JEH RHE

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

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POST DATE
July 2024
ISSUE NUMBER
JEHRHE #12
SECTION
Special issue
THEME OF THE SPECIAL ISSUE
Black and Green? Environmental Histories of the Oil Industry
KEYWORDS
Oil; Industry; Solar; Renewable; Transition

History of Oil and Solar Relationships: Makeups and Breakups

Abstract
Facing an uncertain future, the oil industry confronts a critical dilemma: adapt to a renewable-powered world or stay in the way of it. This echoes a similar challenge during the 1970s energy crisis when many oil companies reconsidered their business strategies and started investing in the emerging niche of renewables, such as solar, only to largely abandon it in the 1980s. By dissecting the strategies and sincerity of Exxon, Mobil, Shell, BP, Amoco, and Arco during this period, this paper delineates both commonalities and distinctions in their approach to creating a solar transition pathway. Drawing on archival accounts, annual reports, secondary literature, and several interviews, this research reveals the complexity within the oil industry, highlighting varying degrees of commitment and challenging the monolithic perception of oil industry actions.

Acknowledgements
The research for this article has been supported by the Dutch Research Council (NWO) under grant VI.C.191.067 Managing Scarcity and Sustainability.

Plan of the article

ISSN 2649-3055

INTRODUCTION: BIG OIL'S SOLAR VENTURES IN THE ENERGY TRANSITION PANORAMA

1 The combustion of fossil fuels, predominantly sourced from the oil industry, stands as one of the biggest contributors to global greenhouse gas emissions, releasing over 30 billion tons of carbon dioxide (CO_2) into the atmosphere each year.[1] Carbon dioxide emissions from fossil fuel consumption are the main driver of climate change, the effects of which are likely to become more and more severe as ambient temperatures rise. To mitigate the worst effects of climate change, the transition toward greener energy sources has become a global imperative.

2 As society increasingly calls for environmental stewardship, the oil industry – one of the main incumbents of the current energy regime – finds itself at a pivotal crossroads. Oil firms are still the predominant entities responsible for meeting global energy demands. Some do so by prioritizing profits, maximizing short-term shareholder value, and thus by exploiting natural resources rashly, without a seemingly genuine commitment to an environmentally sustainable future. Other firms, however, appear to be sincere in adapting their business models for the long-term, striving to lead rather than hinder the energy transition.[2]

3 Historically, this is not uncharted territory for the oil industry. Since the late 1950s, oil firms have sporadically invested in what were then called "alternative energies", starting with nuclear, and in later decades expanding to other alternatives such as coal, geothermal, solar, and so forth.[3] The oil industry's involvement with nuclear energy goes back to the Manhattan project, where chemical and oil companies played key roles by contributing personnel and expertise, in areas like the construction of large technical facilities (similar to building refineries and oil platforms)[4] that the Manhattan project required, and in uranium exploration, mining, and processing.[5] While oil companies remained involved in nuclear power through the 1960s and into the 1970s[6], their focus gradually expanded to include other forms of energy such as geothermal and solar energy.[7] This paper contributes to the understanding of the oil industry's early involvement in solar energy, in particular during the 1970s and 1980s, when oil firms, almost in unison, made unexpected (if hesitant) overtures toward environmental protection, energy conservation, and alternative energy including solar power.

4 The limited scholarly literature on the legacy of the oil and solar relationship is somewhat contradictory, underscoring the complexity of the issue. While some critiques suggest that oil actors, in collusion with governments, undermined further development and upscaling of solar energy,[8] others suggest that oil firms provided critical and genuine support in the initial stages of the solar industry's formation.[9] However, a significant body of scholarship questions these seemingly genuine intentions, often framing them as public relations (PR) or greenwashing. Evidence of the industry's historical awareness of its environmental impact and strategic climate change denial only serve to fuel these doubts about oil industry commitment to sustainability and renewables.[10]

1 Intergovernmental Panel on Climate Change, *Climate Change 2014*.

2 Johnston, Blakemore, and Randolph, 'The role of oil and gas companies in the energy transition'; Pickl, 'The Renewable Energy Strategies of Oil Majors – From Oil to Energy?'; Alagoz and Alghawi, 'The Energy Transition'.

3 Mody, 'Surveying the Landscape'.

4 Ibid., 65.

5 Rhodes, *The Making of the Atomic Bomb*.

6 For more on oil involvement in nuclear energy, particularly in uranium mining, see Bron, 'The Uranium Club: Big Oil's Involvement in Uranium Mining and the Formation of an Infamous Uranium Cartel'.

7 Solar energy power had already been used to power spacecraft since the 1950s.

8 Reece, *The Sun Betrayed*; Emblem, 'How Big Oil Had Controlled the Solar Industry'.

9 Perlin, *From Space to Earth*; Madrigal, *Powering the Dream;* Johnstone, *Switching to Solar;* Williams, *Chasing the Sun*; Hsu, 'How Big Oil of the Past Helped Launch the Solar Industry of Today'.

10 Cherry and Sneirson, 'Chevron, Greenwashing, and the Myth of "Green Oil Companies"'; Franta, 'Early Oil Industry Knowledge of CO2 and Global Warming'; Mommers, 'Shell Made a Film about Climate Change in 1991 (Then Neglected to Heed Its Own Warning)'; Andersson, 'Ghost in a Shell'; Hüzeir, 'BP Knew the Truth about Climate Change 30 Years

5 To better understand the multifaceted motives at hand, this paper retraces the steps of oil firms' investments in and divestments from solar energy, offering a broad, explorative narrative that addresses a gap in the existing academic literature. By investigating whether oil firms' forays into solar energy were image-enhancing measures or genuine gestures towards changing the energy landscape, this study reveals that oil firms were indeed active participants in the early stages of solar technology development. The analysis focuses on overarching similarities but also nuanced strategic differences between oil companies, and thus challenges the perception of the industry as a homogeneous entity. Ultimately, this research suggests that the industry's support of solar energy, at least within the specific historical context explored here, ran deeper than a purely strategic calculation and may have involved a greater degree of genuine interest than often perceived. This historical study also provides important context to understand the complexities and capabilities of the oil industry in transitioning towards a sustainable energy future, a topic of great relevance to the academic community and today's global energy discussions.

6 The structure of the paper unfolds as follows: The first section explains the adoption of a broad overview approach to analyse oil-solar activities, followed by brief contextualization of the industry's external stimuli to engage with alternative energy. The third section documents oil firms' investments in solar energy and explores their entry into this field. A brief analysis of their eventual retreat from solar energy follows. Finally, the conclusion synthesizes these findings, shedding light on the multifaceted motives of oil firms' entry into solar and touches upon the role oil companies have played in the energy matrix, both as guardians of a fossil-fuelled past and prospective stewards of a more sustainable future.

Ago. Now, It's Time to Ban Fossil Industry Advertising'; Li, Trencher, and Asuka, 'The Clean Energy Claims of BP, Chevron, ExxonMobil and Shell'; Supran and Oreskes, 'Assessing ExxonMobil's climate change communications (1977–2014)'.

Methodology: Broad Overview Approach

This paper examines early involvement of oil companies with the solar energy sector, a multifaceted phenomenon that could be investigated through a variety of approaches. This study, however, explores the topic in breadth rather than depth; instead of going into detail for one or two cases, I offer a broad overview of the solar activities of six different oil companies. This approach is more suitable to elucidate the article's thesis for several reasons. 7

First, establishing a broad contextual background, centering on the 1970s oil crises, environmental concerns, regulatory context, and an interest in novel technologies, is essential to understand the collective gravitation of oil companies toward solar energy. Second, given that many oil companies are still secretive about their business affairs, my source base is broad rather than deep. A deep dive into any oil company's flirtation with solar is beyond the scope of this study due to data limitations and pragmatic constraints. Even if the sources were available to zoom in on a particular company's solar activities, doing so would only reveal more about that one firm's actions but would not necessarily contribute to a foundational understanding of the oil *industry's* early forays into solar energy. Given my industry-wide research focus, a broad overview, achieved through analysis of archival documents, industry annual reports and news press releases, scholarly literature, and interviews, is strategically chosen to provide a more comprehensive picture that captures the scope and complexity of oil-solar dynamics. 8

Third, by examining a range of companies, this study reveals insights into collective corporate behaviour and firms' strategic alignment despite the diversity of their approaches, reflecting the heterogeneity in their responses to the same external pressures. Finally, presenting a broader overview could offer a more generalizable understanding that both scholars and industry observers interested in the role of incumbents in the energy transition can build on. Rather than offering definitive answers, this research seeks to unearth new questions and invite more detailed investigations in the future. 9

CONTEXTUAL BACKDROP: OIL'S ENTRY INTO SOLAR

10 The 1970s oil crises shook up the global energy landscape, forcing the oil industry to rethink its traditional fossil fuel business. This period marked the turning point, as major oil companies faced economic, political, and environmental pressures and thus began to explore opportunities in less traditional lines of the energy business. Production declines (some intentional and some not) along with the 1973 OAPEC oil embargo brought the postwar era of affordable, abundant energy to an abrupt end with a sudden shortage of gas and oil supply.[11] The resulting resurgence of energy scarcity debates[12] triggered many reactions. For example, some environmentalists began calling for a "no growth" economy in support of sustainability and quality of life rather than profit. The environmental movement was already enjoying increasing public support, stimulated by publications about adverse industrial practices in the petrochemical industry[13] and disastrous oil spills (e.g., Santa Barbara).[14] That increased public consciousness of dangers to the environment became a potent political force with the inaugural Earth Day in 1970, sending a clear signal to lawmakers that something needed to be done. In the US, for example, regulatory bodies and legislation such as the Environmental Protection Agency and the Clean Air Act in 1970 soon announced an era of environmental regulation to which industry had to respond.[15] This created additional pressure on oil firms already grappling with uncertainties about depletion of oil supplies and true material scarcity.

11 Oil companies recognized that energy security was to be achieved by including a wider range of energy sources, including those on what today would be considered the 'greener' end of the spectrum. Therefore, Western governments and oil firms started to *both* exploit more inaccessible oil fields (for example in Alaska or in the North Sea and Gulf of Mexico),[16] and started investing in R&D related to "alternative" energy sources. The latter included some energy sources no longer labelled as alternative (e.g., natural gas, synthetic fuels from coal, or nuclear power)[17] as well as some that still are (e.g., solar). However, oil firms' involvement in solar was unlike their other ventures, as solar represented a significant departure from their core competencies, making their investment in this technology both intriguing to historians, and more challenging than participants expected at the time.

12 Kaufman and Walker explain that during the 1970s oil companies experienced a significant increase in capital due to price hikes in the petroleum industry, which made them a kind of "industrial bankers."[18] This surge in profits stemmed largely from the 1973 oil crisis, triggered by both increased prices imposed by OPEC and a subsequent embargo by OAPEC targeting countries allied with Israel. OAPEC implemented the oil embargo to pressure Western nations and Japan into adopting a more pro-Arab stance in the aftermath of the 1973 Arab-Israeli conflict.[19] This embargo, coupled with production cuts by OPEC members, sent oil prices skyrocketing.[20]

13 While these geopolitical events were immediate triggers, some scholars argue that the crisis was further amplified by the market behaviour of oil corporations, as they used the crisis to regain control and increase profits.[21] According to Timothy Mitchell[22] oil companies were not passive actors but rather active participants in shaping the crisis and its outcomes. He further

11 Bösch and Graf, 'Reacting to Anticipations'.
12 Richman, 'The Polls'.
13 Carson, *Silent Spring*.
14 Spezio, *Slick Policy.*
15 Ibid.
16 Priest, 'The Dilemmas of Oil Empire'; Mitchell, *Carbon Democracy.*
17 Sabin, 'Crisis and Continuity in U.S. Oil Politics, 1965-1980'.
18 Kaufman and Walker, 'The Strategy-History Connection: The Case of Exxon', 29.
19 Bösch and Graf, 'Reacting to Anticipations'.
20 Schumacher, 'The 1973 Oil Crisis and its Aftermath'. For more on the importance of OAPEC embargo see Garavini, *The Rise and Fall of OPEC in the Twentieth Century.*
21 Bini, Garavini, and Romero, *Oil Shock: The 1973 Crisis and Its Economic Legacy.*
22 Mitchell, 'The Resources of Economics: Making the 1973 Oil Crisis'.

adds that their control over supply, influence on pricing, and close ties with Western governments, allowed them to benefit significantly from the price hikes, solidifying their economic and political power and maximising their own interests.

14 While the extent of the industry's agency on the events of the 1973 oil crisis remains a subject of debate within the literature, their strategic manoeuvres resulted in a huge influx of capital for the oil industry. This period of increased profits coincided with growing interest in solar energy, propelled by events such as the Solar Energy Panel in 1972[23] and the Cherry Hill meeting in 1973.[24] Notably, the Cherry Hill meeting anticipated a rapid decline in the price of photovoltaic (PV) cells; only in the 1980s did it become clear that the price of photovoltaic energy would decline much more slowly than expected. During the 1970s, however, oil actors shared in the optimism for solar energy expressed in these events. Particularly regarding the efficiency of PV cells, oil firms of the 1970s acted on the widely-shared belief that solar electricity generation could become cost-effective and reach grid parity by the late 1980s.

15 That expectation turned out to be premature,[25] as corporations' and government agencies' predictions underestimated the technological and market challenges. Solar PV did indeed have a high terrestrial potential, but it would take far more time than initially anticipated to come close to grid parity. This was very clear to the solar entrepreneurs interested in upscaling the industry from the space program to new markets on earth.[26] As solar entrepreneur Peter Varadi put it:

> We also knew that this is like building a house brick-by-brick and not only looking at a mirage of a central power station made of PV... The investors and [*sic*] mostly were big oil companies, believed the central utility mirage, the "big picture" which the government experts predicted agreed with the huge business models they liked. But we in the trenches were very happy if some of the roadside emergency phones started to use solar electricity.[27]

16 The pervasive optimism surrounding PV, while seemingly premature and overstated, appears to have genuinely influenced oil companies. Their investments in solar energy, rather than being purely strategic manoeuvres, likely stemmed from a belief in the technology's potential, a belief shared by many at the time. Led by government predictions, surplus of cash, and favourable regulatory climate[28] but also recognizing both the market potential and the growing need to overcome restricted access to Middle East oil, firms like Exxon, Mobil, Shell, and BP began acquiring, partnering with, and investing in solar technology companies,[29] mirroring and complementing those oil firms' ventures into coal, petrochemicals and offshore oil and gas.

17 The list of oil companies and/or oilfield firms involved with solar in one way or the other encompasses also American Oil Company

23 The Solar Energy Panel was organized by the National Science Foundation (NSF) and NASA to assess solar energy's potential as a national resource, and made recommendations for research and development, including using photovoltaics to generate terrestrial electricity.

24 The Cherry Hill Conference workshop on Photovoltaic Conversion of Solar Energy for Terrestrial Applications, organized by the NSF, NASA, and the Jet Propulsion Laboratory, brought together around 135 participants from the research, manufacturing, and commercialization communities to discuss the potential of solar energy and the state of photovoltaic technology. The conference defined an active role that government could play in supporting its development. It was predicted the PV cells would experience a rapid decline in price, which did not manifest itself as fast as predicted.

25 Varadi, *Sun above the Horizon*.

26 Since the development of photovoltaic silicon solar cells in the 1950s the commercialization of PV cells faced challenges due to high manufacturing costs, but found success with the US space program onboard spacecraft.

27 Varadi, *Sun above the Horizon*, 109.

28 Oil and gas businesses were compelled to compete on price in the late 1970s when pricing and supply regulations were liberalized in US (the Carter administration) and UK (Wilson/Callahan administration).

29 Lüdeke-Freund, 'BP's solar business model'; Wolfe, *The Solar Generation*: *Childhood and Adolescence of Terrestrial Photovoltaics*; Jones and Bouamane, 'Power from Sunshine: A Business History of Solar Energy'.

(Amoco),[30] Atlantic Richfield (Arco), Chevron,[31] Union Oil of California, General Atomic Co. (at the time co-owned by Gulf Oil and Shell), Occidental Petroleum, Philips, Standard Oil Co. of Ohio (SOHIO),[32] and Texas Instruments (at the time still in part an oilfield services firm). The list also prominently includes the French oil companies Elf Aquitaine[33] and CFP which later combined to form Total Énergies (and which under successive names remained steadily in the PV business).[34] While this list demonstrates the widespread interest in solar across the oil industry, a closer look at six companies, namely Exxon, Mobil, Shell, Arco, Amoco, and BP, reveals the depth and diversity of these ventures.

INVESTMENTS AND UPSCALING: THE GOLDEN ERA OF OIL IN SOLAR

18 Exxon's involvement with solar began through their financial support and subsequent ownership of two subsidiary companies, Solar Power Corporation (SPC) for solar PV, and Daystar for solar cooling and heating systems. The entrepreneurial spirit of individuals like Elliot Berman (SPC) and Gary Nelson (Daystar) played a critical role in this evolution. Elliot Berman, a former industrial chemist at Itek,[35] sought to bring solar photovoltaic technology to regions lacking access to electricity.[36] In 1968, he started his own company, Solar Power Corporation (SPC). However, after facing financial challenges, Berman found a partner in Exxon Enterprises,[37] which initially invested $2.5 million, leading to full ownership by 1975.

19 With SPC under its wing, Exxon saw an opportunity to leverage solar technology to address a pressing operational challenge. Driven by the need for a cheaper and more reliable way to power their offshore platforms, Exxon made a strategic move to integrate solar technology into their operations. Supplying offshore generators with fuel was not only expensive but also risky, given that rigs could be cut off from fuel supplies. SPC's production of solar flat panels, therefore, served as a first step, allowing Exxon to mitigate these challenges while also minimizing the environmental impact of powering their Gulf of Mexico platforms with large and hazardous lead-acid batteries.[38] This success paved the way for Exxon to expand into the relatively small but growing market for remote applications.

Exxon Research and Engineering was simultaneously engaged on another front: developing cost-efficient solar cells for residential applications, thereby significantly enhancing the practicality and accessibility of solar energy.[39] Moreover, the company reported positive economics from its solar investments with a 50% increase in unit sales in 1978 across over 35 countries, including supplying Australian national railways with solar electric modules for powering communications repeaters. This made SPC the company with the largest single commercial contract in the solar electric industry.[40] In addition, SPC also secured major government contracts for various demonstration programs, for instance, designing an installation to provide 175 kilowatts of power to a high school in Beverly, Massachusetts.[41] 20

Similarly to SPC, Daystar Corporation became a leader in its field – provider of systems for solar water heating for residential and commercial buildings. Exxon, impressed by the solar heat collector prototype with effective heat-up 21

30 The former Standard Oil of Indiana.

31 Chevron, or formerly Standard Oil of California, invested in SES (a Shell Oil subsidiary). See Flood, 'Big Oil Reaches for the Sun'.

32 Ethridge, *The U.S. Solar Energy Industries and the Role of Petroleum Firms*.

33 Elf Aquitaine and utility firm Compagnie Générale des Eaux partnered to form Photowatt.

34 Jones and Bouamane, 'Power from Sunshine'.

35 A US spy satellite contractor.

36 Perlin, *From Space to Earth*.

37 Wolfe, *The Solar Generation*.

38 In 1978, the Environmental Protection Agency outlawed the disposing of lead-acid batteries, which had devastating effect on marine life, in the ocean. This law added a sense of urgency for oil companies to come up with a new way to power their platforms. See also Perlin, *From Space to Earth*; Jones and Bouamane, 'Power from Sunshine'.

39 Exxon Corporation, *1977 Annual Report*.

40 Exxon Corporation, *1978 Annual Report*.

41 Ibid.

features developed by Gary Nelson and his colleague from Itek, firstly supported Daystar through equity financing that turned into full ownership.[42] By 1977, the company had successfully sold over 2500 collectors, primarily used for heating household water. This application proved economically advantageous in regions with high electric heating costs. Exxon Enterprises contributed to cost-effective installation practices and innovative home designs, while also working on advancing complementary technologies for cooling buildings.[43] In 1978, Daystar doubled its collector sales compared to 1977, leading to contracts with the US Department of Housing and Urban Development for the installation of its solar heating and cooling equipment at various locations including Gainesville, Florida, and Houston, Texas.

22 The same as Exxon, Mobil found partnership outside of the company, in Mobil's case with Tyco Laboratories, which was looking for collaborators for their novel process for growing ribbon silicon and making ribbon solar cells. The first user and promoter of this type of cell was NASA, but they lost interest after the cells proved to be unstable due to lower conversion efficiency.[44] Therefore, Tyco and its researcher and entrepreneur, Abraham Mlavsky, were looking for a new partner willing to put money into solar development "when the outcome was still speculative."[45] In 1974, Mobil created a joint venture with Tyco Laboratories, the Mobil Tyco Solar Corporation. The company invested around $50 million with Mobil holding 80% of the shares, while Tyco owned the remaining 20%.[46]

23 This new venture was actively working on developing cost-efficient single-crystal silicon ribbons for solar cells, the technology that could potentially reduce production expenses significantly compered to conventional methods. Additionally, a parallel effort in manufacturing started in 1975 in Japan under the license of Mobil Tyco Solar. Both Mobil and Tyco held a 7.5% interest in the company called Japan Solar Energy Co., Ltd., while the rest was owned by Japanese companies.[47]

Mobil Tyco Solar made progress in cost reduction 24
for solar cell production, but projections were that it would take a decade or longer for solar energy to significantly contribute to America's energy supply.[48] Nevertheless, through the 1970s Mobil Tyco Solar remained steadfast in its commitment to pursuing alternative energy sources, as expressed in 1976 in Mobil's biweekly "Observations" paid advertorial in various US newspaper supplements:

> We're betting on it... But it will take time... [E]ven though there's a lot of research activity, chances are the sun won't have a sizable impact on the nation's energy supply before 1990.[49]

In the company's news release, the president 25
and CEO of Mobil Tyco Solar, James McNiel Jr., provided a more specific timeline for the company's vision for generating energy from the sun.

> Barring a major breakthrough, we at Mobil Tyco do not foresee solar-generated electricity having a sizeable impact on the world's energy supply before the last decade of this century... [B]y the year 2000, solar energy in all its forms could be producing as much as two or three percent of our energy requirements, thereby saving one million barrels of oil a day... [P]hotovoltaic solar cells can have a major impact in the next twenty to thirty years, about the time when oil becomes scarce.[50]

42 Reece, *The Sun Betrayed*.
43 Exxon Corporation, *1977 Annual Report*, 21.
44 Jones and Bouamane, 'Power from Sunshine'; Wolfe, *The Solar Generation*.
45 Reece, *The Sun Betrayed*, 171.
46 Mobil Oil Corporation, *Annual Report 1974*, *Annual Report 1976*, *Annual Report 1977*.
47 Mobil Oil Corporation, *Annual Report 1975*.
48 Mobil Oil Corporation, *Annual Report 1976*.
49 Mobil, Observations, A weekly column appeared in *The New York Times*, *Parade*, and other Sunday supplements on February 8, 1976, 2.207_G117_General Subject Files; Mobil Solar Energy Corporation: General; 1974-1982, ExxonMobil Collection, Dolph Briscoe Center for American History, University of Texas (hereafter EMC).
50 News release, 'The Sun's future is brightening', November 1977, 2.207_G117_General Subject Files; Mobil Solar Energy Corporation: General; 1974-1982, EMC.

26 In 1978 the company reported that after 4 years of investment, significant technological advancement in solar had been achieved. However wide-scale application of solar energy was expected to remain costly in the years ahead.[51] Despite these observations, Mobil Tyco Solar was still looking for ways to improve technology, reduce production costs, and explore new markets. By the end of the 1980s the joint venture had reduced fabrication costs for crystalline-silicon solar cells by half and expanded into the European market by selling photovoltaic panels to RWE AG, one of Europe's largest utility companies. Mobil Tyco Solar president, Bernard Gillespie, announced in a news release that the company was strategically targeting the utility industry as its primary customer for PV panels, foreseeing an increasing contribution to new electric capacity. The company emphasized that sales to utility companies indicated the industry's recognition of the benefits of PV technology.[52]

27 Shell was also an early entrant into the solar energy industry. As a truly transnational company, Shell got involved with solar on two continents: in North America through the Shell Oil Company branch, and in Europe through the headquarters of Royal Dutch Shell. The first steps were taken when the North American affiliate, Shell Oil, got in touch with Karl Wolfgang Böer, a physics and engineering professor at the University of Delaware and academic entrepreneur. Böer was founder of Solar Energy Systems, Inc. (SES) where Shell took a minority equity position in October 1973,[53] even before the OAPEC embargo. Shell was attracted to SES's work on a novel cadmium sulphide/copper sulphide solar cell due to its potentially lower costs.

28 Initially, Shell invested $3 million in this project for a pilot line and applied research[54] and further loans, equity investments, and equipment donations followed.[55] With this investment Shell stood out as the sole company that embraced a different approach in the solar energy race, placing its bet on cadmium sulphide solar cells (CDS/CuCS cells), a departure from the prevailing use of silicon solar cells adopted by other firms. In 1977, during a symposium on competition in the solar industry, Julius D. Heldman, the vice president of Shell Development Company, explained the company's entry into solar:

> Shell has sponsored the SES project for several reasons. First, we believe there is an excellent, large future market possibility in photovoltaics. Second, photovoltaic development is characterized by high technological content and risk, both features characteristic of Shell's ventures and, it should be added, of many other oil companies as well. Risk management--technical, marketing, and financial--is the way we make progress. Third, through our experience in risk management, we have learned the necessity of patience. From the outset, we concluded solar electricity would be a long-term haul, with no fast payback in sight, but that has not and will not deter us if the long-term analysis bears enough promise.[56]

29 Over time Shell took more control of SES, first by investing an additional $3.6 million in 1976 when the company acquired 80% of the outstanding shares of SES and made it a subsidiary. These investments were justified as a response to the expanding opportunities for widespread adoption of solar photovoltaic devices, categorized as a "market development program"[57] targeting the off-grid electricity supply market, a sector with enormous potential. By 1976, Shell's SES

51 Mobil Oil Corporation, *Annual Report 1978*.

52 News release, Mobil Solar makes sale to West German utility, 27 September 1988, 2.207_G117_General Subject Files; Mobil Solar Energy Corporation: General; 1974-1982, EMC.

53 SES Loan Agreement with Shell, 19 September 1973, box 27, II.C.3-Agreements 1974, Karl Wolfgang Böer Papers (henceforth KWB).

54 Palz, *Power for the World: The Emergence of Electricity from the Sun.*

55 'The solar market, proceedings on the symposium over the competition in the solar energy industry', FTC, December 1977, Box 58, folder SES Contract, Solar Energy Systems 1973, 1978, 1979, 1984, 1986 Maria Telkes Collection (henceforth MTC).

56 Ibid.

57 Shell Oil Company, *Annual Report 1975* and *Annual Report 1976*.

intensified its efforts to penetrate the photovoltaic market by selling generators for small off-grid systems. Unfortunately, these systems experienced a significant decline in performance, prompting SES to investigate the issues. Shell's investments continued, with $8.6 million in 1977 and an additional $3 million committed for 1978. Despite pouring more money into the business and management's hopes for a swift return to the market, technical problems persisted, leading to a delay in their marketing program in 1978.[58]

30 In the meantime, Royal Dutch Shell was starting a venture in Europe. Namely, in 1981, a Dutch company, Holecsol Systems (part of Holec Energy Systems of Hengelo, Netherlands) was founded to produce solar cells, initially operating under a Solarex[59] license. However, the parent company started getting into financial trouble and wanted to get rid of its solar business. The management approached Shell, which was very sceptical about purchasing the subsidiary. Nevertheless, Holecsol management persuaded Shell to acquire the company in 1984, which later became known as Renewable Energy Systems (R&S).[60] R&S was renamed Shell Solar once Shell decided to make "Renewables" the 5th core division of Shell in 1997 and invested $500 million over 5 years. In 2001-2002 Arco Solar/Siemens Solar's legacy business and assets were purchased by Shell and operated for a limited time as Shell Solar. Shell eventually sold the residual assets in 2006 to Solar World from Germany, which subsequently filed for insolvency in 2017.[61]

31 Next to investments in SES and Holecsol, between 1991 and 1997 Shell also owned a 35% minority stake in Photowatt, the top French PV company. In 1999, Shell also collaborated with Pilkington Solar and jointly invested in the construction of a new solar cell factory. This facility, one of the biggest in Europe, was established at the Gelsenkirchen site belonging to Pilkington's solar subsidiary, Flachglas Solartechnik.[62] At the facility opening, in the presence of several ministers and about 150 media representatives, the CEO of Shell, Jeroen van der Veer, said:

> Shell has been active in [the] energy business for 100 years now. If we want to earn money for another 100 years, which we want, we have to shift to solar energy; because as you all know, oil reserves will not last that long.[63]

The other solar ventures outside the US and 32
Europe were in Japan through the 1985 merger of two oil companies, Showa Oil and Shell Sekiyu, and in Australia with the acquisition of a 50% interest in an Australian company, Solarhart, in 1979.[64] Collectively, all these initiatives positioned Shell as one of the major investors during both the early and subsequent eras of photovoltaic technology.

Next to the already mentioned oil "majors," 33
serious commitment to developing solar technology came from Atlantic Richfield (Arco), a mid-size (i.e., non-major) US oil firm. That company, alongside Exxon, was the only one with a solar cooling and heating subsidiary, Northrup, a prominent player in the solar energy sector. Northrup specialized in manufacturing and marketing solar collectors, along with conventional heating, air conditioning, and heat pump equipment. Recognized as a leader in solar energy, Northrup was celebrated for its innovative contributions to the field.[65] Initially Arco became a minority stockholder of Northrup, Inc. in 1978 before acquiring full ownership a year later. Aiming for accelerated growth in these energy fields[66], Arco secured a $250,000 R&D contract from the US Department of Energy to explore the application of large heat-reflecting mirrors,

58 Mener, *Zwischen Labor und Markt: Geschichte der Sonnenenergienutzung in Deutschland und den USA 1860 - 1986*; Shell Oil Company, *Annual Report 1978*.
59 Details on Solarex follow below.
60 Van Zolingen, Interview. The acronym makes more sense in Dutch: "en" means "and," so "R(enewable) En(ergy) S(ystems)" = "R En S" = "R&S."
61 Miller, 'Why the Oil Companies Lost Solar'.
62 Palz, *Power for the World*.
63 Ibid, 242.
64 Wolfe, *The Solar Generation*.
65 Northrup press release, 'Northrup Introduces New Solar Collectors', 11 April 1978, Box 63, Folder Northrup inc, 1977-1978, MTC.
66 Atlantic Richfield Company, *Annual Report 1977*.

known as heliostats. After successful application at the processing plant operated by Oil and Gas Company in California, the company received a $1 million contract from Sandia Laboratories to design a second-generation heliostat.[67]

34 Arco's PV journey started by acquiring Solar Technology International (STI), a manufacturer of solar cells for new terrestrial markets such as navaids and cathodic protection,[68] founded by Bill Yerkes, a former employee of Spectrolab. In 1976 STI gained market share by installing battery charging panels for a motor company and boosting sales after a crucial order from the Jet Propulsion Laboratory (JPL).[69] Yerkes attracted additional investors for advanced manufacturing equipment, further supporting the company's growth.[70] However, Yerkes admitted that ten more years of research would be needed to produce solar technology at a much-reduced cost.

35 Around that time, Arco became aware of STI's activities and in 1977, upon positive assessment, Arco's leadership decided to acquire STI, which became Arco Solar. During these proceedings Yerkes realized that Arco did not know anything about the solar business. Nevertheless, the company started planning construction of a cutting-edge automated factory for solar cell and panel production, led by Yerkes and supervised by Arco's management. Over the next decade Arco invested $200 million to develop its solar business, pleasantly surprising Yerkes with the substantial scale of the investment and strong commitment.[71]

36 Arco's interest in STI, and solar energy in general, sets the company apart from other oil companies as it contains a bit of a personal note, given the fact that Robert O. Anderson, CEO of Arco, personally visited the STI factory and eagerly followed his company's solar investments. Anderson seems to have been driven by both business acumen and personal affinity with solar energy. As the largest private landowner in America at the time, managing over a million acres of ranch land in arid New Mexico where he raised cattle,[72] Anderson had a keen interest in photovoltaics for water pumping. This very conveniently coincided with Arco's acquisition of STI and their work on a solar-powered water pump for the Bureau of Indian Affairs in (relatively) nearby Albuquerque, New Mexico.[73] Arco's investment in solar, at least under Anderson, reflected the firm's commitment to environmental issues too. Anderson's devotion to environmental responsibility, evident in his advocacy,[74] and Arco's swift response and compliance to the 1970 Federal Clean Air Act, showed a very proactive approach to minimizing environmental pollution from its operations.[75]

37 During the early years, Arco Solar primarily focused on market expansion by lowering manufacturing costs and expanding its distribution network. Arco Solar relatively quickly automated its manufacturing processes, opening the world's largest and most modern solar manufacturing facility in Camarillo in 1980, capable of producing 1 MWP of modules (reaching 100 MWP by 1996).[76] Large scale projects like the 1982 PV plant in San Bernardino County and 1983 Multimegawatt Carrisa Plain were carried out without requiring further tax subsidies.[77] These projects were also prime examples of the long-term, 'brick by brick', commitment to making solar energy cost-competitive, an approach complimented by Peter Varadi, a solar entrepreneur and a founder of Solarex.[78] In addition to these megaprojects, Arco PV systems also found small-scale application in rural places e.g., on the lands of the Navajo Nation in Arizona and New Mexico.[79]

67 Atlantic Richfield Company, *Annual Report 1979*.
68 Williams, *Chasing the Sun*, 86.
69 This order was part of a U.S. Department of Energy program that utilized STI's technology.
70 Jones and Bouamane, 'Power from Sunshine'.
71 Berger, *Charging Ahead*; Johnstone, *Switching to Solar*.
72 Harris, *The Wildcatter. A Portrait of Robert O. Anderson*.
73 Johnstone, *Switching to Solar*.
74 He was a regular speaker at international events on environmental protection and was actively involved in the preparations for the United Nations Conference on the Human Environment in Stockholm in 1972.
75 Jones and Bouamane, 'Power from Sunshine'.
76 Wolfe, *The Solar Generation*.
77 Atlantic Richfield Company, *Annual Report 1983*.
78 Varadi, *Sun above the Horizon*, 111.
79 Atlantic Richfield Company, *Annual Report, 1981*.

38 In the few years to come, Arco Solar eventually had 96 distributors selling in 130 countries and was expanding globally by entering joint ventures with Showa Shell of Japan and Siemens of West Germany. These ventures aimed to produce and market photovoltaic products in the Far East, Africa, and the Middle East, showcasing Arco's efforts to position itself as a world leader in PV technology.[80] The company was also successfully operating two large PV power stations for California utility companies, demonstrating the long-term reliability of the technology.

39 Next to its global expansion, Arco Solar made significant strides in thin film solar technology by supporting Stanford Ovshinsky, who worked on a machine that would make a paper-thin film of PV and silicon technology. Ovshinsky's company, Energy Conversion Devices (EDC),[81] was struggling to raise money for his silicon cell technology. One company to turn him down was Exxon[82] before he successfully locked up the deal with Arco in 1979. Arco initially invested $3.3 million in EDC's production of a new amorphous silicon alloy for a period of 15 months.[83] Already in 1980, Arco invested an additional $9.3 million, which in the coming three years piled up to a total investment of around $25 million before Arco ended the agreement with Ovshinsky.

40 Latecomers to the solar industry were American Oil Corporation (Amoco) and British Petroleum (BP). Amoco's involvement in solar also started with entrepreneurs outside the company. After leaving COMSAT, where they worked on solar panels that powered satellites, Joseph Lindmeyer and Peter Varadi created their start-up, Solarex, in 1973. The company focused on developing affordable photovoltaic products for terrestrial applications, aiming to provide electricity to power electrical equipment for telecommunication.[84] The company was quickly a success, occupying top positions in the PV market as they managed to sell their product to, among others, the US Bureau of Land Management, Forest Service, and the National Weather Service in the continental USA and Alaska, and the state police in the US mountain states.[85] Another big market was the oil and gas industry itself, as Chevron, Exxon, Texaco, Amoco, and Arco became major customers of Solarex's solar modules, used to prevent corrosion, through cathodic protection, on their extensive pipeline and wellhead infrastructure.[86]

41 However, as the company was growing, the founders struggled with a lack of capital to keep the business flourishing. Therefore, investments from other parties were sought, such as Holec, a Dutch electrical company, and Leroy-Somer, a French electric power generating company, which obtained Solarex's license to manufacture photovoltaic cells.[87] In 1979, a major oil company, Amoco, recognized the potential of photovoltaics as a significant energy source and started accumulating stock in Solarex, for which Amoco was apparently willing to pay a premium over market valuation of the stock.[88] Gordon McKague, Amoco's manager of Corporate Development, explained to the *Washington Post* the reasons behind the company's investments in Solarex:

> We are trying to keep our eyes open as to what's going to be available in the future, since we know that Mother Nature and the various governments around the world aren't always favourable to oil companies... We decide to put some money into a small company and watch them grow and help them grow and see where it leads.[89]

42 This investment in a minority stake provided Solarex with the essential funding required to establish a state-of-the-art manufacturing plant. Beyond the equity investment, Amoco

80 Atlantic Richfield Company, *Annual Report 1986*.
81 More on EDC in Hoddeson and Garett, *The Man Who Saw Tomorrow: The Life and Inventions of Stanford R. Ovshinsky*.
82 Reece, *The Sun Betrayed*.
83 Atlantic Richfield Company, *Annual Report 1979*.
84 Palz, *Power for the World: The Emergence of Electricity from the Sun,* 556. Anonymous, 'Lindmayer Seeks Solar-Cell Power'.
85 Varadi, *Sun above the Horizon*.
86 Williams, *Chasing the Sun*, 85.
87 Jones and Bouamane, 'Power from Sunshine'.
88 Potts, 'Amoco Tries to Avert Eclipse of Solar Subsidiary'.
89 Potts, 'Solarex: Money in Sunshine'.

was contemplating financing targeted research and pilot projects.[90] These collective investments opened up market expansion not only in the US but also in Australia, Hong Kong, UK, Switzerland, France, Italy, and the Netherlands, which propelled Solarex to become the world leader in terrestrial PV.[91] According to Varadi, the company benefited greatly from Amoco's support and strategic vision. The company's executives believed in the long-term potential of solar energy and understood the importance of establishing other PV markets, including niche consumer products.[92]

43 BP, another European major, entered the solar energy market at the beginning of 1981. BP formed a solar joint venture with the British engineering company Lucas Energy Systems, established under the wing of Lucas Industries, the UK-based automotive electronics multinational. At first, BP had 50% of the shares. That changed already a year later, when the company acquired full ownership of Lucas Industries, renaming the company BP Solar.[93]

44 The 1980s were marked by rapid expansion mostly in the domain of industrial application. BP Solar's first PV contracts came soon after the company started supplying rural telephony and telecommunications applications in Colombia and Algeria.[94] In 1983 BP Solar set up a BP Solar East Africa office in Kenya. In 1984 BP Solar Systems, with EGS donations, built a 30kW photovoltaic system connected to the public electric grid near Southampton, Great Britain. In 1985 BP Solar bought Tideline's manufacturing plant in Sydney and launched BP Solar Australia.[95] In 1986, BP acquired Standard Oil of Ohio (SOHIO), which had invested around $80 million in the entrepreneurial activities of Stanford Ovshinsky and his amorphous materials and thin-film technology.[96]

For quite some time, BP was very successful in 45
the solar business. Following a change in management in the beginning of 1990s, BP became the second largest European-owned PV manufacturer after Siemens. According to Philip Wolfe, the first CEO of BP Solar, the company became "perhaps the first major PV company to move away from routine annual operating losses... and claim operating profit."[97] In the late 1990s BP accelerated in the market even more after merging with Amoco, owner of Solarex[98] and taking a 50% stake in Solarex. In 1998-99 BP Solar completely absorbed Solarex into its business, propelling the company into the top tier in the solar industry. Strategic partnerships and global expansion at the turn of the century, including plants in India (with Tata), Europe, China, Australia, and the US, made BP Solar the world's second-largest solar company, trailing only Sharp.[99]

BP's involvement in the solar industry evolved 46
over time. Tim Bruton, a former director of R&D at BP Solar recalls that the company rebranded itself from being a technology-driven company in the early 1980s to an environmentally friendly hydrocarbon company in the 1990s to an energy solutions company in the 2000s. "BP saw solar as being a key part of its ongoing strategy. And, you know, it was good publicity."[100] Wolfe, who negotiated the Lucas Industries and BP joint venture shared similar views. In fact, he parted ways with the company when he got the impression that their initial entry into the solar business was mostly because of good PR. He further added "they thought it might be a significant business in the future and it was useful to have a toe in the water."[101] However, strong and dedicated leadership can turn things around, as with Arco's Anderson or BP's CEO John Brown. Even though the company, like others in the oil industry, started facing accusations of greenwashing around the turn of the century, it is also important to acknowledge the company's long commitment and substantial investment until 2011.

90 Varadi, *Sun above the Horizon*.
91 Palz, *Power for the World*, 565; Varadi, *Sun above the Horizon*.
92 Varadi, *Sun above the Horizon*.
93 Wolfe, *The Solar Generation*.
94 Ibid.
95 International Solar Energy Society, *ISES SWC50*.
96 Newham, 'Sohio Stake in Cheap Solar Power'.
97 Wolfe, *The Solar Generation*, 92, 208.
98 Anonymous, 'BP Amoco Buying All of Solarex'.
99 Miller, 'Why the Oil Companies Lost Solar'.
100 Johnstone, *Switching to Solar*, 54-55.
101 Interview with Wolfe.

DIVESTMENT AND WITHDRAWAL: THE DECLINE OF OIL IN SOLAR

47 Following the peak period of oil industry engagement with solar, a combination of external and internal factors led oil companies to scale back their investments in solar technologies. The late 1970s and 1980s saw the rise of neoliberal policies in the US and UK, emphasizing deregulation and reduced government support for alternative energy. This shift pressured oil companies to prioritize short-term profits over long-term investments in technologies like solar. The decline in oil prices throughout the 1980s further diminished the perceived urgency of developing alternative energy sources, as concerns about energy security and resource scarcity faded.[102]

48 Oil companies, now facing pressure from shareholders demanding faster returns on investments, increasingly viewed solar as a distraction from their core oil and gas operations. Exxon, for example, actively opposed regulations and incentives that would have made solar power more competitive with fossil fuels. The intensifying opposition from oil companies towards solar energy suggests that their earlier involvement in the sector, while not necessarily insincere, always remained secondary to protecting their core fossil fuel interests. Yet, despite facing similar external factors, oil companies exited, or kept limited activity, in the solar business at different rates, highlighting again the heterogeneity of their actions.

49 The first one to abandon the solar path was Exxon, even though the partnership with SPC proved to be a game-changer for the company, propelling it to become a major player in the renewable energy industry. Exxon executives, however, remained publicly sceptical about the near-term impact of solar energy. Speaking to students at the Founders Day Convocation at Sweet Briar College in 1979, Exxon CEO C.C. Garvin Jr. stated, "Solar power, in my opinion, is unlikely to be significant until after the turn of the century."[103] This sentiment was echoed by Exxon president Howard C. Kauffmann, who told a meeting of the Securities Industry Association that "oil will continue to be our dominant source of energy supply well into the future. New energy forms will supplement it, but none can be expected to replace it in this century."[104]

50 Indeed, despite a thrilling beginning and a 5% share of the global market for solar panels in the late 1970s, remaining in the solar business was not that attractive to Exxon. Exxon very quickly shifted its attention toward profitability and became increasingly doubtful about the business's long-term viability.[105] Overall, the general rule seemed to be that once a project proved to be technologically unworkable or when market conditions altered drastically, the project was abandoned.[106] As Philip Wolfe, a former president of BP Solar, put it in a recent oral history interview:

> Exxon was quite [an] interesting case. When I visited Exxon, in the late 1970s, and asked why you are in this (solar business), do you have a long-term future, the head of new business development for Exxon said: It is very simple to us. If we think the business is going to be worth a billion dollars within 5 years and we can have 30% share of the world market - we will stay in. And if we don't think that - we will get out. And 9 months later, they got out.[107]

51 There are other reasons for the slowly diminishing role of SPC on the solar market. First, Exxon's short time horizon (around 10 years), probably guided by Cherry Hill conference predictions that "utilization of PV as a viable alternative" is expected within a decade.[108] Second, there was

102 Sabin, *The Bet: Paul Ehrlich, Julian Simon, and Our Gamble over Earth's Future*.

103 C. C. Garvin, Jr., Chairman of the Board of Exxon Corporation, Speech at the Founders Day Convocation, Sweet Briar College, Sweet Briar, Virginia, 10 October 1979, Box 7, folder 59, Wallace E. Pratt papers, Kenneth Spencer Research Library, University of Kansas (henceforth WEP).

104 'Kauffmann sees government policies as energy stumbling block', N.D., Box 7, folder 59, WEP.

105 Pratt and Hale, *Exxon*.

106 Kaufman and Walker, 'The Strategy-History Connection'.

107 Interview with Wolfe.

108 Varadi, *Sun above the Horizon*.

a substantial dependence on government contracts. During the Carter administration, which strongly supported solar initiatives, it was an opportune time for investments in solar energy. However, when Reagan came to power in 1981, the federal budget for photovoltaics was significantly reduced, which affected not only SPC but all other solar companies. SPC had highly skilled technical personnel, and they tried to expand into the commercial market. However, commercial sales require building up incrementally – the 'brick by brick' approach – which takes time. Exxon did not want to commit to that.

52 After losing the government demonstration projects business, and being unable to replace it with commercial opportunities, which were mostly dominated by Solarex and Arco Solar, Exxon closed SPC in 1983.[109] The oil giant made no attempt to sell the business as a going concern, even though there were potential buyers, including management buyouts.[110] Instead, Exxon dismantled the company and sold off its assets to Solarex. Despite this unfortunate end, Berman, under Exxon, managed to significantly reduce the cost of solar cells and spread the global adoption of photovoltaics.[111]

53 A similar fate befell Exxon's subsidiary in solar heating and cooling, Daystar. Even though in 1980 Exxon decided to focus more on the development of "higher technology collector systems", already the next year Exxon announced the sale of Daystar.[112] Daystar was sold due to unprofitability to American Solar King Corporation for $2.3 million, a fraction of the initial $10 million investment.[113]

54 Mobil Solar also closed its doors in 1993 after 19 years of work, despite the evident breakthrough, opening of new markets, and repeated commitment to advancing solar technology and lowering its production costs.[114] The reasons for the decision, perhaps influenced by a change in management that focused on containing costs, profitability, and return to core competencies,[115] were spelled out in a Mobil press release, where the company declared:

> The electric utility industry market for solar energy is small and is unlikely to grow to large-scale demand in the near term... Our photovoltaics technology is good, but it does not provide us with a reasonable business opportunity, either now or in the foreseeable future.[116]

55 Shell's SES as well had a lot of problems turning its technology into a viable commercial product, despite the relatively big investment, state-of-the-art laboratory employing nearly 200 personnel at its peak, and dedicated sales and marketing department. Conversion efficiency was excellent, around 10%, but the company never achieved sales beyond a few kilowatts peak.[117] Amid these challenges, Shell had been considering a shift to silicon-based solar cells since 1976, and ultimately decided to abandon cadmium sulphide technology due to its technical problems, poor performance in the market, and environmental concerns surrounding the use of cadmium.[118] This decision coincided with Shell's complete takeover of SES in 1979.

56 However, abandoning this technology did not mean the end of Shell's commitment to solar, at least for a while. SES's legacy was carried through by a joint venture of Shell and Motorola, Solavolt.[119] Solavolt opened in 1981, focused on developing, manufacturing, and marketing PV panels and systems. However, in 1987, Solavolt announced it would leave the PV industry.[120] It seems that this withdrawal from solar related

109 Ibid.
110 Wolfe, *The Solar Generation*.
111 Perlin, *From Space to EArth*.
112 Pratt and Hale, *Exxon*, 190.
113 Scherer, 'Solar's Bright Promise'; Bushsbaum, 'New Faces Of 1985'.
114 Ibid.
115 Mobil Oil Corporation, *Annual Report 1984*.
116 Southerl, 'Mobil ends solar project, citing market weakness'.
117 Wolfe, *The Solar Generation*.
118 Mener, *Zwischen Labor und Markt*.
119 Ibid.; SCS, Inc, on SES History, Box 58, Folder 116-SES, Inc.-SES & Solavolt, KWB.
120 Watts and Smith, *Photovoltaic Indusry Progress from 1980 through 1986*.

business was part of the divestment trend and return to the "core business" rationale across the oil industry, as around the mid-1980s the solar business started to slip for other companies, such as Arco Solar, too.

57 In 1985 Bill Yerkes left Arco Solar, partially because he was not convinced that the new direction, focused on thin film solar technology, was the right one.[121] He had great respect for some oil executives sent to manage solar business, but his prevailing impression was that most managers put in charge of solar activities did not seem to have any affinity with this business.[122] The management of Arco Solar, however, was convinced that thin-film amorphous silicon would surpass their traditional crystalline silicon products based on wafers. Company executives projected that there would be two markets for the new, inexpensive panels: off-grid uses in developing nations, and "big power utilities that need cheap fuel."[123] The corporation reportedly employed one hundred researchers and tasked them with creating amorphous silicon for solar cells.[124] Already in 1989, though, Arco Solar announced that it was selling its solar business due to unprofitability and a desire to go back to its core business.[125] Siemens A.G. of West Germany purchased the company for an estimated $30-50 million.[126]

58 Solarex, also not immune to the combination of a declining oil price and the withdrawal of federal government support for solar, struggled for a while until Amoco took the company over in 1983 by paying Solarex's debt of $7.3 million to Maryland National Bank.[127] A change in the top management also influenced the approach to solar energy as the new establishment, focused more on the core business, shifted their strategy towards a utilities-oriented solar business that should bring in new revenues.[128] Once Amoco merged with BP, Solarex was absorbed into BP Solar.

Initially, BP invested heavily in solar R&D, spend- 59
ing around $20 million annually in the early 1980s when the company had a lot of money. With the Amoco merger and the rapid growth of the solar market, the emphasis shifted from being a technology leader to being a financially viable company. Just as new solar startups were aggressively investing in production facilities, BP started cutting back on its solar business, mirroring the move by its rival Royal Dutch Shell which also cut off most of its renewable energy assets.[129] Shell abandoned its solar business in 2009 by leaving solar in the hands of the smaller and medium companies, as "we don't see this being something we can scale", said the CEO of Shell.[130] Their focus was still on renewables but in the biofuels sphere, which was closer to their core business focus. By the end of 2011, BP had exited the solar market completely. This corporate strategic decision was justified by the lack of revenue from solar due to increased competition from China and the fact that they perceived solar as a "commoditized" business with a not so bright future.[131]

CONCLUSION AND DISCUSSION

The analysis of six oil companies' involvement in 60
solar energy during the 1970s and 1980s reveals a complex interplay of motivations. While overarching external pressures, such as energy crises, geopolitics, diversification strategy, environmental regulations and governmental support, in similar ways largely influenced industry action, internal factors and ambitions were equally important, yet more diverse.

A shared similarity across the industry was ini- 61
tial confidence that managerial expertise, and experience with risk assessment, marketing, and generally running an energy business, would be

121 Johnstone, *Switching to Solar*.
122 Wolfe, *The Solar Generation*.
123 Johnstone, *Switching to Solar*, 295.
124 Ibid.
125 Johnstone, *Switching to Solar*, 54.
126 Wald, 'Arco to Sell Siemens Its Solar Energy Unit'.
127 Varadi, *Sun above the Horizon*.
128 Varadi, *Sun above the Horizon*.
129 Johnstone, *Switching to Solar*, 55.
130 Miller, 'Why the Oil Companies Lost Solar', 54.
131 Macalister, 'BP Axes Solar Power Business'.

advantageous and applicable for the emerging solar industry. Shell, which might have been more strategic by letting individuals from its chemical business get involved with solar,[132] also failed to yield profits from solar ventures. What differed were internal motivations, such as quick profitability, tentative exploration, and even personal interest and sympathies for solar energy.

62 The provided evidence suggests one should not ignore that PR, seemingly the driving force behind BP's initial entry, or in later decades greenwashing for other companies too, played a role to some extent. However, oil companies also recognized a potential for solving some of their issues, as evident from Exxon's, and later other oil firms', adoption of solar solutions for powering offshore platforms and cathodic protection to prevent pipeline corrosion, as well as for water pumping problems in remote, water scarce areas as seen with Anderson and Arco and other desert area applications.

63 Evidently, the oil industry had money to spare for businesses that could be complementary to their core business and perhaps become profitable. After all, in the 1970s solar power was seen as a 'sexy' emerging sector and a good opportunity to dip a toe in the water and put oil companies in a positive light. Although ultimately driven by profit, oil firms invested a significant amount of money into a solar business that their own executives publicly stated would not take off until the twenty-first century. According to an American Petroleum Institute report,[133] as of 1980 oil firms had invested some $94.2 million in the US solar energy industry. Undoubtedly that might not be a lot of money for oil corporations that have revenues in billions (for example Mobil's earnings in 1978 were $1.1 billion),[134] but it certainly provided a significant impetus for the nascent solar industry. The same API report estimated that "oil companies have thus undertaken what is likely the majority of total private cumulative investment in photovoltaics."

64 That financial support was praised by many industry insiders, including solar entrepreneurs who acknowledged the oil industry's early contributions. Almost none of them was under the impression that big oil wanted to sabotage development of solar, quite the opposite. When the U.S. Senate's Joint Economic Committee questioned Mlavsky about the allegation that oil companies were intentionally hindering solar development, he said:

> Mobil has provided essential support in the program to develop our photovoltaic technology. Without Mobil's backing, this promising technology might have been abandoned by now... As a citizen and PV practitioner, I find it difficult to see how Mobil could have an incentive to slow the development of PV technology... both on the basis of the timeframe of PV development, and on the specific uses of crude oil and natural gas. I see solar energy and the oil business as complementary not competitive. From my experience with Mobil, I think that oil companies have a positive incentive to accelerate the development of solar energy.[135]

65 Echoing this sentiment, Charlie Gay, the former head of the National Renewable Energy Laboratory (NREL) and a former president of Arco Solar, said: "Companies don't invest hundreds of millions of dollars in a technology because they want to destroy it."[136] The financial losses suffered by oil companies when divesting from solar ventures challenge the conspiratorial explanation even further.

66 Ultimately, this paper shows that there is no single factor that can explain the industry's engagement in solar. Moulded by prevailing socio-political factors and internal dynamics, each company navigated the emerging solar energy field with varying degrees of commitment and a distinct mix of motivations, showing the heterogeneous nature of the oil industry's approach to solar. Exxon's short-lived

132 Wolfe, *The Solar Generation*.
133 Ethridge, *The U. S. Solar Energy Industries*.
134 Mobil Oil Corporation, *Annual Report 1978*.
135 Mobil op-ed, 'A cloudy view of solar energy', 3 October 1976, 2.207_G117_General Subject Files; Mobil Solar Energy, EMC.
136 Williams, *Chasing the Sun*.

involvement and overall investment contrasts sharply with Shell's and BP's long-term engagement. While Exxon was focused on a rather short time horizon fixated on large market share and profitability, Shell has had a long and complex commitment to solar energy, with significant shifts in their involvement over the years. Their projections for solar energy evolved from tentative exploration, with an eye toward diversification of the energy mix in the 1970s and 1980s,[137] to proclaiming solar as a "fifth core business" in the 1990s[138] and later predicting it would be "the world's biggest source of energy,"[139] before eventually withdrawing from the solar business. Arco's experience, driven by large investments and passionate commitment to expanding solar markets, was also shaped by the personal vision of Robert O. Anderson, emphasizing the potential of individual actors to shape corporate direction, and a course of energy transition.

Studying the historical relationship of oil and solar is important for understanding the role of incumbent industries in energy transitions as the issues examined in this paper are not merely of historical interest but continue to be a source of ongoing public discourse. Given the pressing global need to decarbonize, understanding the factors that drive or hinder the engagement of fossil fuel companies in creating more sustainable future is paramount. Do these companies have a capacity and willingness to leverage their assets to accelerate the transition, or will they stay in the way of it? Reflecting on past experiences, both successful and less successful stories, can offer valuable lessons for policymakers, investors, and industry leaders to steer along the complex path towards a sustainable energy future.

137 Shell Nederland B.V., *Zonne-energie*.

138 Pinkse and van den Buuse, 'The Development and Commercialization of Solar PV Technology in the Oil Industry', 6.

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