Parametric study for the penetration of combined cycle technologies into Cyprus power system

Dr. Andreas Poullikkas
Electricity Authority of Cyprus

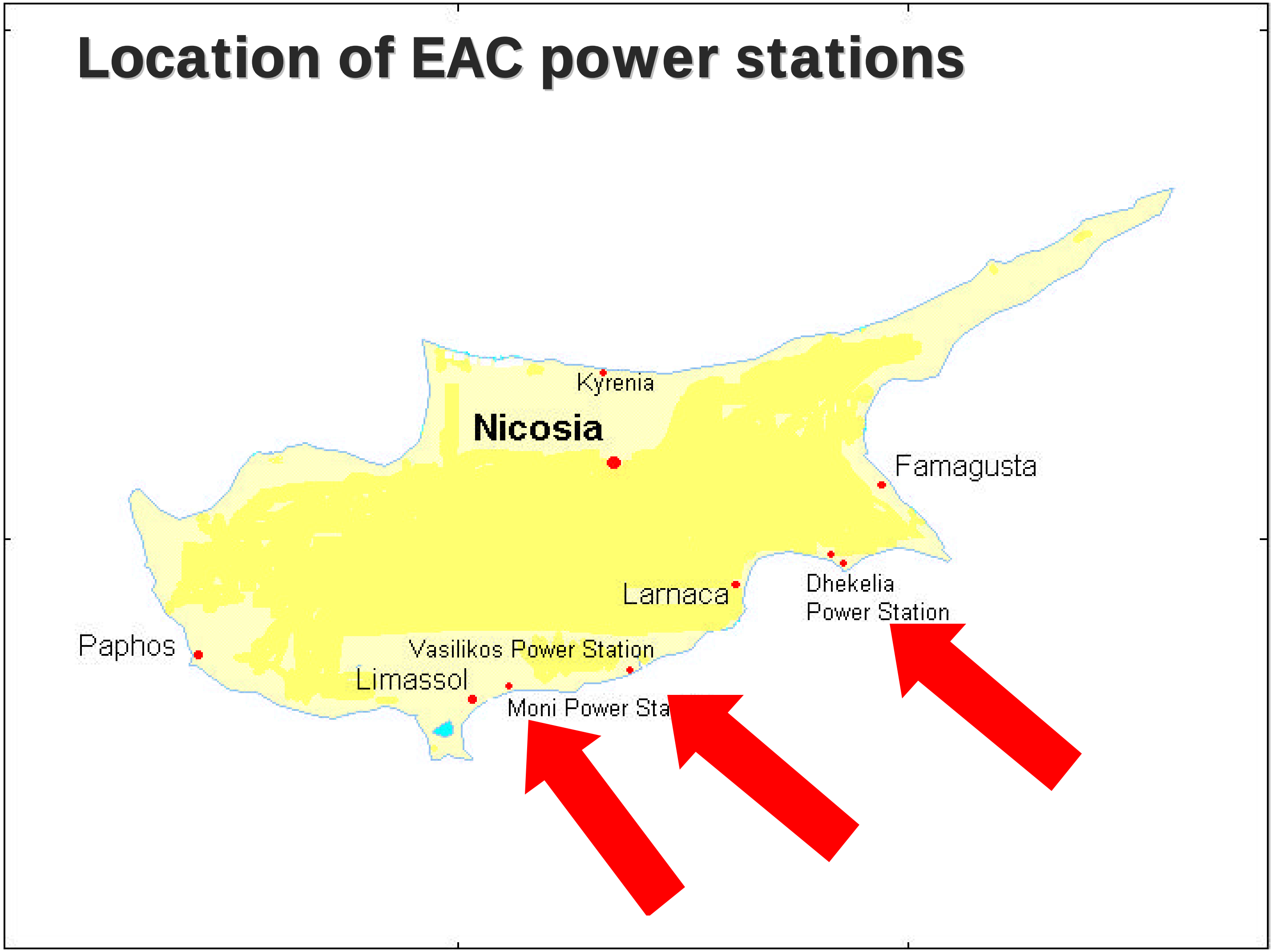
Contents

1. The electricity sector in Cyprus
2. Fuel share (world and Cyprus)
3. Optimisation algorithm
4. Parametric study (data)
5. Cost-benefit analysis - CO_2 emissions
6. Conclusions

Present Status

1. Small isolated island power system
2. Depend on fossil fuels
3. Installed capacity 988MWe
4. Generation 3.552 million kWh (in 2001)
5. Peak load 689MWe (in 2001) - 775 MWe in 2002

The Electricity Sector in Cyprus



Existing generation system

Steam turbine units (HFO)

1. Moni power station 6x30MWe
2. Dhekelia power station 6x60MWe
3. Vasilikos power station 2x130MWe

Gas turbine units (Diesel)

1. Moni power station 4x37,5MWe
2. Vasilikos power station 1x38MWe

Future plans

1. **1x120MWe steam turbine by 2005** (HFO)

2. **1x180MWe combined cycle by 2006** (diesel or natural gas)

3. **RES:**

   Wind energy (in progress 6MWe wind park)

   Photovoltaics (roof-top)

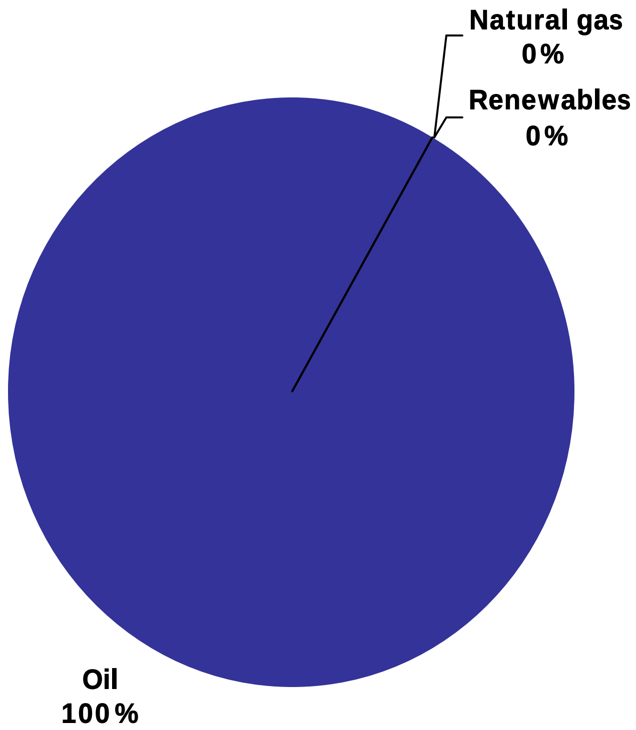
World and Cyprus fuel share for electricity generation

Technology	World*					Cyprus				
	1975	1980	1990	2000	2010	1975	1980	1990	2000	2010
	%									
Coal	36,7	38,1	38,2	37,8	38,2	0,0	0,0	0,0	0,0	0,0
Oil	22,1	19,7	11,3	9,6	8,0	100,0	100,0	100,0	100,0	65,8
Natural gas	2,5	12,0	13,7	14,8	24,3	0,0	0,0	0,0	0,0	28,2
Nuclear	5,9	8,6	17,0	17,6	12,3	0,0	0,0	0,0	0,0	0,0
Renewables	23,0	21,6	19,8	20,2	17,2	0,0	0,0	0,0	0,0	6,0
Total	90,2	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0

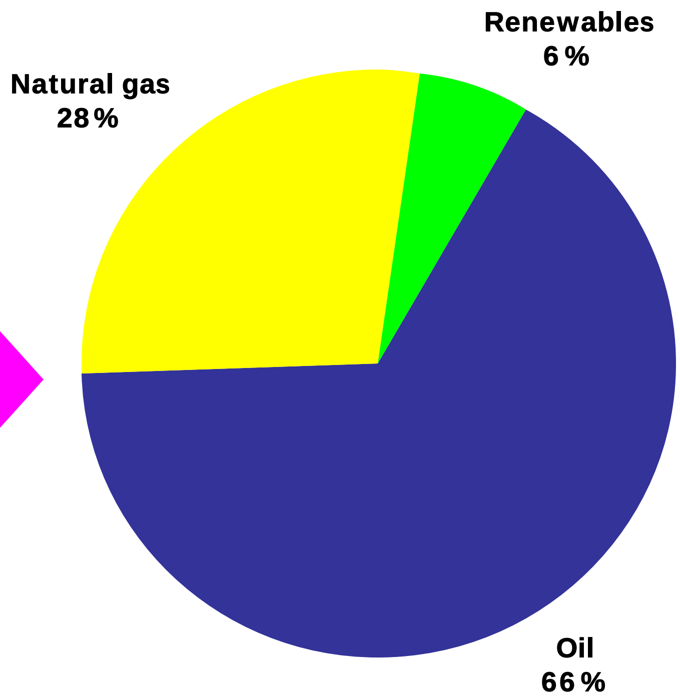
***IEA (International Energy Agency), World Energy Outlook, Paris 2000.**

Cyprus fuel share for electricity generation

Year 2000



Year 2010



Optimisation algorithm

IPP technology selection algorithm*

1. **Economic model**
2. **Evaluation of candidate power technologies:**
   - Capital cost
   - Fuel consumption and cost
   - Operation and maintenance cost
   - Plant load factor
   - Life expectancy etc.
3. **Least cost power generation configuration**

*Poullikkas A., "A technology selection algorithm for independent power producers", *The Electricity Journal*, 2001.

Cost function*

$$\textbf{least cost solution} = \min\left[c_k\right] = \min\left[\frac{C_o + \sum_{j=1}^{n} \frac{C_j}{(1+i)^j}}{P_o + \sum_{j=1}^{n} \frac{P_j}{(1+i)^j}}\right]_k$$

c : electricity unit cost for candidate generation technology k in €/kWh

C_o : production cost of the reference year in €

C : production cost of year j in €

P_o : electricity production of the reference year in kWh

P : electricity production of year j in kWh

i : discount rate in %

*Poullikkas A., "A technology selection algorithm for independent power producers", *The Electricity Journal*, 2001.

Parametric study data

Eligible conventional plants

1. HFO steam turbine (business as usual scenario)

2. Gasoil open cycle gas turbine

3. Natural gas (LNG) open cycle gas turbine

Parametric study data

Combined cycle technology - variations

1. **Fuel type**

2. **Capital cost**

3. **Efficiency**

Parametric study data

Combined cycle technology - advantages

1. High thermal efficiency - LOTHECO, HAT
2. Low emissions
3. Low capital costs
4. Short construction times
5. Less space requirements
6. Flexibility in plant size
7. Fast start-up

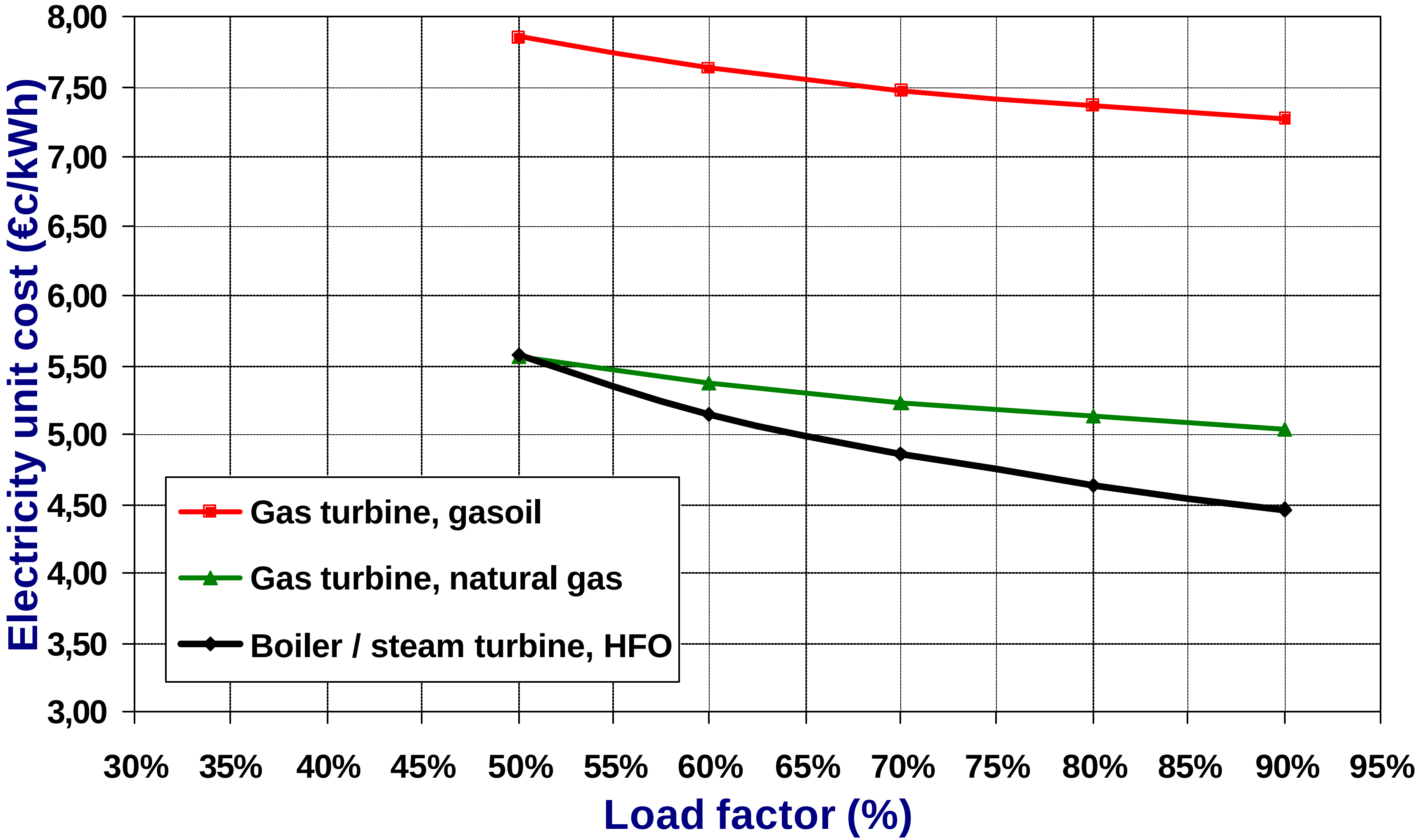
Parametric study data

Technical and economic parameters of candidate technologies

Option No	Technology	Fuel type	Capacity	Capital Cost	Efficiency	Fuel net calorific value	Fuel cost		Fixed O&M	Variable O&M
			MWe	€/kW	%	GJ/t	€/t	€/GJ	€/kW-month	€/MWh
1	Boiler / steam turbine	HFO	120	1258	37,26	41,3	125	3,03	1,4	1,50
2	Gas turbine	Gasoil	81	550	27,14	42,5	190	4,47	1,25	6,00
3	Gas turbine	Natural gas	81	532	28,38	45,0	141	3,13	0,83	4,00
4	Combined cycle	Gasoil	180	700-900	40-70	42,5	190	4,47	1,57	3,20
5	Combined cycle	Natural gas	180	700-900	40-70	45,0	141	3,13	1,25	2,50

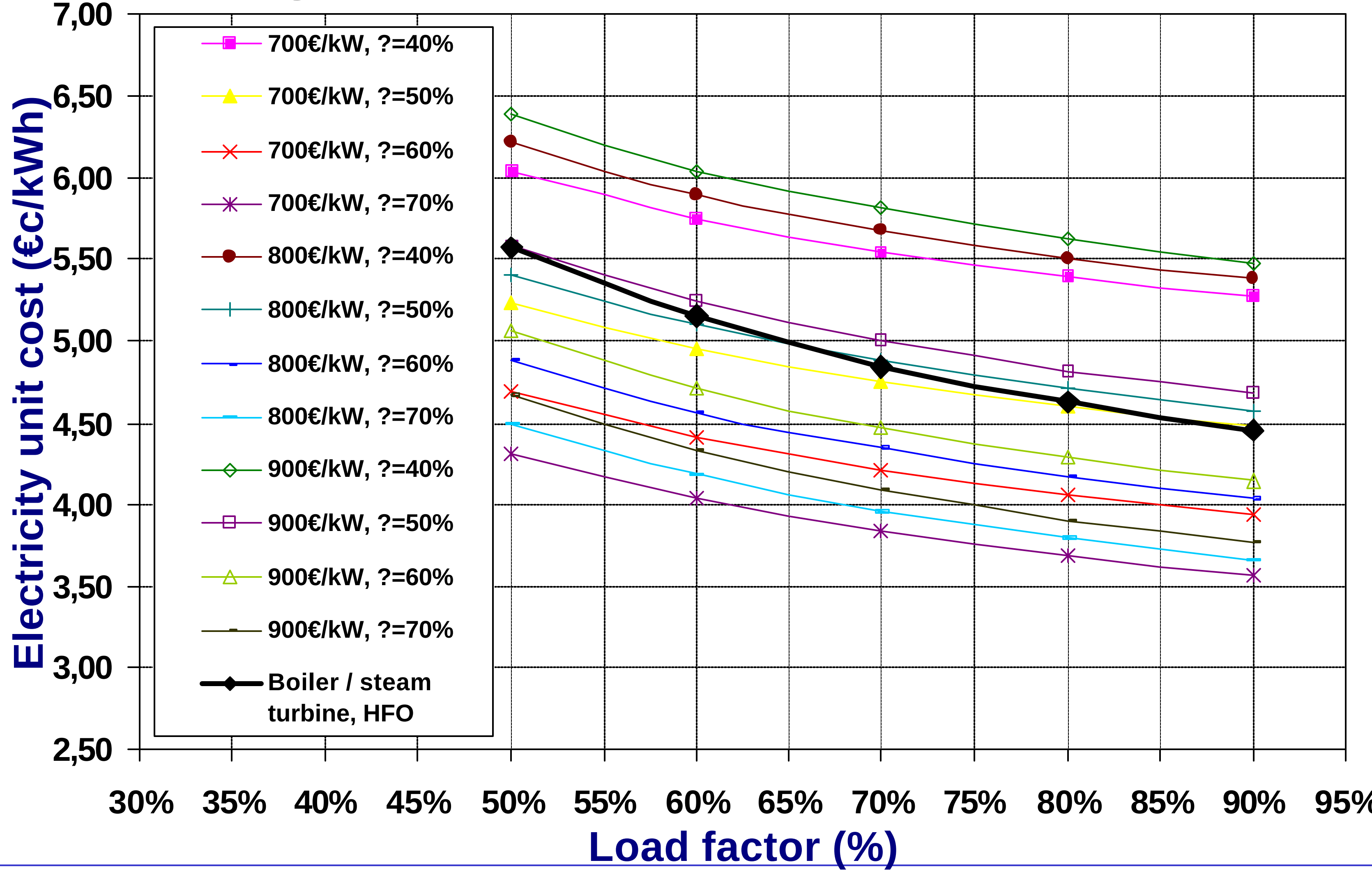
Cost-benefit analysis

Conventional technologies



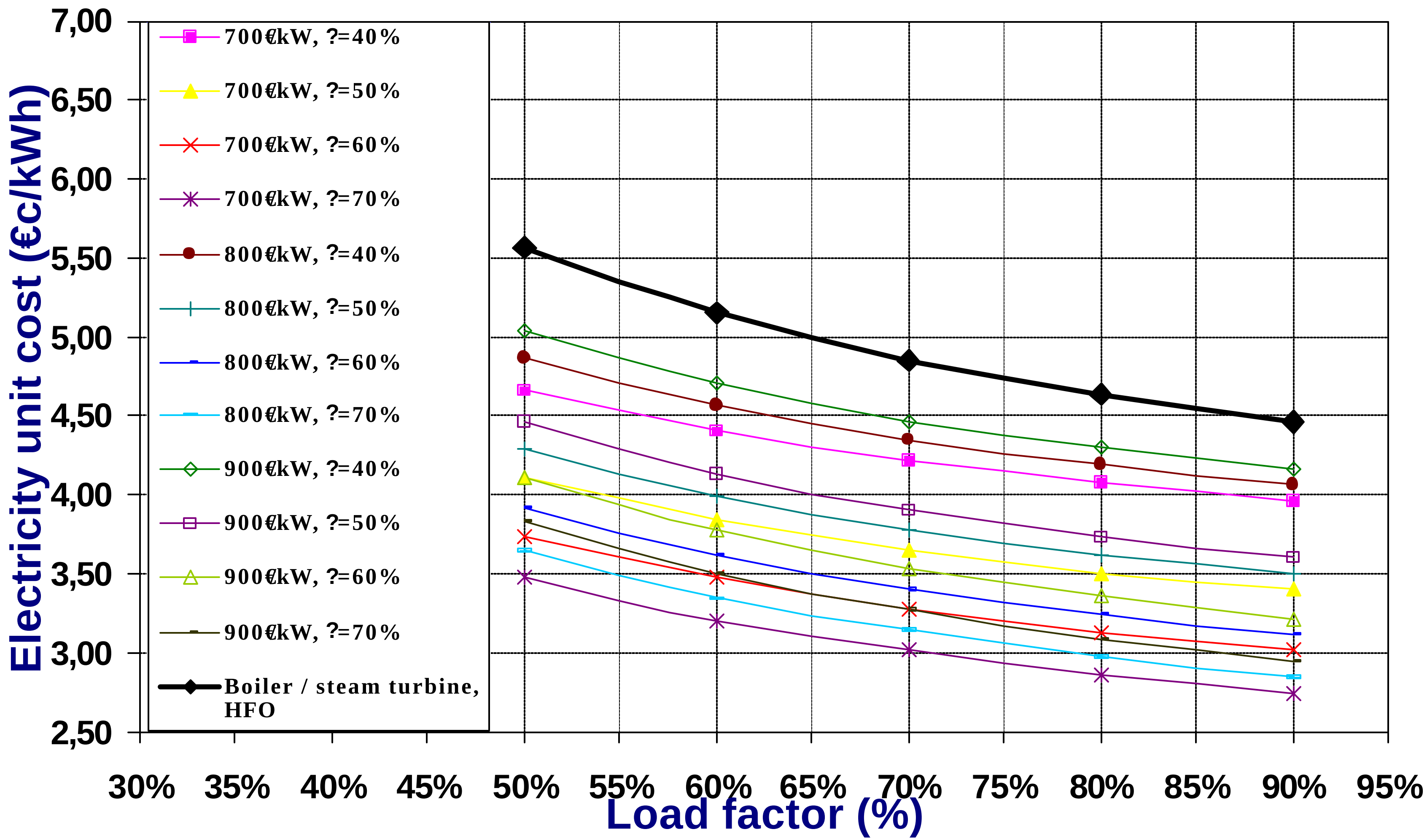
Cost-benefit analysis

Diesel combined cycle



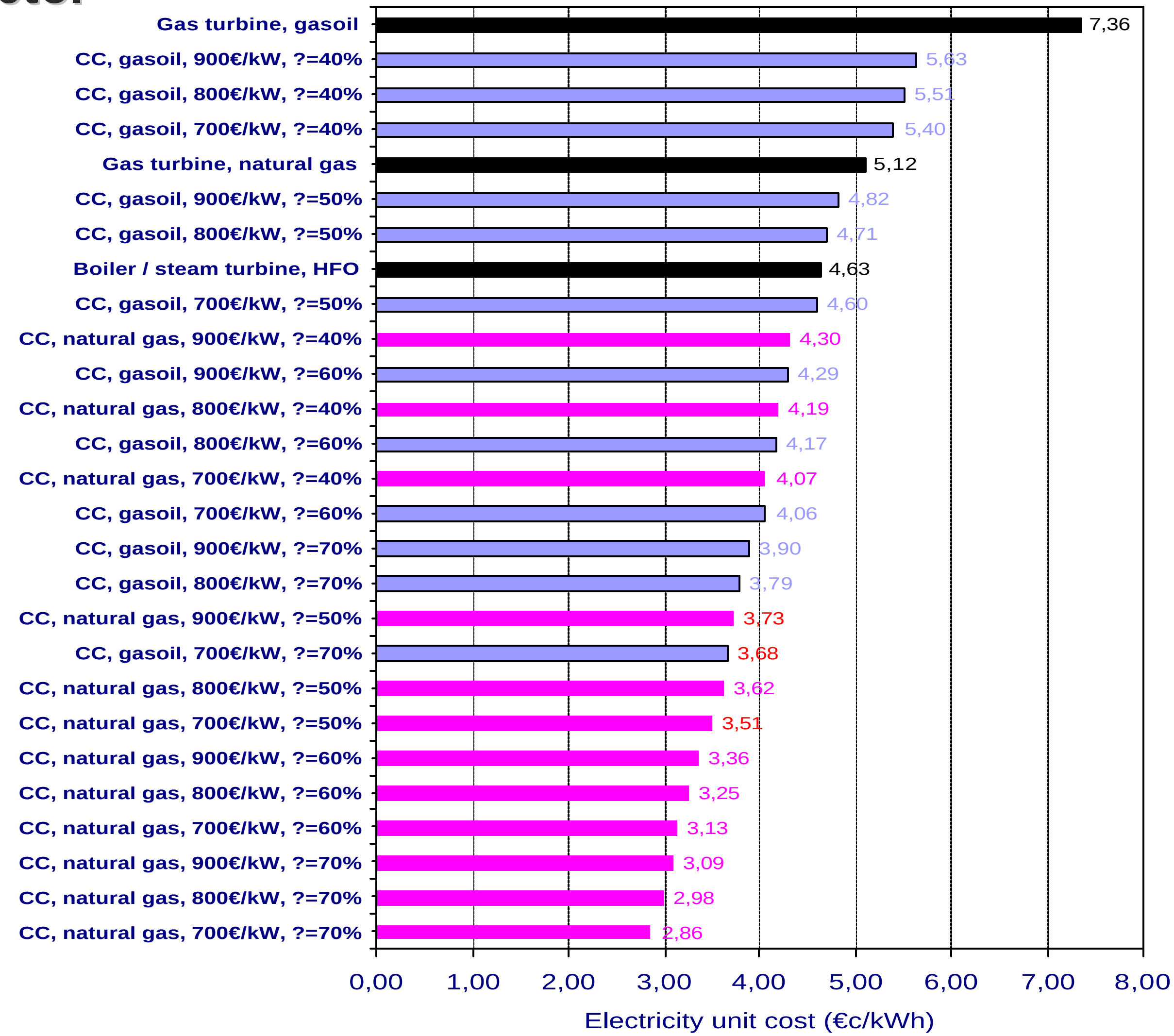
Cost-benefit analysis

Natural gas combined cycle



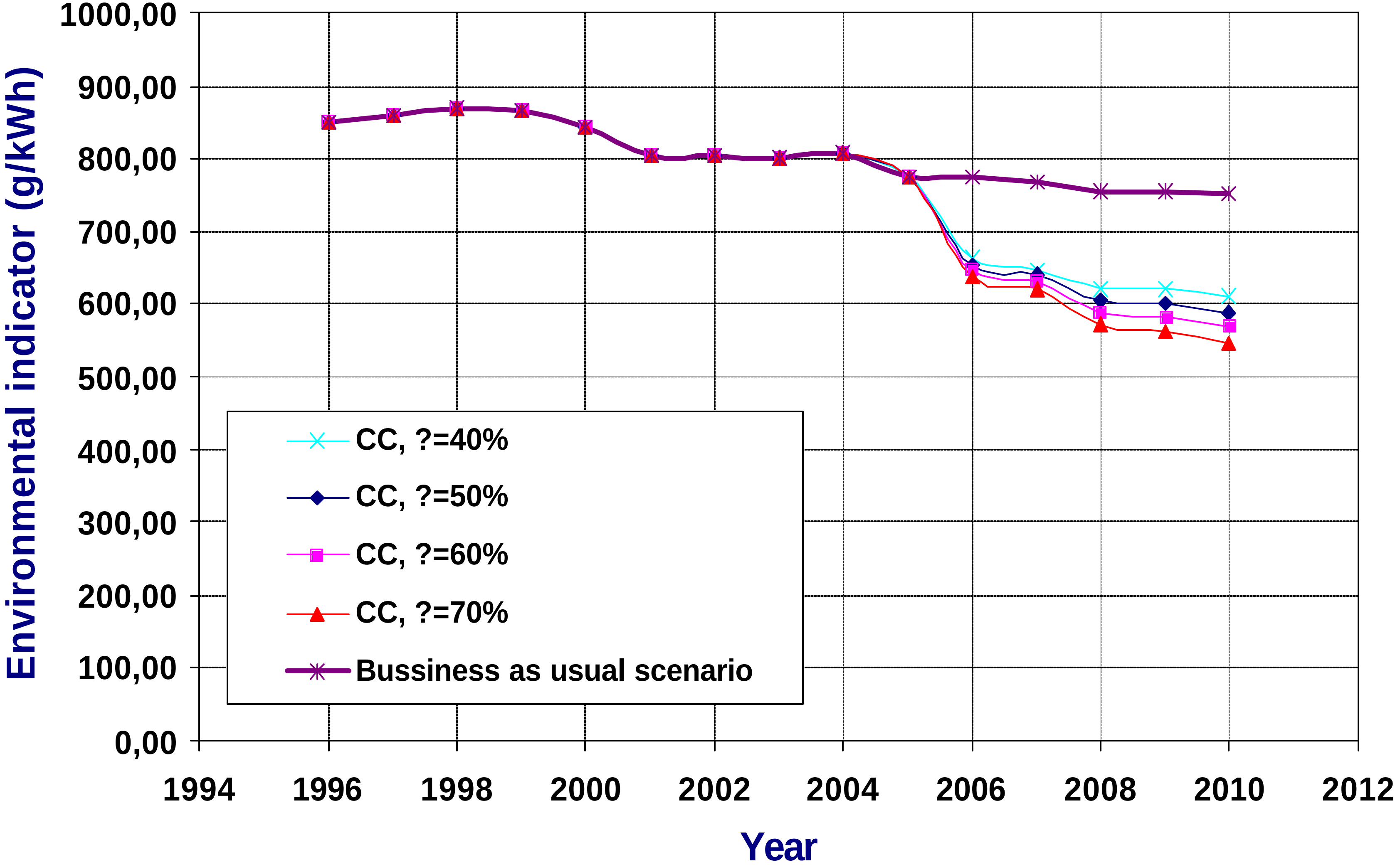
Cost-benefit analysis

80 % load factor



CO_2 emissions

CO_2 emissions environmental indicator for natural gas combined cycle



Conclusions

- **Parametric study for combined cycle technologies**
- **Variations in fuel type, capital cost and efficiency**
- **Cost-benefit analysis:**

Conventional technologies	**least cost solution**	**HFO steam turbine plant**
Gasoil combined cycle	**least cost solution**	**?> 60%, capital cost 700€/kW - 900€/kW**
Natural gas combined cycle	**least cost technology**	

- **Reduction of CO_2 emissions by -18 %** **(year 2010)**