Energy Planning in Greece

The Energy Systems Analysis Laboratory of CRES

USAID meeting-May 2008

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Energy Models

Overall Energy System Planning

National Energy Policy Evaluation and Analysis :

MARKAL (ETSAP-IEA)

Electricity Generation Planning

Electricity Generation Planning: *WASP 4 (IAEA)*

Simulation of the Operation of the Electricity Generation System : *COSTPLUS*

Demand Side Management : *COMPASS*

Electricity Transmission Grid

Siemens Pti-PSS/E

RES Penetration

OptiRES

Energy Statistics-National Information System for Energy

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1998-2003

Dealing with the Kyoto Commitments

Dealing with the Kyoto Commitments and RES-E directive

average emissions of 2008-2012
+25 % compared to 1990

20% RES electricity by 2010

Description of Scenarios presented here

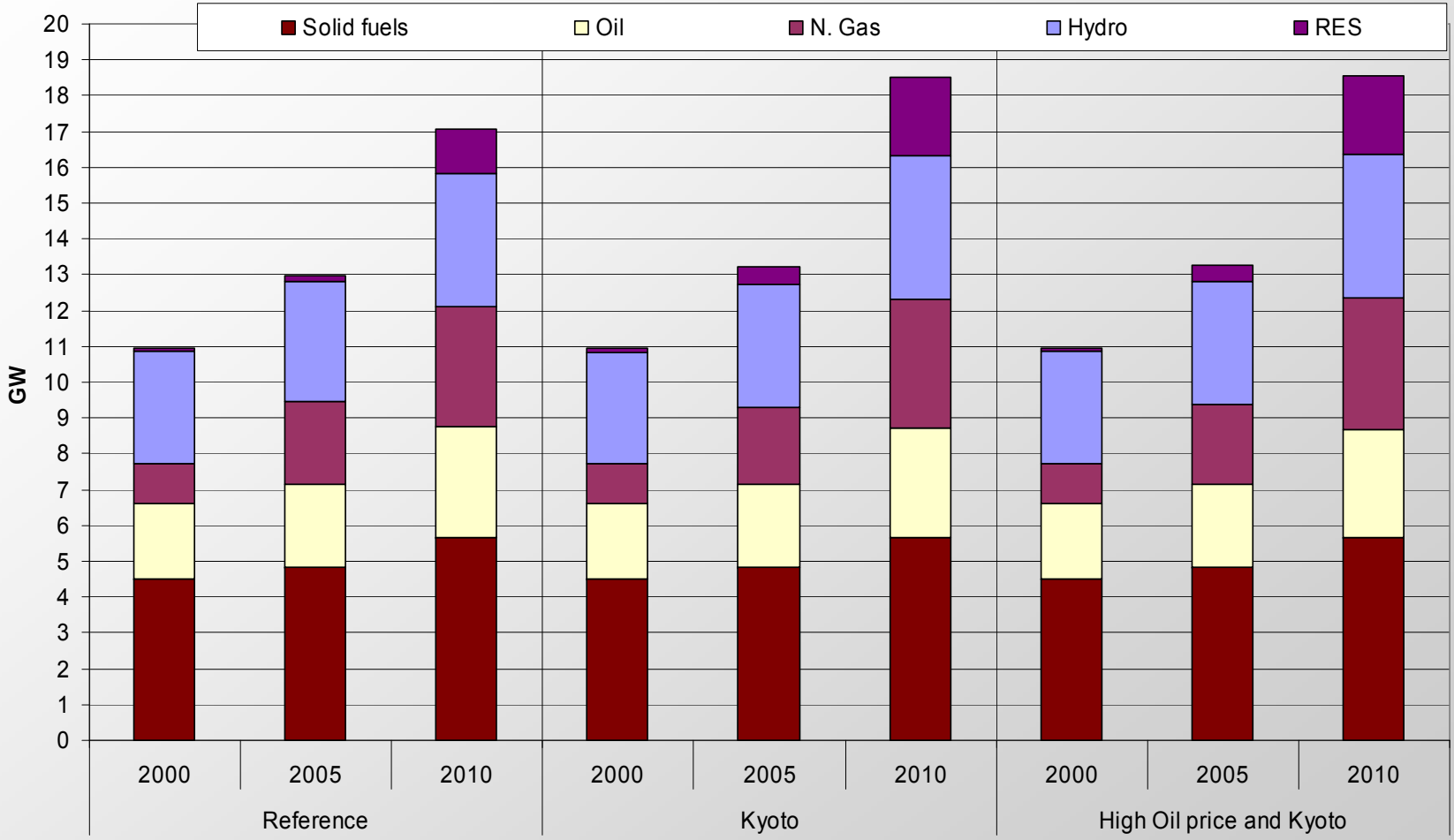
Reference Scenario. Medium Oil prices, without emission limits.

Kyoto Scenario. Medium Oil prices, with Kyoto limits for emissions.

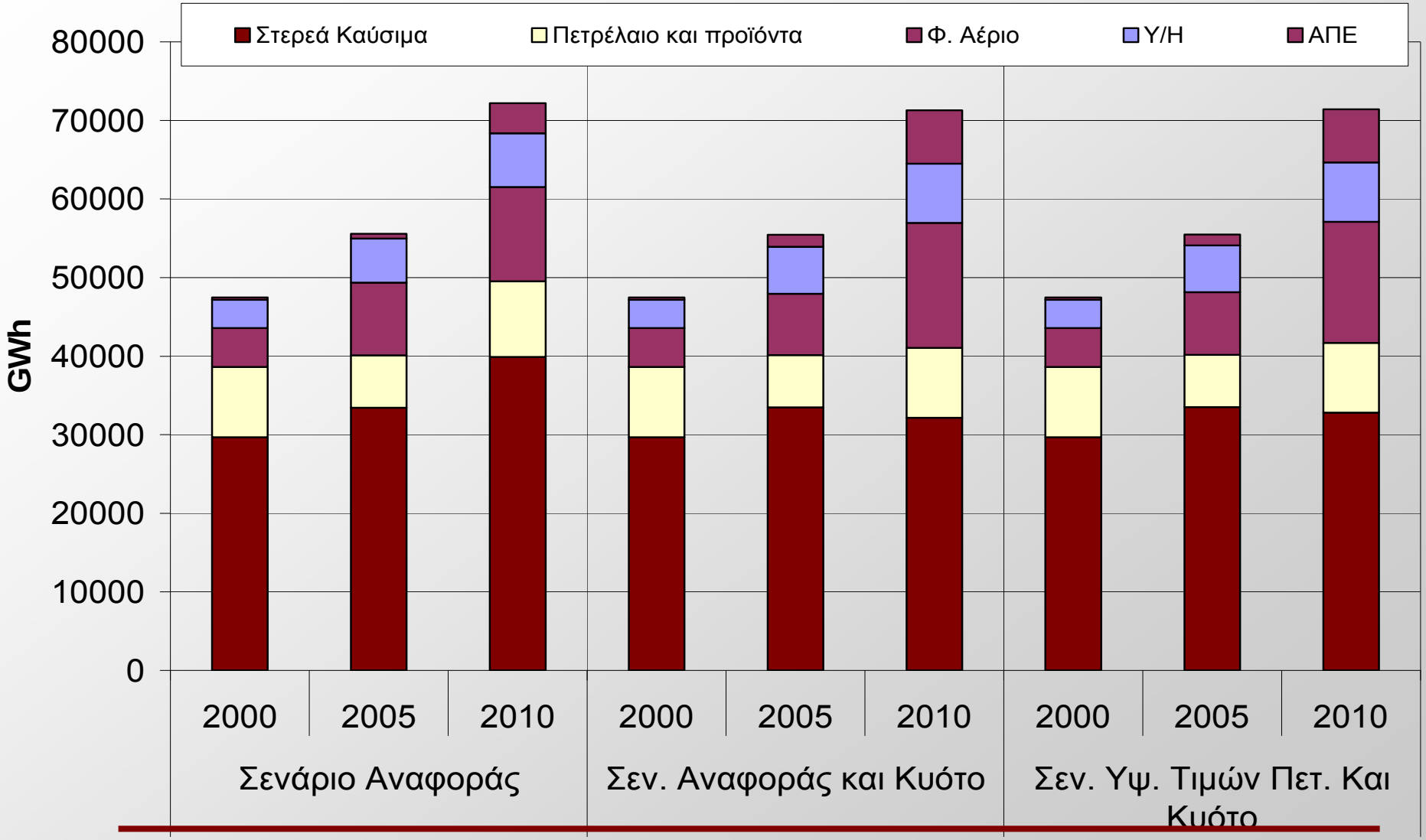
High Oil Prices and Kyoto Scenario. High Oil prices, with Kyoto emission limits.

The Kyoto scenarios include the target of the EU directive for Electricity production from renewable energy sources.

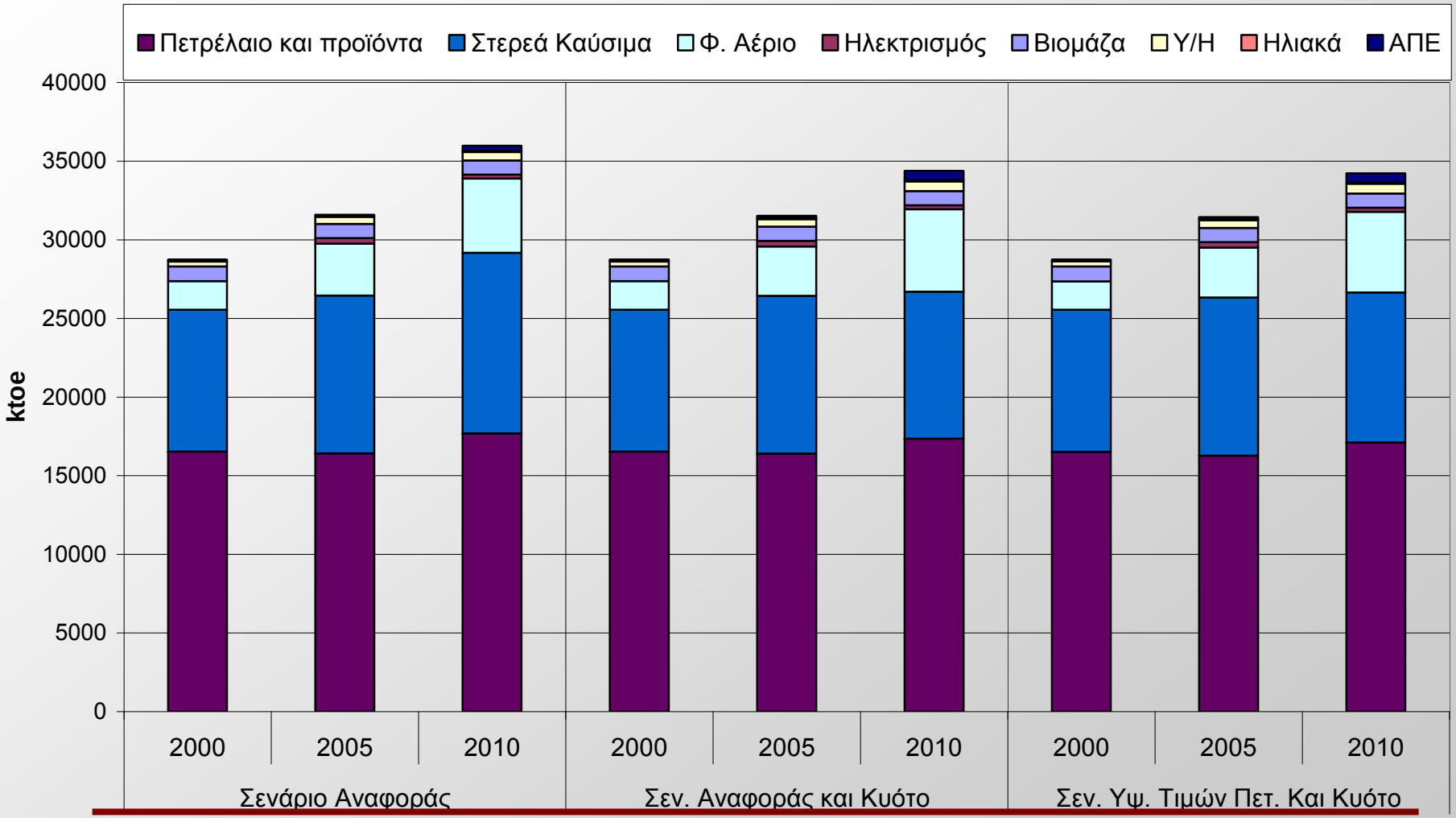
Installed capacity for Electricity Generation



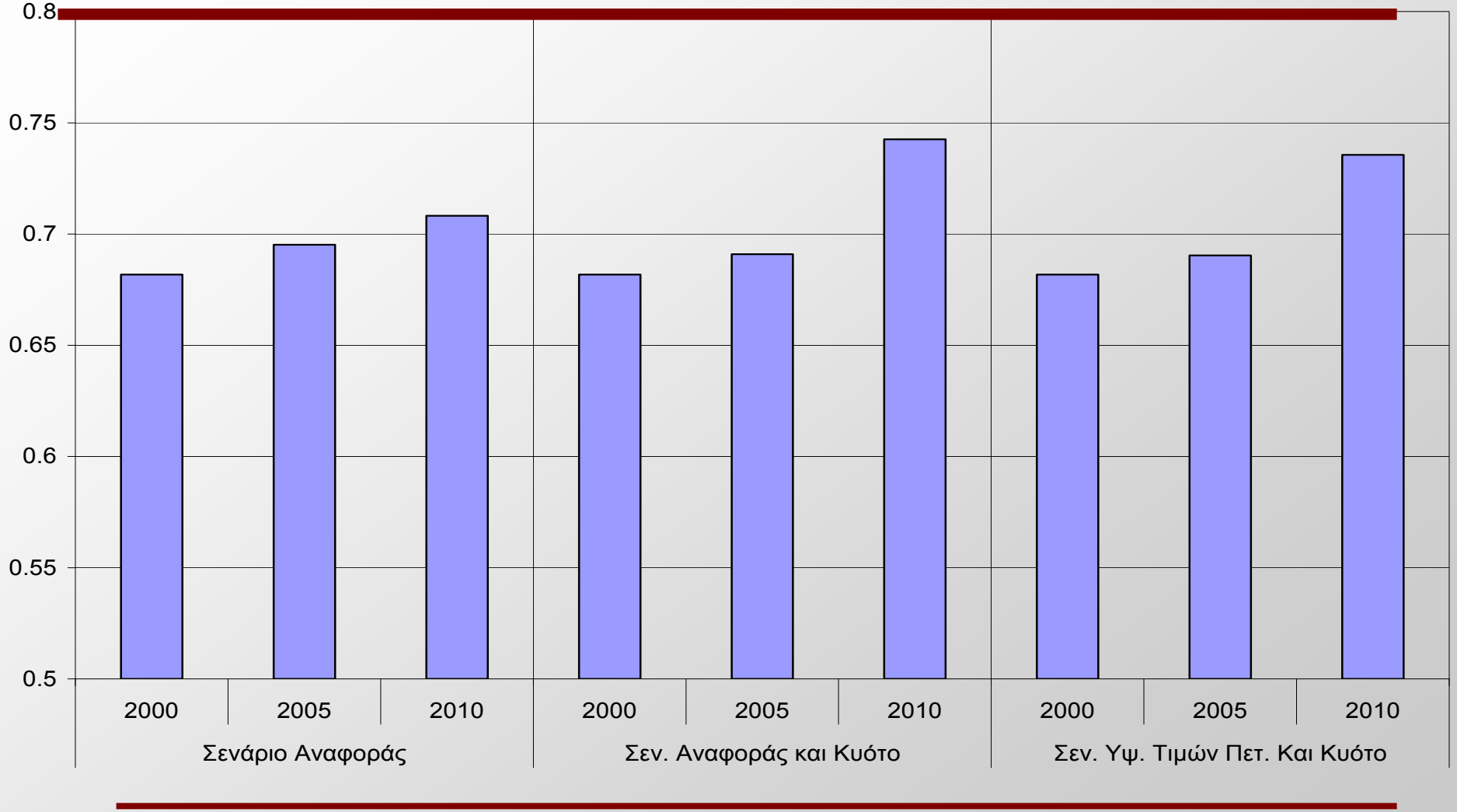
Electricity Generation



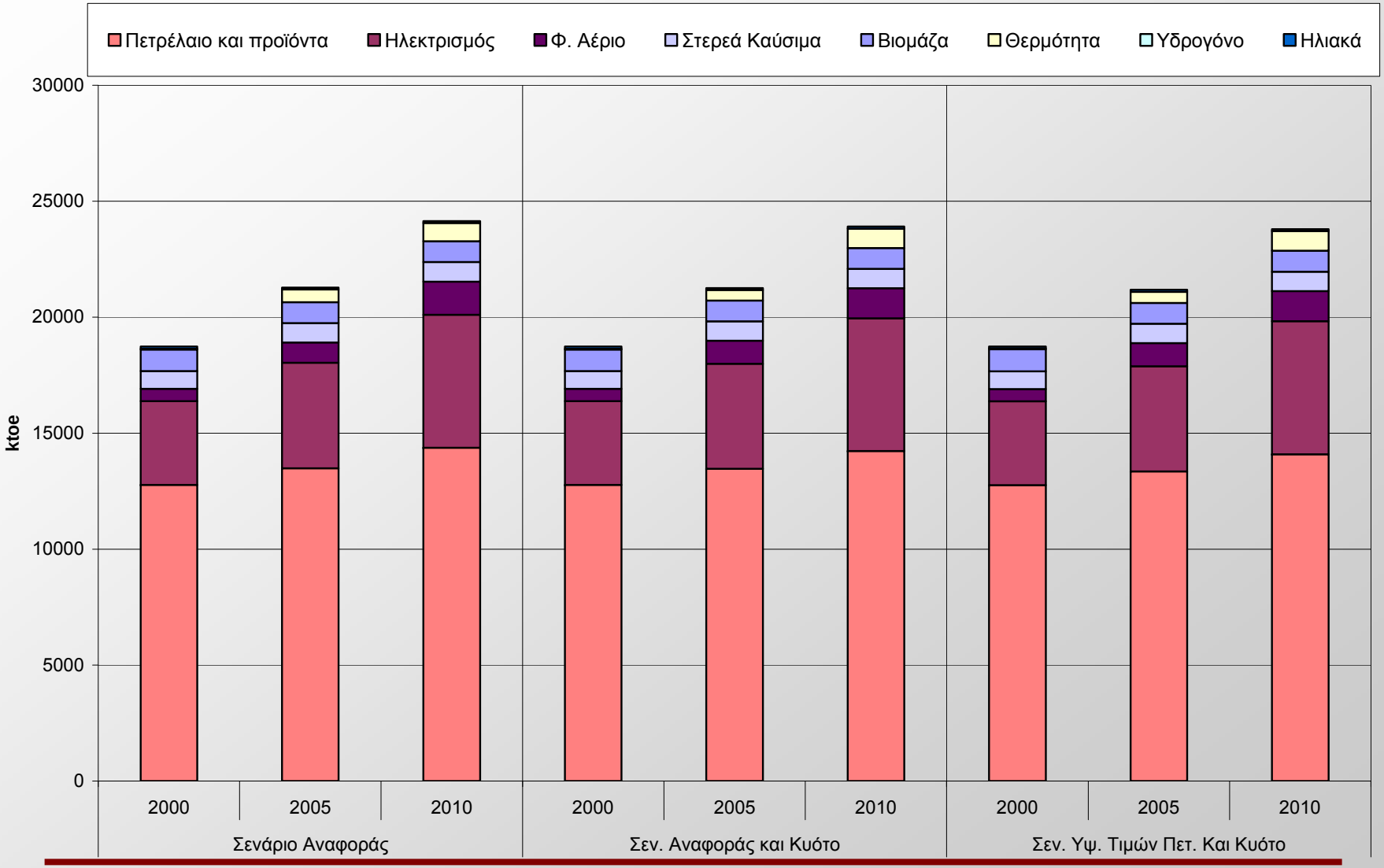
Total Primary Energy Supply



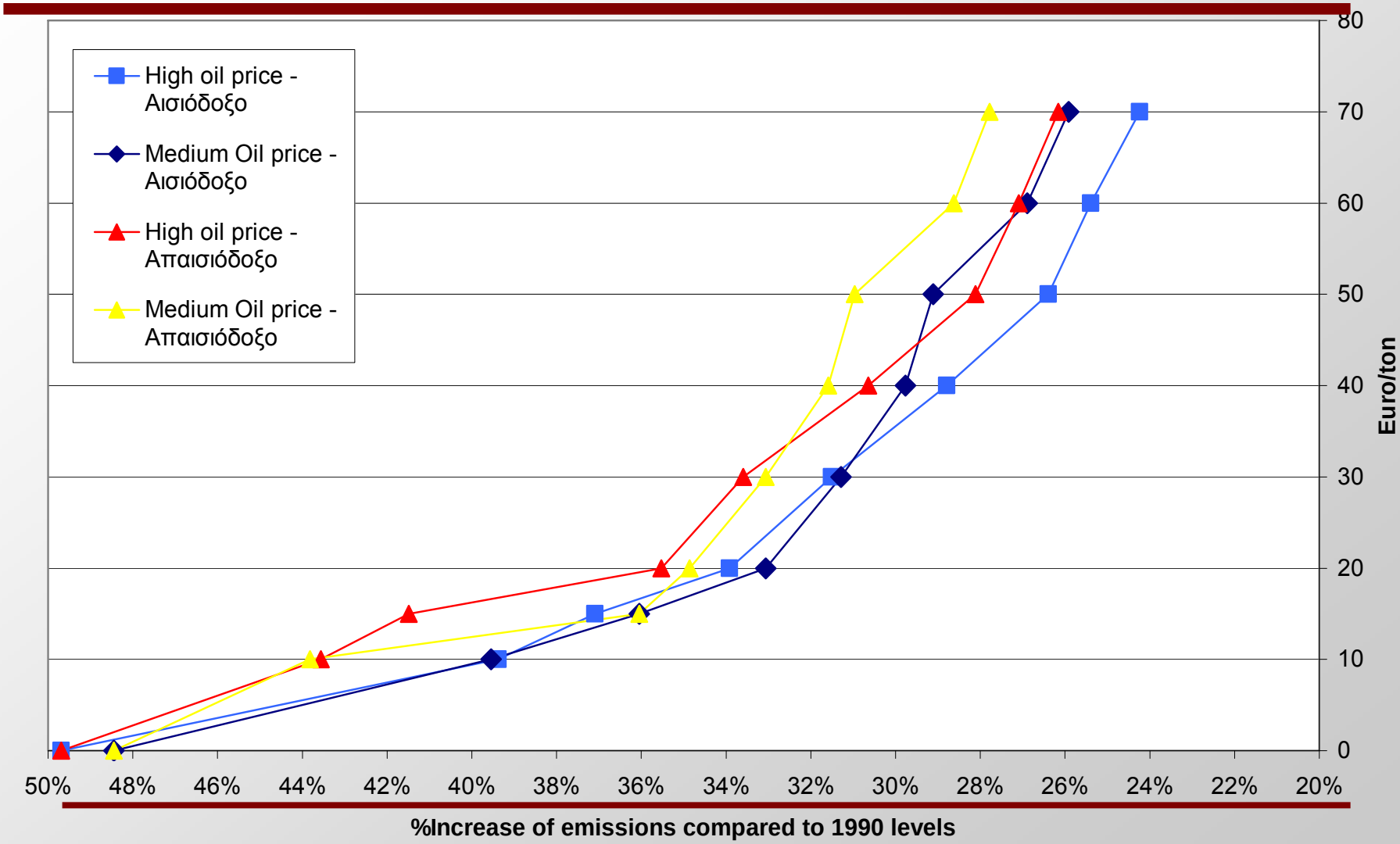
Energy Dependency
(Imports/Total Energy Supply)



Final energy production per fuel



Marginal Cost of avoiding CO2 emissions



Results

- The **CO_2 emissions will be of the order of +48%** in the period 2008-2012 compared to the 1990 levels, without any additional policy measures.

- **This means an annual amount of 11 mil. tons of CO_2. for which permits would have to be paid for.**

Kyoto targets and RES-E directive targets

Production Sector :

- Lignite use in electricity production must be around 55 mil tons/year.
- The lignite burning power stations must not produce more than 50% of electricity in 2010

  or else they should buy emission permits.

Kyoto targets and RES-E directive targets

Production Sector :

- The share of **Natural Gas** in electricity production should be **22%** by 2010

The installed capacity of natural gas fired plants should be about **3.5 GW.**

Kyoto targets and RES-E directive targets

Production Sector :

- **Wind Parks** should have an installed capacity of about **2.1 GW** and **small hydro about 500 MW** reaching the limit of the economic potential.

Kyoto targets
Consumption Sector :

- Penetration of **Natural gas** at the levels projected by **DEPA**.
- Investments for small cogeneration in industry using natural gas should have an installed capacity of about 1GW by 2010.
- **Investments for energy savings and fuel substitution** should be done in all the consumption sectors
- Measures for the promotion of energy savings in households should be adopted.

Differential investments cost for the period (2003-2012)

In order to achieve the Kyoto target

	Medium oil prices million € (2000)	**High oil prices million € (2000)**
Wind	870	870
Small hydro	485	485
CHP	185	310
EE in Industry	220	510
EE in Tertiary	120	35
Total	**1880**	**2210**

EE in Households	650	890

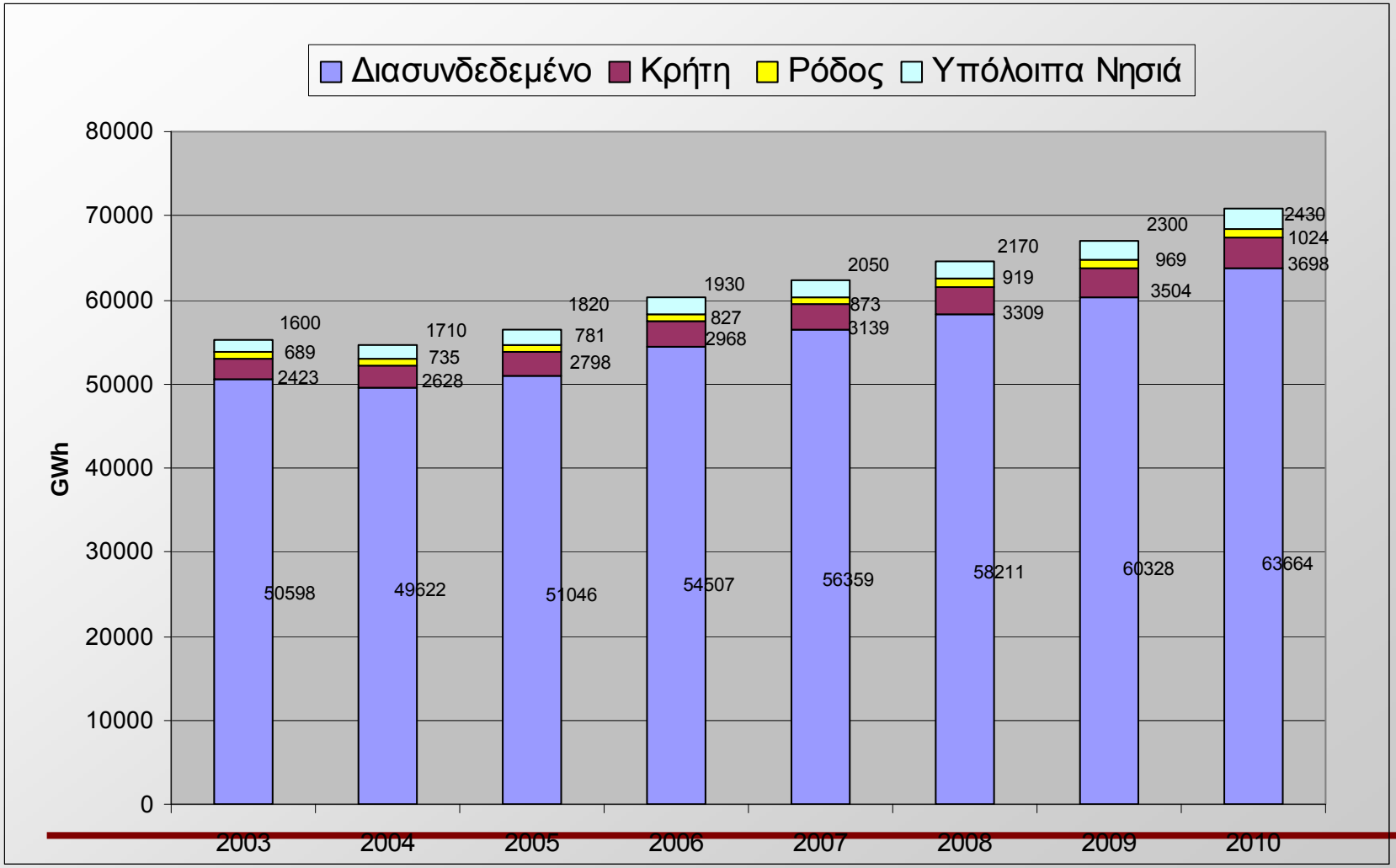
Energy Efficiency Calculations

%	Medium Oil Prices + Kyoto			High Oil Prices + Kyoto		
	2010	2015	2020	2010	2015	2020
Total Final Consumption	-0.5%	-0.9%	-2.4%	-2.1%	-2.3%	-3.4%
Industry	-4.5%	-4.5%	-6.4%	-6.9%	-6.8%	-9.0%
Transport	0.0%	-0.3%	-0.4%	-0.1%	-0.3%	-0.4%
Tertiary	-0.1%	-0.2%	-7.6%	-0.8%	-2.2%	-8.8%

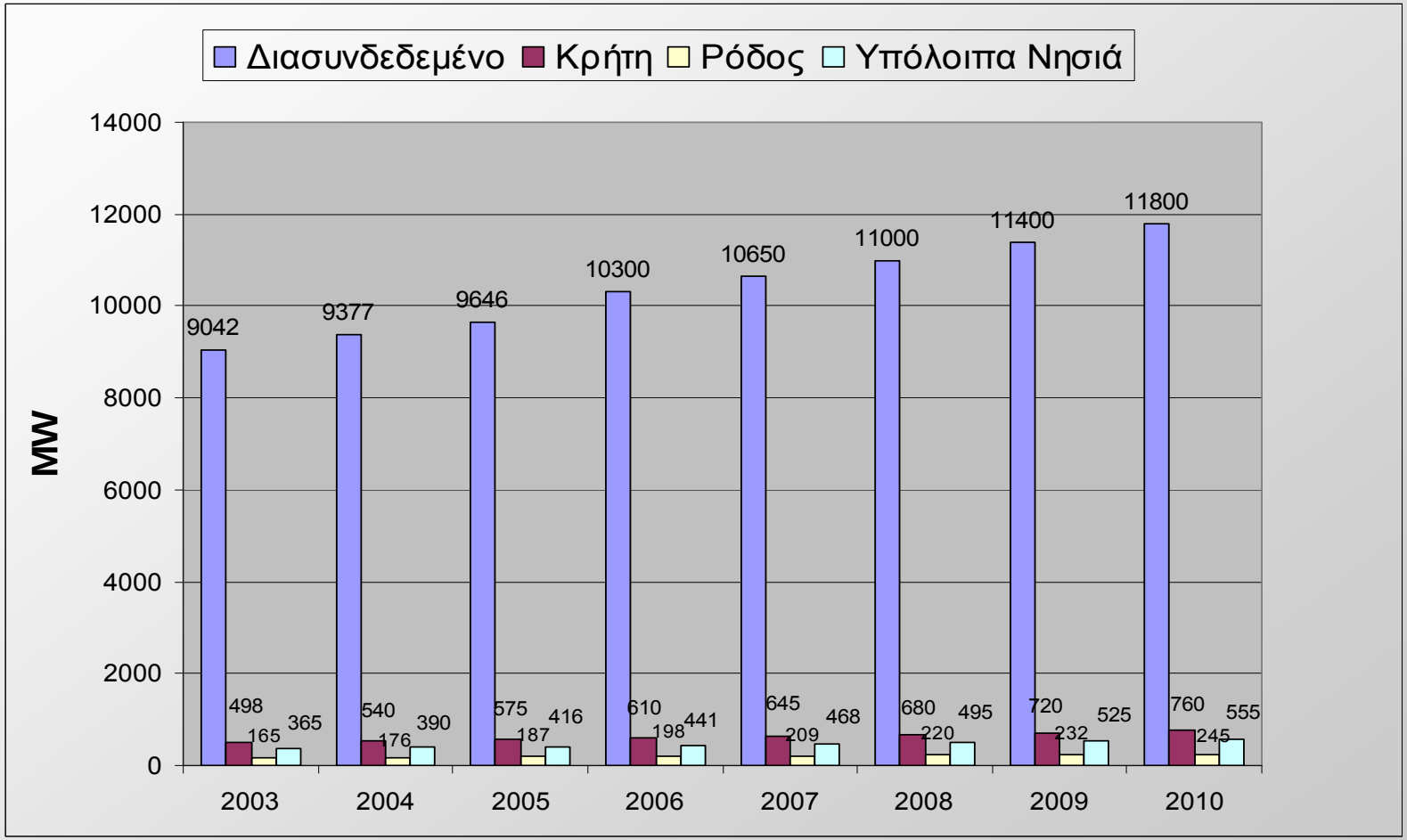
The WASP 4 Model of the IAEA

Electricity generation system programming

Electrical Energy Demand Forecasting

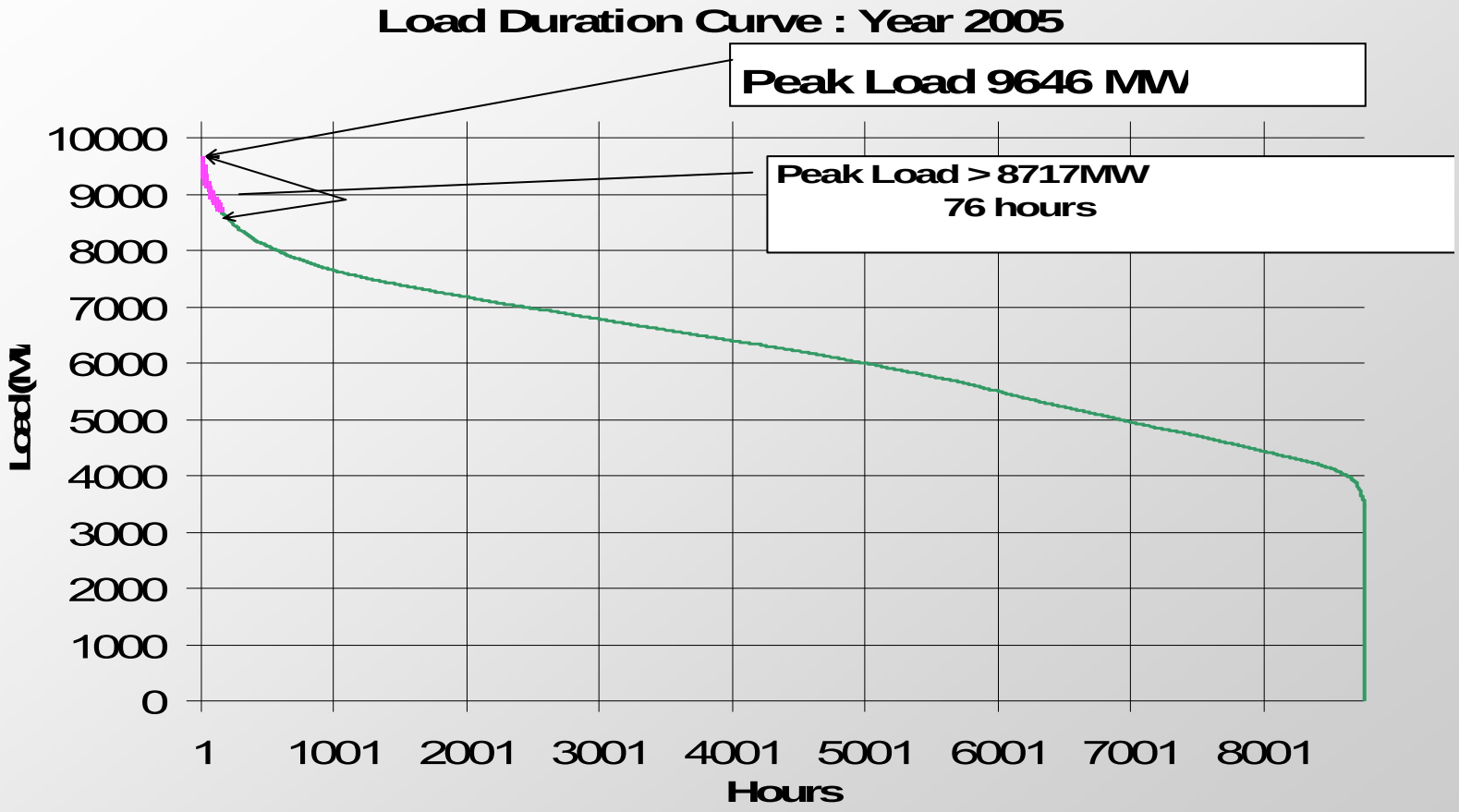


Peak Load Demand Forecasting



Loss of load probability for the mainland system, taking into consideration the interconnections

Έτος	LOLP %	LOLP expressed in hours per year	New Plants Capacity Required (MW)
2004	0.034[2]	**3.0**	
2005	0.037	**3.2**	240
2006	0.005	**0.4**	1350
2007	0.006	**0.5**	360
2008	0.004	**0.4**	450
2009	0.007	**0.6**	240
2010	0.006	**0.5**	700
ΣΥΝΟΛΟ			**3340**


Load Duration Curve : Year 2005
Peak Load 9646 MW
Peak Load > 8717MW
76 hours
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Load(M
1
1001
2001
3001
4001
5001
6001
7001
8001
Hours

Required Capacity for the Mainland System

	Pumped Storage Hydro (MW)	Large Hydro (MW)	Wind (MW)	Thermal (MW)	Total (MW)
2004	650	2028	460	7106	10244
2005	650	2053	485	7346	10534
2006	650	2053	620	8663	11986
2007	650	2053	620	9023	12346
2008	650	2053	780	9473	12956
2009	650	2053	940	9713	13356
2010	650	2053	940	10260	13903

New plants required for the island of Crete

		LOLP expressed in hours per year	Units Technology Type	DI35 (HFO)	OIL (HFO)
			Units Capacity (MW)	35	100
Year	% LOLP				
2005	0.158	14			
2006	0.049	4	70	2	
2007	0.132	12			
2008	0.268	23			
2009	0.104	9	100		1
2010	0.228	20			

New plants required for the island of Rhodes

		LOLP expressed in hours per year	Units Technology Type	DI35 (HFO)	GT60 (LFO)
			Units Capacity (MW)(MW)	30	40
Year	% LOLP				
2005	1.070	94	40		1
2006	0.375	33	30	1	
2007	0.497	44			
2008	0.185	16	30	1	
2009	0.381	33			
2010	0.467	41			

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2004-2008

EC directives and the European Energy and Climate Change Package

Directive 2004/8/EC and the National Potential of CHP

Directive 2006/32/EC and the National Energy Efficiency Allocation Plans

New ETS Directive

New RES Directive

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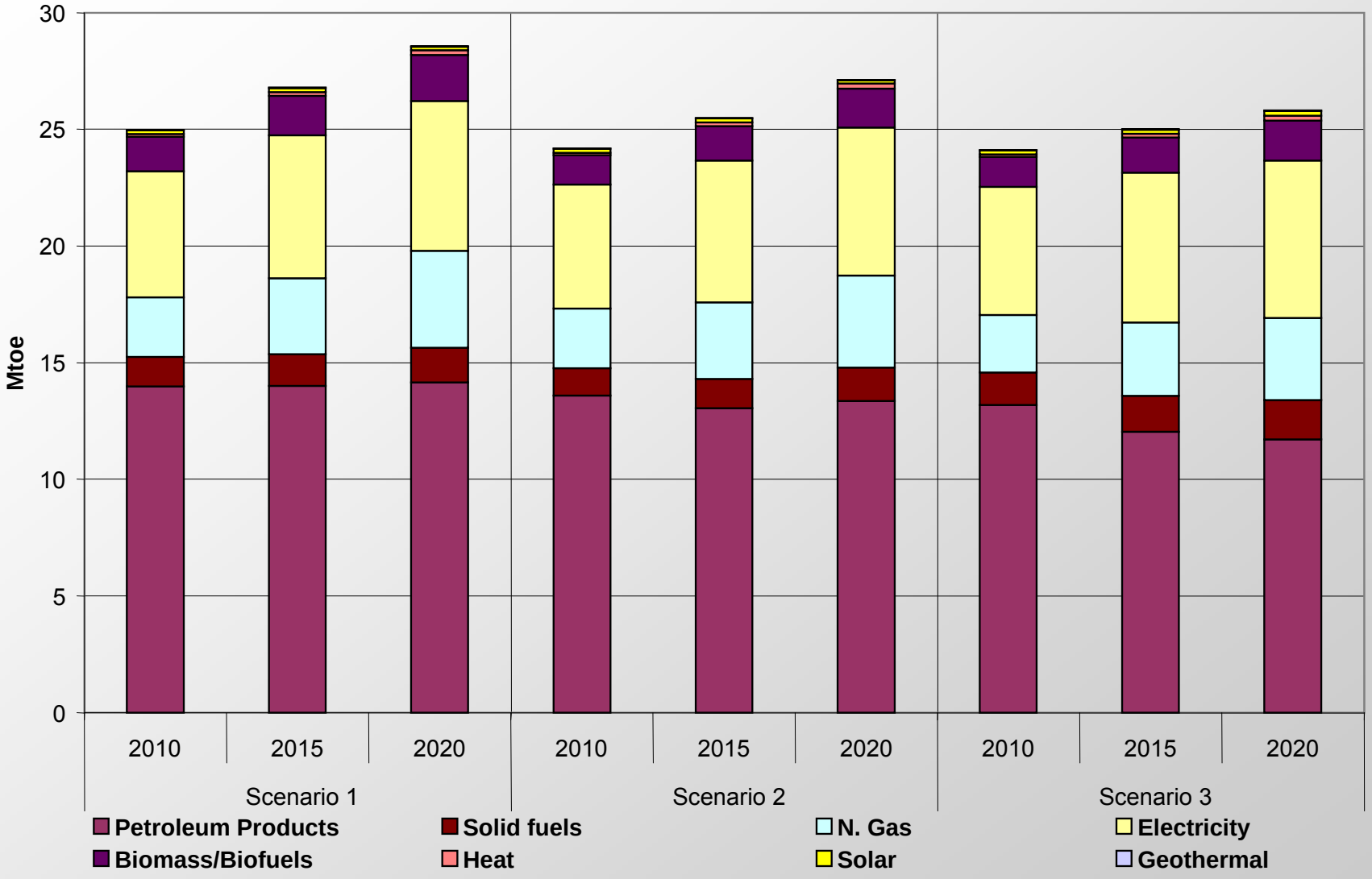
August 2007
1st National Report on Energy Planning of the Ministry of Development

Final Energy Consumption, by product



Summary Results for the year 2020

To be in conformity with the Energy and Climate Change package and the new European Energy Policy the following RES targets are considered as a minimum :

- **Wind parks capacity 5.5 GW in the mainland system and 600 MW in the non-connected islands systems**
- **Total Hydro Capacity 3,9 GW (including large hydro)**
- **800 MW of photovoltaics**

Summary Results for the year 2020

- **300 MW of CHP with biomass**
- **Biofuels : 10 % of the final consumption in transport**

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2008

The burden sharing study in view of the discussions regarding the new RES directive and the new emissions framework

New National Targets for the year 2020

-4 % emissions reduction compared to 2005 for the non-ETS

18 % of RES in the final consumption

9 % energy efficiency by 2016 in the final consumption

Three Scenarios

towards the targets for 2020

Three combinations of conventional and RES technologies are considered for achieving the targets

Installed Capacity for Electricity Generation, Mainland System 2020 Scenario 1

Technology	GW
Lignite-fired steam turbines	4.0
Coal-fired steam turbines	1.8
Combined Cycle Gas Turbines	3.4
Large Hydro	3.7
	12.9
Wind Farms	5.5
Small Hydro	0.2
Photovoltaics	0.6
Biogas	0.2
Biomass	0.2
High Enthalpy Geothermal	0.1
	6.8
Total	**19.7**

Installed Capacity for Electricity Generation, Mainland System 2020 Scenario 2

Technology	GW
Lignite-fired steam turbines	4.0
Combined Cycle Gas Turbines	5.4
Large Hydro	3.7
	13.1
Wind Farms	5.5
Small Hydro	0.2
Photovoltaics	0.6
Biogas	0.2
Biomass	0.2
High Enthalpy Geothermal	0.1
	6.8
Total	**19.9**

Installed Capacity for Electricity Generation, Mainland System 2020 Scenario 3

Technology	GW
Lignite-fired steam turbines	4.0
Coal-fired steam turbines	1.8
Combined Cycle Gas Turbines	3.4
Large Hydro	3.7
	12.9
Wind Farms	7.5
Photovoltaics	0.2
Biogas	0.1
	7.8
Total	**20.7**