The Finance Sector and Climate Change

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Constraining Credit for Coal

By

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Cambridge Scholars
Publishing

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This book first published 2024

Cambridge Scholars Publishing

Lady Stephenson Library, Newcastle upon Tyne, NE6 2PA, UK

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

ISBN: 978-1-0364-1593-8
ISBN (Ebook): 978-1-0364-1594-5

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PREFACE

This book is in many ways a capstone to my career, having retired from paid employment about six years ago. It draws upon many of the threads of my education and subsequent research, beginning with my first year at university studying Physics, Chemistry and Zoology to gain admission to medical school. Medicine, I discovered, was not for me and involved too much rote learning of what was known. I found I was more interested in what was not known, and won a New Zealand Medical Research Council Summer Research Grant to study the changes in post-natal histology of the ductus arteriosus, which I thought might illuminate the formation of arteriosclerosis.

My lack of effort in learning showed and I flunked out of medical school, but I learned something of laboratory research under Bill Trotter and had my interest in the history of science piqued under Douglas Taylor. While I was a failure as a medical student, this experience demonstrated that no learning is ever wasted, especially because my first year Physics education (and Chemistry) equipped me to understand climate science in a way that most political scientists do not.

I then changed course to a Bachelor of Arts with a major in Political Studies and a minor in Anthropology, receiving an excellent grounding in both from the likes of Ham Parker, who had never finished his degree, having been diverted by war and marked forever by his service at Sidi Rezegh, but who knew an immense amount about Middle Eastern archaeology.

For a small politics department, Otago provided me with an excellent grounding in the discipline, especially from Jim Flynn, who was the paragon of polite disagreement based on reason and evidence. He employed me briefly as a research assistant upon finishing my thesis, working on his project on race and intelligence that rewrote the field of educational psychology and leading to what is now known as the Flynn Effect. Wanting to deal with the racist views of Arthur Jensen, Jim fund nothing but ad hominem attacks, so spent 15 years researching the field and found what the mainstream scientists had missed.

Others, like John Raser, exposed me to many of the theories I employ in this book and his book *Simulation and Society* introduced me the perils and pitfalls of simulation and modelling. Tony Wood introduced me to the need for accurate and methodical documentary analysis. The Arts Faculty tea room was also a centre of learning, especially from the philosophers, headed by Alan Musgrave who carried the banner for Karl Popper in the philosophy of science.

My career as a scholar was enhanced by the assistance of several giants, by whom I was fortunate to be encouraged and supported. Foremost here would have to be Ted Lowi, with whom I enjoyed theoretical jousting for 25 years, but also Philippe Schmitter, Karsten Ronit and others active in Research Committee 38 on Politics and Business of the International Political Science Association. Latterly, Hannah Murphy has been a valuable collaborator in developing our work on forum shopping–a topic on which I learned an enormous amount from Bob Reinalda, Arild Underdal and Oran Young at a workshop we held in 2012. And with Peter Carroll three books and several papers on the OECD equipped me to understand the Export Credits case all the better.

On climate change, science and risk I am indebted to Sonja Boehmer-Christiansen, Garth Paltridge, Bernie Lewin, John Zillman (former Director of the Australian Bureau of Meteorology and President of the WMO), and John Adams, and to several negotiators and diplomats: Howard Bamsey, Meg McDonald, Michael L'Estrange, Stuart Harris (all formerly Department of Foreign Affairs and Trade, Australia); Chris Langman (former Australian Ambassador for the Environment and former Ambassador to the OECD); Ian Forsyth (former Australian Ambassador to the OECD); Griff Thompson (US State Department); Harlan Watson (former US Special Envoy to the UNFCC); Brice Lalonde (former French Ambassador for Climate Change); and Gregory Briner (OECD). On climate economics and finance, I thank: Ian Castles (former Chief Statistician and Secretary, Department of Finance, Australia); David Henderson (former Chief Economist, OECD).

I also thank: David Drysdale and Michael Gonter (Export Credits, OECD); Kieran Clarke, Bruce Murphy, Yoko Nobuoko and Peerpat Vithayasrichareon (International Energy Agency). For earlier interviews that added to my knowledge base, John Garrison (World Bank) and Peter Bosshard (International Rivers). I thank Chris Leithner for casting a sympathetic fund manager's eye over the manuscript.

The opinions and any errors are, of course, mine.

I also thank Julie and Maddy for their support and encouragement.

INTRODUCTION

In March 2024 *New Yorker* magazine ran a rather alarmist piece by Elizabeth Kolbert attempting to make sense of the record global ocean temperatures recorded in 2023. That in itself was not unusual. What *was* unusual was that Gavin Schmidt, a mathematician and climate modeller who heads the Goddard Institute for Space Studies of the US National Aeronautical and Space Administration, could not explain the anomaly, which accompanied record atmospheric temperatures (Kolbert, 2024).

Schmidt confessed that "we haven't really known what's going on since about March of last year." He called the situation "disquieting." This was unusual. As co-founder of the rather alarmist climate blog *Real Climate*, Schmidt customarily seized on such evidence of warming to attribute it to elevated levels of carbon dioxide (CO_2) in the atmosphere, forcing an increase in Mean Global Temperature (MGT), with Schmidt and others calling for an urgent mitigation of emissions–especially ending the combustion of coal.

This had long been the dominant meme with climate variability, but Kolbert had to canvas alternative causes of warming, such as the arrival of an El Niño pattern. In addition, in January, 2022 Hunga Tonga–Hunga Ha'apai, an underwater volcano in the South Pacific erupted. Ordinarily volcanoes produce a temporary cooling effect because they emit sulphur dioxide which forms sulphate aerosols that shield the Earth from incoming solar radiation. (Some have even suggested injecting sulphate aerosols into the atmosphere to combat global warming). Hunga Tonga emitted unusually low amounts of sulphur dioxide. But volcanoes also emit water vapour, and Hunga Tonga (being an underwater volcano) emitted a huge amount, increasing the water vapour of the stratosphere by an estimated 13%. Water vapour is by far the most powerful greenhouse gas (GHG) in the atmosphere, and so Kolbert reported that it was believed that its effects were still being felt.

Again somewhat unusually, a possible minor role was attributed to the Sun, which was nearing the peak of Solar Cycle 25, due in 2024 or 2025. Also noted was a 2020 mandate to reduce the sulphur content of shipping fuels (and thus the sulphate aerosols produced), which–together with success globally in reducing air pollution–might have been allowing more solar radiation to reach the surface.

It seems other causes were being considered because the warming in the atmosphere would hardly be able to transfer heat rapidly enough to cause a sudden increase in ocean temperatures–any more than an increase in air temperature could cause a sudden rise in temperature of a cold bath. The basic physics suggest this would not be possible: the mass of the two media are vastly different and the mechanism of heat exchange problematic.

Susan Wijffels, senior scientist at the Woods Hole Oceanographic Institution, even expressed scepticism as to any anthropogenic cause, stating "This could end up just being natural variability." Wijffels was really acknowledging the reality that climate has changed substantially in the past. Leaving aside the Milankovic cycles that cause ice ages and warmer interglacial periods (such as the present one) through changes in the Earth's orbit, there are lesser variations that must be explained. The Roman Warm Period and the Medieval Warm Period are two examples, as is the Little Ice Age 1303-1850. Warming after the end of the Little Ice Age preceded the emission of sizable quantities of CO_2, so it cannot be attributed to that cause.

Wijffels was also acknowledging how little we know about the oceans and their role in climate. A system of Argo floats was deployed commencing in the year 2000 and these are capable of diving as deep as 2,000m and then surfacing to relay their readings, but this means we have accurate readings for what is a twinkling of an eye in geological terms. Since 1979 we have had relatively complete satellite monitoring of surface temperatures, but prior to that temperature was estimated for the air over the oceans–71% of the Earth's surface–from measurement of the temperature of the surface water, which was taken as a proxy for the temperature of the atmosphere. Most recently before the introduction of the Argo system, the temperature of the water was measured at the intake to ships' cooling systems, but usually at (unspecified) variable depths. Prior to that, temperature was taken from water in buckets thrown over the side of ships, with an adjustment in the 1940s as sampling by steel buckets replaced canvas buckets. The temperature of the oceans was quite an inexact science until 2000, as was the temperature of the atmosphere for 71% or the Earth's surface until the commissioning of satellite remote sensing in 1977.

The effect of the Hunga Tonga on MGTs through an increase in water vapour has been considered, but the possibility of volcanic activity playing a more direct role in warming the oceans has received much less consideration.

A significant element in environmentalist thinking is that Nature exists in a delicate, harmonious balance (McConnell & Suzuki, 1997), so that any change is inevitably attributed to human influences. Geologists are quick to point to the changing nature of the Earth, the interior of which is a significant source of heat, and not just that remaining from the formation of the planet. A significant source of heat driving the motion of the tectonic plates is the decay of radioactive isotopes in the crust and mantle, combined with the initial heat from the planet's formation. Geologists are much less likely to adhere to a view of the Earth in a delicate balance, especially because it continues to undergo changes which led to its formation, such as volcanoes and the addition to the surface at mid-ocean spreading zones.

Little is known about volcanic activity hidden by ice sheets and oceans. Only in 2017 were 90 volcanoes discovered under the Antarctic ice sheet. It has been estimated that there are over one million subsea volcanoes, most now extinct with only 119 submarine volcanoes in Earth's oceans and seas known to have erupted during the last 11,700 years. Nevertheless, geologists have identified more than 5,000 active underwater volcanoes, accounting for more than 75% of the total lava that erupts every year. Some, including climate scientist Roy Spencer, are sceptical that sufficient energy is released by subsea volcanic activity (which is often considered to be relatively steady in nature), but seismic activity is not constant, and Arthur Viterito (2016; 2019) has shown that global temperatures correlate more highly with indicators of seismic activity for high geothermal flux areas (HGFA) than with CO_2. Viterito argues that a compelling case for geothermal forcing lies in the heat triggering thermobaric convection and a strengthening of oceanic overturning, which are important mechanisms for transferring ocean heat to the overlying atmosphere.

The suggestion of increasing geothermal flux playing a role in recent warming has not been of much interest. Sceptical climate scientist Judith Curry conducted a blog discussion in 2019 in which she stated that she had rarely seen geothermal activity mentioned as a source of ocean warming. The post stimulated polite discussion, with Spencer and Viterito (among others) participating, but reached no definitive conclusion.

The role of the oceans in warming the atmosphere is clearly important, regardless of what warms the oceans–although it is important to remember that the mass of the oceans is much greater than that of the atmosphere. The mass of the oceans is estimated as 1.384×10^{21} kg, with the mass of the atmosphere 5.148×10^{18} kg, so the mass of the oceans is about 269 times (or three orders of magnitude) greater than the atmosphere (Trenberth and Smith 2005). Transfer from atmosphere to water is likely to limit substantially any increase in atmospheric temperature if it is to warm the oceans in the manner that has been observed. A warm room does not warm a cold bath greatly.

An additional problem lies with the reporting of changes in temperatures as anomalies of MGT from long term averages. This metric masks considerable regional and seasonal variation that seriously undermines the view of forcing by GHGs as the only source of warming. William Kinninmonth (2024) has analysed the data for 1979 to 2022 held by the US National Centers for Environmental Protection and found that the warming was greatest at the poles and greatest when solar radiation was near its lowest (as the darkness of winter set in). These data do not support a dominant role in warming from GHGs in the atmosphere, and Kinninmonth instead points to the direct warming of the tropical oceans by solar radiation that is then carried polewards by ocean currents and weather systems. (A heat lamp can warm a bath, gradually). Warming in the equatorial band has been only 1.1°C per century, while that in the Arctic it is 7.1°C per century and in the Antarctic region 4.1°C per century.

These data are consistent with direct solar radiation received at the equator, but there is no evidence of solar output to account for more than a fraction of this. Nevertheless, Svensmark, et al (2016) have suggested that decreased incoming cosmic ray activity has allowed a greater amount of solar energy to reach the surface of the Earth. Similarly, it is now considered that success in cleaning up particulate and sulphur dioxide emissions (which produce sulphate aerosols) has had a similar effect, as noted above, with restrictions on sulphur in ships bunker fuel attributed for the sudden warming in 2023.

In summary, there are several factors that might be leading to observed warming, and the extremely rapid warming in 2022-23 suggests that some of these have been in play. It is worth noting that the assumed positive feedback from anthropogenic caused GHG forced warming leading to increased water vapour, the dominant GHG was found wanting in observational evidence (Paltridge, Arking & Pook, 2009), but the Hunga Tonga eruption might have had a similar effect.

The rapid increase in MGT suggests that some or all of these other factors might have contributed to recent warming–along with other "unknown knowns" such as century to millennial scale changes in ocean circulations, Earth and sun's magnetic fields, planet/moon gravitational effects, and slow modes of the carbon cycle (Curry, 2019). While the forcing effect is well known, since Arrhenius (1896) it has been known that it is logarithmic, with a diminishing effect with greater volumes as it becomes saturated (hence the assumption of rising water vapour being needed to produce alarming projections).

It is rather heroic to assume that anthropogenic GHG forcing is the only–or even dominant–factor in climate variability, especially because there have been significant changes historically *before* the industrial age. The costs of a decarbonising energy transition therefore must be weighed against the possibility that such a transition might be in vain, and substantial change might still occur, suggesting that adaptation might have been a preferable policy.

The problem is, political and economic interests have locked us in to very much a monocausal explanation, and thus policies that assume this explanation is correct. In this book I explore the role of the finance sector in "locking in" a preferred response to climate change by decarbonisation, funding and supporting non-state actors and governments and acting through international organisations in the World Bank and the Organisation for Economic Cooperation and Development (OECD) to support this policy. In addition to severely restricting African nations from pursuing the path to development that the Global North has enjoyed for almost two centuries, this opened the field for China to expand its global influence by filling the finance gap with its Belt and Road Initiative–until the Covid-19 pandemic limited its capacity and thus its activity in this regard.

Theodore Lowi (1964) showed how different policies evoke different patterns of politics and Paul Pierson (1993; 2006) has shown how policies, once adopted, create new interests that will defend those policies even if they fail–as instruments or in normative justification. The adoption of climate policies created new interests that have supported sympathetic scientists, environment groups and political actors in order to defend and maintain policies that benefit their interests, be they in renewables or gas which produces fewer GHG emissions per unit of energy than coal. In the concluding chapter I extend the analogy of "Iron Triangles" first applied to US politics to "Iron Pyramids" to explain the strength of these relationships. The Iron Pyramid has proven to be quite powerful and has helped repel contrary explanations of climate change–explanations that must be considered if climate policy is to be robust in the face of an uncertain future.

The dubious claims of a "climate emergency", constructed by a powerful coalition of normative and interest-motivated actors (and first identified by a Greens Party councillor in a local government in Darebin City, Melbourne, Australia) is now embedded in governments and supported by the authority of the United Nations. As we shall see, there is very limited evidence that we are indeed in a "climate emergency", outside of climate models that have thus far run hotter than observational evidence and are pumped up with questionable sensitivities to CO_2 and highly unrealistic scenarios of future emissions.

Chief scientist in the US Department of Energy in the Obama Administration, Steven Koonin (2021), became a climate sceptic after noticing that elements that had to be removed from the climate models in order to replicate the past climate were being added back to make future projections that were alarming. Koonin went on to write a masterly sceptical book that deliberately set out to burst the bubble pumped up by the climate scientist-activist-financier-politician Iron Pyramid.

There are many reasons to believe that warming of the atmosphere as the result of human emissions of CO_2 and other GHGs will be relatively mild, and that there are other factors at play–including solar variability, the clearing of sulphate aerosols as pollution has been controlled, cosmic ray activity on clouds, and volcanic activity. Moreover, warming over the past couple of centuries has arguably been beneficial and there is every reason to believe that it will continue to be so–that a "lukewarmer" outlook is justified, which changes the cost-benefit for society of radical decarbonisation and ultimately threatens the benefits to rent seekers.

The Iron Pyramid in the shorter term is, however, quite robust and supported by coordination among media that protect against challenge from contrary views–the very contestation of ideas and evidence that are an essential part of science as an enterprise. Climate change has become, as William Hogan (2023) has put it, like an electrified "third rail" in an underground rail system that is dangerous for any politician to touch. But touch it they must if we are not to continue the current "madness of crowds" that rivals the tulip bubble and South Seas bubble of the past (Mackay, 1999), all the more difficult to break apart because of the strong normative element and global communications which assist the detection and reporting of disaster and a global panic.

The consequences of the response to what could prove to be an exaggerated perception of the risks of anthropogenic climate change are serious, and extend well beyond the costs of attempting what might prove to be a futile attempt to decarbonise the global economy rather than, for example, adapting to the risks that might come if it is as serious as feared. They include restrictions on the ability of developing countries, especially in Africa, to utilise the fossil fuels that have been at the core of development in the Global North that has lifted millions out of poverty since the Industrial Revolution.

At the same time, policy responses restricting fossil fuel utilisation have produced a significant geopolitical shift, because India and (particularly) China have declined to play along–despite assurances that they will do so in future. The result is that both these countries are continuing to develop coal-fired power stations. In the case of China, the restrictions on finance for such purposes in the World Bank and the OECD provided a huge opportunity for it to expand its influence, especially in the rapidly growing Asian region. Until the Covid-19 pandemic, China was able to expand rapidly its influence in the region through its “Belt and Road Initiative” which financed the construction of infrastructure, including fossil fuel power stations.

The Plan of the Book

In Chapter One I set out the place of coal and other energy sources in the context of climate change, while Chapter Two examines how the national interest in the US was reconstructed by financial interests that invested in alternatives to coal, especially, initially, natural gas which produces lower GHG emissions per unit of energy, and then other sources such as renewables. These interests sought to restrict competing energy sources and supported environment groups (Non-governmental Organisations, or NGOs) that would assist in this goal. The US then exported this approach in the World Bank, using its quasi-hegemonic position there, by having the Bank restrict the provision of finance for fossil fuels.

Chapter Three examines in detail a similar attempt which was initially only partially successful in the OECD, when Participants in the Arrangement on Officially Supported Export Credits in November 2015 agreed to a restriction on the use of finance for coal stations using Export Credit Agencies (ECAs). The OECD is a forum with different characteristics to the Bank, with all members possessing equal voting power. A tightening was adopted in 2021 just before COP 26 in Glasgow, permitted by changes in the positions of Australia, Japan and Korea, which had tempered the original decision.

Chapter Four sets out the advantages created for China by the restrictions on finance created by the Bank and the OECD, both with the expansion of coal domestically and the opportunities through the Belt and Road Initiative after the Global North vacated the field, setting out developments in the region, including India. Chapter Five follows Pierson's theme that policies create interests by examining the activities of financial interests in protecting and extending the policies that have favoured them–including by supporting helpful scientists and NGOs and the coordination of media outlets to ensure much of the reporting is in harmony.

Chapter Six sets out the ways in which science has been distorted by those with an interest in accentuating and exaggerating the risk of anthropogenic climate change. Chapter Six brings these threads together and suggests that we are witnessing an "Iron Pyramid", based on the classic theory of Gordon Adams's Iron Triangles in US politics, a model used in US defence contracting: a stable three-way alliance (Adams, 1981). Because climate change is science heavy I suggest a three-sided pyramid to capture the tight relationship between the four (and the strength this structure brings)–with the four apices formed by scientists, political actors, political interests and normatively motivated environment NGOs.

Such a pyramid is stable and strong, and it will be difficult to pull apart should the need arise.

CHAPTER 1

THE PROBLEMS WITH COAL

Of all the energy sources on which modern industrial societies draw, coal is of the greatest concern from the point of view of global warming induced by elevated levels of atmospheric CO_2. While other fossil fuels contain carbon and hydrogen atoms that are oxidised and released upon combustion, coal contains more carbon than, say, natural gas or oil, so energy burning coal results in the formation of more CO_2.

Coal utilisation equipment has been improved substantially in efficiency. Lignite or brown coal has historically been used at little more than 25 percent, but pulverised coal-fired electricity generation has improved considerably, passing 40 percent with the introduction of ‘supercritical” (SC) and then “ultrasupercritical” (USC) technology and now achieving just in excess of 49 percent with advanced ultrasupercritical (AUSC)–with the average of the existing global fleet being 34 percent and edging upwards as more efficient plant is commissioned and older, less efficient plant is retired.

Every 1 percent improvement in efficiency yields a 2-3 percent reduction in carbon dioxide emissions, so new, so-called “high efficiency, low emissions” (HELE) plant has considerable potential to produce more electricity with substantially lower emissions, so that global emissions from coal would be reduced by 30-45 percent if the existing fleet were replaced by “best available technology” (BAT).

Despite this, climate politics has succeeded in characterising coal as the villain, demanding that ideally no coal should ever be burned in the future. Numerous campaigns against coal have been mounted by climate non-governmental organisations (NGOs) calling for bans or other restrictions on the use of coal. To the extent that such restrictions have been imposed they have–like any regulatory policy–created advantage for competing energy sources and those who invest in them. Yet these other sources also have their disadvantages: technical, economic and environmental (including climate change impact).

This chapter surveys these various energy sources and their advantages and disadvantages in order set in context what became known in the United States as a "War on Coal". That "war" was extended from the US's quasi-hegemonic position in the Bank to restrict financing of coal-fired power stations by the Bank. Our main focus here is not on that decision, but the attempt by the US to extend this ban to the OECD by restricting the use of export credits–an attempt softened by states such as Australia, Japan and Korea which were able to limit US ambition and produce a policy more attuned to the needs of developing countries, using the particular characteristics of the OECD.

This is a case study, therefore, showing the importance of arena characteristics for the development of global policy which underly the phenomenon known as "forum shopping" (Kellow, 2012; Murphy & Kellow, 2013). With changes in the positions of the governments of Japan and Korea, this Decision was tightened before the 26th Conference of the Parties (COP 26) in yet another example of forum shopping.

The restrictions on coal finance by the Bank and the OECD opened up opportunities–notably for China, but also for fund operators whose interests coalesced around alternatives to coal and who (having helped push for the adoption of Obama's policy) then defended that position, including by providing support to NGOs and supporting scientific and journalistic endeavours that have exaggerated the extent of climate change, especially with the declaration of a "climate emergency" for which there is little evidence.

Concerns over coal began with US President Jimmy Carter's energy policy adopted in 1977, which anticipated a substantial increase in the use of coal to reduce dependence both on Middle East oil, and (after the accident at Three Mile Island in March 1979) nuclear energy. Concerned scientists drew attention to the historical work of Svante Arrhenius (1896) (who built on that of Joseph Fourier, Claude Pouillet and John Tyndall) suggesting a warming of the atmosphere from increasing emissions of carbon dioxide from fossil fuel combustion.

This concern was tempered by a common view among atmospheric scientists in the 1970s that a decline in mean global temperature (MGT) might portend a sudden onset of a new ice age (see Rasool & Schneider, 1971). The same models were then used to suggest that disastrous global cooling might result from an exchange of nuclear weapons–a so-called "nuclear winter".

The initial concern was later exacerbated by the addition to climate models of a positive feedback loop, with slight warming producing more water vapour, the dominant greenhouse gas (GHG), which then produced more climate forcing. The original science was not especially alarming: "Arrhenius's rule" held that if there was to be an increase in CO_2 "in geometric progression, the augmentation of the temperature will increase nearly in arithmetic progression" (Arrhenius, 1896, 267). As it happened, Arrhenius had welcomed the prospect of some global warming, which he considered might help stave off the next ice age, which was due as the Earth was nearing the end of an interglacial period, and create better growing conditions to feed a growing population.

The issue was pushed along politically by the congressional testimony in 1988 by the director of NASA's Goddard Institute of Space Science, James Hansen, in a carefully stage-managed appearance that occurred on a day selected because it was forecast to be a scorcher in the middle of an El Niño, with the windows to the room opened overnight by a Democratic staffer to overwhelm the air conditioning — all to create a strong visual appearance that would reinforce Hansen's rather doom-laden message. Later in June, the Canadian government hosted a (non-official) climate change conference in Toronto that called for restrictions on emissions.

The Canadian move accorded with their interest set, as they sought to export electricity from their substantial hydroelectric resources and their CANDU nuclear program to the United States, while also putting pressure on the US over "acid rain" from bordering coal plants burning high sulphur coal (Kellow, 1996). Canada had unsuccessfully sought OECD support for the Toronto Conference. The United Kingdom also found climate change a convenient problem. Prime Minister Margaret Thatcher had famously joined battle with the mining unions in the Miners" Strike of 1984-85 in her desire to reform the grossly uneconomic coal mining industry, based largely on old, deep underground pits approaching the end of their economic lives. In September 1988, Thatcher addressed the Royal Society in rather alarmist terms on the topic.

Thatcher prevailed over the miners, breaking the power of the mining unions, and doubling the productivity of coal mining in the UK by 1990 over 1980, but at the cost of a producer subsidy which rose from \$26/tonne in 1986 to \$75/tonne in 1990, reducing to \$18/tonne between 1990 and 1993, increasing productivity by about 50 per cent and halving domestic coal production. (This was a level of productivity that was only a quarter of that prevailing in the USA and Australia). In Germany productivity was static from 1980 to 1992, and the producer subsidy per tonne of coal rose from $62 in 1986 to $115 in 1993. The strength of the mining unions in Germany prevented any reduction of this subsidy, which cost around DM8 billion pa (Australia, 1997; Anderson, 1995; Anderson and McKibbin, 1997). German subsidy support for coal was the highest in the EU, accounting for 71% of the total cumulative support paid in the EU of about €10 billion annually (2012 monetary values) in the years 1970–2012 in the EU28 (EcoFys, 2014, 31). The level of subsidy declined after 2012, facilitated by decarbonisation in response to the climate change issue.

Climate change also emerged as an issue in Germany in response to the movement against nuclear energy, especially after the Chernobyl accident in 1986. Chancellor Helmut Kohl used climate change as an issue to "wedge" his Social Democrat and Green opponents, who promised a nuclear phase-out, or *ausstieg,* proposing to replace nuclear generation with coal in their platforms. Kohl assured German business that he would extend the disadvantage of his climate policies beyond Germany's borders (Hatch, 1995; 2007), and was able to share the benefits of the emission reductions that followed reunification and the collapse of the economy in the East through the European Burden Sharing Agreement (Boehmer-Christiansen et al, 1993).

Kohl's Christian Democrats (long supporters of nuclear power) leapt at the opportunity the threat of climate change provided. Kohl initially set for Germany a target of a reduction of 40 percent by 2020, with the political goal in mind of building support for nuclear energy. He introduced numerous measures aimed at reducing GHG emissions from German industry, but softened the blow by ensuring that any disadvantage would be exported to the EU as a whole (Hatch, 2007). Kohl also wanted to present favourably Germany's climate policy at the July 1990 G7 summit (Hatch, 2007, 46). On 13 June 1990 the German federal cabinet committed to a 25 percent reduction in GHG emissions on 1987 levels by 2005, increased only marginally to 25-30 percent in subsequent decisions to incorporate the former East German emissions (Hatch 2007, 46). The Treaty of Reunification concluded in October 1990 and the subsequent collapse of both economic activity and GHG emissions in the former DDR provided the opportunity to do so–without much economic disadvantage for Germany. Indeed, climate change provided an excuse to reel in coal subsidies.

Between 70 and 80 percent of primary energy use in the former DDR came from lignite, the highest producer of GHGs of all fossil fuels, and the shift to other fuels used more efficiently and the collapse in East German industry saw a decline in (total) German emissions of CO_2 of 14.7 percent between 1987 and 1993 (Hatch, 2007, 47). Together with developments in the UK, this facilitated the development of a Burden Sharing Agreement that reduced the impact on the remaining EU members of a larger reduction target than they might otherwise have committed to, even allowing increases in countries like Sweden that wished to phase out nuclear power. Subsequent to the conclusion of the Kyoto Protocol in 1997, a Social Democrat-Green Coalition government was elected in 1998, and it did not commit to the Kohl target, but rather to a 25% reduction in CO_2 by 2005.

Impetus for international action built through a World Climate Conference held in Geneva in 1979, a conference of experts at Villach in October 1985, and then the formation of the Intergovernmental Panel on Climate Change in 1988. (See Franz, 1997).

Following the establishment of the Intergovernmental Panel on Climate Change came the Framework Convention on Climate Change, and then its Kyoto Protocol. Assisted by German and British interests, as well as Canadian enthusiasm for CANDU nuclear reactors, concerns over transborder acid rain from the US and the prospect of hydro and nuclear exports from hydroelectric projects such as James Bay, coal quickly came to be seen as the villain of the piece. The Thatcher government's privatisation of the electricity sector (driven in part by a desire to address its uneconomic coal sector) resulted in a "Dash For Gas" in the United Kingdom. Thatcher's privatisation of the electricity sector increased capital costs, because private investors had to meet higher private finance costs, rather than pay lower rates of public sector interest, and this meant combined-cycle gas turbine generators were advantaged over coal because of their lower capital costs. Coincidentally, the European Union relaxed a restriction on the use of gas for electricity generation. The result was the replacement of many coal-fired generation plants with combined-cycle gas turbines (CCGT), which offered a reduction in greenhouse gases (GHGs) per kilowatt-hour (kWh) of electricity of around 60%.

Thatcher committed to a reduction in British emissions to 1990 levels by 2005 upon the publication of the First Assessment Report by the Intergovernmental Panel on Climate Change (IPCC) (Whitney, 1990). The inefficiency of the European coal industry meant that policies that would help reduce subsidies were welcome in the EU, as was climate change as a rationale to support high taxes on transport fuels which were comparatively high (and unpopular). The cost of coal for electricity generation in Germany and the UK was approximately four times that in Australia, the USA, South

Africa and Indonesia, so a positive economic benefit could be expected from switching from coal to other fuel sources in Europe, whereas it was a cost for other countries–at least until the fracking revolution in the US.

The "dash for gas" based on North Sea reserves resulted in 20% of fossil fuel-fired capacity in the UK switching from coal to gas between 1990 and 1995 and emissions of CO_2 fell 12% (Bantock and Longhurst, 1995). The UK Kyoto reduction target in the EU bubble of 12.5 percent had effectively already been met and by 2000 Britain was generating 38 percent of its electricity from gas, 28 percent from coal and 24.5 percent from nuclear (*Financial Times*, 26 June 2001). The International Energy Agency reported that the share of coal-fired generation in the UK declined from 65 percent in 1990 to 35 percent in 2003 and average efficiency improved with the retirement of older plant. Gas-fired generation increased from 2 percent to 38 percent, mostly in the early 1990s. From 1990 to 1994, 14 GW of thermal generating capacity (excluding CCGT) was decommissioned, replaced with 9 GW of CCGT by 1994 and 27 GW by 2004. A further 7 GW of thermal capacity, excluding CCGT, was decommissioned by 2004 (IEA, 2007, 104). Woodchips imported from the US and counted as renewable energy are now burned at remaining stations built to burn coal.

The windfall gains from German "wallfall" and the "dash for gas" were parcelled up in the BSA and allowed much more modest Kyoto reduction targets for some EU members (France 0 percent; Italy 6.5 percent) or even increases (Portugal +27 percent; Greece +25 percent; Spain +15 percent; Ireland +13 percent; Sweden +4 percent). This allowed the EU to forge an alliance with G77 developing nations plus China in the Kyoto negotiation, isolating the US and others in what became known as the "Umbrella Group", supported in this by environment groups.

Creating New Interests

As noted above, the focus of climate change related energy policy has focused very much on coal. Oil has not been readily substitutable as a transport fuel, although electric vehicles are beginning to make inroads and natural gas and hydrogen fuel cells show some promise. Coking or metallurgical coal is important in steel manufacture and thermal coal in both cement kilns and electricity generation–the use in which has come under the greatest regulatory attention, especially because competing sources of generation (hydro, nuclear, gas, and non-hydro renewables) comprise competing sectors that are advantaged by any restrictions on coal-fired generation.

Regulatory policies make choices between narrowly defined interests (Lowi, 1964), but they also sometimes have a normative dimension, and even regulation in the public interest creates opportunities for investment in the favoured technology. What Yandle (1983) has called "Bootlegger and Baptist coalitions" comprised of those pressing an interest-based claim and those a normative one can be enormously influential in securing benefits for the interest-based actors. (Yandle drew the analogy from his home state of Georgia, where Baptists opposed the sale of alcohol on Sunday on moral grounds, and bootleggers because they could only make money with such a ban). The presence of the normative actors helps legitimate support for interest-based actors whose self-interest would otherwise stand exposed. Defining climate change policies as primarily about restricting coal use has allowed interests in wind and solar renewables, in particular, to secure regulatory support and direct subsidies in most jurisdictions.

That climate change came to be constructed as a problem which required restrictions on coal was demonstrated by James Hansen himself. Hansen and colleagues (Hansen et al., 2000) produced what became known as the "Hansen Alternative Scenario", which was based on the mitigation of forcing factors (including the Asian brown cloud) that could be achieved more technically easily and at lower cost than focusing on fossil fuels. Mitigating the inefficient indoor combustion of wood and animal dung would have the added benefit of ameliorating the hundreds of thousands of deaths annually from indoor air pollution. Hansen very quickly found himself the target of activists who thought such an approach would allow the fossil fuel industry of the hook too easily.

Hansen and his coauthors were rounded on by groups such as the Union of Concerned Scientists for daring to shift the focus away from fossil fuels and other GHGs covered by Kyoto. Climate change was a valuable problem *because* it could be used to attack fossil fuels. Roger Pielke and others (2009) showed, there were indeed climate forcings other than GHGs that merited attention. Climate change was a valued problem for Hansen's critics precisely because–and if only–it implicated CO_2 as the largest important cause (see Kellow, 2018a).

Hansen learned his lesson, and soon returned to the anti-coal mantra, famously likening trains transporting coal to Nazi trains taking Jews to extermination camps like Auschwitz. Climate change thus became a problem to which the phasing out of coal became the answer (Hansen, 2007; 2009). Reductions in GHG emissions through measures such as increasing efficiency of combustion were not acceptable to the climate activists. This was despite the substantial reductions that were available from such technological innovation, especially valuable for developing countries that had not already industrialised using coal, unlike Europe and North America.

The Coal Industry Advisory Board to the International Energy Agency pointed out before the negotiation of the Paris Agreement in 2015 that the existing world coal fleet was achieving an average conversion efficiency of 33 percent (increased to 34 percent at the time of writing). Lignite or brown coal yielded the lowest efficiency (in the mid-20 percent range) largely because of high water content, with the latent heat of evaporation taking substantial energy that might otherwise have been available for raising steam in a boiler. Pulverised black coal was much more efficient, and the best available technology was ultrasupercritical (USC) black coal which could achieve 45 percent efficiency. Since a 2-3 percent reduction in GHG emissions followed each 1 percent improvement in efficiency, the conversion of the existing global coal fleet over time would produce a 24-36 percent reduction in GHG emissions. (Average efficiency has now increased to 34 percent, but best available technology is now achieving close to 50 percent efficiency so a reduction of 32-45 percent is possible).

Technological improvement has continued, with the most efficient USC technology today already delivering net efficiency rates of almost 50% — and the global average has risen to 34 percent. Whereas 660MW was previously the maximum size of generator sets, they reached 600-1100MW and operating temperatures and pressures increased. The RDK8 steam power plant at the Rheinhafen-Dampfkraftwerk facility in Karlsruhe, Germany owned by EnBW, has achieved a 47.5 percent net thermal efficiency while producing 919 MW of electricity. GE is now marketing advanced ultra-supercritical (AUSC) technology, calling it SteamH. SteamH combines steam plant technology operating with advanced ultra-supercritical conditions and a digital power plant data platform called Predix (GE Steam Power, nd). GE claims 49.1 percent efficiency for AUSC, and the first plant, Pingshan power plant phase two in China of 1350MW was commissioned in December 2020.

GE claims that its innovative software also allows its plant to operate more flexibly. GE claims its Digital Power Plant for Steam can increase operational efficiency up to 1.5 percent over the life of the plant, reduce CO_2 emissions by 3 percent, and allow for 5 percent less unplanned downtime. One drawback with coal-fired generation has been that coal plant cannot ramp up and down quickly to balance a system containing a significant proportion of solar and wind generation, which can fluctuate in output rapidly according to variations in wind strength and insolation at the earth's surface as cloud cover varies–or due to factors like snow cover. GE's technology has improved this limitation on coal-fired generation.

Nuclear is similarly difficult to adjust to sudden changes in output from solar and wind –variable renewable energy (VRE).

Natural Gas

Gas, as a fossil fuel, has also come under attack, but it is not such an easy target. Not only does it contain less carbon, so produces fewer GHG emissions per kWh (as noted above), but it can provide highly flexible generation in single-pass gas turbine generators to help balance electricity systems that contain a sizable proportion of renewables.

Both photovoltaic (PV) solar and wind turbines are prone to considerable variability, even on a regional to local scale as cloud systems can move over PV farms and wind "droughts" can occur, even on a seasonal scale (as occurred in Europe in the autumn of 2021). Especially problematic are periods in the evening, as the sun sets, sea breezes decline and people return home from work and turn on their air conditioners (in summer) or heaters (in winter). In addition to such intraday wind droughts, calm conditions can last for several days and (as the UK and Europe found in the last quarter of 2021) wind yields considerably below the long-term average can occur. In Brisbane, Australia there is a problem called the "Russ Christ Effect", whereby thunderstorms come in from the west in the afternoon and cut rooftop solar generation when households are still running air conditioners because it has not cooled.

France, with its heavy reliance (about 70%) on nuclear electricity, has seen an *increase* in GHG emissions from its electricity sector because it has installed large numbers of wind turbines, and the system has had to be stabilised with single-pass gas turbines. Under pressure from Germany, France spent $33 billion on renewables, over the decade until 2017 (France, 2017). The result was a rise in the carbon intensity of its electricity supply, and higher electricity prices.

The use of natural gas in the United States has helped it reduce GHG emissions to meet their emissions targets. The use of gas produced from "tight" geological formations by the technique of hydraulic fracturing, or "fracking", reduced prices of oil and gas considerably, displacing coal-fired generation on sheer economics. Combined-cycle gas turbines have allowed the US to mimic the results of the UK's "dash for gas". In addition, policy measures adopted by the Obama Administration between 2009 and the beginning of 2017, described by some as a "War on Coal", and various subsidies to renewables helped drive this result. The fracking revolution led to the US becoming a net exporter of energy and the world's largest oil producer, and the displacement of coal from electricity generation saw an increase in coal exports.

There were numerous interests at play around these issues. First, there was an attempt to drive down global prices by Russia and Saudi Arabia, hoping to depress prices so that the slightly more expensive fracking drillers were put out of business. This proved unsuccessful and the competing countries increased their pumping as their economies suffered.

Russia also sought to undermine fracking in the US and Europe by supporting the anti-fracking movement, succeeding in Europe but not in the US. There are extensive shale gas resources lying under continental European countries (and the United Kingdom), but they remain undeveloped, even though existing resources (such as those in the North Sea) are becoming depleted. Europe has been a net importer of natural gas–from Russia. NATO reported in 2014 that Russia was funding the antifracking movement. In 2014 the Secretary-General of NATO reported this extended to Russia providing support for the political movement against fracking to exploit substantial shale gas resources that might have lessened Western European reliance on Russian gas (Johnson, 2014). (See Chapter 5).

By securing opposition to fracking in Europe, Russia maintained the dependence of Western Europe on Russian gas, just has it had done by controversially securing the support of then German Chancellor Gerhard Schröder, who in 2005 was nominated by proposer Gazprom and appointed to head the shareholder committee of Nord Stream AG, which was planning to build a pipeline to bring Russian gas across the Baltic Sea to Germany, by-passing Ukraine and other problematic former USSR satellite countries shortly after he had signed the deal approving it. Schröder had been voted out of office days earlier, and on 24 October he agreed to provide a €1 billion guarantee should Gazprom default on a loan. In 2016, Schröder was appointed manager of Nord Stream 2, Gazprom's expansion of the original pipeline in which Gazprom is sole shareholder, and in 2017 as an independent director of the board of Russia's biggest oil producer, Rosneft.

Western European dependence on Russian gas is linked to many strategic considerations. Disputes between Ukraine and Russia in 2006 and 2009 resulted in Russia stopping gas supplies to Ukraine and thus to European nations that were the at the distant end of the Brotherhood and Soyuz pipelines that flowed through Ukraine. Alternatives that might have reduced reliance on Russia have not been developed. One such proposal, Nabucco, which would have allowed alternative supplies to reach Western Europe, including those from Iraq and Iran, was abandoned in favour of South Stream, another project that exclusively sources Russian gas. Similarly, conflict in Syria, where Russia supports the Assad regime, prevents consideration of investment in a pipeline that might allow the supply of gas from the Persian Gulf, where Qatar and Iran have joint ownership of the South Pars/North Dome gas-condensate field, which contains the world's largest reserves.

Gas in the US and the competition with coal was also riven with interests, but with those of less geostrategic concern. I examine of some of these issues in the next chapter.

Non-hydro Renewables

Renewable sources of energy are widely preferred to fossil fuels by those advocating decarbonisation, but they are not without their problems.

Wind power was widely used historically but was displaced by coal, though it persists in romantic imagery, especially of the Netherlands landscape. Water wheels met the same fate, although hydroelectricity has been a popular source of generation, essentially using the water cycle and gravity to turn turbines by constructing dams or utilising natural lakes at high altitudes. The impact of hydro development on people and environments has frequently given rise to conflict, however. Hydro is not completely free of GHG emissions, because large quantities of steel and cement are required to build concrete dams and vegetation submerged by storages decays, yielding methane–about 25 times more powerful a GHG than carbon dioxide–although these are usually quite low on a per kWh generated basis. One problem with so-called Global Warming Potential (GWP) numbers that state the greater power of methane over carbon dioxide is that they are measured in the laboratory; in the atmosphere there is considerable overlap in the absorption and re-emission spectra of the GHGs, so they must compete with other gases, such as water vapour–by far the dominant GHG.

Climate change impacts are relatively higher with wind and solar.

A valid comparison of emissions from different energy sources must assess the complete life-cycle of the generation source. The steel in a wind generator tower requires perhaps 220 tonnes of coking coal to manufacture. Then coal is required to make the cement that forms their foundations. Photovoltaics do not compare favourably with nuclear energy (Fthenakis and Kim, 2007). One analysis (Ferroni and Hopkirk, 2016) suggested that more energy was consumed in manufacturing solar panels than is produced by them over their lifetime in locations with relatively poor insolation, such as Germany and Switzerland (although this was contested by Raugei et al., 2017). In addition to comparing "Energy Return on Energy Invested" (EROEI), however, the manufacture of photovoltaic panels has a controversial GHG balance. They are often made in China using (inefficient) coal-fired electricity, but manufacturing them also involves the release of chemicals such as the solvents nitrogen trifluoride (NF_3), not covered by the first commitment period of the Kyoto Protocol, but 16,000 times more powerful a GHG than carbon dioxide, and sulphur hexafluoride (SF_6), which is 23,900 times more powerful than carbon dioxide.

Almost always overlooked is the opportunity cost of the land area required. Rooftop solar is fine, but broadscale solar "farms" have considerable land-use requirements. Kelly (2016) points to the land required for solar (and renewables) for a megalopolis like Shanghai (population in excess of 24m): the land required competes with that required to grow food for the city, and one use must be displaced. Also largely overlooked is the requirement under Article 2.1(b) of the Paris Agreement to "foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production. . . ." If food production takes priority, the transmission lines grow larger, and the transmission losses and resource requirements with them. And although only a very small consideration, the insolation falling on solar panels is lost to plants which might photosynthesise and remove carbon dioxide from the atmosphere. Then there is decommissioning and disposal at the end of their economic lives–15 to 25 years. Wind turbine blades and PV panels are made of composite materials that cannot be recycled readily, and the first generation to be retired are currently going to landfill.

The costs of electricity from wind and solar energy have reduced substantially, although they are heavily subsidised in most jurisdictions and the true economic cost of such sources is difficult to determine. Their supporters are prone to exaggerating their supposed advantages over more traditional sources of generation, and to downplaying their disadvantages. Most importantly, renewables are extremely low in density and they are variable or non-dispatchable. The first characteristic means that they have enormous land-use requirements at scale, and typically have capacity factors of only 25-30 percent, meaning that three or four times the average demand for electricity is required in terms of installed capacity. Additional transmission capacity is required, capable of carrying maximum output if congestion is to be avoided, but in use for only 25-30% of the time (and thus transmission costs–and losses–are more expensive than higher density sources).

The second characteristic means that non-hydro renewables or variable renewable energy (VRE) require back-up or storage. Storage for a largely non-dispatchable renewables system can be required on an intra-day, inter-day or even inter-seasonal basis. Many advocates for wind and solar conveniently ignore these disadvantages and cite misleading cost estimates that favour their preferred generation sources but fail to include the costs of providing back-up to ensure system reliability.

One such advocate is the think tank Carbon Tracker, whose first chairman (2010-2018) was Jeremy Leggett, who had been a climate campaigner with Greenpeace International from 1989 to 1996 and founded Solarcentury, now the United Kingdom's largest solar energy company, in 1997. Carbon Tracker is funded by numerous charitable foundations that support many climate NGOs, including the Rockefeller Brothers Fund, the Rockefeller Foundation, and the William and Flora Hewlett Foundation. Also a patron is Next Gen Climate Action, established by billionaire Tom Steyer who founded hedge fund Farallon Capital and made much of his fortune in coal before an epiphany, after which he divested himself of fossil fuel investments and invested in renewables, before seeking the Democratic nomination for the US presidency in 2020. Carbon Tracker is therefore not devoid of interests, and its analyses support those interests. I examine this phenomenon in more depth in Chapter Five.

Carbon Tracker, interestingly, compares the Levelised Cost of Energy (LCOE) of new renewables with the Long-run Marginal Cost (LRMC) of existing coal units, but this is not a like-for-like comparison, because renewables are not dispatchable and have extremely low density. They must therefore be backed up with dispatchable capacity, be it batteries or pumped storage hydro or fossil fuel generation like single pass gas turbines. And (as noted above) because typical capacity factors are only 25-30 percent, their low density means that they require a substantial investment in transmission capacity that must be capable of carrying their full output, but will only be utilised 25-30 percent of the time. The true cost of renewables is the *System*

Levelised Cost of Energy (SLCOE). Additionally, LCOE is an *accounting* measure, and LRMC an *economic* measure, so the two are not comparable.

Storage or back-up are important considerations in electricity systems because the time of demand or consumption does not always match the time when electricity can be generated from renewable sources such as wind and solar, because the wind does not always blow and the sun does not shine at night, and on cloudy days insolation is much reduced. Even hydroelectricity can be variable; some hydro stations can have substantial storage for water, but others are simply run-of-the-river with very little storage, and water must be passed through turbines effectively when it is available or spill. Pumped storage hydro can use intermittent sources to pump water uphill to a suitable storage for release when required, but this is typically only about 85 percent efficient or less, and is often not suited to longer term storage.

Electricity can in many ways regarded as a service, and (as noted above) it is useful to distinguish between intra-day storage (for a few hours), inter-day storage (from one day to the next), and inter-seasonal storage (over several weeks, from summer snow melt, for example) (Kelly, 2016). Batteries are really only useful for intra-day storage and stabilising voltage and frequency in systems with a substantial proportion of non-hydro renewables when wind suddenly drops or clouds come across large areas of solar panels. Ordinarily, large generators on the system are synchronised and can cope with fluctuations in demand (or even loss of a generator) with only small variations in voltage or frequency across the system. Pumped storage hydro is useful over hours to (maximum) days and can be profitable by “banking” electricity when prices are low and selling during times of peak demand (and therefore price).

Electricity grids are complex systems, and the introduction of some elements can have perverse effects. As noted above, the introduction of large amounts of variable wind energy into the predominantly nuclear French system, for example, has required the greater use of single pass gas turbines because nuclear generators cannot ramp up and down readily. In Germany, its *Energiewende* program has not only led to the need to construct extra transmission capacity from the offshore wind capacity in the north to the industrial south, but has often seen increases in the GHG intensity of remaining thermal plant because its required output is variable and it cannot be operated at optimal loading. (Hydro turbines also have a ‘sweet spot” where generation per cumsec of water is optimal and lower or higher loads can waste water; each type of water turbine–Francis, Kaplan and Pelton wheel–has different characteristics).