Theme 3
Conventional Energy Technologies

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2. Thermal power plant technologies
3. Nuclear power plant technologies

1. Status of conventional energy technologies

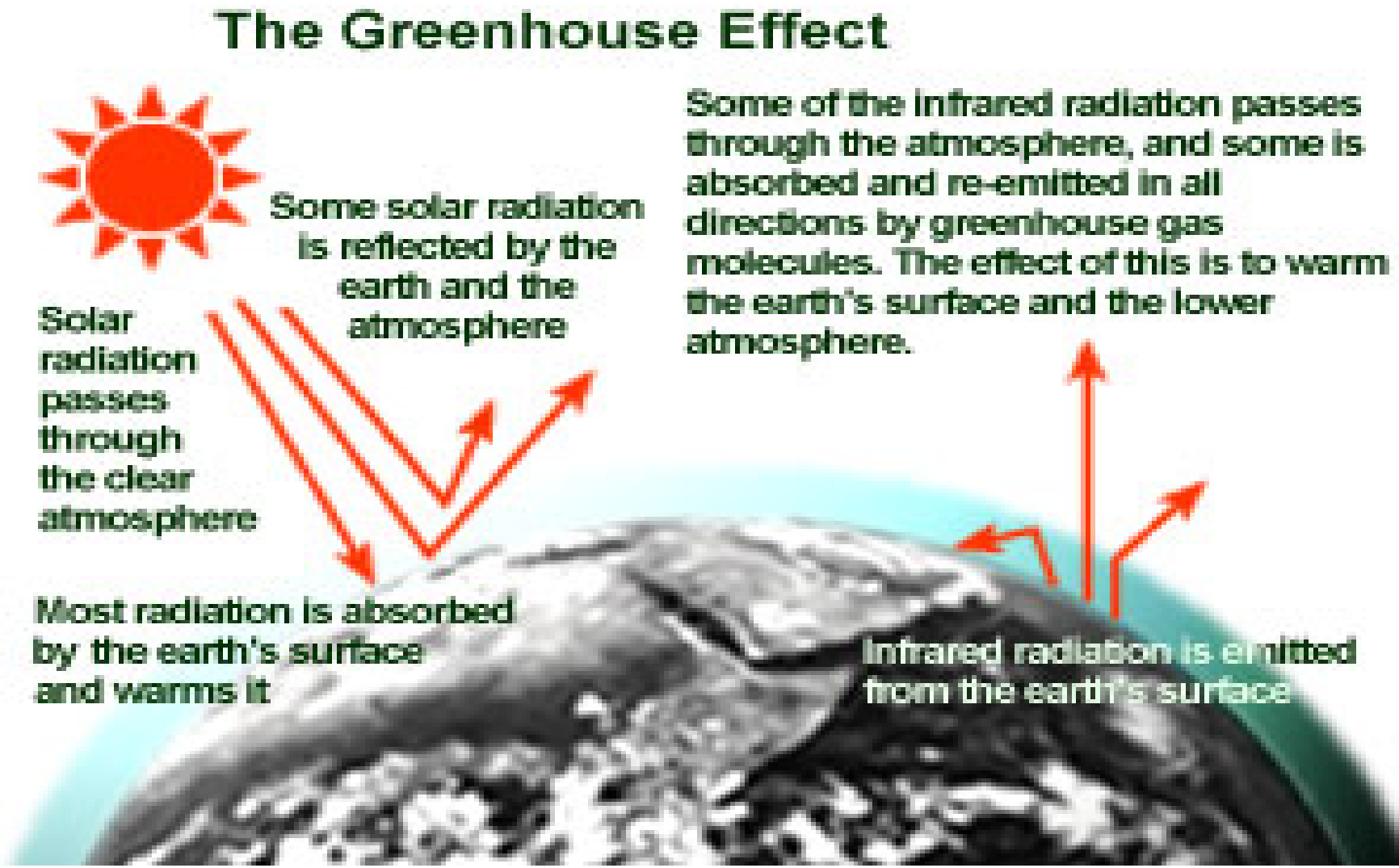
- Energy use and environmental pollution
- Status of fossil fuel sources and fossil fuel electricity generation
- Advanced energy technologies

Energy use and environmental pollution

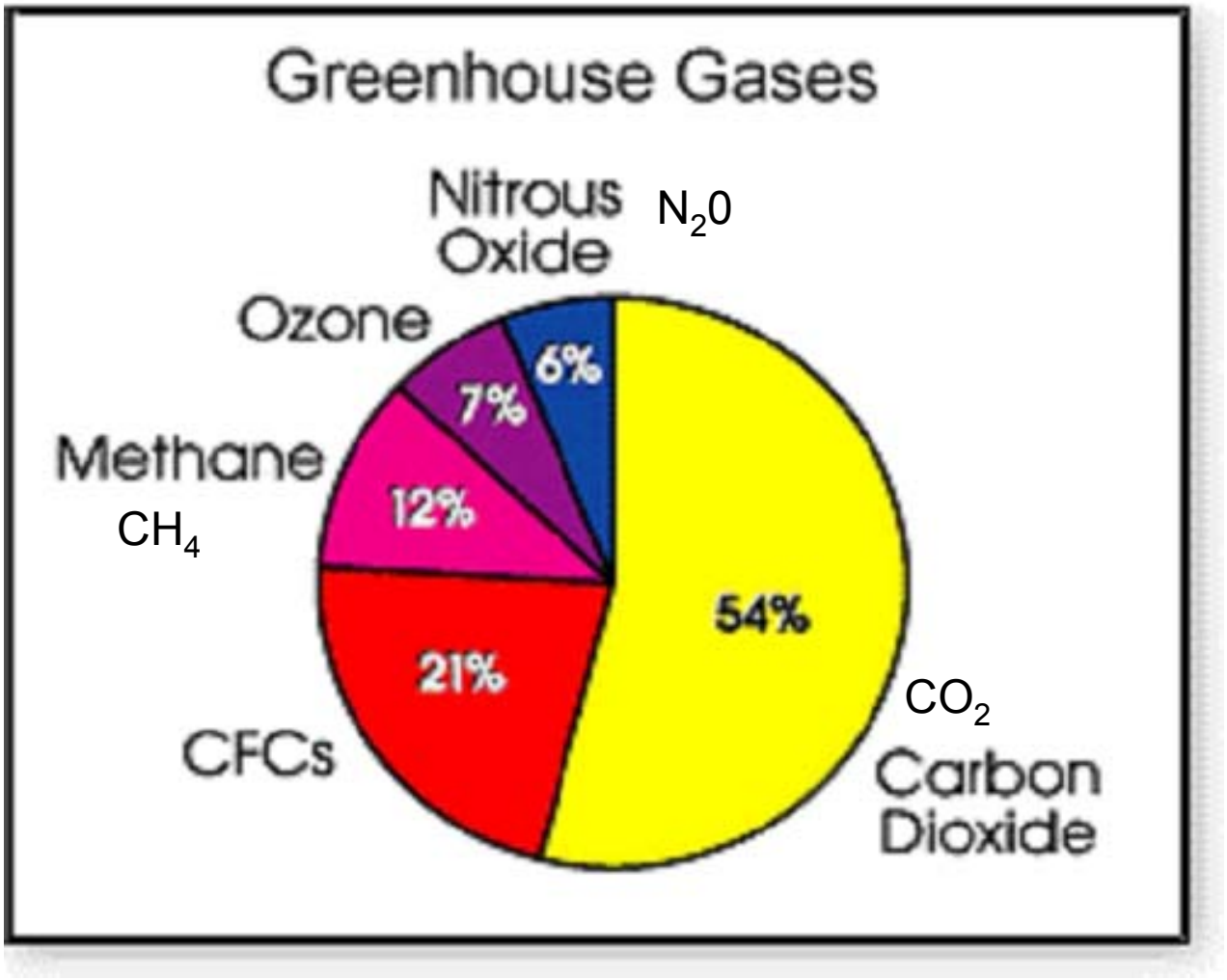
- Air pollution
  - CO2, CO, CnHm, SOx, Nox, greenhouse effect, acid rain
  - Particulate matter (PM10)
- Water pollution
  - pH
  - BOD, COD
- Others
  - Noise
  - Heat

4

Greenhouse effect



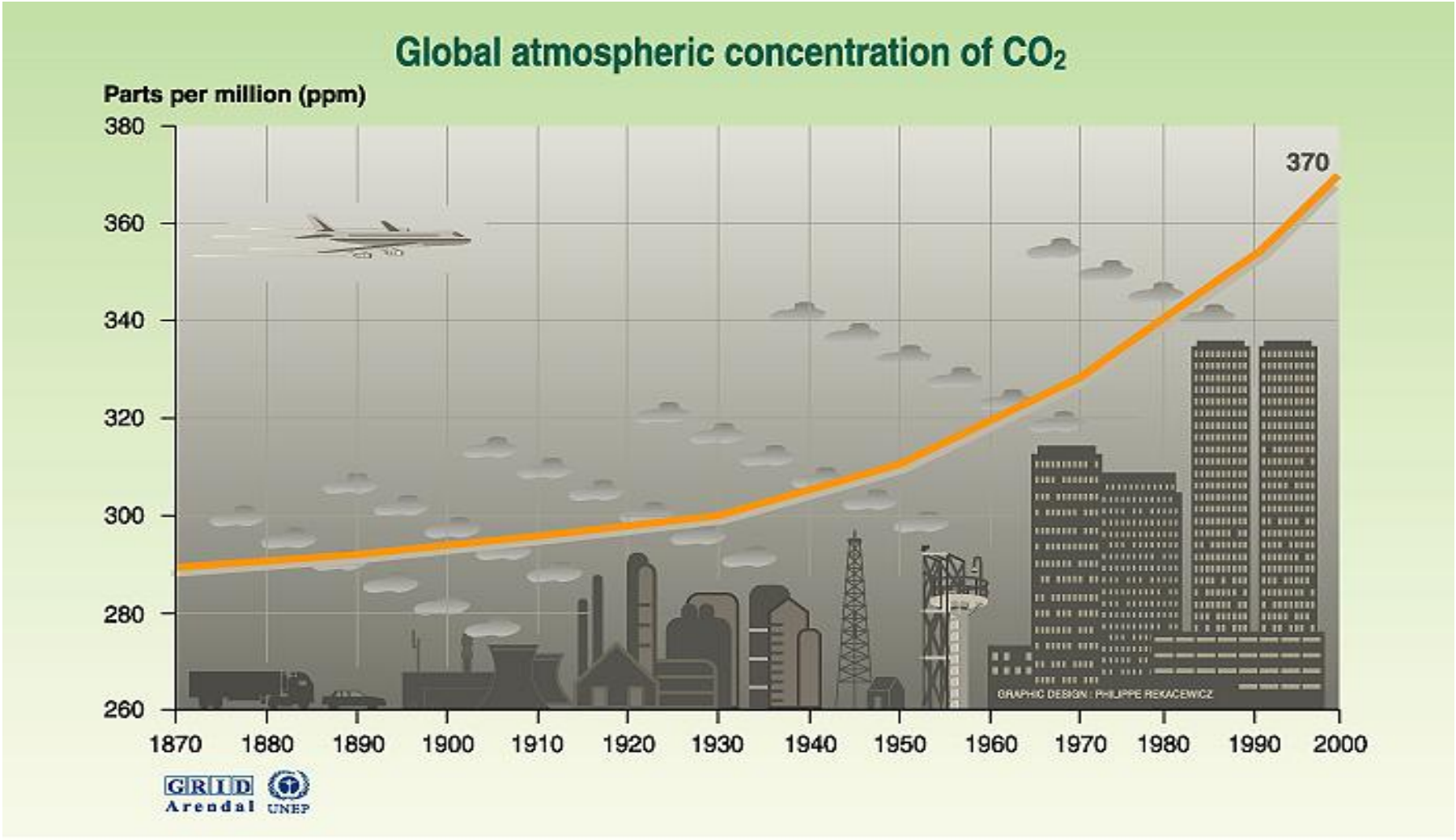
Greenhouse gases



Greenhouse gases and their effect

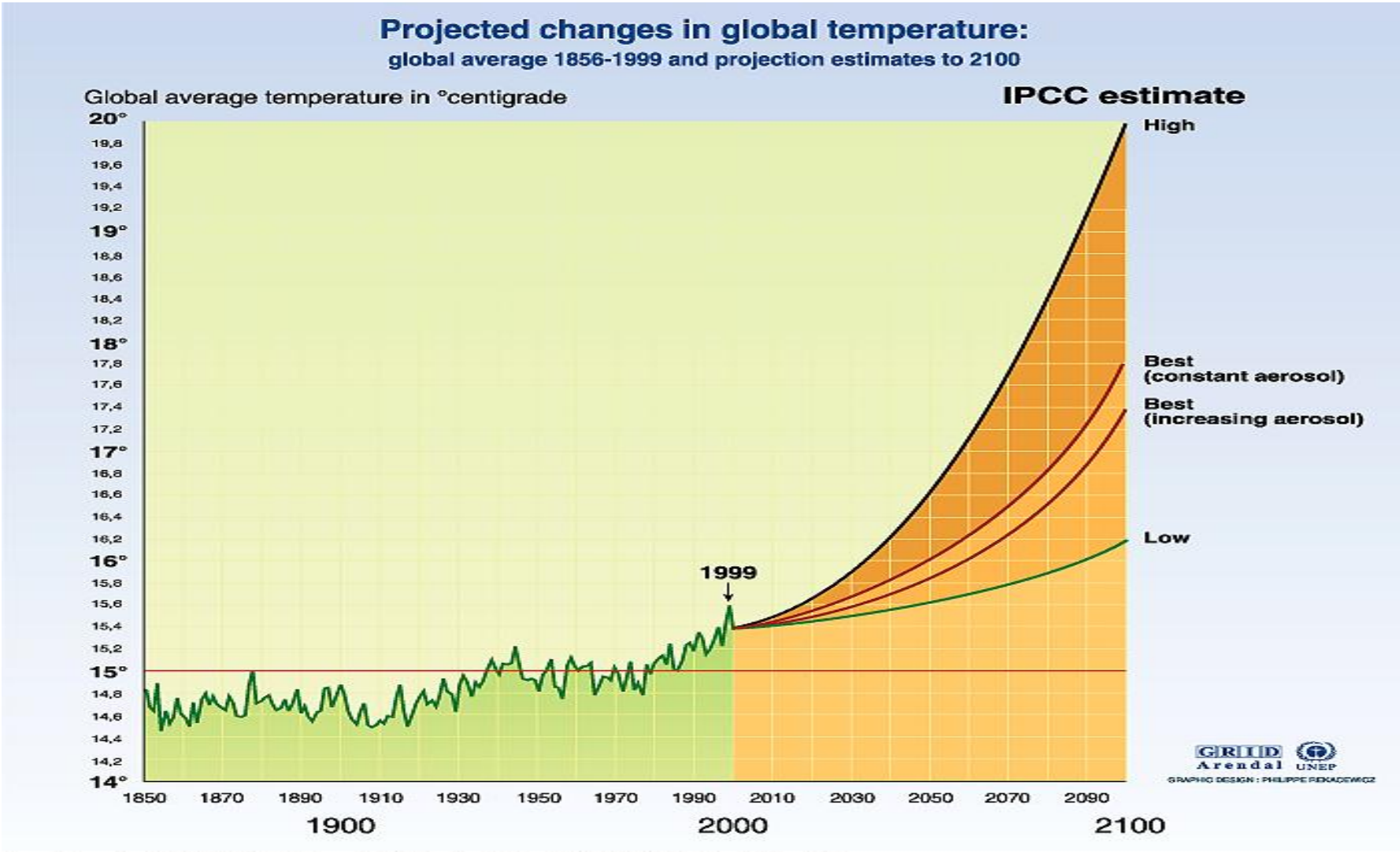
Trace Gas	GWP	Trace Gas	GWP
Carbon Dioxide	1	HFC-143a	4300
CCl4	1300	HFC-152a	120
CFC-11	4600	HFC-227ea	3500
CFC-113	6000	HFC-23	12000
CFC-116	>6200	HFC-236fa	9400
CFC-12	10600	HFC-245ca	640
CFC-I14	7000	HFC-32	550
CFC-I15	7000	HFC-41	97
Chloroform	4	HFC-43-IOmee	1500
HCFC-123	120	Methane	23
HCFC-124	620	Methylenechloride	9
HCFC-141b	700	Nitrous Oxide	296
HCFC-142b	2400	Perfluorobutane	8600
HCFC-22	1700	Perfluorocyclobutane	10000
HFC-125	3400	Perfluoroethane	11000
HFC-134	1100	Sulphur hexafluoride	22000
HFC-134a	1300	Trifluoroiodomethane	<1
HFC-143	330		

Changes in global atmospheric concentration of CO2



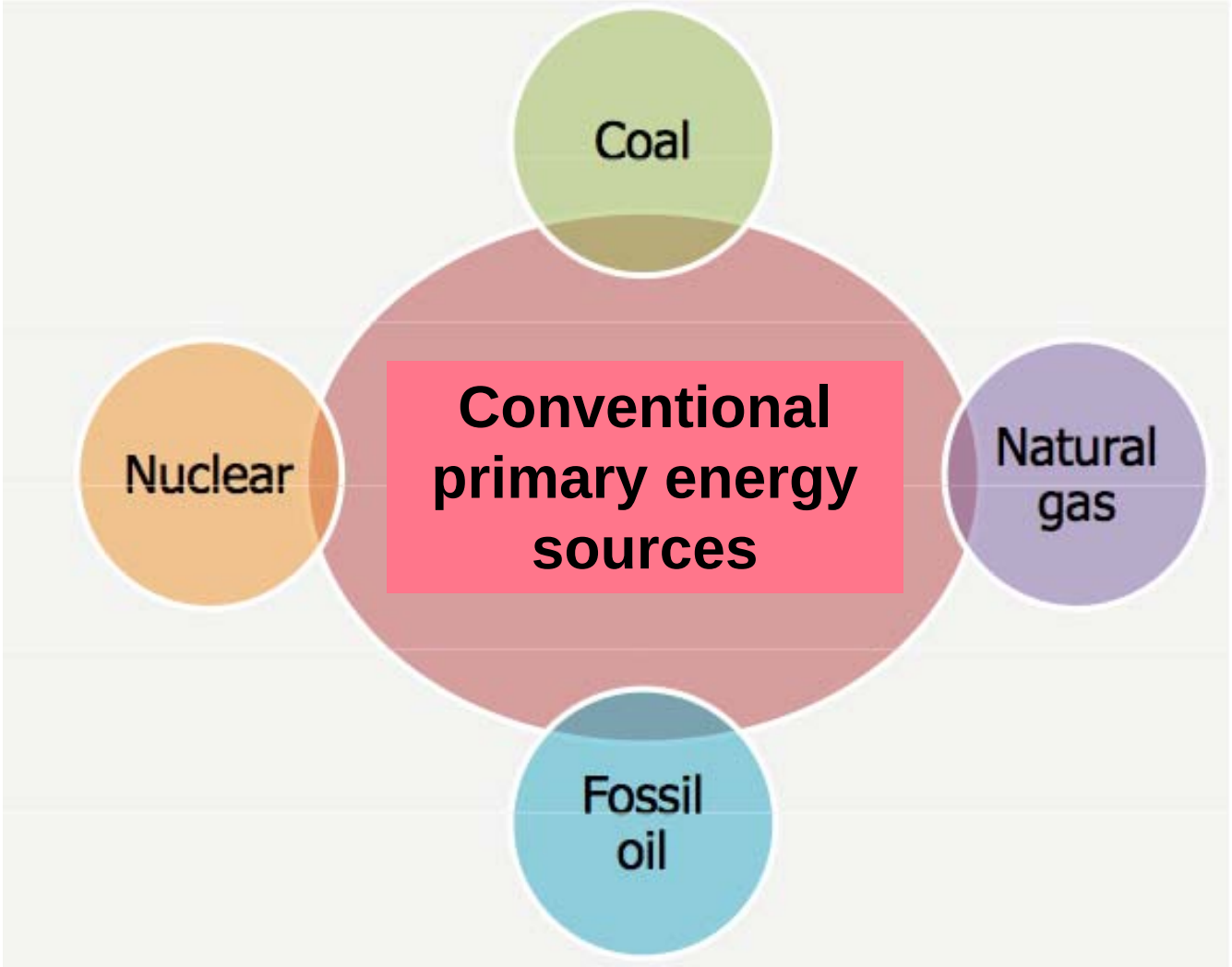
Sources: TP Whorf Scripps, Mauna Loa Observatory, Hawaii, institution of oceanography (SIO), university of California La Jolla, California, United States, 1999

Changes in global temperature

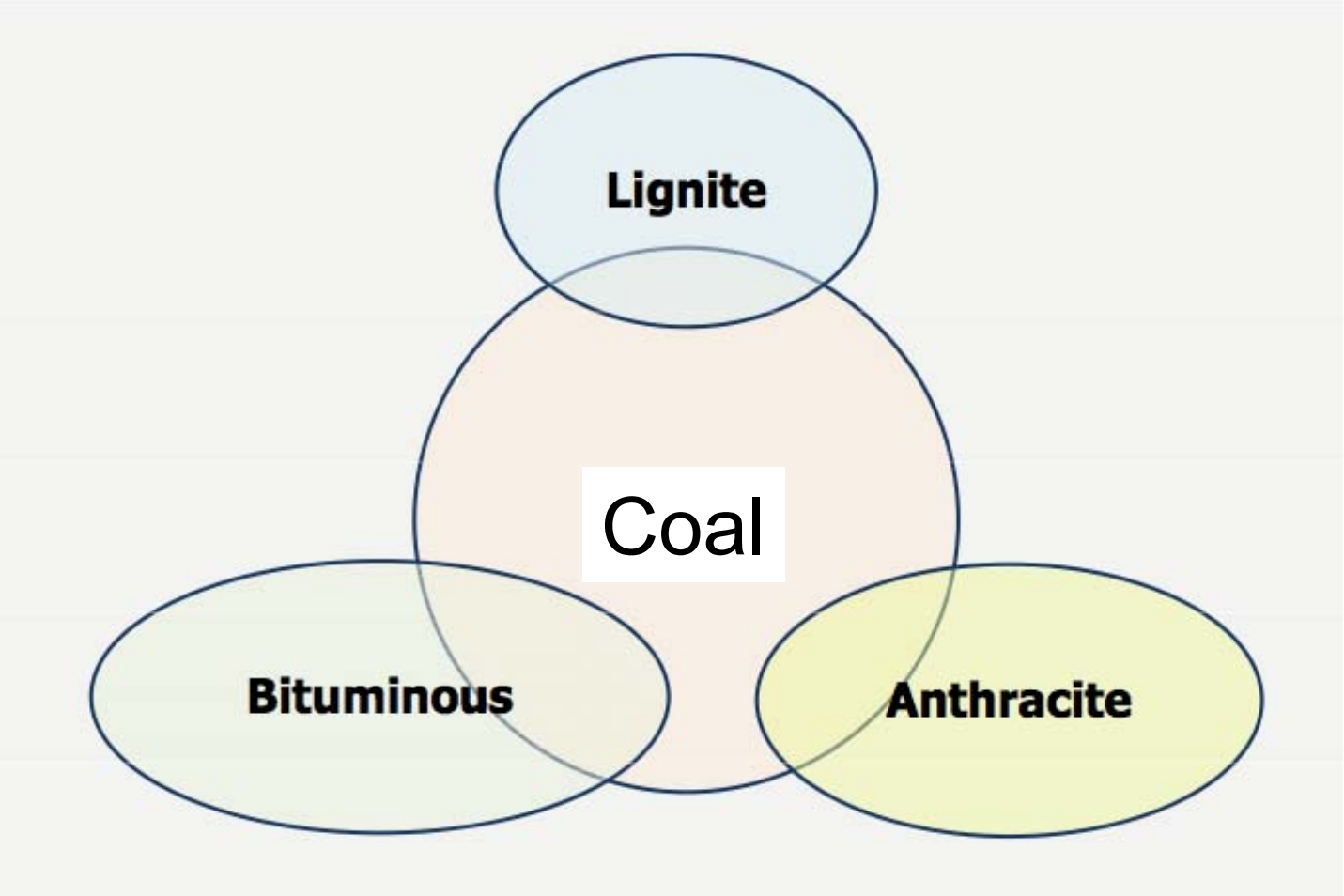


Source : Temperatures 1856 - 1999: Climatic Research Unit, University at East Anglia, Norwich UK. Projections: IPCC report 95.

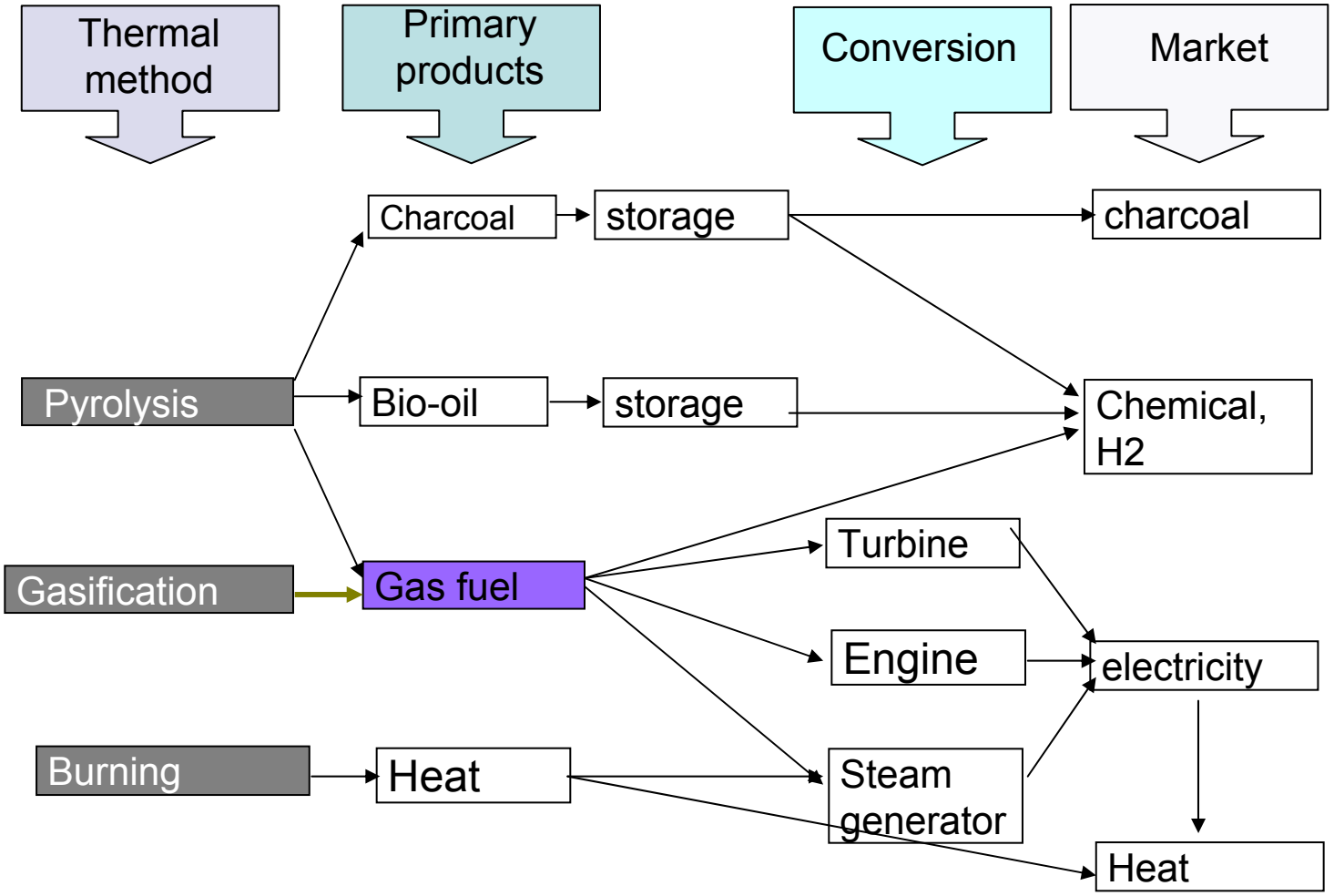
Conventional primary energy sources



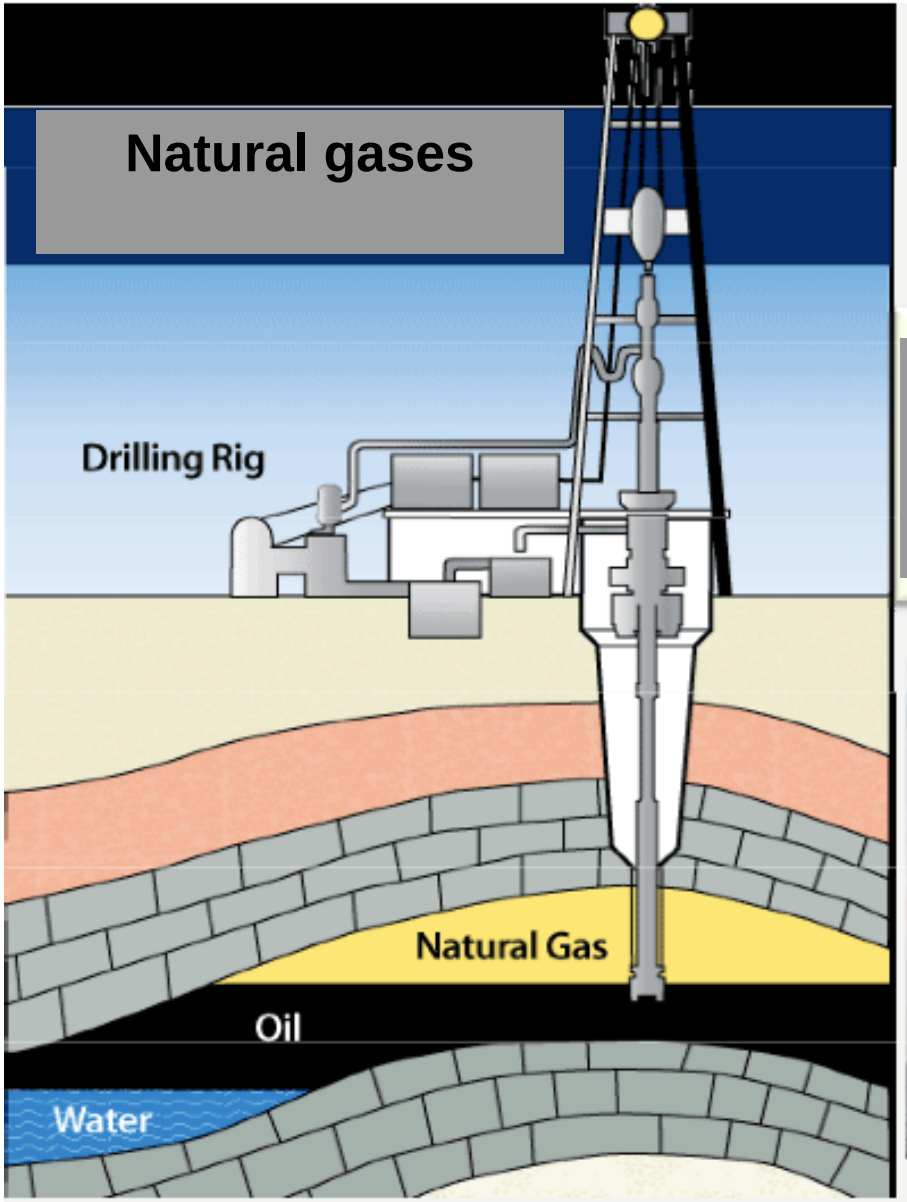
Coal



Energy conversion of coal

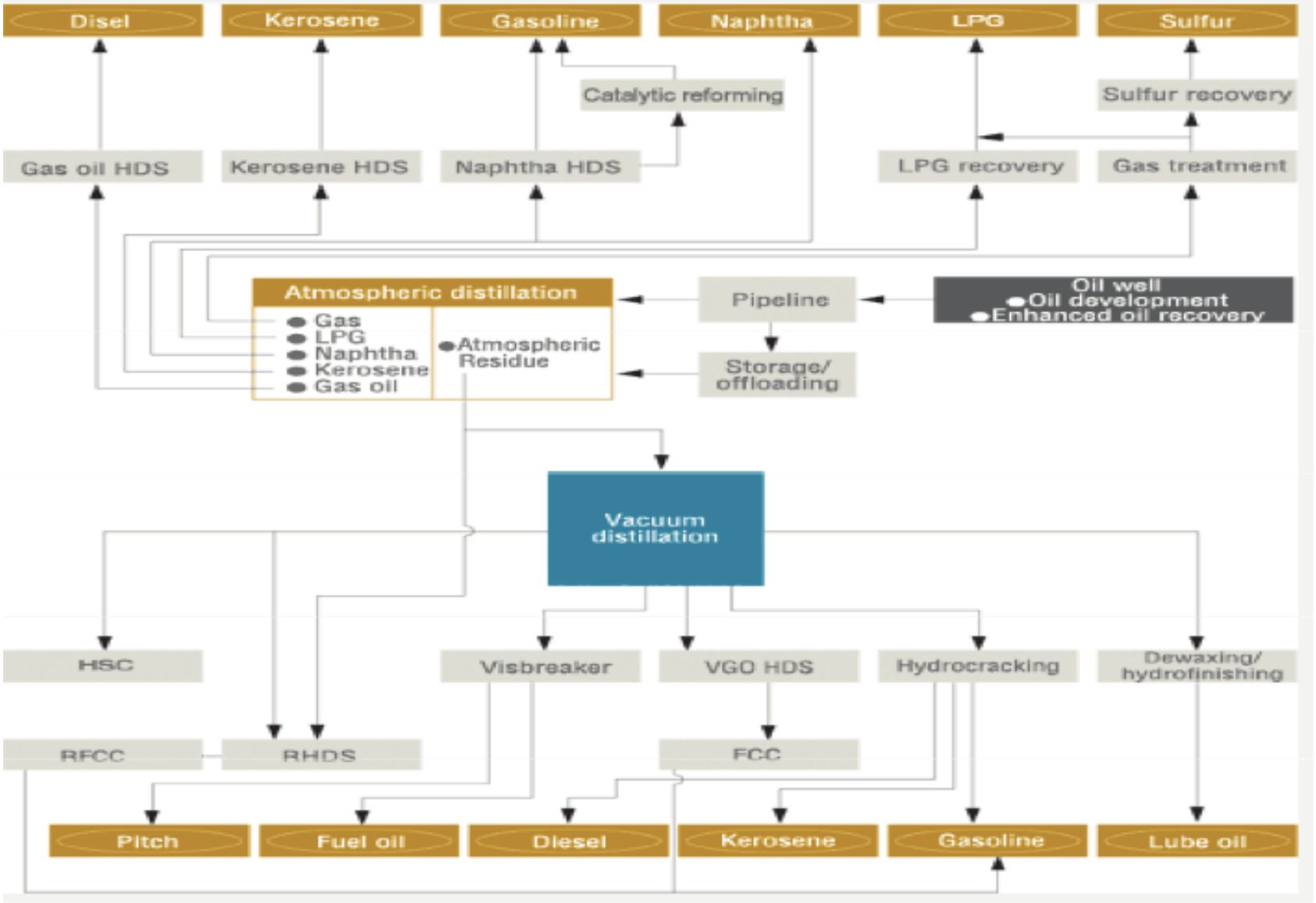


Oil and gas

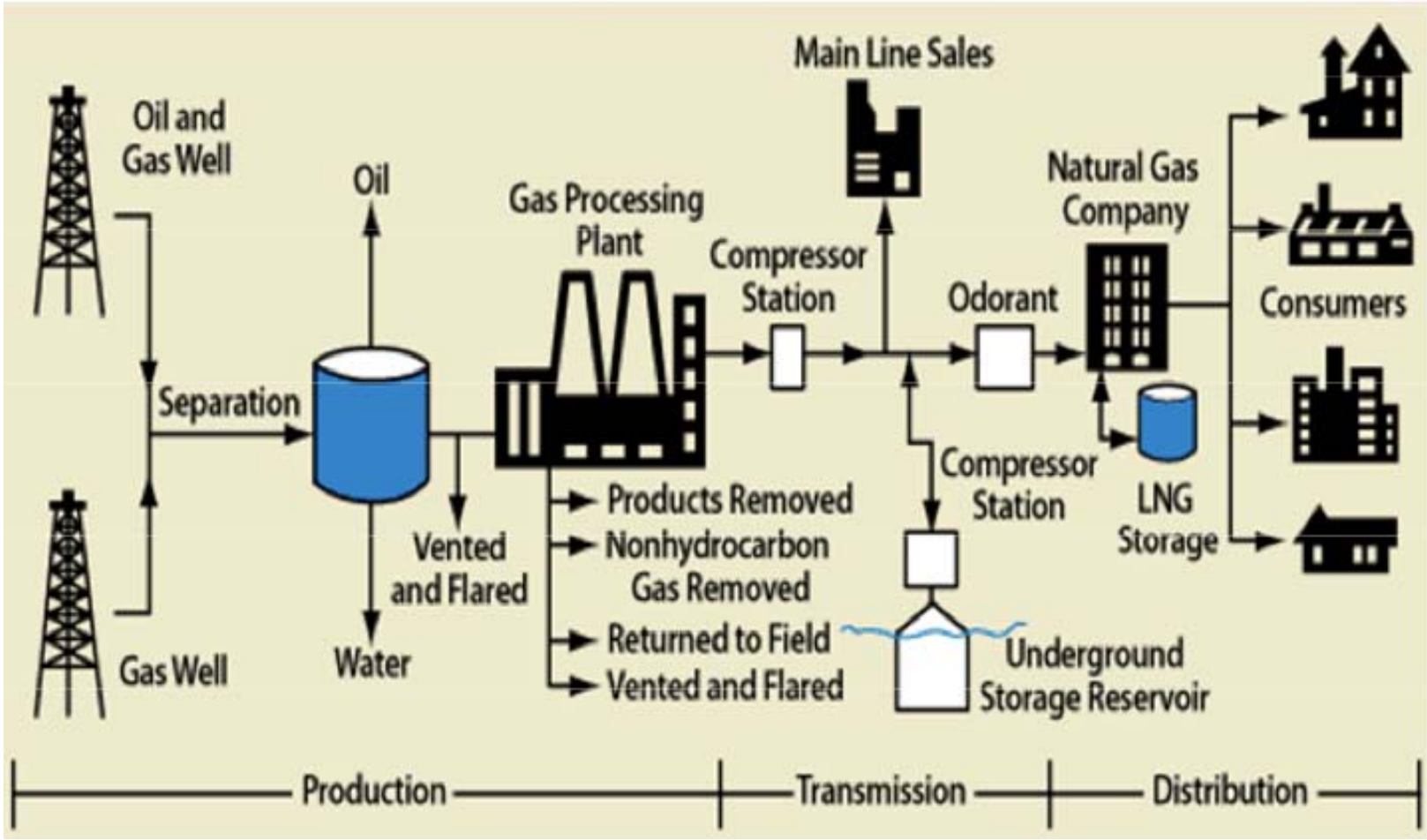


Oil

Energy from oil



THE NATURAL GAS PRODUCTION, TRANSMISSION AND DISTRIBUTION SYSTEM



Energy from nuclear reaction station

Fossil fuel reserves and consumption

World fossil fuel reserves

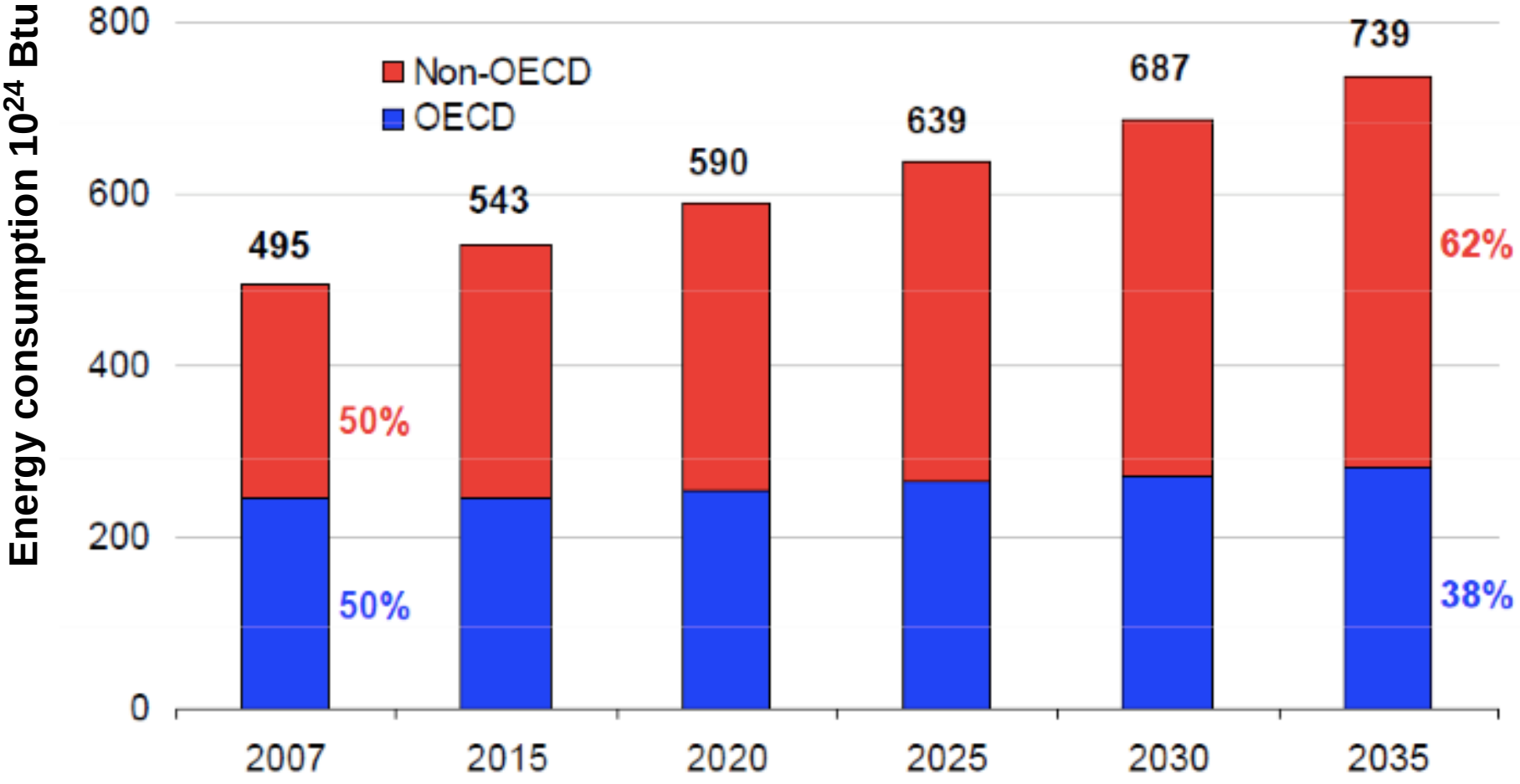
- Coal: 5.245-9.802 billions TOE, exploitation potential: 50%
- Oil: 200 billions TOE, extracted: 53 billions TOE
- Natural gases: 116-141 billions TOE

Energy conversion coefficient

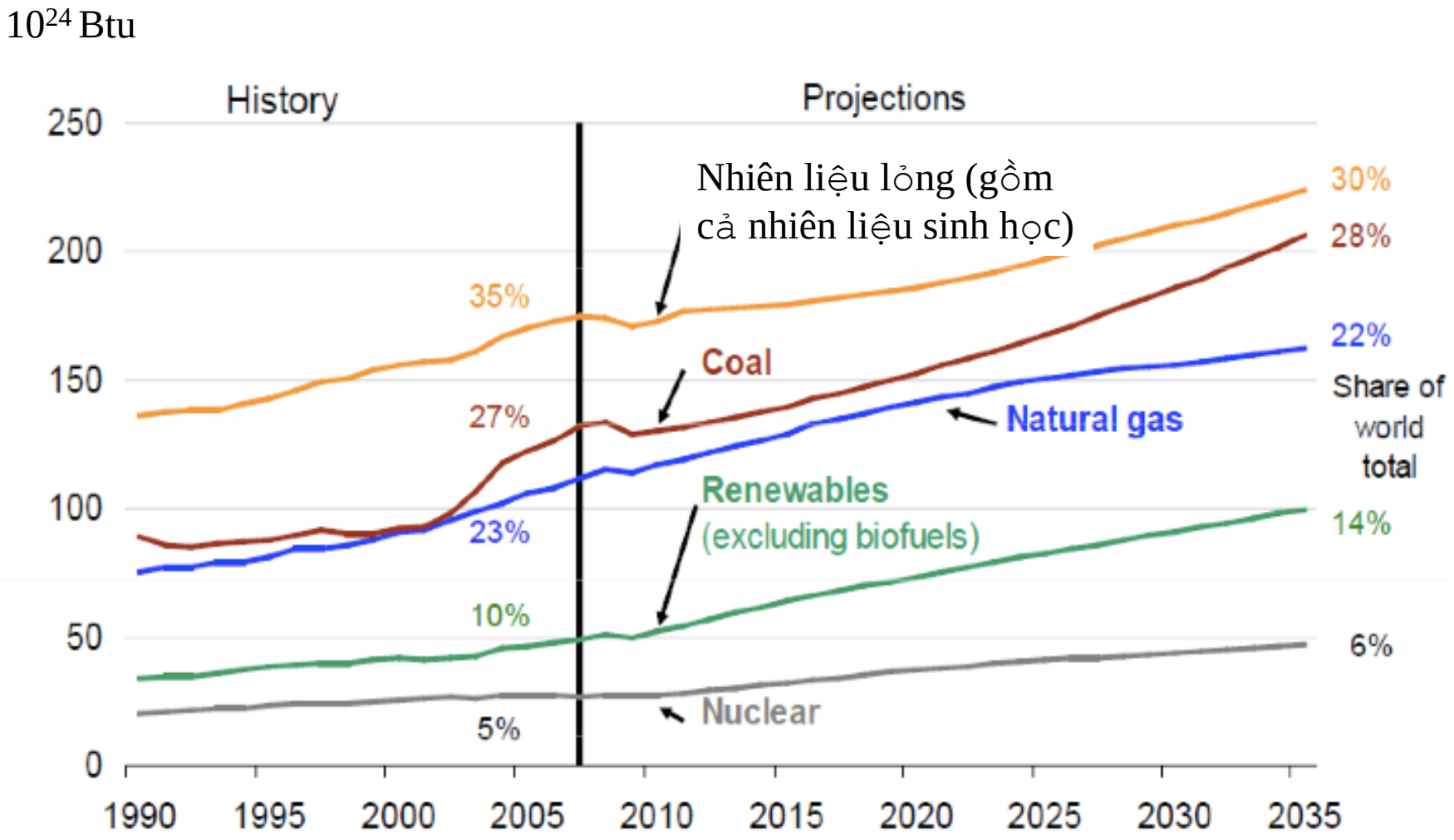
Energy unit	Kilo-calorie kcal	MJ	kWh	BTU	hp.h	mtoe*	mtce*
kcal	1	$4.2x10^{-3}$	$1.2x10^{-3}$	3.968	$1.6x10^{-3}$	$100.3x10^{-9}$	$144.3x10^{-9}$
MJ	239	1	0.2887	947.8	0.3725	$23.88x10^{-6}$	$31.42x10^{-6}$
kWh	860.4	3.6	1	3,414	1.341	$85.98x10^{-6}$	$122.8x10^{-6}$
BTU	0.252	$1.1x10^{-3}$	$2.9x10^{-4}$	1	$3.9x10^{-4}$	$26.27x10^{-9}$	$37.53x10^{-9}$
hp.h	641.6	2.685	0.7457	2,546	1	$64.13x10^{-6}$	$91.61x10^{-6}$
mtoe*	$9.969x10^{6}$	41,868	11,630	$38.062x10^{6}$	15,593	1	1.428
mtce*	$6.979x10^{6}$	29,310	8,142	$26.645x10^{6}$	10,916	0.7001	1

***European union standard:**
1 tce = 29.31 GJ và 1 toe = 41.868 GJ

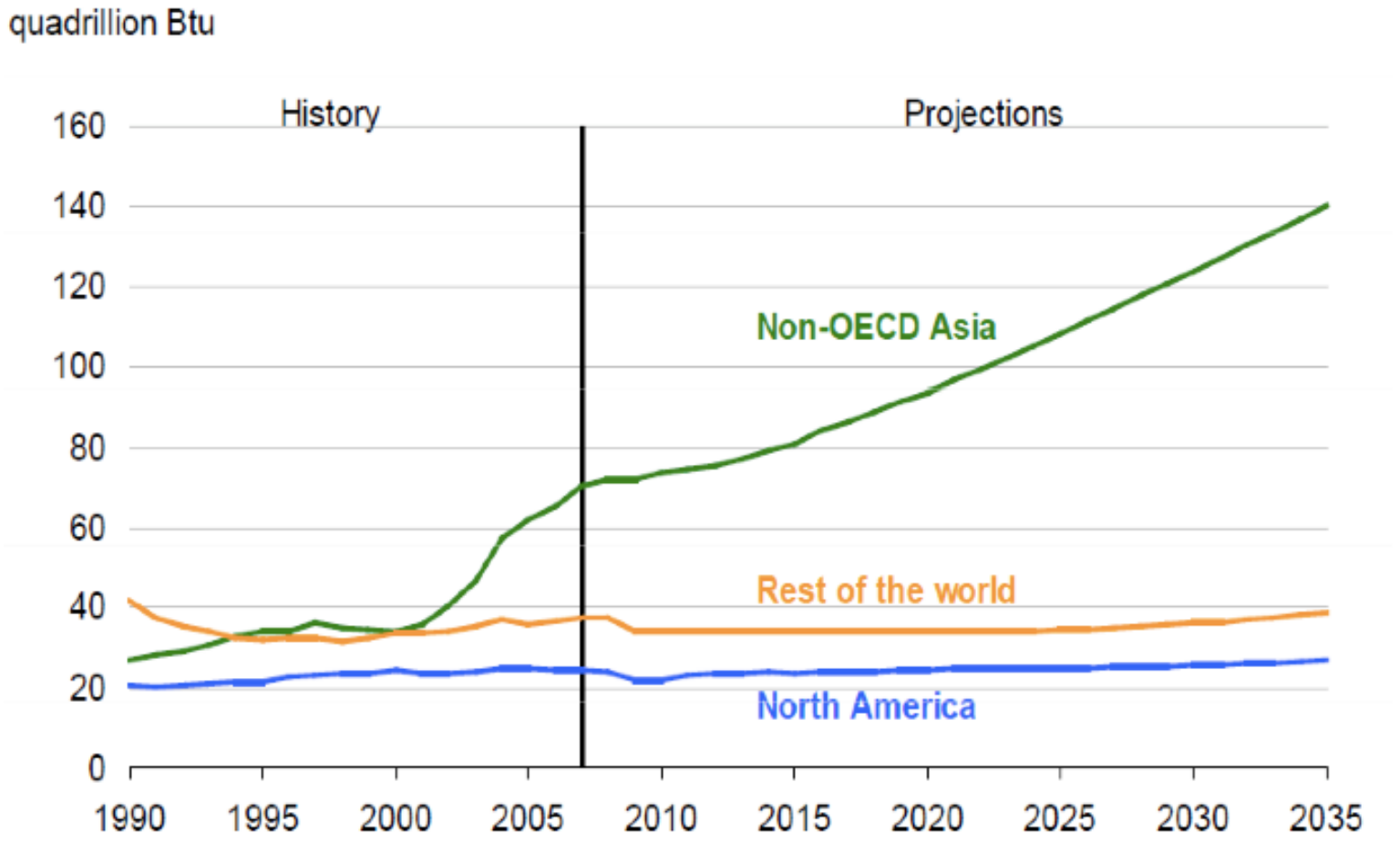
Global energy use



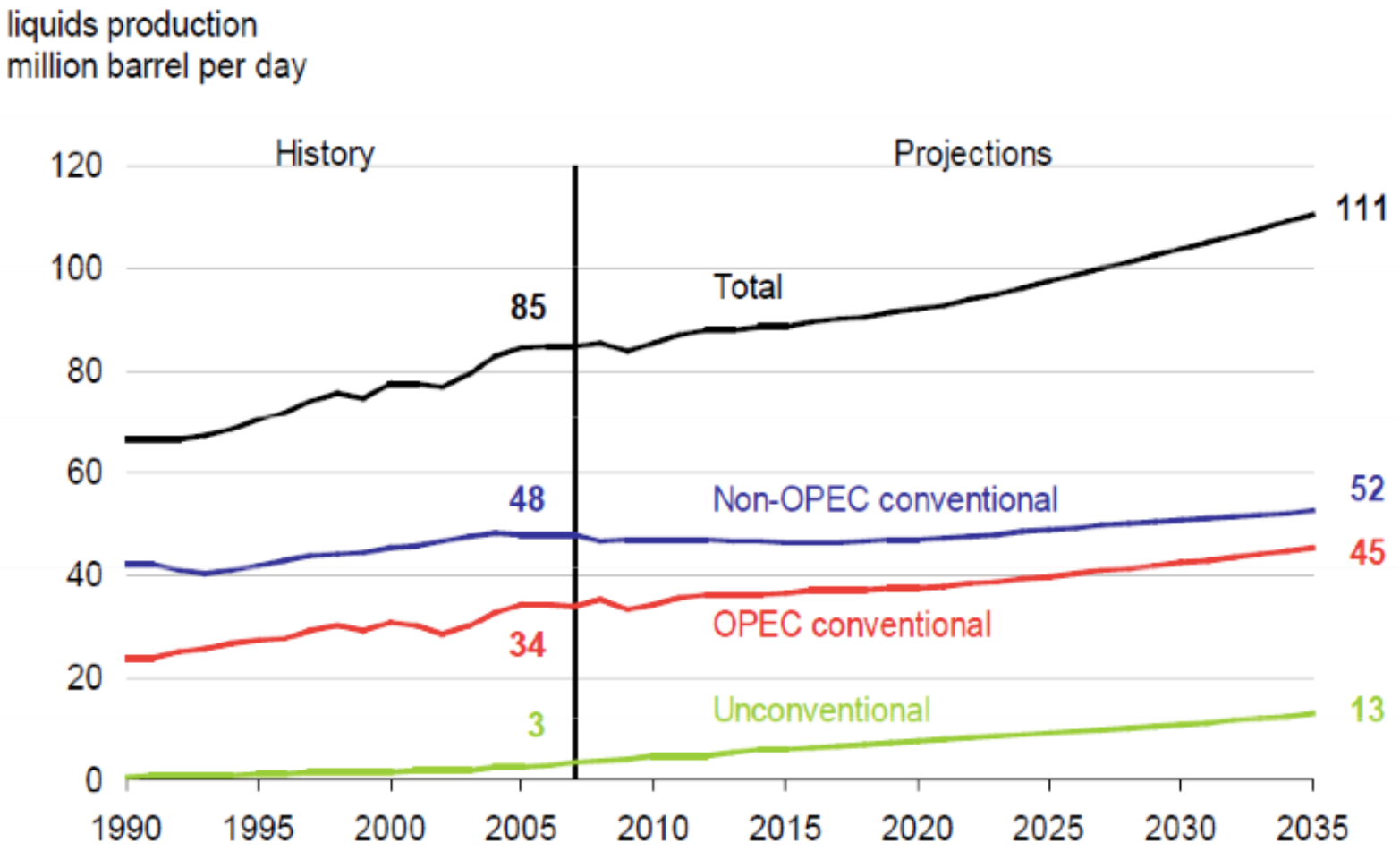
World primary energy consumption



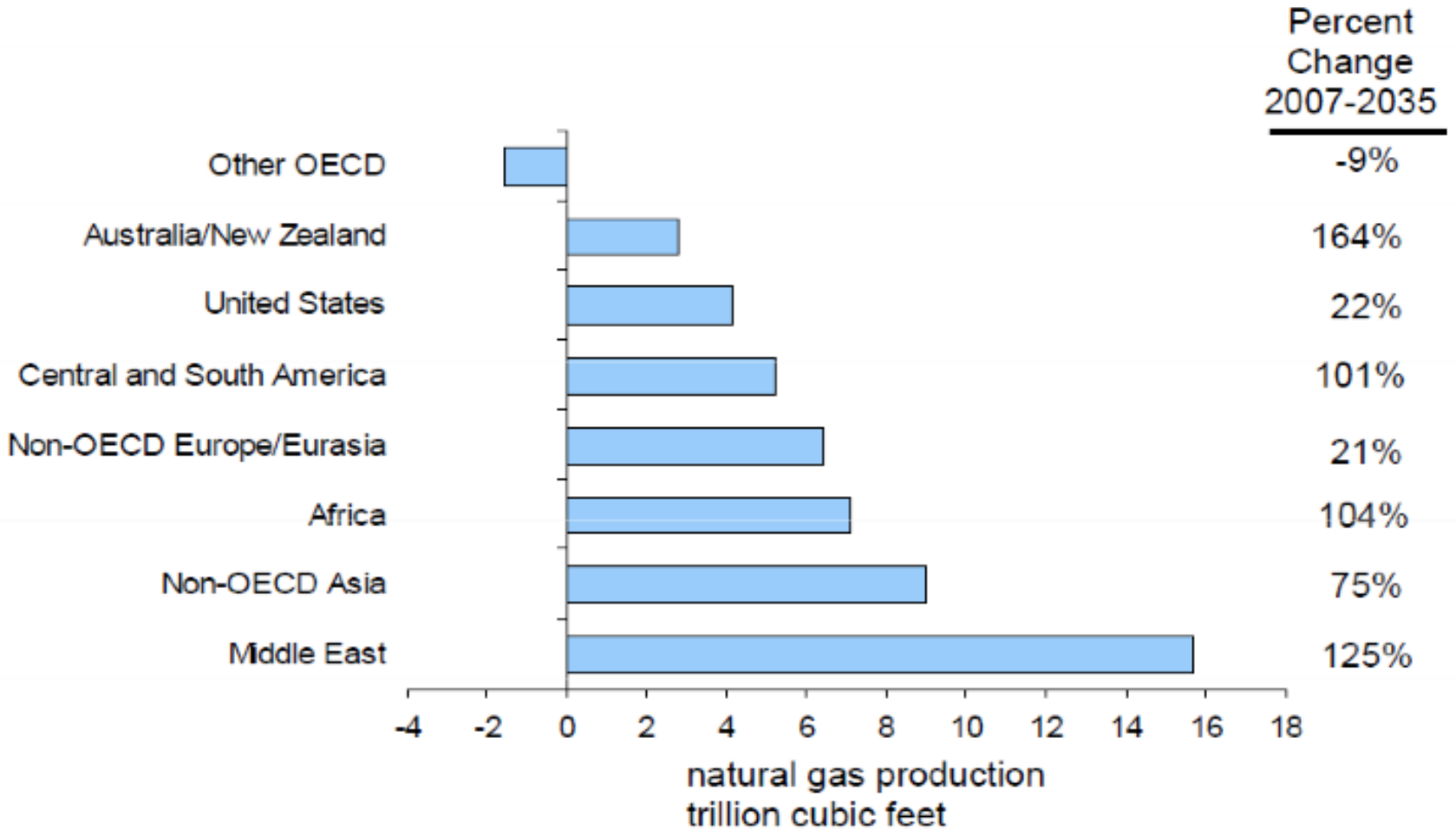
World coal consumption



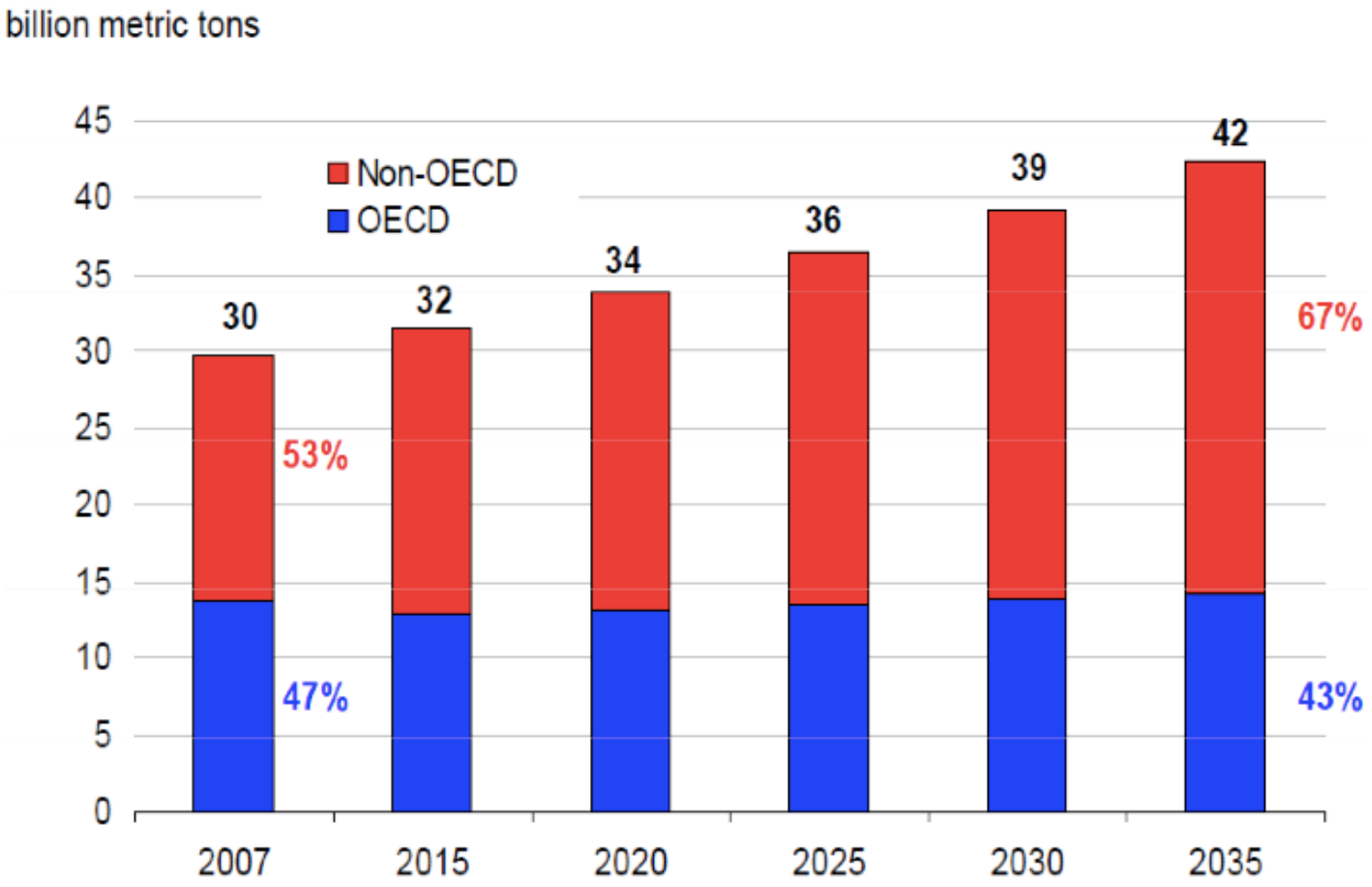
Liquids production projections



Global gas production



Energy CO2 Emissions



Vietnam Energy

Energy Indicators

- In the year 2000:
  - ✓ Energy Intensity: 412 kgOE/1000USD
  - ✓ GDP per capita: 401 USD, GDP growth rate 6.8%
  - ✓ Energy consumption per capita: 154 kg TOE/year
  - ✓ Electricity consumption per capita: 288 kWh/year
- In the year 2005:
  - ✓ Energy Intensity : 500 kgOE/1000USD (USD 1994)
  - ✓ GDP per capita: 645 USD, GDP growth rate 8.4%
  - ✓ Energy consumption per capita: 250 kgOE/year
  - ✓ Electricity consumption per capita: 540 kWh/year

Source: MOIT (2007)

Energy sources in Vietnam

Hydropower: Technical potential:75-83 billions kWh (20.500MW), The North: 51,6%, The Middle: 31,9%, The South: 16,5%;

Coal: Coal reserves till 1/1/2006: 6,16 billion tons, exploitation projection: 50-61 million tons/year (2020); 60,5-64,5 million tons/year (2025);

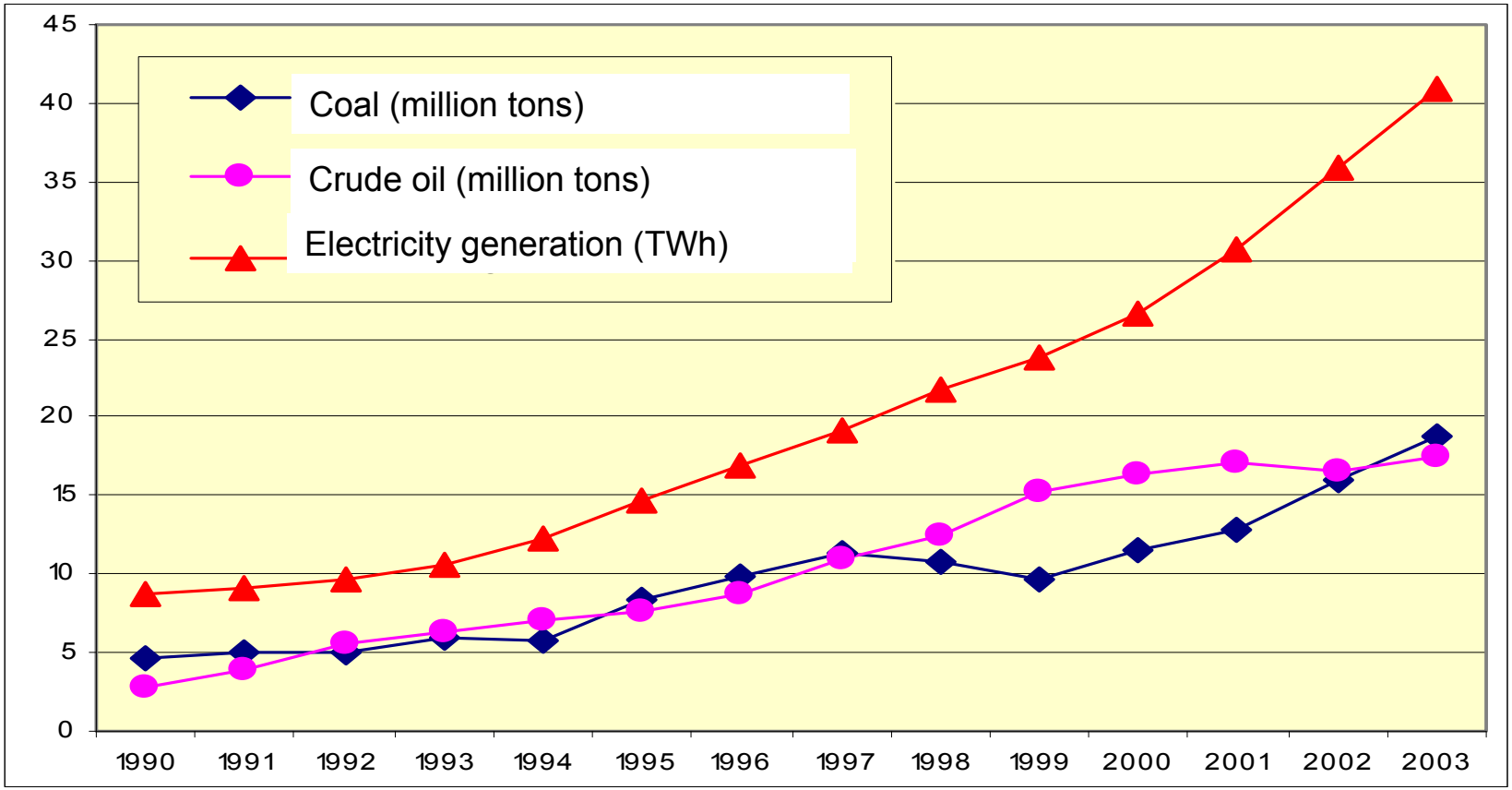
Electricity generation (from coal)

2010:	16,3 – 21,9 million tons
2015:	27,4 – 29,4 million tons
2020:	32,7 – 40,4 million tons
2025:	> 40 million tons

Oil: 2,3 billion tons (extractable: 615-957 million tons)

- **Natural gases**: 1207-1507 billion m^3, extractable: 15,6 billion m^3/year (2020); 16,5 billion m^3/year (2025), for electricity generation: 12-14 billion m^3/year
  - 2005: 6,9 billion m^3
  - 2010: 10,3 billion m^3
  - 2020: 15,6 billion m^3
  - 2025: 16,5 billion m^3 (Southeast continental shelf: 8 – 9 billion m^3, Southwest continental shelf: about 6 – 7 billion m^3)
- **URANI**
  - Assess the potential based on extraction price
  - If extraction price < 80 USD/kg U3O8 → reserves: 55723 tons U308, mainly in Nong Son (Quang nam), generate ~ 9000 MW nuclear electricity.

Vietnam electricity development, 1990-2003



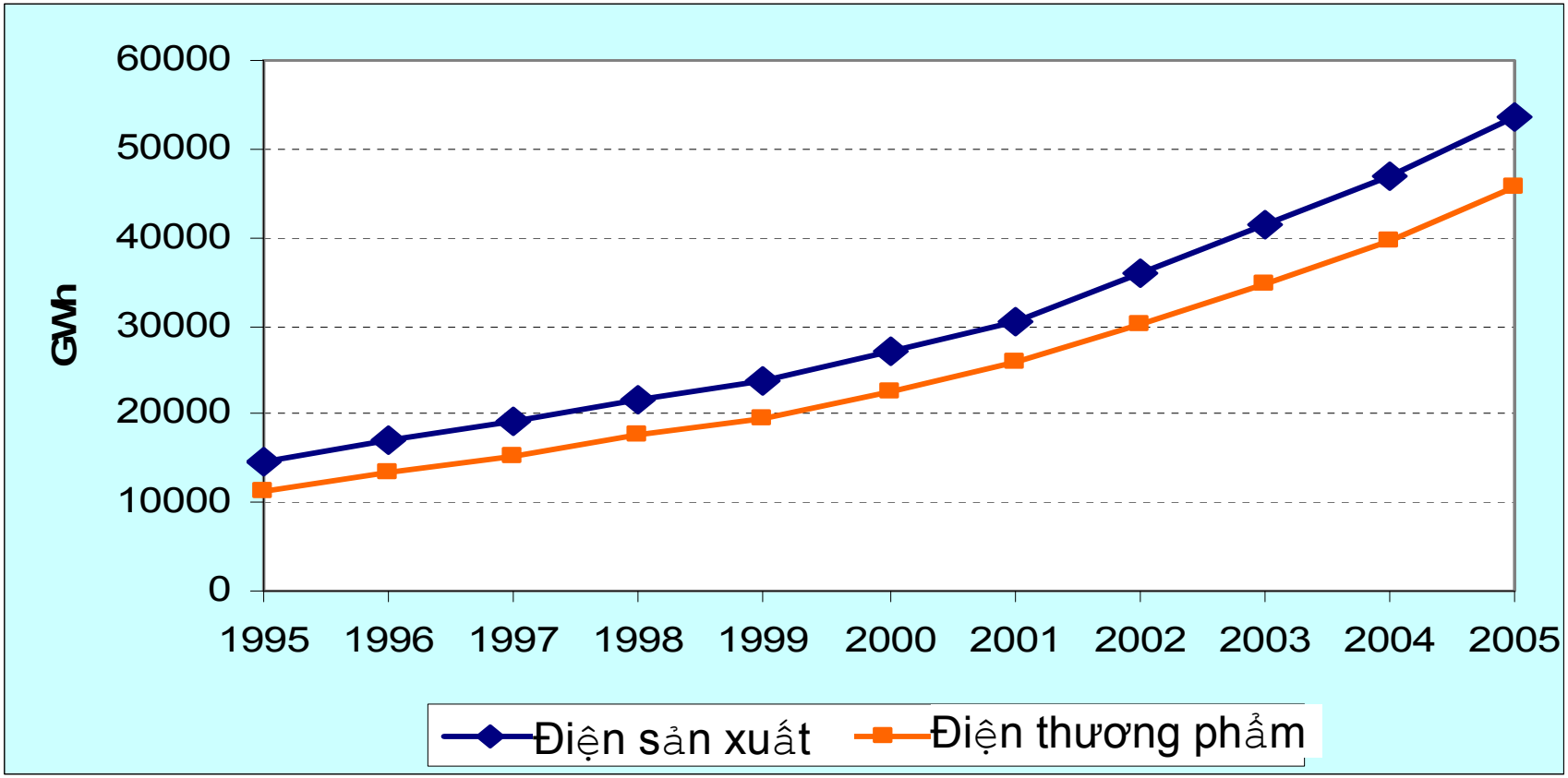
Growth rate 1990-2003:
Coal production: 11,4%,
Electricity generation : 12,7%
Crude oil production:15,6%

Production, 2004:
Coal: 26,3 million tons
Electricity: 46,24 billion kWh
Crude oil: million tons

Energy production in 2005

Production	Unit	Amount
Electricity	Bill kWh	53,5
Coal (Export)	Mill Tons	34,1 (18,0)
Crude Oil	Mill Tons	18,6
Gas	Bill m3	6,9

Growth in electricity demand



Growth rate 1996 -2000: 14.9%
Growth rate 2001 -2005: 15.3%
Transmission and distribution loss reduce from 21.7% (1995) to 12.0% (2005); 11.66% (9/2006)

Socio-economic development scenarios, 2006-2025

Scenario	2006 - 2010	2011 - 2020	2021 - 2025
Scenario	> 9,0	10	9,0
Scenario	8,5	9,0	8,0

Population	2000	2005	2010	2015	2020	2025
(Millions persons)	77.64	83.2	87.8	93.0	97.9	101.6

Additional electricity demand, 2011-2015

1. Scenario 1 - 17%

Năm	2011	2012	2013	2014	2015
Điện TP-GWh	108093	123120	138902	155511	172926
Điện SX-GWh	125235	142443	160476	179415	199227
Pmax-MW	21149	23942	26845	29872	33016

2. Scenario 2 - 20%

Năm	2011	2012	2013	2014	2015
Điện TP-GWh	126455	147975	171178	196203	223047
Điện SX-GWh	146509	171199	197766	226361	256972
Pmax-MW	24742	28775	33083	37689	42586

3. Scenario 3 - 22%

Năm	2011	2012	2013	2014	2015
Điện TP-GWh	138158	164960	194158	225806	259902
Điện SX-GWh	160053	190838	224305	260505	299427
Pmax-MW	26908	32076	37523	43374	49621

Electricity potential from renewable sources

Current:

1500 MW from biomass (sugar production)

0,8 MW wind electricity

1,15 MW solar electricity

Potential:

Small hydropower: ~ 2000 MW

Geothermal: ~ 400 MW

Biomass: 300 - 400MW

Wind: 1400 - 2600 MW

Solar: 4 - 6 MW

Total: 3100-5400 MW

With appropriate policies for electricity generation from renewable sources then the electricity production will be:

1200 MW (2015)

1500-1700 MW (2020)

2000-2400 MW (2025)

Electricity development program and planning viewpoints

- ✓Meet the energy demand of whole country
- ✓Give priorities to hydropower; multi-purpose projects, especially
- ✓Encourage and develop REs
- ✓Construct electricity generation stations suitably, reduce long transmission to avoid transmission loss
- ✓Import electricity from Laos, Cambodia and China
- ✓Consider the risk of in the progress of projects
- ✓Give priorities to ODA, OCR projects
- ✓Encourage IPP, BOT projects

Electricity production and environmental protection

Thermal power electricity

Apply advanced techs with high efficiency, install dust filters, desulfurizer, apply *circulating fluidized bed (*CFB) technology to reduce NOx, utilize cinder to produce construction materials

Planning on stop old thermal power plants

Hydropower and REs

Electricity grid

Advanced energy technologies

Clean Coal Technologies

Coal Cleaning

Coal Briquetting

Integrated gasification combined cycle coal (IGCCC)

Underground coal gasification

Pressurized Fluidized Bed Combustion

Coal- and/or oil water slurry

Fuel cell

Etc,

2. Thermal power plant technologies

Introduction

Basic principles

- Rankine cycle;
- Brayton cycle;
- Combined cycle;

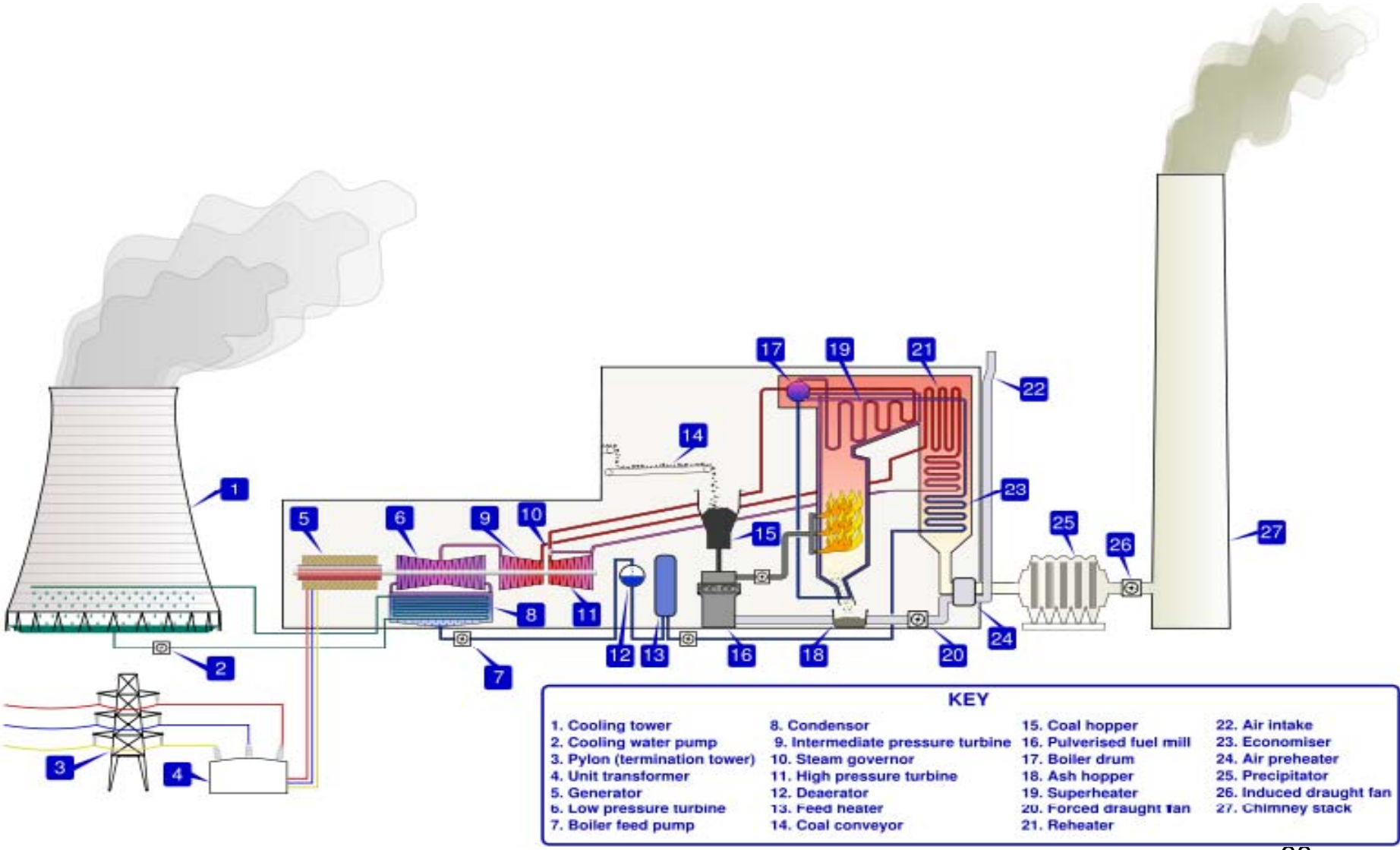
Advantages

Problems and challenges

Conventional energy technologies in Vietnam

Less polluting solid fuel burning technology

Components of thermal power plant



Introduction

Thermal power plants use steam generators – the device that converts fuels into electricity

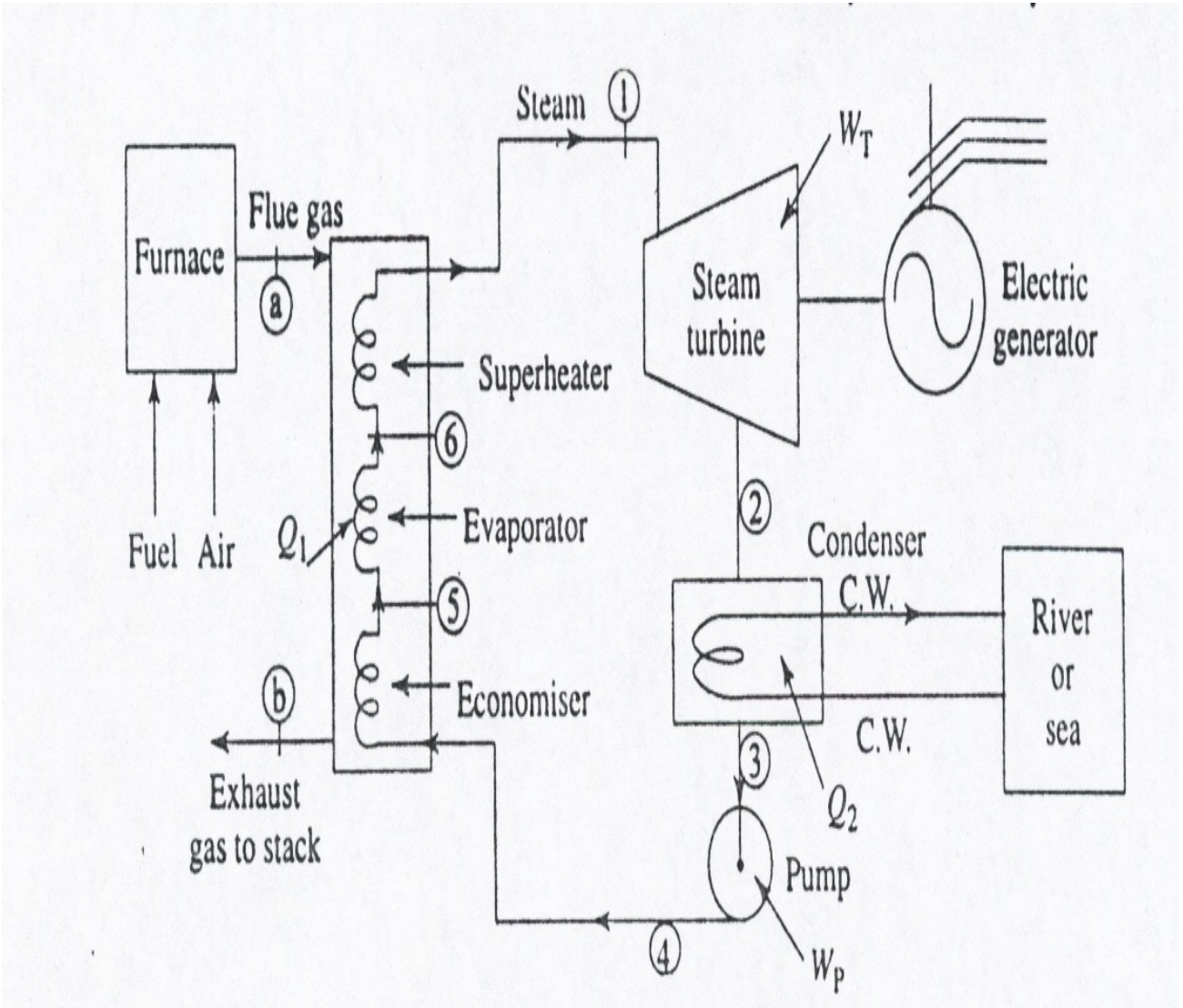
Rankine cycle is used most extensively in steam power plants due to low cost

Fossil fuels (coal, oil, gases) are widely used

Rankine cycle

- Rankine cycle is used most extensively in steam power plants;

- Rankine cycle converts heat into work. The heat is supplied externally to a closed loop, which usually uses water



Law of conservation of energy for steam cycle

- Steam cycle: Closed cycle

$$\sum_{cycle} Q_{net} = \sum_{cycle} W_{net}$$

- Or Q1 – Q2 = WT – Wp
- Q1: kJ/kg
- Q2: kJ/kg
- WT: kJ/kg
- WP: kJ/kg

Energy efficiency of steam cycle

$$\eta_{cycle} = \frac{W_{net}}{Q_1} = \frac{W_T - W_P}{Q_1} = \frac{Q_1 - Q_2}{Q_1} = 1 - \frac{Q_2}{Q_1}$$

Efficiency of thermal power plant

Thermal efficiency

- $\eta_{overall}$

Boiler efficiency

- η_{boiler}

Rankine cycle efficiency

η_{cycle} = 1 □

Mechanical efficiency of steam turbine

- $\eta_{turbine\ (mech)}$

Electricity generator efficiency:

$\eta_{generator}$

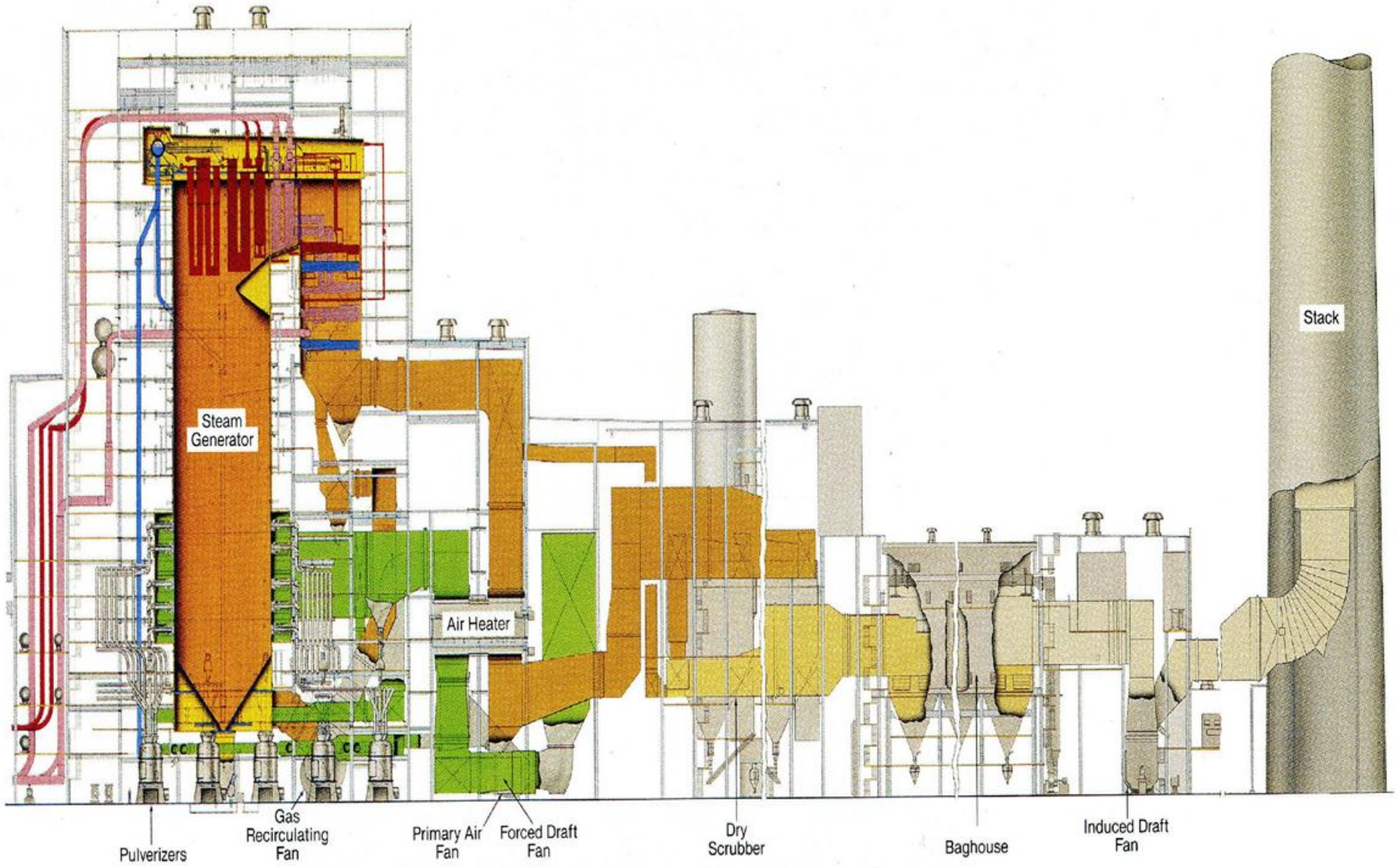
$$\eta_{overall} = \eta_{boiler} \times \eta_{cycle} \times \eta_{turbine\ (mech)} \times \eta_{generator}$$

Components and working principle of steam generator (boiler)

There are different type of steam generator. Basic components of a steam generator are:

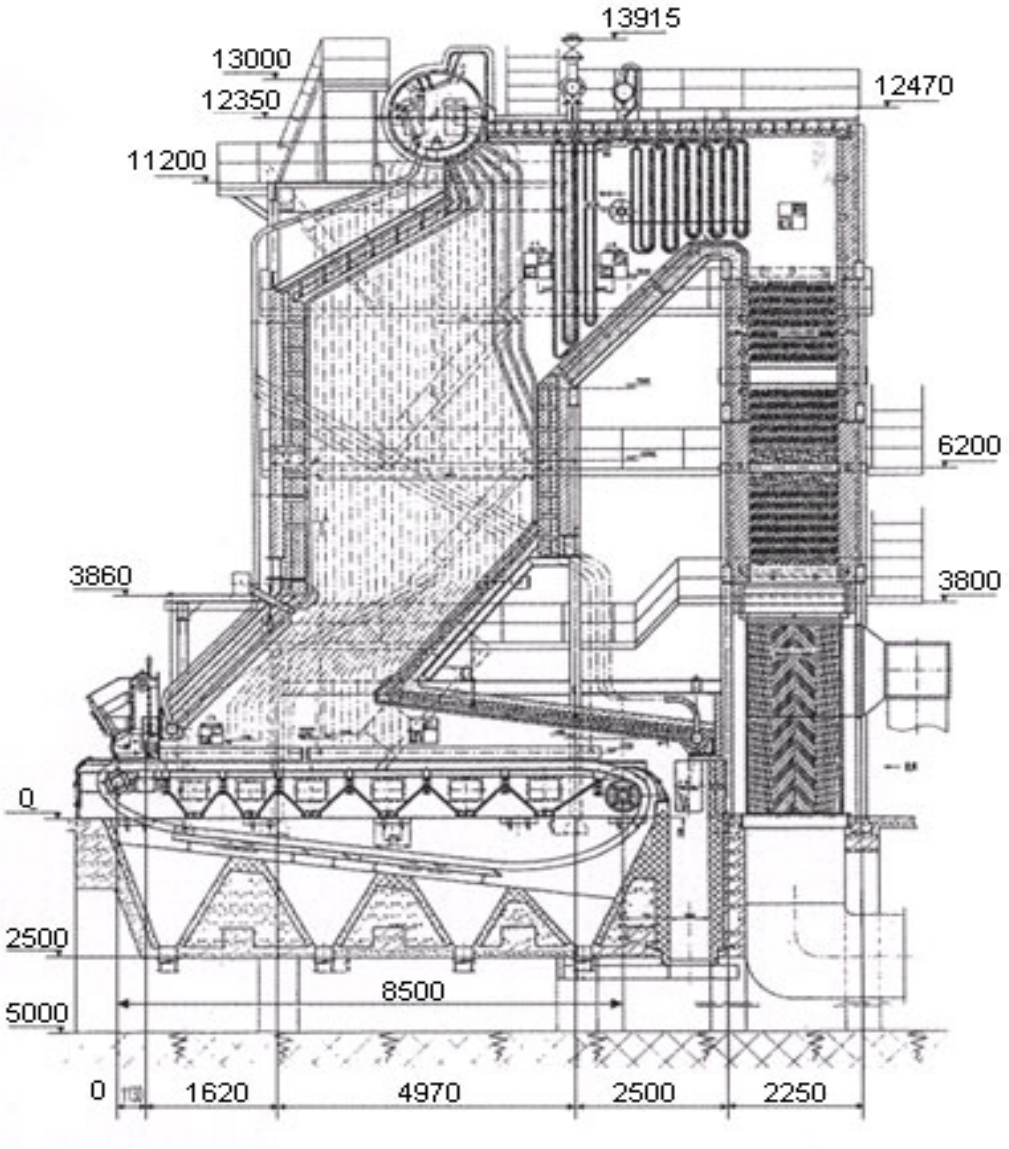
- ✓Furnace: to burn the fuel and generate heat, the heat is initially transferred to water to make steam
- ✓Heat exchanger: superheater, air heater, …
- ✓Auxiliary: air fan, limestone blower, fitter, economizer,…

Scheme of 860 MW steam generator with pollution treatment system

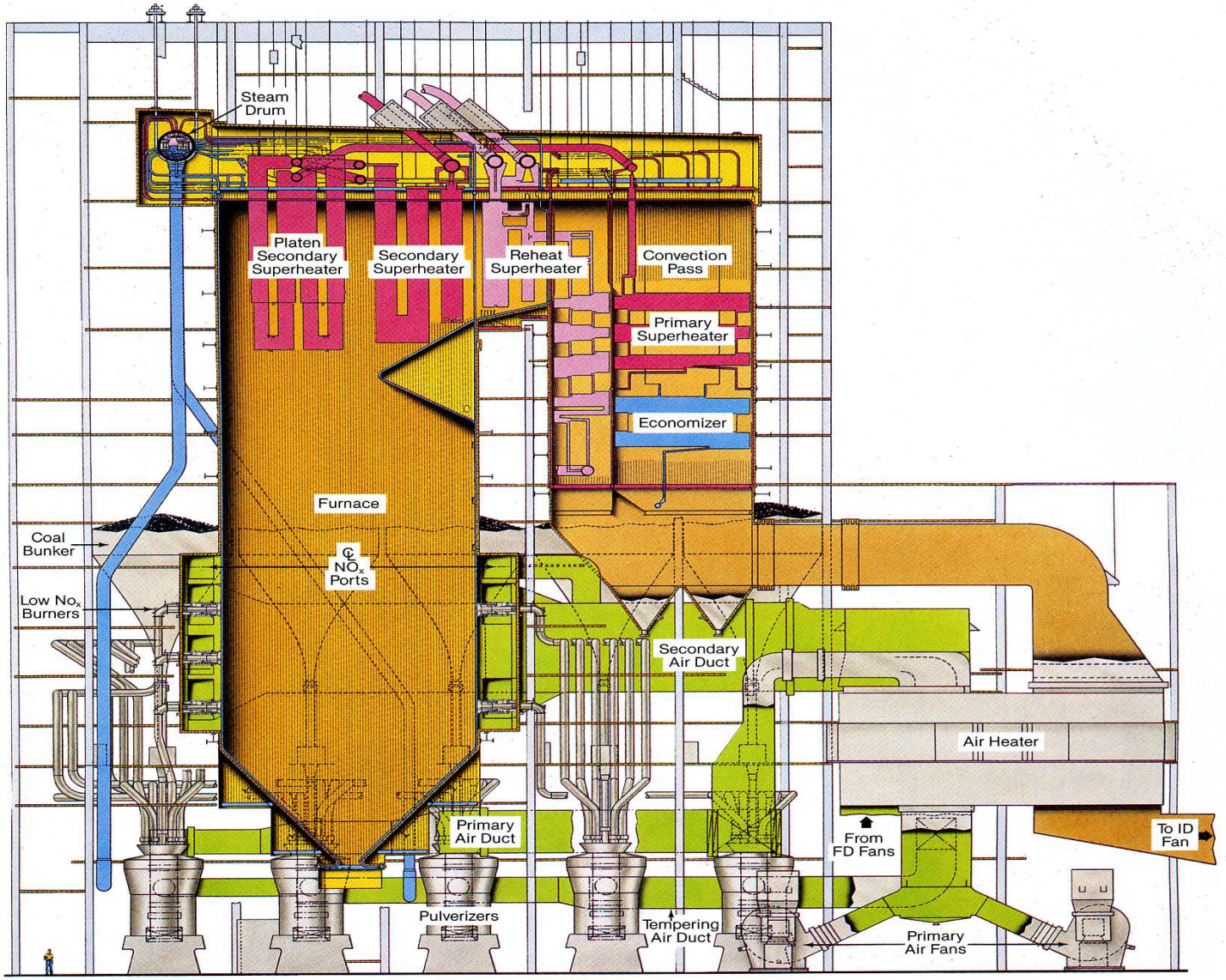


Boiler

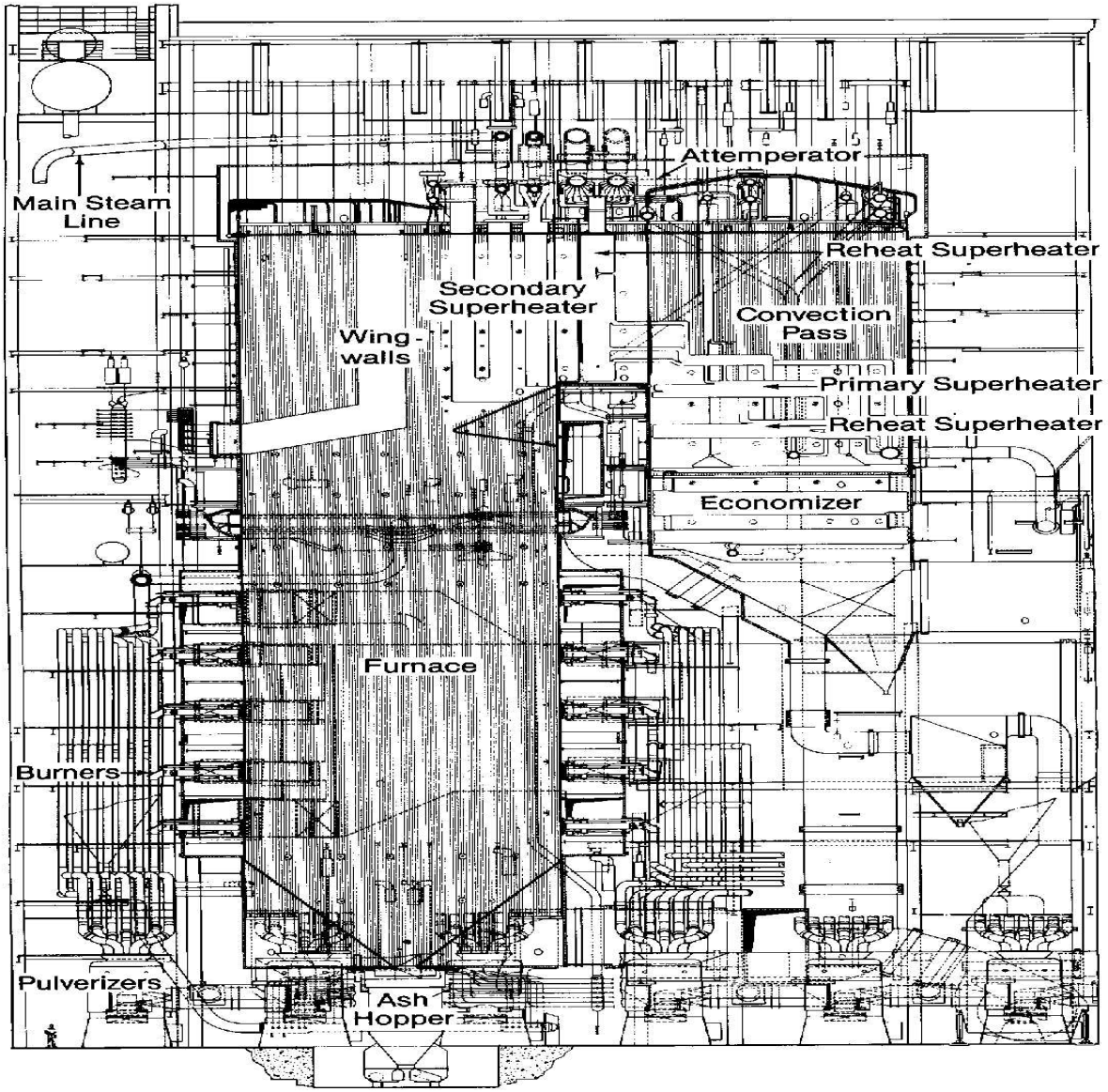
(For small scale electricity generator)



455 MW Pulverized Coal Fired Boiler

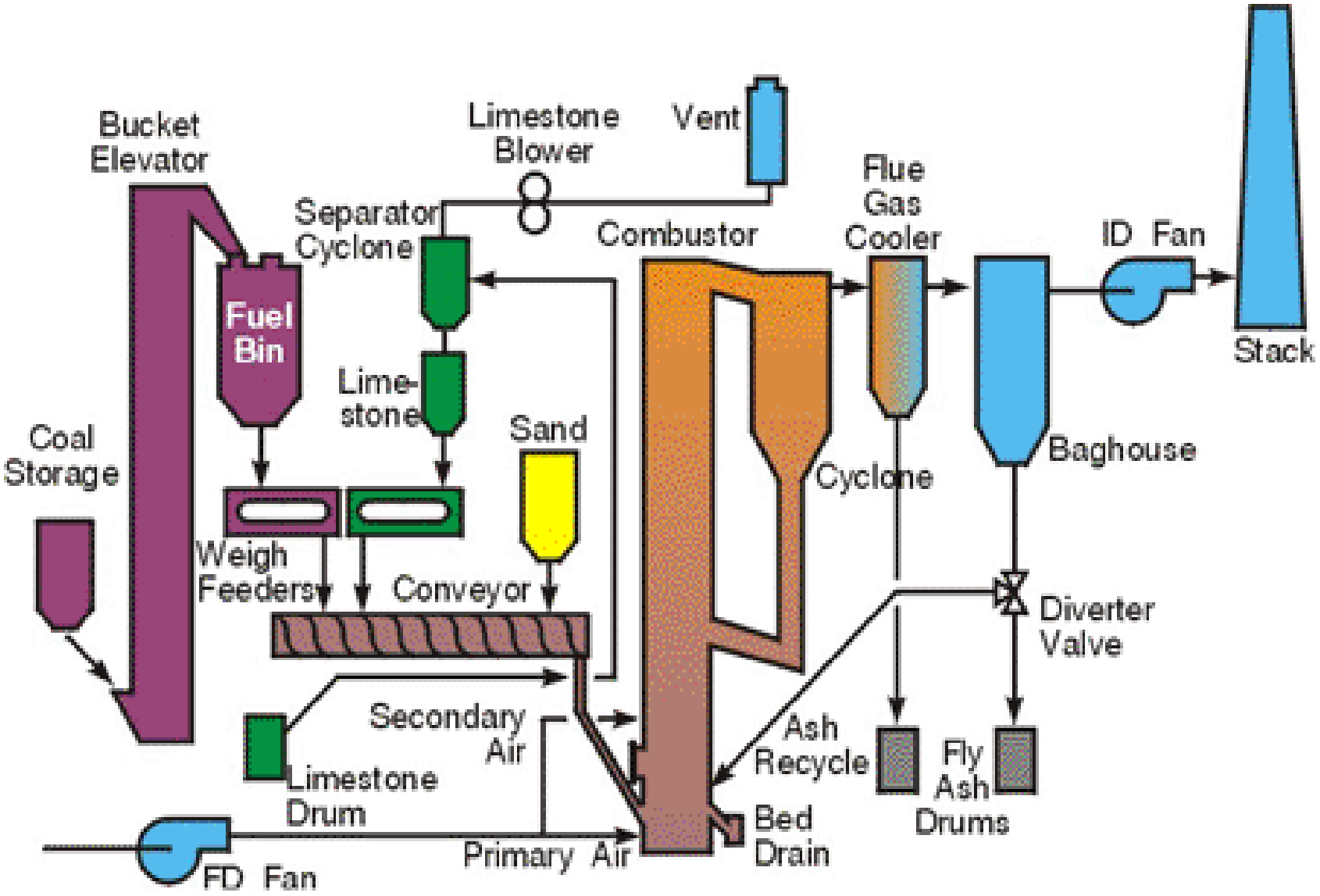


1300 MW pulverized coal boiler (PC Boiler)

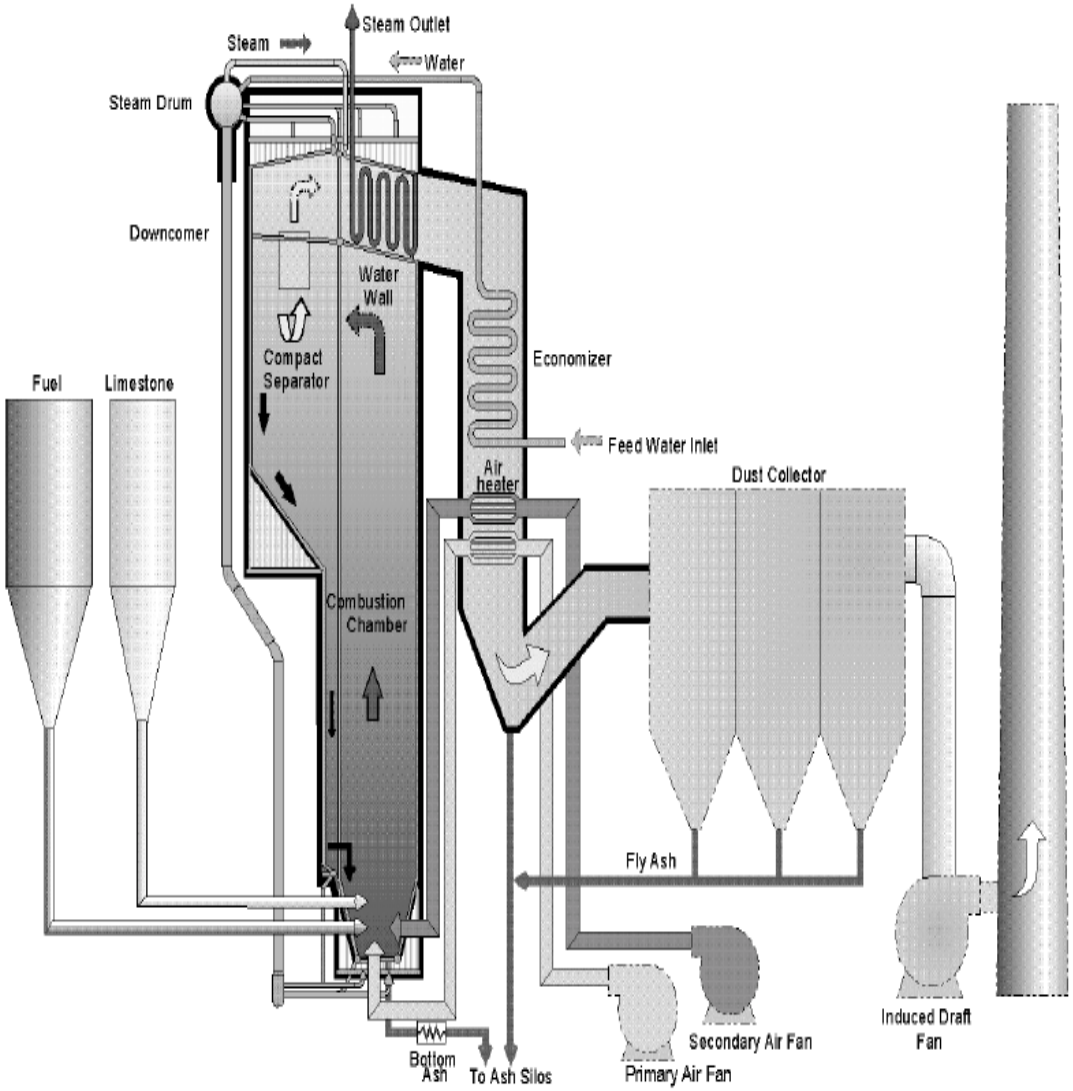


Frame of 300 MW PC Boiler – Uong Bi, Vietnam

Double Drum Coal Fired Steam Boiler

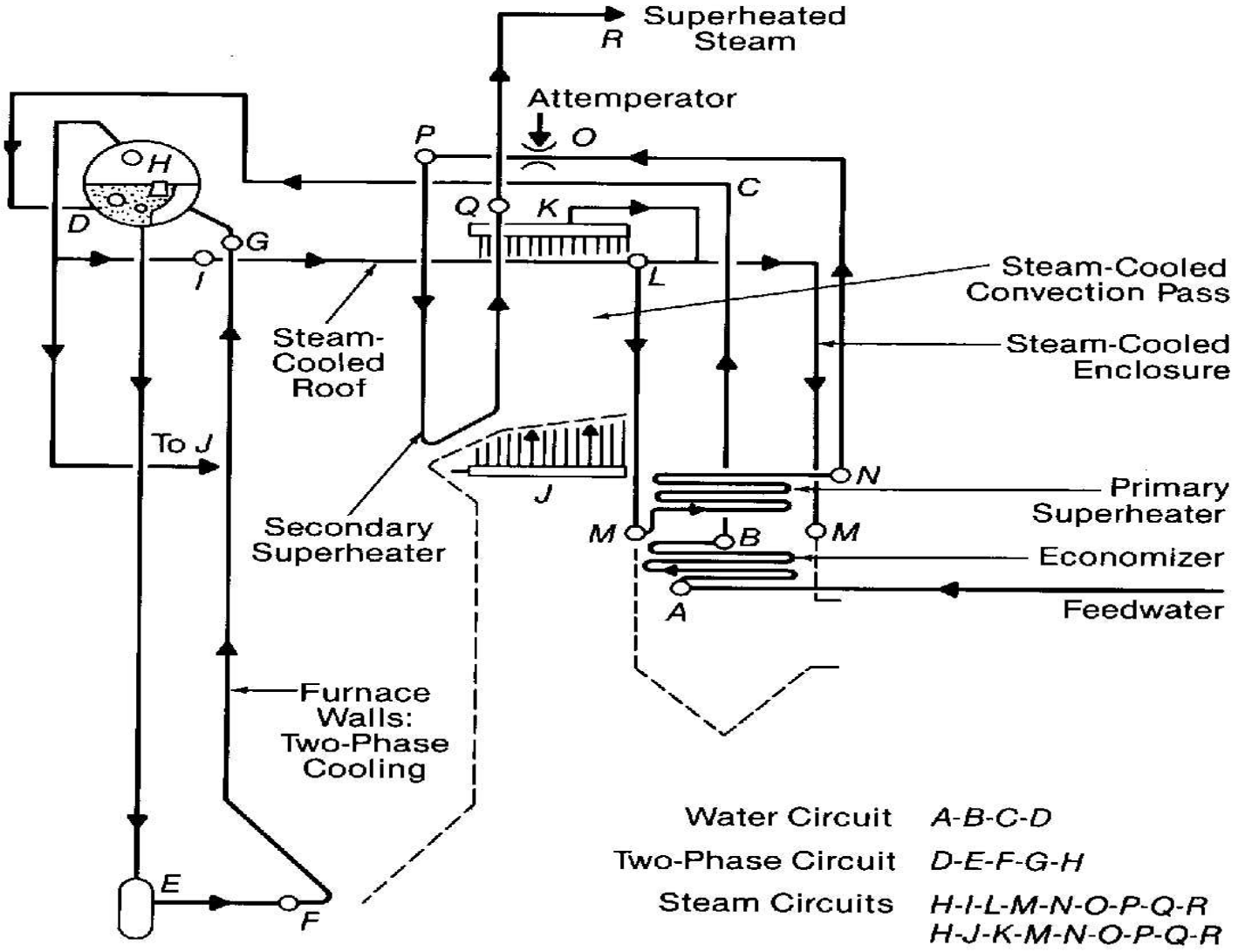


Foster Wheeler's CFB Boiler



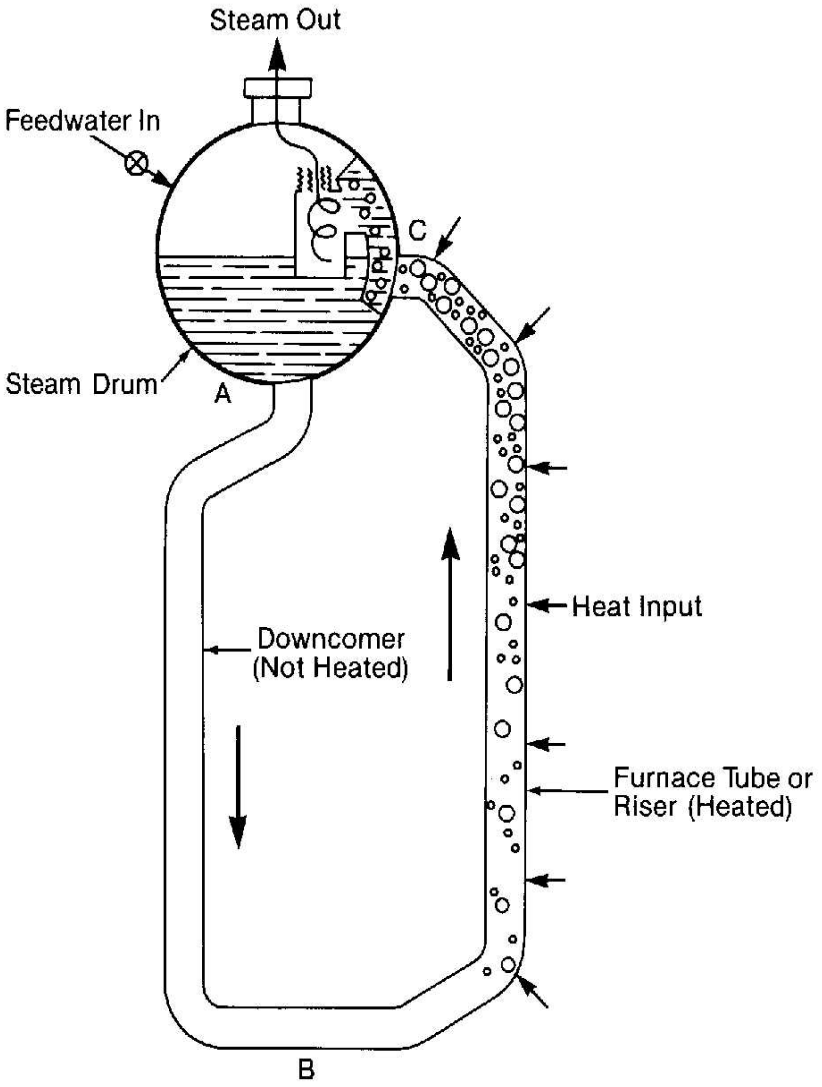
50 MW FW CFB at Na Duong, Vietnam

Working principle

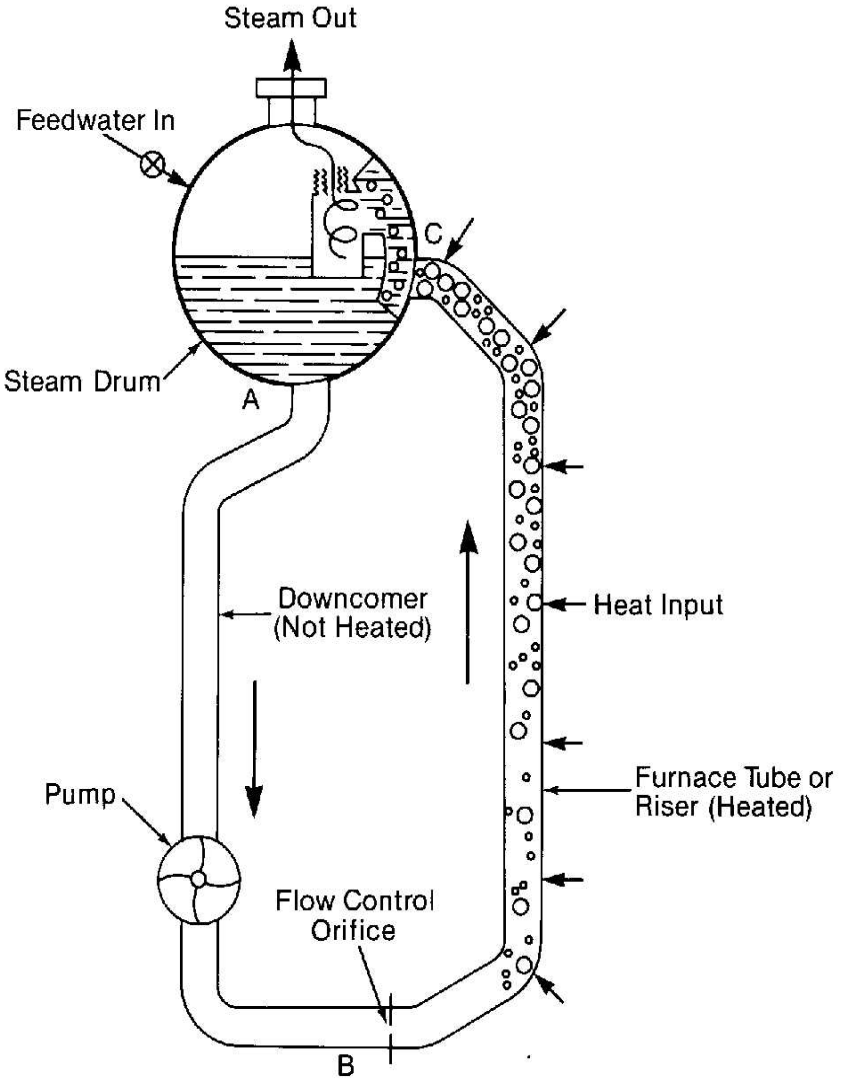


455 MW Natural Circulating Coal-Fired Boiler

Water circulation inside boiler

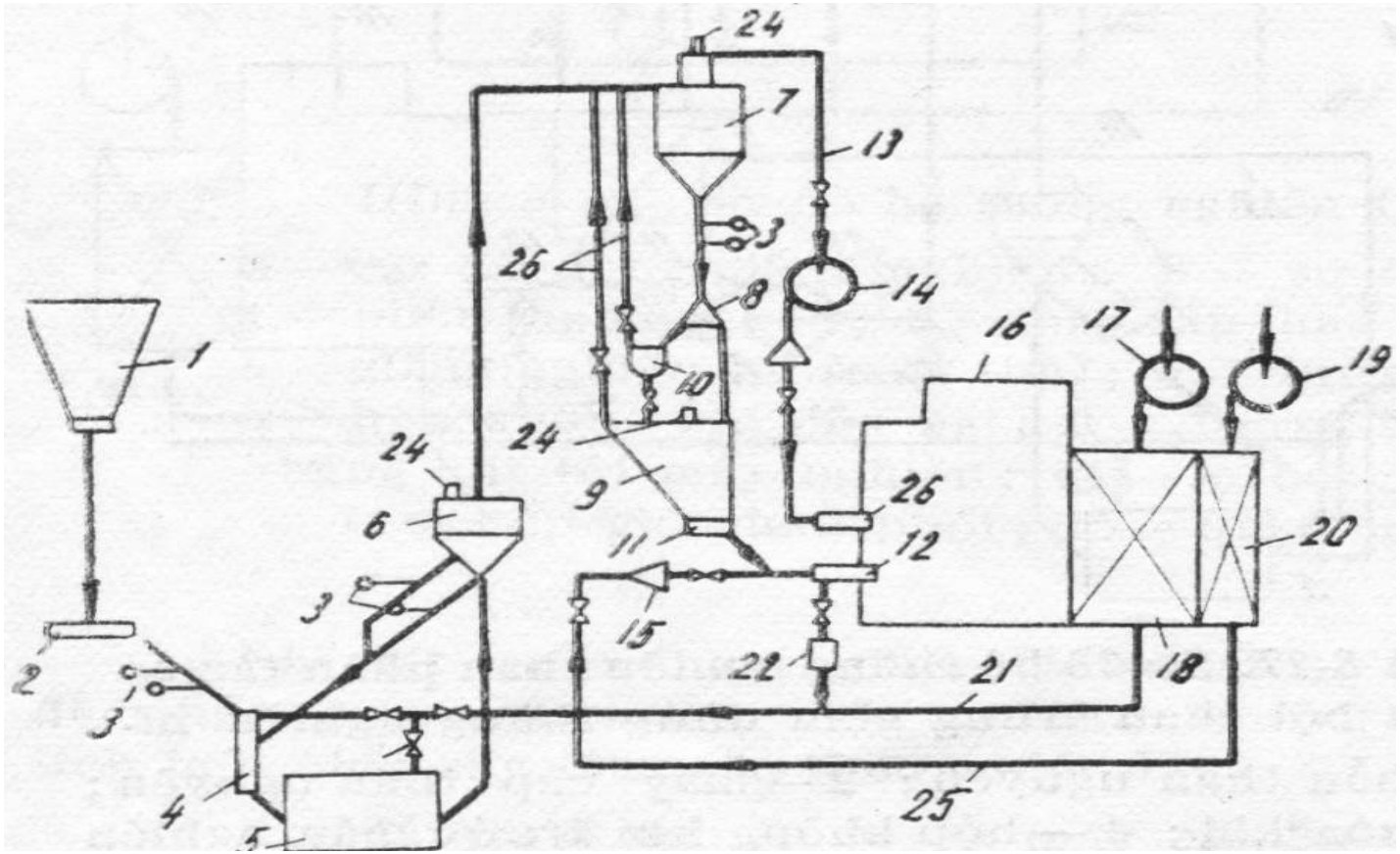


Natural circulation

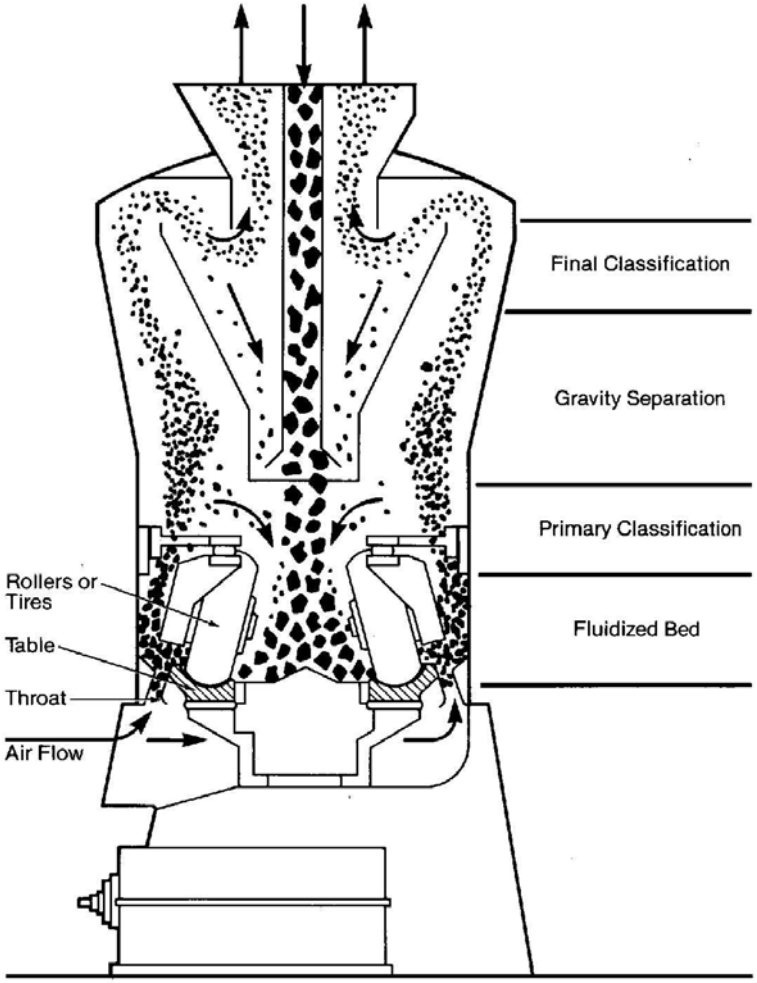


Forced circulation

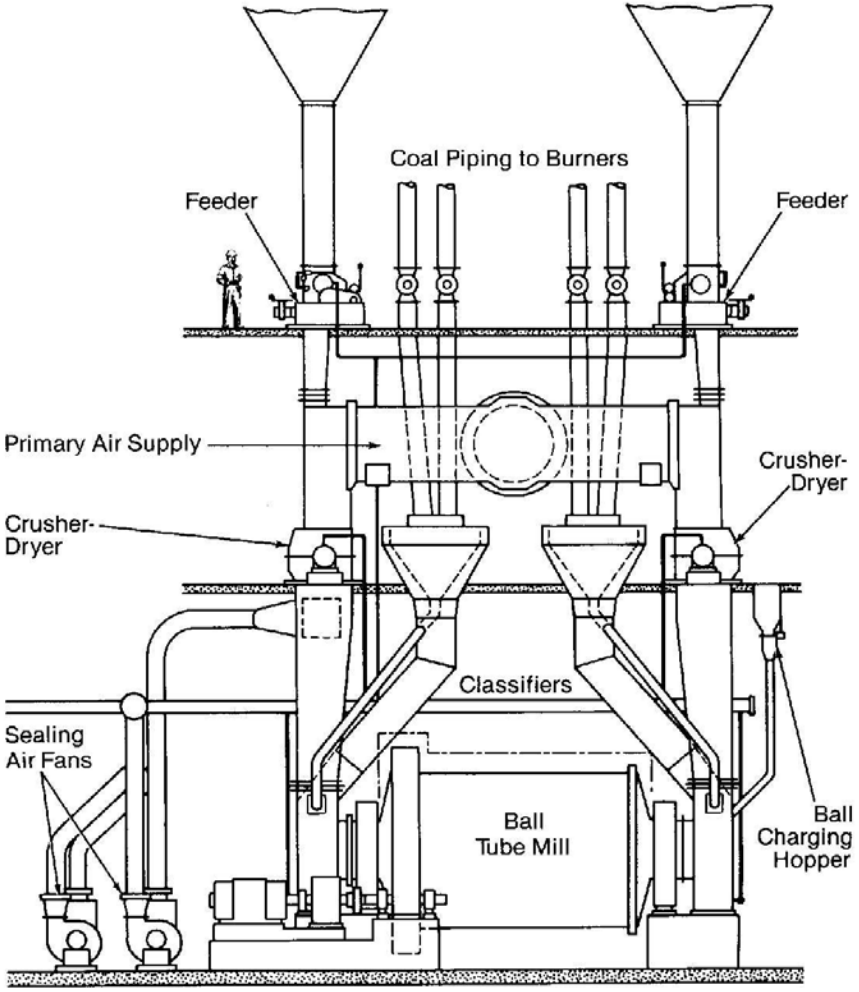
Coal conveyer system



Coal pulverizer



Coal pulverizer (1)



Coal pulverizer (2)