IEA ENERGY TECHNOLOGY DAY
Coal Fired Power and Efficiency
New York 3 May 2006

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http://www.iea-coal.org.uk

IEA Clean Coal Centre Members

Membership character

Our Network

- Kyoto Protocol signatories
- Non-Kyoto signatories
- OECD Countries
- Developing countries (China, India, S. Africa, Brazil)
- Governments
- Industry – coal and power and equipment

Some of our Power Related reports

Completed in last 12 months

International funding sources for major coal investment projects	Feb 06
Implementing clean coal projects under Kyoto	Apr 05
Coal full life cycle analysis	Sep 05
Towards zero emission coal-fired power stations	Sep 05
Fuels for biomass cofiring	Oct 05
Life extension of coal-fired power plants	Nov05
Use of coal in areas of water shortage	Nov 05

In Progress

Public attitudes to new coal power plants

Clean coal technologies for a carbon constrained world

Future developments in IGCC

CO2 capture technologies

Cofiring coal with waste and opportunity fuels

Coal resources for future power generation in China

Towards Zero Emissions

Report by Dr Colin Henderson

Obtainable via IEA CCC website

www.iea-coal.org.uk

Current plant emissions and suggested ZETs targets (stack gas concentrations at 6% O_2, dry)

Techn'gy	SO_2 mg/m^3	NOx as NO_2 mg/m^3	Particles mg/m^3	Mercury	CO_2 kg/MWh
PCC +FGD	100-400 (to 98%)	100-200 (SCR)	10-25		710-920
CFBC	As PCC	<200-400	<50		
PFBC	As PCC	120-400	<50		
IGCC	98-99% removal	<75	<1		
NGCC	Negligible	<30 (SCR)-300	0		~370
PCC as ZETs	<100 (interim) <30 (eventual)	<100 (interim) <50 (eventual)	<10	90% removal	>80% removal
IGCC as ZETs	<25	<25	<1	90% removal	>80% removal

Two tracks for sustainability based on coal

Progressive improvements in emissions, competitiveness, efficiency, for:

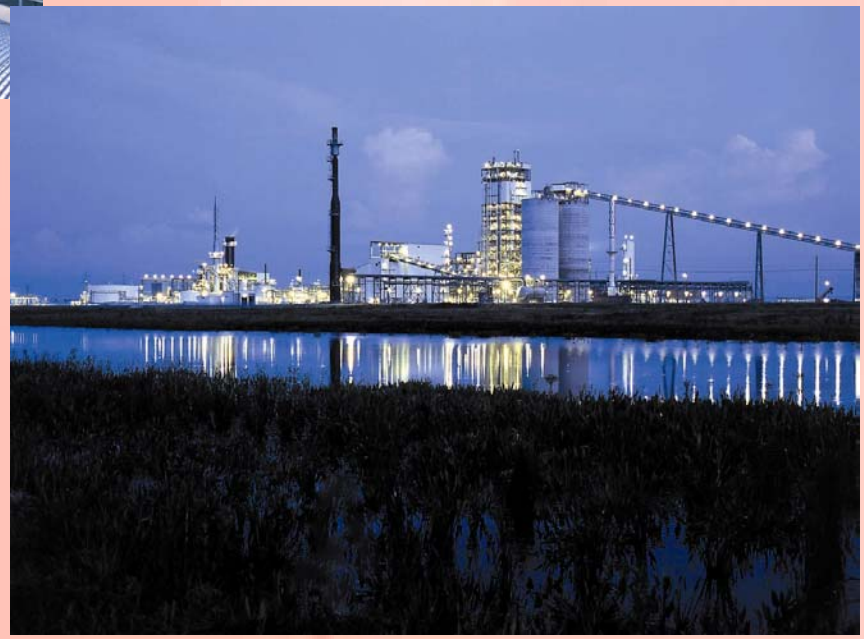
- **interim environmental benefits – all emissions and wastes**
- **a credible platform and, ultimately,**
- **a very high efficiency technology base for near-zero emissions plants**

Develop near-zero emissions plants:

- **CO_2 capture and storage (CCS)**
- **very low conventional emissions**

PCC and IGCC Plant

2 x 660MW sets Iskenderun in Turkey. Built by STEAG AG for 1.5billion$ Operating 2-3 years, meets World Bank emissions standards at 41% efficiency. Uses 3.3m tonnes coal/yr



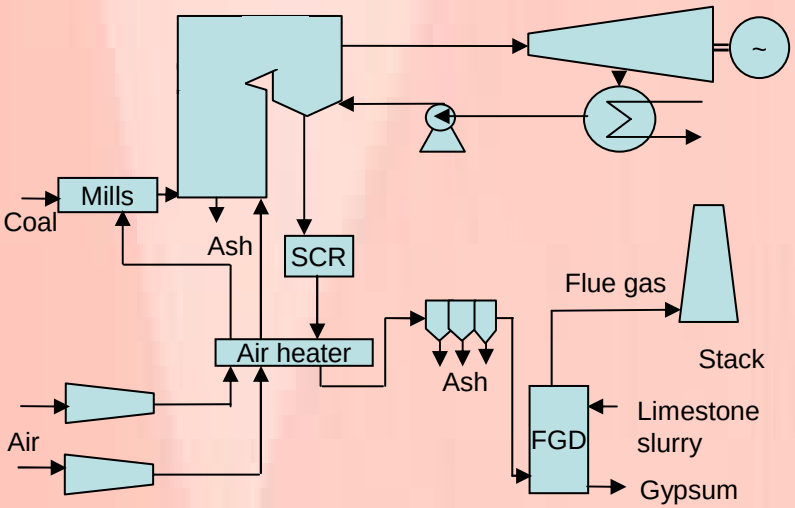
The Tampa 250MW IGCC plant in Florida

Pulverised coal combustion

- 100's of GWe units to ~1000 MWe
- Efficiency to mid-40s% (HHV) in best locations
- Conventional emissions control well established

How will it be in 10 or 20 years?

- Still the most deployed coal technology
- Advanced emissions control
- Further incremental efficiency improvements
- Progression to very high steam conditions ~ 50% efficiencies
- CCS on some plants using flue gas scrubbing or oxygen firing

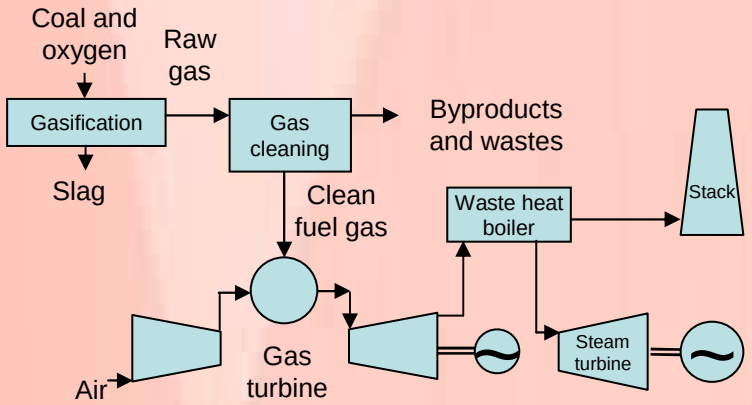


Integrated gasification combined cycle (IGCC)

- **Demonstrations in USA and Europe and, shortly, in Japan**
- **Cost/availability concerns have held back orders but reference plants soon**
- **Efficiency ~40-43% HHV**
- **V. low emissions, Hg capture simple**

How will it be in 10 or 20 years?

- **More widely deployed**
- **Advanced performance and lower cost**
- **New gasifier designs &polygeneration**
- **CCS using pre-combustion capture**

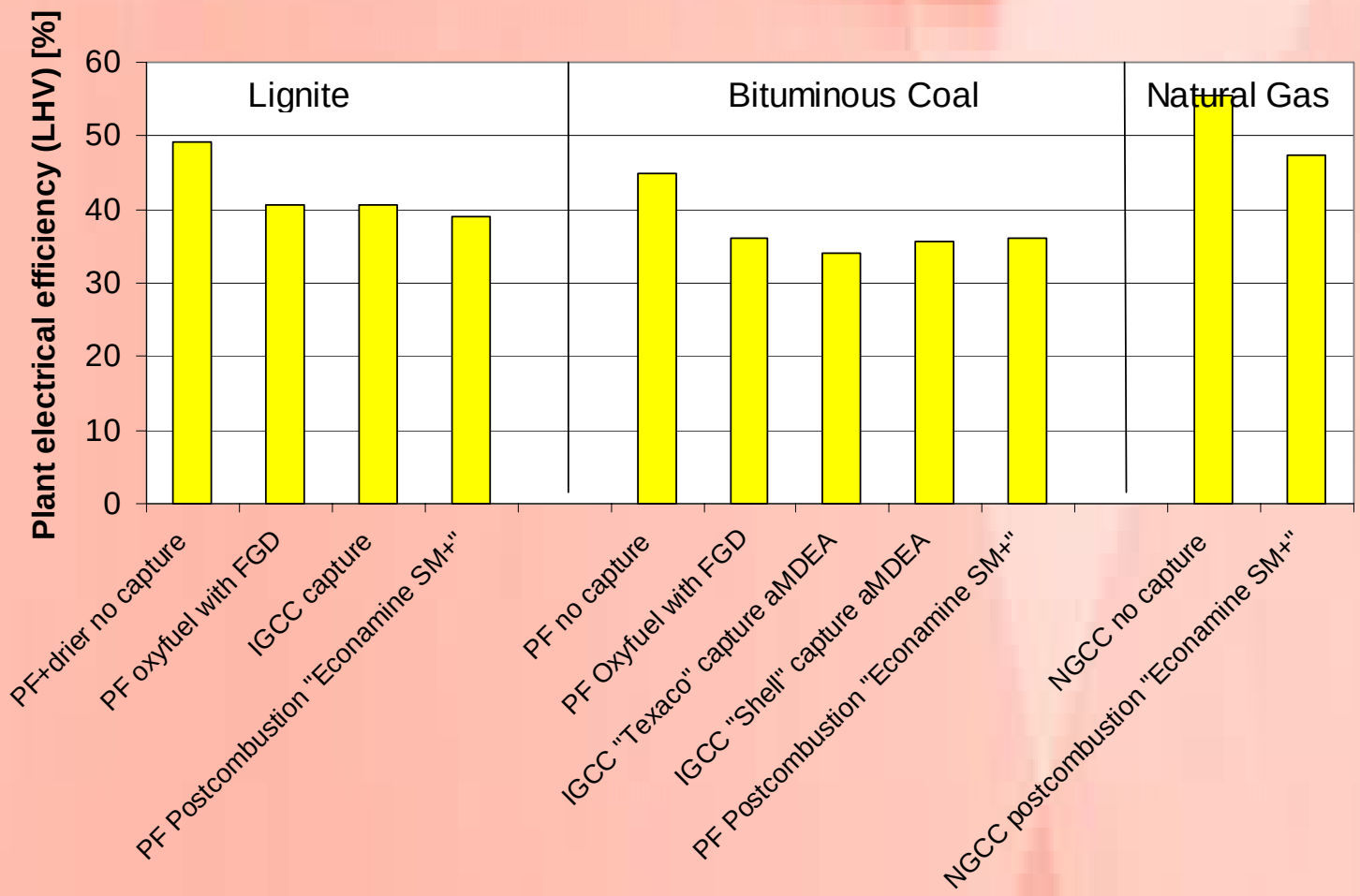


ZETs plants capital cost (US$/kWe net) and net efficiency (% HHV) estimates

	Non-ZETs reference	ZETs
Supercritical PCC, current/near-term	1200 US$/kWe 41% HHV	1900 US$/kWe (flue gas scrubbing) 33% HHV
Ultrasupercritical PCC, long-term	1200 US$/kWe (based on cost equal to above) 48% HHV	1600 US$/kWe (advanced oxy-coal; based on non-ZETs +33%) 40% HHV (non-ZETs - 8% points)
IGCC current/near-term	1400 US$/kWe (dry feed, radiant cooling) 43% HHV 1200 US$/kWe (slurry feed, water quench) 38% HHV	1900 US$/kWe 35% HHV 1500 US$/kWe (slurry feed, water quench) 32% HHV
IGCC advanced, long-term	1300 US$/kWe (based on radiant and advanced O_2 production, reducing cost 7%) 48% HHV	1700 US$/kWe (advanced O_2 production; based on non-ZETs +30%) 41% HHV
NGCC current/near-term	500 US$/kWe 51% HHV	1000 US$/kWe 45% HHV
NGCC advanced	500 US$/kWe 54% HHV	1000 US$/kWe 49% HHV (non-ZETs - 5% pts)

Net efficiencies (LHV) with and without CO2 capture

(Courtesy of Vatenfall – oxy fuel network meeting Cottbus November 2005)



Summary picture on capital costs and efficiencies of ZETs plants

- Main incremental cost of ZETs plants will come from CO_2 capture, which incurs a large specific capital cost penalty
- PCC and IGCC in ZETs forms could be broadly similar in capital cost
- However, range and uncertainty in estimated costs are considerable
- Efficiency penalties of combustion-based ZETs systems could be becoming more similar to those being predicted for IGCC-based ZETs

Estimated generation costs, US cents/kWh

	S/C PCC near term/advanced	S/CPCC-ZETs near term/advanced	IGCC near term/advanced	IGCC-ZETs near term/advanced	NGCC current/ advanced	NGC-ZETs current/ advanced
Capital	2.27/2.27	3.60/3.03	2.65/2.46	3.60/3.22	0.93/0.93	1.85/1.85
O&M fixed	0.47/0.45	0.69/0.58	0.52/0.48	0.69/0.61	0.18/0.18	0.33/0.32
O&M variable	0.20/0.19	0.47/0.40	0.19/0.18	0.44/0.39	0.09/0.09	0.24/0.24
Fuel	1.53/1.32	1.88/1.58	1.46/1.32	1.78/1.53	7.59/7.08	8.50/7.87
Total	4.46/4.22	6.64/5.58	4.82/4.43	6.50/5.75	8.78/8.27	10.92/10.29
CO_2 avoided cost, US$/t	ref	33/24	ref	27/23	ref	70/70

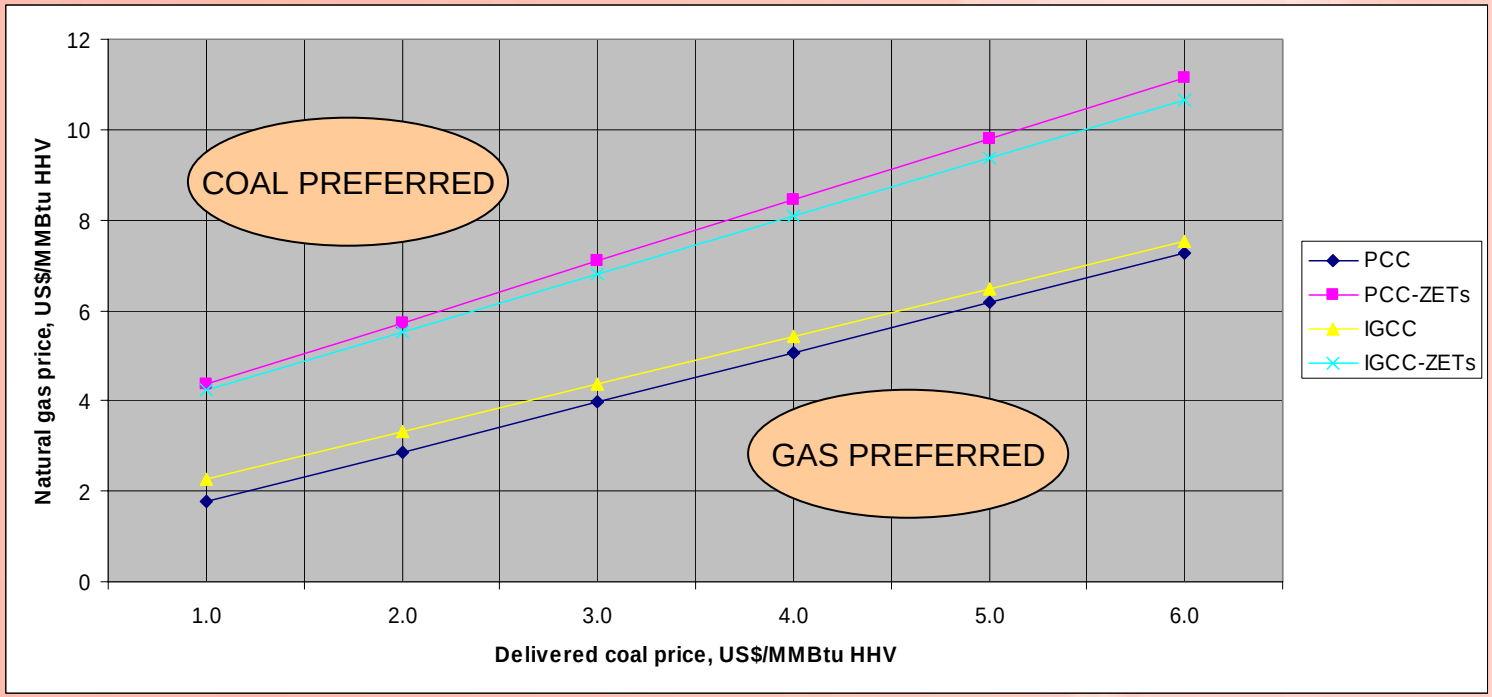
IGCC and IGCC-ZETs based on dry feed, radiant

10% discount rate, 25 years amortisation, 75% capacity factor

Coal price 1.80 US$/MM Btu HHV

Gas price 11 US$/MM Btu HHV (11.8 US$/1000 cu ft)

Breakeven coal/ natural gas prices



Reference is NGCC-ZETs
All plants are near-term

G8 Action Plan for Climate change

Action Plan on Climate Change

Powering a Cleaner Future

The G8 Request – Task 13

We will support efforts to make electricity generation from coal and other fossil fuels cleaner and more efficient by:

- **Supporting IEA work in major coal using economies to review, assess and disseminate widely information on energy efficiency of coal-fired power plants; and to recommend options to make best practice more accessible;**

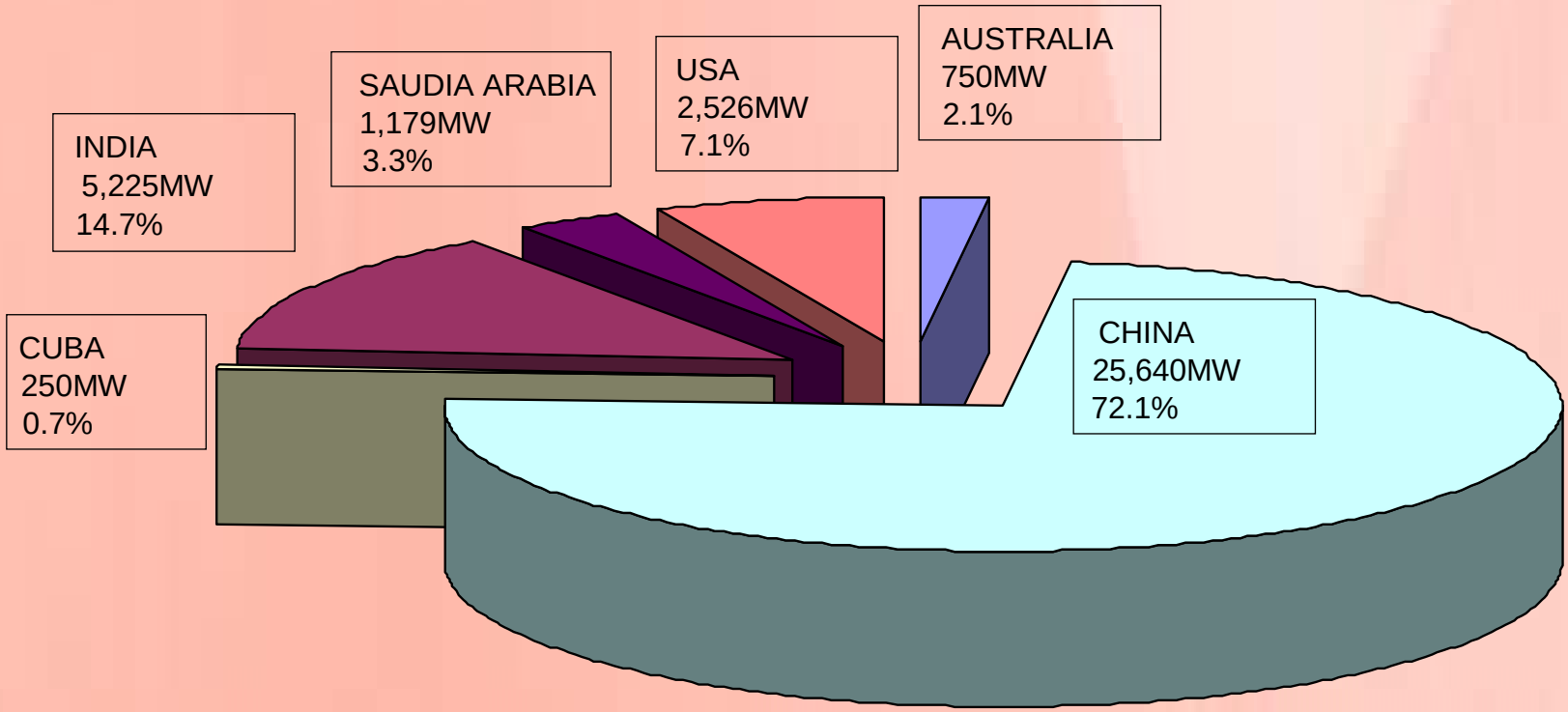
- **Inviting the IEA to carry out a global study of recently constructed plants, building on the work of its Clean Coal Centre, to assess which are the most cost effective and have the highest efficiencies and lowest emissions, and to disseminate this information widely;**

China and India

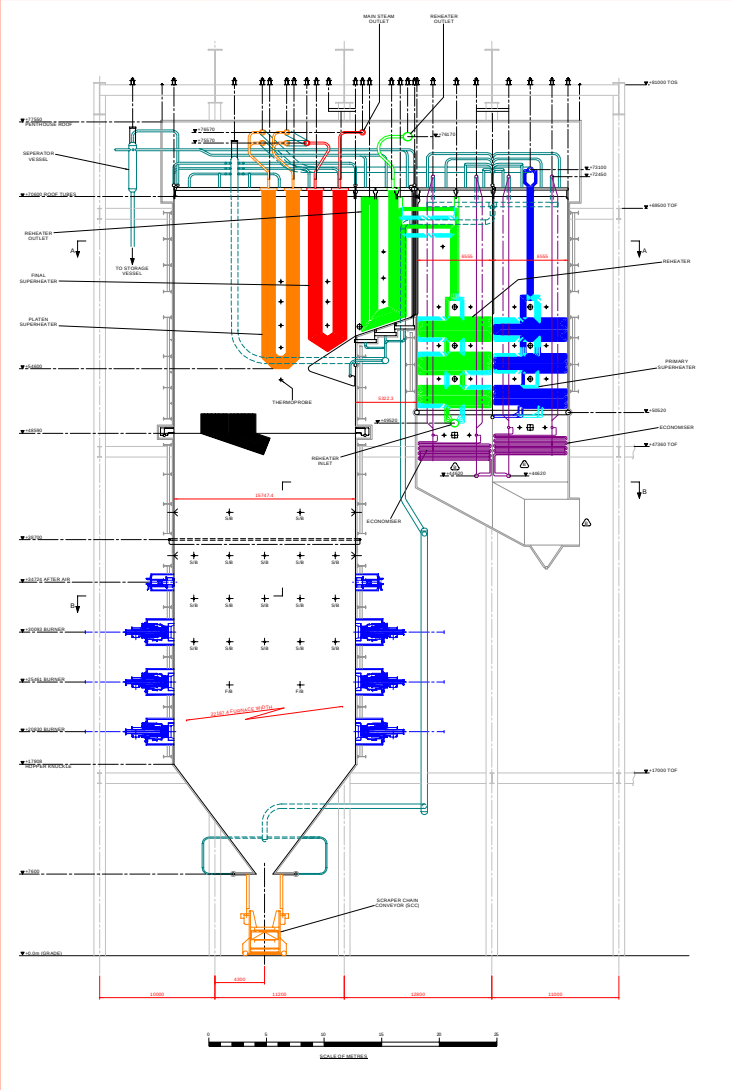
China & IEA Clean Coal Centre

- China an industrial sponsor of the IEA CCC via Beijing Institute of Coal Chemistry
- Two Chinese staff members at the Centre
- Strong links to major industrial groupings and key universities via a Senior Associate
- Study report in preparation (Coal Resources for Power Generation in China) 2006
- World Bank project (H2 production and CO2 sequestration for IGCC) 2006
- Study report (Coal in China) 2003-2004
- World Bank project (non-power sector clean coal technology) 2002-2003

World Boiler Utility Market - 2004



WANGQU 2x600MW

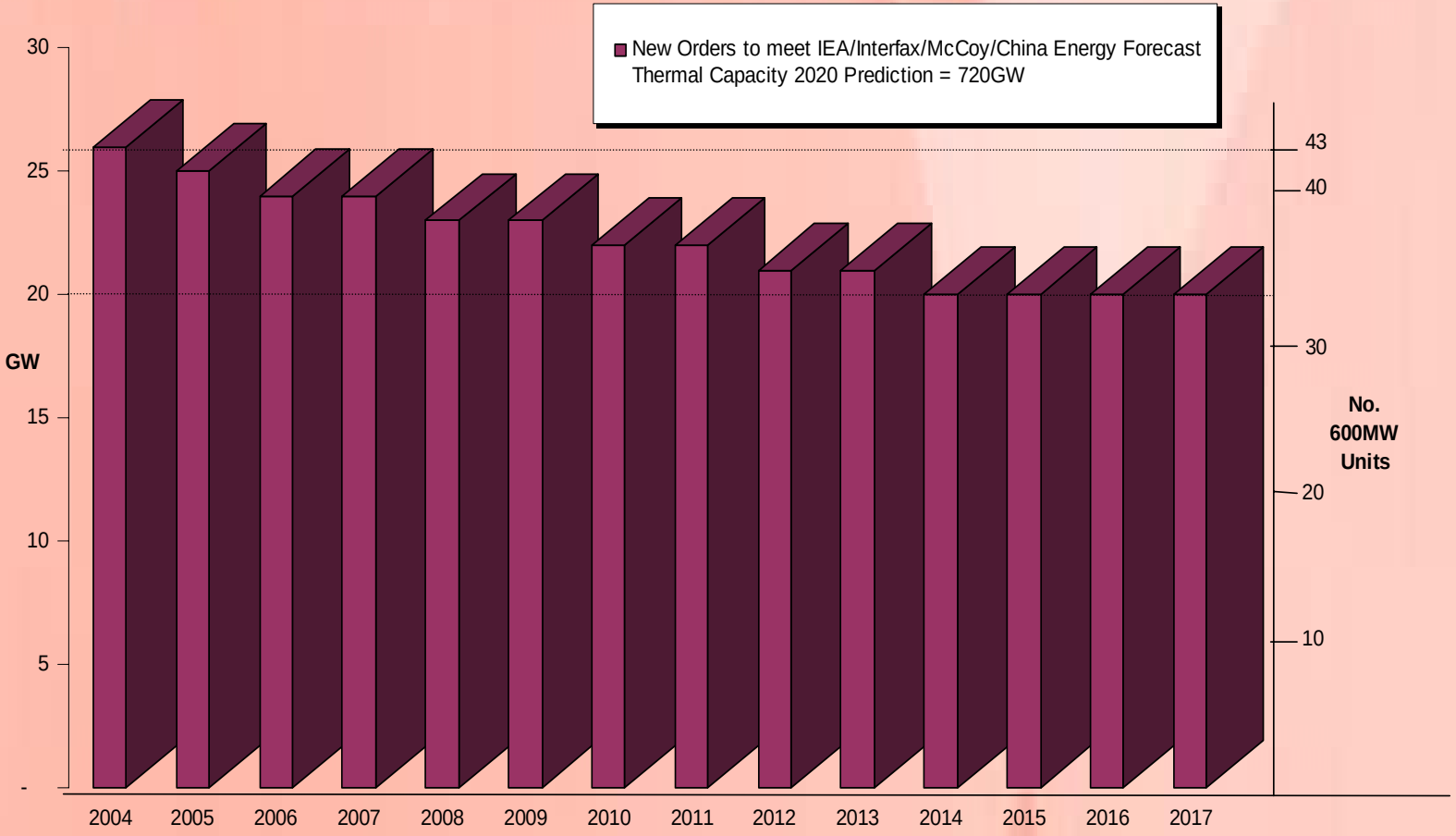


Project funded through JBIC loan to Chinese Government

- **International Bidding competition amongst Babcock Hitachi, IHI, Mitsubishi Heavy Industries, Mitsui Babcock**
- **Supercritical 2 pass boiler selected by Mitsui Babcock**
- **Design Efficiency 41.5% LHV basis**
- **IEA CCC propose to use in G8 case studies**

(Courtesy of Mitsui Babcock)

China – Future Ordering Patterns



India and IEA Clean Coal Centre

- The CCC has a longstanding relationship with Bharat Heavy Electrical Ltd (BHEL) who are India's biggest power plant equipment manufacturer: state owned
- BHEL is a sponsor member of the CCC
- Significant recent reports with Indian aspects
  - Improving Efficiencies of Power plant in Developing Countries (2003)
  - Use of coal in areas of water shortage (2005)
  - Coal Upgrading to reduce CO2 Emissions (2002)

Coal in India

- India has recoverable coal reserves estimated as 92 Gt (cf 247 Gt in the USA, 115 Gt in China and 220,000 in the UK)
- Two-thirds of the coal is used for power generation, and India has acute power shortages in many parts and needs to increase capacity
- India's coals are mainly low grade with a high ash content (40% cf UK or traded coal at 10%) but a low sulphur content (<0.5%)
- Production is 360Mt/y of which 50 Mt is mined underground and 25 Mt is low rank (young) coal
- Investment in power generation capacity is slow. Planned capacity additions in each 5-year plan fall well short of planned additions

Coal in India

- Use of coal washeries to upgrade the coal used would make a significant contribution to increasing plant efficiency and reducing GHGs (and this is probably true in China as well)
- India needs to use clean coal technologies for all new plant, and to upgrade many older ones
- New mega plants are under discussion (up to 4000 MWe size) to be sited either at the minemouth, thus eliminating coal transport, OR on the coast, opening the possibility of importing coal
- About 15 Mt/y of steam coal is imported now, and some estimates suggest that it will be 75 Mt/y by 2010
- Intentions to introduce supercritical PC boilers

Process evaluation and Demonstration Unit (PEDU) (Courtesy of BHEL)

Coal throughput	**18 T / DAY**
Gasifier diameter	**450 mm**
Gasification media	**AIR / Steam mix**
Gasification temp.	**1000° C**
Gasification pr.	**11 kg / cm^2**
Gas calorific value (HCV)	**1050 Kcal / M^3**
Coal size	**1 to 4 mm**

THE END

Thank you for listening

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