



**The 34th International Technical Conference
on Coal Utilization & Fuel Systems
May 31-June 4, 2009**

***Panel: Advanced High Efficient
Coal Fired Power Plants***

***THE STATUS AND DEVELOPMENT OF
SUPERCRITICAL/ULTRA SUPERCRITICAL
UNITS IN CHINA***

Jianxiong Mao

**Department of Thermal Engineering
Tsinghua University, Beijing, China**



China's Installed Capacity & Generated Electricity 2001 2008

Year	Installed capacity MWe	Annual growth rate, □	Generated electricity TWh	Annual growth rate, □	Capacity of thermal power, MWe	Ratio □	Generated electricity TWh	Ratio □
2001	338,490	6.00	1483.9	8.43	253,010	74.75	1204.5	81.17
2002	356,570	5.35	1654.2	11.47	265,550	74.47	1352.2	81.74
2003	391,410	9.77	1905.2	15.18	289,770	74.03	1579.0	82.88
2004	442,390	13.02	2194.4	15.18	329,480	74.48	1810.4	82.50
2005	517,190	16.67	2474.7	12.77	384,130	74.30	2018.0	81.55
2006	622,000	20.27	2834.4	14.54	484,050	77.82	2357.3	81.17
2007	713,290	14.36	3255.9	14.40	554,420	77.42	2698.0	82.86
2008	792,530	10.34	3433.4	5.18	601,320	75.87	2779.3	80.75

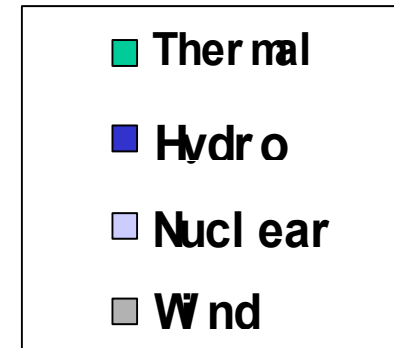
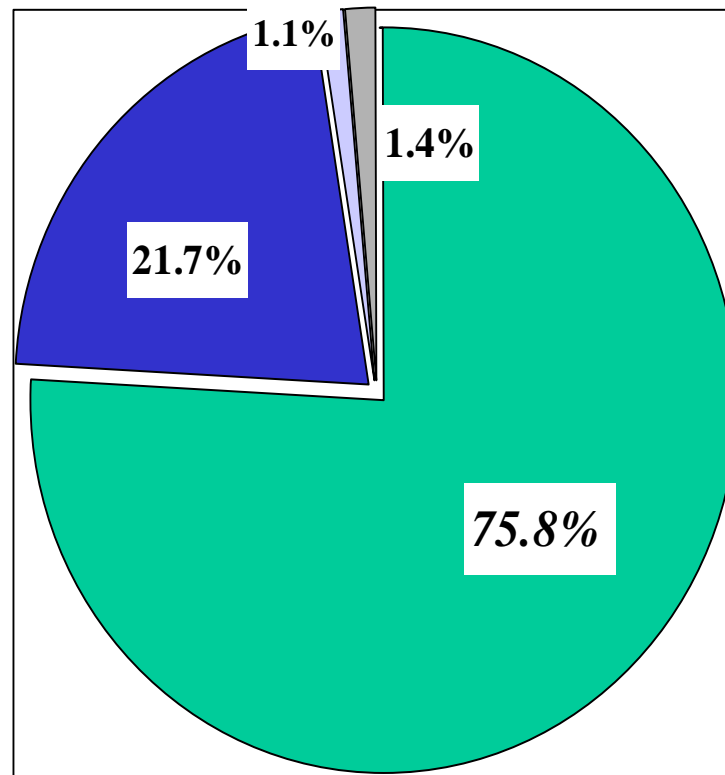
Source: China Electric Power Industry Statistics Analysis, 2008



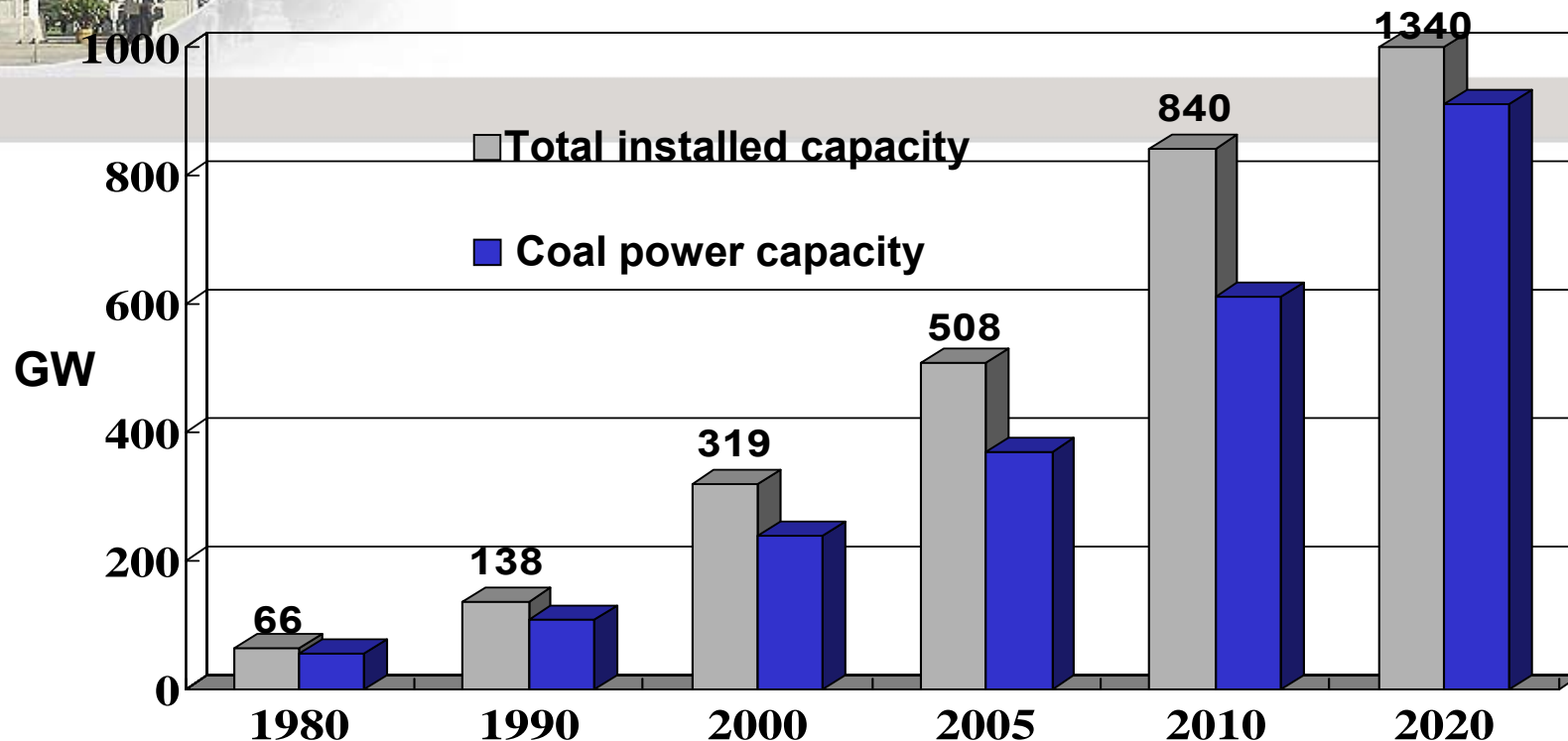
Structure of China's Power Capacity In 2008

Coal power will be in dominant unchangeably for a long time.

China's total Installed capacity in 2008:
792,530MWe



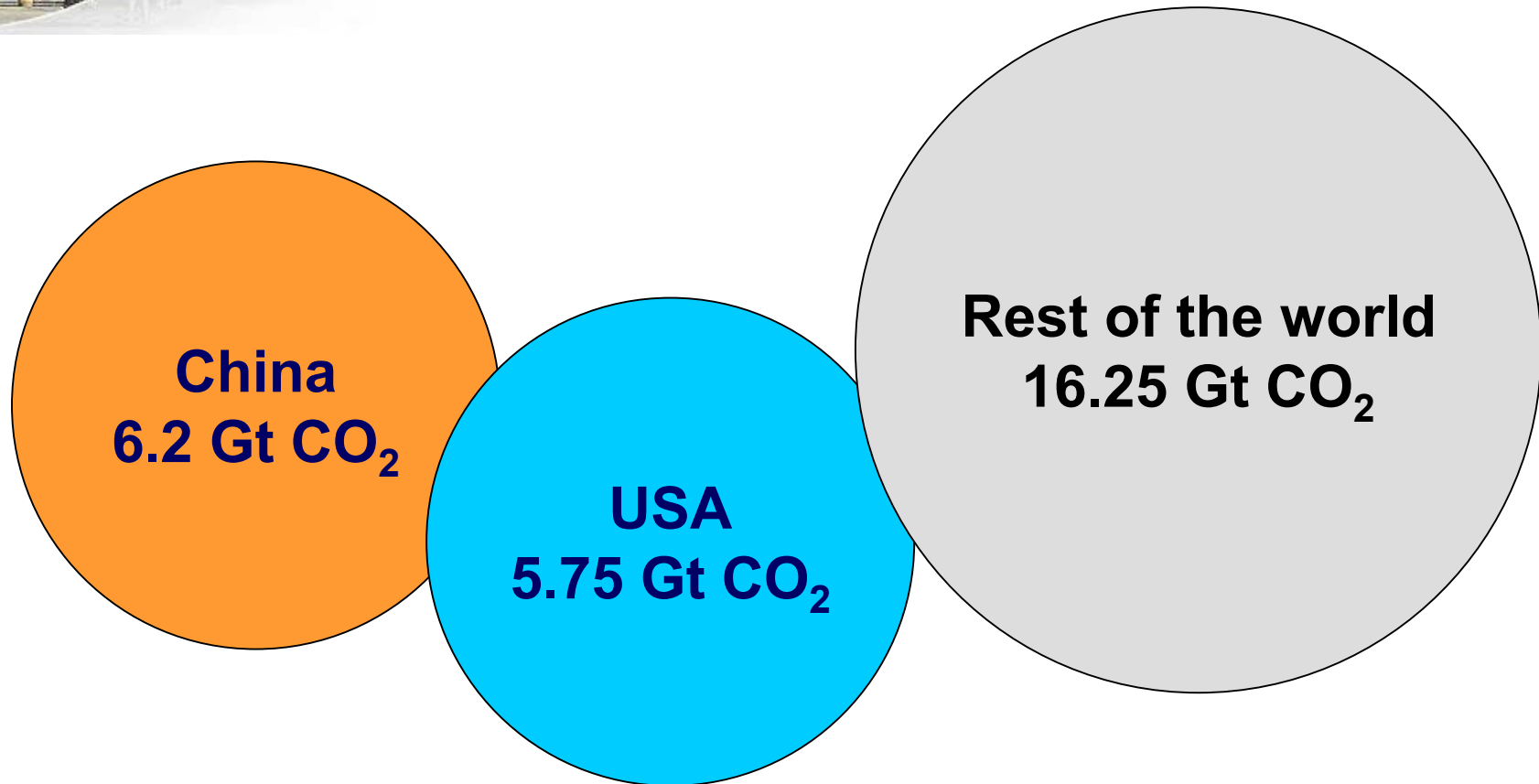
Fast growth Of China's Electric Power Coal Power Will Be In Dominant Unchangeably



- 1850MWe in 1949 and 792,530 MWe in 2008, 428 times of growth in 60 years.
- Total installed capacity for coal power accounted for 76% in 2008.
- Coal power will be in dominant unchangeably for a long time.
- Low efficiency and high emissions are big challenge for China's power sector.



China Has Been The Largest CO₂ Emission Country In The World Since 2007



Source: Netherlands Environmental Agency



Key Issue in China is to Improve Efficiency for Power Generation

Year	2002	2003	2004	2005	2006	2007	2008	World level
Coal consumption (g/kWh)	383	380	376	374	366	357	349	316



Power Efficiency for Different Type of Unit in 2006

Unit capacity MWe	Net coal consumption g/kwh	Net efficiency %	% that of 300MWe
USC 1,000	286.5	43.03	119.0
USC 600	292	42.09	116.4
SC 600	299	41.10	113.7
Sub-critical 300	340	36.15	100
Sub-critical 100	410	29.98	82.9
Sub-critical 50	440	27.93	77.3
Sub-critical 25	500	24.53	68.0
Sub-critical 12	550	22.35	61.8
Sub-critical 6	600+	20.48	56.7

Source NDRC,2007



Structure Of Thermal Power Capacity In China By the end of 2006

Class of capacity (MWe)	Installed capacity (MWe)	Percent of total thermal capacity (%)
600	125,790	26.0
300	82,250	17.0
100-300	130,630	27.0
≤100	114,000	23.6
≤50	91,300	18.9
≤25	51,600	10.7
≤6	21,300	4.4

Source NDRC,2007



The Policy Of “Large Substitutes For Small (LSS)” To Improve Power Efficiency In China

- In 2006, there were **114,000 MWe of small thermal capacity (unit capacity □100MWe)** in China, accounting for 23.6% of total thermal power capacity with low efficiency and high emissions, which was the main cause of low efficiency and high emissions of China’s Thermal power.
- The target of the policy of **LSS** is to finally decommission the 114,000 MWe of small thermal capacity, as first step, the **LSS** program is expected to decommission **about 50% of the small capacity by 2010**, which means, at least **55,000MWe small capacity** must be decommissioned from **2007 to 2010**.
 - Based on the policy of **LSS**, decommissioned capacity of inefficient small size units is the key criteria for a substituting new power project to be included in the national power development plan which is the basis for central government approval of project. For example, a power company has to decommission 840MWe of inefficient small capacity to make itself eligible to get a new project of 2×600MWe SC units approved by the government.
 - For new built thermal power capacity, unit capacity must be 600MWe and above (except CHP) with SC/USC steam parameters. So far, 80% of new orders of thermal power capacity are 600/1000MWe SC/UISC units.



The Scope of Coal Fired Units Which Must Be Decommissioned

Based on the target of nationwide energy saving of 20% by 2010, for power sector, at least 50% of inefficient small coal fired units with total capacity of **55,000MWe** must be decommissioned **by 2010**, which including:

- 1 All the coal fired units with unit capacity 50MWe
- 2 All the coal fired units which have been in operation more than 20 years
- 3 All the coal fired units with unit capacity of 200MWe which operation time has been longer than their design life time
- 4 All the coal fired units which coal consumption has been 15% greater than nationwide average coal consumption in 2005
- 5 All the coal fired units which emissions can not reach national emission standards
- 6 All the coal fired units which do not accord with law and code for thermal power units.



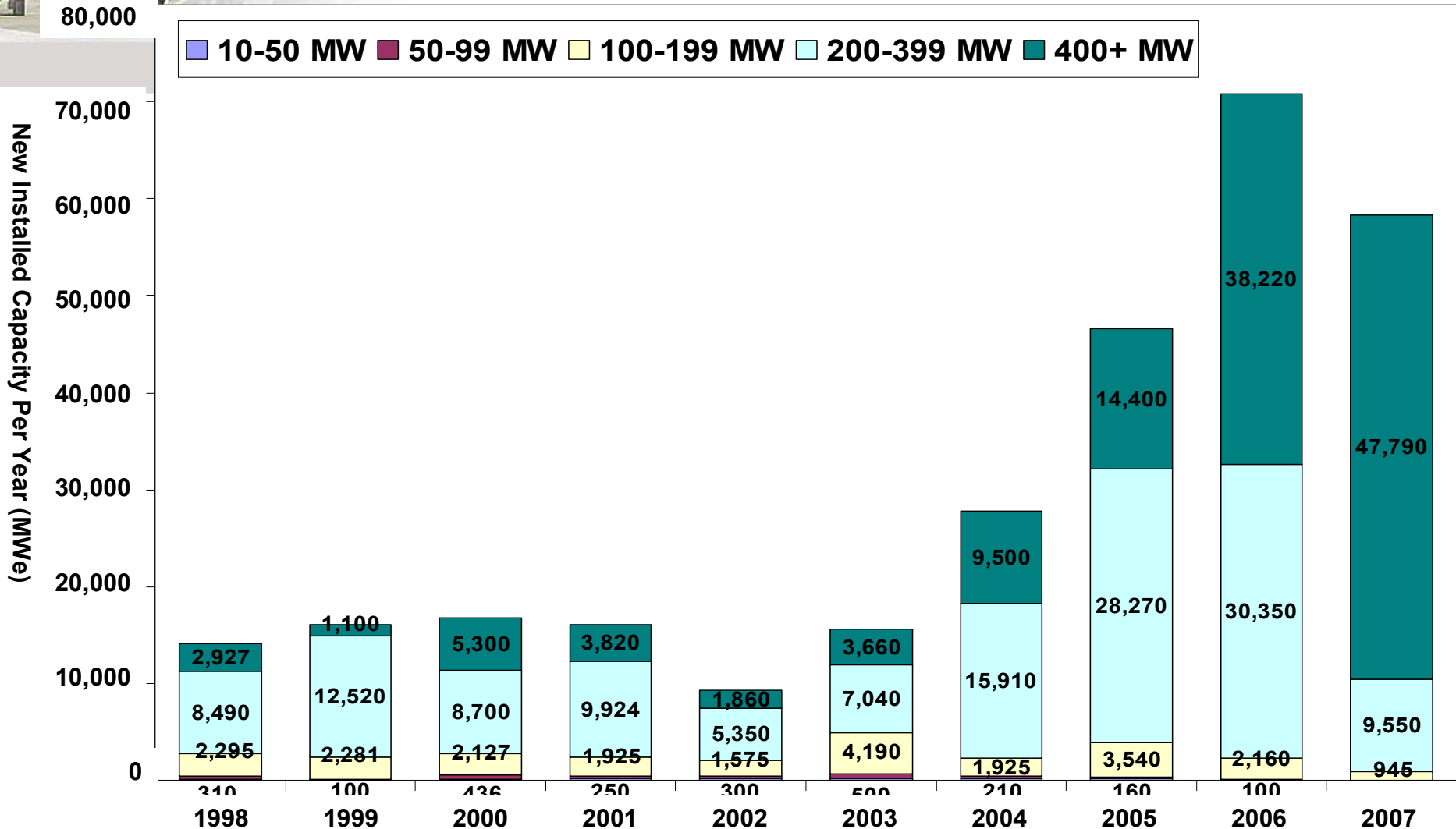
Remarkable Success Of The Policy Of LSS

Since the implementation of the policy of LSS In 2007, **34,200MWe of inefficient small capacity** were decommissioned from 2007 to 2008. Net increase of thermal power capacity with high efficiency was **108,270MWe** which made the nationwide average coal consumption for power generation reduced from **366 gce/kwh** in **2006** to **349 gce/kwh in 2008**, net reduction of average coal consumption was **17 gce/kwh** in 2 years;

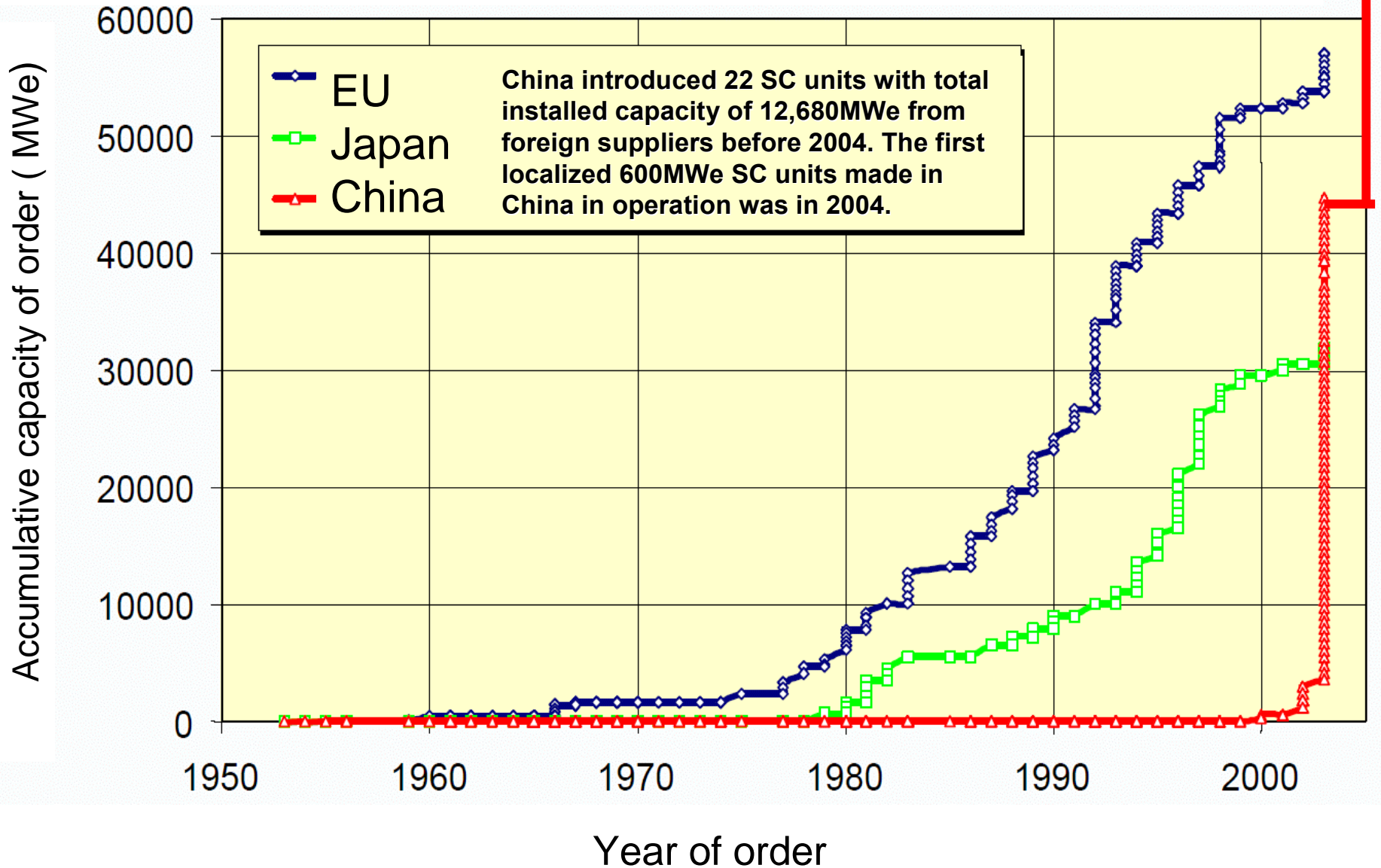
- All the capacity of removed small units has been substituted by high efficient large size units;
- Remarkable success of the policy has been achieved, annual reduction of **of standard coal consumption** was **43 million tons** and **60 million tons of CO₂ emissions** have been reduced since the implementation of the policy.
- There is still some **100,000MWe of inefficient small capacity** (**12%** of total installed capacity) which should be decommissioned in the next few years, to further push LSS forward to adjust the structure of China's power capacity is still the key to further improve power efficiency and reduce emissions in China.



Change Of The Structure For New Installed Thermal Capacity Due To LSS



Comparison Of orders For The Capacity Of SC Units In The World (Except The US)



List Of SC Units Introduced From Foreign Suppliers Before 2004
Total 22 Units with Total Installed Capacity of 12,680MWe

No.	Name of plant	Parameters MWe/PMa/°C	Design coal consumption gce/kwh	Contry of supplier	Date in operation M/D//Y
1	Huaneng Shidongkou,No2	2 ×600MWe 24.4/541/569	295	USA Switzerland	6/12/92
2	Huaneng Nanjing	2 ×320MWe 25.4/545/545		Russia Ukraine	3/10/94
3	Guohua Panshan	2 ×500MWe 23.5/545/545	324	Russia	12/95,5/96
4	Huaneng Yingkou	2 ×320MWe 25.4/545/545		Russia Ukraine	1/12/96
5	Huaneng Yiming	2 ×500MWe 25/545/545	335	Russia	11/98,9/99
6	Fujian Houshi	2 ×600MWe 24.7/571/569	298	Japan	03/00-07/04
7	Suizhong	2 ×800MWe 25.4/545/545		Russia	12/99,9/00
8	Shanghai Waigaoqiao	2 ×900MWe 25.4/545/545		Germany	4/9/04
9	Shanxi Wangqu	2 ×600MWe 24.7/571/569	298	UK Japan	8/06



Large Size Units in Operation in 2007

The capacity of unites with unit capacity >300MWe was 332,673MWe, accounting for~60□ of total thermal capacity

Type of units	Number of units	Coal consumption (g/kwh)	Net efficiency %
USC 1000MWe 7000MWe	7	285.6	43.03
USC 600MWe (1200MWe	3	292	42.09
SC 600MWe class 90,680MWe	112	299	41.10
Sub-critical 300MWe class □162,793MWe□	540	340	36.15
Sub-critical 600MWe 71,000MWe MWe	118	331	37.12



Statistic Of SC/USC Units In China In 2007

Item	In operation		Under construction	New Ordered	
Total Capacity	99,480MWe		>100,000MWe	82,400MWe	
Type of units	SC	USC	SC/USC	SC	USC
Capacity (MWe)	90,680	8,800	>100,000MWe	25,400	57,000
Number of units	112	10	> 167 (Equivalent to 600MWe)	66	65



Statistics of USC Units In China By May 2008

Item	1000MWe		660MWe		600MWe	
	No.	Capacity MWe	No.	Capacity MWe	No.	Capacity MWe
Harbin	16	16,000	18	11,880	10	6,000
Shanghai	36	36,000	16	10,560		
Dongfang	28	28,000	10	6,600		
Beijing B&W	4	4,000	2	1,320	4	24,00
Sub-total	84	84,000	46	30,360	14	8,400
Total	Total number of ordered USC units were 144 by May,2008			Total capacity of ordered USC units were 122,760 MWe by May,2008		

China's New SC/USC Power Plants

*Huaneng Qinbei Power Plant 2×600MWe SC
China's first Localized SC Units in operation in 2004 and 2005*



*Huaneng Yuhuan Power Plant 2×1000MWe USC Units
China's first Localized 1000MWe USC Units in operation in 2006*



Shandong Zouxian Power Plant 2×600MWe SC 2 ×1000MWe USC Units



Shanghai Waigaoqiao Power Plant 2×900MWe SC+2×1000MWeUSC Units





Shanghai Waigaiqiao No.3 Power Plant

Performances of 2×1000MWeUSC Units reaching World Advanced Level

- **Performance test results measured in May 2008 for 2×1000 MWe USC units:**
 - **Power consumption rate with FGD 3.7%**
 - **Net coal consumption with FGD g/kWh : 272.6/272.9**
China's average in 2007: 357; world highest level 289
 - **Net efficiency for power supply with FGD: 45%**
 - **Net heat rate kJ/kWh 7239.3/7241.2**
 - **Boiler efficiency > 94%**
 - **Average LOI of boiler 0.1%**
 - **Lowest turndown ratio without oil support for boiler: 10%**



Main Design Parameters Of Localized SC/USC Units In China

Type of unit	Maximum output t/h/MWe	SH Pressure MPa	SH temperature °C	RH temperature °C	Efficiency/ heat rate %/kJ/kWh
600MWe SC boiler SC turbine	2100t/h 2100MW	25.4 24.2	571 566	577 566	~94% 7545kJ/kWh
600MWe SC boiler USC turbine	1850t/h 640MW	26.2 25.0	605 603	603 600	~94% 7424kJ/kWh
1000MWe USC boiler USC turbine	3000t/h 1005MW	28.0 26.25	605 600	603 600	~94% 7420kJ/kWh



Comparison Of Performances Between Different Type Of Units Made In China

Item	Sub-critical 2×600MWe	SC 2×600MWe		USC 2×1000MWe
Steam parameters	16.7MPa/ 538/538°C	24.5MPa/ 538/566°C	24.5MPa/ 566/566°C	27.5MPa/ 600/600°C
Heat rate (Kcal/kwh)	1877	1830	1780	1772
Efficiency ()	41.97	42.91	43.63	45.01
Coal consumption (gce/kwh)	293	286	282	272.9
Increase of efficiency ()	0	+2.2	+4.0	+7.2

Source: CEC 2008



Comparison Of Capital Investment For SC/USC Units In China in 2007

Type of unit	Static investment US\$	Specific static investment (US\$/kw)	Increase rate
Sub-critical units 2×600MWe	595.05 M	495.88	0
SC units 2×600MWe	618.86M	551.47	4
USC units 2×1000MWe	1027.94M	514.26	3.6

Note 1.Above total investment not includes FGD.

2.Exchange rate of RMB/US\$=6.8

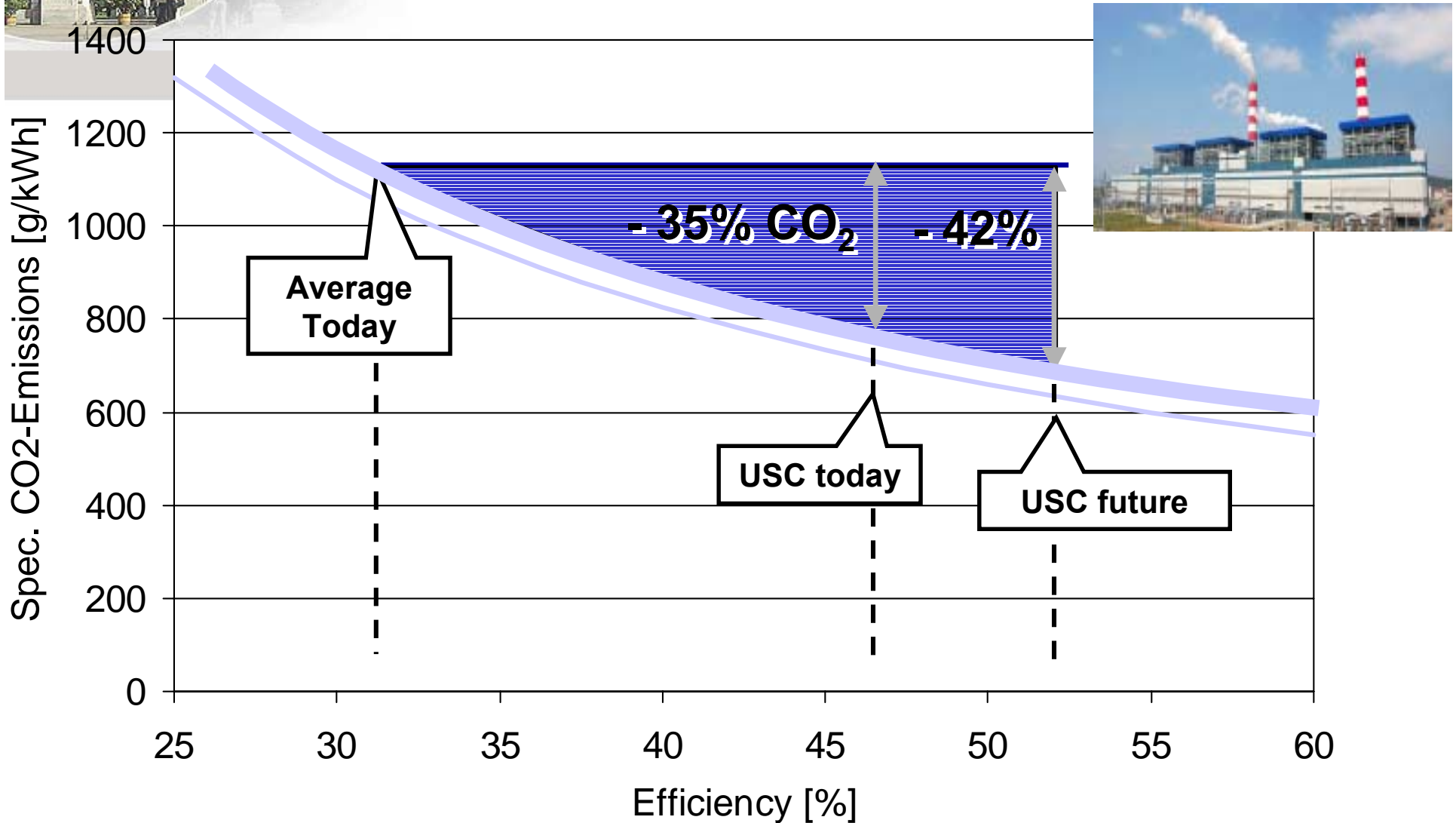


Reliability Index Of SC/USC Units In China In 2007

Unit capacity	Statistic units	Utilization hours (hours/unit.year)	Unscheduled trip times/unit.year	Trip hours hours/unit.year	Equivalent availability
320MWe (sub-critical)	4	6475.5	0.5	37.28	93.31
500MWe (SC)	4	5877.26	0.75	37.83	87.99
600/670MWe (SC)	40	5533.8	1.25	21.79	93.72
800MWe (SC)	2	6541.81	1	22.77	88.88
1000MWe (USC)	3	5244.26	3	31.76	95.54
Total	53	5615.63	1.25	24.38	93.28

The Role of SC/USC Before CCS is Ready

Carbon Dioxide Emissions VS Net Plant Efficiency





China Is Moving Quickly Towards Developing And Demonstrating CCS Technologies Activities Of Domestic Development

□ R&D programs of CCS:

R&D programs supported by China's High Tech Programs such as 863 and 973:

- Tsinghua University (Beijing): Post combustion capture;

Oxyfuel for PC boiler; enhanced oil recovery (EOR)

Policy, system and economic analysis of CCS

- Huazhong University of Science and Technology (Wuhan):

Oxyfuel for PC boiler

- Southeast University (Nanjing): Oxyfuel CFB boiler, coal based CLC

- GreenGen (Huaneng): Pre-combustion (IGCC)

□ Pilot plant/demonstration projects of PCC:

- Huaneng Power Group's post-combustion capture (PCC) pilot project of 3,000 tons of CO₂ per year at Gaobeidian power plant in suburban Beijing (operation in 2008)

- Huaneng Power Group's new PCC test project of 150,000 tons /year of CO₂ will be built at Shanghai Shidongkou Power plant 2011.



China Is Moving Quickly Towards Developing And Demonstrating CCS Technologies

Activities Of International Cooperation

- **China-UK: Near Zero Emissions Coal Project (NZEC)**
- **China-EU: Cooperation Action within CCS China-EU(COACH)**
- **China-EU: STRACO2 project China-USA: Guidelines for Safe and Effective CCS in China**

Tsinghua University and **World Resources Institute (WRI)** have prepared a draft of Guidelines for Safe and Effective CCS in China. This effort is being funded with support from the U.S. Department of State under the Asia Pacific Partnership

- **China-Japan : Enhanced Oil Recovery (EOR) project:**
Daqing Oil Field and **RITE** will jointly engineer to capture 3-4 million tons of CO₂ per annum from two 600 MWe coal-fired power plants, retrofitted for post-combustion CCS and linked by pipeline to a near-by mature oil field to enhance oil production by 30-40 000 barrels per day

China's First Carbon Capture Trial Is Being Rated A Success By China Huaneng Power Company

Huaneng Beijing Gaobeidian Power Plant



Huaneng's post-combustion capture (PCC) pilot plant

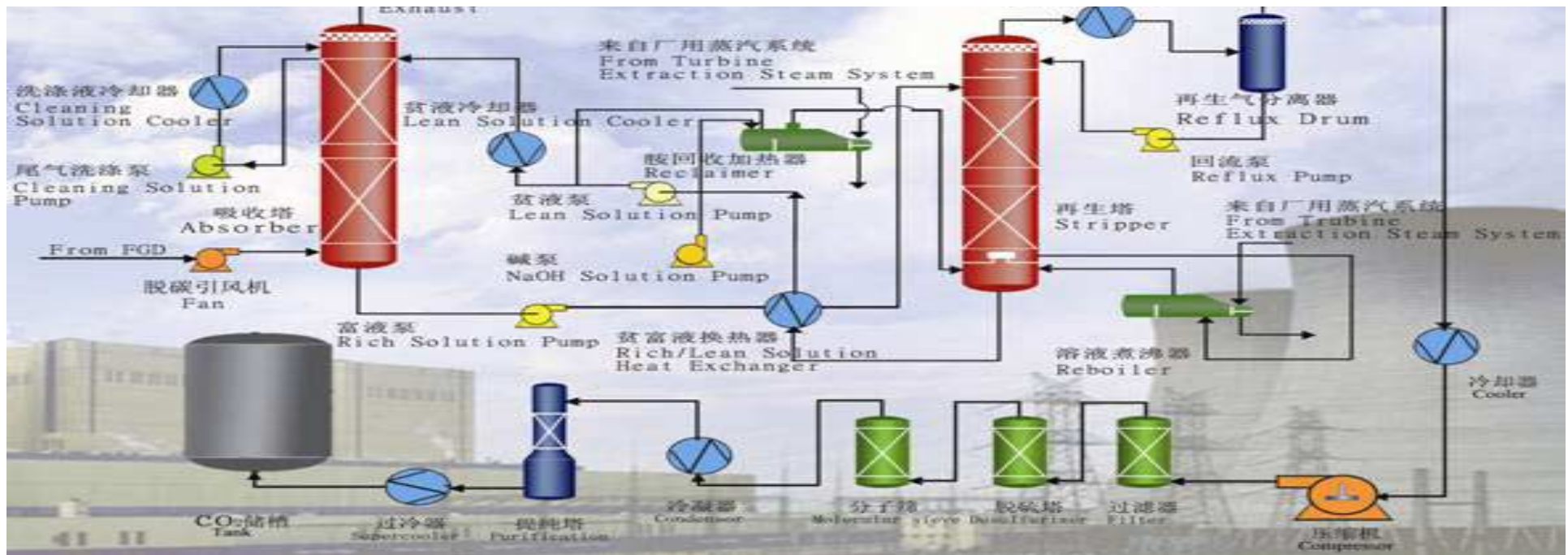


Huaneng's post-combustion capture (PCC) pilot project started in June 2008 at the company's Gaobeidian power plant in suburban Beijing, removing CO₂ after coal combustion. The investment of this project is 20 million RMB (2.95 million USD)

Source: Huaneng Group 2008

CO₂ capture demonstration project in Huaneng

Beijing Gaobeidian Thermal Power Plant



- The technology of Huaneng's pilot plant uses amino alcohol solvents to capture CO₂ from power plant flue gases and has the potential to reduce CO₂ emissions from existing and future coal-fired power plants by more than 85%. The Huaneng pilot plant is designed to capture 3,000 tons of CO₂ per year, CO₂ purity is 99.5%;

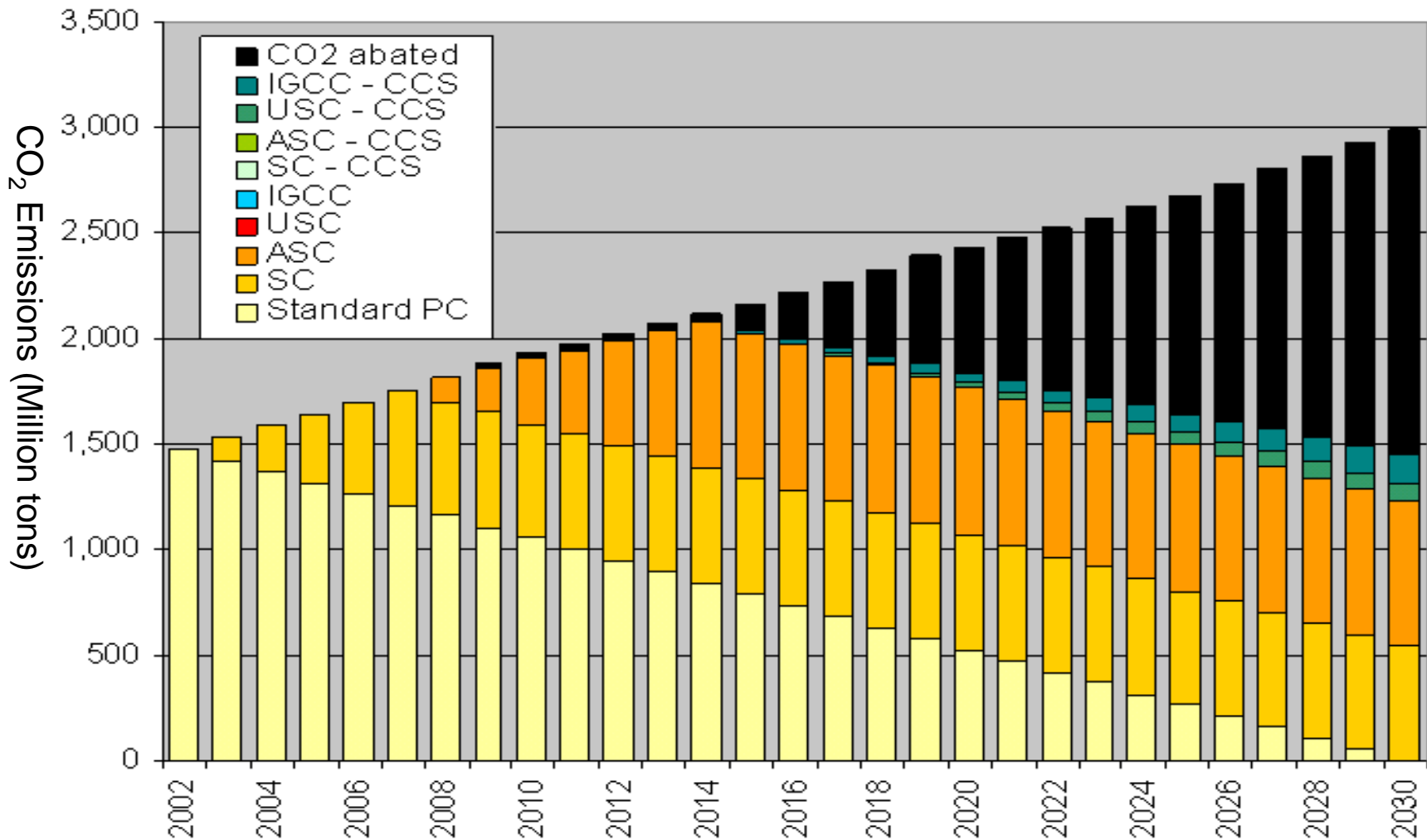
The design parameters of the pilot plant are:

- Flue gas flow to pilot unit: 2000-3000 Nm³/h
- Steam consumption: 3GJ/t CO₂
- Solvent consumption: < 1.35 kg/t CO₂

Source: Huaneng Group 2008



UC/USC Will Play Tremendous Role In CO₂ Reduction For Coal Fired Power Plants In China





Conclusions

- Coal is dominant in China's energy structure and power generation as well;**
- Low efficiency and high emissions are the big challenges for China's power sector;**
- The realistic and available solution is to improve power efficiency as high as possible, to close down inefficient small units and substitute with large size of SC/USC units (LSS);**
- The way forward to go for China is to persist in LSS to make SC/USC be dominant before CCS is ready.**



***Thank you for
Your Attention!***