Coal in a Sustainable Society – Australian experience with LCA

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Ad Hoc Group of Experts on Coal in Sustainable Development
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Overall approach

- Understand coal's role as a reductant and energy source, to help:
  - using LCA and other tools shift the debate from the emotional to the analytical
  - address social and economic aspects
  - provide new information to assist national and international policy considerations
- Identify new improvement opportunities
  - considering the whole coal chain
- Communicate the new facts about coal to all stakeholders (including the community)
  - present coal as a legitimate element in the energy and reductant mix, not coal versus the rest

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Background – coal & energy the underlying theme

1994-97: Marketing support for BHP steel, architects

1997-99: Support for Sydney Olympics 2000, education and 45 other materials and services

1999-00: ACARP Environmental Credentials of Coal

- first pass LCA for electricity generation

2000-02: CISS

- expanded range of electricity and steelmaking case studies
- expanded beyond LCA to include assessment of regional energy supply options (*eg* grids, NG networks, small scale use of coal)
- work still reported on www.ciss.com.au (to be updated in 2005)

2001-08: LCA work transferred to CRC Coal in Sustainable Development www.ccsd.biz

- includes externalities and socio-economic aspects

2002-04: COAL21 support – www.coal21.com.au

- includes techno-economic modelling and technology assessment

(Sept 04: Group transferred from BHP Billiton to CSIRO Energy Technology www.csiro.au

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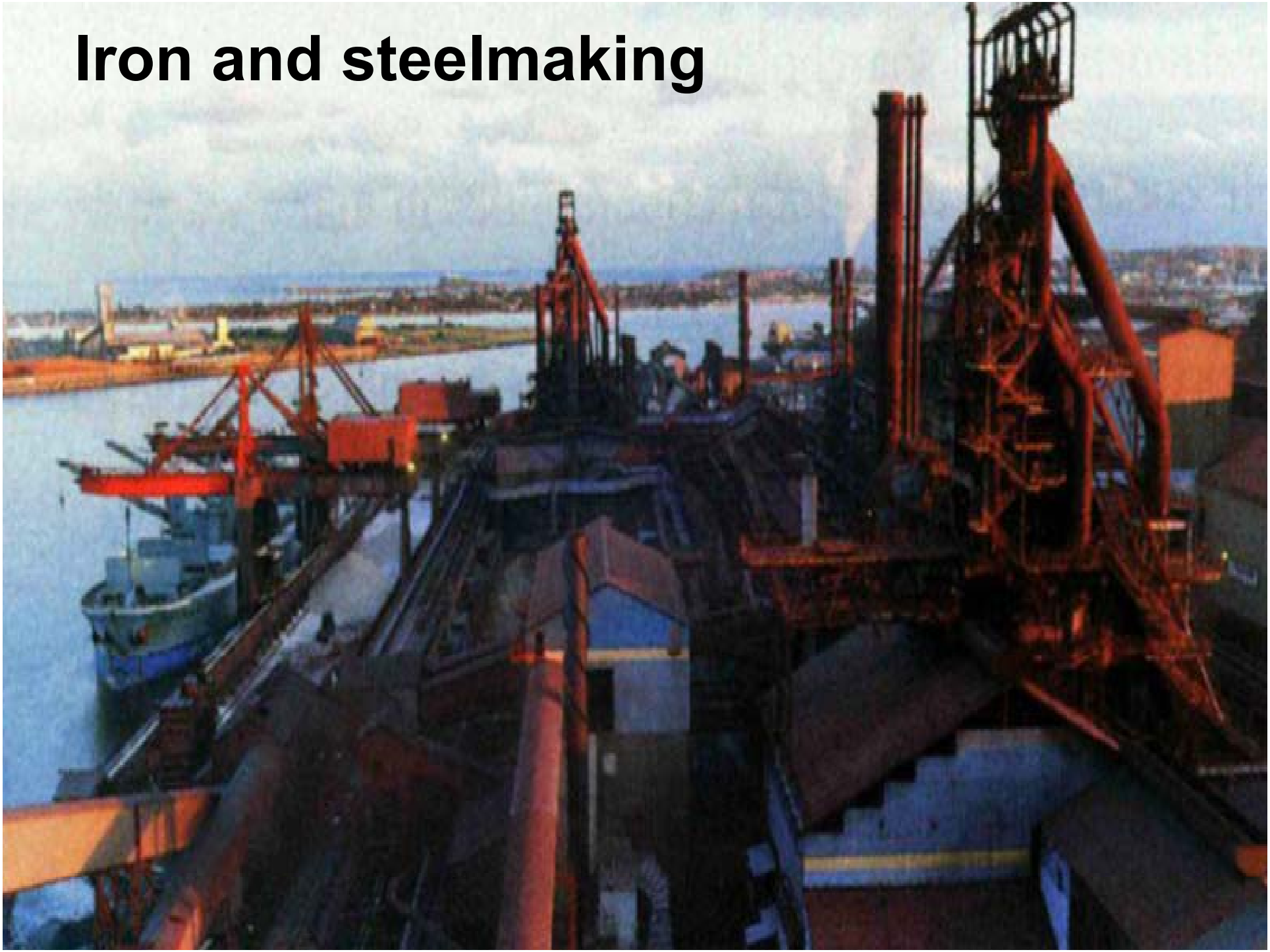
Iron and steelmaking



The steel experience ...

" Steel framing shall not be used for walls, due to its high greenhouse impact in comparison to timber framing"

"Every time you specify timber, you help save the planet"

"The industrial processes involved in metal production produce toxic wastes which pollute the atmosphere and degrade our waterways."

"Buy green pledge a first ..."

" Goods and services providers will be forced to prove their green credentials before selling their products to the public sector, the NSW government said today."

" They include amount and source of raw materials, energy use, air emissions, solid landfill and capacity for recycling."

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Key findings – steel production

- Not much difference between technology options on a life-cycle basis
  - blast furnace is not necessarily the biggest source of GGE
  - at Port Kembla MVA contributes ~15% to GGE
- Strongly dependent on credits for slags and off gases
  - large variations in both slag utilisation and efficiency of steelworks power plants
- Biggest LCA difference due to the need for virgin iron units
  - only part of steel make can come from scrap
  - should not confuse/compare processes for different purposes
- Technology and energy source (coal versus gas) have a lower significance than the efficiency of steel use and design for recycle
  - most strongly dependent on the specifiers and users rather than the steel producers

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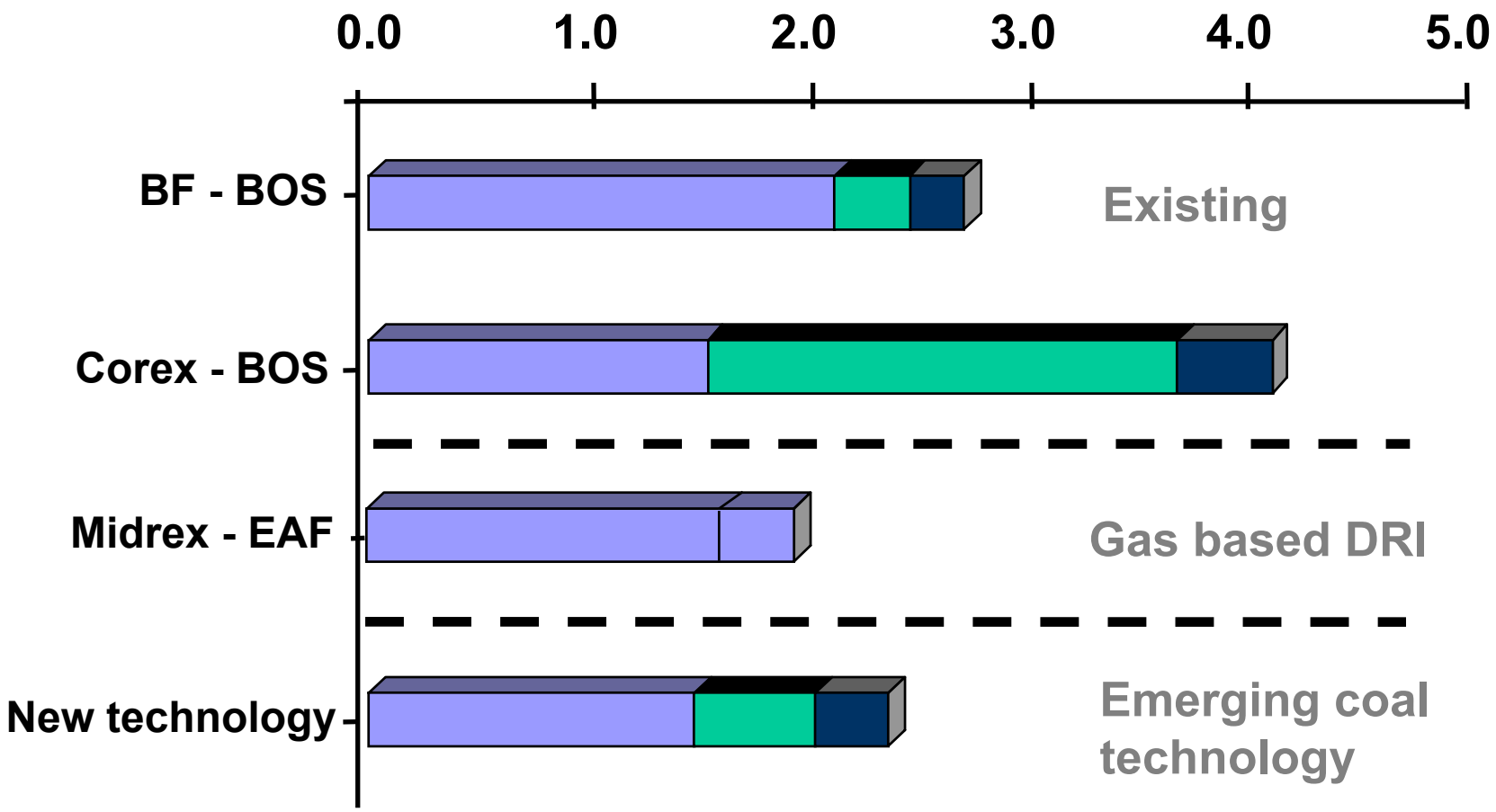
Steel GGE (t CO_2-e/t cast steel)



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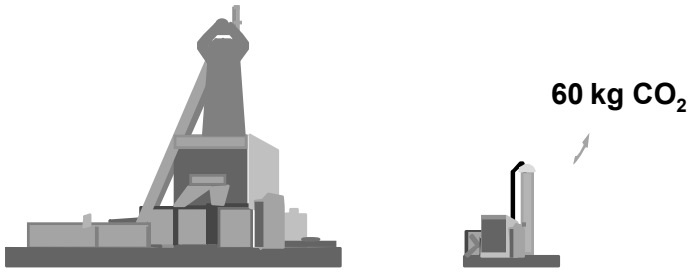
Displacement credits - slags

a) BF slag processing system
(basis 3,500 kg hot metal)



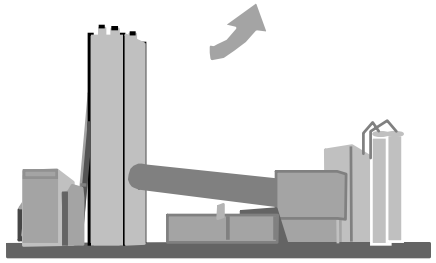
Blast furnace **Slag grinding**

BF slag cement
GGE 60 kg CO_{2-e}
(equivalent to 1,000kg of Portland cement)

1,000kg

b) Cement system

1,020kg CO_2



Limestone and shale quarrying

Cement plant
(includes clinker grinding)

Portland cement
GGE 1,020 kg CO_2-e

1,000kg

No technical or economic issues

Has been limited by attitudes

Often confused with use for aggregate (small benefits)

A product stewardship issue for both coal and steel

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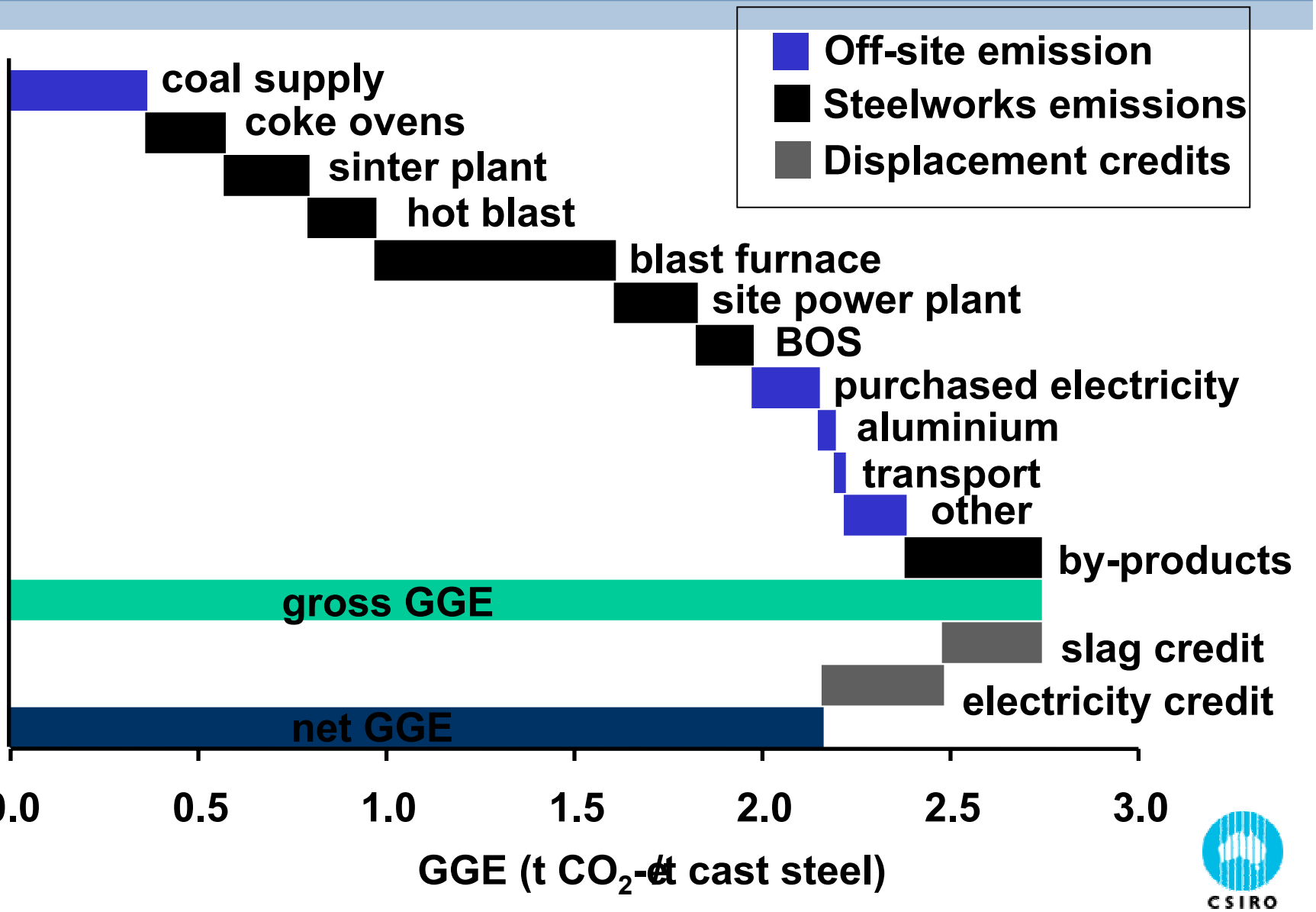
Process improvement targeting



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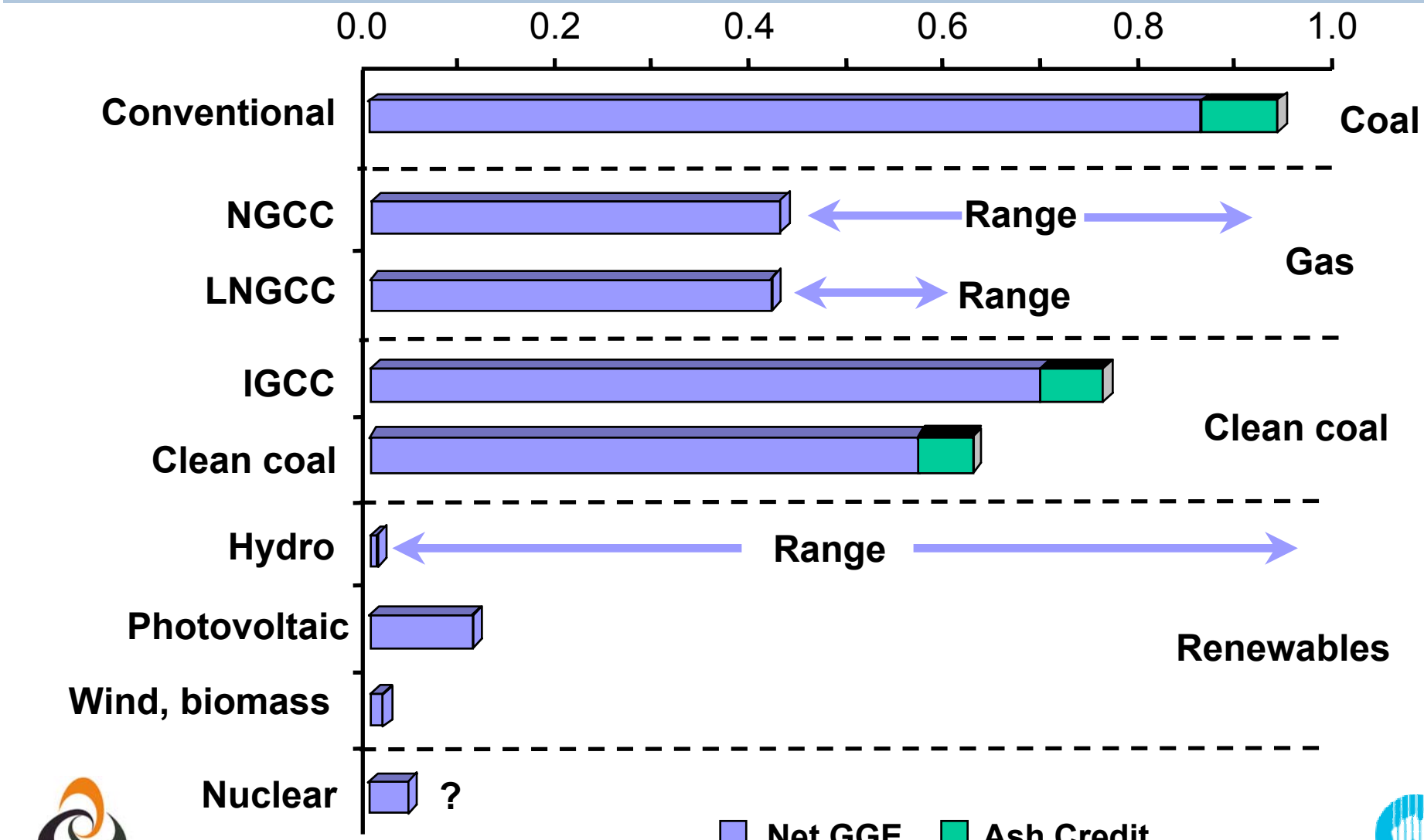
Electricity generation

Electricity GGE (t CO_2-e/MWh)



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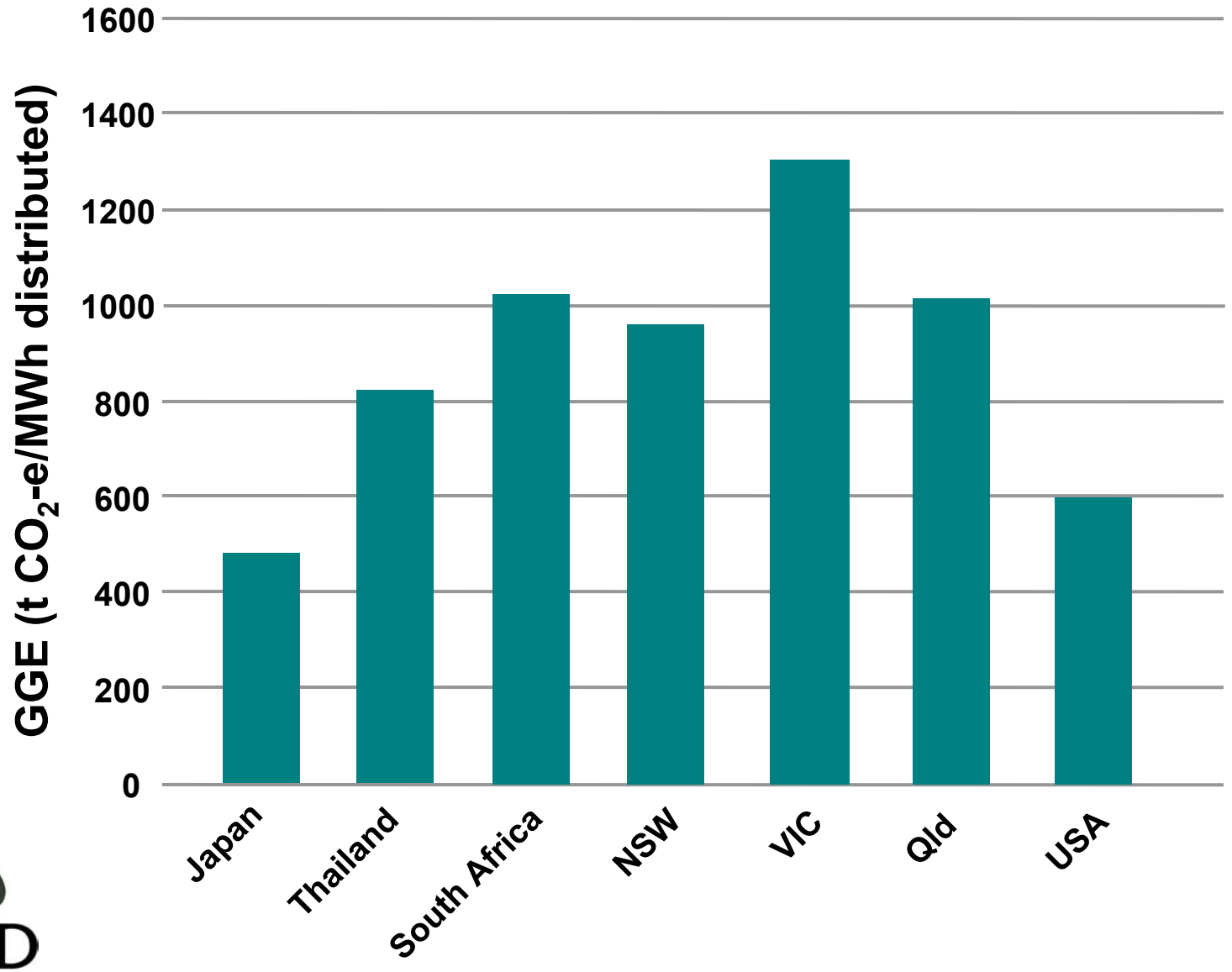
Large range in grid GGE due to energy mix



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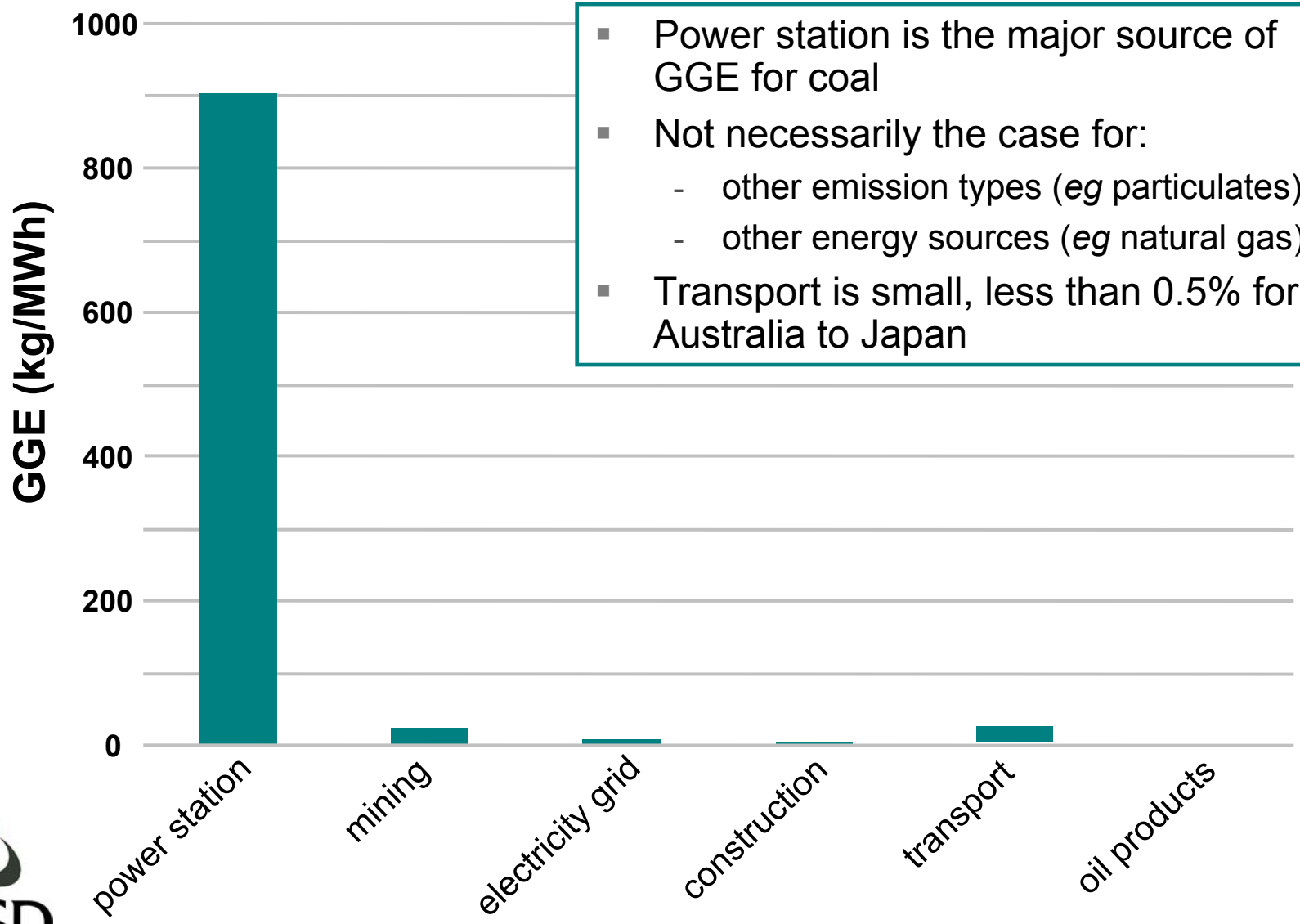
Electricity chain greenhouse emissions



- Power station is the major source of GGE for coal
- Not necessarily the case for:
  - other emission types (*eg* particulates)
  - other energy sources (*eg* natural gas)
- Transport is small, less than 0.5% for Australia to Japan

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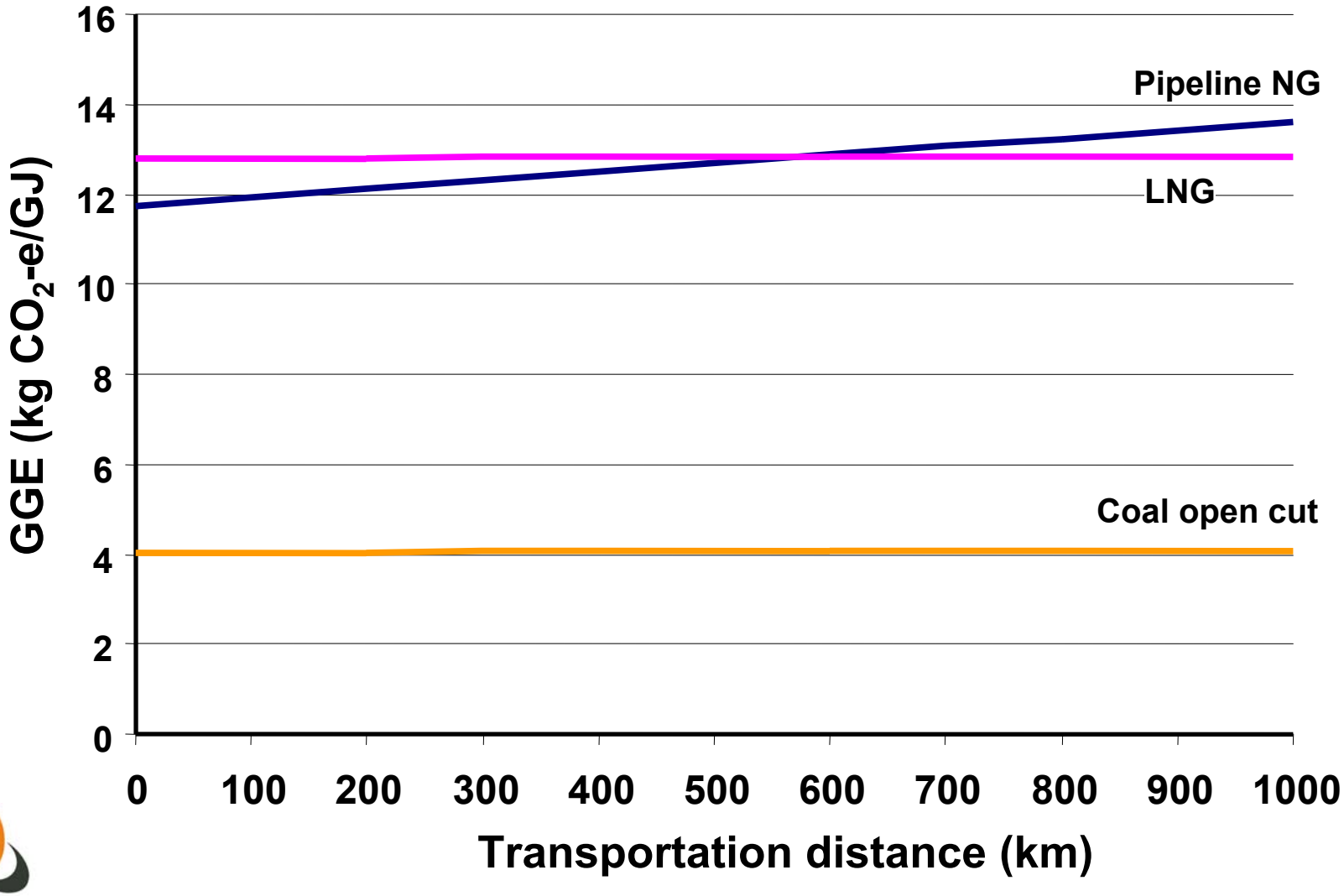
LNG can be better than pipeline gas



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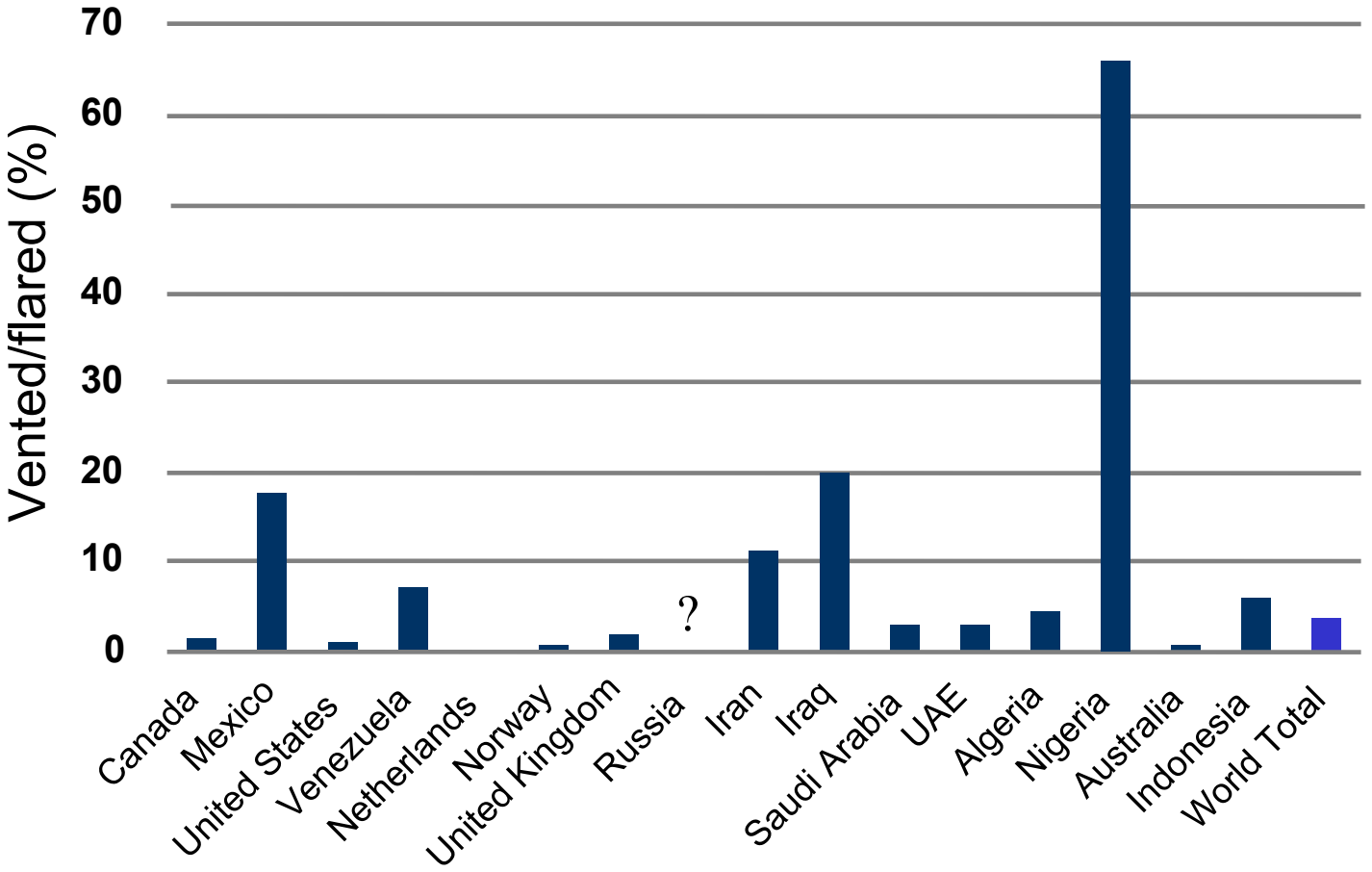
Natural gas - venting and flaring



In 2002 estimates show 4% of world NG production is vented or flared – but varies widely, and data is unreliable

CO_2 stripping gives additional GGE

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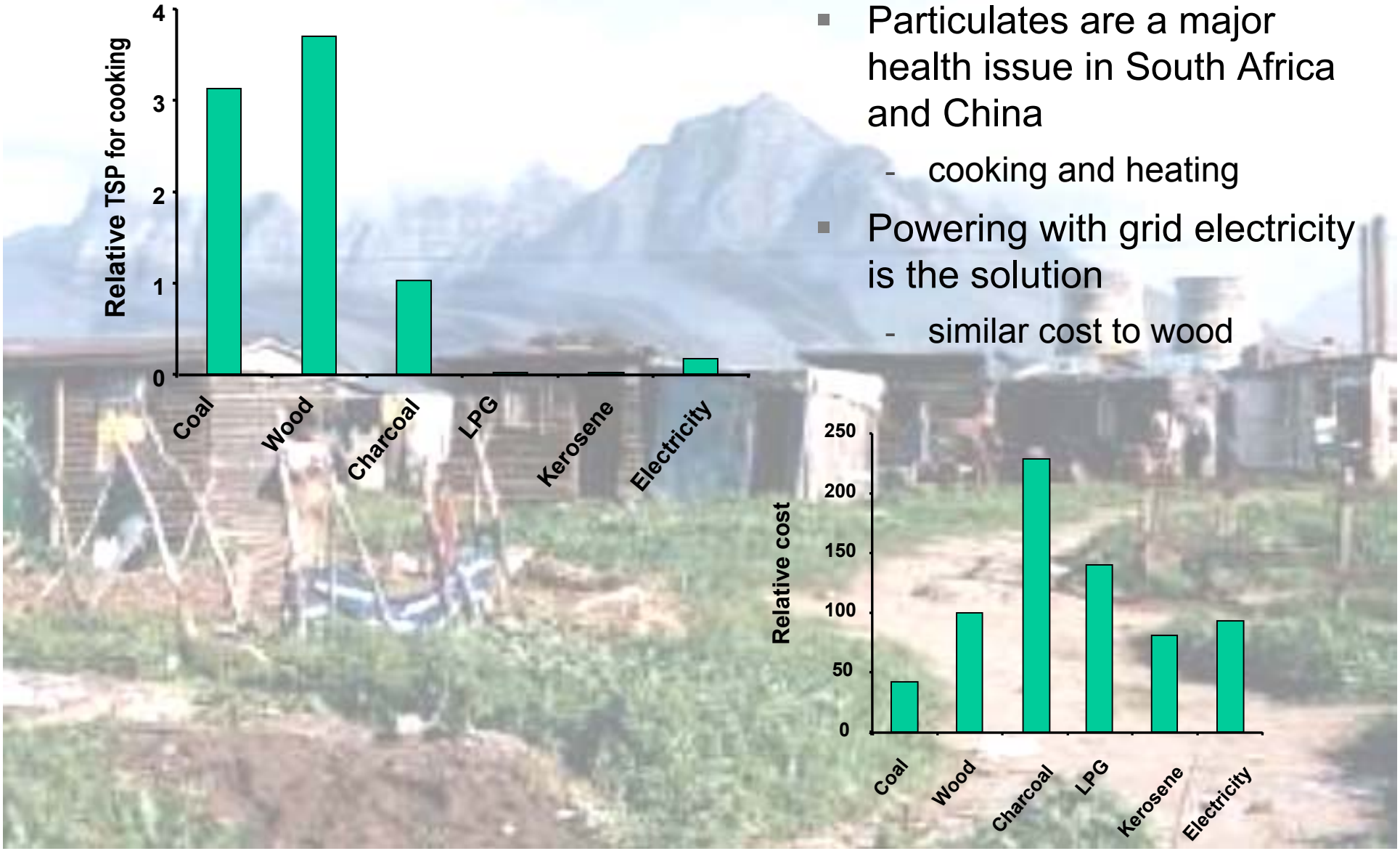
WCI – issues with direct use of solid fuels



- Particulates are a major health issue in South Africa and China
  - cooking and heating
- Powering with grid electricity is the solution
  - similar cost to wood

Water consumption (Australia)

Product/service	Water consumption
Coal fired power (m^3/MWh)	2
Steel (m^3/t cast steel)	2.5
Wood (m^3/m^3)	400
Wheat (m^3/t)	1,000
Rice (m^3/t)	1,500
Household (m^3/person/year)	70

- Australians need 1 million litres of fresh water per person per year
  - includes industry and food production
- In most regions increased attention to water issues for both consumption and contamination

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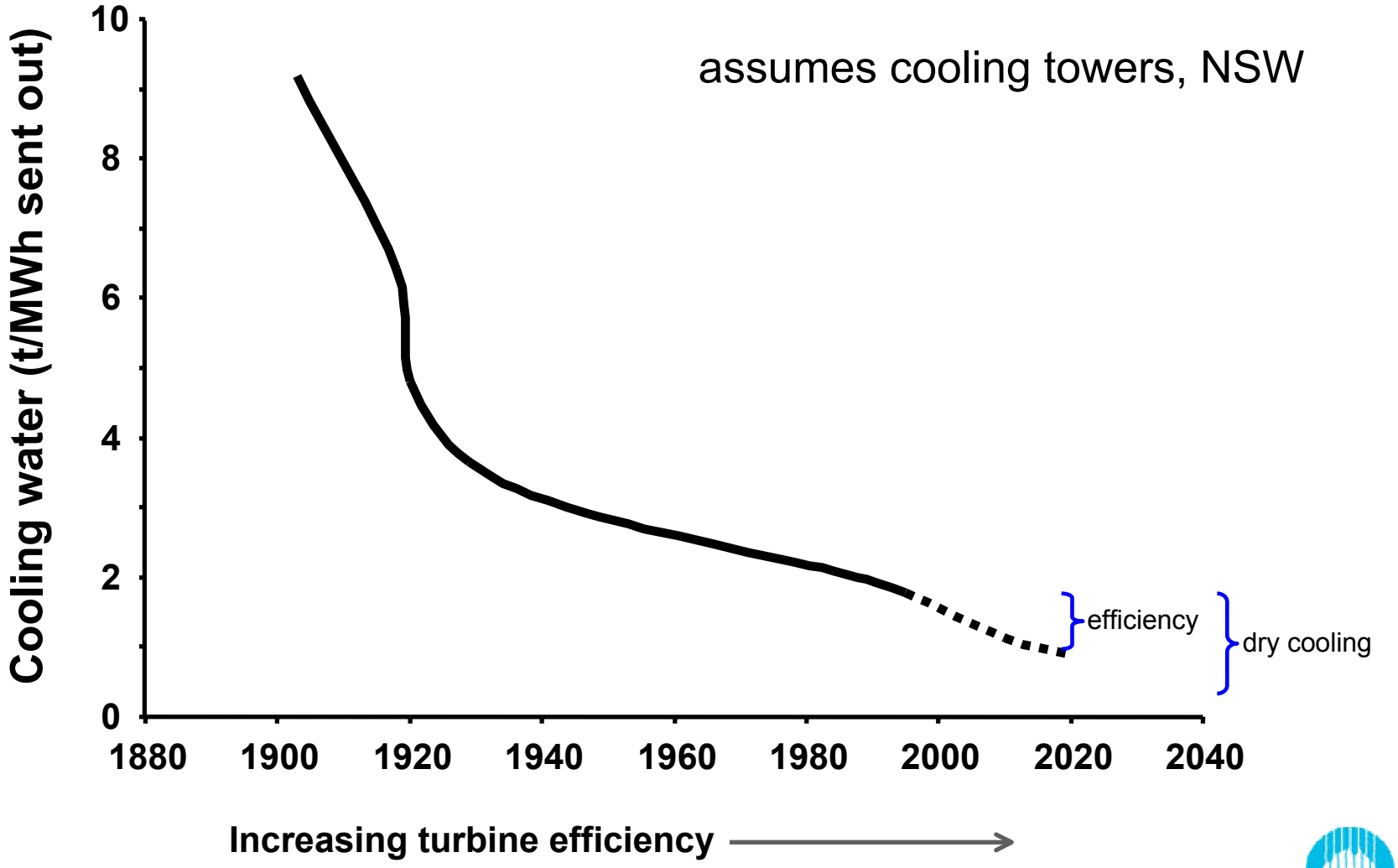
Water still an issue



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Trade-offs

- Consumption depends upon the cooling technology used and the efficiency of the conversion of steam to electricity in the turbine
- 30 m^3 water saved at the expense of an additional 1 t GGE by using dry cooling (~$10-15/t CO_2), plus more NOx, SOx *etc*

Parameter	Kendal (dry cooling)	Kendal (wet cooling)
Inputs		
Energy (GJ)	10.6	10.1
Water (m^3)		
Outputs		
GGE (kg CO_2-e)		
SO_x (kg)	9.8	9.3
SPM (kg)	0.12	0.12
Solid waste (kg)	182	172

All data are per MWh sent out

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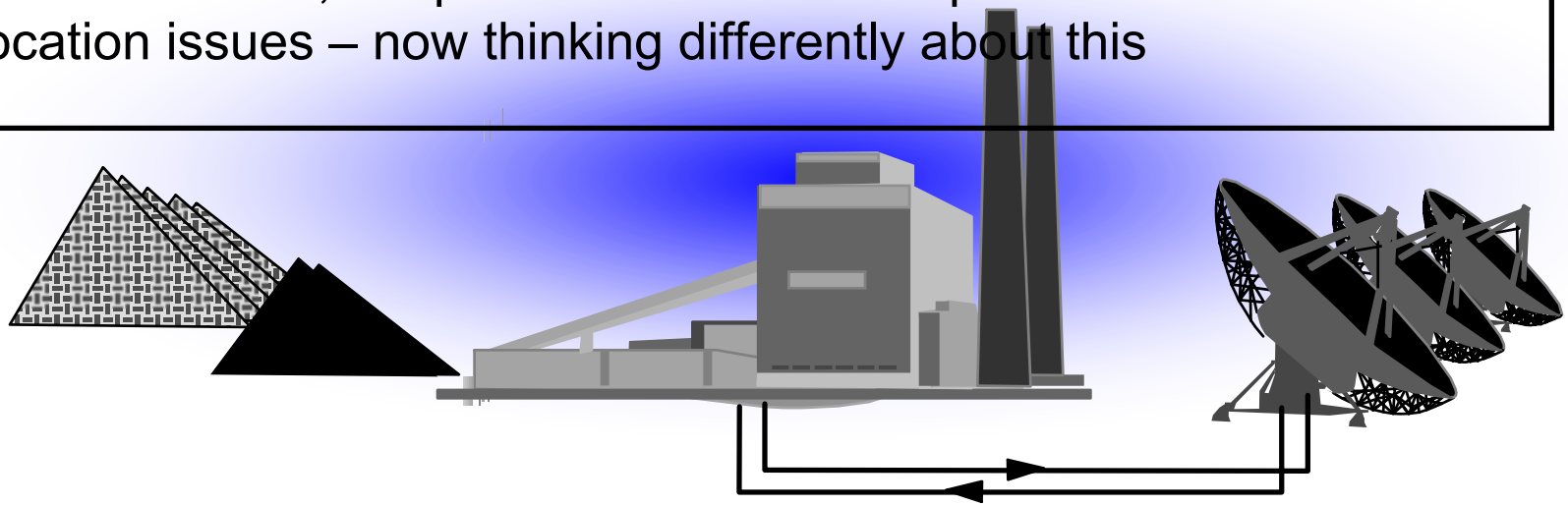
Synergies with renewables

- Coal can promote uptake/efficient use of renewables - by providing an efficient steam cycle and security
- Some biomass, but practical case studies proven difficult due to location issues – now thinking differently about this



Biomass co-firing

35% biomass co-firing (25% for dedicated)

Solar thermal

20-40% solar conversion efficiency (13% for PV)

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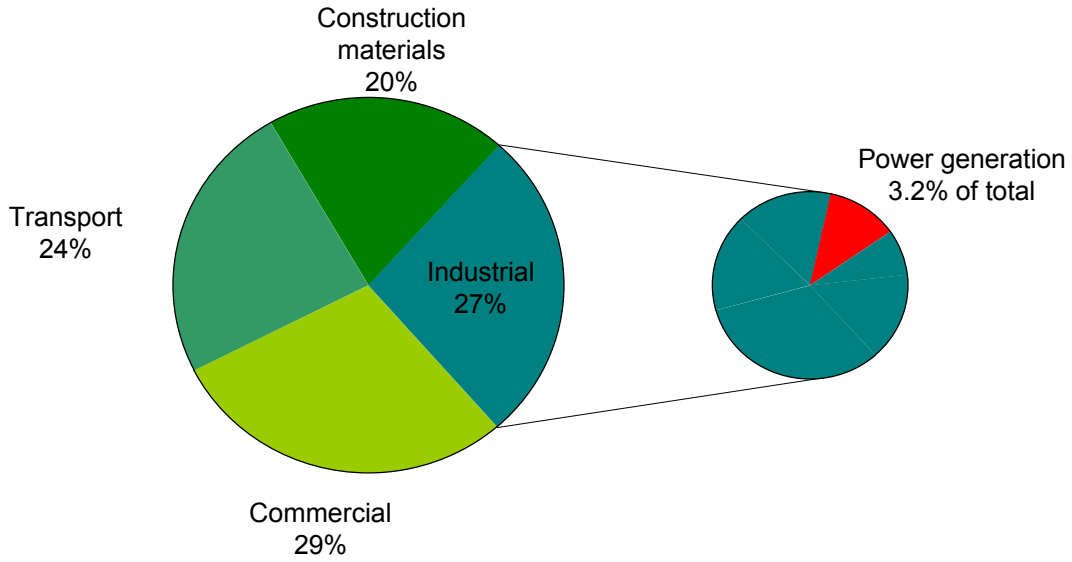
Linking energy with other life cycles - life without nickel?

- Nickel has significant environmental issues in production and for some uses, but …
- High-temperature and corrosion resistant nickel alloys have played an integral part in increasing efficiencies of steam and gas turbines - no alternative for many applications
- Total nickel consumption 1.1 Mt, 3.2% used for power generation
- Over 1973 – 1998, over 60 Gt less CO_2 due to use of nickel, several orders more than emitted in nickel production



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Changed approach

- Initially was to use LCA to help get coal off the back foot by shifting the debate from the emotional to the analytical
  - total system approach based on LCA principles
  - transparent integrity has been the key
  - developing a sound basis for displacement credits
  - quantifying process improvement opportunities
  - present coal as a legitimate element in the energy and reductant mix (not coal versus the rest)
- Now applying broader systems analysis approaches to energy systems:
  - environment, economics and social issues across the coal-chain
  - applying to both current and projected technology pathways
  - application to specific process options
  - using “adaptability and resilience” as a philosophy:

> ***sustainable development is development that preserves or enhances the adaptability and resilience of both the ecological and economic systems …***

- Work program under CRC for Coal in Sustainable Development, COAL21 and CSIRO Energy Transformed Flagship

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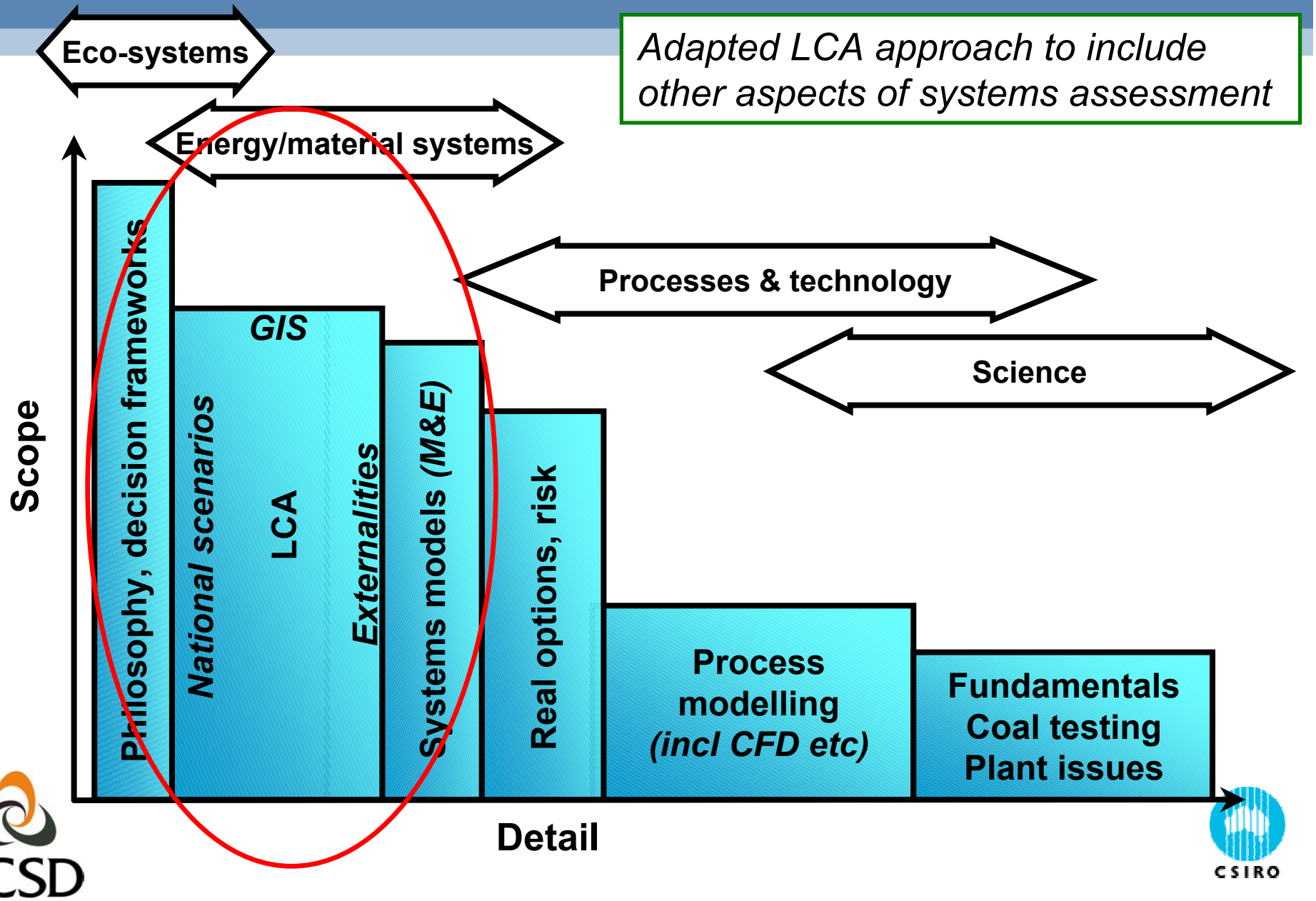
Adapting LCA

Adapted LCA approach to include other aspects of systems assessment



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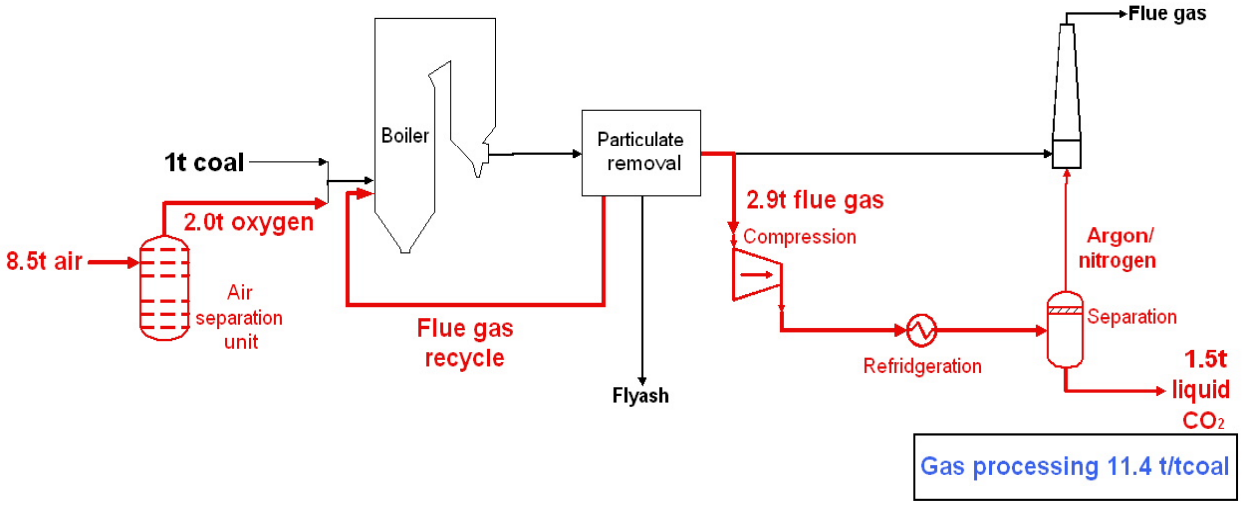
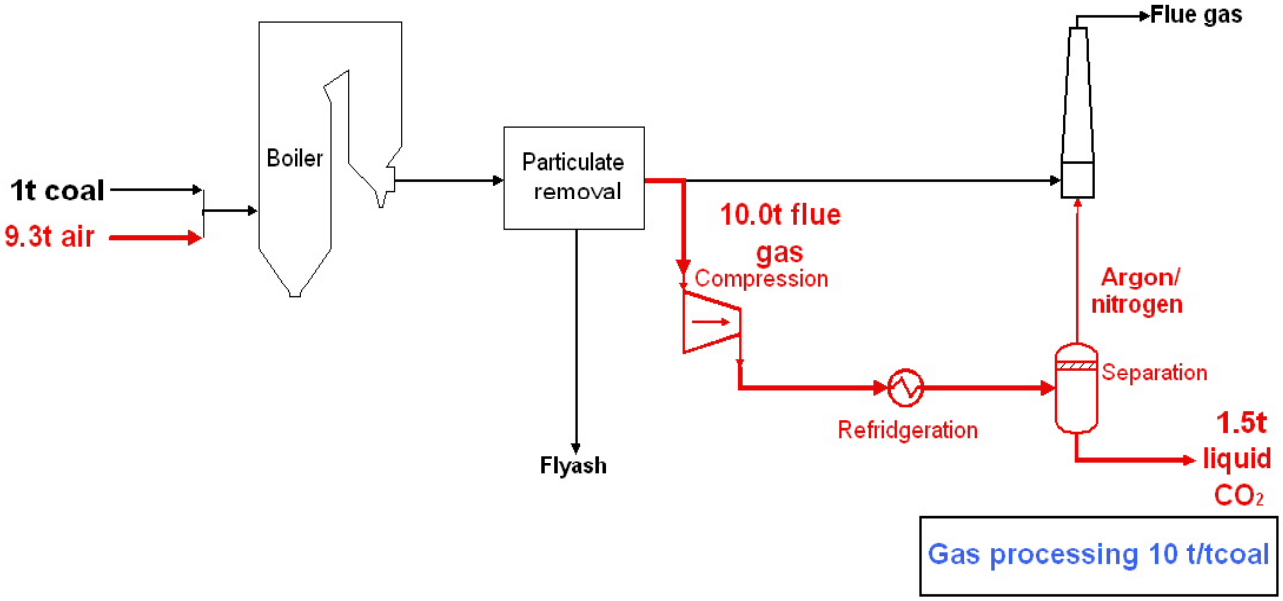
Example: post combustion capture *vs* oxy-pf

O_2-pf-CCS



pf-PCC



Adaptability & resilience

- More flexible operation
- Staged implementation
- Retrofit & relocatable
- Synergy with renewables

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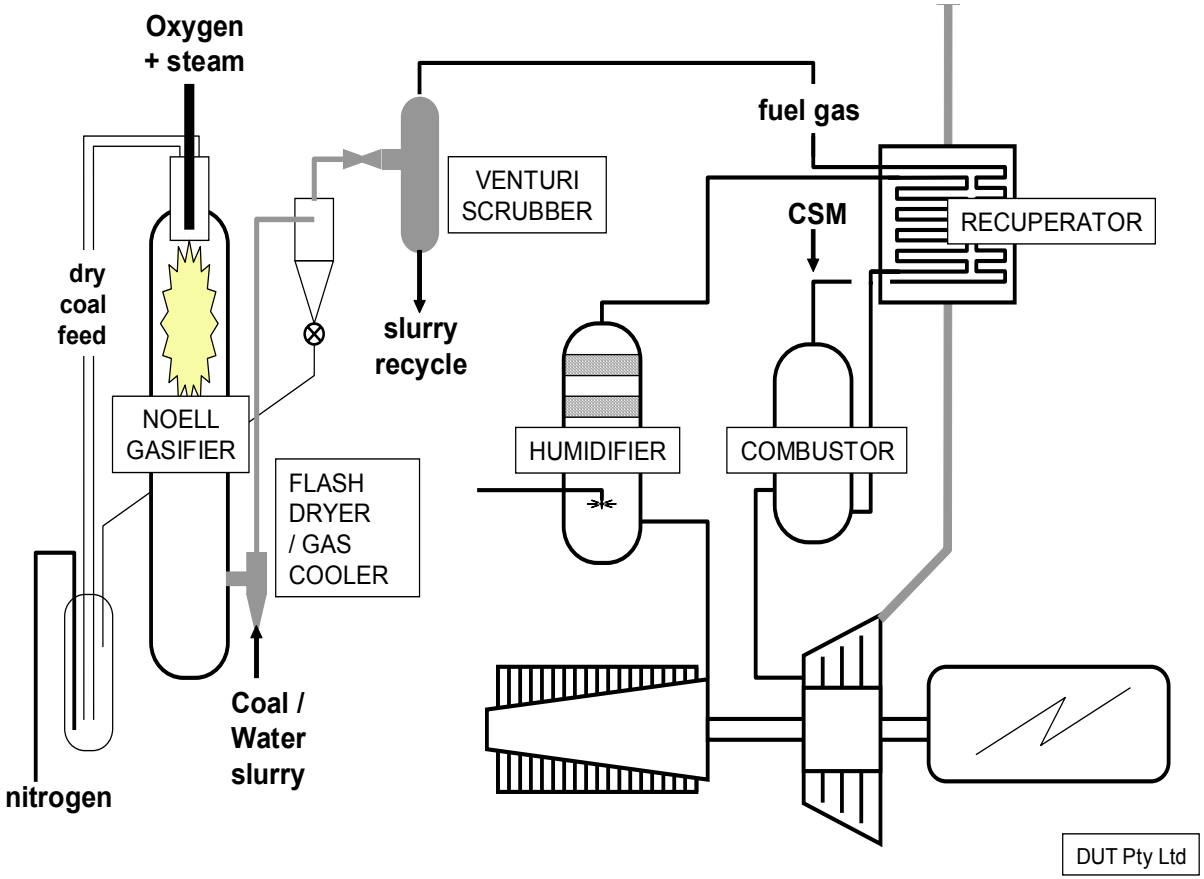
Example: “IDGHAT” for all coals/rejects



Australian improvement on the EPRI IGHAT concept – by DUT Pty Ltd

Sustainability attributes

1. Widest range of coals and wet lignites
2. High moisture coal with no loss of efficiency
3. High ash coal minor loss of efficiency
4. Matches combined cycle efficiency
5. Higher efficiency at small scale
6. Short startup time
7. 30% lower capex
8. Capture ready
9. Water recovery

But .. turbine availability issues (cf CAES and hybrid fuel cell-turbine)

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Concluding comments

- LCA is a powerful technique for obtaining objective information about a product, service or system
  - need not be overly complicated
  - proven valuable to shift the debate from the emotional to the analytical
  - has limitations including lack of linkages to other sustainability attributes (economics, social implications) and spatial/temporal dimensions
- The act of performing an LCA can be more important than the LCA results themselves
  - becomes a way of thinking, which can be incorporated into more detailed assessments of energy systems and socio-economics (not the other way around)
- For Australia, LCA has helped emphasise the need to back options (now) and not perceived winners
  - best options for Australia may differ from those for other regions due to different coal properties, coal intensity, availability of natural gas and renewables, and demographics, and large coal exports affect the local energy coal mix
- Given the continuing interest in CISS, the site www.ciss.com.au will be revised to incorporate the learnings and changed emphasis since 2000

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