Status and costs for CO_2 capture in power generation

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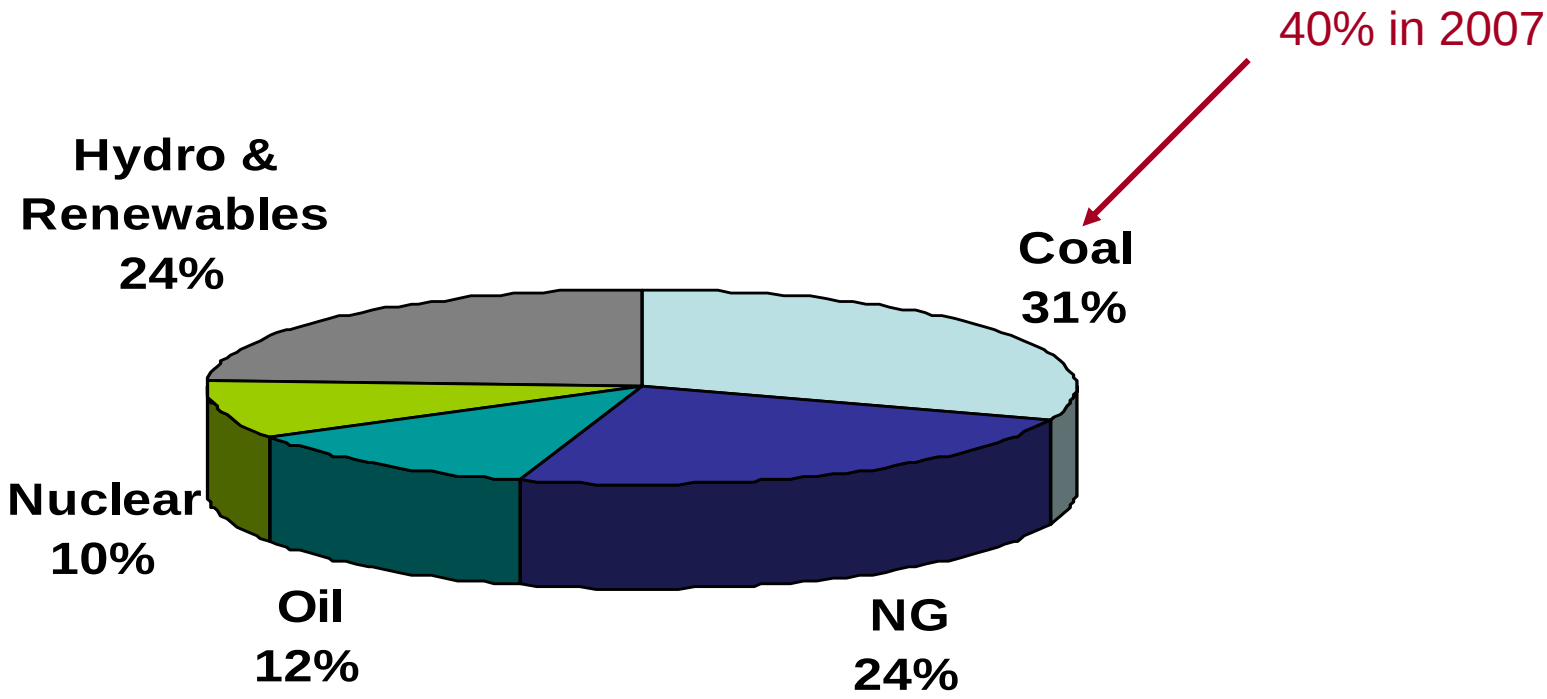
Outline of presentation

- The challenge for CCS in power generation
- The road from IPCC SRCCS 2005
  - Options for capture in power generation
  - Status of CCS
  - Technology costs
- Recent studies on cost of power generation with CCS
- Technology deployment for cost reduction

Sources of global electricity production



Total global production ~3500 GWe

Source: 2002/3

Doubling in capacity by 2030

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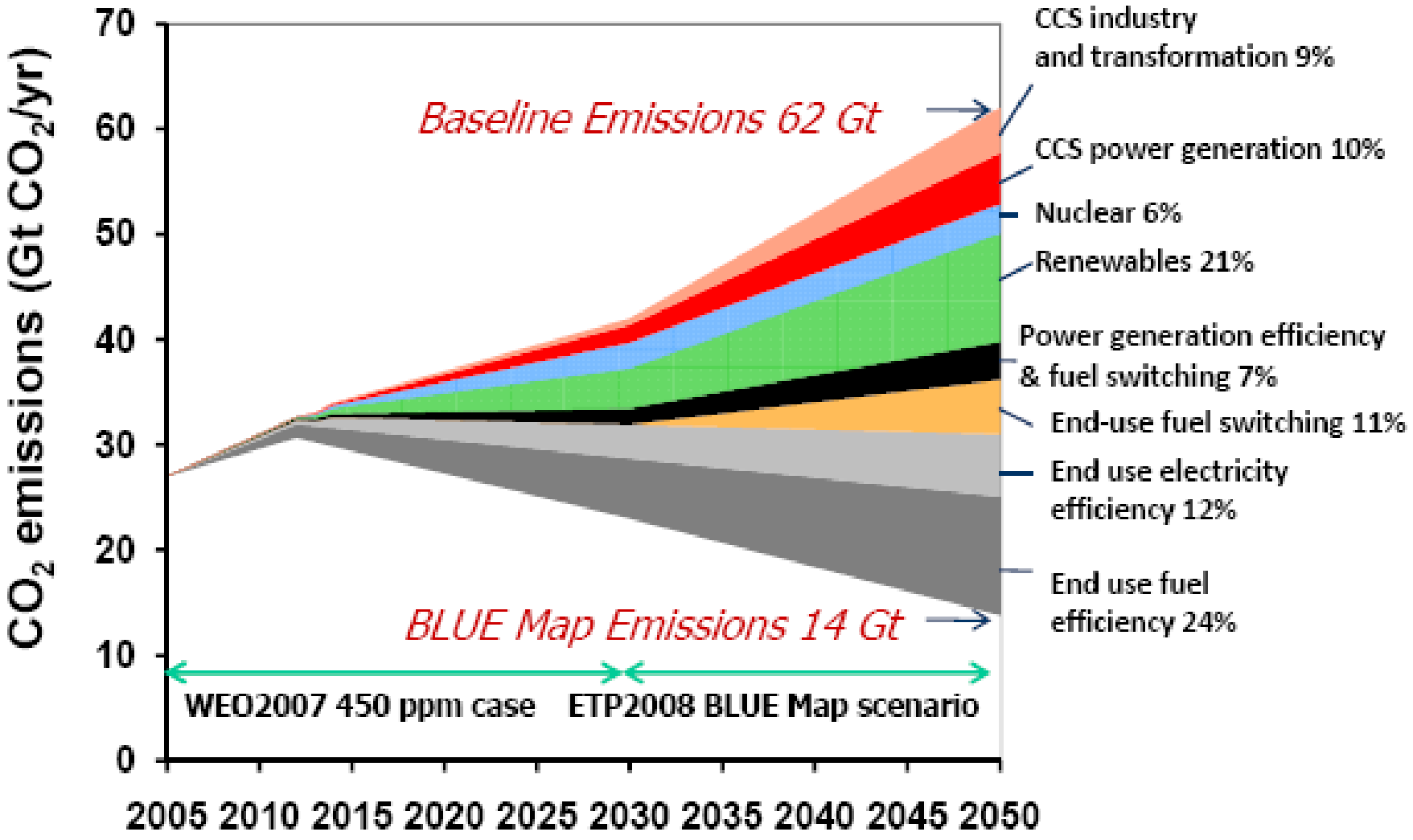
Emissions challenge (-50% of 2005) in 2050



Source: IEA ETP 2008

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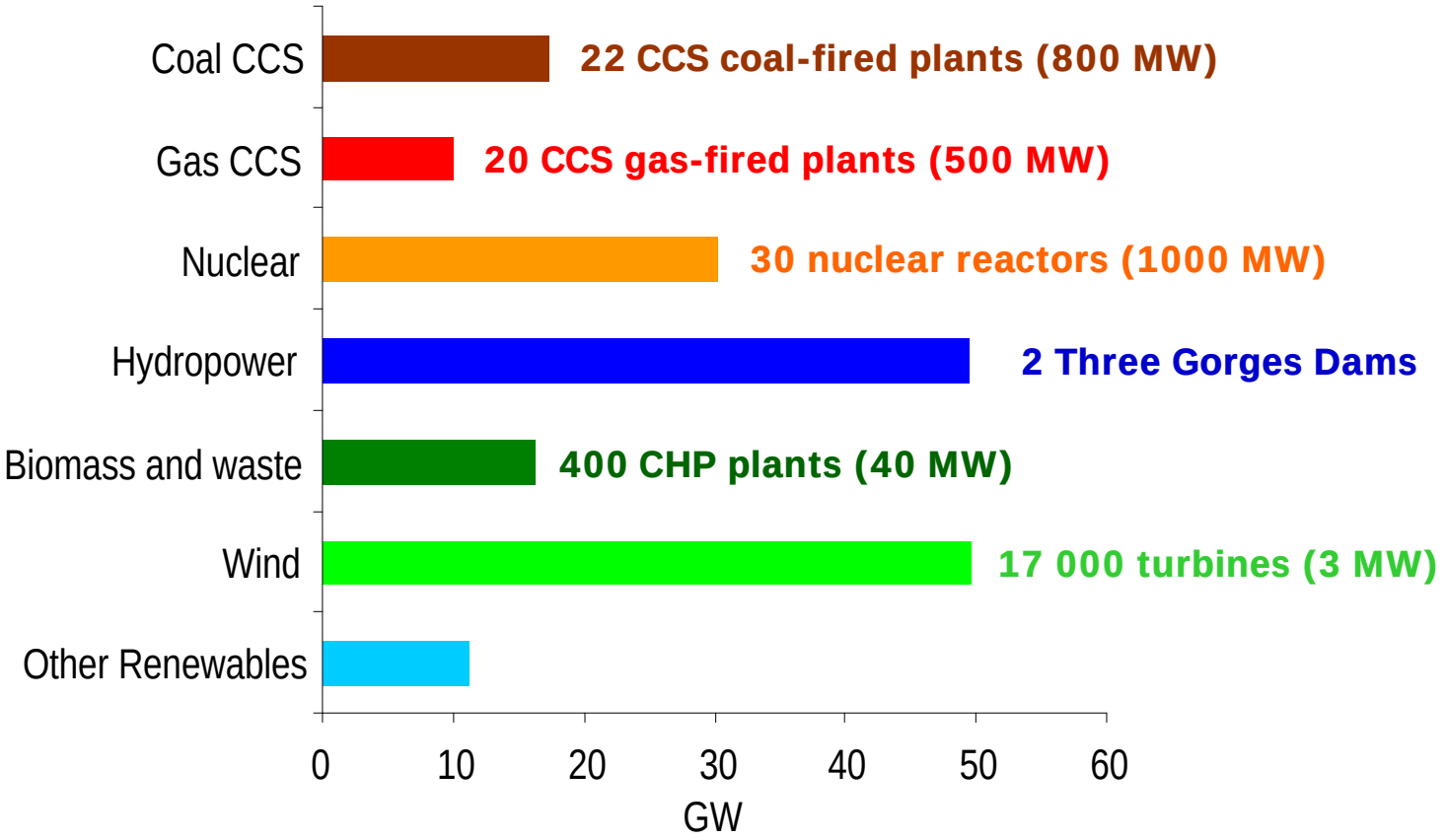
Average Annual Power Generation Capacity Additions in the 450 Stabilisation Case, 2013-2030



A large amount of capacity would need to be retired early, entailing substantial costs

Source: IEA ETP 2008

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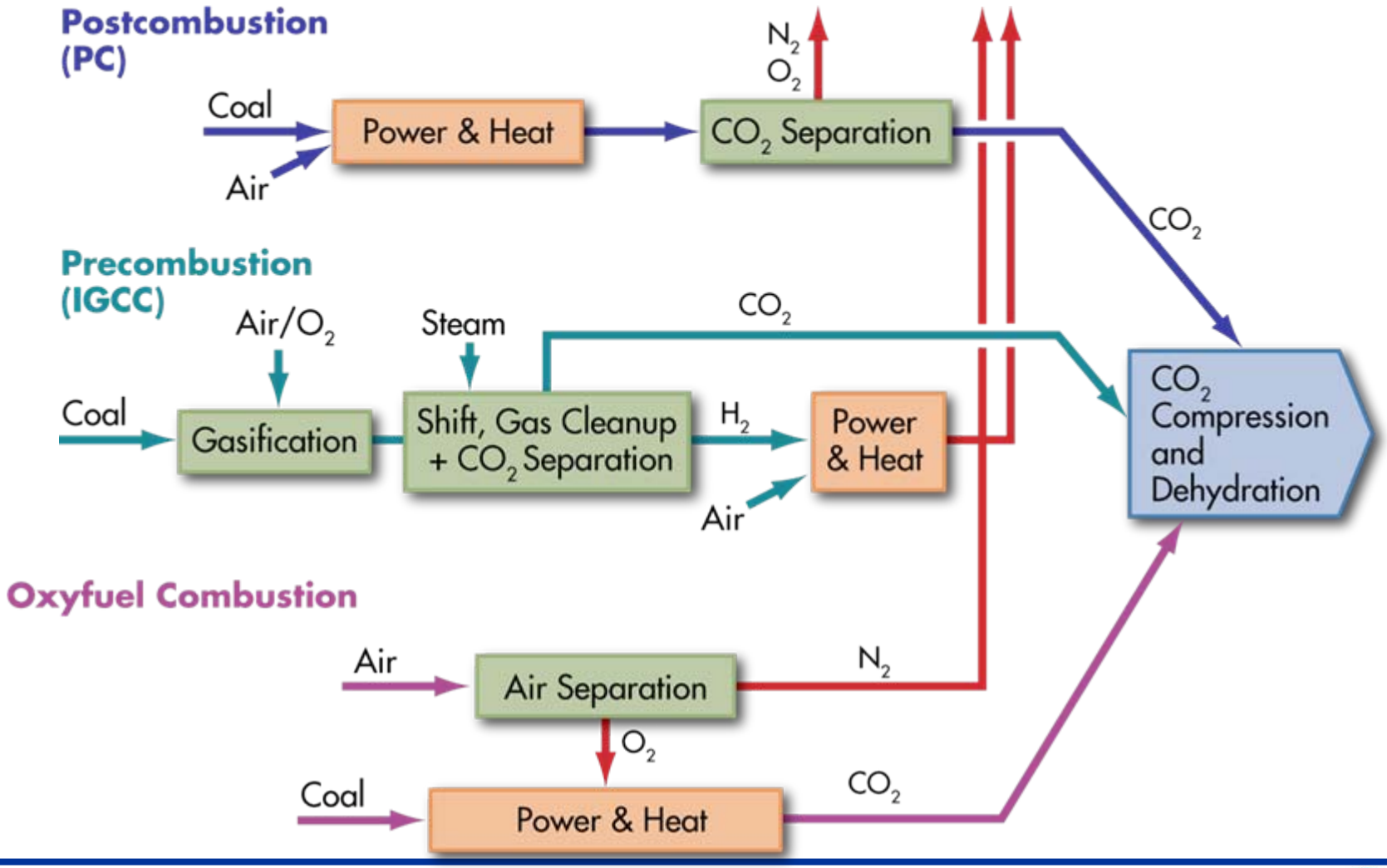
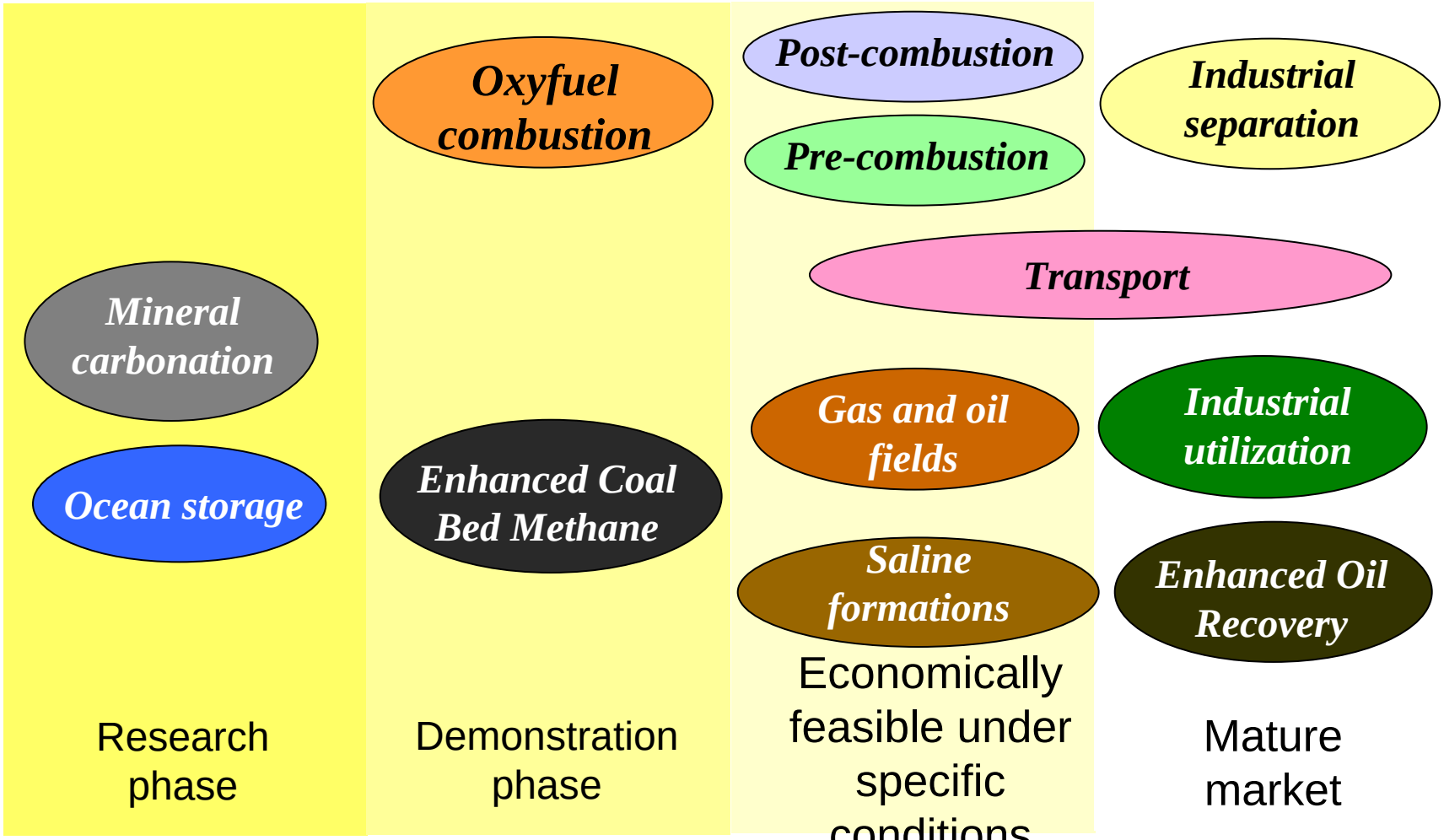
Options for CO_2 capture



Technology maturity of CCS



Derived from the IPCC SRCCS 2005

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Technology maturity - capture in power plants

- Power generation with post combustion capture
  - SC/USC pulverised coal and NGCC power plants are reliable and proven
  - Scale up of solvent capture units/integration with power cycle is unproven.
- Power generation with pre-combustion capture
  - IGCC for coal (1 GWe) is near commercial and proving reliability, better experience with 3 GWe of IGCC capacity on oil and petcoke. No experience to date with reforming/POX/ATR based natural gas power plants
  - Solvent capture units for CO_2 available at scale, integration and power block hydrogen utilisation issues
- Power generation with oxy-fuel combustion
  - No proven experience of operation of pulverised coal power plants in an oxyfuel combustion mode – the issue is *"confidence building"*
  - Large scale air separation units for O_2 production proven and reliable.
  - Some development issues with tail end CO_2 purification
  - CO_2 or hybrid turbines do not exist for oxy-fuel combined cycles

IPCC SRCCS power plant performance and cost data

	NGCC	PC	IGCC
	Rep. value	Rep. value	Rep. value
Thermal efficiency			
% LHV, without capture	56	43	42
% LHV with capture	48	33	35
Percentage point reduction due to capture	8	10	7
Total capital requirement			
$/kW without capture	568	1286	1326
$/kW with capture	998	2096	1825
% increase due to capture	76	63	37
Cost of electricity			
$/MWh without capture	37	46	47
$/MWh with capture	54	73	62
% increase due to capture	46	57	33
$/MWh with CCS			
% increase due to CCS			

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Non-ferrous metal prices

	Prices/US$/tonne			
	Jan-2003	**Jan-2008**	**Peak price**	**Date of peak**
Nickel	8000	28000	54000	June-2007
Copper	1700	6800	8800	May-2006
Aluminium	1350	2400	3250	May-2006

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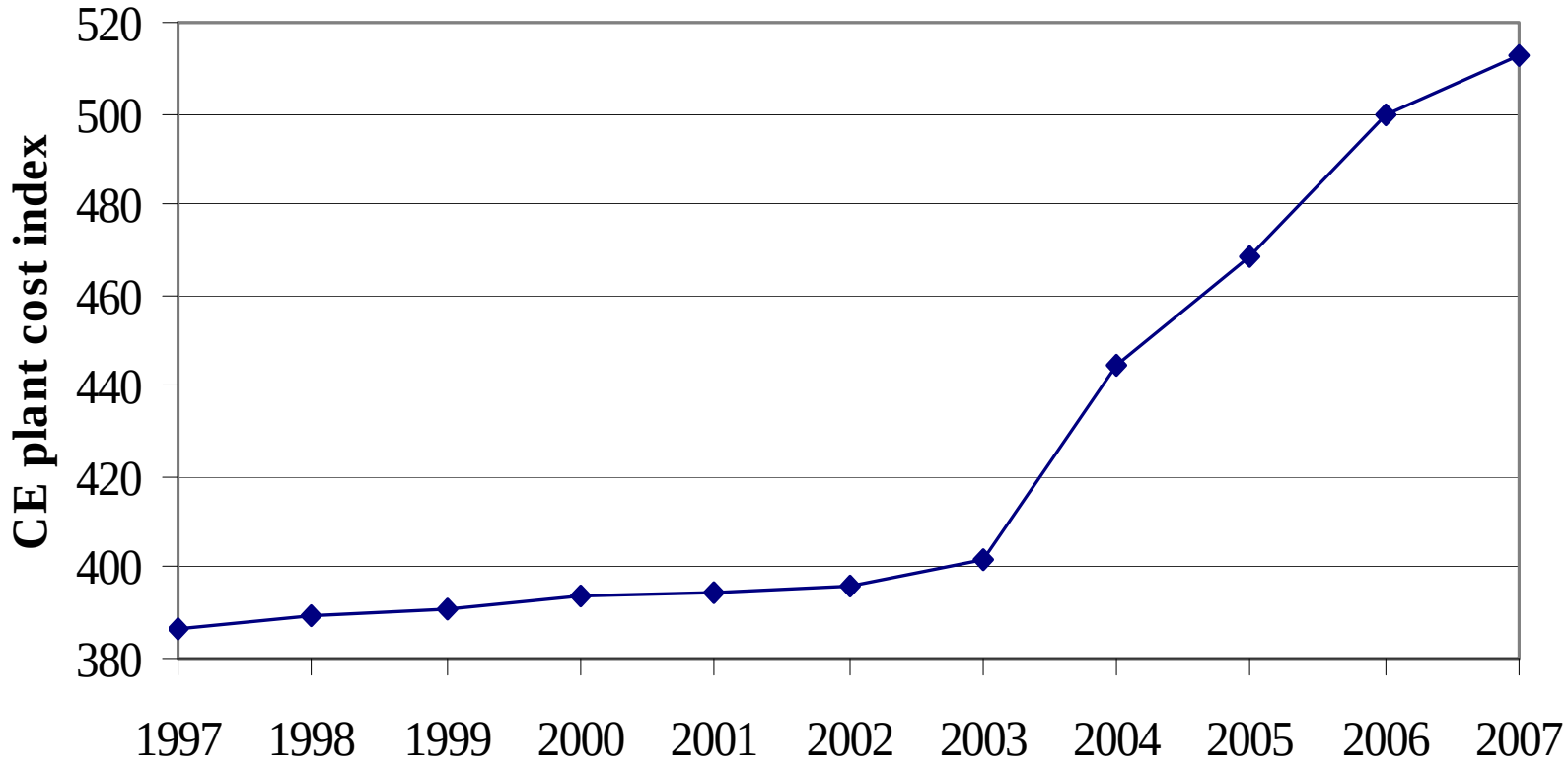
Chemical Engineering Plant Cost Index



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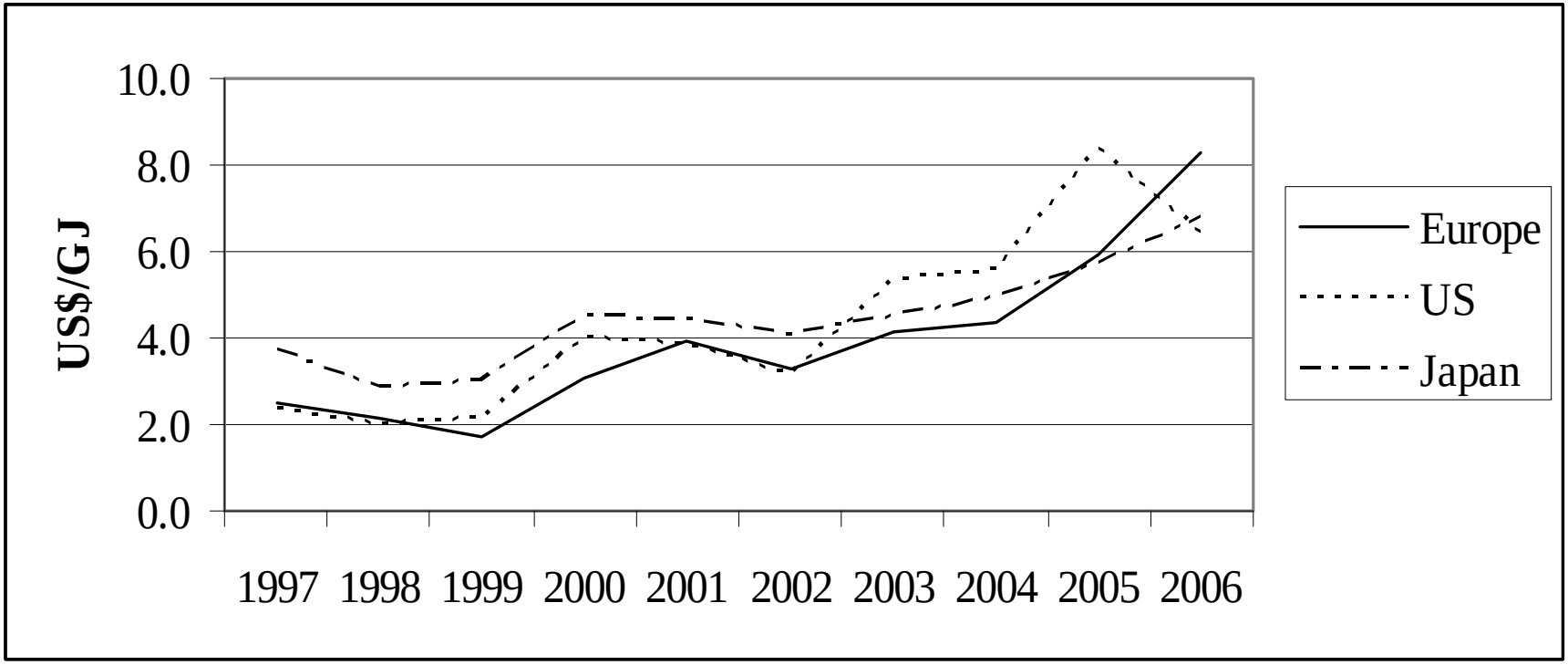
Natural gas prices



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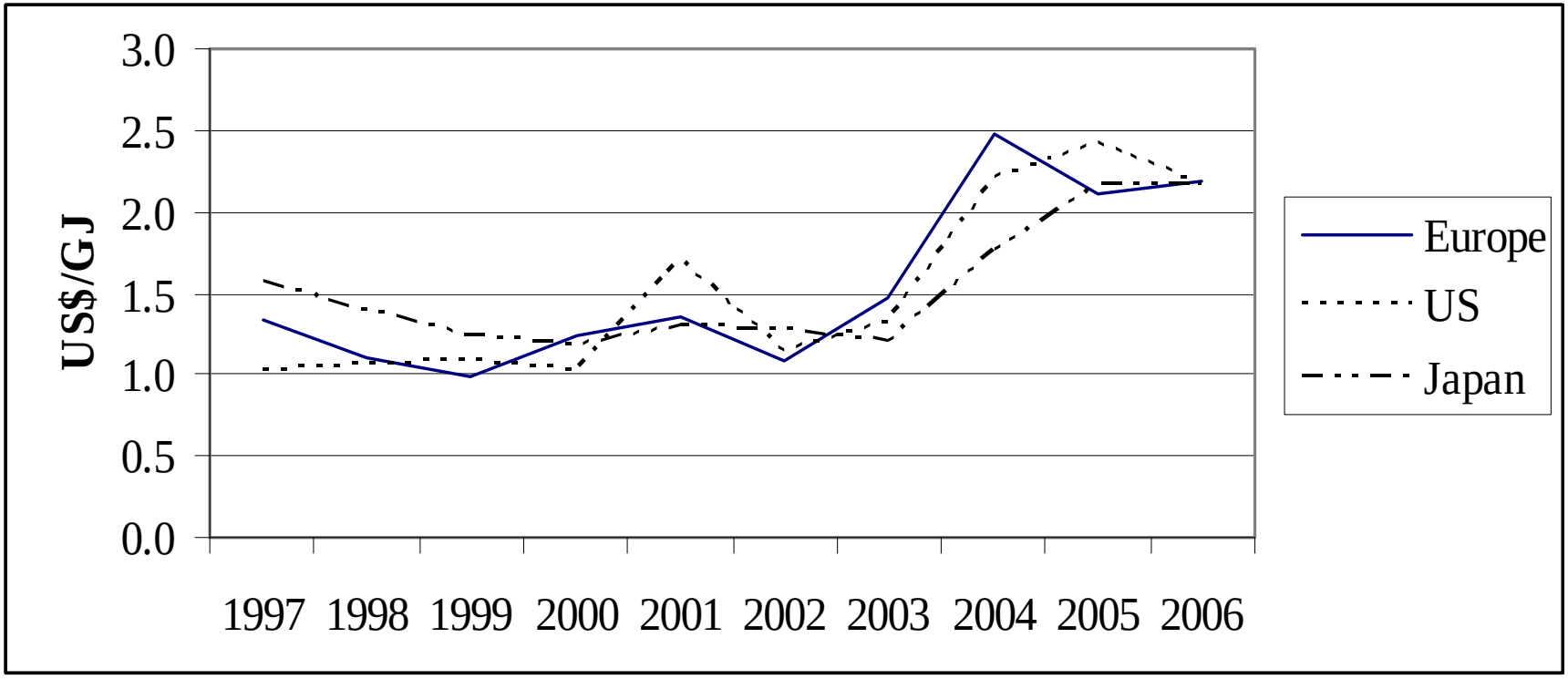
Coal Prices



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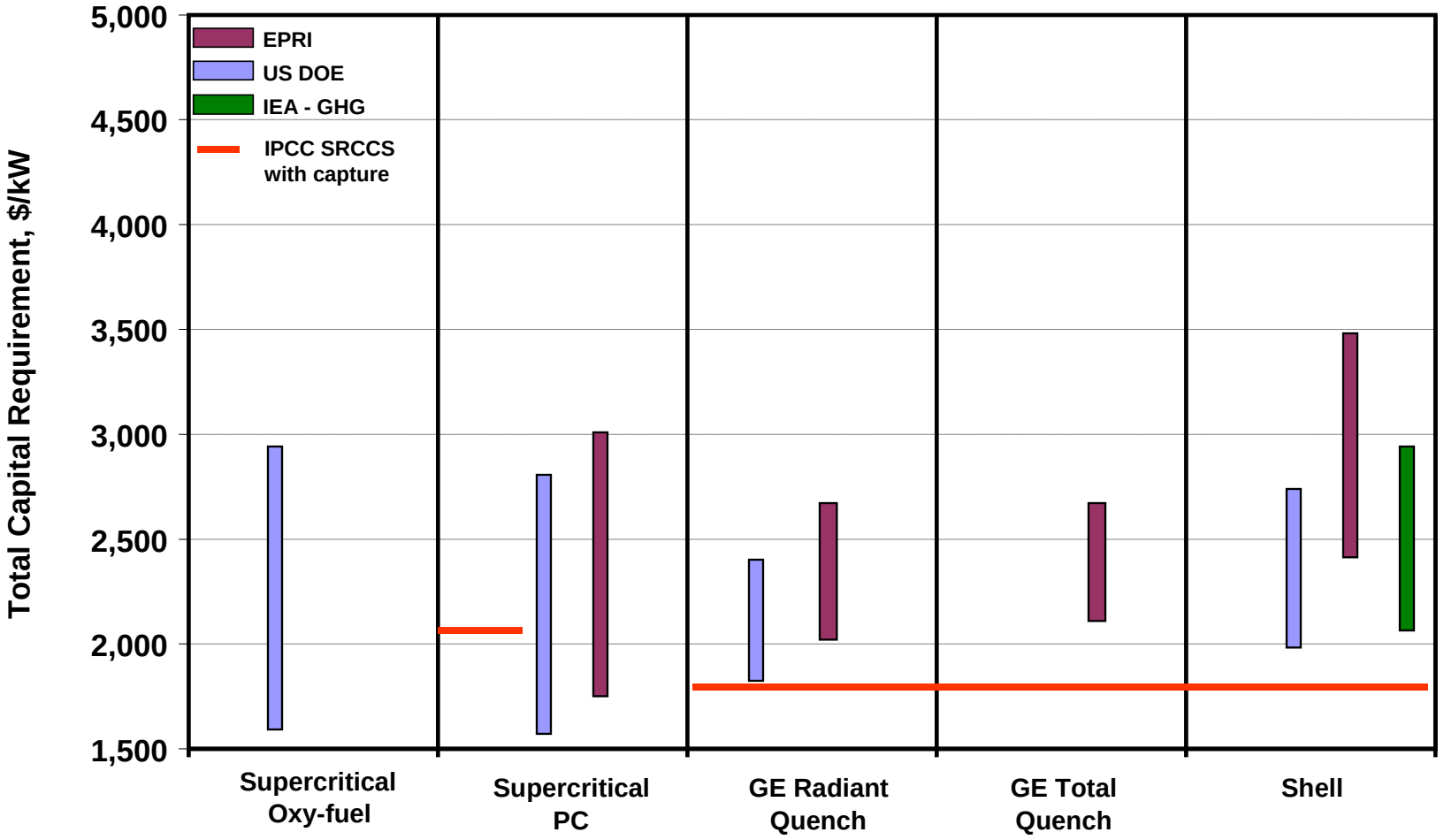
Power plant costs with & without capture



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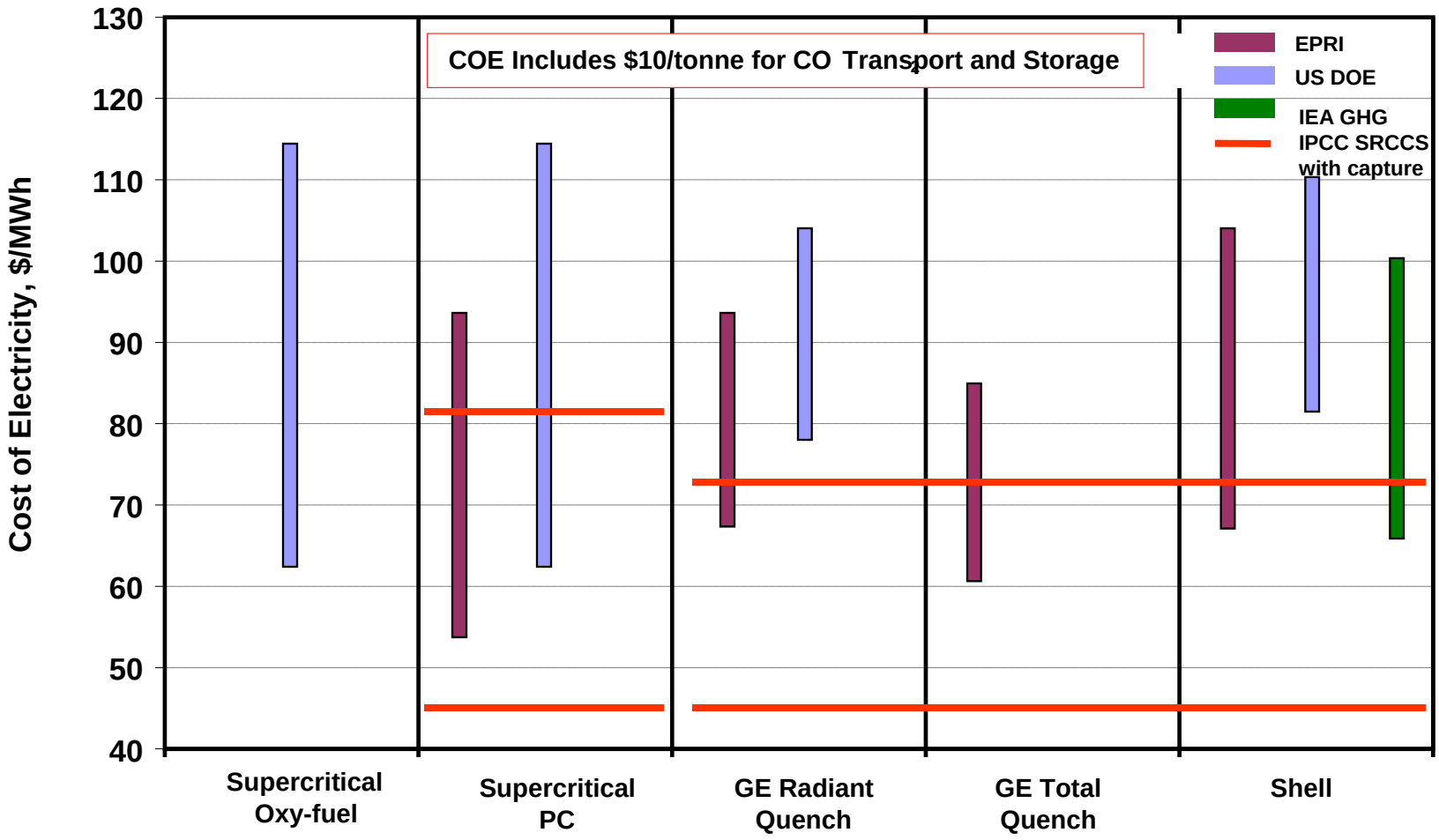
Cost of electricity with & without CCS



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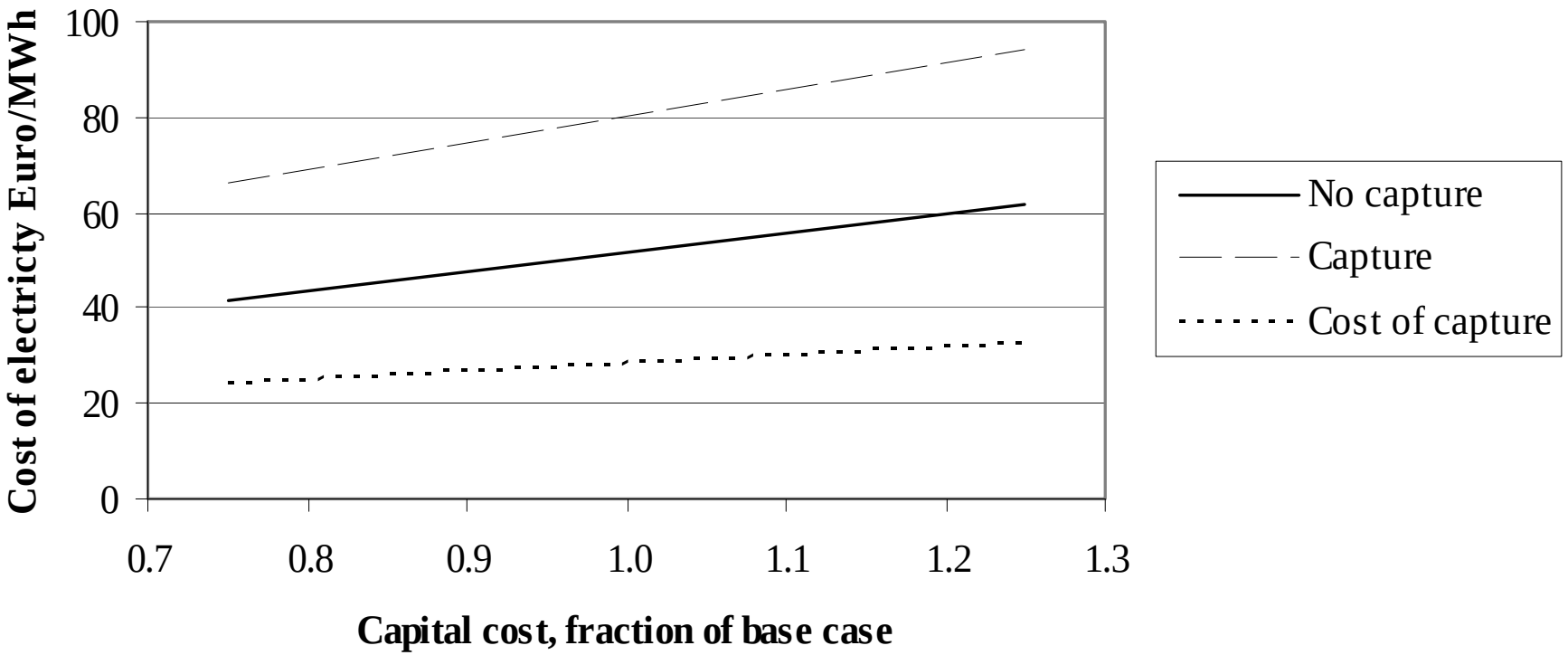
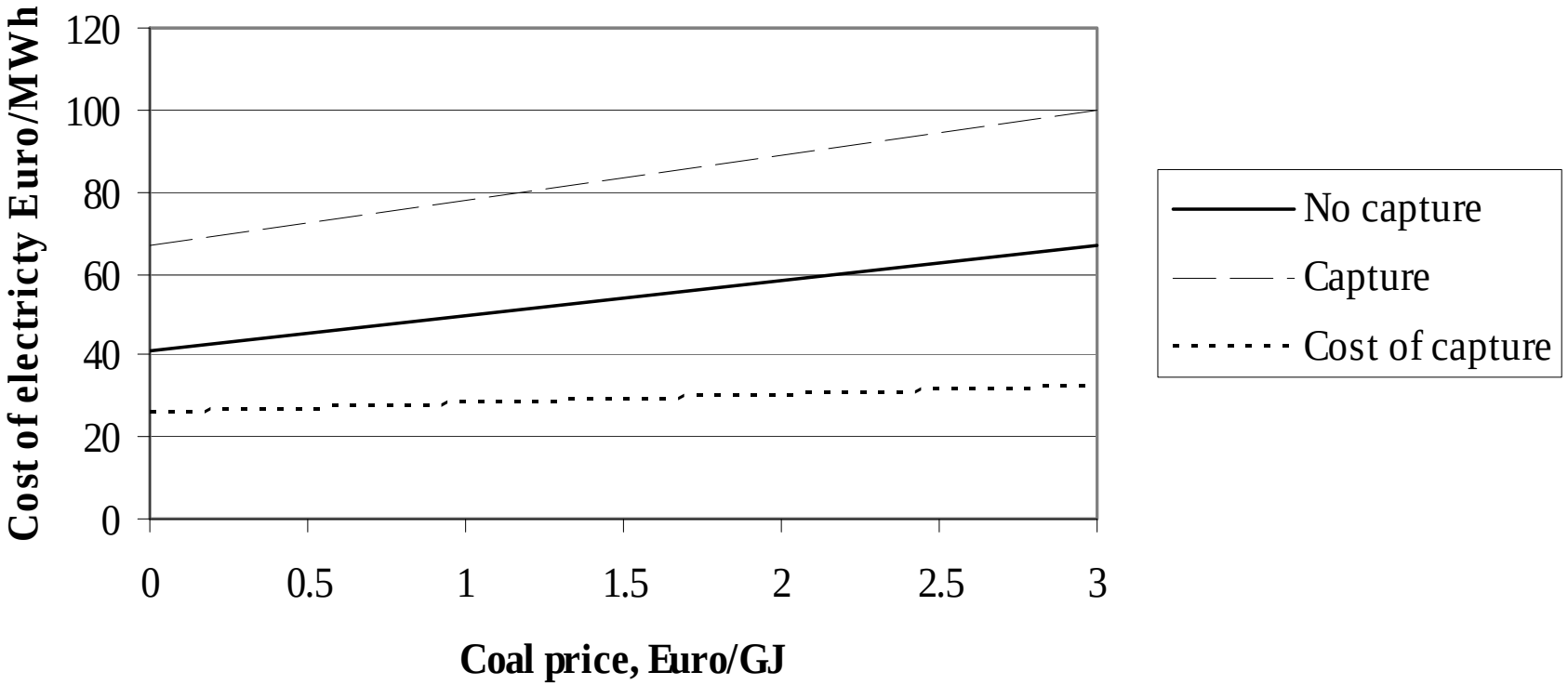
Sensitivity of electricity cost to the capital cost of power plants



Sensitivity of electricity cost to coal price



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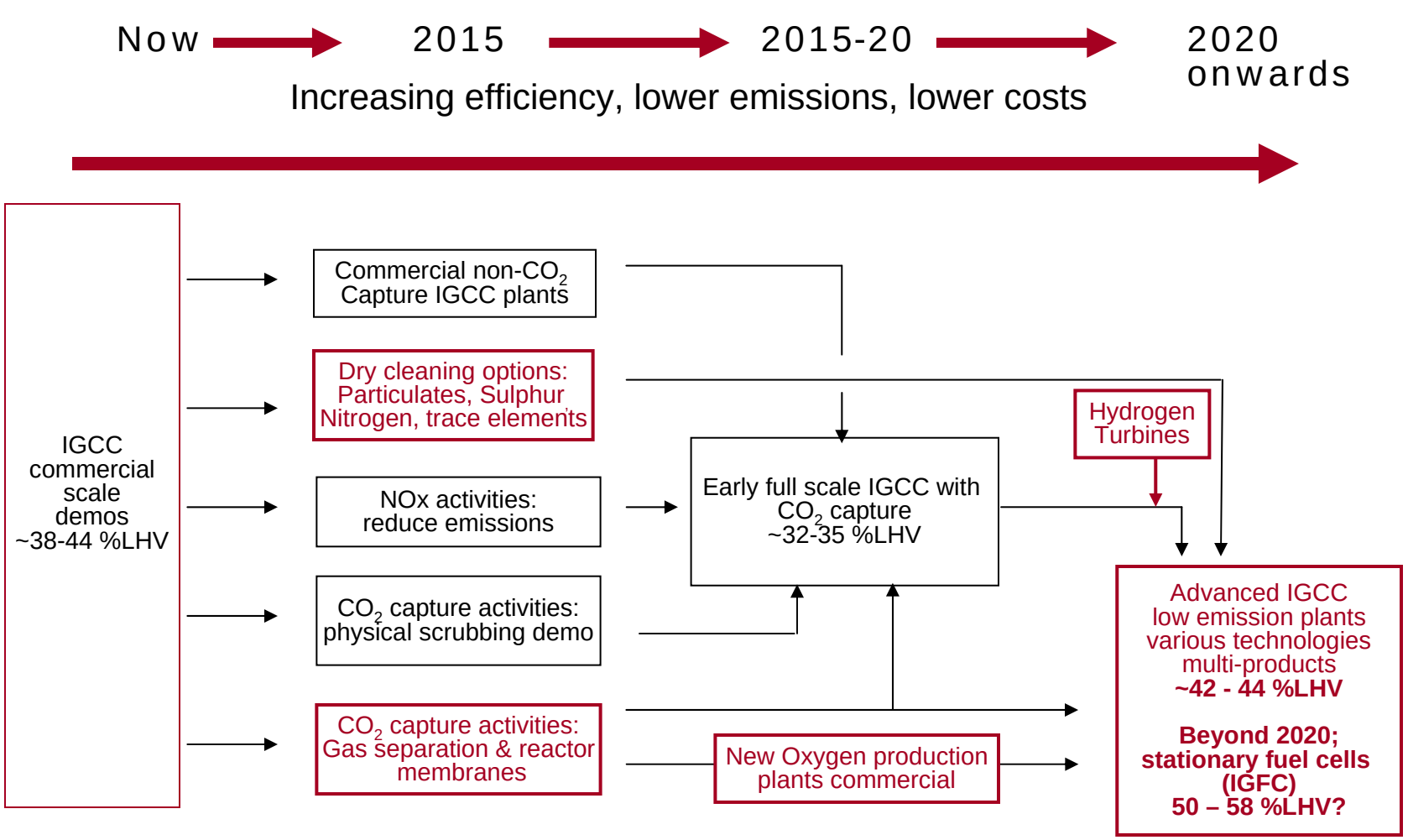
Path to improved coal-fired, IGCC with CCS



An example of technology improvements that can increase energy efficiency and reduce costs by at least 20- 30%

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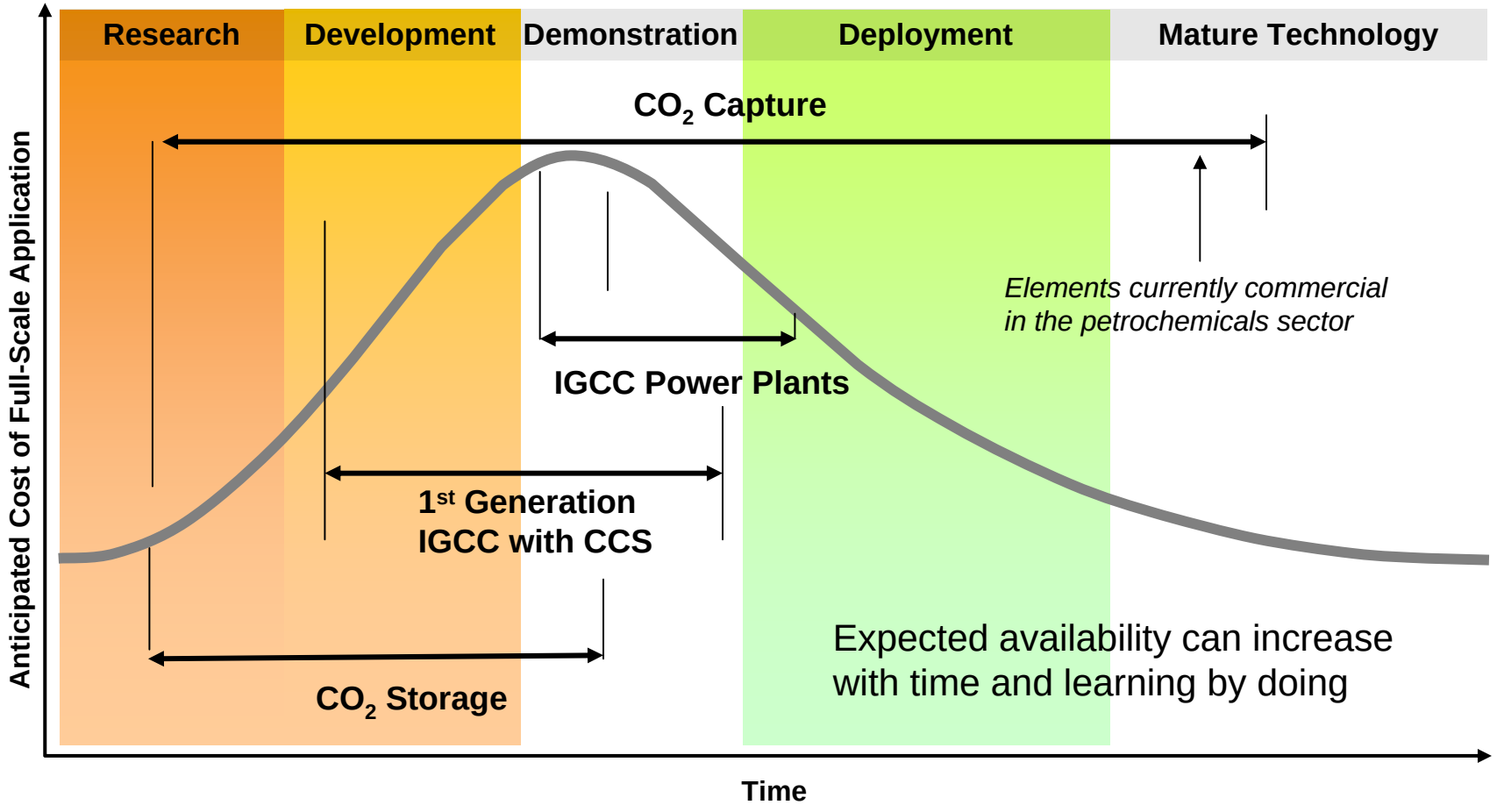
Example of new technology deployment, IGCC



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The message !

……. In the time we have spent talking about CCS plants, the costs have decreased and then increased – we are now in need of real plants in order to reduce both CO_2 emissions and costs…….

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IEA GHG costs of IGCC plants with and without CCS

	Without capture	With capture	Difference for capture
Performance			
Coal feed, MW (LHV)	1800.8	1962.5	
Electricity gross output, MW	891.9	875	
Electricity net output, MW	762.3	655.8	
Efficiency to electricity, %	42.3	33.4	-8.9 % points
Costs			
Capital cost, M€	1266	1560	
Capital cost, €/kW_e	1661	2379	+43%
Without CO_2 transport & storage			
Cost of electricity, €/MWh	52	72	+38%
Cost of CO_2 avoided, €/tonne			31
With CO_2 transport & storage			
Cost of electricity, €/MWh	52	80	+54%
Cost of CO_2 avoided, €/tonne			45

Eur – US $ at time of study $1.25

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EPRI costs of plants with and without CCS

	Supercritical PC	IGCC			
	Post combustion	GE radiant quench	GE total quench	Shell gas quench	Conoco- Phillips full slurry quench
Total plant cost					
Without capture, $/kW	1800	2350	2100	2400	2100
With capture, $/kW	3000	2950	2650	3500	2850
Increase for CO_2 capture %	67	25	26	46	36
Cost of electricity					
Without CCS, $/MWh	53	67	61	67	61
With CCS, $/MWh	93	92	86	105	91
Increase for CCS %	75	37	41	57	49

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US DOE efficiency & costs of plants with & without CCS

	Pulverised coal		IGCC			NGCC
	Post combustion	Oxy-combustion	GE radiant quench	Shell	Conoco-Phillips	Post combustion
Efficiency						
Without capture, % LHV	41	41	39.6	42.6	40.7	56.3
With capture, % LHV	28.2	29.3	33.7	33.2	32.9	48.5
Decrease for capture %	12.8	11.7	5.9	9.4	7.8	7.8
Total plant cost						
Without capture, $/kW	1563	1563	1813	1977	1733	554
With capture, $/kW	2857	2930	2390	2668	2431	1172
Increase for CO_2 capture %	83	87	32	35	40	112
Cost of electricity						
Without CCS, $/MWh	62.9	62.9	78	80.5	75.3	68.4
With CCS, $/MWh	114.4	113	102.9	110.4	105.7	97.4
Increase for CCS %	82	80	32	37	40	42

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