Australian Coal - in 2024

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BE (Min), MAusIMM, SME

30 Sep 24 7a

- Introduction
- Format
- Samples / Links
- Thank you to...

Topics

- Coal formation, properties
- Extraction and trade
- Coal utilisation
- Co2 and Net Zero
- “Clean coal”

COAL

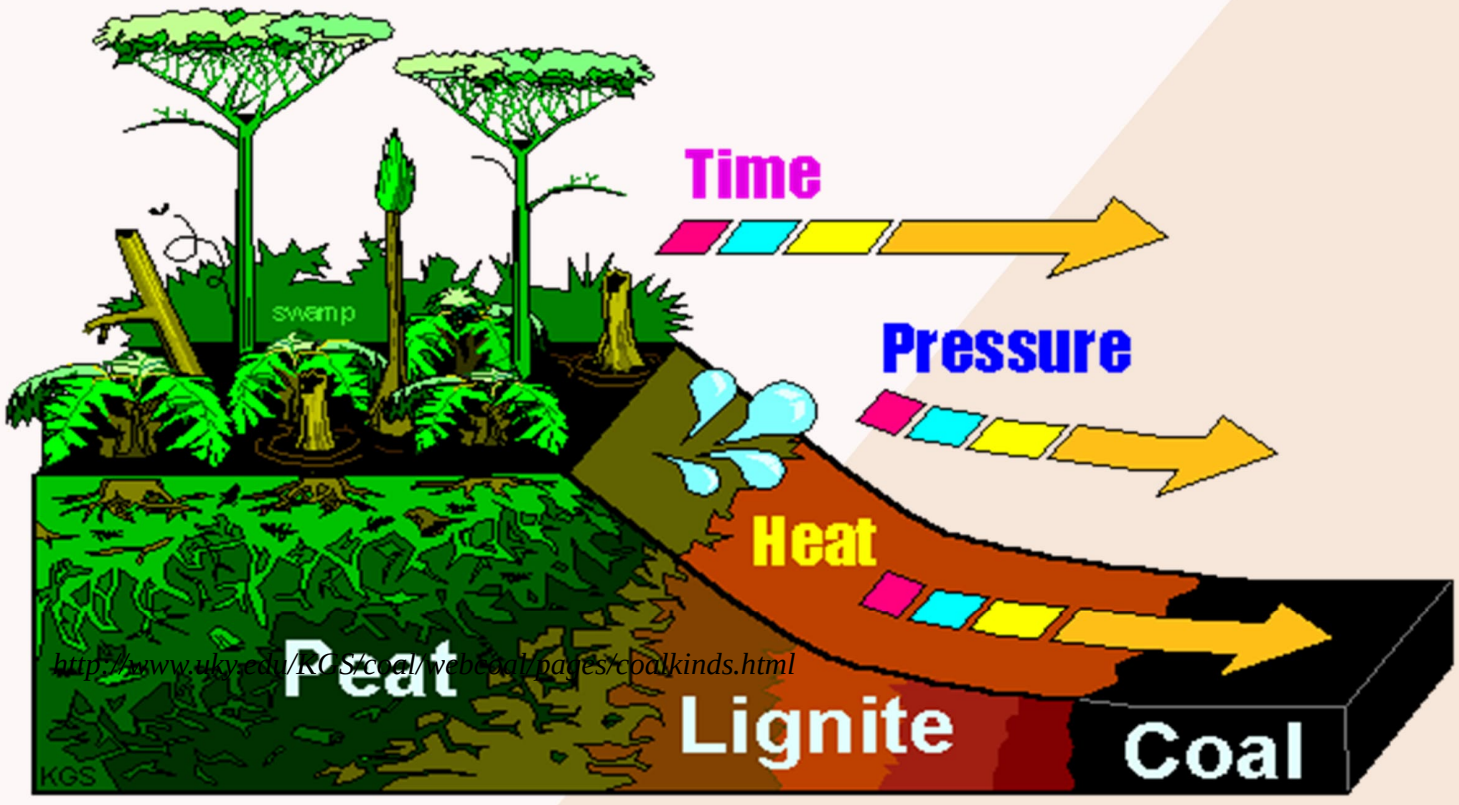
Coal is a hard rock which can be burned as a solid fuel. It contains mostly carbon but also contains hydrogen, sulphur, oxygen and nitrogen.

It is a sedimentary rock formed from peat, by the pressure of rocks laid down later on top. Peat, and therefore coal, is formed from the remains of plants that lived millions of years ago.

Coal can be burned for energy or heat, like in generating steam to turn the turbines of power stations, or in the manufacturing processes used for making steel and cement.

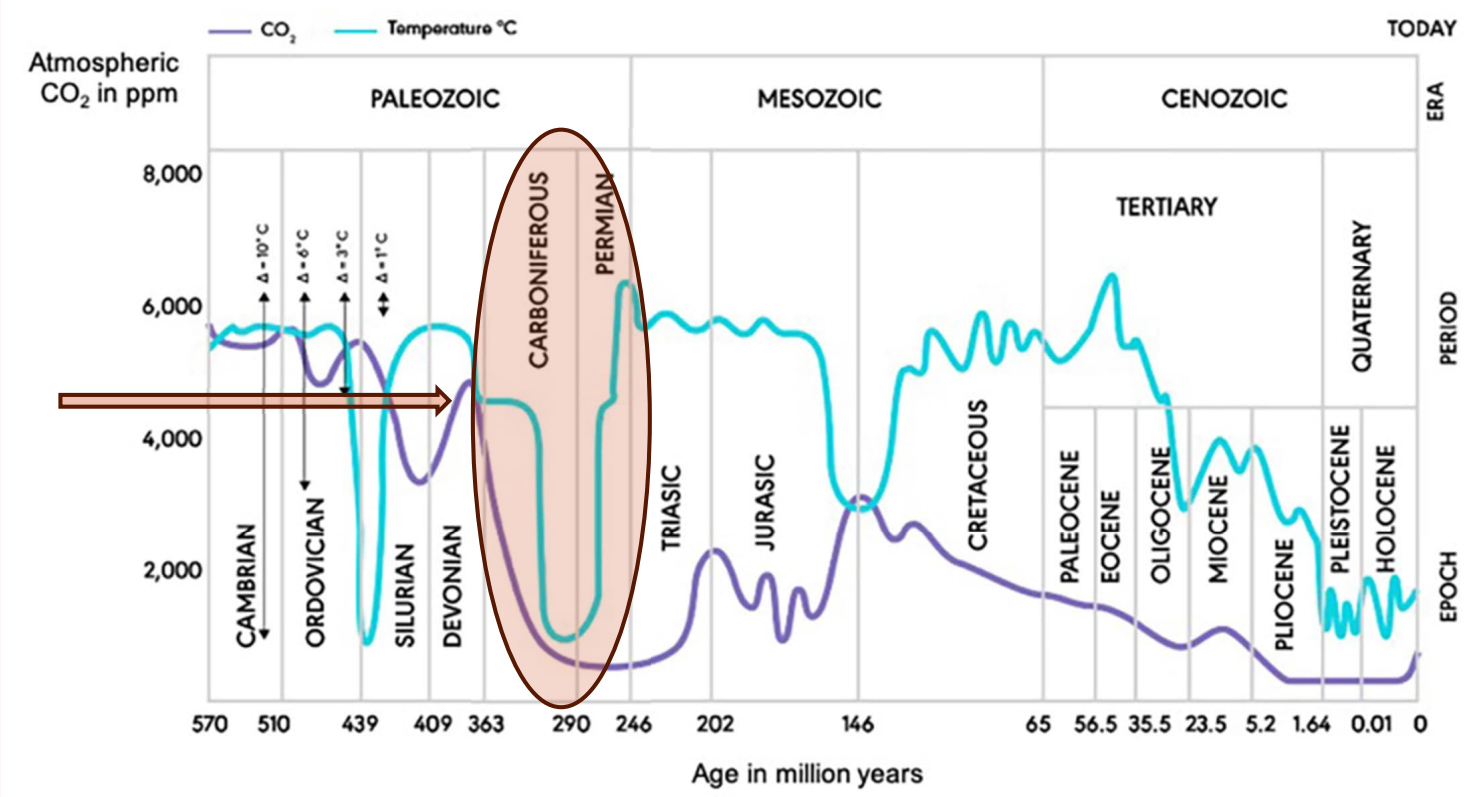
Formation
Key properties
Extraction

Coal Formation

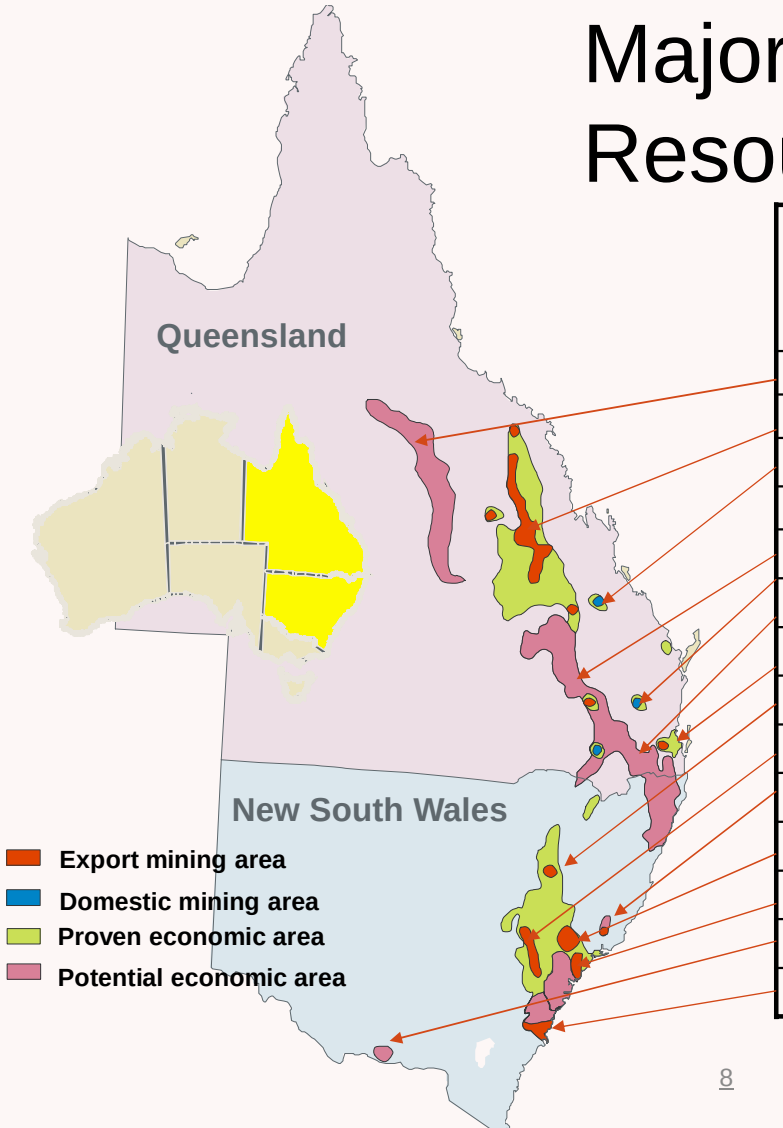


http://www.uky.edu/KGS/coal/webcoal/pages/coalkinds.html

Carboniferous / Permian era - coal formation

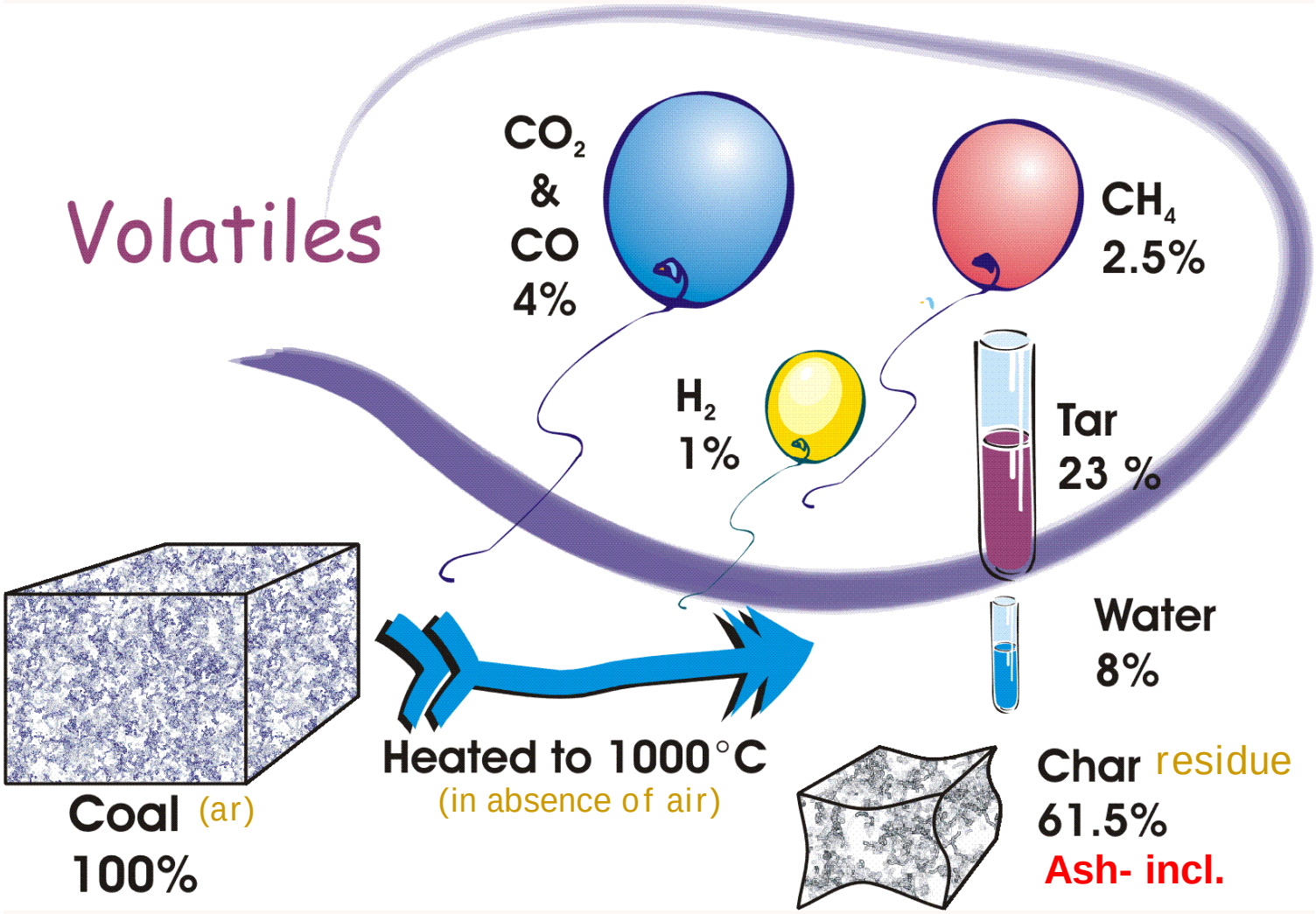


Major Black Coal Resources



Basin	Thermal & Coking Reserves	Typical Thermal daf Volatiles
Galilee	2750 Mt	36 %
Bowen	**25680 Mt**	**7 –35 %**
Callide	825 Mt	34 %
Surat	4280 Mt	51 %
Tarong	1105 Mt	41 %
Moreton	2415 Mt	49 %
Ipswich	560 Mt	36 %
Gunnedah	760 Mt	43 %
Western	1146 Mt	36 %
Gloucester	20 Mt	32 %
Hunter	4272 Mt	39 %
Newcastle	1718 Mt	37 %
Oaklands	1120 Mt	35 %
Southern	810 Mt	26 %

Reserves only include coal contained in mine leases or exploration licences



Components - % as received basis (high volatile coal)

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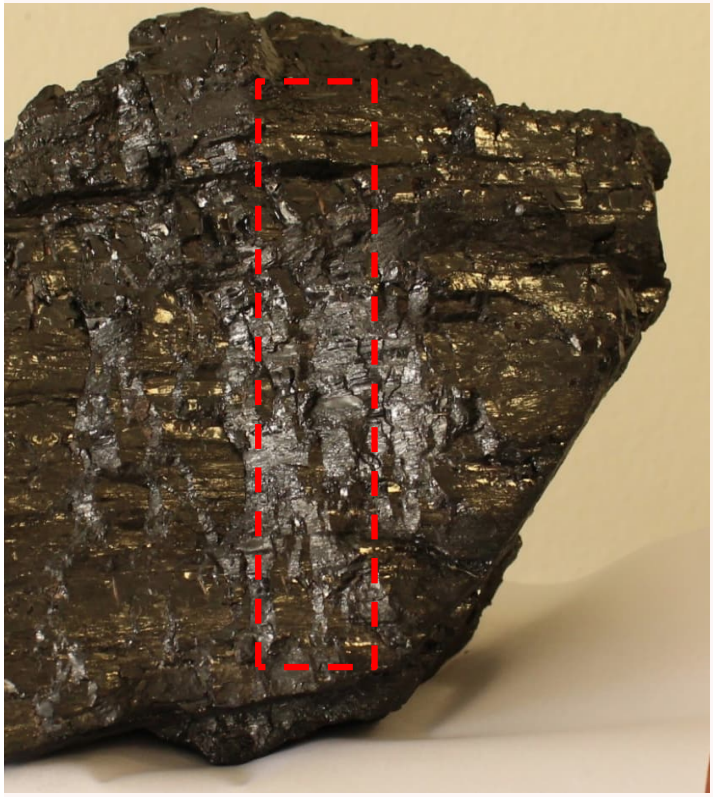
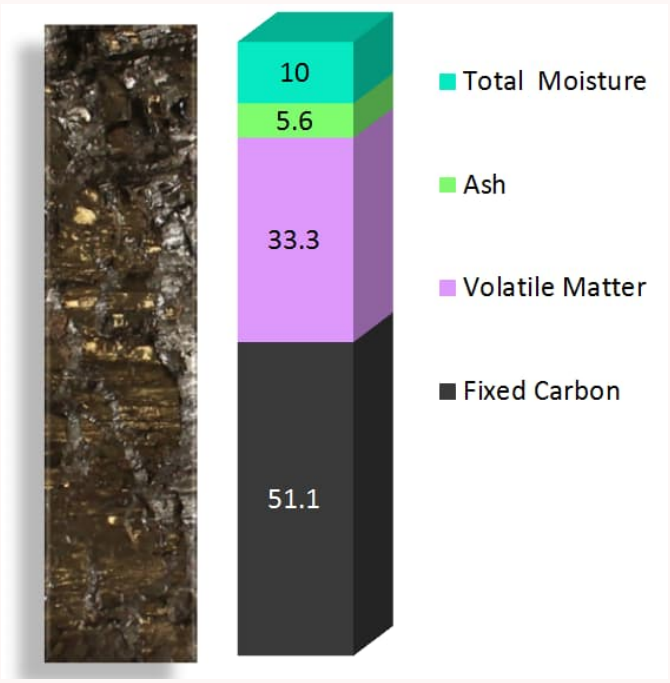
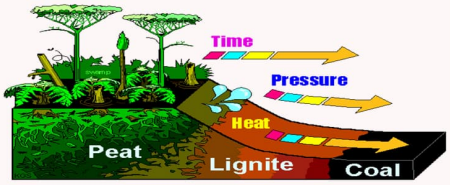




COALIFICATION PROCESS



	COMPOSITION - Weight % dry ash free basis		
	C – Carbon	**H – Hydrogen**	**O – Oxygen**
WOOD	49	7	44
PEAT	60	6	34
LIGNITE	70	5	25
SUB BITUMINOUS	75	5	20
BITUMINOUS	85	5	10
ANTHRACITE	94	3	3

Time, Temp. Pressure

Coal Rank

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Rank refers to the level of MATURATION of a coal

WOOD

PEAT

BROWN COAL-LIGNITE — LOW RANK

SUB-BITUMINOUS COAL — LOW RANK

BITUMINOUS COAL — MEDIUM RANK

SEMI-ANTHRACITE — HIGH RANK

ANTHRACITE — HIGH RANK

Maturation Increasing,

Mainly due to increasing depth of burial (i.e. temperature, pressure)

Mineral matter – “during / after”

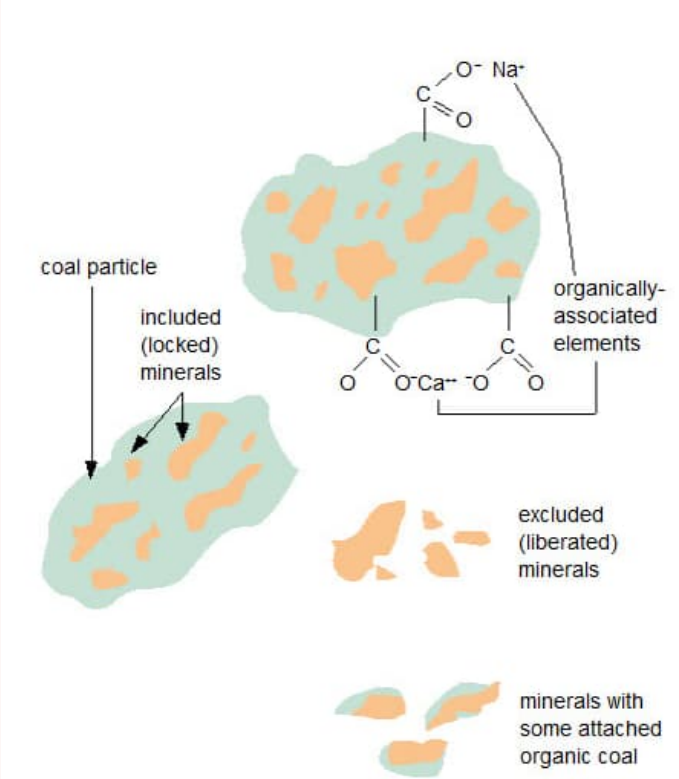
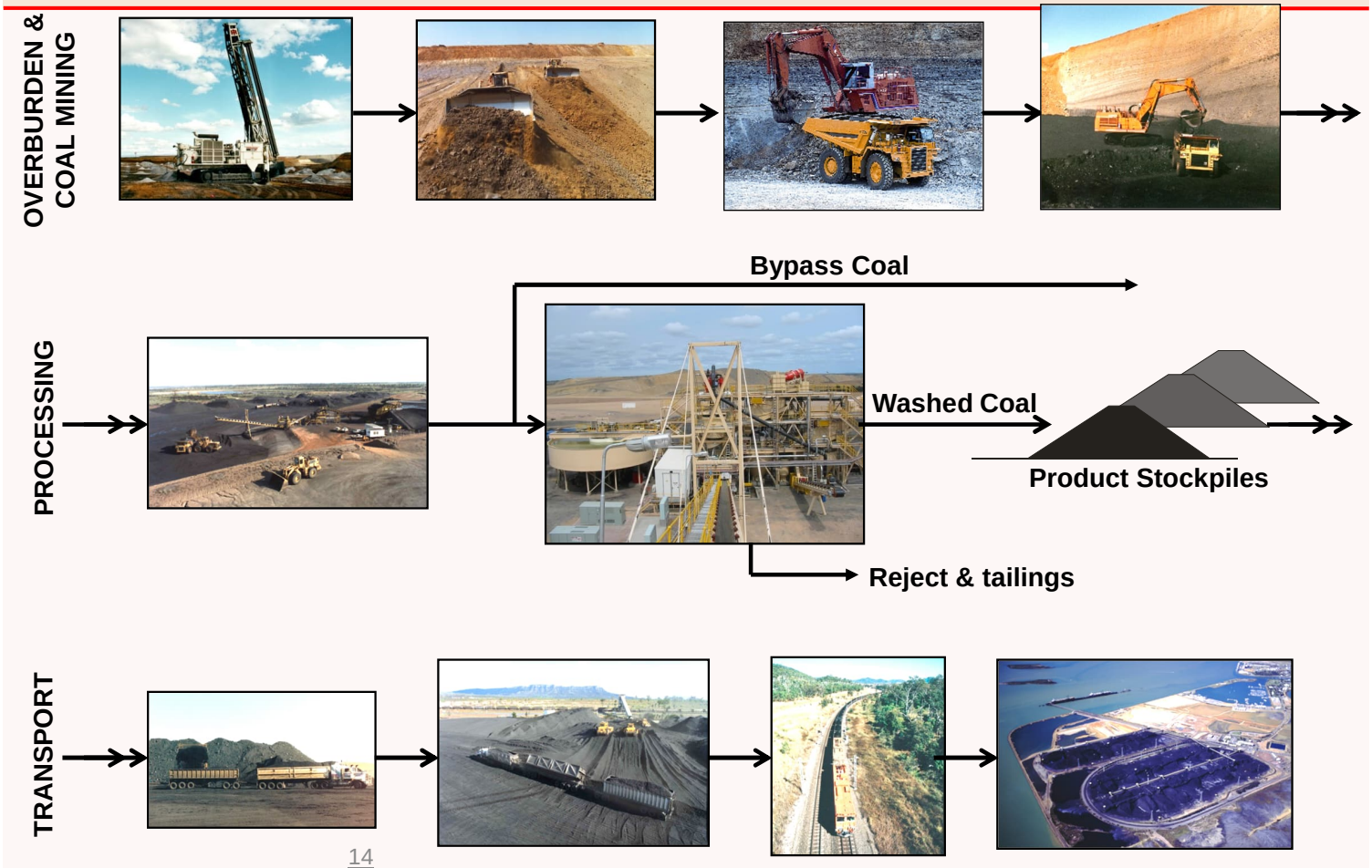


Figure 02 Physical form of mineral matter in coal
(Couch, 1994; Benson and others, 1993)

Typical Open Cut Coal Mine - Operational Flowchart



A busy (overseas) mine

COAL PREPARATION

Coal preparation

- Raw coal > “Clean” coal, “washed” coal, product coal
- Removes impurities. To produce a consistent product for the end-user

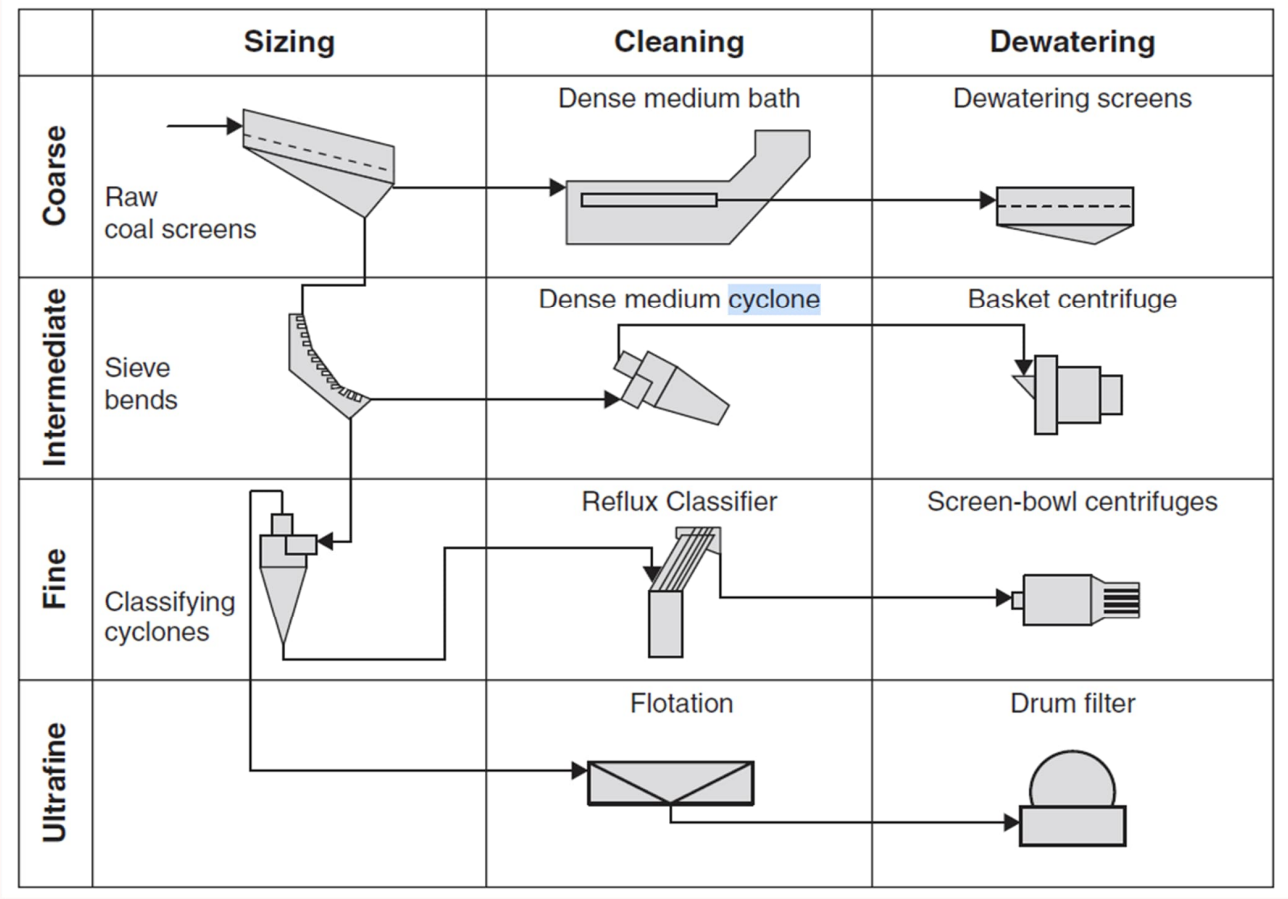
Coal – separation by DENSITY

Laboratory testing – float/sink

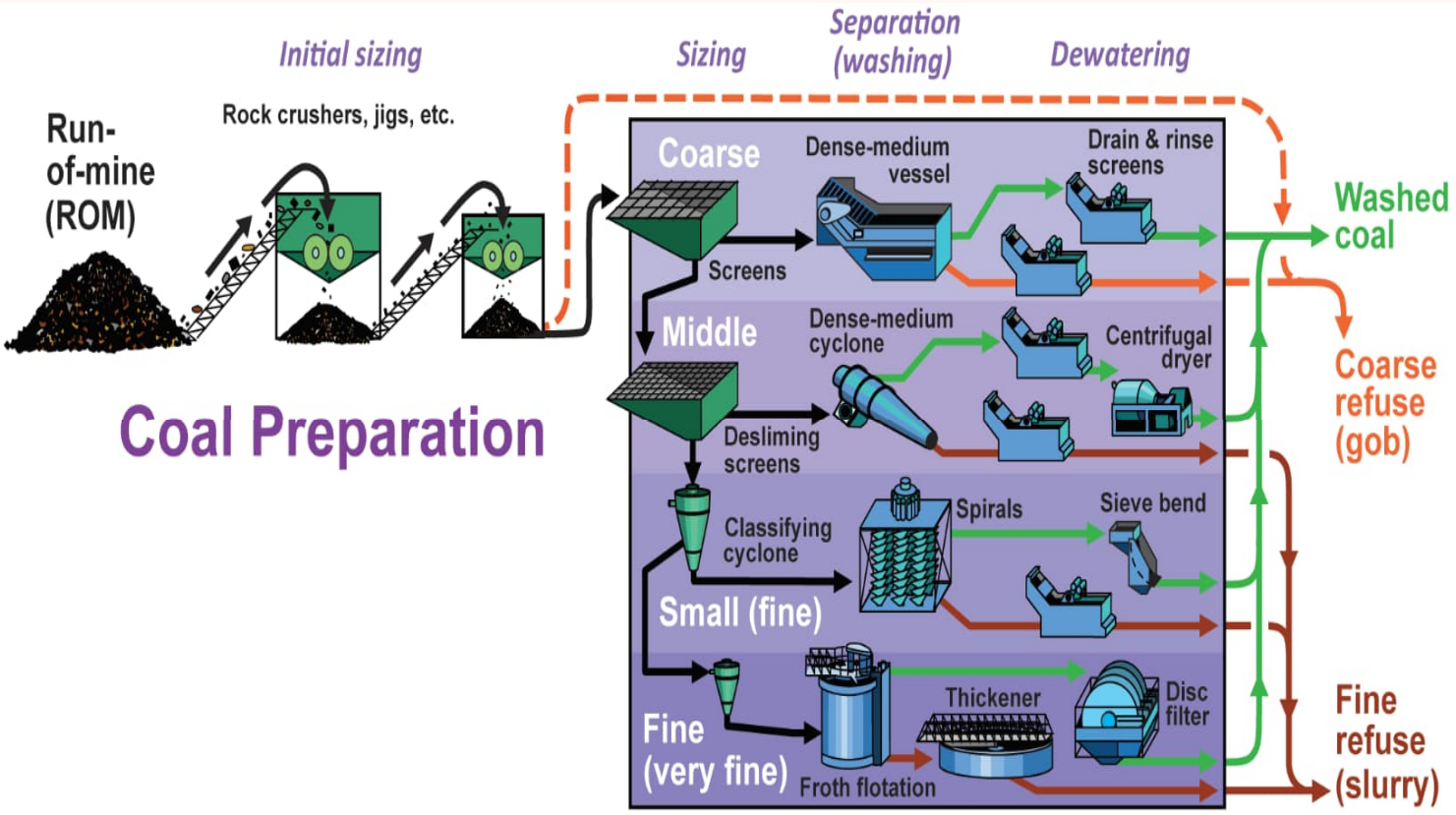
Coal density 1.2-1.5 g/cc
“Rock “ density 2 – 2.3

A washability curve can then be generated.

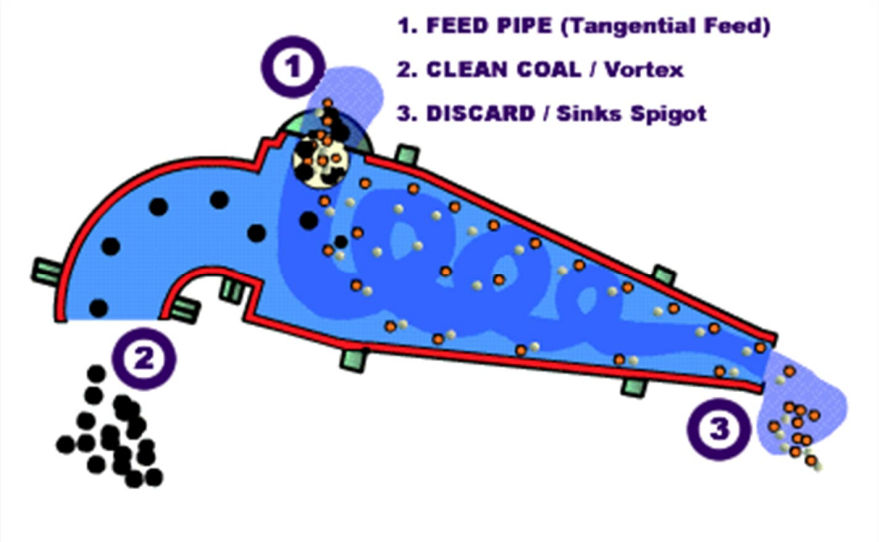
Typical coal preparation plant schematic



Schemtic – coal preparation plant



About 80 % of all export coal has seen one of these…



Dense Medium Cyclone

European coal preparation plant

Small Australian preparation plant

COAL PROPERTIES

Chemical Characterisation

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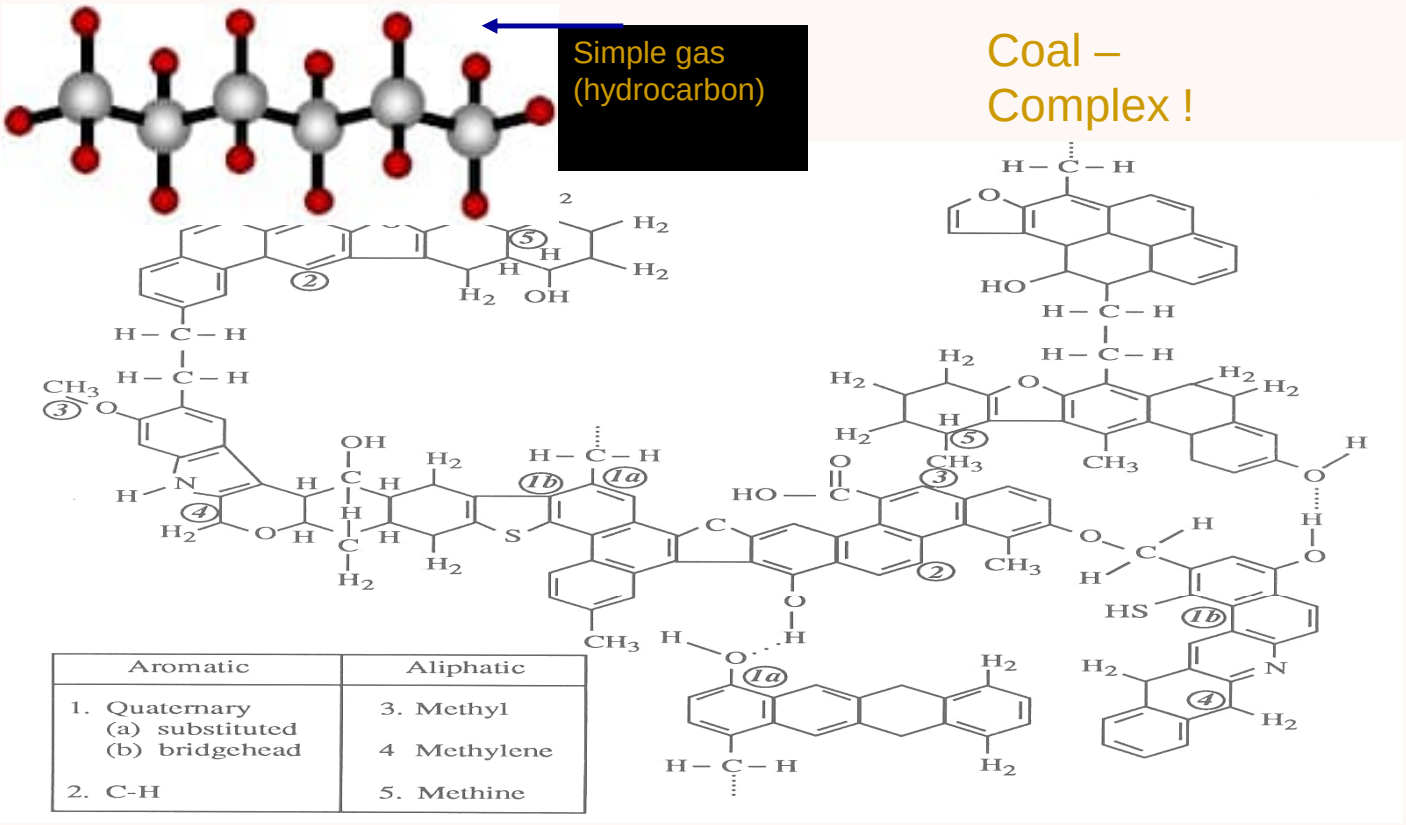
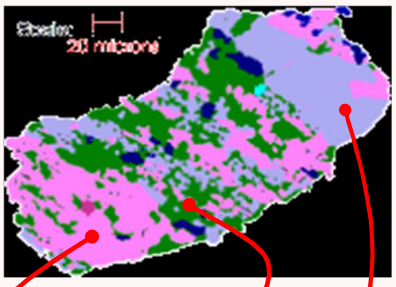
- Total moisture
- **Proximate analysis**
  - Air-dried moisture or inherent moisture
  - Ash (mineral matter)
  - Volatile matter
  - Fixed carbon
- **Total Sulphur**
- Calorific value (Specific Energy) in calories, Joules or BTU
- **Ultimate analysis**
  - C, H, N, S, O
- **Phosphorus / Chlorine**
- **Trace elements**



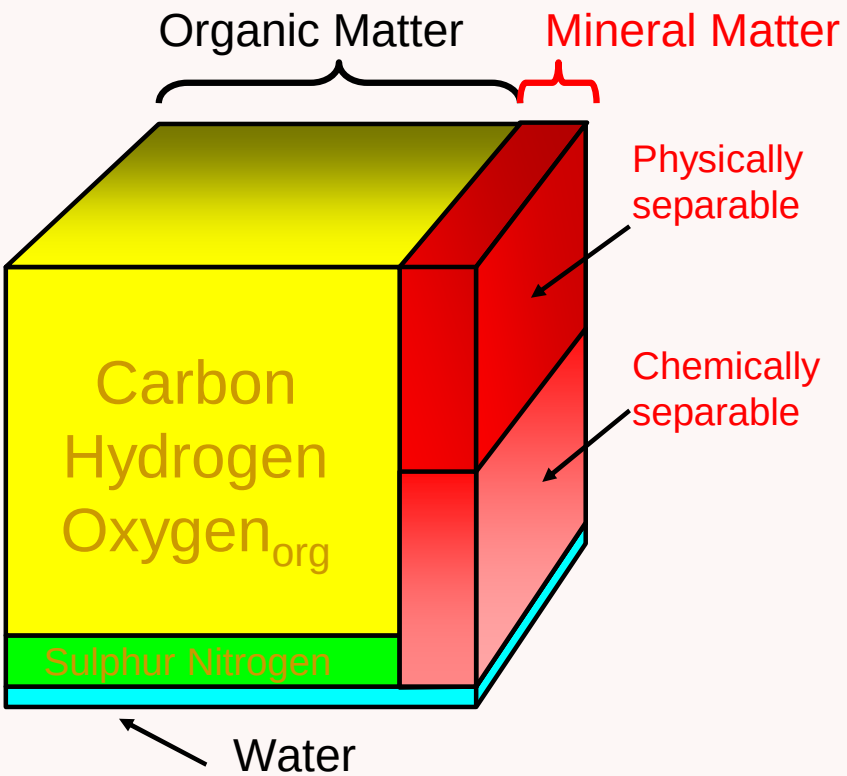
Fundamental Composition of Coal



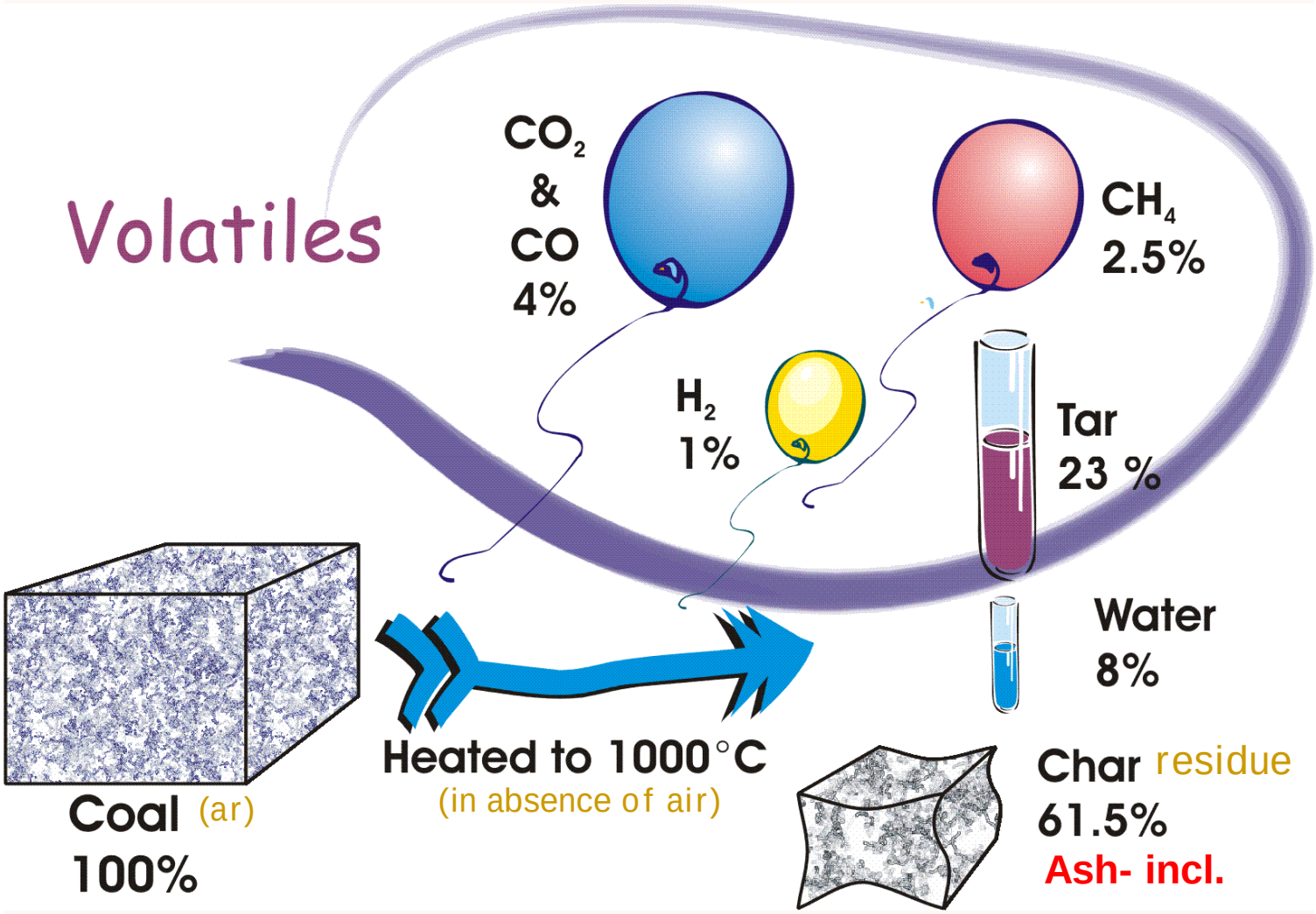
Minerals

Inertinite*

Vitrinite*



* Coal MACERALS


Volatiles
CO_2 & CO 4%
CH_4 2.5%
H_2 1%
Tar 23 %
Water 8%
Coal (ar) 100%
Heated to 1000°C
(in absence of air)
Char residue 61.5%
Ash- incl.

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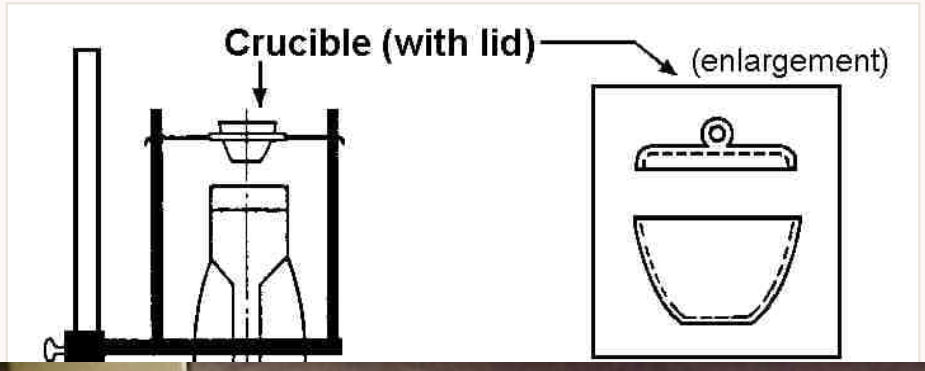
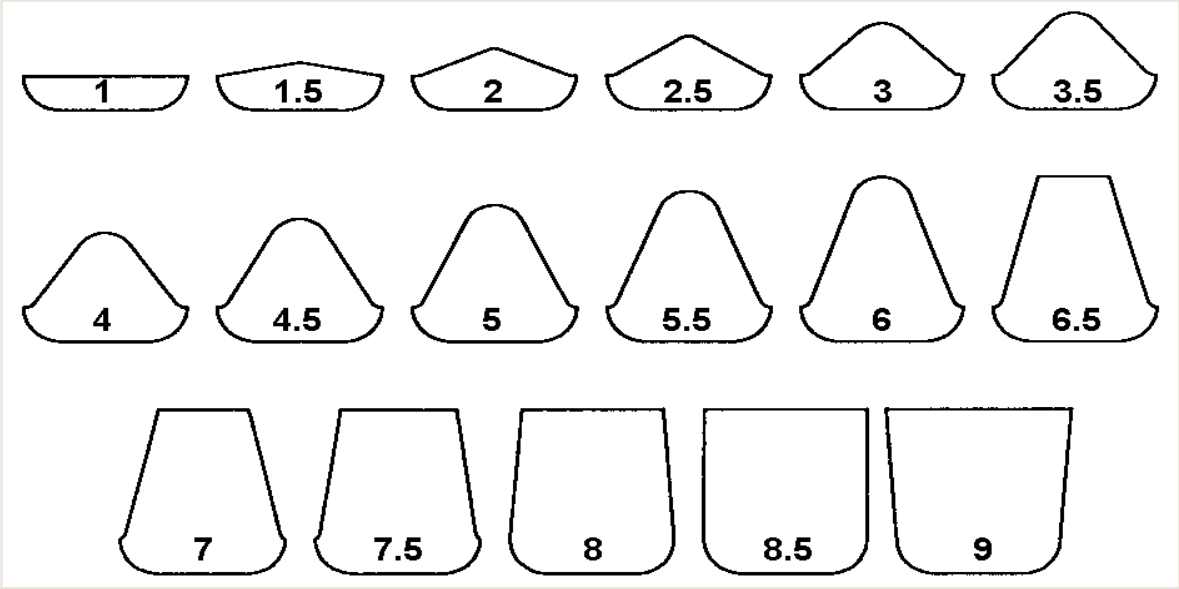
CSN: Assembled Apparatus



CSN: Standard Profiles



Standard button profiles and corresponding crucible swelling numbers

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Coal Quality Workshop
Thermal Coal and Coking Coal
June 2023

WHITEHAVEN COAL

1. What is coal? – coal rank and forms
2. Sampling and testing
3. Thermal coal and power generation
4. Met coal and steel making
5. Coal blending

WHC-Coal-Quality-Presentation-for-analysts.pptx.pdf

Coal
Utilisation
1. Thermal coal

COAL UTILISATION-
Thermal coal and metallurgical coals

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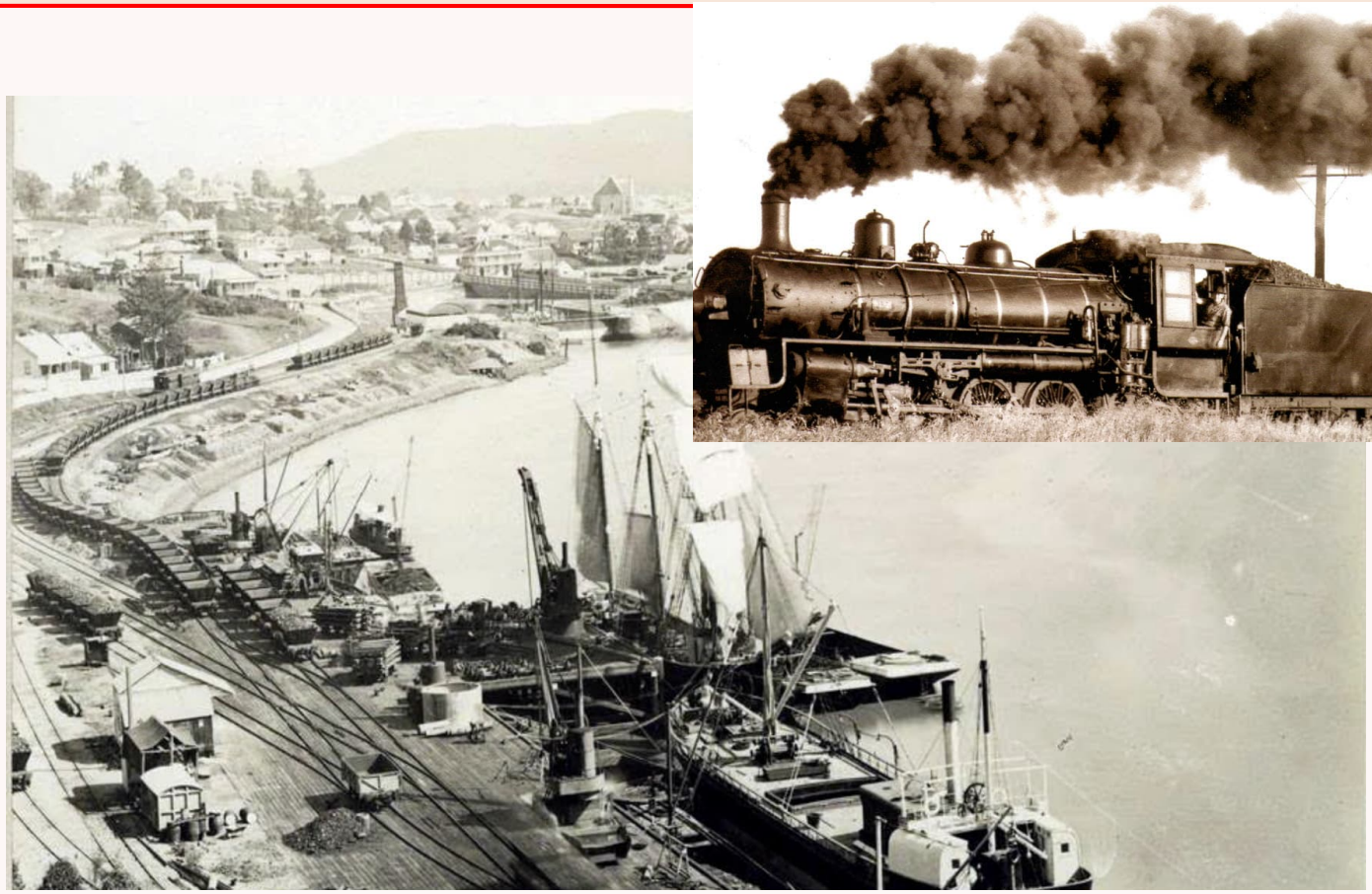
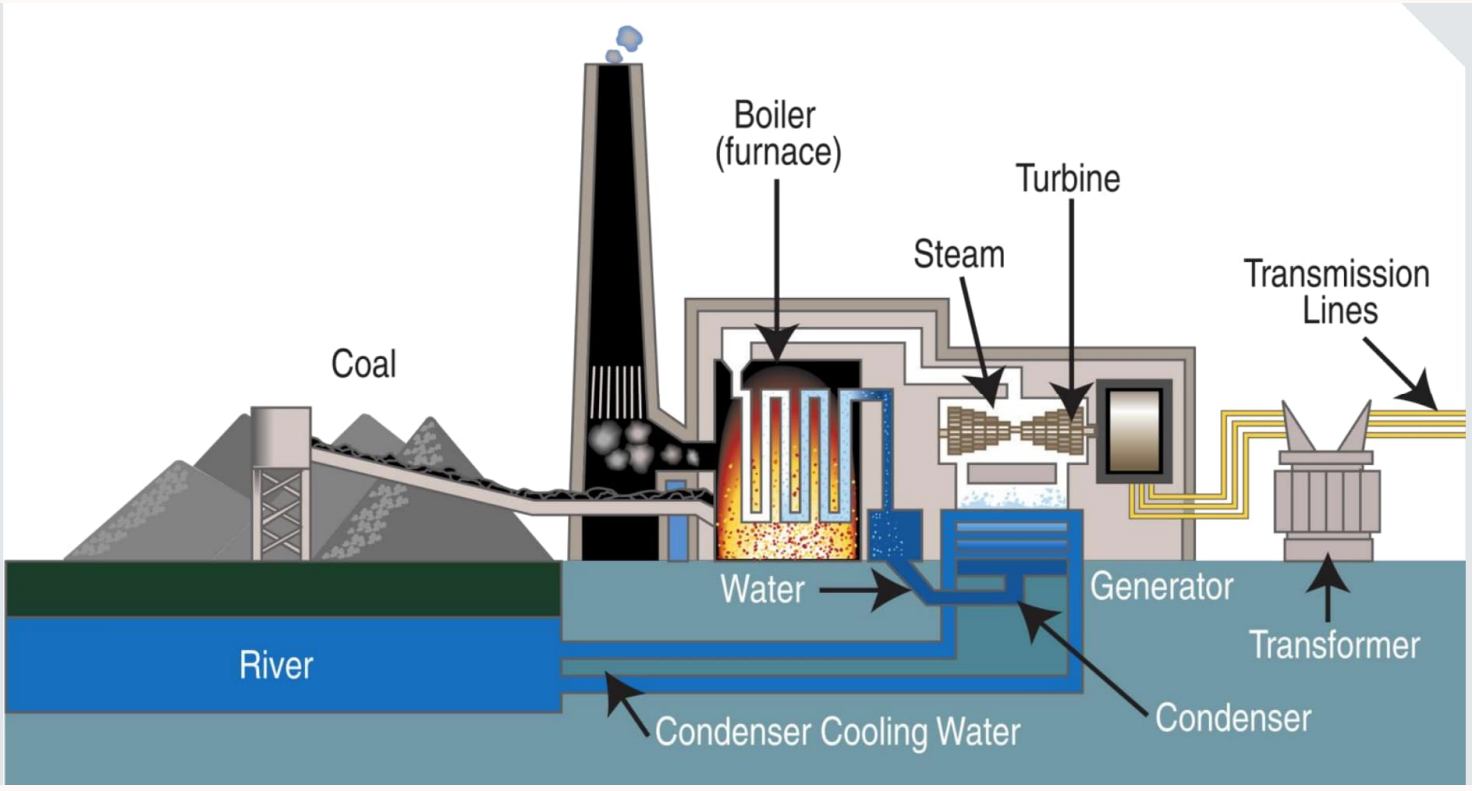
- 1. **COMBUSTION** (of coal in air)
  - ➔ Elevated temperature
  - ➔ Decomposition
  - ➔ Reaction with oxygen $C + 0_2 \Rightarrow CO_2$ exothermic
  - ➔ Heat used for steam raising or…

- 2 **COKE MAKING** (Carbonisation of coal without air)
  - ➔ Elevated temperature
  - ➔ Decomposition (pyrolysis – absence of air)
  - ➔ Coke formation & by-products

Coal loading – South Bank



Coal fired PS



HEKINAN (Japan) Power Station

JAPANESE POWER STATION

Stanwell Power Station

- 4 x 350 MWe
- Opposed wall firing
- Design coal Curragh / Blackwater (fuel ratio 2.5 – 2.8)

Cement Making: (Hard to abate)

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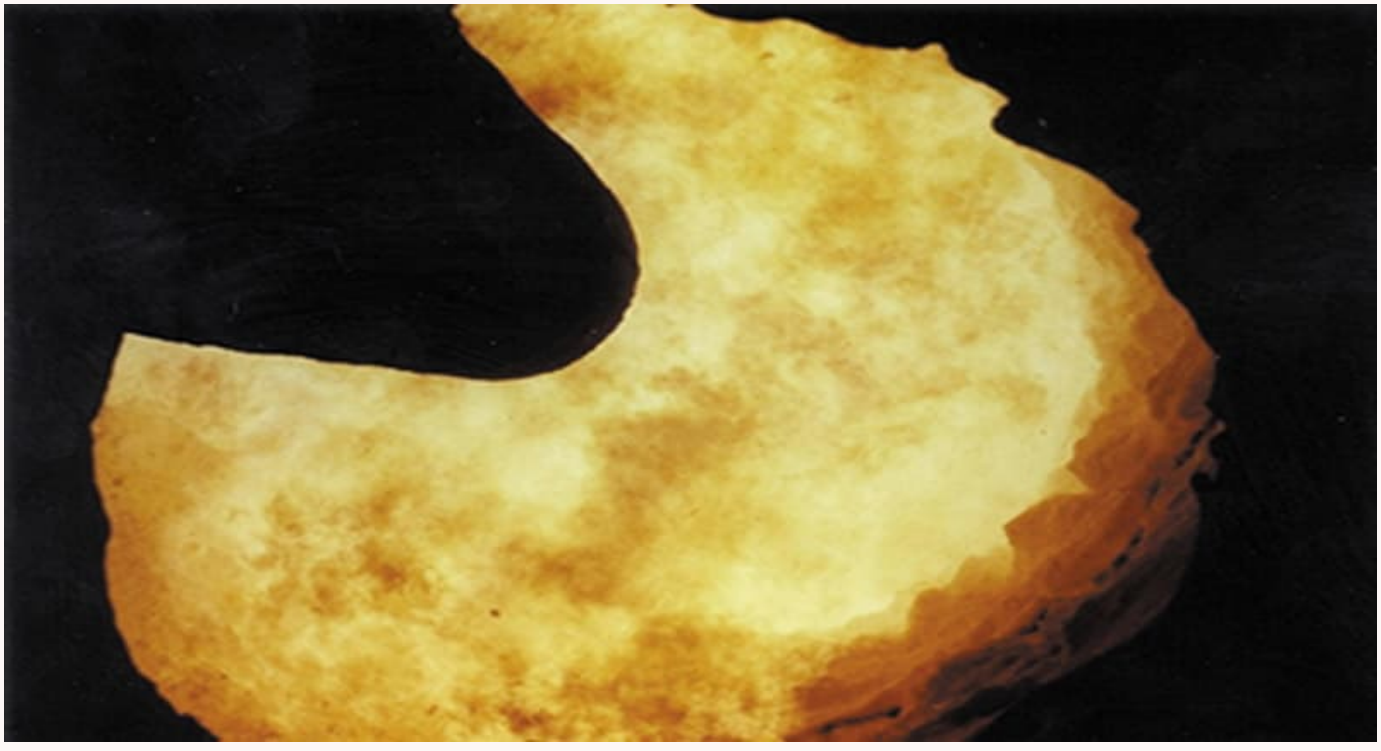
- Chemistry can be complex
- Meal (mixture of ≈75% limestone + ≈15% clay + minor sand, iron oxide and slag) is finely ground and heated
- The two main reactions are...
  - Calcination: at ≈900°C, the limestone decomposes to form lime (calcium oxide) $CaCO_3 \Rightarrow CaO + CO_2$ (endothermic)
  - At ≈1450°C, the lime combines with clay oxides and silica to form clinker
- The clinker is cooled and mixed with gypsum to make portland cement
- Fuel is normally coal, oil, or….any carbon based fuel
- Most of the coal ash is absorbed into clinker .

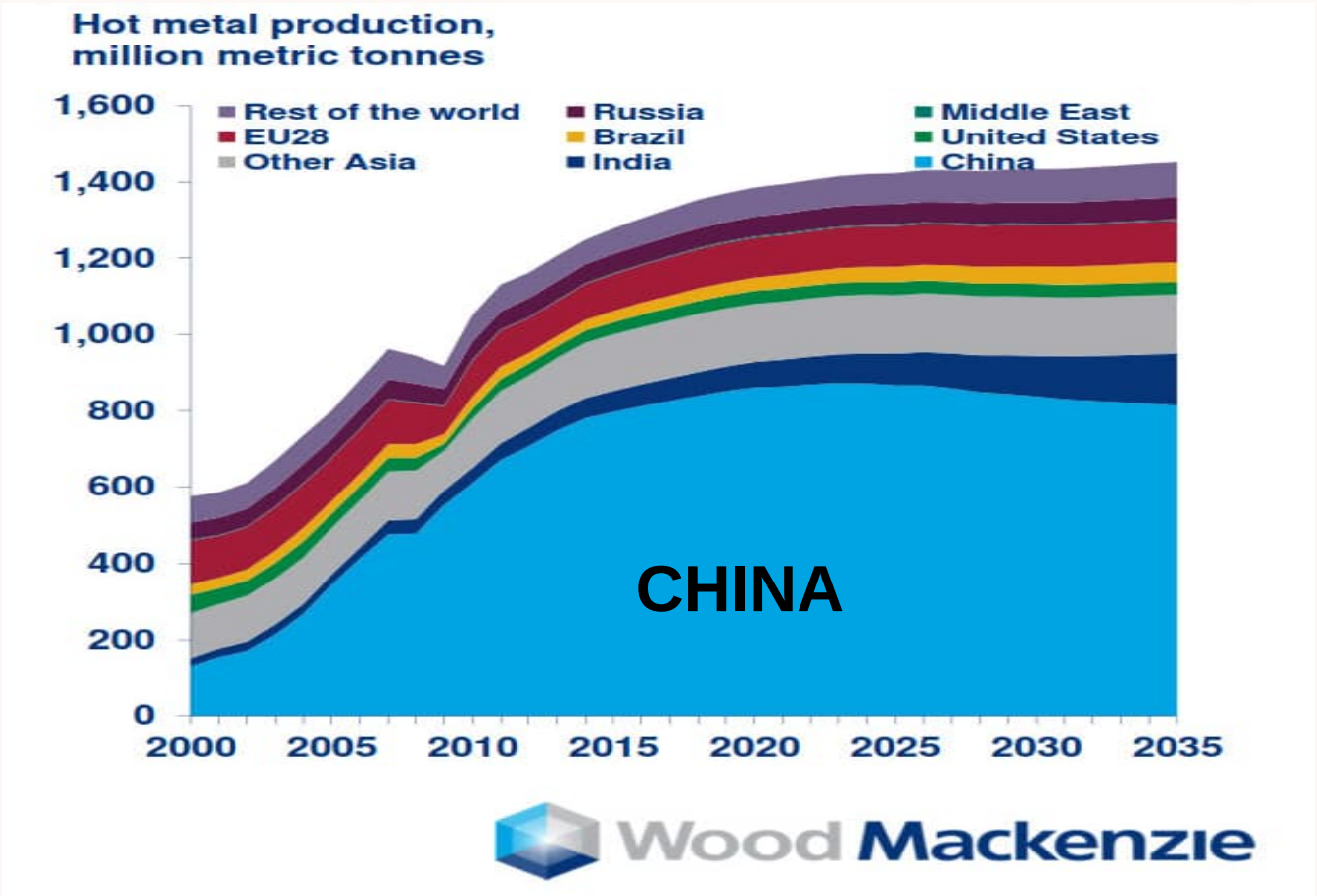


CEMENT KILN FLAME

COAL UTILISATION 2

- **Coking (met) coal**

Global hot metal production - forecast



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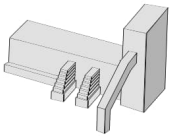
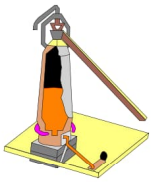
Why do we need coking coal?



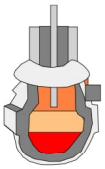
Cokemaking

Coking coal is needed to produce **coke**



Ironmaking

Coke + **iron ore** is used to produce **iron**



Steelmaking

Iron is needed to produce **steel**

(via the Integrated Steelmaking process)

THE BLAST FURNACE

The blast furnace is designed to reduce iron oxide to liquid iron, whilst maintaining hot metal quality and temperature.

All this at the minimum possible cost.

Coke performs the following roles in the BF:

Chemical

- Reductant

  $FeO + C \longrightarrow Fe + CO$

  $Fe_2O_3 + CO \longrightarrow 2FeO + CO_2$

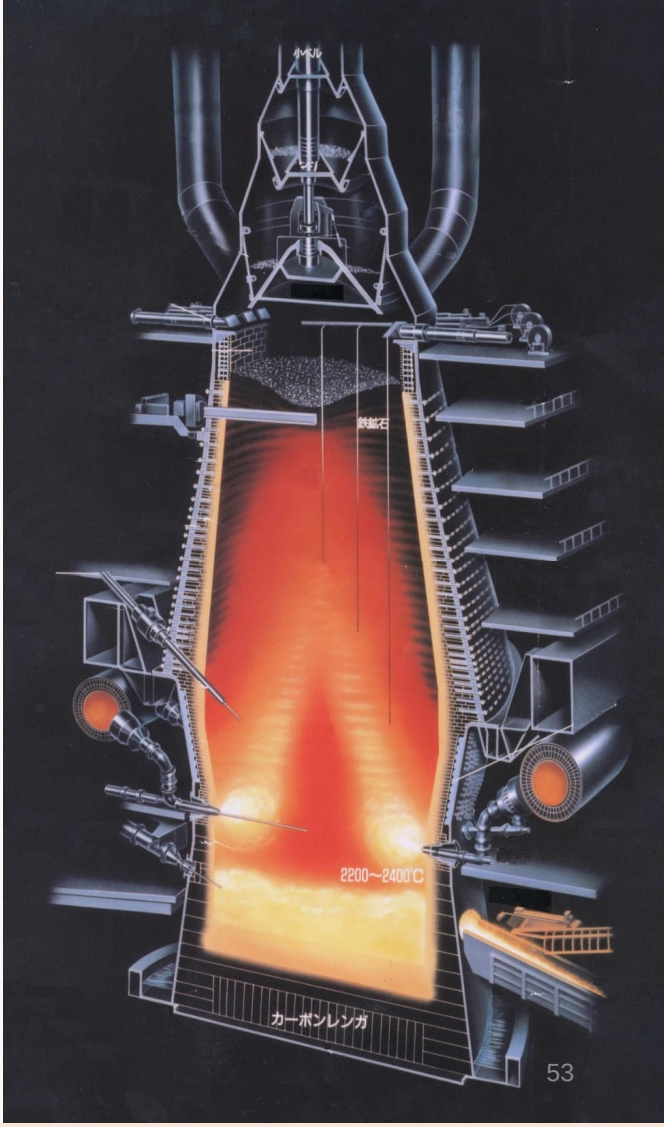
- Carbon dissolved in hot metal (5% approx)

Thermal

- $2C + O_2 \longrightarrow 2CO$

Physical or Structural

- Support burden
- Gas and liquid permeability



BF Input & Output – Typical JSM

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BF : 5150 cu m – 15.0 m dia - 4.1 Mtpa hm (11000 +tpd) - productivity 2.4

COKE BATTERIES
- 125 ovens
- 1.5 Mt coke pa
- CMC – ½ CDQ

Coking coal - (8-12 coals) - 520 kg

COKE:
370 kg/t
11-12 % ash
60-65 CSR

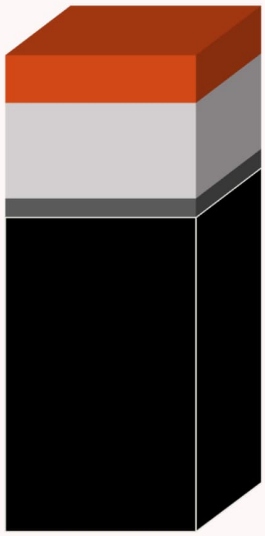
ORE / SINTER / FLUXES
1580 kg/t
70 % sinter

PCI (1 to 3 coals) :
130 kg/t
9 % ash
0.85 RR
3% O2
1100 deg Blast T

1 tonne hot metal
+ Slag : 300kg/t

Other: TRT – bell less top – HM P 0.12 % -

Coking Coal and Coke

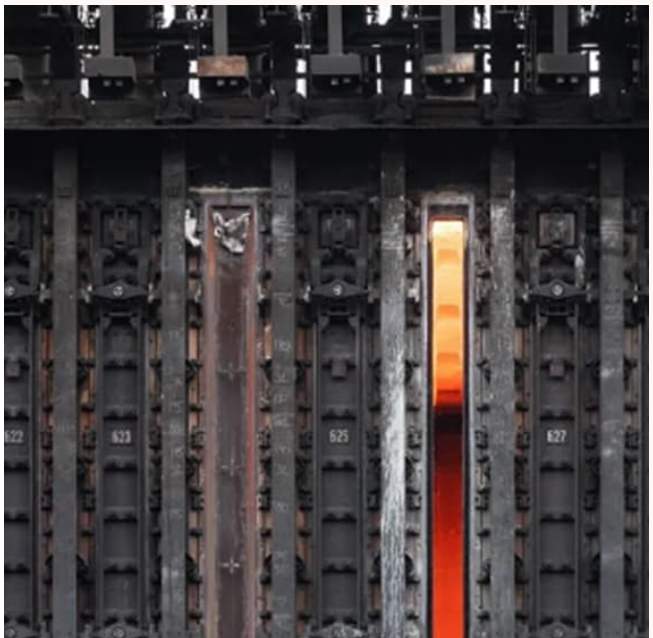


- TM
- CO gas & tar
- Breeze
- Dry coke at BF

1 tonne of coking coal – as shipped.

1 tonne dry, useful **coke** requires ~ **1.5 tonne** of coking coal – as shipped (24% VM coking coal - 10 % TM)

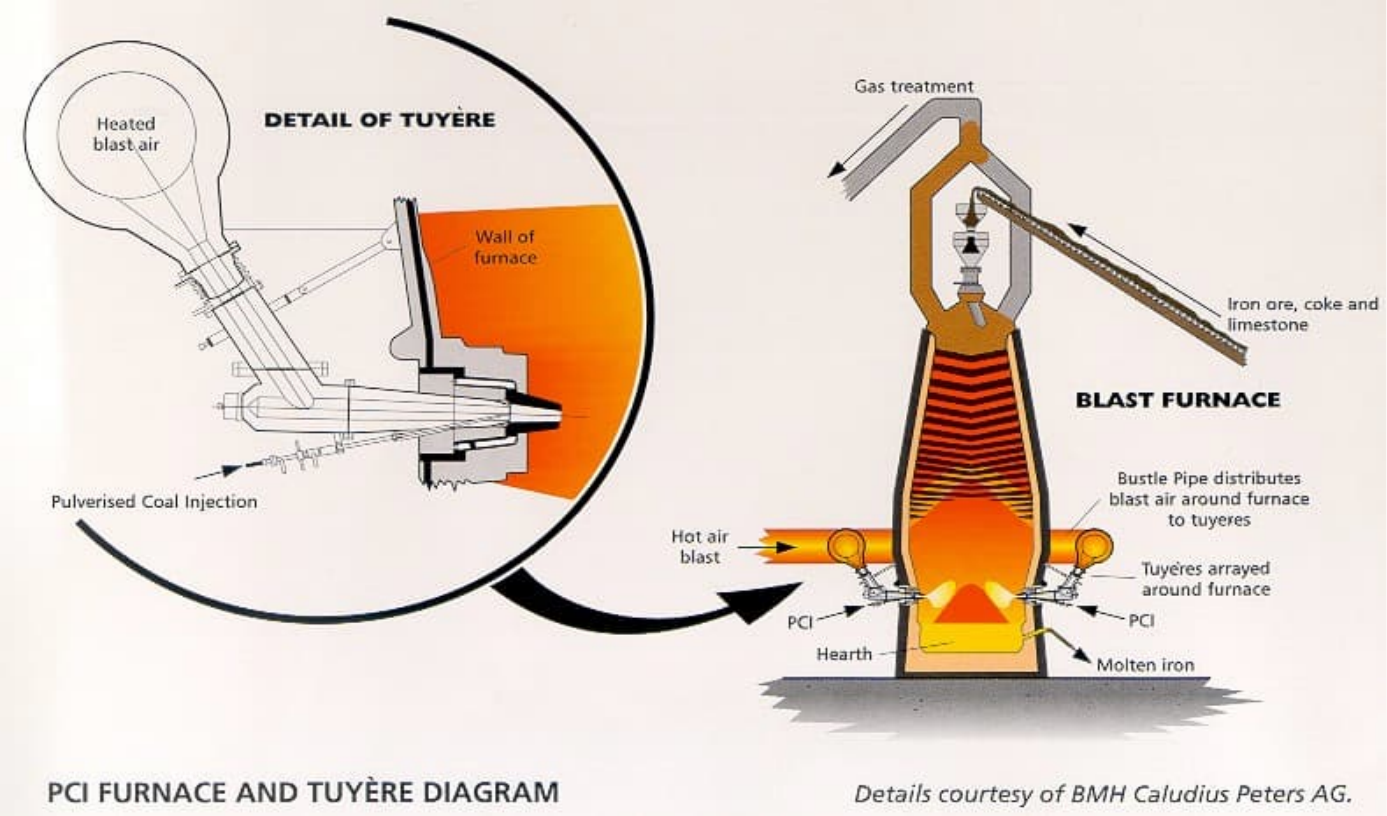
Coke oven batteries



PRIOR TO QUENCHING

HOT COKE - PRIOR TO QUENCHING

LUMPCOKE



BF and TUYERE

PCI (Pulverised Coal Injection)

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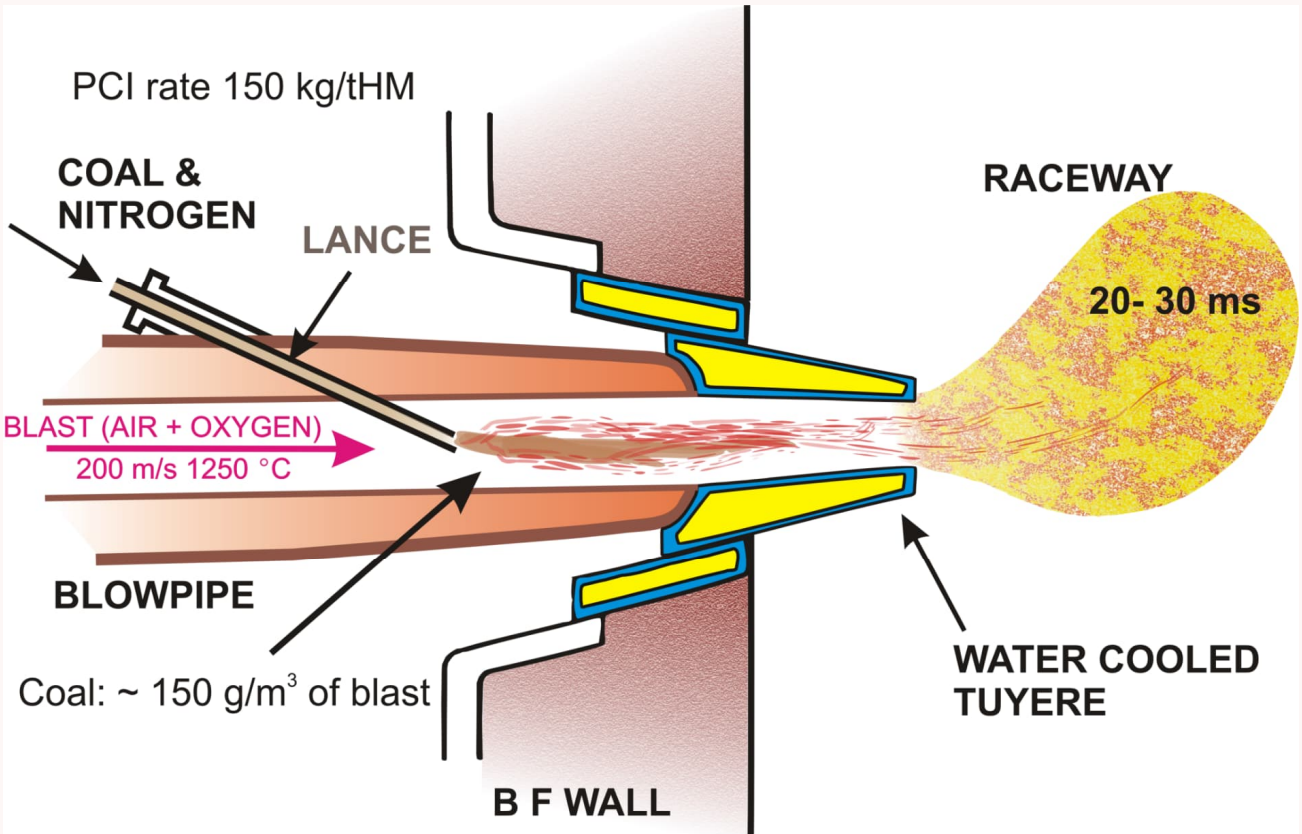
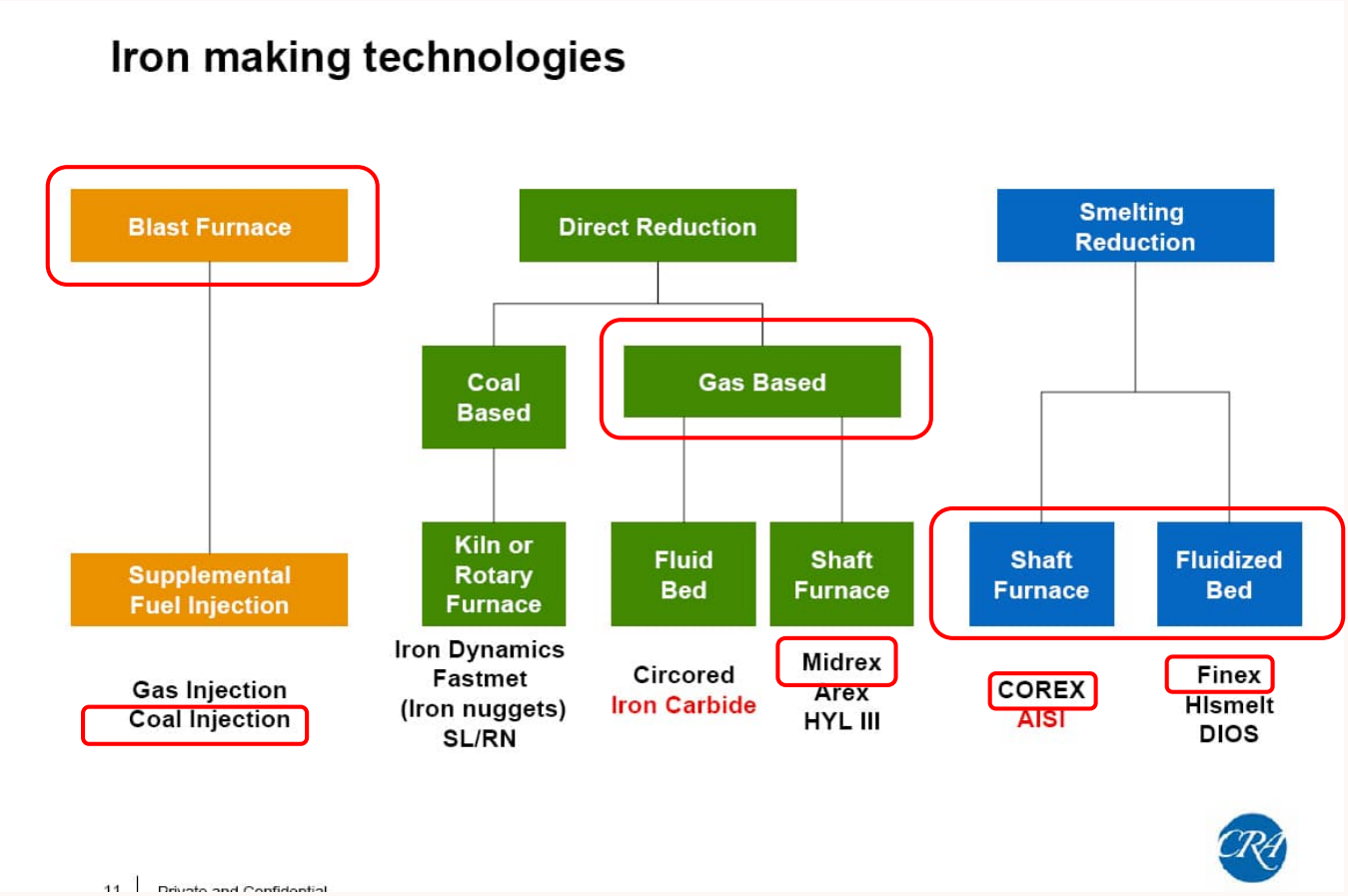
LANCE AND TUYERE ASSEMBLY



Some iron making methods



1. What is coal? – coal rank and forms
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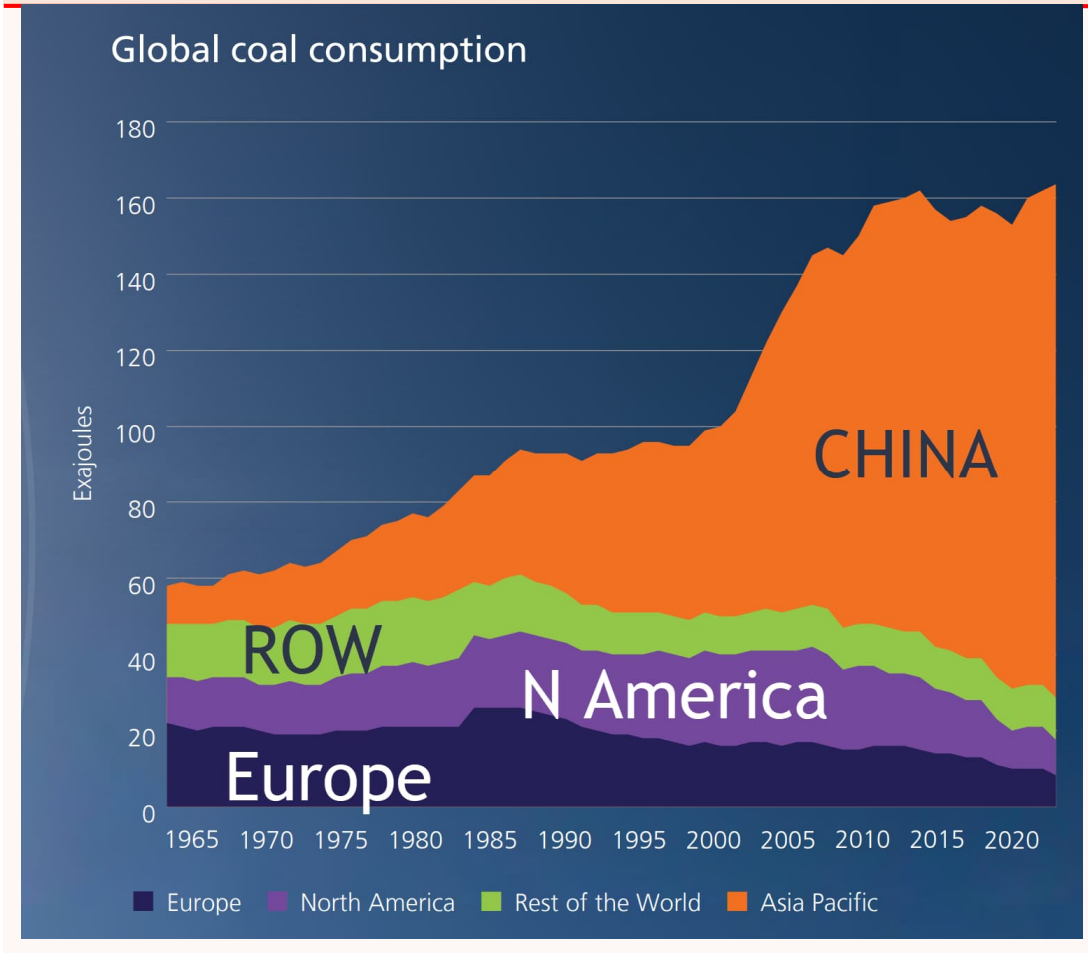
WHITEHAVEN COAL

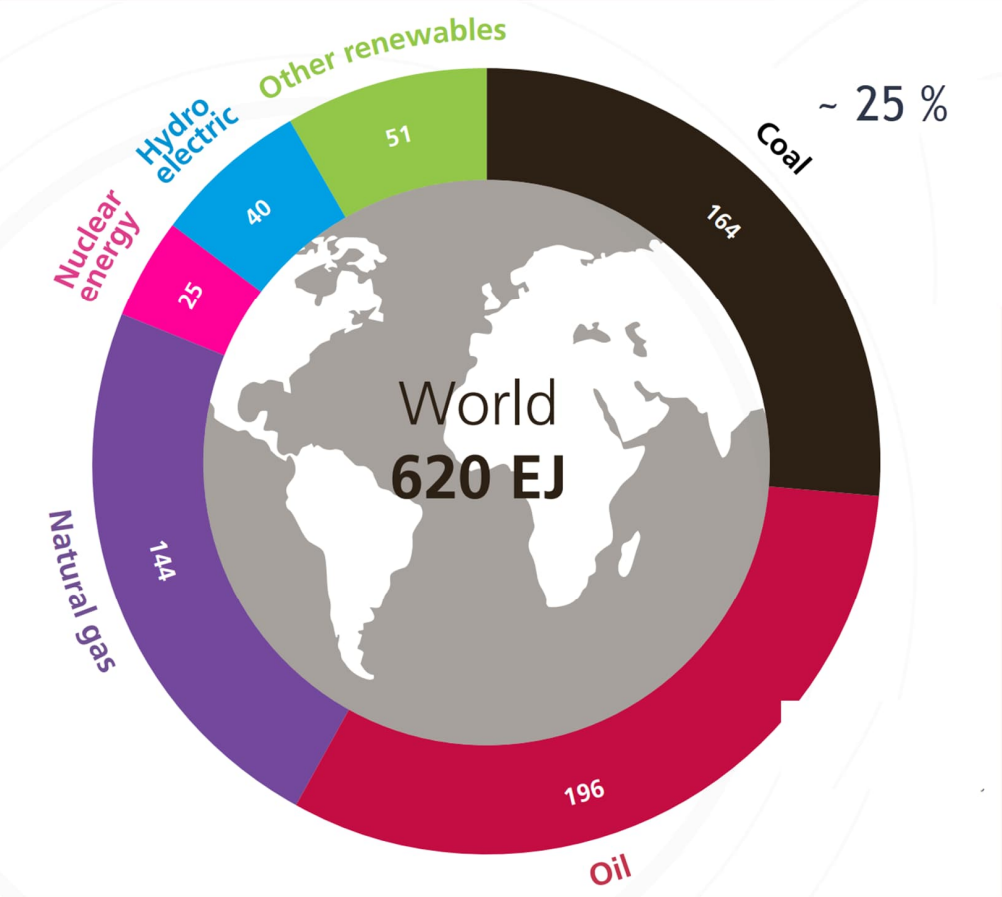
[WHC-Coal-Quality-Presentation-for-analysts.pptx.pdf]

COAL TRADE, Production & Exports

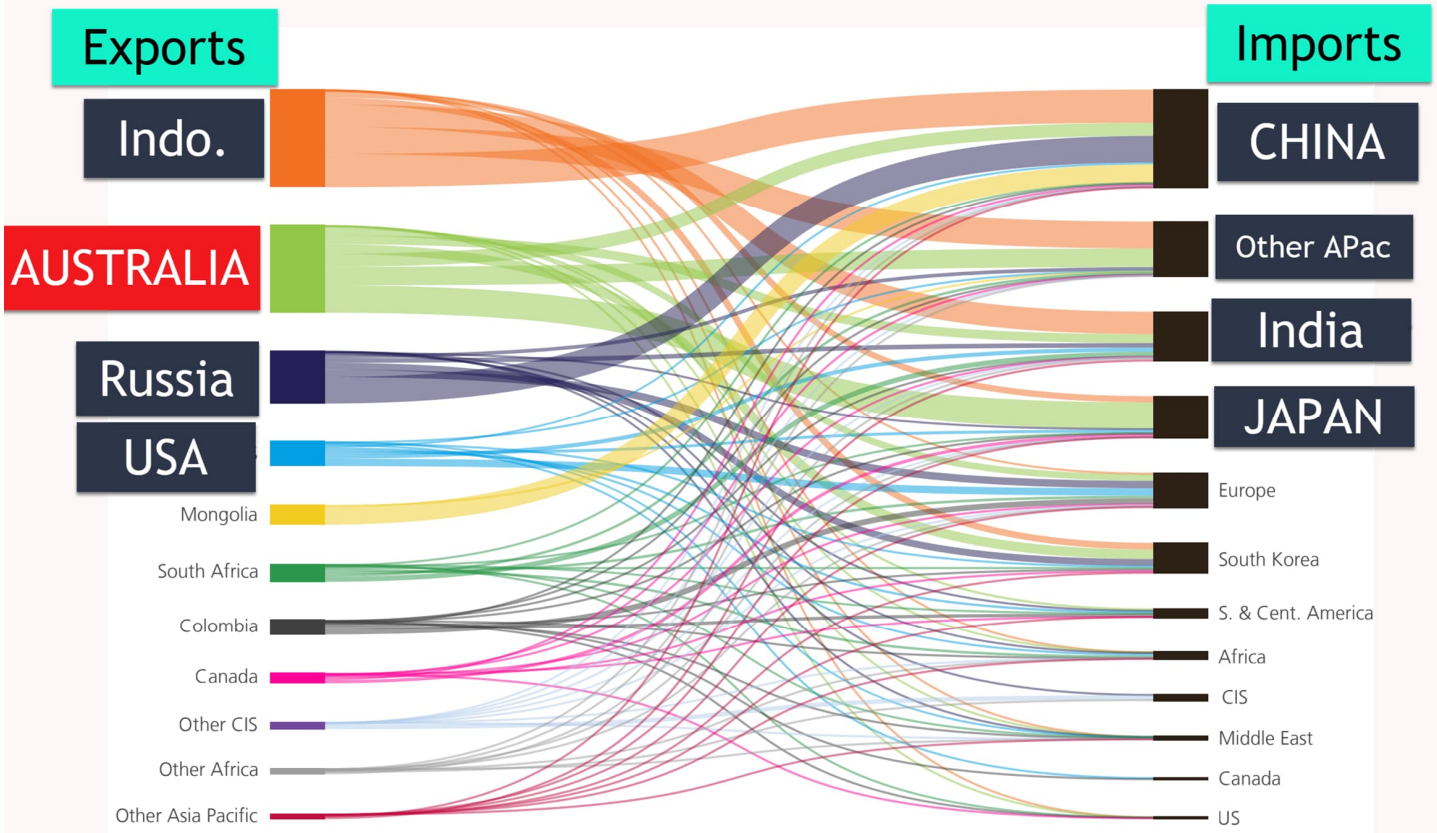
ENRGY production by region



Coal – contribution to global ENERGY consumption



ALL COAL – traded (tonnes)



AUSTRALIAN PORT STATISTICS
AFY Year to Date as at August 2024

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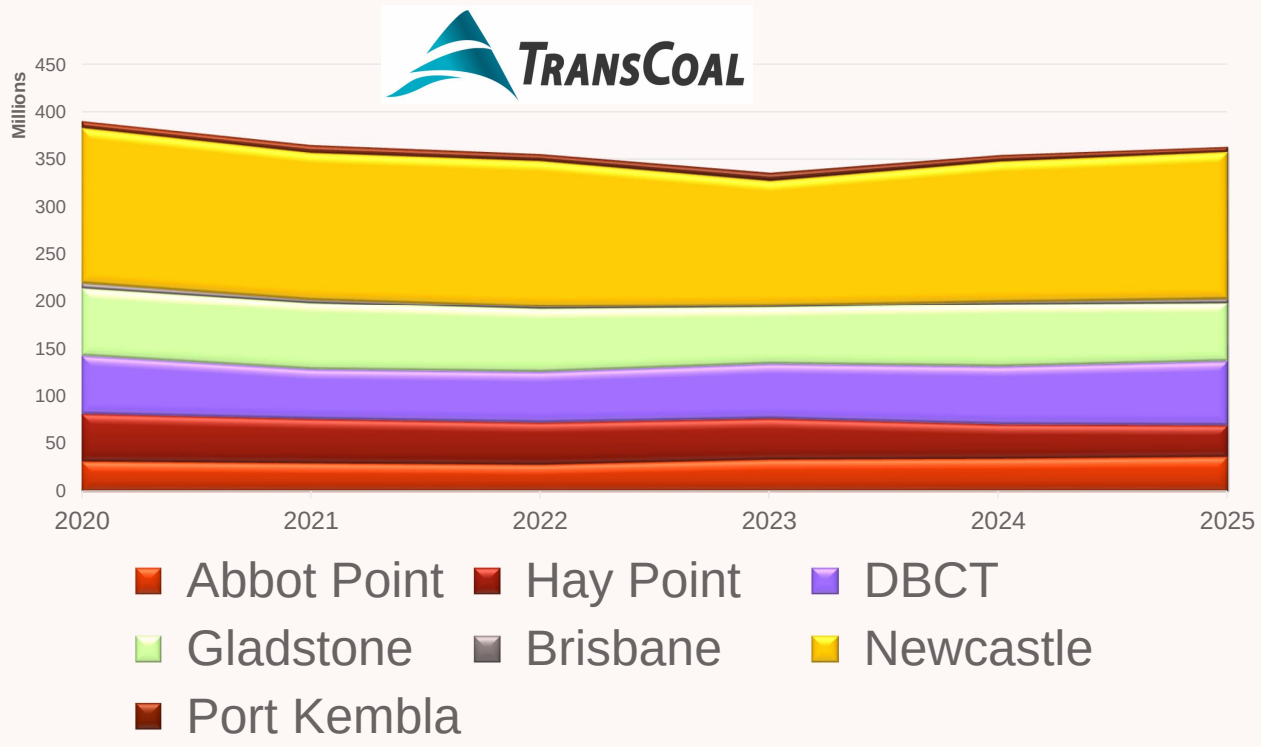

AUSTRALIAN PORT STATISTICS
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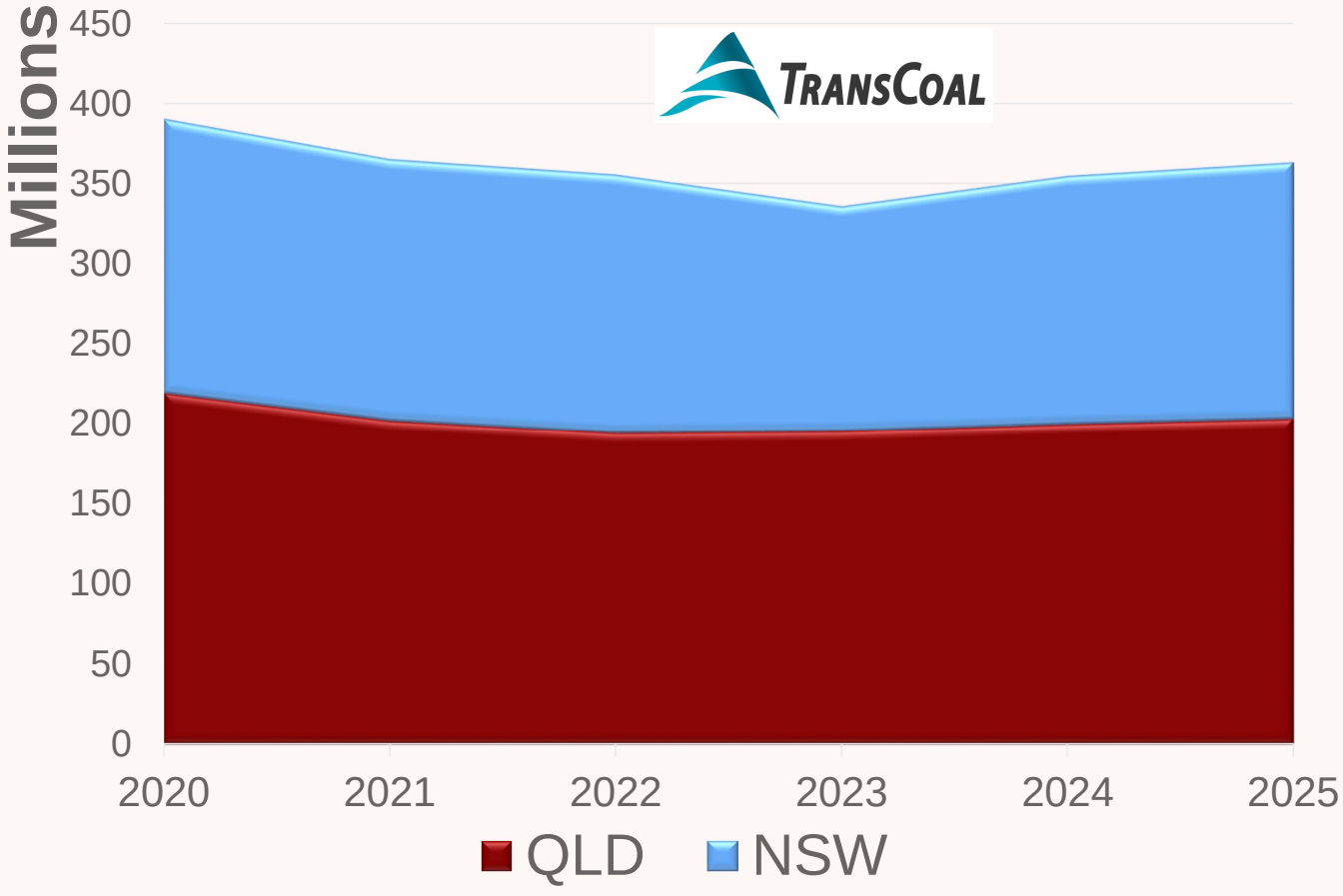
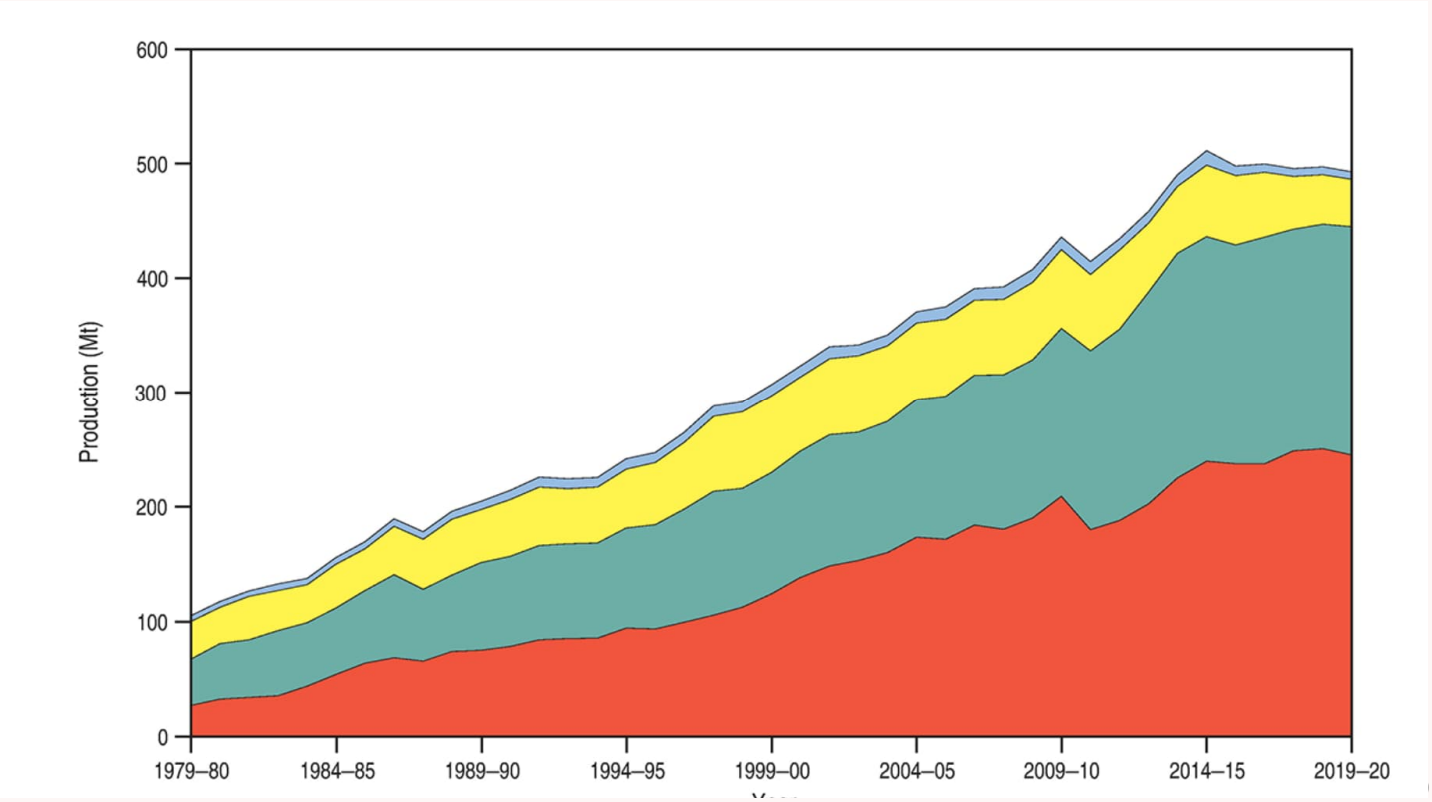


Australian coal production - 20 years to 2020 – includes brown coal



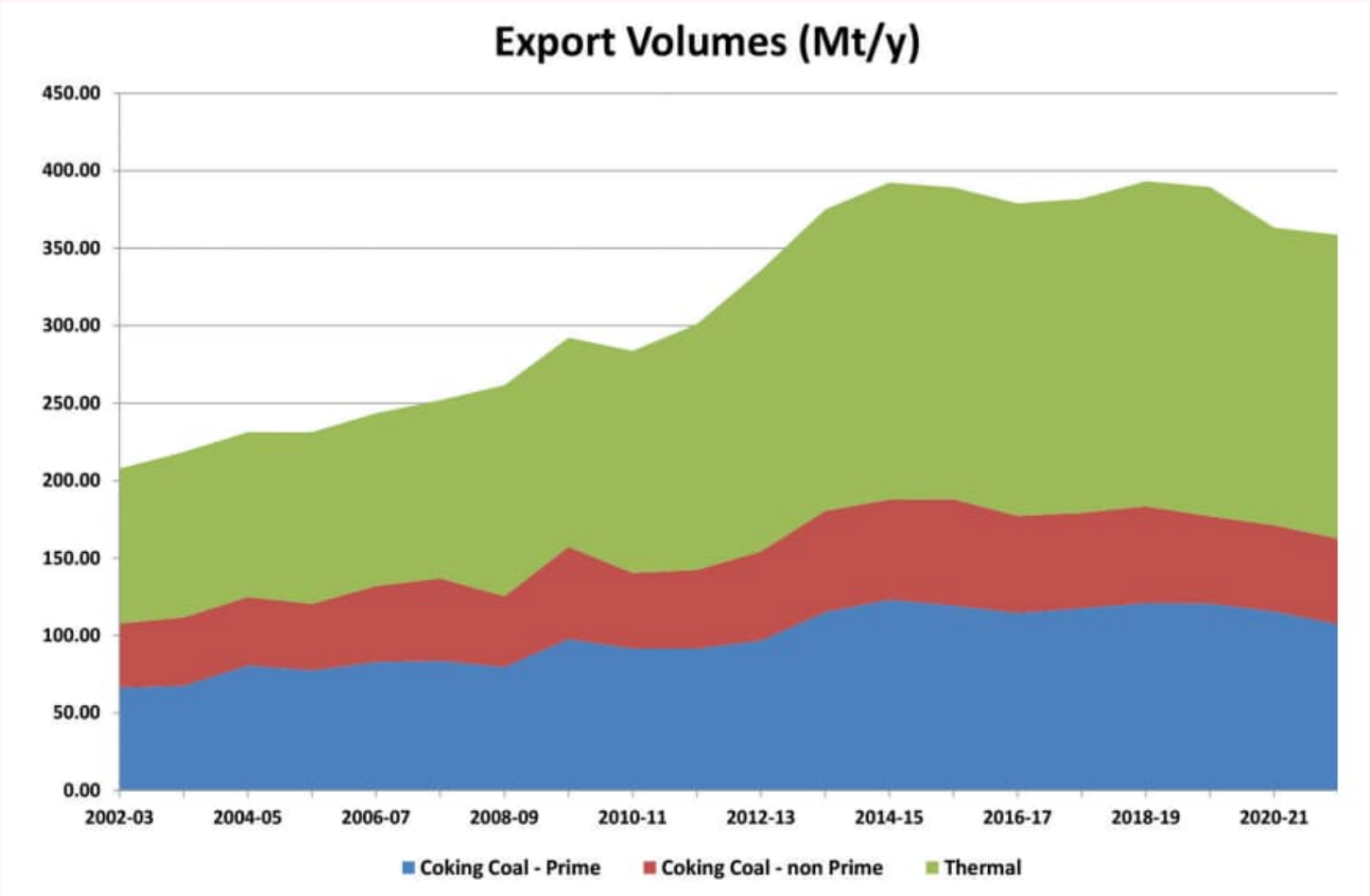
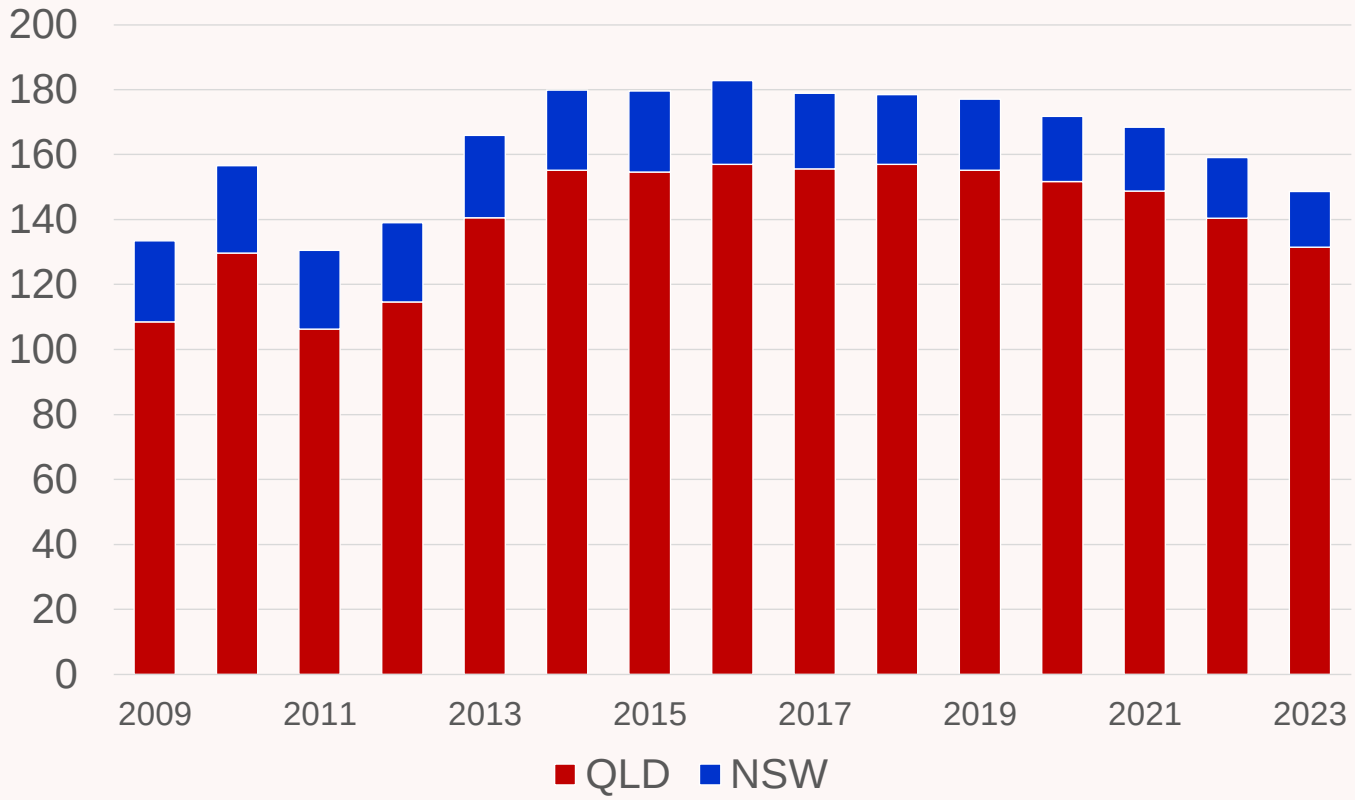


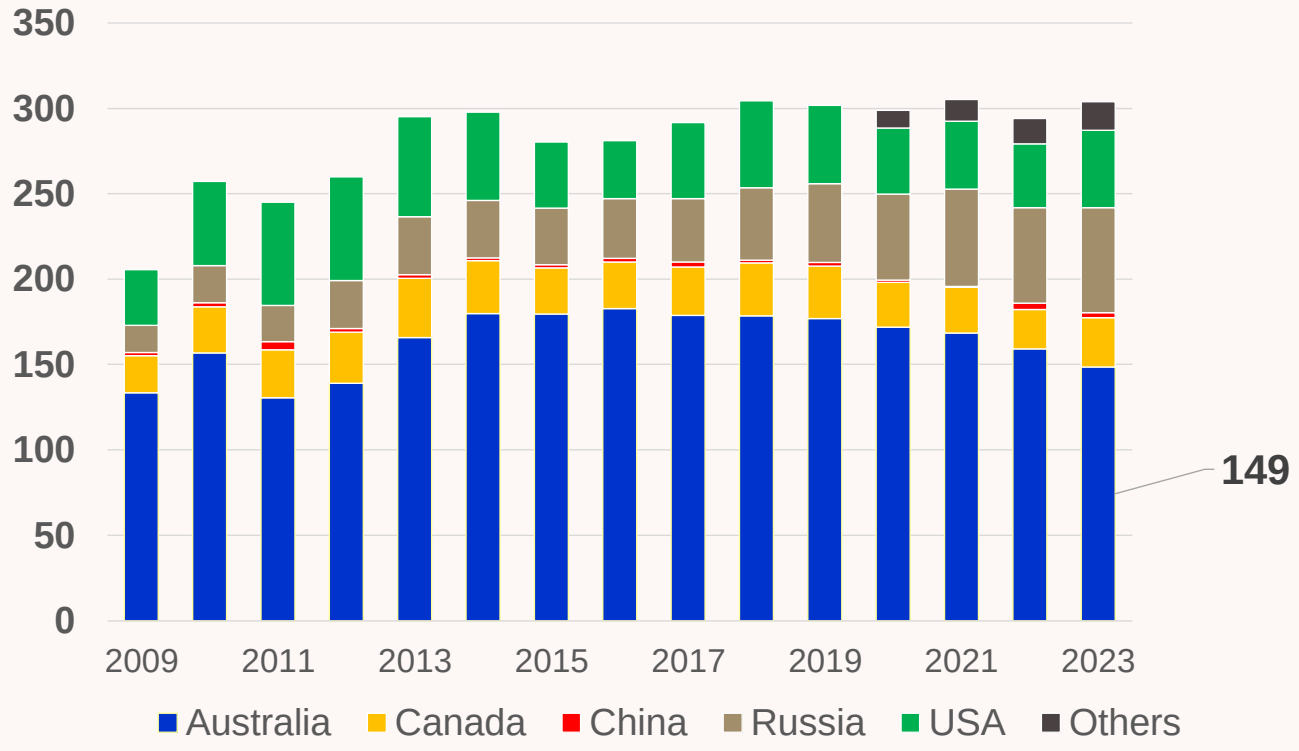
Figure 4: Export coal types

METALLURGICAL coal exports Australia – by state (Mt)



Source: **COMMODITY INSIGHTS**

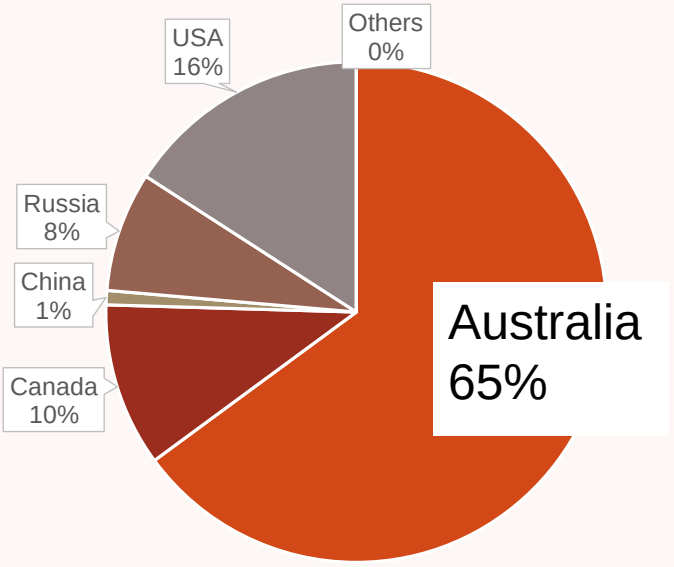
METALLURGICAL seaborne coal exports – by country (Mt)



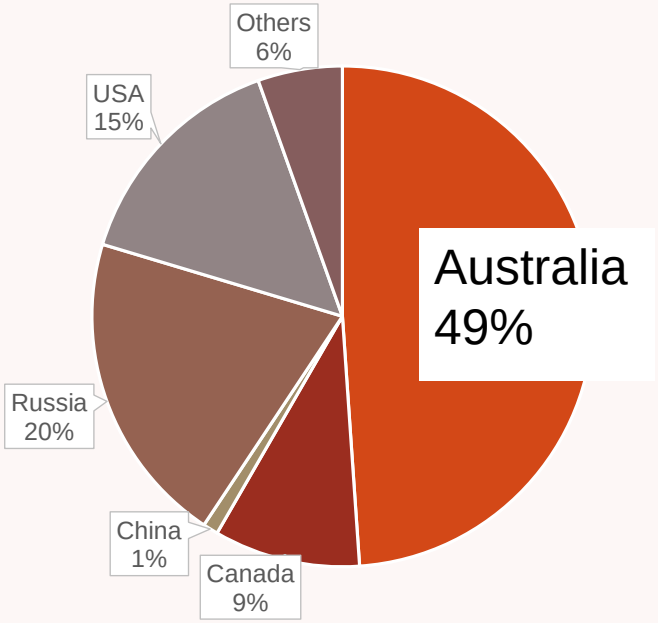
Source: **COMMODITY INSIGHTS**

AUSTRALIAN MET COAL MARKET SHARE HAS FALLEN

- 2009 Exports (Australia 133 Mt)



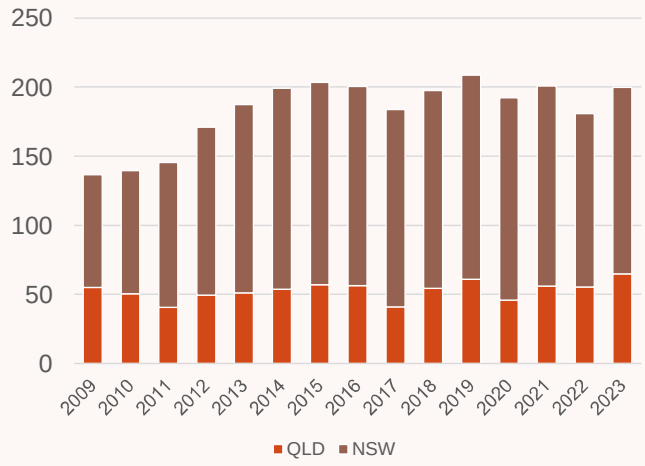
- 2023 Exports (Australia 149 Mt)



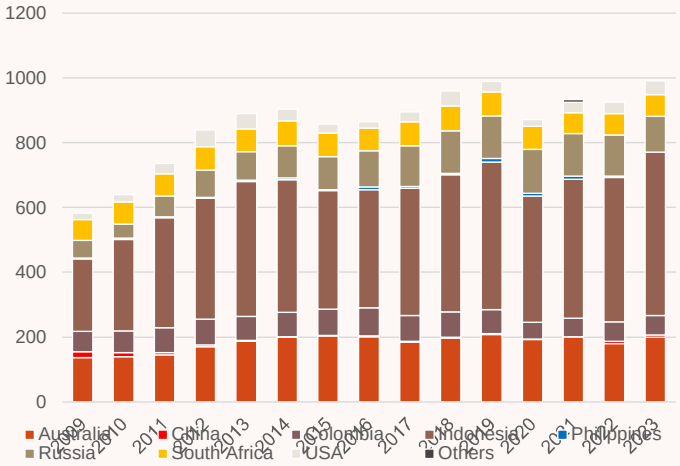
Source: **COMMODITY INSIGHTS**

GLOBAL **THERMAL** COAL EXPORTS HAVE RISEN OVER 65% SINCE 2009

- Australian Thermal Coal Exports (Mt)

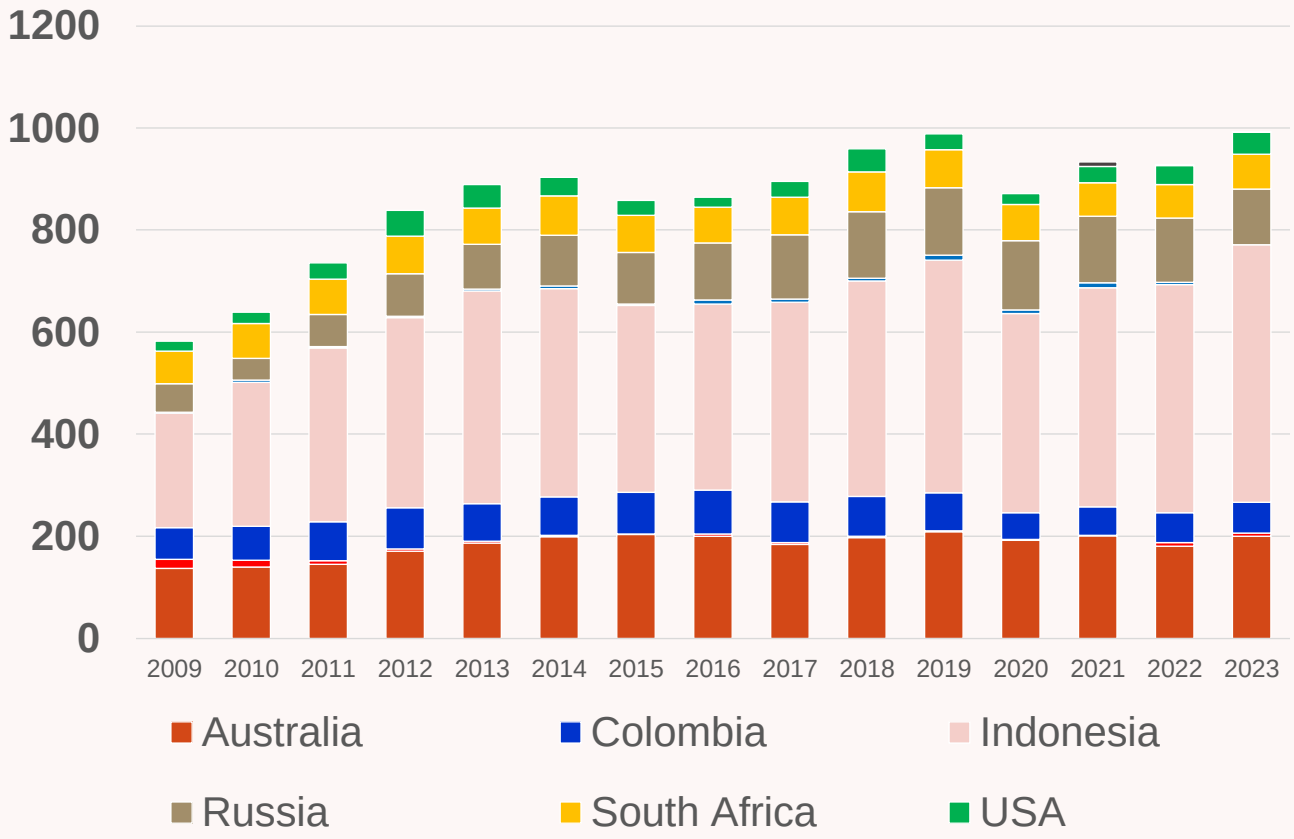


- Seaborne Thermal Coal Exports (Mt)



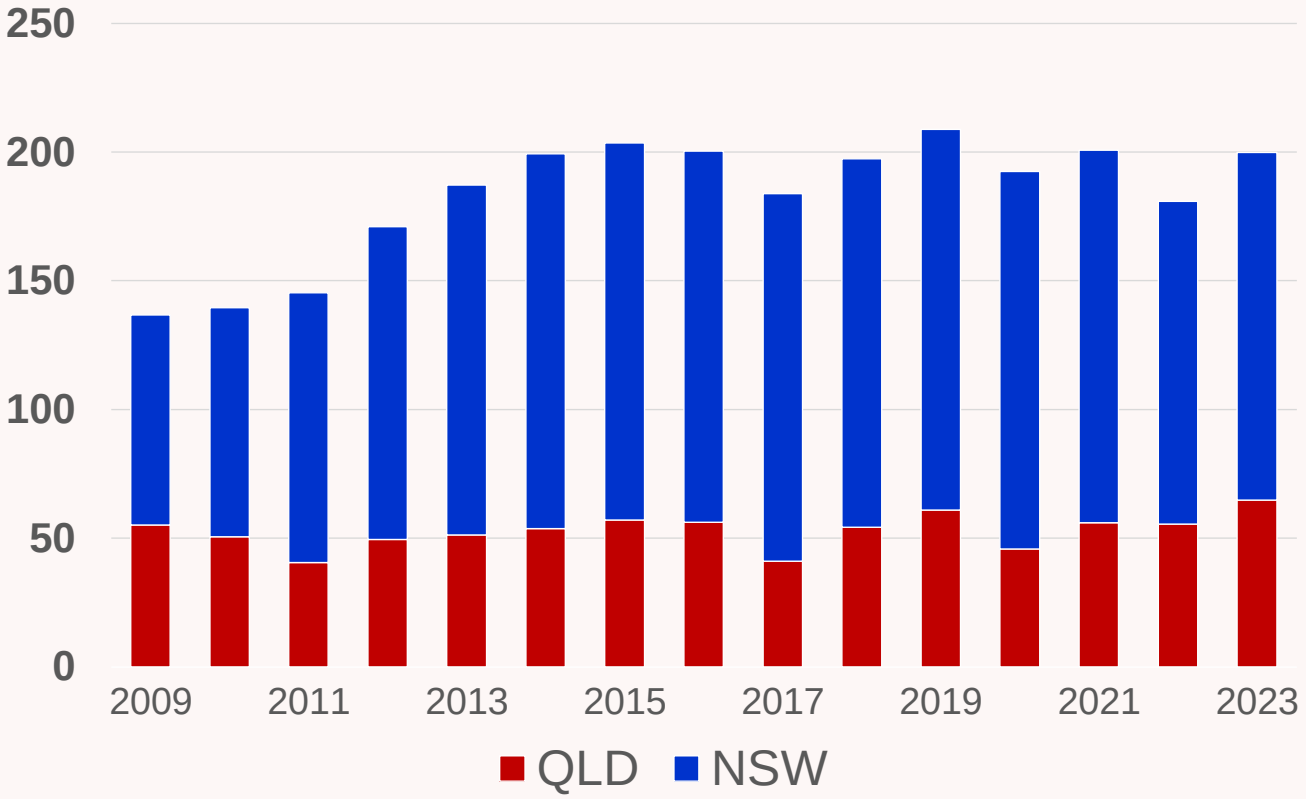
Source: **COMMODITY INSIGHTS**

World **Thermal** Coal Exports (Mt)



Source: **COMMODITY INSIGHTS**

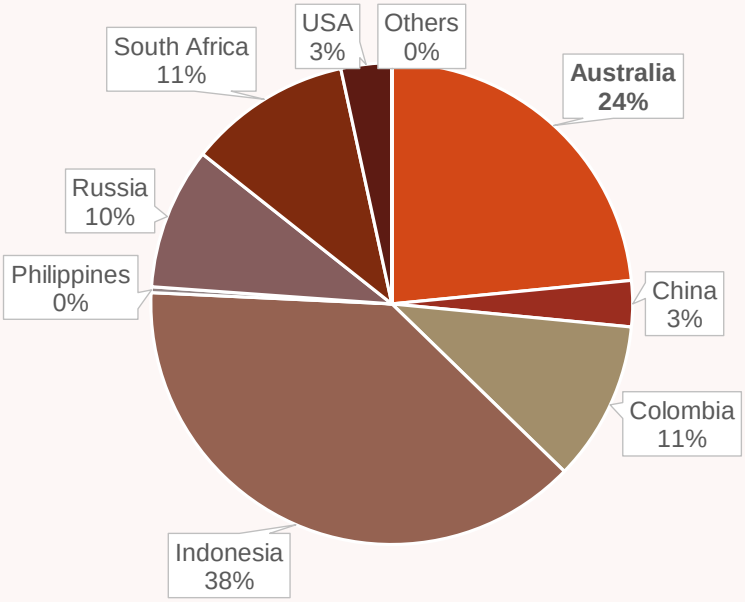
THERMAL COAL – Australian exports by state (Mt)



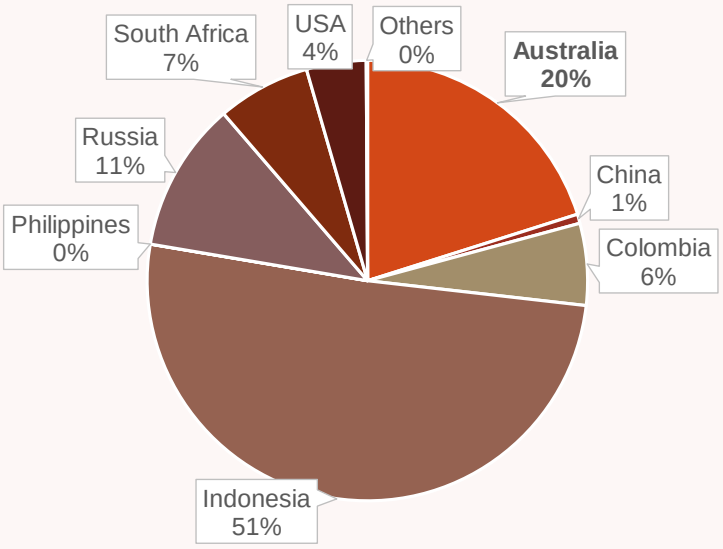
Source: **COMMODITY INSIGHTS**

THERMAL COAL - SEABORNE MARKET

- 2009 Exports (Australia 137 Mt)



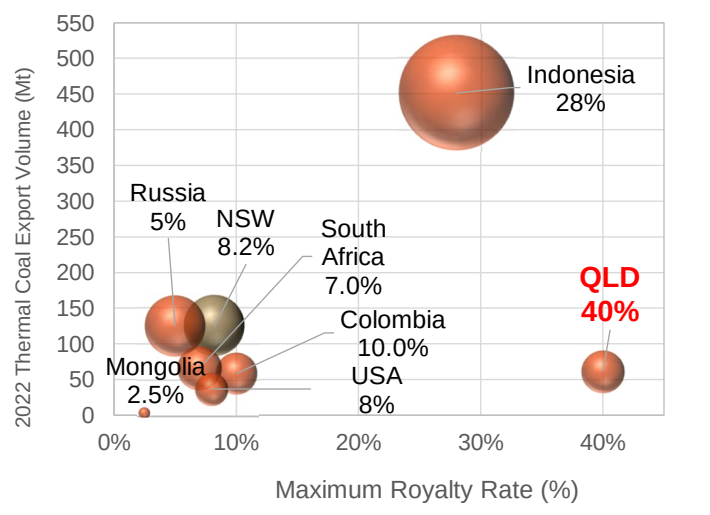
- 2023 Exports (Australia 200 Mt)



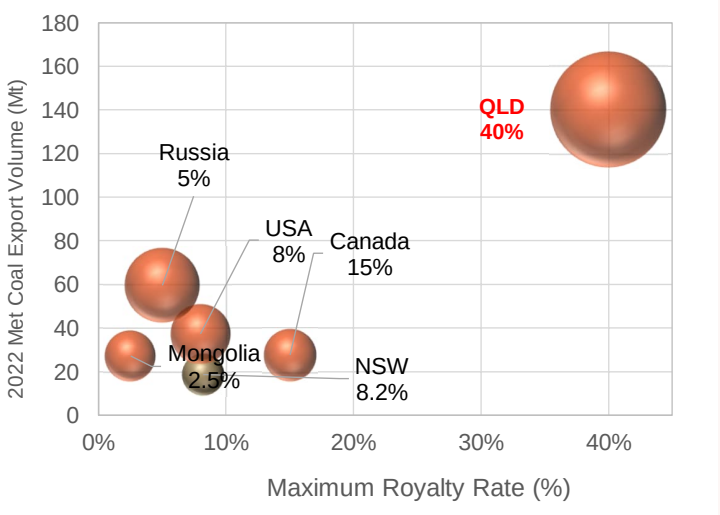
Source: **COMMODITY INSIGHTS**

COAL **ROYALTY** RATES ACROSS ALL MAJOR JURISDICTIONS SHOW QLD AS A DISTINCT OUTLIER

- **Thermal Coal** Jurisdictions



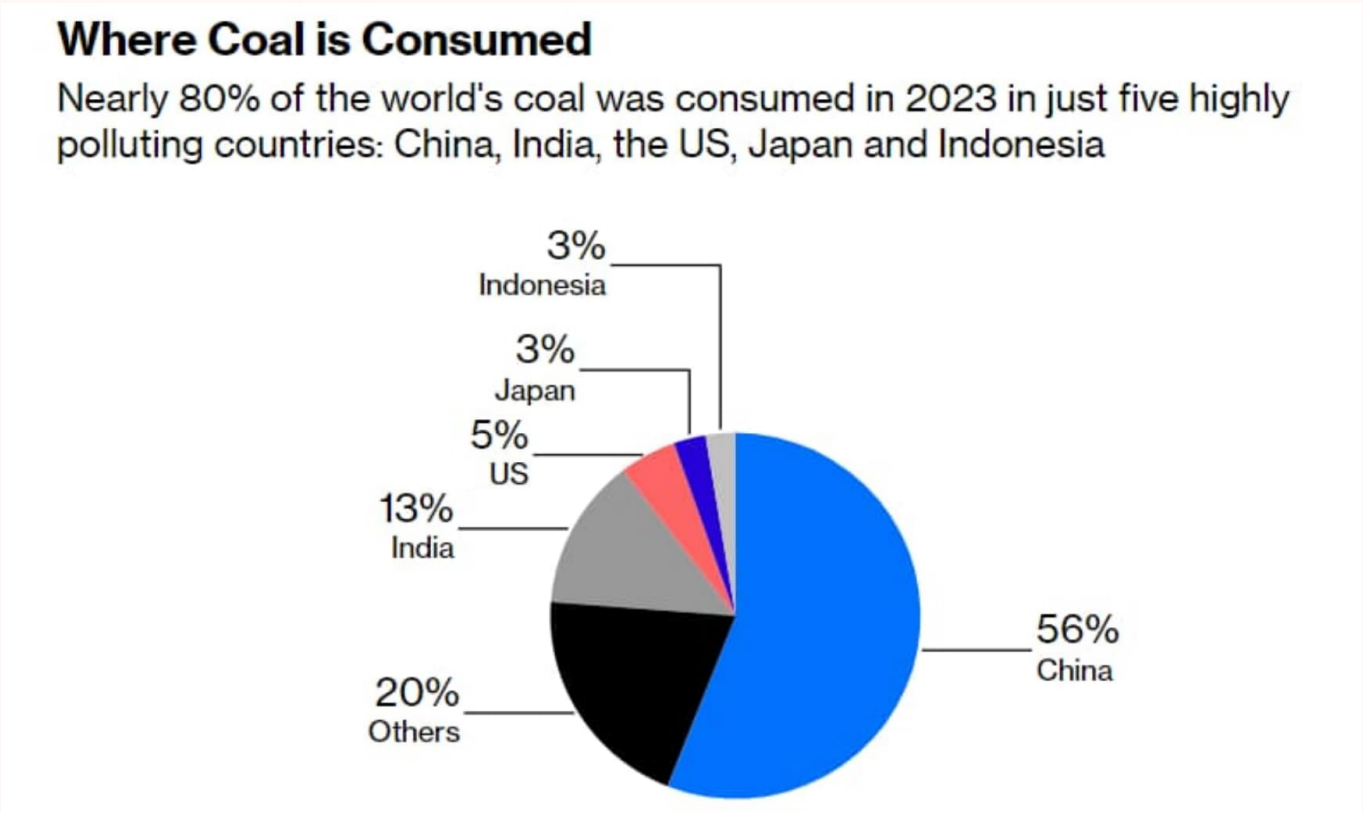
- **Metallurgical Coal** Jurisdictions



Source: **COMMODITY INSIGHTS**

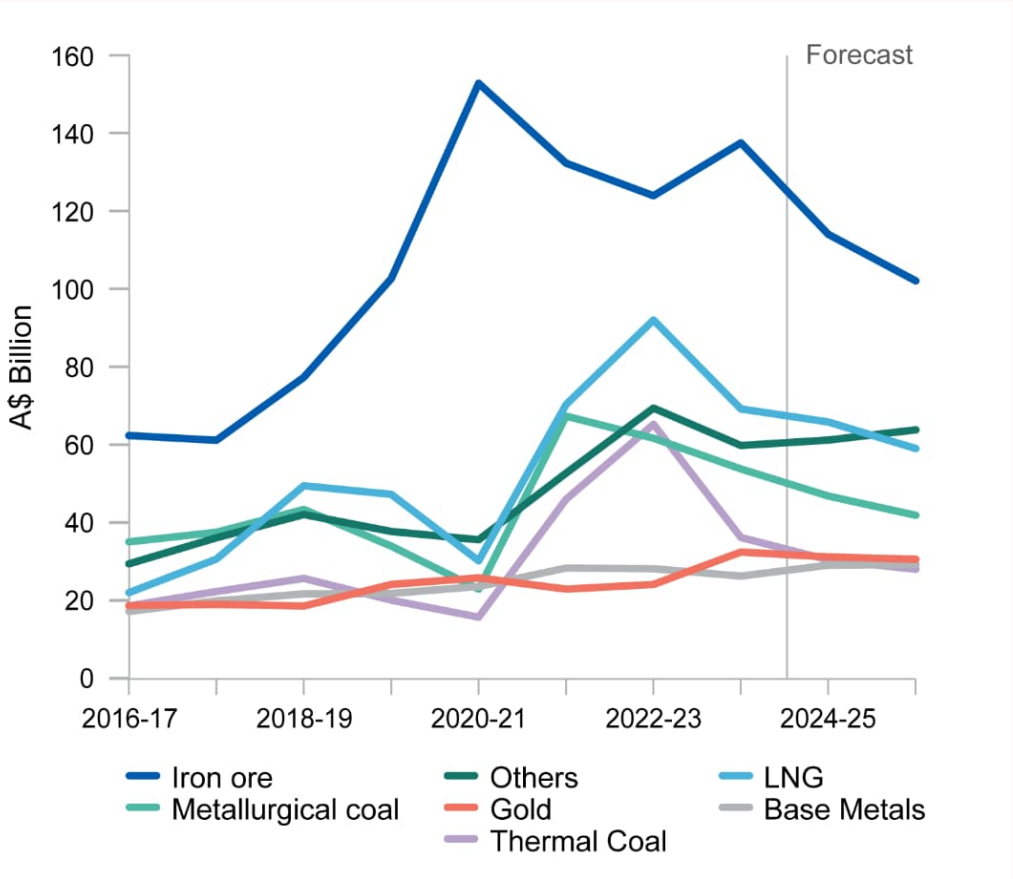
*Size of bubble represents export volumes.

Global coal consumption



Source: THE UNPOPULAR TRUTH

Australia – export income A$billion

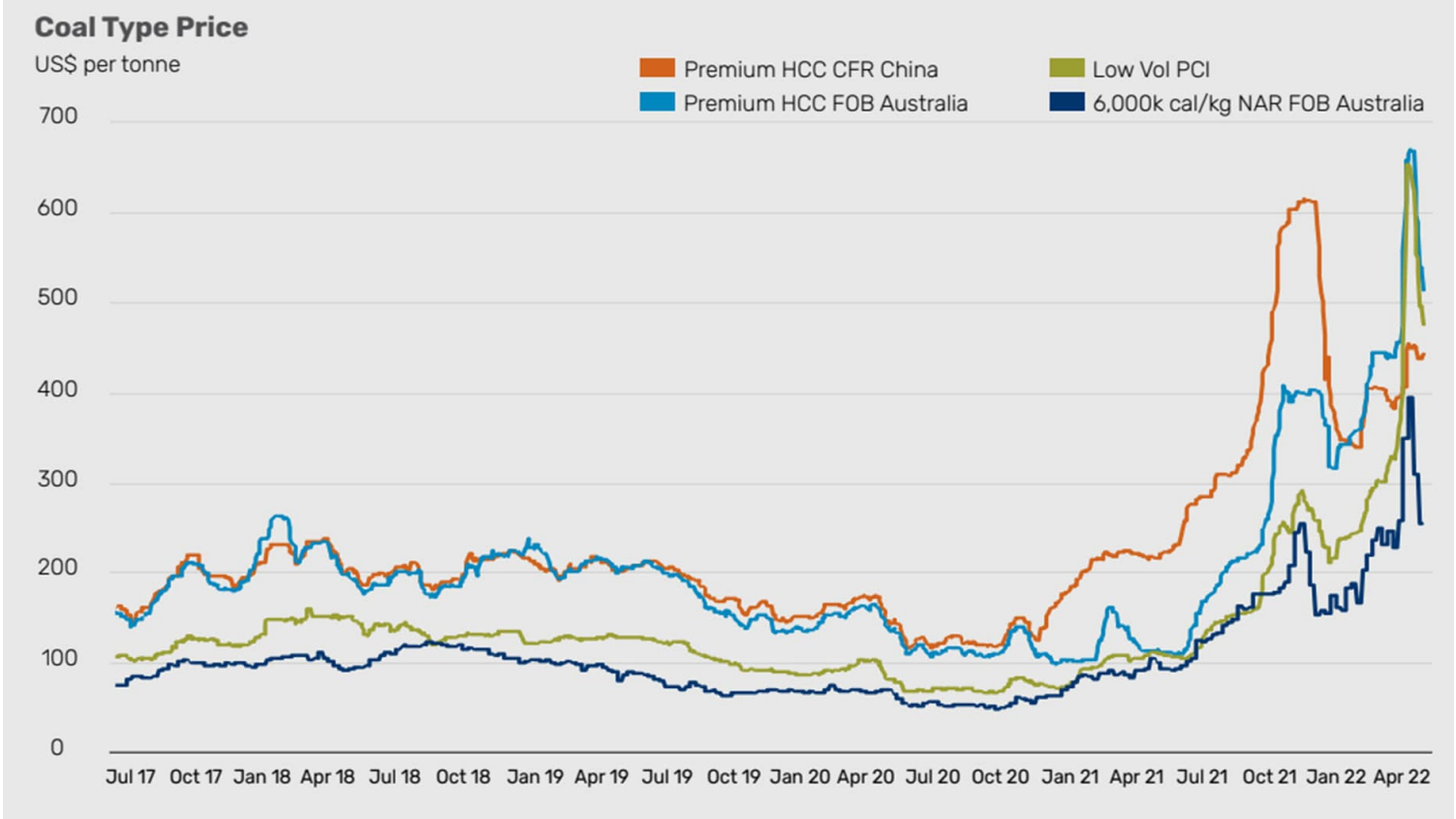


When Met coal and thermal are combined …

Coal is No 2 behind Iron ORE

COAL PRICING

Out of the doldrums



Causes of met coal price swings

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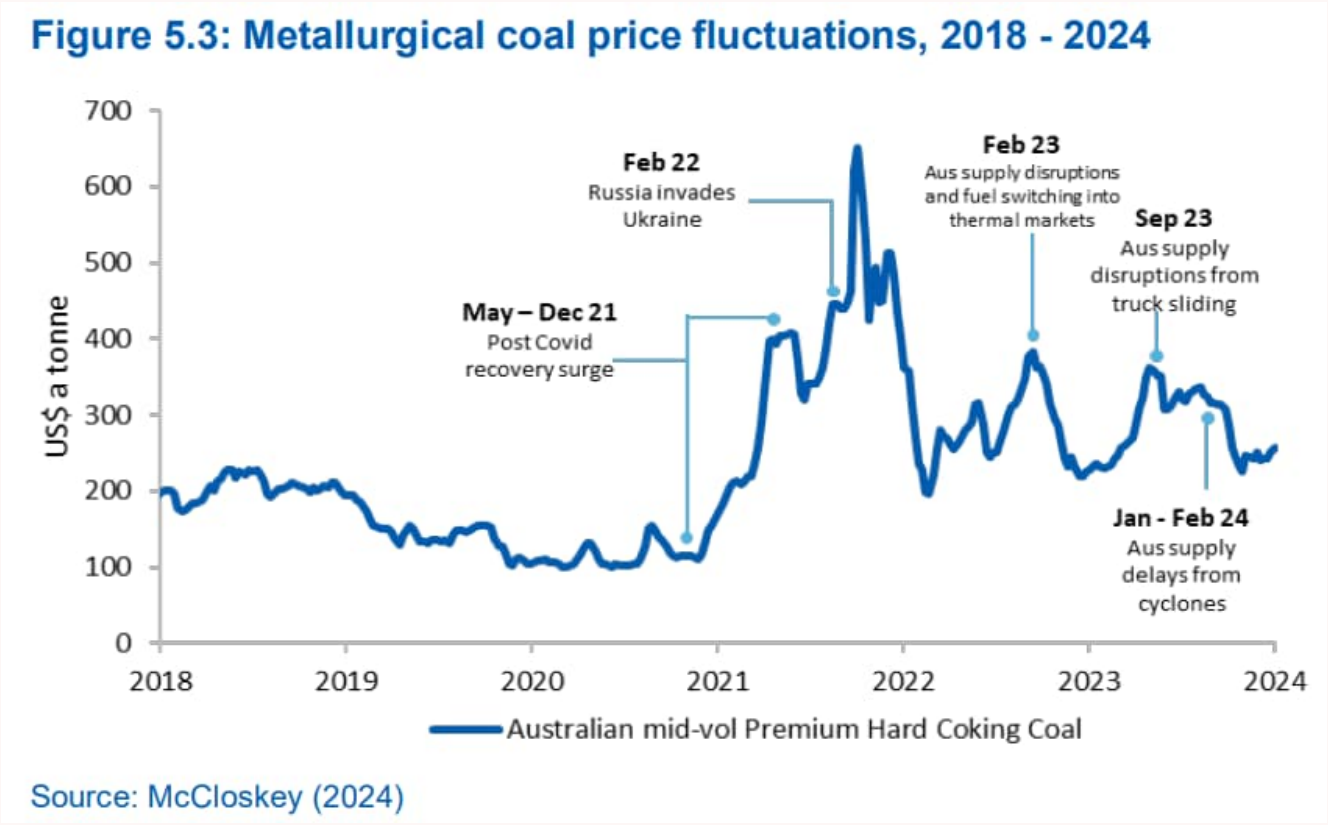

Prices – 3 main coal coal categories

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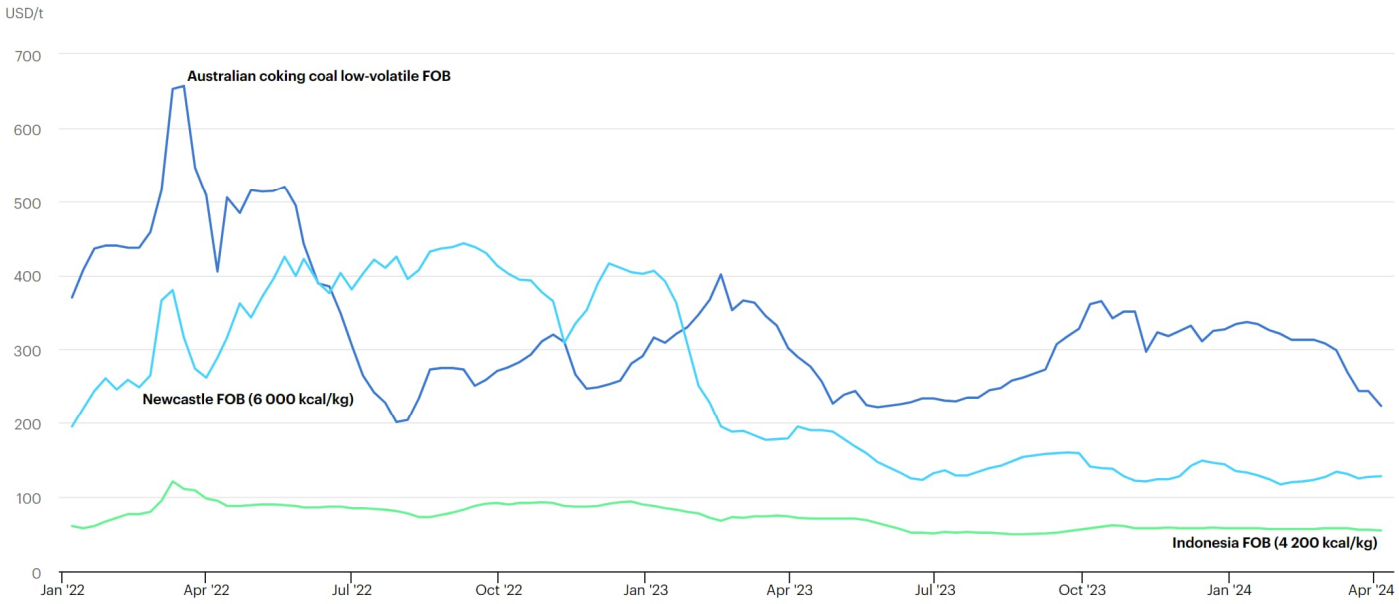

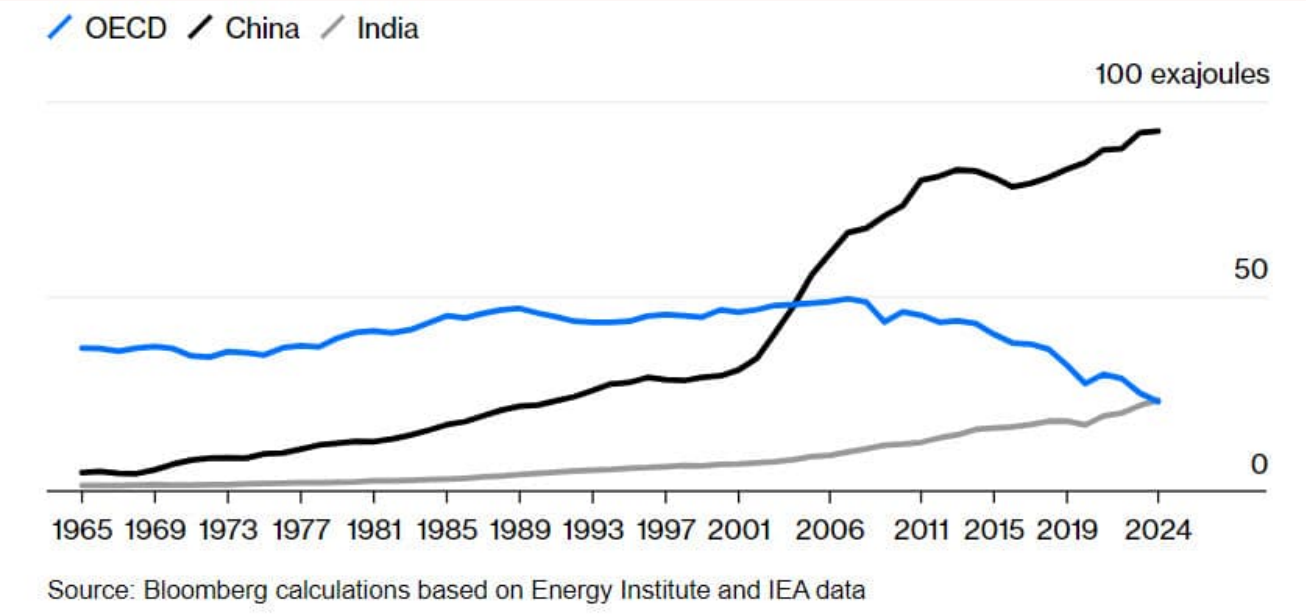

Source: Bloomberg calculations based on Energy Institute and IEA data

Iron making – without coal - example

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DRI Processes - Midrex

Shaft Furnace. Gas Reformer and Gas Cooling

Lump or pellet form

Reducing gas (95% H_2 and CO)

Operated up to H_2/CO ratios of 0.47 to 4.0+

Carry out reduction above 900 °C

Gas rich in CO_2 and H_2O is reformed into CO/H2 via catalyst after cooling

Well established technology (up to 2.5 MT/y)

CleanCOAL
GHG
Net Zero

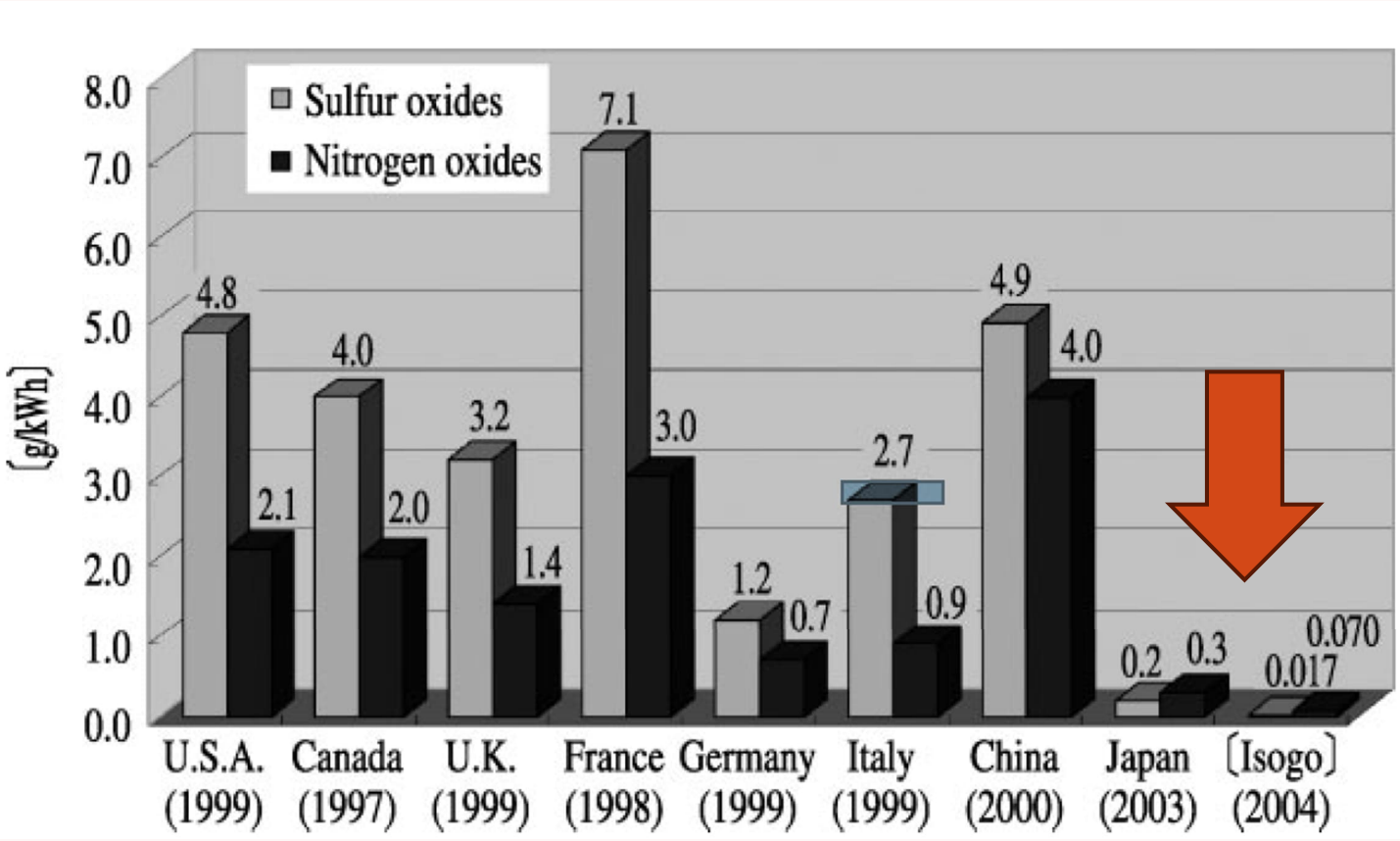
CLEAN COAL>>

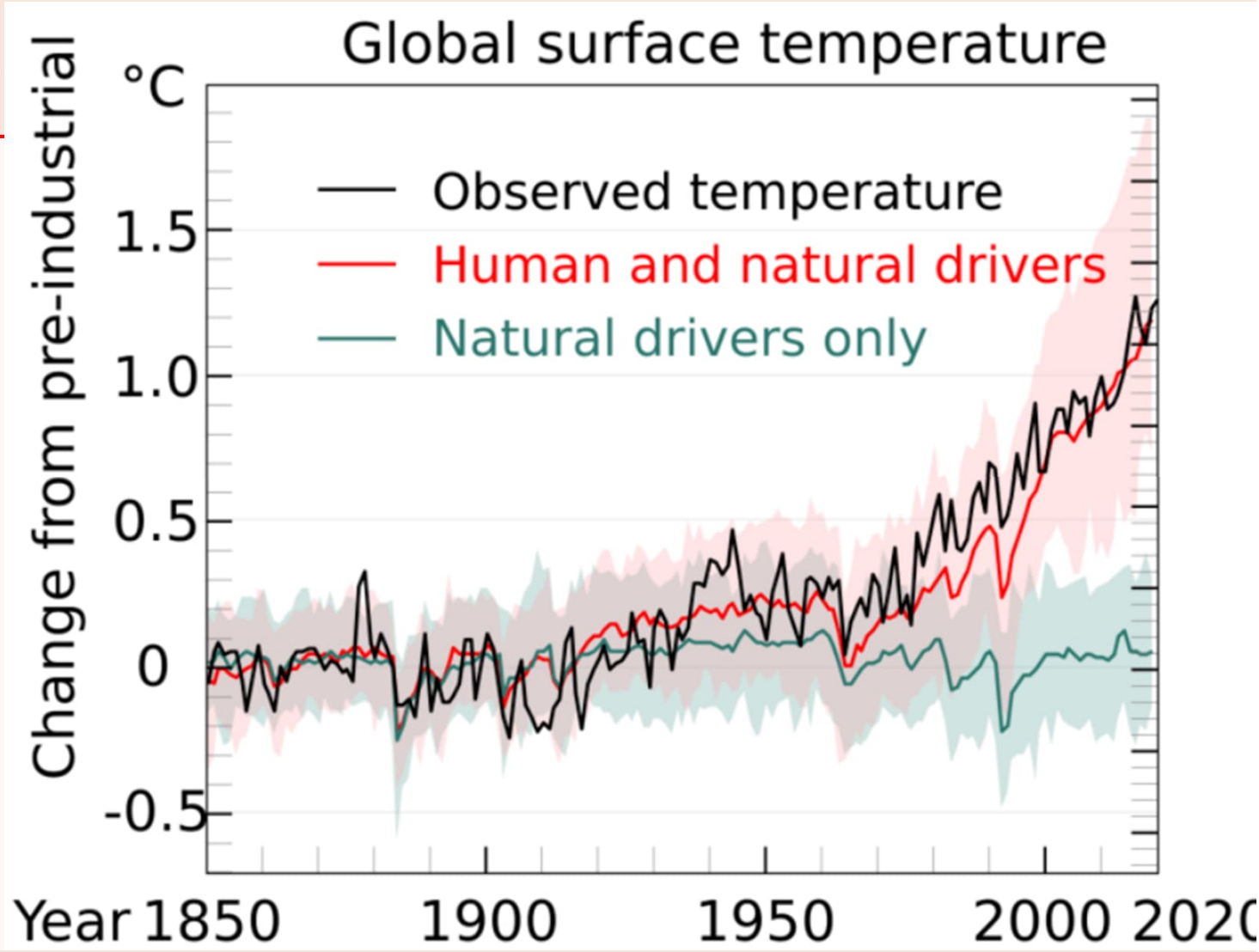
Along with increased coal usage, however, come concerns about the environment. System efficiencies must be improved; coal cannot be used as a "dirty" fuel. Emissions, including carbon dioxide, must be controlled. *Clean coal technology* is not an oxymoron, and using these technologies for efficient coal consumption in an environmentally acceptable manner must be ramped up immediately. This book provides significant information on all of the issues associated with clean coal technologies.

The technologies that used the most coal—combustion, gasification, liquefaction, and carbonization, which is the production of coke—either got their start during the 100-year-plus period of the Industrial Revolution/post–Industrial Revolution era or, in the case of coke production, they made major strides in technology devel-

1 Clean the skies

NO_X and SO_X





2. CO_2

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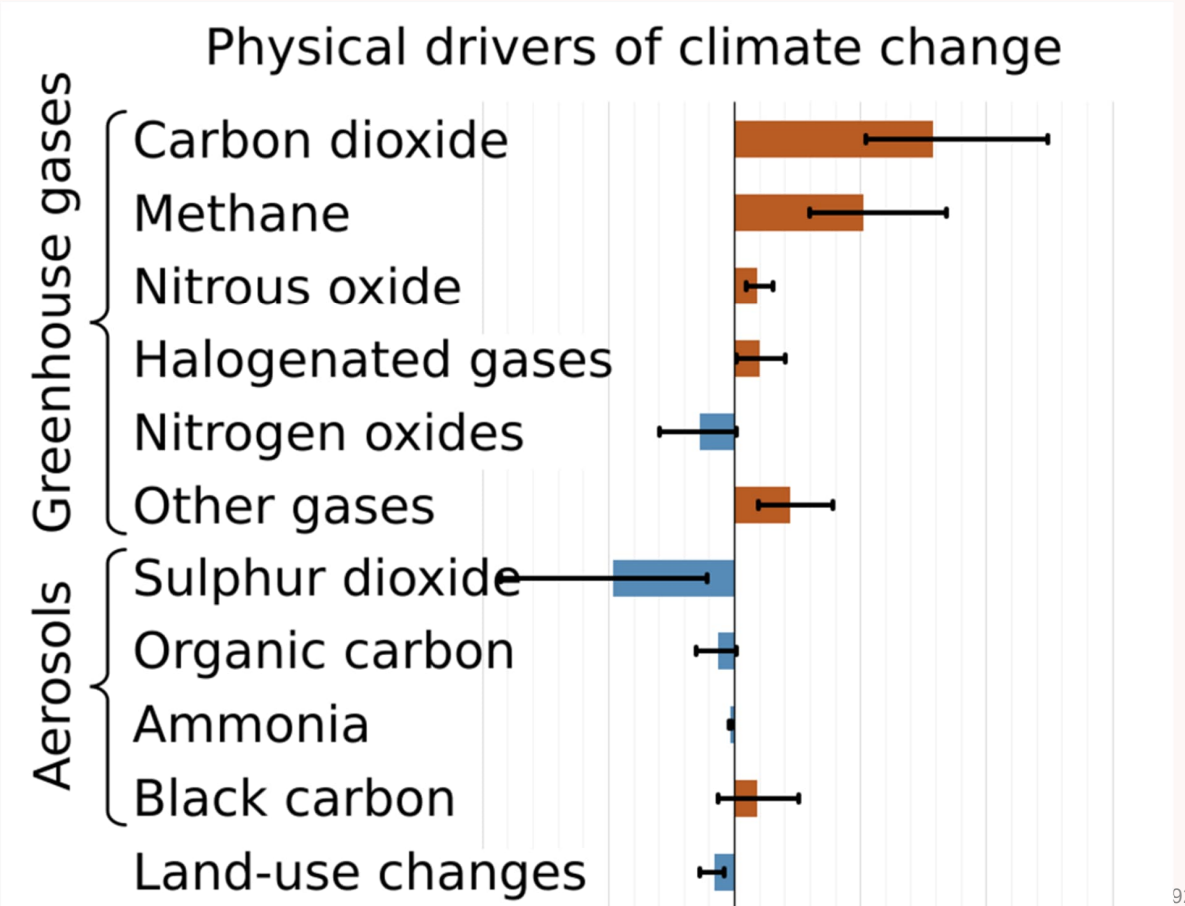

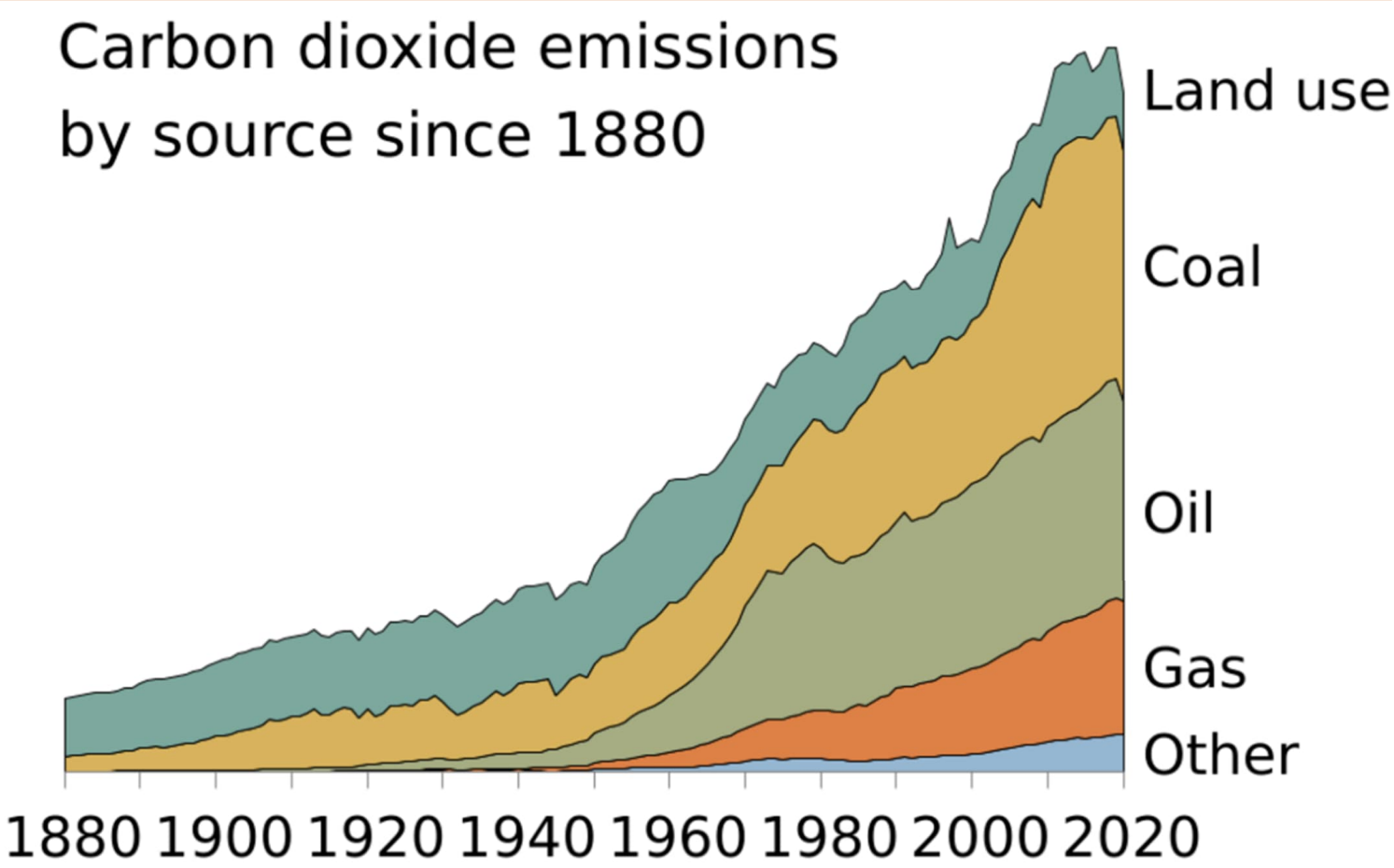

The maths are straightforward…

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1 kg Carbon → 3.7 kg CO_2

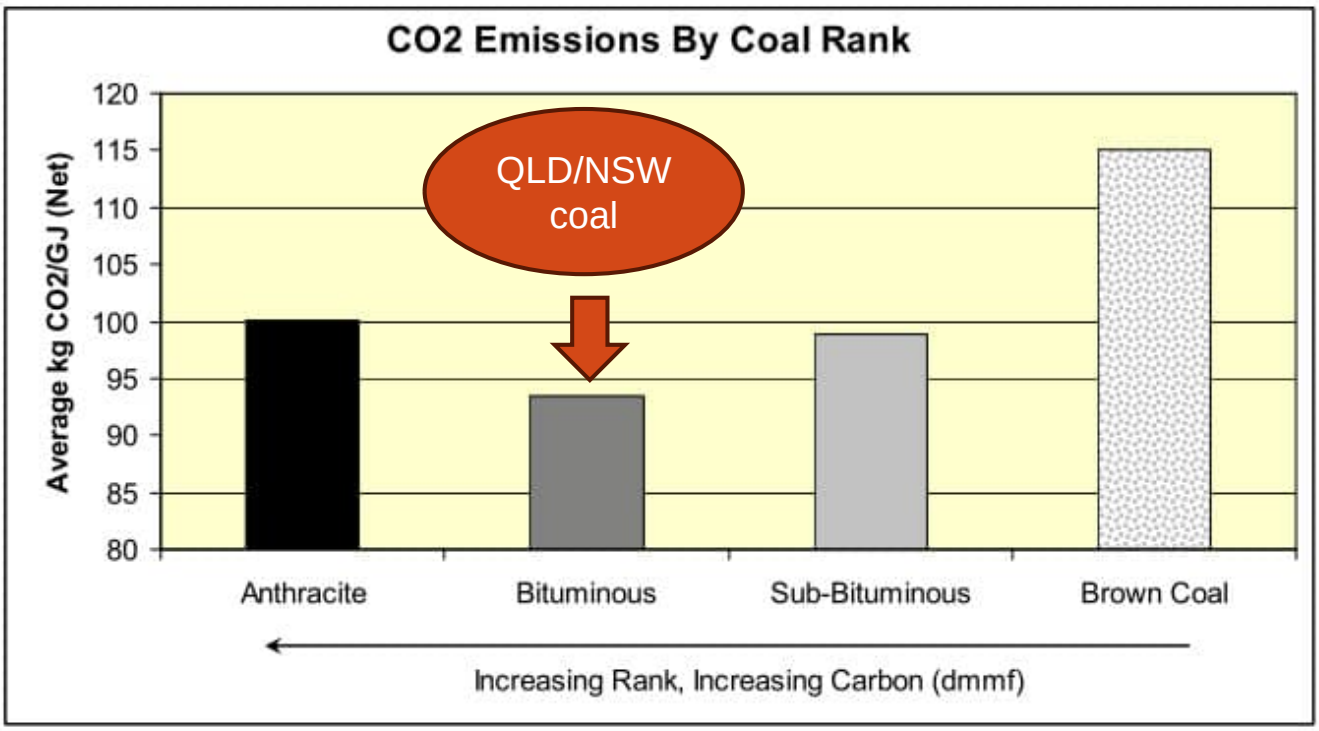
$C + O_2 \longrightarrow CO_2$
$2H + ½\ O_2 \longrightarrow H_2O$
$S + O_2 \longrightarrow SO_2$

Although carbon is by far the largest contributor to the energy produced, due to its overwhelming presence in the organic structure, hydrogen releases over four times more energy than the same mass of carbon. The approximate energy released for each of the above reactions is shown in the table below:

Element	Calorific Value (Approximate Contribution) MJ/kg
Carbon (C)	33.8
Hydrogen (H)	144.2
Sulfur (S)	9.4

Table 1 – Calorific Value, contribution from each element

CO_2 emissions per unit of energy



Pathway to net zero

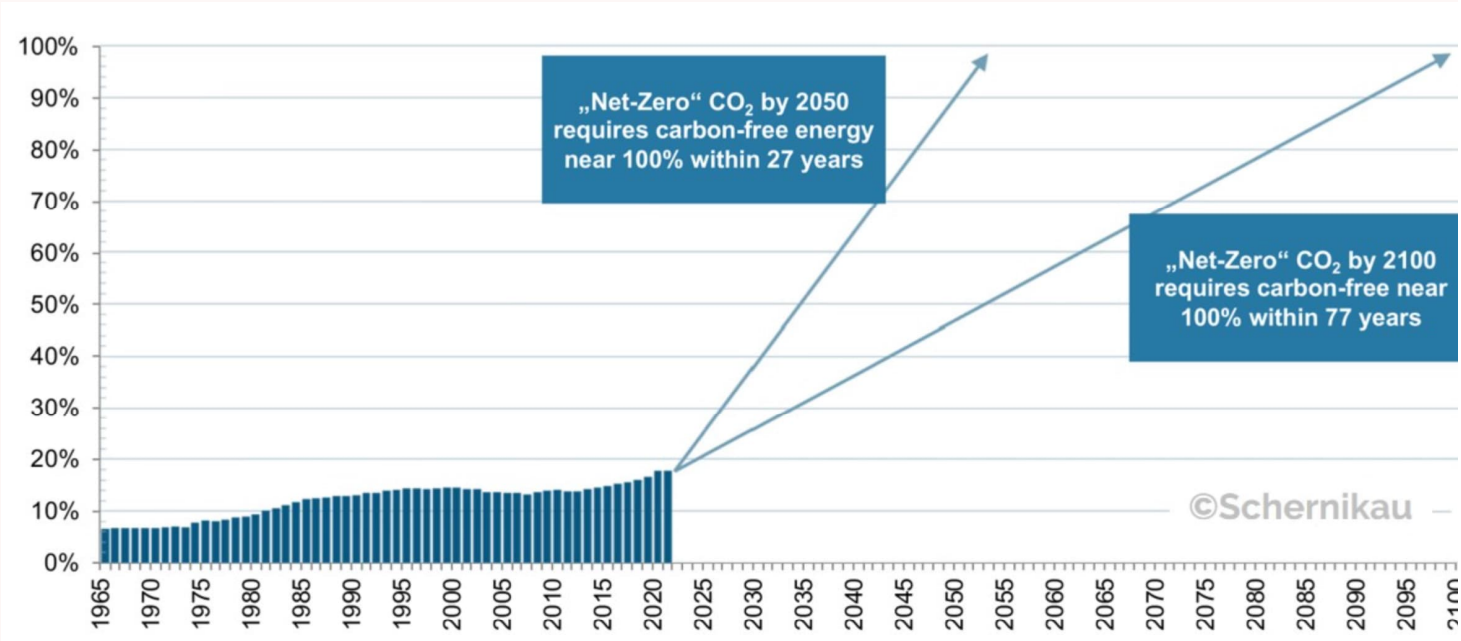


Figure 37: Global primary energy from "carbon-free" sources 1965-2100

Note: Percentage of "carbon-free" energy from wind, solar, hydro, biomass, geothermal, etc. as per BP.

Source: THE UNPOPULAR TRUTH

Global electricity by source

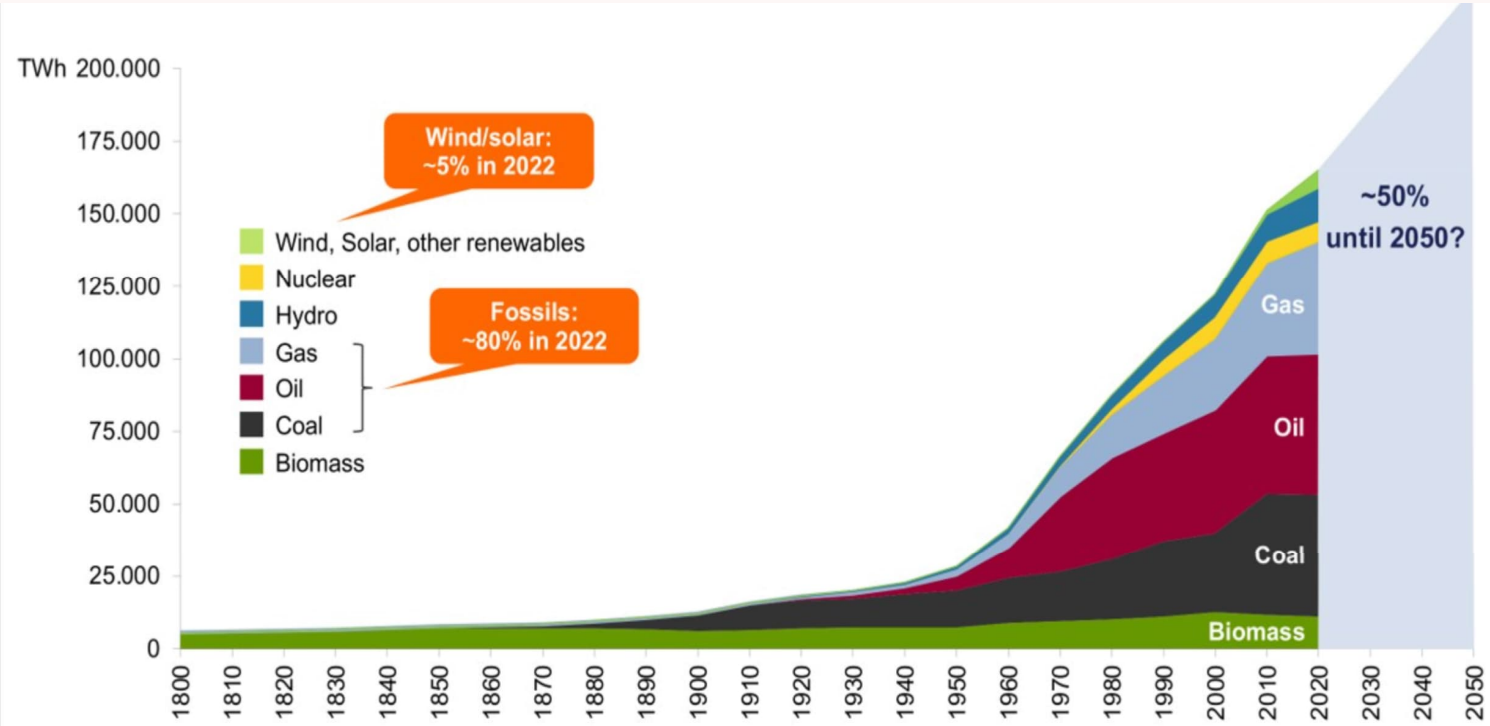
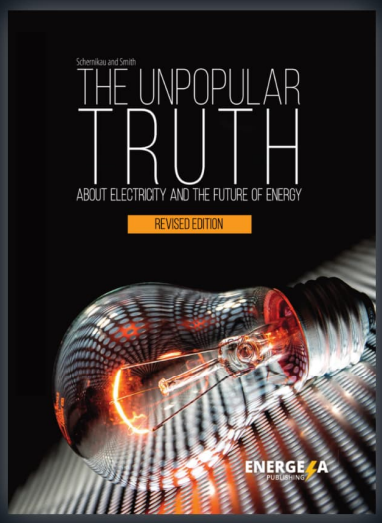


Figure 35: Global primary energy from 1800 to 2050

Source: THE UNPOPULAR TRUTH

Transition to Net Zero



REVISED EDITION OF

THE UNPOPULAR TRUTH

about Electricity and the Future of Energy

BRIDGING THE GAP…

UNCOVER THE SCIENCE OF ENERGY & EXPLORE THE TOUGH QUESTIONS

"Electricity is to modern civilization what blood is to the human body. "

But do we truly understand global energy?

READING SAMPLE

In this groundbreaking new book, The Unpopular Truth about Electricity…, the authors peel back the layers on the global energy economy with a focus on electricity.

What they reveal is startling.

Learn why energy shortages have swept across Europe. Discover whether renewable energy can save us, and which energy sources make the most sense?

Metals needed for green transition

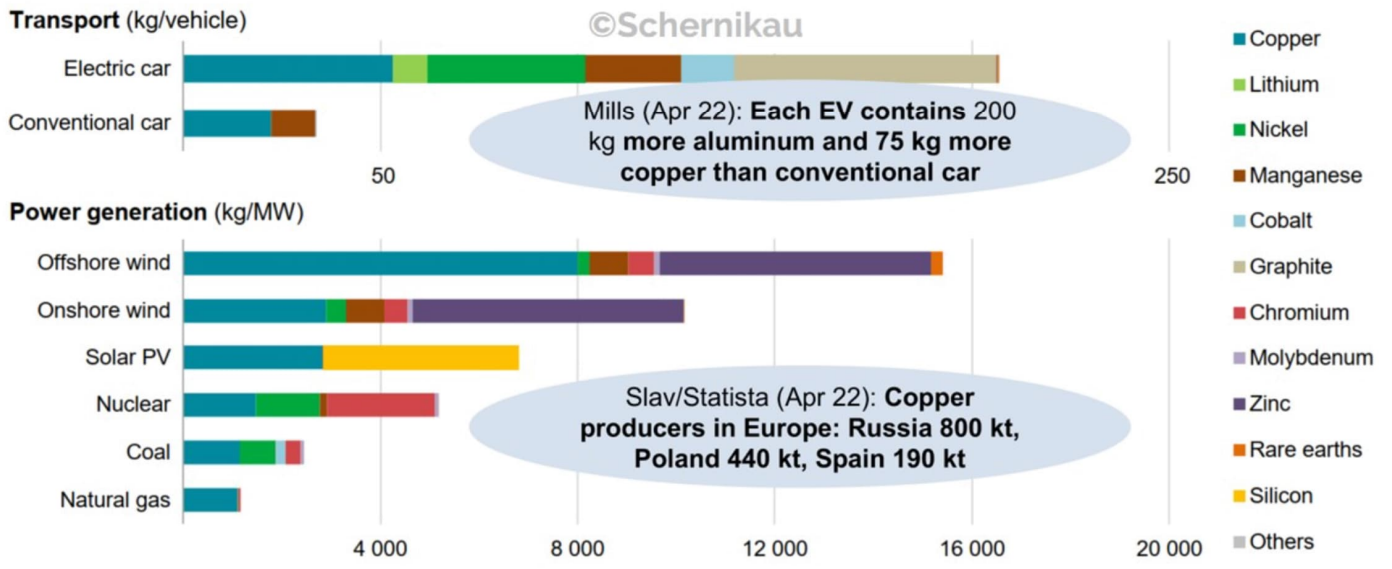
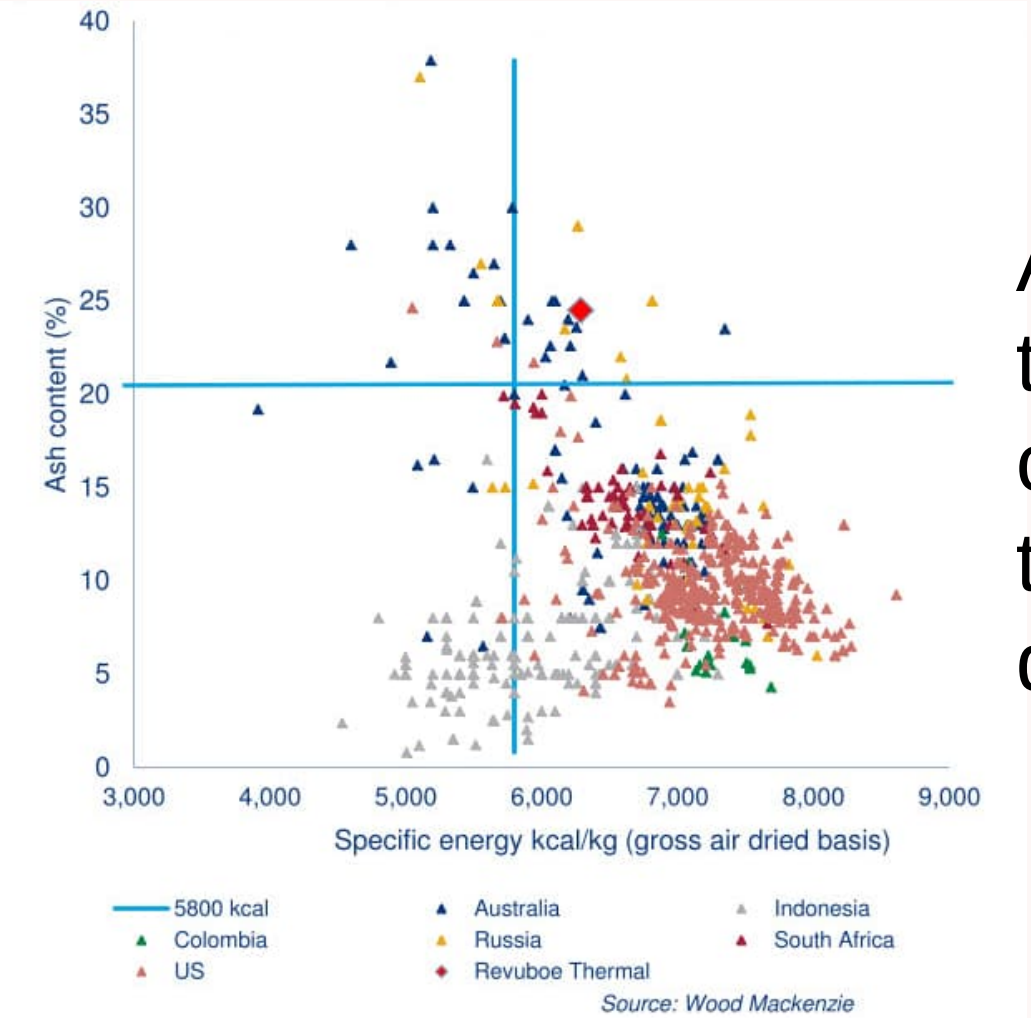


Figure 23: Comparing mineral needs for "renewable" technologies
Source: The Role of Critical Minerals in Clean Energy Transitions, IEA Minerals 2021, p6

Source: THE UNPOPULAR TRUTH

"CLEAN COAL" in environmental context



Australian thermal coals – in the right quadrant…

Australian coals are high in energy, low in sulphur

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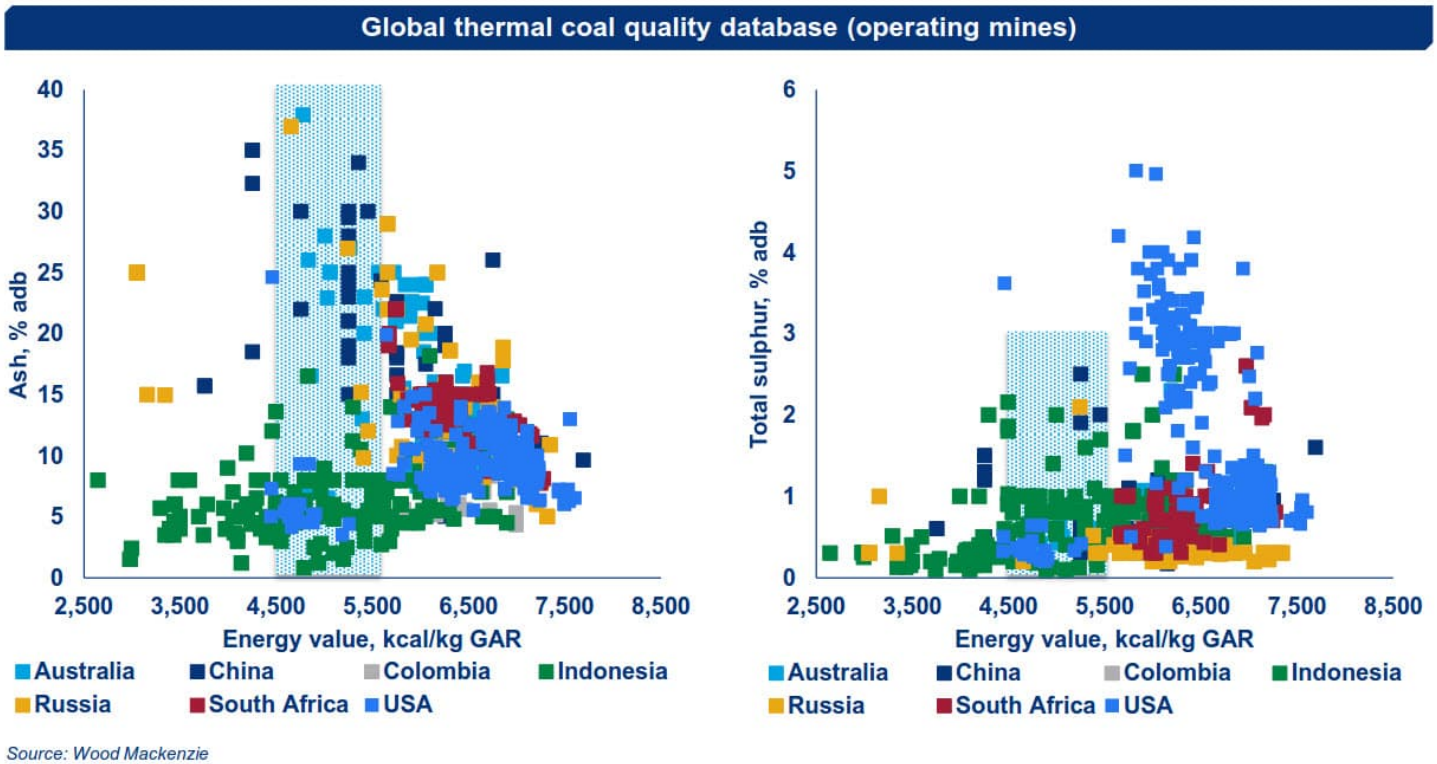
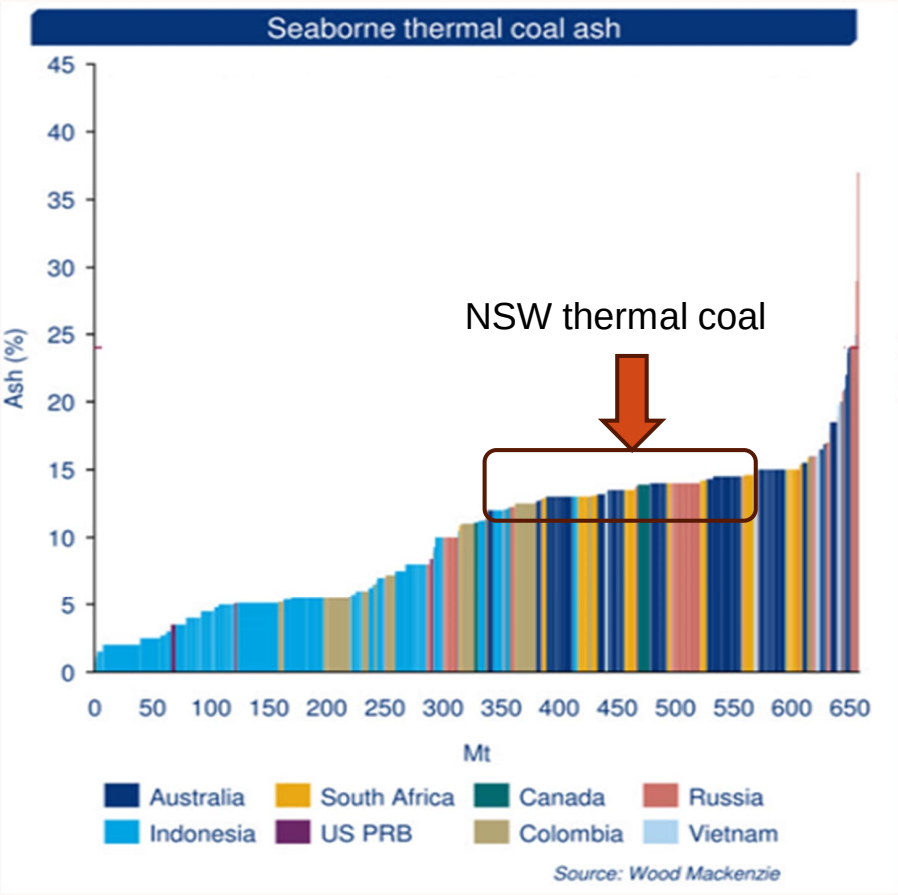


Australian thermal coal ash in perspective



Thermal coal power plants are designed for a range of coals – but cannot readily switch from NEWCASTLE thermal to INDONESIAN sub-bituminous coal

CARBON – and carbon dioxide

$$C + O_2 \longrightarrow CO_2$$
$$2H + \tfrac{1}{2} O_2 \longrightarrow H_2O$$
$$S + O_2 \longrightarrow SO_2$$

Although carbon is by far the largest contributor to the energy produced, due to its overwhelming presence in the organic structure, hydrogen releases over four times more energy than the same mass of carbon. The approximate energy released for each of the above reactions is shown in the table below:

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Sulfur (S)	9.4

Table 1 – Calorific Value, contribution from each element

1 kg Carbon → 3.7 kg CO_2

Emissions are RANK dependant (C + Energy)

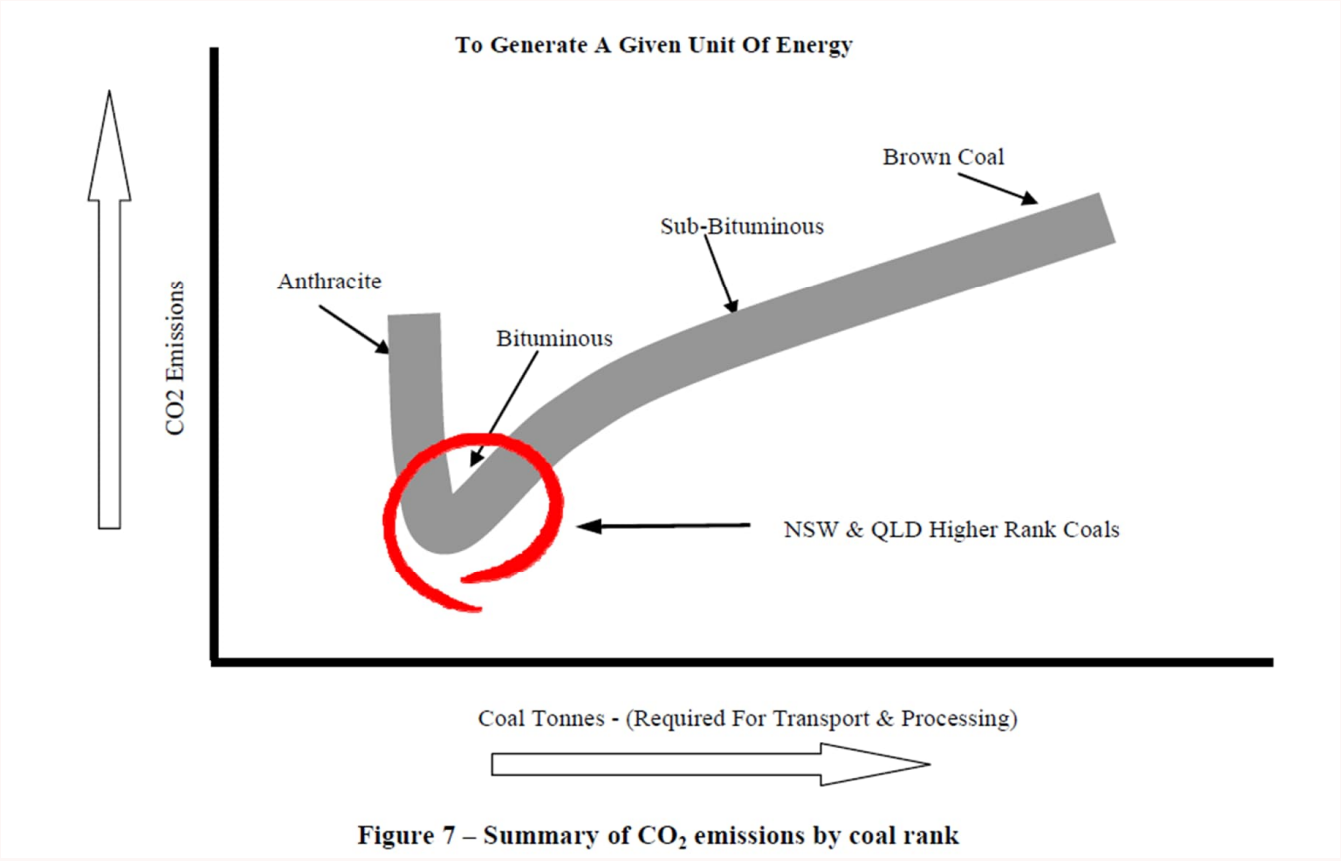
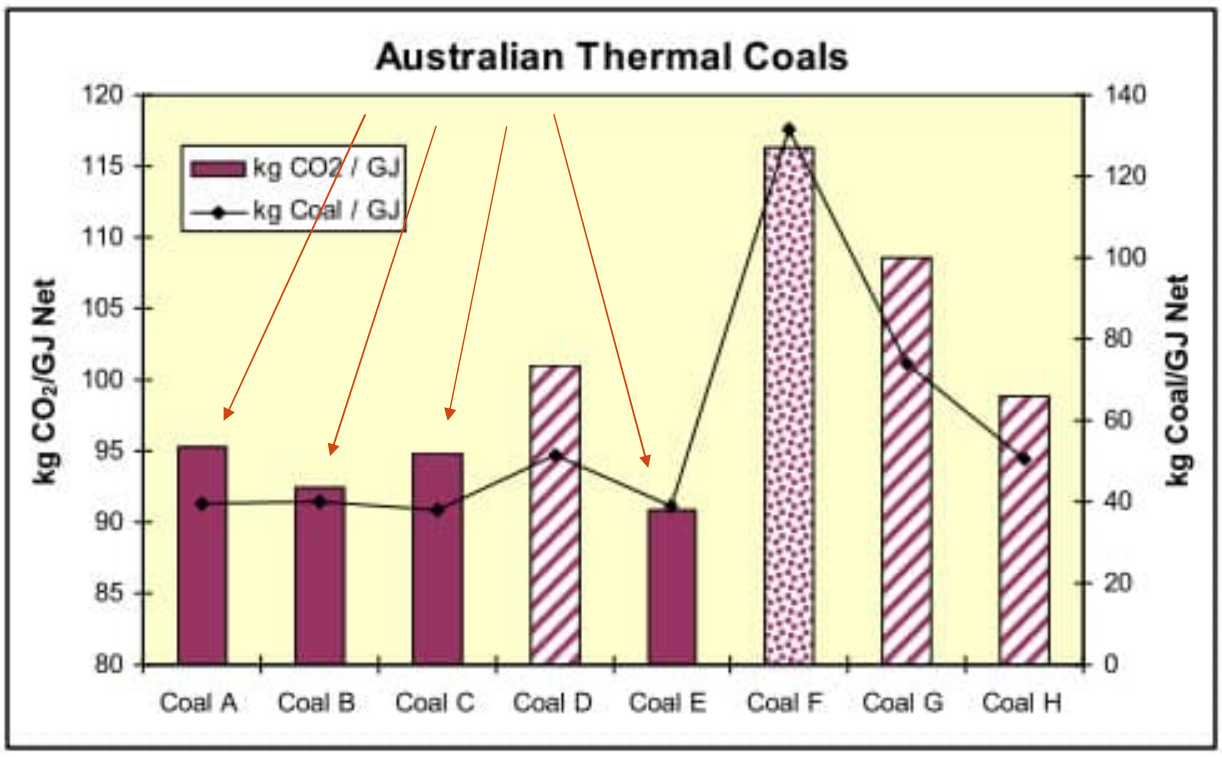


Figure 7 – Summary of CO_2 emissions by coal rank

Australian thermal coals – CO2 emission



The future .....

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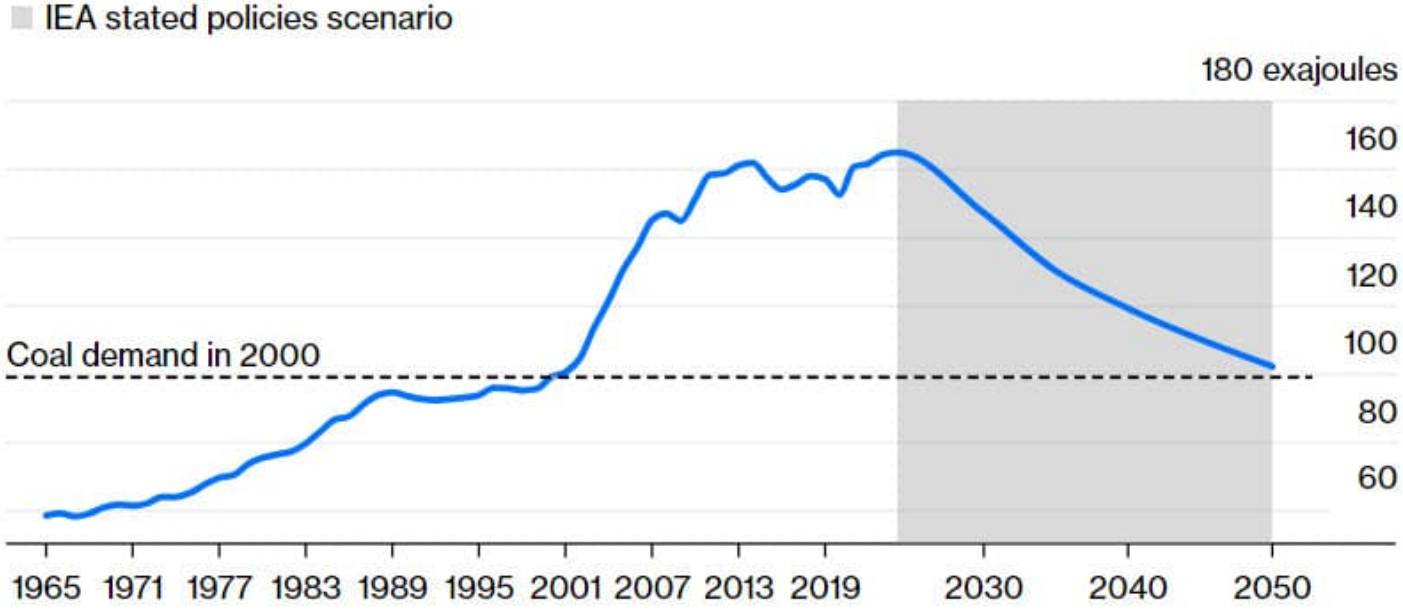
King Coal Demand

Global consumption of coal will rise to an all-time high this year, and under current trends consumption will be higher in 2050 than it was in 2000



Source: Bloomberg calculations based on data from International Energy Agency

Looking ahead…….what are the scenarios for coal ?

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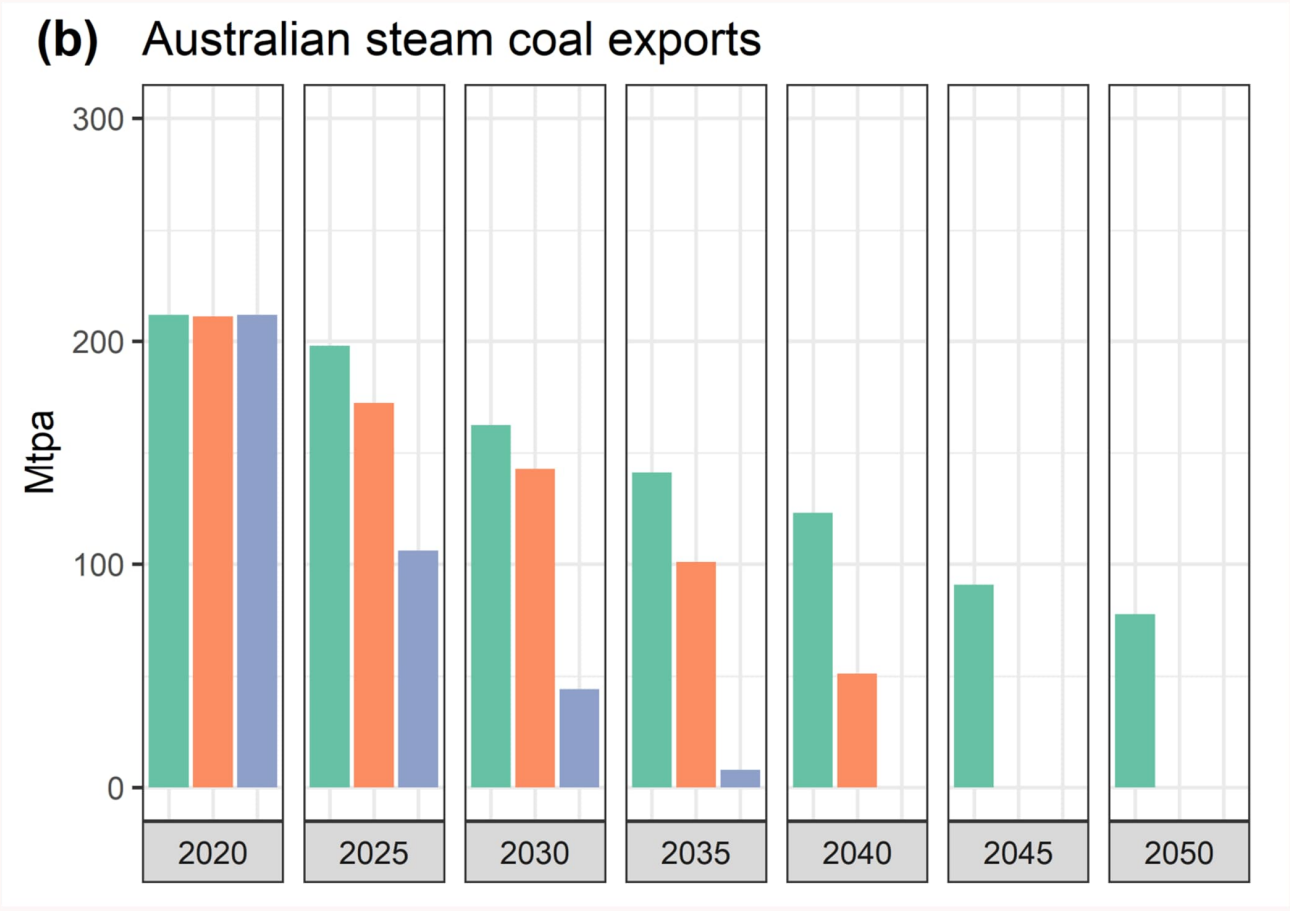

But .. Met coal looks solid for decades….
Waiting for *GREEN steel* options

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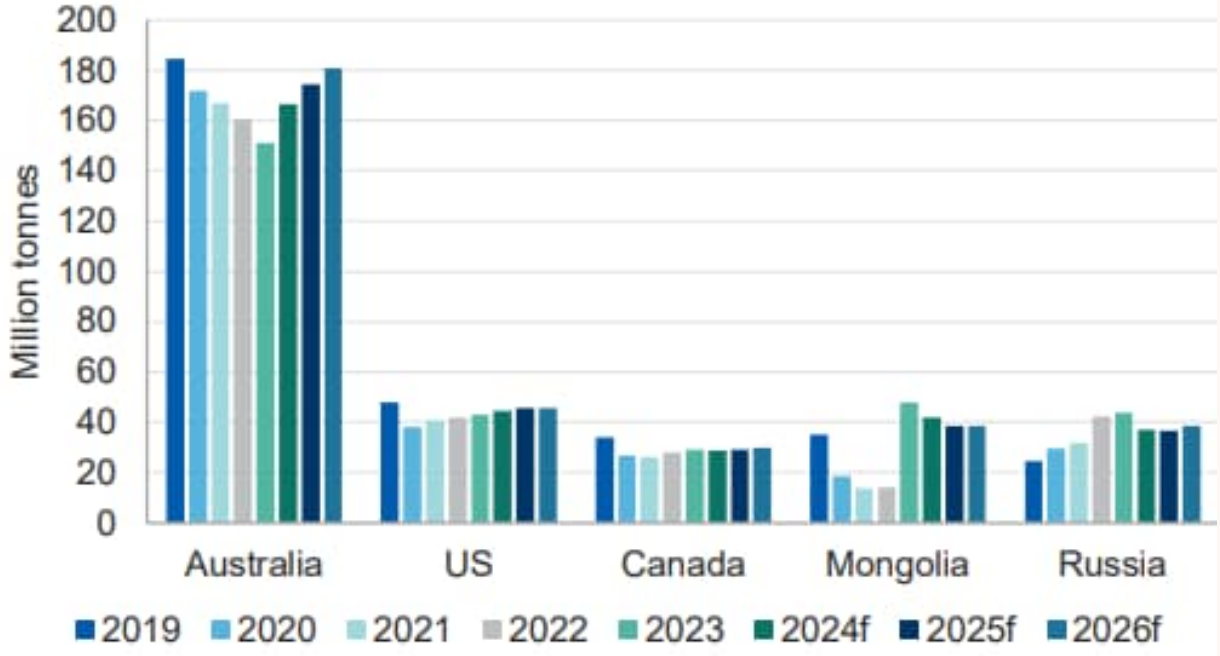
Figure 5.2: Metallurgical coal exports



Notes: f Forecast

Source: McCloskey (2024); Department of Industry, Science and Resources (2024)

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THANKS to:

Commodity Insights

TransCoal