

Projecting the Full Pollutant Cycle from Coal Utilization to 2200: *Understanding the Global Environmental Implications*



NZSSES: 4th Int'l Conf on Sustainability Science & Engineering

Zhehan Weng[#], Gavin Mudd, Carol Boyle

Coal

- Primary energy source since industrial revolution
- Significant Environmental Impacts (air pollutants, GHG, etc.)
- Three Selected Countries: Australia, Canada and the United States of America

Utilization:

- Electricity Generation (dominant use)
- Industrial Processes (steel major use, foundry sand)
- Liquefaction (gasoline or diesel, minor use)

Coal for Future?

Physical Constraints:

- Finite Coal Reserve vs. Infinite Energy Demand

Environmental Constraints:

- Pollution Releases & Emission Intensity associated with coal mining and coal-fired electricity generation

Primary Study Objective:

Combine peak modelling with unit pollutant intensity to project scenarios of pollution loads from coal mining and use

Primary Components of Study

- *Coal Production Analysis and Forecasts to 2200*

A. Historical Coal Production and Quality

B. Coal Production Forecasts to 2200

- *Hubbert-based logistic curves for 'peak coal'*

Air Pollutant Releases and Emissions Intensity

A. Air Pollutant Metrics of Current Coal Production and Electricity Generation

- *eg. kg SO₂ / t coal; kg SO₂ / GWh*

B. Combining Peak Models with Pollutant Releases to 2200



Image © 2008
Image © 2008
© 2008

14.3 km

70 km

33°08'57.98" S 150°47'25.71" E

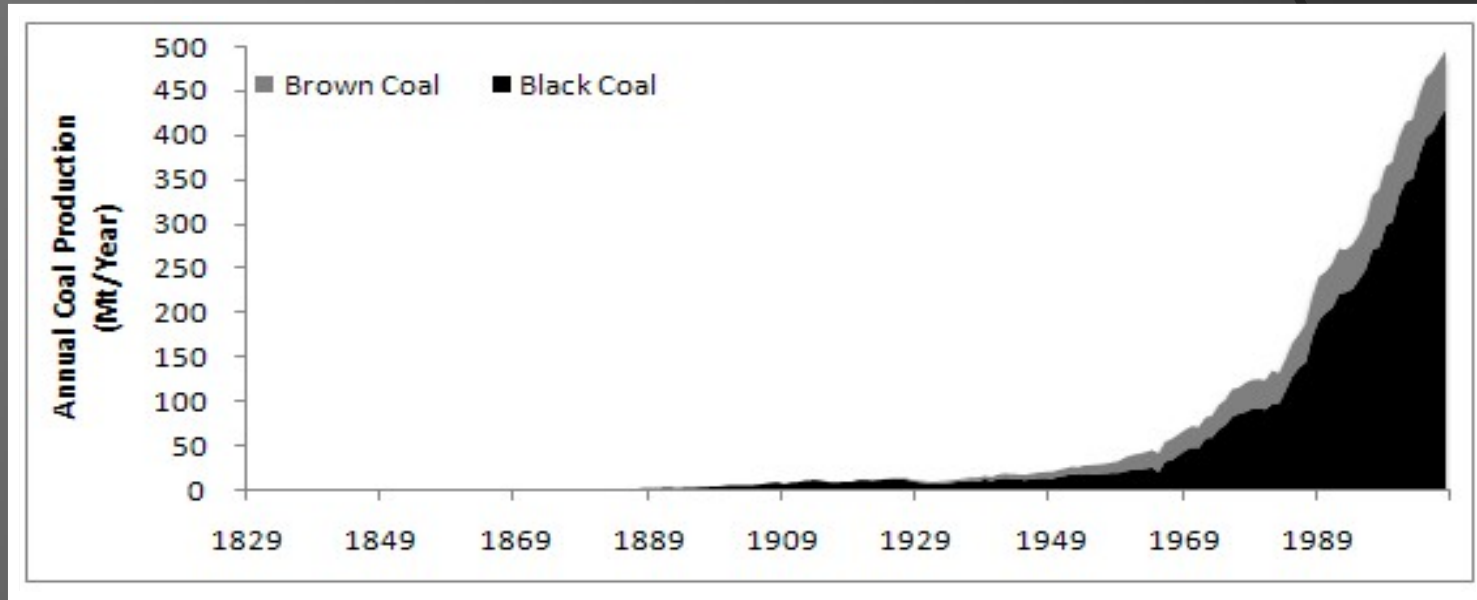
Typical Coal Mine & Power Station...



Loy Yang open cut brown coal mine, Latrobe Valley, Victoria

Australian Coal Production

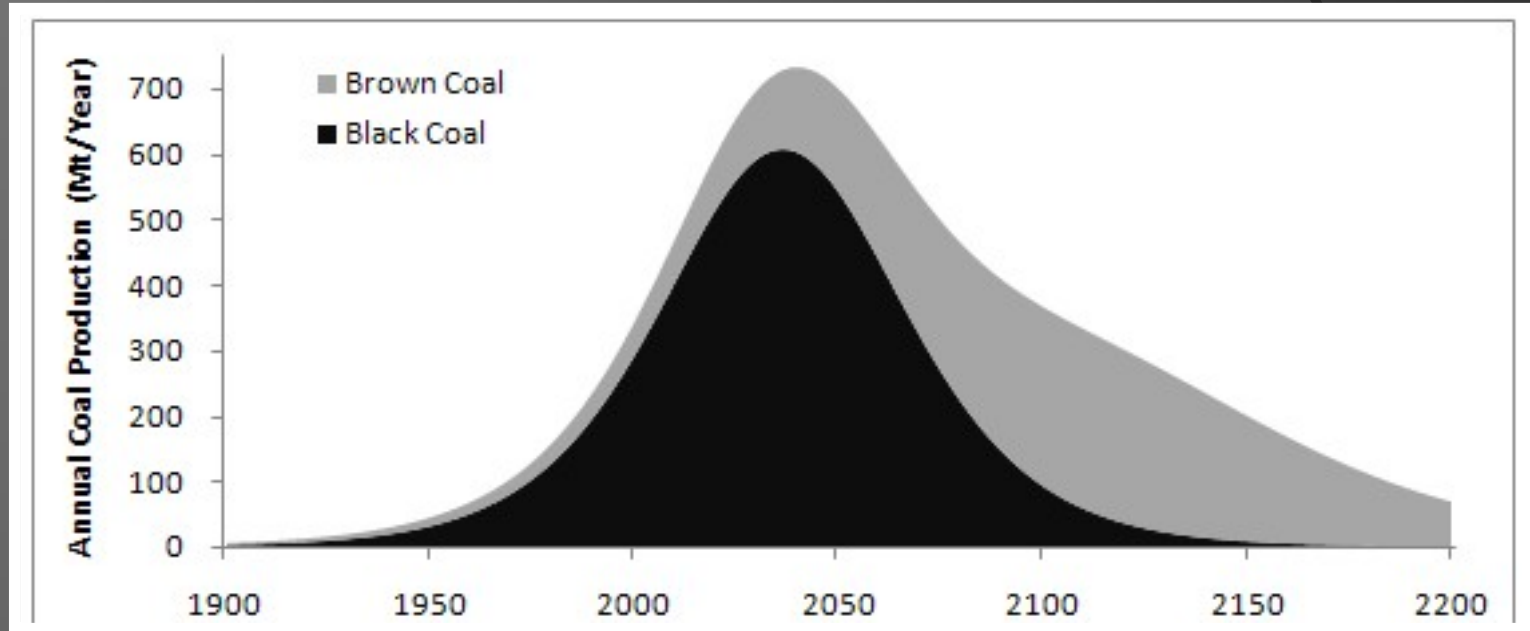
Annual Australian Coal Production by Coal types (1829 to 2008)



- Strong Increasing Trend since 1960s
- Black Coal (Bituminous + Sub-bituminous coal) will continue to dominate AU coal production
- Ratio of Brown Coal (Major Lignite) have increased since 1920s, although ratio of black coal have

Australian Coal Production Forecast to 2200

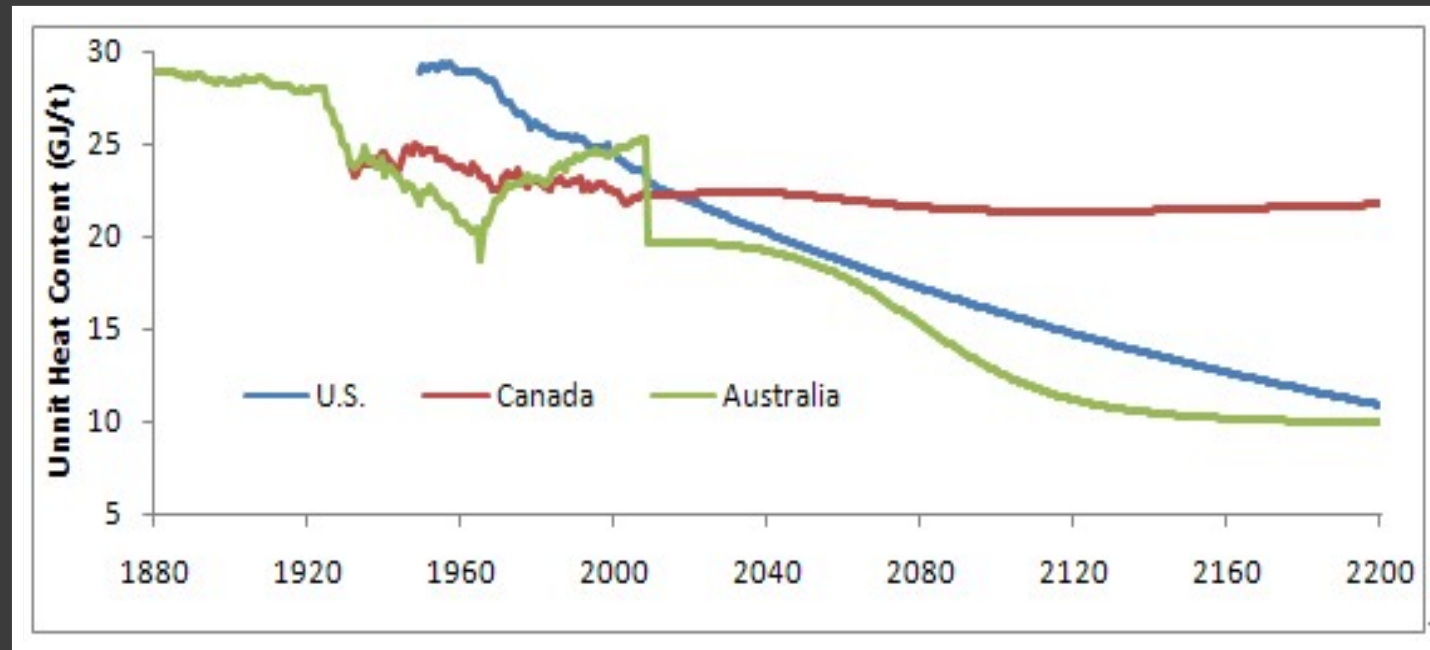
Projected Australian Annual Coal Production to 2200: black and brown separately modeled



- Black coal peaks in 2036 at 607 Mt maximum annual production
- Brown coal peaks in 2106 at 276 Mt maximum annual production
- Shift from high quality coal such as Black Coal to low quality coal is inevitable, especially after 2040.

Coal Quality Forecast to 2200

Coal Quality Trends Forecasts (1880 to 2200)



- Unit Heat Content in GJ/t is a key indicator of coal as fuel
- Canadian coal production trends is relatively consistent compared to U.S. & Australia. Due to its bituminous coal peaks later than sub-bituminous coal.
- Significant decline in coal quality are inevitable, especially after 2050s

Air Pollutant Releases and Emissions Intensity Assessment for Coal Mining & Electricity Generation

Hazelwood Power Station, Victoria

source: (ABC NEWS, 2009)



Key Database

Australia's National Pollutant Inventory (NPI):

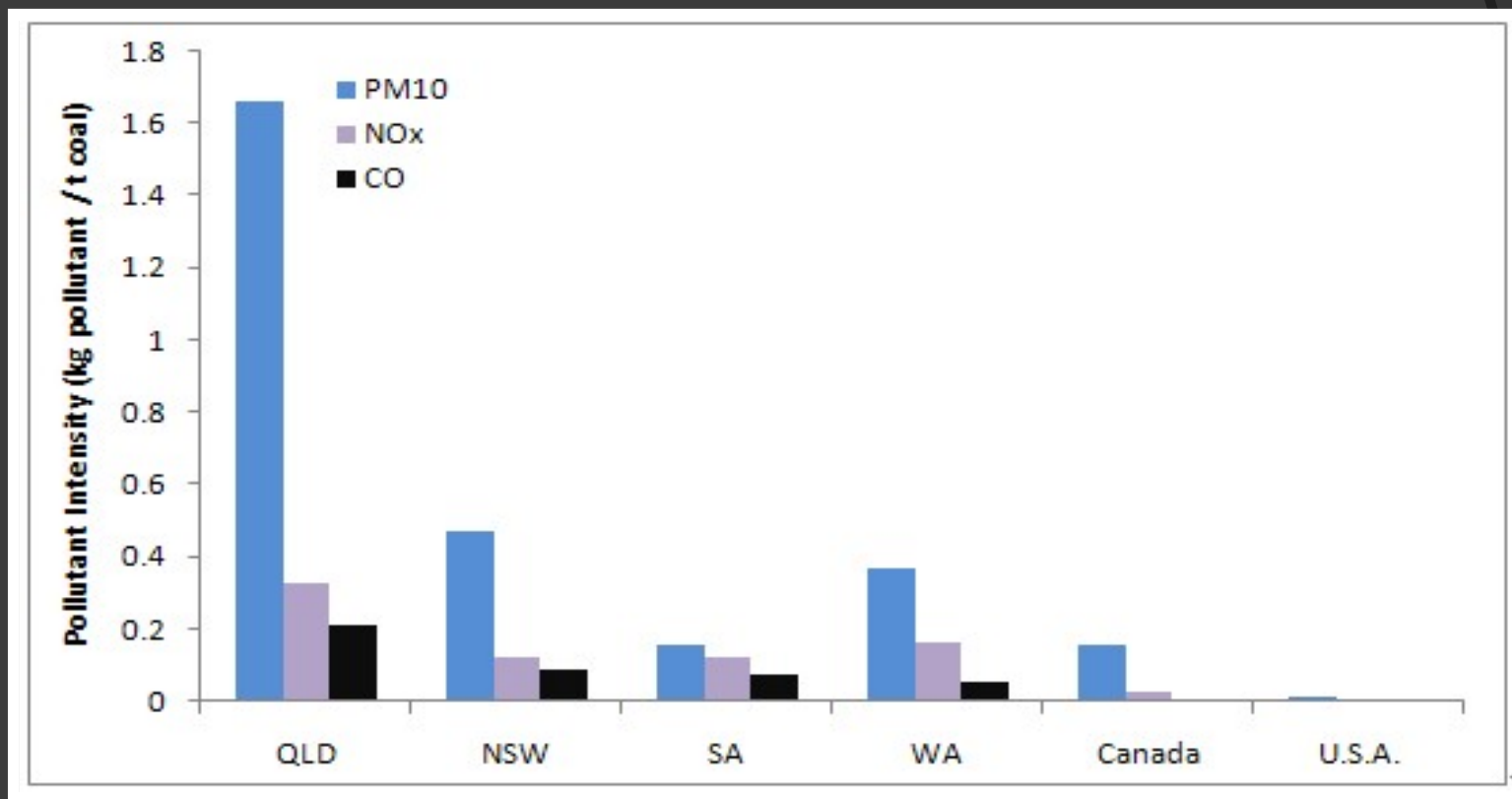
- A publicly accessible database with estimated data on the types and amounts of 93 listed substance emissions to the Australian environment.
- NPI emissions are reported for air, land and water
- NPI data used to calculate pollutant release metrics
 - *eg. kg SO₂ / t coal; kg SO₂ / GWh*
- Canada's NPRI, US EPA's NEI ...

Key Air Pollutants

- *Carbon Monoxide (CO)*
- *Particulate Matter less than 10 microns (μm) in diameter (PM10)*
- *Sulfur Dioxide (SO₂)*
- *Oxides of Nitrogen (NO_x)*
- *Volatile Organic Compounds (VOCs)*

Air Pollutant Releases and Emissions Intensity for Coal Mining

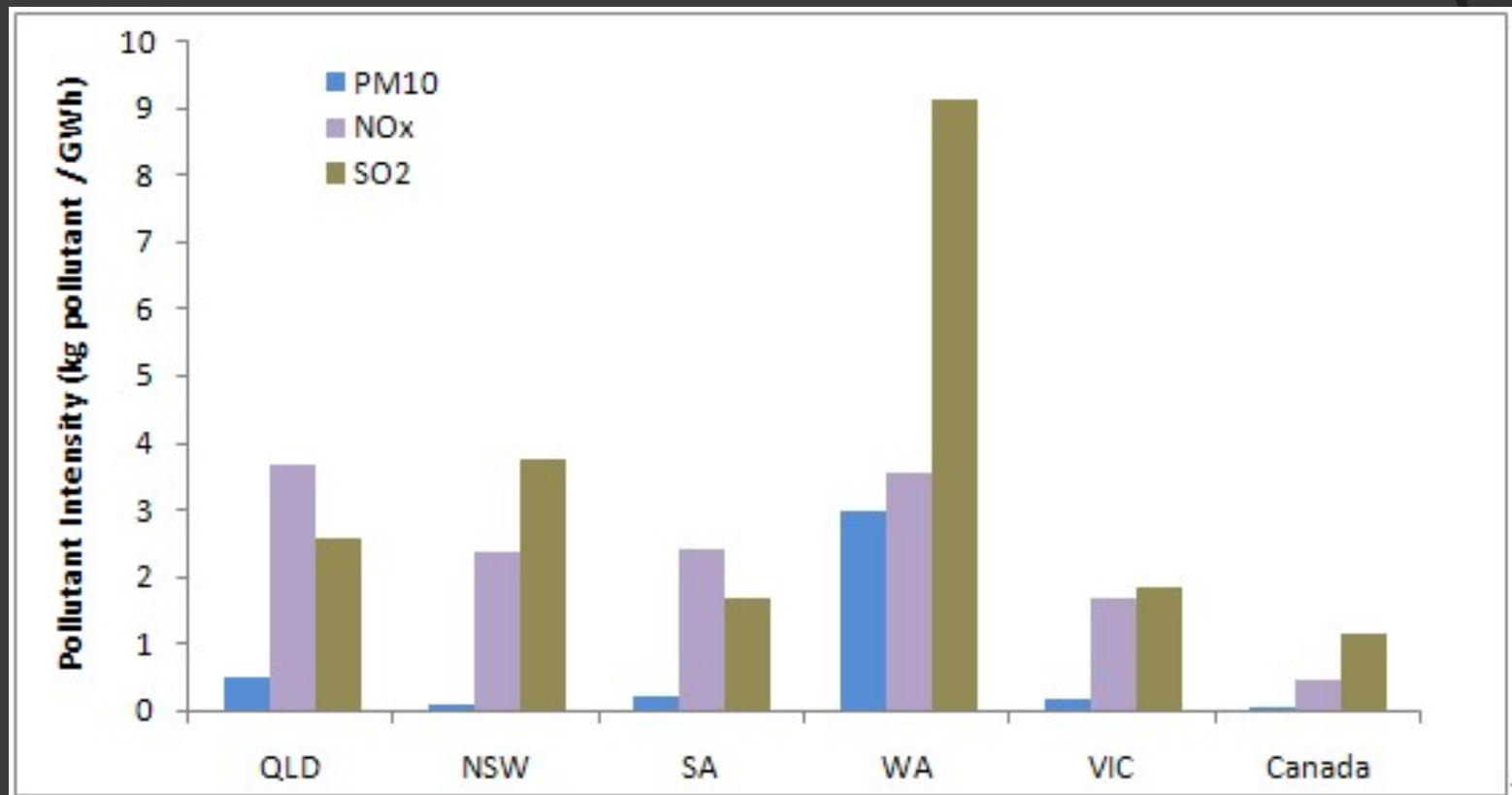
Emission Intensity Associated with Coal Mining; Top 3 pollutants separately plotted



Note: Australian data is based on average emission rate from financial year 1999 to 2008; Canadian data is based on national average of 2007 whilst U.S.A. is average of 2005

Air Pollutant Releases and Emissions Intensity for Coal-Fired Electricity Generation

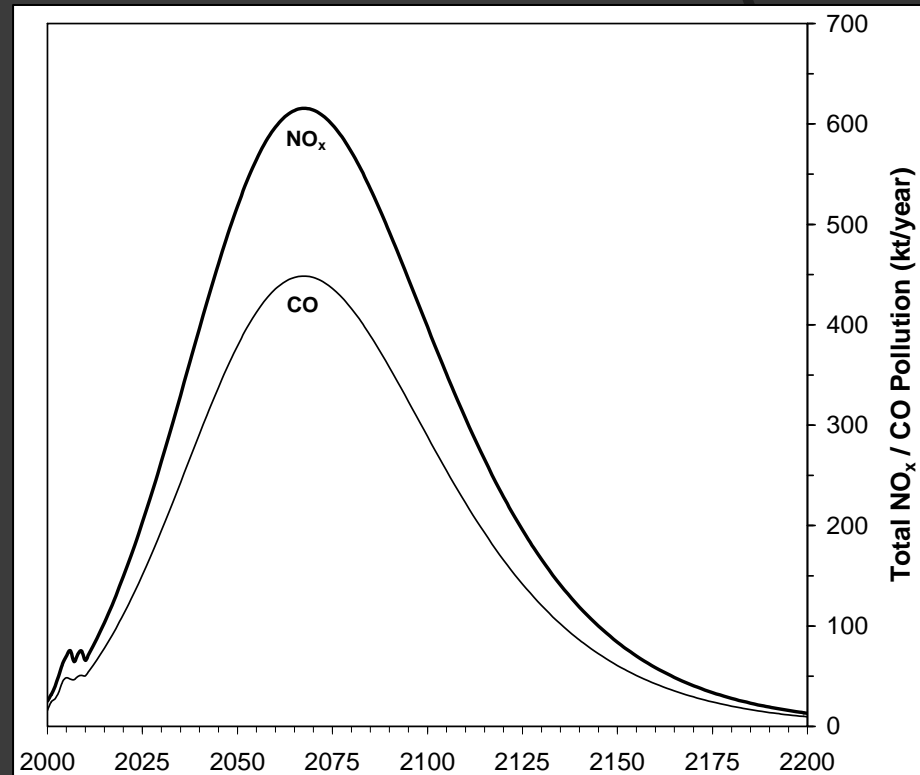
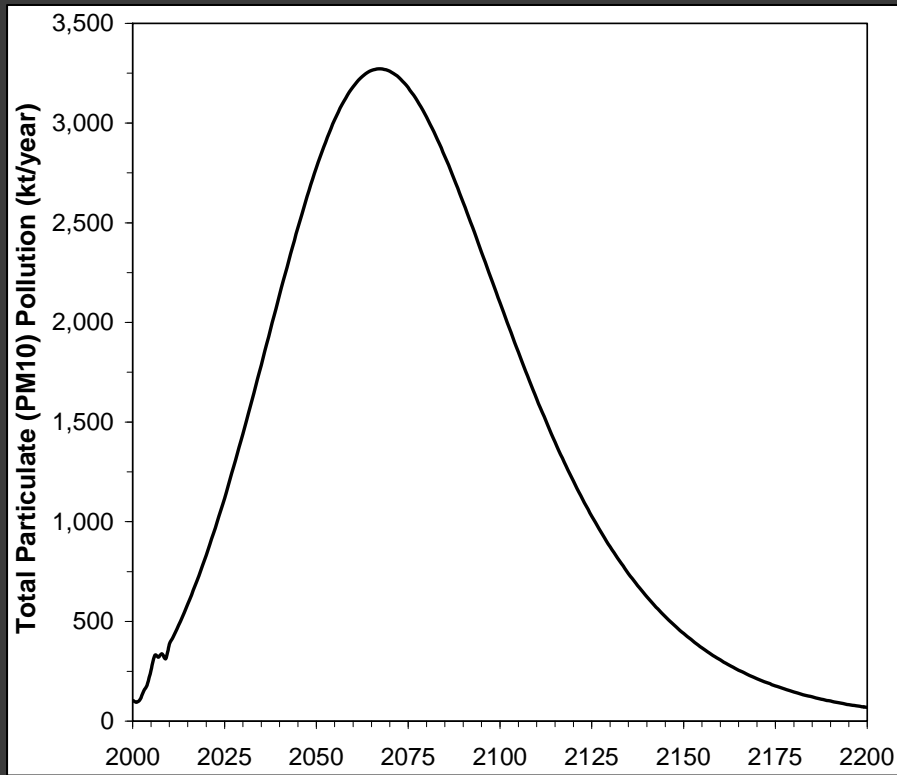
Emission Intensity Associated with Coal basis Electricity Generations; Top 3 pollutants separately plotted



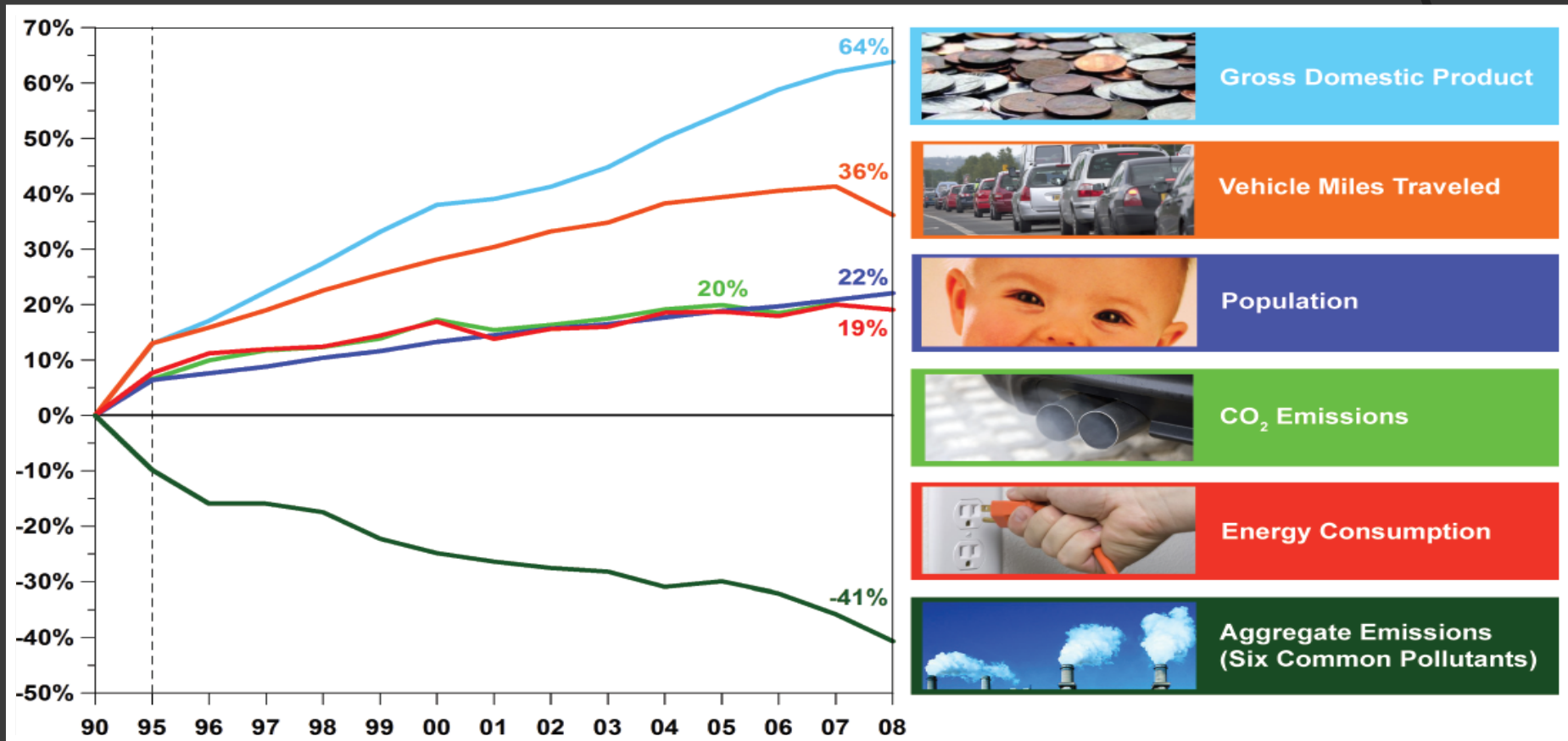
Note: Australian data is based on average emission data from financial year 1999 to 2008; Canadian data is based on national average of 2007 whilst U.S.A. is average of 2005

Australian Air Pollutant Releases and Emissions Intensity Forecast to 2200

Projected Australian Annual Coal-basis Pollutant Emissions to 2200



Comparison of Economic Growth and Emissions in USA, 1990 to 2008



(USEPA, 2008)

Conclusion

- Coal production will continuously grow until 2050. Shifting from high quality coals to low quality coals are common among all forecasts. Therefore significant decline in coal quality are inevitable, especially after 2050s
- Coal quality doesn't necessarily influence pollution releases and emission intensity associated with coal mining and electricity generation(etc. VIC), however the pollution control technologies and facilities do.
- Significant increase in coal production until 2050s could cause simultaneously pollution increase. This could offset the effort we put in current coal basis clean technologies and equipments.
- Inconsistency, various classifications, different monitoring, reporting systems and low quality of pollution data for coal industry then limit the effectiveness of Modelling

Questions?