Early warnings and emerging environmental accountability: Total's responses to global warming, 1968-2021.

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Abstract

Building upon recent work on other major fossil fuel companies, we report new archival research and primary source interviews describing how Total responded to evolving climate science and policy in the last 50 years. We show that Total personnel received warnings of the potential for catastrophic global warming from its products by 1971, became more fully informed of the issue in the 1980s, began promoting doubt regarding the scientific basis for global warming by the late 1980s, and ultimately settled on a position in the late 1990s of publicly accepting climate science while promoting policy delay or policies peripheral to fossil fuel control. This represents one of the first longitudinal studies of a major fossil fuel company's responses to global warming to the present, describing historical stages of awareness, preparation, denial, and delay.

1. Introduction

Since World War Two, the Anthropocene has witnessed an intensification of humans' alterations of the Earth system, as well as an increase in environmental alerts and concern (McNeill and Engelke, 2016; Krausmann et al., 2017). Key to this "Great acceleration", annual fossil fuel extraction has increased sevenfold in the last 70 years resulting in the top 20 fossil fuel firms producing more than one-third of all greenhouse gas emissions since 1965 (Heede, 2014; Climate Accountability Institute, 2020). Since 1945, few industries have been exposed to the intensity of environmental scrutiny and public criticism that the oil industry has faced, relating to pollution from refineries, smog, leaded gasoline, oil spills, and poor monitoring of extraction sites. When climate change emerged as a policy

issue in the 1960s, oil and gas majors were already practiced in managing environmental perceptions by the public, risk research, and regulatory action by governments (Markowitz and Rosner, 2002; Jenkins, 1954).

Much has been documented in recent years on how major fossil fuel companies such as ExxonMobil (Banerjee et al., 2015; Supran and Oreskes, 2017) and Royal Dutch Shell (Mommers, 2018) have navigated climate alerts and controversies via a mixture of internal knowledge development and external public relations activities, with industry associations and coalitions such as the American Petroleum Institute and the Global Climate Coalition playing major roles (Brulle, 2018; Franta, 2018, 2021). These studies have met with great interest due to their analysis of varying strategies among oil majors (Skjærseth and Skodvin, 2003), importance for understanding the history of climate action and inaction, and usefulness for informing current and planned efforts to address climate change. Relatively little, however, has been documented on Total, a company established in the 1920s that a century later has become the world's fourth largest dedicated oil and gas company by market capitalization behind ExxonMobil, Chevron, and Royal Dutch Shell. Although the company's current climate strategy has been scrutinized (Choquet, 2019), its historical response to global warming and to evolving climate science and policy remains an unaddressed topic.

In this paper, we address this research gap by reporting new archival research and primary source interviews documenting Total's long exposure to climate warming research and subsequent industry coordination, public communication, and lobbying activities regarding climate change. While filling this empirical gap, we also aim to contribute to the literature on the global effort deployed in the past fifty years by the fossil fuels industry to produce ignorance, sow doubts on the legitimacy of climate science, struggle against regulations, and maintain legitimacy within the global energy transition. We do so by shedding light on the early exchanges of knowledge and incipient strategies that were articulated within IPIECA (International Petroleum Industry Environmental Conservation Association), an industry association in which Total was actively involved and which has received less attention than the American Petroleum Institute (API) or the Global Climate Coalition (GCC).

Scholarly research on the history of major fossil fuel companies is often limited by restrictions on access to company archives. In contrast, Total's archives, located at the company's headquarters in Courbevoie, France, are partially accessible to researchers and provide an unprecedented look at the history of the company. In addition to these archives, we also interviewed former Total executives, who shared with us their recollections of the company's history with regard to climate change. As a result, we report detailed information that may be obtained regarding other fossil fuel majors should they also provide access to scholars.

Environmental historians have shed light on the history of the Anthropocene, revealing that environmental warnings and awareness predate the late-20th-century discursive turn toward

sustainability. In this context, the Anthropocene can be understood as a history of evolving mechanisms of willful blindness and rationalizations that normalized socio-ecological trajectories and business strategies that accelerated alterations of the planet (Bonneuil and Fressoz, 2016). The history of oil majors' engagement with climate science (Boon, 2019) offers an empirical ground to understand such diverse and evolving mechanisms.

In science and technology studies, the social and cultural "study of the production of ignorance" has helped to understand ignorance as resulting from the organized work of social actors ("agnogenesis") rather than a mere absence of knowledge (Proctor, 2008). In the climate context, the concept of agnotology has mostly been harnessed in order to describe cases in which industrial actors have aggressively attacked the scientific consensus and organized lobbying campaigns (Oreskes and Conway, 2010), as well as to highlight strategic rhetorical framing techniques (Supran and Oreskes, 2021) and disparities between internal knowledge and external communication (Supran and Oreskes, 2017). But an exclusive focus upon the most aggressive ways of producing ignorance may leave understudied other forms of agnogenesis that may be less overt, strategic, intentional, or more banal, such as "willful blindness" that may become normalized within firms (Bovensiepen and Pelkmans, 2020). Furthermore, in addition to overt climate science denial, public relations activities such as pronouncements of corporate stewardship and endorsements of climate science have been documented by scholars as instrumental to corporate efforts to avoid responsibility and resist regulations (Rajak, 2020). The case of Total's multiple and changing stances toward climate science and policy in the last half century helps conceptualize these diverse and multifaceted mechanisms. While we show for the first time that overt denial of climate science was endorsed by Total from at least 1989 to 1994 (for an opposite finding, though lacking internal company sources, see Hove et al., 2002), we also document a temporal sequence of multiple and subtler forms of agnogenesis, such as willful ignorance, responsibility-shifting, strategic philanthropy, promotion of peripheral solutions, and corporate controversy management. Thus, this paper contributes to interdisciplinary efforts to understand the evolving approaches oil majors have taken to climate change, climate science, and mitigation policies.

2. Climate warnings in an era of growing environmental awareness, 1965-1986

Prior research has shown that segments of the petroleum industry, including European majors (Mommers, 2018; Andersson, 2020; Aronowsky, 2021) and the American Petroleum Institute, the primary trade association for the industry in the United States, received warnings about global warming as early as the 1950s and commissioned research on the topic by the end of the 1960s indicating that continued expansion of fossil fuels would cause significant global warming with adverse consequences for the world's societies (Franta, 2018; Robinson and Robbins, 1968). Total (est. 1924) was a member of the API in the late 1960s through its North American subsidiary and therefore may have had access to this information(1).

Our current research was sparked by our discovery of direct proof of Total's awareness of climate science in 1971. In that year, the company's magazine, *Total Information*, contained an article entitled "Atmospheric pollution and climate" (Durand-Dastès, 1971). The article stated:

> Since the 19th century, humans have been burning increasing amounts of fossil fuels. This results in the release of enormous quantities of carbon dioxide [...] The overall amount of carbon dioxide present in the atmosphere, therefore, has increased significantly. [...] The increase has been around 15% over the last 150 years, which is not negligible. And [...] if the consumption of coal and oil keeps the same rhythm in the years to come, the concentration of carbon dioxide will reach 400 parts per million around 2010 [...].
>
> This increase in concentration is quite worrying [...] carbon dioxide plays a large role in the thermal balance of the atmosphere [...] air richer in carbon dioxide absorbs more radiation and heats up. It is possible, therefore, that an increase in the average temperature of the atmosphere is to be feared. The calculated orders of magnitude are obviously small (from 1—1.5°C) but could have important impacts. Atmospheric circulation could be modified, and it is not impossible, according to some, to foresee at least a partial melting of the polar ice caps, which would certainly result in significant sea level rise. The catastrophic consequences are easy to imagine. (Durand-Dastès, 1971, p. 18)

The article's predictions were quite accurate: carbon dioxide concentrations reached 400 parts per million in 2015. Printed at about 6000 copies, the magazine, *Total Information*, was the company's internal and external communication outlet, mostly read by executives, employees, and commercial partners and was available to the public at the French National Library. The above mentioned article was part of a special issue on the environment with a foreword signed by the company's CEO, which

noted that "the defense of the environment is often accompanied by rather strong criticism of large industries including oil companies" (Granier de Liliac, 1971[(2)]).

2.1. Putting Early Climate Warnings in Context

The significance of this early warning becomes clearer if placed in its international scientific and political context. The involvement of carbon dioxide in the greenhouse effect had been known to scientists and discussed in some media since the 19th century (for a detailed chronology including press clipping, see Johnson, 2016), but in the context of the Cold War, when the entire globe from the sea-bed to the upper atmosphere was studied as a potential strategic theater, research on the Earth system accelerated. From 1950 to 1971, at least five lines of research solidified the hypothesis of anthropogenic global warming (Weart, 2003; Edwards, 2010; Howe, 2014; Somerville et al., 2007). First, a reconstruction of the Earth's global temperature since 1800, collected since the 1920s and digitized in the 1960s, highlighted an overall warming trend since the end of the 19th century and a slight cooling trend from 1945-1970. Second, a continuous annual increase in atmospheric carbon dioxide was measured at Mauna Loa Observatory starting in 1958. Third, observations and estimates from the US Geological Survey concluded in the late 1950s that the Arctic ice cap had shrunk by 12% in area and 40% in thickness since 1945, with sea level rising 30—60 cm per century, and that the eventual abandonment of some coastal towns may be necessary (Fleming, 1998, p. 132). Fourth, "general circulation" models were developed in the 1960s, using the first supercomputers to model the Earth's climate in three dimensions, which estimated in 1967 that a doubling of atmospheric carbon dioxide from 280 to 560 ppm would produce an average global warming of 2°C (Manabe, 1967, discussed in Weart, 2003, pp. 107-113). Finally, a fifth line of work documented positive feedback between warming and melting ice and snow through changes in Earth's albedo (Budyko, 1969, discussed in Weart, 2003 p. 86).

These lines of inquiry occurred in a context of growing environmental alerts and movements, and global environmental issues steadily gained prominence in the public sphere (Mahrane et al., 2012). The Earth, which could now be seen from space as a fragile and finite blue ball, had to be managed accordingly. A variety of scientific assessments performed in the 1960s and 1970s helped to bring global warming to the US and international attention. In the United States, a report submitted in 1965 to the White House by the President's Scientific Advisory Committee on the state of the environment warned that

> By the year 2000 the increase in atmospheric CO_2 will be close to 25%. This may be sufficient to produce measurable and perhaps marked changes in climate, and will almost certainly cause significant changes in temperature (President's Science Advisory Committee, 1965, p. 126-127).

Shortly after its release, the President of the American Petroleum Institute mentioned the report in a speech at the organization's annual meeting (Franta, 2018) and President Johnson wrote to

Congress that "This generation has altered the composition of the atmosphere on a global scale through [...] a steady increase in carbon dioxide from the burning of fossil fuels"(Johnson, 1965 quoted by Oreskes and Conway, 2010, p. 171). Additionally, a synthesis carried out at MIT in 1970, *Man's Impact on the Global Environment* (known as the SCEP Report), affirmed the Earth could warm by 0.5°C by the year 2000 and by 2°C in the 21st century (SCEP, 1970, p. 12). In the wake of this study, MIT brought together 30 global atmospheric and climate specialists for two weeks in Stockholm in the summer of 1971, yielding the *Inadvertent Climate Modification Report: Report of the Study of Man's Impact on Climate* (known as the SMIC Report). The report, which also examined the potential for global cooling from aerosol pollutants, stated:

> We know enough of the theory of climate and the construction of climatic models to recognize the possibility of man-made climate change and to have some confidence in our ability to compute its magnitude (...). We have a conviction that mankind can influence the climate (…). We hope that the rate of progress in our understanding can match the growing urgency of taking action before some devastating forces are set in motion (SMIC, 1971, p. 15 and 27).

Climate change also arose as an international concern at the 1972 UN Conference on the Human Environment in Stockholm, where two of the 109 final recommendations called for research and vigilance regarding anthropogenic climate change (Ward and Dubos, 1972, 191-195; United Nations, 1972, recommendations n°70 and 79).

In the French scientific community and public space, the climate issue was less prominent than in the United States. Yet the word was spreading in French decision-making circles. In 1968, a high level symposium on technological forecasts and economic planning held discussions comparing the problem of nuclear waste with "the increase of carbonic gas in the whole atmosphere which might, in a decade or half a century, start to pose problems of global modifications in terrestrial climate". In the face of this dilemma, top scientists, senior public administrators and heads of major French companies including the CEO of Elf (a then state-owned French oil company absorbed by Total in 1999) agreed on the need to develop nuclear energy both for economic and climatic reasons (CTAAT, 1968, p. 51). In 1970 and 1972, two articles on global warming appeared in the journal of the French land planning administration DATAR, the driving force behind the creation of the French Ministry of Environment. The second of these articles reported the findings of the SMIC Report and noted that:

> "We know enough today about climate theory and the construction of climate models to see that humans can very well cause climate change. [...] In the final analysis, therefore, we can only predict what might happen if humanity continued to act in a certain way, much as it is doing now" (anon., 1972, p. 35).

Around the same time, a variety of popular environmental works in English were translated into French, including *The Closing Circle* by Barry Commoner (translated 1971), *Only One Earth* by Barbara Ward and René Dubos (translated 1972), and the *Limits to Growth* report (translated 1972), all of which mentioned the alteration of the global atmosphere and its possible impacts on climate. Additionally, *L'Utopie ou la Mort* ("Utopia or Death"), a French environmental best-seller warning of "irreversible climate changes" and sea level rise, was published by René Dumont (1973[2020], p. 78), who represented the green movement at the 1974 French presidential election.

Often, these warnings of global warming were accompanied by discussions of potential global cooling. By the early 1970s, scientific articles had noted the potential for aerosol particles, especially industrial pollutants such as sulfur dioxide, to block a fraction of incoming solar radiation. Additionally, since past interglacial periods of around ten millennia were followed by relatively rapid glaciation, the slight cooling trend observed between 1940—1970 could lend itself to extrapolations of an imminent ice age, a scenario promoted by various popular magazines in the 1960s and 1970s and included in a CIA report in 1974. Yet a meta-analysis of the scientific literature from 1965—1979 shows most studies predicted warming, with discussion of the cooling hypothesis dwindling by 1973 (Peterson et al., 2008). By 1979, the scientific consensus regarding the existence and magnitude of future warming as a function of greenhouse gas emissions was reflected in the authoritative assessment directed by MIT's Jule Charney, which reviewed prior work and estimated a doubling of carbon dioxide concentrations would produce a global warming of 3°C (Charney et al., 1979).

2.2. Total Facing Climate Warning in the 1970s

The discussion above indicates that the 1971 article published in *Total Information* was not an isolated warning but rather a moment in which the French oil company's top executives were exposed to a growing body of scientific work on global warming. In an interview for this article, Durand-Dastès, a specialist of the climate-monsoon nexus in India and one of the French academics then most familiar with climate research, recalled the time when he wrote for *Total Information* and noted the importance of the growing body of transnational scholarship:

> "I remember having the SMIC report in my hands. [...] I read a lot of meteorology, one of the key areas for climatology, and a lot of American scientific literature[...] The assertion of global warming of 1—1.5°C in coming decades if emissions followed their trajectory was more or less common in all scientific journals. I was reading the *Quarterly Journal of the British Meteorological Society*, *Tellus*, and so on." (Interview with François Durand-Dastès, August 6, 2020)

When asked to elaborate on what he meant by "catastrophic consequences" of a climatic warming, he added:

> The deltas are always the sites of disasters. We all knew that increasing the greenhouse effect could not fail to produce major consequences, but I never imagined it would develop so quickly. In 1971, it was foreseeable that the rising oceans would cause problems in the deltas, and I was familiar with those of South Asia. [...] Cyclone Bhola in 1970 had hundreds of thousands of victims, the Andhra Pradesh cyclone in 1977 had 10,000 dead [...] there were catastrophic cyclones hitting hundreds of thousands of people at the time I was writing this article. The great floods were episodes of conjunction between a typhoon and a high tidal coefficient, but it seemed obvious to me that against a background of global warming, it was going to get worse." (ibid.)

Confronted with multiple warning signals in France, the US, the international arena, and its own magazine, how did Total and Elf (the two major French oil companies which merged in 1999) react? At that time, the French petroleum industry was exposed to growing public criticism following the Feyzin refinery accident in 1966 (in which 18 people died) and the *Torrey Canyon* oil spill in 1967. Total responded by portraying environmentalists as "caught in the trap of nostalgia for a past that was not as preserved as it is assumed" and asserting that "it is technology and not outdated regrets that will ensure or restore a certain quality to the living environment" (Truchot, 1975, p. 20).

With the creation of a French ministry for environment in 1971, French oil companies also feared new regulations on air pollution. This critical scientific, social, and policy context led Total and Elf to establish new structures for managing environmental affairs. In 1971, Elf created its Information and Research Center on Nuisances (CIRN) (Elf, 1974) while Total created a division that would later become its Department for Environment[3]. A former staff member in the early years of that division recalls:

> "At that time [...] oil companies were frowned upon [...] we had to make it known that we were doing something, that we were not just terrible polluters [...] so we put the label 'environment' or 'fight against pollution' to what we were already doing." (Interview with former Total employee, 23 Sept. 2020)

French oil companies also developed collective business strategies: in 1971, UCSIP, the French oil industry business council, published a booklet responding to environmental alerts and criticism. This booklet acknowledged a "slow increase in the average CO_2 content of the atmosphere" that

> "should normally lead to a slight warming effect on the Earth's climate by the end of the century, although not as great as that needed to bring about the apocalyptic effects predicted by some futurologists (melting of polar ice, vast regions submerged...). However, the impact of human activity in the direction of a warming of the climate is very controversial, because of the opposite effects caused in particular by the increase in dust content and the possible increase in the cloudiness of areas of intense aerial activity." (UCSIP, 1971, p. 24-25)

At an international level, executives from Elf and Total participated in meetings of petroleum industry groups such as CONCAWE (Conservation of Clean Air and Water in Europe, which since 1963 had coordinated the response of the refinery sector to pollution regulations) and IPIECA (established in 1974 as stakeholder to the UN Environment Program).

While French environmentalists advocated for a move toward renewable energies, Total, like most other oil majors, strongly invested in coal following the oil shock of 1973. The company joined forces with BP to develop the rich Ermelo coal mine in South Africa in 1976, created Anthracorp Inc. in 1979 to mine coal in the U.S.[(4)], and invested in expanding the coal import capacity at the French port of Le Havre (Ramoisy, 1987, p. 39 and 90-91).

Although scientific research on climate change intensified throughout the 1970s, French oil companies exhibited public silence on the issue. Magazines from Total and Elf, which we reviewed from 1965—2010, did not address climatic change a single time from 1972—1988, even following the 1979 World Climate Conference in Geneva, which was covered in *Le Monde*, or the US National Research Council Report of the same year, which led the journal *Nature* to describe global warming as "the most important environmental issue in the world today"[(5)]. Whether Elf's or Total's external silence was reflected internally among R&D staff and executives remains for future research[(6)]. The API (including the European oil majors) and Exxon, in comparison, both established internal research programs on climate in the late 1970s, and Shell commissioned private research on climate by 1981, despite also exhibiting relative silence in public (Banerjee et al., 2015; Franta, 2021)[(7)].

In any event, by 1984, discussion spread within the global petroleum industry of the business threat posed by global warming. Bernard Tramier, Environmental Director of Elf from 1983 to 1999 (and later of TotalFinaElf after the merger from 2000 to 2003), remembers how Exxon alerted the industry:

> "The moment I remember really being alerted to the seriousness of global warming was at an IPIECA meeting in Houston in 1984. There were representatives from most of the big companies in the world there, and the people from Exxon got us up to speed. [...] They had remained very discreet about their own research [on global warming]

> [...] Then in 1984, perhaps because the stakes seemed to have become too great and a collective response from the profession required, they shared their concerns with the other companies." (Interview with Bernard Tramier, Nov. 5, 2020)

In early 1986, Tramier sent an annual report to Elf's executive committee. In it, he described global warming as certain to occur and a key issue requiring a defensive strategy by the industry:

> "The problems related to the interactions of various pollutants in the upper atmosphere will become of concern in the coming years. The case of ozone is already known, but the accumulation of CO_2 and CH_4 in the atmosphere and the resulting greenhouse effect will inevitably modify our environment. All models are unanimous in predicting global warming, but the magnitude of the phenomenon remains undetermined. The first reactions were, of course, to 'tax fossil fuels', so it is obvious that the oil industry will once again have to prepare to defend itself." [(8)]

The meeting of Elf's executive committee on March 4th, 1986 appears to have marked a turning point in the firm's awareness of anthropogenic global warming. While the topic may have been discussed previously among Elf's executives, it was now present in the minutes of a meeting attended by its top managers, informed through official channels that continued extraction of fossil fuels would "inevitably modify our environment."

3. International Coordination to Delay Fossil Fuel Controls, 1987—1996

For a coordinated, international defense, the French petroleum industry turned to IPIECA. In 1987, the organization held a symposium in Baltimore to review the state of climate science and potential policies. The following year, while meeting at Total's headquarters in Paris, it created the "Ad Hoc Group on the Greenhouse Effect," soon renamed the "Working Group on Global Climate Change" (Interview with Brian P. Flannery, Feb 1 2021). The group was chaired by Duane LeVine, Exxon's manager for science and strategy development, and also included Elf's Tramier, Brian Flannery from Exxon, Leonard Bernstein from Mobil, Terry Yosie from the API, and other representatives from the world's major oil companies. It had three lines of work: 1) "to draw up the state of the science of climate change induced by the possible accentuation of the greenhouse effect, including the main areas of uncertainty," 2) to study "no regrets" response strategies that would benefit the industry, and 3) to consider efficiency improvements and substitutions between different fossil fuels as industry-friendly responses to global warming (LeVine et al., 1990). The group, including Tramier from Elf, sent a dossier on climate to the IPIECA member companies, which included a strategy paper from LeVine, stating:

> "Although some declare that science has demonstrated the existence of PEG [potential enhanced greenhouse] climate change today... I do not believe such is the case. We will require substantial additional scientific investigation to determine how its effects might be experienced in the future" (LeVine, 1989, p. 1)

For the industry to defeat public policies that could "shift ... the energy resource mix" away from fossil fuels, "reduce CO2 emissions by 20%," or "even [require] abandoning resources" (LeVine, 1989, p. 16), LeVine recommended emphasizing uncertainties in climate science and the need for further research, the costs of policy action, and alternative environmental policies that would not threaten the industry's core business. IPIECA's 1990 "briefing document" to its members also included a paper from the API, "Position on Global Climate Change," which echoed LeVine's conclusions (in LeVine et al., 1990; see Rich, 2019, p. 246). Another part of IPIECA's agenda was to postpone any significant controls on CO_2 emissions until detection could provide what the group called a clear "verification of climate change" (Flannery , 1992, p. 20), even though a 1982 internal Exxon document had noted that the statistical detection of global warming might take decades and then come too late ("once the effects are measurable, they might not be reversible," the document observed) (Exxon, 1982). When such detection was finally shown in the IPCC's second assessment report in 1996, the industry attacked both the IPCC and individual scientists connected to the work (see Oreskes and Conway, 2010, p. 200-210).

IPIECA organized a symposium in Rome in April, 1992 to push its agenda before the upcoming UN conference in Rio de Janeiro. After Bernard Tramier (Elf) opened the conference as IPIECA's new chair, the industry representatives, policy makers, and scientists in attendance were told:

> "it is unlikely that we will be able to detect or to refute predictions of climate change from an enhanced greenhouse effect for at least a decade. Also, it is unlikely that we will have confidence in predictive capabilities for many years. [...] model-based projections are controversial, uncertain, and without confirmation." (Flannery, 1992, p. 2).

Tramier recalls this period:

> "Exxon had taken hold of the issue, and that suited us because we [French companies such as Elf and Total] did not have the knowledge or the means to have weight in the scientific community, the Intergovernmental Panel on Climate Change [IPCC], or the UN process. [...] We were a follower of Exxon [...] we agreed that we didn't know enough [scientifically] for emission reductions or [carbon] taxes to be enacted, and we let Exxon do the rest [...] What we did not want was for drastic decisions to be taken before being certain of the reality and the extent of anthropogenic warming. For

> us, the idea of a 20% reduction in emissions [called for at a June, 1988 intergovernmental conference in Toronto] was premature and should not be codified in Rio [the UN conference in 1992]. [...] What we feared was that in this kind of conference, for reasons of diplomacy and communication, the world would take measures harmful to the industry" (Second interview with Bernard Tramier, Nov. 24, 2020).

Hence, the French petroleum industry endorsed the strategy spearheaded by Exxon, which was implemented not only by the API and the Global Climate Coalition (Brulle, 2018, Banerjee et al. 2015, Rich, 2019), but also by IPIECA member companies. Tramier was president of IPIECA from 1991 to 1994 and approved funding of scientific research that could sharpen the industry's ability to emphasize climate model limitations and potentially make global warming appear less alarming, such as work on aerosols and clouds at the Hadley Center in the UK and studies on carbon uptake by oceans at Columbia University in the US (IPIECA, 1992, p. 9). Additionally, in the early 1990s, Elf began placing young, freshly graduated engineers within climatology laboratories in Hamburg and the United States, including UCLA, MIT, and NCAR in order to monitor the latest developments of climate science (Interview with Jean-Paul Boch (Elf), Nov. 20, 2020).

While endorsing Exxon's and IPIECA's strategic production of doubt, the French petroleum companies also promoted uncertainty in their own communication and public relations. In 1992, as the Rio conference approached, Total's environmental director, Jean-Philippe Caruette, emphasized doubt in Total's corporate magazine, now called *Énergies*:

> "Certainly, there is a relationship between the temperature and the carbon dioxide content of the atmosphere, but this relationship does not allow an extrapolation leading to more or less catastrophic scenarios on global warming of the planet [...]. And above all, there is no certainty about the impact of human activities, including the combustion of fossil fuels" (Caruette, 1992, p. 13-14)

During the Rio conference, Total distributed a dossier lamenting that "warming of the Earth [...] polarizes all the attention and gives rise to apocalyptic descriptions of the future," while asserting that "the considerable progress made in climatology since the beginning of the century has not allowed us to dispel the uncertainties regarding the greenhouse effect" and insisting that energy policies should "ensure the growth of [developing] countries, even if it means increasing greenhouse gas emissions to start."[9] Elf followed suit, declaring the day after the summit:

> "Thus, to the still-unknown question of the greenhouse effect, we cannot answer hastily by taxing only European industrialists because we think, without being sure,

> that carbon dioxide emissions could lead to warming of the planet in the years to come." (Elf, 1992, p.1)

Two months later, François-Xavier Ortoli, Honorary President of Total, spoke at the Congress of the World Energy Council in Madrid, saying scenarios predicting 2-5° C of global warming in the 21st century were dubious because:

> "natural sources are much greater than man-made emissions [...] we still have much work to do to understand the complete carbon dioxide cycle, the role of the ocean depths and the biosphere. Scholars are divided on this. Hippocrates says yes, Galen says no. There is some doubt."(10)

In March 1993, Francis Girault, director of foresight, economics and strategy at Elf and close advisor to the company's CEOs (first Loïk Le Floch-Prigent and later Philippe Jaffré), wrote an internal report addressed to the company's board called "Greenhouse effect (proposal for an action plan)"(11) in which he explicitly advocated for an aggressive strategy of doubt. In order to resist "hasty decisions" regarding fossil fuels, Girault proposed in his plan that the company promote the notion that "there are scientific doubts about the greenhouse effect," as well as identify and support "renowned scientists who can intervene positively in the debate".(12) Tramier recalls, "Girault feared the climate issue would result in a tax for us, and he was anti-tax [...] We had to rely on arguments, so he relied on those that said the climate problem was not serious" (Second interview with Bernard Tramier, Nov. 24, 2020). Another Elf engineer from the Environment Direction remembers more simply, "Francis Girault was on an Exxon-style track" (Interview with Jean-Paul Boch, Nov 20, 2020).

This temptation to oppose fossil fuel reductions by strategically promoting scientific uncertainty takes on fuller significance when placed in context of the enormous battle waged by both Total and Elf against energy or carbon taxation in the early 1990s. In 1989, an "eco-tax" was proposed by the European Commissioner for the Environment and in October, 1991 was put on the table by the European Commission (Aykut and Dahan, 2014, p. 235-243). At the same time, French Prime Minister Rocard wrote to his environment minister that "Climatic changes that could result [from greenhouse gases], even if they are still poorly understood in terms of their scope and regional consequences, call into question the current conditions of life on Earth" (GIES, 1990, p. 2) In December 1990, France sent a memorandum to the European Commission that promoted both common quantified targets for industrial countries to reduce their emissions and a fiscal instrument on fossil fuels (eco-tax) (Gouvernement Français, 1990). But a year later, the new French Minister for Industry, Dominique Strauss-Kahn, sought to block the eco-tax. Meanwhile, European oil companies had aligned themselves in opposition through EUROPIA, the European Petroleum Industry Association created in 1989, and found allies in the nuclear industry and other heavy industrial sectors. In May, 1992, the eco-tax proposal was weakened by the European Commission,

who made its implementation conditional on similar policies by the US and Japan, and then blocked entirely the European Council of Industry Ministers. The following month, the President of the European Commission openly pointed to "critics who [had] come [...] first from the oil producers."[13] *The Economist* described the battle against the eco-tax as "the most ferocious lobbying ever seen in Brussels" (Ikwue and Skea, 1994; Skjærseth and Skodvin, 2003, 158-195; Liberatore, 1995) and an internal report written at the end of 1992 by Elf's Francis Girault shows that the company actively participated in defeating it[14]. In his report, Girault welcomed the tax's recent failure, crediting the company's lobbying activities carried out through "hidden direct contacts with the ministerial cabinets and administrations, both in France (Prime Minister, Finance, Environment, Research, European Affairs) and in the European Economic Community"[15]. Tramier recalled that Total was "better than us [Elf] in developing lobbying activities in Brussels, where a full-time employee was positioned" (Interview with B. Tramier, Nov. 5, 2020). The failure of the eco-tax undermined Europe's position at the Rio summit, contributing to limiting the scope and ambition of the UN process, which Girault viewed as a success for the company[16].

When a weakened version of the eco-tax was relaunched in 1994 by the European Commission, Elf and Total again cracked down on it. An internal report presented to the Elf Management Committee estimated "a CO_2 tax would cost around 4 billion FF [French francs] per year to the group," reported that "the actions carried out by the industry have been effective, since today the European eco-tax project has not seen the light of day," and recommended the company continue "to mobilize against the eco-tax"[17]. Elf's CEO, Philippe Jaffré, privately wrote to the French Minister of Foreign Affairs, Alain Juppé, to voice the company's hard opposition as the French presidency of the European Council approached[18].

By 1993-1995, Tramier and some of Elf's other top managers began to feel ill at ease with the company's hard line. In Europe, climate change denial was becoming increasingly counterproductive for oil companies in the face of scientific advances and scrutiny from civil society (hence the eventual departure of Shell and BP from the GCC). Moreover, with the eco-tax proposal buried, oil firms could afford to engage in more subtle corporate environmental messaging, in the wake of the "sustainable development," "corporate responsibility," and "total quality management" turns that the business world had taken since the late 1980s (Bernstein, 2001).

Instead of disputing an overwhelming scientific consensus, the new strategy proposed by Tramier consisted of showing good will to go green. This comprised internal audits and measurements to see where GHG emissions could be inexpensively reduced – an effort that applied, however, only to the company's operations and not to its products. Second, with the Kyoto protocol in sight, the company promoted market based instruments. In this way, voluntary actions and a carbon permit trading system would make technology standards or other "command and control" regulations seem obsolete. Third, efforts towards energy efficiency had to be made more visible. Elf's

environmental director suggested internally "a joint action between Elf and Renault for the development of vehicles consuming less fuel," which would provide positive environmental publicity while also "tak[ing] advantage of the notoriety given by F1 [racing]"[19]. Finally, Elf and Total also turned to environmental conservation to burnish their image: Elf sponsored French botanist Francis Hallé's Canopy Raft Missions to study the forests of Cameroon and Venezuela in 1989 and became a partner of French national and regional parks, while by 1991 Total reoriented its patronage, which until that point had been focused on arts and culture, toward the preservation of biodiversity and the sea[20].

4. Acceptance and Delay, 1997—2006

The years around the 1997 Kyoto conference mark a decisive shift in the political history of climate change. Multiple large petroleum companies, including BP and Shell, left the Global Climate Coalition, which had practiced overt climate denial since its formation in 1989, with a senior Shell employee later explaining that the company "didn't want to fall into the same trap as the tobacco companies who have become trapped in all their lies." (Rich, 2019, p. 186) Perhaps recognizing the reputational and legal risks of overt denial, as well as the potential inevitability of an international agreement, petroleum companies shifted their position toward publicly accepting the findings of the IPCC and promoting the industry as a rational, scientific actor. At Elf, Tramier's strategy of nominal acceptance prevailed over Girault's strategy of overt denial, as the former recalls:

> "at one point Jaffré [Elf's CEO] (...) summoned me to his office to ask me to present what I was proposing. I told him that the trends that would emerge from Kyoto would presumably be an objective of a 5-10% cut in emissions, and that 'we at Elf could make 15%' without excessive expenses. Elf made this announcement of a commitment to reduce its emissions by 15% a few days before Kyoto." (Interview with Bernard Tramier, Nov. 5, 2020).

Jaffré announced the company's turn in the French newspaper *Le Monde* in November, 1997:

> "Whenever we are faced with a subject that gives rise to great fear, such as the hole in the ozone layer or the consequences of genetic engineering, our attitude is scientific. First, we have Cartesian doubt. Then we turn to the scientific community, in which we trust." (*Le Monde*, 1997)

In the same interview, Jaffré announced that Elf would aim for a 15% reduction in its emissions by 2010 (compared to 1990). This cut would come from operations that were relatively inefficient and therefore easier to clean up, with Jaffré noting that "reducing a ton of CO_2 costs us 30 FF in Guinea compared to 230 FF in France [...] Elf subscribes to the American approach for reducing emissions, trusting the mechanisms of the market". Finally, Elf's CEO continued to promote the notion that

global warming was not an urgent problem, noting, "The phenomenon could, in fact, spread over a century or so. A century on the scale of the planet is very short. [...] But on the scale of the capacity for human action, it is long." (*Le Monde*, 1997)

In 1999, Total absorbed Elf and Petrofina, a Belgian oil company. At the same time, the merged company faced a series of high-profile socio-environmental crises, including the sinking of the oil tanker *Erika* off the French coast in December, 1999, the explosion of the AZF chemical factory in Toulouse in September 2001, and a lawsuit filed against Total in April, 2002 regarding alleged forced labor in Burma. After the merger Total temporarily dropped Elf's voluntary emissions targets, but the achievement of a 10% cut in its internal emissions between 1990 and 2000 was nevertheless announced in the 2001 annual report (TotalFinaElf, 2001).

In 2002 the company held its first official internal seminar dedicated to "sustainable development." There, in a question and answer session with top managers, the company's new CEO, Thierry Desmarest, continued to promote uncertainty:

> "Of course, the scientific evidence is not always convincing and is sometimes questionable. This said, I think we have reached a point where a certain level of precautionary principle needs to be taken into account. Thus, in terms of global warming, a certain moderation in emissions level of pollutants is, at the stage of our knowledge, desirable."[21]

While Desmarest's support of a "precautionary principle" suggested a heightened level of care, in effect it rhetorically framed climate policies as discretionary precautions rather than needed preventions. This approach of acknowledging the existence of global warming while downplaying its urgency and scientific certainty continued throughout the early 2000s. In 2002, Total's first sustainability report framed climate change in ambiguous terms, noting, "without the greenhouse effect there would be no life on our planet," and "water vapor is the main greenhouse gas." (Total, 2002, p. 20) The report's glossary described the greenhouse effect as a "natural phenomenon" and equivocally reported that emissions due to human activities "***could be*** the origin of climate change" (our emphasis, Total, 2002, p. 108), thus ignoring the causal relationship confirmed by the IPCC's Second Assessment Report in 1996. The 2003 report also emphasized "uncertainties" and described the greenhouse effect merely as "the hypothesis most commonly accepted by specialists and national governments within the IPCC" (Total 2003, p. 22). The 2004 report attributed the intensifying greenhouse effect to vague "human activity," insisted "uncertainties [...] persist on the origin and evolution of the phenomenon," (Total 2004, p. 69) and suggested the evidence for anthropogenic climate change consisted primarily of a simple correlation between greenhouse gas concentrations and average global temperature, both deflecting attention away from the company's

products and ignoring the causal links provided by physical science and statistical attribution research.

Throughout these years, Total kept a vigilant eye on the elaboration of the EU Emission Trading System (EU ETS), which was initiated after the Kyoto Protocol and finally adopted in 2003. The institutional architecture of the EU ETS was based largely on BP's internal trading system, with Elf and Total playing only a minor role in its design (Cartel 2013; Skjærseth et al., 2008) [22].

Thus, rather than overtly attacking the scientific consensus on climate change, Elf and Total instead emphasized equivocal descriptions of global warming and downplayed the robustness and significance of the available scientific evidence. Meanwhile, the company continued to spend the bulk of its capital expenditures on upstream oil and gas production (more than $30 billion from 2000-2005; figures aggregated from TotalFinaElf 2001, Total 2004) without reporting the sum of its few, scattered investments in non-fossil energy sources. This fossil-heavy strategy was in line with those of other major fossil fuel companies, including ExxonMobil, although European companies such as BP generally promoted their minimal activities in renewables more heavily than their US-based counterparts (Cox, 2008).

5. Managing Public Legitimacy in the Face of Environmental Criticism : 2006—2021

2006 opened a new phase for Total. As the countdown to the COP15 in Copenhagen began, global warming received increased public attention, and the institutionalization of climate policies in France accelerated with the adoption of a national emissions reduction goal of 75% by 2050 (2005 Law on Energy Policy Orientations). In this context, Total organized a climate change conference in order to present itself as receptive to the scientific community, responsible to the public, and able to move in new directions. Held in September 2006, the conference drew over 280 professionals, featured climate researchers as keynote speakers, and benefited from significant media coverage. In his opening speech, Desmarest, Total's CEO, publicly affirmed the company's acceptance of climate science [23]:

> "In the case of the scientific debate, there is a *convergence of views of experts* as to the reality of the phenomenon of warming. The uncertainties no longer relate to the phenomenon itself, but to its magnitude. This lack of precise vision is, moreover, in part attributable to the lack of knowledge of what our climate and energy policies will be in the future. [...] The IPCC perfectly fulfills its unifying mission and the seriousness of its reports is not in dispute." (Total 2006)

From then on, Total consistently recognized the legitimacy of the IPCC. With this embrace, however, the company also reframed its own purported role: climate change was to be theoretically

diagnosed by science but practically solved by business, without the two spheres interfering with one another. In this way, Total promoted its legitimacy to evaluate the climate compatibility of its own business plans and the suitability of climate policies more broadly. Thus, as it vocally supported the IPCC, the company invested more than $60 billion in upstream oil and gas operations from 2005-2009, again without reporting significant aggregate investments in non-fossil energy sources (Total 2005, 2008a, 2009).

Concurrently, Total continued to solidify its public image. In 2007, as European leaders agreed on the landmark 20-20-20 targets, which would pave the way for the first 2008-2009 EU climate and energy policy package (Böhringer 2014), the company created a "Gas & Renewables" division and appointed the former research director of the French national research center CNRS (the oceanographer Jean-François Minster) as its Senior Vice President for Scientific Development. The following year, Total endowed a "Sustainable Development" chair at the Collège de France (Total, 2008b), which was soon held by British climate economist Nicholas Stern.

Yet in this period the company also came under increased public scrutiny. The NGO Friends of the Earth (2008) published *"Total: la mise en examen"* (Total: the indictment). This report constituted one of the first systematic critiques of Total's activities in relation to their climate impact and clearly framed the interests of the petroleum industry as antagonistic to the preservation of the climate system. Moreover, in late 2009, the failure of COP15 in Copenhagen led the transnational climate movement to diversify its strategies and engage more directly with economic and political actors linked to the fossil fuel industry. Civil society actors explored the implications of the "carbon budget" concept (Lahn, 2020) and warned that the market valuations of investor-owned oil and gas majors were inconsistent with global climate goals (CarbonTracker, 2011; McKibben, 2012). In this context, in 2011 a coalition of Total's shareholders organized to file a resolution at the company's annual meeting requesting disclosure of the environmental and climatic impacts of the company's Canadian tar sands operations. Yet Total's board and CEO, Christophe de Margerie, successfully maneuvered to prevent the shareholders from filing the resolution (PhiTrust, 2011). Meanwhile, Total continued to invest heavily in oil and gas. From 2010 to 2014, the company injected approximately $127 billion in upstream exploration and production (Total 2014, 2015a, 2017), while channelling no more than $3 billion toward non-fossil energy sources from (upper limit reconstructed from a cross referencing of Total 2010, 2011, 2014).

As the COP21 conference in Paris approached, Total redoubled its efforts to promote itself as a climate leader. The company announced it would sell Total Coal South Africa – its last operating subsidiary in the coal industry, with an output of 12 million tons produced in 2014 – in June of 2015 (Novethic, 2015). Three months later, it spearheaded the creation of the Oil and Gas Climate Initiative (OGCI), an industry organization endowed with $1 billion by a dozen petroleum companies to promote voluntary climate actions for the period 2017-2027 (Bach, 2019), and in June

2015, Total joined other European petroleum companies in publicly challenging the UN to implement an international carbon price (Total, 2015b).

Total also re-envisioned its internal industrial planning by emphasizing future reductions in product carbon intensity. In 2016, three months after the Paris Agreement was signed, the company's CEO, Patrick Pouyanné, presented "One Total 2035," a roadmap for reducing the carbon intensity of its products (*Les Echos,* 2016). Yet the 2015-2019 period has been marked by sustained capital expenditures of $77 billion in upstream oil and gas production; in comparison, investments in non-fossil energy sources have not exceeded $5 billion (figures aggregated from Total, 2017, 2018, 2019). Without binding controls on the evolution of its energy mix, Total promotes itself as environmentally responsible through future scenario reports, which the company has issued since 2016. Regular updates to these reports generate a flow of complex, technical information that is difficult to interpret or challenge (Choquet, 2019), allowing Total to put the burden of proof on its critics and keep the upper hand in climate controversies. In 2021, Total announced it would rename itself to TotalEnergies and expand its investments in non-fossil energy sources, the same name having already been used by Total in its advertisements in 1977 when it claimed to invest in solar energy without real change in it oil-based business model then (Total, 1977); it remains to be seen how this announcement is acted upon.

6. Conclusion

We have documented half a century of Total's shifting responses to global warming. In 1971 the company published a scientific warning about climate change but was muted in public about the issue for the remainder of the decade. By the mid 1980s, climate change produced heightened concern among the world's oil majors, and French companies Total and Elf began to promote uncertainty regarding climate science, both independently and through the industry association IPIECA, while successfully lobbying against policies to reduce greenhouse gas emissions. At the same time, both companies sought to build environmental credibility through voluntary commitments and environment-themed public relations.

By the late 1990s, the French petroleum industry shifted away from openly disputing climate science but continued to expand its investments in upstream oil and gas production and employed rhetorical strategies that emphasized uncertainty, downplayed urgency, and deflected attention away from fossil fuels as the primary cause of global warming. By the mid 2000s, the merged entity Total intensified its efforts to build scientific credibility, endorsing the IPCC and hosting a conference on climate change. The company began to promote a division of roles between science and business, in which science describes climate change and business solves it, reinforcing its claim to legitimacy in determining appropriate public and corporate policies. This framing enables Total

to portray itself as a socially responsible petroleum company by wrapping continued investments in fossil fuel production in an attractive "energy transition" narrative.

Our study sits at the intersection of environmental and business history and contributes to the field of agnotology - the study of culturally induced ignorance or doubt. While much scholarship on the politics of climate change has framed relationships to science in terms of dichotomous acceptance or denial, the history of Total highlights the multidimensional and graded character of positions regarding climate science, such as publicly embracing climate science while deflecting attention away from fossil fuel products. Examining these multidimensional postures may aid in understanding historical and ongoing responses to global warming.

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Notes

(1) We found representatives of Total Leonard in the API board of directors lists for 1965-1967 and 1974.

(2) The editorial was actually drafted by the secretary general and pillar of the group, Vincent Labouret : see Archives Total, 50ZZ507/58.

(3) Total Archives, 92AA091/160.

(4) https://wiki.total/en/country/total-south-africa. On Total's links with the apartheid regime, see Deneault, 2017.

(5) National Research Council (NRC), *Carbon Dioxide and Climate: a Scientific Assessment: Report of an Ad Hoc Study Group on Carbon Dioxide and Climate*, National Academy of Sciences, Washington, DC, 1979 ; N. Rich, op. cit, 2019, p. 53-59 ; Howe, 2014, p. 115-117.

(6) Neither Total internal press review fascicles nor Elf R&D department archives mention climate issues by 1973-1980 (see Total Archives 09AH0416 and 07AH0077/28-33). Elf and Total, being smaller than Exxon, BP or Shell, did not have the same R&D capacity to follow this issue.

(7) For Shell, see Shell Internationale Petroleum Maatschappij B.V., *The Greenhouse Effect*, 1988, p. 86. Online: https://www.industrydocuments.ucsf.edu/fossilfuel/docs/#id=khfl0228

(8) Total Archives. 11AC0783/106 - B. Tramier. *L'environnement dans le groupe Elf Aquitaine – Bilan 1985. Document préparatoire à la réunion du comité exécutif du 4 mars 1986*. Feb 1986, p. 14.

(9) Total Archives. 00AH001/142. Total, *Les cahiers de l'environnement*, 1992 (a cardboard folder distributed by Elf before and during the Rio 1992 conference).

(10) Historical Archives of the European Union. FXO-95. François-Xavier Ortoli, "Potential Global Climate Change - The Realities?" Speech at 15 th Congress of the World Energy Council, Madrid, 20-25 September 1992, p.2.

(11) Total Archives, 07AH0077/4. SNEA G/DPES, F. Girault, Note à l'attention de MM. les membres du comité de Direction Générale, "Effet de serre (proposition de plan d'action)", March 12, 1993.

(12) Id.

(13) Historical Archives of the European Union. JD-1669. Press conference held by Jacques Delors at the end of the United Nations Conference on Environment and Development, June 13, 1992.

(14) Total Archives, Elf Fund, 07AH0077/4. F. Girault, " Greenhouse effect and environmental tax. Proposals for action ", Nov. 17, 1992.

(15) Id.

(16) Id.

(17) Total Archives, Elf Fund, 07AH0077/4. DRTE, "Environnement Énergie 1994. Bilan Perspectives", p. 16 and 5.

(18) Total Archives, Elf Fund, 07AH0077/4. Philippe Jaffré to Alain Juppé, Oct 14, 1994.

(19) Total Archives, Elf Fund, 07AH0077/4. B. Tramier to P. Castillon, "Effet de serre: actions à entreprendre", Nov. 30, 1992.

(20) *EnergieS* , n°10, July-August 1992, p. 6-7 and 8-11.

(21) Total Archives. 05AA594/14. Premier séminaire de développement durable (Sept. 30-Oct. 2, 2002). Compte-rendu, p.10.

(22) The relative unavailability of corporate archival material from after the year 2000 presents a challenge for reconstructing Total's strategic engagement with the negotiations surrounding the EU ETS quota allocations.

(23) Id.

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SUPPLEMENTARY MATERIAL

Table 1. Key Developments in Climate Science, 1896--1995

For post 1995 developments, see subsequent IPCC group 1 assessment reports: *Third Climate Change 2001: The Physical Science Basis; Fourth Assessment Report, Climate Change 2007: The Physical Science Basis; 5th Assessment Report, Climate Change 2013: The Physical Science Basis; 6th Assessment Report, Climate Change 2021: The Physical Science Basis.* See also R. Somerville, H. Le Treut, U. Cubasch, Y. Ding, C. Mauritzen, A. Mokssit, T. Peterson, and M. Prather (2007). Historical overview of climate change. In *Climate Change 2007: The Physical Science Basis*, Cambridge University Press, 93-127.

Knowledge issues about climate change	Date	Reference / Comments
Anthropogenic emissions of CO_2 may be large enough to influence the global climate.	1896	Arrhenius S., "On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground," *Philosophical Magazine and Journal of Science* 5:41, 1896, 237-276.
CO_2 and water vapor absorption spectra do not entirely overlap, and CO_2 may accumulate in the upper atmosphere where water vapor is absent, thus increasing the infrared optical depth of the atmosphere.	1931	Hulburt E.O., "The Temperature of the Lower Atmosphere of the Earth", *Physical Review* vol. 38, 1876-1890.
CO_2 from fossil fuel combustion is accumulating in the atmosphere and may not be offset by absorption from oceans and plants, leading to a possible continuous increase in the concentration of CO_2 in the atmosphere	1957	Brannon H.R. et al., "Radiocarbon Evidence on the Dilution of Atmospheric and Oceanic Carbon by Carbon from Fossil Fuels", *Transactions of the American Geophysical Union*, 38(5), (1957), 643-650
Atmospheric carbon dioxide concentrations show a continuous annual increase.	1960	Keeling C.D., "The Concentration and Isotopic Abundances of Carbon Dioxide in the Atmosphere", *Tellus*, 12(2), (1960), 200-203
The increase in atmospheric carbon dioxide is expected to produce a global warming effect by the year 2000, with significant impacts on future climate and sea level.	1965	President's Science Advisory Committee (1965). *Restoring the Quality of Our Environment: Report of the Environmental Pollution Panel*. The White House.
First 3D global climate modeling : "According to our estimate, a doubling	1967	Manabe S., & Wetherald R.T., "Thermal Equilibrium of the Atmosphere with a

of the CO_2 content of the atmosphere has the effect of raising the temperature of the atmosphere (whose relative humidity is fixed) by about 2C"		Given Distribution of Relative Humidity", *Journal of Atmospheric Sciences*, 24 (3), (1967) 241-259 For a retrospective analysis of the impact of this paper, see also Weart, S. (2003). *The Discovery of Global Warming*. Cambridge, Harvard University Press
A 25% increase in CO_2 concentration could cause 1.1-7.0 °F of global warming by the year 2000, whereas global aerosols is expected to produce a much smaller global cooling effect of about 0.1°F.	1969	Peterson E.K., "Carbon Dioxide Affects Global Ecology", *Environmental Science and Technology* (1969): 1162-1169.
A positive feedback between planetary warming and melting ice and snow (i.e., changes in the Earth's albedo) can be detected	1969	Budyko M.I., "The effect of solar radiation variations on the climate of the Earth", *Tellus*, 21(1969): 611-619. For a retrospective analysis of the impact of this paper, see also Weart, S. (2003). *The Discovery of Global Warming*. Cambridge, Harvard University Press.
Three-dimensional global climate models indicate potential global warming of 0.5°C by the year 2000 and 2°C in the 21st century.	1970 - 1971	SCEP Report (MIT), *Man's Impact on the Global Environment,* 1970. SMIC Report (MIT), *Inadvertent Climate Modification Report: Report of the Study of Man's Impact on Climate*, 1971.
Global warming from anthropogenic greenhouse gases will dominate global cooling from pollution aerosols.	1970s	Peterson T.C., Connolley W.M., and Fleck J., 2008, "The Myth of the 1970s Global Cooling Scientific Consensus", *Bull. Bitter. Meteor. Soc.*, 89, 1325-1338
Doubling atmospheric carbon dioxide is expected to produce global warming of 3°C plus or minus 1.5°C.	1979	*Carbon Dioxide and Climate: A Scientific Assessment* ("Charney Report", Nat. Acad. Of Sciences)
The time required for renewables to penetrate half of the energy market is estimated to be roughly half a century, indicating the need for prompt action to prevent severe global warming.	1983	Rose D., Miller M., Agnew C., *Global energy futures and CO_2 induced climate change*, MIT Energy Laboratory, 1983.

"We are certain of the following: there is a natural greenhouse effect [...]; emissions resulting from human activities are substantially increasing the atmospheric concentrations of the greenhouse gases. [...] Under business-as-usual, increase of global mean temperature during the 21st century of about 0.3 °C per decade (with an uncertainty range of 0.2 to 0.5 °C per decade)." (Executive Summary, xi) "Our judgement is that: global mean surface air temperature has increased by 0.3 to 0.6 °C over the last 100 years." (Executive Summary, xii)	1990	First Assessment Report (IPCC)
"(...) the essential message of this report continues to be that the basic understanding of climate change and the human role therein, as expressed in the 1990 report, still holds: carbon dioxide remains the most important contributor to anthropogenic forcing of climate change; projections of future global mean temperature change and sea level rise confirm the potential for human activities to alter the Earth's climate to an extent unprecedented in human history; (...) many important aspects of climate change are effectively irreversible. Further, that observations suggest 'a discernible human influence on global climate', one of the key findings of this report, adds an important new dimension to the discussion of the climate change issue." (Preface, xi)	1996	*Second Assessment Report Climate Change 1995 The Science of Climate Change* (IPCC)

Table 2. Main archival documents consulted at Total Archives cited in this article

As state-owned enterprises, Elf and Total established well-organised archives services in the 1980s. The archives are now available to researchers at Total's headquarters (Tour Coupole, 2 place Jean Millier, 92078, Paris La Défense Cedex).
General presentation: https://listes.services.cnrs.fr/wws/arc/athena/2018-09/msg00012/AH_Guide_des_sources_2016_V2.0.pdf
Digitized inventory available at: https://francearchives.fr/fr/inventaires/TOTAL#/

Archive box number	Comments
50ZZ507/58	Vincent Labouret papers (General Secretary). Elements on CFR-Total communication policy, on the development of the magazine *Total information* in the late 1960 and drafting of the op-ed (signed by the CEO by written by Labouret) of the 1971 issue of *Total Information*, on environmental issues. This issue, as well as the full journal collection, is also available at the Bibliothèque Nationale de France
92AA091/160	Total - Direction de l'Information et des Relations Extérieures – Pollution. Documents Total's "coordination environnement" in the 1970s
09AH0416/1-34	CFP-Total Press review of energy issue in France and the world
07AH0077/1-36	Elf R&D department (1970-1995). The Environment Direction was part of this department. This includes 07AH0077/4 - Dossiers liés à la protection de l'environnement, 1993-1994. In this box, can be found - the memo from F. Girault (Director for Prospective), "note à l'attention de MM les membres du comité de Direction Générale, Effet de serre (proposition de plan d'action), March 12, 1993 - the memo from F. Girault, "Effet de serre et écotaxe. Propositions d'action", Nov. 17, 1992. - The internal report "Environnement Énergie 1994. Bilan Perspectives", presented in april 1994 to Elf's executive committee - The letter sent by Philippe Jaffré (Elf's CEO) to Alain Juppé (French Minister for Foreign Affairs), Oct. 14th, 1994.
11AC0783/106	Elf R&D department. This box includes the 1985 Environment Department annual report as Preparatory document to the Elf executive committee, 4 March 1986: Bernard Tramier. *L'environnement dans le groupe Elf Aquitaine – Bilan 1985. Document préparatoire à la réunion du comité exécutif du 4 mars 1986*. Fév 1986.
09AH0492/4	Leaflets, including: Union des Chambres Syndicales de l'Industrie du Pétrole, *Industrie pétrolière et environnement*, 1971.
00AH001/1-428	Chronologies historiques, plaquettes de présentation, revues du groupe. Box 00AH001/142 includes a cardboard folder distributed by Elf before and during the Rio 1992 conference. It entails an article "Environment: Lucidity and Pragmatism" by Jean-Philippe Caruette in *ÉnergieS* [Total's corporate magazine], n°9, May-June 1992, 13-14

05AA594/1-15	TOTAL - Environnement et développement durable (Archives from the Environment Direction), 2000-2004) Box 05AA594/14 includes documents from the 2002 and 2003 internal workshop on Sustainable Development. This includes the transcript of the speech by CEO Thierry Desmarest at the 1st “Séminaire Développement Durable” (Sept. 30- Oct. 2, 2002).

Table 3. Interviews conducted for this research

All interviews are not cited in this article but helped to provide an extensive knowledge of our case study and write an initial longer draft. These interviews were conducted by C. Bonneuil)

Interview Date(s)	Comments
Sep. 23, 2020	Anonymized (at the request of the interviewee), Former Staff (early 1970s to mid 1980s), Elf.
Nov. 5, 2020 Nov. 24, 2020	Bernard Tramier, Former Environmental Director (1983-2003), Elf and then Total-Fina-Elf.
Nov. 20, 2020	Jean-Paul Boch, Former Staff at the Environmental Direction (early 1992-2008), Elf and then Total-Fina-Elf.
Feb. 1, 2021	Brian Flannery, Former Environmental Director, Exxon.
Nov. 2, 2020	Pierre-René Bauquis, Former Total executive (1972-2000s), Advisor of Total CEO from 1995 to 2001.
Aug. 6, 2020	François Durand-Dastès, Professor of Geography, Univ. Paris 7, author of a 1971 article on atmospheric pollution in Total corporate magazine.
May 28, 2021	Jacques Theys, Former High level staff, French Ministry of the environment (1970s-2000s).
June 1, 2021	Jean Audouze, Former scientific advisor of the French President (F. Mitterrand), 1989-1991.
January 1, 2021	Jean-Charles Hourcade, Energy economist, former IPCC coordinating lead author.
May 31, 2021	Jean Jouzel, climatologist, former vice-chair of IPCC Group 1.
April 4, 2021	Brice Lalonde, former French Minister of the environment, 1988-1991.
Nov. 18, 2021	Cédric Phillibert, Former advisor of the French Ministry of the environment (1988-1991).
Nov. 3, 2020	Jean-François Saglio, Former High level staff, French Ministry of the environment (until 1979), then Elf executive (1979-1988).