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A HISTORY OF SOLAR POWER ART AND DESIGN

ALEX NATHANSON



A History of Solar Power Art and Design

This book examines the history of creative applications of photovoltaic (PV) solar power, including sound art, wearable technology, public art, industrial design, digital media, building integrated design, and many others.

The growth in artists and designers incorporating solar power into their work reflects broader social, economic, and political events. As the cost of PV cells has come down, they have become more accessible and have found their way into a growing range of design applications and artistic practices. As climate change continues to transform our environment and becomes a greater public concern, the importance of integrating sustainable energy technologies into our culture grows as well.

The book will be of interest to scholars working in art history, design history, design studies, environmental studies, environmental humanities, and sustainable energy design.

Alex Nathanson is a multimedia artist, A/V engineer, technologist, and educator whose work is focused on both the experimental and practical applications of sustainable energy technologies. He received a M.S. in Integrated Digital Media from NYU Tandon School of Engineering in 2019.

Cover: Björn Schülke, Aerosolar #2 (2010), Courtesy the artist/bitforms gallery

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Introduction

Artists and designers have been exploring the aesthetic possibilities of the modern photovoltaic (PV) cell since its invention in 1954. In that time there has yet to be a comprehensive interdisciplinary survey of the history of solar power as a creative medium, and, as a result, there is limited knowledge of this field. The increasing need for integrating sustainable energy technologies into our culture – brought about by climate change – requires that more work be done in this space, in order to develop the resources needed to adequately address the nuances and challenges of working with PV technologies. This book explores the history of creative practice involving PV solar power, identifies design methodologies and trends, and outlines the unique opportunities for creative expression that PV solar power enables.

Climate change is driving a cultural and societal shift in behavior, and requires embracing sustainable technologies to power our lives. Many of the technical solutions needed to respond to the climate crisis, like solar and wind power, have existed for years. They are tried and true, and even economical. What we lack is the political will and cultural drive. In some parts of the world, the resistance to change is shifting with countries and businesses rising to the challenge, while in other regions, like the United States, the government has yet to mobilize the resources needed to address the dire situation. While this undoubtedly has much to do with power dynamics and entrenched political interests, it is worthwhile to ask to what extent is the climate crisis an aesthetic challenge?¹ Is it an issue of communicating the problem? Is it a branding issue where the solutions seem unpalatable or uncool? Is it a lack of empathy on the part of those with the largest carbon footprint and greatest financial resources? Is it a general inability to imagine a different world that is less toxic and more equitable? The obstinacy is likely some combination of all of these factors, and more.

As PV and the adjacent technologies that are integral parts of many PV systems, like batteries, continue to evolve, the possibilities for new designs and applications will expand. An increasing number of artists will likely incorporate it into their practices as these possibilities emerge and the technology becomes more accessible, culturally relevant, and further integrated into our surroundings. The aesthetics of our built environment have a significant impact on how we move through the world, encompassing everything from the psychological effects of architectural features, to the ergonomic considerations of a consumer device, to the stories we want to communicate through art. We must consider the aesthetics of the response to climate change, not simply for the sake of something “looking good,” but to ensure we develop solutions that actually fit within peoples’ lives, are accessible, inclusive, and communicate what we intend to communicate. Presently, the resources available to artists

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and designers working in this space are severely lacking, because they provide only a traditional understanding of PV technologies. They fail to address aesthetic considerations and user experience issues, central concerns when considering communication and accessibility as important aspects of a project. In order for artists and designers to develop successful PV solar power projects that function properly, while reaching the full artistic potential of the material, there is a need for resources that contextualize the field and speak to the unique considerations in an aesthetic context.

I first interacted with solar power in 2014, when I co-curated an exhibition of electronic artwork in a community garden with Carina Kaufman-Gutierrez for the organization Flux Factory. Even though we were in the middle of New York City – not an area you would typically consider off-grid – the outdoor show had no access to electricity and we needed to figure out how to power the exhibits. Solar power was the best choice for the situation, so we installed a small off-grid system to run the show.

Since then, I have worked extensively with PV as an engineer, artist, and educator. During that period, two experiences in particular solidified the need for more research into aesthetics and PV. First, in my capacity as a multimedia engineer working for artists and art institutions, I am regularly involved with designing solar powered artworks. I have seen numerous examples of large scale public art installations that attempted to be powered by solar power, but failed because of poor planning and a misunderstanding of the nature of PV technology. The most glaring example was a solar powered installation for a large music festival in New York City in 2018 that the producers of the festival sited directly underneath a few large trees, completely obscuring any sunlight. To make matters worse, the company that supplied the solar power equipment to the artists had sold them components that weren't compatible. The artists decided to assemble the solar array, but because the hardware wasn't sized properly, only about 10% of the system was wired together and operating. The installation was promoted as a solar powered artwork even though it was actually running on grid power – a textbook case of greenwashing.² The second experience occurred the summer after Hurricane Maria, in 2018, when both the natural disaster and atrocious humanitarian response devastated Puerto Rico. I was working with an organization to install solar power systems throughout the island. The inability of the organization I was working for to adequately communicate technical information to victims of the hurricane, who were the recipients and future caretakers of the solar power systems we installed, undercut the important work that needed to be done and in some instances led to new problems for people who had already lost so much. While these two situations on the surface may seem completely unrelated, they are united by the need for better communication and education around the technologies that are crucial for mitigating the impacts of climate change.

Climate scientists paint a dire picture of the climate crisis. It requires swift and decisive action to stave off the worst possible future scenarios and limit the global average temperature increase to 1.5C° above pre-industrial levels.³ Climate change impacts every place on earth uniquely, because of geography, economics, and culture. As a result, the response to climate change must address local challenges, incorporate local concerns, and learn from local and Indigenous expertise. The climate crisis exacerbates existing inequality and makes vulnerable populations even more vulnerable. Frontline communities that are most directly impacted by climate change and have historically suffered from environmental racism must play a leading role in

the energy transition. Success in combating climate change will only come with a just transition to cleaner energy infrastructure. The causes of climate change are rooted in the extractive capitalism and colonialism that has ravaged the planet and people all over the world, particularly Indigenous communities, people of color, and residents of the Global South. A just transition must work to heal these historic imbalances, because it is not possible to fix a problem within the very systems that led to the problem in the first place.

A part of the solution to addressing this crisis is communication and education, areas where art and design have a huge role to play. PV creative practice ranges widely in its motivating factors, aesthetic criteria, ethical concerns, direct environmental impact, political goals, and other considerations. There is a long history of artists observing and engaging with the environment, but this engagement does not necessarily have a positive environmental value. Those that are concerned with environmental ethics and an equilibrium between humans and the rest of the planet (as we all should be) are part of an ancient tradition of sustainable land stewardship. PV art and design, like any medium that incorporates materials typically associated with environmental benefit or engages in climate communication, runs the risk of participating in greenwashing, misguided solutionism, green gentrification, overvaluing personal responsibility, lack of accountability for those with the largest climate impacts, and other pitfalls that are common in this space. This book is an attempt to provide a historical framework for practitioners to create informed work.

The lack of historical knowledge in this field has limited the ability of practitioners to build awareness of the existence of this field, develop critical dialog, and create a community of practitioners to support this growing need. On top of that, very few technical resources exist that specifically address the needs of the artists and designers who would be filling this gap. Because a solar cell's output is environmentally dependent, varying widely depending on the amount of light it receives, traditional electronics resources fall short. There is a need for in-depth and interdisciplinary educational resources for aesthetic applications of PV with a critical understanding of design. In the context of a history of this medium, the importance of an interdisciplinary resource lies in the fact that no single field can fully explore the possible applications of the technology, and it is only when looking at it as a whole that the nuances are revealed. In regards to technical resources, there are significant opportunities for practitioners in one discipline to learn the techniques of another area and apply them to their field. In addition to serving artists and designers, whom we could refer to collectively as creative solar power professionals, these same resources can benefit other people working in similarly niche areas of the solar power and climate sciences fields. This can include educators, people in community outreach positions, and other non-engineers who play crucial roles in educating the public and supporting communities most impacted by climate change.

At an academic level, what limited research is available is mostly concerned with the design of residential and utility scale PV installations and, to a lesser extent, of consumer device integrated PV (DIPV). There is almost no art-historical writing on the subject. There are a number of published academic articles written by the artists themselves documenting their own work. While these articles provide insights into their specific practice, they rarely include significant background sections and do not help illuminate this history or easily connect to other artists and designers.

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Institutional support of this type of work, through exhibitions, archives, and other mechanisms is similarly sparse. While many PV art projects have been exhibited and some of the artists are incredibly accomplished, the work is rarely contextualized within the history of PV or presented alongside other PV projects. Unlike other similar and occasionally overlapping fields of artistic practice like eco art and public art, there is no dedicated archive or database specifically focused on PV aesthetics, other than my own archiving work with the Solar Power for Artists Archive.⁴ The lack of support underscores the need to establish this history and identify conceptual frameworks for artists and designers working in this field.

Aside from publications like Land Art Generator's *A Field Guide to Renewable Energy Technologies*,⁵ there are very limited technical resources for PV aimed at artists and designers. There are a huge number of reliable books geared towards electronic artists and hobbyists that contain very useful information on creative applications of electronics, but none deals with PV content in much depth, if at all. They do not address the specific idiosyncrasies and nuances of PV and fall short of the practical needs of creative professionals. These resources typically assume the user has a stable power source, such as a battery. This assumption is generally the starting point for both designing a project and troubleshooting problems. Because a solar cell's output is inherently variable and environmentally dependent, these basic assumptions around the power supply do not hold up. This makes learning, prototyping, and designing from these resources difficult. Practitioners typically rely on finding informal technical information online and applying general electronics educational content to PV, both of which have significant limitations. The worthwhile resources online are most commonly materials that artists have produced for workshops, or documentation from solar power hardware companies, who are incentivized to produce educational content as a way to attract customers and manage user expectations.

In the broader areas of sustainable energy systems and traditional applications of solar power, there are many academic programs that train future engineers and policy makers on all of the complexities of the field. In many areas there are trade schools and continuing education programs with robust curricula for training and credentialing PV technicians. While some of this knowledge, like the basic engineering concepts, is transferable to creative applications, none of these existing programs are appropriate for artists and designers working in this space.

The reasons PV solar power is the primary focus of this book, as opposed to solar power in general or other sustainable energy systems, is that, in addition to its importance to combating climate change, it is accessible, scalable, and expressive. The opportunities for artists and designers to engage with PV are immense. From involvement in the early stage research of the smallest building blocks of these systems, the PV cell, to the end-user experience of mass produced consumer devices, creative professionals have a role to play. Pattern, for example, is an incredibly important aspect of human culture. By reconsidering the pattern of a solar cell, traditionally white lines on a dark blue surface, we have the potential, as the textile designer Marianne Fairbanks has said, to design something that functions not just at a technical level, but also holistically, as a solar collector.⁶ This approach applies not just to the visual aesthetic, but to all design considerations.

In addition to PV growing in use within art and design projects, creative industries at-large will need to adapt to the climate crisis. This transition requires more

sustainable uses of materials, like designing for long-term use rather than planned obsolescence, and reimagining the economics of particular industries. As more artists embrace these technologies, the rest of the art world ecosystem will need to respond. Curators, producers, exhibition designers, and conservators, among others, will need to understand the history and technology to contextualize it, properly display it, and maintain it. Art historians will need to understand this work in the context of the technical capabilities, economics, social values, etc. of the era in which it was produced.

Because there is relatively little interdisciplinary writing in the area of PV art and design, many readers of this book will likely be familiar with either the technical aspects of PV or the art and design aspects, but it is unlikely that more than a few readers will be experts in both. For this reason, the book includes entry-level contextual information to ensure it is approachable for readers in a variety of fields. Additionally, I have attempted to identify design methodologies and aesthetic trends that can be applied broadly across the entire field of PV creative practice in order to illuminate the unique opportunities afforded by PV and to establish a relationship between seemingly disparate projects. Initially, the book tracks this history chronologically, but as the field expands and more creative solar power professionals are working concurrently with dramatically different methodologies it departs from this linear approach in order to focus on specific influential mediums and movements. The practitioners and projects discussed throughout the book are not meant to be a complete list of every PV art or design project that has ever been created, but are meant to illustrate relevant trends and give an accurate picture of the diversity of approaches within the field.

Part 1 contextualizes and defines this medium. **Chapter 1** positions PV aesthetic practices in the context of the larger thoroughly documented history of solar power. The chapter outlines early uses of solar power and explains the variations in contemporary PV systems. It also examines other trends in the solar power industry, such as PV prices and the public's perception of climate change and alternative energy technologies.

Chapter 2 defines PV aesthetics. It describes the unique properties of the technology and the poetics it affords. The chapter concludes with identifying a number of cross-disciplinary design criteria for PV projects.

Part 2 looks at PV art and design in the 20th century. **Chapter 3** looks at the design field, while **Chapter 4** looks at the artwork being made during this time. The PV cell was applied to aesthetic applications, consumer products, and space technologies almost immediately after its invention. However, it was not widely utilized until the 1970s when the oil crisis led to an explosion of investment and research that made solar cells significantly more accessible. This enabled more artists and designers to experiment with the technology. By the end of the 1990s, solar power had found its way into a very wide range of practical applications and artistic media including sculpture, robotics, public art, sound art, and environmental art.

Part 3 explores PV art and design in the 21st century. The turn of the century is a useful demarcation, because it is the beginning of a period of dramatic growth in the PV industry. It also represents a shift towards more refined PV design strategies and an increase in the amount of practitioners creating artwork.

Chapter 5 focuses on wearable technology and textiles in relation to PV. This chapter traces the attempts at both the design and commercialization of textiles and

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wearable technology with integrated PV. Examining the evolving challenges designers faced in this space over the last 20 years, such as problems with supply chains, battery technologies, and the public perception and user experience of these devices, reveals much about the sustainable energy industry and the challenges posed by climate change at large.

Chapter 6 dives into the wide range of approaches that artists have taken when incorporating solar power into sound art. In part due to the ease by which other experimental music concepts and techniques could be applied to working with PV, sound art is one of the largest and most diverse fields within PV artistic practice. Important concepts like John Cage's notion of chance operations can be applied very directly to the variability and randomness that result from the fluctuations of battery-less PV sound-making devices. Musicians have a long history of experimenting with both uses and misuses of technology to make sound, and solar power is no exception.

Chapter 7 addresses traditional notions of solar power art and design in the context of building integrated PV (BIPV). Most of the academic research into PV design is focused on this area and, unlike most other fields; there have been a few attempts to define the aesthetic design criteria of these types of systems. The amount of infrastructure change brought about by the climate crisis will be massive and we will need to design the new sustainable systems with the same aesthetic care we apply to architecture and infrastructure presently. In addition to the mass produced BIPV modules that are intended to augment or blend in seamlessly with existing building materials, a number of artists coming from areas like architectural glass and industrial design have also created BIPV works.

Chapter 8 examines PV sculpture and installation. It encompasses artists who use solar cells as sculptural material, kinetic sculpture, light installations, video installation, and public art. A handful of artists have explored the form of the solar cell and its aesthetic possibilities, creating unique, typically hand built, solar modules displaying text, or graphic designs. This section will also discuss solar farms that arrange solar modules to create images. Since its early development, kinetic sculpture has continued to push forward with an incredibly wide range of dynamic, mostly playful, and occasionally menacing mechanical designs. Video artists, who have a long tradition of exploring the esoteric poetics of many materials, have also focused on examining the poetics of PV when incorporating the material into their work. Public art particularly lends itself to solar power, because most of it is located outdoors. Because of its high visibility, solar powered public art has been a site for public education and activism, typically around the themes of climate change or sustainability.

Chapter 9 looks at product integrated PV (PIPV). The chapter highlights some common PIPV product categories that include lighting, power supplies, vehicles, furniture, office products, toys, and business-to-business applications. The chapter also looks at user experience design within this domain. The user experience of PV products provides insight into how the public understands and engages with this technology.

The final chapter examines a few niche PV media subjects that provide additional insight into the opportunities for artists and designers working with these technologies. These areas are solar powered venues, interfaces for solar powered media, PV printmaking, and PV culinary art. This chapter also looks at potential future opportunities for solar powered art and design.

The history of solar power art and design has generally been tied to the centers of research, manufacturing, and installation within the solar industry, where the technology was most accessible. Initially this occurred in the United States, but was followed soon after by practitioners in Europe, Japan, and Australia. Today, while there are centers of research and manufacturing in particular regions, the solar industry is global. Practitioners all over the world are designing products, making engaging art works, and developing innovative solutions to address complex issues of sustainability and resilience. As the transition towards clean infrastructure progresses and PV technology becomes increasingly accessible all over the world, the scope of PV creative practice will expand along with it and encompass a growing range of stakeholders, techniques, and perspectives. Because this book is the first in-depth history to be written of this siloed medium the challenges associated with documenting and defining it have been significant. This is a highly multi-disciplinary book and as such is indebted to the research, ideas, designs, art projects, and hard work of countless people working in all the various niches of this field. Ultimately, I hope my research into the history of aesthetics and PV moves the solar power conversation beyond simply a discussion of its functional capabilities and considers its role in a culture that must rapidly adapt to a changing climate.

Notes

- 1 Anne Pasek, "Mediating Climate, Mediating Scale" *Humanities* 8, no. 4 (2019): 159.
- 2 Sebastião Vieira de Freitas Netto et al., "Concepts and Forms of Greenwashing: A Systematic Review," *Environmental Sciences Europe* 32, no. 1 (December 2020), doi:[10.1186/s12302-020-0300-3](https://doi.org/10.1186/s12302-020-0300-3). Greenwashing is when an entity, often a company, misleads stakeholders about their environmental impact. A few common forms of greenwashing are using vague and nonspecific claims, juxtapositions with environmental imagery, deflection from unfriendly to friendly environmental behavior, hidden environmental trade-offs, and outright false claims.
- 3 IPCC, 2018: Summary for Policymakers. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. In Press.
- 4 "Archive," Solar Power for Artists, accessed 1/9/2021, <https://www.solarpowerforartists.com/archive/>.
- 5 Robert Ferry and Elizabeth Monoian. *A Field Guide to Renewable Energy Technologies 2nd. Edition* (Land Art Generator, 2019), <http://www.landartgenerator.org/LAGI-Field-GuideRenewableEnergy-ed2.pdf>.
- 6 Marianne Fairbanks, Interview with Alex Nathanson, November 13, 2018.



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Part I



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1 Solar Power in Context

The typical history of PV solar power predominantly focuses on technical, economic, environmental, and political issues.¹ However, these histories have paid little attention to the industry's impact on culture and aesthetics, or vice versa. Understanding the history of solar power, its relationship to other aspects of the energy industry, and the ways they have shaped our world is crucial context for understanding the history of PV in art and design.

While it may be fairly intuitive that artists engage with a particular material in direct proportion to how pervasive it is in society, PV technologies provide a particularly clear picture of that relationship. When examining this traditional history of PV alongside the volume of artists and designers working with these technologies, a noticeable trend emerges. As the price of these materials decreases and they become more present in society, artists and designers incorporate them into their practices in equal measure.

Design and spectacle have long played a role in explaining and demonstrating the possibilities of PV technologies. Aesthetics is inseparable from the solutions to the climate crisis. Art and design have an important role to play, especially in regards to communicating the possibilities and limitations of technology and enabling a more just transition to clean energy. To adequately fulfill this role, artists and designers must contend with the issues that have shaped the history of this technology and their impact on people's lives. The work documented throughout this book, and the concepts and techniques that connect them, are intertwined with the more traditional understanding of the history of solar power.

It has become increasingly clear over the last decade, as the cost of renewables has dropped tremendously and the economic impacts of climate change have increased and are only projected to get worse,² that many of the technologies needed to combat climate change already exist and the barriers to change are more cultural and political than technological or even economic. Art and design are important tools for driving this change.

Sun Culture

The sun's impact on culture begins long before humans could track its position or intentionally make use of its energy. There is no human activity that doesn't require energy and a great deal of this energy is derived from the sun. The sun is, by its very nature, global and pervasive. Its importance, particularly for food and warmth, but also for light and time-keeping, is reflected in how widely it is represented in cultures

the world over. The sun appears prominently in nearly every aspect of human culture, spanning religion, mythology, politics, art, and architecture, to name a few. Many solar themes persist in various forms today, such as contemporary ceremonies and holidays that have their roots in sun-related ceremonies, either directly or indirectly through harvest and fertility celebrations.³

Solar iconography and signifiers are present throughout the world. Madanjeet Singh, an author and diplomat who worked closely with UNESCO documenting cultures around the globe, notes that, “The baffling complexity of solar symbolism is essentially rooted in barely a handful of fundamental motifs, such as the rudimentary shapes of plain or radiate circles, and concentric circles with dots, spirals, wheels, and other nimbus-like shapes, as seen in petroglyphs all over the world.”⁴ In addition to these symbols, a wide range of anthropomorphic and zoomorphic forms became associated with the sun. Sun imagery was intended to convey concepts related to power, godliness, life, and fertility, among other meanings. The inherently global presence of the sun uniquely enabled it to take on both particular and regionally specific cultural significance and also broader and more universally identifiable significance that persists across cultures. The metaphors and iconography found in these early activities can be seen in some PV art and design today still.

Even before knowledge of solar positioning was established, architectural spaces were designed with the sun in mind. Singh has documented a myriad of cultures that related height and mountains to being closer to the sun, and by extension to the divine. Many temples were built on mountains and in the image of mountains to reflect these values. As knowledge of celestial movements grew, architectural spaces were designed as time keeping tools for tracking and visualizing solar events. Stonehenge, which was constructed in various stages beginning around 3000 BCE through 2000 BCE, is one of the more famous of these early examples. While the structure’s exact builders, users, and purposes remain unknown, it is clear that it was designed intentionally for the central axis to align with the sunrise on the summer solstice and sunset at the winter solstice.⁵ A few thousand years later, likely around the 10th century CE, Mayans were capable of tracking the sun closely and created the most meticulous calendars of their era. They designed structures that could cast shadows depicting simple zoomorphic iconography at particular times of year. One of the most prominent examples of this is found at the El Castillo step pyramid at Chichén Itzá, in Yucatán, Mexico. Late in the afternoon on the equinoxes, a triangular pattern evocative of the body of a rattlesnake is projected onto the northern balustrade of the pyramid. The projection, known as the feathered serpent, aligns with a sculpted snake head at the bottom of the staircase.⁶ Even more complex architectural structures built in relation to solar events were created in the 15th and early 16th centuries by the Incas, who worshipped the sun. These complex structures included light tubes that illuminated interior altars at particular times of year and features that could create relatively complex displays of light and shadow in zoomorphic forms, like a puma.⁷ In addition to architectural structures, they used their knowledge of time keeping for religion and agriculture. The full extent of the Inca’s solar knowledge and the degree to which it was incorporated into their built environment is unknown, because Spanish colonizers sought to eradicate their religion and the tools associated with it in the 16th century.⁸

As knowledge of solar technologies spread, particularly in regards to architecture, references to these technologies could communicate increasingly complex meanings.