JOINT REPORT to the Land Court of Queensland on "Climate Change – Emissions"

Adani Mining Pty Ltd (Adani) v Land Services of Coast and Country Inc & Ors

EXPERT DETAILS

Dr Chris Taylor

My business address is URS Australia Pty Ltd, Level 17, 240 Queen Street, Brisbane, QLD 4000.

I am an environmental scientist with 15 years' postgraduate experience in academic research and environmental consultancy, specialising in atmospheric emissions, preparation of emissions inventories, greenhouse gas (GHG) assessments and climate change. I hold the following qualifications:

- MChem in Chemistry (1st class) from the University of Wales, Swansea, UK
- PhD in Atmospheric Chemistry and Climate Change from the University of Reading, UK

A/Prof Malte Meinshausen

My business address is 700 Swanston Street, Level 1, Lab 14 Carlton Connect, Department of Earth Sciences, The University of Melbourne, Parkville 3010, VIC.

Summary of experience:
I am an ARC Future Fellow and Associate Professor at the University of Melbourne in the areas of climate change projections, uncertainties, carbon cycle and international climate change policy, and Director of the Australian-German College of Climate & Energy Transitions at the University of Melbourne. I hold the following qualifications:

- Diploma in Environmental Sciences (Dipl. Env. Sc.) from the Swiss Federal Institute of Technology, ETH Zurich, Switzerland.
- M.Sc. of Environmental Change & Management (Distinction) from the University of Oxford, UK.
- PhD in Climate Change & Policy from the Swiss Federal Institute of Technology, ETH Zurich, Switzerland.

INSTRUCTIONS

We have been instructed to prepare a joint expert report on greenhouse gas and climate change issues for the Land Court of Queensland hearing of objections to the grant of Adani's mining lease (ML) and environmental authority (EA) applications for the mine component (Mine) of the Carmichael Coal Mine and Rail Project (Project).

The scope of this report is the current scientific understanding of climate change, quantification of emissions from the proposed Carmichael Mine (the Mine) and the contribution of those emissions to climate change. This report does not discuss other issues, such as coal supply chain economics.

JOINT REPORT

1. The Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5), published in 2013 and 2014, represents the most comprehensive scientific assessment of the causes, impacts and mitigation measures for climate change to date.

2. The Commonwealth Government report entitled The Critical Decade 2013 climate change science, risks and responses provides a comprehensive synthesis of climate change science with an Australian national focus.

3. The 2010 Queensland Government report entitled Climate Change in Queensland: What the Science is Telling Us provides a comprehensive synthesis of climate change science with a Queensland focus.

4. Human influence on the climate system is clear, and recent anthropogenic emissions of greenhouse gases are the highest in history. Recent climate changes have had widespread impacts on human and natural systems:

    a. Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, and the sea level has risen.

    b. Anthropogenic greenhouse gas emissions have increased since the pre-industrial era, driven largely by economic and population growth, and are now higher than ever. This has led to atmospheric concentrations of carbon dioxide (CO_2), methane and nitrous oxide that are unprecedented in at least the last 800,000 years. Their effects, together with those of other anthropogenic drivers, have been detected throughout the climate system and are extremely likely to have been the dominant cause of the observed warming since the mid-20th century.

c. Emissions of CO_2 from fossil fuel combustion and industrial processes contributed about 78% of the total greenhouse gas emissions increase from 1970 to 2010, with a similar percentage contribution for the increase during the period 2000 to 2010 (high confidence).

d. In recent decades, changes in climate have caused impacts on natural and human systems on all continents and across the oceans.

5. Continued emission of greenhouse gases will cause further warming and long-lasting changes in all components of the climate system, increasing the likelihood of severe, pervasive and irreversible impacts for people and ecosystems. Limiting climate change would require substantial and sustained reductions in greenhouse gas emissions which, together with adaptation, can limit climate change risks.

6. Without additional mitigation efforts beyond those in place today, and even with adaptation, warming by the end of the 21st century will lead to high to very high risk of severe, widespread, and irreversible impacts globally (high confidence).

7. The objective of the United Nations Framework Convention on Climate Change (UNFCCC) is to avoid dangerous interference with the climate system. To meet this objective, Australia and other parties to the UNFCCC envisaged in 2009 a goal to limit the increase in global temperatures to 2°C goal and decided in 2012 to work towards the deep emission reductions required.

8. Australia has pledged to reduce its GHG emissions by five per cent below 2000 levels by 2020. Additional, more significant cuts have been pledged depending on global action towards stable levels of GHGs in the atmosphere. All of these targets are based on net national emissions and, therefore, do not include emissions associated with fuel exported to be used by other nations. India and China, where the majority of product coal from the Mine is expected to be used, have pledged to reduce their emission intensity and/or to peak emissions. However, they have not yet pledged absolute emission reductions

or caps. Recent announcements by China only specified that Chinese national CO_2 emissions will peak before 2030, but the peak level has not been quantified – meaning that additional coal use in China until 2030 could lead to higher emissions up to 2030 and beyond. Existing and any future commitments made by India and China could cover emissions from their own national power generation and hence could affect the scope 3 emissions associated with this Mine. For example, China's Climate Change Action Plan places a limit on coal use for primary energy supply from 2020. China is also carrying out trials of emissions trading schemes in seven cities and provinces, and is planning to implement a national emissions trading scheme to start in 2016.

9. Approaching 2ºC warming there will be significant impacts in Queensland, Australia and globally, including:

    a. In Queensland:
        i. a decline in environmental values including the Great Barrier Reef (IPCC AR5 WGII, 2014; Climate Commission, 2013, p.5 and p.74, Queensland Government, 2010, p.2);

        ii. increased flooding, erosion and damage in coastal areas due to increased numbers of severe tropical cyclones and sea level rise (Queensland Government, 2010, p.15, 25, 27, 38, 40);

        iii. significant increase in heat-related deaths and diseases (Climate Commission, 2013, p. 60-61; Queensland Government, 2010, p.66);

        iv. reduced water availability and increased frequency of droughts, affecting agricultural production (Climate Commission, 2013, p. 65); and

        v. coastal erosion due to sea level rise, projected to be about 40cm higher than today by the late 21st century (IPCC AR5 WG1, 2013).

    b. In Australia:

i. more frequent heat waves (IPCC AR5 WG1, Table SPM.1; Queensland Government, 2010, p.3); and

ii. more frequent and/or more intense droughts (IPCC AR5 WG1, Table SPM.1, Queensland Government, 2010, p.3).

c. Globally:

i. Climate change will amplify existing risks and create new risks for natural and human systems. Risks are unevenly distributed and are generally greater for disadvantaged people and communities in countries at all levels of development. Increasing magnitudes of warming increase the likelihood of severe, pervasive, and irreversible impacts for people, species and ecosystems. Continued high emissions would lead to mostly negative impacts for biodiversity, ecosystem services, and economic development and amplify risks for livelihoods and for food and human security. (IPCC AR5 SYR, p.24)

ii. From a poverty perspective, climate change impacts are projected to slow down economic growth, make poverty reduction more difficult, further erode food security, and prolong existing and create new poverty traps, the latter particularly in urban areas and emerging hotspots of hunger (medium confidence). (IPCC AR5 SYR, p.11)

10. As emissions of CO_2 effectively accumulate in the atmosphere it is the cumulative, not annual, CO_2 emissions that matter for long-term climate change. Thus, whether a project's emissions occur over 60 years or 5 years does not matter for end-of-century climate change or eventual peak warming; what matters are the cumulative emissions. The biophysical reason that cumulative emissions matter is the long time (many hundreds of years to thousands of years) for natural processes in the Earth's system to remove CO_2 that has been added to the carbon cycle (the atmosphere, the oceans and the land biosphere) due to human activity, such as by burning fossil fuels.

Warming caused by CO_2 emissions is effectively irreversible over multi-century timescales.

11. The expected lifetime of the Mine is 60 years. During this time it, and the power stations that it will supply, could to different extents be subject to national and international policies on GHG emissions. Thus, the full emissions associated with the mine might not be realised, if emissions are restricted such that warming is limited to 2 degrees.

12. When carrying out an assessment of the extent that the Mine causes additional cumulative emissions, the Mine cannot be viewed in isolation, but should be seen in terms of the change in global net emissions. The fundamental question that must be answered is to what extent a project or policy will result in a change in global emissions. There is a net change to global emissions to the extent emissions associated with the Mine are not offset by a reduction in emissions elsewhere, or to the extent that they would otherwise occur even if the Mine were not approved. All Emissions from the burning of product coal from this Mine will have a climate impact in the physical cause-effect sense. If those climate impacts are additional to what would have occurred in the absence of the Mine's approval depends on the extent the Mine increases global coal consumption. The calculated cumulative emissions associated with the project, therefore, should be seen as a worst-case net change in global emissions.

13. The impacts of climate change due to CO_2 emissions from fossil fuels such as coal are effectively irreversible for the next millennium, unless measures are taken to remove CO_2 from the atmosphere. Global temperatures will not fall significantly from their peaks for at least a millennium due to CO_2 emissions this century. Induced rises in sea level are even likely to continue to increase over that time period, unless CO_2 is removed from the atmosphere.

14. There are multiple mitigation pathways that, if implemented, would be likely to limit warming to below 2°C relative to pre-industrial levels. These pathways would require substantial emissions reductions over the next few decades and near zero net emissions of greenhouse gases by the end of the century. This

would require negative net CO_2 emissions to offset the remaining positive non-CO_2 greenhouse gases by the end of the century.

15. A global carbon budget of no more than about 1,000 gigatonnes of CO_2 is still available after 2011 in order to stay under the 2°C climate limit with a likely chance (66% likelihood or higher). Assuming at least 2010 emission levels of 37 gigatonnes CO_2 of total CO_2 emissions for the years 2012-2015, the remaining carbon budget for after 2015 is 850 gigatonnes CO_2.

16. Exploitation of the current proven reserves of coal could result in emissions of approximately 4,000 to 7,000 gigatonnes of CO_2 which would vastly exceed 2°C warming, unless carbon capture and storage becomes viable.

17. Dr Taylor has recalculated emissions from the Mine using updated emissions factors from the National Greenhouse Accounts Factors where appropriate. Dr Taylor has also estimated Scope 3 emissions associated with the Mine using the assumptions detailed in Annex 1. Scope 3 emissions include transport by rail, shipping and combustion of the product coal. Scope 1, 2 and 3 emissions are presented in Table 1. Prof. Meinshausen has calculated emissions from the burning of product coal using its estimated average ash content, moisture content and carbon content. Full assumptions are shown in Annex 1. The calculated total of 4.49 gigatonnes CO_2 is consistent with Dr Taylor's calculations of 4.64 gigatonnes CO_2, which include emissions from rail and shipping of the product coal.

Table 1 – Scope 1, 2 and 3 emissions associated with the Mine

Scope	Annual average emissions (tCO_2-e)	Life of mine emissions (tCO_2-e)
Scope 1	628,723	37,723,358
Scope 2	808,898	48,533,904
Scope 3	77,395,516	4,643,730,979
Scope 1+2	**1,437,621**	**86,257,262**
Scope 1+2+3	**78,833,137**	**4,729,988,241**

18. Using the above estimates, the cumulative emissions proposed to be authorised are approximately 0.53-0.56% of the carbon budget that remains after 2015 to have a likely chance of not exceeding 2 degrees warming.

19. As noted above, this is an estimate of a worst-case or maximum impact on net global emissions. The change in net global emissions would depend on the net change in global coal consumption resulting from the approval of the Mine, whether carbon sequestration and storage technology is used when burning the coal, and whether the projected amount of coal would be produced over the course of the lifetime of this mine or limited before its end-of-lifetime (e.g. due to new climate policies).

20. Although cumulative emissions are important for assessing the Mine, it is significant that these emissions will occur over at least 60 years. At current global emission rates (that is assuming no further growth in emissions) the stated global carbon budget would be exceeded approximately 20 years from now, by which time less than one third of the calculated cumulative emissions associated with the Mine would have occurred.

21. Current international pledges to reduce emissions are insufficient to achieve the stated goal of limiting warming to 2 degrees. Therefore, if this goal is to be achieved, significant changes in national and international policies and practices relating to GHG emissions would be required during the life of the Mine. If these occur, the Mine and the power stations that it supplies could potentially be subject to the resulting national policies and legislation e.g. by implementing carbon capture and storage, revoking operation licenses or setting economic incentives to discontinue operation. Any emissions associated with the Mine could, therefore, be regulated under these policies, the production could be limited and/or the emissions could form part of the global emissions that would be released before the 2 degree warming threshold is crossed. Approval of the Mine, therefore, could be either consistent or inconsistent with the goal of limiting warming to 2 degrees, depending on a range of external factors such as coal supply chain economics, whether there is a potential premature end of the project before its end-of-lifetime, and to what

degree carbon sequestration and storage is used when burning the coal – with some factors beyond the scope of this report.

22. The cumulative emissions related to this mine (4.49 or 4.64 gigatonnes CO_2-e) are amongst the highest in the world for any individual project, and – to the knowledge of the authors – the highest in the Southern Hemisphere. Compared to the global level, annual coal production will be approximately 0.8% of global production in 2013. Associated emissions from burning the coal will be equivalent to approximately 0.2% of current global GHG emissions. The annual emissions associated with the Mine could be equivalent to approximately 14% of Australia's base year greenhouse gas emissions in the year 2000 (567 Mt). Taking into account carbon embedded in Australia's current coal and gas exports (940 Mt), this fraction would be lower, i.e. approximately 5% of base year emissions. Whilst the burning of the coal would not fall within Australia's national greenhouse accounts, the magnitude of the annual emissions associated with the burning of the coal would be equivalent to approximately three times Australia's annual emissions reduction target of 5% below 2000 levels by 2020.

Annex 1 – Emissions Calculations

A – Calculations based on the carbon content.

1. The cumulative downstream emissions authorised by the proposed Mining Lease and Environmental Authority can be estimated from average ash content, moisture content and carbon content of the product coal in addition to any emissions resulting from using coal from the overburden.

2. The assumptions for estimating downstream emissions from burning the product coal of cumulatively approximately 4.49 gigatonnes CO_2 are:

    a. Produced Product coal from the underground and opencut coal seams over the life of the mine of 720,330,921 tonnes and 1,606,215,072 tonnes, respectively (information provided by project proponent).
    b. An average ash content of approximately 24% for the underground and 31% for the opencut coal seams of this Mine (estimated from average of coal seams D, E and F (underground) and AB (opencut) in Table 4.17 Coal Seam Average Quality Results in EIS Volume 2, Document 2.04 at Table 4-16).
    c. A total moisture content of approximately 3.2% for the underground and 4.5% for the opencut coal seams (estimated from average of coal seams D, E and F (underground) and AB (opencut) in Table 4.17 Coal Seam Average Quality Results in EIS Volume 2, Document 2.04 at Table 4-16).
    d. An average carbon content on the dry ash free basis of approximately 79.2% and 78.3% for the underground and opencut coal seams, respectively (information provided by project proponent).

The above assumptions, especially those detailed under 2.b and 2.c are subject to uncertainty. However, as the agreement with the alternative estimation method in section B below shows, there is broad agreement between the two results.

B – Calculations based on the energy content.

3. Emissions may also be calculated using the expected average energy content of the product coal (21.78 GJ/kg), the volume of coal (noted above) and the National Greenhouse Accounts emission factor for coal power generation (88.43 kg CO2-e/GJ).

4. Other life of mine scope 3 emissions include:
    a. Rail transport in Queensland (updated from the EIS using 2014 emission factors) of 38,535,293 t CO_2-e
    b. International shipping of 309,375 t CO_2-e calculated assuming:
        i. average distance by sea of 4,688 nm
        ii. large cape size 220,000 DWT vessels emission factor of 2.5 g CO2-eDWT/n mile (Man Diesel and Turbo, 2014, Propulsion Trends in Bulk Carriers)
    c. Negligible emissions from rail at the destination.

Annex 2 – Areas of disagreement.

23. Dr Taylor notes that the Terms of Reference (ToR) for the Project required the proponent to:

- Provide an inventory of projected annual emissions for each relevant greenhouse gas, with total emissions expressed in 'CO_2 equivalent' terms for the following categories:

  - scope one emissions, where 'scope one emissions' means direct emissions of greenhouse gases from sources within the boundary of the facility and as a result of the facility's activities

  - scope two emissions, where 'scope two emissions' means emissions of greenhouse gases from the production of electricity, heat or steam that the facility will consume, but that are physically produced by another facility.

- Briefly describe method(s) by which estimates were made.

24. Dr Taylor notes that the ToR follow GHG accounting convention in requiring calculations of scope 1 and 2 emissions only. In Australia, reporting obligations for scope 1 and scope 2 GHG emissions are set under the National Greenhouse and Energy Reporting Act 2007 and Regulations. These require corporations that meet specified thresholds to report annually on GHG emissions, energy use and energy production. Scope 3 emissions are not reported under NGER.

25. Dr Taylor notes that an Environmental Impact Statement (EIS) was submitted in November 2012 that addressed the requirements of the ToR regarding GHG emissions. Following public notification and submissions, a supplementary EIS (SEIS) was prepared. This provided an update to estimated scope 1 and 2 GHG emissions from the Mine.

26. Dr Taylor notes that Scope 3 emissions are not reported because the organisation does not have operational control of the emissions. The scope 3 emissions of one organisation are the scope 1 or 2 emissions of another;

including scope 3 emissions would, therefore, result in double counting in the national inventory. For example, burning of the product coal is a scope 3 emission for other parts of the supply chain such as the mine and operators of the rail, port and shipping involved in transporting the coal. It is a scope 2 emission of the end-user of the electricity and scope 1 emission of the power station. Under normal carbon accounting practices, emissions from the burning of the coal should, therefore, be attributed to the power station receiving coal from the Mine.

27. In response to Dr. Taylor's statements above, A/Prof Meinshausen notes he expected inventory practices in Australia to be outside the scope of this joint report. Furthermore, A/Prof Meinshausen notes that in order to estimate climate change impacts that result from a certain project, it does not matter which scope (1, 2 or 3) the emissions are resulting from. Distinguishing among scopes can be a relevant issue when it comes to building emission inventories, but seems irrelevant when it comes to assigning potential responsibility for additional emissions to a certain project. While the operational control over the emissions could be important when it comes to sulphate dioxide emissions or other pollutants, the burning of the coal will result in basically all carbon turned into carbon dioxide irrespective of the precise burning process. Thus, any operational control over the burning process (apart from carbon sequestration and storage, CCS) does not change the ultimate amount of CO_2 emissions resulting from the produced coal. Furthermore, the resulting climate change is the same, no matter where the CO_2 emissions occur geographically, whether in Australia or overseas. The *contribution* to climate change is hence unequivocally clear in a physical cause-effect sense, i.e. that mining coal from a permanent storage (the coal mine) will ultimately lead to higher CO_2 concentrations and climate change (unless the carbon is returned to a permanent storage, e.g. via CCS again).

28. A/Prof. Meinshausen further notes that a*ttributing responsibility* of the resulting climate change to either the action of (a) getting the carbon out of the ground in the first place or to (b) burning the coal for electricity or (c) to using the fossil-fuel generated electricity for energy services seems to be a value judgement, and outside the scope of this report. All three parts of the chain,

i.e., (a) mining, (b) coal-fired electricity production and (c) fossil-fuel related electricity use, can be jointly "responsible" – but the question of responsibility is unrelated to and hence cannot be answered by a reference to inventory accounting practices in Australia.

QUALIFICATION OF OPINION

Further information regarding coal quality of the underground and open cut mines would have been useful in estimating emissions associated with the Mine. However, broad agreement between alternative calculation methods shows that this uncertainty would not affect the findings of this joint report.

EXPERT STATEMENT

We confirm the following:

- the factual matters stated in this report are, as far as we know, true
- we have made all enquiries that we consider appropriate
- the opinions stated in this report are genuinely held by us
- the report contains reference to all matters we consider significant
- we understand our duty to the court and have complied with the duty
- we have read and understood the Land Court Rules as they apply to this report
- we have not received or accepted instructions to adopt or reject a particular opinion in relation to an issue in dispute in the proceeding.

Chris Taylor
cn=Chris Taylor, o=URS, ou,
email=chris.p.taylor@urs.com, c=AU
2014.12.23 19:48:21 +10'00'

.....

Chris Taylor, Brisbane, 22nd December 2014

Digitally signed by Malte Meinshausen
DN: cn=Malte Meinshausen, o=The University of Melbourne, ou=Department of Earth Sciences, email=malte.meinshausen@unimelb.edu.au, c=AU
Date: 2014.12.23 20:09:46 +11'00'

Malte Meinshausen, Melbourne, 22nd December 2014