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Origins of Terrestrial Solar Power

"Where shall I begin, please your Majesty?" he asked.

"Begin at the beginning," the King said, very gravely, "and go on till you come to the end: then stop."

Lewis Carroll [3]

If we were to begin at the beginning of the story of solar energy, we would go all the way back to the formation of the sun and the earth. Virtually all the energy we use comes straight from the sun; only atomic and geothermal energy use a resource that is not directly solar in origin. Sunshine fueled the growth of the organisms that gave rise to the earth's coal, oil, and gas deposits. Today it grows the trees and crops for our biomass and biogas production. It is the source of the rain for our hydropower and wind for the turbines.

But let's not begin this story in prehistory.

If we were to begin with when solar energy was first used to produce electricity, we would go back before Albert Einstein's Nobel Prize in 1921, which many will be surprised to hear was for his work on photoelectricity [4], not quantum theory. We would need to look at the previous century's achievements of the Becquerel family in discovering the phenomenon of deriving an electric charge from sunlight – the photovoltaic effect [5]. We'd look at the work of Bell Laboratories and others in the mid-twentieth century on early solar cells, and the first applications of photovoltaic (PV) devices in space in 1958. But I intend to cover the birth of photovoltaics only fleetingly.

Instead, this story begins with the "first oil crisis" of 1973–1974. That one event, more than any other, heightened mankind's awareness that the energy sources it so desperately depended on were neither ubiquitous nor infinite. This led to dramatically increased interest in what at the time was called "alternative energy." It also led to the formation of the International Energy Agency in 1974. Furthermore, the sudden increase in the oil price brought about by the crisis

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started a progressive change in attitude about the value of energy, and made hitherto costly looking alternatives more attractive.

This congruence of factors led to what I consider to be the start of the terrestrial photovoltaics industry. This is when Joseph Lindmayer, Peter Varadi, Bill Yerkes, and Ishaq Shahryar left the US space solar industry to establish independent PV companies; and Elliot Berman persuaded Exxon to back his solar enterprise. It is when electronics and energy companies in Europe and Japan shifted photovoltaics out of their research laboratories and into business units. And it is when marketing of solar systems for use on earth really began, although there had been isolated earlier applications.

Having decided where to begin, the next decision is where to end. The end of a millennium is a notable juncture in any case, and 1999 was the year when cumulative solar photovoltaic capacity reached its first gigawatt (1 billion watts) [6]. It also proved to be a turning point for renewable energy. It was just into the new millennium when national feed-in tariffs were first introduced for solar power; and they, more than any other mechanism, created the climate for explosive growth in renewables generally and solar power in particular.

This book therefore focuses on terrestrial photovoltaics between 1973 and 1999. For convenience, I refer to this period as simply *our time frame*, *the early PV era*, or *the first solar generation*.

1.1 OPEC Oil Crisis

The first oil crisis was sparked in October 1973 when some members of OPEC proclaimed an oil embargo in response to American supply of arms to Israel in the Yom Kippur War. At the time petroleum consumption by industrialized countries was rising rapidly and the price of oil was about $3 per barrel.

The Organization of Arab Petroleum Exporting Countries (OAPEC) comprised the Arab members of OPEC including Syria and Egypt, who had started the war. The embargo covered shipments not only to the United States but also to Canada, Japan, the Netherlands, and the United Kingdom.

The resulting strain on international relations led to intensive diplomacy headed by the Nixon administration's Secretary of State, Henry Kissinger. The prospect of a negotiated settlement between Israel and Syria eventually led to the embargo being lifted in March 1974, by which time the global oil price had risen fourfold to almost $12.

OPEC members, led by Saudi Arabia's Sheikh Yamani, recognized the leverage they could exert and agreed to use the world price-setting mechanism for oil to increase their income. The continuing relatively high price of oil, and a keener appreciation of the concept of energy security, led industrialized nations to consider other energy options more actively.

1.2 Energy Security

Before this oil shock, the supply of fossil fuel was assumed to be virtually infinite. It was OPEC's constraint on supply that, albeit artificial, sowed the seeds for a more realistic view.

Although the expression "peak oil" wasn't coined until later, some analysts now started to consider the lifetime of available fossil fuel deposits and the dynamics between rates of discovery, exploitation, and consumption. Shell's M. King Hubbert had first postulated his peak theory in 1956 [7] and projected in 1974 that US oil consumption could by 1995 exceed the pace of new discovery [8]. The name Peak Oil was given to this phenomenon [9] in 2002 and this concept is now widely accepted, although the precise dates remain a topic for debate.

The concept of "energy security" has subsequently been broadened to take into account other factors such as the political stability of the regions where energy is produced, and risks associated with transporting it to the point consumption. Other threats such as terrorism also need to be weighed in the balance.

The second oil crisis provided further impetus to the growth of renewable energy. This started in 1979 when oil production in Iran declined after the revolution there, and it was exacerbated the following year by the outbreak of the Iran–Iraq war, which almost stopped production in Iran and severely curtailed Iraq's output.

So energy security, in the form of the availability and price shocks of the oil crises, provided the first major stimulus for terrestrial photovoltaics; and although the circumstances have changed, energy security remains a substantial driver today.

Let's briefly consider other significant drivers, even if their impact was not so weighty at the start of our time frame.

1.3 Climate Change

Climate science was still very much in its infancy in the early 1970s. The link between atmospheric carbon dioxide and methane with global temperatures was not widely recognized; or as a skeptic might put it, "climate change had not yet been invented."

Climate change considerations did not in practice become a substantial inhibitor to fossil fuel usage, or a main driver to the growth of renewables, until some two decades later. Toward the end of the twentieth century, climate change became the primary motivation for supporting renewables and creating the incentives that allowed solar energy to progress from adolescence toward adulthood.

1.4 Other Drivers of the Early Renewable Energy Sector

Along with the external drivers, summarized above, a number of internal drivers were also at play.

Key to the development of any new industry are the companies and people who get it started. From the very beginning, the terrestrial PV space was occupied by a broad cross section of independent and multinational companies. For the independents, we can presume that they were inspired by the concerns of their principals.

The motivation of the larger companies is not always so clear-cut. For many, it was an issue of strategic diversification or expansion, as further discussed in Chapter 7. But some seem to have viewed their involvement as market research, to keep tabs on this new sector – maybe even seeing it as a threat – and others seem to have seen it as a PR exercise.

Ultimately, of course, any new industry is all about the people. Tales of many intrepid PV pioneers will crop up during this story, and some of them are individually profiled in Chapter 10.

1.5 That Sisyphus[1] Feeling

Terrestrial usage of solar power was viewed with widespread skepticism for several decades. This resistance took many forms.

For a start, many people just did not believe that it could work. They thought it was some kind of trick; "you just can't produce energy out of thin air." This may be partly because PV is a solid-state technology – harder to understand, when all previous experience of electricity generation was based on rotating machinery.

Next came questions about reliability and longevity. Of course, any new invention needs to prove itself, and people want to see it in action before they commit. The whole field of semiconductor technology was only a few years old and people weren't yet used to electronic devices, which are now so much part of everyday life.

More rational resistance came on the grounds of cost, and this will be addressed further as the book progresses. Remember that most traditional power generation involves plants where the upfront capital cost is relatively low, but the operating and fuel costs are high. Neither power engineers nor finance directors had economic models that could attribute fair value to the negligible running costs of a solar power plant.

Resistance was often particularly marked in more temperate climates. "Power from the sun? You've come to the wrong place!" Many assumed that PV

1 Mythical Greek king condemned by the Gods to eternally roll a boulder uphill.

technologies could work only in the sunniest places. It seemed incongruous that daylight is the only input required, and counterintuitive that systems are more efficient at low temperatures.

Finally, it doesn't take a conspiracy theorist to recognize that a successful solar industry threatens the business model of traditional energy producers. Political pressure was certainly brought to bear to slow the deployment of many environmental technologies. There are those who believe that similar tactics were adopted inside the industry as well.

All in all, there was a lot of resistance, and even more inertia, to slow the early progress of the industry. The effort required to secure and maintain the attention, political support, and funding felt like the unending struggle to push a boulder uphill.