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A handwritten signature in blue ink that reads 'Sia Lagos'.

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Important Information

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Supplementary Expert Report

Federal Court of Australia

Pabai & Anor v Commonwealth of Australia (VID622/2021) (Proceedings)

10 November 2023

Preamble and declaration

I have been asked to produce a supplementary expert report in response to a supplementary letter of instruction which is included at Annexure A. I have read the letter and responded to all questions asked in it. I have read, understood and complied with the Expert Evidence Practice Note (**GPN-EXPT**) of the Federal Court and the Harmonized Expert Witness Code of Conduct and agree to be bound by them.

All opinions expressed herein are my own and are based wholly or substantially on my specialised knowledge arising from my training and experience as a climate scientist. As with my initial expert report, in preparing this supplementary report I have been supported by Dr. Zebedee Nicholls who has acted as my research assistant in a number of assignments. Their previous experience (which is detailed in the curriculum vitae at Annexure C of my initial expert report) has given them the knowledge of the subject matter for them to effectively provide that support under my close supervision and direction

I have made all inquiries which I believe are desirable and appropriate and no matters of significance which I regard as relevant have, to my knowledge, been withheld from the Court. I have referenced all assumptions and material facts on which my opinions are based throughout my report.

A handwritten signature in black ink, appearing to read 'M. Meinshausen'.

Professor Malte Meinshausen
Geography, Earth and Atmospheric Sciences
The University of Melbourne
Parkville VIC 3052

Supplementary expert report

Question 1: Does anything in the Canadell or Pitman reports lead you to change or clarify the opinions expressed in your expert report dated 14 July 2023?

1. My answer: No.

Question 2: Do you disagree with any of the opinions expressed in the Canadell or Pitman reports? If so, please explain why.

2. I read the reports by Dr Pep Canadell and Prof Andy Pitman in relation to the specific questions they were asked to address. In the area of my specific expertise, I would like to offer three clarifications.

Clarification 1: Every GHG emission contributes to global warming.

3. In relation to paragraphs 37, in the first sentence of paragraph 41 Prof. Andy Pitman writes:

“Given global and regional climate models cannot separate the impact of a difference of 2 Watts per square metre,”

4. This statement has to be seen within the context that Prof. Andy Pitman provides in Paragraph 37 of his report. It would be categorically incorrect to interpret that statement as meaning, “2 Watts per square metre extra radiative forcing would not cause detectable and attributable differences in climate i.e. climate change”. The fact that two modelling ranges for two different scenarios overlap does not mean that they are identical. It also does not mean that we are unable to separate out the reasons for the variations.
5. In terms of analogies, the interior temperature of a house in Melbourne is determined by multiple factors, i.e., the insulation (which varies from house to house, just like the modelled effects of climate feedbacks vary from climate model to climate model), the fluctuations of the weather (a bit like the natural variability in the case of projected global-mean or regional temperatures) and any heating sources, like whether a gas oven is switched on or not (which is to be seen as a parallel to our anthropogenically induced radiative forcing effect of warming on the climate system). Even if the interior temperatures across houses that do and don't have gas ovens overlap (because temperature is determined by multiple factors, not just whether an oven is on or not), we can still determine the contribution of the gas oven to the interior temperature of houses.

6. In the climate change scientific literature, this part of science that considers different contributing causal factors is called "attribution", where individual weather events or regional climate effects are attributed to, for example, anthropogenically induced climate change. Many of these attribution studies exist already today (IPCC AR6 WG1 Box TS.10 "Event Attribution", pages 108-110 of the Technical Summary IPCC AR6 WG1¹).
7. Specifically, while some models might overlap in their temperature projections, despite differences in radiative forcing of 2 Watts per square metre, that does not mean that the forcing itself has no effect. *Ceteris Paribus*, we know that an increase in radiative forcing, particularly one as large as 2 Watts per square metre, has a warming effect. While there is the possibility that other factors may mask that effect at first sight, this masking does not mean there is no effect. If the same climate model with the same implementation of feedbacks (i.e. representing a particular understanding of how sensitive our Earth is to warming) is run twice, once with a 2 Watt per square metre higher and once with a 2 Watt per square metre lower forcing, there would be a difference in the resulting time series of modelled global and regional climate effects. That long-term difference might or might not be within the range of natural variability for one region or impact of interest, but again, being masked by other factors does not negate the established scientific fact that emissions cause an increase in radiative forcing, which in turn causes global mean warming and associated impacts.
8. It would be a misinterpretation to assume that the scientific consensus is that emissions below a certain threshold have zero effect, or that impacts are only caused above a certain threshold of emissions. There is a threshold below which we cannot detect or robustly separate out the effect of individual underlying causes to a particular climate impact because of limits to our modelling and observations, but this limit of our scientific capability should not be used to justify an assumption that there is no effect (particularly given that basic physics tells us the exact opposite: there will always be some effect).
9. I only comment on the scientific nature of the climate science part that considers the attribution of climate impacts to anthropogenically induced climate change and how that could be proportionally attributed again to subsets of total global emissions. Thus, scientifically speaking, there is no question that any greenhouse gas emission causes radiative forcing, and – in aggregate – they then cause global-mean warming with various regional climate impacts, that might or might not be smaller or larger in magnitude than natural variability or our capability to directly measure the

¹ *Climate Change 2021: The Physical Science Basis Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, Technical Summary* at p. 108-110.

temperature change on site. Hence, for any specific climate impact event the probability of occurrence (or alternatively, the intensity of an impact and associated damages) will change – even if the event would have naturally occurred and climate change may or may not have been the dominant contributor to overall damages amongst a multitude of contributors. See for example the high-level risk diagrams in Figure SPM.6 , IPCC AR6 WG1.²

Clarification 2: CO₂-only and lower bound of all-GHG warming contributions.

10. On Pep Canadell's section 4b1. As Dr. Pep Canadell writes, the estimate on the basis of the Transient Climate Response to Cumulative CO₂ emissions (**TCRE**) is based solely on CO₂, which is approximately 70% of GWP-weighted emissions in the case of Australia. For the short time-period since 2014, non-CO₂ warming can be expected to contribute to warming at least as much as their GWP-100 weighted share of greenhouse gas emissions. It might also be substantially more than that, as e.g. the GWP-20, which is a better proxy of impacts over a 20-year time horizon, suggests three times higher (compared to GWP-100) impacts for short-lived emissions such as CH₄ (see Table 7.15 or Figure 7.21 in the IPCC AR6 WG1 report which highlights the high near-term warming equivalence of methane).
11. As a result, Dr. Canadell's estimate should be seen - as he correctly writes - as a CO₂-only temperature impact of Australia's greenhouse gas emissions. Further below, I use GWP-100 as the equivalency metric between non-CO₂ and CO₂ emissions to derive a lower bound for the all-GHG temperature impact of Australia's greenhouse gas emissions. Over the short time period since 2013, the effect of CH₄ and other non-CO₂ emissions in aggregate will be underestimated by the GWP-100 equivalency metric, which is why my estimate will be a lower bound. This adjustment does not change the order of magnitude of the calculated temperature effect, but the additional ~30% of warming in the case of Australia does increase the accuracy with which one can place Australia's warming contribution in the context of any other country's warming contribution over the same time period.

Clarification 3: Australia's warming contribution in the context of those from other countries.

12. For comparison, below I present Table 1 with 205 countries for which detailed annual emission data is available. I use the consolidated GHG data of the PRIMAP-hist data product, which consolidates country-reported greenhouse gas emission

² *Climate Change 2021: The Physical Science Basis Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, Summary for Policymakers, Figure SPM.6.*

data and third party data and is frequently used by UNFCCC³ and other international institutions.⁴ Using principally the same calculation steps as Pep Canadell, I calculate the warming contributions of all 205 countries based on their cumulative 2014-2021 CO₂ and GHG emissions, their counterfactual trajectories towards net-zero emissions by 2024 and their difference. My calculations use the same best-estimate value of the TCRE quantity (Transient Climate Response to cumulative emissions of carbon dioxide) of 1.65°C/TtC (degree centigrade per Tera tonne of carbon), which equates to 0.45*1E-6 °C/MtCO₂ (degree centigrade per Mega tonne of carbon dioxide).

13. Given that Australia's difference of actual historical emissions towards the counterfactual transition towards net-zero emissions by 2024 is around 1000 Mt CO₂, Pep Canadell derived a value of 0.00045°C, which is basically identical with the one I derive here based on the slightly different inventory dataset (0.00043°C). Thus, in terms of the scientific calculations, there is no difference or disagreement between myself and Dr. Canadell and Professor Pitman.
14. Just to allow the reader to put those very small warming contributions into context, it might be useful to consider Australia's contribution in the context of those from other countries. Using the same calculation as Dr. Canadell for computing the temperature effect of the difference in emissions between actual historical emissions over 2014 to 2021 and the linear phase-out trajectory, one finds that a number of countries have stronger absolute warming contributions, namely e.g. China (0.016 degree C), United States (0.0059°C), or India (0.0041°C). See column F in the below Table 1.
15. The first amendment one could perform is to calculate the lower bound of overall GHG induced temperature over the same time period, rather than only the CO₂ part. Australia's warming contribution then increases by ~30% from 0.00043°C to 0.00064°C, while the overall relative picture stays similar (see paragraph 10 and 11 above). China (0.020°C), United States (0.0079°C), and India (0.0053°C) lead the table as the countries that contributed most with their GHG emissions that lie above such a linear phase-out trajectory from 2013 to 2024 (see column E of the below Table 1).
16. The comparison might be a bit clearer, though, if one actually compares the warming effect of total cumulative emissions over 2014 to 2021. That is because the rationale

³ See e.g. fn 12 in UNFCCC (2022), *Technical document – Approach and methods for estimating emission levels resulting from the implementation of nationally determined contributions and long-term visions, strategies and targets*, available at <https://unfccc.int/documents/624734>.

⁴ Gütschow, J.; Pflüger, M. (2023), *The PRIMAP-hist national historical emissions time series v2.5 (1750-2022)*. PRIMAP-hist, version 2.5, and its HISTCR historical data, which is based on officially country reported data, where available, is freely available here: <https://zenodo.org/records/10006301>. The PRIMAP data product was initiated by myself in my former research group at the Potsdam Institute for Climate Impact Research.

of applying the same phase-out trajectory that reduces emissions to net-zero by 2024 to India (or any other country than Australia) is not clear. India's emissions in excess of any kind of 'fair share' trajectory over the 2013 to 2021 time period will be much smaller or even zero.

17. Thus, the below table calculates that overall contribution to global warming arising from total emissions from 2014 to 2021 (column D in below Table 1), indicating that Australia has a rank #17 among the 205 analysed countries. All the countries with higher individual warming contributions than Australia also have higher populations.⁵
18. When calculating this total (lower bound) of GHG-induced warming contributions due to emissions from 2014-2021, the country with the highest absolute warming contribution is again China with 0.045°C, followed by the United States with 0.021°C, and India with 0.01°C.
19. As Prof. Andy Pitman implies in his statement, even temperature differences of this magnitude (0.045°C) are not detectable within natural variability and current measurement techniques - although this is irrelevant when it comes to the question who proportionally contributed to the total anthropogenically induced climate change, which is by now very well detectable across many regions and climate impact indicators (see paragraph 6 above).
20. Lastly, given that all these total warming contributions that are higher than Australia's (column D) arise from countries that have higher, or even substantially higher populations, it is useful for context to divide the overall temperature contributions by the respective countries' populations. This yields a temperature contribution per capita, which is much smaller than a total country contribution, but useful as an indicator of the average contribution to climate change per person in each country.
21. The analysis is shows that none of the 16 countries⁶ with higher absolute temperature contributions (column D) has per-capita temperature contributions as high as Australia (column G). Australia has a world rank of per-capita warming

⁵ The analysis uses the mid-of-the year total population data provided by the United Nations, Department of Economic and Social Affairs, Population Division data, World Population Prospects 2022, available at [https://population.un.org/wpp/Download/Files/1_Indicators%20\(Standard\)/EXCEL_FILES/1_General/WPP2022_GEN_F01_DEMOGRAPHIC_INDICATORS_COMPACT_REV1.xlsx](https://population.un.org/wpp/Download/Files/1_Indicators%20(Standard)/EXCEL_FILES/1_General/WPP2022_GEN_F01_DEMOGRAPHIC_INDICATORS_COMPACT_REV1.xlsx)

⁶ China, United States, India, Indonesia, Russian Federation, Brazil, Japan, Islamic Republic of Iran, Germany, Canada, Saudi Arabia, Nigeria, Republic of Korea, Mexico, Pakistan, South Africa

contribution over that time period of #11 (column J). The ten countries with higher per-capita emissions are countries with lower absolute emissions.

22. The key point is that climate change has many contributors, each small on their own. However, the sum of all the individual countries' and people's contributions cause anthropogenic climate change.
23. In this context, it is instructive to examine the implications of paragraph 44 in Prof. Andy Pitman's expert statement, when it is stated that:

"It is not possible to link or demonstrate this change in GHG emissions and any avoided increase in global mean temperature to any change in temperature, rainfall or other phenomenon over the Torres Strait. The amounts of avoided emissions are simply too small to demonstrate any link between these emissions and any climate impact. "

In combination with the final sentence in Prof. Andy Pitman's statement, saying:

"This indicates that if Canadell's calculations were incorrect by a factor of 100 and very probably a factor of 1000, my assessment in Paragraph 44 would remain the same. "

24. A 100 times higher contribution than Australia's (considering only the part of emissions above the hypothetical net-zero phase out line towards 2024) is - according to Dr. Pep Canadell's calculations (which are basically identical to mine here): $0.00045^{\circ}\text{C} * 100 = 0.045^{\circ}\text{C}$. A 1000 times higher contribution would be 0.45°C .
25. Thus, not even the highest emitting country in the world, China, and even when considering ALL of its GHG emissions over 2014-2021 (not only emissions above a certain counterfactual) would qualify under this benchmark that is set here. Even the emissions of the whole of China would be considered as falling under the umbrella of Professor Pitman's statement at paragraph 44 that *"The amounts of avoided emissions are simply too small to demonstrate any link between these emissions and any climate impact."*
26. Given that anthropogenically induced climate change is now an established fact (IPCC), we can also attribute regional climate changes and some individual events to anthropogenic climate change, which is the flourishing research area of attribution science (see paragraph 6 above). Also, there is no scientific doubt that every greenhouse gas emission contributes to global warming (IPCC AR6 WG1). CO₂ and

well-mixed GHG have globally the same effect, no matter where and by whom they are emitted.

27. Thus, asking for the identification of measuring individual country's contributions to observed climate impacts seems to miss the point that all carbon dioxide and greenhouse gas emissions contribute to warming and that we are now in a position to identify the aggregate effect of anthropogenic emissions on climate change. The question hence is often not whether one has the technical instruments to measure the effect of a certain emission amongst natural variability in a certain region, but rather whether the overall observed climate change can (in part) be attributed to anthropogenically induced climate change and then how to (proportionally) attribute that change to emitters of greenhouse gases.

28. As a climate scientist, I can comment on the causal contribution of a certain amount of emissions to global-mean warming. With regards to this causal contribution, I do not think that us climate scientists have any differing opinions, as evidenced by the fact that our calculations pretty much agree in terms of the temperature contribution caused by Australia's emissions over the considered timeframe.

Column	A	B	C	D	E	F	G	H	I	J
	Cumulative GHG emissions 2014-2021			Estimate of temperature contribution (°C)					World Rank (out of 205 countries)	
Country.	GHG Inventory (MtCO ₂ eq)	Counterfactual Zero emissions by 2024 (MtCO ₂ eq)	Difference (MtCO ₂ eq)	Lower bound for GHG-induced warming for column A	Lower bound for GHG-induced warming for column C	CO ₂ -induced warming for column C	As column D, but per capita (°C/cap)	As column E, but per capita (°C/cap)	Induced warming (column D)	Induced warming per capita (column G)
China	99910	56404	43506	4.5E-02	2.0E-02	1.6E-02	3.2E-11	1.4E-11	1	47
United States	46374	28759	17614	2.1E-02	7.9E-03	5.9E-03	6.2E-11	2.4E-11	2	16
India	22534	10663	11871	1.0E-02	5.3E-03	4.1E-03	7.3E-12	3.8E-12	3	159
Indonesia	13266	6590	6676	6.0E-03	3.0E-03	2.5E-03	2.2E-11	1.1E-11	4	75
Russian Federation	12072	6799	5273	5.4E-03	2.4E-03	1.6E-03	3.7E-11	1.6E-11	5	34
Brazil	10841	6576	4265	4.9E-03	1.9E-03	9.0E-04	2.3E-11	9.0E-12	6	70
Japan	9631	6364	3267	4.3E-03	1.5E-03	1.3E-03	3.5E-11	1.2E-11	7	42
Iran, Islamic Republic of	8381	4293	4088	3.8E-03	1.8E-03	1.4E-03	4.3E-11	2.1E-11	8	23
Germany	6617	4317	2301	3.0E-03	1.0E-03	9.1E-04	3.6E-11	1.2E-11	9	38
Canada	5612	3392	2221	2.5E-03	1.0E-03	7.9E-04	6.7E-11	2.6E-11	10	13
Saudi Arabia	5589	2784	2805	2.5E-03	1.3E-03	1.0E-03	7.0E-11	3.5E-11	11	12

Nigeria	5559	3022	2537	2.5E-03	1.1E-03	7.7E-04	1.2E-11	5.5E-12	12	125
Korea, Republic of	5317	3146	2170	2.4E-03	9.8E-04	8.7E-04	4.6E-11	1.9E-11	13	22
Mexico	4385	2574	1810	2.0E-03	8.1E-04	4.0E-04	1.6E-11	6.5E-12	14	106
Pakistan	4234	1993	2241	1.9E-03	1.0E-03	5.2E-04	8.4E-12	4.4E-12	15	149
South Africa	4115	2530	1586	1.9E-03	7.1E-04	5.7E-04	3.1E-11	1.2E-11	16	48
Australia	3986	2573	1413	1.8E-03	6.4E-04	4.3E-04	7.0E-11	2.5E-11	17	11

Table 1 - Cumulative GHG emissions, temperature contributions and world ranks of the top 17 countries (in terms of total induced temperature changes by GHG emissions from 2014-2021).

PHI_x FINNEY_x MCDONALD

7 November 2023

PRIVILEGED AND CONFIDENTIAL

Professor Malte Meinshausen

By email: [REDACTED]

Dear Professor Meinshausen,

Pabai & Anor v Commonwealth of Australia (VID622/2021) (Proceeding)

1. Supplementary Letter of Instruction

1.1. We refer to:

- (a) our letter of retainer dated 27 May 2022 (**Retainer Letter**);
- (b) our letter of instruction dated 31 May 2023 (**Letter of Instruction**); and
- (c) your expert report dated 14 July 2023 (**Your Report**).

1.2. We confirm that you are retained by Uncle Pabai Pabai and Uncle Paul Kabai (**Applicants**) to act as an independent expert in the matter of *Pabai & Anor v Commonwealth of Australia*, VID622/2021 (**Proceeding**).

1.3. We confirm that the confidentiality obligations in respect of documents and information provided to you for the purpose of this engagement are governed by the terms of the Retainer Letter and the Deed of Confidentiality dated 27 May 2022.

1.4. We also remind you of the roles and duties of expert witnesses as set out in the Retainer Letter and ask that you refer to them as you prepare your expert report(s) in this proceeding. In particular, please take some time to reacquaint yourself with the following documents, which we provided to you with our original letter:

- (a) the Federal Court of Australia Expert Evidence Practice Note (**GPN-EXPT**), including the Harmonised Expert Witness Code of Conduct (the **Code**) at Annexure A of that Practice Note and the Concurrent Expert Evidence Guidelines (the **Guidelines**) at Annexure B (collectively, the **Practice Note**); and
- (b) Rule 23.13 of the *Federal Court Rules 2011* (Cth).

1.5. The purpose of this letter is to request that you prepare a supplementary written report providing your independent expert opinion in response to the questions outlined at Annexure B to this letter.

2. Brief of Materials

2.1. Set out at Annexure A is an index of the documents provided to you, which supplement your brief. If you would prefer to receive a copy of some or all of the Annexure A documents in hard copy, please do not hesitate to contact us with such a request.

2.2. If you consider that you require any additional documents or materials in order to complete your work, please request such materials from us.

3. Your Opinion

- 3.1. Once you have reviewed the material in your brief, we request that you provide a written report addressing the questions set out in Annexure B to this letter.
- 3.2. In answering the questions outlined at Annexure B please provide detailed reasons for your opinions, including the facts or assumptions that affect your reasoning and conclusions.

4. Preparation of Your Report

- 4.1. We would be grateful if you would set out the answers to the questions at Annexure B in a written report, having regard to the requirements set out in the Practice Note.
- 4.2. After you have had the opportunity to consider the questions at Annexure B, as well as the materials listed in Annexure A, we would be grateful if you could advise of any material not currently in your brief which you require to respond to any of the Annexure B questions.

If you have any questions, please do not hesitate contact me [REDACTED]

Yours faithfully,



Brett Spiegel
Principal Lawyer
Phi Finney McDonald

Encl.

ANNEXURE A**Index to Brief**

Tab No.	Date	Description of document(s) / category
A	EXPERT REPORT	
A1.	6 October 2023	Expert Report of Professor Andrew Pitman
A2.	6 October 2023	Expert Report of Dr Pep Canadell

ANNEXURE B

1. Please review the expert reports of Professor Andrew Pitman and Dr Pep Canadell and answer the following questions:
 - (a) Does anything in the Canadell or Pitman reports lead you to change or clarify the opinions expressed in your expert report dated 14 July 2023?
 - (b) Do you disagree with any of the opinions expressed in the Canadell or Pitman reports? If so, please explain why.