Oil's Nuclear Frames : The oil industry shaping the environment with "innovative" nuclear technologies since the long 1970s

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Dans Revue d'Histoire de l'Énergie **2024/1 n° 12** , pages 1h à 15
Éditions Comité d'histoire de l'électricité et de l'énergie

DOI 10.3917/jehrhe.012.0009
Date de mise en ligne : 22/01/2025

JEH RHE

Journal of Energy History
Revue d'histoire de l'énergie

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DATE DE PUBLICATION
juillet 2024
NUMÉRO DE LA REVUE
JEHRHE #12
RUBRIQUE
Dossier
THEME DU DOSSIER
Black and Green? Environmental Histories of the Oil Industry
MOTS-CLÉS
Pétrole ; Nucléaire ; Environnement ; Durabilité

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Résumé
Dans le cadre des débats sur les énergies alternatives et l'environnementalisme, les acteurs pétroliers ont joué un rôle important en s'engageant activement dans les débats et en investissant dans les énergie alternatives au cours de longues années 1970. En particulier, l'énergie nucléaire était souvent considérée comme un projet de diversification. En étudiant la façon dont les acteurs pétroliers ont structuré leurs investissements dans des « innovations » telles que la technique In Situ Leaching pour l'extraction de l'uranium (Mobil Oil) et la fusion nucléaire (Exxon, Shell et Gulf Oil), cet article soutient que plusieurs influents acteurs pétroliers ont reconnu l'impact environnemental des combustibles fossiles et de la fission nucléaire au cours des années 1970. Toutefois, ces acteurs ont présenté leurs technologies comme des technofixes « respectueux de l'environnement ». Ce faisant, souvent l'impact environnemental de ces nouvelles technologies a été négligé, ce qui a influencé les débats sur ces technologies jusqu'à aujourd'hui.

Remerciements
This article was supported by a Netherlands Organization for Scientific Research Vici grant, 'Managing Scarcity and Sustainability: The Oil Industry, Environmentalism, and Alternative Energy in the Age of Scarcity,' VI.C.191.067 (https://managingscarcity.com/). The author was the recipient of research grants from the American Institute of Physics and the Committee for the History of Electricity and Energy (the latter funded by Électricité de France).

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ISSN 2649-3055

WORK FOR THE FUTURE

1 "Nuclear fission is the only currently available alternative major energy source, which can bridge the foreseeable shortfall.....This is by no means an encouraging prospect.....Nuclear fission leads to dangers for humans and the environment."[1] Shortly after the publication of the Club of Rome's *Limits to Growth* report (1972), the major oil company Royal Dutch Shell funded and contributed to a Dutch pamphlet (later also translated and published in the US by Shell) responding to the findings of the report on resource scarcity, population growth and environmental pollution. Although in more popular accounts *Work for the Future* (In Dutch *Werk voor de toekomst*) is regularly perceived as mostly critical to the methods used in *Limits to Growth*, the authors of *Work for the Future* actually did agree with the geophysical constraints posed by the *Limits* report.[2]

2 The pamphlet made clear that fossil fuels had significant drawbacks in terms of resource scarcity and environmental impact, ranging from rising levels of carbon dioxide in the atmosphere to the loss of biodiversity.[3] Nuclear energy was regarded the only reasonable alternative. For this energy source too, however, the authors foresaw major drawbacks regarding the health and environmental hazards posed by nuclear waste and potential accidents.[4]

3 Regardless of the conspicuous role of oil major Royal Dutch Shell in this publication with Shell's CEO Gerrit Wagner as one of its main authors, the oil company still invested in various nuclear energy projects in the following years. The Royal Dutch Shell Group, together with Gulf Oil and Allied Chemicals, became involved in reactor manufacturing, fuel reprocessing, the development of a gas-cooled breeder reactor, and nuclear fusion research.[5] Sometimes discarded as a "misguided," "bizarre, comic even" strategy, other major oil companies diversified into nuclear energy production in the same period as well. In 1975, of the approximately eighty companies searching for U.S. uranium reserves, twenty of these were oil companies, controlling about one-half of the country's uranium reserves and contributing about one-third of the production. Gulf Oil, via their subsidiary General Atomic, obtained 18 percent of the annual percentage of the U.S. nuclear reactor orders in 1971. The American oil major Exxon invested in uranium mining, fuel fabrication, reprocessing, fusion research, and even developed a highly experimental uranium enrichment project based on laser heating.[6]

4 Recently, energy historians Helmuth Trischler, Robert Bud, and Stathis Arapostathis considered nuclear energy to be a 'public technology', trying to understand the roles of a variety of actors that helped shape the discourses about the energy source across multiple nation states, and argued for more focus on public perceptions broader than only activist stances.[7] Although some scholars (including various energy historians) did study the role of industrial parties in creating a narrative of nuclear energy as safe, reliable, and necessary for continuing economic

1 Beek et al., *Werk voor de toekomst*, 17. Translation from Dutch by author: original quote: "Kernenergie is de enige nu beschikbare alternatieve grote energiebron, die het voorspelbare tekort kan overbruggen....Dit is bepaald geen bemoedigend vooruitzicht.....Kernsplitsing leidt tot gevaren voor de mens en milieu."

2 Beek et al., 3-15. See for popular accounts Tielbeke, *We waren gewaarschuwd: over een profetisch milieurapport en wat we er (niet) mee deden*; Metze, *Hoog Spel: De politieke biografie van Shell*, 375.

3 Beek et al., 24-32.

4 Beek et al., 16-17.

5 Sluyterman, *Concurreren in turbulente markten: geschiedenis van de Koninklijke Shell, deel 3*, 102-109; Verbong et al., *Een kwestie van lange adem: de geschiedenis van duurzame energie in Nederland*, 48-56.

6 John J. McCloy, "Horizontal Divestiture", 14 May 1976, box 38, folder 43, John J. McCloy Papers, College Archives and Manuscript Collections, Amherst College; Hertsgaard, *Nuclear Inc.: The Men and Money Behind Nuclear Energy*, 289; Pratt and Hale, *Exxon: Transforming Energy, 1973-2005*, 185-189; Josephson, Meyer and Kaijser, 'Nuclear-Society Relations from the Dawn of the Nuclear Age,' 34-37; Parra, *Oil Politics: a modern history of petroleum*, 212; Bron, 'The uranium club: Big Oil's involvement in uranium mining and the formation of an infamous uranium cartel'; Ezell, *Innovations in Energy: the Story of Kerr-McGee*.

7 Trischler and Bud, 'Public technology: nuclear energy in Europe,'187-21; Arapostathis, Bud, and Trischler, 'Nuclear energy in Europe: a public technology,' 230-253.

growth, the role of nuclear-oil firms – with their ubiquitous involvement in nuclear energy during the 1970s and background in two major polluting energy sources with both oil and nuclear fission – in relation to environmental discourses specifically has been understudied.[8]

5 Over the past few years, the role of the oil industry as a big contributor to rising CO2 emissions and important player in the environmental debates since the 1970s have put the industry increasingly into the limelight with historians studying the companies in their technopolitical roles of employing strategies of stimulating doubt, concealing evidence, and flat-out denialism, sometimes even tracing back these strategies to the 1950s.[9] Following the observation by Christophe Bonneuil, Pierre-Louis Choquet and Benjamin Franta that in the early 1990s the oil and nuclear industries found each other in opposing international environmental regulations such as carbon taxation, this article investigates the intertwined origins of those two industries in relation to environmental debates during the preceding decades.[10] By doing so, this article tells a more nuanced story with oil companies embracing a technological optimistic framework during the 1970s by publicly acknowledging environmental problems of both nuclear fission and petroleum combustion, and also presenting themselves as part of the solution to these problems by being an incubator for technological innovation and socially engaged personnel based on their nuclear diversification projects.[11]

Based on a study of various public outings produced by multiple major oil companies – ranging from pamphlets to public lectures and statements in lawsuits that are collected from various archival collections produced by oil companies like Shell, ExxonMobil, and Gulf Oil -, this article argues that these oil actors used a specific subset of their nuclear projects to present their companies as an ally in solving many of the environmental problems posed by fossil fuel combustion and the production of regular nuclear energy. Especially investments in the In Situ Leaching (ISL) technique for uranium mining and the potential production of nuclear fusion energy were presented as "environmental friendly" solutions to the problems discussed in pamphlets such as *Work for the Future*. 6

To analyse the oil firms' nuclear frames, this articles uses the definition of framing as stated by Robert Entman: "to frame is to select some aspects of a perceived reality and make them more salient in a communicating text, in such a way as to promote a particular problem definition, causal interpretation, moral evaluation, and/or treatment recommendation for the item prescribed."[12] In their public communication during the 1970s, various oil firms selected specific aspects of the environmental problems posed by reports like *Limits to Growth*. These aspects included air and water pollution (and even increasing carbon dioxide levels) due to fossil fuel combustion, and the environmental impact of radioactive waste, thermal pollution caused by the cooling systems of nuclear reactors, and waste tailings produced by uranium mining projects.[13] According to multiple 7

8 Schüring, 'Advertising the Nuclear Venture: The Rhetorical and Visual Public Relation Strategies of the German Nuclear Industry in the 1970s and 1980s,' 369-368; Strunz, 'The German Energy Transition as a Regime Shift,'150-158; Hertsgaard, *Nuclear Inc.*

9 Franta, 'Early oil industry knowledge of CO2 and global warming,' 1024-1025; Walker, *More heat than life: The tangled roots of ecology, energy, and economics*, 30; Oreskes and Conway, *Merchants of Doubt: How a Handful of Scientists Obscured the Truth on issues from Tobacco Smoke to Global Warming*.

10 Bonneuil, Choquet and Franta, 'Early warnings and emerging environmental accountability: Total's responses to global warming, 1971-2021,' 5.

11 According to Andrew Basiago, 'technological optimism' entails "the doctrine that a growing number of technological improvements in such areas as food production, environmental quality and energy will sustain life as human population soars". Basiago, 'The limits of technological optimism,' 17-22; Seefried, 'Rethinking Progress. On the Origin of Modern Sustainability Discourse, 1970-2000,' 379-386.

12 Entman, 'Framing: Toward Clarification of A Fractured Paradigm,' 52.

13 Also in recent years the nuclear industry is increasingly discussed in light of its environmental impact, both regarding the direct consequences of the nuclear industry - including waste tailings in the uranium industry (Hecht; Hill and Ashipala), thermal pollution at power stations (Walker;

oil actors – including CEO's of major oil companies – these environmental issues were caused by an unrestricted industry, and were problematic since they negatively impacted both human health and future economic growth. To counter these problems, industrial firms had to be supported to develop "innovative" (a framing adding a positive spin to the nuclear technologies) and "environmentally friendly" nuclear technologies.

8 By using these frames, the oil firms not only publicly acknowledged many of the environmental problems that were posed by both petroleum and nuclear energy, but also tried to protect their investments in regular nuclear fission. By presenting "environmentally friendly" innovations for the future with nuclear fusion and In Situ Leaching, nuclear fission was presented as a bridge toward this clean future. Still, in their presentation of In Situ Leaching and nuclear fusion as an answer to existing environmental problems, oil companies also deliberately neglected the environmental impact of these new technologies. As this article shows, the "environmentally friendliness" of ISL and fusion was a frame – which is still often used today – that was created by the various oil firms to legitimize their nuclear investments in the 1970s and deliberately ignored problems with groundwater and pollution with leaching projects and the radioactive waste produced by nuclear fusion reactors.

INDUSTRY AS AN ALLY IN SOLVING ENVIRONMENTAL PROBLEMS

The publication of *Limits to Growth* by Club of 9
Rome further fuelled the debates about environmental concerns that were already sparked by Rachel Carson's *Silent Spring* and Paul Erlich's *Population Bomb*. Concerns mounted about a rapidly growing population, growing welfare and consumption, and a resulting increase in environmental pollution.[14] From the start, actors connected to the oil industry participated in these debates. As the study of Andrew Hoffman shows, trade journals like the *Oil and Gas Journal* experienced a surge in articles concerning 'the environment' and its problems during the late 1960s and early 1970s. These articles were dominated by a technological optimism celebrating the industry's efforts and opportunities to develop new, innovative technologies that could solve many of the problems posed by air and water pollution that were produced by the petrochemical industry.[15] Also, following the publication of *Limits to Growth*, oil actors such as Maurice Strong, George Mitchell, Joseph Slater, and Robert O. Anderson organised and shaped the international debates on resource scarcity and environmentalism based on the findings of the Club of Rome.[16]

Within the major, international, oil companies 10
too, some environmental limits were publicly acknowledged. The most explicit example is offered by Shell's Gerrit Wagner. As one of his first acts as the new CEO of Shell in 1972, he participated in the Dutch committee reacting to *Limits of Growth*.[17] He not only ordered his

Högselius), and the radiation emitted from atomic weapon tests and radioactive waste – and the use of environmental science by nuclear proponents to frame nuclear developments as beneficial for health and the environment (Oatsvall). Hecht, *Residual Governance: how South Africa foretells planetary futures*; Hecht, *Being Nuclear: Africans and the Global Uranium Trade*; Hill and Ashipala, '"Follow the Yellowcake Road": Historical Geographies of Namibian Uranium from the Rössing Mine,' 32-54; Pritchard, 'An envirotechnical disaster: nature, technology, and politics at Fukushima'; Hamblin, *Poison in the Well: Radioactive Waste in the Oceans at the Dawn of the Nuclear Age*; Oatsvall, *Atomic Environments: Nuclear Technologies, The Natural World, and Policymaking 1945-1960*; Walker, 'Nuclear power and the Environment: The Atomic Energy Commission and Thermal Pollution,' 964-992; Högselius, 'Atomic Shocks of the Old: Putting Water at the Center of Nuclear Energy History,' 1-30.

14 Walker, 3-31.

15 Hoffman, 'Trends in Corporate Environmentalism: The Chemical and Petroleum Industries, 1960-1993', 47-64.

16 Schleper, *Planning for the Planet: Environmental expertise and the International Union for Conservation of Nature and Natural Resources, 1960-1980*, 48; Mody, 'Spillovers from Oil Firms to U.S. Computing and Semiconductor Manufacturing: Smudging State-Industry Distinctions and Retelling Conventional Narratives,' 619.

17 Van Seumeren, *Gerrit A. Wagner: Een loopbaan bij de Koninklijke*, 18-72; Metze, 266, 276, 294-297; Beek et al., 4; Buelens, *Wat we toen al wisten: de vergeten groene geschiedenis van 1972*, 111.

personal assistants at Shell to translate and distribute the reaction, but also repeated, and elaborated on, many of its ideas in various public outings and speeches as CEO of Shell.[18]

11 Representing Shell, Wagner presented a view on 'the environment' that acknowledged the dangers of an unrestricted industry for the environment. Wagner stated that the protection of the environment should not be left solely to the same industry that also posed the threats. Without governmental supervision and regulations the industry would often fail to pay attention to the environment by the industry would often end up lacking. Market mechanisms alone would not be sufficient to protect the environment.[19]

12 In his public outings, however, Wagner also presented industrial firms, with multinational corporations in particular, as part of the solution to these environmental problems. Through their international contacts, vast amounts of socially engaged employees and technological expertise, industrial parties should be regarded allies on the way forward according to Wagner, in this way embracing a technological optimistic frame. Often the technology needed was already there, and the industry only was to be supported to invest their considerable resources in developing these innovations.[20] One of the prime examples used by Wagner was the potential role of industrial involvement in the development of nuclear energy. Although Wagner agreed with many of the environmental concerns posed by energy derived from regular nuclear fission, industry was to be supported in developing new, cleaner nuclear technologies to overcome the problems with regular nuclear energy production, and to replace it with 'cleaner' nuclear fusion in the future.[21]

13 This was a frame that Wagner backed up with considerable investments by Shell. In 1973, Shell officially entered the nuclear energy business after being involved as shareholder in the Dutch nuclear enrichment projects for several years.[22] In a joined venture together with Gulf Oil, Shell became the owner of General Atomics, a highly regarded company in nuclear research and the development of nuclear reactors. With this joint venture, Shell focussed on the development of experimental high temperature gas-cooled reactors, fuel reprocessing, and nuclear fusion research. In over a decade, the oil company would spend over 500 million dollars (now approximately 1.5 billion U.S. dollars) in nuclear developments before divesting their nuclear projects between 1979 and 1984.[23]

14 Although sometimes less explicit, this frame used by Wagner regarding oil investments in nuclear projects was also present in the public outings by other prominent oil actors. George Piercy, a chemical engineer and senior vice president and director of Jersey Standard Oil (later Exxon), already stated in 1969 that his company entering the nuclear fuel business was based on the belief that they had ways of making "a significant, positive contribution" in innovating the nuclear business. With the influx of capital, labour, and technological and scientific expertise, they would be able to provide superior nuclear fuel cycle products and services for electric utilities for the decades to come according to the oil executive.[24] Six years later, the general manager of Exxon Nuclear, Raymond Dikeman, elaborated on the environmental aspects of nuclear power in a radio recording, organized by Exxon. Although he was less critical than Wagner - even nuclear fission, according to Dikeman, was more environmentally friendly than conventional fuels

18 Wagner, 'De onderneming en het milieu: "Tussentijds bestek", Paleislezingen, Amsterdam, 27 april 1973,' 72-81; Buelens, 'The ubiquity of Royal Dutch Shell in the Netherlands as a case of banal petroculture'.

19 Wagner, 'De onderneming en het milieu,' 74-75.

20 Wagner, 'De onderneming en het milieu,' 74-75; Wagner, 'Economie niet denkbaar zonder multinationale onderneming', 82-88.

21 'Wagner (Shell): andere bronnen energie aanboren'.

22 Streefland, *Jaap Kistemaker en uraniumverrijking in Nederland*, 256; Kistemaker, *De geschiedenis van het Nederlandse Ultracentrifuge Project: hoe een nieuwe industrie ontstond*, 18-23.

23 Sluyterman, 109.

24 Jersey Standard, "Executive says Jersey Standard's nuclear work will expand competition and efficiency", 30 October 1970, Box 2.207/K96B, ExxonMobil Historical Collection, Dolph Briscoe Center for American History.

- he acknowledged that nuclear power faced environmental problems from radioactive waste during various stages of the nuclear fuel cycle. However, these problems were easily solved with new technologies: other forms of nuclear power, storing waste in glass or blasting it away into space, and cleaner mining techniques.[25]

MINING URANIUM IN NATURE'S WAY

15 One of these "cleaner" mining techniques that was presented as a technofix for the environmental problems was In Situ Leaching (ISL). At first glance, mining projects by means of leaching methods constitute only a few visible traces: a small production gathering line, a well, and some pipes**.** That most of the installations were underground enabled its promoters to sell leaching as environmentally friendly over the dark and dirty mine shafts penetrating the earth with underground mining or the hellish landscapes produced with open pit mining. Not to mention the lack of massive piles of leftover rocks that are commonly found around the more traditional mining projects. For proponents it was easy to present ISL as moving mining away from such clear environmental violence, offering a future where the mining needed for man's welfare and flourishing nature can coexist.

16 This also was the image projected in a 1978 flyer by the U.S. oil major Mobil on their uranium mining projects based on ISL techniques. *Leaching: Mining Uranium in Nature's Way* is richly illustrated with a cross section of a model of an ISL uranium mining project.[26] The flyer shows snakes, birds, vegetation and a healthy, clean river surround a small selection of pipes peeping through a lush surface. Underneath, pipes carefully penetrate several sedimentary layers to subsequently pump up the uranium accumulated over millennia in the deposits beneath. A colourful and peaceful image is portrayed to convince the reader that leaching only does little damage to the local environment.

17 In present day still regularly referred to as an "environmentally friendly" mining technique, ISL is currently used in around 57 percent of worldwide uranium production.[27] Contrary to removing mineralised rock from the ground commonly practiced in more traditional mining forms, leaching dissolves the minerals already underground to then pump the solution, "pregnant" with the dissolved minerals, to the surface where the minerals are recovered. In the case of uranium, the groundwater in the deposit is fortified with a complexing agent and an oxidant. These oxidants can be hydrogen peroxide, while the complexing agent usually consists of sulfuric acids. According to the World Nuclear Association, in 2019 a total of 31,435 tonnes of elemental uranium was produced by ISL. Most of these tonnes were mined in Kazakhstan, but also in Uzbekistan, U.S., Australia, China and Russia.[28]

18 Because of the resemblance with the engineering principles of waterflooding techniques commonly used within the oil sector, oil actors were already involved with the development of ISL for uranium mining since the late 1960s. Some oil companies even were the forerunners and greatest advocates for the introduction of ISL. In the U.S. and Australia in particular, oil companies developed and operated many of the ISL mining projects commencing in the 1960s and 1970s.[29] In Australia, two of the four biggest ISL projects were directly managed by oil companies: the Beverley deposit in South Australia was discovered in 1969 by the Oilmin-Transoil-Petromin group of companies, and the Manyingee deposit,

25 Exxon Conversations, ""Exxon and Nuclear Energy", Guest: Raymond L. Dikeman, President, Exxon Nuclear Company", 6 October 1975, Box 2.207/K96B, ExxonMobil Historical Collection, Dolph Briscoe Center for American History.

26 Mobil Corporation, "Leaching: Mining Uranium in Nature's Way", 1978, box 2.207, folder F120, ExxonMobil Historical Collection, Dolph Briscoe Center of American History.

27 E.g. Burron, 'In-situ leaching: a cleaner, greener, cheaper way to mine'; EnCore energy, 'In-Situ Recovery and What Makes It a Great Mining Method'; CSIRO, 'In-situ recovery: mining with minimal landscape disturbance'.

28 World Nuclear Association, 'In Situ Leach Mining of Uranium'.

29 IAEA, *In Situ Leach Uranium Mining: An Overview of Operations*, 24-25.

located in northern part of the Carnarvon basin in Western Australia, was discovered in 1974 by a joint venture led by Total Australia, the Australian subsidiary of *Compagnie Française Petroleum* (CFP, later Total).[30] Also in the United States, especially in Texas where waterflooding techniques for oil extraction were already popular, ISL quickly gained popularity with oil companies like Atlantic Richfield and Mobil Oil taking the lead.[31]

19 For the researchers at the Mobil Research and Development Corporation labs in Dallas and Princeton and the engineers at Mobil's Exploration and Producing Division, ISL proved a way to make new mining projects in Bruni, Texas, profitable.[32] In Mobil's outward communications about their leaching projects, however, the environment played a central role. More than a solution to potential resource scarcity, the environmental benefits of ISL over traditional uranium mining were presented as the main reason to invest in this new technology. Not only in the colourful flyer *Mining Uranium in Nature's Way*, but also in other pamphlets, articles and interviews, Mobil's managers emphasized that leaching involved only limited above-ground disturbance of nature, no piles of waste rock were created, and that even the groundwater was safe. Often packaged in exhaustive descriptions of the thriving, flourishing flora and fauna surrounding the plant's sites, the "innovative" mining method was portrayed as an environmentally friendly technique, an innovation born of the technological ingenuity of the oil industry.[33]

20 In these communications the oil company paid little to no attention to the environmental impact of leaching. Mobil explicitly stated that there was no impact on soil and groundwater. Although it was not until the 1990s that more fundamental criticism of leaching methods would be raised from the ranks of environmentalists, partly in response to some large-scale environmental accidents with leaching projects around the Straz mines in the Czech Republic, many of the problems were already known to scientists and policy makers in 1978, even within the industry.[34] These problems included the expensive and difficult restoration of the local environment. Gypsum precipitation, higher salinity and the spread of some heavy metals and radionuclides proved to be returning problems. There were serious doubts whether the groundwater quality and geochemical conditions in an acid leached aquifer zone could be restored by natural attenuation.[35]

21 From the start, the oil industry involved in ISL tried to counter these arguments. In a 1979 lawsuit on the environmental impact of a pilot uranium extraction project near Crownpoint, N.M. (owned by Mobil Oil), the oil firm intervened to showcase the environmental benefits of the plant. The suit, regarded as a testcase for the leaching industry, was followed closely in several local journals and professional mining journals. The oil company's arguments persuaded the US District judge to issue an order that the economic and social impacts appeared "to be overwhelmingly favourable."[36] These advantages were not to be "offset by the very minor and speculative environmental impacts plaintiffs assert," according the judge. This led the *Albuquerque Journal*'s editorialist to conclude that "those sincerely concerned with protecting the environment, as distinguished from those determined to halt any and all energy projects and to escalate fuel costs, should welcome and applaud the innovative project launched by Mobil near Crownpoint."[37]

30 IAEA, 14-16.

31 Underhill, 'In-Situ Leach Uranium Mining in the United States of America: Past, Present, and Future,' 26.

32 Mobil Corporation, "Leaching: Mining Uranium in Nature's Way", 1978, box 2.207, folder F120, ExxonMobil Historical Collection, Dolph Briscoe Center of American History.

33 E.g. "For Uranium, the Future is Now," *Mobil Overview* 2, no. 1 (1978), box 2.207/F120, ExxonMobil Historical Collection, Dolph Briscoe Center of American History.

34 Mudd, *An Environmental Critique of In Situ Leach Mining: The Case Against Uranium Solution Mining*, 75-79; Hebel et al., 'Report to the American Physical Society by the Study Group on Nuclear Fuel Cycles and Waste Management'.

35 Mudd, 'Critical Review of acid in situ leach uranium mining: 1. USA and Australia,' 390.

36 "Crownpoint: A Landmark Opinion", *The Miner* 1, 4 (1979), box 2.207/F120, ExxonMobil Historical Collection, Dolph Briscoe Center of American History.

37 'Editorial'.

DONUT ECONOMY

22 The oil industry employed similar strategies regarding their investments in nuclear fusion research. The production of electricity from nuclear fusion had been a dream among scientists already since the 1930s. From the Second World War, countries around the world established projects to control the fusion process. Although it seemed theoretically possible to stabilize a fusion reaction for a sufficient amount of time to produce electricity, it proved difficult to actually engineer such a reactor. After a series of failures and false claims of success, the worldwide fusion research efforts declined during the 1960s.[38] This changed in 1968 when Russian scientists reported a breakthrough with their donut-shaped tokamak reactor, claiming better stabilized plasma and higher temperatures. During the following decade, international nuclear fusion research was revived and industrial parties joined the bandwagon.[39]

23 A common expectation among various oil actors was that nuclear fusion could become commercially applicable within twenty to thirty years. In their internal employee magazines, the manager of laser fusion studies at Exxon Research and Engineering Company, Dan Grafstein, plainly stated that "fusion power offers the best hope for providing commercial power for the future – certainly for the next century".[40] Regardless the timeframe of multiple decades, various oil companies invested in experimental fusion projects. Exxon started their fusion research in 1972. At the Laboratory of Laser Energetics of the University of Rochester, New Jersey, Exxon engaged in a project called Omega X to demonstrate that with a laser of ten kilojoules scientific breakeven would be possible.[41] Mobil, and its predecessor Socony, had been involved in experimental fusion science already since 1969. In Princeton, New York, plasma physicists of Mobil worked on trying to make detailed measurements on the density of the plasma – the thin cloud of energetic, charged particles that provide reactor fuel.[42]

24 Also Shell and Gulf Oil, through their joint venture General Atomics, supported big experimental fusion projects. With the tokamak confirming his theory that plasma could be stabilized by multipole magnetic fields, General Atomics' chief physicist Tihiro Ohkawa developed a series of tokamaks with vertically elongated plasma cross sections, called the *doublet*. This line of research resulted in three experimental reactors built by General Atomics during the 1970s and early 1980s, used to study ways to improve the plasmas' stabilization inside the reactor.[43] Especially the Doublet III, the third reactor in the series, became the flagship of Gulf Oil and Shell's investments in nuclear fusion. In several pamphlets and press releases, Shell and Gulf Oil promoted their "largest privately-owned centre engaged in fusion research, development, design and construction" by stating that the Doublet III was "a major step towards fusion power."[44]

25 Like with In Situ Leaching, oil actors presented their nuclear fusion projects as "environmentally friendly". Fusion reactors were presented as a technological innovation that guaranteed the continuation of human prosperity in a healthy environment. In the promotional

38 Märkl, *Big Science Fiction: Kernfusion und Popkultur in den USA*; Herman, *Fusion: The Quest for Endless Energy*.

39 Peacock et al., 'Measurement of the Electron Temperature by Thomson Scattering in Tokamak T3,' 488-490.

40 Quote as represented in "Fusion: as old as the sun; as new as tomorrow", *Exxon* Manhattan, 23 July 1976, box 2.207/K96B, ExxonMobil Historical Collection, Dolph Briscoe Center of American History.

41 "Fusion: as old as the sun; as new as tomorrow".

42 Mobil Oil, "Mobil Probe Aids Search for Controlled Nuclear Energy", 18 May 1969), box 2.207/F160, ExxonMobil Historical Collection, Dolph Briscoe Center of American History.

43 Interview of Tihiro Ohkawa by Stuart "Bill" Leslie, 23 May 2006, Niels Bohr Library & Archives, American Institute of Physics.

44 General Atomics, "Doublet III: A Major Step Towards Fusion Power", 1978, box 6, folder A, Princeton Plasma Physics Laboratory Records, Princeton University; General Atomics, "Doublet III", 1978, box 6, folder A, Princeton Plasma Physics Laboratory Records, Princeton University; Interview of Tihiro Ohkawa by Stuart "Bill" Leslie; Herman, F*usion*, 203-204.

material for the Doublet III from 1977, researchers and managers at General Atomics stated that the promise of inexhaustible power would be "an empty one if there are safety problems or adverse environmental side effects" and that their fusion reactors did not encounter these problems.[45] The total amount of fusion fuel present in a fusion reactor at any one time would be small, and the physics of a fusion process would make a runaway reaction impossible, even if parts of the reactor system failed. Also, General Atomics claimed there was no risk of thermal pollution. There were no risks of biological hazards by radioactivity or the release of chemical combustion products to the atmosphere, making nuclear fusion both safer and cleaner than nuclear fission and the burning of hydrocarbons according to the oil-funded company.[46]

26 With this frame the oil actors presented nuclear fusion as a perfect example of the technological innovations it developed, while also ignoring well known problems with radioactive waste produced by fusion reactors.[47] According to Nobel Laureate, nuclear physicist, and consultant for Exxon Nuclear, Hans Bethe, radioactivity would not be eliminated by the introduction of fusion. In 1974 he stated that both the hydrogen isotope that was commonly used in fusion reactions, and the structural material in the reactor will be made radioactive. "Disposal of radioactive wastes will still be with us, and also the problem that heat will continue to be produced after the reactor is shut down."[48] Still, there was no trace of it in the public communication from the oil industry. Fusion was be portrayed as a completely "clean"‘ alternative to nuclear fission and fossil fuels.

45 Quote from General Atomics, "Doublet III: A Major Step Towards Fusion Power".

46 General Atomics, "Doublet III: A Major Step Towards Fusion Power".

47 Vrouwe, *Hittebarrière: Vijftig jaar plasmafysica bij FOM-Rijnhuizen 1959-2009*, 66.

48 Hans Bethe, "Energy Crisis and Nuclear Power", 1974, box 20, folder 8, Hans Bethe Papers, Cornell University Rare and Manuscript Collection.

A BRIDGE TO THE FUTURE

With their nuclear frames, oil companies tried to 27
protect their new position as full-fledged energy companies by claiming the responsibility for a long-term, "environmentally friendly" energy supply and presenting their investments in regular nuclear fission as bridge toward this clean future. Already in 1967, forecasts from oil economists and geophysicists announced this strategy. In a long-range outlook for the petroleum industry presented for the Society of Petroleum Engineers, Gulf Oil's in-house economist T.D. Lumpkin argued that the only way forward for oil firms was transform into "energy companies". "In an increasingly "dynamic world" where alternative energy sources such as nuclear energy made big strides in the field of electricity generation, only managements that would transform their companies to energy companies "were the ones who would continue to lead their companies on to success" according to Lumpkin.[49]

Lumpkin regarded air and water pollution caused 28
by petroleum combustion as one of the main reasons for a diversification strategy for oil companies. "Whether it is the air over our cities or the water in our streams, pollution must be recognized as a problem and steps must be taken to control it," he claimed. As part of "responsible citizenship," the petroleum industry had to live up for the unwanted consequences of air pollution for sulfur in residual fuel oil and unburned gasoline: "there are obvious consequences of failing to accept forthrightly the share of the responsibility which is rightfully ours."[50]

This reasoning permeated the thinking of the 29
board rooms of the major oil companies. In their annual report over 1967, the board of Gulf Oil celebrated a successful year with new high records in net income, cash dividends paid, and in volumes produced, processed, and sold throughout the company's businesses. However, Gulf's

49 T.D. Lumpkin, 'The long-range outlook for the petroleum industry", 1967, box 1, folder 20, Gulf Oil Corporation Records, Heinz History Center - Detre Library and Archives.

50 T.D. Lumpkin, "The long-range outlook for the petroleum industry".

board also expressed worries about sustaining this streak of success for the long-term, focusing on the increasing debates on environmental pollution from petroleum. The company's CEO, Ed Brockett, noted that besides declining oil production in the United States and governments in the Global South attempting to nationalize Gulf's assets, also political and public pressure in the US forced the oil industry to reduce air and water pollution from petrochemical products. According the board, the company needed to invest in alternative energy sources to preserve its growth and nuclear energy was considered the most viable option.[51]

30 Gulf's following nuclear investments in 1967 were therefore explicitly framed as the oil firm's answer to environmental problems posed by the petroleum industry, a frame shared with oil companies such as the French state-owned company Elf-ERAP (later Total) in the same period.[52] In the same period, also many other major oil companies started diversification projects into nuclear energy. The Mobil Oil Company launched a large-scale uranium prospecting project, and Exxon founded a subsidiary called Jersey Nuclear (later Exxon Nuclear) which developed nuclear research, and uranium mining and enrichment projects also in 1967.[53] Also Shell started its nuclear diversification in 1967 by acquiring a stake in the Dutch uranium enrichment project.[54]

31 So, when nuclear energy was also increasingly criticized for its environmental impact during the late 1960s and early 1970s, this directly threatened already existing diversification strategies and frames from the oil companies. In several countries, anti-nuclear activists increasingly linked nuclear power plants to environmental disasters, such as the killing of tens of thousands of fish in the Hudson River attracted to the heated waste water from the Indian Point Nuclear Power Plant. Sometimes linking themselves to early Green parties, anti-nuclear activists organized themselves against, often specific, nuclear projects.[55]

32 To counter the concerns about the environmental impact nuclear power plants, the oil companies embraced the technological optimist frame in which their "innovative" nuclear technologies played a central role. The companies acknowledged the environmental impact of nuclear fission, but they positioned their regular nuclear investments as building a bridge to a "clean" and "innovative" nuclear future. The development of In Situ Leaching was deliberately presented as a clean alternative to traditional, more polluting, mining techniques that had been common in the uranium mining industry – which ironically already included many participating oil companies.[56] According to the oil firms, the cleaner mining practices would increasingly take over, a transition that could only take place with the expertise of the oil industry in waterflooding techniques.[57]

33 The oil research in nuclear fusion was also presented as future solution to the environmental problems of both oil and nuclear fission, but this research was expected to still take at least twenty years. Investments in nuclear fission were presented as a necessary step to bridge

51 E.D. Brockett and B.R. Dorsey, "Letter to the Shareholders," Gulf Oil Corporation, *1967 Annual Report Gulf Oil Corporation* (Pittsburgh: Gulf Oil Corporation, 1968), 3-5.

52 Bonneuil, Choquet and Franta, 'Early warnings and emerging environmental accountability,' 3.

53 "Double-Duty Prospectors", 1968, box 2.207/F120, ExxonMobil Historical Collection, Dolph Briscoe Center of American History; "H. Eugene McBrayer: transcript of an interview conducted by James J. Bohning at Mercer Island, Washington", 11 May 1995, The Chemical Heritage Foundation, Oral History Transcript #0144.

54 Kistemaker, *De geschiedenis van het Nederlandse Ultracentrifuge Project*, 18-23; Streefland, *Jaap Kistemaker en uraniumverrijking in Nederland*, 256.

55 Lifset, 'Nuclear Power in America: The Story of a Failed Energy Transition,' 527; White, *The Organic Machine: The Remaking of the Columbia River*; Presas I Puig and Meyer, 'One Movement or Many? The Diversity of Antinuclear Movements in Europe,' 83-111.

56 Amundson, *Yellowcake Towns: Uranium Mining Communities in the American West*, 24-25; Ringholz, *Uranium Frenzy: Boom and Bust on the Colorado Plateau*, 13, 60; Bron, 'The Uranium Club,' 62.

57 Mobil Corporation, 'Leaching: Mining Uranium in Nature's Way', 1978, box 2.207, folder F120, ExxonMobil Historical Collection, Dolph Briscoe Center for American History.

the gap between an oil fueled economy, and a safe, and clean, future with inexhaustible energy from nuclear fusion.[58] According to Hans Bethe in 1974, fusion was the most important of the alternatives to non-fossil energy. With the emergence of the tokamak reactor the prospects for fusion looked better than ever before, he stated. However, Bethe acknowledged that due to engineering problems and the long time it would take to upscale fusion to an industrial power plant still at least thirty years had to be bridged and a first appreciable contribution might only be expected in 2010 or 2020, arguing for a continuation of the investments in traditional nuclear fission projects.[59]

CONCLUDING OBSERVATIONS

34 Even today, many of the previous discussed nuclear frames from the oil industry prevail. In the decades following the introduction of ISL in uranium mining, the technology would become, and is still, widely used in the uranium industry, surpassing both underground and open pit mining as the primary mining technique.[60] While several scientists already indicated that using chemical leaching methods for uranium mining impacted the local environment, the industry managed to fend off tightened regulations that did affect other forms of uranium mining for leaching in the United States and Australia.[61] Promotion material and lobbying efforts from the oil companies ignored or downplayed these problems. Recently, major oil companies such as the French TotalEnergies again promote leaching diluents for uranium mining as "environmentally friendly".[62]

35 Oil companies also increasingly return to the development of fusion energy in a time when new fusion projects are again funded with the premise that they will soon deliver clean, reliable and affordable energy.[63] Shell, Equinor, ENI and Chevron now invest in fusion technology, funding various start-ups with the goal to advance the research and potential commercialization of this energy source.[64] According to a 2020 press release from Chevron, the company invests in Zap Energy Inc., a Seattle-based start-up company that develops modular nuclear fusion reactors, to "enhance the company's focus on a diverse portfolio of low-carbon energy resources with the capacity to provide communities across the globe access to, reliable, and ever-cleaner energy."[65]

As this chapter showed, these oil-nuclear 36
frames originate from the roles oil firms played in the environmental discourse surrounding both petroleum and nuclear fission during the 1970s. The oil industry's nuclear frames aimed for enshrining the belief that the development of these new technologies reduced the need for environmental policies, and invite extra investments in "environmental friendly" technologies like nuclear fusion and leaching. By presenting clean and alternative nuclear technologies, oil firms framed their investments in regular nuclear power as bridging a gap to a "environmentally friendly" nuclear future. By affirming the environmental problems of nuclear power but presenting a technofix in return, oil firms claimed that investments in nuclear power were still necessary for a clean future, despite criticism from environmental organizations and reports such as *Limits to Growth*.

This also was the thrust of Shell's involvement 37
in *Work for the Future*. The Shell-dominated response to the *Limits to Growth* debate embraced many of the noted issues surrounding

58 'Wagner (Shell): andere bronnen energie aanboren'; Beek et al., *Werk voor de toekomst,* 17.

59 Hans Bethe, 'Energy Crisis and Nuclear Power', 1974, box 20, folder 8, Hans Bethe Papers, Cornell University Rare and Manuscript Collection.

60 World Nuclear Association, 'In Situ Leach Mining of Uranium'.

61 Mudd, 75-79.

62 TotalEnergies, 'Metal Mining with Elixore diluents'.

63 Shaw, 'Germany announces nuclear fusion funding programme'; Department for Energy Security & Net Zero, *Towards Fusion Energy 2023: The next stage of the UK's fusion energy strategy*, 9.

64 Deign, 'Why Are Oil and Gas Companies Investing in Nuclear Fusion?'; Velasco, 'Oil Industry Explores Viability of Nuclear Fusion'.

65 Chevron, 'Chevron invests in nuclear fusion start-up'.

environmental pollution from fossil fuels and nuclear power. On the other hand, for the immediate issues caused by fossil fuels, nuclear power was seen as the only viable alternative, despite its environmental impact. To meet these problems, new, clean, technologies within nuclear power had to be developed by the same industry that produced the pollution, often with the help of governmental subsidies and regulations.

38 By presenting these frames, this article argued that the oil actors actively acknowledged environmental problems from both fossil fuels and nuclear power. Problems such as air and water pollution from petroleum combustion, and thermal pollution and environmental and health effects from radioactive waste with energy production from traditional nuclear fission projects, were actively addressed as part of a strategy to defend the nuclear diversification strategies from the oil industry.

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