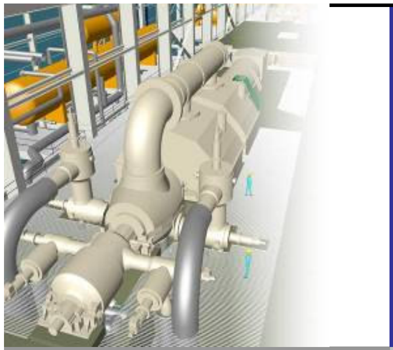


POWERGEN ASIA 2008

Kuala Lumpur - Malaysia - October 21 - 23, 2008

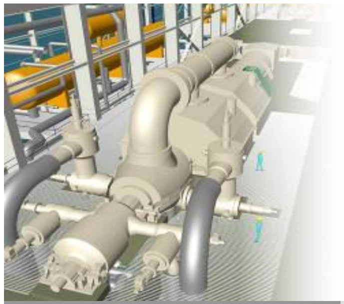
CONTENT

- History
- Asia related Facts
- Energy Consumption
- Efficiency Evolution
- Coal Reserves
- Cost Saving
- ST Unit Size Evolution
- SC / USC Technology
- SC / USC Power Plants Worldwide Summary
- Efficiency Improvement
- 50 Hz RPP
- 60 Hz RPP
- OT Boiler
- Boiler Materials
- ST Configurations
- ST Materials
- Selected SC / USC Power Plants

Latest Development in Supercritical Steam Technology

Miro R. Susta
IMTE AG Power Consulting Engineers
Switzerland

imteag.com



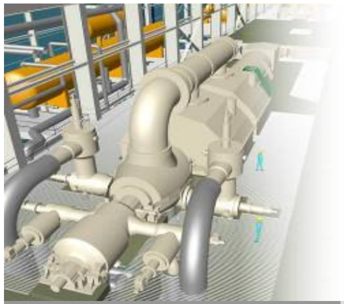
Electricity Power Generation History

113 years

- 1895 ⇨ Cambridge Power Station produced 3 x 100 kW using Parsons STGs
- 1896 ⇨ Niagara Falls Hydro Power Plant produced 3.7 MW at 2.35 kV / 25Hz
- 1900 ⇨ First 1 MW Parsons STG units put in operation in England (10bar / 200°C)
- 1903 ⇨ 1st Commonwealth Edison Power Plant ST produced 5 MW (12.5bar/275°C)
- 1900–1920 ⇨ STGs operated at 1,200rpm (20Hz); Unit Capacity up to 65 MW
- 1914-1915 ⇨ STs for Military Cargo Ships 6-20MW (10-16bar / 300-350°C)
- 1915 ⇨ Establishment of ASME Code
- 1930 ⇨ Pulverized Coal Technology
- 1920 – 1935 ⇨ ST operated at 1,500-1,800rpm; Unit Capacity up to 200 MW
- 1935–1953 ⇨ ST operated at 3,000-3,600rpm; Unit Capacity up to 200 MW
- 1957 ⇨ 1st USC Power Plant, 120MW Philo 6 (310bar / 612°C)
- 1960 ⇨ Eddystone USC Power Plant, 325 MW (345bar / 650-565-565°C)
- 1960 – 1963 ⇨ 1st Commercial Nuclear Power Plants produce Electric Power
- 1980 ⇨ Large STs reached Unit Capacity up to 1,300MW
- 1900 – 1980
  - kWh-Costs decreased every decade + Generating Capacity doubled every 8 – 12 years
- Last Decade of 20th century ⇨ Golden Times for NG fired CCGT Power Plants
- First Decade of 21th Century Renaissance of SC / USC Technology
- 2008 ⇨ Worldwide Power Generation Capacity ≈3,200GW (≈1,300GW from Coal)

Powergen Asia 2008

© IMTE

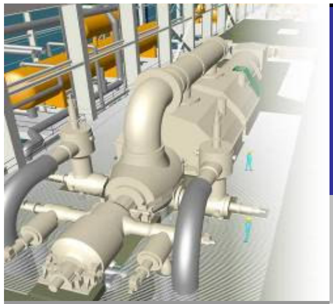


ASIA

- ⇨ In 2030 the primary energy consumed by China & India will represent around 25% of the world consumption.
- ⇨ Majority of SC unit are being built in Asia, especially in China & India.
- ⇨ China & India will be responsible for around 40% of the growth in the world's primary energy consumption.
- ⇨ China is planning to install 90GW of new power generation capacity over next 2-3 years.
- ⇨ Indian demand will grow from 130 GW to 280 GW over the next decade, an increase of 150 GW .
- ⇨ CO_2 emissions are expected to grow by factor 2 in 2030.
- ⇨ In the period from now until 2030 Asia will require of about 8 trillion USD on energy infrastructure (350 billion USD/Year).
- ⇨ Indonesia is also planning first SC power plants.
- ⇨ Coal demand from electric power generation sector is expected to grow fast in Asia.

China
&
India
Main driving force in Asia

© IMTE



Main Concerns with Energy → Electricity Supply

Technology
&
Fuel

© IMTE

- **Affordability**

  Investment - Technology – Fuel – O&M → Tariff

- **Reliability**

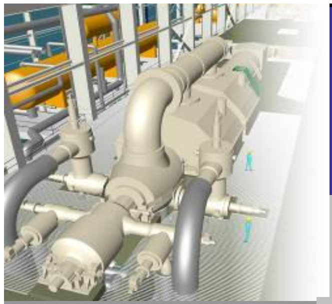
  Technology – Fuel – O&M → Availability

- **Accessibility**

  Grid Connections → Distribution Network

- **Environmental Acceptability**

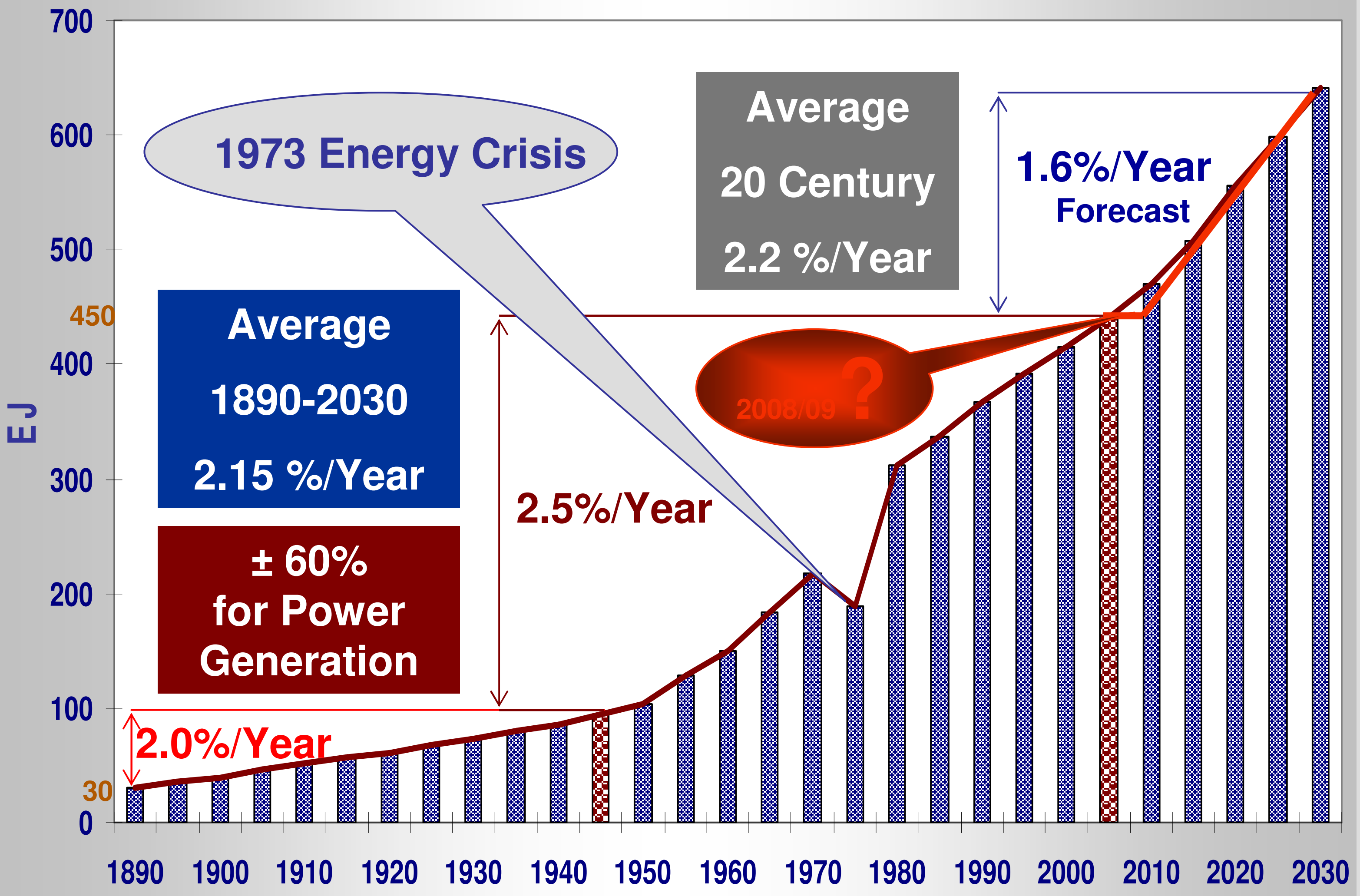
  Technology – Fuel – O&M → Emissions



IMTE AG Power Consulting Engineers

www.imteag.com

Worldwide Overall Energy Consumption



1973 Energy Crisis

Average
20 Century
2.2 %/Year

1.6%/Year
Forecast

Average
1890-2030
2.15 %/Year

± 60%
for Power
Generation

2.5%/Year

2.0%/Year

1Exajoule (EJ) =
10^{18} Joule
0.948 x 10^{15} Btu

Powergen Asia
2008

© IMTE

IMTE AG Power Consulting Engineers

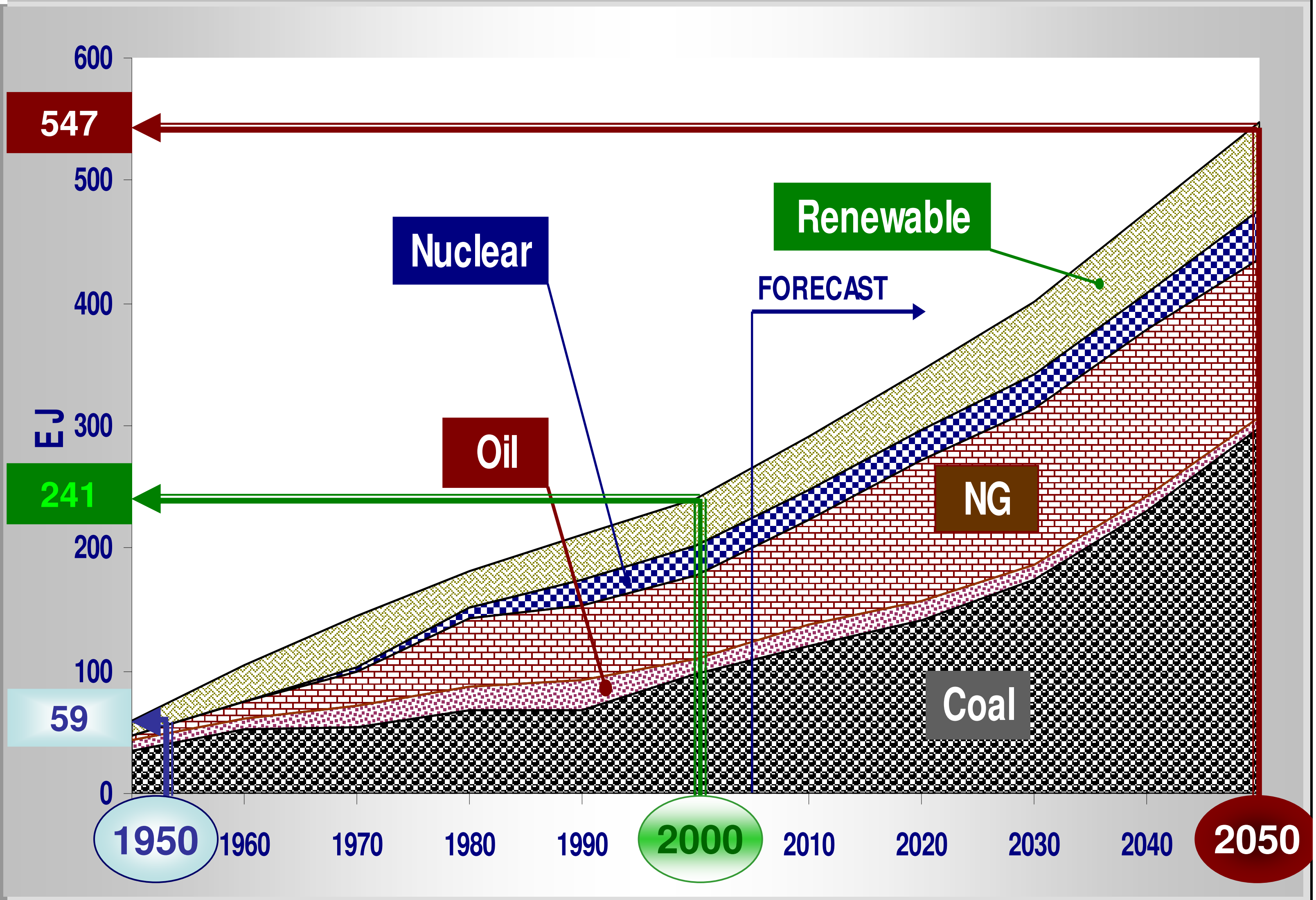
www.imteag.com

Worldwide Overall Energy Consumption for Power Generation

2050	
Coal	54.5%
Oil	1.5%
NG	23.7%
Nuclear	7.3%
Renewable	13.0%

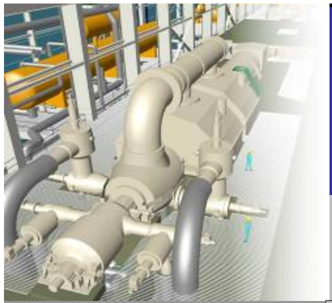
2000	
Coal	40.5%
Oil	5.1%
NG	27.8%
Nuclear	10.1%
Renewable	16.8%

1950	
Coal	59.6%
Oil	14.5%
NG	5.2%
Nuclear	0.0%
Renewable	20.7%

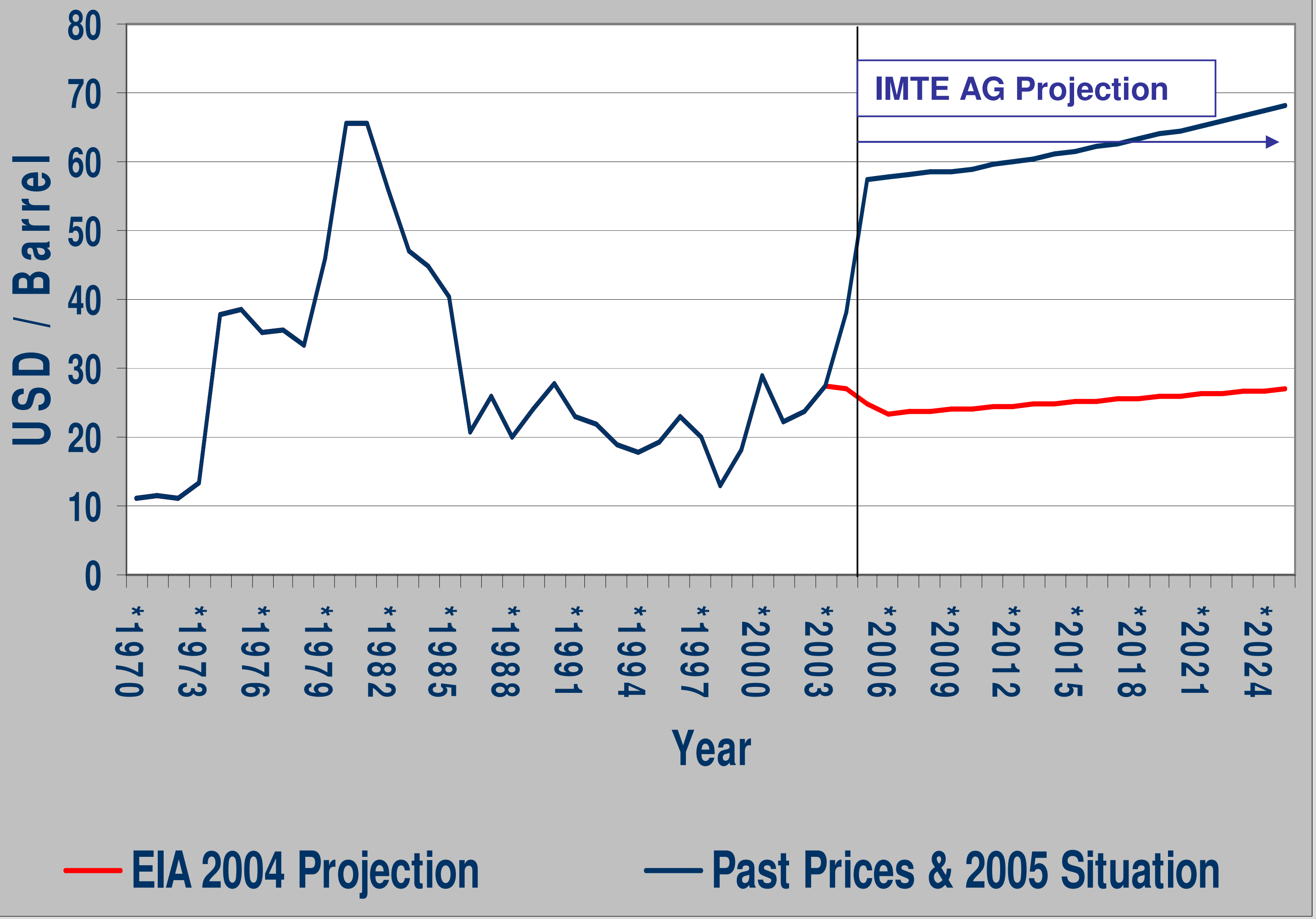


Powergen Asia 2008

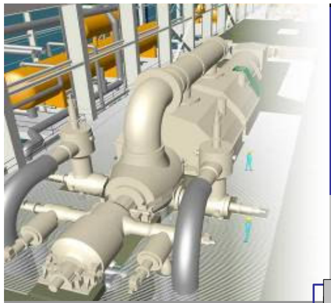
© IMTE



Crude Oil Price Status 2005 (Powergen Asia 2005)



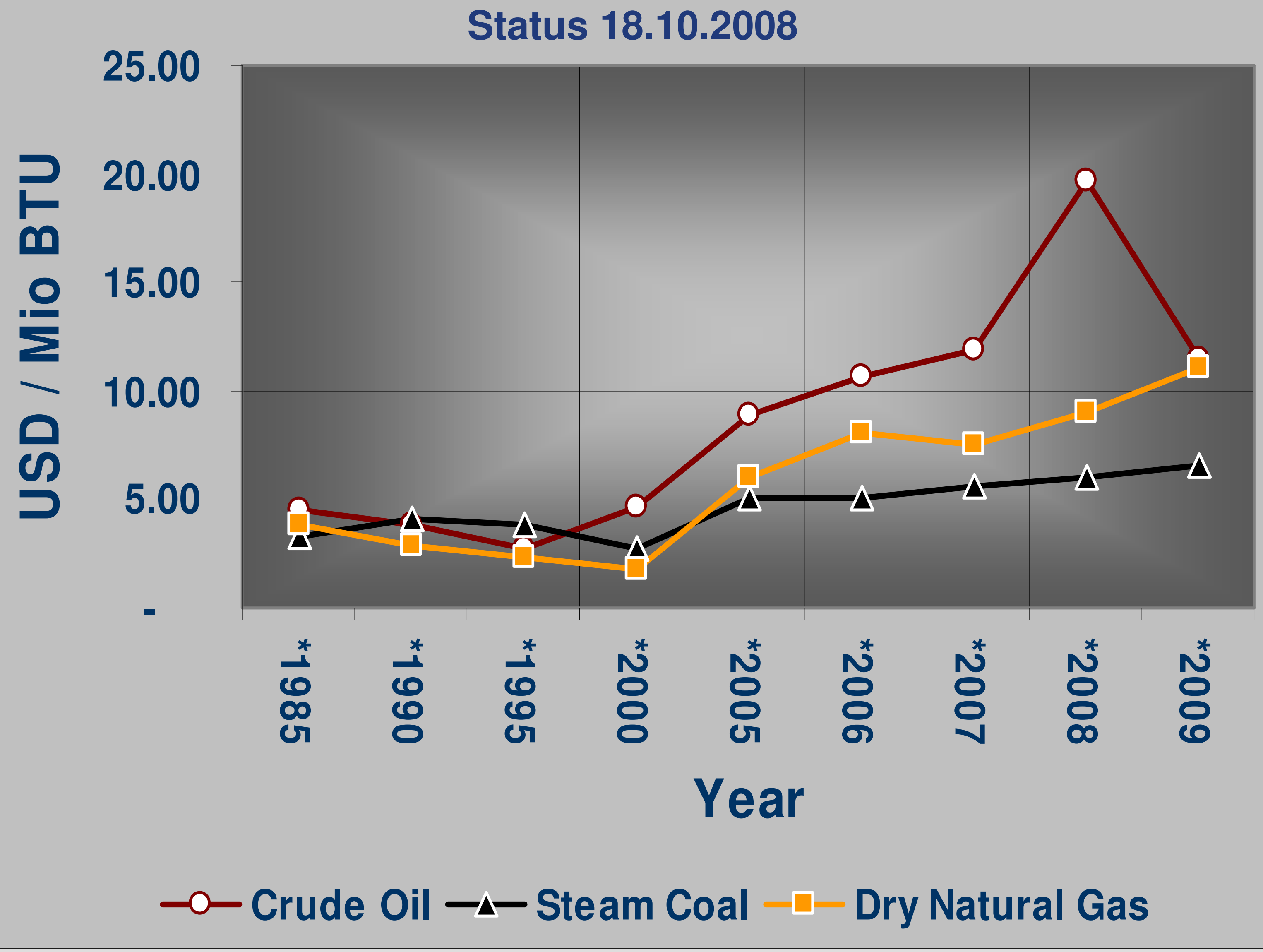
© IMTE



IMTE AG Power Consulting Engineers

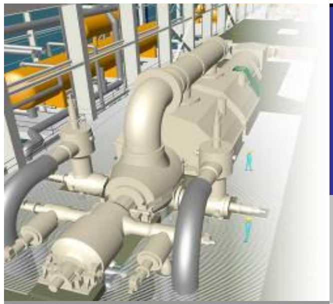
www.imteag.com

Crude Oil Price vs. Natural Gas & Coal



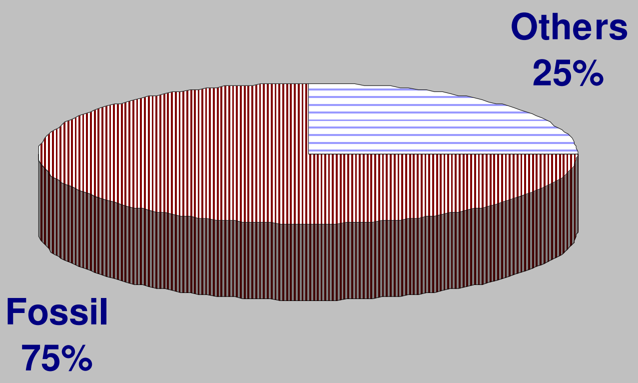
Powergen Asia 2008

© IMTE



Worldwide Power Generation Energy Sources

2008

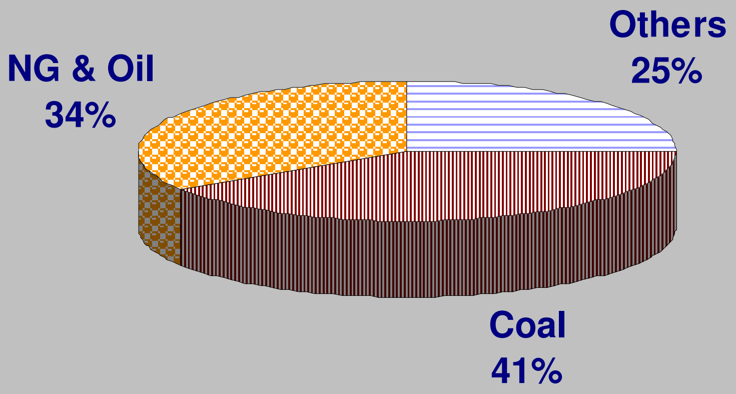


Others

- ⇨ Nuclear
- ⇨ Geothermal
- ⇨ Hydro
- ⇨ Other Renewable

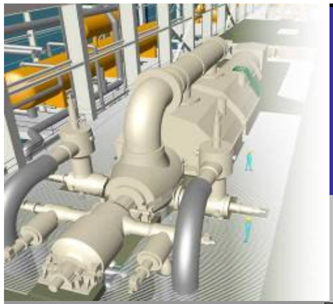
Fossil

- ⇨ Coal
- ⇨ Natural Gas
- ⇨ Fuel Oil



Powergen Asia
2008

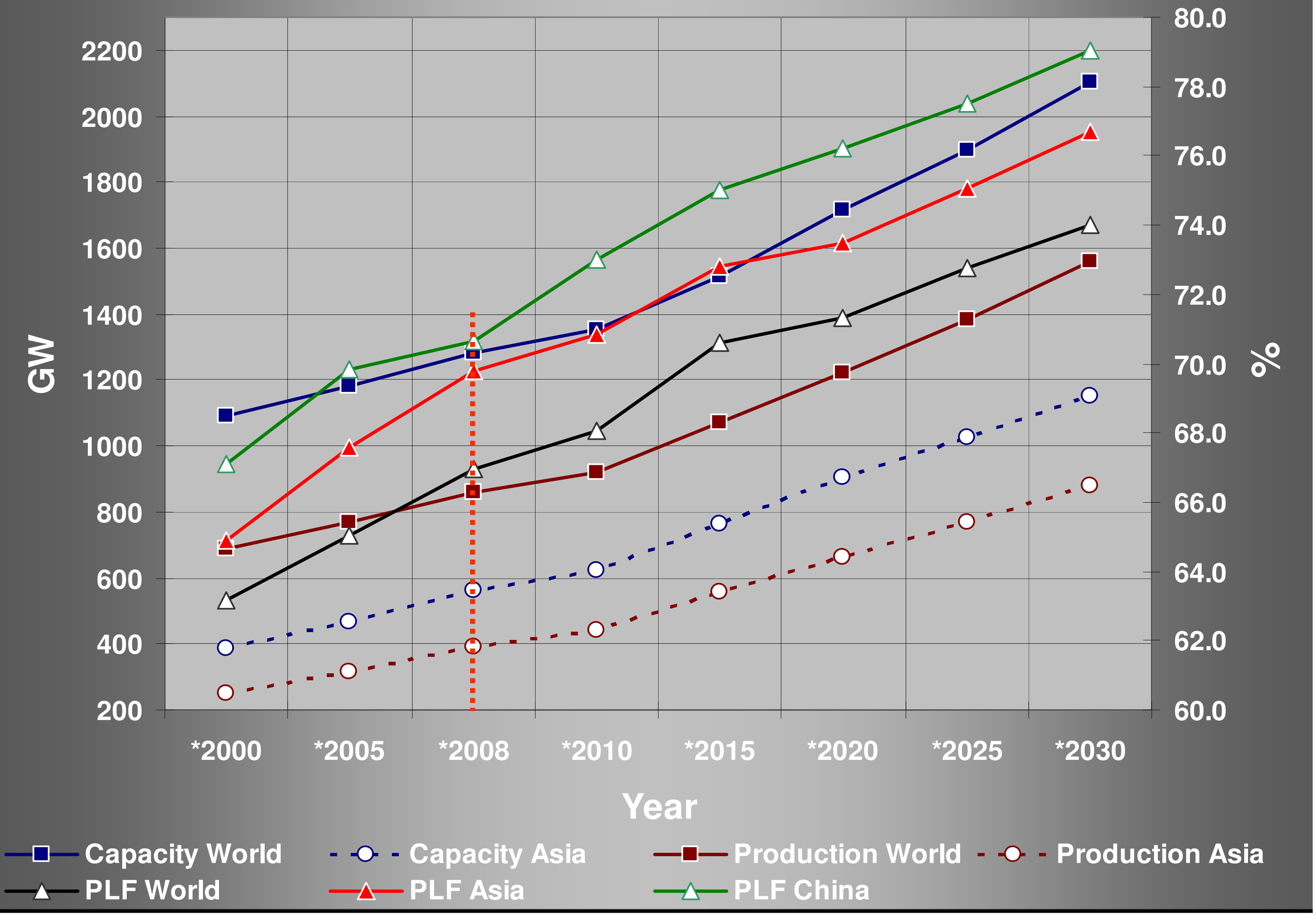
© IMTE



IMTE AG Power Consulting Engineers

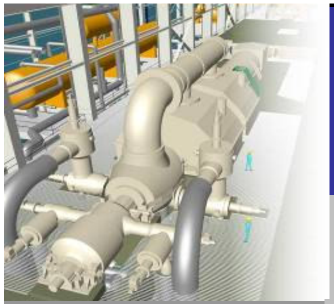
www.imteag.com

Coal Fired Power Generation Capacity vs. Production

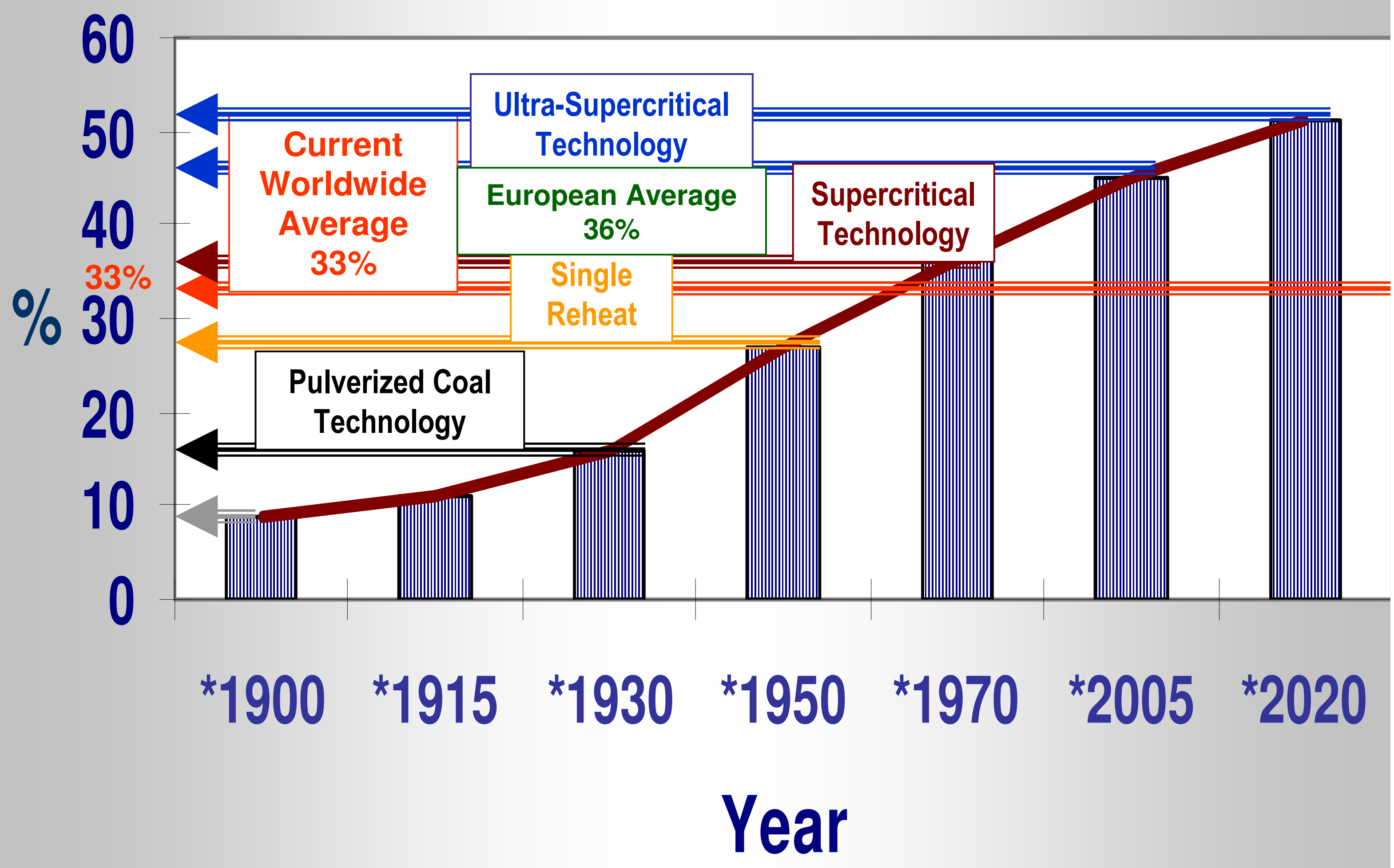


Powergen Asia 2008

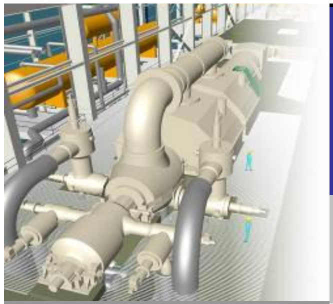
© IMTE



Coal Fired Power Generation Efficiency Evolution



© IMTE



Worldwide Present & Projected Future Coal Reserves

1 Short Ton=
0.907 M Ton

Reserves in 2007

1,000 Billions Short Tons

Annual Consumption (2007)

4 Billions Short Tons

250 Years

Projected Reserves in 2030

30% Efficiency Scenario

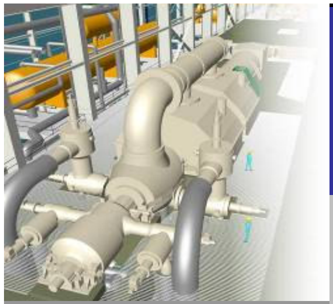
138 Years

Projected Reserves in 2030

40% Efficiency Scenario

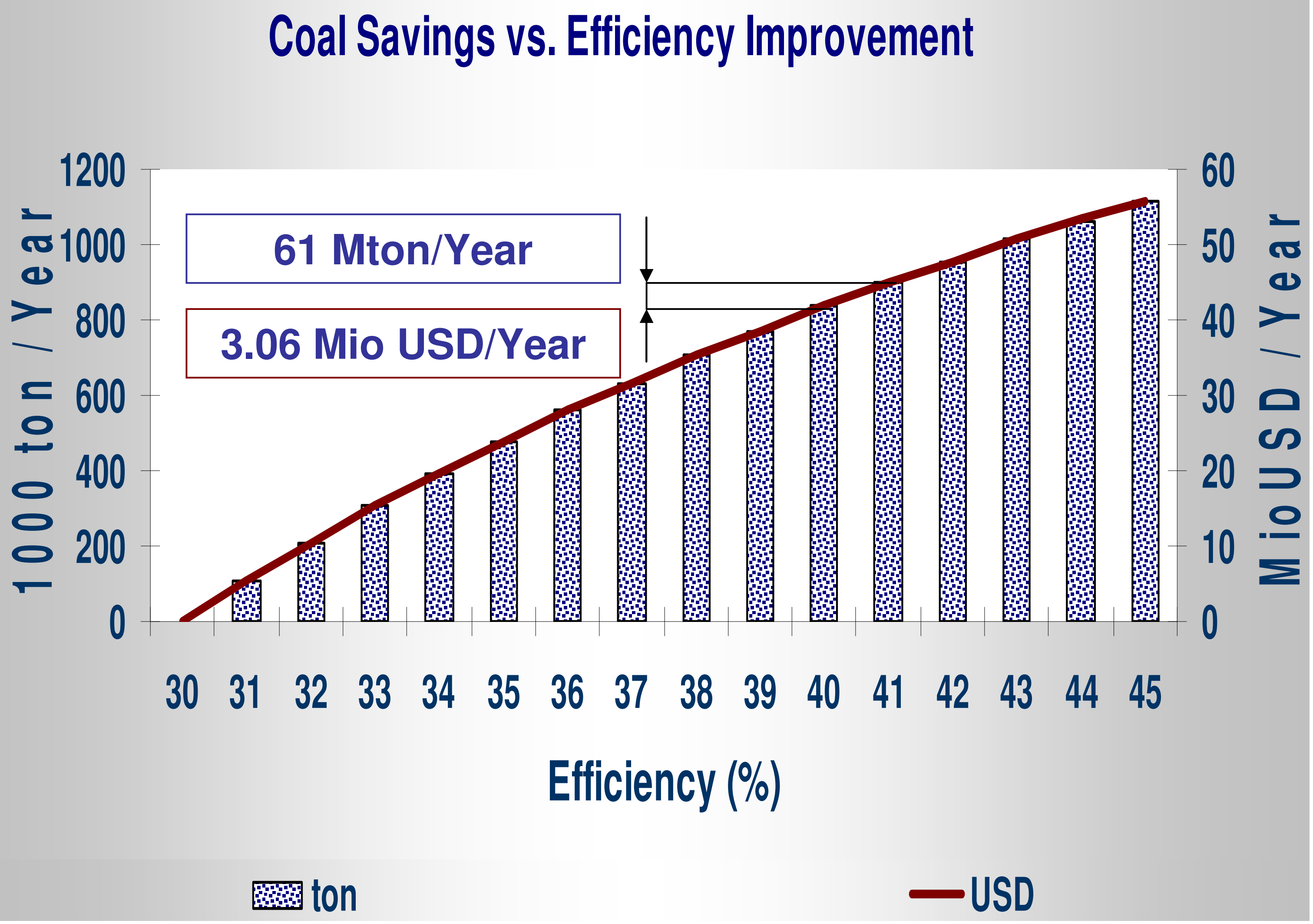
190 Years

© IMTE



1,000MW ** 6,000 kcal / kg (25,120 kJ / kJ)
50USD/ton (2.1 USD / Mio Btu) ** PLF=80%

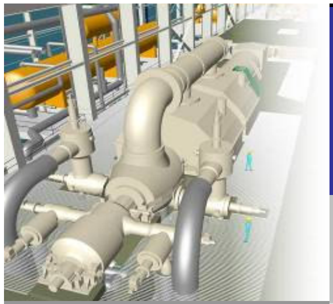
1% Improvement
40%→41%



61 Mton/Year

3.06 Mio USD/Year

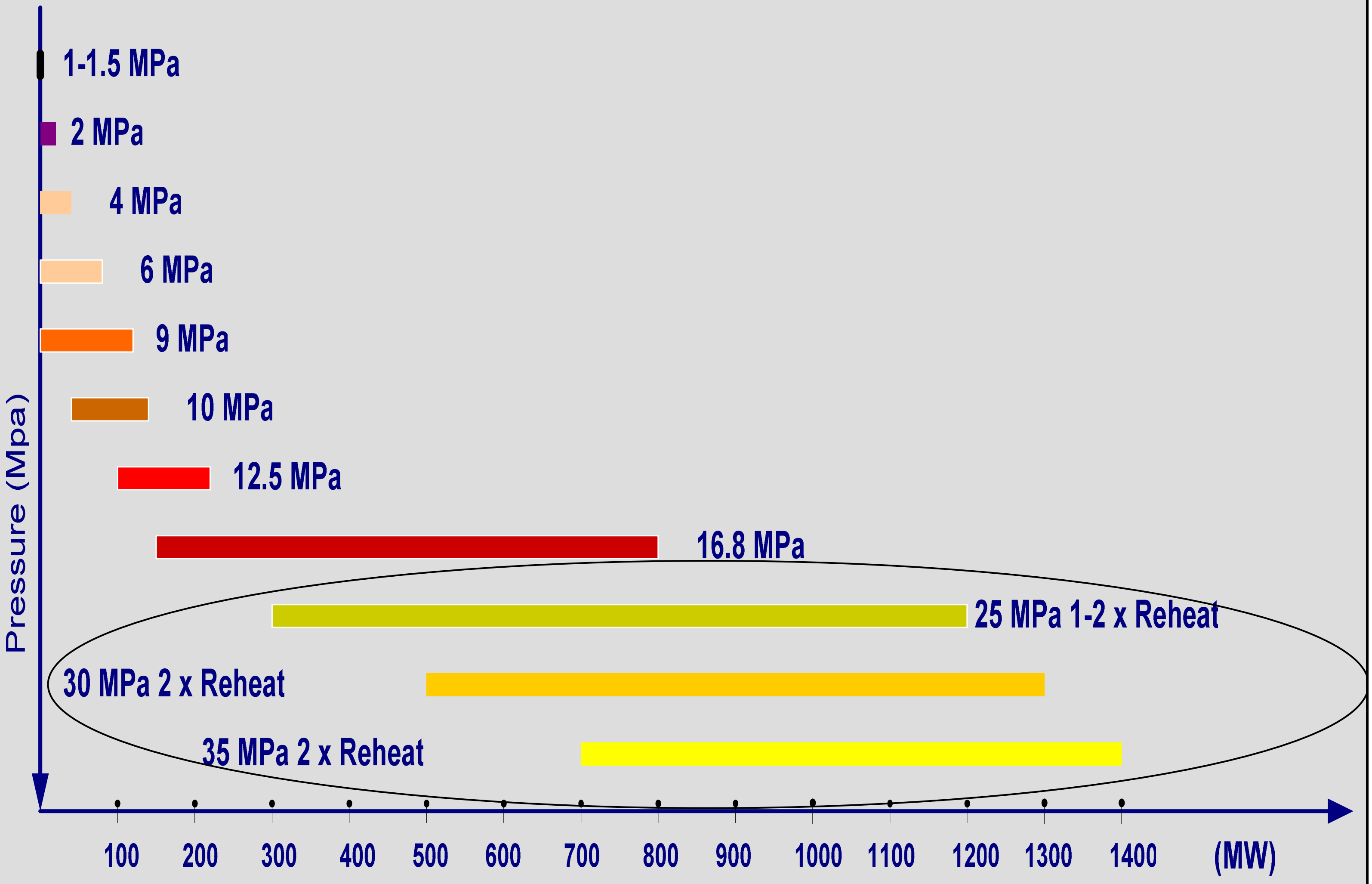
© IMTE



IMTE AG Power Consulting Engineers

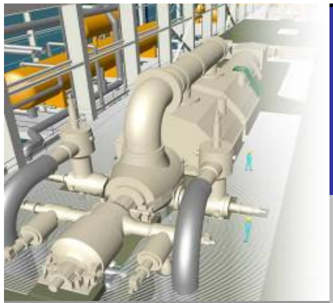
www.imteag.com

Evolution of ST Unit Size

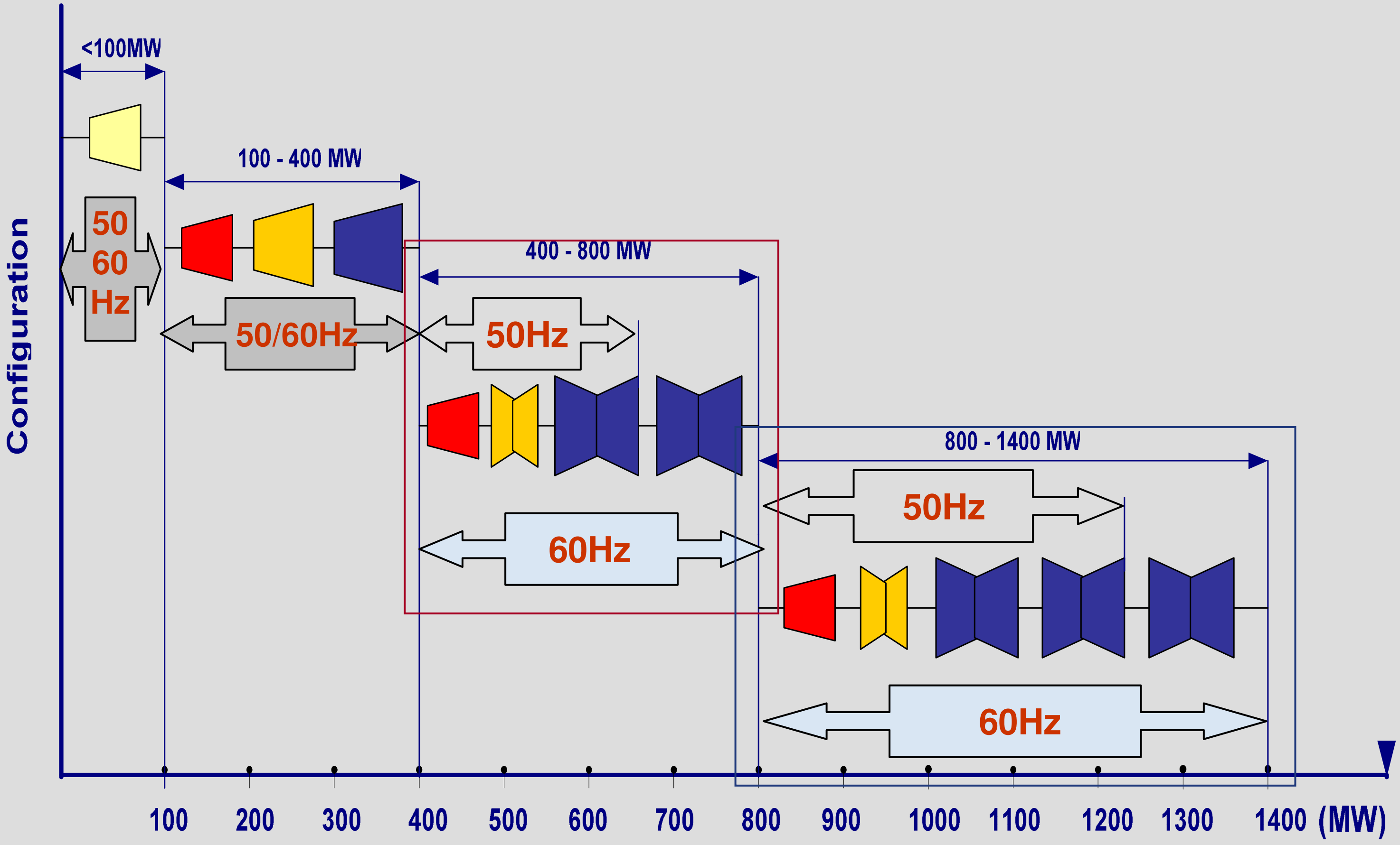


Powergen Asia
2008

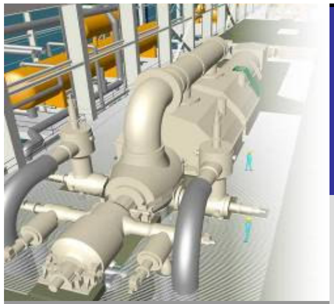
© IMTE



ST Unit Configuration



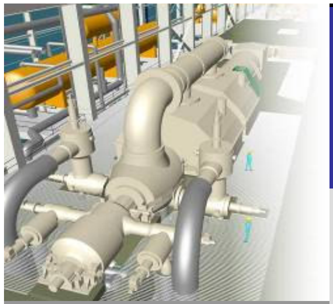
© IMTE



Supercritical Water-Steam Cycle Technology

Powergen Asia
2008

© IMTE



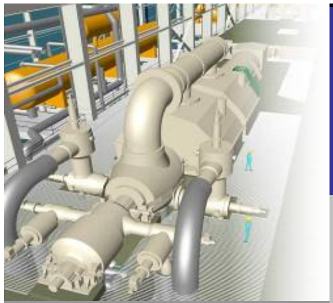
Supercritical is a thermodynamic expression describing the state of a fluid above a certain pressure when there exists no clear distinction between the liquid and gaseous phases.

$\geq$ 22.064 MPa (220.64 bar)

$\geq$ 374.81 ºC

One of the primary means of increasing the efficiency of steam power plants is to increase live steam pressures to super- or ultra-supercritical conditions.

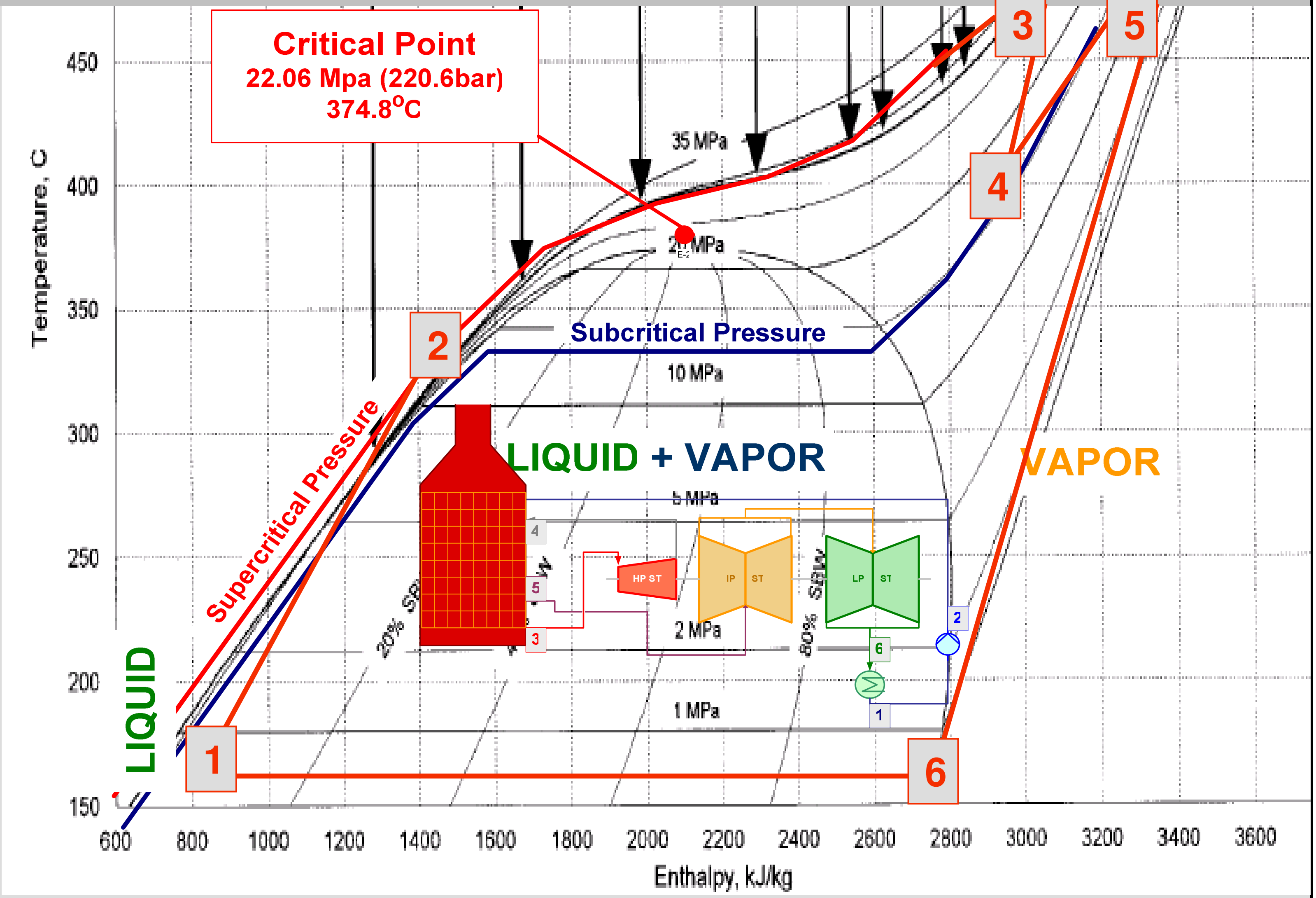
© IMTE



IMTE AG Power Consulting Engineers

www.imteag.com

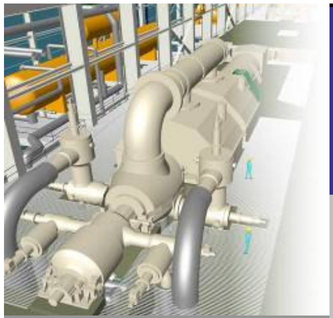
Heat Transfer Subcritical vs. Supercritical Cycle



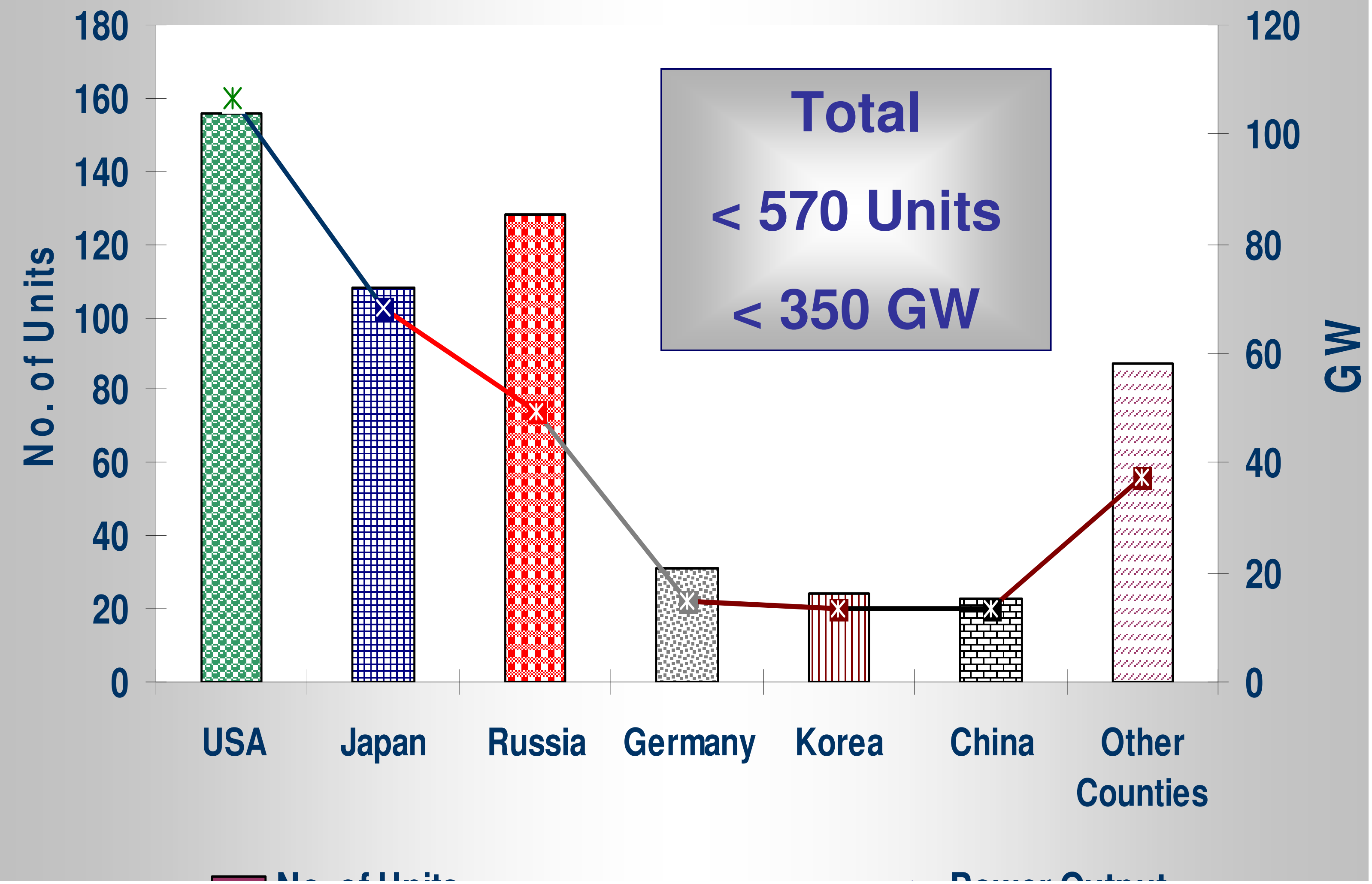
Critical Point
22.06 Mpa (220.6bar)
374.8°C

Powergen Asia
2008

© IMTE



Worldwide Number and Capacity of Coal Fired SC/USC Power Plants in Operation (2008)



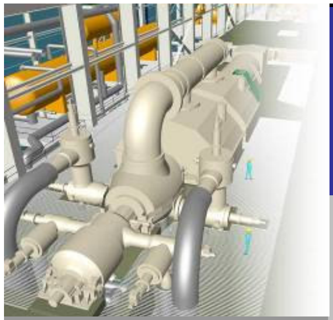
Total

< 570 Units

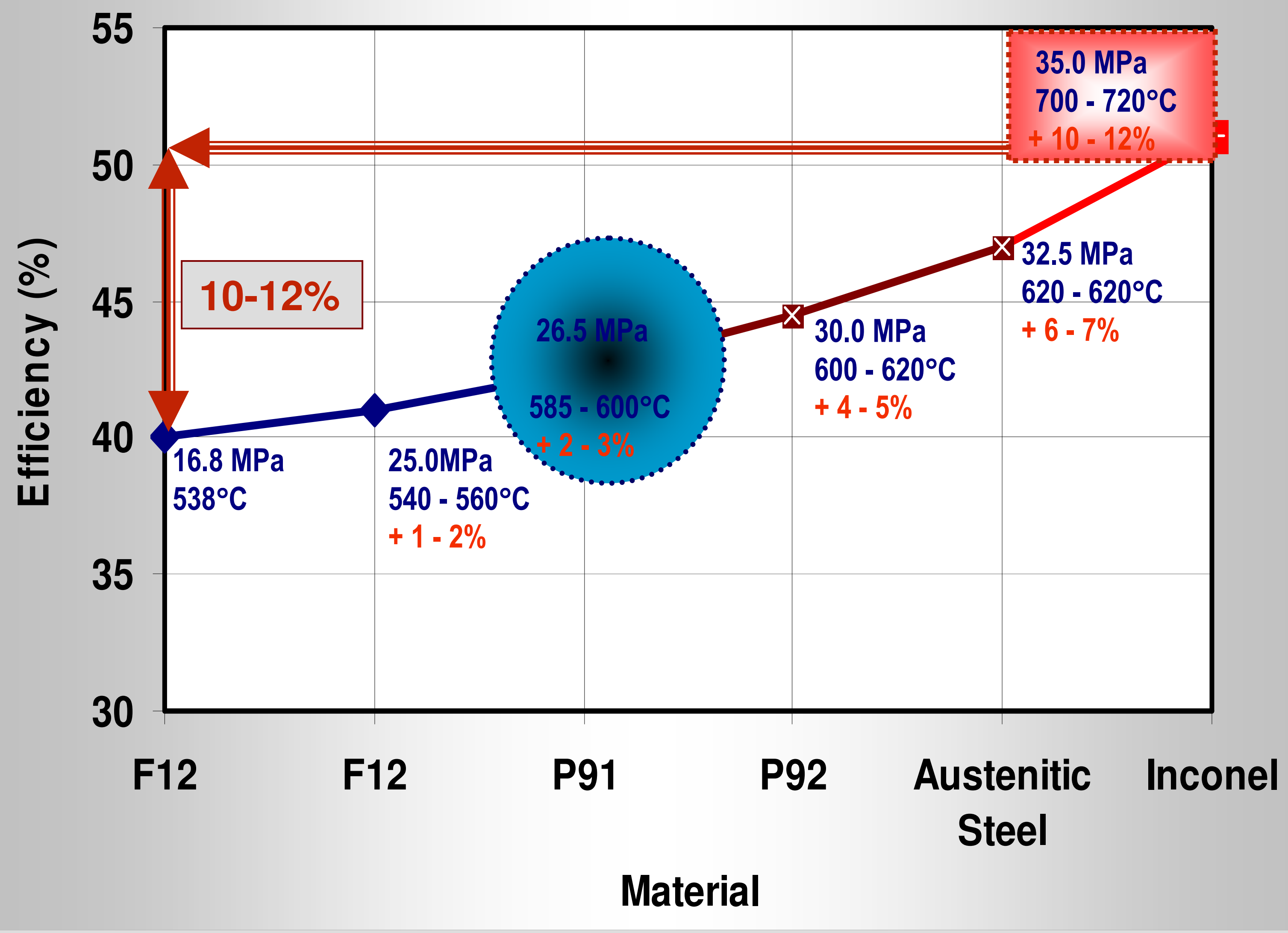
< 350 GW

Powergen Asia 2008

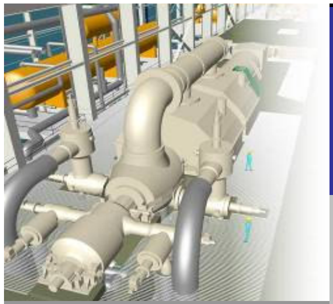
© IMTE



Potential in Increase in Net Efficiency



© IMTE

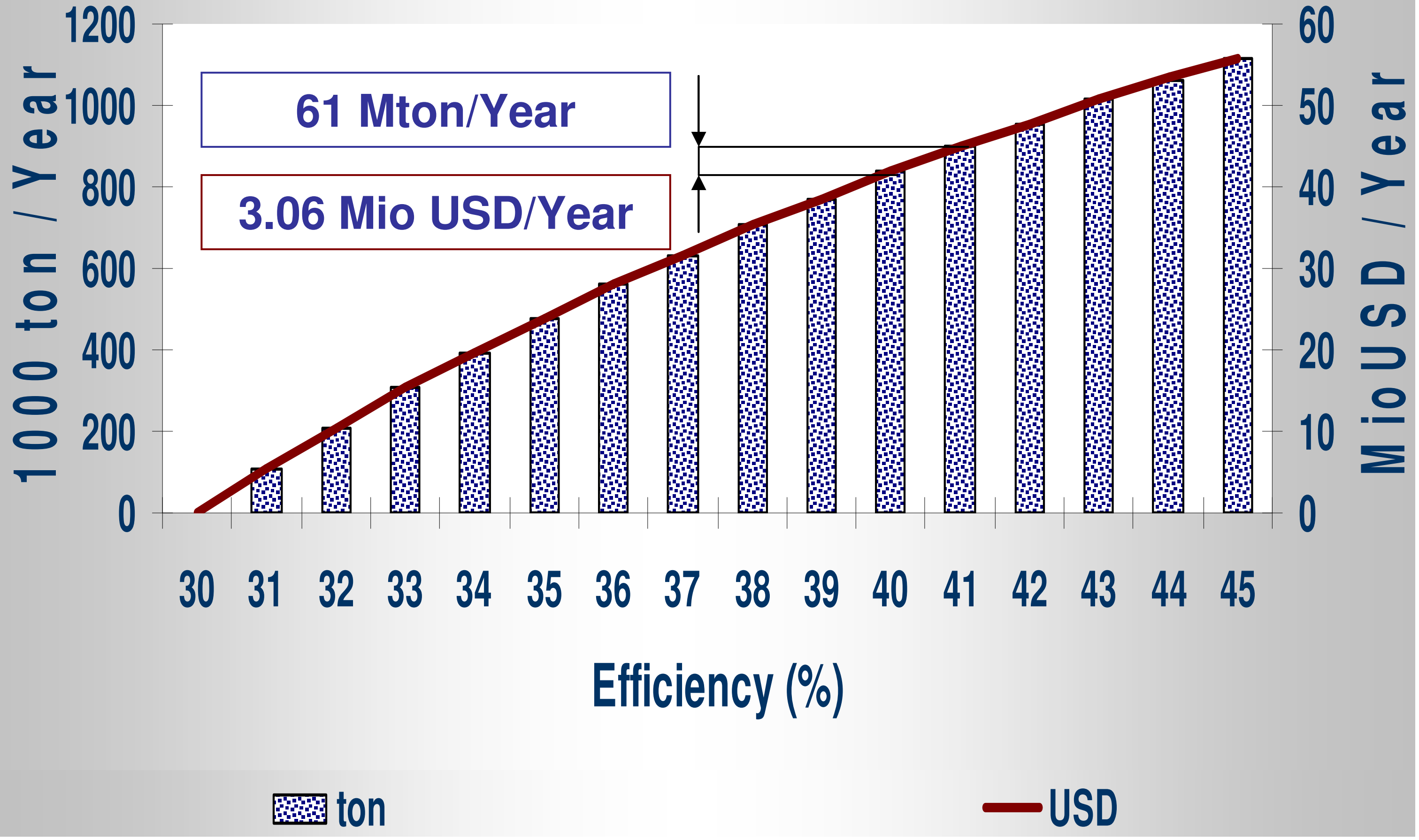


1,000MW ** 6,000 kcal / kg (25,120 kJ / kJ)
50USD/ton (2.1 USD / Mio Btu) ** PLF=80%

1%
3.06MioUSD/Y

10%
30.6MioUSDY

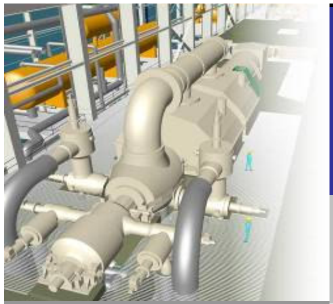
Coal Savings vs. Efficiency Improvement



61 Mton/Year

3.06 Mio USD/Year

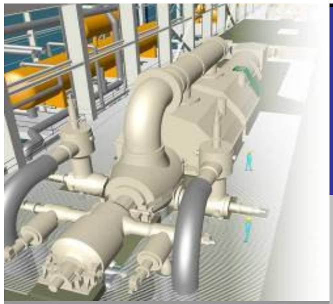
© IMTE



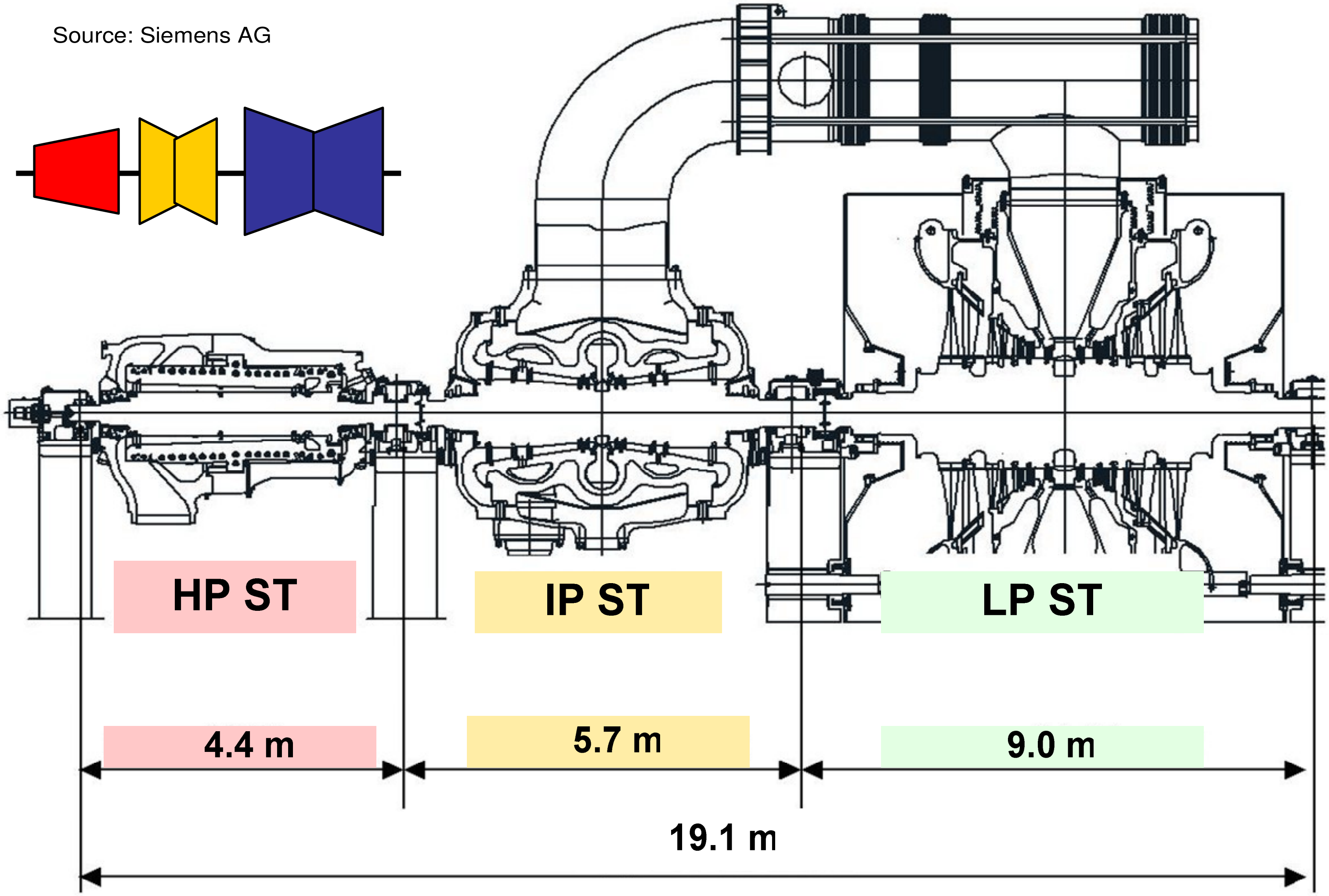
50Hz RPP – Main Parameters

Plant Gross Capacity	600 MW
Plant Net Capacity	552 MW
Live Steam Pressure	28.5 MPa
Live Steam Temperature	600 ºC
Reheat Pressure	6.0 MPa
Condenser Pressure	4.5 kPa
Feed Water Temperature	303 ºC
Reheat Temperature	620 ºC
Heat Rate$_{NET/LHV}$–Efficiency	45.9 % → 7,843 kJ / kWh
Boiler Type	OT-Benson
ST Type	3 Casing – Single Reheat 1SF HP-1DF IP-1DF LP

© IMTE

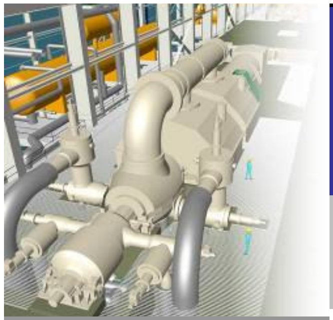


$600MW_{GROSS}$ 3-Casing (50Hz) USC Steam Turbine

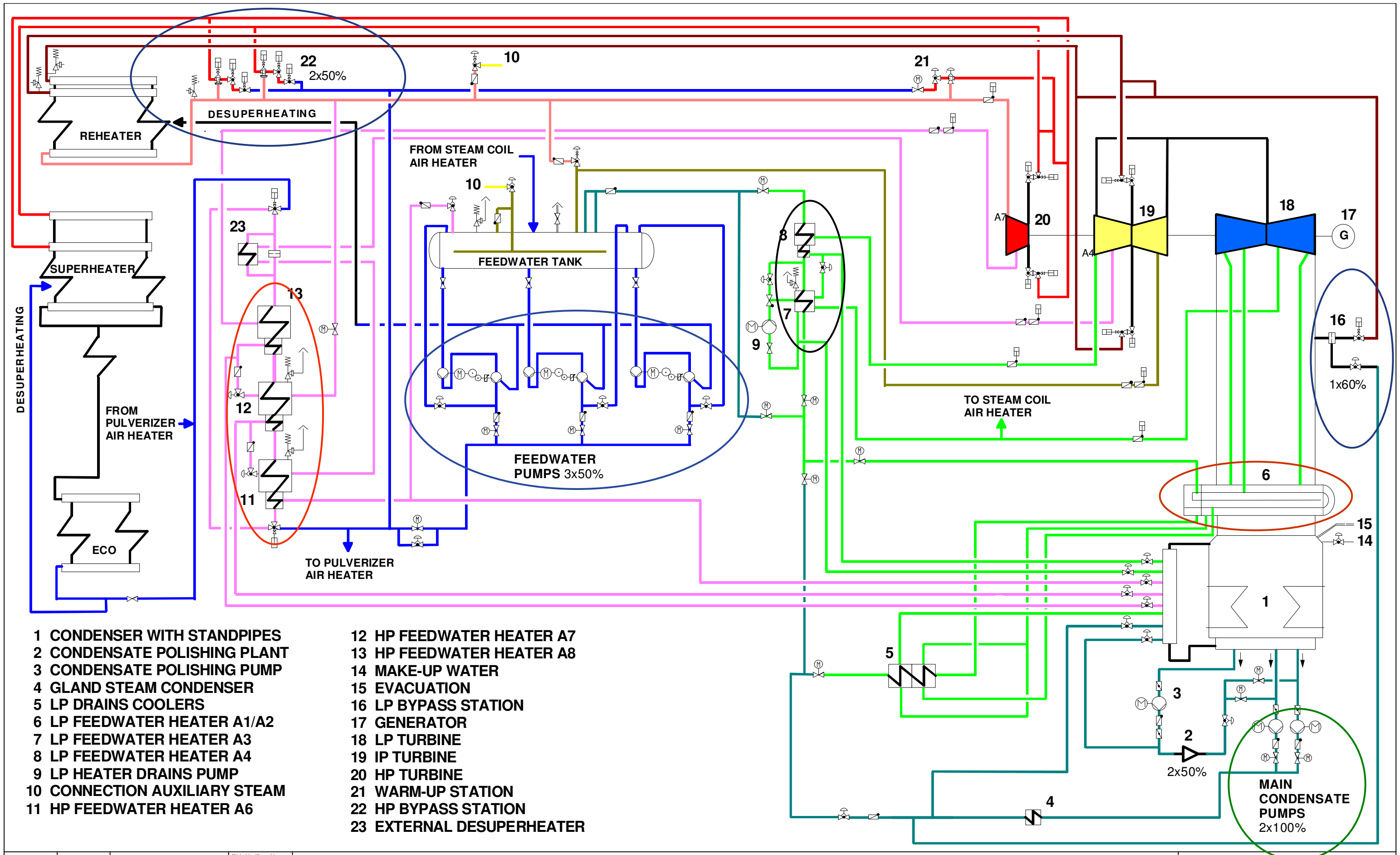


Source: Siemens AG

© IMTE



50 Hz RPP – Water Steam Cycle Diagram



1 CONDENSER WITH STANDPIPES
2 CONDENSATE POLISHING PLANT
3 CONDENSATE POLISHING PUMP
4 GLAND STEAM CONDENSER
5 LP DRAINS COOLERS
6 LP FEEDWATER HEATER A1/A2
7 LP FEEDWATER HEATER A3
8 LP FEEDWATER HEATER A4
9 LP HEATER DRAINS PUMP
10 CONNECTION AUXILIARY STEAM
11 HP FEEDWATER HEATER A6
12 HP FEEDWATER HEATER A7
13 HP FEEDWATER HEATER A8
14 MAKE-UP WATER
15 EVACUATION
16 LP BYPASS STATION
17 GENERATOR
18 LP TURBINE
19 IP TURBINE
20 HP TURBINE
21 WARM-UP STATION
22 HP BYPASS STATION
23 EXTERNAL DESUPERHEATER

PKZ/PC	UA/ Type of Doc.	Inhaltskennzeichen / Contents Code	Zhl.-Nr./Reg.No.
ZDK006	XG02	L	
Dienstst./Dept. W715	UNID		Index Rev. - Datum/Date 2003-09-30
vgl_RKW NRW_basis_8_engl.dsf		NOT BINDING FOR EXECUTION	

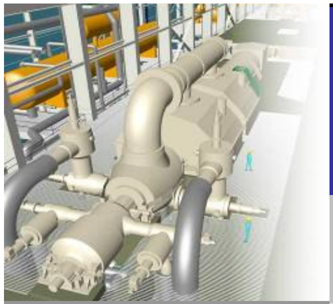
🟦 Condensate Supply	🟫 Feedwater Storage / Deaeration	🟥 Main Steam Piping System	🟥 Hot Reheat Piping System
🟩 LP Feedwater Heating	🟦 Feedwater Supply	🟥 Cold Reheat Piping System	🟨 Auxiliary Steam Piping System
	🟪 Feedwater Preheating		

RKW NRW
MODULES OF
WATER STEAM CYCLE
PREFERRED VARIANT

Siemens Power Generation PG

Powergen Asia 2008

© IMTE

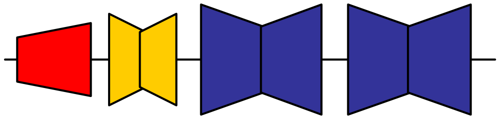


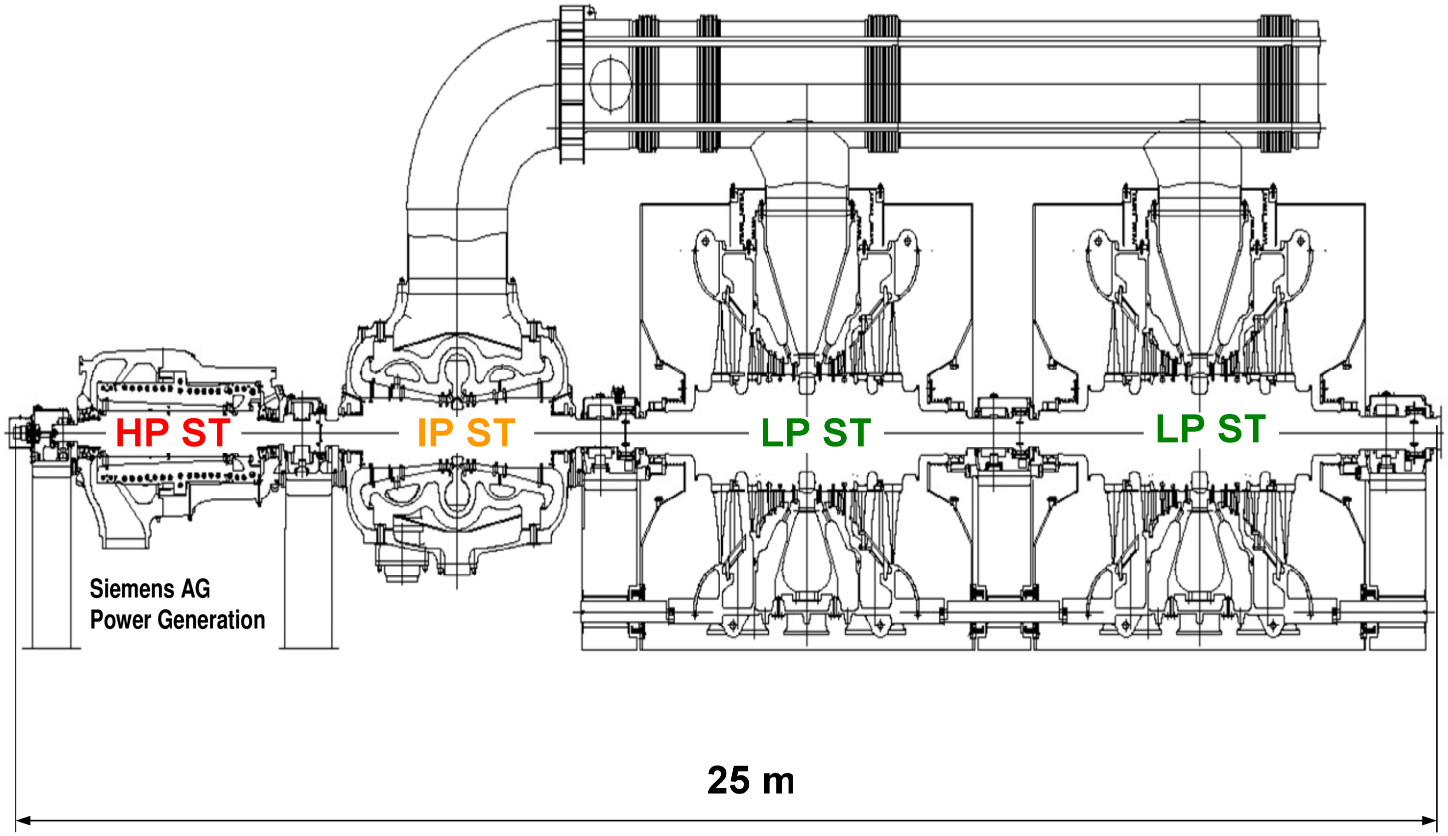
60Hz Varioplant – Main Parameters

Plant Gross Capacity	800 MW
Plant Net Capacity	725 MW
Live Steam Pressure	28.5 MPa
Live Steam Temperature	600 ºC
Reheat Pressure	6.0 MPa
Condenser Pressure	4.5 kPa
Feed Water Temperature	303 ºC
Reheat Temperature	610 ºC
Heat Rate$_{NET/LHV}$–Efficiency	45.8 % → 7,844 kJ / kWh
Boiler Type	OT-Benson
ST Type	4 Casing – Single Reheat 1SF HP-1DF IP-2DF LP

© IMTE

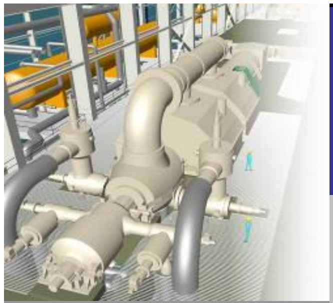
800MW$_{GROSS}$ 4-Casing (60Hz) USC Steam Turbine



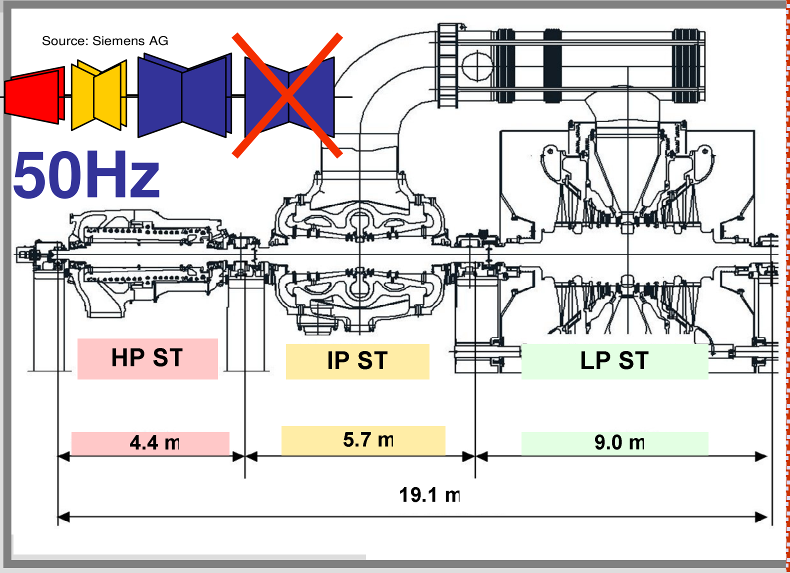


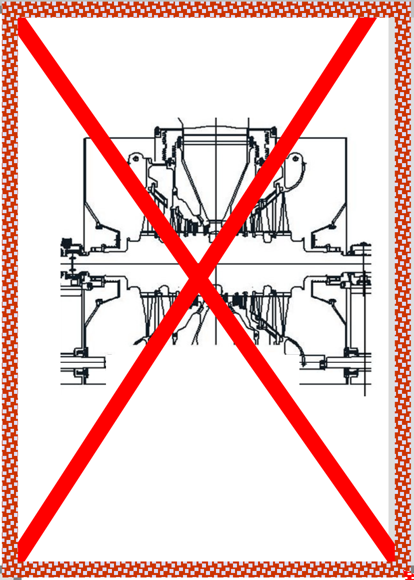
Powergen Asia 2008

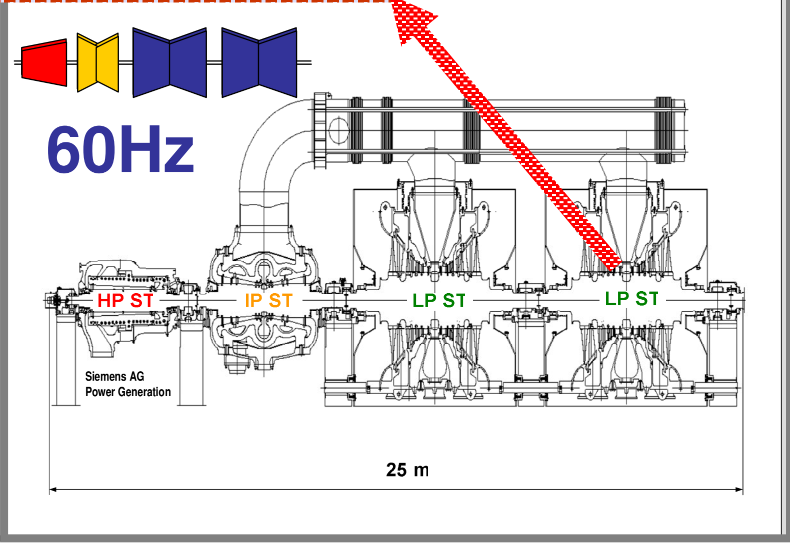
© IMTE



50 Hz vs. 60 Hz





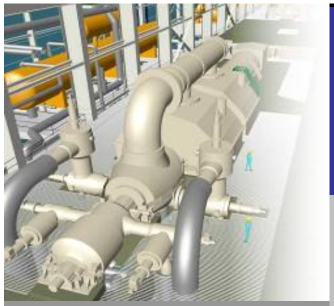


Mach 2.2 (~720m / sec) at Last Stage Blade End allows

55” Blade for 50Hz (Titanium)

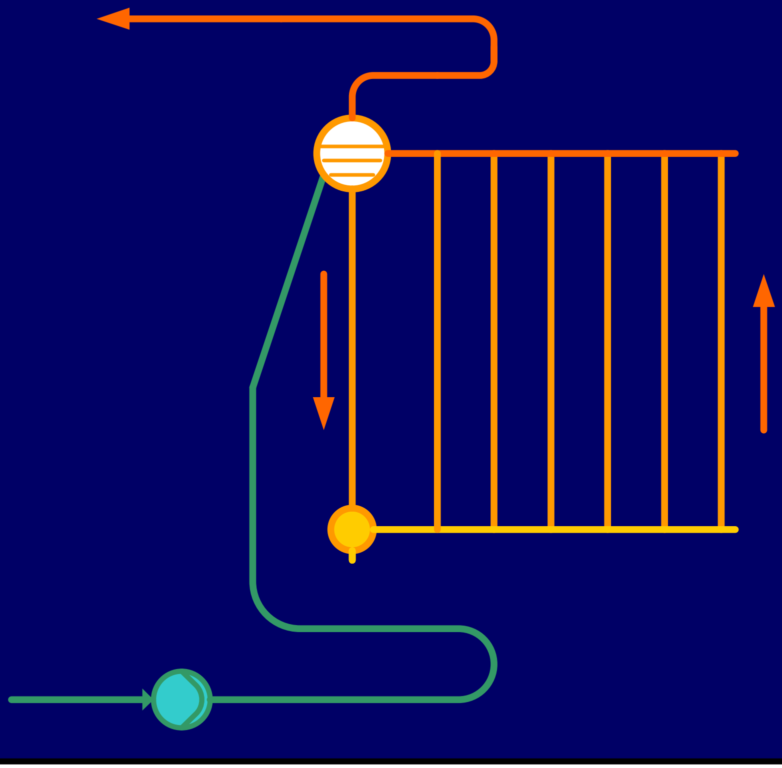
43” Blade for 60Hz (Titanium)

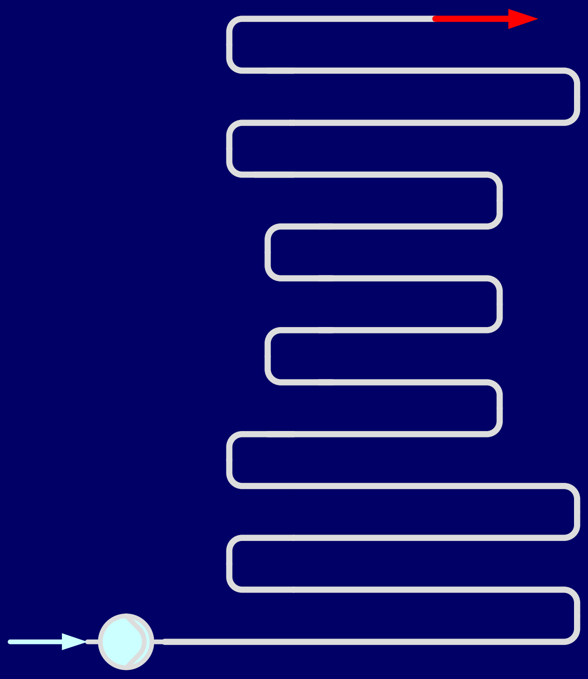
© IMTE

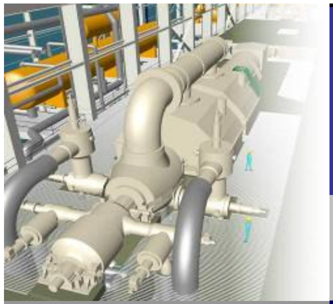


Drum vs. OT Boiler

Drum Type Boiler	OT Type Boiler
Operational Pressure	Operational Pressure
1.0 – 18.0 MPa	2.0 – 40.0 MPa



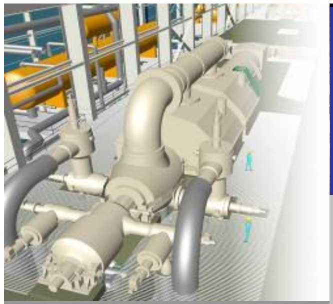




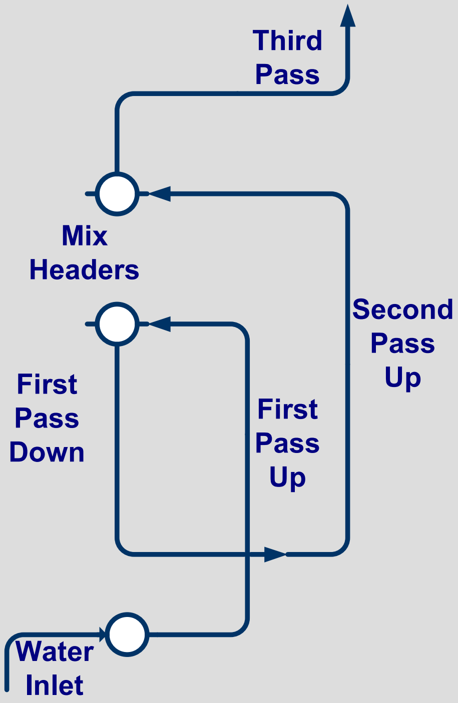
Drum vs. OT Boiler

Drum Boiler	OT Boiler
➢ Restricted to Sub-Critical Pressures	❖ Both Sub- & Super-Critical Pressures
➢ Low Efficiency at Part Load	❖ Highest Efficiency at Part & Full Load
➢ Long Start-up Times	❖ Short Start-up Times
➢ Thick Walled Components (HP Drum) →Higher Thermal Stresses	❖ Thermoelastic Construction →Lower Thermal Stresses
➢ Feed Water Flow Control by Drum Water Level Control	❖ Feed Water Flow Control by after Evaporator Temperature / Enthalpy Control
➢ Lower Load Transients (4-5%)	❖ Higher Load Transients (6-8%)

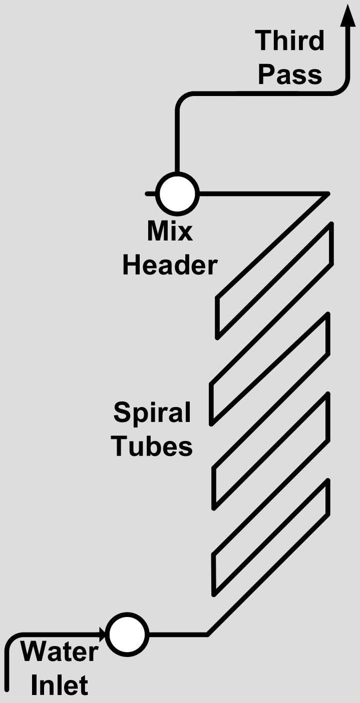
© IMTE



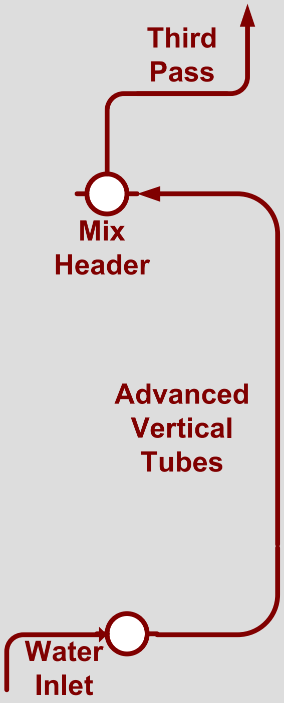
OT Boiler Furnace Arrangements



Vertical Tube
Arrangement
High Mass Flux



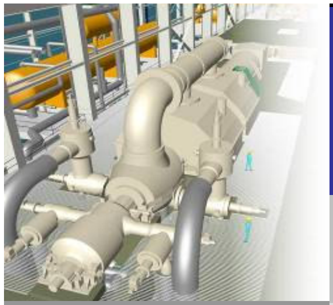
Spiral Tube
Arrangement
High Mass Flux



Advanced Vertical
Tube Arrangement
Low Mass Flux

Powergen Asia
2008

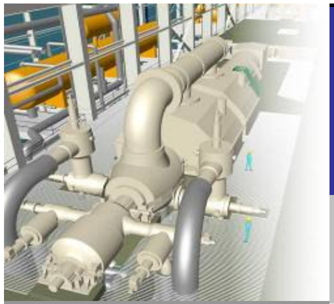
© IMTE



Advantages of Vertical vs. Spiral Arrangement

- Cheaper Manufacture & Assembly
- Maintenance Friendly
- Part Load up to 20% at highest Main Steam Temperatures
- Reduced Slagging of Furnace Walls
- Lower Evaporator Pressure Loss
- Lower Auxiliary Power Requirement
- Simple Start-up System.

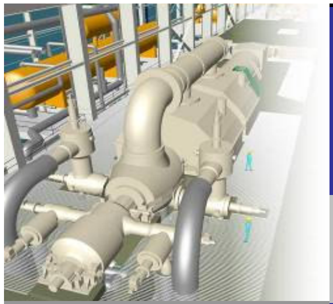
© IMTE



Low Mass Flux Design (LMFD)

- Current OT boilers use Furnace Tube Mass Fluxes (FTMF) designs >1,500-1,800kg/m^2s.
- FTMF levels below 1,000-1,200kg/m^2s → (LMFD) minimize the furnace dynamic pressure losses.
- Thermo-hydraulic behavior of the LMFD becomes similar to natural circulation boilers.

© IMTE



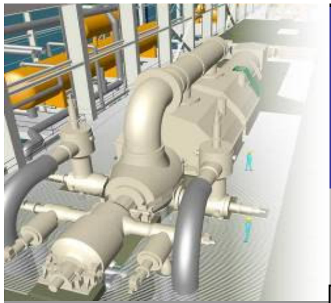
Low Mass Flux Design (LMFD)

Combination Vertical Tube Arrangement with Low Mass Flux Design

⇩

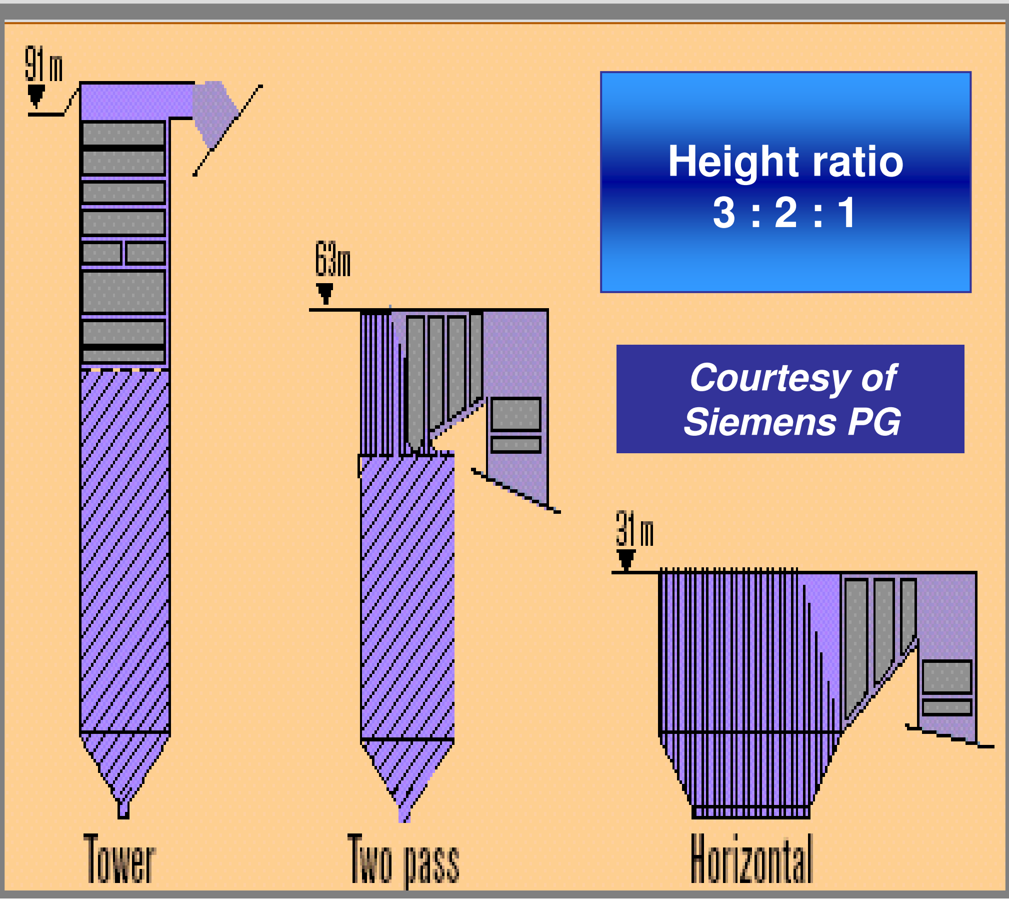
Highly Efficient & Reliable Boiler with Outstanding Operating Characteristics at any Load from 20% part Load up to Design Base Load.

© IMTE



OT Boiler Design Alternatives

Height Comparison of 500MW Coal Fired OT Boilers

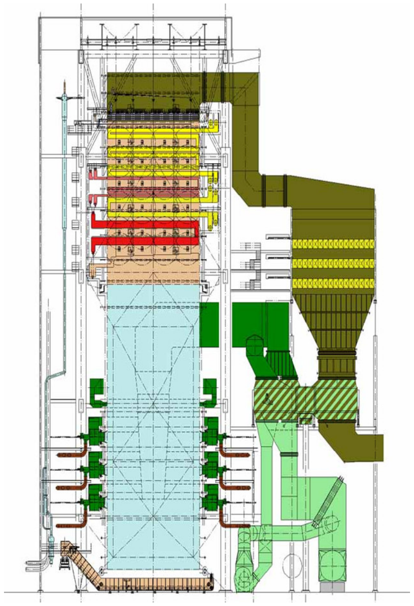


Height ratio
3 : 2 : 1

Courtesy of Siemens PG

© IMTE

OT Boiler Design Alternatives



Floor space: 2,975 m²
Volume: 166,000 m³
Efficiency: 95%

Tower Boiler →

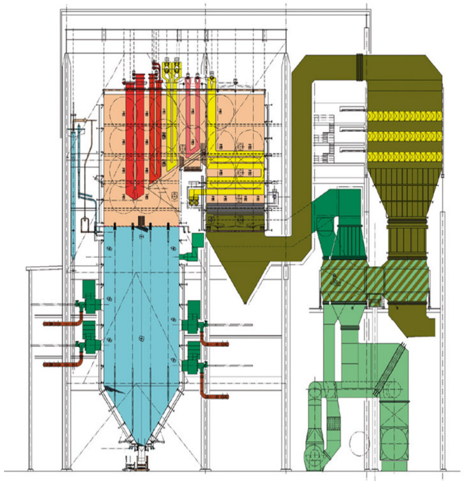
Lowest Steel & Pressure Parts & Floor Space Requirement.

Allows Multilevel Coal Feeders.

High Hight.

© IMTE

OT Boiler Design Alternatives



Floor space: 4,164 m²
Volume: 197,000 m³
Efficiency: 95%

Two-Pass Boiler →

High Steel, External Piping, Pressure Parts & Floor Space Requirement.

Short Assembly Time.

Low Height.

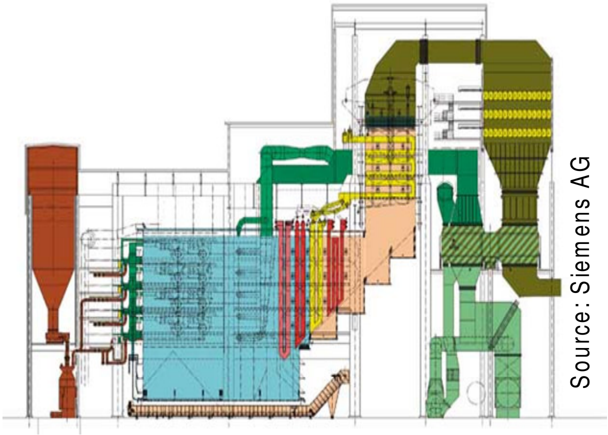
© IMTE

OT Boiler Design Alternatives

Horizontal Boiler →

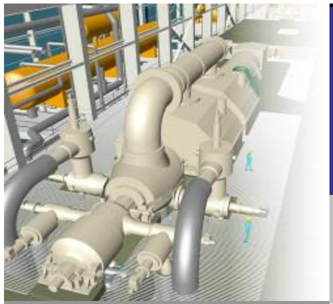
Lowest External Piping Requirement, High Steel & Floor Space Requirement.

Low Height.


Source: Siemens AG

Floor space: 4,600 m^2
Volume: 209,000 m^3
Efficiency: 95%

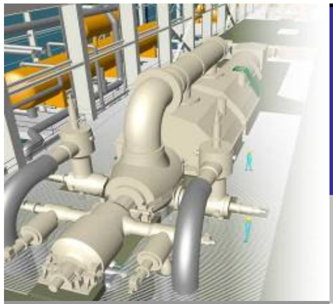
© IMTE



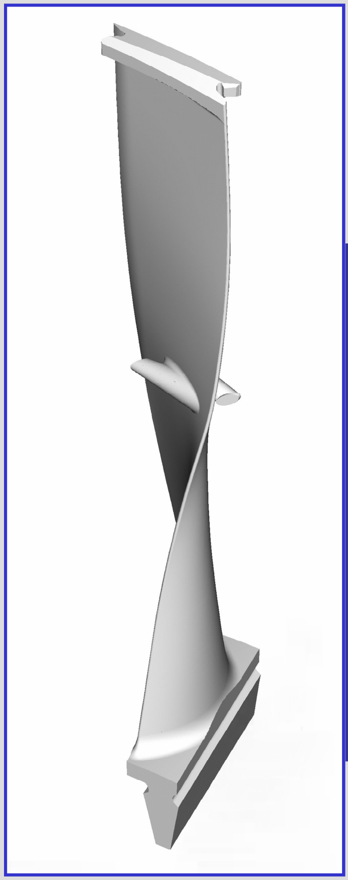
Boiler Temperature & Material Development

Live Steam Pressure MPa	Live Steam Temperature °C	Date	Material	Equivalent to
<20.0	<520	Since Early 60's	X 20	Cr Mo V 11 1
<25.0	<540	Since Early 80's	P 22	2 ¼ Cr Mo
<30.0	<560	Since Late 80's	P 91	9Cr – 1Mo
<33.0	<620	Since 2004	P 92	X10CrWMoVNb9-1 EUROPE STBA29-STPA29 JAPAN
<35.0	<700	Start 2010	Super Alloys	CCA 617 - IN 740 – Haynes 230 – Save 12

© IMTE



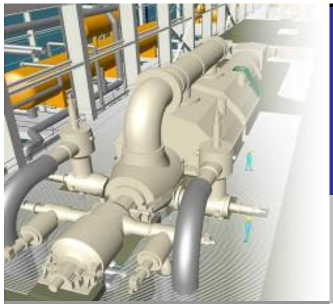
Design Features (50Hz) $16m^2$ Last Stage Blade



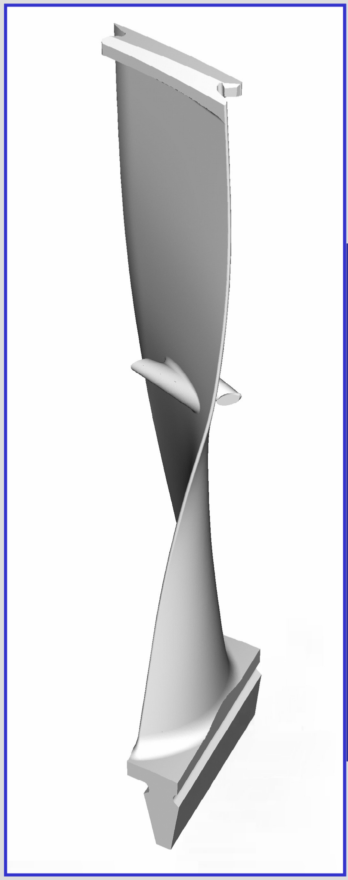
➢Rotor Diameter	1,900 mm
➢Blade Length	1,400 mm (55”)
➢Speed at Blade End	738 m/s
➢Mach No at Blade End	2.24
➢Blade Connection	Shroud & Snubber
➢Blade Material	Titanium

Source: Siemens AG

© IMTE



Design Features (60Hz) 10.3 m² Last Stage Blade



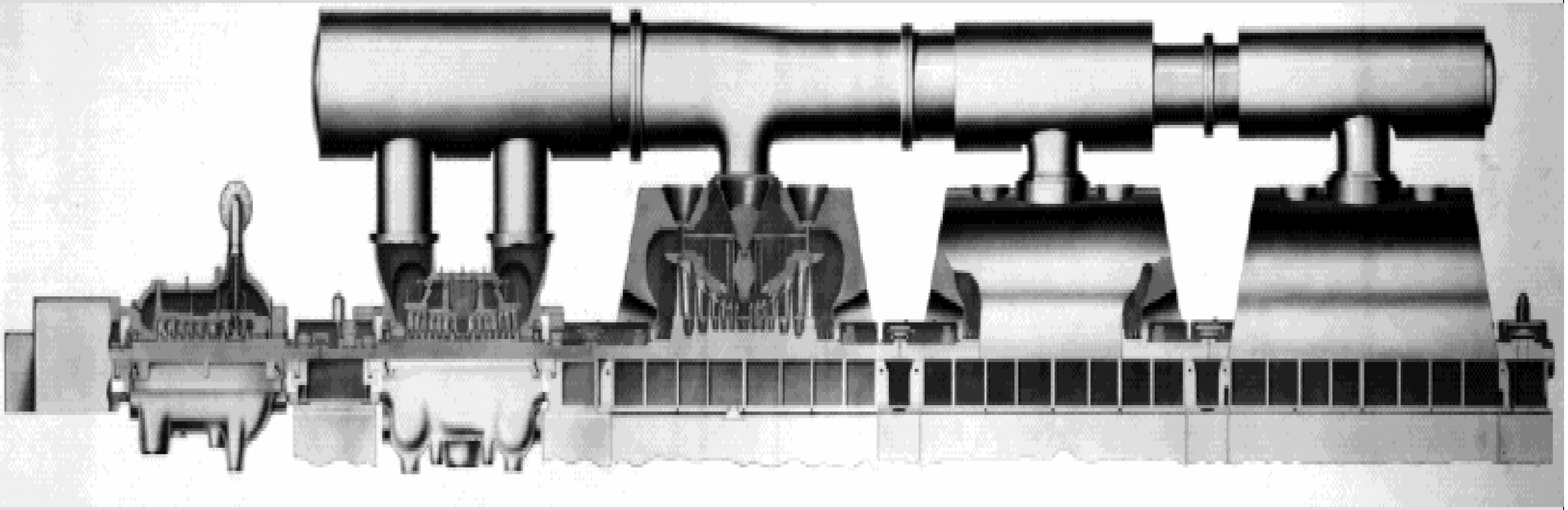
➢ Rotor Diameter	1,700 mm
➢ Blade Length	1,067 mm (42.0'')
➢ Speed at Blade End	722 m/s
➢ Mach No at Blade End	2.18
➢ Blade Connection	Shroud & Snubber
➢ Blade Material	Titanium

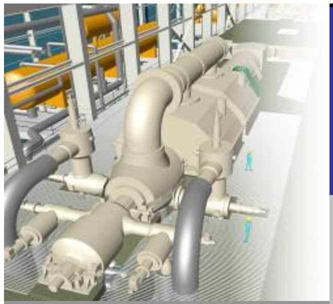
Source: Siemens AG

© IMTE

ST Common Configurations

Steam turbine tandem compound configuration: Five-casing, six-flow, with single reheat, > 1200 MW, 310 bar

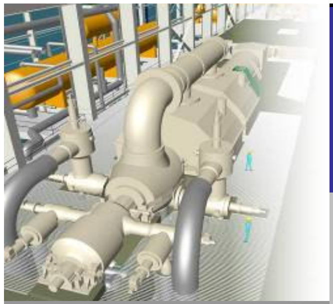




ST Material Development (50Hz)

Steam Temperature	≤560°C	≤620°C	≤700°C
Rotor	1Cr Mo V forging 12Cr Mo V Nb N 26Ni Cr Mo V11 5	9-12Cr W Co forging 12Cr Mo W V Nb N	IN 625 / IN 740 CCA 617 Haynes 230
Nozzles Valves	Cr Mo V Cast 10Cr Mo V Nb	9-10% Cr (W) Cast12Cr W (Co)	CCA 617 IN 625 / IN 714
Inner Casing Shells	1-2 Cr Mo Cast Cr Mo V Cast 9Cr 1 Mo V Nb (up to 590°C)	9-12% Cr (W) Cast12Cr W (Co)	CCA 617 IN 625 IN 740 (up to 760°C)
Blading	10Cr Mo V Nb N Titanium (last rotor row)	9-12% Cr W Co Titanium (last rotor row)	Wrought Ni-Base Titanium (last rotor row)
Bolting	9-12% Cr Mo V NI 80A; IN 718	9-12% Cr Mo VIN 718	Nimonic105 / 115 / 718Allvac 718 Plus Waspaloy

© IMTE



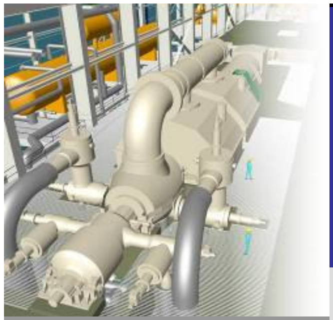
Creep Strength of Materials – Typical Example

Materials for applications below 600°C		
Material	Creep Strength (kN/cm^2)	Max. Temperature (°C)
12% Cr Steel → X 20	600	<620
9 Cr Steel → P 92	1,200	<620
Supper Alloys	3,000	<620
Materials for applications between 620 and 700°C		
Martensitic Steel	1,000	<650
Austenitic Steel	1,000	<700
Materials for applications above 700°C		
Super Alloys	1,000	<750

© IMTE

NEURATH G	NEURATH	RWE POWER AG	1100.000	CON	2010	COAL	LIG
OAK GROVE (TX) 1	OAK GROVE (TX)	TXU POWER CO LLC	860.000	PND	2009	COAL	LIG
OAK GROVE (TX) 2	OAK GROVE (TX)	TXU POWER CO LLC	860.000	PND	2009	COAL	LIG
LAGISZA 8	LAGISZA	PKE ELEKTROWNIA LAGISZA SA	460.000	CON	2009	COAL	BIT
ELM ROAD 1	ELM ROAD	WE POWER LLC	615.000	CON	2009	COAL	BIT
BARH 1	BARH	NTPC LTD	660.000	CON	2009	COAL	x
SIPAT 2	SIPAT	NTPC LTD	660.000	CON	2009	COAL	x
COMANCHE (CO) 3	COMANCHE (CO)	PUBLIC SERVICE COLORADO	816.000	CON	2009	COAL	x
YONGHUNGDO 4	YONGHUNGDO	KOREA SOUTH-EAST POWER CO	870.000	CON	2009	COAL	BIT
TIANJIN BEIJIANG 1	TIANJIN BEIJIANG	TIANJIN BEIJIANG POWER PLANT	1000.000	CON	2009	COAL	x
TIANJIN BEIJIANG 2	TIANJIN BEIJIANG	TIANJIN BEIJIANG POWER PLANT	1000.000	CON	2009	COAL	x
WAIGAOQIAO-3 NO 2	WAIGAOQIAO	SHENERGY COMPANY LTD	1000.000	CON	2009	COAL	BIT
ZOUXIAN 8	ZOUXIAN	HUADIAN POWER INTL CORP	1000.000	CON	2009	COAL	BIT
PATNOW 9	PATNOW	ZES ELEK PATNOW-ADAMOW-KONIN	464.000	CON	2008	COAL	LIG
WESTON (WI) 4	WESTON (WI)	WISCONSIN PUBLIC SERVICE CORP	500.000	CON	2008	COAL	x
PORYONG 7	PORYONG	KOREA MIDLAND POWER (KOMIPO)	500.000	CON	2008	COAL	BIT/SUB
PORYONG 8	PORYONG	KOREA MIDLAND POWER (KOMIPO)	500.000	CON	2008	COAL	BIT/SUB
NINGDE 2	NINGDE	DATANG INTL POWER GEN CO	600.000	CON	2008	COAL	BIT
HUANGGANG DABIESHAN 1	HUANGGANG DABIESHAN	CHINA POWER INTL DEVELOP LTD	600.000	CON	2008	COAL	x
HUANGGANG DABIESHAN 2	HUANGGANG DABIESHAN	CHINA POWER INTL DEVELOP LTD	600.000	CON	2008	COAL	x
QINGHE 11	QINGHE	CHINA POWER INVESTMENT CORP	600.000	CON	2008	COAL	x
YAOMENG-2 NO 1	YAOMENG	CHINA POWER INTL DEVELOP LTD	600.000	CON	2008	COAL	BIT
YAOMENG-2 NO 2	YAOMENG	CHINA POWER INTL DEVELOP LTD	600.000	CON	2008	COAL	BIT
TORREVALDALIGA NORD 5	TORREVALDALIGA NORD	ENEL SPA	660.000	CON	2008	COAL	x
TORREVALDALIGA NORD 6	TORREVALDALIGA NORD	ENEL SPA	660.000	CON	2008	COAL	x
TORREVALDALIGA NORD 7	TORREVALDALIGA NORD	ENEL SPA	660.000	CON	2008	COAL	x
SIPAT 1	SIPAT	NTPC LTD	660.000	CON	2008	COAL	x
KOGAN CREEK 1	KOGAN CREEK	CS ENERGY CORP LTD	750.000	CON	2008	COAL	x

SC / USC POWER PLANT DATABASE



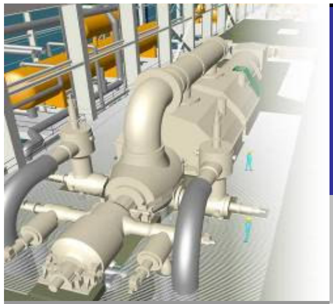
SC & USC Data Base

- Total SC / USC Power Plants → 717 (COD 1959-2016)
- Coal: 460 ∗ Gas: 178 ∗ Oil: 79
- Last 140 SC/USC PP (from 2005) only <u>coal fired</u>
- Retired: 23 ∗ Operational: 574 ∗Construction: 64 ∗ Design & Planning: 48

USA	→ 190
Japan	→ 130
Russia & Ukraine	→ 118
Europe	→ 82
China & India	→ 77
Former SU Countries	→ 45
South Korea	→ 34
Rest of the World	→ 26
Rest of Asia	→ 15

© IMTE

				$_{GROSS}$)	$\%_{LHV/NET}$ ($\%_{LHV/GROSS}$)		
1	Boxberg	Germany	50	915	41.7	26.7 / 555 / 578	2000
2	Niederaussem 1	Germany	50	965	43.2	26.0 / 580 / 600	2003
3	Boa 2 & 3 Neurath	Germany	50	2 x 1100	>43.0	26.0 / 595 / 595	2010
4	Westfalen 1 & 2	Germany	50	2 x 765	46.0	28.5 / 600 / 610	>2010
5	Niederaussem 2&3	Germany	50	2 x 1050	45.2	27.2 / 600 / 605	2010/11
6	Council Bluffs	USA	60	790		25.3 / 566 / 593	2007
7	Weston 4	USA	60	500		26.2 / 580 / 580	2008
8	Comanche 3	USA	60	750		26.2 / 570 / 570	2009
9	Elm Road 1 & 2	USA	60	2 x 600		26.2 / 570 / 570	2009/10
10	Iatan 2	USA	60	850		25.5 / 585 / 585	2010
11	Genesee 3	Canada	60	495		25.0 / 570 / 568	2005
12	Emshaven 1 & 2	Netherlands	50	2 x 780	>46.0	28.5 / 600 / 610	>2010
13	Lagisza (CFB Boiler)	Poland	50	460	43.3	27.5 / 560 / 580	2009
14	Misumi	Japan	60	1000		25.5 / 600 / 605	1998
15	Tsuruga 2	Japan	50	700		25.5 / 597 / 595	2000
16	Tachibana-wan 1	Japan	60	(700)		24.1 / 565 / 593	2000
17	Tachibana-wan 2	Japan	60	1050	43.1	26.4 / 605 / 613	2001
18	Hekinan 4 & 5	Japan	60	(2 x 1000)	42.0	25.0 / 571 / 596	2001/02
19	Isogo 1	Japan	50	600	43.0	25.0 / 600 / 610	2002
20	Hekinan 4 & 5	Japan	60	2 x 1000		25.0 / 571 / 596	2001/02
21	Tomato-Atsuma	Japan	50	(700)		25.0 / 603 / 602	2002
22	Hitachi-Naka 1	Japan	50	(1000)		25.4 / 604 / 602	2003
23	Kobe 2	Japan	60	700		24.1 / 537 / 565	2005
24	Isogo 2	Japan	50	600		25.0 / 600 / 620	2009

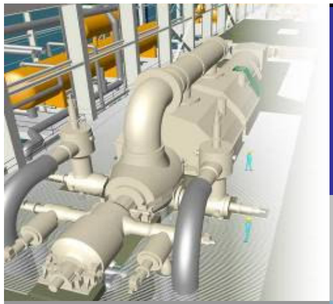


Lagisza 460 MW USC Power Plant - Poland

- World’s largest and first supercritical CFB boiler with OT- technology.
- Lower total plant investment, better net plant efficiency and fuel firing flexibility.
- Boiler designed for bituminous coal or mixture of bituminous coal with wet coal slurry (30%) and/or biomass (10%).
- Staged low temperature combustion & limestone feeding → SO_2 & NOx < $100 mg/Nm^3$
- Low furnace heat flux & low mass flux with vertical tubes → lower tube stress & pressure drop.
- Flue gas temperature of 85°C → combustion air preheating → efficiency improvement
- Net plant LHV efficiency of 43.3%.
- Scheduled COD in 2009.

© IMTE

Pos	Power Plant Name	Country	Hz	Power Output MW$_{NET}$ (MW$_{GROSS}$)	Thermal Efficiency %$_{LHV/NET}$ (%$_{LHV/GROSS}$)	Main Steam MPa /°C /°C	COD
25	Cogan Creek	Australia	50	750		25.0 / 540 / 560	
26	Waigaoqiao I	PR China	50	2 x 900		25.8 / 542 / 568	2004
27	Changshu	PR China	50	3 x 600	42.0	25.9 / 569 / 569	2006
28	Wangqu	PR China	50	2 x 600	43.0	24.7 / 571 / 569	2007
29	Waigaoqiao II	PR China	50	1000		27.0 / 600 / 600	2007
30	Huaneng	PR China	50	4 x 1000		26.5 / 600 / 600	2006/08
31	Yuhuan	PR China	50	4 x 1000	43.0 - 45.0	27.5 / 605 / 600	2006/08
32	Zouxian IV	PR China	50	2 x 1000		27.0 / 600 / 600	2008
33	Yonghung 1 & 2	S. Korea	60	(2 x 800)		25.5 / 569 / 569	2004
34	Tangjin 5 & 6	S. Korea	60	2 x 500		25.5 / 569 / 596	2005
35	Yonghung 3 & 4	S. Korea	60	(2 x 870)		25.5 / 569 / 596	2008/09
36	Poryong 7 & 8	S. Korea	60	2 x 500		25.5 / 569 / 596	2008
37	Taean 7 & 8	S. Korea	60	(2 x 550)			2008
38	Hadong 7 & 8	S. Korea	60	2 x 500		25.5 / 569 / 596	2009
39	Sasan	India	50	(5 x 800)		25.5 / 569 / 569	2008
40	Sipat	India	50	(3 x 660)	39.0	25.0 / 540 / 568	2008
41	Shahapur	India	50	(3 x 800)			2011
42	Mundra	India	50	(5 x 800)			2012



Boxberg 907 MW USC Power Plant - Germany

Photographs courtesy of Siemens Power Generation AG

26.6 MPa / 545 °C / 581 °C

Powergen Asia 2008

© IMTE

Niederaussem 1 – 965 MW USC Power Plant Germany

Photograph courtesy of Siemens Power Generation AG

27.5 MPa / 580 ºC / 600 ºC

Powergen Asia 2008

© IMTE

Tachibana-Wan 1050 MW SC Power Plant – Japan

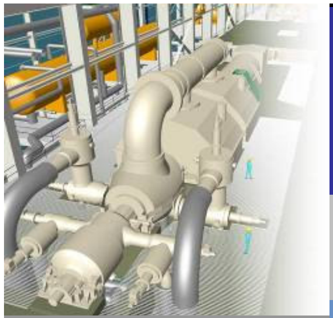
25.9 MPa

600 ºC / 610 ºC

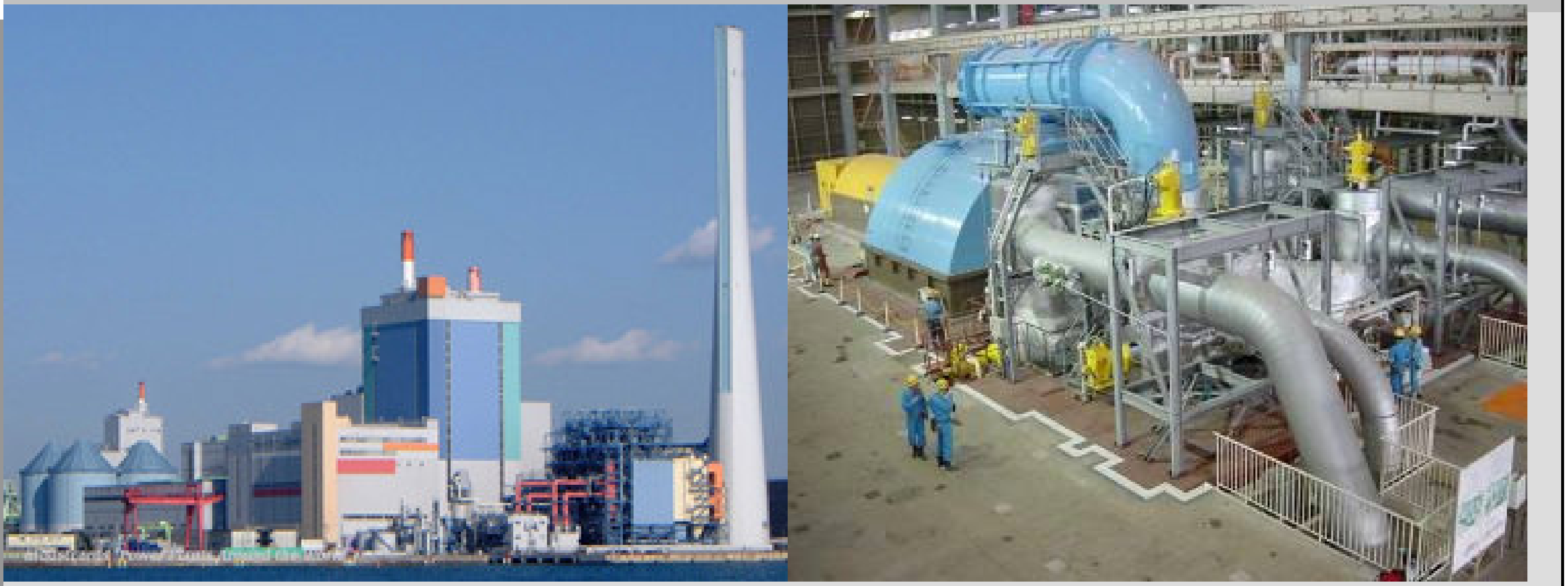
Photographs courtesy of IHI Ltd

Powergen Asia 2008

© IMTE



Shin-Isogo 600 MW USC Power Plant - Japan



Photographs courtesy of Electric Power Development Co & Siemens AG

Powergen Asia 2008

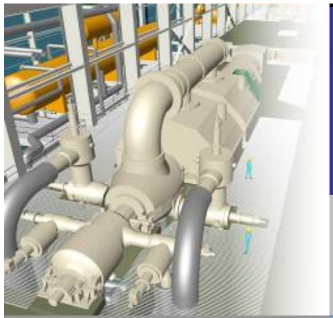
28.0 MPa / 605 °C / 613 °C

© IMTE

Misumi 1000 MW SC Power Plant - Japan

25.0 MPa / 600 °C / 605 °C

© IMTE



Waigaoqiao 2x900 MW USC Power Plant–PR China

Photographs courtesy of Siemens Power Generation AG

27.9 MPa / 542 °C / 562 °C

© IMTE

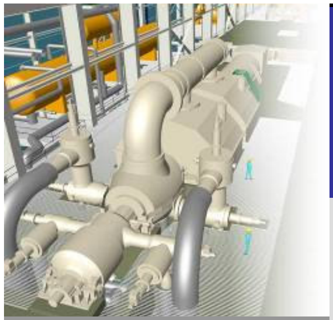
Huaneng Yuhuan 4x1000 MW USC Power Plant – PR China

Photographs courtesy of Ministry of Construction PR China

Powergen Asia 2008

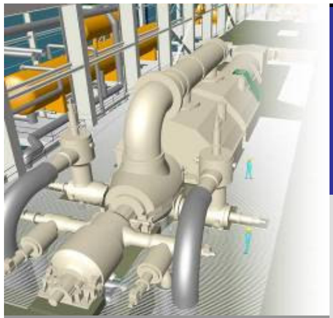
IMTE AG

26.5 MPa / 600 ºC / 600 ºC



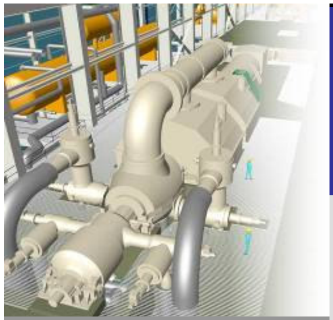
Summary
&
Conclusions

© IMTE



According to the World Coal Institute, more than 40% coal is worldwide used for power generation and it is expected to be the fuel of choice for the foreseeable future as power producing companies deploy technologies that offer cleaner, more efficient coal-fired based electric power production.

© IMTE

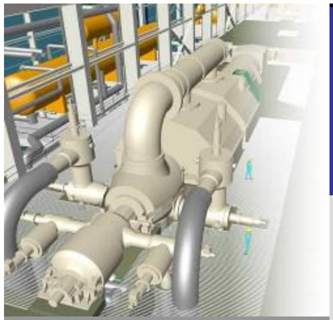


Most of the coal fired power plants to be build worldwide during next decades will be of:-

IGCC Technology; and

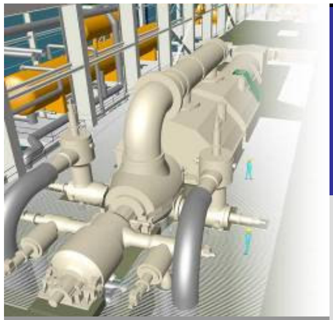
Pulverized Coal Fired SC/USC Technology

© IMTE



- Both IGCC and SC & USC Technologies are enjoying a steeply growing market share.
- However, IGCC market specifically, is not following this bullish trend yet- reason is higher investment costs than the cost of SC & USC Technology.

© IMTE



SC & USC Power Generation Technology will gain superiority over conventional (sub-critical) power plants from the following reasons:-

Higher Efficiency

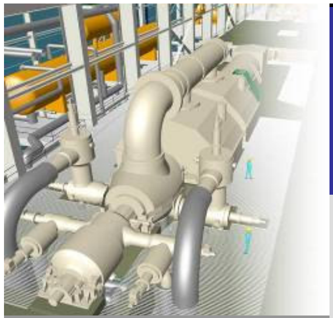
Excellent Load Behavior

Compactness

Lower Specific Weight

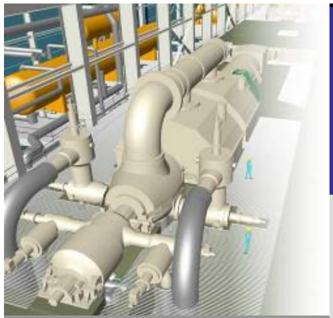
Environmental Friendliness

© IMTE



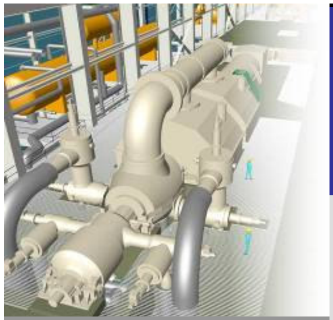
Double reheat cycles are being more often implemented to improve efficiency and reduce the problems concerning erosion by water drops of the LP ST last stage blades.

© IMTE



Vertical Tube Arrangement with Low Mass Flux Design is the preferable, highly efficient & reliable option for boiler design.

© IMTE

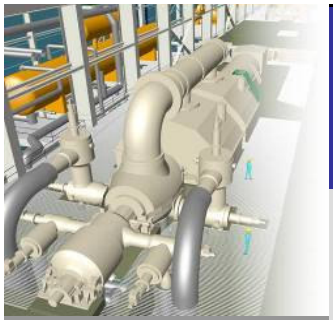


Current SC pulverized coal based power plants are working with net efficiencies in the range of:-

44 - 46%

8,180 - 7,830 kJ / kWh

© IMTE



Options to increase efficiency above

50 %

7,200 kJ / kWh

in

USC Power Plants

rely on elevated steam conditions as well as on future process improved

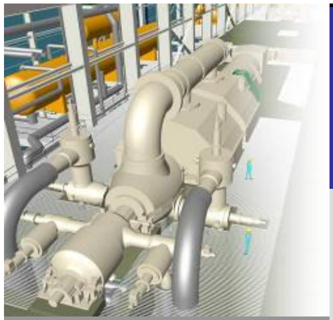
and

quality of used high pressure

and

high temperature materials.

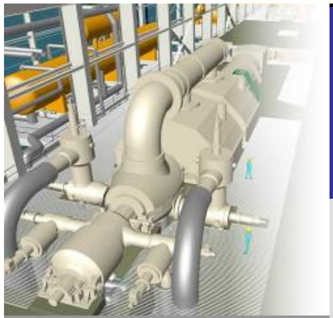
© IMTE



Steam conditions up to
30 MPa/600℃/620℃
are achieved using steels with
12 % Cr content

Steam conditions up to
32.5 MPa/620℃/620℃
can be achieved with Austenite
steels.

© IMTE



Nickel-based alloys may permit

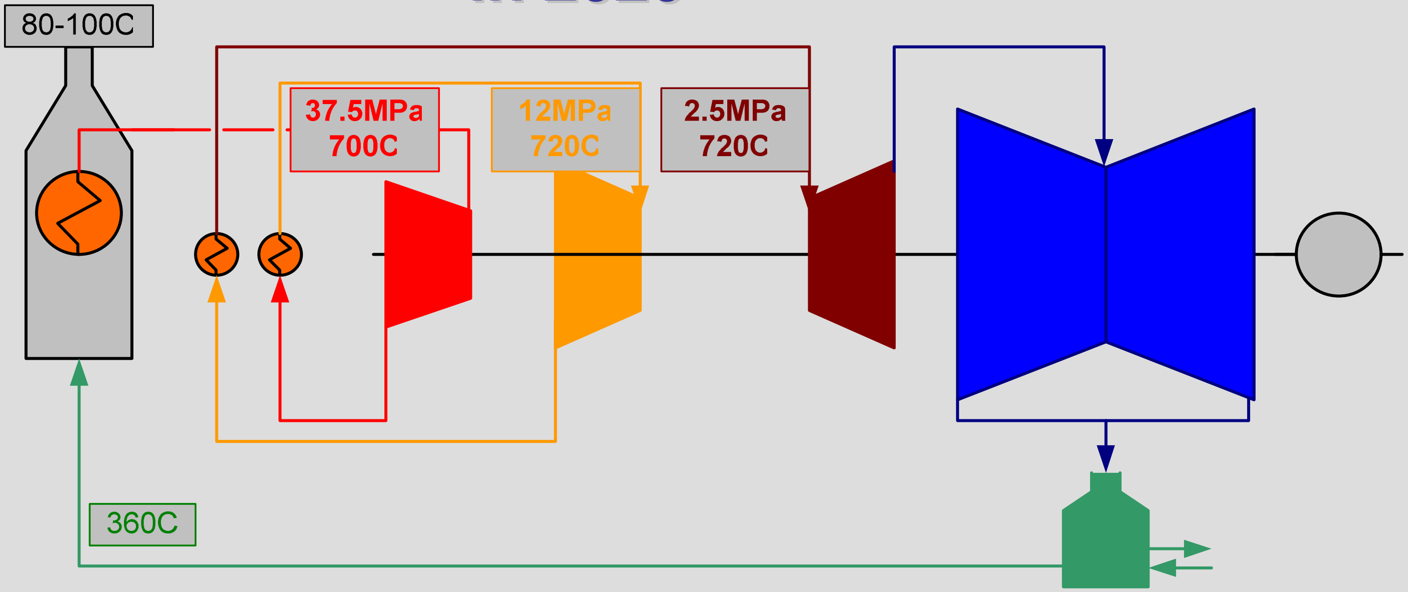
37.5 MPa / 720℃ / 720℃

yielding efficiencies of:-

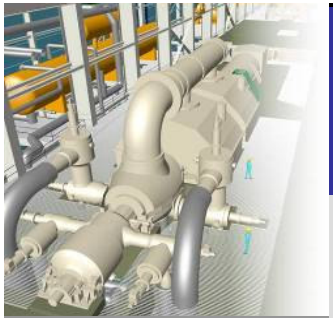
50 - 52%

7,200 – 6,900 kJ / kWh

in 2020



© IMTE

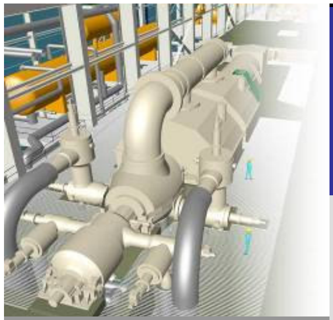


Early problems experienced with the first and second generation of SC and USC power plants have been overcomed.

Overall outlook for pulverized coal-fired SC/USC power plant technology is promising and its further growth lies ahead.

Intensity of this growth will depend on the following factors:

© IMTE



- Worldwide acceptance of USC technology.
- Further development of NG vs. Coal price.
- Reduction of investment & life cycle costs.
- Further Improvement of availability & reliability.
- Efficiency improvement.
- Further reduction of specific emissions.

© IMTE

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

THANK YOU

Powergen Asia 2008

IMTE AG

Power Consulting Engineers, Switzerland

imteag.com