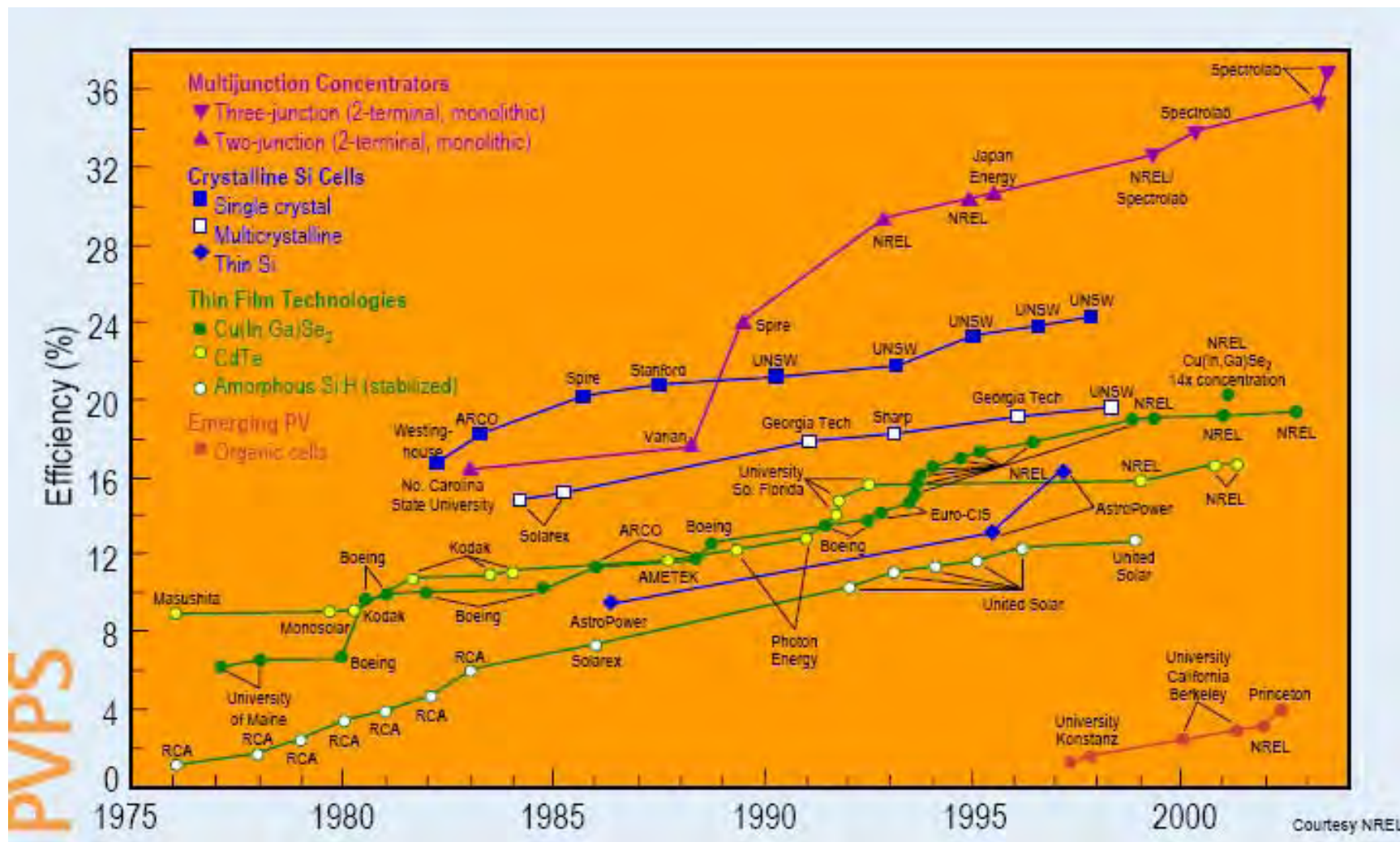
PV technologies today

Technology	Small cell Laboratory	Large cell Laboratory	Laboratory Pilotprod.	Industry Pilotprod.	Industry Production
Crystalline Silicon, monocrystalline					
Crystalline Silicon, multicrystalline					
Crystalline Silicon, high efficiency					
Crystalline Silicon, ribbon					
amorphous Silicon					
Ga As					
CIS / CIGS					
CdTe					
Crystalline Silicon, thin film					
Dye sensitised					
Others					

Πωλήσεις διαφόρων τεχνολογιών ΦΒ



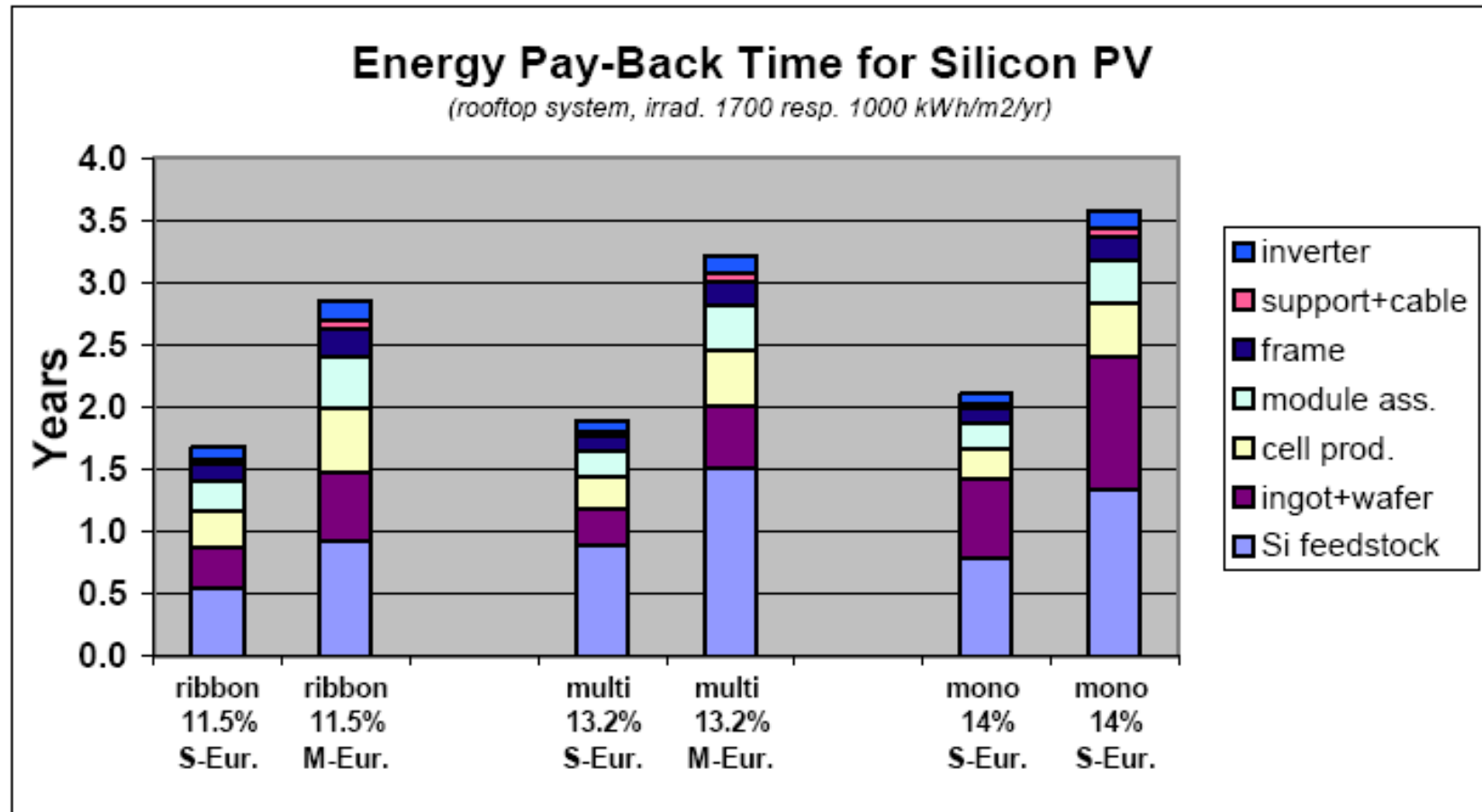
Εξέλιξη απόδοσης ΦΒ υλικών



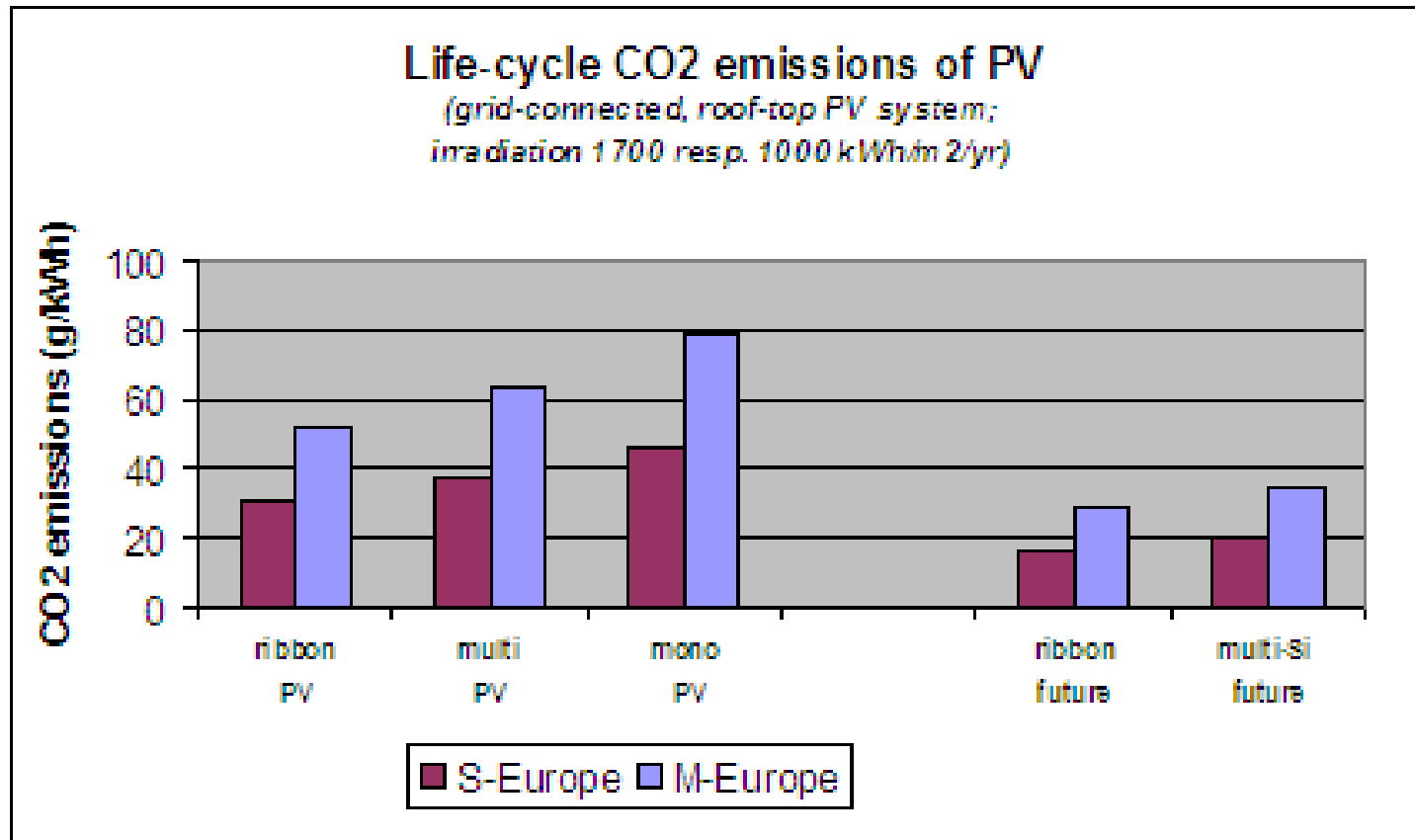
Σημερινή και αναμενόμενη απόδοση ΦΒ συστημάτων

	Silicon PV technologies					
	Multi-crystalline		Single-crystalline		Amorphous	
	Present	Future	Present	Future	Present	Future
Cell efficiency	14%	16%	15.5%	18%	–	–
Module efficiency	12.1%	14.5%	12.7%	14.8%	6%	10%
Primary energy content for module manufacturing (MJ/m²)	4 200-11 600	2 600	6000-13 900	3 100	1 200	840
Module lifetime (years)	25	30	25	30	10	15

Ενεργειακή απόσβεση κατασκευής ΦΒ συστημάτων



Εκπομπές ΑΦΘ κατά τον κύκλο ζωής ΦΒ συστημάτων



Τάσεις Διεθνούς Αγοράς

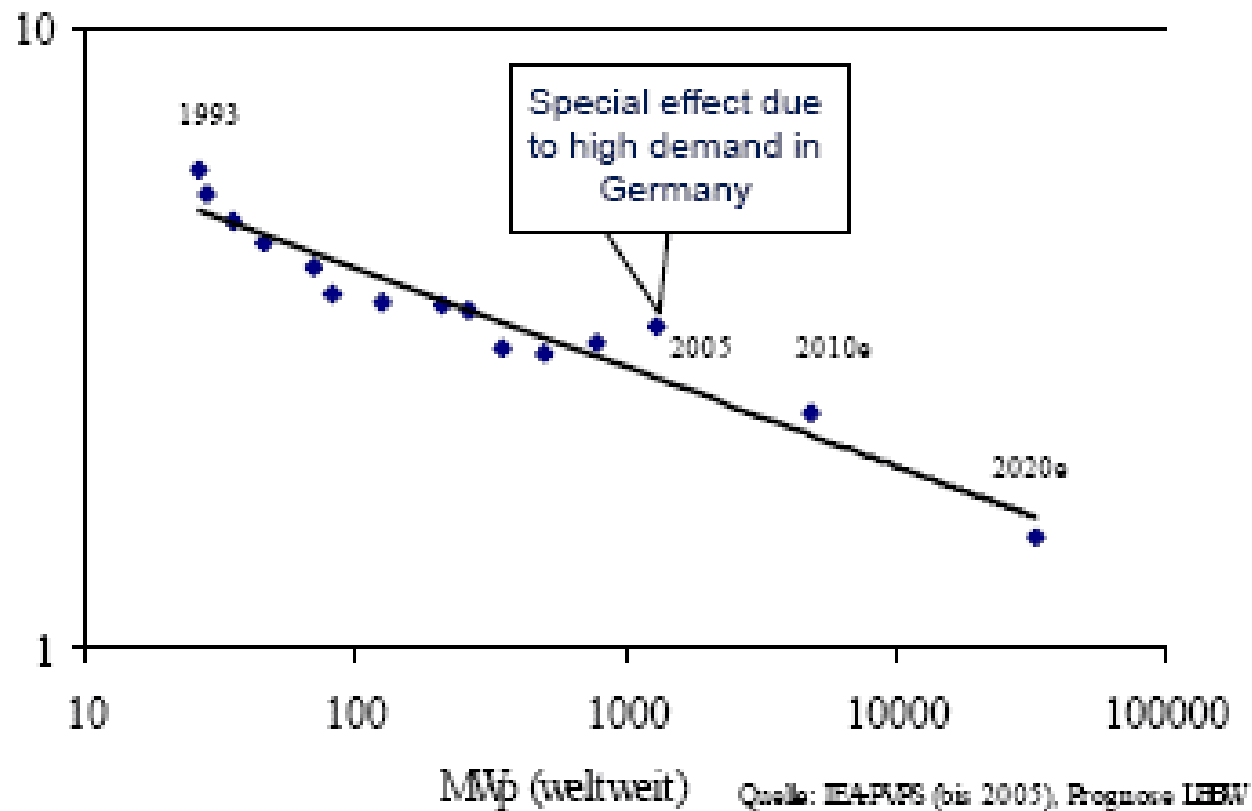
facets

further action on climate, environment, energy, economy, technology & sustainability

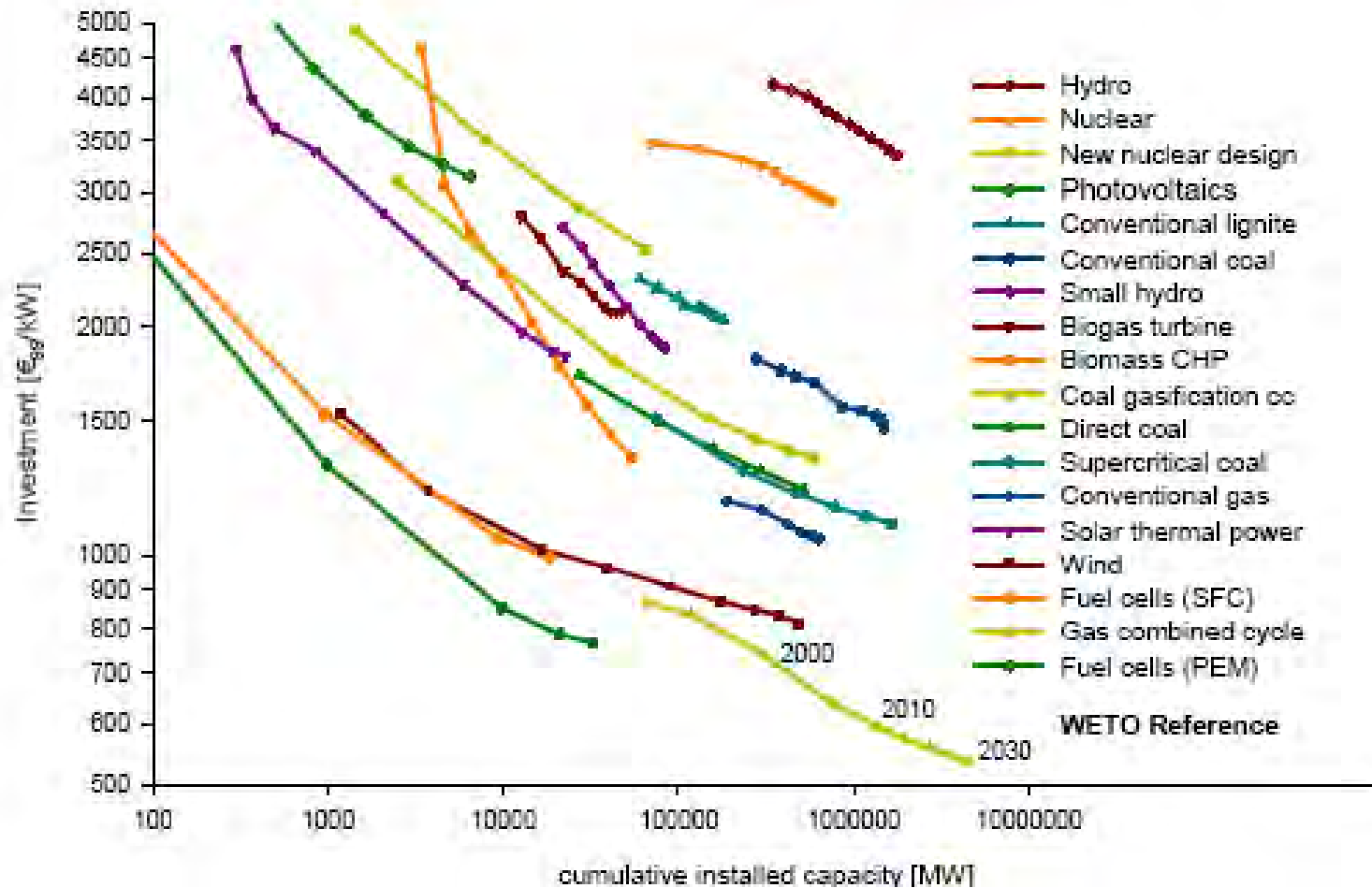


Πρό

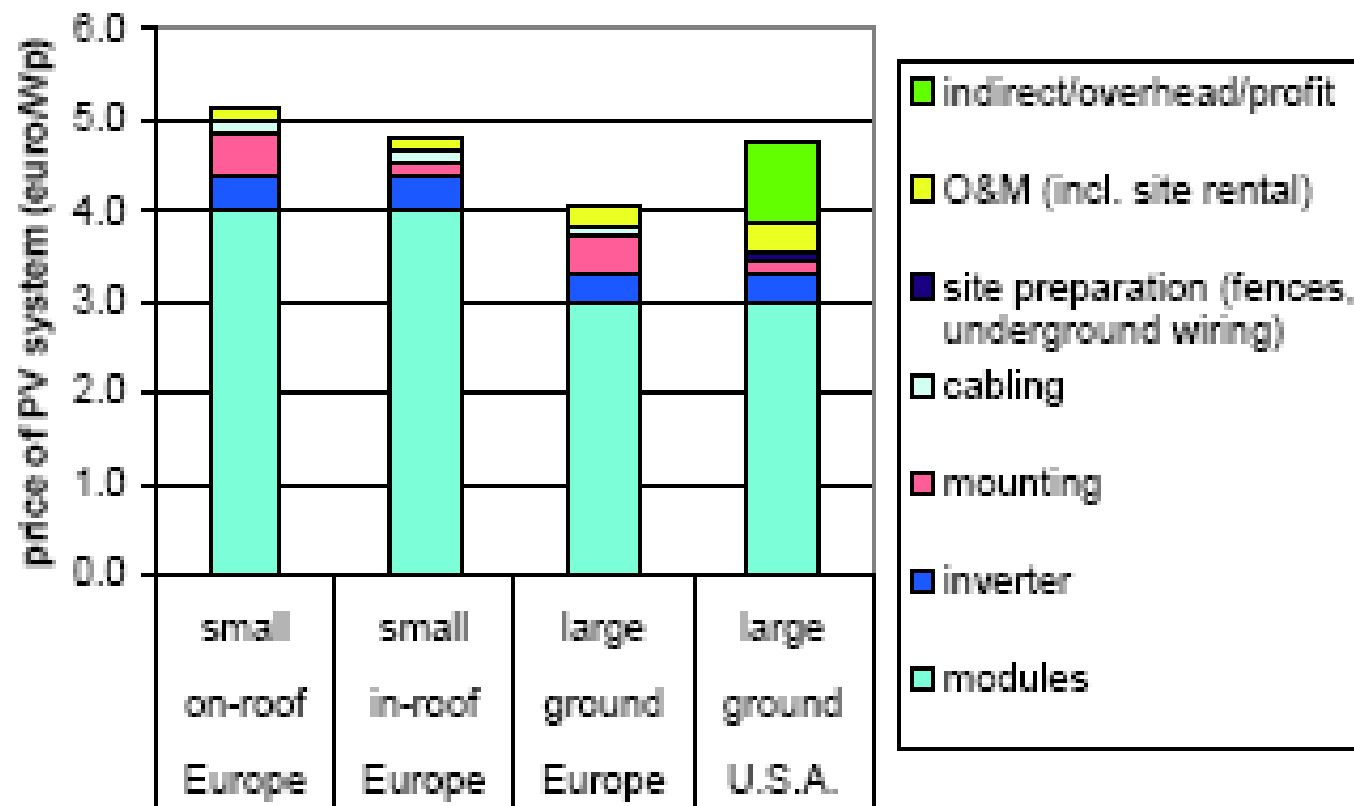
€/W_p Prices of solar modules and newly installed capacity
(Deutschland)



EU world Energy Outlook 2006: Καμπύλη Μάθησης Τεχνολογιών

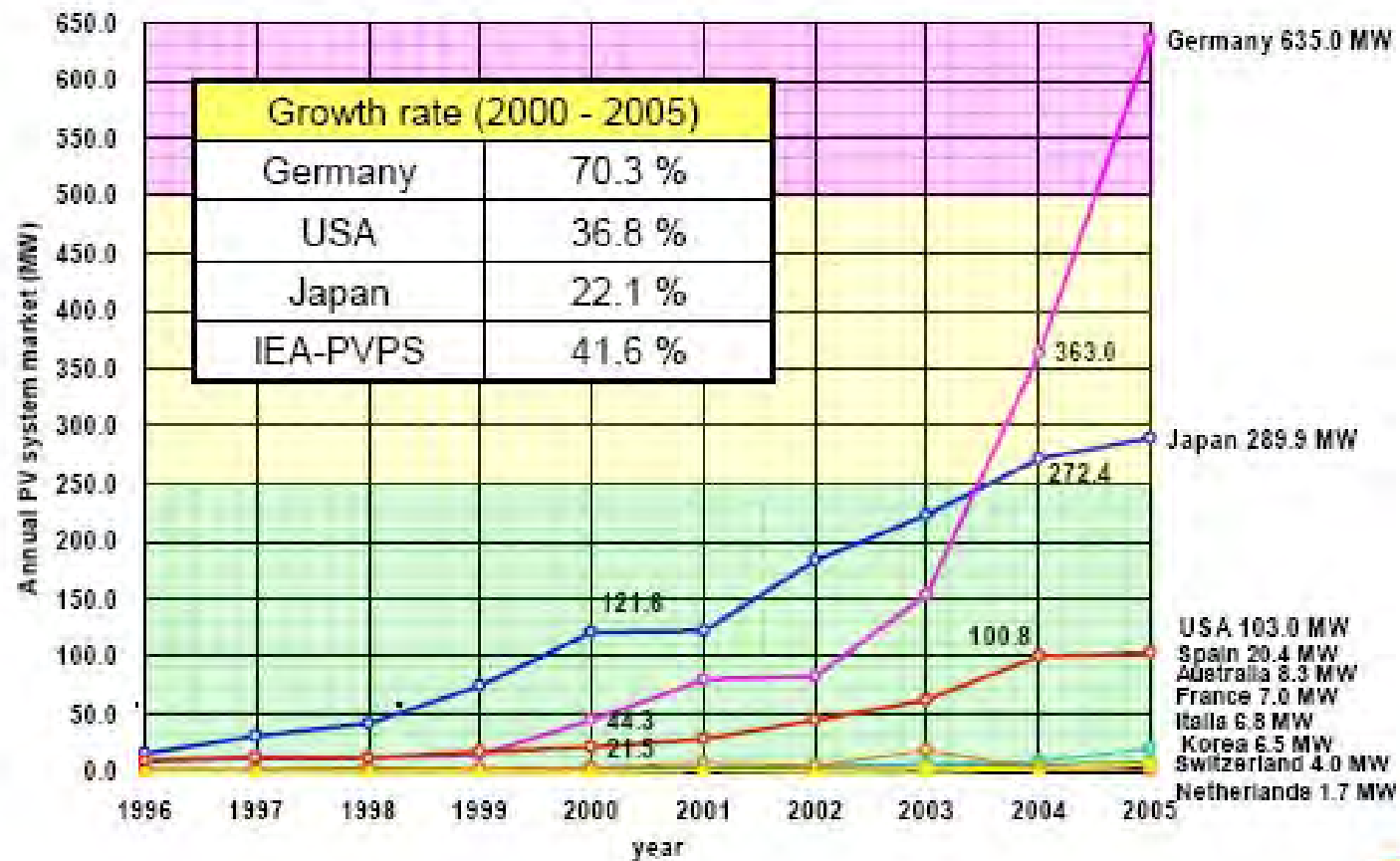


Τιμές ΦΒ Συστημάτων (2006)



(De Wild-Scholten et al Sept 2006)

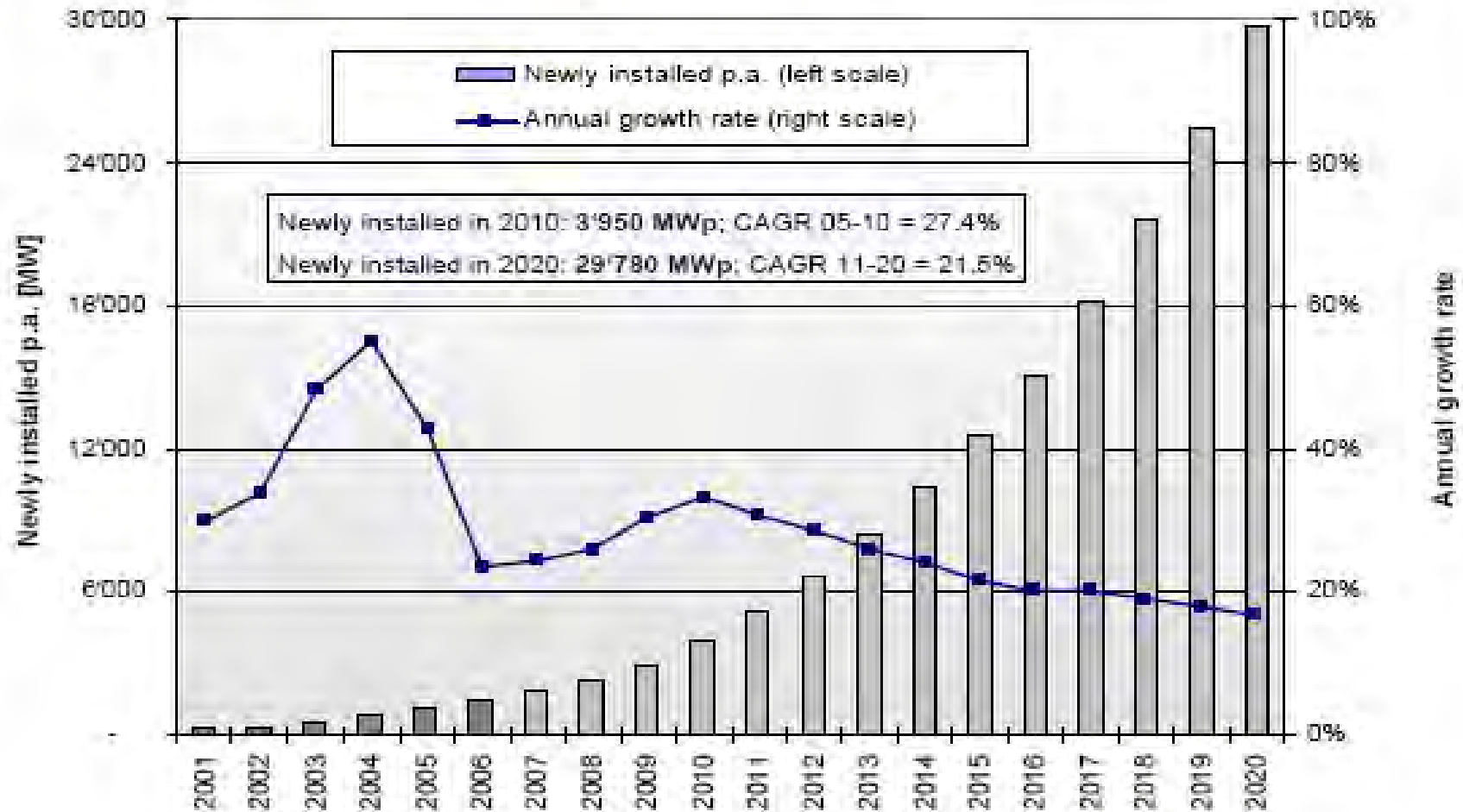
Ετήσιες εγκαταστάσεις νέων ΦΒ συστημάτων



Source: Trends in photovoltaic applications in selected IEA countries between 1992 and 2005. September 2006



Sarasin Long-term forecast



Quelle: Sarasin Schätzung, Nov. 2006

Πρόβλεψη εκπομπών ΑΦΘ – Πλέον πρόσφατο Σενάριο Αναμενόμενης Εξέλιξης & Ενεργειακός τομέας (II)

Annual market size by region

(Unit: MW)

Region	Country	2005	2010	2015	2020	2025
Europe	Germany	700	1,200	1,293	1,359	1,428
Asia	Japan	291	1,038	2,451	3,129	2,975
	China	44	211	1,351	8,657	13,942
	India	16	180	968	1,947	3,509
	Thailand	8	82	306	762	1,227
Oceania	Australia	8	89	398	989	1,412
North America	USA	105	603	2,240	3,608	5,811
South America	Brazil	3	62	332	827	2,057

Source: EPIA, Greenpeace „Solar Generation“, September 2006



Πρόβλεψη χρονικής εξέλιξης τιμών kWh από ΦΒ

(Unit: Eurocent/kWh)

		2005	2010	2015	2020	2030	2050
		30.0		15.0		6.0	3.0
		45	30		10		
	Residential	18.0 - 25.1	10.2 - 14.1	6.3 - 7.8			
	Commercial	12.5 - 17.3	7.1 - 9.4	4.7 - 6.3			
	Utility	10.2 - 17.3	7.8 - 11.8	3.9 - 5.5			
		27.47	15.41		9.38	4.69	

Source:

EU: Strategic Research Agenda (SRA) for Photovoltaic Solar Energy Technology, PV-TRAC (July 2006)

Germany: PV R&D Roadmap, developed during the 9th BMU strategy meeting of representatives from German industry and research institutes (November 2005) (In Southern Europe)

USA: The Solar America Initiative, NREL (February 2006)

Japan: PV Roadmap Toward 2030 (PV2030), NEDO (June 2004)

Conversion Rate: 1 USD = 79.4131 EUR, 1 JPY = 0.67 EUR (as of November 1, 2006)



Ανταγωνισμός και Συγκρίσεις

facets

further action on climate, environment, energy, economy, technology & sustainability

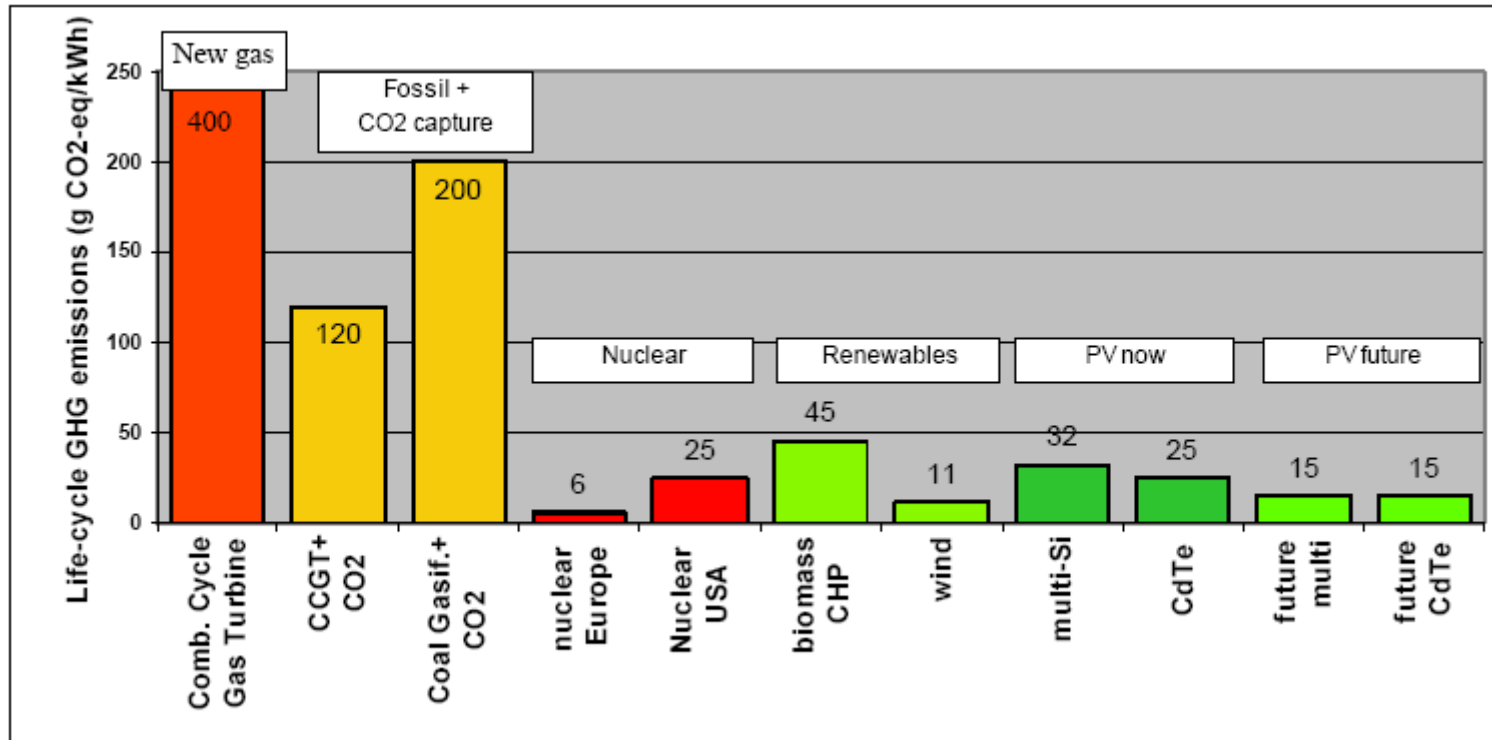


Αναμενόμενες Τιμές Ενεργειακών Συστημάτων (\$/MW)

	2010	2030	2050
Coal condensing power plant	1050	930	880
Natural gas combined cycle	440	400	395
Wind	1140	950	890
Photovoltaic	3450	1420	1060
Biomass CHP	2890	2140	1920
Geothermal CHP	9510	5350	4560
Concentrating solar power plant	2700 ^a	4000 ^b	3600 ^b
Ocean energy	3900	1930	1610

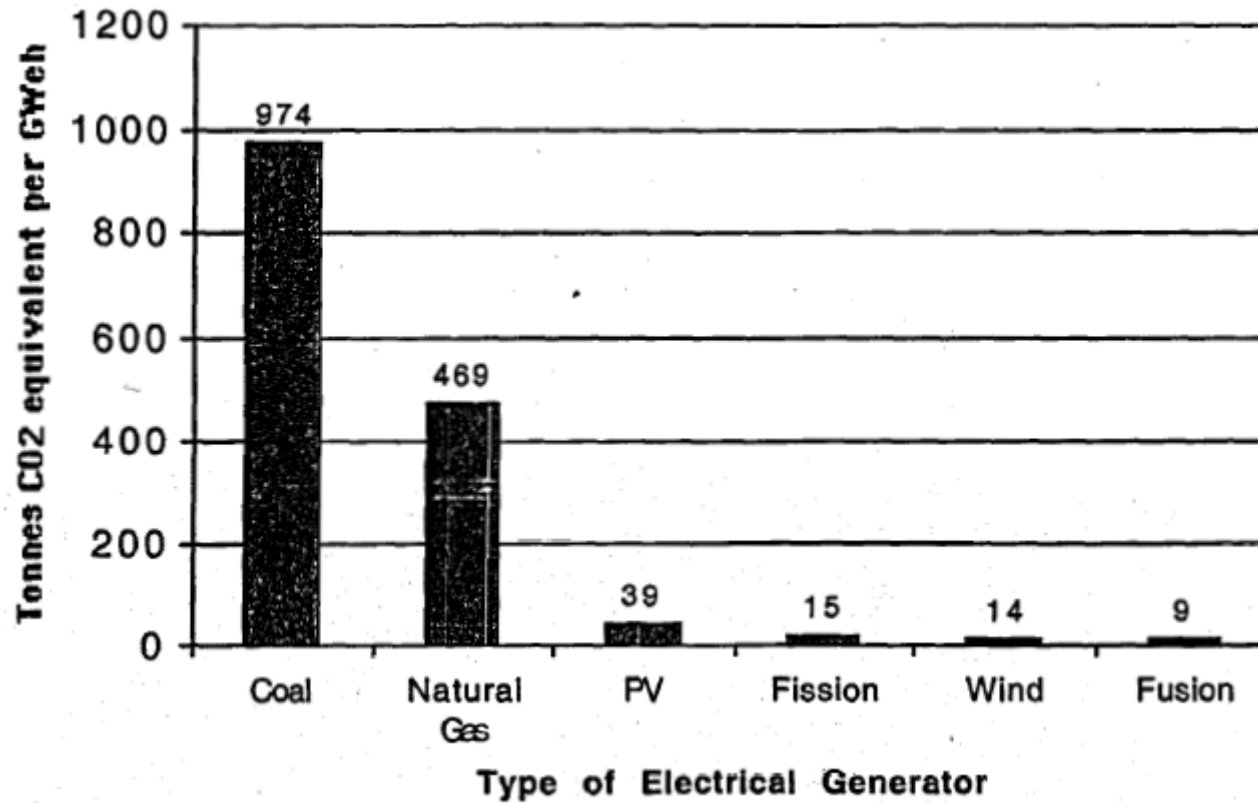
(Krewitt et al. 2007)

Εκπομπές ΑΦΘ ανα kWh στην ζωή ΦΒ συστημάτων



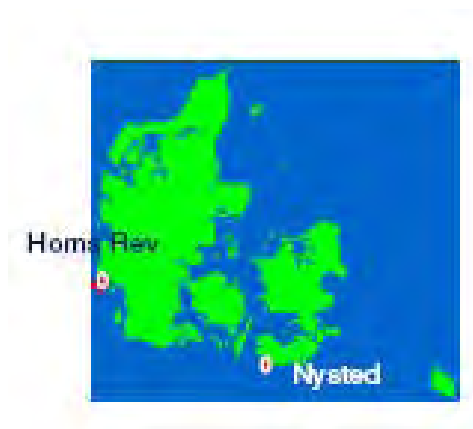
Alsena, de Wild-Scholten & Fthenakis Sept 2006

Εκπομπές ΑΦΘ ανα kWh στην ζωή ΦΒ συστημάτων

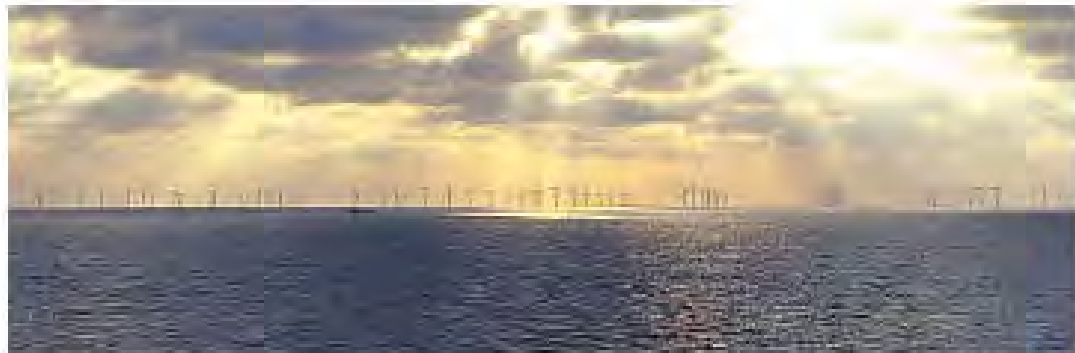


DOE report U of Wisconsin 2003 (Meier)

Denmark



Project: Horns Rev and Nysted
Location: Denmark
Capacity: 160 MW each
Commissioned: 2002/2003



Their leading position may soon be overtaken - **Scottish Power** has announced starting a 322 MW project and a **Norwegian project** of 1,500 MW.

The Mojave Desert site has already nine solar thermal power plants in operation, summing 354 MW.



Project: Mojave solar park (6000 acres)
Location: California, U.S.A.
Capacity: 553 MW
No. of Mirrors: 1.2 million
Expected: 2011

DOE



Project: Solar One (400 acres)

Location: Nevada, U.S.A.

Capacity: 64 MW Solar thermal power plant

No. of Mirrors: 184,000

Commissioned: June 2007

<http://www.youtube.com/watch?v=ccCjB9mu5CI>

Thermal Solar Concentrating Tower (USA)



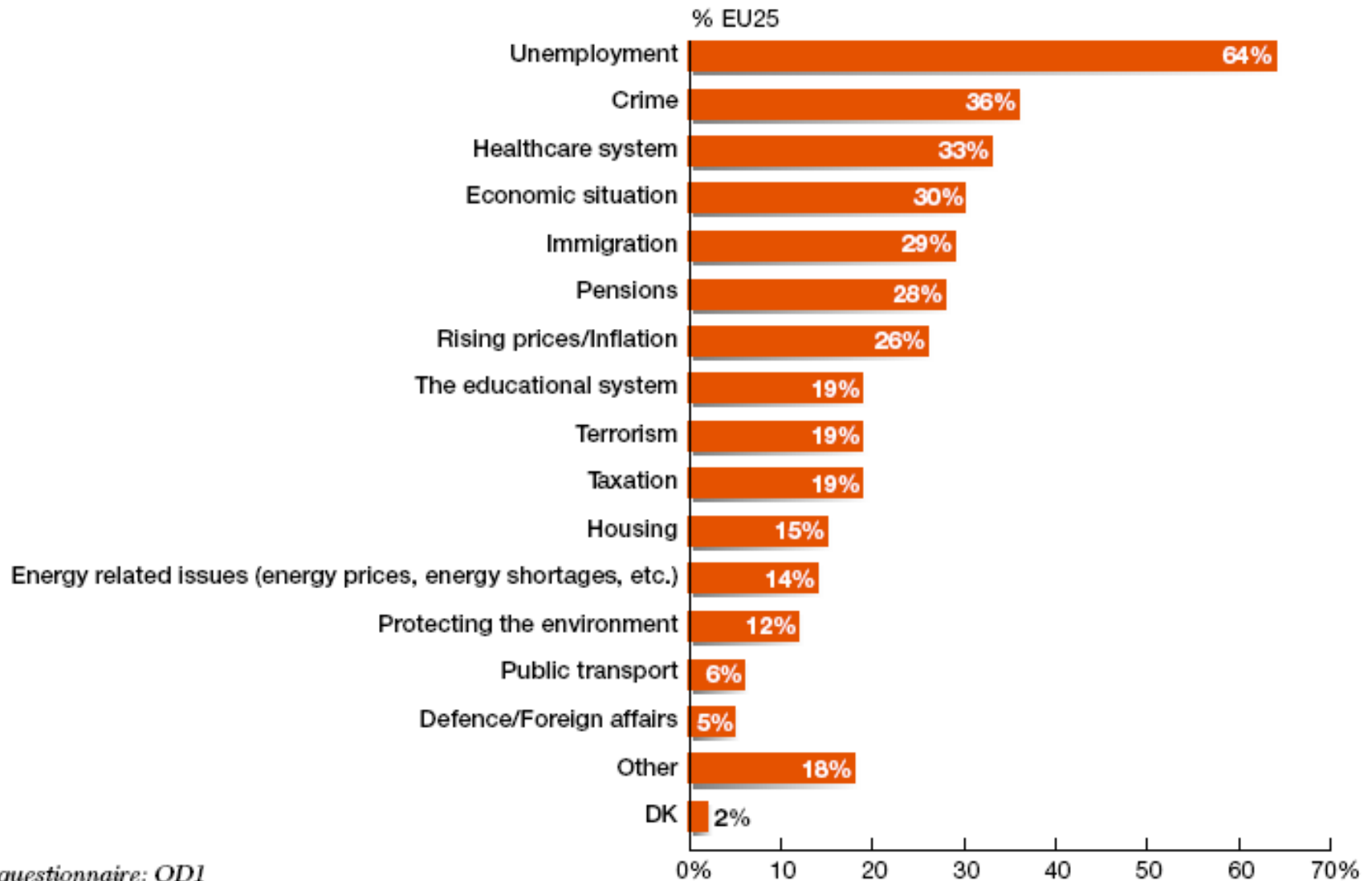
Και στην Ελλάδα;

facets

further action on climate, environment, energy, economy, technology & sustainability



Eurobarometer 2006: which issue



Source questionnaire: QDI

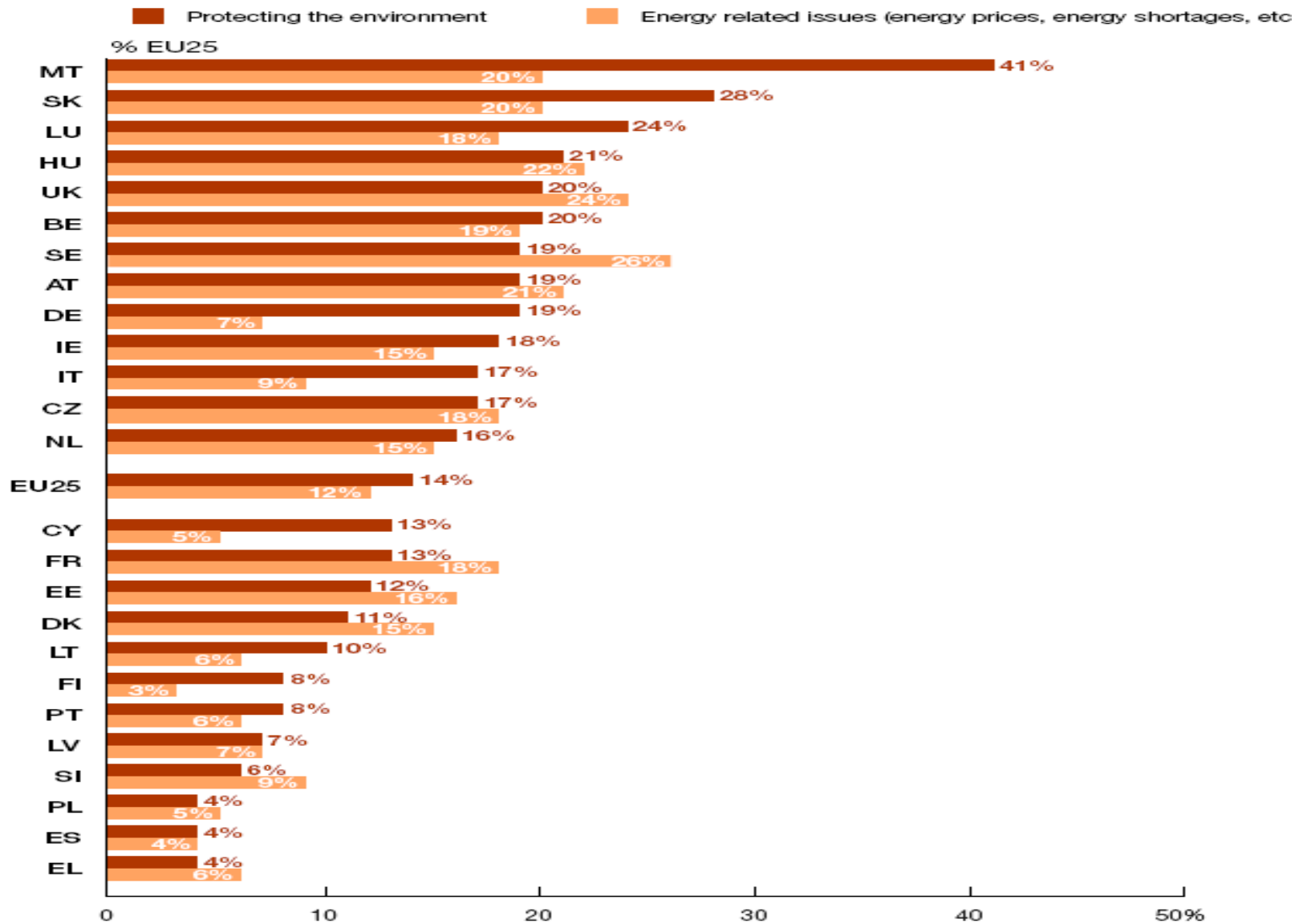
Οι προτάσεις της Ε. Επιτροπής της 10.1.2007/1

Ενεργειακοί στόχοι και Περιβαλλοντικοί στόχοι αλληλένδετοι:

- ❑ Εσωτερική Αγορά-unbundling & αναβάθμιση ΡΑΕ
 - ✓ σημαντικό για την καλή λειτουργία του EU ETS
 - ✓ μείωση εμποδίων για ΑΠΕ
- ❑ ΑΠΕ: 20% της ενέργειας υποχρεωτικά μέχρι το 2020
 - ✓ διαφοροποίηση στόχων μεταξύ ΚΜ
 - ✓ ευελιξία στόχων μεταξύ τομέων για κάθε ΚΜ
- ❑ Περιλαμβάνεται στόχος 10% μέχρι το 2020 για βιοκαύσιμα σε κάθε ΚΜ
- ❑ Πυρηνικά: ότι θέλει το κάθε ΚΜ
- ❑ Βιώσιμη παραγωγή ενέργειας από ορυκτά καύσιμα με στόχο σχεδόν μηδενικές εκπομπές μέχρι το 2020
- ❑ Σκοπεύοντας σε ένα στρατηγικό σχέδιο για ανάπτυξη ενεργειακής τεχνολογίας

⇒ **Μείωση εκπομπών CO₂ από ενέργεια κατά τουλάχιστον 20%**

Eurobarometer 2006: What are the most important issues facing your country today?



Eurobarometer 2006: During the last year, have you done any of the following to save energy?

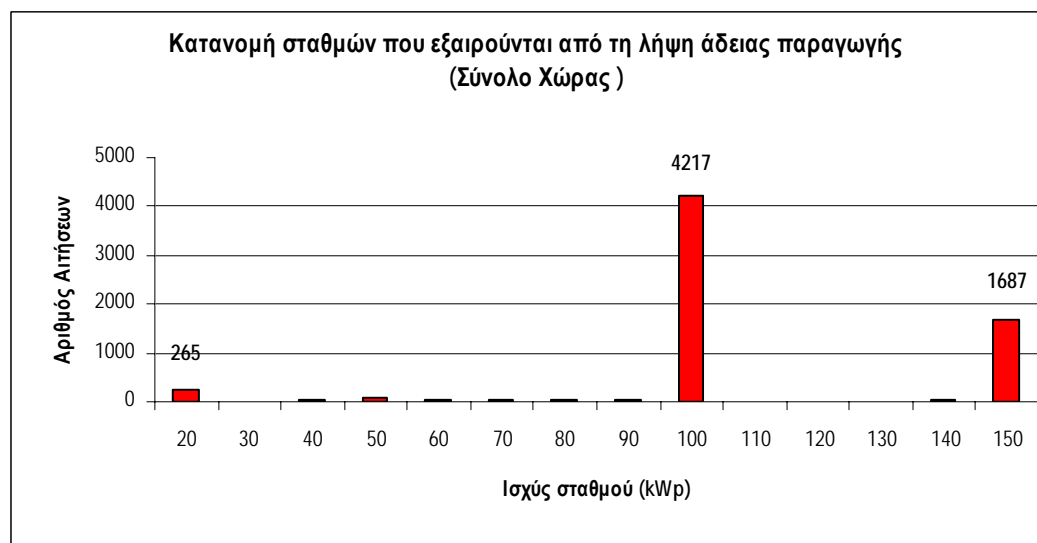
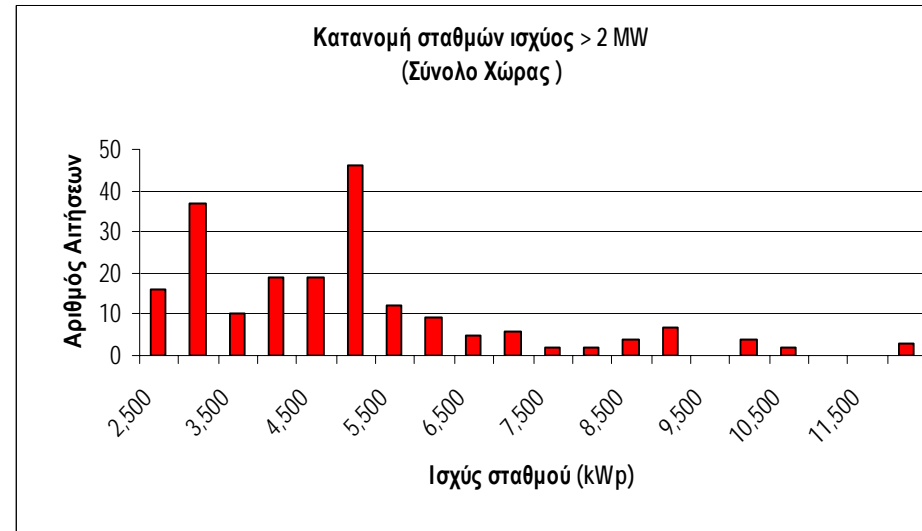
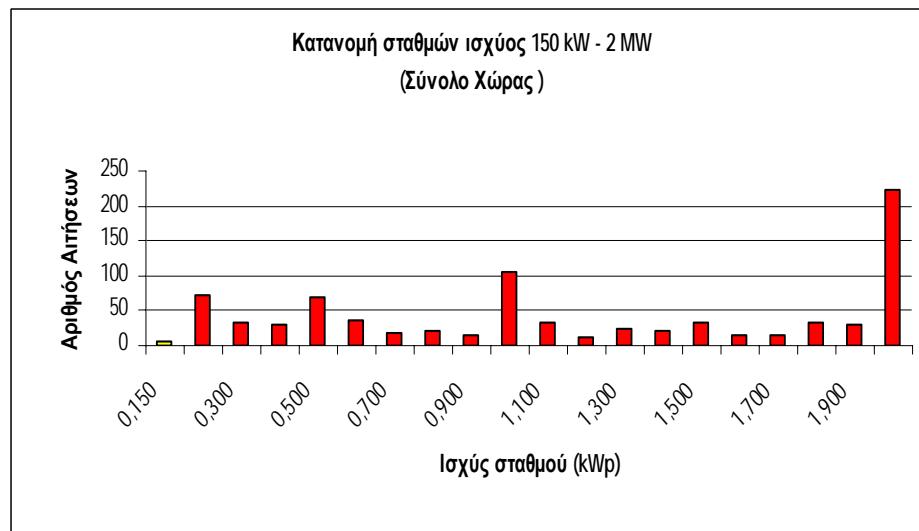
QD16 During the past year, have you done any of the following to save energy? (MULTIPLE ANSWERS POSSIBLE)

	Cut down on lighting and the use of domestic electrical appliances	Cut down on heating and/or air conditioning	Used your car less	Insulated your house (walls, windows, etc.)	Reduced your driving speed	Used public transport more	Took initiatives to save energy at work	Changed your car to another one which uses less fuel	None
EU25	48%	42%	21%	20%	16%	13%	8%	8%	21%
BE	<u>47%</u>	55%	24%	25%	25%	17%	9%	7%	12%
CZ	39%	27%	15%	<u>36%</u>	8%	14%	6%	9%	23%
DK	60%	<u>36%</u>	17%	24%	16%	13%	10%	11%	18%
DE	<u>55%</u>	59%	36%	20%	27%	18%	9%	12%	14%
EE	<u>45%</u>	13%	14%	47%	4%	15%	8%	14%	15%
EL	29%	<u>33%</u>	12%	15%	5%	16%	1%	2%	41%
ES	45%	27%	8%	5%	5%	9%	4%	2%	<u>37%</u>
FR	<u>49%</u>	56%	29%	26%	36%	13%	9%	10%	10%
IE	<u>35%</u>	41%	18%	15%	12%	10%	8%	5%	28%
IT	36%	36%	16%	11%	9%	9%	8%	4%	22%
CY	55%	<u>53%</u>	21%	8%	20%	4%	8%	6%	22%

Πρόβλεψη Ενεργειακών Μεγεθών - Πλέον πρόσφατο Σενάριο Αναμενόμενης Εξέλιξης

	2005	2010	2015	2020
Ακαθάριστη Κατανάλωση Ενέργειας (ktoe)	31314	35547	38780	41833
Ακαθάριστη Κατανάλωση Ενέργειας ΑΠΕ (ktoe)	1551	2228	2624	2989
Καθαρή Παραγωγή Ηλεκτρισμού (ktoe)	4850	5599	6658	7470
Παραγωγή Ηλεκτρισμού ΑΠΕ (ktoe)	536 (4.9- 11.0%)	832 (6.3- 14.9%)	1084 (6.8- 16.3%)	1266 (7.1- 16.9%)
20% ΑΚΕ από ΑΠΕ (ktoe) μέχρι το 2020 & 20% Εξοικ. Ενέργειας				6693
Φ/Β 500MW από N3468 και 500MW επιπροσθέτως	1600kWh/ kWstc			130
10% Βιοκαύσιμα(ktoe)/2				829/2
Άλλες ΑΠΕ 30%				948
Εγκατεστ. Ισχύς (MW) Αιολικά	685	1742	2745	3303+9784

Ενδιαφέρον για ΦΒ: Η Κατάσταση Σήμερα 22-10-2007



Αναμενόμενες αποδόσεις διαφόρων ΦΒ συστημάτων για την Ν. Ευρώπη

	<i>sc-Si</i>	<i>mc-Si</i>	<i>a-Si</i>
PV plant	11.7	13.0	15.7
Retrofit flat roof	17.8	20.7	38.3
Retrofit tilted roof	17.2	20.1	42.9
Retrofit facade	11.8	13.9	23.4
Integrated tilted roof	20.4	24.3	71.3
Integrated glass facade	14.4	17.2	37.8
Integrated tilted roof with heat recovery	33.3	39.7	123.5
Integrated glass facade with heat recovery	24.7	29.7	65.5

Μήπως ;;;

- ❑ 760 MW ΦΒ κοστίζουν €3.8Δισ και με 40% επιδότηση €1.52Δισ στο κράτος
- ❑ Με το κονδύλι της επιδότησης θα μπορούσαν να έχουν δοθεί 43000 συστήματα των 5kW **δωρεάν!!!**
- ❑ Το κάθε οικιακό σύστημα των 5kW θα απέδιδε περίπου 6300kWh (κάτι παραπάνω από τις 4000kWh που καταναλώνει το τυπικό νοικοκυρό που θα εξοικονομούσε με σημερινές τιμές αγοράς €300 τον χρόνο.
- ❑ Επίσης τα 760MW κοστίζουν περίπου €350Εκατ τον χρόνο απο την αγορά στα €450/MWh και για 20 έτη άρα άλλα 10000 δωρεάν συστήματα τον χρόνο!!!
- ❑ Μήπως θα πρέπει την επόμενη φορά να το ξανασκευτούμε;
- ❑ Μήπως θα πρέπει να δούμε και να συγκρίνουμε την οικονομοτεχνική απόδοση και άλλων δράσεων;