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Carbon Footprint Scenarios for Renewable Electricity Generation in Australia

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SUSTAINABILITY ASSESSMENT PROGRAM

Rationale

- Growing electricity consumption
  - 143% (2012 – 2050)
- Electricity generation is the largest emitting industry
  - 35 % of total GHGE (2012)
- Government targets:
  - 80% reduction of GHGE (2000 – 2050)
  - 30 TWh electricity from renewables in 2020
- Many low carbon options
  - Great potential for decarbonisation

(Geoscience Australia and ABARE 2010; ClimateWorks et al. 2014; Dpt. of Climate Change and Energy Efficiency 2014; Elliston et al. 2014; Froome 2015)

Scope

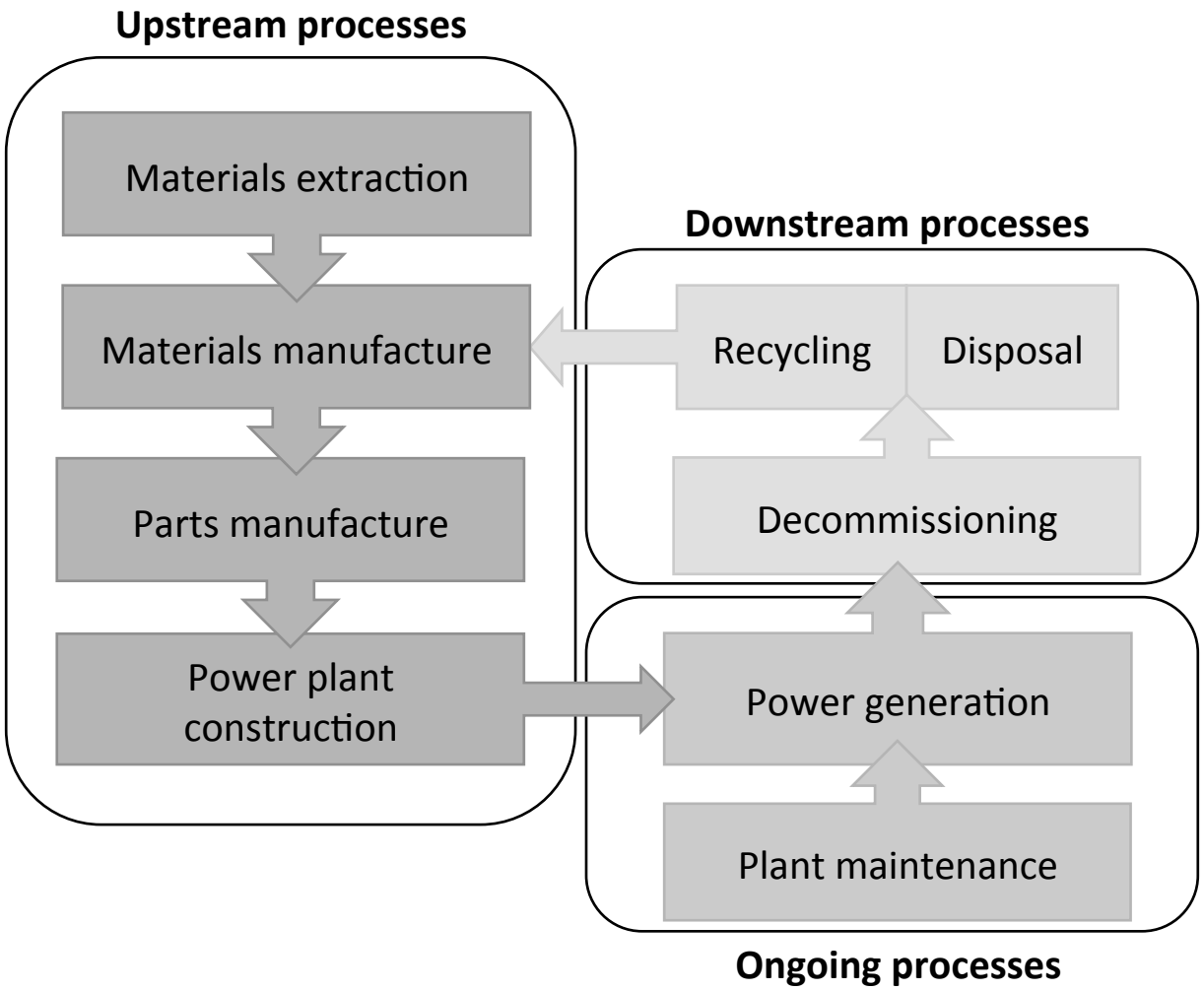
- Hydro (run-off river and reservoir)
  - Most mature renewable fuel
  - Reservoir facilities produce main output
- Wind (onshore and offshore)
  - Dramatic growth over last 10 years (30% p.a. on average)
  - One offshore project planned in SA
- Solar PV (Cadmium Telluride)
  - PV is the fastest increasing renewable technology in Australia
  - Higher future growth of CdTe than c-Si PV
- Concentrated solar thermal (parabolic trough)
  - 40% of total energy mix by 2050
  - Differences in emissions are small
- Geothermal (hot dry-rock)
  - Only two operating so far
  - Hot dry-rock is most advanced design option

(ClimateWorks et al. 2014; CEC 2014; Bahadori et al. 2013; IEA 2010; NREL 2012)

Research Question

- How “climate friendly” is the large-scale implementation of renewables?
  - How large is the carbon footprint of these energy carriers?
  - How much total emissions are emitted during the whole life cycle?
  - How big are indirect emissions caused along the supply chain?
  - Which materials are especially carbon intensive?
  - Which energy option performs better?
  - Can the 80% target be achieved by decarbonising the electricity sector?

Method: Life Cycle Assessment



(Dolan and Heath 2012)

Method: Input-Output Analysis

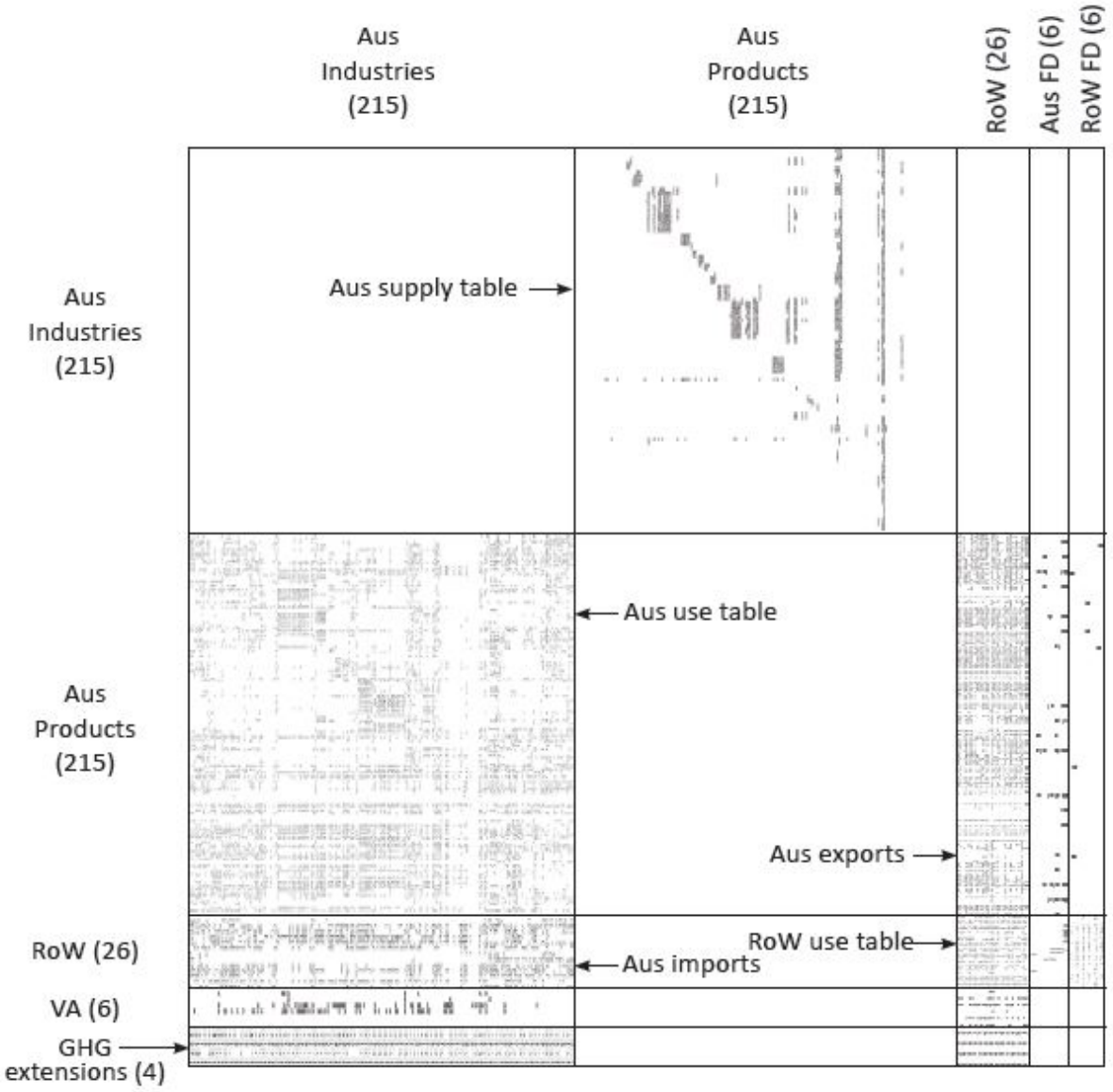
Two-region Supply-and-Use Table:

Australia:

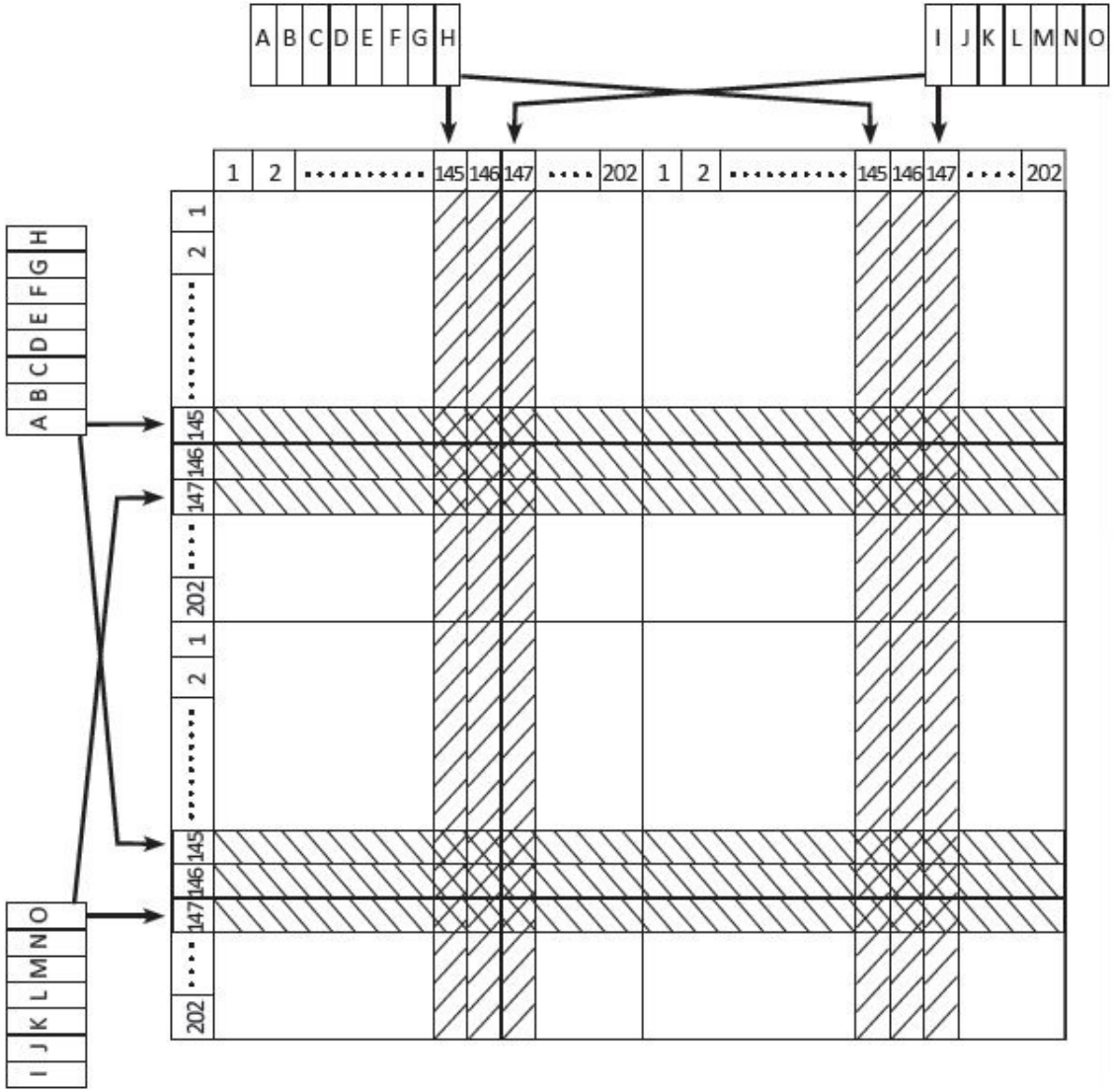
215 sectors from IELab

RoW:

26 sectors from Eora

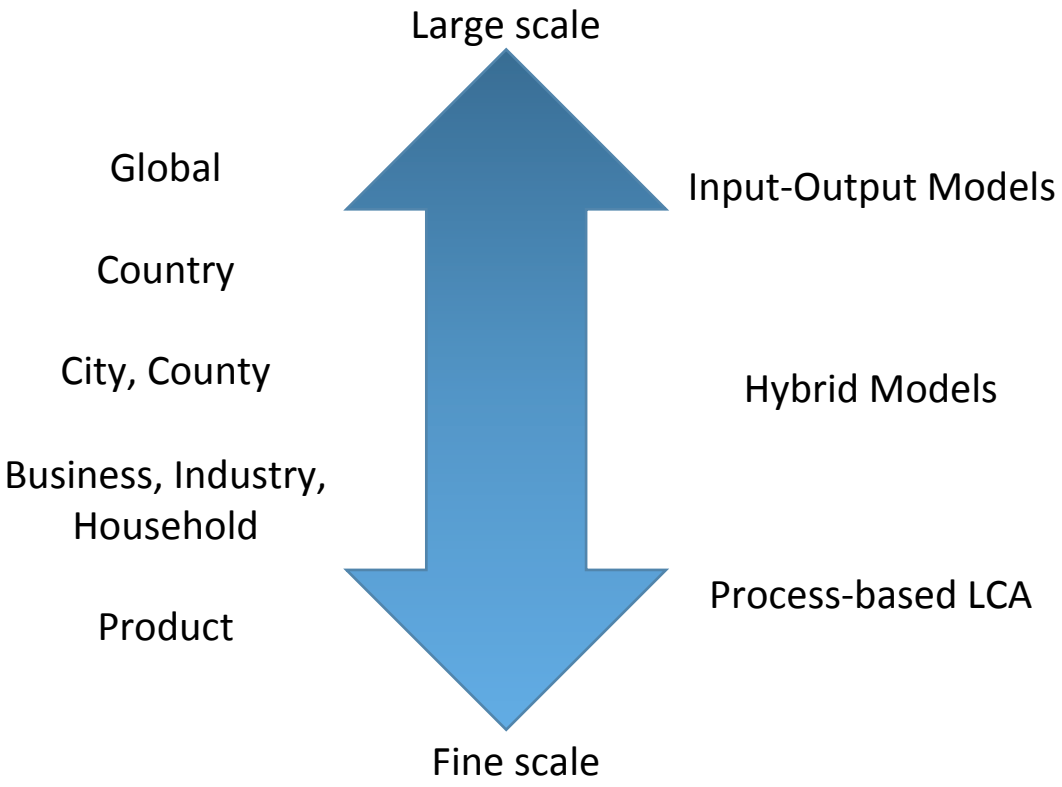


Method: Disaggregation of the Electricity Sector



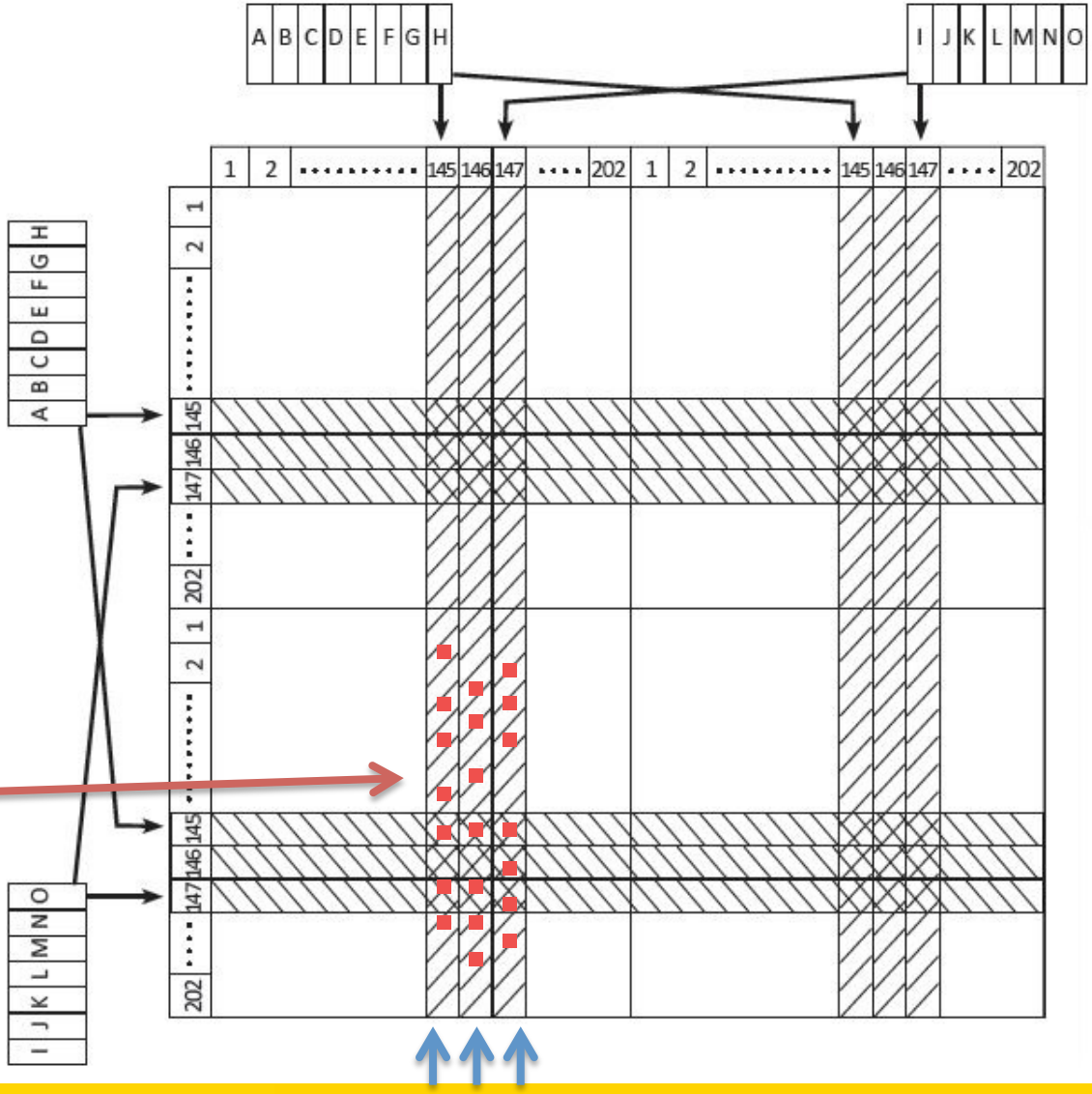
Method: Hybrid Life Cycle Assessment

- Hybrid Input-Output-based Life Cycle Assessment
  = Combination of Input-Output Analysis and Process-based LCA

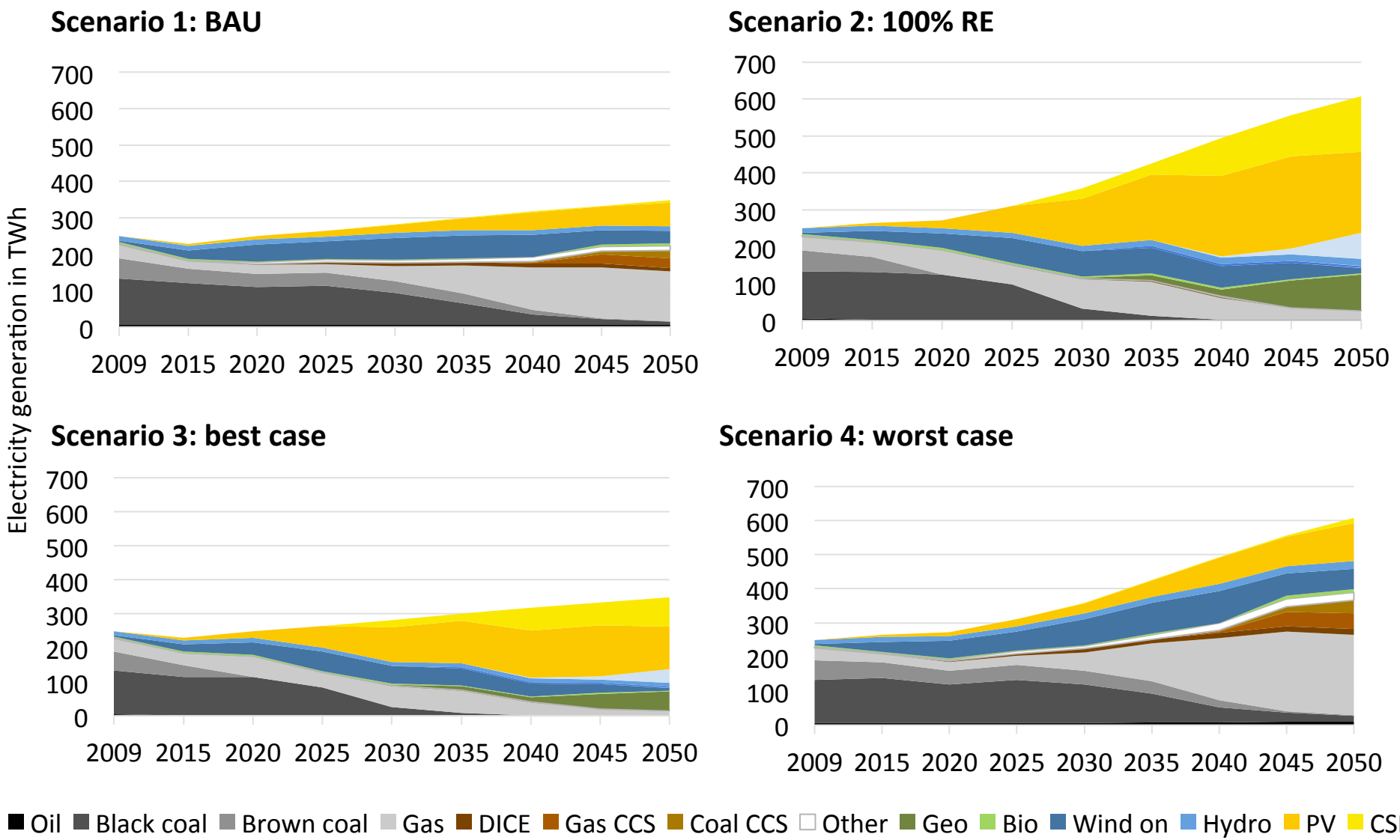


(Peters 2010)

Method: Disaggregation of the Electricity Sector

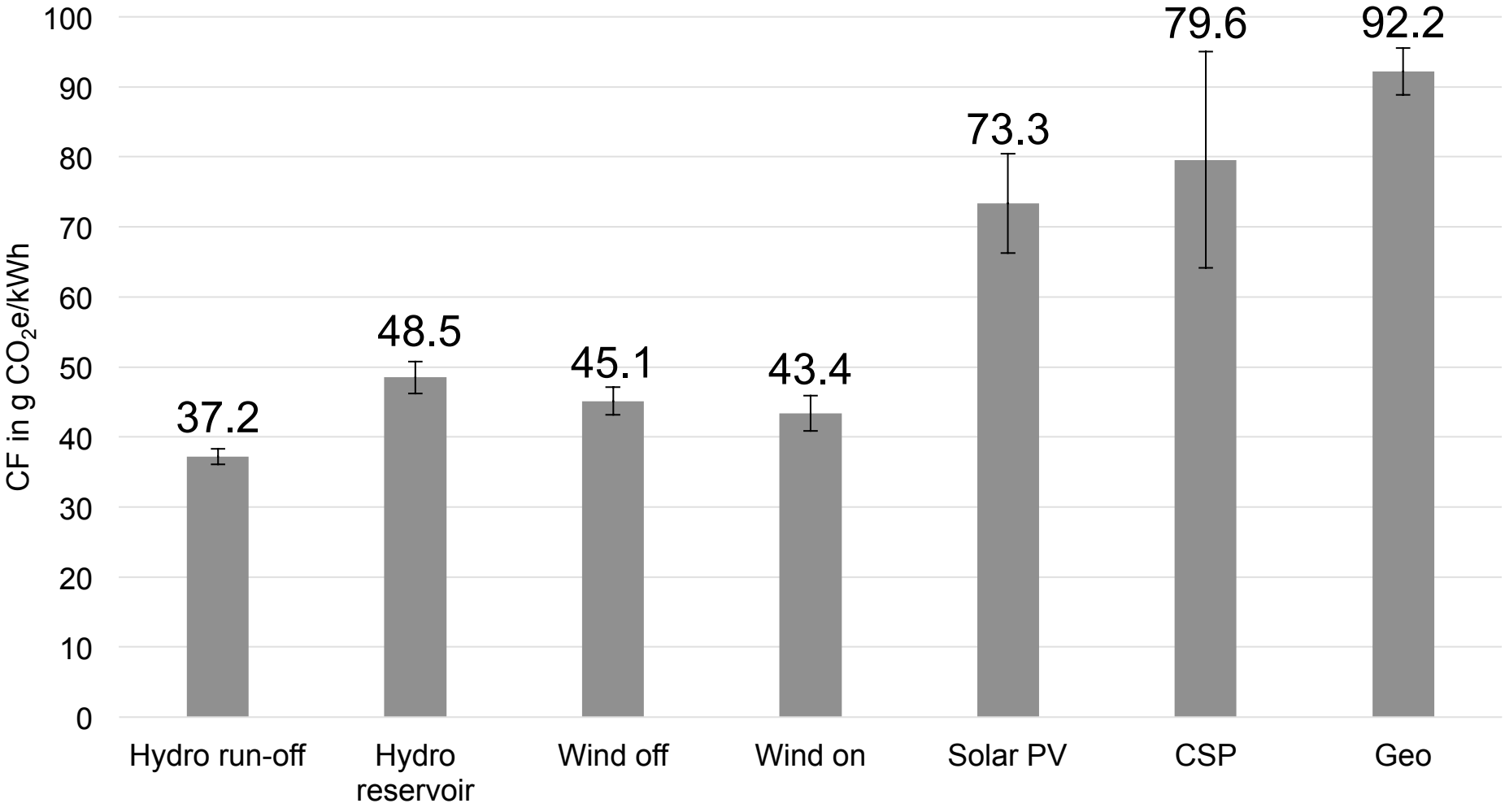


Method: Scenario Analysis

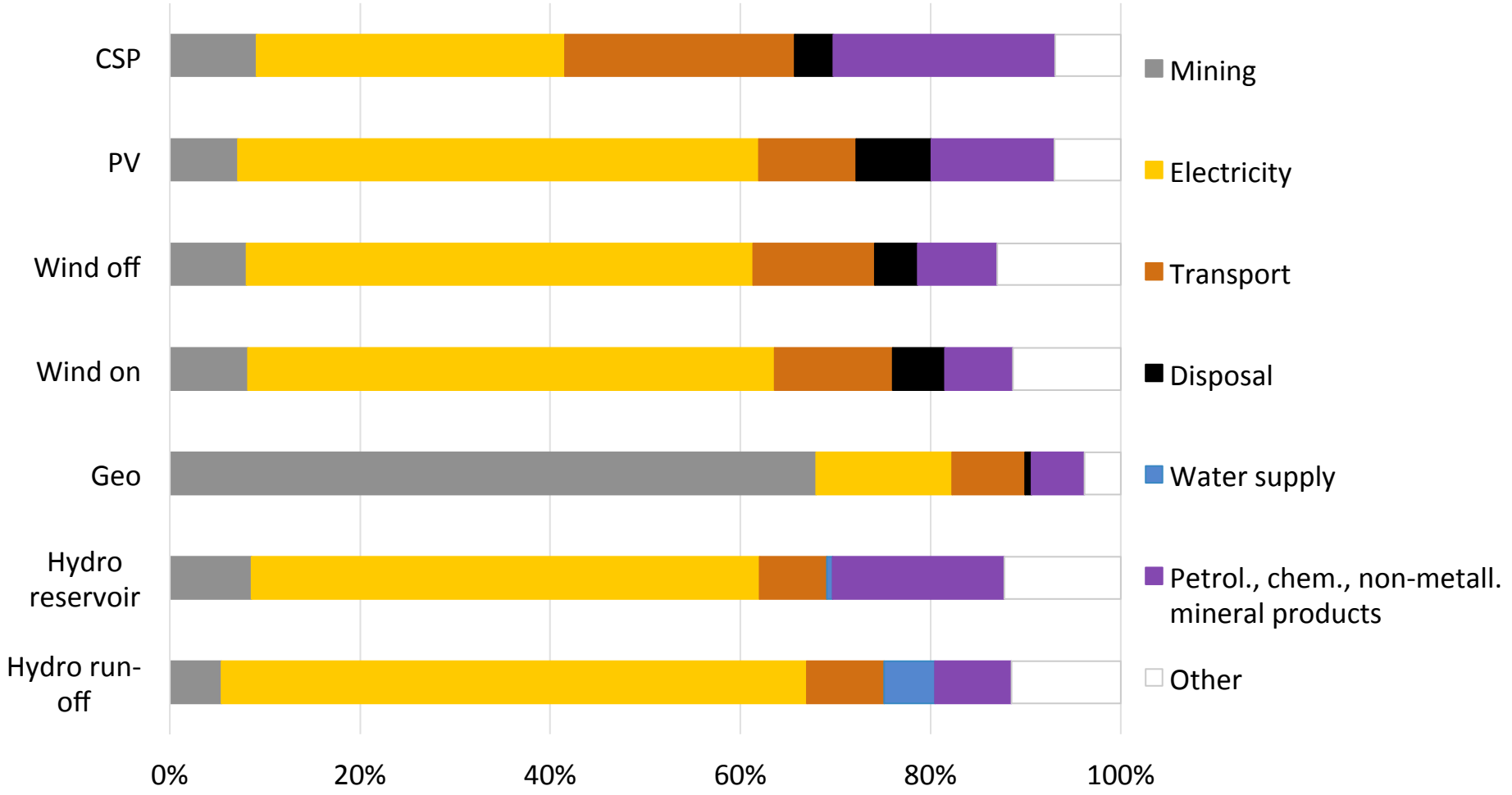


(CSIRO 2014, ClimateWorks et al. 2014)

Results: Carbon Footprints of Renewable Fuels

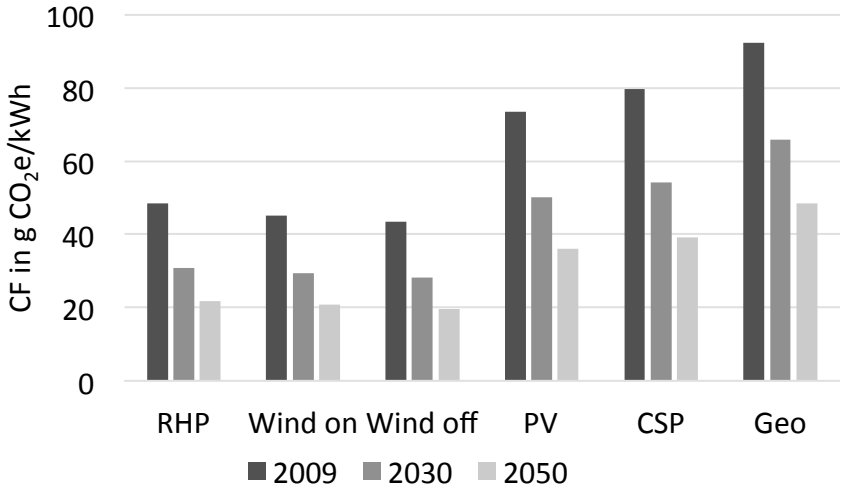


Results: Carbon Footprint Decomposition

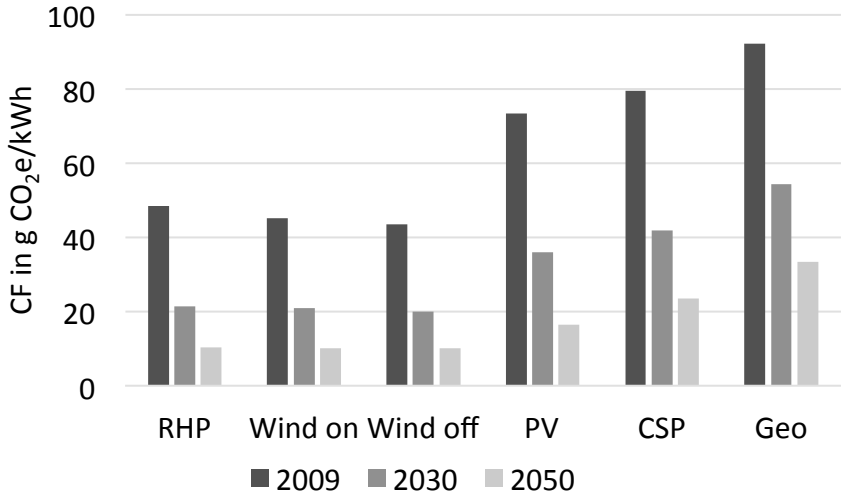


Results: Carbon Footprint Time Series

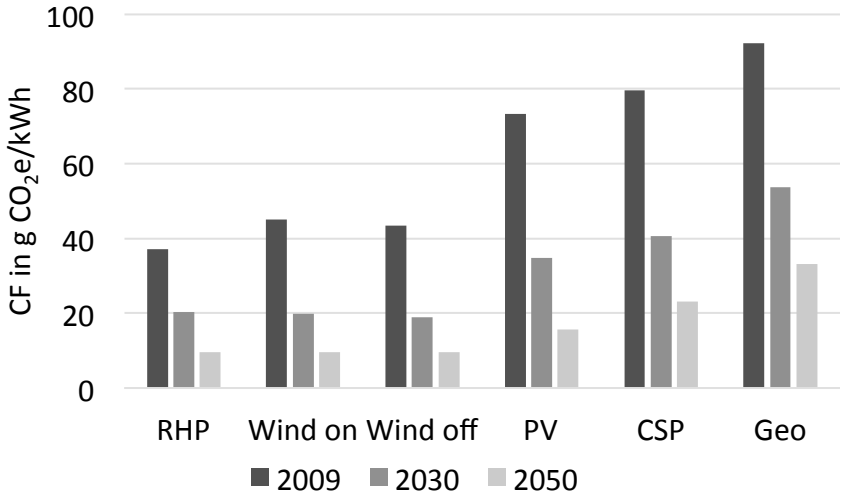
Scenario 1: BAU



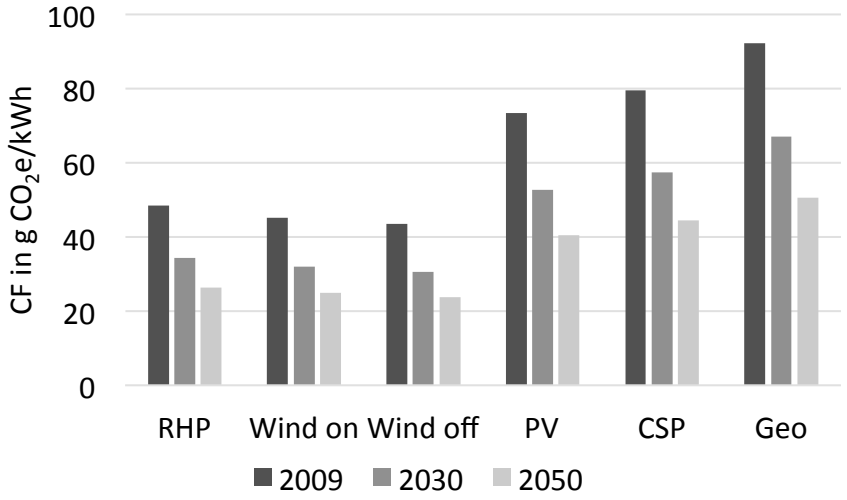
Scenario 2: 100% RE



Scenario 3: best case

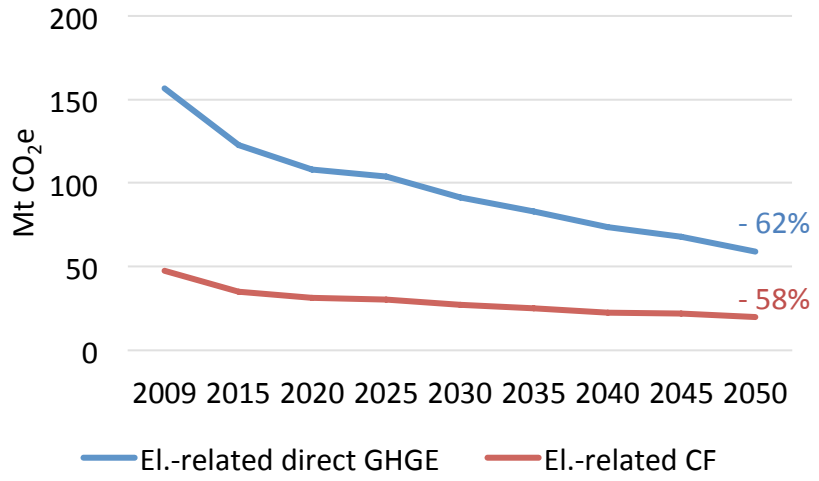


Scenario 4: worst case

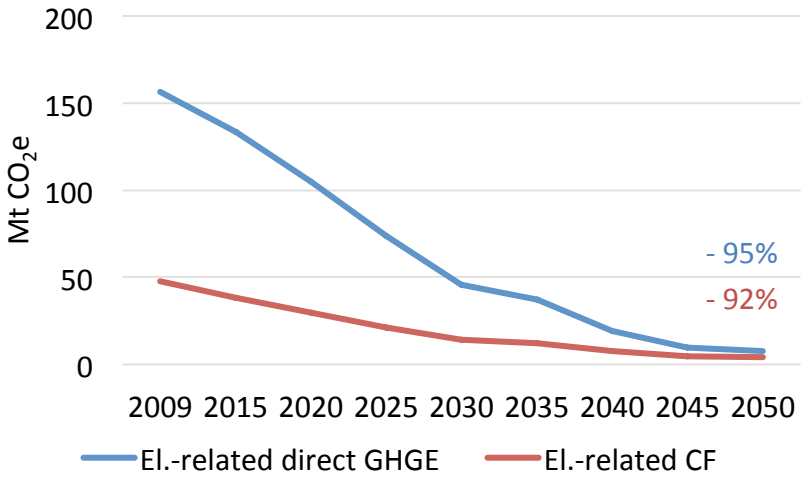


Results: Carbon Footprint vs. Direct GHGE

Scenario 1: BAU



Scenario 2: 100% RE



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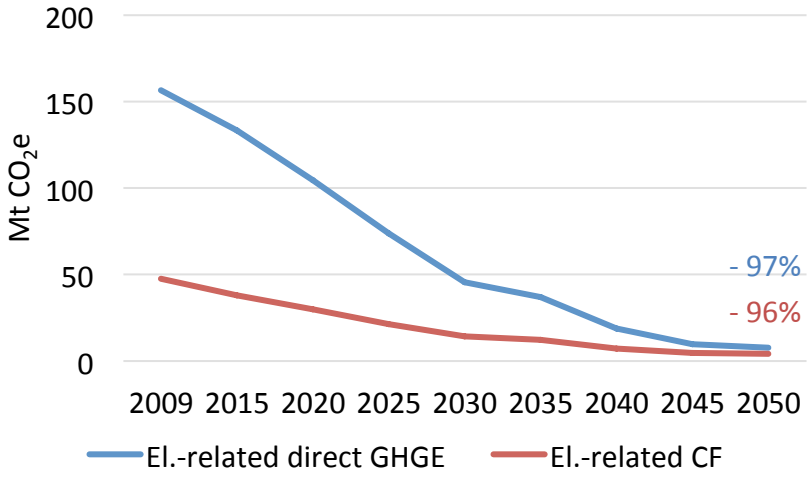
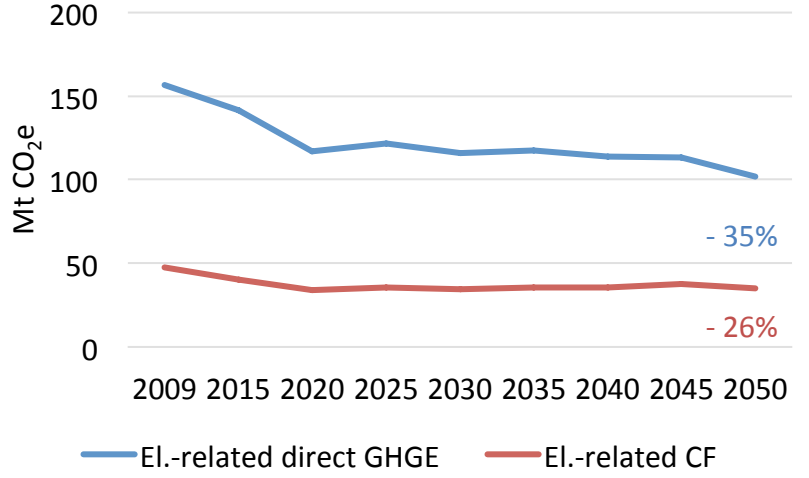
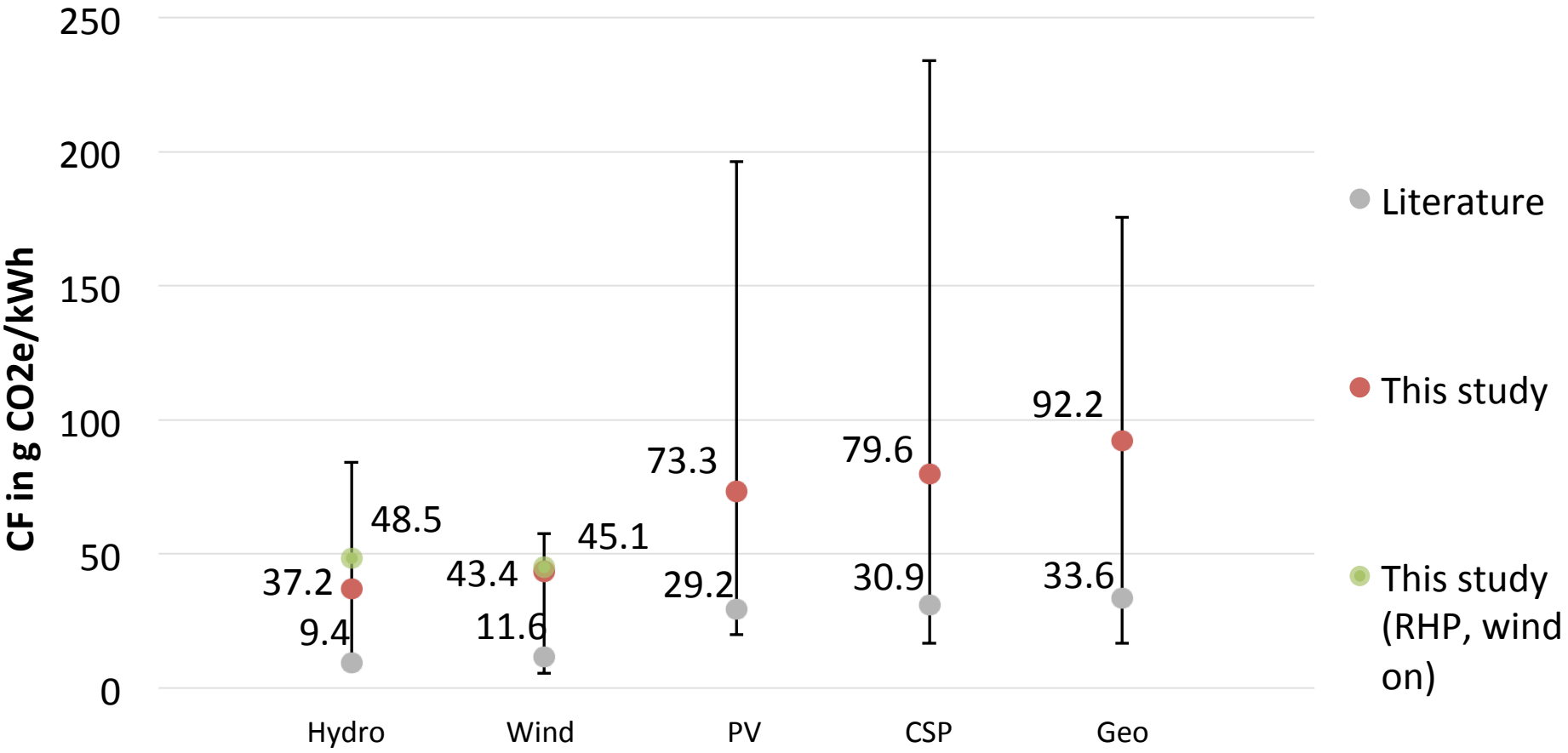


Scenario 4: worst case



Discussion: Comparison with Other Studies



(Asdrubali et al. 2014)

Discussion: Results and Implications

- Importance of accounting for indirect emissions
- Run-off river HP has the lowest CF
- More intensive penetration of renewables is desirable
- 80% target is not met
  - Best case: 19% / 27% (producer- / consumer-perspective)
- Need to decarbonise additional sectors
- Are technological advancements sufficient?

(ABS 2013)

Thank you!

Who‘s got the first question?

References

ABS. 2013. 4604.0 - Energy Account, Australia, 2011-12. available online at: http://abs.gov.au/ausstats/abs@.nsf/Lookup/4604.0main+features42011-12#USE%20OF%20ENERGY.

Asdrubali, F., G. Baldinelli, F. D'Alessandro, F. Scrucca. 2015. Life cycle assessment of electricity production from renewable energies: Review and results harmonization. *Renewable and Sustainable Energy Reviews* 42 1113–1122.

Australian Government, Department of Climate Change and Energy Efficiency. 2014. Fact sheet: Australia's Emissions Reduction Targets. Canberra, Australia: Australian Government.

Bahadori, A., C. Nwaoha, S. Zendehboudi and G. Zahedi. 2013. An overview of renewable energy potential and utilisation in Australia. *Renewable and Sustainable Energy Reviews* 21 582–589.

CEC. 2014. Clean Energy Australia Report 2013. Australia: Clean Energy Council.

CSIRO. CSIRO eFuture - Explore scenarios of Australia's electricity future. Available online at: http://www.efuture.csiro.au/.

ClimateWorks Australia, ANU, CSIRO and CoPS. 2014. Pathways to Deep Decarbonisation in 2050: How Australia can prosper in a low carbon world: Technical report. Australia: ClimateWorks.

Crawford, R.H. 2006. Validation of the use of input–output data for embodied energy analysis of the Australian construction industry. *Journal of Construction Research* 6(1) 71–90.

Dolan, S.L. and G.A. Heath. 2012. Life Cycle Greenhouse Gas Emissions of Utility-Scale Wind Power. Systematic Review and Harmonization. *Journal of Industrial Ecology* 16(S1) 136-154.

Elliston, B., I. MacGill and M. Diesendorf. 2013. Comparing least cost scenarios for 100% renewable electricity with low emission fossil fuel scenarios in the Australian National Electricity Market. *Renewable Energy* 66 196-204.

Elliston, B., I. MacGill and M. Diesendorf. 2014. Least cost 100% renewable electricity scenarios in the Australian National Electricity Market. *Energy Policy* 59 270–282.

Geoscience Australia and ABARE. 2010. Australian Energy Resource Assessment. Report 2010. Canberra, Australia: Geoscience Australia and ABARE.

IEA. 2010. Energy Technology Perspectives: Scenarios & Strategies to 2050. Paris: International Energy Agency.

NREL. 2012. Life Cycle Greenhouse Gas Emissions from Concentrating Solar Power. Golden, CO: National Renewable Energy Laboratory.

Peters, G.P. 2010. Carbon footprints and embodied carbon at multiple scales. *Current Opinion in Environmental Sustainability* 2 245–250.