Malaysia Power 2003

Kuala Lumpur 28. – 29. April 2003

Supercritical Steam Power Plants - an Attractive Option for Malaysia?

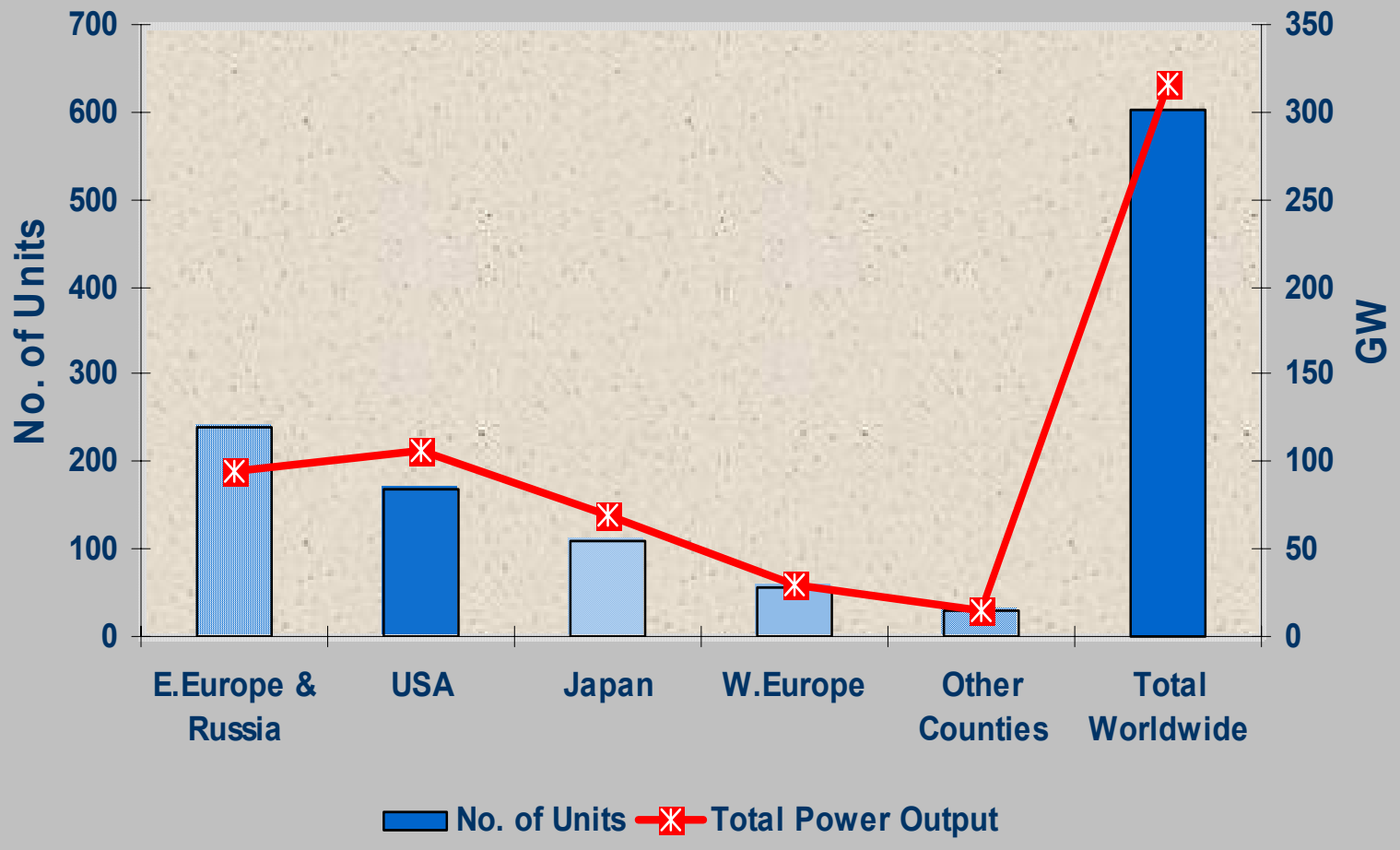
Miro R. Susta
IMTE AG Power Consulting Engineers
Switzerland

Peter Luby
INGCHEM Technical Advisory Services
in Power Generation
Central Europe

Advanced Coal Fired Power Generation Technologies

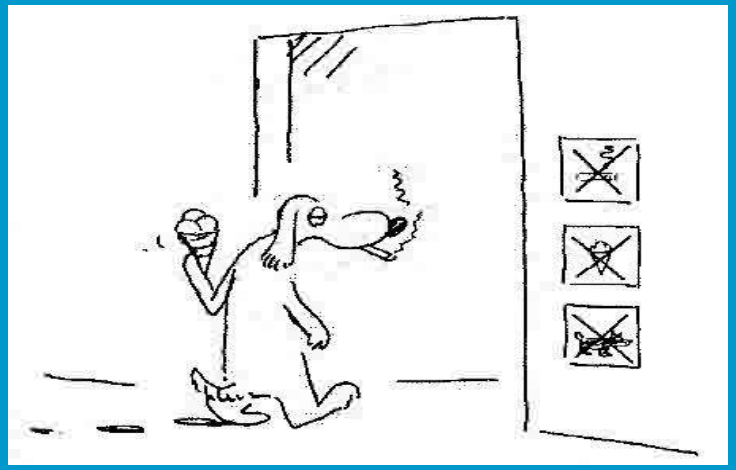
- Supercritical Steam (SC)
- Ultra-SC (USC)
- Pressurized Fluidized Bed Combustion (PFBC)
- Integrated Gasification Combined Cycle (IGCC)
- Hybrid Combined Cycle (HCC)
- Direct Coal fired Combined Cycle (DCCC)
- Molten Carbonate Fuel Cell (MCFC)
- Magneto Hydrodynamics (MHD) Power Generation

SSC Power Plants Worldwide

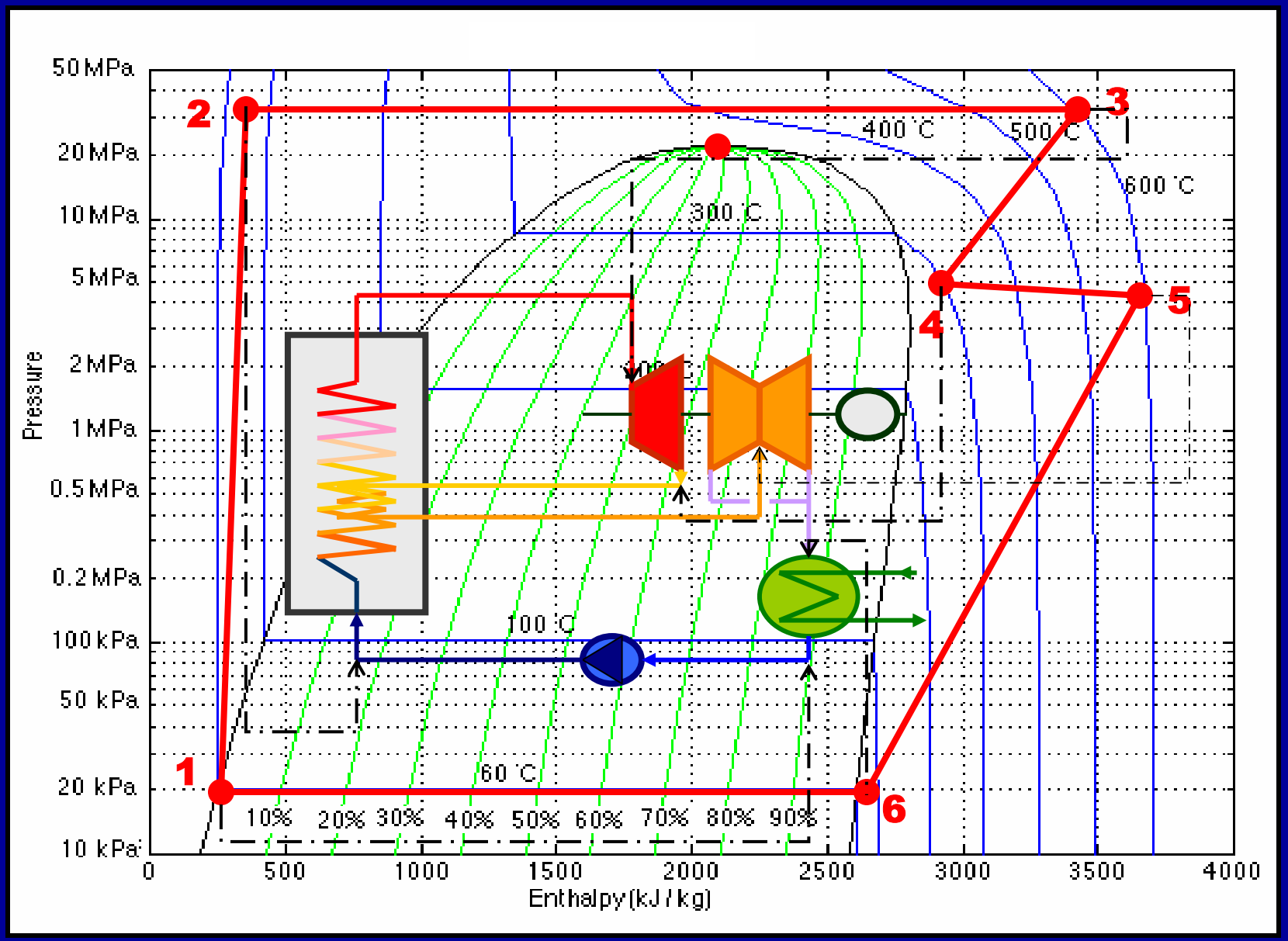


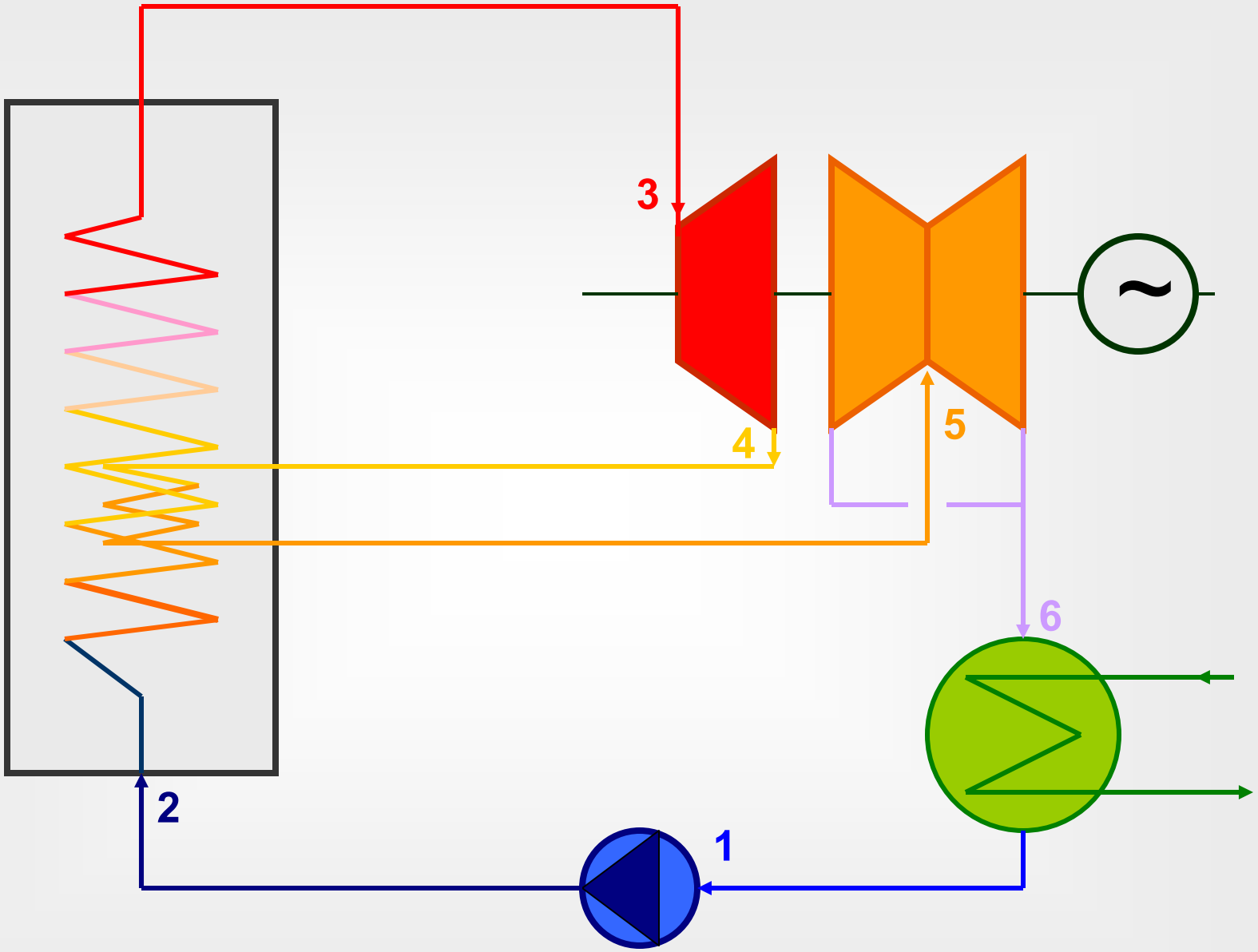
What is Supercritical?

What is Supercritical?

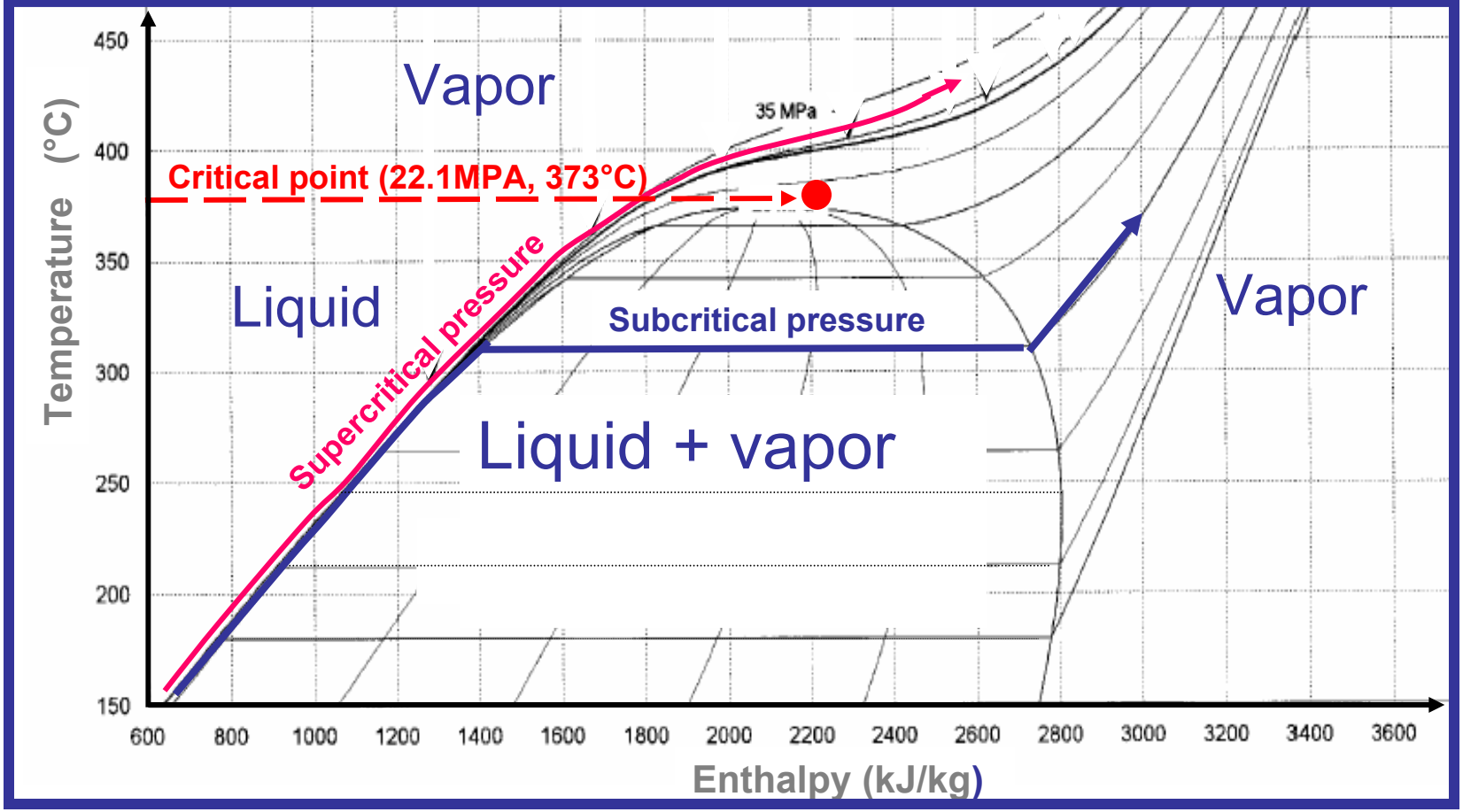


What is Supercritical?


50 MPa
20 MPa
10 MPa
5 MPa
2 MPa
1 MPa
0.5 MPa
0.2 MPa
100 kPa
50 kPa
20 kPa
10 kPa
Pressure
0
500
1000
1500
2000
2500
3000
3500
4000
Enthalpy (kJ / kg)
400 °C
500 °C
600 °C
300 °C
100 °C
60 °C
10%
20%
30%
40%
50%
60%
70%
80%
90%
1
2
3
4
5
6



Isobaric processes in either subcritical or supercritical regime



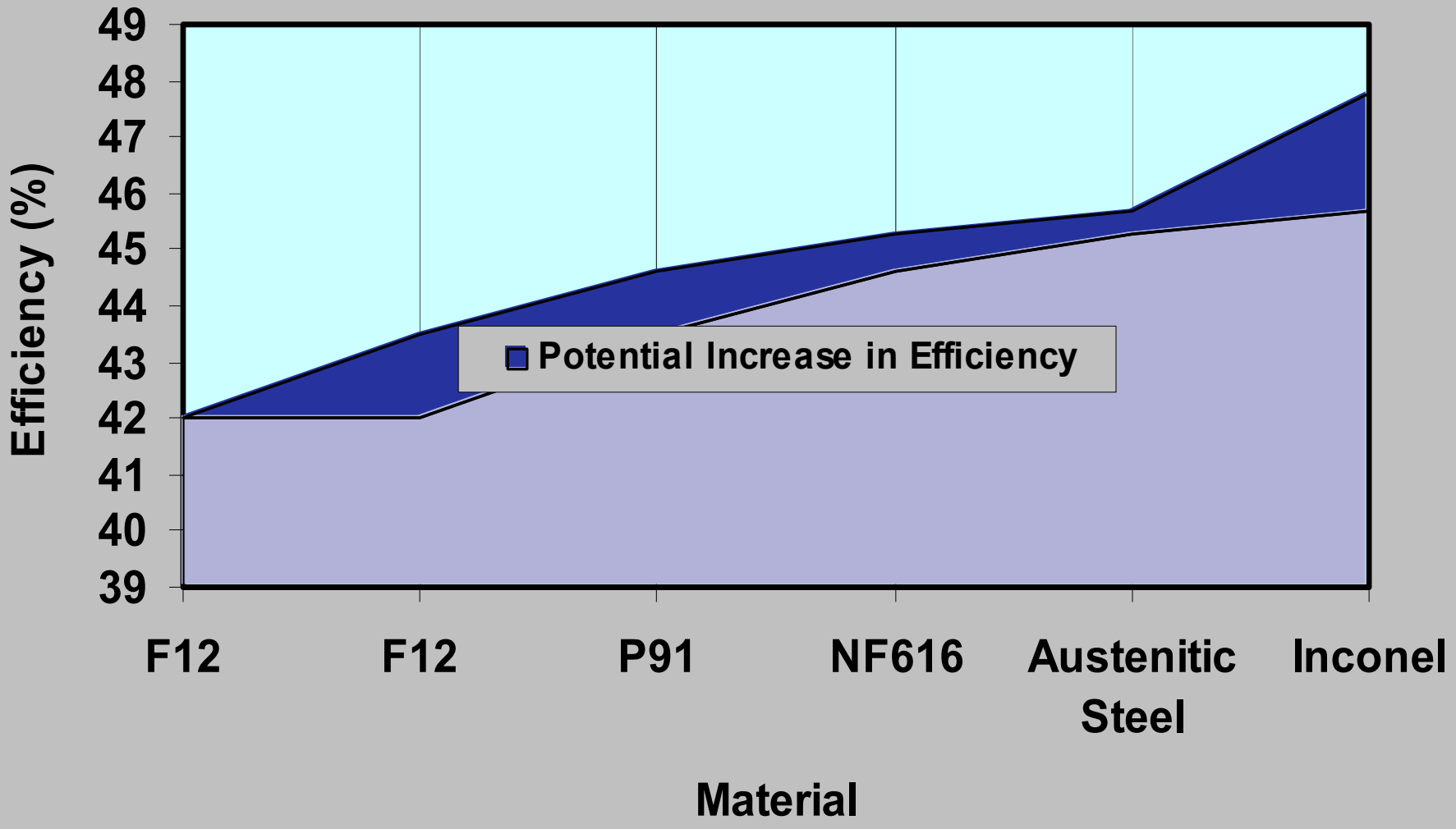
Supercritical vs. Conventional

Plant Type	Price (US$/kW)	Steam Pressure (MPa)	Steam Temperature (°C)	Auxiliary Consumption (%)	Efficiency (%)	CO_2 (g/kWh)	SO_2 (g/kWh)
Conventional	1100	165	538 / 538	4-6	< 40.0	≈ 855	≈ 2.4
580°C - SC	1300	290	580 / 580 / 580	5-7	> 42.0	≈ 780	≈ 2.2
700°C - SC	1350	365	700 / 700 / 700	6-8	> 48.0	≈ 710	≈ 2.0

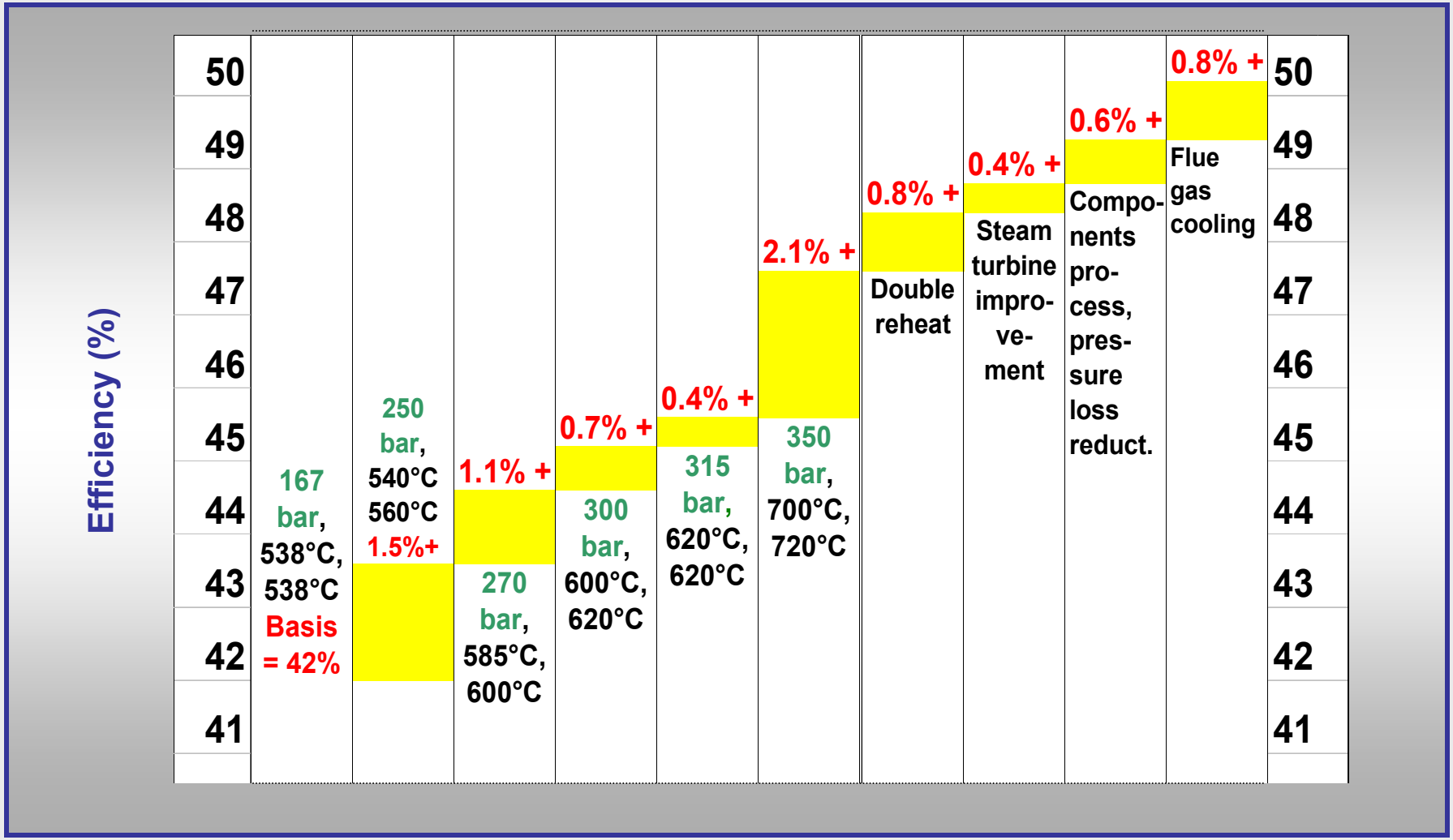
- Both, conventional (subcritical) and SC technology is commercially available in wide range of size.
- Compared with conventional power plant, SC technology with higher efficiency and consequently lower specific flue gas throughput is much cleaner method of electricity generation.
- Conventional technology however, provides greater coal flexibility.
- Higher temperatures encountered in SC units' makes corrosion more critical, thus coals with slugging or corrosion potential are less suitable for SC plants.

State-of-the-art SC power plants have an efficiency of about 46% and satisfy current emission standards worldwide.

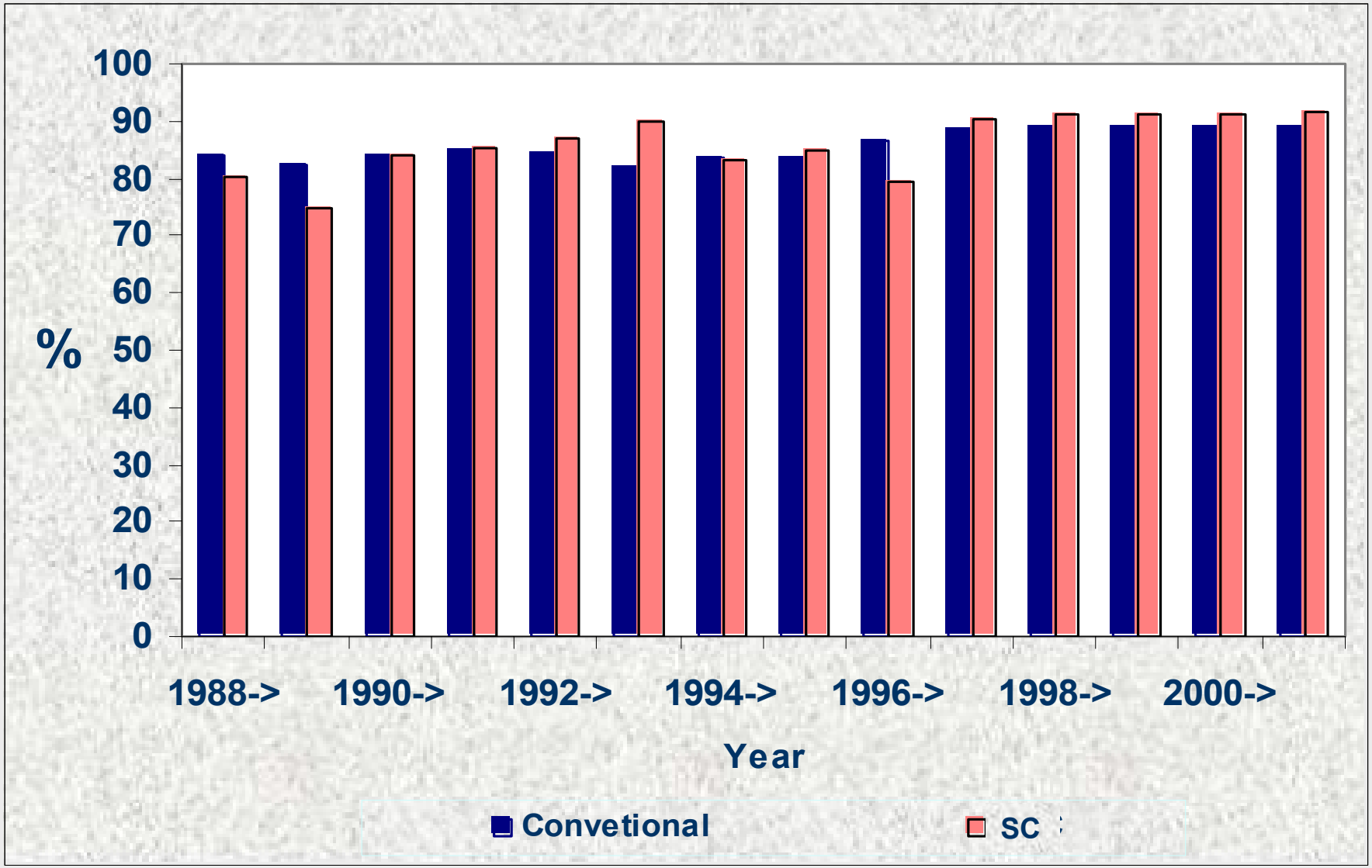
Potential Increase in Efficiency through new Materials and Steam Parameters



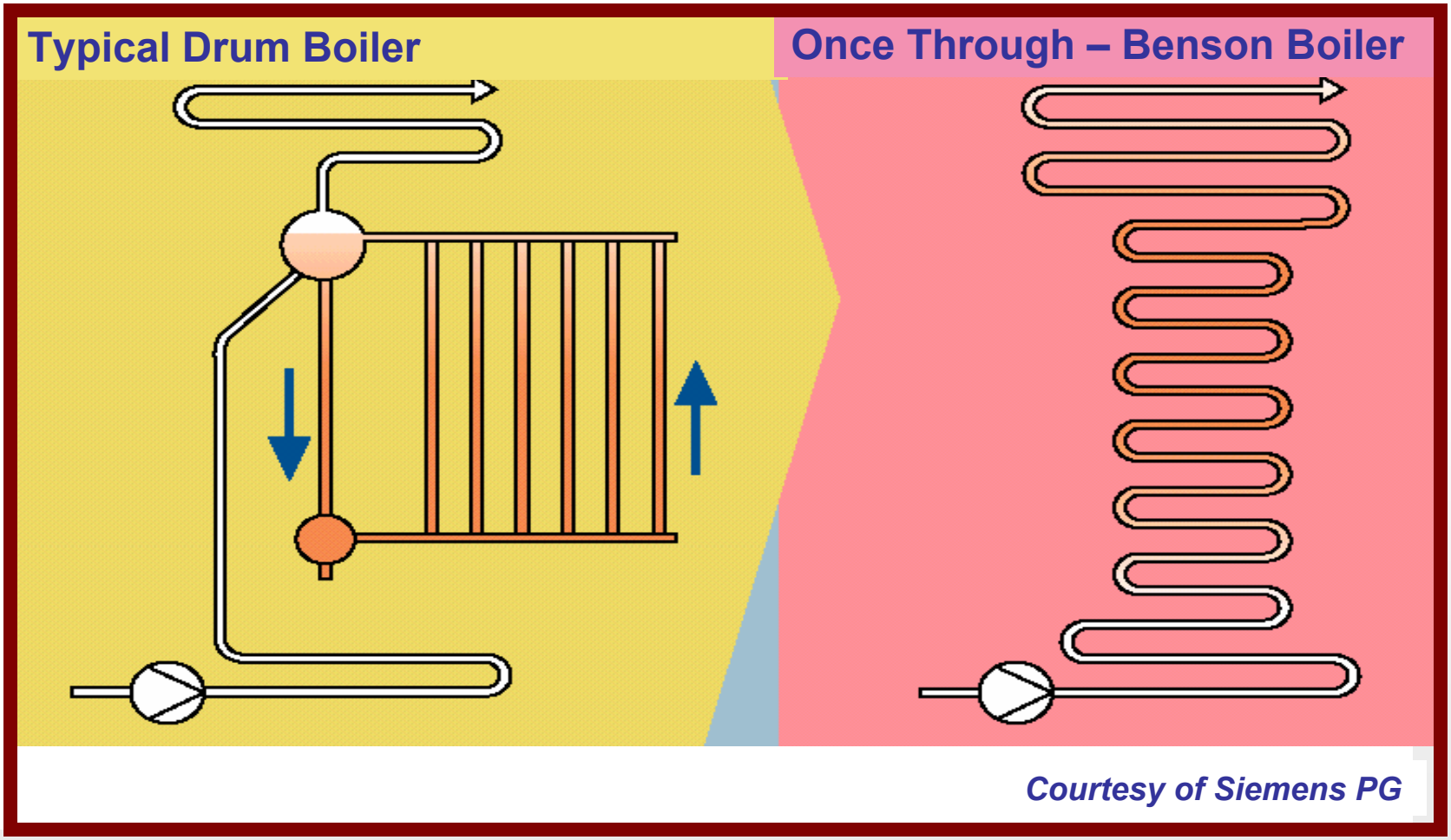
Efficiency Improvement Potential for Coal fired Steam Power Plants



Power Plant Availability ** Conventional vs. SC

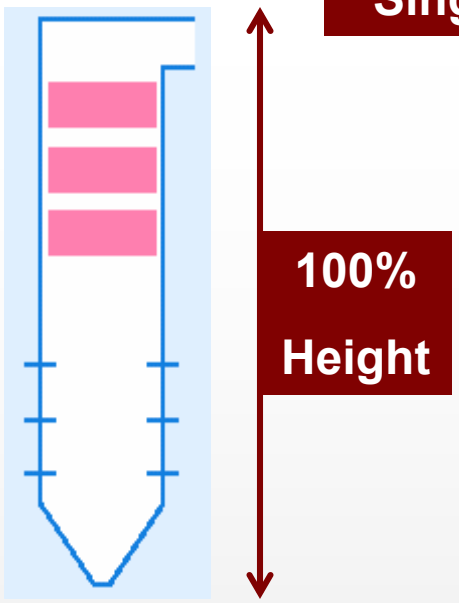


Basic Alternatives of Boiler Arrangement



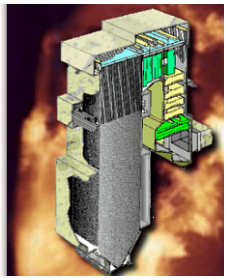
Benson Boiler – Basic Configurations

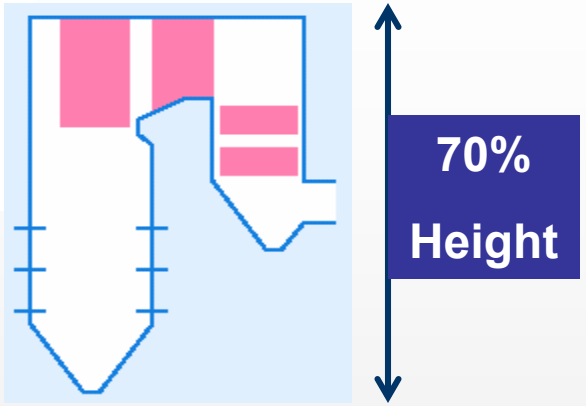
Single-pass



- Simple construction of membrane walls
- Lower erosion of heating surfaces by ash
- Smaller built-up area

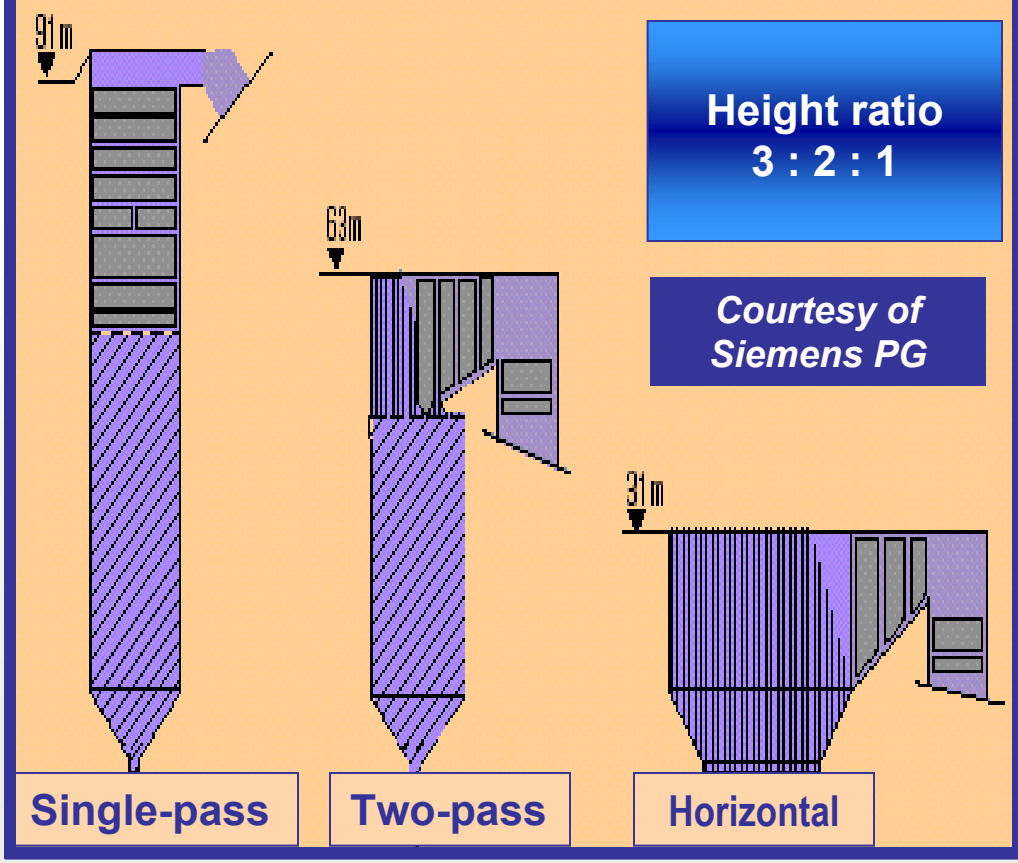
Two-pass



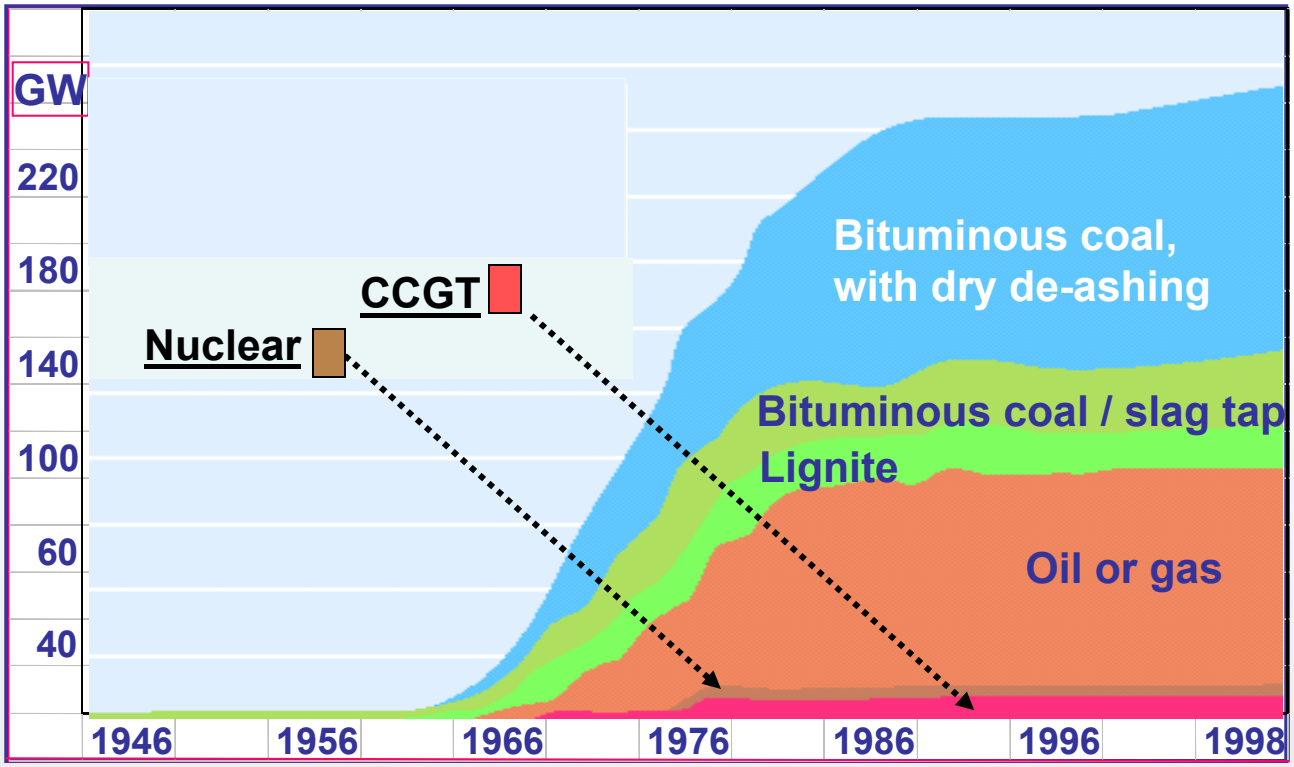


- Dimensioning of convection section independent of furnace
- Shorter assembly times due to parallel assembly of first and second pass
- Lower overall height

Height Comparison of 500MW Coal Fired Boilers

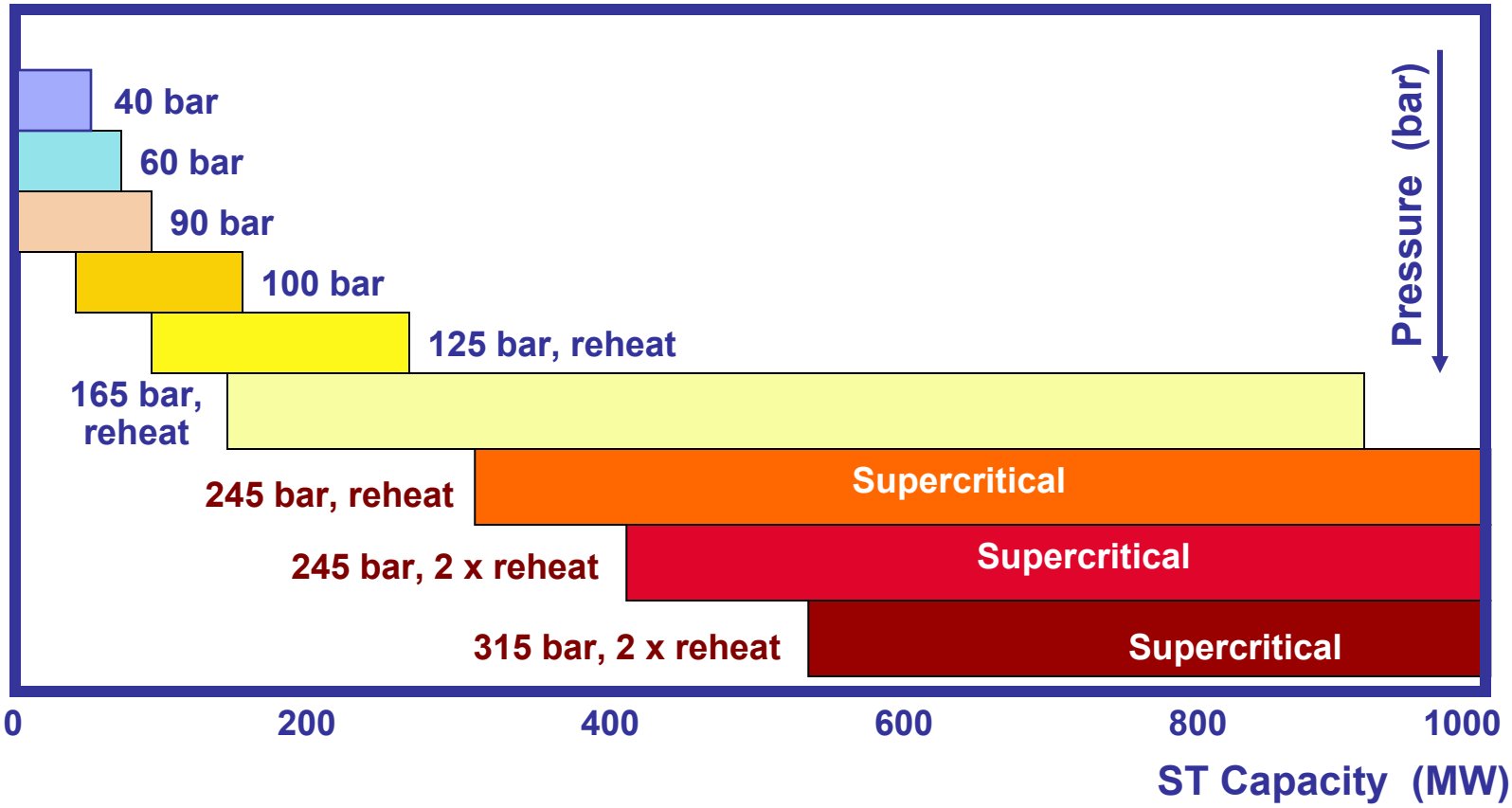


Cumulative Steam Capacity of Worldwide ordered Benson Boilers



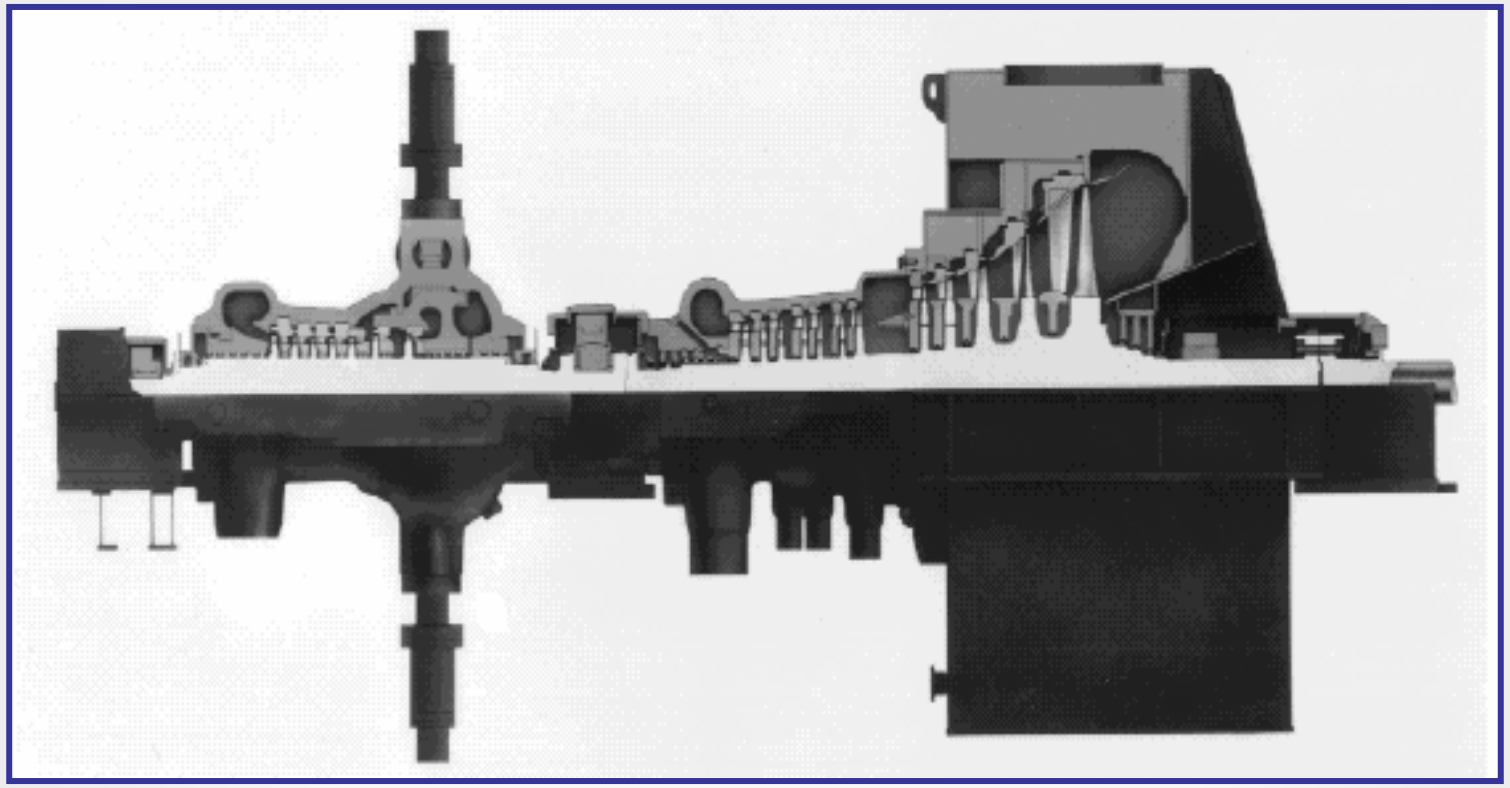
Courtesy of Siemens PG

Common Steam Turbine Capacities vs. Live Steam Pressure



Tandem Compound Steam Turbine

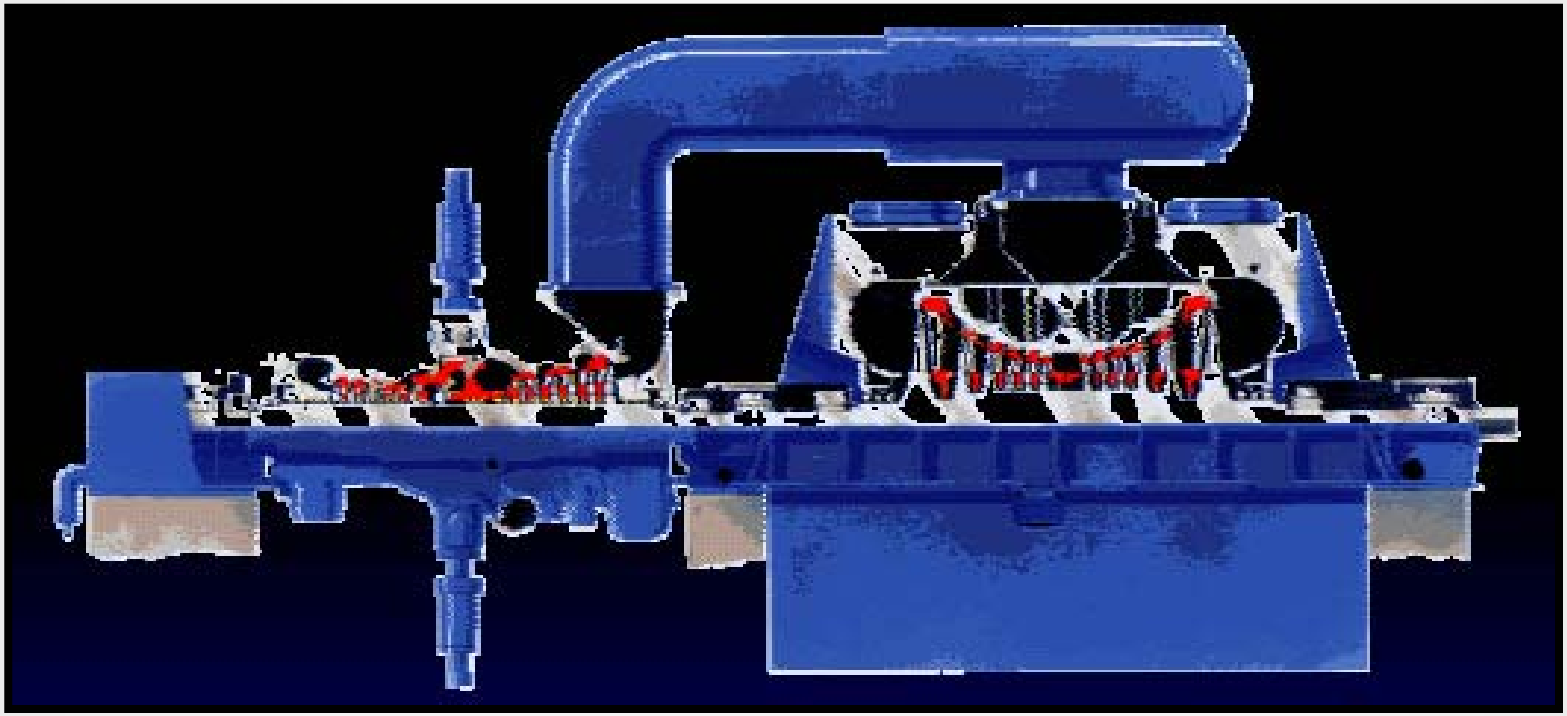
Two-Casing * Single-Flow



Applicable for the smallest utility ratings.

Tandem Compound Steam Turbine

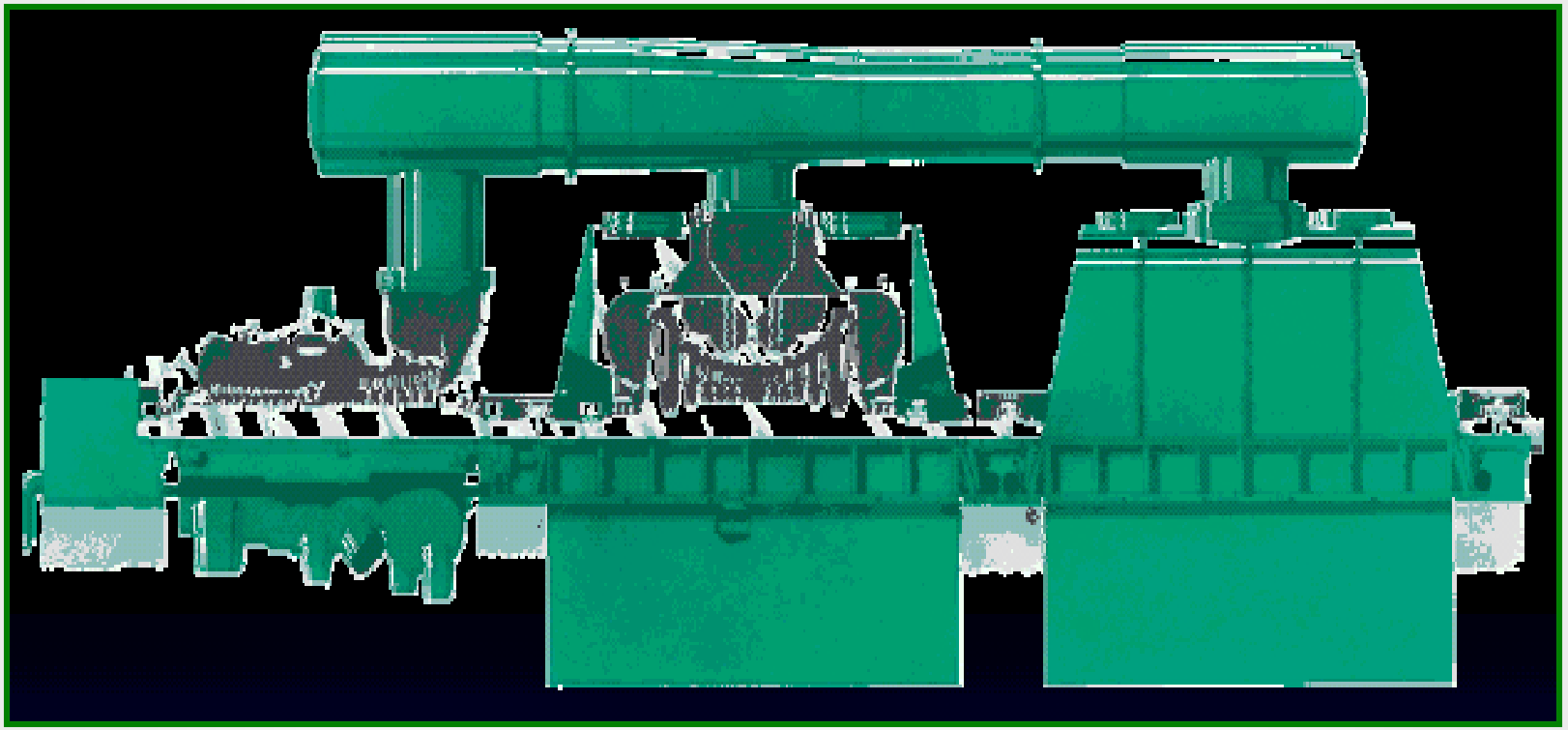
Two-Casing * Double-Flow * LSB 750 mm –1000 mm * 170 bar / 565°C / 565°C



Applicable for 300 – 500 MW Units

Tandem Compound Steam Turbine

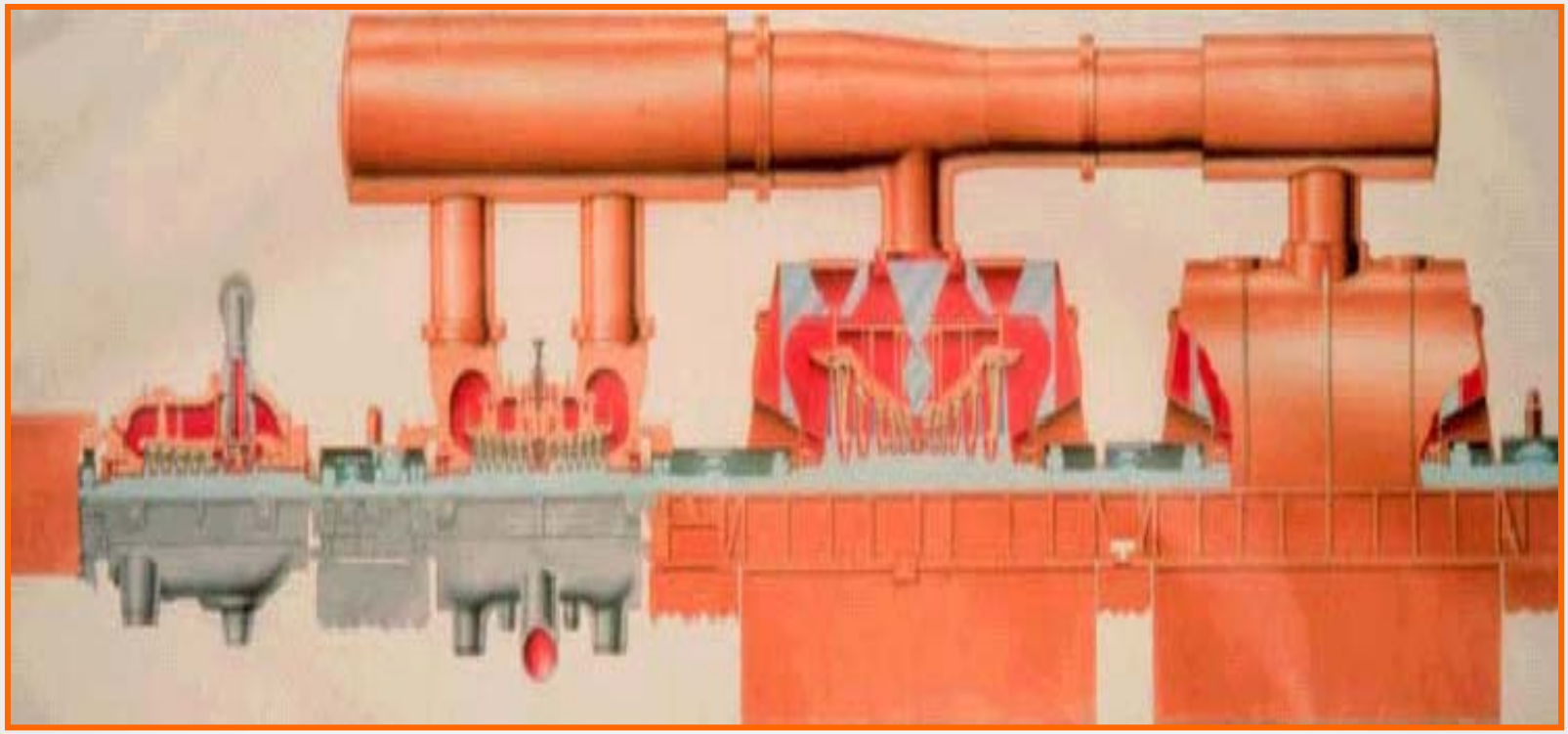
Three-Casing * Four-Flow * LSB 750 mm – 850 mm * 170 bar / 565°C / 565°C



Applicable for 500 – 700 MW Units

Tandem Compound Steam Turbine

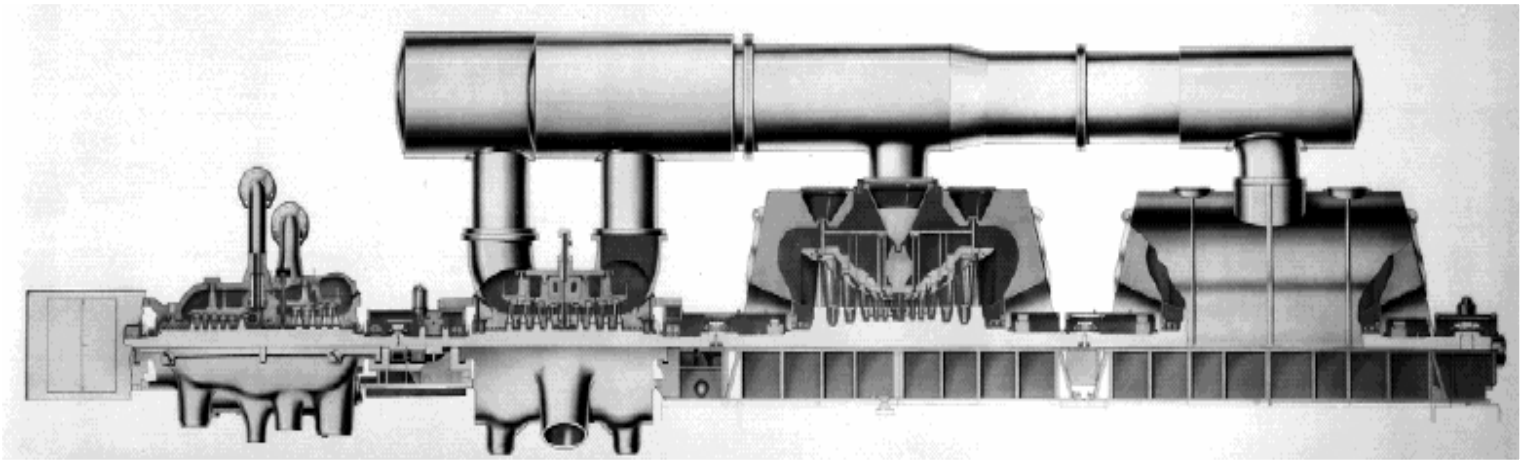
Four-Casing * Four-Flow * LSB 850 mm – 1000 mm * 245 bar / 565°C / 565°C



Applicable for 700 – 900 MW Units

Tandem Compound Steam Turbine

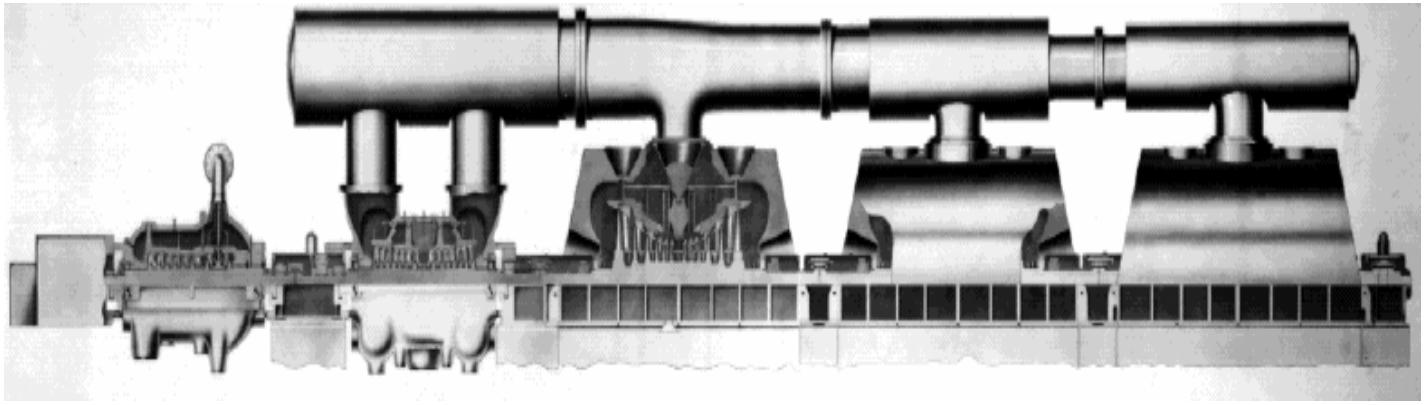
Four-Casing * Four-Flow * Double Reheat * 310 bar



Applicable for 900 - 1200 MW Units

Tandem Compound Steam Turbine

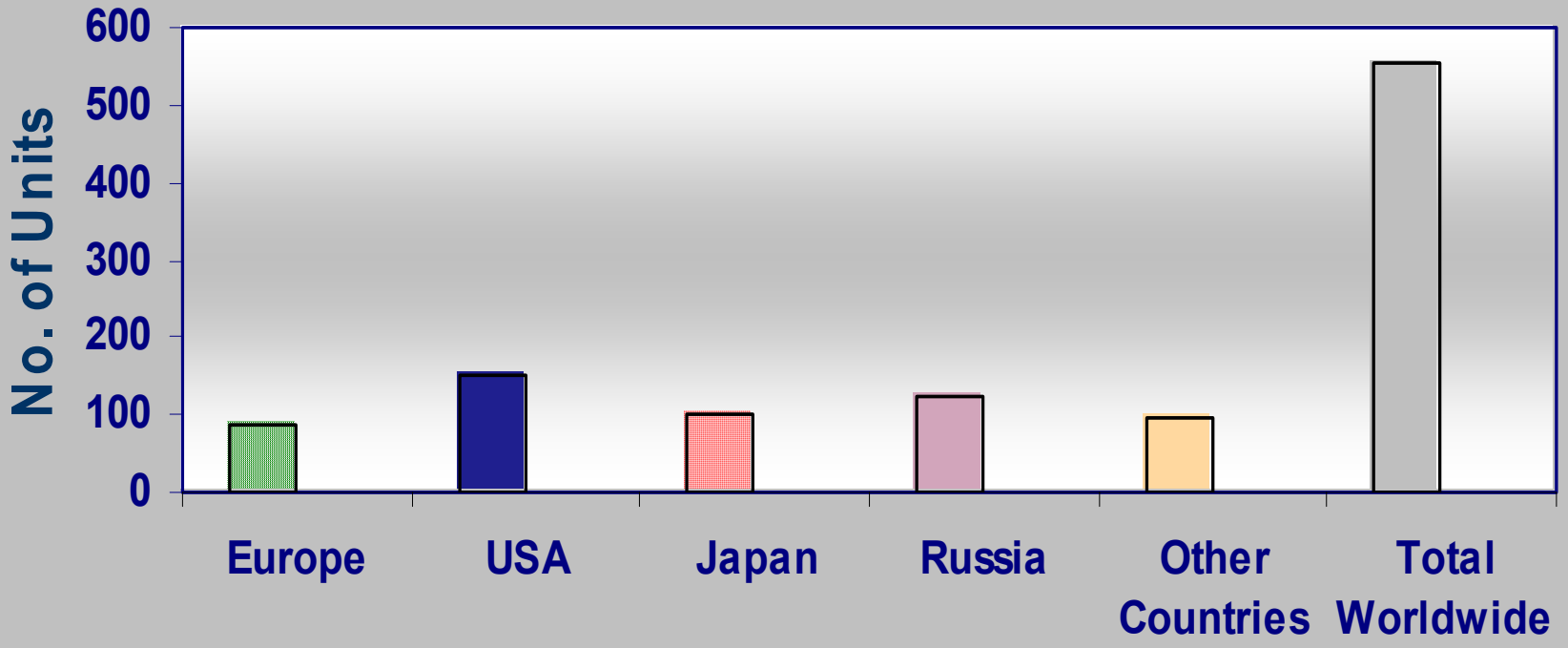
Five-Casing * Six-Flow * Single Reheat * <310 bar



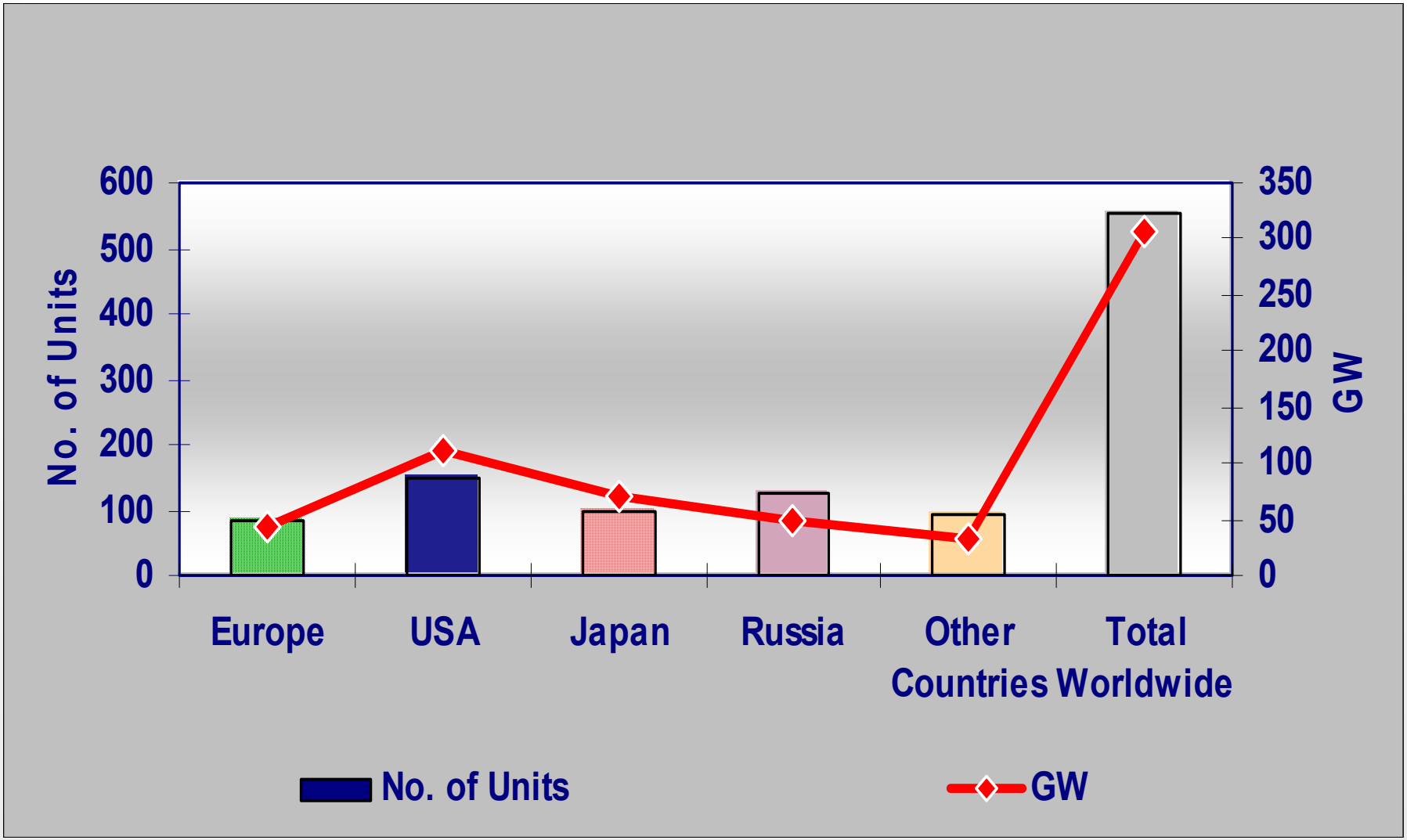
Applicable for < 1200 MW Units

Main steam temperature	600°C	538°C
Rotor	New 12 Cr forging	Cr-Mo-V forging
Nozzle chamber	12 Cr cast steel	2 ¼ Cr – 1 Mo cast steel
Inner casing	12 Cr cast steel	1 ¼ Cr – ½ Mo cast steel
No.1 blade ring	12 Cr cast steel	1 ¼ Cr – ½ Mo cast steel
No.2 blade ring	2 ¼ Cr – 1Mo cast steel	1/2 Cr – ½ Mo cast steel
Outer casing	2 ¼ Cr – 1Mo cast steel	1 ¼ Cr – ½ Mo cast steel
Rotating blade	Refractory alloy (R-26)	12 Cr forging
Main steam stop valve	9 Cr forging	2 ¼ Cr – 1Mo forging
Main steam governing valve	9 Cr forging	2 ¼ Cr – 1Mo forging

SC Power Plants Worldwide



SC Power Plants Worldwide



Selected SC Power Plants

Power Plant Name	Country	Power Output (MW)	Steam Parameters (kPa / °C / °C)	Efficiency (%)	Commercial Operation
Schwarze Pumpe	Germany	2 x 800	250 / 544 / 562	41.0	1992
Staudinger Unit	Germany	500	250 / 540 / 560	43.0	1993
Lippendorf	Germany	2 x 800	268 / 554 / 554	42.4	2000
Niederaussem	Germany	1000	275 / 580 / 600	45.2	2002
Boxberg	Germany	1000	266 / 545 / 581	43.0	2000
Nordjyllaend	Denmark	410	285 / 580 / 580	47.0	1998
Esbjerg 3	Denmark	415	250 / 560 / 560	45.3	1992
Studstrupvaerket	Denmark	400	270 / 540 / 540	42.0	1985
Fynsvaeket – 7	Denmark	420	250 / 540 / 540	43.5	1991
Hemweg-8	Netherlands	700	250 / 535 / 563	44.0	1994
Isogo 1 & 2	Japan	2 x 500	245 / 600 / 600	46.0	2001
Misumi 1	Japan	600	250 / 605 / 600	46.0	2001
Tachibanawan-2	Japan	3 x 700	250 / 600 / 610	47.0	2000
Waigaoqiao	China	2 x 900	279 / 542 / 562	42.7	2004
Yonghungdo	S. Korea	2 x 800	246 / 566 / 566	43.5	2004

1600 MW SCPP Schwarze Pumpe Germany

Owner	SVK Schwarze Pumpe / VEAG
Fuel	Lignite
Commercial operation	1997 / 1998
Steam parameters	250 bar 544°C / 562°C
Boiler	OT, GEC Alsthom / EVT EV
Efficiency	41 %

Schwarze Pumpe

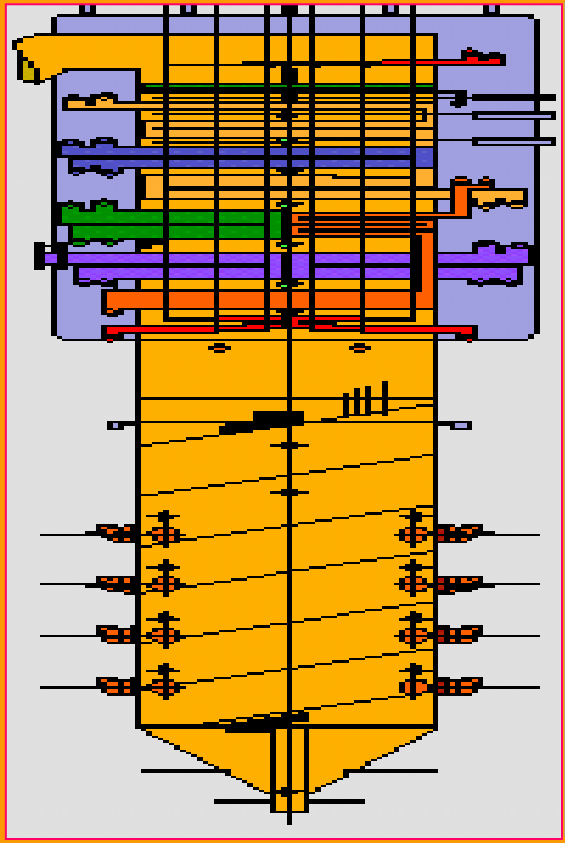
965 MW SCPP Niederaussem-K Germany

Owner	RWE Energie
Fuel	Rhenish raw lignite, LHV = 8 –10.5 MJ/kg
Commercial operation	November 2002
Steam parameters	285bar, 580°C, 600°C
Boiler	OT,Alstom ES/Babcock Kraftwerkstechnik/Steinmueller
Efficiency	45.2 %

907 MW SCPP Boxberg Germany

Owner	VEAG
Fuel	Lignite
Commercial operation	2000
Steam parameters	266bar, 545°C, 581°C
Boiler Steam turbine	OT, Steinmueller Siemens HMN, 5-casing, 6 flow
Efficiency	42.7 %

965 MW SCPP Nordjyllandsvaerket Denmark



Owner	Elsam A/S
Fuel	Bituminous coal
Commercial operation	1998
Steam parameters	290bar, 582°C, 580°C, 580°C
Boiler	Benson, single-pass, tower-type, from Burmeister & Waine
Efficiency	47%

700 MW SCPP Hemweg-8 Holland

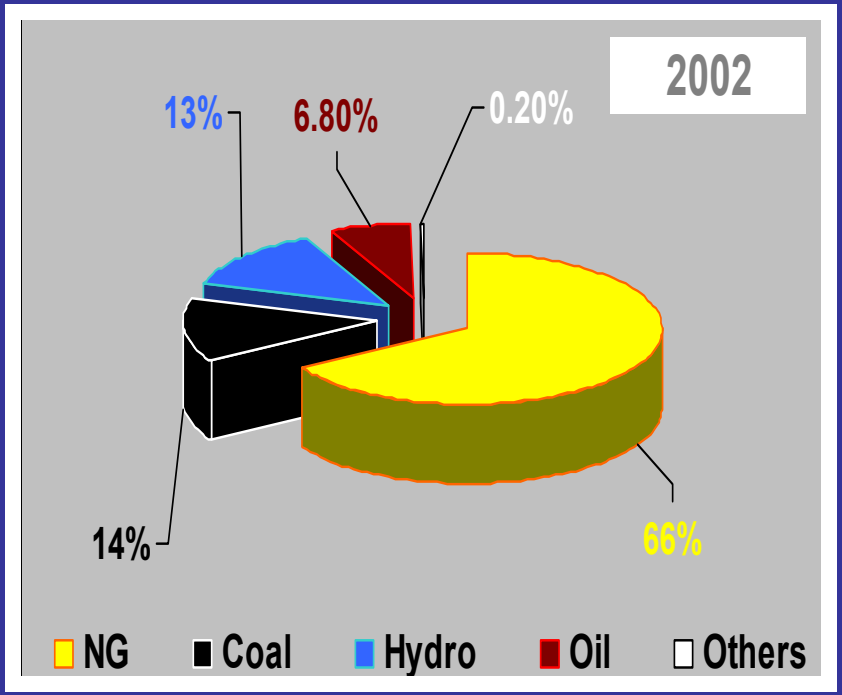
Owner	Energieprodukti-bedrijk UNA
Fuel	Bituminous coal
Commercial operation	1994
Steam parameters	260bar, 540°C, 568°C
Boiler	Benson, two-pass Babcock Energy, Stork Ketels
Efficiency	44.0%

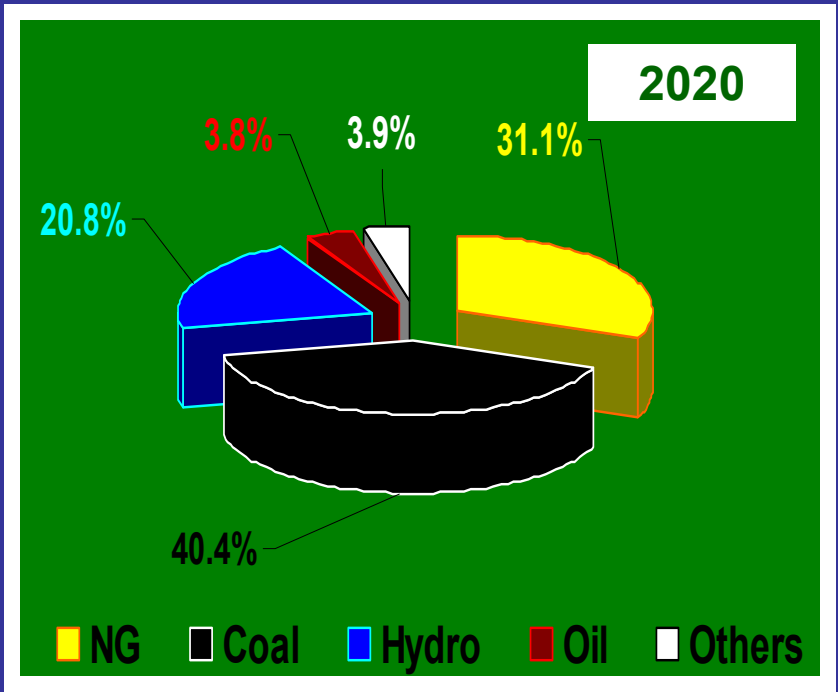
1000 MW SCPP Misumi Japan

Owner	**Chubu Electric Power Corporation**
Fuel	**Bituminous coal**
Commercial operation	**1998 - 2001**
Steam parameters	**250 bar, 605°C, 600°C**
Boiler	**Once – through, sliding pressure operation**
Efficiency	**46 %**

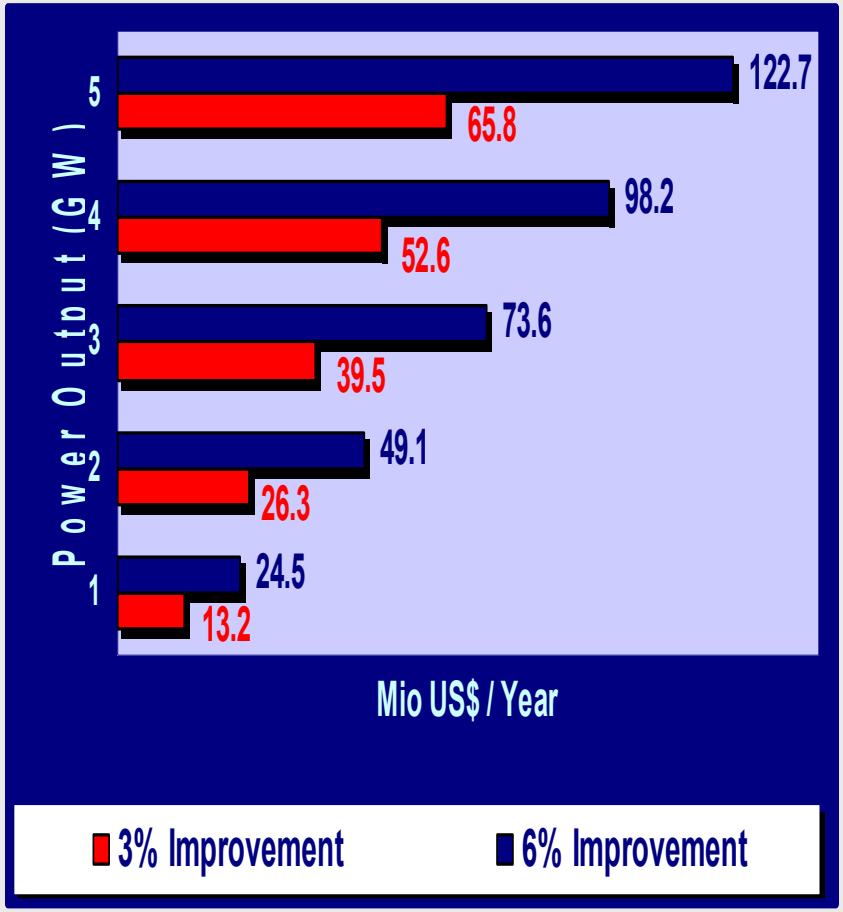
Does SC Technology suit to Malaysia's Power Generation Environment?

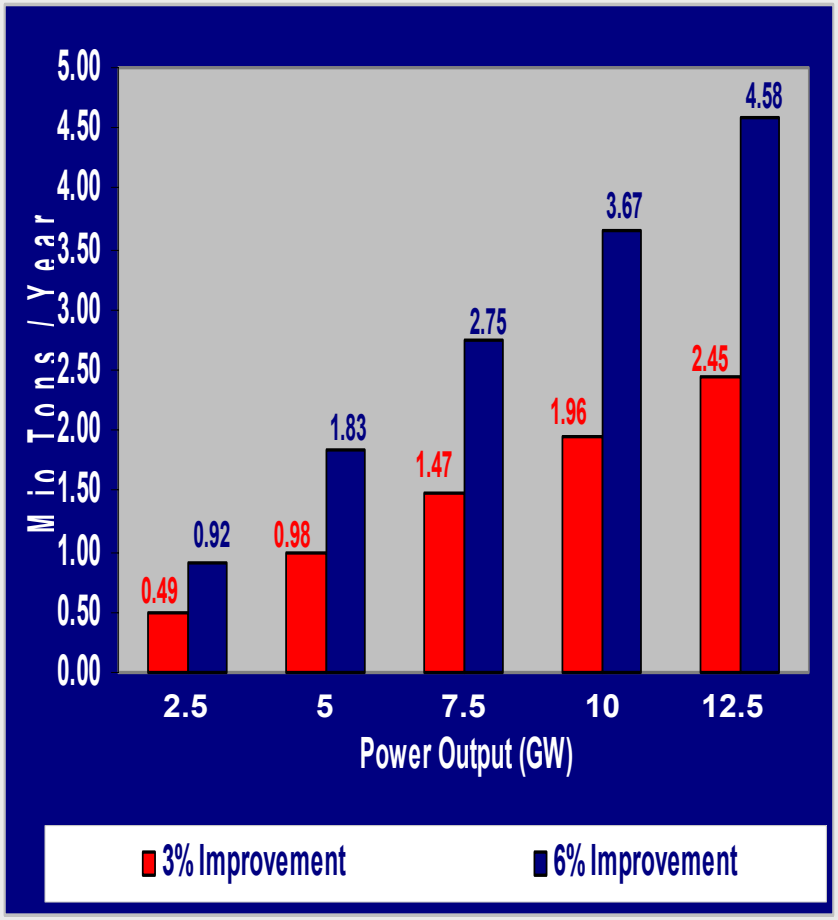
Present and Expected Fuel Split in Malaysia





Annual Savings





Example

- 3% - 6% efficiency improvement can save annually up to 3 millions metric tons of coal or between 100 Mio and 200 Mio US$ per each 10 GW power generation capacity.
- Basic data used for this calculation:

  Coal LHV → 28'000 MJ/ton,

  Load Factor → 85%

  Coal Price → 30 US$/ton

Early problems experienced with the first and second generation of SC and USC power plants are underway to be overcome.

Currently, SC and USC power plants with steam conditions up to 300 bar, 600℃ / 620℃ have been matured and become high efficiency commercialized technology.

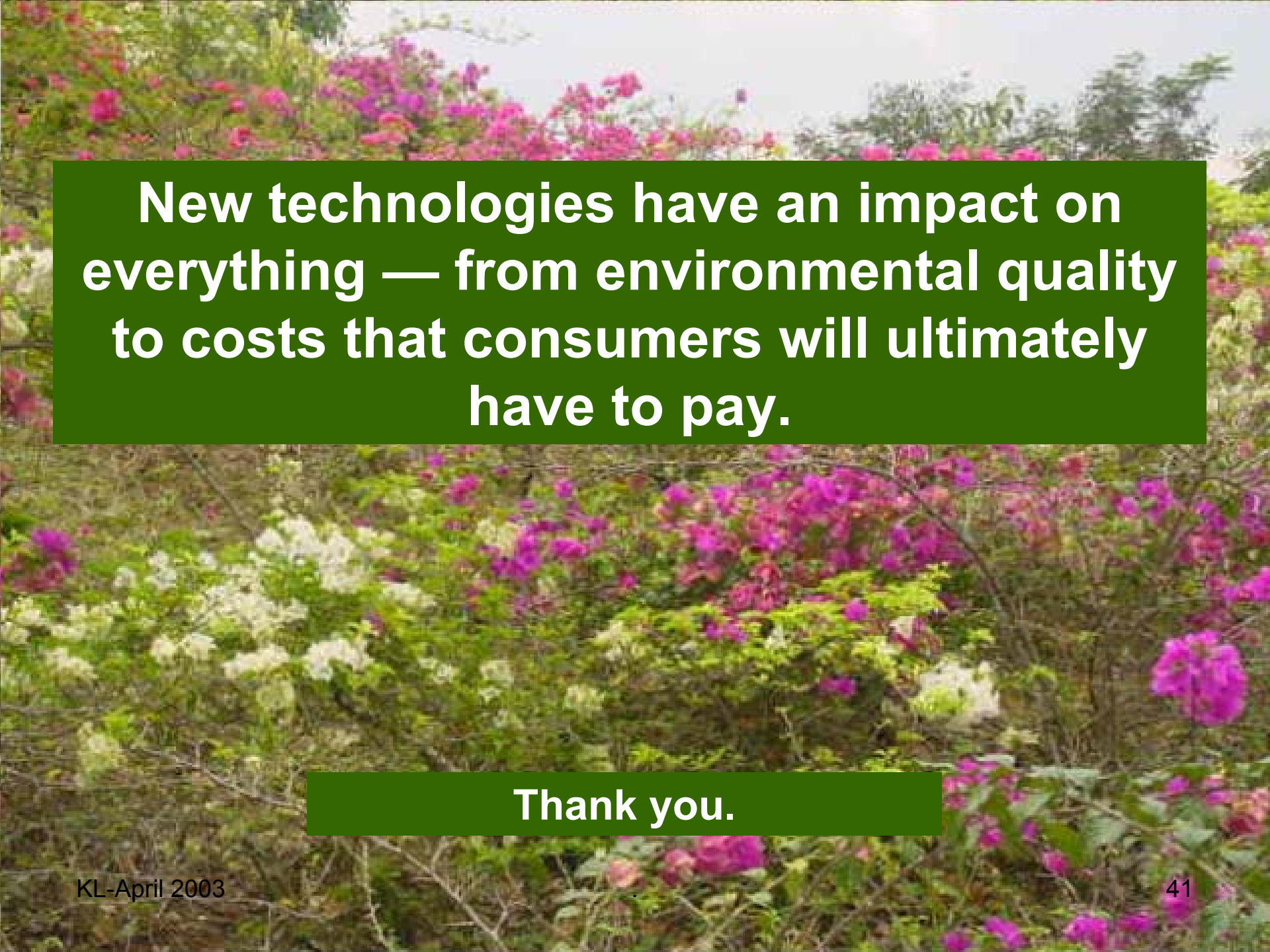
The largest commercial units with capacity of 1300 MW have reached ambitious efficiency of 47%.

SC and USC coal fired power plants will have broad prospects of development in this centaury.

Outlook for coal fired SC power plant technology is very positive and its further growth lies ahead.

Intensity of this growth will depend on the following factors:

- Worldwide acceptance of SC and USC technology;
- Development of NG / Coal price ratio;
- Further improvement of availability and reliability;
- Further efficiency improvement;
- Operational characteristics;
- Emissions level (mainly CO2, SO2 and NOx);
- Life cycle costs.


New technologies have an impact on everything — from environmental quality to costs that consumers will ultimately have to pay.
Thank you.