



# Emissions Reductions from Co-burning Ammonia with Coal in Japan: The Need For Green Ammonia

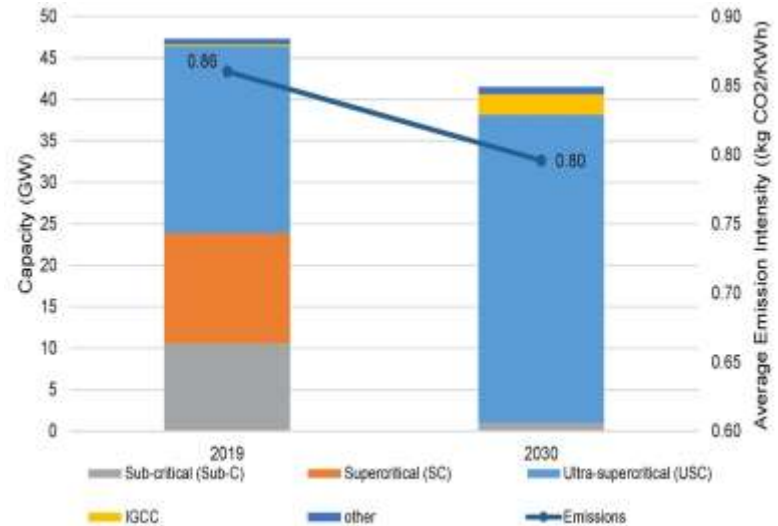
Matthew Stocks, Reza Fazeli, Llewelyn Hughes and Fiona Beck  
ANU Grand Challenge: Zero-Carbon Energy for the Asia-Pacific

# Why ammonia co-burning in coal power plants?

- Japan net zero by 2050 target
- Targeting significant emission reductions for Paris
  - 26% below 2013 levels by 2030
- 190MT of 310MT reduction is attributed to the power sector
- Coal is about 32% of total electricity generation

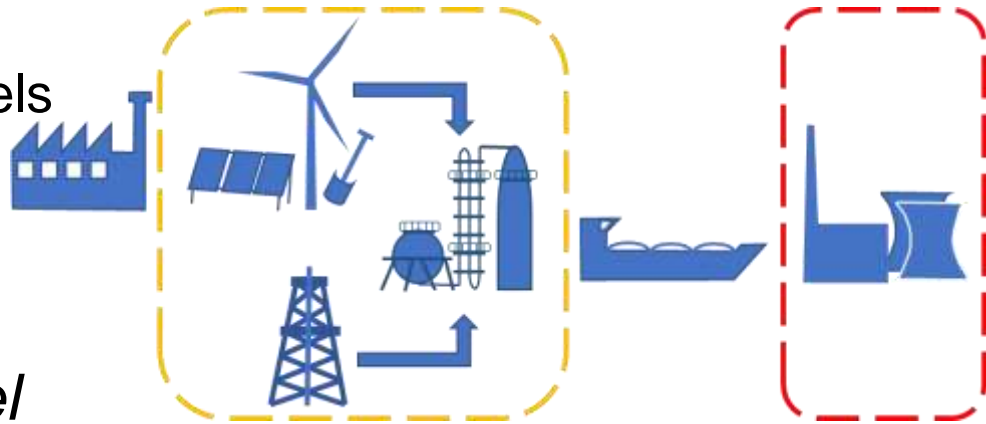
# Current policy Japan

- Natural coal retirements too slow
- Closure of all sub- and super-critical coal by 2030
- Energy efficiency expected to reduce replacements
- Expect about 19% reduction in coal electricity generation emissions



# Country level emissions

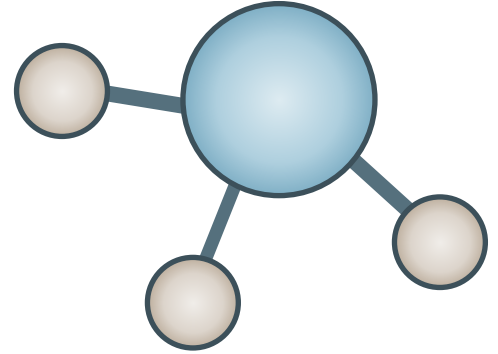
- Australia largest supplier of thermal coal to Japan
- Japan exploring low carbon fuels
- Partnering with Australia in hydrogen production



- *What are the country level implications of low emissions fuel transition?*

# Ammonia as fuel

- No GHG emissions in combustion
- Existing global supply chain (fertiliser)
- Easy to liquefy and transport
- Existing use in coal plants for  $\text{NO}_x$  suppression
- Low flammability/flame speed, high ignition temperature
- 20% ammonia (LHV) combustion with pulverised coal demonstrated at scale



# Ammonia production

BAT Steam Methane Reforming/Haber-Bosch (SMR/HB)

Highly integrated energy flows

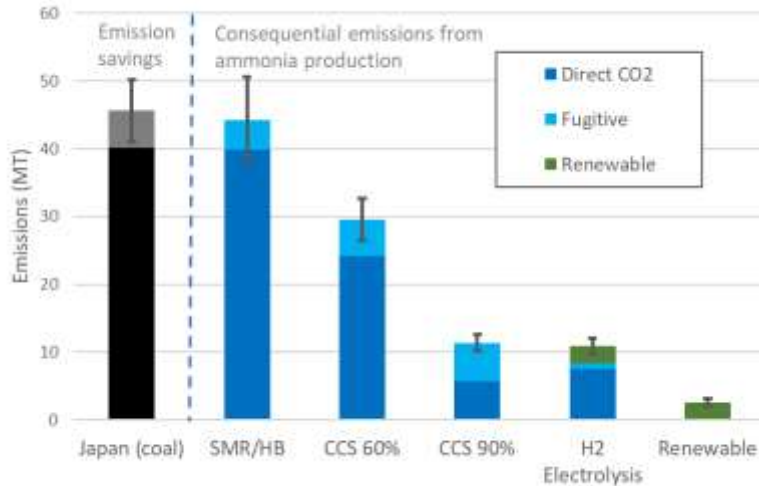
- $\text{H}_2 \quad \blacktriangleright \quad 2\text{H}_2\text{O} + \text{CH}_4 + \text{energy} \Rightarrow 4\text{H}_2 + \text{CO}_2$
- $\text{NH}_3 \quad \blacktriangleright \quad \text{N}_2 + 3\text{H}_2 \Rightarrow 2\text{NH}_3$  (exothermic but energy for compression/separation)

Five alternatives explored

- SMR/HB with 0%/60%/90% CCS in  $\text{H}_2$  SMR process
- Hydrogen electrolysis injected in standard SMR process
- Fully renewable ammonia (electrolysis + electric HB)



# National emissions



- BAT process no change in global emissions
  - Effective emissions transfer from Japan to Australia
- CCS benefit diminished by fugitive emissions
- 100% renewable process reduces emissions in Japan and Australia



# Summary and Conclusions

- Ammonia co-combustion actively pursued in Japan
- Significant emission differences between ammonia production approaches
- 100% renewable ammonia reduces net emissions in Japan and Australia
- Carbon policy will be key driver of pathway
- [Ammonia working paper](#) on ZCEAP website

