PROFILE AND STATEMENT
OF PETER C. FRUMHOFF, PhD

I am Dr. Peter C. Frumhoff. I am the Director of Science and Policy and Chief Climate Scientist at the Union of Concerned Scientists (UCS). As such, I guide organizational-wide strategies to bring robust scientific expertise to bear on strengthening public understanding and public policies, develop new cross-program science and policy initiatives, and serve as senior liaison with the scientific community, policymakers, and the media. As a global change ecologist, I have published and lectured widely on climate science and policy, the climate responsibilities of fossil fuel companies, the energy-water-climate nexus, and the conservation and management of tropical forests and biological diversity.

I also serve on the board of atmospheric sciences and climate of the US National Academy of Sciences, the board of directors of the American Wind Wildlife Institute, the steering committee for the Center for Science and Democracy at UCS, and the board of editors of *Elementa: Science of the Anthropocene.* Previously, I served on the Advisory Committee on Climate Change and Natural Resource Science at the US Department of Interior, and the board of editors of *Ecological Applications*.

I was also a lead author of the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), which was awarded the Nobel Peace Prize in 2007, lead author of the 2000 IPCC Special Report on Land Use, Land-use Change and Forestry, and Chair of the 2007 Northeast Climate Impacts Assessment (NECIA).

In 2014, I was a Cox Visiting Professor in the School of Earth Sciences at Stanford University. Previously, I taught at the Fletcher School of Law and Diplomacy, Harvard University and the University of Maryland, and was a AAAS Science and Diplomacy Fellow at the US Agency for International Development. I am also a non-faculty associate of the Harvard University Center for the Environment.

My work is cited frequently in print and electronic media and I have testified before the U.S. Congress on multiple occasions. I received my PhD in ecology and MA in zoology from the University of California at Davis, and a B.A. in psychology from the University of California at San Diego.

I was invited by Ms. Desiree Llanos Dee, Climate Justice Campaigner of Greenpeace Southeast Asia (Philippines), one of the petitioners in the human rights and climate change case, to be a witness and resource person for the petitioners to speak present findings of a recent study that I co-authored, entitled "*The rise in global atmospheric CO_2, surface temperature and sea level from emissions traced*

to major carbon producers,"[1] in the first public hearing of the case on March 27-28 at the Commission on Human Rights in Quezon City, Philippines.

I agreed to be a witness and resource person for the petitioners and answer in writing questions to be asked of me. On 07 March 2018, the legal representatives for the petitioners, Attorneys Zelda Soriano and Hasminah Paudac, through their legal liaison, Ms. Anna Dominique Esmeralda, sent the questions which I personally answered. On 16 March 2018, I have discussed these answers to Attorneys Zelda Soriano and Hasminah Paudac via Skype. Also in attendance was Attorney Kristin Casper, Greenpeace's international legal coordinator.

I submit the following statement, along with my *Curriculum Vitae*, to the Commission on Human Rights which I commit to elaborate and clarify in the public hearing:

Q1: Dr. Frumhoff, can you please walk us through the study "The rise in global atmospheric CO2, surface temperature and sea level from emissions traced to major carbon producers"?

A1: Policy, legal, and academic debates about responsibility for climate change have long focused on countries' responsibility—the framework used for the international climate negotiations. However, attention is increasingly turning to the responsibilities of non-state actors, particularly the producers of fossil fuels. Scientific information can help inform societal assessment of their responsibilities for the climate damages resulting from the carbon emissions traced to the use of their products.

Peer-reviewed research published by Richard Heede in 2014 in the scientific journal *Climatic Change* found that nearly two-thirds of all industrial carbon emissions starting from the industrial revolution onward through 2010 can be traced to just 90 carbon producers— primarily investor- and state-owned fossil fuel companies such as ExxonMobil, BP, Chevron, Royal Dutch Shell, Peabody Energy, Gazprom, and Saudi Aramco, as well as cement manufacturers (Heede 2014).

But the question remained: how much of the change in climate that the world is now experiencing is due to these emissions traced to the products of specific companies? Can we measure, for example, their contributions to the rise in global surface temperature and sea level?

In 2017 an international research team led by Dr. Brenda Ekwurzel, senior climate scientist at the Union of Concerned Scientists, published a peer-reviewed study that provided a robust answer to that question. Other members of the research team include Dr. Myles Allen, a distinguished climate scientist at the University of Oxford, Richard Heede, author of the 2014 paper noted

[1] A copy of which was attached to petitioners' *Manifestation* dated 06 December 2017 and marked as **Exhibit** "**H**" during the preliminary conference held on 11 December 2017. Also available at: https://link.springer.com/article/10.1007/s10584-017-1978-0, last accessed on 02 March 2018.

above, and myself. The team incorporated emissions data from the 90 carbon producers identified by Heede (2014) into a simple, well-established climate model that captures how carbon dioxide and methane emitted into the Earth's atmosphere lead to the extra trapping of heat, driving increases in global surface temperature and sea level.

Using this model, the research team quantified the results of including or excluding different natural and human contributions to climate change—including the very specific contributions of emissions traced to these companies' products (Ekwurzel et al. 2017). The new study analyzed the climate change impacts of each company's carbon dioxide and methane emissions for two time-periods: 1880–2010 and 1980–2010. The latter time period was chosen as indicative of a key factor relevant to the societal assessment of company climate responsibility.

The results of the study, published in the scientific journal *Climatic Change*, show that emissions from the products of 90 major fossil fuel producers and cement manufacturers contributed nearly half of the global temperature rise and about 30 percent of global sea level rise between 1880 and 2010, among other findings.

Q2: What was the motivation, if any, in making this study?

A2: Policymakers in several jurisdictions around the world are now considering whether fossil fuel producers bear some responsibility for the damages from climate change resulting from emissions from their products. Our intent in this research was to inform such considerations.

Of course, the question of responsibility for climate damages is not singularly the domain of science. Historical analyses indicate that senior executives in leading investor-owned fossil fuel companies knew about the risks of their products by 1980 or earlier, but did not bring those risks to the attention of the public and their shareholders; rather, many of these companies supported and engaged in efforts to sow doubt about the risks of their products (Banerjee 2015; Frumhoff, Heede, and Oreskes 2015).

The editors of the journal *Climatic Change* invited Professor Henry Shue of the University of Oxford, a leading expert in ethics, equity, justice and philosophy, to write a commentary on ethical implications of the Ekwurzel et al (2017) paper and such related historical evidence. His commentary, published alongside Ekwurzel et al (2017), argued that fossil fuel companies "… knowingly violated the most basic moral principle of 'do no harm,' and now they must remedy the harm they caused by paying damages and their proportion of adaptation cost."

Q3: Can you please explain what does a peer-reviewed research mean?

A3: Peer review means that the journal (in this case, *Climatic Change*) invites scholars with expertise in the subject area of a submitted paper to provide a critical written assessment of the quality of the research and its adherence to

editorial standards of the journal. These assessments are solicited and assessed before research papers are accepted for publication. The editors of the journal may reject or require significant changes in papers before publication in response to such independent peer reviews. The vast majority of scholarly journals rely on volunteer editors and reviewers. Peer review in the sciences, including in climate science, is the core mechanism by which rigorous standards and best practices of scientific quality in publications are maintained.

Q4: In the study, it states that your group extended Richard Heede's calculations using a simple climate model. What was the reason, if any, in extending Heede's calculations?

A4: Richard Heede's data show annual emissions of carbon dioxide and methane to the atmosphere. They are not a direct calculation of the consequent changes in climate resulting from those emissions. See also answer to question # 1.

Q5: What is this simple climate model?

A5: We use a global energy-balance coupled climate-carbon-cycle model to assess the change in atmospheric carbon dioxide and methane concentrations, radiative forcing, global mean surface temperature, and global sea level rise resulting from emissions traced to these 90 major carbon producers.

Q6: What are the advantages, if any, in using this climate model?

A6: Climate models that rely on the underpinnings of reduced-complexity climate models and fully coupled earth-system models have several advantages. Calibrated with historical observations and fully coupled global climate models, they can provide robust output to characterize global atmospheric carbon dioxide, methane, radiative forcing, global mean surface temperature, and global sea level. This approach allows for natural and anthropogenic forcings to be included or excluded to test the relative contributions from human-caused emissions at policy-relevant levels of uncertainty.

Q7: Was there a basis, if any, in using this particular climate model?

A7: The model used here is well-established in the scientific literature. It is based on the impulse response function approach presented in the Intergovernmental Panel on Climate Change fifth assessment report, published in 2014.

Q8: On pages 5 to 8 of your study, you mentioned of three (3) global influence of emissions traced to major carbon producers, which are: atmospheric carbon dioxide, global mean surface temperature, and global sea level. Can you please enlighten us on major findings of your study?

A8: Here are some of the major findings:

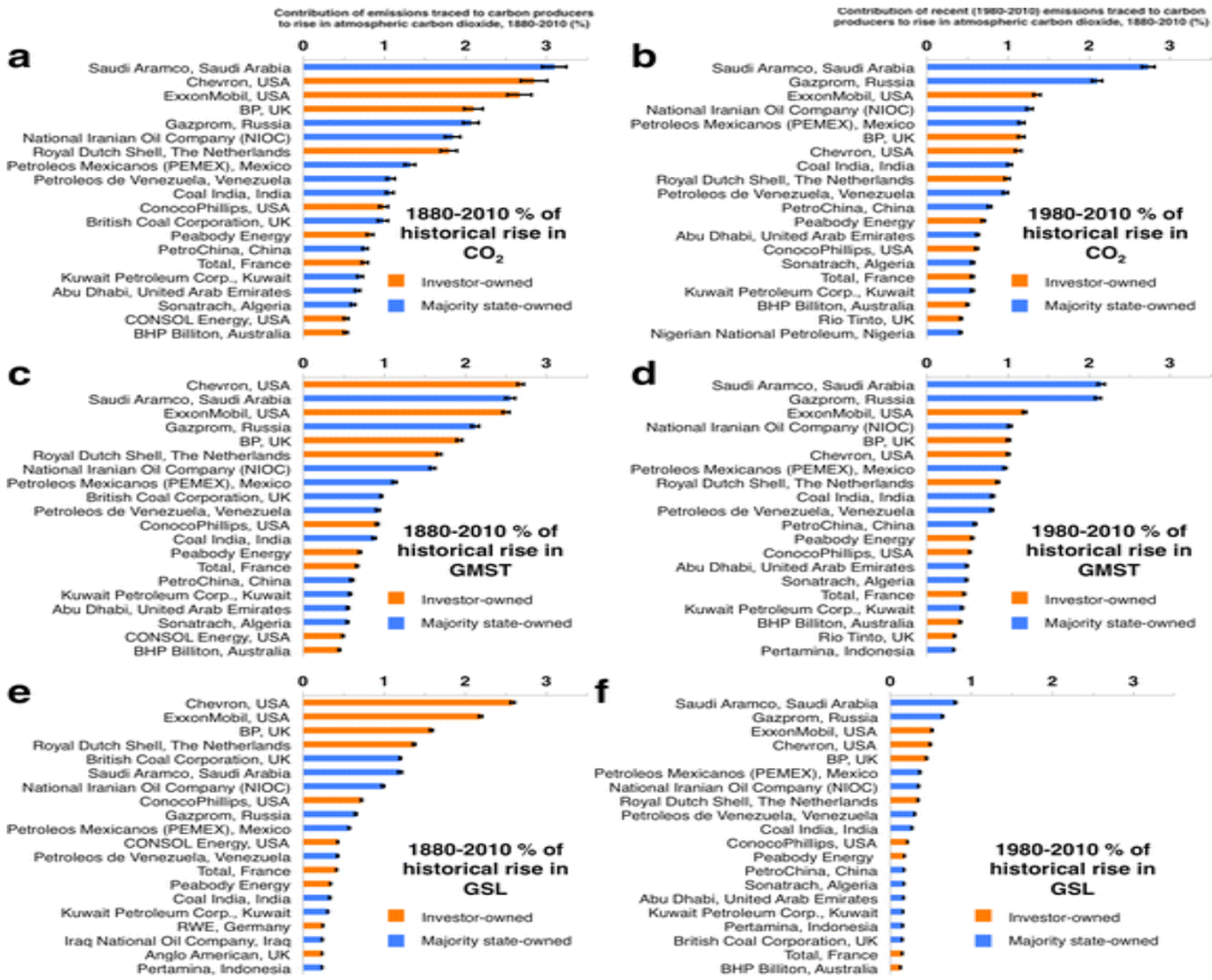
- Emissions traced to the 90 largest carbon producers contributed approximately 57 percent of the observed rise in atmospheric carbon dioxide, nearly 50 percent of the rise in global average temperature, and around 30 percent of global sea level rise between 1880-2010;

- Emissions linked to 50 investor-owned carbon producers, including BP, Chevron, ConocoPhillips, ExxonMobil, Peabody, Shell and Total, were responsible for roughly 16 percent of the global average temperature increase from 1880 to 2010, and around 11 percent of the global sea level rise during the same time frame;
- Emissions tied to the same 50 companies from 1980 to 2010, a time when fossil fuel companies were aware their products were causing global warming, contributed approximately 10 percent of the global average temperature increase and about 4 percent sea level rise; and
- Emissions traced to 31 majority state-owned companies, including Coal India, Gazprom, Kuwait Petroleum, Pemex, Petroleos de Venezuela, National Iranian Oil Company and Saudi Aramco, were responsible for about 15 percent of the global temperature increase and approximately 7 percent of the sea level rise between 1880 and 2010.

The published paper presented the full range of values for climate sensitivity and other parameters modeled. The findings noted above are those using best-estimate parameters, which yielded results that most closely align with historical observations over recent decades.

Q9: Other than what you have mentioned, are there any striking findings related to the carbon producers that your group was able to uncover?

A9: Our research characterizes the contribution of carbon dioxide and methane emissions traced to individual companies to increases in atmospheric carbon dioxide, global mean surface temperature and global sea level. Results for each of the top twenty companies are shown in the figure below.



Legend: Contribution of historical period, 1880–2010 (**a**, **c**, **e**), and recent 1980–2010 (**b**, **d**, **f**) emissions traced to top 20 investor-owned and majority state-owned industrial carbon producers to atmospheric CO_2, GMST, and GSL rise from 1880 to 2010. *Bar values* are the median best-estimate full historical forcing model simulations with the *error bars* showing the first and 90th removal order of each carbon producer.

Q10: Given all these findings, what was your group's conclusion, if any?

A10: Our study demonstrates that the proportional increase in atmospheric carbon dioxide, global mean surface temperature, and global sea level from emissions traced to major carbon producers is quantifiable and substantial. The analyses presented here could be extended to examine the contribution of emissions traced to major carbon producers to other impacts, such as historical increases in ocean acidification or the mortality impacts from extreme heat and other extreme events.

Size of contribution, such as calculated in this study, is one factor to consider in assessing responsibility for climate change consequences. Other factors include consideration of differences among carbon producers in how they responded to the scientific evidence of the climate risks of their products. We hope that these factors, coupled with ethical, legal, and historical

considerations, inform discussions about carbon producer responsibilities to contribute to limiting climate change through investment in mitigation, support for adaptation, and compensation for climate damages.

Q11: Have any of the investor-owned companies commented on your study?

A11: Not to my knowledge.

Q12: Do you know if this study you co-authored, "The rise in global atmospheric CO2, surface temperature and sea level from emissions traced to major carbon producers," and Richard Heede's "Tracing anthropogenic carbon dioxide and methane emissions to fossil fuel and cement producers, 1854-2010" have been used in any legal proceeding? And if so, how?

A12: I am aware that Heede (2014) and Frumhoff, Oreskes and Heede (2015) have been cited in the lawsuits six cities and counties in California have filed against thirty-seven major fossil fuel companies for the climate harms caused by their products.

They have also been citied in separate complaints filed against five major fossil fuel companies for climate harms, complaints filed by the cities of New York, San Francisco and Oakland, California.

I have not examined how, specifically, these studies were cited in these complaints.

Q13: ***Other than this study, are there any articles or publications made by your organization (Union of Concerned Scientists [UCS]) regarding the matter which might prove useful for the Commission's inquiry?***

A13: Frumhoff, P. C., R. Heede, and N. Oreskes. 2015. The climate responsibilities of industrial carbon producers. *Climatic Change* 132: 157-171. doi: 10.1007/s10584-015-1472-5.

Mulvey, K., S. Shulman, D. Anderson, N. Cole, J. Piepenburg, and J. Sideris. 2015. Climate deception dossiers: Internal fossil fuel industry memos reveal decades of corporate disinformation. Cambridge, MA: Union of Concerned Scientists. Online at www.ucsusa.org/ sites/default/files/attach/2015/07/The-Climate-DeceptionDossiers.pdf

Other papers cited in this affidavit:

Heede, R. 2014. Tracing anthropogenic carbon dioxide and methane emissions to fossil fuel and cement producers, 1854–2010. *Climatic Change* 122:229–241. Doi:10.1007/s10584-013-0986-y

Banerjee N (2015) Exxon's oil industry peers knew about climate dangers in the 1970s, too. *Inside Climate News*

Shue, H. (2017) Responsible for what? Carbon producer CO_2 concentrations and the energy transition. *Climatic Change* 144:591. doi:10.1007/s10584-017-2042-9

Q14: ***Can you walk us through these articles or publications*?**

A14: Frumhoff et al (2015) explores the conceptual territory of climate responsibility, considers the distinctive responsibilities of the major investor-owned producers of fossil fuels, assesses the actions these companies took and could have taken to act upon the scientific evidence of climate change and conclude that major investor-owned fossil energy companies carry significant responsibility for climate change. This conclusion rests on four key pillars:

- These companies have produced a large share of the products responsible for climate change;
- They continued to produce them well after the danger was well-established scientifically and recognized by international policymakers;
- They worked systematically to prevent the political action that might have greatly limited further emissions, including through unethical practices such as promoting disinformation; and
- While now ostensibly acknowledging the threat represented by climate change and the need for reductions in emissions, they continue to engage in business practices that drive expansive emissions from fossil fuel production and use for decades

Frumhoff et al (2015) argue that it is still possible for these companies to effectively contribute to a solution, including by paying "for a share of the harms resulting from the use of their products, both for the damages that have already occurred and the costs of preparing to limit the damages from further, now unavoidable impacts that responsible actions by these companies could have, and should have, helped to avoid."

Mulvey et al (2015) documents the decades' long campaign by several of the world's largest fossil fuel companies to deceive the public by "distorting the realities and risks of climate change, sometimes acting directly and sometimes acting indirectly through trade associations and front groups." The internal documents collected and excerpted in the report show that for nearly three decades, major fossil fuel companies "knowingly worked to distort climate science findings, deceive the public, and block policies designed to hasten a needed transition to a clean energy economy."

Q15: Based on your extensive research, do you have any insights on what steps respondent Carbon Majors should take to remedy, eliminate, and prevent human rights harms resulting from the fossil fuel products they extract and sell?

A15: Yes. Drawing on the extensive evidence of that major investor-owned fossil fuel companies bear distinctive responsibilities for climate change, I propose that companies should take the following actions:

- *Renounce disinformation.* Stop all corporate support for disinformation on climate science and policy, including affiliation with or funding of lobbying groups involved in spreading disinformation.
- *Plan for a world free from carbon pollution***.** Align the company's business model with a carbon-constrained world consistent with the goal of keeping warming well below a 2°C increase above pre-industrial levels, as established in the Paris Climate Agreement.
- *Support fair and effective climate policies***.** Consistently and actively advocate for fair and effective policies to reduce heat-trapping emissions at the subnational, national, and international levels.
- *Fully disclose climate risks.* Fully disclose the financial and physical risks of climate change to the company's business, including its infrastructure and reserve assets.
- *Pay their fair share of climate costs.* Agree to pay a share of the costs of climate-related damages and climate change adaptation, particularly to support the worlds' most climate vulnerable nations and communities.

Q16: Are you ready and willing to swear this Statement under oath before the Philippine Commission on Human Rights, if required to do so?

A16: Yes.

16 March 2018

Peter C. Frumhoff, PhD
(Signature and date of signing)